A1

ESQUIMALT GRAVING DOCK

PRELIMINARY HAZARD ASSESSMENT FORM

Number of Pages: 4

PRELIMINARY HAZARD ASSESSMENT FORM

Project Number:	**R.026729.002** **South Jetty Reconstruction**
Location:	**Esquimalt Graving Dock**
Date:	August 17, 2016
Name of Departmental Representative:	Patrick Truong, Project Manager
Name of Client:	EASS-EGD
Name of Client Project Co-ordinator	Wyatt Wright

Site Specific Orientation Provided at Project Location **Yes X** **No** ☐

Notice of Project Required **Yes X** **No** ☐

NOTE:
PWGSC requires "**A Notice of Project"** for all construction work related activities.

NOTE:
OHS law is made up of many municipal, provincial, and federal acts, regulations, bylaws and codes. There are also many other pieces of legislation in British Columbia that impose OHS obligations.

Important Notice: This hazard assessment has been prepared by PWGSC for its own project planning process, and to inform the service provider of actual and potential hazards that may be encountered in performance of the work. PWGSC does not warrant the completeness or adequacy of this hazard assessment for the project and the paramount responsibility for project hazard assessment rests with the service provider.

TYPES OF HAZARDS TO CONSIDER	Potential Risk for:				COMMENTS
Examples: Chemical, Biological, Natural, Physical, and Ergonomic Listed below are common construction related hazards. Your project may include pre-existing hazards that are not listed. Contact the Regional Construction Safety Coordinator for assistance should this issue arise.	**PWGSC, OGD's, or tenants**		**General Public or other contractors**		Note: When thinking about this pre-construction hazard assessment, remember a **hazard** is anything that may cause harm, such as chemicals, electricity, working from heights, etc; the **risk** is the chance, high or low, that somebody could be harmed by these and other hazards, together with an indication of how serious the harm could be.
	Yes	**No**	**Yes**	**No**	
Typical Construction Hazards					
Concealed/Buried Services (electrical, gas, water, sewer etc)	**X**		**X**		No natural gas services on site
Slip Hazards or Unsound Footing	**X**		**X**		
Working at Heights	**X**		**X**		
Working Over or Around Water	**X**		**X**		
Heavy overhead lifting operations, mobile cranes etc.	**X**		**X**		

Marine and/or Vehicular Traffic (site vehicles, public vehicles, etc.	X		X		
Fire and Explosion Hazards	X		X		
High Noise Levels	X		X		
Excavations	X		X		
Blasting	X		X		
Construction Equipment	X		X		
Pedestrian Traffic (site personnel, tenants, visitors, public)	X		X		
Multiple Employer Worksite	X		X		
Electrical Hazards					
Contact With Overhead Wires		X		X	
Live Electrical Systems or Equipment	X		X		
Physical Hazards					
Equipment Slippage Due To Slopes/Ground Conditions		X		X	
Earthquake	X		X		
Tsunami	X		X		
Avalanche		X		X	
Forest Fires		X		X	
Fire and Explosion Hazards	X		X		
Working in Isolation	X		X		
Working Alone	X		X		
Violence in the Workplace	X		X		
High Noise Levels	X		X		
Inclement weather	X		X		
High Pressure Systems	X		X		
Other:					
Hazardous Work Environments					
Confined Spaces / Restricted Spaces	X		X		Service Tunnels are restricted spaces. Electrical Vaults are confined spaces.
Suspended / Mobile Work Platforms	X		X		
Other:	X		X		Overhead cranes
Biological Hazards					
Mould Proliferations		X		X	
Accumulation of Bird or Bat Guano		X		X	
Bacteria / Legionella in Cooling Towers / Process Water		X		X	
Rodent / Insect Infestation		X		X	
Poisonous Plants		X		X	
Sharp or Potentially Infectious Objects in Wastes	X		X		Multiple employer workplace
Wildlife	X		X		Resident deer population

Chemical Hazards					
Asbestos Materials on Site	X		X		Asbestos is known to exist at specific locations within service tunnels.
Designated Substance Present		X		X	
Chemicals Used in work	X		X		Active ship repair facility
Lead in paint	X		X		Paint on steel and concrete surfaces is known to contain lead. Lead dust has also recently been identified in multiple locations within some buildings and service tunnels.
Mercury in Thermostats or Switches		X		X	
Application of Chemicals or Pesticides		X		X	
PCB Liquids in Electrical Equipment		X		X	
Radioactive Materials in Equipment		X		X	
Other:					
Contaminated Sites Hazards					
Hazardous Waste	X		X		Suspected contaminated soils
Hydrocarbons	X		X		Suspected contaminated soils
Metals	X		X		Suspected contaminated soils
Other:	X		X		Suspected contaminated soils
Security Hazards					
Risk of Assault	X		X		Multiple employer workplace
Other:	X		X		No unauthorized entry to site.
Other Hazards					

Other Compliance and Permit Requirements[1]	YES	NO	Notes / Comments[2]
Is a Building Permit required?		X	
Is an Electrical permit required?	X		Required for any electrical work on site
Is a Plumbing Permit required?	X		
Is a Sewage Permit required?			No discharge of sewage allowed.
Is a Dumping Permit required?			No dumping allowed on site
Is a Hot Work Permit required?	X		
Is a Permit to Work required?		X	
Is a Confined Space Entry Permit required?	X		
Is a Confined Space Entry Log required?	X		
Discharge Approval for treated water required?	X		

Notes:

(1) Does not relieve Service Provider from complying with all applicable federal, provincial, and municipal laws and regulations.
(2) TBD means To Be Determined by Service Provider.

Service Provider Acknowledgement: We confirm receipt and review of this Pre-Project Hazard Assessment and acknowledge our responsibility for conducting our own assessment of project hazards, and taking all necessary protective measures (which may exceed those cited herein) for performance of the work.			
Service Provider Name			
Signatory for Service Provider		**Date Signed**	
RETURN EXECUTED DOCUMENT TO PWGSC DEPARTMENTAL REPRESENTATIVE PRIOR TO ANY WORK COMMENCING			

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ESQUIMALT GRAVING DOCK

ENVIRONMENTAL POLICY

Number of Pages: 1

Esquimalt Graving Dock
Environmental Policy

It is the goal of the Esquimalt Graving Dock, in partnership with the ship repair industry, to be the premier ship repair, construction and maintenance facility on the west coast of North America.

The Esquimalt Graving Dock and its Users realize that environmental management is an integral part of attaining that goal. Through the implementation of an ISO 14001 Environmental Management System, we are committed to managing the actual and potential environmental impacts of our operations.

To meet our commitment we will:

- *Protect the natural environment and prevent pollution.*
- *Meet or exceed applicable federal, provincial and municipal legislation and regulations; uphold departmental policies; and abide by industry standards, practices and other requirements related to our identified environmental aspects.*
- *Establish and review our programs, objectives and targets to ensure we are meeting our environmental commitments.*
- *Communicate openly with our employees, Users, tenants, contractors, suppliers, neighbours and other stakeholders regarding our Environmental Management System and the nature of our operations.*
- *Educate our employees and the Users of our facility to ensure they are aware of and understand their roles and responsibilities in protecting the environment.*
- *Meet the evolving needs and expectations of our industry and community through the continual improvement of our systems, programs and procedures.*

Marilea Pirie
Director General
Engineering Assets
Strategy Sector

Jim Milne
Director
Esquimalt Graving Dock
Engineering Assets
Strategy Sector

David Latoski
Operations Manager
Esquimalt Graving Dock
Engineering Assets
Strategy Sector

Public Works and Government Services Canada

Travaux publics et Services gouvernementaux Canada

Canada

August 2013

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ESQUIMALT GRAVING DOCK

HOT WORK APPLICATION FORM

Number of Pages: 1

Subject: **Hot Work Application, Procedures, Terms and Conditions for Approval**

Company Name:

Date: _____ Required Start Time: _____

Location /Building _____ Estimated Completion Time: _____

Dept /Contractor _____ Expires on (date /time) _____

Area /Floor _____ Is a Fire Watch Required? Yes ☐ No ☐

Work to be Done _____ Special Precautions _____

_____ _____

Before application approval, the undersigned Contractor/ Department and any representatives are required to read and understand all relevant codes and standards in accordance with the National Fire Code of Canada, 2005, Division B, Section 5.2. Hot Works, and NFPA 51B Standard for Fire Prevention During Welding, Cutting, and Other Hot Work, 1999 Edition.

Area Pre-Inspection (for EGD use only)

Fire Safety Rep: (print name) _____

Fire Safety Rep: (sign) _____

Date of Inspection: _____

Contractor/ Department

Company / Department Representative: (print name) _____

Signed: _____

Date: _____

Approved ☐ Denied ☐

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ESQUIMALT GRAVING DOCK

SAMPLE BOOKING SHEETS

Number of Pages: 4

Public Works and Government Services Canada | Travaux publics et Services gouvernementaux Canada

Canada

Bookings Summary

Drydock

VESSEL	SECTION	DOCKING DATES	BOOKING DATE
EDC 140M QUEEN OF COQUITLAM	**2 & 3**	**SEP 8 - OCT 3, 2012**	**JAN 11, 2006@11:40**
VSL 160M COASTAL RENNAISANCE	**1 & 2**	**OCT 4 - OCT 24, 2012**	**MAY 1, 2012@12:53**
EDC 126M FRPD 309	tentative	Oct 25 - Nov 21, 2012	Aug 15, 2012@10:18
VSL 241M GREAT LAND	**1 & 2 & 3**	**JAN 2 - JAN 22, 2013**	**OCT 19, 2011@14:51**
BCF 110M Skeena Queen	tentative	Jan 2 - Jan 25, 2013	Nov 9, 2009@16:56
BCF 140M Queen of Oak Bay	tentative	Jan 9 - Jan 30, 2013	Oct 22, 2007@16:09
BCF 168M SPIRIT OF BRITISH COLUMBIA	**2 & 3**	**JAN 23 - FEB 7, 2013**	**NOV 9, 2009@17:09**
EDC 95M Deepsea Vessel	tentative	Mar 1 - May 6, 2013	Jun 22, 2011@08:04
BCF 150.75M Northern Expedition	tentative	Mar 1 - Mar 29, 2013	Nov 9, 2009@17:05
BCF 160M COASTAL CELEBRATION	**2 & 3**	**APR 4 - APR 21, 2013**	**SEP 12, 2011@12:17**
BCF 110M SKEENA QUEEN	**1**	**APR 4 - APR 21, 2013**	**SEP 12, 2011@12:04**
VSL 83M AMERICAN DYNASTY	**3**	**APR 22 - APR 29, 2013**	**DEC 16, 2009@14:00**
VSL 246.5M CELEBRITY CENTURY	**1 & 2 & 3**	**APR 30 - MAY 14, 2013**	**MAR 14, 2011@15:41**
BCF 85M Mayne Queen	tentative	May 6 - May 19, 2013	Sep 12, 2011@13:58
VSL 134.2M HMCS VANCOUVER	**2 & 3**	**MAY 15 - OCT 31, 2013**	**JAN 18, 2007@12:22**
EDC 95M FRASER TITAN	**1**	**MAY 20 - JUN 20, 2013**	**DEC 4, 2011@11:32**
BCF 85M POWELL RIVER QUEEN	**1**	**SEP 4 - SEP 30, 2013**	**NOV 9, 2009@17:08**
BCF 102.4M Island Sky	tentative	Sep 17 - Oct 11, 2013	Oct 17, 2011@09:53
VSL 294M Island Princess	tentative	Sep 19 - Oct 6, 2013	Mar 4, 2011@20:19
BCF 102.4M Island Sky	tentative	Oct 1 - Oct 25, 2013	Feb 28, 2012@17:11
BCF 72M Kwuna	tentative	Oct 1 - Dec 8, 2013	Nov 9, 2009@17:01
* VSL 114.6M MV Alaska Ocean	tentative	Oct 1 - Nov 18, 2013	Sep 28, 2012@16:05
BCF 117M Northern Adventure	tentative	Oct 7 - Nov 4, 2013	Nov 9, 2009@17:04
BCF 85M Bowen Queen	tentative	Oct 18 - Nov 14, 2013	Nov 9, 2009@16:58
BCF 140M Queen of Cowichan	tentative	Oct 25 - Nov 15, 2013	Nov 9, 2009@16:59
BCF 130M Queen of Nanaimo	tentative	Oct 30 - Nov 22, 2013	Dec 9, 2011@14:21
BCF 130M Queen of Burnaby	tentative	Oct 31 - Nov 15, 2013	Oct 17, 2011@11:31
BCF 85M Bowen Queen	tentative	Nov 1 - Nov 18, 2013	Feb 28, 2012@17:36
BCF 117M Northern Adventure	tentative	Nov 1 - Nov 18, 2013	Feb 28, 2012@17:55
VSL 217M Horizon Tacoma	tentative	Nov 18 - Dec 6, 2013	Jun 1, 2010@07:39
VSL 256M North Star	tentative	Nov 19 - Dec 9, 2013	Feb 22, 2011@10:08
BCF 140M QUEEN OF COWICHAN	**1 & 2**	**NOV 19 - DEC 9, 2013**	**FEB 28, 2012@16:19**
BCF 130M QUEEN OF NEW WESTMINSTER	**2 & 3**	**NOV 19 - DEC 9, 2013**	**NOV 9, 2009@17:03**
BCF 89.84M Quinsam	tentative	Dec 1 - Dec 31, 2013	Nov 10, 2009@10:03
BCF 117M Northern Adventure	tentative	Dec 10 - Dec 19, 2013	Feb 28, 2012@17:11
BCF 89.84M QUINSAM	**3**	**JAN 2 - JAN 28, 2014**	**JAN 25, 2012@11:05**
BCF 168M Spirit of Vancouver Island	tentative	Jan 8 - Jan 22, 2014	Nov 10, 2009@10:20
VSL 256M North Star	tentative	Jan 21 - Feb 6, 2014	Feb 22, 2011@10:11

VESSEL	SECTION	DOCKING DATES	BOOKING DATE
BCF 140M QUEEN OF SURREY	**2 & 3**	**JAN 29 - FEB 19, 2014**	**NOV 10, 2009@10:19**
BCF 96M Queen of Cumberland	tentative	Feb 4 - Feb 25, 2014	Nov 10, 2009@10:30
VSL 255M Midnight Sun	tentative	Feb 7 - Mar 3, 2014	Feb 22, 2011@10:12
BCF 96M QUEEN OF CUMBERLAND	**3**	**FEB 21 - MAR 14, 2014**	**MAR 12, 2012@10:33**
CCG 83M Sir Wilfred Laurier	tentative	Feb 21 - Mar 21, 2014	Feb 6, 2008@14:19
BCF 61M North Island Princess	tentative	Apr 1 - Apr 25, 2014	Nov 10, 2009@10:24
BCF 114.58M Queen of Chilliwack	tentative	Apr 2 - Apr 30, 2014	Sep 12, 2011@15:47
BCF 150.75M Northern Expedition	tentative	Apr 7 - May 4, 2014	Sep 12, 2011@15:58
VSL 237M Volendam	tentative	May 1 - May 17, 2014	Mar 3, 2009@08:06
VSL 238M crystal symphony	tentative	May 8 - May 31, 2014	Jun 19, 2012@14:22
DND 130M HMCS Algonquin	pending	May 15 - Oct 30, 2014	Jul 29, 2009@05:23
VSL 134.2M HMCS OTTAWA	**2 & 3**	**MAY 15 - OCT 30, 2014**	**JAN 18, 2007@12:26**
BCF 50M Quadra Queen II	tentative	May 15 - Jun 7, 2014	Nov 10, 2009@10:23
BCF 34M Nimpkish	tentative	Jun 23 - Jul 25, 2014	Nov 10, 2009@10:26
VSL 294M Deepsea Vessel	tentative	Sep 1 - Oct 7, 2014	Sep 19, 2011@10:48
CCG 69M John P Tully	tentative	Oct 5 - Nov 2, 2014	Feb 6, 2008@14:15
BCF 52.21M Kuper	tentative	Oct 14 - Nov 7, 2014	Nov 10, 2009@10:27
BCF 160M Coastal Rennaisance	tentative	Oct 17 - Oct 31, 2014	Nov 10, 2009@10:21
BCF 140M Queen of Alberni	tentative	Oct 17 - Oct 30, 2014	Nov 10, 2009@10:33
BCF 130M Queen of Burnaby	tentative	Oct 25 - Nov 14, 2014	Sep 13, 2011@09:27
BCF 140M Queen of Oak Bay	tentative	Nov 14 - Dec 12, 2014	Sep 13, 2011@09:30
VSL 256M North Star	tentative	Nov 18 - Dec 3, 2014	Feb 22, 2011@10:20
VSL 255M Midnight Sun	tentative	Dec 4 - Dec 22, 2014	Feb 22, 2011@10:22
BCF 96M Queen of Capilano	tentative	Jan 5 - Jan 23, 2015	Nov 10, 2009@11:02
BCF 168M Spirit of British Columbia	tentative	Jan 21 - Feb 11, 2015	Nov 10, 2009@11:14
DND 130M HMCS ALGONQUIN	**1 & 2**	**APR 1 - SEP 7, 2015**	**JUL 24, 2012@09:59**
VSL 134.2M HMCS REGINA	**2 & 3**	**APR 1 - SEP 7, 2015**	**JAN 18, 2007@12:32**
BCF 160M Coastal Celebration	tentative	Apr 10 - Apr 24, 2015	Nov 10, 2009@11:04
BCF 50M Tachek	tentative	Apr 13 - Jun 7, 2015	Nov 10, 2009@11:15
BCF 75M Howe Sound Queen	tentative	Apr 27 - Jun 14, 2015	Nov 10, 2009@11:07
BCF 160M Coastal Inspiration	tentative	May 13 - May 28, 2015	Nov 10, 2009@11:09
BCF 48M Tenaka	tentative	Jul 7 - Aug 5, 2015	Nov 10, 2009@11:17
BCF 168M SPIRIT OF BRITISH COLUMBIA	**2 & 3**	**SEP 11 - NOV 13, 2015**	**JUN 20, 2011@10:40**
BCF 102.4M Island Sky	tentative	Sep 21 - Oct 18, 2015	Sep 12, 2011@17:28
BCF 130M Queen of Nanaimo	tentative	Oct 15 - Nov 5, 2015	Nov 10, 2009@11:10
BCF 140M Queen of Coquitlam	tentative	Nov 3 - Nov 19, 2015	Sep 13, 2010@17:45
BCF 96M Queen of Cumberland	tentative	Nov 16 , 2015 - Jan 22, 2016	Nov 2, 2011@14:34
BCF 130M Queen of New Westminster	tentative	Nov 17 - Dec 1, 2015	Nov 10, 2009@11:11

North Landing Wharf

VESSEL	SECTION	DOCKING DATES	BOOKING DATE
VSL 172M HMCS PROTECTUER	**BOOKED**	**AUG 31 - DEC 5, 2012**	**JUL 29, 2009@05:18**
*** JM 22.86M EARL'S BARGE**	**BOOKED**	**OCT 2 - OCT 4, 2012**	**OCT 1, 2012@12:30**
BCF 168M SPIRIT OF BRITISH COLUMBIA	**BOOKED**	**FEB 8 - MAR 1, 2013**	**JAN 19, 2012@16:06**
BCF 160M Coastal Celebration	tentative	Apr 21 - May 7, 2013	Jun 4, 2012@11:08
BCF 110M Skeena Queen	tentative	Apr 21 - May 1, 2013	Jun 4, 2012@11:05
VSL 246.5M CELEBRITY CENTURY	**BOOKED**	**APR 27 - MAY 2, 2013**	**MAR 12, 2012@08:43**

VESSEL	SECTION	DOCKING DATES	BOOKING DATE
VSL 246.5M CELEBRITY CENTURY	**BOOKED**	**MAY 13 - MAY 19, 2013**	**MAR 30, 2012@10:55**
BCF 85M Mayne Queen	tentative	May 19 - Jun 9, 2013	Jun 4, 2012@11:13
EGD 244M NLW OPEN WATER DREDGING PROJECT (PROPOSED DATES)	**BOOKED**	**JUN 1 , 2013 - MAR 31, 2014**	**JUN 25, 2012@09:14**
BCF 85M POWELL RIVER QUEEN	**BOOKED**	**SEP 30 - OCT 14, 2013**	**JUN 4, 2012@11:16**
BCF 140M QUEEN OF COWICHAN	**BOOKED**	**OCT 25 - NOV 18, 2013**	**MAR 28, 2012@14:52**
BCF 117M Northern Adventure	tentative	Nov 4 - Dec 5, 2013	Jun 4, 2012@11:22
BCF 85M Bowen Queen	tentative	Nov 14 - Nov 29, 2013	Jun 4, 2012@11:27
BCF 89.84M Quinsam	tentative	Dec 1 , 2013 - Jan 1, 2014	Mar 28, 2012@14:50
BCF 130M QUEEN OF NEW WESTMINSTER	**BOOKED**	**DEC 8 - DEC 16, 2013**	**MAR 12, 2012@10:32**
BCF 89.84M QUINSAM	**BOOKED**	**JAN 28 - JAN 30, 2014**	**JUN 4, 2012@11:31**
BCF 96M QUEEN OF CUMBERLAND	**BOOKED**	**FEB 10 - FEB 20, 2014**	**MAR 28, 2012@09:50**
BCF 140M QUEEN OF SURREY	**BOOKED**	**FEB 20 - MAR 19, 2014**	**APR 3, 2012@14:18**
DND 130M HMCS Algonquin	pending	Apr 1 - May 14, 2014	Jul 29, 2009@05:13
EGD 244M NLW OPEN WATER DREDGING PROJECT (PROPOSED DATES)	**BOOKED**	**JUN 1 - SEP 30, 2014**	**JUN 25, 2012@11:36**
DND 130M HMCS Algonquin	pending	Oct 31 - Dec 31, 2014	Jul 29, 2009@05:15
DND 130M HMCS ALGONQUIN	**BOOKED**	**MAR 4 - MAR 31, 2015**	**JUL 24, 2012@10:01**
DND 130M HMCS ALGONQUIN	**BOOKED**	**SEP 8 - DEC 2, 2015**	**JUL 24, 2012@10:03**

South Jetty

VESSEL	SECTION	DOCKING DATES	BOOKING DATE
VSL 134.2M HMCS WINNIPEG	**BOOKED**	**AUG 31 , 2012 - APR 23, 2013**	**JAN 18, 2007@12:17**
EGD 153M SJ SHEETPILE WALL CONSTRUCTION (PROPOSED DATES)	**BOOKED**	**OCT 1 , 2012 - APR 20, 2013**	**JUN 25, 2012@09:37**
EDC 140M QUEEN OF COQUITLAM	**BOOKED**	**OCT 3 - OCT 26, 2012**	**MAY 1, 2012@08:15**
VSL 70.4M NAVAL VESSEL	**BOOKED**	**NOV 1 , 2012 - JAN 31, 2013**	**DEC 24, 2010@10:10**
VSL 134.2M HMCS VANCOUVER	tentative	Apr 10 - May 30, 2013	Jan 18, 2007@12:19
BCF 160M Coastal Celebration	tentative	Apr 21 - May 7, 2013	Jun 4, 2012@11:09
BCF 110M SKEENA QUEEN	**BOOKED**	**APR 21 - MAY 1, 2013**	**JUN 4, 2012@11:06**
EGD 153M SJ SHEETPILE WALL CONSTRUCTION (PROPOSED DATES)	**BOOKED**	**MAY 2 - SEP 30, 2013**	**JAN 11, 2012@11:38**
KB 143.29M JOIDES RESOLUTION	pending	May 15 - Jun 1, 2013	Aug 24, 2012@07:16
BCF 85M Mayne Queen	tentative	May 19 - Jun 9, 2013	Jun 4, 2012@11:15
EGD 138M SOUTH JETTY OPEN WATER DREDGING (PROPOSED DATES)	**BOOKED**	**JUN 1 , 2013 - MAR 31, 2014**	**JUN 25, 2012@09:42**
BCF 85M Powell River Queen	tentative	Sep 30 - Oct 14, 2013	Jun 4, 2012@11:18
VSL 134.2M HMCS VANCOUVER	**BOOKED**	**OCT 31 , 2013 - NOV 7, 2014**	**JAN 18, 2007@12:21**
BCF 117M Northern Adventure	tentative	Nov 4 - Dec 5, 2013	Jun 4, 2012@11:24
BCF 85M Bowen Queen	tentative	Nov 14 - Nov 29, 2013	Jun 4, 2012@11:28
VSL 134.2M HMCS OTTAWA	tentative	Jan 3 - Feb 28, 2014	Jan 18, 2007@12:23
BCF 89.84M Quinsam	tentative	Jan 28 - Jan 30, 2014	Jun 4, 2012@11:32
VSL 134.2M HMCS OTTAWA	**BOOKED**	**OCT 30 , 2014 - NOV 14, 2015**	**JAN 18, 2007@12:25**
VSL 134.2M HMCS REGINA	tentative	Jan 5 - Mar 3, 2015	Jan 18, 2007@12:28

VESSEL	SECTION	DOCKING DATES	BOOKING DATE
VSL 134.2M HMCS REGINA	BOOKED	SEP 7 , 2015 - OCT 1, 2016	JAN 18, 2007@12:30

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ESQUIMALT GRAVING DOCK

PRACTICES AND PROCEDURES PERSUANT TO THE CANADIAN MARINE ACT

Number of Pages: 13

Esquimalt Harbour
Practices and Procedures

As of April 2016

1. Preamble
2. Definitions
3. Authority of Harbour Official
4. Entry, Movement, Departure Clearances
5. Controlled Access Zones
6. Small Vessels
7. Anchorage
8. Derelict, Abandoned, Illegally Moored or Anchored Vessels
9. Sewage Discharge
10. Marine Spill Response
11. Speed Limits
12. Tug or Pilot Services
13. Towing of Ships
14. Securing, Crewing, and Propulsion Requirements for Ships
15. Turning of Propellers Alongside
16. Scaling and Painting of Ships
17. Equipment Protruding Beyond Ship's Side
18. Rafting of Ships
19. Ship-to-Ship Transfers
20. Activities that Require Pre-Authorized Approval

1. Preamble

1-1 These practices and procedures may be amended from time to time, as circumstances dictate. An emergency amendment may be made to these practices and procedures without notice, however, under normal conditions advance notice of no less than 30 days will be given.

1-2 For the purpose of these practices and procedures, where a subject is referred to in the singular, it will also represent the plural of the same subject.

1-3 These practices and procedures are made pursuant to the *Canada Marine Act* and amplify the Natural and Man-made Harbour Navigation and Use Regulations. They have been derived from Transport Canada's Practices and Procedures for Public Ports and form part of the Harbour Control Instructions that are used by the Queen's Harbour Master, to govern the operation of Esquimalt Harbour.

1-4 Under the *Canada Marine Act* Section 59 Subsection (1)(a), it is an offence, subject to financial penalty, if a person or ship does not follow these practices and procedures.

1-5 For official nautical information on Esquimalt Harbour, refer to Chart 3419, published by Canadian Hydrographic Services.

1-6 Esquimalt Harbour (48°26′N, 123°26.5′W) is a designated public port. Its limits are defined as all the navigable waters, including any foreshore, within the Juan de Fuca Strait northwards of a line running east and west through the southernmost tip of the Brothers Islands.

1-7 The Esquimalt Harbour Practices and Procedures are intended to promote the safe and effective use, navigation, and environmental stewardship of the harbour. They are to be followed by all harbour users, including ships entering, manoeuvering, berthed, departing, or anchored in the waters of Esquimalt Harbour, designated by regulations pursuant to Part 4, Section 104 of the *Canada Marine Act*.

1-8 Unless authorized by a harbour official, no person shall, by act or omission, do anything or permit anything to be done in the harbour that has, or is likely to have, any of the following results:

a. jeopardize the safety or health of persons;
b. interfere with navigation;
c. obstruct or threaten any part of the harbour;
d. interfere with an authorized activity;
e. divert the flow of a river or stream, cause or affect currents, cause silting or the accumulation of material or otherwise reduce the depth of the waters;
f. cause a nuisance;
g. cause damage to ships;
h. adversely affect sediment, soil, air or water quality; or
i. adversely affect harbour operations.

2. Definitions

2-1 "CAZ" means a Controlled Access Zone, designated by the Minister of National Defence, which includes all corresponding airspace above, and water and land below the zone. In general, CAZs are areas intended to create buffer zones, to ensure the safety and security of Canadian Forces and Department of National Defence naval vessels, materiel, and property, warships under the control of a visiting force, acting under the *Visiting Forces Act*, and personnel.

2-2 “CLEARANCE” means granting authorization to carry out a manoeuvre or task. This can be given verbally, in writing, or transmitted by electronic means.

2-3 “DANGEROUS GOODS” has the meaning assigned in Section 2 of the *Transportation of Dangerous Goods Act*.

2-4 “HARBOUR OFFICIAL” means officials appointed pursuant to Sections 106 and 108 of the *Canada Marine Act* and include the Queen’s Harbour Master, Deputy Queen’s Harbour Master, Harbour Traffic Control Officer, or designated harbour official.

2-5 “HOT WORK” means any work that uses flame or that can produce a source of ignition, such as heating, cutting or welding.

2-6 “KNOTS” means nautical miles per hour.

2-7 “MASTER” means master, owner, agent, operator, or person in charge of a ship.

2-8 “PILOT” refers to Department of National Defence Pilot, BC Coast Pilot, or PSPC Docking Master.

2-9 “PLEASURE VESSEL” means a vessel that is used exclusively for pleasure and does not carry fee paying passengers.

2-10 “PRINCIPAL TOWING SHIP” means the towing ship, the Master of which is responsible for the manoeuvring and conduct of all ships being towed.

2-11 “PSPC” within the context of these practices and procedures, means Public Services and Procurement Canada (PSPC) - Esquimalt Graving Dock (EGD) and designated PSPC Officers employed at this facility. In the case of vessels undergoing work of any kind at the PSPC/EGD facilities, clearance/permission from the designated officers of PSPC will be deemed to have the same authority as that of a harbour official.

2-12 “SCALING” includes scraping, sanding, chipping, grinding, sandblasting, hydroblasting or any other means of dislodging paint, rust or other unwanted material from the hull, superstructure, machinery or equipment contained on-board a ship.

2-13 “SEAPLANE” includes any aircraft designed to manoeuvre on water.

2-14 “SHIP” means every description of vessel, boat or craft designed, used or capable of being used, solely or partly for marine navigation, whether self-propelled or not and without regard to the method of propulsion, and includes a seaplane and a raft or boom of logs or lumber.

2-15 “SMALL VESSEL” means all ships less than 20 metres in length.

2-16 “TOWED SHIP” means any ship that is not self-propelled and in order to manoeuvre, it must be pushed or pulled by another ship.

2-17 “TRAFFIC CONTROL OFFICER” refers to the Officer of the Watch on duty in the Queen’s Harbour Master Harbour Control Office, or in the Regional Joint Operations Centre, Maritime Forces Pacific.

3. Authority of Harbour Official

3-1 A harbour official may issue instructions directly to a ship. These instructions may be given verbally, electronically, or in writing. Notwithstanding the means by which they are conveyed, they carry the same weight.

3-2 A harbour official is the sole authority concerning all matters related to marine traffic control within the limits of Esquimalt Harbour including assigning berths or anchorages or authorizing a ship to stay. In the absence of authorization from a harbour official, a ship taking up a position in the Esquimalt Harbour limits, because of the information obtained from other sources, may have to change its position upon receipt of instruction from a harbour official.

4. Entry, Movement, Departure Clearances

4-1 All vessels entering or departing Esquimalt Harbour are required to contact the Queen’s Harbour Master (QHM) Operations on VHF Channel 10 or by telephone at 250-363-2160.

4-2 No ship that has explosives (Class 1 as indicated in the *Transportation of Dangerous Goods Act*) on-board shall enter, depart, or move within the limits of Esquimalt Harbour unless authorized by a harbour official.

4-3 All ships, prior to entering, moving, or departing Esquimalt Harbour, shall contact a harbour official, by VHF Channel 10, to obtain clearance. Ships are to give as much advance notice as is practical (minimum of one hour). The following information will be included in the clearance request:

a. ship name and port of registry;
b. time of arrival;
c. estimated time of departure;
d. length, breadth, and draft of the ship;
e. the presence of dangerous goods on-board; and
f. harbour destination.

4-4 Ships requesting clearance from a harbour official, to enter Esquimalt Harbour and berth at a private facility or the PSPC Esquimalt Graving Dock, shall first obtain permission from the owner or official of the facility in question.

5. Controlled Access Zones

5-1 The harbour is open to the public within the limitations set out in an Order in Council regarding Controlled Access Zones. This provides for security zones surrounding Department of National Defence property and warships berthed or moving in the harbour.

5-2 The Minister of National Defence has designated the entire area of Esquimalt Harbour and its approaches, from the southern extremity of Albert Head and the western tip of Saxe Point, to be a Controlled Access Zone. Any vessel operating in close proximity of this zone may be approached and hailed by the Department of National Defence.

5-3 In accordance with the Notice to Mariners, vessels are at all times to remain 100 metres away from stationary vessels and 200 metres away from vessels underway. Unauthorized intrusions could lead to Federal prosecution.

5-4 Any vessel may be hailed by QHM and hailed and approached by any Military Police or Military Force Protection vessel. Due to Force Protection/security requirements, access to the harbour can be restricted and/or blocked.

6. Small Vessels

6-1 All pleasure vessels entering the harbour must be licenced or registered.

6-2 Small vessels, operating within the limits of Esquimalt Harbour, shall comply with the following:

a. these practices and procedures, as administered by the Harbour Authority; and
b. all applicable acts, laws, rules, regulations, schedules, and guidelines pertaining to small vessels, including but not limited to the *Canada Shipping Act* Small Vessel Regulations.

6-3 Pleasure vessels, whether power driven or sail, and small vessels, which are operating under the guidance of the Small Vessel Regulations, shall not impede the passage and manoeuvring of larger commercial ships or naval ships within the limits of Esquimalt Harbour, and shall, at all times, maintain a lookout while underway.

7. Anchorage

7-1 Pleasure vessels may only anchor north of a line drawn between the south end of Richards Island and the north end of Smart Island. Every pleasure vessel anchored in Esquimalt Harbour shall be moored with two anchors and in the manner directed by a harbour official. Rafting of pleasure vessels, at anchor, is not permitted. A harbour official must first approve anchoring in any other area of the harbour.

7-2 With the permission of a harbour official, a ship may anchor in the anchorages described as follows:

Anchorage	**Latitude**	**Longitude**	**Radius**
A	48°23.82 N	123°27.10 W	2.5 cables
B	48°24.19 N	123°27.69 W	2 cables
C	48°24.28 N	123°26.76 W	2.5 cables
D	48°24.44 N	123°25.97 W	2.5 cables
F	48°24.96 N	123°26.08 W	2 cables

7-3 No ship shall anchor in that part of the entrance to Esquimalt Harbour as follows:

Beginning, at the south-east point of Albert Head; THENCE, 085° (T) 2.4 nautical miles; THENCE, 000° (T) 2.1 miles to the west edge of Saxe Point; THENCE, westerly along the shore to Grant Knoll; THENCE, on a straight line to Yew Point; THENCE, southerly along the shore to the south-east point of Albert Head, as shown on Canadian Hydrographic Service Chart 3419.

7-4 No ship shall anchor in that portion of Esquimalt Harbour known as Constance Cove and situated east of a line drawn between Duntze Head and Ashe Head.

7-5 No ship shall anchor in that part of Esquimalt Harbour bounded as follows:

Commencing, at the most southerly point of McCarthy Island; THENCE, easterly 275 metres on a bearing 112 (T); THENCE, northerly 175 metres on a bearing 021 (T); THENCE, westerly 265 metres on a bearing 292 (T); THENCE, southerly on a bearing 201 (T), to meet the north shore of McCarthy Island; THENCE, along the shore of McCarthy Island to the place of beginning, as shown on Canadian Hydrographic Service Chart 3419.

8. Derelict, Abandoned, Illegally Moored or Anchored Vessels

8-1 Where the owner or person in charge of a vessel in the harbour is not available or refuses or neglects to obey any order to move the vessel, the authority may, at the risk and expense of the owner of the vessel:

a. take possession of and move the vessel;

b. use any means and force reasonably necessary to move the vessel;
c. berth, anchor, moor the vessel at any place satisfactory to the Harbour Authority; or
d. remove and dispose of the vessel.

9. Sewage Discharge

9-1 No ship or pleasure vessel, or person on-board a ship or pleasure vessel, shall discharge sewage into the tidal waters of Esquimalt Harbour. Sewage means human excrement and wastes from toilets and other receptacles intended to receive or retain human body wastes or other wastes, but does not include galley or washing-facility wastes. In addition, any vessel in Esquimalt Harbour that has a toilet must be fitted with a functioning Transport Canada approved holding tank or Marine Sanitation Device.

10. Marine Spill Response

10-1 Any person, facility, vessel or property, which causes a marine spill into Esquimalt Harbour, referred to as the Responsible Party, shall be responsible for the reporting, clean-up, and cost of the incident.

10-2 The Responsible Party is required to notify Emergency Management British Columbia (1-800-663-3456), the Harbour Authority (250-363-2160), and initiate clean-up.

10-3 Once notified, the Harbour Authority will assess the situation, monitor the response, and provide assistance, as necessary.

10-4 In the event that the Responsible Party is either unwilling or unable to respond, the Harbour Authority may assume control of the response. Alternately, the Harbour Authority may request assistance from the applicable Federal Authority (e.g. Environment Canada, Canadian Coast Guard).

11. Speed Limits

11-1 All ships manoeuvring within the limits of Esquimalt Harbour shall proceed at a safe speed not to exceed 7 knots.

11-2 In special circumstances, a harbour official may grant permission for ships to exceed the speed limit.

11-3 Ships shall reduce speed to minimum wake when passing berthed ships or vessels engaged in any marine operation or as directed by a harbour official.

12. Tug or Pilot Services

12-1 When circumstances and conditions threaten environmental protection, safety of port infrastructure or navigational safety, a harbour official may require ships to obtain the services of a Pilot and tug(s).

13. Towing of Ships

13-1 The principal towing ship is at all times responsible for the safety and manoeuvring of its tow.

13-2 A ship that is towing another ship shall have sufficient power to manoeuvre the towed ship in all conditions that may be encountered throughout the evolution. Such power may be provided by the use of an additional towing ship to augment the principal towing ship.

13-3 When entering or departing Esquimalt Harbour, a ship shall use a towline length that permits immediate and positive control over the towed vessel.

13-4 A trailing tug shall be used for any towed vessel proceeding east of a line drawn between Ashe Head and Grant Knoll or working in or exiting from Constance Cove, due to the risk of damage to other ships or port infrastructure. Any deviation from this procedure must be approved, in advance, by the Harbour Authority. Towing vessels are responsible for their tow, in all conditions, and must ensure that sufficient assets are employed to account for all contingencies that may arise.

14. Securing, Crewing, and Propulsion Requirements for Ships

14-1 All ships within the limits of Esquimalt Harbour shall have sufficient crew on-board to safely manoeuvre the ship alongside, or to depart a harbour facility, when instructed to do so by a harbour official. Crew in sufficient numbers, shall be present at all times, to monitor the ship for safety and security purposes, and to ensure that mooring lines and gangways are properly tended and emergencies are responded to.

14-2 Subject to Sections 14-3 and 14-4, propulsion power shall be available, at reasonable notice, to move the ship when instructed to do so by a harbour official. Before any repairs, maintenance, or other works are undertaken, that may hinder the ship's ability to move in a harbour facility or anchorage, clearance shall be obtained from a harbour official.

14-3 Any time emergency repairs are commenced on a ship, at an Esquimalt Harbour facility, the Master of the ship will report to a harbour official, the nature of the repairs and outline the affect it has on the ship's ability to move. The Master shall provide an estimate of the time required to complete the repairs to a condition where the ship is capable of being safely moved.

14-4 Clearance will only be given to leave a ship unmanned, while within the limits of Esquimalt Harbour, if harbour officials are satisfied that the Master of the ship has made adequate securing arrangements, that mooring lines are tended, and that arrangements are in place to move the ship if instructed to do so. Since it is understood that the time required for preparing to move an unmanned ship may be longer than that required for a fully crewed ship, the length of the notification period will be agreed upon before this clearance is granted.

15. Turning of Propellers Alongside

15-1 A ship, when secured at a harbour facility in Esquimalt Harbour, shall not commence basin trials by turning shafts or engaging bow thrusters, without first obtaining permission from a harbour official, and taking the necessary precautions not to endanger the integrity of the harbour facility, its physical assets, other ships, or the environment.

15-2 Clearance may be conditional on extra precautions being followed, such as the use of additional mooring lines, tug assistance, and the equipment or machinery being run at minimum speed.

16. Scaling and Painting of Ships

16-1 A ship at anchor or at a berth, within the limits of Esquimalt Harbour, shall obtain clearance from a harbour official to perform scaling and painting of a ship's hull, machinery, or superstructure. Prior to clearance being granted, the person requesting the clearance, shall make an assurance that adequate measures will be taken to protect the environment from the waste material created by the operation.

16-2 Scaling and painting shall not interfere with the operation of another user, within the limits of Esquimalt Harbour. If a scaling operation involves hot work, then it shall not take place without a Hot Work Permit.

17. Equipment Protruding Beyond Ship's Side

17-1 Unless authorized, no rigging, cargo gear or other equipment on-board any ship berthed in Esquimalt Harbour shall overhang or project overboard, in a manner that may endanger life or property, or create a hazard to navigation. If any ship requires equipment to extend beyond the sides of the ship, they shall obtain clearance from a harbour official.

17-2 If any cargo gear or equipment is already swung out and another ship is manoeuvring in the vicinity, a harbour official may require the gear to be swung inboard until the danger is past.

18. Rafting of Ships

18-1 A ship may make fast to, or secure alongside another ship in Esquimalt Harbour, at a harbour facility, only with the clearance of a harbour official.

18-2 At federal government harbour facilities, every ship, when ordered by a harbour official, shall permit another ship to make fast to, or secure alongside it. Sufficient mooring lines, from the outboard ship, shall be passed ashore to ensure that excessive stresses are not placed on the inner ship's lines, and the outboard ship shall ensure that adequate fendering is provided.

18-3 Where a ship is made fast to, or secured alongside another ship, a free and unencumbered passage over the inner ship shall be allowed to the outboard ship for loading, unloading, and access to and from the shore.

18-4 To avoid overloading jetty bollards, ships shall assess the strain being placed on individual bollards before attaching multiple berthing lines.

19. Ship-to-Ship Transfers

19-1 No ship-to-ship transfer of goods shall take place until a harbour official has given clearance. Ship-to-ship transfers will be approved by a harbour official, only if the official has been appraised of the intention, and is of the opinion that all necessary steps shall be taken to preserve the integrity of the environment, and that there will be no adverse effects on other users of Esquimalt Harbour.

20. Activities that Require Pre-Authorized Approval

20-1 Pursuant to the Natural and Man-made Harbour Navigation and Use Regulations of the *Canada Marine Act*, **the approval of a harbour official is required prior to the commencement of all activities, including but not limited to the following:**

1. Conducting a diving operation:

    a. prior to commencement and upon completion of diving operations; and
    b. all appropriate safety measures shall be taken, including, but not limited to hoisting flag Alpha, informing nearby vessels, and maintaining a constant listening watch on VHF Channel 10.

2. Conducting a salvage operation:

   a. notice to harbour users to avoid area of salvage operation;
   b. measures taken to reduce or mitigate further risk or damage; and
   c. emergency response resources notified.

3. Transporting, loading, unloading or transhipping explosives or other dangerous goods, industrial waste or pollutants:

   a. conducted at a specified facility or between adjacent ships/barges, using appropriate cargo transfer equipment;
   b. measures taken to reduce or mitigate risk;
   c. displaying an all-around red light or flag Bravo; and
   d. emergency response resources notified.

4. Carrying out an oil transfer operation, a chemical transfer operation or a liquefied gas transfer operation:

   a. conducted at a specified fuelling facility, between adjacent ships, or from a bunkering barge alongside, using appropriate cargo transfer equipment;
   b. measures taken to reduce or mitigate risk;
   c. emergency response resources notified; and
   d. displaying an all-around red light or flag Bravo.

5. Conducting a dredging operation:

   a. results of the dredging operation will improve the use of the harbour;
   b. minimize impact on marine traffic and harbour use; and
   c. an environmental assessment must be completed and approved.

6. Excavating or removing any material or substance:

   a. results of the excavation/removal operation will improve the use of the harbour;
   b. minimize impact on harbour use;
   c. an environmental assessment must be completed and approved; and
   d. coordination with upland property activities/landowners.

7. Building, placing, rebuilding, repairing, altering, moving or removing any structure or work:

   a. results of these works will improve the use of the harbour;
   b. minimize impact on marine traffic and harbour use;
   c. an environmental assessment must be completed and approved; and
   d. coordination with upland property activities/landowners.

8. Placing or operating a light or day marker:

   a. suitable device to be used;
   b. minimize impact on marine traffic and harbour use; and
   c. light characteristics are to be in accordance with The Canadian Aids to Navigation System.

9. Casting adrift a ship, log or other object:

   a. minimize impact on marine traffic and harbour use; and
   b. measures taken to mark obstruction and mitigate impacts.

10. Conducting a race, regatta, trial, demonstration, organized event or similar activity:

   a. minimize impact on marine traffic and harbour use.

11. Causing a fire or explosion, conducting blasting or setting off fireworks, including setting off a flare or other signalling device.

12. Placing a placard, bill, sign or device.

13. Swimming:

   a. permitted without permission in areas normally associated with recreational swimming.

14. Launching a ship by slipway or crane.

15. Conducting the take-off or landing of a sea-plane.

16. Laying up a ship.

17. Mooring or anchoring a floating structure:

   a. ensure berthing or moorage in a specified area that does not interfere with harbour use and traffic;
   b. an environmental assessment must be completed and approved; and
   c. minimize the possibility of nuisance and nuisance complaints.

18. Fishing or crabbing:

    a. as depicted on Canadian Hydrographic Service Chart 3419, fishing is prohibited in the entrance to Esquimalt Harbour, and in an area east of McCarthy Island; and
    b. it shall only be conducted in areas that minimize the impact on marine traffic, harbour use, and it shall be conducted in accordance with the Department of Fisheries and Oceans Canada licencing requirements.

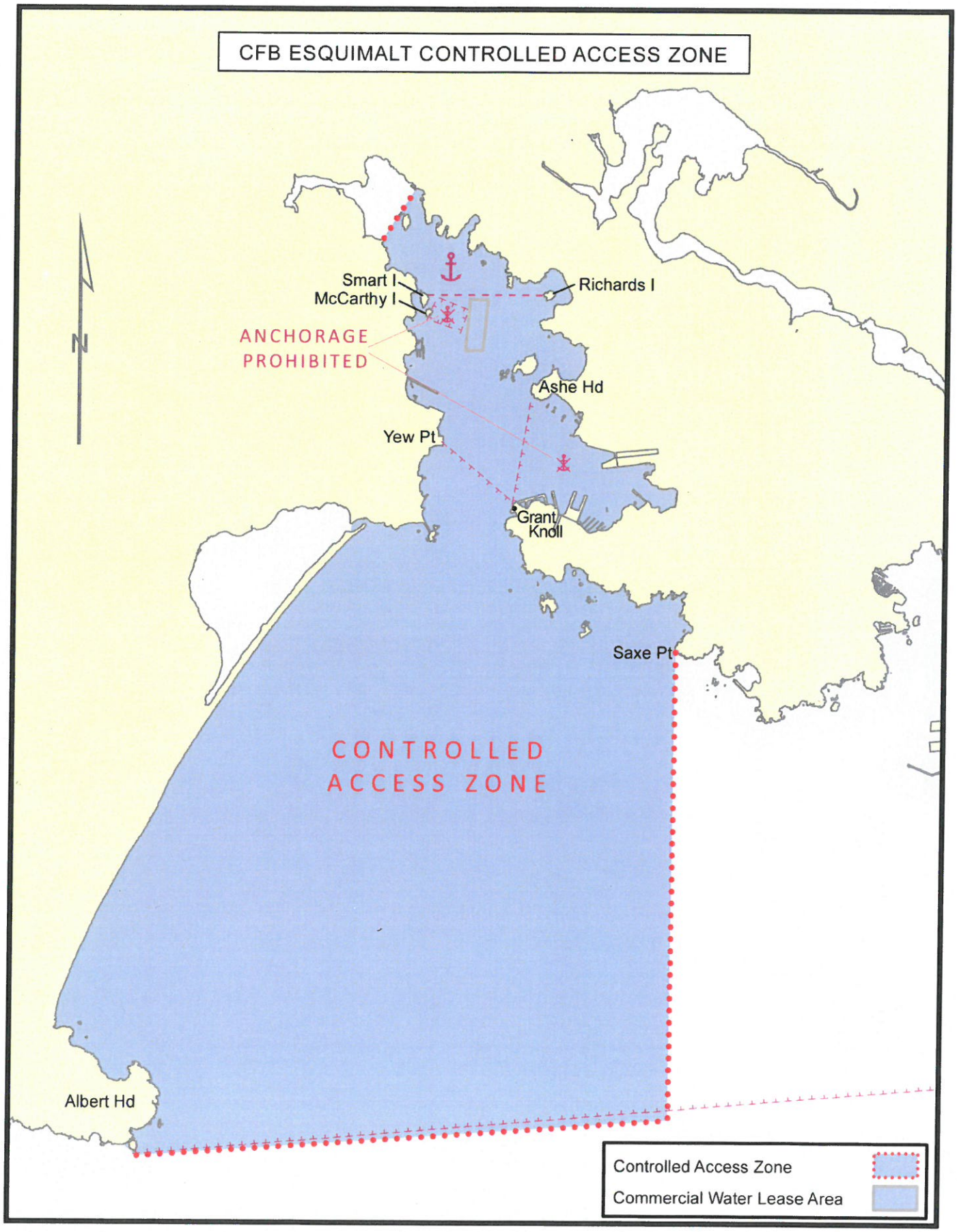
19. Conducting aquacultural research or operations.

B4b

ESQUIMALT GRAVING DOCK

ESQUIMALT HARBOUR CONTROLLED ACCESS MAP

Number of Pages: 1


CFB ESQUIMALT CONTROLLED ACCESS ZONE
N
Smart I
McCarthy I
Richards I
ANCHORAGE PROHIBITED
Ashe Hd
Yew Pt
Grant Knoll
Saxe Pt
CONTROLLED ACCESS ZONE
Albert Hd
Controlled Access Zone
Commercial Water Lease Area

B5

ESQUIMALT GRAVING DOCK

TARIFF SHEET

Number of Pages: 1

Annex 1 – Tariff of dock charges

(Sections 2, 4, 5, 8, 17, 20, 33, 34, and 38)

► ▼ Table Summary

Article	Services and Facilities		April 1, 2015
1	Booking		$5,177.50
2	Draining, per section		$5,177.50
3	Berthage, per metre, per day		$6.05
4	Rail Mounted Crane, per hour	(*a*) with light hook	$475.37
		(*b*) with main hook, up to 50 tonne lift	$686.64
		(*c*) with main hook, over 50 tonne lift	$1,056.38
5	Mobile Crane, per hour	(*a*) 9-tonne crane	$132.05
		(*b*) 20-tonne crane	$169.02
		(*c*) 30-tonne crane	$206.00
		(*d*) Forklift	$100.36
		(*e*) Tower Crane	$169.02
6	Air Compressor (first), per manifold hour		$116.20
7	Air Compressor (second), per manifold hour		$110.92
8	Air compressor (wheeled), per manifold hour		$58.10
9	Motorized vessel, per hour		$192.06
10	Fresh water, per cubic metre		$1.33
11	Electric power, per kilowatt hour		$0.16
12	Tie-up or letting go		$840.30
13	Overtime labour services, dry-dock employee, per hour		$103.72
14	Security services, per vessel, per day		$475.37
15	Dockage, 1 Section, per day		$3,106.50
16	Dockage, 2 Sections, per day		$10,355.00
17	Dockage, 3 Sections, per day		$14,497.00
18	Dockage per ton, per day: under 5,000 gross tonnage		$0.00
19	Dockage per ton, per day: 5,000-34,999 gross tonnage		$0.12
20	Dockage per ton, per day: 35,000-69,999 gross tonnage		$0.11
21	Dockage per ton, per day: 70,000-89,999 gross tonnage		$0.10
22	Dockage per ton, per day: over 89,999 gross tonnage		$0.09
23	Sewer Discharge, per litre		$0.01
24	Vacuum loader		$68.66

Date modified: 2014-11-20

B6a

ESQUIMALT GRAVING DOCK

ASBESTOS MANAGEMENT PLAN- PART 1

Number of Pages: 10

ESQUIMALT GRAVING DOCK

ASBESTOS MANAGEMENT PLAN

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PACIFIC REGION
ENVIRONMENTAL SERVICES

Updated: April 2012

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PREFACE

The Asbestos Management Plan is required in order to comply with the Canada Labour Code and provincial regulations governing the safe work environment for employees, public and contractors visiting or working in buildings containing asbestos.

NOTE: (Provincial Regulation – Part 6 of the Regulation 185/99 – as prescribed under the British Columbia Occupational Health and Safety Act).

The Asbestos Management Plan (AMP) will perform several functions:

- To act as a common term of reference for the safe operation and management of buildings containing asbestos materials;
- To be a central depository of information for each facility;
- To act as a control mechanism to ensure compliance;
- To communicate roles and responsibilities of those required to work with or around asbestos materials; and,
- To communicate the accepted departmental procedures for working with asbestos materials.

This document provides information, procedures, and work practices necessary to the establishment of an Asbestos Management Plan (AMP). The AMP sets guidelines for all facility maintenance, alteration, repair or other activities that may disturb asbestos; and provides ongoing re-assessment of friable asbestos materials. If continuing disturbance or severe deterioration of friable asbestos is indicated, the material will be removed. Major renovations will be preceded by total removal of friable asbestos materials in the project area.

The AMP describes work practices for minor disturbance of friable asbestos materials (plaster and mechanical insulation), and non-friable materials (Low and Moderate Risk work). **This document is divided so that specific sections can be copied and provided to the worker or contractor performing the work.** The AMP includes policies for inspection of work, air monitoring, and worker training.

The AMP does not describe work procedures for major asbestos removal. Such removal is classified as High Risk work. These procedures generally require an experienced contractor, and, therefore are not detailed in this AMP document. This type of work usually requires a “project specific approach” and should be coordinated and monitored by the Regional Asbestos Coordinator and/or Project Manager.

DEFINITIONS

Abatement - control or attend to.

Amended Water - water which has been treated with a chemical agent to enhance the wetting of asbestos material prior to removal.

Area by area survey - survey of large areas where each plane within the area is sampled visually and scientifically tested for the presence of asbestos containing materials, i.e. corridors, assembly areas, total basement boiler rooms.

Asbestos – a group of naturally occurring mineral silicates which are capable of being separated into fibres. Asbestos comes from the Greek word “indestructible”.

Amosite - "brown asbestos" is from the amphibole family.
Chrosidilite - "blue asbestos" is from the amphibole family. No longer/very rarely used.
Chrysotile - "white asbestos" is from the serpentine family. Most commonly used
Other Types – Actinolite, Anthophyllite, Tremolite

Asbestos Containing Material (ACM) - a manufactured article containing 1% or more asbestos by weight at the time of manufacture or other materials which contain 1% or more asbestos as determined by X-ray diffraction or optical polarizing microscope analytical techniques.

Asbestos Process - refers to any handling of materials which generates airborne asbestos fibres, including:

- sawing, cutting, drilling or abrasion of asbestos materials;
- packing or unpacking of asbestos;
- installation or removal of asbestos insulation or coverings;
- mixing or application of asbestos cements, plasters, putties or similar compounds;
- cleaning of asbestos-contaminated clothing; or
- storage, conveyance or disposal of materials containing asbestos.

Containment - an isolation system designed to effectively contain asbestos fibres within a designated work area where asbestos-containing material is handled, removed, encapsulated or enclosed, and includes a glove bag.

Encapsulation - treatment of an asbestos-containing material which penetrates the material and binds all the fibres together.

Enclosure - isolation of asbestos-containing material, from adjacent occupied areas in a building, by physical barriers such as gyproc, plywood, or metal sheeting, to prevent the release of airborne asbestos fibres into these areas.

Friable Asbestos Product (Material) - ACM, that when dry, can be crumbled, pulverized or powdered by hand pressure. This definition also includes dust or debris arising from non-friable materials that are, or will become, crumbled, pulverized or powdered, i.e., asbestos containing plaster disturbed by demolition. Friable asbestos - suspect products include: sprayed asbestos

products (fireproofing, thermal insulation, acoustic insulation or decorative products) applied in 1974 or earlier; acoustic or texture plaster applied in 1983 or earlier; mechanical insulation installed in 1983 or earlier (jacketed or not); compressed mineral fibre ceiling tiles installed in 1983 or earlier.

Generic survey - spot check type survey where a small number of random samples are done at different locations of similar or non similar materials to get a localized perspective as to where asbestos containing materials are located. This type of survey would be good in areas such as boiler rooms where high concentrations of most materials are suspect to contain asbestos in localized areas such as boiler jacketing, pipe lagging, and exhaust breaching.

Phase Contrast Microscopy (PCM) - approved Treasury Board method for measurement of airborne particulate matter.

Polarized Light Microscopy (PLM) - method of detection for small amounts of asbestos in bulk samples.

Risk of Exposure to Asbestos Fibres - the risk of exposure to asbestos fibres when handling friable asbestos material is much greater than when handling hard, well-bonded asbestos material like vinyl-asbestos floor tile or asbestos cement products.

Room by room survey - survey of individual rooms where each plane within the room is sampled visually and scientifically tested for the presence of asbestos containing material.

Serpentine and amphiboles - rock types.

TEM - method of detection used for positive identification of airborne asbestos fibres via the use of an electron microscope.

Waste Asbestos - a waste containing friable asbestos fibres or asbestos dust in a concentration greater than 1% by weight either at the time of manufacture, or as determined by the test method "Asbestos in Bulk Samples-Dispersion Staining", Industrial Hygiene Laboratory Analytical Methods.

CONTACT LIST

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Kim Wilson Best Practices Coordinator	825 Admirals Road Victoria, BC V9A 2P1	Office: (250) 363-3914 Cell: (250) 213-6540
David Latoski Operations Manager	825 Admirals Road Victoria, V9A 2P1	Office: (250) 363-8056 Cell: (250) 889-5808
Bob Desmarais Yard Supervisor	825 Admirals Road Victoria, V9A 2P1	Office: (250) 363-0274 Cell: (250) 888-0141
Wyatt Wright Pumphouse Supervisor	825 Admirals Road Victoria, V9A 2P1	Office: (250) 363-3768 Cell: (250) 213-5154
Joe Lezetc Electrical Supervisor	825 Admirals Road Victoria, V9A 2P1	Office: (250) 363-3991 Cell: (250) 213-2545
Jack Gale Crane Supervisor	825 Admirals Road Victoria, V9A 2P1	Office: (250) 363-0272 Cell: (250) 213-9683
Jim Milne EGD General Manager	825 Admirals Road Victoria, V9A 2P1	Office: (250) 363-3256 Cell: (250) 812-7208
Amy Moizumi PWGSC Regional Asbestos Coordinator	19th Floor 800 Burrard St. Vancouver, BC	Office: (604) 666-6321

EMERGENCY PROCEDURES

If Moderate Risk work procedures cannot be strictly observed due to the urgency, some judgment will be required of the person responsible for the work, and other staff or contractors responding to the emergency. The general principle of emergency response work is to protect the workers performing the repair and to minimize the exposure of others to airborne asbestos. The procedures given below should be followed to the extent possible in the circumstances of the emergency.

VACATE the area of unnecessary personnel.

CONTACT immediate Supervisor for guidance on contamination, or, in the absence of same, the EGD Operations Manager, the EGD Environmental Coordinator, the EGD Best Practices Coordinator, the EGD Yard Supervisor, the EGD Pumphouse Supervisor, the EGD Electrical Supervisor, the EGD Crane Supervisor, or the PWGSC Regional Asbestos Coordinator.

LIMIT the asbestos contamination.

- Construct enclosure around area if time permits.
- Shut down ventilation system serving area.
- Use drop sheet under work to minimize clean-up if possible.

Worker performing the repair shall wear protective respirator and disposable suit. If normal work clothes are worn they must be disposed of as asbestos waste if visibly contaminated.

Perform emergency repair with minimum disturbance of asbestos.

Obtain asbestos equipment and perform clean-up of visible material before allowing unprotected personnel to enter area. Use HEPA filtered vacuum or wet cleaning. Dispose of all cleaning supplies as contaminated waste.

The worker should wipe off or vacuum disposable clothing and footwear. Proceed to washroom to wash face and hands.

The EGD Environmental Coordinator (or, in absence of same, the EGD Operations Coordinator, the EGD Best Practices Coordinator, the EGD Yard Supervisor, the EGD Pumphouse Supervisor, the EGD Electrical Supervisor, the EGD Crane Supervisor) will INFORM the following of the emergency:

INFORM the following of the emergency:

- All personnel/clients in the building
- EGD Health and Safety Committee Chair
- PWGSC Regional Asbestos Coordinator
- Occupational & Environmental Health Services, Health Canada (OEMs, HC)
- Human Resources Development Canada – Labour Program, Occupational Safety
- WorkSafeBC (when private sector clients/contractors present)

Before removing an enclosure, monitor the air to confirm acceptable levels and document readings. **OBTAIN** verification from OEMs (HC) on air monitoring requirements. If the regulatory bodies do not perform the monitoring, hire a qualified consultant.

Arrange for the EGD Project Managers to **INSPECT** the work as soon as possible and, in conjunction with the regulatory bodies, to **OVERSEE** the work and **APPROVE** the corrective work required.

DOCUMENT the disposal of the asbestos and the procedures used.

EMERGENCIES - GENERAL INFORMATION

Examples of possible emergencies:

- an asbestos clad boiler explodes
- a heating main breaks and floods the building

Most asbestos emergencies are unique, but basic procedures apply in all cases:

- handle emergencies as quickly as possible;
- follow standard procedures; and
- notify regulatory agencies and the EGD Environmental Coordinator at once.

The main goal is to limit contamination. Decontaminate and/or enclose problem areas with polyethylene. Shut off air-handling units to affected areas and post warning signs.

In a minor emergency, decontamination may be handled by trained in-house personnel or by a reputable asbestos contractor.

The asbestos emergency situation is under control when the asbestos relating to the emergency is enclosed.

Before removing an enclosure, monitor the air to confirm acceptable levels and document readings. If the regulatory bodies do not perform the monitoring, hire a qualified consultant.

B6b

ESQUIMALT GRAVING DOCK

ASBESTOS MANAGEMENT PLAN- PART 2

Number of Pages: 46

ESQUIMALT GRAVING DOCK ASBESTOS MANAGEMENT PLAN

1.0 INTRODUCTION TO THE PROGRAM

1.1 Objectives

The Asbestos Management Plan is formulated to meet the following objectives:

- To identify all friable asbestos materials. Friable asbestos materials are defined in the Program;
- To maintain all accessible friable asbestos materials in good condition;
- To prevent unintended asbestos exposures to client staff and visitors, contractors, and PWGSC staff;
- To manage all construction and maintenance activities that might disturb asbestos materials;
- To comply with all federal, provincial, territorial, and municipal requirements for occupational health and safety, and environmental control.

1.2 Response to Policy Directives

The Asbestos Management Plan has been developed to meet federal and provincial regulatory requirements.

The Asbestos Management Plan meets the requirements for employee health protection set out in Treasury Board Manual, Human Resources Management, Procedures for Occupational Exposure to Asbestos, Chapter 4-03, 1994 and in the Deputy Minister's Directive, Asbestos Management, and Code of Practice (DM 057).

1.3 Regional Asbestos Coordinator

A position of Regional Asbestos Coordinator will exist to provide services for asbestos control. Name and telephone number of the Regional Asbestos Coordinator is the following:

Regional Asbestos Coordinator
Name: Amy Moizumi (Vancouver Office)
Tel: 604-666-6321
Fax: 604-775-6645

1.4 Regulatory Requirements

PWGSC has responsibilities as building owner, tenant, landlord, and employer, under the following regulations and statutes:

- Canada Labour Code, Part II
- Canadian Environmental Protection Act
- Provincial and territorial occupational health and safety legislation (Part 6 of Regulation 185/99 – as prescribed under the British Columbia Occupational Health and Safety Act);

- Provincial and territorial environmental protection legislation (British Columbia Ministry of Environment - *Waste Management Branch*).

2.0 DEPARTMENTAL POLICIES

2.1 Friable Asbestos Products in Leased Premises

When PWGSC is considering leasing space in a building built before 1983, PWGSC shall be provided with an asbestos survey that addresses and includes analysis of all friable materials as defined in the PWGSC Asbestos Management Plan. The survey shall be signed by and conducted under the direction of a person competent in asbestos control, such as a Professional Engineer, a Certified Industrial Hygienist, or a Registered Occupational Hygienist.

PWGSC will not lease space where there is friable asbestos material (other than properly encapsulated or enclosed asbestos containing insulation on mechanical systems) within the space to be occupied.

The Department may lease space in buildings where friable asbestos products are present elsewhere in the building, provided there is an asbestos management plan in place that meets the minimum requirements of the PWGSC Asbestos Management Plan.

A copy of the lease building asbestos management plan shall be submitted to PWGSC as a condition of issuance of the lease.

2.2 Definition of Friable Asbestos Products

For the purposes of the Asbestos Management Plan, a friable asbestos material is a material that when dry can be crumbled, pulverized or powdered by hand pressure, and includes dust or debris arising from non-friable materials that is or will become crumbled, pulverized or powdered (such as asbestos-containing plaster disturbed by demolition). Friable asbestos-suspect products include, but are not limited to:

- Sprayed asbestos products (fireproofing, thermal insulation, acoustic insulation, or decorative products) applied in 1974 or earlier.
- Acoustic or texture plaster applied in 1983 or earlier.
- Mechanical insulation installed in 1983 or earlier, whether or not jacketed.
- Compressed mineral fibre ceiling tiles installed in 1983 or earlier.

2.3 Detection Limit of Bulk Analysis

Asbestos-containing material is defined as any material found to contain asbestos at or above the detection limit of asbestos fibres set provincially, as determined by the standard Polarized Light Microscopy method for the analysis of bulk samples. The provincial detection limit is:

RECOGNIZED LIMITS FOR PLM METHOD

Province(Region)	Detection Limit
British Columbia	1.0 %

PWGSC will adopt the above Provincial regulated limits.

3.0 ASBESTOS INVENTORY AND ASSESSMENT

The EGD Environmental Coordinator will arrange for a complete survey and assessment of asbestos materials.

The initial survey to provide the Asbestos Inventory and Assessment will be performed on a building-by-building and room-by-room basis. The inventory information will be held in a regional database. This database should allow for easy retrieval for reports to be submitted as and when required.

The survey will address all of the friable asbestos materials, as defined in the Asbestos Management Plan (AMP), plus applications of floor finishes and asbestos-reinforced cement products (i.e. asbestos cement sheeting and piping).

The evaluation of friable asbestos materials will follow the criteria given in **Appendix A**.

The analysis of bulk samples will be performed to the detection limits given in **Section 2.3**, and by laboratories accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the U.S. National Institute of Science and Technology (NIST) for Polarized Light Microscopy analysis of asbestos materials. Health Canada laboratory and Labour Canada laboratory are acceptable.

The survey will be conducted under the direction, and signed by a person competent in asbestos control, such as a Professional Engineer, a Certified Industrial Hygienist, or a Registered Occupational Hygienist.

The EGD Environmental Coordinator will arrange for copies of the completed Asbestos Inventory and Assessment reports and annual re-assessments to be held at the following location:

- A location in each building, accessible to maintenance staff and contractors.

Copies will also be retained by the Regional Asbestos Coordinator.

The EGD Environmental Coordinator will utilize the services of the Regional Asbestos Coordinator to arrange for removal or repair of damaged or deteriorated friable asbestos materials identified by the Asbestos Inventory and Assessment.

4.0 RE-ASSESSMENT

The EGD Environmental Coordinator will arrange for a yearly re-assessment of all friable asbestos materials in exposed, accessible locations.

Copies of the re-assessment reports will be distributed to holders of the Asbestos Inventory and Assessment reports.

The EGD Environmental Coordinator will utilize the services of the Regional Asbestos Coordinator to arrange for removal or repair of damaged or deteriorated friable asbestos materials identified by the yearly re-assessments and when High Risk removal and repairs are required.

5.0 NOTIFICATION

5.1 General Notification

Under the Canada Labour Code, government employees have to be informed of any asbestos in facilities they work in. To this, the EGD Environmental Coordinator will provide a written interim notice of the presence of friable asbestos materials, as known at the time the Asbestos Management Plan (AMP) comes into effect, to the EGD Operations Coordinator, who will ensure written notice is provided to the following groups:

- EGD Health and Safety Committees representatives. (PWGSC and Users);
- Maintenance employees; and
- Contractors who may enter parts of the building where friable asbestos materials may be present, i.e. telecommunications firms, boiler maintenance contractors. Refer to **Appendix I** for a Contractor Notification and Acknowledgement form.

The EGD Environmental Coordinator will provide copies of these notices to the Regional Asbestos Coordinator, who will maintain them.

5.2 Notification Updates

After receipt of the Asbestos Inventory and Assessment reports, the EGD Environmental Coordinator will provide an updated written notification to the groups listed in **Section 5.1**.

5.3 Notification Requirements for Planned Asbestos Work

DO NOT START an asbestos removal project, testing and/or maintenance without notifying the clients and appropriate authorities.

Client Notification
The clients should be informed by the EGD Environmental Coordinator or their representative.

Notification of Authorities
The following authorities should be contacted;

(a) Labour Canada
(b) Occupational and Environmental Health Services (Health Canada)
(c) WorkSafeBC

6.0 TRAINING

All PWGSC personnel, who have responsibilities under the Asbestos Management Program, must be trained on Asbestos. The training is available in modules, so that staff can receive the training necessary for their particular duties. This is also to prevent duplication with previous training. The Department Training Coordinator and the Regional Asbestos Coordinator will maintain records of training. Record of such training will be kept on the employee's file.

6.1 Asbestos Management Training

Asbestos Management Training will be provided to the management staff at the EGD including the Operations Coordinator, Yard Supervisor, Pumphouse Supervisor, Electrical Supervisor, and Crane Supervisor. Appropriate levels of training shall be provided to Project Managers dedicated to the EGD or those that are frequently involved with projects at the EGD. This is to ensure that all staff who has responsibilities under the Asbestos Management Plan is properly trained and possess the required knowledge to work in an asbestos environment. The training will include an introduction to the Asbestos Inventory and Assessment reports, health hazards of asbestos exposure, regulations, the Asbestos Management Plan, classification of asbestos work, asbestos project control, and emergency procedures.

6.2 Asbestos Procedures Training

Training will be provided to maintenance workers who will perform Low and Moderate Risk work leading to disturbance of asbestos products. The training will include an introduction to the Asbestos Inventory and Assessment reports, health hazards of asbestos exposure, regulations, the Asbestos Management Plan, Low and Moderate work practices, and disposal procedures. Upon completion of the training, workers shall sign a form acknowledging the training received. See **Appendix H**, Certificate of Training for Asbestos-Related Work.

Respirator training will be provided to all those who will perform Moderate Risk work, and all those who will perform Low Risk work and request a respirator. The training will cover limitations of use, facial hair, fitting, and maintenance of respirators. Persons provided with a respirator will be fit-tested with the assigned respirator, using the CSA irritant smoke method. **Appendix E** gives notes on respirator fitting and maintenance. Persons who will wear tight-fitting respirators will be required to be clean-shaven where the respirator seals to the face. Depending on the extent of asbestos work to be undertaken and case-by-case evaluation, PWGSC may provide workers with facial hair alternate respirators that do not require a facial seal. Reference should be made to the new *CSA Z94.4, Selection, Care and Use of Respirators*.

6.3 Asbestos Awareness Training

Training will be provided to all maintenance and operations personnel who may work around asbestos materials, or who supervise workers or contractors. The training will introduce the Asbestos Inventory and Assessment reports, health hazards of asbestos exposure, the Asbestos Management Plan, and emergency procedures.

This training shall also be made available to the EGD Safety and Health Committee.

7.0 CLASSIFICATION OF ASBESTOS WORK

Asbestos work will be classified as Low, Moderate and High Risk according to the following criteria:

LOW RISK WORK (Type 1)

- Low Risk work activities include moving cleaned, sealed bags of asbestos material in a covered container through a work area, and working near disturbed friable asbestos-containing materials.

MODERATE RISK WORK (Type 2)

- Removal or replacement of asbestos containing compressed mineral fibre type ceiling tiles.
- Entry into ceiling spaces, crawl spaces, pipe tunnels, etc., where friable asbestos debris is present.
- Using hand tools to cut, shape, drill, grind, or remove non-friable asbestos-containing products.
- Minor removal of friable asbestos materials, limited to a maximum of $0.3m^2$ ($3\ ft^2$).
- Drilling (with wetting agents or with local exhaust ventilation) through non-friable asbestos-containing materials.
- Backing mounting screws out of asbestos cement products and removing the boards or tile intact.
- Buffing floor tiles with a course disc.
- Collecting samples of laboratory analysis.
- Analyzing samples of asbestos or asbestos-containing materials in the laboratory.
- Handling asbestos-containing materials in sealed containers at the workplace.
- Removing any part of a false ceiling to gain access to a work area when friable asbestos-containing materials are, or are likely to be, lying on the surface of the false ceiling.
- Removing drywall materials where joint filling materials contain asbestos.
- Removing an entire piece of equipment or pipe with the asbestos-containing material remaining effectively intact.
- Demolishing a block wall that has asbestos debris in the cavity.
- Dismantling a treated enclosure at completion of an asbestos removal project.
- Moving bags of asbestos-containing material by hand.
- Setting up and removing a glove-bag apparatus for the removal of pipe insulation when the insulation is in good condition.
- Using a “single” glove-bag method to remove asbestos insulation from piping systems.
- Using a HEPA vacuum to clean ceiling tiles or light fixtures with light to moderate contamination.
- Using HEPA vacuum to clean an area before setting up a High Risk enclosure.

HIGH RISK WORK (Type 3)

- Work not permitted under Low or Moderate Risk work.
- Removing, encapsulating, or enclosing friable asbestos-containing materials.
- Cleaning, maintaining, or removing air-handling equipment in buildings where spray fireproofing materials containing asbestos have been applied to the airways or ventilation ducts or have been used as spray-on insulations.
- Repairing, altering, or dismantling any part of a boiler, furnace, kiln, or similar device in which insulating materials containing asbestos have been used or applied.
- Demolishing, dismantling, altering, or repairing any part of a building or structure in which insulating materials containing asbestos were used, or in which asbestos-containing products were manufactured.
- Removing non-friable materials in circumstances where the materials will be damaged, resulting in friable asbestos waste or a significant release of fibres.
- Carrying out multiple moderate-risk work activities in a limited area, i.e. multiple glove bag operations.

8.0 IDENTIFICATION AND CONTROL OF ASBESTOS-RELATED WORK

8.1 Maintenance Work

The EGD Supervisors are responsible to review all maintenance work for the possibility of disturbance of asbestos materials.

If there are friable asbestos materials in the area of maintenance, but the EGD Supervisors or a designate judge that the friable materials will not likely be disturbed by the maintenance work, the EGD Supervisors must caution the maintenance staff or the contractor of the presence of friable asbestos materials.

If there is a friable or non-friable asbestos material in the area of maintenance, and this will be disturbed by the intended work, the EGD Supervisors, in conjunction with the EGD Environmental Coordinator, will classify the work as Low, Moderate or High Risk.

The PWGSC Project Manager or Regional Asbestos Coordinator will be responsible to review or direct all maintenance work that will require High Risk work.

At the completion of any maintenance work that involves asbestos removal or repair, a report will be provided to the Regional Asbestos Coordinator.

8.2 Asbestos-Related Work Record

The supervisors of PWGSC staff performing Low or Moderate Risk work will be responsible to ensure that a record is completed for each period of work. These records shall be copied to the employee's employment file, and a copy forwarded to the Regional Asbestos Coordinator. **Appendix G** gives an example of an Asbestos-Related Work Record.

All PWGSC employees who will perform Low and Moderate Risk work shall be medically examined through the facilities of Health Canada. The examinations shall be carried out in accordance with the Treasury Board Occupational Health evaluation standard.

Documentation should also be placed on the employee's medical file that they are asbestos workers.

8.3 Renovations and Construction Work

The EGD Environmental Coordinator and Project Manager will review the asbestos survey reports prior to all renovation and construction work for the possible impact on asbestos materials.

Prior to projects that includes the demolition of plaster, testing of the plaster for asbestos will be undertaken unless previous comprehensive testing in the building has shown this plaster to be asbestos-free. Records of plaster test results will be maintained by EGD Environmental Coordinator along the with the asbestos surveys of the building.

If there are friable asbestos materials in the renovation area, but the Project Manager or the Regional Asbestos Coordinator judges that the friable materials will not likely be disturbed by the maintenance work, the Project Manager must notify, in writing, the maintenance staff or the contractor of the presence of friable asbestos materials.

The Project Manager will provide a Hazardous Materials report (a prescribed listing of asbestos, lead, and other hazardous materials) prior to tendering the work.

The Project Manager, will classify the disturbance of asbestos materials as Low, Moderate or High Risk work.

The Project Manager will arrange for specifications to be prepared for asbestos work, following the National Master Specification, with alterations for special provincial requirements, where needed.

At the completion of project work that alters the amount or condition of friable asbestos materials, the Environmental Coordinator will amend the Asbestos Survey and Assessment report to reflect the changes. This alteration will be noted in the building survey and distributed to holders of the Asbestos Inventory and Assessment reports.

8.4 Low Risk, Moderate Risk, and Glove Bag Procedures

Appendices B, C, and D give standard practices for performing Low and Moderate Risk work, as well as glove bag asbestos work, respectively.

8.5 Project Inspection and Air Monitoring

Low and Moderate Risk work will be subject to the normal maintenance or project inspection provided to non-asbestos work by PWGSC. Asbestos specific air monitoring or inspection will not be mandatory.

The Project Manager will arrange for inspection and air monitoring of High Risk asbestos projects. In an occupied building or a building in use, inspection and air monitoring will be provided on a daily basis. If the building is not occupied, inspection shall be at critical stages of the work unless provincial standards require daily inspection.

In British Columbia, to ensure that work areas are properly inspected and monitored, the following must be done:

a) Inspect the containment and all decontamination facilities for gaps and breaks at least daily. Complete a visual check as well as a smoke-tube test to ensure that air flow from the clean areas into the containment areas. Measuring the air pressure differential between clean and containment areas is also recommended. **Keep a record of such inspection for at least 10 years.**

b) Take air samples to determine asbestos fibre concentrations, both during the asbestos work and before the containment is removed. The minimum sampling requirements are as follows:

- On a daily basis, take samples outside the containment when there are unprotected persons in the immediate vicinity of the containment.
- During every shift, sample the air in the clean room during removal and clean up operations. Sampling must cover at least half of the total duration of the work shift and at least one decontamination sequence at the end of the work shift. Analyze filters and notify workers of the results within 24 hours.
- Take “occupational” air samples to determine or assess the adequacy of work procedures and controls, or when changes to the work procedures occur.

High Risk removal projects will be subject to final clearance air testing. The clearance criteria will be a maximum fibre concentration of **0.01 fibre/ml of air**, as determined by the standard PCM method. Health Canada or a third party consultant may perform the clearance. The NIOSH method 7400 will be used. One clearance air sample shall be obtained for every 110m^2 of containment.

8.6 Emergency Asbestos Work

Procedures for immediate response to floods, pipe breaks, ceiling collapses, or other emergencies that affect asbestos materials, are given in **Appendix F**. The general principles of emergency asbestos work are to protect the responder and prevent tenants and visitors from having an asbestos exposure.

9.0 AIR MONITORING AND BULK ANALYSIS

9.1 Air Monitoring for Hazard Assessment

Air monitoring will not be used as the primary resource for the assessment of hazard from asbestos materials. If the Project Manager is requested to perform air monitoring under normal conditions of building use (i.e. away from asbestos work) the measurements may be made by the Transmission Electron Microscopy (TEM) analytical method.

9.2 Air Monitoring During Asbestos Work Procedures

The EGD Project Managers may arrange for air monitoring during High Risk work, to confirm the safety of work practices and the effectiveness of work area isolation. These measurements would be made by the Phase Contrast Microscope (PCM) method recognized by Labour Canada and provincial occupational health and safety authorities. Health Canada monitors the air outside the removal area to protect the federal employees.

PCM measurements will be made by NIOSH Method 7400.

Analysis of PCM samples will be performed by Health Canada or individuals or organizations successfully participating in a recognized external quality control program.

9.3 Bulk Sample Collection and Analysis

Appendix J gives procedures for collection and labeling of bulk samples for asbestos analysis.

Analyses of materials to determine asbestos content will be performed by Health Canada or by private laboratories accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the U.S. National Institute of Science and Technology. The laboratories shall report to the limits of detection given in **Section 2.3**.

10.0 FACILITIES AND WASTE DISPOSAL

10.1 Equipment and Supplies

The Esquimalt Graving Dock will maintain a stock of the necessary asbestos-related equipment, as required for Low and Moderate Risk work, for those facilities where PWGSC staff will perform asbestos work.

10.2 Waste Disposal

Where PWGSC staff will perform asbestos work, asbestos debris will be packaged in double-bagged containers or other suitable containers, by staff completing the project. These containers will be held at a secure location in the building. The EGD Environmental Services will arrange for periodic collection.

APPENDIX A

EVALUATION AND RECOMMENDATION CRITERIA FOR CONTROL OF ASBESTOS CONTAINING MATERIALS (ACM)

1.0 ASSESSMENT OF CONDITION

Spray Applied Fireproofing, Insulation and Texture Finishes

To evaluate the condition of ACM spray applied as fireproofing, thermal insulation, or texture, decorative or acoustic finishes, the following criteria are applied:

GOOD
Surface of material shows no significant signs of damage, deterioration or delaminating. Up to one percent visible damage to surface is allowed within range of **GOOD**. Evaluation of sprayed fireproofing requires the surveyor to be familiar with the irregular surface texture typical of sprayed asbestos products. **GOOD** condition includes unencapsulated or unpainted fireproofing or texture finishes, where no delaminating or damage is observed, and encapsulated fireproofing or texture finishes where the encapsulation has been applied after the damage or fallout occurred.

POOR
Sprayed materials show signs of damage, delaminating or deterioration. More than one percent damage to surface of ACM spray.

In observation areas where damage exists in isolated locations, both **GOOD** and **POOR** condition may be reported. The extent or percentage of each condition will be recorded on the survey or re-assessment form. **FAIR** condition is not utilized in the evaluation of the sprayed fireproofing, sprayed insulation, or texture coat finishes.

The evaluation of ACM spray applied as fireproofing, non-mechanical thermal insulation, or texture, decorative or acoustic finishes which are present above ceilings, may be limited by the number of observations made, and by building components such as ducts or full height walls that obstruct the above ceiling observations. Persons entering the ceiling are advised to be watchful for ACM **DEBRIS** prior to accessing or working above ceilings in areas of buildings with ACM regardless of the reported condition.

Mechanical Insulation

The evaluation of the condition of mechanical insulation (on boilers, breaching, ductwork, piping, tanks, equipment, etc.) utilizes the following criteria:

GOOD
Insulation is completely covered in jacketing and exhibits no evidence of damage or deterioration. No insulation is exposed. Includes conditions where the jacketing has minor surface damage (i.e. scuffs or stains), but the jacketing is not penetrated.

FAIR
Minor penetrating damage to jacketed insulation (cuts, tears, nicks, deterioration or delaminating) or undamaged insulation that has never been jacketed. Insulation is exposed but not showing surface disintegration. The extent of missing insulation ranges should be minor to none.

POOR
Original insulation jacket is missing, damaged, deteriorated or delaminated. Insulation is exposed and significant areas have been dislodged. Damage cannot be readily repaired.

The evaluation of mechanical insulation may be limited by the number of observations made and building components such as ducts or full height walls that obstruct observations. It is not possible to observe each foot of mechanical insulation from all angles.

Non-Friable and Potentially Friable Materials

Non-friable materials generally have little potential to release airborne fibres, even when damaged by mechanical breakage. However, some non-friable materials, i.e. exterior asbestos cement products, may have deteriorated so that the binder no longer effectively contains the asbestos fibres. In such cases of significantly deteriorated non-friable material, the material should be treated as a friable product.

1.1 EVALUATION OF ACCESSIBILITY

The accessibility of building materials known or suspected of being ACM is rated according to the following criteria:

ACCESS (A)
ACM is located in areas of the building within reach (from floor level) of all building users. This would include areas such as gymnasiums, workshops, and storage areas where activities of the building users may result in disturbance of ACM not normally within reach from floor level.

ACCESS (B)
ACM is located in frequently accessed maintenance areas within reach of maintenance staff, without the need for a ladder. These include:

- areas within reach from a fixed ladder or catwalk, i.e. tops of equipment, mezzanines;
- frequently entered pipe chases, tunnels and service areas.

ACCESS (C EXPOSED)
ACM is in an area of the building above 8'-0" where use of a ladder is required to reach the ACM. This only refers to ACM that is exposed to view, from the floor or ladder, without the removal or opening of other building components such as ceiling tiles, or service access door or hatch. Does not include infrequently accessed service areas of the building.

ACCESS (C CONCEALED)
ACM is in an area of the building that requires the removal of a building component, such as lay-in ceilings or access panels, into solid ceiling systems. Includes rarely entered crawl spaces, attic spaces, etc. Observations will be limited to the extent visible from the access points.

ACCESS (D)
ACM is located within areas of the building behind inaccessible solid ceiling systems, walls or mechanical equipment, etc. where demolition of the ceiling, wall or equipment, etc. is required to

reach the ACM. Evaluation of condition and extent of ACM is limited or impossible, depending on the surveyor's ability to visually examine materials in ACCESS D.

1.2 ACM DEBRIS

Debris from Friable ACM

The presence of fallen ACM is noted separately from the presumed friable ACM source (sprayed fireproofing, thermal insulation, texture, decorative or acoustic finishes or mechanical insulation) and is referred to as **DEBRIS**.

Debris from Damaged Non-Friable ACM

The presence of fallen ACM from damaged non-friable ACM is also reported separately from the non-friable ACM source. Only fallen non-friable ACM that has become friable is reported as **DEBRIS**.

The identification of the exact location or presence of **DEBRIS** on the top of ceiling tiles is limited by the number of observations made and the presence of building components such as ducts or full height walls that obstruct observations. Workers are advised to be watchful for the presence of **DEBRIS** prior to accessing or working in proximity to mechanical insulation or above ceilings in areas of buildings with ACM regardless of the reported presence or absence of **DEBRIS**.

1.3 ACTION MATRIX AND DEFINITIONS

The Asbestos Management Plan requires the following responses:

- Immediately clean-up **DEBRIS** that is likely to be disturbed.
- Remove, repair or enclose friable ACM in **POOR** or **FAIR** condition whose continued deterioration will result in **DEBRIS** that is likely to be disturbed.

The following factors are also considered in making site-specific recommendations for compliance with the regulation and the practical implementation of the Asbestos Management Plan:

i. ACM in **POOR** condition is not routinely repairable. If an abatement action is necessary, removal is the recommended action (enclosure is a viable option in unusual circumstances).

ii. Mechanical insulation in **FAIR** condition can be repaired or removed based on the following general recommendations applied on a case by case basis (Note: Either repair or removal are legally acceptable options for the treatment of ACM found in **FAIR** condition):

   - Repair ACM mechanical insulation found in **FAIR** condition in **ACCESS (B)** or **ACCESS (C EXPOSED)** areas;

- Remove ACM mechanical insulation found in **FAIR** condition in **ACCESS (B)** and **ACCESS (C EXPOSED)** areas, where future damage to the ACM is likely to occur;
- Remove ACM mechanical insulation found in **FAIR** condition with **ACCESS (A)** to eliminate the potential for re-damaging ACM by all building users.

iii. ACM in **GOOD** condition present in **ACCESS (A)** can be managed by surveillance, as long as future renovation, maintenance or demolition does not disturb it. However, pro-active removal of the ACM in **ACCESS (A)** should be considered where damage is possible by ongoing occupant activity (accidental or intentional).

iv. Non-friable or manufactured products are considered in the action matrix as follows:

- Non-friable or manufactured products reported in **POOR** condition or friable **DEBRIS** resulting from the deterioration of non-friable ACM are treated as friable materials and the appropriate Action, depending on accessibility, is determined from the Action Matrix for friable ACM.

- For non-friable or manufactured products reported in **GOOD** condition, Action 7 (surveillance) is recommended regardless of Accessibility.

v. Remove all ACM from a particular area where small quantities of asbestos are present and removal will negate the need for the use of the Asbestos Management Plan in that area.

With these principles in mind the following Action Matrix Tables establish the recommended asbestos control action. Note that factors not included in the above discussion, such as an owner's policy decision to remove material, knowledge of upcoming maintenance, etc., may result in a recommendation that differs from this table. The **ACTIONS** are described in full following the table.

ACTION MATRIX TABLE

FRIABLE ACM

	CONDITION			
ACCESS	**GOOD**	**FAIR**	**POOR**	**DEBRIS**
(A)	ACTION 5/7[1]	ACTION 5/6[2]	ACTION 3	ACTION 1
(B)	ACTION 7	ACTION 6/5[3]	ACTION 3	ACTION 1
(C EXPOSED)	ACTION 7	ACTION 6	ACTION 4	ACTION 2
(C CONCEALED)	ACTION 7	ACTION 7	ACTION 4	ACTION 2
(D)	ACTION 7	ACTION 7	ACTION 7	ACTION 7

1. If material in **ACCESS (A)/GOOD** condition is not removed **ACTION 7** is required.
2. If material in **ACCESS(A)/FAIR** condition is not removed **ACTION 6** is required.
3. Remove ACM in **ACCESS (B)/FAIR** condition if ACM is likely to be disturbed.

1.4 ACTION DEFINITIONS

ACTION 1 - Immediate Clean-Up of DEBRIS that is Likely to Be Disturbed
Restrict access that is likely to cause a disturbance of the ACM **DEBRIS** and clean up ACM **DEBRIS** immediately. Utilize correct asbestos procedures. This action is required for compliance with regulatory requirements. The surveyor should immediately notify the Asbestos Coordinator of this condition.

ACTION 2 - Isolate Areas with ACM DEBRIS
At locations where ACM **DEBRIS** can be isolated in lieu of removal or cleaned up, use appropriate means to limit entry to the area. Restrict access to the area to persons utilizing Moderate Risk Work Procedures. The precautions will be required until the ACM **DEBRIS** has been cleaned up, and the source of the **DEBRIS** has been stabilized or removed.

ACTION 3 - ACM Removal Required for Compliance
Remove ACM for compliance with regulatory requirements. Utilize asbestos procedures appropriate to the scope of the removal work.

ACTION 4 - Moderate Risk Work Procedures for Access into Areas Where ACM is Likely to be Disturbed by Access
Use Moderate Risk Work Procedures when entry or access into an area is likely to disturb the ACM. **ACTION 4** must be used until the ACM is removed (Use **ACTION 1** or **2** if **DEBRIS** is present).

ACTION 5 - Proactive ACM Removal
Remove ACM in lieu of repair, or at locations where the presence of asbestos in **GOOD** condition is not desirable.

ACTION 6 - ACM Repair
Repair ACM found in **FAIR** condition, and not likely to be damaged again or disturbed by normal use of the area or room. Upon completion of the repair work treat ACM as material in **GOOD** condition and implement **ACTION 7**. If ACM is likely to be damaged or disturbed, during normal use of the area or room, implement **ACTION 5**.

ACTION 7 - Routine Surveillance
Institute routine surveillance of the ACM. Trained workers or contractors must use appropriate asbestos precautions for activity in the area which may create a risk for disturbing the ACM.

APPENDIX B

LOW RISK WORK PROCEDURES

1.0 LOW RISK WORK PROCEDURES

For locations of non-friable asbestos materials, refer to the current version of the Asbestos Inventory and Assessment Report.

NOTE: Low Risk Work Procedures assume the non-friable material can be removed with relatively little risk of generating airborne fibers. Generation of debris is permissible as long as the debris can be wetted and completely removed. If the work will release more than a trivial amount of dry loose dust, do not proceed. The Regional Asbestos Coordinator will determine which of Low Risk, Moderate Risk or High Risk procedures are appropriate.

1.1 EQUIPMENT

All equipment must be on site before proceeding.

Vacuum
Use of a vacuum is optional. Wet cleaning methods may be used in place of a vacuum. If a vacuum is used it must be equipped with a high efficiency particulate (HEPA) filter and all brushes, fittings, etc. The vacuum must only be opened in an enclosure following Moderate Risk Procedures, or in a laboratory exhaust hood. The vacuum exterior should be carefully wet-cleaned after emptying.

Respirators
Use of a respirator is optional. However, a respirator is strongly advised for work on sheet flooring, any type of ceiling tile, and other work performed overhead. PWGSC will supply, at the worker's request, a half face respirator with HEPA filters, with training on use and qualitative fit testing. Respirator must be used according to written use procedures provided to the worker as per training procedures. Filters must be changed after 24 hours of wear or sooner if breathing resistance increases. No person using the respirator shall wear facial hair which affects the seal between respirator and face.

Protective Clothing
Reusable or disposable clothing may be used. Non-disposable clothing with visible asbestos contamination shall be cleaned with a HEPA vacuum and handled as contaminated asbestos material. Disposable clothing and respirator filters to be disposed of as asbestos waste.

Other Equipment
- plastic sheet (0.15mm / 6 mil polyethylene) - to serve as a drop sheet;
- hand pump sprayer with nozzle or alternative method to wet material;
- labeled yellow asbestos waste bags (6 mil) - for all asbestos waste, disposable equipment, plastic, etc.; and,
- small tools and cleaning supplies - e.g. scouring pads, sponges, brushes, buckets, etc.

1.2 OTHER PROTECTIVE MEASURES

Do not eat, drink or smoke in the work area.

On leaving work area, proceed to washroom and wash all exposed skin on hands and face.

1.3 PREPARATION

Before disturbing non-friable asbestos materials, cover floor and surfaces below work with polyethylene sheeting to catch debris.

Wherever dust on a surface is likely to be disturbed remove with HEPA vacuum or damp cloth.

1.4 EXECUTION

Removal of Vinyl Asbestos Floor Tile (less than 0.1m^2)

Do not use electric powered scrapers.

Start removal by wedging a heavy-duty scraper in seam of two adjoining tiles and gradually force edge of one tile up and away from floor. Do not break off pieces of tile, but continue to force balance of tile up.

Continue removal of tiles using hand tools, removing tiles intact wherever possible. When adhesive is spread heavily or is quite hard, it may prove easier to force scraper through tightly adhered areas by striking scraper handle with a hammer using blows of moderate force while maintaining scraper at 25° to 30° angle to floor. When this technique cannot loosen tile, removal can be simplified by heating tile thoroughly with a hot air gun until heat penetrates through tile and softens the adhesive.

When tiles are removed, place into asbestos waste receptor. Do not break into smaller pieces.

After removal of small area scrape up adhesive remaining on floor with a hand scraper until only a thin smooth film remains. Where deposits are heavy or difficult to scrape, a hot air gun may be used. Deposit scrapings in the asbestos waste disposal bag. Do not dry scrape surface of adhering pieces of tile. Do not use powered electric scrapers.

On completion of area, vacuum clean floor with HEPA vacuum or wet mop. Dispose of the mop head as contaminated waste.

1.5 WASTE TRANSPORT AND DISPOSAL

Place waste into asbestos labeled disposal bag, seal with tape, clean the exterior of the bag with a clean cloth, and place into a second clean bag, also to be sealed with tape. Use a barrel, fibre drum, or cardboard or wooden box in place of the second bag when the asbestos waste material is likely to tear the inner bag. Seal the outer container.

Provide storage area for holding minor amounts of asbestos waste in sealed containers. Garbage containers shall be labeled and assigned exclusively for asbestos waste.

Dispose of the waste in compliance with provincial regulations. The EGD Environmental Coordinator will arrange for disposal.

APPENDIX C

MODERATE RISK WORK PROCEDURE

1.0 MODERATE RISK WORK PROCEDURES

For locations of asbestos materials, refer to the current version of the Asbestos Inventory and Assessment Report.

1.1 EQUIPMENT

Equipment required for the work must be on-site before proceeding.

Vacuum
An asbestos-approved vacuum (HEPA filtered), equipped with brushes, fittings, etc. The vacuum must only be opened by a properly protected worker within a Moderate Risk enclosure.

Respirators
Workers within the work area shall wear approved respirator. Respirators and filters will be provided by the employer, and individually assigned to workers. Respirator shall be a half-face piece respirator with high efficiency filters. Respirators must be properly worn throughout the entire time that the worker is in the area of the work from first disturbance of the asbestos material until the final cleaning of the area and bagging of waste is complete. Change filters after 24 hours of wear or sooner if breathing resistance increases. No person using the respirator shall wear facial hair which affects seal between respirator and face.

Protective Clothing
All workers shall wear disposable coveralls with attached elasticized hood. Coveralls should be worn with the hood in place at all times. Coveralls may be vacuumed or wet wiped clean for re-use, for a maximum of 8 hours cumulative wear. Suit and head cover shall remain in place until worker leaves work area or the enclosure is dismantled. Boot covers or dedicated boots are recommended.

Other Equipment
- plastic sheet (6 mil polyethylene) - to erect a total enclosure or to serve as drop sheet;
- wood framing or clips to support polyethylene sheeting, as appropriate to work area;
- tape to fasten plastic enclosure to ceiling or to tape drop sheet to floor; 3/4" double-sided tape recommended for attaching polyethylene to T-bar ceiling;
- labeled asbestos waste bag (6 mil) - for all asbestos waste, disposable suit, plastic for disposal, etc.;
- pump sprayer containing water with wetting agent to wet asbestos as necessary; dilute wetting agent 2 oz per gallon of water;
- asbestos warning signs;
- cleaning supplies - e.g. scouring pads, sponges, brushes, buckets, etc.
- insulation repair supplies (lagging compound, cloth, PVC covers); and,
- encapsulating sealer, for brush or airless spray application.

1.2 OTHER PROTECTIVE MEASURES

Do not eat, drink or smoke in the work area.

On completing clean up of work area, use vacuum or wet cloth to clean hands, face, respirator and boots. Remove protective equipment and proceed to nearest washroom to wash exposed skin on hands and face.

1.3 SCHEDULING OF WORK

Schedule work when occupants are absent. If persons are present, do not start work.

If work above ceiling is required on an emergency basis when area is occupied, have the Department advise occupants to vacate area until work is complete and clearance is given to return.

1.4 PREPARATION

Shut down ventilation systems to and from the work area. Seal over all ventilation openings, diffusers, grilles, etc. with plastic and tape.

Where practical, clear areas of movable furnishings or equipment. This should include anything which occupants may wish to use during work period. Any furnishings or equipment not removed shall be adequately covered and sealed using 6 mil polyethylene and tape. The intent of the protection is to provide an airtight envelope to protect the articles from airborne dust or splashed debris.

Post signs or barrier tape to indicate asbestos hazard and requirement for protective clothing for anyone entering the space.

For small rooms, cover walls with plastic such that the complete room becomes the work area. For larger rooms, erect enclosure of 6-mil polyethylene of suitable dimensions to enclose the work area and scaffolds and ladders required to gain access. If a suspended ceiling is present, the enclosure shall extend to the ceiling line. The enclosure shall be as airtight as conditions permit including the provision of a double overlapping flap at the entrance. The floor of the work area shall be a layer of 6-mil polyethylene sealed to the plastic walls of the enclosure.

Don protective clothing and respirator prior to removing ceiling tile or disturbing pipe jacketing or sprayed fireproofing.

1.5 EXECUTION

To remove less than 0.1m^2 of fireproofing or texture plaster, saturate using amended water solution, by use of a pump sprayer. Do not remove the asbestos material until the material is thoroughly wetted to the substrate. **Do not use water where electrical hazard exists.**

To remove pipe insulation when the use of glove bags are impractical, first wet any area of damage, then carefully cut jacket. Keep insulation surface wetted by mist of water with wetting agent. Remove insulation in large sections and place immediately in disposal bag. After large pieces have been removed, saturate debris on mechanical equipment and clean all exposed surfaces with abrasive pads, sponges, cloths, etc.

To repair pipe insulation, use drop sheet under area of work to aid clean-up of any dislodged material. **Plastic enclosure is not required.** Mist any exposed insulation to wet surface and apply lagging paint and canvas or PVC jacketing as required.

For removal of suspended ceiling tiles (where asbestos debris is present on top of tiles or equipment to be accessed), remove the first tile carefully and vacuum all surfaces. Vacuum the upper surface of each subsequent tile prior to removal. Store tiles in the work area.

Remove dust and loose friable material likely to be disturbed in the process of doing the work, with a HEPA vacuum or by damp wiping.

When asbestos material is removed, all pieces should be placed directly into 6 mil polyethylene bags as they are removed. Avoid dropping material to floor wherever possible. After bulk removal is complete, wet wash the exposed surface.

Frequently, and at regular intervals during the work, clean up dust and waste in the work area by wet mopping, placing in disposal bags, or by HEPA vacuuming.

After completion of removal, seal exposed ends of fireproofing, texture plaster, or mechanical insulation with heavy layer of encapsulating sealer. Apply sealer coat to surfaces from which asbestos material was removed.

At completion of work, decontaminate equipment, tools and materials used in the work area by wet cleaning or HEPA vacuum.

Dispose of drop sheets and enclosures by wetting the polyethylene, then folding into disposal bags. Do not reuse drop sheets or enclosures.

Before leaving work area, decontaminate shoes and protective clothing by using HEPA vacuum or damp wiping. When protective clothing is to be disposed of, it shall be decontaminated as above and placed in labelled disposal bags. Workers shall vacuum all exposed skin, suit and respirator, and proceed to nearest washroom to wash hands and face.

1.6 WASTE TRANSPORT AND DISPOSAL

Place waste into asbestos labelled disposal bag, seal with tape, clean the bag, and place into a second clean bag, also to be sealed with tape. Use a barrel, fibre drum, or cardboard or wooden box in place of the second bag when the asbestos waste material is likely to tear the inner bag. Seal the rigid outer container.

Provide storage area for holding minor amounts of asbestos waste in sealed containers. Containers shall be labelled and assigned exclusively for asbestos waste.

Dispose of waste in compliance with provincial regulations. The EGD Environmental Coordinator will arrange for disposal.

APPENDIX D

GLOVE BAG WORK PROCEDURES

1.0 EQUIPMENT

All equipment must be on site before proceeding with the work. Note that these procedures are primarily based on the use of Safe-T-Strip polyvinyl chloride movable glove bags. Only the Safe-T-Strip glove bag is allowed.

Glove Bag
Prefabricated, 0.25 mm (10 mil) minimum thickness polyvinyl-chloride bag with integral 0.25 mm (10 mil) thick polyvinyl-chloride gloves and elasticized port. Bag shall be equipped with reversible double-pull double throw zipper on top. Bag must incorporate internal closure strip if it is to be removed from pipe for re-use elsewhere.

Prefabricated polyethylene glove bag, single use, not movable.

Provide size and configuration appropriate for insulation to be removed. Once filled, bag must be disposed of. Bag shall not be emptied and reused.

Securing Straps
Reusable nylon straps at least 25mm /1" wide with metal buckle for sealing ends of bags around pipe and/or insulation.

Water Sprayer
Garden reservoir type, low velocity, capable of producing mist or fine spray with water containing wetting agent. Wetting agent shall be diluted 2 oz. per gallon of water.

Respirators
Workers using glove bag must wear approved respiratory protection. Respiratory protection must be equal to or exceed protection of half-face respirator with high efficiency filters. Respirators must be kept in position from the time the worker attaches the glove bag to the pipe until final cleaning of the pipe and bagging of waste is completed. Filters shall be changed after 24 hours of wear or sooner if breathing resistance increases. No person using respirator shall wear facial hair which affects the seal between respirator and face.

Protective Clothing
Workers shall wear disposable suit with attached head cover. Suit and head cover shall remain in place until worker completes cleaning of pipe. Suit may be cleaned for re-use or disposed of as asbestos waste.

Other Equipment
- labeled asbestos waste bags 0.15mm (6 mil) - for all asbestos waste in glove bag, disposable suit, cleaning materials, etc.
- asbestos warning signs
- wire saw - saw with flexible serrated wire blade and handles to allow use inside glove bag
- knife with fully retractable blade for use inside glove bag
- plastic sheet (4 mil polyethylene) to cover exposed or damaged section of pipe prior to attaching glove bag
- tape - to fasten plastic to pipe if required
- cleaning supplies, e.g. scouring pads, sponges, brushes, buckets, etc.

- HEPA vacuum, for evacuating air from bag prior to removing bag from pipe

1.2 OTHER PROTECTIVE MEASURES

Do not eat, drink or smoke in the work area.

On completing clean-up of work area, use HEPA vacuum or wet cloth to clean hands, face, respirator and boots. Remove protective equipment and proceed to nearest washroom to wash all exposed skin on hands and face.

1.3 SCHEDULING OF WORK

Schedule work when occupants are absent. If persons are present, do not start work.

1.4 PREPARATION

Where practical, clear area below pipe of moveable furnishing or equipment. Provide scaffold as required to reach pipe.

Post an asbestos warning sign at all entrances to room in which the procedure is being used. Use rope or tape barriers to separate work area.

Segregate the area of asbestos work from other parts of the building required to remain in use using polyethylene walls or barrier tape.

Shut off and seal all diffusers, vents and other openings to ventilation and exhaust systems in the room with polyethylene secured with tape.

Cover all items or equipment located in the designated work area with polyethylene if the items or equipment cannot be cleaned in the case of a spill. Tape the polyethylene in place. The polyethylene should cover a width equal to the height of the pipe from the floor, with a minimum width of 12 feet, where required.

Seal all openings or voids in the vicinity of the glove bag operation with one layer of polyethylene secured with tape.

Check condition of pipe insulation where work will be performed. If the pipe insulation has minor isolated damage, mist surface and patch with tape. If damage is more extensive, wrap pipe with plastic and "candy stripe" it with duct tape first. If pipe insulation is severely damaged and cannot be simply repaired, glove bag is not appropriate. (**See Moderate Risk Procedures**)

Pre-clean with HEPA vacuum or wet methods any loose material on surface of pipe or any material on the floor. If significant amount of material is on floor, Moderate Risk procedures may be required for clean-up. (**See Moderate Risk Procedures**)

Place necessary tools in bottom of glove bag.

1.5 EXECUTION

Zip the bag onto the pipe and seal each end to the pipe with the securing straps. Do not pull the bag tightly to the ends - a small amount of slack allows better room to work within the bag. If a vertical bag is in use, ensure lower strap passes through plastic grommet and cloth tab on zipper.

Place hands into gloves and use necessary tools (wire saw, utility knife, wire cutters) to remove insulation from pipe. Arrange insulation in bottom of bag to obtain full capacity of bag. Roll jacketing carefully to minimize the possibility of ripping or puncturing the bag.

Insert nozzle of spray pump into bag through valve and wash pipe and interior of upper section of bag thoroughly. Use one hand to aid washing process. Wet surface of insulation in lower section of bag and any exposed ends of asbestos insulation remaining on pipe.

Prior to removing the bag from the pipe, wash the top section of the bag and tools thoroughly. Insert nozzle of HEPA filtered vacuum into bag through elasticized valve and evacuate air from bag. Seal the closure strip, remove the vacuum nozzle and straps, and remove the bag. Re-install and seal in new location before reopening closure.

If bag is to be moved along the same pipe, loosen securing straps, move bag, re-seal to pipe using double-pull zipper to pass hangers. Repeat insulation removal operation.

If during use the glove bag is ripped, cut or opened in any way, cease work and repair opening before continuing work. All spilled material must be cleaned up and removed with a HEPA vacuum or wet cleaning.

To remove tools after completion of insulation removal, thoroughly wash top section of bag and tools. Place tools in one glove, pull hand out inverted, twist to create a separate pouch, tape inside-out glove at two separate locations 1" apart to seal pouch. Remove inside-out glove and tools by cutting between the tape seals.

Place glove pouch and tools into the next clean glove bag to be used. Alternately, place the tool pouch into water bucket, open pouch underwater and clean tools, then allow to dry.

Prior to disposal of bag, evacuate the bag with a HEPA vacuum. Pull a 6 mil polyethylene bag over glove bag before removing from pipe. Remove securing straps. Unfasten zipper. Seal glove bag and seal 6 mil polyethylene bag.

After removal of bag ensure pipe is clean of all residue. If necessary, after removal of each section of asbestos, vacuum all surfaces of pipe, using HEPA filtered vacuum equipment or wipe with wet cloth.

Seal all surfaces of freshly-exposed pipe with encapsulating sealer to tack-down any residual dust. Cover exposed ends of any remaining asbestos insulation with lagging cloth or tape.

Before leaving work area, decontaminate shoes and protective clothing by using HEPA vacuum or damp wiping. When protective clothing is to be disposed of, it shall be decontaminated as above and placed in labelled disposal bags. Workers shall vacuum all exposed skin, suit,

respirator and hair (after removing hood) and proceed to nearest washroom to wash hands and face.

1.6 WASTE TRANSPORT AND DISPOSAL

Provide storage area for holding minor amounts of asbestos waste in sealed containers. Containers shall be labelled and assigned exclusively for asbestos waste.

Dispose of waste in compliance with provincial regulations. The EGD Environmental Coordinator will arrange for disposal.

APPENDIX E

RESPIRATOR FITTING, INSPECTION, CLEANING AND DISINFECTION

1.0 NOTES FOR AIR PURIFYING HALF FACEPIECE RESPIRATORS

WARNING: This respirator does not supply oxygen. It must not be used in oxygen deficient atmospheres (<19.5%); in poorly ventilated areas or enclosed spaces such as tanks or small rooms; for abrasive blasting or firefighting; or for protection against contaminants excluded or not covered by the applicable Approval Label.

Respirators must be approved for protection against asbestos. Check for NIOSH certification. Please refer to *CSA Z94.4, Selection, Care and Use of Respirators*. Federal employees must comply with Z94.4.

1.1 RESPIRATOR FITTING

Persons required to wear respirators must first pass a qualitative fit-test administered according to the current version of *CSA Standard Z-94.4*. The fit-test should be repeated yearly.

The respirator wearer must be clean-shaven along all the seal points for proper protection. Even stubble growth may be sufficient to reduce the seal of the face piece, and therefore the protection. The respirator approval is voided for users with facial hair which interferes with the seal.

1.2 INSPECTION ITEMS PRIOR TO EACH USE

1. Examine face piece for:
   - dirt
   - cracks, tears or holes
   - distortion and inflexibility
   - crack or breaks in filter holders, worn threads and missing gaskets

2. Examine head straps for:
   - breaks or tears
   - loss of elasticity
   - broken or malfunctioning buckles and attachments

3. Examine valves for:
   - detergent residue, dust or other material on valves or valve seats
   - cracks, tears or distortion in the valve material
   - missing or defective valves or valve covers

4. Examine filter for:
   - proper filter for protection against asbestos (High Efficiency Particulate)
   - incorrect installation, loose connections, missing or worn gaskets or cross threading
   - cracks or dents in filter housing

5. Leak-checks:
   Perform the following tests on each donning:

   - **negative pressure test:** cover inlets to filters, breathe in and hold breath; respirator should be drawn to face for minimum of 10 seconds (if not, check exhalation valve and fit)

   - **positive pressure test:** cover exhalation valve cover and puff out slightly and hold breath; respirator should slightly pressurize and still hold seal (if not, check inhalation valves and fit)

1.3 RESPIRATOR CLEANING AND DISINFECTION

1. Remove filters and disassemble face piece. Discard or repair defective parts.

2. Wash components in warm water (50°C - 60°C) with mild detergent, using a brush. Cleaning and disinfectant solutions are available from respirator manufacturers.

3. Thoroughly rinse components in clean, warm water.

4. Air dry or hand dry components with a clean, lint-free cloth.

5. Reassemble respirator and test to ensure that all components are working properly (see above). Be careful to check that valves are not lost in the cleaning.

1.4 FILTER CARTRIDGE HANDLING AND REPLACEMENT

1. Filter cartridges should be sealed on the inlet side with tape once used.

2. Filters can be re-used until an increase in breathing resistance is noted. Under typical Moderate Risk conditions, filter cartridges should last a minimum of 24 hours.

APPENDIX F

PROCEDURES FOR EMERGENCY ASBESTOS WORK

If Moderate Risk procedures cannot be strictly observed due to the urgency, some judgement will be required of the person responsible for the work, and other staff or contractors responding to the emergency. The general principle of emergency response work is to protect the workers performing the repair and to minimize the exposure of others to airborne asbestos. The procedures given below should be followed to the extent possible in the circumstances of the emergency.

1. Clear area of all occupants.

2. Construct enclosure around area if time permits.

3. Shut down ventilation system serving area.

4. Worker performing repair shall wear protective respirator and disposable suit. If normal work clothes are worn they must be disposed of if visibly contaminated.

5. Use drop sheet under work to minimize clean-up if possible.

6. Perform emergency repair with minimum disturbance of asbestos.

7. Obtain asbestos equipment and perform clean-up of visible material before allowing unprotected personnel to enter area. Use HEPA filtered vacuum or wet cleaning. Dispose of all cleaning supplies as contaminated waste.

8. The worker should wipe off or vacuum disposable clothing and footwear. Proceed to washroom to wash face and hands.

9. Notify the EGD Environmental Coordinator and the EGD Operations Coordinator regarding the asbestos disturbance. The EGD Environmental Coordinator will contact the Project Manager to arrange for removal, clean-up or repair of the asbestos material.

APPENDIX G

ASBESTOS-RELATED WORK RECORD

APPENDIX H

CERTIFICATE OF TRAINING FOR ASBESTOS-RELATED WORK

APPENDIX I

CONTRACTOR NOTIFICATION AND ACKNOWLEDGEMENT

APPENDIX J

BULK SAMPLE COLLECTION PROCEDURES

BULK SAMPLE COLLECTION PROCEDURES

1. Sample the material when the area is not in use. Only those persons needed for sampling should be present in the immediate area.

2. Spray the material with a light mist of water to prevent fibre release during sampling. Do not disturb the material any more than necessary.

3. Materials of different appearance should be sampled separately. Mechanical insulation must be sampled separately on all systems, tanks, vessels, etc. Sample both the straight sections of pre-formed insulation and the insulating cement typically present at elbows, fittings, etc. (unless visually identified as fibreglass).

4. Collect the sample by penetrating the entire depth of the material, as the insulation may have been applied in more than one layer or covered with paint or other protective coating.

5. Depending on the condition of the material, significant amounts of airborne fibres can be generated during sampling. The use of a respirator is recommended for all sampling.

6. If pieces of material break off during sampling, the contaminated area must be cleaned up with a HEPA vacuum cleaner or by wet cleaning. Any debris generated must be placed in plastic bags, labelled, sealed and disposed of as asbestos waste.

7. Place samples in labelled plastic bags with a zip-lock closure or in sealed plastic vials. Samples shall be identified with the following information:
   - Sample Number
   - Building
   - Room Number
   - Date of Sampling
   - Name of Sampler
   - Source of sample, e.g. Cold Water Pipe, Cold Water Fitting, etc.

8. Temporarily seal any openings created to collect the sample, for example, with metal foil tape wrapped completely around the pipe. Advise the EGD Environmental Coordinator or Regional Asbestos Coordinator.

9. Analysis must be performed by a laboratory accredited by the National Voluntary Laboratory Accreditation Program (NVLAP). Contact the EGD Environmental Coordinator or Regional Asbestos Coordinator for a list of acceptable laboratories.

APPENDIX K

ROLES AND RESPONSIBILITIES

ROLES AND RESPONSIBILITIES

Regional Asbestos Technical Coordinator (Non-Mandatory)

- To maintain a technical competency within Environmental Services.
- To provide technical training to staff.
- Working with the Regional Asbestos Coordinator to develop training packages for various groups of staff involved with asbestos.
- Provide asbestos audit and survey when requested.
- To provide advisory support to the Regional Asbestos Coordinator.
- To provide communication on technical issues.
- Develop and maintain contracts for asbestos related services.
- Provide technical support and advice to staff.
- Conduct the quality assurance evaluations of survey reports performed by others.
- Conduct the quality assurance evaluations of removal and repair work being performed by others, when requested.

Regional Asbestos Coordinator (Mandatory)

- To develop and maintain a liaison with EGD Environmental Coordinator for day-to-day reporting and communication.
- To arrange for a complete survey and assessment of asbestos materials.
- Will decide the degree/detail of surveys required to meet Departmental Policy. (This is to be done in concert with Regional Asbestos Technical Advisor).
- Will decide the degree/detail of reassessment of all friable asbestos materials in exposed locations. (This is to be done with Regional Asbestos Technical Advisor).
- To maintain and manage a regional inventory of asbestos. Inventory to include all test results, positive and negative.
- To establish a system of keeping the reports to ensure ready access to all staff.
- To establish an acceptable paper trail to deal with removal and repair of asbestos.
- To establish an acceptable system of notifying EGD Environmental Coordinator of new findings of asbestos.
- To maintain a regional inventory of trained personnel and the level of training given.
- To maintain a consistency standard within the Region.
- To provide communication on management issues.
- To develop a standard reporting form to be used to report on maintenance repair and removal work.

EGD Environmental Coordinator

- Ensure that the requirements for asbestos management are fully implemented.
- Assist in reviewing all maintenance work requirements against survey information to determine the possibility of friable asbestos being disturbed, and classifying the work based on the approved criteria.
- Notify, in writing, Workplace Safety and Health Committees and Representatives, employees, and contractors of the existence of friable ACM, and provide updates on conditions as modifications or changes are made.

- Maintain asbestos inventory, assessment and reassessment reports and ensure that a copy of this information is maintained in a location that is accessible to maintenance staff and contractors
- Obtain the approval of the Regional Asbestos Coordinator prior to arranging for the removal or repair of damaged or deteriorated friable ACM.
- Submit all High Risk work requirements to the Regional Asbestos Coordinator for review prior to arranging for the work to be undertaken.
- Consult the Regional Asbestos Coordinator, when necessary, to determine the impact of a specific project with regards to ACM.
- Ensure a stock of required equipment is maintained for work classified as Low and Moderate Risk.
- Assist in identifying and providing a suitable storage area for waste resulting from asbestos work, and assist in arranging for waste removal.

EGD Management

- Ensure that the requirements for asbestos management are fully implemented within their area of responsibility.
- Review all maintenance work requirements, within their area of responsibility, against survey information to determine the possibility of friable asbestos being disturbed, and classify the work based on the approved criteria.
- Notify, in writing, the EGD Environmental Coordinator of maintenance work that may impact upon ACM, and provide updates on conditions as modifications or changes are made.

All Contractors

This includes anyone contracted to do work on the interior or exterior of PWGSC buildings.

- To review the asbestos survey reports prior to all renovation and construction work for the possible impact on asbestos.
- To complete *"Contractor Notification and Acknowledgement" form.*
- Not to disturb asbestos materials as part of their doing their work. The disturbance of asbestos building materials may only be undertaken by contractors who have received training in asbestos-related precautions.
- As a condition of their contract to provide services and materials to PWGSC, their company will not disturb asbestos-containing materials without prior notification to the EGD Environmental Coordinator. This firm and its workers, while working in this "location of work", will follow all procedures specified by the PWGSC Asbestos Management Program.

All Contractors, Doing Work Involving Asbestos

This includes any work on the interior or exterior of PWGSC owned buildings involving asbestos.

- To ensure they follow all procedures specified by the PWGSC Asbestos Management Plan and work specification.
- To ensure that they complete all the required documentation required by the PWGSC Asbestos Management Plan.

APPENDIX L

LOG BOOK

ESQUIMALT GRAVING DOCK ASBESTOS MANAGEMENT PLAN

LOG BOOK FOR ANNUAL VISUAL INSPECTION

NAME OF INSPECTOR:_____ DATE: _____

BUILDING	ACM IDENTIFIED	LOCATION	MATERIAL	ORIGINAL CONDITION	PRESENT CONDITION
Back gate guardhouse	yes	exterior cladding	cement board	Good	
	yes	floor tiles	beige vinyl	Good	
Drydock service tunnels	yes	north & east perimeter	cement piping REMOVED in 2004 Stubs remaining where pipes enter tunnel walls	Good	
Pumphouse	yes	throughout EGD systems	Gaskets and Plating	Good	
PWGSC Admin	yes	boiler room	wallboard	Good	
		Crawl space	Pipe insulation REMOVED But treat area with caution as due diligence		
VSL Admin	yes	floor tile	beige vinyl	Good	

Details of Action required (if any):

_____
_____
_____
_____

Date Action Initiated:_____

ACM INSPECTION LOG

Date	Area	Inspection Comments	Initial

ESQUIMALT GRAVING DOCK ASBESTOS MANAGEMENT PLAN

ASBESTOS SPILL RESPONSE LOG

DATE: _____

PERSON REPORTING SPILL: _____

PERSON RESPONDING TO SPILL ADVISORY: _____

ACTION:

- **Area Isolation** ☐
- **Spill Containment** ☐
- **Personnel Advised** ☐

INCIDENT REPORT: _____

_____

_____

_____

_____

_____

_____

RECOMMENDED DECONTAMINATION: _____

_____

_____

_____

_____

_____

DECONTAMINATION FOLLOW-UP:

Were recommendations followed? _____
(If NO, give details on back)

Abatement Contractor: _____

C1

ESQUIMALT GRAVING DOCK

ENVIRONMENTAL EFFECTS EVALUATION

KEYSTONE ENVIRONMENTAL (2016)

Number of Pages: 78

Keystone Environmental
Knowledge-Driven Results

ENVIRONMENTAL EFFECTS EVALUATION

Esquimalt Graving Dock
South Jetty Reconstruction Project
Esquimalt, BC

Prepared for:

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
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Project No. 13024

September 2016

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LIST OF ACRONYMS

BCMOE	British Columbia Ministry of Environment
bml	Below Mudline
BMP	Best Management Practice
CCME	Canadian Council of Ministers of the Environment
CD	Chart Datum
CDC	Conservation Data Centre
CEAA	Canadian Environmental Assessment Act
CFSA	Canadian Forces Sailing Association
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRA	Commercial, Recreational or Aboriginal
CRD	Capital Regional District
CRIS	Coastal Resource Inventory System
CSR	Contaminated Sites Regulation (BC *Environmental Management Act*)
DFO	Fisheries and Oceans Canada
DND	Department of National Defence
DR	Departmental Representative
dw	Dry Weight
E	Endangered (COSEWIC and SARA designation)
EA	Environmental Assessment
EAP	External Assessment Point
EEE	Environmental Effects Evaluation
EGD	Esquimalt Graving Dock
EM	Environmental Monitor
EMP	Environmental Management Plan
EMIP	Environmental Monitoring Implementation Plan
EPP	Environmental Protection Plan
FCSAP	Federal Contaminated Sites Action Plan
FISS	Fisheries Information Summary System
HC	Health Canada
HHWLT	Higher High Water Large Tide
HWM	High Water Mark
Leq(24)	24 h Equivalent Noise Level
LLWLT	Lower Low Water Large Tide
NAR	Not at Risk
NLW	North Landing Wharf

LIST OF ACRONYMS (CONT'D)

PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated biphenyls
PEL	Probable Effects Level
PPE	Personal Protective Equipment
PVC	Polyvinyl chloride
PWGSC	Public Works and Government Services Canada
QEP	Qualified Environmental Professional
QHM	Queen's Harbour Master
SARA	Species at Risk Act
SC	Special Concern (COSEWIC and SARA designation)
SedQCTCS	Sediment Quality Criteria for Typical Contaminated Sites (CSR Schedule 9)
SMA	Sediment Management Area
SEL	Sound Exposure Level
SPL	Sound Pressure Level
SPW	Sheet Pile Wall
SQGs	Sediment Quality Guidelines
T	Threatened (COSEWIC and SARA designation)
TBT	Tributyltin
TRB	Temporary Re-suspension Barrier
TSS	Total Suspended Sediment
TTS	Temporary Threshold Shift
UTM	Universal Transverse Mercator
VEC	Valued Ecosystem Component
VSC	Valued Social Component
VNHS	Victoria Natural History Society
WQG	Water Quality Guideline
WQMP	Water Quality Monitoring Plan

Units

dB	Decibel
dBA	Decibel (A-weighted)
kPa	Kilopascal
km	Kilometre
m	Metre
m^2	Square metre
m^3	Cubic metre
NTU	Nephelometric Turbidity Units
ppm	parts per million
µg	Microgram
µPa	Micropascal

1. INTRODUCTION

This Environmental Effects Evaluation (EEE) has been prepared by Keystone Environmental Ltd. for Public Works and Government Services Canada (PWGSC), and Contractors regarding the works associated with the Esquimalt Graving Dock (EGD) South Jetty Reconstruction project (the Project).

This EEE describes the existing environment, including the full range of physical, biological and socioeconomic valued components, and evaluates the potential environmental effects of the Project works on each of these valued components as well as the effects of the environment on the Project. After considering the implementation of mitigation measures specific to each valued component, the significance of residual effects is determined.

1.1 Background

The EGD facility is located in Constance Cove in Esquimalt Harbour approximately 4.5 km northwest of Victoria, BC (See Appendix A1). The EGD is a non-military, solid-bottom dry dock that has been operating since 1926. It was constructed to provide maintenance for private, government and military vessels and is owned and operated by PWGSC. Portions are leased to tenant ship maintenance companies to work on vessels in the dry dock (PWGSC, 2010).

There is a long history of naval and industrial activity dating back to the mid-1800s in Esquimalt Harbour. Naval and industrial activities have contributed to contamination of sediment within the EGD legal Waterlot. Operating procedures and handling of wastes generated by maintenance activities have been improved over time to mitigate additional contamination of sediments or surface water. The EGD facility has obtained ISO 14001 Environmental Management System (EMS) certification (2001) and operates according to environmental Best Management Practices (BMP) tailored to current operations (PWGSC, 2010).

In the 1940s the EGD South Jetty was constructed along the southern face of the dry dock, primarily out of timber. In 1985, the central portion of the South Jetty was removed and replaced with steel piles and a concrete deck to increase load capacity and replace deteriorated timber elements. In 2015/2016, the remainder of the timber portion of the South Jetty was removed due to its age and condition, allowing for remediation of the seabed through dredging to remove contamination and placing an engineered cap comprised of layers of sand, filter material and rock as shown in Appendix A2 (Anchor QEA LLC [Anchor] and Klohn Crippen Berger [KCB], 2014).

A new steel pile supported concrete structure will be constructed in the footprint of the recently demolished timber portion of the South Jetty to accommodate large vessels and address health, safety, and seismic risks associated with the removed aging structure (Herold Engineering Ltd. [Herold], 2016).

The Project is a component of a remediation program within Esquimalt Harbour that has been undertaken by PWGSC and DND. Completed phases are shown below:

Table 1-1 Remedial Phases Completed within Esquimalt Harbour

Phase	Sub Phase	Description
Phase 1		Completed in 2014 and consisted of three parts (Phase 1A, 1B and 1C)
	1A	Phase 1A consisted of temporary sheet pile wall (SPW) installation around the South Jetty to minimize erosion and re-suspension of contaminated under-jetty sediments into adjacent areas that were dredged as part of Phase 1B.
	1B	Phase 1B involved dredging contaminated sediments in open-water areas outside the South Jetty: EGD legal Waterlot (owned by PWGSC); A buffer area around the EGD legal Waterlot (owned by DND); and, Munroe Head intertidal zone, located to the north of the EGD legal Waterlot (administered by PWGSC).
	1C	Phase 1C was completed in April 2014. Works involved construction of habitat (marsh benches) at Dunn's Nook to serve as habitat offsetting for disruption to fish habitat in Phase 1 as described in Fisheries Act Authorization No. 11·HPAC·PA3·00016. Dunn's Nook is located on the west shore of Esquimalt Harbour at DND CFB Esquimalt – Colwood.
Phase 2		This phase involved re-driving and cutting the sheet pile wall (SPW) to 0 m chart datum (CD) and installation of a Temporary Re-suspension Barrier (TRB) to overlap the re-driven SPW, demolition of the timber pile supported jetty (including removal of timber pilings and the concrete deck structure under the high mast light structure), remediation of the under-pier area (dredging, placement of capping material and slope armour material) and removal of TRB and SPW.

The Project involving the reconstruction of the South Jetty is the next component to this program and is scheduled to begin in late 2016. Construction activities are to be completed in compliance with this EEE, including the Environmental Management Plan (EMP) attached in Appendix B. This EEE has been updated from previous editions for Phase 1 and 2 produced by Golder (2012a) and G3 (2014a) for PWGSC.

1.2 Regulatory Framework

The following federal, provincial and municipal regulatory requirements have been considered during the preparation of this EEE. Construction activities must be carried out using methods that comply with federal, provincial, regional and municipal bylaws (where applicable). The following permits and status have been considered in the EEE:

1.2.1 Federal Acts

Construction activities shall be conducted in accordance with federal Acts and Regulation, including the following:

Table 1-2 Federal Acts

Federal Act	Regulation/Schedule
Canada Marine Act,1998 (amended 2014)	Natural and Man-made Harbour Navigation and Use Regulations
Canada Shipping Act, 2001 (amended 2013)	Collision Regulations
Canadian Environmental Assessment Act, 2012 (amended 2013)	Regulations Designating Physical Activities
Canadian Environmental Protection Act, 1999	-
Constitution Act 1982	-
Fisheries Act, 1985 (amended 2013)	Marine Mammals Regulations
Migratory Birds Convention Act, 1994	Migratory Birds Regulations
Navigation Protection Act, 2014 (formerly the *Navigable Waters Protection Act*, 1985)	Navigable Water Works Regulations
Species At Risk Act, 2003 (amended 2013)	Schedule 1 – List of Wildlife Species at Risk
Transportation of Dangerous Goods Act, 1992 (amended 2009)	-

1.2.2 Provincial Acts

While works are being conducted on a federally-managed site, provincial acts and regulations may apply to aspects of the work depending on the Contractor's methodology. The Contractor will be responsible for complying with any applicable provincial requirements, which may include the following:

Table 1-3 Provincial Acts

Provincial Act	Regulation/Code
Environmental Management Act, 2003	Contaminated Sites Regulation
	Spill Reporting Regulations
	Hazardous Waste Regulation
	Industrial Non-hazardous Waste Landfills Code of Practice
Heritage Conservation Act, 1996	
Wildlife Act, 1996	

1.2.3 Regional & Municipal Bylaws

Construction activities must be carried out using methods that comply with regional and municipal bylaws (where applicable). The following permits and status have been considered in the EEE:

Table 1-4 Regional and Municipal Bylaws

Bylaw
Capital Regional District (CRD). 2006. Capital Regional District (CRD) Sewer Use Bylaw No. 2922 (Consolidated).
City of Colwood. 1986 (amended 1992). Bylaw No. 38 – A Bylaw to Regulate Noise within the City of Colwood.
Corporation of the Township of Esquimalt (Township of Esquimalt). 2005. Streets and Traffic Regulation Bylaw, 2005, No. 2607 (Consolidated).
Corporation of the Township of Esquimalt (Township of Esquimalt). 2007. Official Community Plan.
Corporation of the Township of Esquimalt (Township of Esquimalt). 2014. Maintenance of Property and Nuisance Regulation, 2014, No. 2686.

1.2.4 Status of Permits and Requirements

The following Table 1.5 presents the status of permits and requirements for the project. Details of the permit correspondence are presented in Appendix C.

Table 1-5 Required and Current Permits

Legislation or Regulation	Permit Name	Current Status
Fisheries Act	Letter, dated August 12, 2016, file no. 14-HPAC-00210	Updated letter to DFO Request for Review for change in construction schedule. Request August 17, 2016 from DFO has requested further information about project. Currently preparing information for the DFO.
Navigation Protection Act Need notice to mariners based on lighting changes not to impeded vessel traffic	Notice of Works	A previous approval no. 8200-2003-500198, under the former Navigable Water Protection Act has been referenced in other documentation.
Fisheries Act	Scientific Fish Collection Permit	Not applied for and likely not necessary unless construction changes and fish collection is required.
Species at Risk Act	Section 73 Permit	Not applied for and not necessary
CEAA 2012	Section 67	Not necessary

2. PROJECT INFORMATION

2.1 Project Description

The EGD is located at 825 Admirals Road in Constance Cove, in Esquimalt Harbour, Esquimalt, BC. The South Jetty is located at the coordinates shown in Table 2-1. The Project works will occur within the Project Area as defined in the Herold (2016) Site Plan (Appendix A3).

Table 2–1 South Jetty Location Coordinates

Coordinate System	Easting	Northing
Universal Transverse Mercator (UTM)	Zone 10U 0468483E	5364805N
Latitude/Longitude	Latitude 48.435640	Longitude 123.425891

The objective of the Project is to reconstruct the South Jetty wharf structure that was demolished in 2015/2016 as part of the Phase 2 waterlot remediation works recent completed at the Site. Redevelopment of the new South Jetty will involve driving new steel piles in a grid pattern, the construction of a new deck out of pre-cast and cast-in-place concrete, and the integration of the various mechanical, electrical and water services (Herold, 2016). Additionally, the tug boat wharf in the southeast corner of the Project Area and the east end approach will be redesigned and rebuilt to suit the EGD facility's current and future needs.

2.1.1 Project Justification

The deconstruction of the former South Jetty wharf was required to allow for the under-pier sediment remediation works funded by the Federal Contaminated Sites Action Plan (FCSAP). The former wharf was constructed with aging timber components which needed to be replaced. A new steel pile supported concrete Jetty will be constructed in the footprint as the recently demolished timber portion of the Jetty within the same footprint, in order to accommodate large vessels and address health, safety, and seismic risks associated with the removed aging structure (Herold, 2016).

2.1.2 Evaluation of Alternatives

Alternatives to replacing the South Jetty as proposed are not feasible options for the following reasons:

- The South Jetty cannot change location as it is servicing the existing dry dock and would be cost prohibitive to construct elsewhere;
- Leaving an aging timber supported South Jetty would have resulted in additional maintenance and repairs and would not address health and safety or seismic risks.
- Using timber instead of steel and concrete to construct the Jetty would require more long-term maintenance.

2.2 Scope of the Project

2.2.1 Project Overview

The South Jetty structure will be supported by steel pipe piles (installation method to be determined by the Contractor and to be addressed in the contractors EPP). Piles will be driven through the remediated area with the capping material either conserved or replaced. Formwork, rebar and tremie concrete (for displacement pile caps next to the timber crib) will be placed underwater by divers (Golder, 2012). Reinforced concrete pile plugs (connection of piles to cap beams), pre-cast concrete cap beams, pre-cast utilidor sections, and pre-cast fender panels (includes grouting) will be installed in the intertidal area. Installation of pre-cast concrete beams (for deck support, includes grouting), formwork, rebar and concrete for cast-in-place deck slab above the High Water Mark (HWM).

Based on preliminary design drawings and information provided by Herold (2016- Appendix A3), the Project Area encompasses an area of approximately 23,850 m^2 with two work areas defined within the Project Area: the south jetty section (approximately 95 m by 56 m and 5,320 m^2) and the west jetty section (approximately 24.5 m by 220 m and 5,390 m^2). The substrate elevation within the Project Area ranged from approximately -12.0 m to 5.0 m CD prior to dredging and capping works as shown in Appendix A3 (Herold, 2016). .

Herold (2016) outlined the following Project works:

Table 2-2 Project Activities

Project Activities	Description
1	Driving 67 (+/- 3) – 914 mm diameter steel piles
2	Driving 140 (+/- 3) – 762 mm diameter steel piles
3	Precast concrete pile caps fabricated offsite to be installed on piles, including seven precast caps installed at the mud line with cast in place securements
4	Precast concrete deck panels fabricated offsite to be installed on pile caps
5	Cast in place concrete topping slab to be poured above deck panels
6	Construction of cast in place concrete retaining wall at east end within upper intertidal zone

In the intertidal area at east approach, granular sub-base foundation will be placed and compacted for concrete retaining wall, as well as formwork, rebar and concrete for cast-in-place retaining wall (Golder, 2012a; G3, 2014c; PWGSC, 2014). Under-deck stormwater drainage pipework, fenders, mooring bollards, wharf ladders, utility kiosks, and miscellaneous deck hardware will be installed (Golder, 2012a; PWGSC, 2014).

At the east approach of the South Jetty, the tug boat float will be reinstalled with new piles. Minor earthworks will also occur within the upper intertidal zone to tie in the new East Approach retaining wall with the existing retaining wall with the in the northeast corner of the Project Area (see Appendix A3). From these works, approximately 900 m^3 of excavated material will be stockpiled on site, tested for potential contaminants and disposed accordingly.

2.2.2 Residual Management

Following remediation under the South Jetty, a risk management approach was undertaken to place an engineered cap over some undisturbed residual contamination that was found where excavation was expected to be limited because of concerns regarding the stability of adjacent structures and accessibility for the removal of sediment beneath the existing steel pipe pile structure. The risk management approach was used to prevent and minimize exposure of aquatic organisms to contaminated sediments.

In areas that were dredged, residual contamination may have been generated as a result of settling of sediments that were suspended during the dredging process. A layer of sand was added to isolate any residual contamination, followed by a layer of armour material.

Works will need to be undertaken in a manner that maintains the engineered cap cover over contaminated sediment and does not spread contamination to adjacent areas.

2.2.3 Schedule

The reconstruction of the South Jetty is scheduled to begin in October 2016 and continue for a year and a half until April 2018.

Table 2-3 Schedule

Milestone	Approximate Date
Construction Start Date	October 2016
Construction Completion Date	April 2018

3. EXISTING ENVIRONMENT

3.1 Methods

3.1.1 Background Review

To characterize the existing environment in and adjacent to the works, various databases were reviewed in Golder (2012a) and G3 (2014a) including:

- BC Conservation Data Centre Species and Ecosystem explorer
- Fisheries Information Summary System (FISS)
- BC Habitat Wizard
- Capital Regional District Harbours Atlas
- BC Coastal Resource Information System (CRIS) database
- Community Mapping Network
  - Wildlife tree stewardship atlas
- Species at Risk Public Registry
- Fisheries and Oceans Canada (DFO) Website
  - Herring Spawning Records
- Environment Canada Website
  - Species at Risk Mapping Application
  - Canadian Climate Normals

In addition to the Project information provided in the Appendices and References of this EEE, information was also provided in Golder (2012a) and G3 (2014a) from review of the following reports:

- Archipelago Marine Research Ltd. (Archipelago) habitat surveys (2008, 2009, 2012)
- Golder Associates Ltd. (Golder) EGD Waterlot remediation reports (2006, 2007, 2009–2013)
- SLR Consulting Ltd. (SLR) EGD Waterlot remediation reports (2014)
- PWGSC EGD Waterlot remediation reports (2014)

Observations of the physical and biological environment within the Project Area were predominantly based on marine biophysical information, including underwater video of seabed conditions beneath the South Jetty, conducted by South Coast Diving during February, 2009, in support of Golder's project-related reports (from G3, 2014a):

3.1.2 Species at Risk Assessment

Golder (2012a) and G3 (2014a) conducted a review of several databases to determine if species at risk are known to occur, or have the potential to occur, in or adjacent to the Project Area. The CDC database was searched for recorded occurrences of species at risk in and adjacent to the Project Area. The Species at Risk BC website (BCMOE, 2013) and the CDC's Known Occurrences online mapping system and the BC Species and Ecosystem Explorer were searched for species at risk that have the potential to occur in the Project Area. Ranges for potential species were cross referenced with habitat preferences and habitat present in the Project Area to determine which species are likely to occur (Golder, 2012a; G3, 2014a).

3.2 General Descriptions of the Environment

3.2.1 Physical Environment

3.2.1.1 Climate

As provided in Golder (2012a), climate conditions for the Coastal Douglas Fir Biogeoclimatic Zone that contains the Project Area are typically warm, dry summers and mild, wet winters (Nuszdorfer et al., 1991). The average air temperature in nearby Victoria was reported to range from 5.6 to 14.4°C, with average monthly precipitation between 17.9 and 152.6 mm (EC, 2014).

3.2.1.2 Surface Water

The Project Area lies within the sheltered marine waters of Constance Cove, which is approximately 500 m wide at its entrance from Esquimalt Harbour (Golder, 2012a). Substrate elevations within the Project Area range from approximately 5 m CD in the intertidal down to -10.5 m CD in the subtidal areas seaward of the jetty (Herold, 2016).

3.2.1.2.1 Tides and Currents

The higher high water large tide (HHWLT) for Esquimalt Harbour is 3.4 m elevation CD, and the lower low water large tide (LLWLT) is 0.7 m CD (Golder, 2012a). Currents within Constance Cove and under the South Jetty are typically low during the ebb and flood phases of the tide and highly variable in direction, with a net drift from east to west in Constance Cove (Golder, 2012a). Average current speed is 0.04 m/s with a maximum of 0.12 m/s (Golder, 2012a).

3.2.1.2.2 Water Quality

Water quality measurements have been obtained by several firms in and around the project area (Golder, 2006a, b; SLR, 2009). In 2005, several surface water samples at varying depths were collected in by Golder. In 2008, additional samples were collected by SLR (Golder, 2006a, b; SLR, 2009). In general, metals were below or at federal (CCME, 1999) and provincial (BCMOE, 2006) water quality guidelines (WQGs). There were slightly higher concentrations near the dry dock mouth than to the west. Polycyclic aromatic hydrocarbons (PAHs) were below

WQGs except near Outfall D in 2005, which may have been contributed from upland sources (G3 (2014a). Other potential sources were the presence of creosote-treated piles, discharge of bilge water from vessels and operation of vessels. Concentrations of tributyltin (TBT) ranged from two to ten times the Canadian Council of Ministers of the Environment (CCME) WQG near Outfall D in 2005 however not during 2008 sampling.

During Phase 1B water samples were collected throughout the site. Metals were within CCME (2014) and BCMOE (2014) guidelines with 4.9% of analyzed samples (58 of 1,178 samples) exceeding guidelines (SLR, 2014); 12 occurred in background and ambient samples, while 46 were down current from the EGD dredging areas. The majority of exceedances were for copper (52 of 58 metal exceedances). Not all of the exceedances found down current from dredge areas were associated with increased Total Suspended Solids (TSS) and/or turbidity G3 (2014a).

No exceedances were found for PAH guidelines described in Golder (2012c), which included 1,240 samples analysed for total and/or dissolved PAHs (SLR, 2014). There are currently no applicable guidelines for PAHs and dissolved metals. In areas of known high polychlorinated biphenyl (PCB) concentrations, and at the outset of Phase 1B, water samples were collected during dredging and found all 8 samples had values below detection limits for PCBs (SLR, 2014).

3.2.1.3 Substrate

3.2.1.3.1 Intertidal Substrate

Wood pilings, some exposed cobble, wood debris and a concrete wall were present in the intertidal zone beneath the South Jetty (G3, 2014a). Following the recent South Jetty remedial demolition and dredging works, the intertidal substrate is understood to have been reconstructed with a Type 3 engineered cap (0.30 m rock armour layer over a filter layer, overlying Type 2 sand) from the information provided by Anchor and Klohn (2014) in the Engineered Capping Plan design drawings (Appendix A2). No as-built plans are available yet for the recently completed remedial dredging and capping works.

3.2.1.3.2 Subtidal Substrate

Substrate under the South Jetty consisted of silt with shell fragments and some cobble under the western extent. Silt and shell fragments along with gravel/cobble/boulders were present under the middle and eastern portion of the jetty (Archipelago, 2009). Anthropogenic debris consisting of glass, wood fragments, metal debris, rubber, tires, PVC pipe fittings, fabric, aluminium cans, and concrete was present in underwater video surveys (Golder, 2009). Dive surveys identified cans, cables, metal objects, and other garbage (Archipelago, 2004). Anchor chains, metal, old collapsed sheet pile wall, sunken wooden deck type structure (Archipelago, 2000) and cut off timber piles were observed under the South Jetty (Archipelago, 2009). Concrete counterweights, timber bracing, steel debris, rope and mooring chains were observed during debris survey prior to installation of the sheet pile wall (G3, 2014a).

After completion of the Phase 2, remedial dredging and placement of an engineered cap should have occurred resulting in 5 types of substrate as described below and shown in Anchor & KCB (Appendix A2)

Table 3-1 Engineered Cap

Engineered Cap	Description
Type 1	0.15 m rock amour layer over a filter layer, overlying a sand layer
Type 2	0.15 m rock amour layer over a filter layer, overlying a sand layer
Type 3	0.30 m rock amour layer over a filter layer, overlying a sand layer
Type 4	0.30m rock amour layer over a filter layer, overlying a sand layer
Type 5	0.15 m rock amour layer

The Type 1 cap is the dominant substrate within the south portion of the Project Area, and the Type 3 cap is the dominant substrate within the west portion. An impermeable geosynthetic layer is also shown in two areas along the landward edge of the south portion of the new wharf.

3.2.1.3.3 Sub-Seabed Characteristics

Detailed Site Investigations were completed in and around the project area by Golder (2013) as provided in the Existing Conditions & Geotechnical Information figure in Appendix A3. The following subsurface investigations were conducted within the Project Area:

- Sediment coring in February 2009 as part of a Supplementary Site Investigation (Golder, 2009);
- Sediment coring as part of a Detailed Site Investigation (Golder, 2011c, 2013);
- Sonic drilling in August 2009; and,
- Sonic and mud rotary drilling and cone penetration testing in September and October 2009 and at the Munroe Head beach intertidal area in September 2010.

These investigations found that the sub-surface sediment around the South Jetty was typically coarser grained sediments and fill overlying Upper Marine Sediments, Victoria Clay and glacial till (Golder, 2011c, 2013). During the Phase 2 works, 40,000m^3 of material was dredged from the South Jetty, with removal up to 6.3 m and averaging 2.5 m along the former sheetpile wall (Anchor, 2015).

3.2.1.3.4 Sediment Quality

Prior to undertaking Phase 2, sediments located under the South Jetty had contaminant concentrations that exceeded the CCME Probable Effect Level (PEL) Sediment Quality Guidelines (SQGs) for the protection of marine aquatic life (CCME, 2014), as well, as the provincial generic numerical sediment criteria for typical marine sediments ($SedQC_{TCS}$) listed in Schedule 9 of the CSR. Contaminants including PCBs, PAHs, metals, dioxins, furans and

pesticides, were present at concentrations greater than the CCME PEL SQGs and CSR $SedQC_{TCS}$ (Golder, 2006a, b, 2009, 2010 and 2011c). Tributyltin (TBT), found in antifouling coatings for ships, was present in sediments throughout the site. Since there are no federal guidelines or provincial standards for TBT to compare bulk chemistry data, low (0.75 µg/g dry weight [dw]) and moderate (2.5 µg/g dw) risk threshold levels were developed using environmental risk assessment methods (Golder, 2011a).

The Waterlot adjacent the South Jetty contained contamination generally located within the upper 1.0 m to 2.0 m of sediment. Contamination was associated with black organic silt surficial sediments and suspect fill materials. Contamination from 1.0 to 2.0 m below mud line (bml, approximately -12.0m cd) was encountered beneath and around the South Jetty. Under the South Jetty, contamination was associated with thicker accumulations of organic black silt, fill materials, and coarser grained sediments. Suspect sand-blast grit was observed around and beneath the South Jetty (G3, 2014a).

Hydrocarbon-like odours were noted during sub-surface investigations. PAH contamination was found as far as 7 m bml beneath the South Jetty, in association with wood debris and hydrocarbon-like odours, which may be from creosoted timber piles. Other contaminants (including copper, arsenic, lead, TBT, mercury and zinc) were found as deep as 6.5 m bml (Golder, 2011c, 2013).

A preliminary ecological risk assessment prepared in 2006 for the Waterlot, showed sediments beneath the South Jetty were found to be moderately to highly toxic for sediment-dwelling organisms, as indicated through impairment of survival, growth and reproduction of laboratory toxicity test organisms (Golder, 2006a, b).

In 2016, 40,000 m^3 of contaminated sediment and 200 m^3 of hazardous waste were removed under Phases 1 and 2, and covered with a cap of 2.20 m to 2.80 m above the post-dredge surface, consisting of clean sand (1.0-1.3 m), filter material (0.30-0.60 m), and up to 0.90 m of rock armour typically 0.15 to 0.30 m in median diameter (Anchor & KCB, 2014).

Minor works require completion in the east end of the Project Area in order to tie into the existing retaining wall, with the expected removal of 900 m^3 of contaminated material. These upper intertidal sediments will be stockpiled at a suitable upland location at the EGD facility until analytical testing has been completed and the appropriate disposal alternative is selected.

3.2.1.3.5 Sediment Transport (from G3, 2014a)

Migration of sediment including potentially contaminated material is primarily driven by propeller-induced re-suspension of seabed sediments resulting from vessels moving around the harbour. Once suspended in the water column, prop-wash and tidal and wave-driven currents cause these sediments to drift within the surrounding harbour, including in and out of EGD Waterlot.

The measurement of currents within Constance Cove indicated the net current drift through the Waterlot is generally east to west (Golder, 2011b). This net current drift is the residual between ebb and flood currents. This direction of sediment drift was oriented approximately parallel to the Waterlot boundary, with an offshore (southerly) drift within this larger east to west drift of sediments.

The assessment of sediment transport and contaminants also indicated a net drift of sediments in dynamic equilibrium from east to west through the Waterlot (GeoSea, 2009 in Golder, 2012a). The offshore drift pattern was also interpreted from these data. The dynamic equilibrium from these analyses suggested a net balance between sediments that are eroded and those that are deposited. This interpretation of equilibrium supports the concept of re-suspension and mixing of seabed sediments within the Waterlot and adjacent areas.

Due to the sediment transport processes discussed above, recontamination of the Waterlot following remediation as a result of sediment migration into the Waterlot from the rest of the harbour has been identified as a concern in the longer term (GeoSea, 2009 in Golder, 2012a).

Concentrations of contaminant inputs from the rest of the harbour would be expected to be similar to those seen in central Constance Cove (typically in the range of 2 to 5 times CCME PELs; Golder, 2012a).

No change in sediment transport mechanisms is expected.

3.2.2 Biological Environment

A description of the pre-remediation marine biological environment beneath and in the vicinity of the South Jetty is provided in G3 (2014a), based on Archipelago (2009). However, conditions will have changed following the demolition of portions of the timber-supported South Jetty, the removal of contaminated sediments and the capping and armouring works. Specifically, post-remediation changes to the environment may include:

- Replacement of soft (contaminated) sediments with (clean) rocky substrate
- Removal of encrusting/attached biota associated with timber piles that were removed (e.g. barnacles and sponges [Archipelago, 2009]).
- Reduction in infauna and sessile benthic invertebrates associated with the dredged substrate underneath the South Jetty (e.g., plumose anemones [*Metridium senile* and *M. farcimen*], hydroids, tunicates, anemones [*Urticina* spp.], giant rock scallops [*Crassadoma gigantea*], nudibranchs, sea stars [*Pisaster brevispinus*], and sea urchins [*Strongylocentrotus purpuratus*] as reported in Archipelago [2009]).
- Temporary displacement of motile marine invertebrates and benthic fishes during demolition and dredging works (e.g. Cancer crabs [Cancridae] and other crabs, coonstripe shrimps [*Pandalus danae*], gobies (possibly *Lepidoglobus Lepidus* or *Rhinogobiops nicholsii*] and unidentified sculpins underneath, or near the South Jetty [Archipelago, 2009]).

The following sections provide information on biological valued components in the Project Area, including components that may be considered ‘fish and fish habitat’ under the federal *Fisheries Act*. Under the *Fisheries Act*, fish are defined as “shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.” Fish habitat is defined as “spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes.”

3.2.2.1 Marine Vegetation

The project footprint had no macroalgae, vegetation or eelgrass (Archipelago, 2009). With the addition of rock and temporary removal of the South Jetty, photosynthetic organisms may have an opportunity to colonize hard substrates temporarily. However, as reconstruction of the South Jetty is expected to occur within a year of completing placement of a riprap cap, macroalgae is not expected to have had sufficient time to colonize the newly placed rock under the South Jetty. The new South Jetty pier is being constructed in the same footprint as the original pier; therefore, no net change in productivity is expected for photosynthetic organisms in the area.

3.2.2.2 Marine Invertebrates

Prior to the Phase 1 and 2 works, the following marine invertebrates were present within the project footprint (Golder,2012a, *Archipelago, 2009*):

- Barnacles and encrusting sponges were ubiquitous on pilings, cobbles and boulders
- Cancer crabs (*Cancer* sp.) and plumose anemones (*Metridium senile*) were abundant at the western end of the jetty and decreased in abundance to the east
- Other species observed included hydroids, tunicates, anemones (*Utricina* sp.), giant rock scallop (*Crassadoma gigantean*), nudibranchs, coonstripe shrimp (*Pandalus danae*), red rock crab (*Cancer productus*), decorator crabs, northern kelp crab (*Pugettia producta*), spiny pink sea star (*Pisaster brevispinus*), and purple urchins (*Strongylocentrotus purpuratus*)

Pioneer broadcast spawner species such as barnacles and limpets may have begun to colonize the recently placed engineered cap layer. Crabs, anemones and other motile invertebrates may also have begun to move in from areas adjacent to the recent dredging and cap placement works.

Northern abalone (*Haliotis kamtschatkana*) is a federally threatened and provincially red-listed gastropod. Underwater surveys were completed in 2008 and 2012 to determine if Northern Abalone were present within Esquimalt Harbour. Eight locations were examined in Esquimalt Harbour (Archipelago, 2008), as well as five transects in Munroe Head and six transects at the North Landing Wharf areas of the EGD Waterlot (Archipelago, 2012). Only one was found at the wave exposed mouth of Esquimalt Harbour (Duntze Head) approximately 1.1 km away.

An unconfirmed sighting of an abalone was reported in Constance Cove. The sighting was unconfirmed because it was observed on unclear underwater video and the identification could not be verified (Archipelago, 2008). No abalone were observed during engineering inspection dives within the Waterlot or subsequent work (December, 2008; February-March, 2009 and March, 2010, Archipelago, 2009; Golder, 2009; M. Spani, pers. comm., February 14, 2011).

The lack of abalone observed within Esquimalt Harbour and existing conditions under the South Jetty prior to Phase 1 or 2 suggest there is limited suitable habitat and a low probability of abalone present with a density of >0.1 abalone/m² (Lessard et al., 2007). Abalone were therefore not anticipated to be present within the footprint of the South Jetty prior to undertaking

remediation. The 0.1 abalone/m² threshold is based on the short term goal of the National Recovery Strategy[1]. As described in the "Impact Assessment Protocol for Works and Developments Potentially Affecting Abalone and Their Habitat" (Lessard & Campbell, undated), if abalone are observed, and the higher 90% confidence intervals of the mean density (H90CI) for all sizes is <0.1 abalone/m², DFO may provide approval for a project to proceed (see also Lessard et al., 2007).

The Olympia oyster (*Ostrea conchaphila*), a native federally-listed species of concern and a provincially blue-listed species, is found in the Gorge Waterway and Portage Inlet. This oyster grows on hard substrate (rock, man-made debris) in the Gorge Waterway and on clumped oyster shells in Portage Inlet where substrate is silty sand. No known occurrences of Olympia oysters are present within Esquimalt Harbour (CRD, 2010). Olympia oyster is not anticipated to be present under the South Jetty.

No clam beds were known to be present under the South Jetty. No soft sediments are currently anticipated with the addition of the engineered cap consisting of rock.

3.2.2.3 Fish (from G3 2014a)

Towed video surveys only observed a few fish species in Esquimalt Harbour (Archipelago, 2009). Observations included two starry flounders (*Platichthys stellatus*) at the entrance of the Graving Dock. Other fish (sculpin and flatfish) were observed throughout the survey, but were not identified to the species level. Six observations of flatfish, two sculpin and 15 unidentified fish were documented (Archipelago, 2009).

Video taken at the NLW identified an unidentified greenling, goby, gunnel and flatfish in addition to black rockfish (*Sebastes melanops*), potential yellowtail rockfish (*S. flavidus*), copper rockfish (*S. caurinus*) and juvenile rockfish (G3 2014a, Archipelago, 2009).

Near the South Jetty, fish observed in the video included an unidentified goby (either the bay goby [*Lepidoglobus lepidus*] or black eyed goby [*Rhinogobiops nicholsii*]), a sculpin, and a juvenile rockfish (Sebastes sp.). Juvenile yellowtail rockfish (S. flavidus) and other juvenile rockfish were observed but could not be identified in the CFSA Marina (Archipelago, 2009).

EGD records indicate that Pacific herring (*Clupea pallasii*), Chinook salmon (*Oncorhynchus tshawytscha*), Coho salmon (*O. kisutch*), unidentified salmon species (*Oncorhynchus sp.*), starry flounder (*Platichthys stellatus*), lingcod (*Ophiodon elongates*) and unidentified perch have been trapped in the dry dock (G3 2014a, Archipelago, 2009). At any one time, the number of herring ranged from >500 to >1,000 fish, and salmon trapped ranged from 1 to 4 fish. At the entrance of the graving dock a bubble curtain was installed in 2003, which reduced fish entrapped (K. Ritchot, pers. comm. January. 4, 2011).

Mill Stream (Hazlic Creek, ID B068181), flows into the northwest portion of Esquimalt Harbour and contains Coho salmon, anadromous cutthroat trout (O*. clarkii clarkii*) and steelhead (anadromous rainbow trout; O. mykiss) (BCMOE, 2014). Coho salmon were present in 2003 when the stream was last inspected according to salmon escapement data indicated (DFO,

[1] http://www.sararegistry.gc.ca/virtual_sara/files/plans/rs_Northern_Abalone_0907_e.pdf (accessed Sept. 2016).

2010b). The Fisheries Inventory Summary System show cutthroat trout present until 1977 (BCMOE, 2010). If Coho salmon and steelhead still exist in Mill Stream, they could also be present in portions of Esquimalt Harbour. Their presence would be limited to transitory, based on their life history. The South Jetty does not contain ideal habitat for cutthroat trout (e.g., eel grass and kelp beds; CRD, 2014a). Cutthroat trout that migrate to the sea usually remain nearshore and extensive migrations can occur along shore to feeding areas, however, cutthroat trout have not been observed in Esquimalt Harbour.

Herring spawning has occurred in areas of Esquimalt Harbour (DFO, 2010b); however, DFO's cumulative herring spawn records from 1928 to 2001 show that herring spawn was recorded by surface observation only one time on March 25, 1993[2]. According to DFO analysis of cumulative herring spawn, this was classified as a 'minor' spawn and ranked within the bottom 25% of ranked shoreline kilometre segments (DFO, 2010c).

Are they not spawning anymore

3.2.2.4 Aquatic Mammals (from G3 2014a)

Harbour seals (*Phoca vitulina richardsi*) are resident within the coastal waters of BC (SARA, 2010) and common to Esquimalt Harbour (CRD, 2014b, c). Harbour seals were observed during buoy deployment and re-capture in October of 2010 near the site (K. Zottenberg, pers. obs., 2010) as well as during dive surveys along the NLW in February of 2010 (M. Spani, pers. obs.). Several harbour seals were listed in the EGD's database of organisms trapped within the dry dock. Harbour seals are not listed under federal Species at Risk legislation.

The northern river otter (*Lontra canadensis*) is common in Victoria Harbour and in parts of Esquimalt Harbour and Esquimalt Lagoon (CRD, 2014d). It not considered to be a marine mammal under the Marine Mammal Regulations, but it dies inhabit intertidal and near-shore environments where this species has an important ecological role (Melquist and Dronkert, 1987). Engelstoft and Mogensen (2005), state that Northern river otters were considered relatively abundant based on their study which included Esquimalt Harbour. The density of northern river otter dens has been documented to be lowest in urban areas. This is likely due to the disturbance to rolling, feeding, and denning sites (Giere and Eastman, 2000). However, this species is relatively common in the area (Engelstoft and Mogensen, 2005) and were observed on and around the dry dock during buoy deployment and re-capture exercises in October 2010 in Pilgrim Cove (K. Zottenberg, pers. obs., 2010), during dive surveys along the North Landing Wharf in February of 2010 (M. Spani, pers. obs.) and during seabed investigations in the CFSA Waterlot (north of Munroe Head) in September 2010.

Rare observations of California sea lions (*Zalophus californianus*) and Steller sea lions (*Eumetopias jubatus*) have occurred in Esquimalt Harbour (G3 2014a). A winter haul-out site (non-breeding assemblage) for both species was identified in the CRIS database at Race Rocks Ecological Reserve, approximately 20 km from Esquimalt Harbour (BC Government, 2010; DFO, 2010d). Steller sea lions were observed in Esquimalt Harbour during dive surveys along

[2] http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/Spnrec18-eng. html#1933

the NLW in February of 2010 (M. Spani, pers. obs.). A sea lion (unknown species) was also listed in EGD's database of organisms that was trapped in the dry dock. While California sea lions are not listed by SARA, Steller sea lions are listed under SARA as special concern (2005).

The documented geographical ranges and proposed critical habitat of northern and southern resident killer whales (*Orcinus orca*) include coastal regions of Vancouver Island and the Strait of Juan de Fuca, Haro Strait, Boundary Pass and Strait of Georgia, however, DFO does not consider Esquimalt Harbour and Victoria Harbour to be critical killer whale habitat (DFO, 2006). No killer whale sightings were recorded during field surveys to support the EGD project. There are also no killer whale sightings reported in the databases maintained by the Cetacean Research Program (DFO) or the BC Cetacean Sightings Network, which keeps data from 1973 to 2005 (DFO, 2006). Resident and Bigg's (transient) killer whales (Orcinus orca) are very unlikely to occur in Esquimalt Harbour. Southern resident and Bigg's (transient) killer whales are listed under SARA as endangered and threatened respectively (2008).

Harbour porpoise (*Phocoena phocoena*) and Dall's porpoise (*Phocoenoides dalli*) are typically found in inlets and bays around Vancouver Island (CWS, 2004). Reported sightings near Esquimalt Harbour include stranded or dead harbour porpoises and one record of a Dall's porpoise, including a single harbour porpoise observed at Saxe Point outside of the Harbour, and one harbour porpoise near Esquimalt Lagoon (DFO unpub. data; Hall, 2004). No other sightings were found after completion of desktop reviews conducted by the project team nor were any observed during field surveys or Site inspections (G3 2014a). Both porpoise species are unlikely to occur in Esquimalt Harbour. Harbour porpoises are listed under SARA as special concern (2005) while Dall's porpoises remain unlisted.

Mainly seals and some occurrences of sea lions have been observed within Esquimalt Harbour. The area appears to be used primarily as a movement corridor. There is a low probability of finding these species under the South Jetty.

3.2.2.5 Birds (from G3 2014a)

Prior to the Phase 1 and 2 works, an osprey (*Pandion haliaetus*) nest was identified on top of a high-mast light standard, on the west side of the South Jetty during a Phase 1 survey. The nest was relocated under a permit issued pursuant to the BC Wildlife Act (Permit #NA 12-76959) as part of Phase 1. The nest was relocated to a pole built outside of the Project Area. Since relocation, ospreys have not been observed nesting in the Project Area.

The next closest recorded osprey nest to the South Jetty is located across the water approximately 1,400 m away outside of the project area at a military facility at the end of Wilfert Road near Dunn's Nook in Colwood, BC (CMN, 2013).

Other birds that may use Esquimalt Harbour include Gaviiformes (loons), Pelecaniformes (pelicans and allies), Podicipediformes (grebes), Anseriformes (swans, geese and ducks), Charadriiformes (shorebirds and allies) and Passeriformes (perching birds or passerines). Common birds observed around Esquimalt Harbour during annual Christmas bird counts include loons, grebes, cormorants, ducks, gulls, herons, geese, raptors and passerines (VNHS, 2013). These birds may occur around the site; however, most are unlikely to nest due to active construction activities.

Barn swallows (*Hirundo rustica*), a provincially blue-listed species, may nest under South Jetty; however, as indicated below, no old or active nests were observed (Golder, 2010) and suitable nesting locations like the timber portion of the South Jetty has been removed. A site visit on July 28, 2010 found no nests (active or inactive) along the shoreline, including areas under the South Jetty. A majority of birds occurring within the project area are protected under the Migratory Birds Convention Act (1994). Under this Act, possession of a migratory bird or nest and deposition of a harmful substance (to birds) into waters or area frequented by migratory birds is prohibited.

3.2.2.6 Species at Risk

3.2.2.6.1 Species at Risk Designations

Provincial

The Provincial government assigns a rank or listing of 'red' or 'blue' to a species based on its status within BC. The Provincial rankings categories provided below apply to individual species as well as natural plant communities that require special attention:

Table 3-2 Provincial Species at Risk Listing Definitions

Provincial Listing	Description
Red	Any indigenous species, subspecies or plant community that is extirpated, endangered, or threatened in BC; and,
Blue	Any indigenous species, subspecies or community considered to be of special concern (formerly vulnerable) in BC.

No legal protection or designation is associated with provincial species at risk rankings. Instead, these designations help guide conservation, land use planning, management and protection activities within the province.

Federal

On a Federal level, species ranking is provided by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), established under Section 14 of the *Species at Risk Act* (*SARA*). COSEWIC is a group of experts that assesses, which wild species of animal, plant or other organisms are in danger of disappearing from Canada and designates the following status categories under Sections 15 to 26 of the *SARA*:

Table 3-3 Federal Species at Risk Ranking Definitions

Species Ranking	Description
Endangered (E)	a species facing imminent extirpation or extinction;
Threatened (T)	a species likely to become endangered if nothing is done to reverse factors leading to its extirpation or extinction;
Special Concern (SC)	a species that is likely to become threatened or endangered because of a combination of biological characteristics and identified threats; and,
Not At Risk (NAR)	a species that has been evaluated and found to be not at risk. SARA contains general prohibitions that make it an offence to: • kill, harm, harass, capture, or take an individual of a species listed in Schedule 1 of SARA as endangered, threatened or extirpated; • possess, collect, buy, sell or trade an individual of a species listed in Schedule 1 of SARA as endangered, threatened or extirpated; or, • damage or destroy the residence (e.g., nest or den) of one or more individuals of a species listed in Schedule 1 of the *SARA* as endangered, threatened or extirpated, if a recovery strategy has recommended the reintroduction of that extirpated species.

Schedule 1 is the official list of wildlife species at risk receiving legal protection under the *SARA*.

Although Schedule 1 lists other designations in addition to endangered, threatened and extirpated, the prohibitions of the Act do not apply to these species. In some circumstances, federal prohibitions could be applied to other species on private or provincial Crown land if it is deemed that provincial or voluntary measures do not adequately protect a species and its residence.

3.2.2.6.2 Species at Risk Occurring in and Adjacent to the Project Area

The CDC online mapping database (BCMOE, 2016b) has no records of species at risk at or under the South Jetty. The closest occurrence is a Macoun's meadow-foam (*Limnanthes macounii*), which is a terrestrial vascular plant, located approximately 750 m away (BCMOE, 2016). Steller sea lion and purple martin were also observed in areas within 2 km of the Project Area (BCMOE, 2016b).

Several masked sensitive occurrences overlap the Project Area. Prior to Phase 1 and 2 works, the CDC was of the opinion that the masked occurrences would not be adversely affected (K. Stipec, email pers. comm., January 11, 2011).

3.2.2.6.3 Species at Risk Potentially Occurring in and Adjacent to the Project Area

Golder (2012a) identified 33 species at risk (not including shoreline plants and insects species) with potential to occur within the Project Area; the list included 17 birds, six marine mammals, five fish, one turtle, one marine gastropod and one bivalve. Results were obtained from the BC Species and Ecosystem Explorer database (BCMOE, 2011) and BC Species at Risk website (BCMOE, 2013).

Golder (2012a) and G3 (2014a) identified 15 species that have the likelihood to occur within the Project Area based on habitat preferences and ranges matching site conditions prior to Phase 1 and 2. Steller sea lion is a species at risk that has a potential to occur within and adjacent to the Project Area based on their observed proximity to the EGD, although the probability of occurrence is low.

3.3 Socio-Economic Environment

3.3.1 Site History (from Golder, 2012a)

Before contact with Europeans, the area was used by the Esquimalt and Songhees First Nations. The Chiefs of both Nations have indicated that Esquimalt Harbour was like a breadbasket for the Lekwungen people. The First Nations regularly harvested foods such as salmon, cod, sturgeon, clams, seal, ducks, geese, and herring roe within a very short distance of their Longhouses. When salmon passed the western shore of the island and around the southern point (Haro Strait) on their way to the Fraser and other major rivers on the mainland, the Songhees and Esquimalt (and their neighbours) harvested them in reef nets. Waterfowl were also hunted in the area with bow and arrow, spears or nets. Hunting and gathering of plants, roots and berries occurred year-round in the forested areas surrounding the harbour. The following site history is a summary of information provided in Golder's "EGD Waterlot Detailed Site Investigation" report (Golder 2010a).

From 1850 to 1860, the headquarters of Constance Cove Farm (associated with the Hudson's Bay Company) was located at Skinners Cove, at the location of the present-day EGD.

In 1921 construction of the EGD was initiated in response to several demands including larger marine vessels, increased commercial vessel traffic and demands of World War I. The dry dock was constructed by blasting and removing bedrock and using the blast rock as infill for areas surrounding the dry dock. The blast rock, along with other materials, supported the construction of a temporary railway, and preliminary construction of the North Landing Wharf and South Jetty. By 1926 the dry dock was in operation and the Harbour was designated as a Federal Harbour.

Pilgrim Cove appears to have been developed sometime around 1932, with construction of dock structures and a small wharf and potential in-fill of a section of the shoreline. A shipwright was reported to be located to the southern side of the EGD on the shoreline of Pilgrim Cove.

In 1940, the South Jetty was extended east and southeast (timber piled structure), as part of dock expansion. Munroe Head was also developed at this time utilizing blast rock as fill material, and an additional shipyard (known as Yarrows No. 2 Yard) was built on Munroe Head. The structures built included: a marine railway and two building berths, together with associated machinery, welding and storage facilities associated with ship building and maintenance. In 1945 (after WWII), Yarrows No. 2 Yard, located on Munroe Head, was closed. From 1945 to 1948, part of the property was leased from the Crown and the lease expired in the summer of 1948. A portion of the Yarrows No. 2 property (beyond the current Project Area) was sold to Manning Timber Products in 1948, and the area was developed into a sawmill with a drying kiln,

a spur line from E & N Railway, a transformer station, and an electrical substation. A site plan of Munroe Head dated 1952, identifies two berths running perpendicular to the shoreline and labelled as “Berth No.1 (fill)” and “Berth No.2 (fill)”. These berths extended through the intertidal area of Munroe Head which forms part of the current Project Area. The foundations for the marine slipway are still located on the Munroe Head intertidal beach area.

During the 1970s, the dry dock continued to be utilized by Contractors for repair and construction of smaller vessels. The EGD served the country through two world wars and through expansion of west coast trade.

Between 1984 and 1985, further upgrades were made to the South Jetty structure. An approximately 13 m by 195 m long concrete wharf structure located to the north side of the timber piled jetty structure was constructed and a timber infill section was added between the north and south aprons. South and west crane pads (concrete deck and timber piles) were also added in 2005.

3.3.2 Current Land Use

The EGD accommodates large ships including cruise ships, ferries, large bulk and cargo vessels and Canadian military vessels (i.e., Department of National Defence [DND]) for repair and refit work G3 (2014a). The maintenance and ship building operations at the EGD are carried out by private firms. No change in land use in the Project Area has occurred.

3.3.3 Surrounding Land Use

The Project Area is located within the asserted traditional territories of the Songhees Nation and the Esquimalt Nation. Approximately 150 m north of the project are two First Nation reserves including the New Songhees First Nation Reserve No.1A and the Esquimalt First Nation Reserve. Additional residential areas are located approximately 550 m east of the Project Area; these residential areas do not have shoreline access to the EGD Waterlot. No change in surrounding land use has occurred.

3.3.3.1 Navigation (from Golder, 2012a and G3 2014a)

Esquimalt Harbour is administered by DND and is governed by the Canada Marine Act, the Natural and Man-Made Harbour Regulations (pursuant to the Canada Marine Act), and local Practices and Procedures (Government of Canada, 2014a). The harbour is open to the public within the limitations set out in an Order in Council regarding Controlled Access Zones that provide for security zones around warships berthed or moving in the harbour. All vessels entering or departing Esquimalt Harbour are requested to contact Queens Harbourmaster (QHM) Operations (Government of Canada, 2014a).

Ship repair work at EGD takes place 24-hours-a-day, seven-days-a-week, 365-days-a-year (PWGSC, 2014). Given that ship repair takes place at all times, ships frequently navigate in and out of the Project Area. Emergency docking of ships at the dry dock may need to occur during the Project.

No changes have occurred with the navigation information provided for the Project Area and surrounding harbour.

3.3.3.2 Commercial, Recreational or First Nations/Subsistence Fisheries (from G3 2014a)

In accordance with the Natural and Man-Made Harbours Regulations, fishing and crabbing are Schedule 1 listed activities that are prohibited without personal authorization from a harbour official; as such, fishing and crabbing are not authorized within, and in the immediate vicinity of, the Project Area.

A commercial crab fishery exists or existed in Esquimalt Harbour (BC Government, 2010; DFO, 2010b); however, DND indicated that the licences for the commercial crab fishery are no longer active (G. Smith, pers. comm.). Despite not being considered to be a popular area for sport fishing; a coho salmon (Oncorhynchus kisutch) sport fishery, of unknown size, exists in the harbour (DFO, 2010b). A commercial squid fishery also exists within Esquimalt Harbour (BC Government, 2010); however, it is small in size. The squid fishery season extends from April 1 to March 31 (DFO, 2014d) and remains active (G. Smith, pers. comm.). A permanent on-going, year round, bivalve shellfish closure exists in Esquimalt and Victoria Harbours and the coastal waters (extending from Albert Head in the west and Gonzales Point in the east; DFO, 2013). No harvesting is permitted for any purpose due to a sanitary closure; a biotoxin closure is also in place in this region (DFO, 2014b). In addition, permanent bivalve fishing prohibitions (no fishing for any purpose) are in place (1) within 300 m of industrial and municipal outfall discharges, and (2) within a minimum 125 m of marinas and wharves (DFO, 2013).

According to Fisheries and Oceans Canada (DFO) Fishery Notice (FN0807, issued October 9, 2009), a consumption advisory is in place for Esquimalt Harbour, covering recreational and First Nation harvest of seafood. This notice provides the recommended maximum weekly intake, in accordance with Health Canada (HC) recommendations for adults and toddlers, of Dungeness crab (Metacarcinus magister, formerly Cancer magister) hepatopancreas and muscle, red rock crab hepatopancreas and muscle, sea urchin roe, and rockfish muscle. FN0807 also reaffirms that Esquimalt Harbour is already closed for the harvest of bivalve shellfish.

Commercial and consumptive fishing has been understood to take place in Esquimalt Harbour by various groups, including First Nations (SLR, 2010). PWGSC and DND have indicated that First Nations fish in the CFSA area, north of the Project Area, and that in the past First Nations were observed fishing within the Phase 1 Project Area (G. Smith, pers. comm.).

First Nations have indicated that they have ongoing subsistence or cultural uses in the harbour. Both the Esquimalt and Songhees Nations assert aboriginal rights and interests within the harbour area; however, shellfish or other marine foods have rarely been harvested within the Project Area for at least 30 years (Cornerstone, 2011).

No changes have occurred in the fisheries usages within Esquimalt Harbour or the Project Area.

3.3.3.3 Noise and Light (from Golder, 2012a and G3, 2014a)

During 'high' activity levels at EGD, in particular related to sandblasting and pump house noise, 24 h Equivalent Noise Level (Leq[24]) of 64 decibels (A-weighted; dBA) have been measured at the property boundary near the EGD main office (Wakefield, 1997). This noise level was comparable to the sound generated by arterial traffic at a monitoring station on Esquimalt Road approximately 1.5 km southeast of the EGD (Leq(24) levels = 63 dBA). Sandblasting in berths 3 and 4 (at the east end of the dry-dock) caused Leq(24) levels of 59 dBA at a immediately adjacent neighbourhood site (Stancombe Place, approximately 20 m from the property boundary and 150 m from berths 3 and 4).

EGD's BMP#12 (Nuisance Pollution [Noise/Odour/Light]) includes provisions for scheduling noisy activities for daytime hours (07:00 to 23:00 h on weekdays, and from 07:00 to 19:00 h on weekends and holidays) and for following applicable municipal bylaws (Township of Esquimalt, 2014).

Contractors shall adhere to the Township of Esquimalt Maintenance of Property and Nuisance Regulation (No. 2826) and the City of Colwood Bylaw (No. 38). If complaints are received, work activities must be modified to reduce the noise generated.

The Township of Esquimalt regulation prohibits any noise or sound which disturbs, tends to disturb, or will likely disturb the quiet, peace, rest, enjoyment, comfort or convenience of persons in the neighbourhood or vicinity between:

- 22:00 and 07:00 h Monday to Friday; and,
- 22:00 and 09:00 h on a Saturday, Sunday or holiday.

The Bylaw to Regulate Noise within the City of Colwood (1986) prohibits the disturbance of the quiet, peace, rest, enjoyment, comfort or convenience of the neighbourhood or of persons in the vicinity, and stipulates the following construction hours:

- 07:00 to 19:00 h Monday to Saturday; and,
- 08:00 to 17:00 h on Sundays and statutory holidays.

Work may be performed outside of these hours with approval by the PWGSC Departmental Representative (DR). For the Project a guideline of 85 dBA will be implemented; however, this is subject to change at any time based on resident feedback. Any complaints in regards to the noise level received are to be the reported to the DR and noted in the daily reporting. The EMP (Appendix B) also addresses light as potential nuisance pollution. Night time dock operations can involve the use of spotlights.

3.3.3.4 Archaeology Summary (from G3, 2014a)

An Archaeological Overview Assessment was conducted for the overall Project Area which included the area beneath the South Jetty (Golder, 2012b). In summary, the assessed archaeological potential for the Work Site was as follows:

- no potential was identified for a heritage wreck in the Project Area (Northern Maritime Research, 2002); and,
- potential was identified for intact archaeological materials located under the western part of the South Jetty.

An Archaeological Impact Assessment (AIA) was conducted in November 2014. No historically significant material was identified.

4. SCOPE OF THE ASSESSMENT

This Environmental Effects Evaluation (EEE) is specific to the EGD South Jetty Reconstruction Project (the Project). The spatial extent of the Project is the Project Area provided in Herold (2016) and the adjacent biophysical and socioeconomic components discussed in Sections 3.2 and 3.3. The temporal extent of this evaluation includes the time for South Jetty reconstruction works, scheduled to begin in October 2016 and continue for a year and a half until April 2018.

This EEE describes the existing environment, including physical, biological and socioeconomic components within and adjacent to the Project area. The EEE assesses the potential environmental effects of the Project works on each of these Valued Ecosystem Components (VECs) and Valued Social Components (VSCs), the effects of the environment on the Project, and determines the significance of residual effects after mitigation measures are implemented.

Table 4-1 Checklist of VECs/VSCs Pertinent to the Project Works (Golder, 2012a)

Valued Ecosystem or Social Components	Potential Effect of Project on Component (Y/N)	Potential Effect of Component on Project (Y/N)
Physical Components		
Air Quality (dust, emissions)	Y	N
Weather/Climate/Microclimate (wind, precipitation, temperature, inversion, fog)	N	Y
Surface Water (quantity, quality, shoreline/bottom alteration, flow variation, current, tides, wave action)	Y	N
Substrate (erosion, compaction, settling, stability, sediments)	Y	N
Biological Components		
Marine Vegetation	Y	N
Marine Invertebrates	Y	N
Fish/Fish Habitat (population change, productive capacity, habitat modifications)	Y	N
Aquatic Mammals (population change, productive capacity, habitat modification)	Y	N
Birds (population change, productive capacity, habitat modification)	Y	N
Species at Risk (Provincial and Federal)	Y	N
Socio-Economic Components		
Fisheries	Y	N
Noise/Light	Y	N
Human Health and Safety	Y	N

5. EVALUATION OF ENVIRONMENTAL EFFECTS, MITIGATION, AND SIGNIFICANCE

The potential effects (including cumulative effects) of the Project activities for each of the valued components provided in Table 4–1 are identified and characterized in sections below. Mitigation measures and BMPs are provided to offset potential negative effects, and the significance of potential residual effects is evaluated using the criteria outlined in Section 5.1.

The updated EMP prepared for the Project (see Appendix B) is a companion document to this EEE, and builds upon the information provided in the initial EMP produced by Golder (2012a) and G3 (2014c) for PWGSC for works at the EGD.

5.1 Significance Criteria

The significance of residual effects (i.e., the potential effects remaining after mitigation measures and BMPs are implemented) were characterised based the matrix provided by Golder (2012a), which takes into consideration magnitude, geographic extent, and duration of the effect; frequency of conditions causing the effect; and, permanence and ecological context of effect. Table 5-1 describes the criteria used to determine the significance of potential residual effects associated with the reconstruction of the South Jetty.

Table 5-1 Residual Effects Significance Matrix (Golder, 2012a)

Criterion	Low (Not Significant)	Moderate (Potentially Significant)	High (Significant)
Magnitude (of the effect)	Effect is evident only at or nominally above baseline conditions.	Effect exceeds baseline conditions, however is less than regulatory criteria or published guideline values.	Effect exceeds regulatory criteria or published guideline values.
Geographic Extent (of the effect)	Effect is limited to the project site/footprint.	Effect extends into areas beyond the project site / footprint boundary.	Effect is trans-boundary in nature.
Duration (of the effect)	Effect is evident only during the construction phase of the project.	Effect is evident during construction and/or the operational phase of the project.	Effects will be evident beyond the operational life of the project.
Frequency (of conditions causing the effect)	Conditions or phenomena causing the effect occur infrequently (i.e., < once per year).	Conditions or phenomena causing the effect occur at regular intervals although infrequent intervals (i.e., < once per month).	Conditions or phenomena causing the effect occur at regular and frequent intervals (i.e., > once per month).
Permanence (of effect)	Effect is readily reversible over a short period of time (i.e., one growing season).	Effect is not readily reversible during the life of the project.	Effect is permanent.

Criterion	Low (Not Significant)	Moderate (Potentially Significant)	High (Significant)
Ecological Context (of effect)	Area with evidence of environmental effects by human activities. Effect results in minimal disruption of ecological functions and relationships in the impacted area.	Relatively pristine area. Effect results in some disruption of noncritical ecological functions and relationships in the impacted area.	Pristine area/not affected by human activity. Effect results in disruption of critical ecological functions and relationship in the impacted area.

5.2 Effects Assessment of Project on Environment

The effects assessment of valued physical components is summarized in Appendix 2, Table B4 of G3 (2014a). Physical components assessed for the Project works included:

- Air Quality
- Tides and Currents
- Water Quality
- Substrate Quality (assessed within the Fish and Fish Habitat section)

The biological component assessment included (Table 4-1 of G3 (2014a):

- Fish and Fish Habitat
- Aquatic Mammals
- Birds
- Species at Risk
- Marine vegetation
- Marine invertebrates

5.2.1 Physical Components

5.2.1.1 Air Quality

5.2.1.1.1 Characterization of Project Effects

There is a potential for air quality to be negatively affected by the Project works through:

- Exhaust emissions from machinery (e.g., vessels and equipment);
- Dust generation from upper intertidal excavation works and terrestrial upland construction activities;
- Release of hydrocarbon vapours from potentially contaminated upland material; and,
- Airborne particles from the application of spray coatings, finishes, paints, etc.

5.2.1.1.2 Mitigation Measures for Air Quality Effects

To mitigate the potential negative effects of the Project works on air quality, the following measures will be implemented (G3, 2014a):

- Vessels and equipment will be well maintained and in good working order;
- Efforts will be made to minimize exhaust emissions through excessive unattended vehicle idling and other methods identified in a prepared contractor EPP. Vessels and equipment will use low sulfur fuels. Idling of vessels and equipment will be minimized and will not occur near building doorways or air intakes;
- Routine checks of exhaust systems and equipment will be performed to identify current or potential deficiencies. Any deficiencies must be repaired immediately;
- To reduce potential dust emissions during construction activities, the Contractor will employ dust control measures (such as the use of dust screens/partitions or water as a dust suppressant), control measures must be of sufficient to fully contain the source of airborne particles;
- Workers near excavated sediment or soil shall have appropriate personal protective equipment (PPE) based on the Contractors' Health and Safety Plan;
- Hydrogen sulfide (H2S) monitoring will be undertaken in and around the work area during any excavation activities. Workers will have appropriate PPE and/or training for H2S if they are working in potentially affected areas. If H2S concentrations in air exceed applicable guidelines (10 parts per million [ppm], ceiling short-term exposure level), appropriate safety equipment (e.g., respirators with applicable filters) will be issued to workers (WorkSafeBC, 2014). The Contractor will be responsible for preparing a Health and Safety Plan detailing appropriate PPE, training and safe work practices for H2S;
- Waste transported from Contractor's off-site offload facility will be covered and secured in watertight containers to minimize release of odours, dust, wastewater and other materials;
- Spray coatings, etc. will not be applied during conditions that render containment ineffective; and,
- In the event that a nuisance odour or airborne discharge (including hydrocarbon vapours) the DR, and subsequently EGD Environmental Services must be notified. If particulate matter levels in the air exceed 100 µg/m^3 corrective actions must be taken.

5.2.1.1.3 Characterization of Residual Effects

Some emissions of exhaust and dust may occur after mitigation measures are applied.

5.2.1.1.4 Significance of Residual Effects

The likelihood of residual effects to air quality (i.e., after mitigation) is low, with the magnitude of these effects predicted to be slightly above baseline conditions. The duration may be limited to the duration of construction activities.

5.2.1.2 Tides/Currents

5.2.1.2.1 Characterization of Project Effects

No effects on tides and/ or currents are anticipated as a result of reconstruction activities, or subsequent operations. Once the TRB has been removed prior to the South Jetty reconstruction Project works, water flow in the project area is expected to return to pre-remediation patterns.

5.2.1.2.2 Mitigation Measures for Effects to Tides and Currents

No mitigation measures are expected to be required.

5.2.1.2.3 Characterization of Residual Effects

No residual effects are expected.

5.2.1.3 Water Quality

5.2.1.3.1 Characterization of Project Effects

Water quality within the Project Area may be negatively affected by the Project works through the following:

- The introduction of deleterious substances (e.g., fuels, oils, greases, etc.) to the harbour and adjacent areas, following accidental release from on-site heavy machinery and/or vessels during the construction works, as well as during the operational activities after construction is complete;
- A temporary increase in TSS from in-water construction works (e.g., pile driving, earthworks at the East Approach). Increased suspended sediments may impede fish swimming, feeding and/or predator avoidance, and may cause gill irritation (or direct mortality, in extreme cases);
- Erosion or sedimentation events from upland activities;
- The contamination of water and/or sediment due to operational activities at the wharf;
- The potential release of hydrocarbons from construction equipment or refuelling activities; and,
- The introduction of cementitious (alkaline) materials in the water during construction works, which could affect water quality (i.e., increased pH and suspended solids) and fish present in the Project's vicinity.

Concrete

Cast in place concrete has the potential to adversely impact water quality due to:

- Toxicity concerns from the alkaline pH of concrete; and,
- Physical effects from smothering (suspended solids).

Uncured concrete may raise the alkalinity, and consequently, the pH of the water it comes in contact with. Based on the water quality criteria established for the protection of aquatic life in marine and estuarine waters, pH should fall within the range of 7.0–8.7 units (CCME, 2014).[3] In addition, concrete contains high levels of fine particles, which may cause an increase in TSS in the aquatic environment. The effects of increased TSS are identified above (section 5.2.1.3.1).

5.2.1.3.2 Mitigation Measures for Water Quality Effects

To mitigate the potential negative effects of the Project works on water quality, the following measures will be implemented (modified from G3, 2014a):

- An Environmental Monitor (EM) will be on-site during Project activities to monitor water quality;
- Water quality will comply with water quality guidelines identified in Table 5-2 (BCMOE, 2016a);

Table 5-2 Water Quality Guidelines for Turbidity and Suspended Sediments

Water Use	Turbidity	Non-filterable Residue (Total Suspended Solids)
Aquatic Life (Fresh, Marine, Estuarine)	• Change from background of 8 Nephelometric Turbidity Units (NTU) at any one time for a duration of 24 h in all waters during clear flows or in clear waters • Change from background of 2 NTU at any one time for a duration of 30 d in all waters during clear flows or in clear waters • Change from background of 5 NTU at any time when background is 8–50 NTU during high flows or in turbid waters • Change from background of 10% when background is > 50 NTU at any time during high flows or in turbid waters	• Change from background of 25 mg/L at any one time for a duration of 24 h in all waters during clear flows or in clear waters • Change from background of 5 mg/L at any one time for a duration of 30 d in all waters during clear flows or in clear waters • Change from background of 10 mg/L at any time when background is 2–100 mg/L during high flows or in turbid waters • Change from background of 10% when background is > 100 mg/L at any time during high flows or in turbid waters

- Should water quality values exceed the guidelines, a full height silt curtain or equivalent will be deployed to isolate construction activities that are causing water quality exceedances;

[3] Values outside this range may be acceptable, if it can be demonstrated that such values are resulting from natural processes (CCME, 2014).

- Any hydraulic machinery used in water will use environmentally-friendly hydraulic fluids (i.e., non-toxic to aquatic life, and biodegradable);
- If storage of fuels occurs on site, a 'Fuels, Chemicals and Materials Storage and Handling Plan' will be developed, in compliance to Ministry guidelines (Ministry of Water, Land and Air Protection; MWLAP, 2002);
- Grounding of equipment/machinery on the harbour bottom will be avoided to prevent sediment mobilization; any barges used will be tied to the existing wharf or held in place with spuds;
- The Contractor will be required to prepare a Construction Work Plan and Environmental Protection Plan (EPP) describing specific measures to be implemented addressing the provisions of the EMP. The EPP will address all Project activities, including pile driving, concrete works, excavation works at the East Approach, and residual management; including water quality management in accordance with federal and provincial standards
- No deleterious substances may be released into any watercourse;
- Washing, refuelling and servicing of equipment, as well as storing of fuel and other materials will be identified in the contractors EPP and be conducted a minimum of 30 m away from any regulated watercourse or storm sewer, or at designated locations (if applicable), to prevent deleterious substances from potentially entering any regulated watercourse;
- The Contractor will have spill containment response and reporting measures in place;
- Appropriate equipment will be used to prevent sedimentation/erosion (e.g., silt fencing, geotextile, covering piles) whenever necessary. The Contractor will minimize amount of bare soil exposed at one time and stabilize disturbed soils as quickly as possible. Any accumulated sediment resulting from construction activity shall be managed to minimize water quality effects.

Should on-site wastewater[4] management be conducted, the following mitigation measures will be followed:

- Wastewater will not be discharged from on-site personnel hygiene/toilet facilities, or decontamination activities.
- Any wastewater produced as a result of Project works (e.g., equipment decontamination wastewater) shall be tested prior to discharge in the EGD Project Area to ensure compliance with applicable water quality performance objectives for where it is to be released. If criteria and/or objectives cannot be met, wastewater shall be treated at an authorized Wastewater Treatment Facility.

For excavation activities the following mitigation measures will be followed:

- All excavation of Hazardous Waste shall be sequenced and completed such that no recontamination of the project footprint occurs; the Contractor assumes ownership of any soil, sediment or other material once it is loaded on to a barge or other vessel for transport from the Project Area for disposal.

[4] Wastewater is defined as waters produced from construction activities, decontamination activities and personal hygiene facilities.

- The Contractor will follow contract specification operational controls to minimize disturbance of substrates.
- The Contractor shall immediately notify the DR if any excavated material is identified as Hazardous Waste Quality Sediment.
- Hazardous Waste Quality Sediment must be safely transported to and disposed of by the Contractor at the approved Hazardous Waste Management Facility following all relevant mitigation measures and criteria in the EMP for transport and disposal of excavated material;
- Trucks or barges will not be overloaded to minimize loss of material and prevent instability. Measures to prevent excavated sediment or soil from falling into the marine environment during loading;
- Grounding of equipment and barges will only permitted if approved by the DR.

For excavation activities using upland-based excavators and/or a barge-mounted derrick the following mitigation measures will be followed:

- Work will be conducted during periods of low tide whenever practicable. If in-water works is required, sediment control measures must be in place to prevent transport of sediment away from the Work Area.
- Works must minimize the potential for infilling, water inundation and re-suspension/transport of contaminated sediments that could lead to adverse water quality impacts and/or recontamination of remediated areas.

For upland transport of excavated material be required, the following mitigation measures will be followed (as per G3, 2014a):

- Excavated material will be transported to an approved landfill by an appropriately licensed hauler, in accordance with applicable federal (e.g., *Transportation of Dangerous Goods Act*), provincial (e.g., *Environmental Management Act*, BC Hazardous Waste Regulation) statutes and regulations, municipal bylaws, and guidance and protocols.
- Once offloaded, the material may be safely transported to the appropriate, approved Treatment, Hazardous Waste Management or Disposal Facility in accordance with federal, provincial and local laws and regulations.
- Waste transported from Contractor's off-site offload facility will be covered with a tarp and adequately secured in watertight containers to minimize release of odours and dust and ensure no spillage; haulers must use only designated routes for transport of the material (e.g., designated truck routes).
- Contractor is responsible for all misplaced waste and debris material and are required to notify and coordinate with appropriate authorities if material is misplaced during transport to the off-site offload facility or during completion of offloading, transport, and disposal activities.

For disposal of excavated material and debris, the following mitigation measures will be followed:

- Treatment and/or destruction of soil or other waste materials must be completed in accordance with the EMP (Appendix B) and applicable federal, provincial and municipal regulations, guidance, procedures, and protocols.
- Disposal and/or treatment of any sediment, soil, debris, water or other waste material will only occur at licensed and approved Disposal, Treatment or Hazardous Waste Management Facilities.
- Contractor must provide appropriate information to be able to track all material from the Project Area to the Treatment, Hazardous Waste Management or Disposal Facility.
- The location of the Treatment, Hazardous Waste Management or Disposal Facility shall not change without notification, review and acceptance by the DR.
- Contractor shall not move waste from one Disposal/Hazardous Waste Management Facility to another Disposal/Hazardous Waste Management Facility once the Certificate of Disposal has been submitted.
- Soil or other material sent to a Disposal Facility or Hazardous Waste Management Facility must be permanently stored at that facility.
- Some excavated debris may not be accepted with excavated material by Disposal Facilities. Contractor must coordinate with the Disposal Facility to determine if debris needs to be screened and sorted prior to upland transport and disposal;

During construction activities, the following mitigation measures will be followed:

- Buoyant items that become detached from their original position (i.e., floating debris) are not to float beyond the Project Area and are to be removed as soon as possible.
- Pile-driving will be conducted using appropriate work procedures that ensure compliance with the EMP and BMPs.
- The washing of sand or gravel from new asphalt, debris from drilling or cutting, or other materials into storm drains and marine environment by sweeping will be minimized.
- Any seals, coatings, paints or finishes required will be applied during dry periods.
- Any items designated for re-use (e.g., fender and dolphin piles) must be decontaminated prior to reinstallation;

Any concrete works in or near water will include the following measures (G3, 2014a):

- The Contractor is responsible for taking all measures necessary to prevent an accidental release of any concrete to the marine environment. In the event of accidental release, the Contractor is responsible for providing an appropriate spill response to limit potentially deleterious substances from entering the water and to ensure compliance with water quality criteria.
- Fast-curing concrete intended/formulated specifically for marine applications will be used.

- All equipment will be properly sealed, have locked connections where present and shut off valves. Crews will ensure that concrete forms are not filled to overflowing. Excess or spilled concrete must be collected immediately and disposed of in an appropriate location.
- barriers (e.g., poly sheets) will be used as appropriate to prevent splashing of the concrete over the forms and into the water or intertidal area during pouring.
- concrete washout water and solids will be collected and retained in leak proof containers, so that this caustic material does not reach the soil surface then migrate to surface waters, groundwater or the marine environment.
- when fresh water is used to cure concrete, runoff must be monitored for acceptable pH levels. If the pH levels are outside the allowable limits then the runoff water must be contained until the pH is between 7.0 and 8.7 pH units and turbidity is <25 NTU, measured to an accuracy of +/- 2 NTU.
- equipment and tools that have come into contact with concrete will be washed down in a designated area away from the intertidal and drainages (e.g., streams and municipal drains) so that concrete products are prevented from entering the marine environment or other watercourses.
- when grinding cured concrete, dust and fines entering the water must not cause an increase to the turbidity above the allowable limits. In the event that the levels are outside acceptable ranges preventative measures are to be introduced.
- pH will be monitored frequently by the EM in the waterbody immediately adjacent to the Work Area until the works are completed. Contractor must implement emergency measures if pH surrounding the activity has changed more than 1.0 pH unit, measured to an accuracy of +/- 0.2 pH units from the background level, or is below 7.0 or above 8.7 pH units (EMP). Contractor must contact the DR to report emergency procedures are being performed. EM will contact DR if necessary.
- Immediate clean-up of excess/spilled concrete.

The following mitigation measures will be followed for spill prevention, detection and response:

- Workers shall be made fully aware of the spill prevention and response procedures including notification to the DR.
- All spills shall be reported in accordance with the BC Spill Reporting Regulations (1990, pursuant to the Environmental Management Act), EGD BMPs (PWGSC, 2010), EGD Spill Contingency Plan, Fisheries Act, and EMP.
- comply with applicable discharge limitations and requirements as defined in the EMP.
- excavated material or dewatering wastewaters will not be discharged to EGD on-site sewer systems.
- Contractor shall take due care to ensure no deleterious materials, including sediment-laden runoff, leave the EGD Project Area.
- Contractor's off-site offload facility or enter any surface water or stormwater at or near the EGD Project Area, Contractor off-site, offload facility or during transport of materials over water or land.

- Equipment fuelling and/or lubricating shall occur at the EGD Project Area in accordance with the EMP, EGD BMPs and EGD fuelling protocols. Berthed vessels receiving fuel from a truck or a barge will require a containment boom be installed before filling and must follow EGD BMPs and the EMP. Emergency hydrocarbon spill response shall be included in EPP and follow practices outlined in the EMP, and EGD BMPs.
- The use of any paints, corrosion protective coatings, wood preservatives, or any other potentially deleterious substances that may be applied to surfaces that will have contact with the marine environment shall be applied in accordance with the EMP, EGD BMPs, and environmental protection measures outlined in the EPP.
- To prevent airborne particles, overspray or waste from entering the waterbody containment such as tarps, shrouds or portable structures shall be used where necessary.
- Ensure hydraulic machinery, if required, use environmentally sensitive hydraulic fluids that are non-toxic to aquatic life and that are readily or inherently biodegradable.
- Oil, fuel and other deleterious substances are to be stored away from pathways to the aquatic environment (e.g., storm drains, edge of dock).
- Any equipment remaining on site overnight shall have appropriately placed drip pans or other spill/leak containment measures.
- Equipment decontamination wastewater shall be contained, treated and tested prior to discharging at the EGD Project Area provided it meets water quality performance objectives. Wastewater generated as part of these activities that cannot meet these requirements shall be disposed of at an appropriate Wastewater Treatment Facility.

5.2.1.3.3 Characterization of Residual Effects

There is the potential for release of deleterious substances from construction activities; however, if mitigation measures are applied residual effects are expected to be very low.

5.2.1.3.4 Significance of Residual Effects

The overall significance of residual effects on water quality is considered low.

5.2.2 Biological Components

The following Biological Components effects assessment is summarized in G3 (2014a).

5.2.2.1 Fish & Fish Habitat

The following section provides an assessment of the Project works on fish and fish habitat in the Project Area. Under the *Fisheries Act*, “fish” are defined as “parts of fish; shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals; and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.” In addition, “fish habitat” is defined as “spawning grounds and any other areas, including and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes”.

5.2.2.1.1 Summary of Habitat Characteristics of Project Area

The South Jetty under-pier area was characterized as having low fish habitat value, as a result of sediment contamination, which the EGD Waterlot Remediation Project addressed. This habitat was also largely shaded by the deck and structural supports of the jetty. The shading prevents low colonization by photosynthetic algae and creates a low abundance and diversity of organisms, as was reported by Archipelago (2009) during the baseline studies. A summary of the habitat features beneath the jetty is provided below (G3, 2014a):

- Substrate in transects at the western end of the jetty consisted predominantly of silt with shell fragments, and limited (10% -20%) cobble in one transect;
- Substrate in eastern transects consisted predominantly of silt with shell fragments along the southern portions of the transects, and predominantly of a mix of gravel, cobble and boulder along the northern portions of the transects;
- Attached macroalgae (including kelp) were not observed, whereas drift algae were observed occasionally throughout the survey area;
- Barnacles and encrusting sponges were ubiquitous on pilings and coarse substrate (cobble/boulder) throughout the surveyed transects;
- Graceful rock crab (*Metacarcinus gracilis*) and plumose anemone (*Metridium senile*) were abundant in transects at the western end of the jetty, but decreased in abundance towards the east. The plumose anemone was often associated with the wood pilings and hard substrate (native and anthropogenic) occurring on or embedded in the seabed, while graceful rock crab was commonly observed around the pilings;
- Other species observed included hydroids, tunicates, anemone (*Urticina sp.*), giant rock scallop (*Crassadoma gigantea*), nudibranchs, coonstripe shrimp (*Pandalus danae*), red rock crab (*Cancer productus*), decorator crab (*Oregonia sp. or Chorilia sp.*), northern kelp crab (*Pugettia producta*), spiny pink seastar (*Pisaster brevispinus*), and purple sea urchin (*Strongylocentrotus purpuratus*);
- Few fish were observed; an unidentified goby (possibly Bay Goby [*Lepidoglobus lepidus*] or Blackeye Goby [*Rhinogobiops nicholsii*]), unidentified sculpin, and a juvenile rockfish (*Sebastes sp.).*
- Abundant anthropogenic debris was present along the transects, such as wood debris (stick, wood tie), rope/wire/cable, polyvinyl chloride (PVC) electrical box, metal/steel, sheet of fabric, fibreglass ladder, aluminium cans, cardboard, concrete, anchor/chain, paper, plastic and old pilings (Golder, 2009a). A possible sunken wooden dock or suspected old firewall was also present, partially buried in the sediment.

The biophysical conditions within the Project Area will have changed from those presented in Golder (2012a) and G3 (2014a) following the demolition of portions of the timber-supported South Jetty, the removal of contaminated sediments and the capping and armouring works. Specific changes to the environment include:

- Replacement of contaminated soft sediments with clean rocky substrate (0.15–0.30 m cobbles).

- Removal of encrusting/attached biota associated with timber piles that were removed (e.g. barnacles and sponges [Archipelago, 2009]).
- Reduction in infauna and sessile benthic invertebrates associated with the dredged substrate underneath the South Jetty (e.g. plumose, hydroids, tunicates, anemones, giant rock scallops, nudibranchs, sea stars, and sea urchins as reported in Archipelago [2009]).
- Temporary displacement of motile marine invertebrates and benthic fishes during demolition and dredging works (e.g. Cancer crabs [Cancridae] and other crabs, coonstripe shrimps, gobies and unidentified sculpins underneath or near the South Jetty [Archipelago, 2009]).

5.2.2.1.2 Characterization of Project Effects

The potential environmental effects of Project activities to fish species that are part of a commercial, recreational or Aboriginal (CRA) fisheries, to fishes that support such a fishery, and to at-risk fish species were assessed, along with impacts to aquatic habitat. Pathways of Effects (DFO, 2010) were also considered, where applicable.

5.2.2.1.2.1 Shading of Marine Vegetation

The new South Jetty wharf structure will create shading within the footprint of the previous structure and no net increase in shading will occur. Since the footprint of the re-constructed South Jetty will be the same as before the commencement of the EGD Waterlot remediation works, and considering the low abundance of macroalgae recorded during the baseline studies (Archipelago, 2009), effects to marine vegetation as a result of shading is expected to be low.

5.2.2.1.2.2 Disturbance or Removal of Fisheries Resources

Due to the recent dredging and capping within the Project Area associated with the under-pier sediment remediation works, the substrate is not expected to yet be colonized. Therefore, no disturbance or removal of fisheries resources is expected with the Project works.

5.2.2.1.2.3 Direct Impact to Fish

Potential direct impacts to fish from the Project works include:

- Temporary impacts to fish through generation of turbidity, which may impair the gills of fish.
- The introduction of deleterious substances in the water, either through a pulse event (such as a spill) or gradual contamination (through various operational activities), could potentially result in fish kill (in the immediate vicinity) and/or reduction of productive capacity as a result of habitat destruction;
- Sound pressure in excess of 30 kPa from pile driving could result in injury to fish bladder, and possibly death of fish in the immediate area of pile installations, and can affect marine mammals identified (detail below).

5.2.2.1.2.4 Underwater Noise/Pressure

Underwater noise/ sound pressure generated from impact pile driving method can cause behavioural changes and physiological injuries in fishes and marine mammals. Effects may include Popper et al. (2014): Hearing impairment (either a temporary reduction in hearing sensitivity (>6 dB) from temporary threshold shift (TTS); and temporary masking of natural conspecific, competitor or predator sounds; or a permanent loss due to death of sensory hair cells, or damage to innervating auditory nerve fibers or other tissues in the auditory pathway)

- Damage to anatomical structures (e.g., hematoma, haemorrhage and/or laceration of fins, capillaries and organs; deflation, hematoma or laceration of swim bladder; etc.)
- Death (e.g., directly from barotrauma or indirectly from reduced fitness attributed to barotrauma that leads to predation or disease)

Recent studies have suggested the majority of sound pressure effects on fish and marine mammals occur mainly through behavioural responses as opposed to direct physical injury or mortality (Ellison et al., 2012; Popper et al., 2014). Impact pile driving may disrupt the behavior of marine mammals present within kilometers of the Site (Dahl et al., 2015), and may affect the animal's ability to grow, survive and reproduce. Popper et al., (2014) provides the following examples:

- Changes in swimming behaviour and orientation, including startle reactions
- Changes to schooling patterns and horizontal and vertical distributions
- Effects on communication between conspecifics and detection of predators or prey
- Population-level effects from disrupting migrations of sub-populations or impacts to success of breeding or foraging

As discussed in G3 (2014a), DFO has previously required a sound level limit of 30 kPa measured 1-2 m from the source in authorizations for projects involving pile driving. The 30 kPa limit of sound pressure is equivalent to a sound pressure level (SPL) of 210 dB (re 1 µPa; Richardson et al., 1995; Urich, 1975). SPLs associated with impact pile installation vary substantially and depend on many factors including pile type and diameter, substrate characteristics, hammer size, etc. (Popper *et al*, 2014).

In addition to the peak SPL, recent research has highlighted the importance of considering the sound exposure level (SEL) also expressed in decibels (dB; referenced to 1 uPa2·s). The cumulative SEL over the duration of the exposure is considered a more robust metric for evaluating the potential impact to marine animals of underwater noise associated with pile installation by impact hammers (Popper *et al*, 2014).

5.2.2.1.2.5 Light

As discussed in G3 (2014a), the use of spotlights or other directed sources of artificial light for night-time dock construction activities (and subsequent operations) may alter natural light regimes in aquatic environments and potentially disrupt fish and invertebrate behaviour

(e.g., increased/ decreased orientation, attraction or avoidance which can affect predator-prey relationships, foraging, reproduction, migration, communication and other behaviour [Rich and Longcore, 2006], and lead to changes in ecosystem function [Depledge et al., 2010]).

5.2.2.1.3 Mitigation Measures for Effects on Fish and Fish Habitat

The following measures will be implemented to mitigate for potential Project effects on fish and fish habitat:

- An EM will be on-site to monitor environmental compliance with the EMP during Project activities;
- Works will be conducted in a manner that does not result in the deposit of a deleterious substance into waters within or outside the Project Area;
- Water quality performance criteria and mitigation measures in section 5.2.1.3.2 of this EEE and procedures defined in the EMP (Appendix B) will be followed;
- A silt curtain or equivalent will be used around the Site if water quality criteria cannot be maintained; the silt curtain will be assessed daily to ensure it is functioning as required;
- Suspected or observed Pacific Herring spawn on equipment or substrate within or adjacent to the Project Area will be communicated to the DR as soon as possible, as stipulated in the EMP (Appendix B);
- The DR will assess the herring spawn and a management action or stop-work-order may be enacted until the eggs have hatched and detached from the equipment or Project Area as per the EMP. DR will contact DFO if necessary;
- When installing pilings, the use of vibrational pile driving techniques where practical and feasible are preferred over impact pile driving, to reduce the potential for higher SPLs underwater. The use of “vibro-hammers” for pile installation minimizes the effects on fish and marine mammals by decreasing the peak SPLs;
- Avoid or minimize the instances of multiple concurrent underwater noise generating activities when practicable (e.g., multiple pile driving activities at the same time). Where multiple underwater noise generating activities are required at the same time, they will be sequenced when possible to minimize the duration of overlapping activities;
- Underwater noise will be monitored as per the EMP (Appendix B), in accordance with the following:
  - the sound from pile driving will not exceed 30 kPa at a distance of <2 m outside of the Project Area;
  - if the sound level exceeds 30 kPa at a threshold distance of <2 m outside of the Project Area, efforts will be made to reduce the intensity of the sound generated through the use/ re-adjusting of bubble curtains. Multiple bubble curtains may be required.
- Minimizing potential effects on the marine environment from light pollution includes minimizing the use of spotlights and turning off unnecessary lights. Spotlights will be directed away from marine areas when possible or lights fitted with shrouds to direct light to the immediate work area;

- Cease in-water works if at any point it is suspected that fish may be harmed.

Although not anticipated, if the potential impacts on motile benthic invertebrates, such as crabs, sea stars and sea urchins at the Site became a concern (i.e., due to the presence or certain species and/or abundance of animals), these organisms could be removed (via SCUBA diving) and relocated to adjacent areas with similar habitat. Should a salvage of benthic marine invertebrates be required, an application for the appropriate permit has been submitted to DFO and a licence is expected to be issued before the commencement of the construction works.

5.2.2.1.4 Work Timing Windows

As indicated in the Request for Review (PWGSC, 2014) and supporting documents (G3, 2014a): "Subject to agreement by applicable regulatory agencies and the implementation of appropriate controls, some work will need to occur outside of these windows to accommodate the construction schedule and sequencing which is driven in part by operational considerations at the EGD."

The Project Area is located in DFO Area 19 – Victoria (DFO, 2014c). The following are time periods when the timing windows of least risk are open and construction may occur.

- Summer Window: July 1 to October 1; and,
- Winter Window: December 1 to February 15

Construction is scheduled to begin in late October 2016 (PWGSC, pers. comm.) and continue through to April 2018. There is a possibility returning adult Coho Salmon and Steelhead Trout could be migrating through the area in the fall and winter, respectively (Golder, 2012a). Juvenile salmon could also migrate through the area, in the spring. Spawning Pacific Herring could also be present from the end of February to April (Hay and McCarter, 2015). Although the risk to these species as a result of Project activities is considered low, the following specific mitigation measures could be implemented during periods of in-water works outside the timing windows:

- An EM will monitor all in-water activities due to potential presence of salmonids and/or Pacific Herring during respective sensitive periods;
- If salmonids and/or Pacific Herring are observed near the Site during respective sensitive periods, additional measures will be implemented to reduce the risk of serious harm to fish. Measures will be described in the Contractors EPP and may include:
  - Increased water quality sampling;
  - Increased sound pressure testing (i.e., during pile driving);
  - The installation of additional bubble curtain, silt curtain and/or other exclusion devices

Should the EM consider the above measures ineffective at protecting fish from serious harm, temporary cessation of in-water work may be recommended by the DR, until the risk is diminished or additional mitigation measures are implemented.

Summary of Potential Risks

The proposed Project works represent a low risk to CRA fishes (e.g. salmonids, Pacific Herring, Lingcod, rockfishes, etc.), given that the probability of negative interaction is low (as the habitat is generally unsuitable), and the consequence of such an unlikely interaction is mitigated by the implementation of provisions of this EEE and the EMP (Appendix B).

As discussed in Golder (2012a), sensitive fishes are not likely to occur in or around the Project Area due to the following reasons:

- Esquimalt Harbour does not have significant salmon spawning streams draining into it; therefore, returning spawners are not expected to be significantly present within Esquimalt Harbour;
- Esquimalt Harbour is not a common area of herring spawn; and,
- Esquimalt Harbour is not within or adjacent to a rockfish conservation area.

The mitigation measures are expected to be protective of Pacific Herring spawners from February to June; however, if herring spawn on equipment, equipment will need to be de-activated until herring eggs adhered to the equipment hatch and larvae have dispersed into the water column. Based on long-term records of herring spawning timing in the Strait of Georgia (Hay and McCarter, 1999), the likelihood of herring spawning on Project equipment is relatively low prior to March and after mid-April, as this is the range of first and last dates of spawning in the more recent period of record (i.e., mid 1980s to late 1990s).

Direct mortality due to suspended solids is not expected as the excavation works that have the potential to cause the greatest TSS will be occurring within the upper intertidal area which will be conducted during periods of low tide with a protective armour layer placed over disturbed sediments if the area will become exposed to tides and waves.

Summary of Mitigation Measures

The following mitigation measures will be implemented for the protection of fishes:

- Work will be discontinued in the event herring behaviour differs from the established and expected norms. If herring spawn on equipment, that equipment will be de-activated and the DR will be notified. Management actions or a stop-work-order will be enacted until eggs adhering to the equipment hatch and the larvae disperse into the water column (G3, 2014c);
- Harmful effects to migrating salmon in October and November are not expected provided that mitigation measures are applied (as discussed in Section 5.2.2.1.3 and 5.2.2.1.4).

5.2.2.1.5 Characterization of Residual Effects

No residual effects from the shading of marine vegetation, the loss of fish habitat and noise are expected after mitigation and compensation are applied. Some residual effects are expected as some temporary disruption to fishes and marine mammals may occur.

5.2.2.1.6 Significance of Residual Effects

Residual effects to invertebrate, fish and marine mammal are expected to be low as the effect is limited to the Project Area, is evident only during the duration of the Project and is occurring in a previously disturbed area.

5.2.2.2 Aquatic Mammals

5.2.2.2.1 Characterization of Project Effects

Based on a literature review performed by Golder (2012a) and G3 (2014a) and experience with similar projects, the likelihood for direct physical injury to aquatic mammals from interaction with vessel traffic or barge activity is expected to be low. Pinnipeds tolerate close and frequent approaches by vessels, as well as construction activity, and although they usually avoid areas of anthropogenic activity, they have been observed investigating project areas during work, with no evidence of adverse effect.

The potential for the Project to affect aquatic mammals (i.e., harbour seals, Steller/California sea lions and river otters) is mainly related to underwater noise from pile driving. These have the potential to disturb mammals present in the area. Disturbing marine mammals is prohibited under the *Fisheries Act* (Marine Mammal Regulations). As there are currently no applicable underwater noise criteria for physical injury or behavioural disturbance in Canadian legislation, the assessment of underwater noise effects on aquatic mammals was therefore based on noise levels reported in the available literature (Golder, 2012a; G3, 2014a).

The threshold peak impulse sound pressure level (SPL) for direct physical trauma or injury to aquatic mammals is generally considered to be >200 dB (re 1 µPa; Gordon et al., 2003). The underwater noise pressure threshold for behavioural disturbance to pinnipeds is 160 dB (re 1 µPa) for pulsed sounds (e.g., impact pile driving), and 140 dB (re 1 µPa) for continuous sounds (e.g., dredging; Southall et al., 2007). A SPL of 140 dB (re 1 µPa) is similar to a sound pressure of 0.01 kPa, 160 dB (re 1 µPa) is similar to a sound pressure of 0.1 kPa and 200 dB (re 1 µPa) is similar to a sound pressure of 10 kPa (Richardson et al., 1995; Urich, 1975).

Measured in-water SPLs resulting from impact pile driving (i.e., via hammer) have ranged from 131 to 135 dB (re 1 µPa) at a distance of 1,000 m from the source, and up to 200+ dB (re 1 µPa) at 1 m from the source (Richardson et al., 1995). Based on these values and standard noise attenuation losses in water, physical injury/hearing impairment from sound pressures generated by pile-diving is not expected for aquatic mammals occurring at a distance >100 m from the source. Impact pile driving noise is more likely to result in behavioural effects to aquatic animals than physical injury; if unmitigated, pile driving noise may result in masking of communication and other environmental sounds, or produce a startle response which could temporarily displace animals. No effect at the population level is anticipated and behavioural disturbance, should it occur, will likely be confined to a small number of individuals due to the low abundance of aquatic mammals recorded in Esquimalt Harbour (G3, 2014a).

5.2.2.2.2 Mitigation Measures for Effects on Aquatic Mammals

The following measures will be implemented to mitigate potential effects of construction on marine mammals (Golder, 2012a; G3, 2014a):

- Monitoring for aquatic mammals will be implemented by the EM during any in-water activities.
- A visual watch will be maintained within Constance Cove for pinniped (e.g., harbour seals) or cetaceans (e.g., harbour porpoise) during pile driving, along with underwater sound pressure monitoring (via hydrophone). There are 3 aquatic mammal zones around the Project Area (Appendix A4 from G3, 2014a):
  - a Discretionary Pinniped Safety Zone (25 m from the Project Boundary);
  - a Discretionary Cetacean Safety Zone (500 m from the western most point of the Project Boundary); and,
  - a Cetacean Safety Zone (500 m from the in-water works and sliding east-west as in-water work progresses east-west).
- If any aquatic mammal enters the applicable Discretionary Zone the environmental monitor will assess the potential for activities to disturb or interfere with the aquatic mammal. Low risk activities may continue at the discretion of the DR.
- If a cetacean enters the Cetacean Safety Zone all in-water work will be suspended and the DR will be contacted by the EM for direction.
- Should a marine mammal be seen within the established Safety Zones, activities will be suspended until the animal exits the appropriate zone, or if no subsequent sighting occurs for 10 minutes after the initial observation.[5]
- The safety zone for pinnipeds and cetaceans was set in consultation with DFO (March 11, 2011) which has a mandate to specifically address protection of listed species. Cetaceans are not expected to be present in Esquimalt Harbour; however, there have been SARA-listed species observed in the lower Vancouver Island region.
- In the event that a marine mammal becomes trapped within the Project Area, the observer shall contact the DR immediately. The DR may contact the Fisheries and Oceans Canada Injured and Distressed Marine Mammal Reporting Hotline at 1-800-465-4335. Under no circumstances will any Contractor, EM or DR attempt to capture or molest any aquatic mammal.
- The approach to pile installation will, when practical and feasible, maximize the use of vibration pile driving over impact pile diving as the former method is associated with lower underwater sound pressure levels.
- Pile driving noise attenuation methods (such as bubble curtains) and deterrent techniques (such as 'soft start'/ ramping procedure – commencing each pile drive with a few half-strength strikes) will be used whenever possible.

[5] Hauled-out pinnipeds are considered to be in a low risk situation; suspension of work is not required unless signs of distress are observed in these animals.

- The sound will not exceed 30 kPa at a distance of <2 m from source of sound (monitored in accordance with the EMIP). If the sound level exceeds 30 kPa at a threshold distance of <2 m from source of sound, efforts will be made to modify the activity to reduce the intensity of the sound generated as per the EMP.
- Concurrent multiple underwater noise generating activities will be minimized when practicable (e.g., avoiding multiple pile driving activities at the same time). Where multiple underwater noise generating activities are planned, they will be sequences where possible to minimize construction duration.

5.2.2.2.3 Characterization of Residual Effects

Residual effects on aquatic mammals from Project activities are anticipated to be low. Residual effects are not expected from underwater noise and disturbance from in-water activities. It is expected that the proposed 'soft start' procedure will result in aquatic mammals temporarily leaving the area during impact pile driving; however, all species are expected to return once these activities have been completed.

5.2.2.2.4 Significance of Residual Effects

Since the area has a low abundance of fish and invertebrates (Archipelago, 2009), it is not considered an important feeding ground for aquatic mammals. Any residual effects on aquatic mammals are expected to be low (in terms of number of animal effects and the magnitude of the effect) and temporary in nature.

5.2.2.3 Birds

5.2.2.3.1 Characterization of Project Effects

Noise/Light/Air Quality

Noise, light and fumes generated during construction and operations could result in bird avoidance of the Project area.

The primary sources of concern for noise during the Project will be combustion engines and pile driving. Noise levels experienced by the operators of heavy machinery have been measured in the range of 86–102 dBA for equipment such as excavators, backhoes, and mobile cranes (WCB, 2000). Pile driving equipment causes similar (diesel and pneumatic types) or lower (gravity or bored types) areal noise levels. With the possible exception of impact pile driving, noise levels generated during the Project are expected to be similar to those listed above in the immediate vicinity of the source and is moreover expected to dissipate to or lower than levels measured for typical EGD operations. If left unmitigated, noise could result in masking of communication and other environmental sounds that animals listen to and/or produce a startle response potentially displacing animals.

Night-time construction activities and dock operations may involve the use of spotlights or other directed sources of light to illuminate the work space. Artificial light may disrupt animal behaviour; it may cause increased/ decreased orientation, attraction or avoidance which can affect predator-prey relationships, foraging, reproduction, migration, communication and other behaviour (Rich and Longcore, 2004). The potential for nuisance effects from light is similar to that for typical EGD activities (G3, 2014a). No effect at the population level is anticipated and behavioural disturbance, should it occur, will likely be confined to the number of individuals present in the vicinity of the Project Area at any given time.

Nesting

Disturbing nesting birds or their nest is prohibited under the provincial *Wildlife Act*. There was an osprey nest located on a high-mast light standard on South Jetty, which was relocated to outside the Project Area (under Permit #NA 12-76959).

Birds observed in and adjacent to Esquimalt Harbour during annual Christmas bird counts include loons, grebes, cormorants, herons, geese, ducks, gulls, raptors and passerines (among others; VNHS, 2013). Although birds may travel thought and forage in the Project Area, most are unlikely to nest due to limited nesting habitat in the Project Area (Golder, 2012a). Passerine birds may nest adjacent to the Project Area in trees and shrubs along the shore. Birds that temporarily occur in the Project Area are not likely to be affected by the Project.

Harmful Substances

The deposition of substances harmful to birds is prohibited in waters or areas frequented by migratory birds, under the federal *Migratory Birds Convention Act* (1994). Birds have been observed foraging in the area (anecdotally); therefore, the primary concern is the release of a substance or chemical into the environment that a bird may ingest or come into direct contact with.

5.2.2.3.2 Mitigation Measures for Effects on Birds

The following measures will be followed to mitigate effects on birds:

- All previously described mitigation measures to prevent the release of deleterious substances must be followed.

The following measures will be followed to mitigate effects from noise and light:

- Maintain equipment in good working order and switch it off when not in use;
- Implement best practices for construction such as installation mufflers on machinery for noise control;
- Employ noise barriers if applicable;
- The use of soft-start procedures for impact pile driving may serve as a deterrent to birds; allowing them to exit the immediate work area before noise levels ramp up;

- Contractor to meet the construction noise level guideline (85 dBA; subject to change based on public feedback) at property boundary or modify activities;
- Undertake noisier work during daytime hours and modify activities based on noise monitoring and resident feedback;
- Unnecessary lighting will be shut off when not in use;
- Spotlights will be directed away from residential areas or lights will be fitted with shrouds to direct light to the immediate work area.

To mitigate effects on nesting, mitigation measures will include the following:

- The EM must notify the DR if nesting activities are observed within the Project Area.
- If nests or nesting activity is encountered the DR will immediately be notified by the EM and if possible, the nests will be removed after regulatory permits are obtained. If possible, any nest will relocated by a qualified QEP to an appropriate location (BCMOE, 2005a) in consultation with the BCMOE and in accordance with the *BC Wildlife Act* and federal Migratory Birds Regulations (pursuant to the *Migratory Birds Convention Act*).

5.2.2.3.3 Characterization of Residual Effects

There are not expected to be any residual effects from the South Jetty reconstruction after the identified effects discussed in Section 5.2.2.3.1 (e.g., harmful substances, noise, light, air quality) are mitigated if monitoring is conducted and work is modified/ stopped as required. If nesting is observed the appropriate course of action will be determined in consultation with BCMOE and in accordance with the BC *Wildlife Act* and federal Migratory Birds Regulations (pursuant to the *Migratory Birds Convention Act*).

5.2.2.3.4 Significance of Residual Effects

Residual effects on birds from the Project activities are expected to be low.

5.2.2.4 Species at Risk

5.2.2.4.1 Birds

5.2.2.4.1.1 Characterization of Project Effects

Federally and provincially listed bird species that may temporarily occur in the Project Area but are not likely to be affected by the Project are presented in Table B2 (Golder, 2012a; G3, 2014a).

5.2.2.4.1.2 Mitigation Measures to Protect Bird Species at Risk

Mitigation measures to protect birds listed as Species at Risk are the same as those for unlisted birds and are outlined in Section 5.2.2.3.2.

5.2.2.4.1.3 Characterization of Residual Effects

Residual effects on birds listed as Species at Risk are the same as those for unlisted birds and are outlined in Section 5.2.2.3.3.

5.2.2.4.1.4 Significance of Residual Effects

It is anticipated that no residual effects (Table 5-1) are expected from work within the area if monitoring is undertaken and work is stopped or modified as necessary.

5.2.2.4.2 Fish

5.2.2.4.2.1 Characterization of Project Effects

No listed fish species are expected to be present.

5.2.2.4.2.2 Mitigation Measures to Protect Fish Species at Risk

Not required.

5.2.2.4.2.3 Characterization of Residual Effects

Not required.

5.2.2.4.2.4 Significance of Residual Effects

Not required.

5.2.2.4.3 Invertebrates

5.2.2.4.3.1 Characterization of Project Effects

Not applicable.

5.2.2.4.3.2 Mitigation Measures to Protect Invertebrate Species at Risk

Not applicable.

5.2.2.4.3.3 Characterization of Residual Effects

Residual effects are not expected after mitigation measures are implemented.

5.2.2.4.3.4 Significance of Residual Effects

Not applicable.

5.2.2.4.4 Aquatic Mammals

5.2.2.4.4.1 Characterization of Project Effects

Three SARA-listed marine mammal species have some potential to occur in the Project Area: Steller sea lions (*Eumetopias jubatus*), harbour porpoises (*Phocoena phocoena*) and killer whales (*Orcinus orca*). Although a Steller sea lion has been previously observed in the Project Area, Esquimalt Harbour is not considered important habitat for this species. Harbour porpoises and killer whales have not been reported in the Project Area, and are not expected to occur in Esquimalt Harbour during Project works (Golder, 2012a; G3, 2014a). Effects to listed aquatic mammals are similar to those effects outlined in the Aquatic Mammal Section 5.2.2.2.1.

5.2.2.4.4.2 Mitigation Measures to Protect Aquatic Mammal Species at Risk

Mitigation measures outlined in Section 5.2.2.2.2 will be implemented to mitigate effects to listed aquatic mammals.

5.2.2.4.4.3 Characterization of Residual Effects

Residual effects on SARA-listed aquatic mammals are expected to be low and are the same as those outlined in Section 5.2.2.2.3 for unlisted aquatic mammals.

5.2.2.4.4.4 Significance of Residual Effects

See Section 5.2.2.2.4 for the significance of residual effects on aquatic mammals.

5.2.2.5 Shading of Marine Vegetation (Algae/Eelgrass)

5.2.2.5.1 Characterization of Project Effects

No marine vegetation is expected to be present. There is expected to be no net change in productivity or abundance.

5.2.2.5.2 Mitigation Measures for Effects on Marine Vegetation

Not applicable

5.2.2.5.3 Characterization of Residual Effects

Not applicable

5.2.2.5.4 Significance of Residual Effects

Not applicable

5.3 Socio-Economic Components

5.3.1 Fisheries

5.3.1.1 Characterization of Project Effects

Active fisheries in Esquimalt Harbour include a small-scale commercial squid fishery, a Coho Salmon recreational fishery, and a First Nations fishery. These fisheries could be impacted through degraded water quality and through potential mortality of fish from Project activities. Interference with fishery vessels is not expected since the Waterlot is a restricted access area where fishing is not allowed.

5.3.1.2 Mitigation Measures

To mitigate effects to fisheries, measures outlined in the Water Quality Section and the Fish and Fish Habitat Section will be implemented.

5.3.1.3 Characterization of Residual *Effects*

Residual effects after mitigation are not expected.

5.3.1.4 Significance of Residual *Effects*

Not applicable.

5.3.2 Human Health & Safety

5.3.2.1 Characterization of Project Effects

Human health and safety could be affected by direct contact with contaminated sediments during the excavation works at the East Approach.

5.3.2.2 Mitigation Measures

Personal protective equipment (i.e., gloves) will be worn by workers to avoid direct contact with potential contaminants in the excavated sediment.

5.3.2.3 Characterization of Residual Effects

No residual effects are expected after mitigation.

5.3.2.4 Significance of Residual Effects

Not applicable.

5.3.3 Noise and Light

5.3.3.1 Characterization of Project Effects

The primary noise sources of concern during the Project will be combustion engines and pile driving activities. Noise levels experienced by the operators of heavy machinery have been measured in the range of 86–102 dBA for equipment such as excavators, backhoes, and mobile cranes (WCB, 2000). Pile driving equipment causes similar (diesel and pneumatic types) or lower (gravity or bored types) noise levels.

With the exception of impact pile driving, the noise from equipment used for the South Jetty Reconstruction Project is expected to be similar to that listed above in the immediate vicinity of the source and is moreover expected to dissipate to or lower than levels measured for typical EGD operations, although it is possible that impulsive (i.e., abrupt and short lived) sound such as may be caused by metal striking metal may exceed specified bylaw noise levels.

The Project Area will need to be lit during night-time works. The potential for nuisance effects from light is similar to that for typical EGD activities.

5.3.3.2 Mitigation Measures

The following measures will be implemented to mitigate effects from noise and light on the workers and community:

- Maintain equipment in good working order and switch it off when not in use;
- Implement best practices for construction such as installation mufflers on machinery for noise control;
- Workers shall wear appropriate personal protective equipment (PPE);
- Contractor will follow all EMP BMPs;
- Contractor will meet the construction noise level guideline (85 dBA; subject to change based on resident feedback) at property boundary or modify activities;
- Noisier work (such as impact pile driving) shall be undertaken during daytime hours and activities modified based on noise monitoring and resident feedback; and,
- Spotlights will be directed away from residential areas or lights will be fitted with shrouds to direct light to the immediate work area.

In addition to these mitigation measures, a notice for the Project will be distributed to nearby residences and a 24 hour hotline at EGD will be available for residents to call with noise concerns.

5.3.3.3 Characterization of Residual Effects

Residual effects may include some short-term disturbance to nearby residents, depending on the type of noise.

5.3.3.4 Significance of Residual Effects

After mitigation, the significance of residual effects is expected to be low as the effect is at or nominally above baseline conditions; the effects is evident only during the duration of the Project and the effect is readily reversible.

5.3.4 Archaeology

5.3.4.1 Characterization of Project Effects

None applicable.

5.3.4.2 Mitigation Measures

In the event of an archaeological find, Chance Find Procedures shall be followed by the Contractor.

5.3.4.3 Characterization of Residual Effects

None applicable.

5.3.4.4 Significance of Residual Effects

None applicable.

5.4 Effects Assessment of Environment on the Project

5.4.1 Tides, Wind, Waves & Heavy Rain

5.4.1.1 Characterization of Project Effects

Works will not be conducted when adverse weather conditions are present. The project will take into account weather warnings are issued by Environment Canada.

5.4.1.2 Mitigation Measures

The following measures will be implemented to mitigate negative effects of the environment on the Project:

- Tide tables, current tables and marine weather reports will be consulted daily, prior to commencing work, and as necessary throughout the day, to avoid adverse environmental interactions.
- Work will not take place during times when adverse environmental conditions are present; work shall not be conducted during heavy rains, rough weather and sea conditions (e.g., strong winds and waves). Marine weather and sea conditions may change rapidly; forecasts are to be consulted as necessary.
- The Contractor may stop work due to Health and Safety concerns based on weather conditions. The decision regarding whether to work will be made by the Contractor in coordination with PWGSC and QHM.
- PWGSC has the authority to direct the Contractor to stop work if deemed necessary;

5.4.1.3 Characterization of Residual Effects

No residual effects are expected after mitigation measures are implemented.

5.4.1.4 Significance of Residual Effects

Not applicable.

5.5 Accidents & Malfunctions

Accidents that could occur during the construction and operational phases of the Project include vessel collisions and groundings. Malfunctions may involve machinery break-down, equipment maintenance, emissions and waste materials. Spills of deleterious substances, such as fuel and hydraulic fluid, from the barge or other mechanical equipment are also possible (G3, 2014a). To mitigate negative effects to the environment from accidents and malfunctions, the following measures will be implemented:

- Work will be conducted in accordance with the requirements of this EEE, the EMP, WQMP, industry standards, all relevant federal and provincial legislation (e.g., *Fisheries Act* and *BC Environmental Management Act*) and municipal bylaws.
- Project components will comply with the provisions of the *Navigation Protection Act*.
- Marine work will be conducted in accordance with the *Canada Shipping Act* and regulations and orders pursuant to the Act, including displaying appropriate lights/day signals (Collision Regulations) and the qualification of operating personnel.
- Vessels and machinery will arrive on site in a clean/good condition and are to be maintained free of fluid leaks and invasive species.
- Vessels and equipment will be inspected daily for malfunctions, leaks. The Contractor will maintain logged records of inspections.
- All work will be conducted in a manner that does not result in the deposit of a toxic or deleterious substance into any watercourse.

- Refuelling and washing of machinery or equipment will take place in designated areas as defined in the final contractor EPP. No regulated watercourse or municipal storm sewer will be negatively affected by refuelling and/or washing of machinery or equipment.
- Appropriate spill control equipment (e.g., spill kits) will be kept on site during the work. Operating personnel are to be familiar with the contents and use of spill response equipment and the location and operation of emergency 'shut-offs.
- A spill prevention plan and emergency response procedures are to be developed by the Contractor and posted on-site.
- Tide tables, current tables and weather reports will be consulted prior to commencing work to avoid adverse environmental interactions such as barge grounding. Work will not take place during times when adverse environmental conditions are present; dredging shall not be conducted during rough weather and sea conditions (e.g., strong winds and waves). Marine weather and sea conditions may change rapidly; forecasts are to be consulted as necessary.;
- Contractor may decide to stop work due to Health and Safety concerns based on weather conditions. The determination regarding whether to work, based on weather conditions, will be made by the Contractor in coordination with PWGSC and QHM. PWGSC has the authority to direct the Contractor to stop work if deemed necessary.
- General waste materials are to be contained on-site for appropriate off-site disposal. Garbage bins with appropriate lids are to be used on-site. Materials and debris are not allowed to become waterborne. During periods of wind and waves, the barge and work areas are to be inspected to make sure garbage containers and materials are secured.

5.6 Follow-up Requirements

Since no significant adverse residual environmental effects after mitigation are anticipated as a result of the South Jetty reconstruction activities, a post-construction program is not currently prescribed.

5.7 Environmental Monitoring

A qualified Environmental Monitor (EM) will be retained by the Contractor to oversee, evaluate and report on the implementation and effectiveness of the environmental mitigation and control measures. The authority of the EM will be presented in the contractor EPP. The EM will be present on-Site during construction activities that could result in serious harm to fish and fish habitat, and will conduct regular inspections (which may be concurrent with the above). The EM will be responsible for communicating the mitigation measures and best management practices to implement by the construction crew. The EM will also assist the Contractor with achieving the objectives of the EMP, and Contractor's EPP, as well as the conditions of the regulatory approvals and permits for the Project. Where possible, practices described in *A Users' Guide to Working In and Around Water* (BCMOE, 2005b) will be applied.

The EGD has implemented an Environmental Management System (EMS) certified under ISO 14001 standard: "the EMS provides a framework for identifying potential impacts, and ensures adequate controls are in place to effectively manage them" (PWGSC, 2010). The environmental BMPs are prescribed to reduce potential environmental impacts of common activities and operations at the EGD.

Environmental monitoring tasks will be conducted by, or under the supervision of a QEP (e.g., qualified RPBio.) with suitable education, experience, accreditation and knowledge that they may reasonably be relied upon to provide advice regarding environmental management of the Project.

Various personnel may be required to undertake different monitoring components for the Project (e.g., water quality, aquatic mammals, etc.) and the experience of the personnel used shall reflect those needs.

Tasks to be performed by the EM include, but may not be limited to:

- Conducting water quality monitoring;
- Conducting marine mammal monitoring (visual and/or acoustic, as required);
- Communicating directly with DR regarding the monitoring results;
- Providing ongoing guidance to the DR on the implementation of mitigation and control measures;
- Assessing whether environmental mitigation and control measures are functioning as desired; and,
- Documenting and reporting on work activities and the implementation of environmental mitigation measures.

The DR will communicate directly with the Contractor regarding management actions, including stop-work-orders. The EM will contact the DR immediately if a stop-work-order is required under the following conditions:

- If activities are contravening the mitigation measures recommended in this EEE, or EMP;
- If activities contravene the terms and conditions of environmental permits and approvals; and,
- If the construction activities contravene existing legislative and regulatory requirements.

Should a stop-work-order be considered necessary, Project activities that are causing any noncompliance to initiate the stop-work-order will be suspended only under the direction of the DR, until a solution is identified and corrective measures are implemented to achieve compliance with requirements. After the corrective measures are implemented and there is conformance, the works may continue.

The EM will be responsible for preparing the following environmental reports:

- Technical memoranda summarizing pre-work environmental orientation meetings;

- Weekly environmental monitoring reports summarizing the environmental issues encountered and mitigation measures implemented to resolve any issues;
- Environmental incident reports, including non-compliance issues or concerns will be provided to the DR for review and distribution to regulatory agencies; and
- Environmental Monitoring Completion Report including representative photographs, and a factual summary of construction activities, water quality results, effectiveness of mitigation measures, and how problems were managed.

The EM will monitor work performance against the requirements outlined in regulatory approvals, Authorizations, permits, and EMP, as well as environmental protection goals provided in the EMP and contract requirements. The DR will perform regular audits of the project to confirm adequate monitoring and environmental compliance is occurring.

5.8 Environmental Management Plan

The development and implementation of an EMP and environmental monitoring program will clearly define the procedures and controls to achieve mitigation of potential Project effects, and objectives to maintain environmental performance. The following are some of the elements which will be considered in the EMP:

- Water quality management plan
- Fisheries and wildlife protection plan
- Sediment and erosion control plan
- Air quality monitoring plan
- Noise control plan
- Fuels, chemicals and materials storage and handling plan
- Spill response plan
- Waste and hazardous waste management plan

An EMP, prepared by G3 (2014c) and revised to address the activities and environmental requirements anticipated for the South Jetty Reconstruction Project (Appendix B) and will form the basis for the Contractors EPP. The purpose of the EMP is to provide guidance to the Contractor with a comprehensive set of guidelines for protecting VECs during the Project by avoiding, where possible, and mitigating potential adverse effects. The EMP includes information on applicable environmental legislation and regulations, environmental monitoring responsibilities, and environmental construction requirements (such as performance objectives for water quality management). The EMP also outlines requirements for the Contractor's EPP to address emergency spill response and waste management. The Contractor will be required to provide PWGSC with an EPP to detail how the environment will be protected as laid out in the EMP.

6. PROFESSIONAL STATEMENT

Findings presented in this assessment are based upon (i) reviews of available documentation and discussions with available personnel and regulatory representatives, (ii) review of available records and the terms and conditions for the planned activities. Consequently, while conclusions and recommendations documented in this report have been prepared in a manner consistent with that level of care and skill normally exercised by other members of the environmental science and engineering profession, practising under similar circumstances in the area at the time of the performance of the work, this report is intended to provide information and to suggest mitigation strategies to reduce, but not necessarily eliminate, the potential for environmental impacts to occur as a result of planned activities in the Study Area. This management plan is meant to be a living and flexible document that can be used to provide guidance regarding appropriate management of species.

This environmental assessment has been prepared solely for the internal use of PWGSC on behalf of DND, and federal agencies providing expert advice to the project pursuant to the agreement between Keystone Environmental Ltd. and PWGSC. Any use which other parties make of this report, or any reliance on or decisions made based on it, are the responsibility of such parties. Keystone Environmental Ltd. accepts no responsibility for damages, if any, suffered by other parties as a result of decisions made, or actions based, on this report.

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7. REFERENCES

7.1 Legislation and Bylaws

7.1.1 Federal Acts

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  - Natural and Man-made Harbour Navigation and Use Regulations
- *Canada Shipping Act,* 2001 (amended 2013)
  - Collision Regulations
- *Canadian Environmental Assessment Act,* 2012 (amended 2013)
  - Regulations Designating Physical Activities
- *Canadian Environmental Protection Act,* 1999
- *Constitution Act*, 1982
- *Fisheries Act,* 1985 (amended 2013)
  - Marine Mammals Regulations
- *Migratory Birds Convention Act,* 1994
  - Migratory Birds Regulations
- *Navigation Protection Act,* 2014
- *Species At Risk Act,* 2003 (amended 2013)
- *Transport of Dangerous Goods Act,* 1992 (amended 2009)

7.1.2 Provincial Acts

- *Environmental Management Act*, 2003
  - Contaminated Sites Regulation
  - Hazardous Waste Regulation
  - Spill Reporting Regulations
- *Heritage Conservation Act*, 1996
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APPENDIX A

FIGURES

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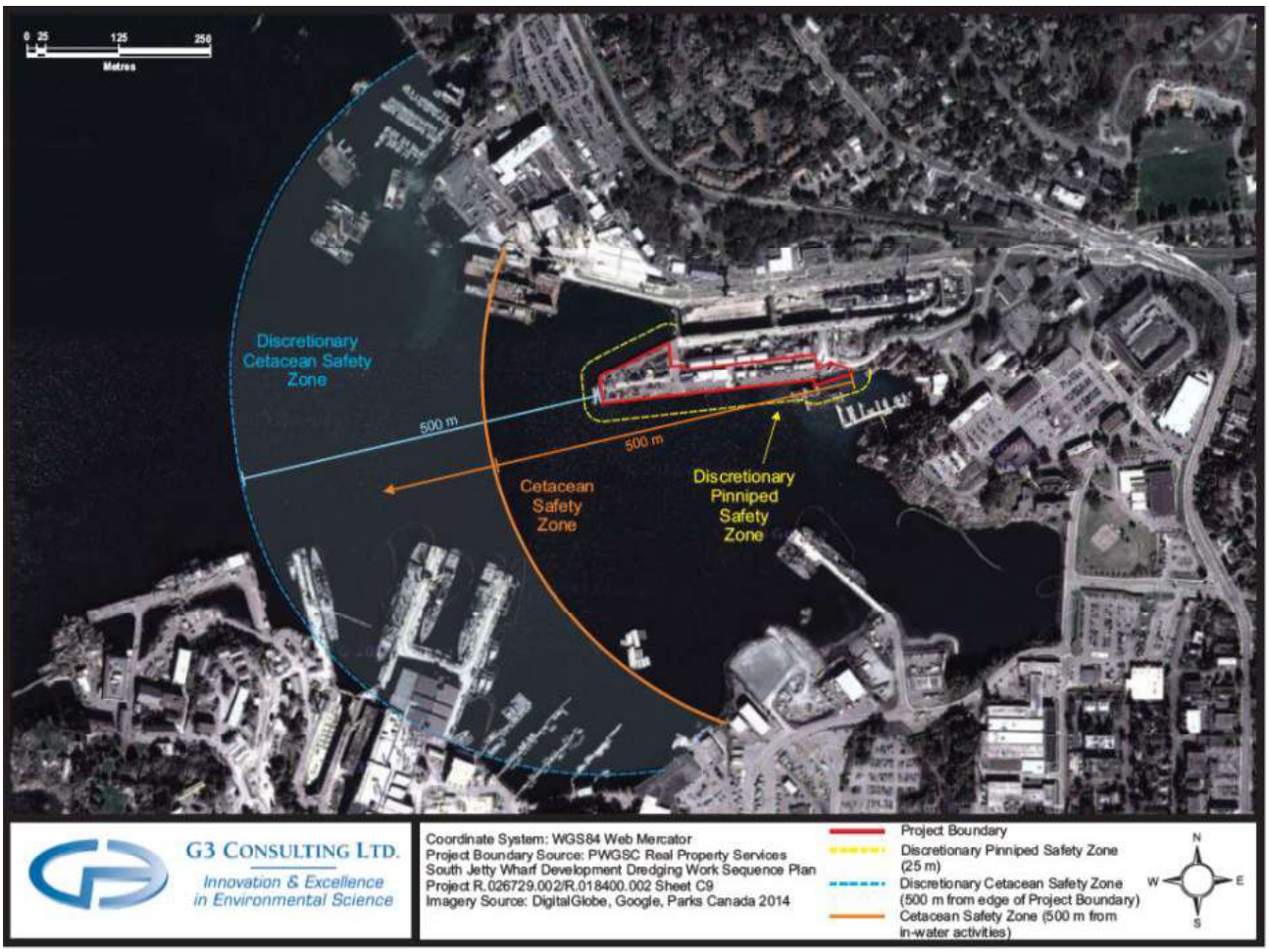

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ESQUIMALT GRAVING DOCK

ENVIRONMENTAL MANAGEMENT PLAN

KEYSTONE ENVIRONMENTAL (2016)

Number of Pages: 199

Keystone Environmental
Knowledge-Driven Results

ENVIRONMENTAL MANAGEMENT PLAN

Esquimalt Graving Dock
South Jetty Reconstruction Project
Esquimalt, BC

Prepared for:

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LIST OF ACRONYMS

BCMPDCA	British Columbia Marine and Pile Driving Contractors Association
BMP	Best Management Practices
DFO	Fisheries and Oceans Canada
DND	Department of National Defence
DPM	Deputy Project Manager
DR	Departmental Representative
EC	Environment Canada
EEE	Environmental Effects Evaluation
EGD	Esquimalt Graving Dock
EIR	Environmental Incident Report
EM	Environmental Monitor
EMBC	Emergency Management BC
EMIP	Environmental Monitoring Implementation Plan
EMP	Environmental Management Plan
EPP	Environmental Protection Plan
ESCP	Erosion and Sediment Control Plan
H_2S	Hydrogen sulphide
HWM	High Water Mark
MWLAP	Ministry of Water, Land and Air Protection
MOE	Ministry of Environment
MSDS	Material Safety Data Sheets
PCO	Project Coordination Officer
PWGSC	Public Works and Government Services Canada
QEP	Qualified Environmental Professional
QHM	Queens Harbour Master
SBPISW	Standards and Best Management Practices for Instream Works
SPM-O	Senior Project Manager — Operational (also acts as the DR)
SPM-T	Senior Project Manager – Technical
TC	Transport Canada
TRB	Temporary Resuspension Barrier
VNHS	Victoria Natural History Society
WHMIS	Workplace Hazardous Materials Information System
WQMP	Water Quality Monitoring Plan

UNITS

cm	Centimetre
dB	Decibel
kPA	Kilo Pascal
m	Metre
m^2	Square metre
m^3	Cubic metre
NTU	Nephelometric Turbidity Units
$\mu g/m^3$	Micrograms per cubic meter

1. INTRODUCTION

This Environmental Management Plan (EMP) was prepared by Keystone Environmental Ltd. (Keystone Environmental) on behalf of Public Works and Government Services Canada (PWGSC) for the Esquimalt Graving Dock (EGD) South Jetty Reconstruction Project (the Project), located on the north shore of Constance Cove, in Esquimalt Harbour, Vancouver Island (Appendix A, Figure A1). The EMP was adapted in part from the EGD Phase 2 South Jetty Under-Pier Sediment Remediation Project EMP prepared by G3 Consulting Ltd. (G3, 2014) for PWGSC.

The Contractor will be responsible for compliance with all applicable environmental protection measures. Regardless of company affiliation or source, all subcontractors are subject to the same rules and regulations as the Contractor and must abide by the conditions of regulatory approvals obtained for the reconstruction works. This EMP applies to all Contractors involved in the Project and any personnel, whether working for the Contractor or observing/monitoring on-Site during reconstruction works. Thus, where the word "Contractor" is used, it applies to any company or personnel as described above.

1.1 Project Description and Schedule

The EGD is located at 825 Admirals Road in Constance Cove, in Esquimalt Harbour, Esquimalt BC. The South Jetty is located at Universal Transverse Mercator (UTM) coordinates 10U 0468483E 5364805N (Latitude 48.435640, Longitude 123.425891). The Project works will occur within the Project Area as shown in the Herold (2016) Site Plan (Appendix A).

The objective of the Project is to reconstruct the South Jetty wharf structure that was demolished in 2015/2016 as part of the Phase 2 waterlot remediation works recent completed at the Site. Construction of the new South Jetty will involve driving new steel piles in a grid pattern, the construction of a new deck out of pre-cast and cast-in-place concrete, and the integration of the various mechanical, electrical and water services (Herold, 2016). The tug boat wharf in the southeast corner of the Project Area and the east end approach will be redesigned and rebuilt to suit the EGD facility's current and future needs.

The South Jetty structure will be supported by steel pipe piles (installation method to be determined by the Contractor). Piles will be driven through the remediated area with the capping material either conserved or replaced. Formwork, rebar and tremie concrete (for displacement pile caps next to the timber crib) will be placed underwater by divers (Golder, 2012). Reinforced concrete pile plugs (connection of piles to cap beams), pre-cast concrete cap beams, pre-cast utilidor sections, and pre-cast fender panels (includes grouting) will be installed in the intertidal area. Installation of pre-cast concrete beams (for deck support, includes grouting), formwork, rebar and concrete for cast-in-place deck slab above the High Water Mark (HWM).

Based on preliminary design drawings and information provided in Appendix A by Herold (2016), the Project Area encompasses an area of approximately 23,850 m^2 with two work areas defined within the Project Area: the south jetty section (approximately 95 m by 56 m and 5,320 m^2) and the west jetty section (approximately 24.5 m by 220 m and 5,390 m^2).

The substrate elevation within the Project Area ranged from approximately -12.0 m to 5.0 m chart datum prior to dredging and capping works as shown in Appendix A (Herold, 2016).

Herold (2016) outlined the following Project works:

- Driving 67 (+/- 3) – 914 mm diameter steel piles.
- Driving 140 (+/- 3) – 762 mm diameter steel piles.
- Precast concrete pile caps fabricated offsite to be installed on piles, including seven precast caps installed at the mud line with cast in place securements.
- Precast concrete deck panels fabricated offsite to be installed on pile caps.
- Cast in place concrete topping slab to be poured above deck panels.
- Construction of cast in place concrete retaining wall at east end within upper intertidal zone.

In the intertidal area at east approach, granular sub-base foundation will be placed and compacted for concrete retaining wall, as well as formwork, rebar and concrete for cast-in-place retaining wall (Golder, 2012a; G3, 2014c; PWGSC, 2014). Under-deck stormwater drainage pipework, fenders, mooring bollards, wharf ladders, utility kiosks, and miscellaneous deck hardware will be installed (Golder, 2012a; PWGSC, 2014).

Minor earthworks will also occur within the upper intertidal zone to tie in the new East Approach retaining wall with the existing retaining wall with the in the northeast corner of the Project Area (see Appendix A). From these works, approximately 900 m^3 of excavated material will be stockpiled on site, tested for potential contaminants and disposed accordingly.

In addition to these works, the tug boat facility (i.e., float) at the east approach of the South Jetty will be reinstalled with new piles.

The reconstruction of the South Jetty is scheduled to begin in October, 2016 and continue for a year and a half until April 2018.

1.2 Review, Permitting and Applicable Legislation

The following federal, provincial and municipal regulatory requirements have been considered during the preparation of this EMP.

1.2.1 Federal Acts

Construction activities shall be conducted in accordance with federal Acts and Regulation, including the following:

Table 1-1 Federal Acts

Federal Act	Regulation/Schedule
Canada Marine Act,1998 (amended 2014)	Natural and Man-made Harbour Navigation and Use Regulations
Canada Shipping Act, 2001 (amended 2013)	Collision Regulations
Canadian Environmental Assessment Act, 2012 (amended 2013)	Regulations Designating Physical Activities
Canadian Environmental Protection Act, 1999	
Constitution Act 1982	
Fisheries Act, 1985 (amended 2013)	Marine Mammals Regulations
Migratory Birds Convention Act, 1994	Migratory Birds Regulations
Navigation Protection Act, 2014 (formerly the *Navigable Waters Protection Act*, 1985)	Navigable Water Works Regulations
Species At Risk Act, 2003 (amended 2013)	Schedule 1 – List of Wildlife Species at Risk
Transportation of Dangerous Goods Act, 1992 (amended 2009)	

1.2.2 Provincial Acts

While works are being conducted on a federally-managed site, provincial acts and regulations may apply to aspects of the work depending on the Contractor's methodology. The Contractor will be responsible for complying with any applicable provincial requirements, which may include the following:

Table 1-2 Provincial Acts

Provincial Act	Regulation/Code
Environmental Management Act, 2003	Contaminated Sites Regulation
	Spill Reporting Regulations
	Hazardous Waste Regulation
	Industrial Non-hazardous Waste Landfills Code of Practice
Heritage Conservation Act, 1996	
Wildlife Act, 1996	

1.2.3 Regional & Municipal Bylaws

Construction activities must be carried out using methods that comply with regional and municipal bylaws (where applicable). The following bylaws have been considered in the EEE:

Table 1-3 Regional and Municipal Bylaws

Bylaw
Capital Regional District (CRD). 2006. Capital Regional District (CRD) Sewer Use Bylaw No. 2922 (Consolidated).
City of Colwood. 1986 (amended 1992). Bylaw No. 38 – A Bylaw to Regulate Noise within the City of Colwood.
Corporation of the Township of Esquimalt (Township of Esquimalt). 2005. Streets and Traffic Regulation Bylaw, 2005, No. 2607 (Consolidated).
Corporation of the Township of Esquimalt (Township of Esquimalt). 2007. Official Community Plan.
Corporation of the Township of Esquimalt (Township of Esquimalt). 2014. Maintenance of Property and Nuisance Regulation, 2014, No. 2686.

1.2.4 Permits and Approvals

Permits and/or approvals for the Project will be included in Appendix B as they become available.

1.3 Objectives of the EMP

The main objectives of this EMP are the protection of environmental resources that could be potentially impacted during the works. The EMP provides a framework through which potential environmental risks will be managed during the reconstruction of the South Jetty (G3, 2014). Specifically, the EMP identifies:

- Regulatory obligations that will govern Project implementation;
- Roles and responsibilities of PWGSC and its agents and Contractors that will undertake the work;
- Mitigation measures, Best Management Practices (BMPs), established protocols and measurable environmental requirements to be applied;
- Monitoring to be undertaken to verify that the work is being carried out in accordance with regulatory and contractual obligations.

This EMP addresses risks identified for the Project works as well as those identified through the engineering design process. Additionally, the EMP is a living document, which provides for adaptive management should subsequent risks be identified.

1.4 Environmental Protection Plan (from G3, 2014)

Prior to commencement of the Project, an Environmental Protection Plan (EPP) is to be prepared by the Contractor(s) implementing the work to document Site and activity-specific details of planned work procedures and mitigation actions (including methods, equipment and approaches) to be implemented during the work to achieve compliance with regulatory approvals for the Project, contract requirements, and this EMP. The EPP will provide the following general information:

- Organization chart and names of persons responsible for EPP implementation and compliance;
- Names and qualifications of persons responsible for manifesting waste to be removed from site;
- Contingency procedures in the event that environmental protection goals are not being met;
- Methods for monitoring vessels and barges for leakage; and,
- Site layout figures and supporting schematics (e.g., showing work and laydown areas).

The Contractor will be responsible for preparing an EPP specific to their assigned activities, which may include, but not be limited to, the following components:

- Wastewater Management and Disposal Plan, including management and/or discharge of wastewater derived from construction activities and personal hygiene and decontamination facilities on-site
- Pollution Control Plan
- Stormwater Pollution Prevention Plan
- Temporary Erosion and Sedimentation Control Plan
- Sustainable Remediation Efforts (e.g., equipment management, energy and air emissions, Waste Management Plan, energy reduction)
- Noise/Light Control
- Water Quality Control Plan, including proposed working practices and Temporary Re-suspension Barrier Control Plan (if applicable)
- Waste Reduction Work Plan

A Water Quality Monitoring Plan (WQMP) has also been incorporated into Section 6.1.5. The WQMP provides water quality monitoring criteria for implementation of management action, decision frameworks and identifies monitoring locations and rationale.

2. ENVIRONMENTAL SETTING

This section provides a summary of the resources and uses at the Project Area.

2.1 Aquatic Resources

As a result of historic shoreline modifications and contamination, biological communities demonstrate low abundance and diversity of macroalgae and benthic invertebrates (Golder, 2012a). No kelp beds, eelgrass or clam beds were observed within the Project Area.

Rockfish (*Sebastes* sp.), Pacific Herring (*Clupea pallasii*) and Pacific salmon species (*Oncorhynchus* sp.) have been observed in the EGD and surrounding Waterlot; however, finfish observations have been infrequent and dominated by flounders and sculpins (Archipelago, 2009; unpublished EGD records).

Harbour seals (*Phoca vitulina richardsi*), northern river otter (*Lontra canadensis*) and California (*Zalophus californianus*) and Steller sea lions (*Eumetopias jubatus*) have been observed in Esquimalt Harbour; however, use of the Work Site appears to be transitory. Cetaceans such as resident and transient (*Bigg's*) killer whales (*Orcinus orca*), harbour porpoise (*Phocoena phocoena*) and Dall's porpoise (*Phocoenoides dalli*) are known to occur in coastal regions of southern Vancouver Island; however, they are unlikely to occur in Esquimalt Harbour (G3, 2014).

2.2 Terrestrial Resources

Project works will be primarily marine-based, with terrestrial ecological resources potentially affected confined to birds and small vertebrates (G3, 2014). Birds observed in and adjacent to Esquimalt Harbour included loons, grebes, cormorants, herons, swans, geese, ducks, gulls and passerines, among others (VNHS, 2013). These birds may traverse and forage in the Work Site; however, most are unlikely to nest due to limited habitat.

Passerine birds may nest adjacent to the Project Area in trees and shrubs along the foreshore. Barn swallows (*Hirundo rustica*), a provincially blue-listed species, may nest under the South Jetty; however, as indicated below, no old or active nests were observed during a field assessment in 2010 (Golder, 2010).

Terrestrial wildlife species including deer, raccoons and mink have been observed within the EGD property (G3, 2014). The area may be used as breeding or foraging grounds or for passage to other areas. Intertidal areas are often used by raccoons and other small vertebrates for foraging; however, the Phase 2 Project Area would provide a small portion of their diet given that the intertidal area is of low quality and highly disturbed (G3, 2014).

2.3 Species at Risk

Federally or provincially listed aquatic species that could occur within the Project Area (G3, 2014) include:

- Northern abalone (*Haliotis kamtschatkana*);
- Olympia oyster (*Ostrea conchaphila*)
- Steller sea lion (*Eumetopia jubatus*);
- Harbour porpoise (*Phocoena phocoena*); and,
- Killer whale (*Orcinus orca*; Northeast Pacific southern resident population and West Coast transient [Bigg's] population).

Terrestrial species listed as at risk that could possibly occur in the Project Area (G3, 2014) include:

- Barn swallow (*Hirundo rustica*);
- Brandt's (*Phalacrocorax penicillatus*) and double-crested (*P. auritus*) cormorants;
- Caspian tern (*Hydroprogne caspia*);
- Common murre (*Uria aalge*);
- Great blue heron (*Ardea herodias fannini*);
- Marbled murrelet (*Brachyramphus marmoratus*); and,
- Purple martin (*Progne subis*).

2.4 Archaeological Resources

Based on an archaeological overview assessment (Golder, 2012b), and Archaeological Impact Assessment (AIA) conducted in November 2014 (Golder, 2015), no historically significant material was identified at the Project Area. It is unlikely archaeological resources may be uncovered during the works; however, chance find procedures should be implemented. Under such protocols, work will be suspended if suspected archaeological resources are encountered, the Department of National Defence (DND) and other appropriate authorities will be notified, and a management plan will be developed for protection of the resources. If human remains are found, the local Royal Canadian Mounted Police (RCMP) detachment should be notified.

2.5 Navigation Resources

Esquimalt Harbour is administered by DND and governed by the Canada Marine Act, Natural and Man Made Harbour Regulations (pursuant to the Canada Marine Act) and local Practices and Procedures (Government of Canada, 2014). The harbour is open to the public within the limitations set out in an Order in Council with respect to Controlled Access Zones that provide for security zones around warships berthed or moving in the harbour. Vessels entering or departing Esquimalt Harbour are requested to contact Queens Harbour Master (QHM) Operations. Given that ship repair may take place at all times, ships frequently navigate in and out of the Project Area, and emergency docking of ships at the graving dock may need to occur during the Project (G3, 2014).

3. ROLES AND RESPONSIBILITIES

3.1 Public Works and Government Services Canada

As the proponent of the Project, PWGSC has the overall responsibility for the Project and the following obligations:

- Administration of contracts
- Construction management and confirmation of Contractor compliance with plans and contract requirements, including those related to environmental protection
- Verifying compliance with terms and conditions of regulatory permits, approvals and Authorizations as mandated under federal and provincial legislation
- Managing communications and relations with EGD Operations and tenants, public stakeholders, regulatory agencies and First Nations
- Coordinating review of the Contractor's EPP

EGD staff, the contractors designated Environmental Monitor, and Contractor implementing, inspecting and reporting on the effectiveness of the environmental protection and mitigation measures will follow directions and correspondence through PWGSC representative:

Mr. Patrick V Truong, P. Eng.,
Project Manager
Public Works and Government Services Canada
219 – 800 Burrard Street, Vancouver, BC V6Z 0B9
E-Mail Patrick.Truong@pwgsc-tpsgc.gc.ca

3.2 Contractors

The Contractor will be responsible for the actions of their agents, employees and sub-contractors and will undertake all reasonable actions to have environmental protection measures in place and working effectively throughout construction, staging, and laydown areas. The Contractor is responsible for:

- Adhering to requirements set forth in any regulatory document (e.g., legislation), and all contract requirements, including this EMP.
- Undertaking effective communication with work crews and sub-contractors such that environmental responsibilities and requirements are understood prior to the commencement of work, and are implemented during the work. This will include disseminating information from orientation and other meetings to personnel not in attendance at those meetings.
- Retaining an appropriately qualified person to prepare the EPP and evaluate performance against the requirements outlined in regulatory documents and BMPs, as well as environmental protection goals provided in this EMP and contract requirements.
- Retaining an appropriately qualified environmental monitor to the satisfaction of PWGSC.

- Implementing and conducting work activities in a manner that adheres to the water quality criteria detailed in the WQMP (section 6.1.5).
- Using equipment and implementing work procedures and controls to prevent and/or reduce work-related disturbance to environmental, social, heritage, archaeological and cultural resources.
- Implementing General and Activity Specific BMPs as defined in Section 6 and Appendix C, Appendix D and Appendix E of this EMP.
- Implementing preventative and corrective measures in response to non-conformance with stated criteria (i.e., WQMP criteria), regulatory documents and the contract requirements including this EMP.
- Responding immediately to emergencies and incidents as defined in Section 4 of this document.
- Reporting and documenting all environmental incidents, as outlined in this EMP.
- Incorporating environmental protection strategies into the design and planned work practices.
- Correcting deficiencies and non-compliance upon direction from the DR.
- Conducting routine visual checks on vehicles, fuels storage areas, and equipment at the start of each day to identify potential equipment leaks.
- Remaining on call to respond to environmental issues.
- Providing individuals that are appropriately trained and equipped to respond to environmental incidents, such as spills.
- Conducting quality assurance sampling when required.
- Reporting all water quality data collected in weekly reports to PWGSC (daily reports in the event of exceedances of the acceptable criteria, such as water quality or underwater pressure during pile driving).

3.3 Environmental Monitor

In addition to the Contractor's appropriately qualified person, the Contractor will retain an Environmental Monitor to confirm that environmental management measures and controls are implemented in accordance with regulatory documents, environmental components of the contract requirements, including this EMP and WQMP water quality criteria, as well as the EPP prepared by the Contractor. Environmental monitoring tasks are to be conducted by, or under, the supervision of a Qualified Environmental Professional (QEP) following procedures outlined in the Environmental Monitoring Implementation Plan (EMIP) in Section 5. For the purposes of this EMP, a QEP is defined as an applied scientist specializing in the area of biology, who:

- Is registered in British Columbia and in good standing with an appropriate professional organization; and,
- Through suitable education, experience, accreditation and knowledge, may reasonably be relied upon to provide advice regarding environmental management of the Project.

It is anticipated that various personnel may be necessary to undertake different monitoring components for the Project (e.g., water quality, aquatic mammals, etc.) and the experience of the personnel used should reflect those needs.

The Environmental Monitor will:

- Prepare an EMIP that outlines the type and frequency of observations and data collection that will be made (including quality control sampling).
- Prepare and deliver environmental orientation sessions to work crews.
- Document work activities and evaluate them against regulatory documents, environmental components of the Contractor's Contract, this EMP and the WQMP provided in Section 6.1.5.
- The EM will advise PWGSC DR when work practices may need to be modified or improved to achieve the established environmental protection goals of the Project.
- Compile and maintain environmental monitoring data, including visual observations, and related documentation (including environmental monitoring reports).
- Assist in responding to emergencies and environmental incidents as defined in Section 4.

Different roles and types of monitoring personnel will be defined in the EMP.

4. ENVIRONMENTAL INCIDENTS

Environmental incidents should be fully understood by all Contractors conducting activities in the Project Area. An environmental incident is defined as an event that has caused, or has the potential to cause, one or more of the following:

- Damage to aquatic or terrestrial habitat that has not been approved by regulatory authorities.
- Adverse/harmful effects to human health, fish, wildlife or other environmental resources.
- Adverse publicity associated with impacts on the environment.
- Violation of statutes, conditions of permits, regulations or environmental damage.

Examples of environmental incidents include, but are not limited to:

- Spills of oil, fuel, or other potentially hazardous chemicals.
- Discharges of deleterious substances into the marine environment and/or fish-bearing watercourses.
- Water coming into contact with curing concrete and entering a watercourse.
- Landslides, erosion, or floods with the potential to adversely affect environmental quality.
- "Serious harm to fish," which is the death of fish or any permanent alteration to, or destruction of, fish habitat.

All environmental incidents are to be reported to the DR immediately. An Environmental Incident Report (EIR) is to then be prepared and submitted by the Contractor, sub-contractor or PWGSC's designated Environmental Monitor to provide a timely and accurate internal written notification of environmental incidents to PWGSC. The deadline for submission of the EIR is within 24 hours following an incident. The EIR, an example of which is provided in Appendix F, is to include the following:

- Date and time of the incident
- Who or what activity generated the incident
- Who reported and responded to the incident
- Agencies notified or on-scene
- Safety and/or environmental concerns
- Substance spilled (if unknown describe appearance, odour)
- Estimated quantity spilled, the duration of the release and the basis for estimate
- Location of spill
- Polluter and/or source of spill
- Location and estimates of size and media affected environment (marine, land, etc.)
- Consequences (fish kill, spill contained, evacuation, etc.)

- Actions taken to mitigate the incident and estimate of effectiveness
- Preventative measures implemented following the incident

The written EIR is not intended to take the place of verbal notification of an incident requiring immediate action or further notification of regulatory agencies (e.g., a spill that affects neighbouring properties or requires assistance in the supply or deployment of containment equipment). In addition to formal EIR written reporting and Emergency Management BC (EMBC) reporting (where required), the DR will be notified when an incident occurs. As well as internal reporting to PWGSC it may be necessary in some situations for PWGSC to notify regulatory agencies (Environment Canada [EC], DFO, MOE), local municipal environmental representatives (Township of Esquimalt, City of Colwood), owners of neighbouring properties (e.g., DND, QHM) of the environmental incidents. PWGSC will determine what reporting is warranted and undertake these actions as deemed necessary.

In the event that the incident is considered an emergency and the DR is unavailable, or where a delay in notification could result in environmental damage or risk to human health, PWGSC's Environmental Monitor will provide these notifications. Notification of corrective measures and closure of the incident may also be reported, as per direction from the DR.

Contractors must be familiar with EGD's spill prevention and response procedures (EGD Spill Contingency Plan; Appendix G).

5. ENVIRONMENTAL MONITORING

Environmental monitoring describes the processes and activities that will assist the Contractors in the implementation of environmental commitments detailed in regulatory documents and BMPs to maintain the quality of the environment and protect ecological and human health.

5.1 Environmental Monitoring Implementation Plan

An Environmental Monitoring Implementation Plan (EMIP) outlines the protocols to be followed by the Environmental Monitor to confirm and document Project compliance with applicable regulations, the EMP, and the acceptable water quality criteria. The following activity specific EMIP has been developed for the Project.

5.1.1 Water Quality Monitoring Component

Water quality monitoring will be conducted, as required by the site-specific conditions and activities. *In situ* parameter measurements, such as dissolved oxygen, pH and turbidity are commonly used to evaluate potential localized effects on water quality. Water quality will be monitored "up current" and "down current" of in-water works or surface runoff. Background water quality measurements will be collected from a location which is not influenced by Project works, to be approved by the DR. Water quality criteria will adhere to the WQMP (Section 6.1.5).

Sampling in and around marine operations will be limited to a safe distance, such that sudden drops/movements in the rig or crane cable(s) will not endanger monitoring personnel. The Environmental Monitor will be present during activities with when there is potential to cause serious harm to fish or fish habitat. Frequency and duration of monitoring events can be modified at the discretion of the DR. Full-time monitoring is required during in-water works.

When and where applicable and appropriate, the *British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (MOE, 2016) will be used for comparison to *in situ* measurements.

5.1.2 Hydrophone Monitoring Component

In-water pile-driving activities will be monitored with a hydrophone when the potential for over-pressurization may occur, as per the BMPs for Pile Driving (DFO, undated; BC Marine and Pile Driving Contractors Association, 2006; Appendix D. Monitoring will allow assessing the effectiveness of mitigation measures in place, and/or implementing further measures, should the impact pressure approach the recommended threshold [i.e., upper maximum pressure] of 30 kPa). Sound impact pressure is measured with a hydrophone, attached to a blast- or seismic-monitoring device, with internal memory and storage (e.g., Blast-Mate III Seismograph).

"Ramp-up" (or "soft-start") at the commencement of hammer pile driving is recommended: at start-up, the hammer is dropped two or three times at less than full capacity. This protocol allows marine mammals in the vicinity to leave, as well as assessing whether mitigation

measures are required (given previous experience with the equipment to be used and various pile sizes, those first impacts should be well below 30 kPa). If mitigation measures are in place and the registered pressure is at, or exceeds the threshold, the hammer can be stopped and corrective action taken, such as ensuring that the bubble curtain is distributing bubbles evenly. Additional curtains may be required up current and at different water depths, if tidal flow is pushing the bubbles away from the pile.

5.1.3 Marine Mammal and Migratory Bird Monitoring Component

The presence of marine mammals and birds observed in the vicinity of the works will be documented (i.e., species, number of individuals, estimated distance and observed behaviour). When possible, identifying features will be noted. Behaviour will be noted, and if the behaviour appears to be altered in a negative manner due to the work-related activities, work will cease until the animal moves out of the zone of influence. Any such interactions will be noted. Marine mammal action procedures will follow the safety zones and reporting protocols outlined in Section 6.1.6 of this EMP.

5.2 Environmental Monitoring Reporting Procedure

Reporting will involve submission of daily and weekly environmental monitoring reports. Weekly reports will be of a quality suitable for submission to regulatory agencies, First Nations and public stakeholders, as required during the course of the Project. Monitoring reports are to be prepared by the Environmental Monitor and include, at a minimum, the following information:

- A description of construction activities undertaken during the reporting period.
- A description of environmental issues and corresponding mitigation measures implemented.
- Tracking of emerging and outstanding environmental issues.
- Results of monitoring and testing (e.g., water quality data, noise data, observations of aquatic mammals).
- Photos documenting construction activities, environmental issues, corresponding mitigation measures and any adopted lessons learned.

The Environmental Monitor will also prepare an Environmental Completion Report one month following completion of the work. This report will provide an overall summary of the Project including, representative site photographs, a summary of monitoring data collected, a summary of construction activities, environmental management and issues during construction, how these issues were managed, mitigation measures and additive measures in response to lessons learned and recommendations.

5.3 Orientation and Meetings

Environmental requirements of the Project will be addressed in regular meetings to provide Contractor and their crews with information to carry out the obligations of regulatory documents and the environmental requirements of the contract, including this EMP.

5.3.1 Pre-construction meetings

The pre-construction meeting held between the Contractor and PWGSC will include an environmental agenda item that addresses, at a minimum, the following:

- A review of environmental requirements of the contract
- Transfer of further relevant information or precautions that PWGSC is aware of, and which pertain to the contract
- Consequences of non-compliance with environmental law and other regulatory guidance and contract specific environmental requirements
- Reporting and response procedures for environmental incidents and emergencies

5.3.2 Pre-work Orientation meetings

The Environmental Monitor will attend and document pre-work orientation meetings (which may be conducted in association with regular Contractor meetings) with field crews prior to the initiation of work to advise them of the site-specific environmental requirements of work at that location. Additional orientation meetings will be undertaken as necessary, for example when project conditions and/or activities change or new Contractors enter the site.

Contractors' staff will sign and date a Pre-Work Orientation Record confirming that they have received an orientation. The Environmental Monitor will maintain a registry of Contractors' employees who have attended pre-work orientation meetings, together with copies of meeting records. These records will be kept on file for auditing by PWGSC.

5.3.3 Tailgate Meetings

Daily tailgate meetings are required for the Contractor staff to ensure they are appropriately aware and prepared for the day's activities and associated health, safety and environmental risks. Tailgate meetings will be documented, signed by each employee involved and retained at the start of each project activity. On days that are scheduled to be near or associated with environmentally sensitive areas or impact environmental values, the Environmental Monitor will attend to identify the location of, outline mitigative strategies for site-specific environmental requirements. The Contractor will keep a record of environmental requirements addressed in daily tailgate meetings, which can be provided to PWGSC upon request.

6. ENVIRONMENTAL REQUIREMENTS AND BEST MANAGEMENT PRACTICES

The following sections present an overview of the environmental requirements of the Project. These requirements, along with applicable legislation, guidance documents, contract requirements, and permits and approvals, will form the basis for environmental mitigation and protection strategies to be implemented during reconstruction of the EGD South Jetty.

General and activity-specific BMPs are detailed in these sections. It is the responsibility of the Contractor, sub-contractors and Environmental Monitors to be familiar with the requirements and BMPs included herein. The Contractor is responsible for compliance with BMPs, legislation and other environmental requirements. The contractors Environmental Monitor will be responsible for confirming that construction activities are conducted in accordance with all environmental requirements and BMPs, and will provide guidance to correct deficiencies where observed.

6.1 General BMPs

The following are general BMPs to be followed during Project activities undertaken in and about the EGD facility. They are a broad set of BMPs identifying a range of environmental goals and as such, should be used in conjunction with Activity Specific BMPs where applicable. These BMPs should be consulted at all times as to their application to a given activity. It is the responsibility of the individual conducting work activity at the EGD site to ensure compliance with all BMPs detailed below in addition to any additional Activity Specific BMPs that may apply.

The General BMPs apply to all Contractors conducting activities at the EGD site and are divided into the following categories:

- Environmental Monitoring
- Regulations
- Working In or About Water
- In-water Works Outside Timing Windows
- Water Quality Management Plan
- Marine Animal Interactions
- Terrestrial Animal Interactions (excluding birds)
- Bird Interactions
- Noise & Lighting Control
- Spill Prevention
- Erosion & Sedimentation Control
- Air Quality Management
- Waste Management (Including Hazardous Waste)
- Site Access

6.1.1 Environmental Monitoring

Environmental monitoring associated with this section (General BMPs) will be undertaken by the Contractors Environmental Monitor to ensure compliance with all relevant BMPs, the WQMP and assessment criteria to verify that performance objectives are being met and enable management decisions in the event that the performance objectives are not met. It is the responsibly of the individual conducting the activity to ensure the application of all applicable BMPs are implemented in accordance with this EMP.

It is the responsibly of the individual conducting the activity to ensure the application of all applicable BMPs are implemented in accordance with this EMP.

6.1.2 Regulations

The following regulations apply to the project:

- All local bylaws, rules, and regulations, including provincial and municipal legislation, which are enforced in the EGD Project Area shall be complied with by the Contractor
- The Contractor shall *meet or exceed requirements of the contract documents, specified standards, codes, and referenced documents,* and shall maintain records to demonstrate compliance
- *In the event of any conflict or discrepancy between requirements, the more stringent* standards/criteria *shall apply*
- *Workplace Hazardous Materials Information System (WHMIS*; Health Canada 2015) *guidelines and procedures must be followed by all workers. Material Safety Data Sheets (MSDS) must be available to all workers for all products used on-site.*

6.1.3 Working in or About Water

For works in and around water the following BMPs should be implemented to mitigate potential effects of construction activities:

- Equipment (e.g., heavy machinery) used in and around water will be kept clean and in good working condition (i.e., free of leaks, excess oil, and grease).
- Equipment washing, refuelling and servicing will be conducted away from the water (i.e., no closer than 30 m), unless the contractor prepares a refuelling plan that is approved by PWGSC.
- Any hydraulic machinery used in water will use environmentally-friendly hydraulic fluids (i.e., non-toxic to aquatic life, and biodegradable).
- Construction-affected run-off water (e.g., water in contact with uncured concrete) must not be discharge to EGD on-site sewer systems.
- Wastewater discharge from personnel hygiene/decontamination facility or toilet facilities is not permitted on-site. These wastewaters are to be disposed off-site at a permitted Wastewater Treatment and Disposal Facility.

- Wastewater produced at the Work Site (e.g., equipment decontamination wastewater) should be tested prior to discharge in the EGD Project Area to ensure compliance with applicable water quality performance objectives for where it is intended to be released (i.e., water quality outside isolated sediment containment areas must meet acceptable criteria).
- Waste material or debris must not be dumped in or near any waterways, and must be disposed of in the appropriate manner.
- Silt fences or other appropriate control measures shall be used, where needed, to minimize soil or intertidal sediment transport into marine or freshwater environment.
- The Contractor shall thoroughly investigate and understand the implications of the tide, current, wind, and sea state in Esquimalt Harbour when installing, removing, adjusting, moving and monitoring the effectiveness of any silt curtains or sediment barriers if required for the Project.

6.1.4 In-water Works outside Timing Windows

In addition to measures already identified throughout this report, the following BMPs shall be implemented during works with the potential to adversely affect the marine environment during works conducted outside the Timing Windows for least impact to fish (i.e., July 1 to October 1 and December 1 to February 15):

- Monitoring by a qualified environmental monitor, on site during all in-water activities, to specifically monitor for the presence of salmonids and/or Pacific Herring during respective sensitive periods;
- If salmonids and/or Pacific Herring are observed near the Site during respective sensitive periods, additional measures will be implemented to reduce the risk to these fishes. Measures may include, but may not be limited to:
  - Increased water quality sampling
  - Increased sound pressure testing (i.e., during pile driving)
  - The installation of additional bubble curtain, silt curtain and/or other exclusion devices
- Should the EM consider the above measures inefficient at protecting fish from serious harm, temporary cessation of in-water work may be recommended, until the risk is diminished or additional mitigation measures are implemented.
- The Contractor shall thoroughly investigate and understand the implications of the tide, current, wind, and sea state in Esquimalt Harbour when installing, removing, adjusting, moving and monitoring the effectiveness of any silt curtains or sediment barriers if required for the Project.

6.1.5 Water Quality Management Plan

Implementation of the following BMPs within this WQMP will mitigate the risk of construction activities to ambient water quality in the Project area during South Jetty reconstruction.

- At the commencement of in-water works, such as pile driving, *in situ* water turbidity will be monitored against the water quality guidelines for aquatic life (MOE, 2016), as shown in Table6-1.

Table 6-1 Water Quality Guidelines for Turbidity and Suspended Sediments

Water Use	Turbidity	Non-filterable Residue (Total Suspended Solids)
Aquatic Life (Fresh, Marine, Estuarine)	• Change from background of 8 NTU at any one time for a duration of 24 h in all waters during clear flows or in clear waters • Change from background of 2 NTU at any one time for a duration of 30 d in all waters during clear flows or in clear waters • Change from background of 5 NTU at any time when background is 8–50 NTU during high flows or in turbid waters • Change from background of 10% when background is > 50 NTU at any time during high flows or in turbid waters	• Change from background of 25 mg/L at any one time for a duration of 24 h in all waters during clear flows or in clear waters • Change from background of 5 mg/L at any one time for a duration of 30 d in all waters during clear flows or in clear waters • Change from background of 10 mg/L at any time when background is 2–100 mg/L during high flows or in turbid waters • Change from background of 10% when background is > 100 mg/L at any time during high flows or in turbid waters

- Should the turbidity values exceed the guidelines, a silt curtain will be deployed around in-water works to mitigate sediment transport. The silt curtain may also serve as fish exclusion device.
- Equipment (e.g., heavy machinery) used in and around water will be kept clean and in good working condition (i.e., free of leaks, excess oil, and grease).
- Any hydraulic machinery used in water will use environmentally-friendly hydraulic fluids (i.e., non-toxic to aquatic life, and biodegradable).
- If storage of fuels is to occur on site, a 'Fuels, Chemicals and Materials Storage and Handling Plan' will be developed, in compliance to Ministry guidelines (Ministry of Water, Land and Air Protection; MWLAP, 2002).
- Equipment washing, refuelling and servicing will be conducted away from the water (i.e., no closer than 30 m), unless the contractor prepares a refuelling plan that is approved by PWGSC.
- A spill containment kit will be accessible onsite and a Spill Response Plan prepared by the contractor and approved by PWGSC will be developed and communicated to the construction crew.

- Any concrete works in or near water will follow measures recommended in Subsections 41(e) and 42(d) of the MOE. 2004. Standards and Best Management Practices for Instream Works (SBPISW; MOE, 2004), as well as the following:
  - Concrete will not be poured directly into the water.
  - Where appropriate, fast-curing concrete intended/formulated specifically for marine applications will be used.
  - Poly sheets/tarps will be used during pouring to prevent splashing of concrete over the forms and into water, where practical.
  - Immediate clean-up of excess/spilled concrete.
    - Contractor will keep cylinders of CO2 equipped with regulators, hoses, and a gas diffuser on site to deploy into the ocean water should spilled concrete cause pH levels to become more alkaline than the permitted levels of 7.0–8.7 (MOE, 2016)
  - Equipment and tools will be washed in location such that concrete does not enter the water.
- Grounding of equipment/ machinery on the harbour bottom will be avoided to prevent sediment mobilization; barges will be tied to the existing wharf or held in place with spuds.
- For upland construction works, the following measures are recommended:
  - Covering any stockpiles to prevent erosion during periods of rain and/or wind
- Directing any suspect waters away from the marine environment

6.1.6 Marine Animal Interactions

Marine animals present in the Project Area with the potential to be adversely impacted by Project activities include finfish, aquatic invertebrates and marine mammals, and include Species at Risk (SAR), which are protected under the *Species at Risk Act*.

The following BMPs should be implemented to mitigate the risk of interactions with marine animals during construction:

- Interactions with fish and aquatic wildlife are to be avoided.
- Should any SAR be observed within isolated or contained work areas during construction, the DR will be notified immediately and management actions will be taken (e.g., suspend work, notify DFO, and adhere to DFO protocols for species recovery).
- A Discretionary Cetacean Safety Zone shall be established 500 m from the edge of the Project boundary, a Cetacean Safety Zone shall be established 500 m from any in-water construction activities, and a Pinniped Safety Zone shall be established 25 m from the edge of the Project boundary (Appendix A, Figure A3). If marine mammals enter the respective safety zones, the DR is to be notified immediately. The DR shall make the decision to suspend or continue works based on observations and construction activities.
- If work is suspended, activities will not resume until the Environmental Monitor has confirmed to the DR that the marine mammal is outside the applicable safety zone, or if a minimum of 20 minutes has elapsed since the animal was last sighted within the safety zone.

- The Contractor and all staff are responsible for immediately notifying the Environmental Monitor of any cetacean observations, and any pinniped observations within the pinniped safety zone.
- If aggregations of Pacific Herring or salmon are observed anytime within or in close proximity to the Work Area, the DR must be notified immediately. The DR will assess the potential for activities to disturb or interfere with the fish, decide on appropriate management actions and notify the Contractor and EM. The DR may also contact DFO at their discretion.
- Observations of Pacific Herring spawn, which may attach to equipment or marine structures, should be communicated to the DR as soon as possible. The Contractor should be familiar with the appearance of herring spawn. Unattended structures and equipment shall be inspected prior to removal or use should removal or use coincide with Fisheries Timing Windows.
- The DR will assess/confirm any herring spawn identified by the Contractor or Environmental Monitor. Management actions or a stop-work-order may be enacted with operations not re-commencing until the eggs have hatched and detached from equipment.

6.1.7 Terrestrial Animal Interactions (excluding birds)

Terrestrial wildlife, including deer, raccoons, and mink, have the potential to be present in the Project Area at the time of works. The following BMPs shall be followed for the protection of terrestrial wildlife:

- Interactions with terrestrial wildlife are to be avoided.
- If injured or abandoned wildlife are observed, the DR is to be immediately contacted. The DR will contact EGD Environmental Services to decide on appropriate management actions. Injured or abandoned wildlife must not be handled by anyone without proper experience, equipment and authorization to do so.
- Approval from EGD Environmental Services and appropriate government authorities (e.g., DFO, EC, MOE) must be obtained prior to relocation or removal of wildlife.
- If any change in behaviour of any terrestrial organisms is observed, the DR shall be notified as soon as possible.

6.1.8 Bird Interactions

Although no known bird nests are located in the Project Area, there is potential for birds to be perching, foraging or nesting in the area at the time of construction. The following BMPs for the protection of birds shall be followed:

- Open-top pilings should be covered with a temporary seal to prevent perching birds from entering the column. A conical cover would restrict birds from nesting atop pilings.
- All works are to be conducted in compliance with the federal *Migratory Birds Convention Act, Migratory Birds Regulations* and the BC *Wildlife Act.*

- If any nesting bird, nest or eggs are identified within the EGD Project Area, they must not be disturbed and the DR is to be notified immediately. The DR will determine the appropriate management actions will be taken.
- A permit will be required if a nest or eggs are to be moved.

6.1.9 Noise and Lighting Control

The EGD Environmental Policy (2014) makes a commitment to follow all applicable municipal laws and regulations. Daily operations at the EGD Project Area must therefore adhere to criteria of the Corporation of the Township of Esquimalt Maintenance of Property and Nuisance Regulation (2014, No. 2826) and City of Colwood Noise Bylaw (1986, No. 38).

The following BMPs shall be followed to meet noise and light objectives:

- Spotlights will be directed away from residential areas or fitted with shrouds to direct light to the immediate Work Area
- Unnecessary lighting or interim lighting should be shut off when not in use.
- A maximum allowable noise level of 85 dBA for the EGD Work Site shall constitute a working guideline, subject to change dependent on receipt of any residential noise complaints. In this event, work activities must be modified to reduce noise generated.
- Complaints regarding noise are to be directed, through the DR, to EGD Security, Health and Safety Department, where a Concern Document will be filed.
- When possible, noisier work activities shall be performed during daylight hours
- Construction activities and scheduling may be modified based on resident feedback and the results of noise monitoring
- All construction equipment shall be maintained in good working order and operated with exhaust systems in good repair to minimize noise and in accordance to the machines specification.
- Noise barriers shall be used where practicable if required.
- Equipment should be shut down when not in use.
- If required, the Environmental Monitor shall monitor noise during construction activities at the Project boundary and EGD property boundary.
- Induced underwater noise levels during construction should not exceed 30 kPa. The Contractor's appropriately qualified person will be required to monitor underwater noise levels during impact driving of piles 24" in diameter or greater. The Environmental Monitor may also conduct underwater noise monitoring.
- Exceedances of the 30 kPa limit will be reported to the DR immediately and measures to reduce noise must be implemented.

6.1.10 Spill Prevention

An environmental spill is the release of any deleterious substance(s) which is dangerous to health or environmentally unfriendly. Spill response procedures shall be completed in accordance with the EGD Spill Contingency Plan.

The following BMPs shall be followed to reduce potential for environmental spills and associated adverse effects:

- All workers on-site must be familiar with WHMIS procedures and guidelines. Any handling, transport or storage of WHMIS "controlled products" must follow appropriate WHMIS guidelines.
- Contractors shall be fully aware of the spill prevention and response procedures.
- The DR shall be immediately informed of all spills that occur at the EGD Project Area and at Contractor's Off-Site Offload Facility.
- An Environmental Incident Report shall be prepared for any spills.
- In the event of a spill, the Contractor shall immediately notify the DR, contain and assess the spill, and take necessary steps to prevent further discharge.
- The Contractor is responsible for immediate cleanup of spills and restoration of the area to the satisfaction of DR or other regulatory agencies, when involved.
- Spill kits including grey absorbents to clean up both water based fluids and hydrocarbons, white absorbents that repel water and float on water to clean up hydrocarbons only (e.g., motor oil, jet fuel, diesel, gasoline, hydraulic oil), yellow absorbents to clean up aggressive fluids such as acids and solvents, must be kept at the EGD Project Area.
- The Contractor shall take due care to ensure no deleterious materials, including sediment- or concrete- laden runoff, paints, coatings or preservatives and fuel or oil, leave the EGD Project Area or Contractor's Off-Site Offload Facility or enter any surface water or stormwater at or near the EGD Project Area or Contractor Off-Site Offload Facility.
- Do not refuel or service equipment within 30 m of any watercourse or surface water drainage unless appropriate spill prevention and control measures are in place.
- Equipment shall not be washed within the Project Area without proper containment.
- Equipment and machinery must be regularly inspected by the Contractor to confirm they are free of leaks, excess oil and grease.
- The EGD Fuelling and Oil Transfer Policy and Checklist must be followed (Appendix H).
- EGD Fuel and Waste Oil Transfer Checklist must be submitted to the EGD Pumphouse and signed off before any fuelling or transfer operations occur.
- All berthed vessels receiving fuel from a truck or a barge or transferring greater than 10 tonnes of oil per day require a containment boom. The specification of such a boom requires review and approval by the DR.

- If the Contractor is planning to discharge any deleterious materials, including water discharge (effluent) or sediment-laden or concrete-laden runoff, leaving the EGD Project Area or Contractor's Off-Site Offload Facility, they are responsible for ensuring that appropriate discharge permits are obtained and remain on-site at all times, and that discharge meets permit requirements and applicable water quality criteria.
- Use of any paints, corrosion protective coatings, wood preservatives or any other potentially deleterious substances that may be applied to surfaces that could have potential contact with the marine environment, shall be applied in accordance with the EGD BMPs and appropriate environmental protection measures.
- Any equipment remaining on-site overnight shall have appropriately placed drip pans or other spill/leak containment measures and must be placed as far away from the marine environment as possible.
- Measures for the containment of potentially harmful substances due to rinses, cleaning water, solvents, wood preservatives and other potentially harmful or toxic substances shall be identified and implemented by Contractor in a manner to prevent leakage, loss or discharge into the sewers, storm drain system or marine environment.
- Any waste materials should be collected, stored and disposed of in an appropriate manner.
- Application of fog seals, tack coats or other coatings should be avoided during periods when rainfall is likely.
- During the purging of tanks and associated lines, appropriate procedures must be followed to prevent the release of any fuels or other deleterious substances to the surface, surface water, catch basins or soils within.
- All stored materials that have the potential to negatively impact the environment, infrastructure or workers must be appropriately labelled following WHMIS protocols, including the product name, first aid information and personal protective equipment (PPE) requirements.
- Materials must be stored in storage areas that are suitable for the materials (e.g., protected from the weather, ventilated if necessary).
- For long-term storage, appropriate secondary containment suitable for the quantity and nature of the product being stored must be present.
- Short-term storage and working areas must be clearly labelled and located away from pathways to any watercourse on impervious surfaces protected from the weather.
- All materials must be secured appropriately during transport.

6.1.11 Erosion and Sediment Control

Sedimentation of the marine environment can have adverse impacts on fish and fish habitat through smothering of substrate or marine vegetation, interference with light penetration, and gill abrasion or clogging. The following general BMPs shall be implemented to reduce the probability and impacts of sedimentation resulting from erosion.

- The Contractor shall be responsible for preparation and submission of an Erosion and Sediment Control Plan (ESCP) as part of the EPP. The ESCP shall include drawings showing locations and positioning of Erosion and Sediment Control measures, such as silt fencing, interceptor ditches or stormwater conveyances, and gravel berms or check-dams.
- Work should be performed in a manner to control surface drainage from any cuts, fills, borrow or waste disposal areas, stockpiles, and staging or construction areas.
- Minimize amount of bare soil exposed at one time that may migrate to the marine environment.
- Stabilize disturbed soils as quickly as practical. Remove accumulated sediment resulting from construction activity from adjoining surfaces, drainage systems, and watercourses and repair damage caused by soil erosion and sedimentation as directed by the DR.
- Provide and maintain temporary measures which may include concrete blocks, silt fencing, hay or straw bales, geotextiles, drains, berms, terracing, riprap, temporary drainage piping, dikes, and other construction, required to prevent erosion and migration of silt, mud, sediment, and other debris to the marine environment, or to other areas of site where damage might result, or that might otherwise be required by laws and regulations.
- Hay or straw bales should be wire-bound or string-tied; securely anchored by stakes or rebar driven through bale 300 mm to 450 mm into ground; filled with hay or straw to prevent water from escaping between bales; and entrenched minimum of 100 mm into ground. Repair or replace damaged bales, end runs and undercutting beneath bales.
- Silt fences should be assembled as a ready to install unit consisting of geotextile attached to drivable posts. Water escaping from silt fences should not be allowed enter the marine environment and should be treated and disposed of accordingly. Conditions may dictate that a heavy duty fence (with net backing) is required.
- Geotextile should be uniform in texture and appearance, having no defects, flaws, or tears that would affect physical properties and containing sufficient ultraviolet ray inhibitors and stabilizers to provide minimum 2-year service life from outdoor exposure in a saline environment. If necessary, net backing should be industrial polypropylene mesh joined to geotextile at both top and bottom with double stitching of heavy-duty cord, with minimum width of 750 mm.
- Install temporary barriers in and around storm sewers.
- Plan construction procedures to avoid equipment encroachment onto marine environment or drainage ditch banks which may deposit into the marine environment. In event of damage, promptly notify the DR and take action to mitigate impacts; restore affected bank or water body to existing condition.
- Check erosion and sediment control measures daily and after each rainfall to ensure operational integrity, and promptly correct deficiencies.
- Remove temporary erosion and sediment control devices upon completion of work unless otherwise directed by the DR. Spread accumulated sediments to form a suitable surface for seeding or dispose of and shape area to permit natural drainage to satisfaction of the DR. Materials, once removed, become the property and responsibility of the Contractor.
- Construct fill and waste areas by selective placement to avoid erosive surface silts or clays.

- Existing embankments or embankment protection shall not be disturbed unless approved by the DR.
- Periodically inspect earthwork to detect evidence of erosion and sedimentation; promptly apply corrective measures.
- If sediment and/or debris from work areas accumulate in low areas, storm sewers, roadways, gutters, ditches, or other areas where it has the potential to migrate to the marine environment, the Contractor must remove accumulation and restore area to original condition.

6.1.12 Air Quality Management

The following BMPs shall be implemented to reduce the probability of impacts resulting from emissions and particulate matter associated with Project construction:

- Dust and airborne particulate containment should be large enough to adequately enclose or segregate the working area. To reduce potential dust emissions during hot, dry weather, if being left overnight or if there are strong winds, sediment on barges, in trucks, or stockpiled on land will be covered or wetted as required.
- Ensure that dust generated from all Contractor operations, such as barge or truck transportation, material stockpiling and demolition work, is controlled by dust screens and/or water application if necessary.
- Apply water as required for dust control. Dust control methods shall be chosen such that a minimal amount of water is required. Apply water with distributors equipped with spray system to ensure uniform application and with means of shut off.
- Runoff from water used for dust control shall be collected and handled as other Project wastewater.
- Temporary dust tight screens or partitions must be provided to localize dust generating activities, and for protection of workers, finished areas of work, marine environment and public.
- Maintain and relocate dust screens as necessary and remove dust screens at completion of those portions of the work that may generate airborne dust.
- Secure and cover material in open trucks hauling excavated material and re-use the covers.
- If Contractor's dust and particulate control is not sufficient for controlling dust and particulates into atmosphere a stop-work-order may be enacted by the DR or other Project authorities. The Contractor shall consult with the DR to determine procedures to resolve the problem. Necessary changes will be made to operations prior to resuming excavation, handling, processing, or other work that may cause release of dust or particulates.
- Spray coatings (e.g., paint, sealants) must not be applied under conditions that render containment ineffective.
- The EGD has a hand-held particulate monitor used in the event of a large or nuisance airborne discharge. If particulate matter levels in the air exceed 100 µg/m3 corrective actions must be taken.

- Nuisance-level hydrogen sulfide (H2S), such as those that may be detected by sense of smell may occur during dredging activities. The Contractor should evaluate the potential for H2S in their Health and Safety Plan. If H2S concentrations in air exceed guidelines (10 parts per million, ceiling short-term exposure level 1) then appropriate safety equipment (e.g., respirators with applicable filters) will be issued to workers.
- In the event that odours are noted or complaints are received, H2S monitoring should be undertaken in and around work areas where personnel are or need to be actively working.
- Contact the DR in the event of a nuisance odour or airborne discharge.
- Vehicle idling should be avoided whenever possible, especially near building doorways or air intakes.
- The Contractor should maintain equipment and vessels in good working order and use environmentally considerate fuels wherever possible.
- Perform routine checks of exhaust systems to identify actual or potential deficiencies and correct them in a timely manner. Repair or change out chronically deficient or severely defective equipment.

6.1.13 Waste Management (including Hazardous Waste)

Wastewater is defined as waters produced from construction activities and personal hygiene and decontamination facilities on-site and excludes barge dewatering effluent. The following general BMPs should be implemented to limit probability of waste related impacts:

- Disposal/recycling of waste generated during the project shall be done in compliance with federal, provincial and municipal legislation, regulations, and bylaws, as applicable. The facilities to be used must be reviewed and approved by the DR.
- Regularly inspect the Site for unidentified or improperly stored materials.
- Ensure all containers (i.e., drums, totes, etc.) are in good condition and have a clean exterior at all times.
- Store equipment decontamination facility wastewater in separate tanks from those used for wastewater from personnel hygiene/decontamination facility.
- Provide, operate and maintain wastewater storage tanks when and where appropriate.
- Store batteries in a manner that prevents leakage of acid to the environment. Dispose of dead batteries at an appropriate facility.
- Ensure waste accumulation areas are organized and covered to reduce exposure to environment and wildlife.
- Recycle solid waste such as plastic, glass, aluminum, mixed paper and cardboard. Recycling areas should be conveniently located and easily identifiable.
- Encourage the use of recyclable products to reduce the solid waste impact on the environment.
- Segregate other solid waste, such as scrap metal, wood, electronics, polystyrene foam and soft plastics for recycling at an approved facility.

- Clean debris from work areas immediately after any maintenance activity. Dispose of collected material appropriately.
- Rubbish and/or waste materials shall not be buried on the EGD Project Area. Rubbish or waste generated on-site should be disposed of in appropriate manner and at an appropriate facility.
- Waste or volatile materials, such as mineral spirits, oil, or paint thinner shall not be disposed of into waterways, storm sewers or sanitary sewers. Generated waste should be placed in waste specific containers and deposed of appropriately.
- Wastewater from personnel hygiene/decontamination facility or toilet facilities shall not be discharged on-site. Disposal of these wastewaters must be conducted at an off-site permitted Wastewater Treatment Facility.
- Wastewater produced at the Work Site (e.g., equipment decontamination wastewater) should be tested prior to discharge in the EGD Project Area to ensure compliance with applicable water quality performance objectives for where it is intended to be released.
- If barge dewatering is required, barge effluent or discharge must meet the applicable water quality criteria for the receiving area.
- Connect pumps, piping, valves, miscellaneous items and necessary utilities as required for operation of facilities; and protect tanks, valves, pumps, piping and miscellaneous items from freezing, leaks or systemic failure. Check items and utilities regularly to confirm they are free of leaks.
- Hazardous waste should be segregated into separate containers. Ensure designated hazardous waste storage areas are away from active work areas.
- Hazardous waste/materials shall be transported in compliance with the Transportation of Dangerous Goods Act and BC Hazardous Waste Regulation.
- All means of containment and transport of hazardous waste must comply with the safety standards of the Transportation of Dangerous Goods Act and display all applicable prescribed safety marks and labels.
- Hazardous waste shall not be diluted or mixed with other hazardous or non-hazardous wastes.

6.1.14 Site Access

The following BMPs shall be implemented to prevent environmental impacts resulting from vehicle access to the site:

- Prevent sediment or debris migration on access roads. Clean access roads at least once per shift to a level which removes dust and fines and limits dust and air pollution.
- Vehicle idling should be avoided especially near building doorways or air intakes.
- Any large deliveries by truck must be approved by the DR and EGD Operations before arriving on-site.

- The Contractor shall establish minimally-intrusive and well-designed traffic patterns for on-site activities and plans to minimize on-site impacts and reduce off-site traffic congestion. This plan should be reviewed and approved by the DR.
- Traffic management measures (such as 'flag person') approved by the DR prior to implementation shall be in place if required at site access points to direct traffic.
- Contractor shall clean all equipment prior to arrival at the EGD Project Area to ensure that no invasive vegetative species are present on the equipment and to prevent the introduction of deleterious material into the surrounding environment.

6.2 Activity Specific BMPs

In addition to General BMPs identified, specific BMPs for individual activities are detailed in this section. Where appropriate, the BMPs may be further divided by activity within a given activity. This list should not be considered exhaustive and the Contractor is required to implement all industry standards surrounding specific activities. In addition, the Contractor must also implement all permitting and regulatory requirements associated with the activity. It is the responsibility of all Contractors to identify and implement all BMPs applicable to their activity.

The Contractor shall ensure that all personnel acting on behalf of the Contractor are also aware and have the necessary experience, training and resources to appropriately implement the BMPs. The Contractor's Environmental Monitor shall conduct monitoring and ensure compliance with applicable BMPs relating to specific activities detailed in this section.

6.2.1 Piling Installation General Requirements

- BMPs for Pile Driving (DFO, undated; BC Marine and Pile Driving Contractors Association, 2006; Appendix D) will be followed during pile installation, including the following measures:
  - Underwater sound pressure levels will be monitored (via hydrophone) <5 m from the pile being driven by a qualified EM at the commencement of the works to ensure thresholds (i.e., 30 kPa and 160 dB) are not exceeded.
  - Should the measured pressure levels exceed thresholds, the exceedances will be noted and reported to the DR immediately, at which point work may be suspended immediately to allow for implementation of additional mitigation measures. Any change in methods and/or ground conditions may require further hydrophone monitoring.
  - Deployment of a bubble curtain is recommended should an impact hammer be utilized for driving steel piles (as per BMPs; BCMPDCA/DFO, 2006).
  - Mitigation measures (e.g., avoiding multiple piles been driven at one time, deployment of a bubble curtain over the length of the wetted pile to reduce the shock waves, etc.) should be implemented as appropriate to mitigate effects of underwater noise on the surrounding environment.
  - A 25 metre pinniped safety zone and a 500 metre cetacean safety zone will be established (Appendix A, Figure A3). If a marine mammal is observed within these respective zones, works shall be suspended until the animal has left the safety zone.

  - In the event that pile installation causes a fish kill, the DR shall issue a stop-work-order. The Contractor will be responsible for introducing effective means to reduce the level of shock waves or similar measures that will prevent fish from entering the potentially harmful shock wave area.
- Water quality during all pile driving or extraction activities must comply with the criteria provided in the WQMP (Section 6.1.5).
- Pile cut-offs, waste or any miscellaneous unused materials will be recovered for disposal in a designated facility or placed in storage. Under no circumstances will materials be returned to the marine environment or stockpiled on-site.
- The use of vibratory pile driving and removal methods, where practical and feasible, is preferred over impact pile driving to minimize noise and sound pressure effects on aquatic life.

6.2.2 Concrete Works

- Ensure that all works involving use of concrete, cement, mortars and/or other cement or lime-containing construction materials will not deposit (directly or indirectly) sediments, debris, concrete, leachate, concrete fines or wash water into or about any watercourse.
- Immediately report to the DR spills of sediment, debris, concrete fines, wash or contact water of reportable quantities and begin clean-up. DR may contact EMBC Environmental Emergency Management Plan Incident Reporting Hotline 1 -800-663-3456 and Department of Fisheries and Oceans (DFO) Observe, Record and Report Hotline 1-800- 465-4336.
- When grinding, cutting or demolishing cured concrete, dust and fines should be prevented from entering the water and water quality performance criteria in the WQMP must not be exceeded.
- Monitoring of pH should be measured to an accuracy of +/- 0.2 pH units from the background level to ensure allowable ranges are maintained when performing any concrete works about water (e.g., grinding concrete where dust or fines may enter the water, pouring concrete, washing equipment). In the event that the levels are outside the acceptable ranges (7.0 to 8.7 [MOE, 2016]) the DR must be notified and preventative measures are to be introduced (e.g., catch basins to recover the runoff and neutralizing prior to disposal).
- All equipment for concrete work must be properly sealed and have locked connections where present. Crews will ensure that concrete forms are not filled to overflowing. Excess or spilled concrete must be collected immediately and disposed of in an appropriate location.
- Barriers will be used as appropriate to prevent splashing of the concrete over the forms and into the water or intertidal area during pouring.
- Concrete washout water and solids will be collected and retained in leak proof containers, so that this caustic material does not reach the soil surface then migrate to surface waters, groundwater or adjacent watercourses. Collected water must be monitored for acceptable pH levels (as per EMIP). If the pH levels are outside the allowable limits then the runoff water must be contained until the pH is between 7.0 and 8.7 pH units and turbidity is <25 nephelometric turbidity units (NTU), measured to an accuracy of +/- 2 NTU.

- Equipment and tools that have come into contact with concrete will be washed down in a designated area away from the intertidal and drainages (e.g., streams and municipal drains) to prevent concrete products from entering watercourses (tidal waters, streams, drains).

6.2.3 Selective Site Demolition

- Any jetty attachments selected for re-use on-site (e.g., cable trays, safety ladders, chains, bolting materials, bull rails) must be cleaned and/or decontaminated at the designated on-site decontamination area prior to storage and reinstallation.

6.2.4 Structure Relocation

- Temporary location of the tug boat wharf, between relocation and reinstallation, should be within the Project Boundary and is subject to approval by DR.

6.2.5 Wood, Plastic and Composites BMPs

In addition to the General BMPs stated in Section 6.1 the following BMPs may apply:

Wood Treatment

- Any wood or timbers to be treated shall be cut to final length prior to treatment.
- Field treatment of newly exposed timber components for re-use (e.g., cutting, cracking, holes) is to be done in a manner to prevent preservative from entering any watercourse.
- Do not apply field treatment in conditions that render containment ineffective (i.e., raining).
- Dispose of any unused preservative at a Hazardous Waste Facility and any treated timber waste (including sawdust) at a facility approved to dispose of treated timber material.

Timber

- All structures for re-use (e.g., designated bull rails, timber chocks, dolphin and fender piles) shall be decontaminated prior to re-installation.
- Any treated timber waste must be disposed of in accordance with federal, provincial and municipal laws and policies.
- Timbers to be treated shall be cut to final length prior to treatment.

6.2.6 Finishes BMPs

In addition to the General BMPs stated in Section 6.1 the following BMPs may apply:

Painting Exterior Metal Surfaces

- Use containment such as tarps, shrouds or portable structures to prevent airborne particles from entering the atmosphere and depositing on surface waters or surfaces leading to watercourse.
- Airborne particle containment should be large enough to adequately enclose or segregate working areas.
- Place containment beneath and around structures being painted to ensure overspray or runoff does not reach waters or surfaces leading to watercourse.
- Do not paint during conditions that render containment ineffective (e.g., windy).
- Ensure paint, solvents and other applicable materials are stored securely when working alongside structure and water edges.
- Ensure any floor grates are covered to prevent spills from reaching waters or surfaces leading to watercourses.
- Waste generated from grinding and hand tooling must be prevented from entering any watercourse.
- Ensure empty paint cans and other associated wastes from painting are stored properly, protected from the weather and removed as soon as possible.
- Left over paint and paint derived materials should be disposed of appropriately in accordance with manufactures guidelines and, where appropriate, at a registered facility.

6.2.7 Earthworks BMPs

In addition to the General BMPs stated in Section 6.1 the following BMPs may apply:

Excavating, Trenching & Backfilling

- Design open excavations to protect against flooding and damage due to surface water run-off.
- Dispose of water generated from earthworks activity in a manner not detrimental to any portion of work completed or under construction.
- Work will be conducted in a manner that does not result in the deposit of a toxic or deleterious substance into waters. Water quality will be assessed in accordance with the relevant WQMP criteria.
- Isolate work areas from all water (including flowing and standing) that can contact the ocean to inhibit water transport of materials into the surrounding environment.

General Fill

- Select appropriate fill material and placing methods, provide suitable equipment and sequence the work so that the specified quality of fill is produced.

- Information regarding the source (e.g., supplier, location, environmental quality) of imported materials (e.g., aggregate for concrete) and appropriates certificates are to be provided by the supplier to PWGSC.
- General fill used at in the Phase 2 work area shall consist of durable, natural granular material, free of organics, with no more than 8 % by weight passing the 75 µm (No. 200) sieve. Recycled materials from off-site sources, including but not limited to concrete, asphalt pavement and glass, shall not be used as fill. The maximum particle size shall not exceed 150 mm.
- The presence of fines within imported armour rock material will be minimized. This may require pre-washing of the material.
- Conduct ongoing quality control sampling and testing at the loading conveyor to confirm that the general fill materials conform to the Project requirements. The material gradation testing rate for general fill shall be not less than one test for every 100 m^3 placed in the work. All quality control test reports shall be submitted to DR for review and approval prior to placement of that material.
- All general fill and sand fill shall be imported by road transport and unloaded directly within the Project Area.
- The road must be swept at the end of each day, or more frequently if required, to remove any loose materials.
- Contractor shall provide adequate flag-persons and/or traffic signal devices to prevent interference with emergency vehicles or traffic of other dock users and Contractors when transporting fill materials.

6.2.8 Exterior Improvement BMPs

In addition to the General BMPs stated in Section 6.1 the following BMPs may apply:

Aggregate Material Recovery

- At the end of each working day, roadways shall be swept and made clear of debris, fallen rock and dust arising from rock and concrete deliveries to DR's satisfaction.

Asphalt Paving

- Prevent discharge containing asphalt, grout, concrete or other waste materials from reaching storm drains, watercourse and/or marine environment. During rain events, portable asphalt mixing equipment should be covered by an awning or other simple structure to avoid direct contact with rainfall to inhibit mobilization of materials in rainwater.
- Prevent the application of fog seals, tack coats or other coatings, if required, during periods when rainfall is likely.
- Minimizing washing of sand or gravel from new asphalt, debris from drilling or cutting or other materials into storm drains watercourse and/or marine environment by sweeping or washing.

During Construction

- Use drip pans, ground cloths, heavy cardboard or plywood wherever concrete, asphalt, or asphalt emulsion chunks and drips are likely to fall unintentionally from mixing equipment (e.g., beneath extraction points) to minimize asphalt runoff into the surrounding environment.
- Accumulations of concrete runoff, aggregate chunks, and other solids must be collected for proper disposal prior to removing the containment or cover devices to prevent contamination of the surrounding environment.
- Provide catch basin covers, inlet protection or similarly effective containment devices over all nearby catch basins such that runoff from the construction activity does not enter the stormwater drainage system surface runoff or marine waters.
- Direct wash water exposed to aggregate to areas where sediments will be filtered and not drain to stormwater, watercourse or marine areas.
- If wastewater cannot be directed to suitable areas on-site, it should be contained, collected and disposed of in an approved manner.

Clean-up

- Designate a wash out area on-site where application and mixing equipment cleaning should be conducted. This washout area should also be used to contain excess material and slurry. The area should be designed to appropriately contain all waste generated.
- Clean equipment off-site when practical and avoid any silt-laden discharge directly or indirectly into the watercourse. This includes trucks and equipment that can return to the batch plant for washing.
- Sweep the pouring area at the end of each day, or more frequently as needed, to collect loose aggregate chunks and dust. Do not hose down the area to stormwater drains or intertidal area.

Saw Cutting

- Slurry and sediment from saw cutting operations should be confined to the immediate work area by using temporary berms or diversion structures. Cover or barricade all nearby stormwater drains during saw cutting to prevent any materials from entering the stormwater drainage system.
- Residue from cutting or grinding operations should be picked up and contained using a vacuum attached to the cutting machine. Residue should not flow across pavement or be left on the pavement surface. Street sweeping or washing down the area that collects and treats the water may be required.
- Avoid saw cutting operations during rainfall events unless cuttings, sediment and wash water can be contained and disposed of appropriately.

- Spills of chemicals used to expose aggregate, should be contained to prevent them from draining to streets, lanes or other areas where it may reach the marine environment or stormwater drainage system. Any spill of reportable quantities must be reported to DR immediately.

6.2.9 Waterways and Marine Construction BMPs

In addition to the General BMPs stated in Section 6.1 the following BMPs may apply:

- All work must abide by the conditions of all applicable legislation and regulations.
- Vessels and equipment will be well maintained and kept in good working order.
- Contractors operating marine vessels within the Project area should minimize re-suspension of sediments resulting from prop wash or thrusters by operating at minimal speed whenever possible.
- Grounding of barges may need to occur; however, this shall only occur in areas where excavation/dredging and replacement of surficial substrate (engineered capping) has been authorized and completed to prevent disturbance of established sessile marine organisms.
- Contractor shall be responsible for the safe overwater and terrestrial transport of all waste materials (including all construction debris, and associated stormwater runoff containing potentially deleterious substances) in accordance with federal, provincial, regional/municipal laws and regulations and all Project specific documents.
- Ensure hydraulic machinery, if required, uses environmentally sensitive hydraulic fluids that are non-toxic to aquatic life and that are readily or inherently biodegradable.
- Wastewater produced at the Work Site (e.g., equipment decontamination wastewater) should be tested prior to discharge in the EGD Project Area to ensure compliance with applicable water quality performance objectives for where it is intended to be released.
  - If criteria cannot be met wastewater shall be treated at an authorized Wastewater Treatment Facility. No deleterious substances may be released into any watercourse.
- Work will be conducted in a manner that minimizes induced turbidity such that it does not result in exceedance of water quality criteria (Section 6.1.5).

DFO Marine/Estuarine Fisheries Timing Windows (DFO, 2014b)

The least risk work windows for Esquimalt Harbour are:

- December 1 to February 15 (winter window)
- July 1 to October 1 (summer window)

Project related activities are expected to occur year-round. Works conducted out of the least risk windows have an increased risk to fish. In most cases, this can be mitigated with appropriate best management practices such that no serious harm to fish occur.

In-water Transportation

- Contractors shall be responsible for the safe transport of all waste materials (e.g., construction debris) in accordance with federal, provincial and regional/municipal laws and regulations and conditions as set forth in the permits and contract terms.
- Contractor shall assume liability for misplaced waste and debris material arising out of their activities, and is required to notify and coordinate with appropriate authorities if material is misplaced or lost during transport to the certified Off-Site Offload Facility or during completion of offloading, transport and disposal activities.
- Transport of any debris shall be performed using a watertight barge with sidewalls of sufficient height to fully contain the debris.
- Contractor is responsible for detailing the methods for monitoring haul barges for leakage during transport of material and contingency actions should a leak be observed. If leakage is observed, however minor, barge transport operations shall be halted and not restarted until repairs are made and approved. The DR must be notified of any leaks.
- Provide registration, licencing and certificates of seaworthiness for each haul barge to be used on the Project. In addition, material transportation by barge will require the Contractor to obtain an Authorization from Transport Canada Harbour Master pursuant to the Canada Marine Act and from DND QHM. If vessels undergo any repairs certificates must be re-submitted.

Off-Site Stockpiling

- Any material stockpiled off-Site shall be contained to prevent any loss or run-off to the surrounding environment.
- The operation of an Upland Staging Area will consider the need for containment, coverage of stockpiles, use of erosion and sedimentation controls, and management of water runoff.
- Stockpiles, where practicable and feasible, must be located 30 m or greater away from watercourses (the space available is limited and constrained by operational requirements).
- Construct stockpile areas using berms or other barrier devices to prevent uncontrolled spreading of debris and/or contaminated sediment.
- Cover stockpiles to prevent erosion during periods of rain and/or wind. BMP1 1 Collect and treat/dispose of water draining from stockpile areas.
- Stockpiled material should be prevented from freezing.
- Materials must not be stockpiled for extended periods of time unless approved by DR.
- Upon completion of work, Contractor will return the Off-Site Stockpiling area to pre-project condition.

Upland Transportation

- Waste transported to/from Contractor's Off-Site Offload Facility will be covered with a tarp and adequately secured in watertight containers to minimize release of odours and dust and ensure no spillage.
- Haulers must use only designated routes for transport of the material (e.g., designated truck routes; Appendix I for Esquimalt Truck Routes).
- Contractor is responsible for all misplaced waste and debris material and is required to notify and coordinate with appropriate authorities if material is misplaced during transport to the Off-Site Offload Facility or during completion of offloading, transport, and disposal activities.

7. PROFESSIONAL STATEMENT

Findings presented in this assessment are based upon (i) reviews of available documentation and discussions with available personnel and regulatory representatives, (ii) review of available records and the terms and conditions for the planned activities. Consequently, while conclusions and recommendations documented in this report have been prepared in a manner consistent with that level of care and skill normally exercised by other members of the environmental science and engineering profession, practising under similar circumstances in the area at the time of the performance of the work, this report is intended to provide information and to suggest mitigation strategies to reduce, but not necessarily eliminate, the potential for environmental impacts to occur as a result of planned activities in the Study Area. This management plan is meant to be a living and flexible document that can be used to provide guidance regarding appropriate management of species.

This environmental assessment has been prepared solely for the internal use of PWGSC on behalf of DND, and federal agencies providing expert advice to the project pursuant to the agreement between Keystone Environmental Ltd. and PWGSC. Any use which other parties make of this report, or any reliance on or decisions made based on it, are the responsibility of such parties. Keystone Environmental Ltd. accepts no responsibility for damages, if any suffered by other parties as a result of decisions made, or actions based, on this report.

September 13, 2016
Date

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BC Environmental Management Act.

8.1 Legislation and Bylaws

8.1.1 Federal Acts and Regulations

- Canada Marine Act, 1998 (amended 2014)
  - Natural and Man-made Harbour Navigation and Use Regulations
- Canada Shipping Act, 2001 (amended 2013)
  - Collision Regulations
- Canadian Environmental Assessment Act, 2012 (amended 2013)
  - Regulations Designating Physical Activities
- Canadian Environmental Protection Act, 1999
- Fisheries Act, 1985 (amended 2013)
  - Marine Mammals Regulations
- Migratory Birds Convention Act, 1994
  - Migratory Birds Regulations
- Navigable Waters Protection Act, 1985
- Navigation Protection Act, 2014
- Species At Risk Act, 2003
- Transportation of Dangerous Goods Act, 1992 (amended 2009)
  - Transportation of Dangerous Goods Regulations

8.1.2 Provincial Acts and Regulations

- Environmental Management Act, 2003

  - Contaminated Sites Regulation
  - Hazardous Waste Regulation
  - Spill Reporting Regulation
  - Industrial Non-hazardous Waste Landfills Code of Practice
- Heritage Conservation Act, 1996
- Wildlife Act, 1996

8.1.3 Regional and Municipal Bylaws

- Capital Regional District (CRD). 2006. Capital Regional District (CRD) Sewer Use Bylaw No. 2922 (Consolidated). [online] Available at: https://www.crd.bc.ca/docs/default-source/source-control-pdf/ regional-source-control-bylaw---crd-bylaw-2922. pdf?sfvrsn=4.
- City of Colwood. 1986 (amended 1992). Bylaw No. 38 – A Bylaw to Regulate Noise within the City of Colwood. [online] Available at: https://colwood.civicweb.net/Documents/ DocumentDisplay.aspx?ID=168.
- Corporation of the Township of Esquimalt (Township of Esquimalt). 2005 (amended to 2014). Streets and Traffic Regulation Bylaw, 2005, No. 2678. [online] Available at: http://www.esquimalt.ca/files/PDF/Bylaws/Bylaw_2607_-_Streets_and_Traffic_Regulation_ 2014.pdf.

APPENDIX A

FIGURES

Figure A1: Esquimalt Graving Dock Waterlot Sediment Remediation Project Area Map

Date: June 20, 2014
Coordinate System: NAD83 UTM Zone 10
Adapted from Golder, 2012a; Reference Department of natural Resources.
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G3 CONSULTING LTD.

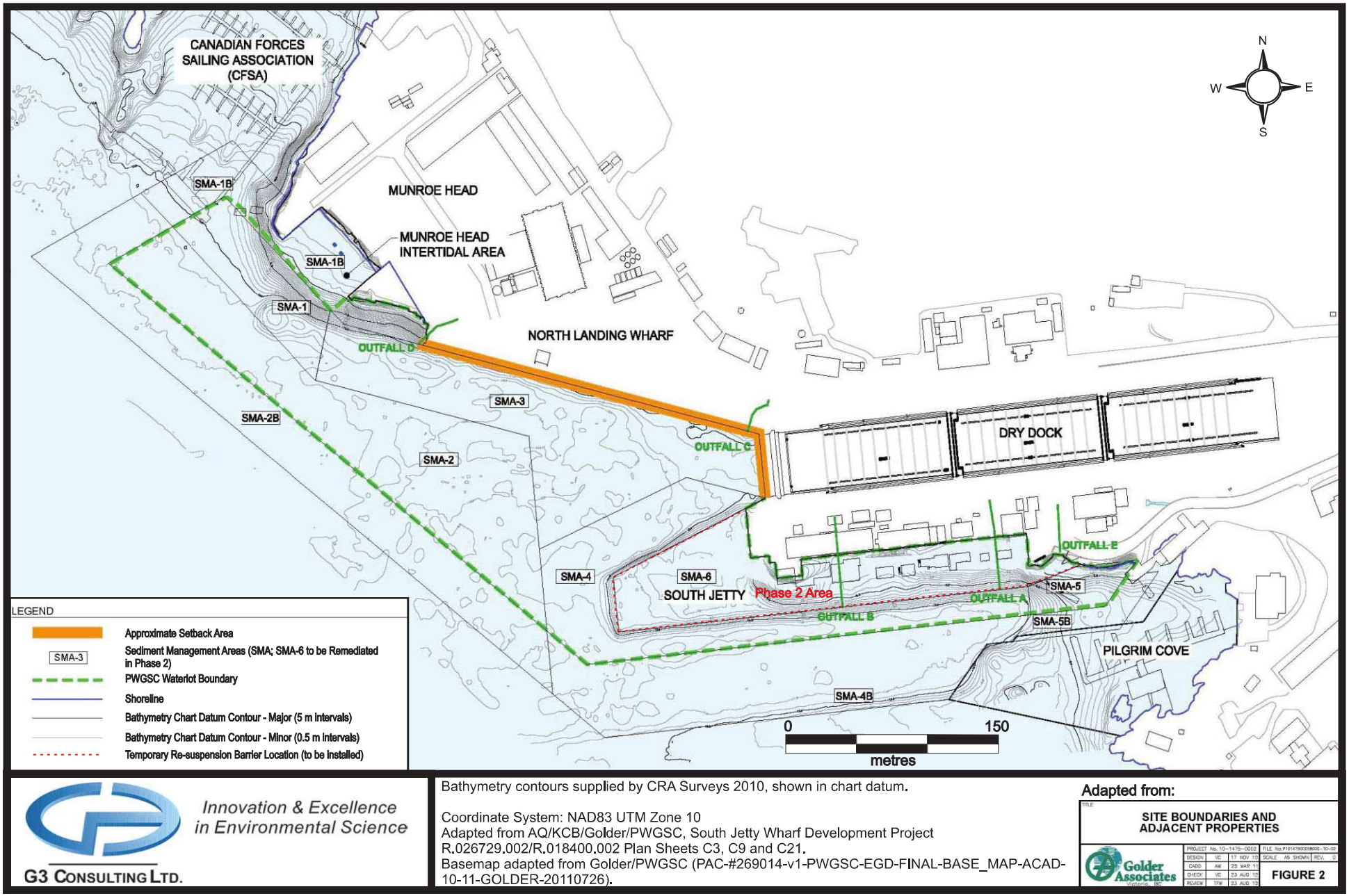
Adapted From:

PROJECT PUBLIC WORKS GOVERNMENT SERVICES CANADA
EGD WATERLOT SEDIMENT REMEDIATION PROJECT
ENIVORNMENTAL ASSESSMENT
ESQUIMALT, B.C.

Golder Associates Victoria, BC

PROJECT	10-1475-0002		FILE No.	10147500028000-10-01	
DESIGN	VC	24 FEB 11	SCALE	AS SHOWN	REV. 0
CADD	AW	9 MAR 11			
CHECK	VC	23 AUG 12			
REVIEW	TM	23 AUG 12			

Figure A2: Site Boundaries and Adjacent Properties



G3 Consulting Ltd.

Innovation & Excellence in Environmental Science

Bathymetry contours supplied by CRA Surveys 2010, shown in chart datum.

Coordinate System: NAD83 UTM Zone 10
Adapted from AQ/KCB/Golder/PWGSC, South Jetty Wharf Development Project R.026729.002/R.018400.002 Plan Sheets C3, C9 and C21.
Basemap adapted from Golder/PWGSC (PAC-#269014-v1-PWGSC-EGD-FINAL-BASE_MAP-ACAD-10-11-GOLDER-20110726).

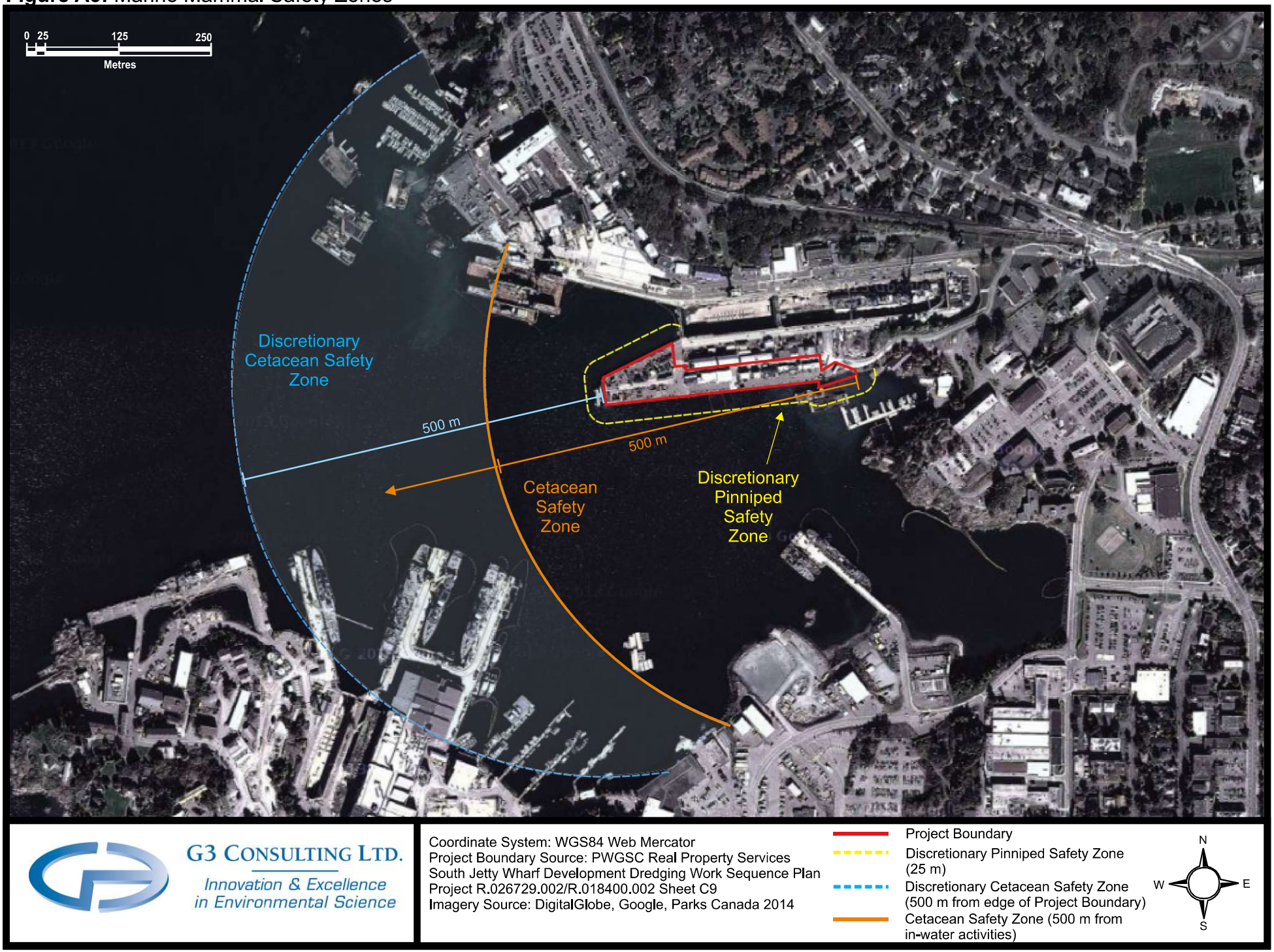
Adapted from:

TITLE: SITE BOUNDARIES AND ADJACENT PROPERTIES

Golder Associates Victoria, BC

PROJECT No. 10-1475-0002			FILE No. P1014750002B000-10-08
DESIGN	VC	17 NOV 10	SCALE AS SHOWN REV. 0
CADD	AW	25 MAR 11	
CHECK	VC	23 AUG 13	FIGURE 2
REVIEW	TFW	23 AUG 13	

Figure A3: Marine Mammal Safety Zones



APPENDIX B

PERMITS AND APPROVALS

Fisheries and Oceans Canada | Pêches et Océans Canada

Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC, V9T 6N7

Your file *Votre référence*

May 13, 2014

Our file *Notre référence*
14-HPAC-00210

Cliff Rhodes, Portfolio Director
Public Works and Government Services Canada
219-800 Burrard Street
Vancouver, BC, V6C 0B9

VIA E-MAIL: Cliff.Rhodes@pwgsc-tpsgc.gc.ca

Dear Mr. Rhodes:

Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish.

The Fisheries Protection Program (the Program) of Fisheries and Oceans Canada received your proposal on February 26, 2014.

Your proposal has been reviewed to determine whether it is likely to result in serious harm to fish which is prohibited under subsection 35(1) of the *Fisheries Act*.

Our review consisted of:

- Request for Review form and attached Figures and Photos

We understand that you propose to:

- Demolish the existing South Jetty pier
- Dredge and remediate contaminated sediments
  - 5,225 m2 intertidal coarse sediment and bedrock
  - 6,893 m2 subtidal unconsolidated sediment
- Construct a new South Jetty pier
- Remove existing sheet pile containment wall

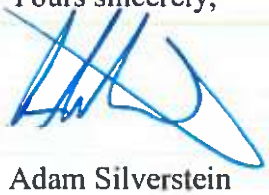
Provided that the mitigation measures identified in your Request for Review form are incorporated into your plans, the Program is of the view that your proposal will not result in serious harm to fish. No formal approval is required from the Program under the *Fisheries Act* in order to proceed with your proposal.

If your plans have changed or if the description of your proposal is incomplete, or changes in the future, you should consult our website (http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html) or consult with a qualified environmental consultant to determine if further review is required by the Program.

Please notify this office at least 10 days before starting your project. A copy of this letter should be kept on site while the work is in progress.

If you have any questions, please contact Byron Nutton at our Nanaimo office at 250-756-7221, by fax at 250-756-7229, or by email at byron.nutton@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with the Program.

Yours sincerely,



Adam Silverstein
Manager, Regulatory Reviews
Fisheries Protection Program

APPENDIX C

EGD ENVIRONMENTAL BEST MANAGEMENT PRACTICES

Keystone Environmental
Knowledge-Driven Results

Esquimalt Graving Dock

Environmental Best Management Practices

Prepared By:
Public Works and Government Services Canada
Environmental Services

Date: October 6, 2010
Version: 04

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Overview

The **Esquimalt Graving Dock (EGD)** is a federal-government-operated, multi-user ship repair and maintenance facility located in Esquimalt, British Columbia. The facility has been in operation since 1925, and provides service to local, Federal, and international vessels. The vessel repair and maintenance work at the EGD is carried out by privately owned shipyards that rent the required sections of the drydock and lease upland work space from the government, and pay a fee for services such as cranes, compressed air, water and power.

Industrial ship maintenance and repair operations have the potential to result in significant environmental issues and impacts. To help identify and manage these potential impacts, the EGD has implemented an **Environmental Management System (EMS)** certified under the internationally recognized standard **ISO 14001**. The EMS provides the framework for identifying potential impacts, and ensures adequate controls are in place to effectively manage them.

This manual contains a series of recommended **Environmental Best Management Practices (EBMPs)** to reduce potential environmental impacts of common activities and operations at the Esquimalt Graving Dock. The manual contains guidance for those operating at the EGD, and is intended to complement existing environmental legislation. It does not remove the responsibility of all contractors and companies operating at the facility to abide by all applicable regulatory requirements and industry standards. All users of the facility are expected to follow the EBMPs.

For further information on environmental rules and standards contact the EGD Environmental Department.

Environmental Policy

It is the goal of the Esquimalt Graving Dock, in partnership with the ship repair industry, to be the premier ship repair, construction and maintenance facility on the west coast of North America.

The Esquimalt Graving Dock and its Users realize that environmental management is an integral part of attaining that goal. Through the implementation of an ISO 14001 Environmental Management System, we are committed to managing the actual and potential environmental impacts of our operations.

To meet our commitment we will:

- *Protect the natural environment and prevent pollution.*
- *Meet or exceed applicable federal, provincial and municipal legislation and regulations; uphold departmental policies; and abide by industry standards, practices and other requirements related to our identified environmental aspects.*
- *Establish and review our programs, objectives and targets to ensure we are meeting our environmental commitments.*
- *Communicate openly with our employees, Users, tenants, contractors, suppliers, neighbours and other stakeholders regarding our Environmental Management System and the nature of our operations.*
- *Educate our employees and the Users of our facility to ensure they are aware of and understand their roles and responsibilities in protecting the environment.*
- *Meet the evolving needs and expectations of our industry and community through the continual improvement of our systems, programs and procedures.*

Bonnie MacKenzie	Jim Milne	David Latoski
Director General	Director	Operations Manager
Engineering Assets	Esquimalt Graving Dock	Esquimalt Graving Dock
Strategy Sector	Engineering Assets	Engineering Assets
	Strategy Sector	Strategy Sector

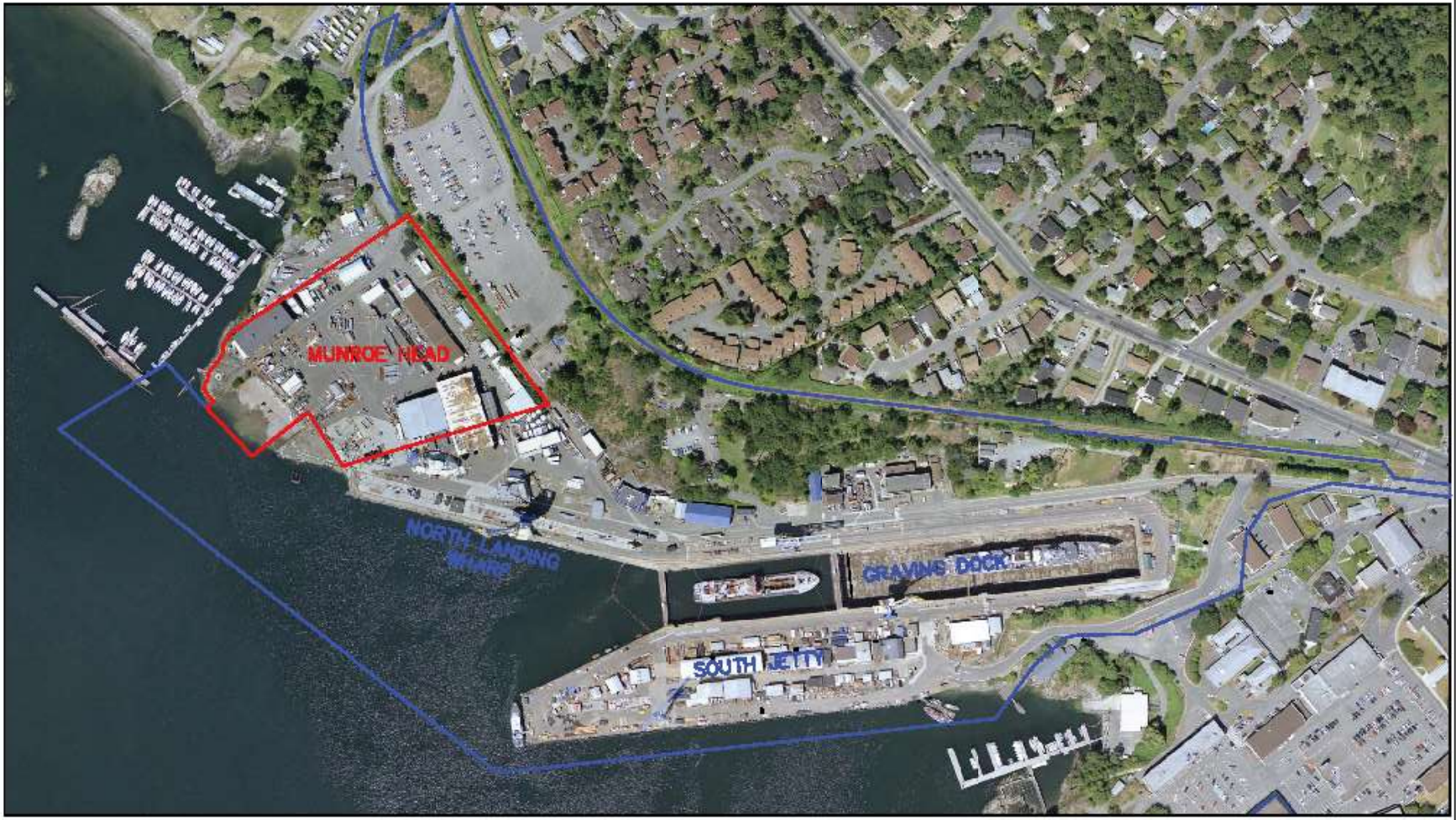
JULY 2009

Public Works and Government Services Canada | Travaux publics et Services gouvernementaux Canada

ISO 14001
EMS-011
CQSB

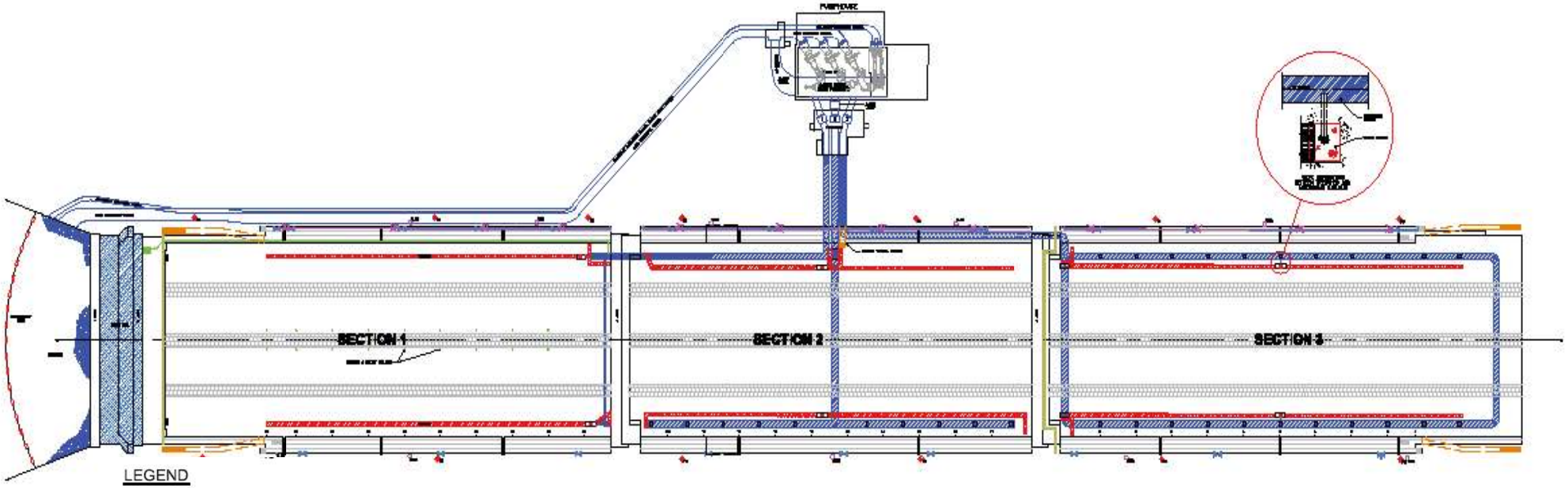
Canada

Esquimalt Graving Dock



ESQUIMALT GRAVING DOCK
DRAINAGE PLAN

Note: It is intended that this drawing be printed in colour.
If printed in black and white some detail will be lost.



LEGEND

LADDER	
STAIR	
FIRE ACCESS	
ELECTRICAL CONN.	
AIR CONNECTION	
WATER CONNECTION	
WATER PIPE	
TRENCH GRATE	
TUNNEL GRATE	
TUNNEL MANHOLE	
NET CAGE- MAIN TUNNEL ACCESS	
TRENCH DRAIN	
DE-WATERING TUNNEL	
SILL PUMP & PIPE	
MOON POOL	

ESQUIMALT GRAVING DOCK:
1178' (361.8m) LONG
128' (41.2m) WIDE
48.5' (15m) DEEP

THIS DRAWING IS NOT TO SCALE

BMP #1

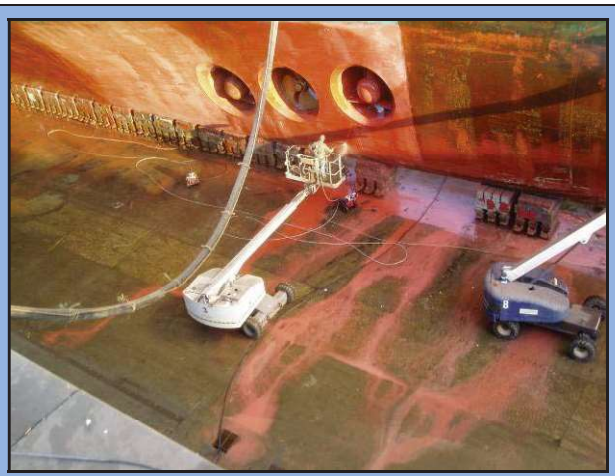
High Pressure/ Ultrahigh Pressure Washing

One of the first activities to occur on a dry-docked vessel is the high pressure washing of the vessel hull to remove salts and marine growth prior to surface preparation or painting. This typically involves pressure washing the hull and/or super structure with water at 2,000 – 3,500 psi, which may produce large volumes of paint contaminated wastewater. Shipyards may use an Ultra High Pressure (UHP) washing process (from 40,000 – 55,000 psi) to completely remove all paints, eliminating the need for further surface preparation prior to painting. This operation generates even larger volumes of wastewater and solids, which will need to be managed.

Management of Wastewater on the Graving Dock Floor

- Ensure all wastes and wastewater discharges resulting from hull washing activities are collected and disposed properly.
- Coordinate high pressure washing operations to ensure effective collection of wastewater.
- Close all sump well valves in the floor collection system prior to and during high pressure washing operations.
- Divert contaminated wastewater that falls outside of the dock floor containment area away from the tunnel drains.
- Direct non-contaminated water (i.e. ballast water, cooling water) away from contaminants on the dock floor.
- Collect and dispose of stormwater that comes into contact with contaminants.
- Do not use environmentally harmful detergents or additives in wash water.

All wastewater containing paint contaminants must be directed to the collection drains and sumps on the drydock floor, collected, and sent for treatment.



Antifoulant contaminated wash water entering the trench drain sump wells on dock bottom.

Section 1 Considerations – Caisson Leakage and Sediment

Diversion of sill water away from pressure washing areas

Water leaking into Section 1 of the graving dock from the caisson can be diverted from the work area by using a sump pump hooked to the PVC pipe installed along the north wall of the graving dock (Section 1).

Managing Entrained Sediment

Harbour sediment may become trapped in section 1, and accumulate in the corners, trenches and sumps. The users of the section will need to be aware of this. This sediment will have to be removed if it becomes contaminated with pressure washing wastewater, sandblast grit, paint chips, paint overspray, or other contaminants.

The sill diversion pump removes clean saltwater from the pool at the front of Section 1(moon pool) and discharges to the tunnel drains through a hard pipe on the dock wall.

Sediment from the harbour often settles on dock bottom after dewatering. This may become contaminated with paint, etc. and must be disposed of.

Ultra High Pressure (UHP) Washing

Ultra high pressure washing generates significant volumes of wastewater and sludge that may pose a challenge for collection and disposal.

- Prepare in advance for the management of the UHP waste.
- Remove all water, sludge and debris generated from UHP washing from the dock.
- Ensure the sludge is disposed of at an appropriately permitted facility.

The hull of a cruise ship being ultra high pressure washed. Inset: sludge produced during ultra high pressure washing.

Management of Small Vessel High Pressure Wastewater in the Upland Areas

- Perform pressure washing only in designated areas where wastewater management can be effectively achieved.
- Completely block off all drains prior to use for collecting wastewater from pressure washing.
- Ensure sufficient equipment is available for the timely collection and removal of wash water.
- Clean up work area and drains prior to removal of collection equipment. (i.e. filter cloth, plugs, tarps)

A small vessel is power washed on the North Landing Wharf (NLW).

The trench drain is blocked and a sump pump is installed to collect wash water into a tote.

Example of styrofoam blocks used as a drain blocker on the NLW.

Example of a pump set up used to collect wash water on the NLW.

BMP #2

Abrasive Blasting

Abrasive blasting is a common operation performed at the Esquimalt Graving Dock (EGD) to prepare vessel surfaces for painting. However, this operation creates challenges with respect to controlling air emissions and the waste materials generated.

Fugitive emissions from blasting operations have the potential to negatively affect employees, facility users, neighbours, equipment and infrastructure. The dust from blasting may contain harmful environmental pollutants which may enter the harbour directly or via stormwater runoff.

Waste grit may be contaminated with antifouling paint which poses a risk to marine life if not handled properly.

Dust Control

- Cover all blast media (new and used) during transport.
- Use containment such as tarps, shrouds or portable structures to prevent airborne particles from entering the atmosphere and surface waters.
    - Containment should be large enough to adequately enclose or segregate the working area.
    - Ensure containment devices are connected so there are no gaps.
    - Ensure that containment reaches the dock floor or walls

Adequate Containment

Inadequate Containment

- Where physical containment techniques are not sufficient to prevent fugitive emissions water curtains may be used to mitigate dust emissions in problem areas.
- Do not abrasive blast during conditions that render containment ineffective (i.e. during windy conditions)
- Minimize dust emissions by ensuring blast nozzles are angled close to perpendicular and aimed slightly downward during blasting.
- No abrasive blasting of vessels shall be performed while vessels are docked at the North Landing Wharf or South Jetty

Air Quality Alarm

The Esquimalt Graving Dock has an onsite PM_{10} monitor in partnership with the Ministry of Environment.

If particulate matter levels in the air exceed 100µg/m^3 an alarm sounds in the Pumphouse, at which time corrective actions must be taken.

Waste Grit Management

- Remove waste grit from work areas as soon as possible.
- Store all waste grit in appropriate containers to prevent stormwater and wind impacts.
- Cover all skips, storage bins, tanks, and hoppers to prevent dust emissions.
- Dispose of waste grit in accordance with applicable provincial regulations.

Store all waste grit away from drains, to prevent contaminated water migrating into the marine environment.

Sweep waste grit under the vessel to prevent it from being washed down the drain.

Store waste grit in appropriate containers, protected from inclement weather.

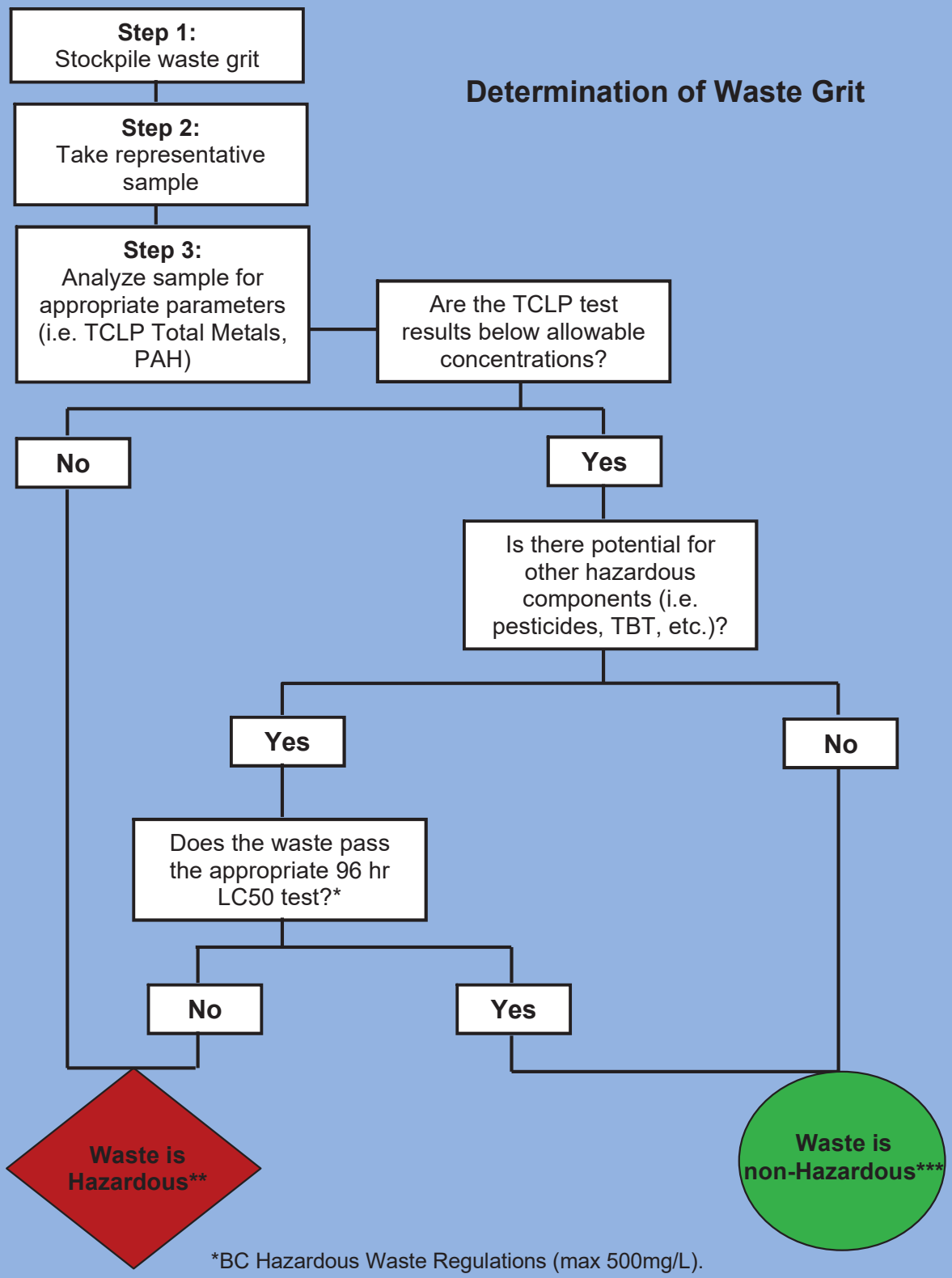
Remove waste grit from work areas as soon as possible.

Keel/Bilge Blocks

Keel and bilge blocks on dock bottom present a challenge for clean up of spent waste grit.

Excess blocks stored in dock bottom may be moved prior to sandblasting, or covered to prevent grit from collecting between the blocks.

Determination of Waste Grit



*BC Hazardous Waste Regulations (max 500mg/L).

**Waste must be disposed of at a permitted facility.

***non-Hazardous waste may be considered "Controlled" and must be disposed of at an approved facility.

BMP #3
Painting and Coating

Ship repair and maintenance often requires painting and coating of vessel surfaces to protect from corrosion or to inhibit growth of marine life. The industrial nature of marine paints, in particular antifouling paints, may result in negative impacts to the environment and surrounding infrastructure if not properly managed.

Paint Overspray
Paint overspray has the potential to impact the marine environment, soils, neighbouring residences, and nearby equipment and infrastructure.

- Use containment such as tarps, shrouds or portable structures to prevent airborne particles from entering the atmosphere and surface waters.
    - Containment should be large enough to adequately enclose or segregate the working area.
    - Ensure containment is secured so there are no gaps.
    - Ensure that containment reaches the dock floor or walls.

Adequate Containment

Inadequate Containment

- Do not spray paint during conditions that render containment ineffective (i.e. windy).
- Place containment beneath and around structures being painted on dock floor and in work areas to ensure overspray does not reach the surrounding area (i.e. during painting of anchor chains, grates, etc.).
- Manage overspray on the graving dock floor to prevent safety hazards (e.g. slippage).

For vessels docked in **Section 1** ensure that overspray does not reach the sill water. Avoid docking vessels so they extend over sill area.

Painting Dockside

- Do not spray paint vessels docked at the North Landing Wharf or South Jetty.
- Use rollers and brushes to paint vessels dockside
- Ensure tarps are in place below work areas, as well as in between the vessel and the dock to prevent spills and drips from entering the water.
- Ensure paint cans are stored securely when working alongside vessel edges.
- Ensure floor grates of manlifts are covered to prevent spills to the marine environment
- Waste generated from grinding and hand tooling must be prevented from entering the marine environment.

Ensure tarps are in place to prevent overspray impacting the surrounding work area.

While painting vessels berthed at the North Landing Wharf and the South Jetty do not spray paint, and take measures to prevent paint from entering the marine environment.

Temporary Paint Storage/Mixing Areas

- Must be under cover to protect from inclement weather
- Only in designated areas
- Must be on secondary containment (a tarp at minimum)
- Ensure empty paint cans and other associated wastes from painting are stored properly, protected from the weather, and removed from dock bottom as soon as possible.

In **rare** situations (i.e. shape of the vessel combined with ideal weather conditions) containment may not be necessary to prevent overspray from escaping the area.

In this situation, the User must notify PWGSC **prior** to beginning the work, and obtain approval, **in writing**, to paint without completely enclosing the vessel. Restrictions and monitoring requirements will be applied.

To this date this has only been allowed in three situations:

- painting underneath a flat bottom barge
- painting the underwater hull portion of the midsection of a cruise ship
- painting of a C-class ferry underwater hull area during calm wind conditions

BMP #4

Dry Dock Floor Management and Cleanup

Drain Management

- All sump well valves must be closed prior to and during power washing operations.
- Cover all tunnel drains and net cages during sandblasting, painting and power washing to prevent contaminants from entering the marine environment.
- In the case of a spill or release on dock bottom all sump well valves must be closed and all contaminated material contained and removed from dock bottom.
- Direct all contaminated water to the trench drain system, to avoid entering the tunnel drains.
- Collect and properly dispose of all contaminated water. Ensure sufficient equipment is available for contaminated water collection.
- Ensure all non-contaminated water is directed away from work areas and into the tunnel drain system. (i.e. ballast water, cooling water, caisson sill water).

Sediment Management

- Segregate any marine sediment which may enter the dock during vessel transfer from pollutants generated from vessel repair in order to reduce the amount of wastes requiring disposal.
- Collect and properly dispose of marine sediment that becomes contaminated with waste generated from vessel repair.
- Remove all contaminants and residues from the trench drains and sump wells prior to flooding at the end of work period.

Hazardous Materials Management

- Store hazardous materials (i.e. fuel, paint, waste oils) away from the drains on dock bottom.
- Store hazardous materials to the inside of the trench drains so that any spills or releases can be captured.
- Store hazardous materials in areas protected from the weather, water curtains and other water sources.
- Ensure adequate spill response equipment is in close proximity to hazardous material transfer operations. At a minimum one spill kit is required per section of the graving dock.

Housekeeping

- Remove waste sandblast grit from the work area as soon as possible to prevent migration of grit contaminants into tunnel drain system.
- Store wastes collected from the dock floor in appropriate secondary containment and removed from dock bottom as soon as possible.

Residual paint in the cans, may drip out of the skip and enter the marine environment through the drain systems.

Leaving garbage around the work site attracts wildlife such as seagulls, racoons, and rats.

When cleaning dock bottom, skips of waste sandblast grit may leak contaminated water and should be removed as soon as possible.

All hazardous materials must be stored in appropriate containment and away from tunnel drain system.

Inspection and Cleanliness

- Prior to flooding, the drydock must be cleaned to meet the Esquimalt Graving Dock (EGD) Standard of Cleanliness, as determined by the EGD undocking supervisor.
- Users must ensure that the dock floor is free of deleterious substances prior to flooding.
- Water may be used to clean the dock floor; however, any wastewater generated must be collected and disposed of properly.
- If a vessel occupies a shared portion of a dock section each User must clean the trench drains up to and including the section sump well.

Example of a dock floor that would pass inspection.

Example of a dock floor that would not pass inspection.

EGD Standard of Cleanliness

Due to the importance of drydock cleanliness prior to flooding, and since quantitative testing is impractical due to time and cost restrictions, the following guidelines will be used to assess cleanliness of drydock surfaces.

- All drydock surfaces, including stairwells and sills must meet the standard for "**residue free**" prior to flooding of the drydock. **"Residue free"** is considered met when a person of normal visual acuity, while standing, is unable to detect visible accumulations of potential pollutants.

- This includes, but is not restricted to, the removal of abrasive grit, paint residues, cutting and grinding wastes, oil and grease, food and drink containers, ear plugs, dust masks, rope, cigarette packs, or any other refuse that may have been deposited during the work period.

- Debris of natural origin that may have been deposited during the previous flooding of the drydock, such as wood, sand, silt, seaweed, or marine life may be exempt from these requirements, as long as it will not contaminate the environment upon reintroduction.

Important Locations	Acceptable	Not Acceptable
Ramps		
Sills		
Keel Blocks		
Trench Drains		
Sump Wells		

BMP #5

Hazardous Materials Handling and Storage

A variety of materials are used, stored and transported by the Users at the Esquimalt Graving Dock (EGD). If not handled appropriately, these materials have the potential to negatively impact worker health and safety, infrastructure or the environment.

Long Term Storage

Users must have designated storage areas suitable for the materials they use on site. These areas must:

- Have appropriate secondary containment suitable to the quantity and nature of the material in that area
- Ensure materials are stored in accordance with compatibility requirements
- Be protected from the weather
- Have placards and ventilation (where applicable)
- Have controlled access

Short Term Storage and Working Areas

These areas must be:

- Clearly identified and labelled
- Located away from pathways to the marine environment
- Located on impervious surfaces (i.e. concrete, asphalt)
- Protected from the weather

Materials must be:

- Stored in containers appropriate for the nature of the material
- Labelled appropriately with product name, first aid information, and PPE requirements.
- Secured appropriately during transport

MSDS for all products stored on site must be available to all employees.

Empty containers must be labelled “Empty”.

Inspect all valves and storage containers for rust or damage before use.

Federal Regulation for Fuel Storage Tanks

As the EGD is a Federal facility, any storage tanks onsite may fall under the Petroleum and Allied Petroleum Products *Storage Tanks Regulations* (2008). Tenants may be required to register their tanks with Environment Canada.

National Fire Code

This code outlines the containment, labelling and location requirements for flammable liquid storage.

Areas to Avoid Storing Containers of Hazardous Materials

Drains: Although the trench drains provide the opportunity to collect accidentally released materials, if a tote or drum is placed directly over top or beside a drain the material will flow directly into it and the spill may not be noticed until it is too late.

Fire Holes: On the South Jetty the fire holes flow directly into the harbour. If any containers fail near the fire holes, the material will not be able to be recovered once it is in the harbour..

South Jetty and North Landing Wharf Edges: Any containers placed near the edge of the jetties have the potential to spill directly into the harbour as there are no berms or secondary containment available.

BMP #6

Waste Management and Recycling

Operations at the Esquimalt Graving Dock (EGD) generate a variety of waste streams including hazardous waste, international wastes, and general refuse and recyclables.

Hazardous Waste

Hazardous wastes generated at the EGD may include waste oil and oil filters, antifreeze, batteries, paint and solvents, oily rags and absorbent materials, spent grit, solids generated during power washing, and asbestos. Appropriate management of hazardous waste will reduce environmental liability associated with inappropriate disposal and storage as well as reduce the risk of human injury and environmental impact.

Hazardous waste storage shall be segregated from new product storage.

- Ensure designated storage areas are away from active work areas.
- Ensure areas are covered to reduce exposure to environment and wildlife.
- Ensure that waste accumulation areas are organized.

Hazardous waste should be segregated into separate containers.

- Ensure containers used are appropriate for the type of waste (i.e. separate drums for waste oil, oil filters, antifreeze, batteries, paint and solvents, oily rags and absorbent material, spent grit)
- Store batteries in a manner that prevents leakage of acid to the environment.
- Properly dispose of contaminated clean-up materials (i.e. absorbents, rags, etc.)
- Do not dilute or mix hazardous waste other hazardous or non-hazardous wastes.
- Cover waste containers to prevent exposure to weather (i.e. rain)

Clearly label all hazardous waste containers.

- Labels should Include: type of waste, generator/company name, and contact information

Asbestos

All asbestos containers and asbestos-containing materials must be identified by signage and labelling in accordance with applicable legislation.

Companies which engage in asbestos related work at the EGD must be qualified to do so.

Biological Waste

Marine life removed from vessel hulls may contain paint contaminants. This waste may be considered a controlled or hazardous waste and would need to be handled and disposed of accordingly.

Recycling

All Users of the EGD are responsible for collecting and disposing of the solid waste they generate from their activities, properties and vessels they are responsible for.

- Recycle solid waste such as plastic, glass, aluminum, mixed paper and cardboard. Recycling areas should be conveniently located and easily identifiable.
- Segregate other solid waste, such as scrap metal, wood, electronics, polystyrene foam and soft plastics for recycling at an approved facility.
- Leaf and yard waste collected on property should be composted at designated sites located on dock property.
- Construction and demolition waste should be reused or recycled wherever cost effective and technically feasible.
- Encourage the use of recyclable products to reduce the solid waste impact on the environment.

International Waste

Like hazardous waste, International Wastes may pose a threat to human health and the environment.

Dunnage from vessels has been known to carry invasive insects to local areas. Foreign dunnage must be identified, stored, and disposed of at an approved facility.

Food wastes may carry pathogenic organisms that could cause illness to those handling it. Food wastes shall be kept in separate, closed containers. The Canadian Food Inspection Agency (CFIA) will inspect foreign vessels and issue directions on disposal.

BMP #7
Fuelling and Oil Transfer

At the Esquimalt Graving Dock (EGD) the transfer of oil and fuel is a common activity. An accidental release during these operations has the potential to negatively impact the environment, and health and safety of those at the facility.

- Prior to any fuelling or oil transfer operations an emergency plan must be in place, adequate spill response equipment must be available, and employees aware of spill response procedures must be on hand.
- All transfer and storage equipment must be in good condition, tested, and properly connected.
- Do not place storage and transfer equipment near pathways to the marine environment (i.e. storm drains, edge of the dock).
- Berthed vessel fuelling operations involving trucks and barges as well as bulk oil transfers exceeding 10 tonnes (10,000 L) per day must comply with the **EGD Fuelling and Oil Transfer Policy and Checklist**.

Vessel Fuelling and Bulk Oil Transfer

Definition of Oil: as described in the Canada Shipping Act oil is considered petroleum in any form, including: crude oil, fuel oil, sludge, oil refuse, and refined products.

- All berthed vessels receiving fuel from a truck or a barge require a containment boom.
- Transfers of greater than 10 tonnes of oil per day to/from a berthed vessel require a containment boom.
- An **EGD Oil Transfer Checklist** must be filled out and signed by representatives from the truck and the vessel and submitted to EGD representatives in the pumphouse prior to fuelling or oil transfer operations.
- Transfer operations must comply with the *Canada Shipping Act*, *Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals Subdivision 5*.

Containment Boom Rental

The Esquimalt Graving Dock has a boom and deployment equipment available for rent. To arrange for booking or rental contact the EGD Operations Manager.

An orange containment boom surrounds the vessel while being fuelled

The EGD boom reel and containment boom

Example Scenario Requirements

Scenario 1: Fuelling a berthed vessel

- Completed and signed EGD Oil Transfer Checklist submitted to EGD Pumphouse
- Containment boom adequately secured at both ends.
- Emergency response plan in place.
- Adequate spill response equipment and qualified personnel available.

Scenario 2: Fuelling a vessel or bulk oil transfer (greater than 10 tonnes a day) in the drydock

- Completed and signed EGD Oil Transfer Checklist submitted to EGD Pumphouse.
- Pumphouse operator on site prepared to shut down auxiliary pumps in case of an emergency.
- Receiving containers located away from pathways to the harbour (i.e. tunnel drains).
- Adequate spill response equipment and qualified personnel available.
- Emergency response plan in place.

Scenario 3: Bulk oil transfer from berthed vessel (greater than 10 tonnes a day)

- Completed and signed EGD Oil Transfer Checklist submitted to EGD Pumphouse.
- Containment boom adequately secured at both ends.
- Receiving containers located away from pathways to the harbour (i.e. storm drains, edge of dock).
- Emergency response plan in place.
- Adequate spill response equipment and qualified personnel available.

Scenario 4: Onshore oil transfer between containers

- All containers located away from pathways to the harbour (i.e. storm drains, edge of dock).
- Emergency response plan in place.
- Adequate spill response equipment and qualified personnel available.

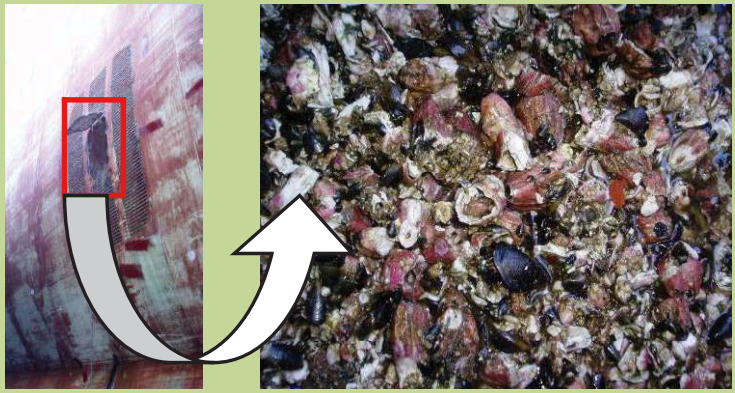
BMP #8

Invasive Species (Ballast Tanks and Hulls)

Invasive species are a significant threat to the marine ecosystems of British Columbia and Esquimalt Harbour. In 2000 a Fisheries and Oceans sponsored study of invasive species found that Esquimalt Harbour had a disproportionately high number of non-indigenous species. It has been widely recognized that the primary source of non-indigenous marine species in local waters are the ballast tanks and hull surfaces of transoceanic vessels.

Marine growth removed from vessel hulls must not be allowed to enter the harbour through the graving dock drainage system.

- Ballast Water
  - Vessels must follow Transport Canada Ballast Water Control and Management Regulations
- Ballast Tank Sediment
  - Shipyards must follow Transport Canada Ballast Water Control and Management Regulations
  - Sediments removed from the ballast tanks at the EGD must be contained, collected and disposed of at an authorized facility.
  - **Sediments must not be allowed to enter the harbour.**
- Anchor chain-growth
  - All biological material removed from anchor chains must be contained, collected and disposed of appropriately.
- Sea chests
  - All biological material removed from sea chests must be contained, collected and disposed of appropriately.



Sea chests such as this one from a cruise ship docked at the EGD often contain a significant amount of marine life. If not managed appropriately this marine life has the potential to negatively impact the local ecosystem of the harbour

BMP #9

Fish and Wildlife Management

The daily operations and activities of the Esquimalt Graving Dock (EGD) have the potential to negatively impact wildlife which frequents the property.

Fish

Fish and other marine life have the potential to become stranded in the graving dock during normal vessel docking/undocking operations. This may include, but is not limited to: salmon, octopus, other fish species, and seals.

- The bubble curtain must be employed during vessel transfer into and out of the graving dock.
- EGD employees must monitor the graving dock for stranded fish and/or other marine life during dewatering.
- Whenever possible, EGD employees must retrieve fish and marine life and safely return them to the Esquimalt Harbour.
- Users are prohibited from removing fish and marine life from the graving dock.

Report all instances of fish and marine life interaction with the Graving Dock to EGD Environmental Services

Authorization for the Destruction of Fish (Section 32)

The EGD has received authorization for the destruction of fish associated with normal operation of the graving dock from the Department of Fisheries and Oceans.

Conditions of the Authorization:

- Take all reasonable precautions to prevent the trapping and mortality of fish
- Monitor the success of preventative measures and retrieval success
- Report to the DFO annually

Wildlife

A variety of wildlife is known to occupy areas of the EGD property. In some cases wildlife may use the facility as a nesting/breeding ground, while others are present for short periods of time to pass to another location or to feed. Activities and operations at the EGD have the potential to impact the well being of wildlife at the facility.

Such wildlife includes: deer, raccoon, mink, river otter, great blue heron, osprey, raven, cormorants and a variety of other common nesting and song birds.

- All wildlife must be left alone
- Injured or orphaned wildlife must not be handled without proper experience and equipment.
- Dispose of dead wildlife appropriately.
- Prior approval from EGD Environmental Services is required for the relocation or removal of nesting wildlife.

In all cases, call EGD Environmental Services for wildlife related incidents

EGD Wildlife Management Plan Contact Information

Conservation Officer
T: (250) 391-2225 (daytime)
1-800-663-9453 (after hours call centre-will take messages and pass along to the Conservation Officer)

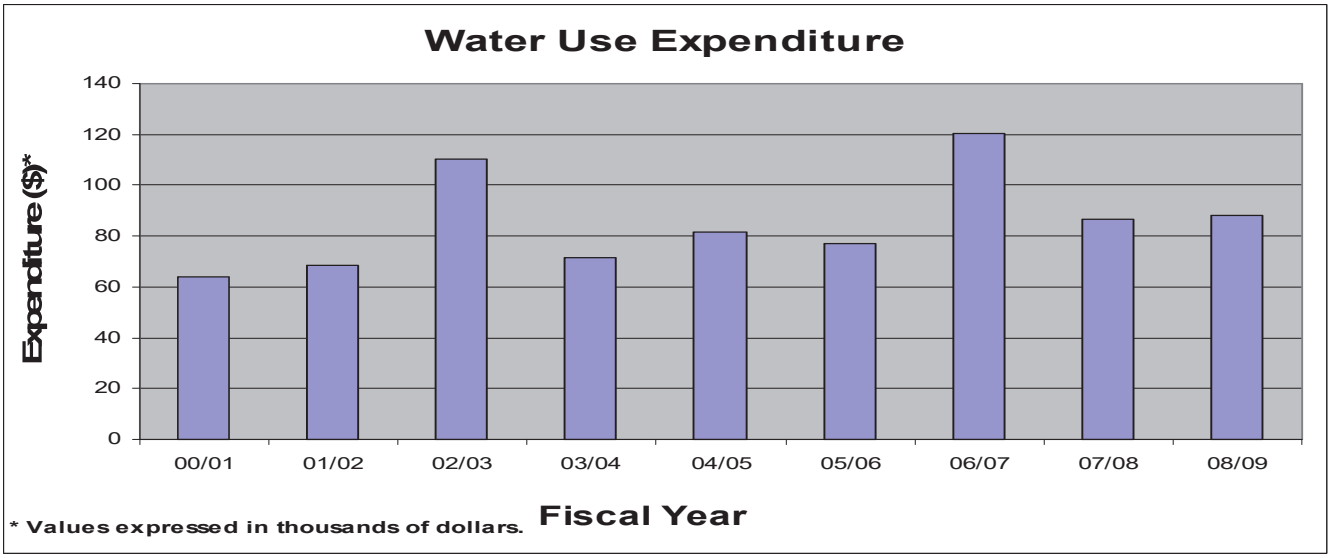
BC SPCA Wild ARC
(Animal Rehabilitation Centre)
T: (250) 478-9453

Vancouver Aquarium Rehabilitation/Rescue
T: (604) 258-7325

BMP #10
Water Use

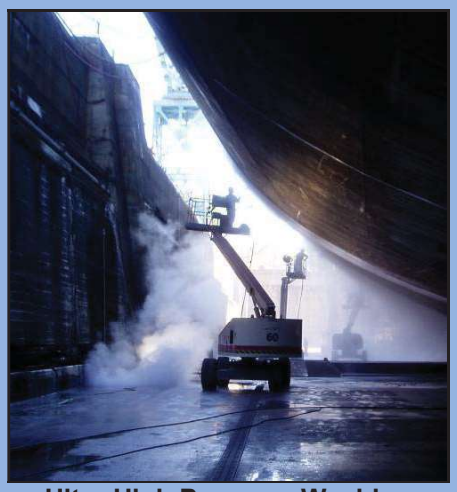
Water consumption and the quality of water are considerations of the environmental management system at the Esquimalt Graving Dock (EGD).

Water Consumption
Large volumes of water are used during normal operations at the facility; because of this the EGD is considered a high volume user of fresh water in the Capital Region.



Significant Water Consuming Activities

Water Curtains
Water curtains are used to mitigate the escape of dust from sandblasting operations in dock bottom



Ultra High Pressure Washing
Ultra high pressure washing uses large amounts of water at high pressure to scour paint and biological material from the hulls of ships

In order to reduce the amount of water consumed onsite:

- Only use water curtains when all other attempts to contain particulate emissions from sandblasting have failed.
- Avoid use of freshwater to clean work areas (e.g. graving dock bottom, wharves, jetties).
- Maintain fittings in buildings and on equipment to prevent leakages.

Metered Water Use at the Esquimalt Graving Dock

- Users must ensure that water is accessed from a metered line when connecting to the water distribution system

- Portable meters are to be used where necessary.

- Pumphouse must be contacted for proper access to the water distribution system.

The EGD maintains the water distribution system.

- Flushing of the entire system is conducted on an annual basis.
- Collection and analysis of water in comparison to drinking water quality guidelines is conducted regularly.

The water distribution system at the EGD was originally designed as a firefighting system; therefore, the water in certain areas of the system may not be considered potable.

- Users are responsible for ensuring that the water they use meets guidelines for the purpose intended.

BMP #11
Energy Conservation

The Esquimalt Graving Dock (EGD), as a facility, is a major energy consumer. Inefficient energy use may result in a negative economical and environmental impact. Economical impacts are associated with inefficient electrical usage (i.e. cost). Environmental impacts include those associated with the consumption of fuel (i.e. air emissions).

Electrical Consumption

There are a number of opportunities to increase the efficiency of electrical usage at the EGD:

- Turn off lights when not in use (flood lights, office buildings)
- Turn off equipment when not in use
- Use energy efficient equipment whenever possible
- Stagger equipment start-up to decrease load on electrical system

Fuel Consumption and Emissions

The second largest source of greenhouse gas emissions from the dock is employee commuting and fuel consumption. Some opportunities to decrease the amount of fuel consumed by day to day activities are:

- Use energy efficient vehicles
- Use alternative fuels/energy sources if possible
- Avoid idling vehicles
- Use shore power whenever possible
- Encourage staff to find alternative means for commuting to work (i.e. carpool, public transit, cycling)

Idling Vehicles

Idling Vehicles produce unnecessary air emissions and noise.

- Do not idle vehicles near building doorways or air intakes
- Vehicles must be turned off if idling for more than 3 minutes in a 60 minute period

Greenhouse Gas Emissions:

Energy consumption results in the production and release of greenhouse gas emissions through the combustion of fossil fuels. Every aspect of work at the EGD results in the release of greenhouse gases whether it is running the cranes or printing a report. It is important to minimize energy consumption wherever possible to mitigate the release of harmful greenhouse gases.

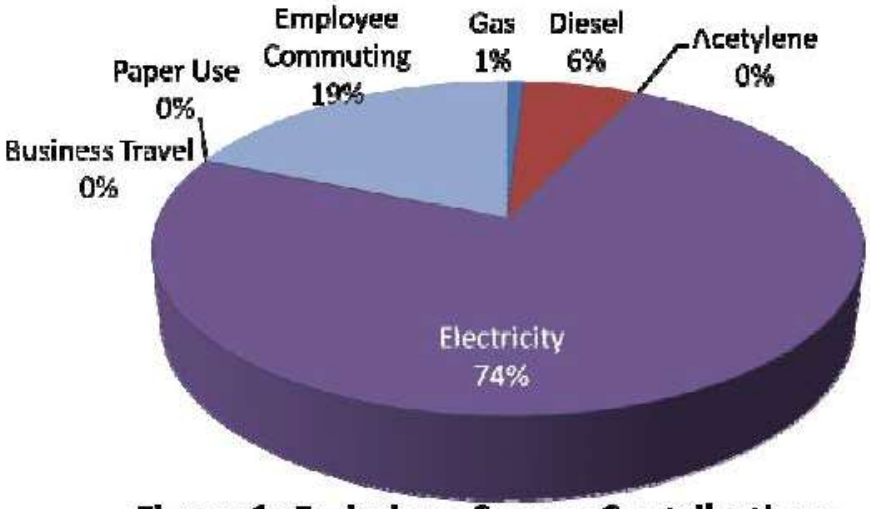


Figure 1: Emissions Source Contributions 2006/2007

The Royal Roads University (RRU) Greenhouse Gas Audit determined that the largest source of carbon emissions at the EGD was electricity use. Employee commuting was the second largest greenhouse gas producer.

Shore Power

When vessels are moored at the North Landing Wharf or the South Jetty it is important that they utilize shore power. With shore power the generator can be turned off thereby saving fuel and preventing the release of harmful air pollutants.

BMP #12

Nusiance Pollution (Noise/Odour/Light)

The daily operations of the Esquimalt Graving Dock (EGD) tenants have the potential to negatively impact the work and living environment of neighbouring businesses and homes. Nuisance pollution is often created by noise, odour and light.

Noise

- The main sources of noise at the EGD include sandblasting, drilling, hammering, compressors, generators and the crane warning bell. Even general shop repair activities generate large amounts of noise.

- Whenever possible schedule noisy activities for daytime hours 0700 hrs to 2300 hrs on weekdays, and from 0700 hrs to 1900 hrs on weekends and holidays. Through worker education and good practice the generation of high-level intermittent or non-continuous noises can be minimized.
- The EGD Environmental Policy makes a commitment to follow all applicable municipal laws and regulations, therefore it is expected that the daily operations at the EGD will meet the Esquimalt Noise Control Bylaw (2677).

The EGD is considered an “Activity Zone” and the neighbouring area is considered a “Quiet Zone”. Building and infrastructure related projects at the EGD may fall under the definition of a “Construction Zone” as per the Esquimalt Noise Control Bylaw.

Esquimalt Noise Control Bylaw		Noise Receiver Zone	
		Quiet	
		Day	Night
Noise Source Zone	Activity	60 dBA	55 dBA

Construction Zone

Building and infrastructure related projects at the EGD may fall under the definition of a “Construction Zone” as per the Esquimalt Noise Control Bylaw. The definition of a construction zone according to the Esquimalt Noise Control Bylaw is:

a) the erection, alteration, repair, relocation, dismantling, demolition and removal of a building;
b) structural maintenance, power-washing, painting, land clearing, earth moving, grading excavating, the laying of pipe and conduit, concrete placement, and the installation, or removal of construction equipment, components and materials in any form or for any purpose;
c) any work being done in connection with any of the work listed in paragraphs (a) or (b);

The noise level limit for a “Construction Zone” is **85 dBA** day and night.

Odour

- Daily dock operations often create strong and unpleasant odours whether from the release of VOCs, H_2S, organic materials, or chemicals an offensive smell can reduce the quality of the work environment for neighbouring tenants and home owners.
- In the event that odours are negatively affecting other tenants or stakeholders odour mitigating measures may be required.
- Contact EGD Environmental Services in the event of a nuisance odour from an unknown source.

H_2S Meter

The EGD utilizes an H_2S meter to ensure that any emissions released from the sanitary sewer system that create nuisance odours are not hazardous to adjacent work areas.

Light

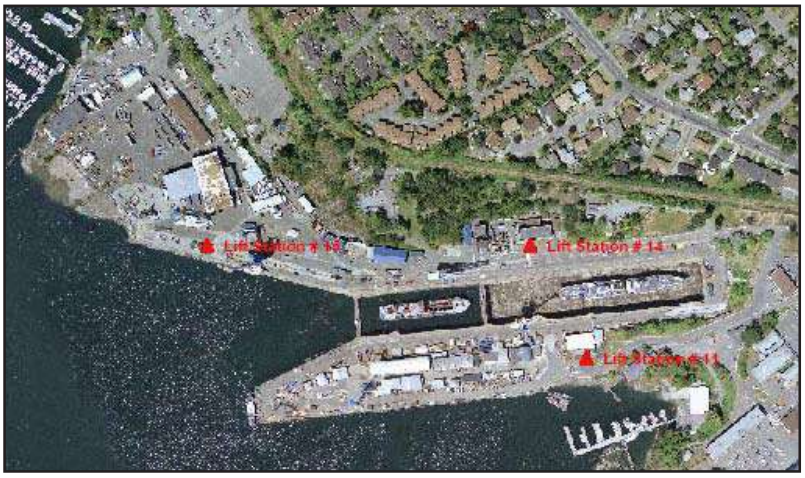
- Night time dock operations require spotlights to provide a safe work environment. However for residential neighbours strong spotlights can be a significant intrusion.
- Utilizing spotlights only when absolutely necessary will help prevent disturbing the neighbours as well as provide a more energy efficient work environment.
- Changing the direction of the lights may reduce the effect they have on the neighbours.
- Turn off or report to your supervisor any unnecessary lights left on.

BMP #13

Sanitary Waste Management and Sewer Use

The Esquimalt Graving Dock is authorized by the Capital Regional District (CRD) as a ship and boat waste disposal facility.

Discharge to the sanitary sewer at any location other than at the LS#15, LS#11 or the four vessel connections at the Graving Dock is prohibited.



The EGD is authorized to discharge to the sanitary sewer at the:

- Lift Station #15 (LS#15),
- Lift Station #11 (LS#11) and
- And the four vessel connections in the graving dock.

Permitted wastes include:

- sanitary waste
- grey water
- treated superchlorinated water*

Prohibited wastes include:

- bilge and ballast water
- wastewater sludge
- fuel and oil, paint, paint thinner, solvents, and products containing toxic chemicals

***Superchlorinated Water:** must not be discharged to the sanitary sewer unless it has been dechlorinated to less than 5 ppm chlorine.

- Users must notify the Pumphouse before conducting any discharges to the sanitary sewer. Typical methods of discharge are: large (connection to a vessel), and small (portable discharges from totes).
- Users must complete a Sanitary Sewage Discharge Form and provide it to the Pumphouse prior to discharging to the sanitary sewer.
- Pumphouse Operators will ensure that sanitary sewer discharges are in accordance with applicable regulations and authorizations.
- Pumphouse Operators will provide all completed Sanitary Sewer Discharge Forms to EGD Environmental Services, who will submit quarterly reports to the CRD.
- Users must ensure a sample collection point is accessible at the point of discharge.

BMP #14

Spill Preparedness and Response

The Esquimalt Graving Dock (EGD) is committed to the protection of human health and the environment. Safety and environmental management programs have been implemented at the EGD to reduce the potential for accidents and spills. Emphasis is placed on the prevention of spills, and although the potential for spills can be reduced through these programs, spills do happen.

All Users operating at the EGD must have the capability to effectively manage spills resulting from their activities and operations.

- User employees must have adequate training in spill response
- User employees must have access to appropriate spill response equipment and materials
- Users must have plans and procedures in place to respond to spills

For spills which are beyond the capability of the User or are not being effectively responded to by the User, the EGD will provide assistance. The EGD has additional resources available, including:

- Spill kits and response materials for land and water based spills
- Spill response boom, deployment reels and boat
- Staff trained to deal with land and water based spills

For access to the EGD spill response resources, contact EGD Management or Commissionaires.

For spills beyond the capability of the facility to manage, the DND, Port Operations and Emergency Services Branch (DND POESB) will provide support for response to land and water based spills.

ALL Spills Must Be Reported to EGD Management

Trench Drains: The EGD has installed trench drains throughout the site. These drains are easily accessible and allow for rapid containment and recovery of materials spilled on the property or in the drydock.

Environmental Emergency Contacts (24 Hours):

EGD Commissionaires	250-363-3784
Provincial Emergency Program (PEP)	1-800-663-3456
DND POESB/QHM	250-363-2160 or VHF Channel 10
Canadian Coast Guard	1- 800-889-8852 or VHF Channel 12
Environment Canada	604-666-6100

BMP #15

In-water Hull Cleaning and Maintenance

The cleaning of the underwater hull in water has the potential to release harmful contaminants into the marine environment.

In-water Hull Cleaning

- In-water hull cleaning of vessel hulls that are coated with antifouling paint is prohibited at the Esquimalt Graving Dock.
- Vessels coated in non-biocide containing paints (such as silicone based), may be considered on a case by case basis and must be approved by EGD Management prior to the commencement of hull cleaning activities.

Did you know?

Antifouling paints and their residues contain heavy metals, such as copper, that are toxic to aquatic organisms, including salmon and shellfish. Wash water and solid residues from the washing, scraping, sanding, and blasting of antifouling paints from boat hulls are considered "deleterious substances" under the *Fisheries Act*. Releasing these wastes to fish bearing waters is a violation of the Act.

Vessel berthed at the North Landing Wharf for in-water hull washing. In-water hull washing must not release antifouling paint. Discoloured water is an indication that you may be harming the environment.

In-water Hull Maintenance

- Users must receive approval from EGD Management prior to commencement of hull maintenance.
- Cleaning of the anodes, inlets, props, transducers, etc.
- Underwater maintenance required for operational and inspection purposes is permitted at the Esquimalt Graving Dock.

For inquiries regarding in-water hull washing please contact the Esquimalt Graving Dock Management at (250) 363-8056

BMP #16

Housekeeping

An organized, clean facility provides an environment that reduces the potential for pollutants to enter surface and ground water through spills and accidents. General cleanliness will lead to more organized and consistent handling of hazardous materials and waste products.

Clean-Up

- Clean debris from work areas immediately after any maintenance activity. Dispose of collected material appropriately.
- Ensure garbage and recycling containers are available in all leased areas and are emptied regularly.
- Do not use running water to clean the work areas where the contaminated water could enter the storm drainage system.

- Ensure trench and storm drains within designated leased areas are kept clean and free of debris.
- Sweep and/or clean the active working area of the yard on a regular basis.

Storage

- Do not store material/equipment outside of identified boundaries of leased areas.

- Regularly inspect the lease areas for unidentified or improperly stored materials.
- Place a drip pan underneath vehicles and equipment when performing maintenance. Promptly transfer the used fluids to the proper waste or recycling drums.
- Ensure all containers (i.e. drums, totes, etc.) are in good condition and have a clean exterior at all times.

BMP #17

Stormwater Management

Stormwater has been identified as one of the primary pathways of contaminant loading to the harbour from daily Esquimalt Graving Dock (EGD) operations. Common contaminants found in stormwater samples include cadmium, copper, chromium, arsenic, tributyltin (TBT), extractable petroleum hydrocarbons (LEPH/HEPH), and total suspended solids (TSS). Five stormwater catchment areas terminate into the harbour from the EGD property.

A stormwater monitoring program has been implemented at the EGD. The stormwater outfalls will be sampled semi-annually in the spring and fall. Waste grit separators have been installed upstream of the five stormwater outfalls. These help to remove contaminants or debris that enter the storm drain system from daily operations at the EGD, in particular they remove: fuel or oil, paint, sandblast grit, general debris.

Materials Storage:

- Store hazardous materials away from storm drains and trenches.
- Store hazardous materials away from the South Jetty fire holes. These holes lead directly to the marine environment.
- Ensure totes, drums and pails containing hazardous materials are protected from the weather.

Storm Drains:

- Ensure storm drains are kept clear of debris to prevent flooding during heavy stormwater events.
- When using trench drains for secondary containment, ensure the containment system is monitored and removed in a stormwater event. A blocked trench drain may cause flooding of the area.
- Conduct regular inspections of trench drains in lease areas to ensure they are kept clear of debris.

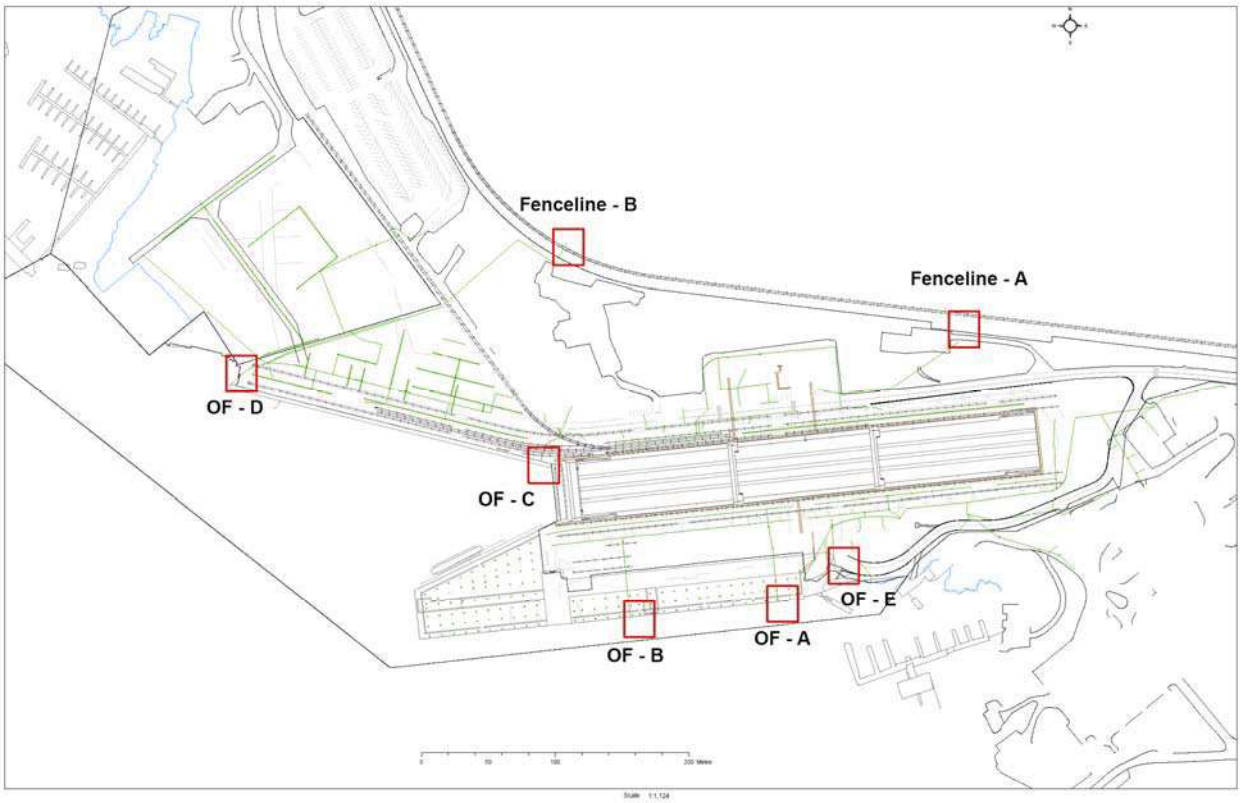
During heavy rain events in dock bottom:
Stormwater has the potential to mix with wash water during power washing operations in dock bottom. To reduce the amount of wash water requiring treatment it is good practice to stop power washing operations until storm water can be controlled.

- Sump well valves may be opened to allow storm water to drain in to the tunnel drains if the area is clear of contaminants and debris.
- Sump wells containing visibly contaminated material must be pumped out and cleaned prior to opening the valves.
- Ensure there is capacity in the trench drain/sump well system to manage the expected stormwater volume to prevent flooding of the dock floor.

Stormwater Monitoring Program

- Stormwater sampling is conducted semi-annually in the spring and fall by EGD Environmental Services.
- Stormwater samples are tested for: total metals, total suspended solids, tributytin, LEPH/HEPH and microbiological parameters.

EGD Stormwater Monitoring Program Sample Sites



BMP #18

Property and Infrastructure Maintenance, Modifications and Construction

There are significant environmental issues and potential impacts related to the management of Esquimalt Graving Dock properties and infrastructure. Any new construction or modifications to the infrastructure at the EGD must consider environmental issues in the project planning.

Infrastructure Maintenance

Maintenance and repair of the aging EGD infrastructure often results in waste generation and other environmental issues which need to be addressed.

Minor Concrete Work

- Contain dust from cutting and drilling.
- Prevent runoff to the storm drains.

Use of Preserved Wood

- Avoid use of creosote preserved timbers where possible.
- Follow applicable guideline for use of preserved wood products.
- Creosote wood waste may be considered a hazardous, restricted or controlled waste.

Demolition/Renovation

- Ensure structures are assessed for the presence of hazardous materials (i.e. lead paint, asbestos) prior demolition or renovation.

Infrastructure Modification and Construction

All construction projects taking place at the EGD need to be assessed for environmental impacts, and plans put in place to mitigate these impacts.

Environmental Impact Assessment

- Any significant changes to infrastructure, changes to an existing lease or application for a new lease, must be approved by EGD Management.
- Prior to the approval of an infrastructure project, a CEAA Environmental Impact Assessment may be required.
- An Environmental Approval Form must be filled out for new lease applications and changes to existing leases.

*****The Environmental Impact Assessment and Environmental Approval Form outlines specific environmental protection and mitigation measures required*****

Common project related aspects that require management include: noise, dust, hazardous materials, storm water runoff, and prevention and management of accidental releases and spills. Requirements for the operational aspects are identified in previous sections of these EBMPs.

Significant non-operational aspects related to construction projects may include:

- Loss of Green Space and Vegetation
- Management of Archaeological Impacts
- Soil Management

Loss of Green Space and Vegetation

The EGD property includes an area of vegetation that provides many benefits. It is home to a number of sensitive native plant species, provides habitat for wildlife, and acts as a buffer between the industrial operations of the drydock and ship repair operations and the neighbouring residential area.

All projects which have the potential to impact vegetation must be reviewed and approved by EGD Management.

Archaeological Considerations

The EGD property and surrounding area has a rich First Nations history. There are four Provincially Registered Archaeological Sites listed within the property boundaries of the EGD.

- All excavation projects must be reviewed and approved by EGD management prior to work beginning
- Depending on the scale of the project a detailed Archaeological Impact Assessment may be required.

Esquimalt Graving Dock Archaeological Overview Assessment

An Archaeological Overview Assessment was carried out in 2010 which outlines the archaeologically sensitive areas on the EGD property and identifies areas of high archaeological potential. Archaeological significant materials found during excavation projects at the facility include artefacts, shell midden, faunal and human remains.

Soil Management

The EGD has undergone significant capital and operation and maintenance projects in recent years. Extensive investigations into the soil conditions (chemical contamination and structure), utility mapping and identification of archaeological conditions have taken place. The industrial history of the facility has resulted in the contamination of the soil and in-fill material used on site. The primary contaminants commonly found at levels exceeding industrial soil standards include: arsenic, cadmium, copper, lead, mercury, zinc, and polycyclic aromatic hydrocarbons (PAH).

Requirements for Excavations at the EGD

Planning Excavation

1. Consult with EGD Facility Management to identify:
   - Project area and excavation boundaries.
   - Known utilities, structures, and historical information regarding the proposed excavation area.
   - Known contaminated soil locations, the nature and level of contaminants potentially in the soils to be excavated.
   - Archaeologically significant areas, requirements for mitigation archaeological impacts, and dealing with unanticipated archaeological finds.

2. Prepare a plan for management, stockpiling, and sampling of soils to be excavated. Key issues to be identified include:
   - Turnaround times for samples may be up to 2 weeks.
   - Parameters to be sampled may vary depending area of excavation. Common parameters include total metals, leachable metals, PAHS, and hydrocarbons (LEPH, HEPH).
   - Stockpile areas must be approved by EGD Management.
   - Soils which exceed the CCME Industrial Levels or BC CSR Industrial levels must be disposed of off site at an approved location.
   - Soils which are below industrial standards may remain on site if geotechnically suitable, approved by EGD Management, and there is an identified use for the soil.

3. Ensure contractors and employees are aware of the health and environmental risks associated with the suspected contaminated soils and have procedures in place to mitigate these risks. This includes adequate Personal Protective Equipment (PPE) and hygiene practices (i.e. no smoking, wear gloves)

Conducting Excavation

1. Ensure appropriate PPE and hygienic precautions are in place to prevent exposure to contaminants in the soils.
2. Monitor all excavations for visible soil contamination or archaeologically significant material.
3. Ensure soil is stockpiled, sampled and analysed in accordance with the BC MOE Technical Guidance on Contaminated Sites (January 2009).
4. Ensure soils suspected of contamination are stockpiled on an impervious surface and covered with a minimum 6 mil PVC or plastic liner to prevent exposure to wind, storm water runoff or people.
5. Imported fill material must be certified clean by the supplier.

After Excavation

1. Ensure all soil is disposed of at approved facilities.
2. Obtain disposal certificates from the receivers of contaminated soils.
3. Report to EGD Management on the volume, analysis of results, excavation details and dimensions.
4. Provide all as-builts and project drawings to EGD management in the format compatible with the EGD drawing standards.

Requirements for Small Excavations (less than $10m^3$)

In areas of suspect contamination: soil must be removed, stockpiled and sampled. Soil cannot go back into the excavation or used elsewhere on site until it is determined through analysis to contain contaminants less than industrial soil standards. The EGD management must give approval for any reuse of excavated soil on site.

In areas of non-suspect contamination: soil may go back into the excavation if geotechnical suitable. The EGD management must give approval for any reuse of excavated soil on site.

APPENDIX D

PILE DRIVING BEST MANAGEMENT PRACTICES

Keystone Environmental
Knowledge-Driven Results

Best Management Practices for Pile Driving and Related Operations – BC Marine and Pile Driving Contractors Association - November, 2006

The BC Marine and Pile Driving Contractors Association and Fisheries and Oceans Canada (DFO) have developed a Best Management Practices Policy for pile driving operations and related activities when working on the water within the province of British Columbia.

The Pile Driving Industry utilizes many different construction methods, equipment and materials in order to complete the contractual obligations for its client. Hammers; including drop, diesel, air, vibratory and hydraulic, vibroflot, and rotary, air and churn drills are the primary instruments in a pile driving operation. These hammers and drills are supported by a wide variety of heavy equipment, including a range of conventional cranes (truck mounted, crawler and pedestal mounted), spud scows, support barges and other water borne equipment. The piling types include treated timber (primarily creosote), concrete and steel (pipe, h-beam and sheet). Construction projects have the potential to utilize a number of different combinations of equipment and materials. It is the purpose of this document to examine the characteristics of each potential combination and develop a Best Management Practices Policy that will meet the following criteria:

-Maximize environmental protection
-Avoid contravention of the Fisheries Act
-Provide construction services economically

1)- Basic Rules of Operation

When in an aquatic environment, contractors will employ the following BASIC Best Management Practices:

- All equipment will be maintained in good proper running order to prevent leaking or spilling of potentially hazardous or toxic products. This includes hydraulic fluid, diesel, gasoline and other petroleum products.
- Storage of fuels and petroleum products will comply with safe operating procedures, including containment facilities in case of a spill.
- Pile cut-offs, waste or any miscellaneous unused materials will be recovered for either disposal in a designated facility or placed in storage. Under no circumstances will materials be deliberately thrown overboard.
- Contractors will have emergency spill equipment available whenever working near or on the water.
- Contractors, where possible, will position their water-borne equipment in a manner that will prevent damage to identified fish habitat (eg: eelgrass, kelp beds, shellfish beds, salt marshes, etc.). Where possible, alternative methods

- will be employed (eg. Use of anchors instead of spuds). In the event that, despite precautions, the contractor is aware that fish habitat has been inadvertently damaged, the incident must be reported to and discussed with the DFO assessor to ensure that appropriate remedial action is taken.
- Prior to the commencement of any work, the contractor will complete and forward the attached "Notice of Project" to the Department of Fisheries and Oceans. Letters of advice or Habitat Authorizations may be required, depending on the scope of work proposed.
- If contractors are working and a herring (or other fish) spawning occurs, the work will be temporarily suspended and the appropriate DFO contact notified.
- There will be no restriction of work during closure periods (the only exception being when spawning is present – all work must cease and the DFO habitat assessor must be contacted for further instructions), provided the contractors employ an exclusion device (protective netting or geotextile material suspended in the water column around pile driving area) around the work area to prevent fish access or when required, an effective method of mitigating shock waves (bubble curtain).
- Whenever shock wave monitoring (hydrophone) is performed at a marine construction site and the findings are available to the contractor, the data will be forwarded to the BC Marine and Pile Driving Contractors Association and Svein Vagle at the Institute of Ocean Sciences in Sidney, BC. It is hoped that a database can be built that will more precisely define work procedures and reflect the safest and most economical approach to protecting the fish and their habitat.

2)-Timber Piling (creosote):

When driving timber piling, the following Best Management Practices will be employed to prevent impact to marine fish and their habitat:

- Where possible, new timber piles will comply with the best Management Practices for the use of treated wood in aquatic environments as developed by the Canadian Institute of Treated Wood and the Western Wood Preservers Institute and the DFO document "Guidelines to Protect Fish and Fish Habitat from Treated Wood Used in Aquatic Environments in the Pacific Region".
- Where the above is not possible, creosote piling will stand (weather) for a period of 45 days prior to installation.
- These requirements are for new piling only. Re-used piling will not normally be subject to any additional treatments (timberfume is a provincially licensed preservative that is available for treatment of used piles), however, pilings with excessive creosote should be avoided. Reuse of suitable piles should be encouraged. In the case of mooring piles exposed to significant wear, the contractor should encourage the owner to protect the piling with rub strips as per the "Guidelines for use of Treated Wood".

- Timber piling is normally driven using a drop hammer, a diesel/air impact hammer or a small vibratory hammer. Because of the relative small diameter of the timber pile, and its excellent energy absorbing quality, there is little threat of sound pressure impacts to fish and their habitat when driving timber piles.
- Environmental monitoring of sound pressure impacts is not required.
- An attempt should be made to determine whether least impact means full extraction of the piling or if leaving a stub that would interfere with navigation is acceptable. If complete demolition is required on timber piles structures, the contactor will remove the piling by mechanical means and avoid breaking the piling at the mud line or below. It may be appropriate to cut off the piling flush with the mud line. All demolition operations should be monitored in order to control construction debris and determine whether there are any effects on fish or fish habitat.

3)-Concrete Piles

When driving concrete piles, regardless of which hammer is being used, the following Best Management Practices will be employed to minimize/prevent impacts to fish habitat:

Concrete Piles 24 inch diameter and less

- The physical design of 24 inch concrete pile dictates that: 1/ the energy required must be controlled in order to prevent the pile from breaking and 2/ the concrete construction of the pile will absorb the energy. These two factors are expected to result in low level shock wave emission (less than 30 kPa.) and minimal or no effects to fish and their habitat should result.
- Environmental monitoring of sound pressure levels is generally not required.

Piles Larger than 24 inch diameter

- When driving concrete piles with a diameter greater than 24 inches using an impact or hydraulic hammer, the following Best Management Practice will be employed to minimize the impact on fish habitat:
- Visual and hydrophone monitoring of the impact on fish by the sound waves emitted will be required. If sound pressures over 30 kPa are measured or a fish kill occurs, the contractor will introduce effective means of reducing the level of the shock waves. Appropriate mitigating measures would be the deployment of a bubble curtain over the full length of the wetted pile. This should reduce the shock waves to an acceptable level.
- If, despite the introduction of preventative measures, further visual/hydrophone monitoring reveals unacceptable conditions (fish kill or

sound pressure over 30 kPa), the work will stop immediately, the DFO assessor will be contacted, and the methods will be reviewed and corrected

4)-Steel Pipe Piles

Piles smaller than 24 inch diameter

When driving steel piles 24 inches in diameter and less, regardless of the type of hammer being used, the following Best Management Practices will be employed to prevent impacts to fish habitat:

- Because of the small diameter of the pile it is assumed that the energy required to drive the pile to the final point of installation will not result in shock waves in excess of 30 kPa, therefore, protective measures to reduce shock waves are not expected to be required.
- If, however, ground conditions during pile installation cause a fish kill, work will cease and contractors will be responsible for introducing effective means of reducing the level of shock waves or will introduce measures that will prevent fish from
  entering the potentially harmful shock wave area. Appropriate mitigating measures would include the deployment a bubble curtain over the full length of the wetted pile. This technique should reduce the shock waves to an acceptable level.
- If, despite the introduction of preventive measures, further visual/hydrophone monitoring reveals unacceptable conditions (fish kill or sound pressure over 30 kPa), then the work will stop immediately and the methods will be reviewed and corrected (in consultation with DFO).

Piles larger than 24 inches in diameter

When driving steel pipe piles with a diameter greater than 24 inches using impact or hydraulic hammers, the following Best Management Practices will be employed to prevent impacts to fish habitat:

- Hydrophone and visual monitoring of the effects of the shock waves on fish will be required. If a fish kill occurs, the contractor will introduce effective means of reducing the level of the shockwave. Appropriate mitigating measures would be the deployment of a bubble curtain over the full length of the wetted pile.
- If, despite the introduction of preventative measures, further visual/hydrophone monitoring reveals unacceptable conditions (fish kill or sound pressure over 30 kPa), then the work must stop immediately and the work methods will be reviewed and corrected (in consultation with DFO).

5)-Steel Sheet Piles and H-piles

When driving steel sheet piles and H-piles with a drop hammer, an impact hammer or a vibratory hammer, the following Best Management Practices will be employed to minimize the impact on fish habitat:

- It is anticipated that the driving of these types of piles will not generate shock waves in excess of 30kPa, therefore, mitigating measures are not expected to be required.
- If, however, ground conditions during pile installation cause a fish kill, work will cease and contractors will be responsible for introducing effective means of reducing the level of shock waves or will introduce measures that will prevent fish from
  entering the potentially harmful shock wave area. Appropriate mitigating measures would include the deployment a bubble curtain over the full length of the wetted pile. This technique should reduce the shock waves to an acceptable level.
- If, despite the introduction of preventive measures, further visual/hydrophone monitoring reveals unacceptable conditions (fish kill or sound pressure over 30 kPa), then the work will stop immediately and the methods will be reviewed and corrected (in consultation with DFO).

6)-Stone Column Construction

When installing stone column using a vibroflot, the following Best Management Practices will be employed to prevent impacts to fish habitat:

- The vibrating action and air flush associated with the operation of the probe results in a high degree of turbidity. When this level exceeds the criteria as outlined in the British Columbia Approved Water Quality Guidelines, the contractor will introduce containment methods that are designed to isolate the contaminated area and to prevent
  fish from entering the contaminated area. Silt curtains and netting are two methods that can provide the necessary protection.
- When supplying the aggregate to the probe, the contractor will ensure that spillage is prevented, thereby providing additional protection to fish habitat.
- An independent environmental consultant will be used to monitor turbidity levels.

7)-Underwater Drilling and Blasting

When performing underwater drilling and blasting the following Best Management Practices will be employed to prevent impacts to fish habitat:

Underwater Drilling

- Generally, drilling underwater is a process that has very little impact on fish or fish habitat. The procedure does not generate shock waves.
- Contractors will ensure that all attachments (hydraulic connections and couplings) are in good operating order and inspected prior to the start of every day. Spill kits and containment booms must be maintained on-site in case of spills.
- Depending on soil conditions and the potential for turbidity, drill cuttings will be deposited adjacent to the operation, contained on the sea bed or pumped to the surface for deposit into containment skiffs or scows for land disposal when it is determined that the drill cuttings are unsuitable for return to the environment.

Underwater Blasting

Contractors required to perform blasting underwater will provide the following protection to prevent impacts to fish habitat:

- Because of the potential for harmful shock waves resulting from a blast, a protection shield will surround the immediate blast area. This would be in the form of an air-induced bubble curtain, which has the primary purpose of absorbing the shock wave and a secondary purpose of preventing fish from entering the blast area.
- In order to protect against flying rock, mats (rubber) will be placed over the blasting area. The placement of the mats may also provide protection for any fish swimming in the immediate area.
- Monitoring of fish movement and concentrations will be conducted using a sounder to determine if fish herding or scaring techniques (seal bombs) can be utilized to reduce the presence of fish in the blast area. If fish scaring techniques are deemed necessary, the DFO habitat biologist or technician responsible for reviewing the project must be consulted to determine a method that will present the lowest risk to fish mortality.

8)-Cleaning out Pipe Piles:

When cleaning out pipe piles (i.e.: air lifting) the following Best Management Practices will be employed to prevent impacts to fish habitat:

- Generally, sediment contained in the pipe will be pumped to the surface and processed through an approved containment system and disposed of at an approved landfill site.
- If the contractor knows that the sediment is toxic, the sediment must not be redistributed in the area. If sediment is non-toxic, and if fish are not present in

the area, and adjacent fish habitats are not a concern (contact DFO), it may be acceptable to:

1. Pump the sediment through a discharge tube and allow it to settle in the immediate area with or without a silt curtain to contain the sediment.
2. Pump the sediment through a discharge tube and additional flex hosing and redirect it back to the base of the pile.

9) Containment of Concrete Residue and Water Run Off

When placing concrete in form work over or in water, the following Best Management Practices will be employed to prevent the impacts to fish habitat:

Pouring concrete

- Spills: When pouring concrete all spills of fresh concrete must be prevented. Concrete is toxic to fish due its high pH. If concrete is discharged from the transit mixer directly to the formwork or placed by wheelbarrow, proper sealed chutes must be constructed to avoid spillage.
- If the concrete is being placed with a concrete pump, all hose and pipe connections must be sealed and locked properly to ensure the lines will not leak or uncouple. Crews will ensure that concrete forms are not filled to overflowing.
- Sealing forms: All concrete forms will be constructed in a manner which will prevent fresh concrete or cement-laden water from leaking into the surrounding water.

Curing concrete

- When fresh water is used to cure concrete, the run off must be monitored for acceptable pH levels. If the pH levels are outside the allowable limits then the run off water must be contained and neutralized.

Grinding concrete

- When grinding cured concrete, the dust and fines entering the water must not exceed the allowable limits for suspended solids. When grinding green or incompletely cured concrete and the dust or fines are entering the water, pH
  monitoring will be conducted to ensure allowable ranges are maintained. In the event that the levels are outside the acceptable ranges, preventative measures will be introduced. This may include introducing silt curtains to contain the solids and prevent fish from entering a contaminated area or constructing catch basins to recover the run off and neutralizing it prior to disposal.

Patching concrete

- Spills: When patching concrete, all spills must be contained and prevented from entering the water.

Washing hand tools, pumps and transit mixer

- All tools, pumps, pipes, hoses and trucks used for finishing, placing or transporting fresh concrete must be washed off in such a way as to prevent the wash water and excess concrete from entering the marine environment. The wash water will be contained and disposed of upland in an environmentally acceptable manner.

Whenever there is the possibility of contaminants entering water, the contractor will monitor pH levels to ensure acceptable levels.

NOTICE OF PROJECT

Project Location:

To: Fisheries and Oceans Canada Attention:

Telephone/Fax/email:_____

From: “Contractor”

Telephone/Fax/email:_____

Representative:

Please be advised of the following marine/pile driving project:

Project Name:

Project Location:

Project Manager/Superintendent:

Project Telephone/Fax/email:_____

Project commencement date:

Project Information:

Type: Bearing Fender Mooring

Number of Piles:

Pile Diameter (if steel)

Type of Driving: Vibro Drop Hammer _____

Special Conditions at the Bottom (use of pins, sockets, epoxy, concrete, other)
_____

General Equipment On-Site (barge, truck, crane, etc.) _____

Signature of Contractor: _____

Date: _____

APPENDIX E

FIRE PREVENTION BEST MANAGEMENT PRACTICES

Best Management Practices
for
Fire Prevention

For Works, Buildings, and Vessels within the Esquimalt Graving Dock

Prepared for:

Public Works and Government Services Canada
Esquimalt Graving Dock

Date: Revised January 26, 2009

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1. Introduction

Best Management Practices (BMP) are ways of lowering the Fire Risk/Fire losses through good Fire Prevention Practices, Fire and Building Code Compliance of the National, Provincial, Municipal Bylaws, NFPA Standards, and the Fire Commissioner of Canada Standards. BMP also include Indoor and Outdoor Storage of Combustible Products and Dangerous Goods the Storage and Handling of Flammable and Combustible Liquids, Hazardous Processes and Spray Operations

The benefits derived from implementing BMPs include:

Code Compliance
Safer working environment
Lower the Risk of Loss of Life due to Fire and Explosion
Lower the Risk of Fire losses due to Fire or Explosion

1.a Authority Having Jurisdiction

The Authority Having Jurisdiction for The Esquimalt Graving Dock is the General Manager of the Dock or his/her designate.

Note. Authority Having Jurisdiction (AHJ) (Definition by National Fire Protection Association)

The phrase "authority having jurisdiction" used in this document is in a broad manner, since jurisdictions and approval agencies vary, as to their responsibilities. Where public safety is primary, the authority having jurisdiction may be federal, provincial, municipal, or other regional department or individual such as a fire chief; chief of a fire prevention bureau, or other having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurers company representative may be the authority having jurisdiction. In many circumstances, the property owner or his/her designated agent assumes the role of authority having jurisdiction; at government installations; the commanding officer or department official may be the authority having jurisdiction.

1.0 Scope

This document shall apply to all contractor facilities and equipment used to repair, service, construct, store, haul, and fuel vessels and small craft within the property owned or managed by the Esquimalt Graving Dock (PWGSC).

These Best Management Practices are for the Fire Prevention in Works, Buildings, and Vessels in the Esquimalt Graving Dock (PWGSC) area. The Esquimalt Graving Dock (PWGSC) provides specific guidelines that shall be followed by all individuals who conduct activities on property owned or managed by the Esquimalt Graving Dock (PWGSC). The purpose of this Best Management Practice document is to compliment existing Codes, Standards, Lease Agreements, Municipal Bylaws, Public Works Act, Occupation Health & Safety Regulation (BC), Canada Labour Code Part II, and WCB Regulations.

1.0.1 Purpose

This document is intended to provide a minimum acceptable level of safety to life and property from fire and other hazards at the Esquimalt Graving Dock (PWGSC).

Every reasonable means of preventing fire shall be provided and supplemented by means of detection, protection equipment that permits the prompt discovery, retard the spread, and permit extinguishment of any fire before it has passed the incipient stage. These fire-fighting methods shall include fire watching, fire extinguisher training, co-ordination and co-operation with the Esquimalt Graving Dock (PWGSC) primary emergency responder.

Nothing in this document shall be construed as prohibiting the immediate dry docking of a vessel whose safety is imperil, as by sinking condition or by being seriously damaged. In such cases, all necessary precautionary measures shall be taken as soon as practical.

1.0.2 Abbreviations/Acronyms

FC	Fire Commissioner of Canada Standards adopted by the Treasury Board of Canada
BCFC	British Columbia Fire Code 1998
NFC	National Fire Code of Canada 1995
NFPA	National Fire Protection Association
CEC	Canadian Electrical Code
BCEC	British Columbia Electrical Code
BCBC	British Columbia Building Code 1998
NBC	National Building Code of Canada
CSA	Canadian Standards Association
ULC	Underwriters Laboratories of Canada
TC	Transport Canada
ISPS	International Ship & Port Security Code
EGD	Esquimalt Graving Dock
PWGSC	Public Works and Government Services Canada

1.0.3 Definitions

"Approved " - acceptable to the authority having jurisdiction. (As applied to the Esquimalt Graving Dock (PWGSC) see 1.a page 3)

"Authority Having Jurisdiction" **-** the organization, office, or individual responsible for approving equipment, installation, or a procedure

"Contractor" - any company, firm, shipyard, corporation, government department, vessel using/ leasing the Esquimalt Graving Dock (PWGSC) or areas within the Esquimalt Graving Dock (PWGSC) for repairs, construction, conversion, lay-up of vessels, or a shiprepair related business.

"Building" **-** any structure used or intended for supporting or sheltering any use or occupancy.

"Combustible Liquid" - a liquid that has a close-cup flash point at or above 37.8 degrees C.

"Flammable Liquid" - a liquid that has a close-cup flash point that is below 37.8 degrees C. and the maximum of vapor pressure of 40 psi (2068mm Hg) at 37.8 degrees C.

"Hot Work" - the use of any equipment involving open flames or producing heat or sparks, including, without being limited to, cutting, welding, soldering, brazing, grinding, gouging, adhesive bonding, thermal spraying and thawing pipes.

"Shall" - a mandatory requirement

"Should" - a recommendation or that which is advised but not a mandatory requirement.

1.1 Fire and Emergency Response Plans

All contractors within the Esquimalt Graving Dock (PWGSC) area shall have Fire, Emergency, and Earthquake Response Plans in place. A copy of these plans shall be given to the Esquimalt Graving Dock (PWGSC) Best Practices Coordinator for review. These plans are to be reviewed on an annual basis by the contractor and Esquimalt Graving Dock (PWGSC) Best Practices Coordinator or his/her representative.

1.2 Emergency Response Drills

All contractors will participate in emergency response drills on an annual basis in accordance with Occupational Heath & Safety Regulation (BC) Emergency Procedures Training and Drills.
Drills will be held at the least disruptive times to minimize the impact of work stoppage to the contractor.

1.3 Hot Work Permits

All contractors within the Esquimalt Graving Dock (PWGSC) area shall have written hot work procedures and permits in place. A copy of the procedures and permits shall be given to the Esquimalt Graving Dock (PWGSC) Best Practices Coordinator. These procedures and permits are to be reviewed on an annual basis by the contractor and Esquimalt Graving Dock Best (PWGSC) Practices Coordinator or his/her representative. If any contractor does not have written hot work procedures and permits in place, the contractor shall be subject to article 1.3.a of this document. Contractors written hot work procedures and permits do not apply to common areas of the yard. All contractors shall obtain a hot work permit issued by the Esquimalt Graving Dock (PWGSC) Best Practices Coordinator, or his/her representative for all common areas within the Esquimalt Graving Dock areas

1.3.a. Hot work permits will be issued by Esquimalt Graving Dock (PWGSC) Best Practices Coordinator or his/her representative for all areas other than shipboard work and work on leased property. Permits shall be posted in the area of hot work. All hot work shall comply with the National Fire Code of Canada, British Columbia Fire Code 1998, CSA W117.2, “Safety in Welding, Cutting, and Allied Processes”, NFPA 51B Standard for Fire Prevention in Use of Cutting and Welding Processes. 2003 Edition. FC 302 Standard for Welding and Cutting June 1982.

1.4 Flammable and Combustible Liquids

All contractors, sub-contractors, and agents shall comply with Part 4 of the National Fire Code of Canada, British Columbia Fire Code 1998.

1.5 Spray Coating Operations

All contractors who are involved in spray coating operations other than on board a ship in the dry dock or a ship berthed alongside, the contractor shall comply with Section 5.4. Spray Coating Operations in the British Columbia Fire Code 1998, and the National Fire Code of Canada 1995.

1.6 Fire Protection

All contractors shall comply the following:

- British Columbia Fire Code Part 2 Section 2.16. Part 3, Part 4, Part5, and Part 6 2005
- National Fire Code of Canada Part 3, Part4, Part 6, 2006
- NFPA Standard 1 Uniform Fire Code 2003 Edition
- NFPA Standard 10 Standard for Portable Fire Extinguishers 2006 Edition
- NFPA Standard 51 B Standard for Fire Prevention During Welding, Cutting, and Other Hot Work 2006 Edition
- NFPA Standard 101 Life Safety Code 2003 Edition
- NFPA 303 Standard for Fire Protection of Marinas and Boatyards 2006 Edition
- NFPA Standard 306 Standard for the Control of Gas Hazards on Vessels 2006 Edition
- NFPA Standard 307 Standard for the Construction and Fire Protection of Marine Terminals, Piers and Wharves 2006 Edition
- NFPA Standard 312 Standard for Fire Protection of Vessels During Construction, Repair, and Lay-up 2006 Edition
- CSA C22.1 Electrical Installations, British Columbia Electrical Act and pursuant Regulations
- CSA W117.2 Safety in Welding, Cutting, and Allied Processes
- FC 302 Standard for Welding and Cutting June 1982
- Transport Canada TP3177E Standard for the Control of Gas Hazards in Vessels to be Repaired or Altered
- Workers` Compensation Board of British Columbia Occupational Health Safety Regulation

1.6. Continued

All contractors in conjunction with the Esquimalt Graving Dock (PWGSC) Best Practices Coordinator or his/her representative, shall do a post docking inspection of the vessel if the vessel is over 30.5M (100ft). The contractor or their representative shall complete a post docking inspection form along with the vessels fire control plans and crew list within 24 hours of the vessels arrival at the Esquimalt Graving Dock (PWGSC) facility. These forms and fire control plans will be given to Esquimalt Graving Dock (PWGSC) Best Practices Coordinator to be kept in the Esquimalt Graving Dock (PWGSC) Incident Command Post in the Esquimalt Graving Dock (PWGSC) administration building.

All contractors shall comply with NFPA Standard 312 Fire Protection of Vessels during Construction, Repair and Lay-up 2006 Edition and shall apply to all vessels, with the exceptions of vessels 30.5M (100ft) or less in length.

While vessels are at berths or in dry dock, temporary fire hoses supplied from shore connections to Esquimalt Graving Dock (PWGSC) Fire Equipment Boxes and a Portable Foam Units, shall be placed aboard the vessel and shall be connected and ready for use. The ratio shall be at least one hose for each 200 ft (62 m) of vessel length. This shall apply to all vessels, with the exceptions of vessels 30.5M (100ft) or less in length. Vessels 30.5M (100ft) or less in length and deemed vulnerable by the AHJ, may be required to have readily available, a temporary fire hose supplied from a shore connection to an Esquimalt Graving Dock (PWGSC) Fire Equipment Box and a Portable Foam Unit.

All contractors shall sign out the required fire equipment from the Esquimalt Graving Dock (PWGSC) stores person in the operation building.

If the contractor is unable to place the fire equipment onboard the vessel, the contractor or their representative shall inform an EGD representative the rationale and sign a non-compliance form. A copy of the non-compliance form shall be given to the Esquimalt Graving Dock (PWGSC) Best Practices Coordinator kept on file with the post docking inspection reports.
(A non-compliance form can be obtained from the Esquimalt Graving Dock stores person in the operations building)

On vessels under repair, the vessel's fire system piping, where the system is intact and capable of being used, shall be connected to water supplies from the yard by means of temporary shore-to-ship connections.

All contractors engaged in the breaking-up of vessels shall comply, to all required codes and regulations.

Smoking is permitted in contractors designated smoking areas only. Smoking is not permitted on board vessels in for repair or refit. All contractors shall post no smoking signs on all gangways to vessels in the EGD area.

1.7 Building Construction

All building construction whether permanent or temporary shall be built and located in accordance with the British Columbia Building Code 1998, British Columbia Fire Code 1998, National Building Code of Canada 2006, National Fire Code of Canada 2006, Municipal by-laws & Permits, plus any other applicable codes and standards.

1.7.1 Building Construction Compliance

All structures built, erected, or relocated on property owned or managed by Esquimalt Graving Dock (PWGSC) shall comply with Article 1.7 of this document.

1.8 Building Construction

Prior to any type of construction, major renovation, placement of trailers or temporary buildings, permits must be obtained from the Municipality of Esquimalt. The plans and copies of the permits shall be by submitted the contractor to the Operations Coordinator of the dock or his/her representative for approval. Plans and permits should be submitted well in advance of the planned project as this would expedite the approval process.

1.9 Building /Site Inspections by AHJ or Emergency Responder

As per the signed lease agreement Art. 11.02 the tenant agrees to comply with all requests and orders from the AHJ , primary emergency responder or Esquimalt Graving Docks (PWGSC) Representative

.

1.10 Compliance with Laws, Rules, and Regulations

Pursuant to any signed lease agreement the tenant shall comply with this document.

1.11 Marine Transportation Security Act / International Ship & Port Facility Security Code

All contractors shall be compliant to the Marine Transportation Security Act / International Ship & Port Security Code Codes when required.

1.12 Orientation of Subcontractors

Contractors are required to give to all visitors, or sub-trades/contractors hired by them to perform work within the Esquimalt Graving Dock (PWGSC) area, or on vessels within the Esquimalt Graving Dock (PWGSC) area, an orientation in the Esquimalt Graving Dock (PWGSC) Safety Regulations, and Emergency Procedures.
NOTE: For all 911 emergency calls the caller must state to the operator that you are calling from the Esquimalt Graving Dock and give your exact location in the dock area. Then the caller must call the main gate at 363-3784 and inform them that emergency services are on their way to the Esquimalt Graving Dock and give them you exact location in the dock area.

1.13 Flammable Material, and Dangerous Cargo Vessels

All work on vessels, barges, rigs and similar floating structures shall comply with Transport Canada TP3177E Standards for the Control of Gas Hazards in Vessels to be Repaired or Altered.

Vessels that carry explosives or other dangerous cargo such as flammable gases, hazardous chemicals, and flammable liquids, but excluding fuel and storage in specifically designated spaces, shall not be permitted to enter

the EGD until materials are removed and spaces have been certified as gas free. The gas free certificates are to posted and a copy given to the Esquimalt Graving Dock (PWGSC) Best Practices Coordinator

1.14 Code Compliance

All contractors working and leasing space within the Esquimalt Graving Dock (PWGSC) areas shall comply with all required codes in this document, all contractors shall supply their own copies of all required codes and regulations pertaining to this document. Failure to comply with the Esquimalt Graving Dock (PWGSC) Beat Management Practices for fire prevention and all required codes could mean immediate denial of dock services.

1.15 Reporting of Fires.

All fire regardless of size once extinguished shall be reported to the responding fire department and to the Esquimalt Graving Dock (PWGSC) Best Practices Coordinator immediately.

Reference Publications

This document or portions there of, are referenced within this document and shall be considered part of the requirements of this document.

- NFPA Standard 1 Uniform Fire Code 2003 Edition
- NFPA Standard 10 Standard for Portable Fire Extinguishers
- NFPA Standard 51 B Standard for Fire Prevention During Welding, Cutting, and Other Hot Work 2006 Edition
- NFPA Standard 101 Life Safety Code 2003 Edition
- NFPA 303 Standard for Fire Protection of Marinas and Boatyards 2006 Edition
- NFPA Standard 306 Standard for the Control of Gas Hazards on Vessels 2006 Edition
- NFPA Standard 307 Standard for the Construction and Fire Protection of Marine Terminals, Piers and Wharves 2006 Edition
- NFPA Standard 312 Standard for Fire Protection of Vessels During Construction, Repair, and Lay-up 2006 Edition
- CSA C22.1 Electrical Installations, British Columbia Electrical Act and pursuant Regulations
- CSA W117.2 Safety in Welding, Cutting, and Allied Processes
- FC 302 Standard for Welding and Cutting June 1982
- Transport Canada TP3177E Standard for the Control of Gas Hazards in Vessels to be Repaired or Altered

- Workers` Compensation Board of British Columbia Occupational Health Safety Regulation
- NFPA 303 Standard for Fire Protection of Marinas and Boatyards 2006 Edition
- NFPA Standard 306 Standard for the Control of Gas Hazards on Vessels 2006 Edition
- Transport Canada TP3177E Standard for the Control of Gas Hazards in Vessels to be Repaired or Altered
- Workers` Compensation Board of British Columbia Occupational Health Safety Regulation
- National Fire Code of Canada 2006
- British Columbia Fire Code 1998

APPENDIX F

EXAMPLE REPORTING TEMPLATES

IR #:

LOCATION OF INCIDENT:

Attached: ☐ Photographs ☐ Supporting Information

BRIEF DESCRIPTION OF INCIDENT:

Date:

Time:

CAUSE OF INCIDENT:

User/Contractor:	*Vessel*:
Spilled or Released Materials:	*Quantity of Spilled or Released Materials:*

AFFECTED ENVIRONMENT:

☐ Marine ☐ Atmosphere ☐ Other (specify)

☐ Ground ☐ Groundwater _____

INCIDENT REPORTED BY:

Name/Organization: **Contact Information:**

PERSONNEL RESPONDING TO INCIDENT:

ACTIONS TAKEN TO MITIGATE INCIDENT:

ACTIONS TAKEN FOR PREVENTATIVE MEASURES:

This Section For Environmental Services Office Use Only
NOTIFICATION: Notified User/Agent/Vessel: ☐ yes ☐ no if yes, indicate which: Notified External Agency: ☐ yes ☐ no if yes, indicate which Agency: Any changes in the documented procedures resulting from the corrective and preventative action? ☐ yes ☐ no if yes, provide details: Is follow up required? ☐ yes ☐ no If yes, provide details of follow-up actions required:
REPORT FORM COMPLETED BY: Name: Date:

PHOTOGRAPHS: **Photo #:**	**Photo #:**
Photo #:	**Photo #:**
Photo #:	**Photo #:**
Photo #:	**Photo #:**
Photo #:	**Photo #:**

PRE-WORK ORIENTATION RECORD		
Date:		Orientation Delivered By:
Work / Area:		
Issues addressed:		

By signing this record, the person is acknowledging that they have received orientation on the noted date.

Name		Affiliation
(PRINT)	(SIGNATURE)	

ENVIRONMENTAL MONITORING REPORT - WATER QUALITY	
Date/Time:	General Site Conditions (weather, vessel traffic):
Monitor:	
Work being undertaken:	

Water Quality Measurements					
Date:	Time:	Location	Depth	Turbidity (NTU)	Action Required (Y/N)*

** Note in issues tracking table*

Summary of laboratory data as applicable:

Append photos and laboratory reports as applicable

ENVIRONMENTAL MONITORING REPORT - WATER QUALITY ISSUE TRACKING			
Issue	Date Issue Noted	Mitigation Measures Recommended	Date Issue Resolved

ENVIRONMENTAL MONITORING REPORT – NOISE MONITORING	
Date:	General Site Conditions (weather, vessel traffic):
Monitor:	
Work being undertaken:	

Noise Measurements				
Date	Time	Location	Sound Level (dBA)	Action Required (Y/N)*

** Note in issues tracking table*

Summary of noise monitoring data as applicable:

ENVIRONMENTAL MONITORING REPORT – NOISE MONITORING ISSUE TRACKING			
Issue	Date Issue Noted	Mitigation Measures Recommended	Date Issue Resolved

ENVIRONMENTAL MONITORING REPORT – AQUATIC MAMMALS	
Date:	General Site Conditions (weather, vessel traffic):
Monitor:	
Work being undertaken:	

Noise Measurements				
Date	Time	Location	Sound Level (kPA)	Action Required (Y/N)*

** Note in issues tracking table*

Summary of noise monitoring data as applicable:

Append photos as applicable.

ENVIRONMENTAL MONITORING REPORT – AQUATIC MAMMALS ISSUE TRACKING			
Issue	Date Issue Noted	Mitigation Measures Recommended	Date Issue Resolved

APPENDIX G

EGD SPILL CONTINGENCY PLAN

Keystone Environmental
Knowledge-Driven Results

Esquimalt Graving Dock Spill Contingency Plan

Prepared By:
Public Works and Government Services Canada
Environmental Services

Date: February 2010
Version: 03

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1.0 Introduction

1.1 Purpose

The Esquimalt Graving Dock (EGD) is committed to the protection of human health and the environment. Extensive safety and environmental management programs have been implemented at the EGD to reduce the potential for accidents and spills. Although the potential for spills can be reduced through these programs, spills do happen. The EGD Spill Contingency Plan was developed for those occasions when spills occur.

Specifically, the purpose of the EGD Spill Contingency Plan is to act as both policy and as a resource guide during spill events that occur within the Esquimalt Graving Dock and adjacent waters.

1.2 Scope

The EGD Spill Contingency Plan is intended to provide guidance to PWGSC Employees, EGD Users, and can be used as a resource for external spill response teams, in the event of a spill on land and/or the marine environment, generated at the Esquimalt Graving Dock property or water lot. The scope is intended primarily for 1st and 2nd level response, but provides notification requirements in the event that a 3rd level spill occurs.

2.0 Roles and Responsibilities

2.1 PWGSC Employees

PWGSC employees are responsible for understanding the information provided in both the EGD Spill Contingency Plan and the EGD Emergency Response Plan Handbook. PWGSC employees are expected to be able to appropriately respond to all PWGSC generated Level 1 and 2 spills.

Communication with external stakeholders, including the media, will be handled in accordance with the Public Works and Government Services Canada's protocol including Departmental Policy - 009, Critical Incident Reporting.

2.2 Esquimalt Graving Dock Users

Users are responsible for understanding the information provided in the EGD Spill Contingency Plan and the EGD Emergency Response Plan Handbook. In addition, each of the Users are responsible

for developing Level 1 spill contingency plans, practicing those plans, and having the appropriate spill kits on site.

In the event of a spill, Users are responsible for reporting spills in accordance with applicable legislation as well at to PWGSC Environmental Services.

3.0 Spill Response Procedures

3.1 Definition of a Spill

For the purposes of the EGD Spill Contingency Plan, a spill can be defined as the abandonment, deposition, discharge, dumping, emission, escape, exhaust, throwing, injection, leakage, pouring, placement, release seepage, and/or spraying of a deleterious or hazardous material. This can occur during storage, handling, use, and/or transport.

3.2 Six Steps to Spill Response

There are six steps to follow when responding to a spill:

1. Assess the Risk
2. Protect Yourself and Others
3. Stop the Source/Contain the Spill
4. Clean the Spill
5. Dispose of Waste
6. Report the Spill

1. Assessing the Risk

Determine what hazards associated with the product that has spilled. Gather as much information as possible about the product and how it should be handled and cleaned up. Specific product information can be obtained from the product label, hazard symbol, or the Material Data Safety Sheet (MSDS) located on the site and location map in appendix IV. Once the product information is assessed, the level of response required can be determined. There are 3 levels of response, depending on the nature of a spill. The level is determined during the first step to responding to a spill: assessing the risk.

a) **Level 1 Response – Generator/Discoverer Responds**

A level 1 response is where the generator or discoverer of the spill is capable of adequately responding to the spill himself or herself. This applies to both PWGSC staff and EGD Users.

b) **Level 2 Response – PWGSC Response Team and Resources Deployed**

A level 2 response is a where the generator or discoverer of a spill does not have the capability for responding to the spill and/or assistance is required.

c) **Level 3 Response – External Agencies Call in for Assistance**

A level 3 response is required when the spill is assessed to be out of the capability of the generator or discoverer and external response organizations, are required to assist or manage the incident.

2. Protecting Yourself and Others

It is important to protect yourself and others in the event of a spill. Notifications should be made to a number of personnel including employees, supervisors, safety representatives, tenants of the facility and the site commissionaires, who may be affected by the incident. Use of proper personal protective equipment (PPE) is also required. There are 4 levels of PPE:

- ***A*** – full membrane and respiratory protection
- ***B*** – full respiratory and limited membrane protection
- ***C*** – limited respiratory and membrane protection
- ***D*** – normal work safety gear (hard hat, safety glasses, etc.)

Most spills at the Esquimalt Graving Dock require level D protection.

3. Stopping the Source and Containing the Spill

It is important to ensure that the risk has been assessed prior to attempting to stop the source and contain the spill. For example, products may be flammable; therefore, need to be handled in an appropriate manner (e.g. no smoking in the immediate area). There are a number of ways to stop the source and contain a spill.

4. Cleaning the Spill

There are three types of spill supplies that can be found at the Esquimalt Graving Dock: oil only, universal, and hazardous material. The oil only products are meant for use in aqueous environments as well as on land (with the exception of loose absorbent type products). The oil only pads and absorbent socks will float on water and should be used for any oil based marine spills in the harbour.

The universal pads will pick up both oil and water based products, but are meant to be used for land based spills only. As the universal pads and absorbent socks absorb water based products, these supplies would sink if used in the marine environment.

There are spill supplies designed for chemical spills such as acids, bases, and oxidizers. These response supplies are specially designed to be inert and not react chemically with the product being cleaned up.

Three large yellow spill kits are available; one in the fuel storage area, one in the pump house, and one in front of the operations center compound. These spill kits contain both oil only and universal spill response supplies.

A spill supply shed is located adjacent to the Operations Centre building, and contains a large variety and quantity of spill supplies. Personnel should become familiar with the contents of the spill supply shed, and the uses of the various types of supplies.

Refer to Appendix IV for site and location map with specific spill kit locations.

5. Disposing of Waste

Waste generated from the cleanup of a spill needs to be disposed of properly. Open top drums and hazardous materials bags are available for disposal of waste. Waste of different origins should not be mixed for disposal. All waste containers need to be labeled prior to filling. Waste containers should be visibly stored in designated areas with secondary containment, such as the EGD hazardous materials storage vault located adjacent to the Operations Centre building.

6. Notification and Reporting the Spill

Notification of a spill to the proper authorities will depend on the severity of the spill, once the risk has been assessed.

For example:

- In the event of the discovery of a minor spill or sheen on water, the alert may be made by two way VHF radio on Channel 4. Dock employees will stand by and await further direction from the Incident Commander

- If a spill occurs on water that is not within the capability of the generator/discoverer or EGD personnel and resources, the Provincial Emergency Program (PEP), DND Pollution Control, the Canadian Coast Guard, or an external contractor will be contacted immediately.

- In the event of the discovery of a major spill (land or water), the general alarm can be activated at one of the stations indicated on the site plan (Appendix IV). This will ensure that all available resources are made available to respond to the spill.

- If a spill occurs after hours, the discoverer will contact the Incident Commander. The Incident Commander will activate a recall of key personnel as required. Emergency contact numbers are located in Section 4.0.

- Internal emergency alerting procedures are also described in the EGD Emergency Response Plan Handbook.

All spills are reportable to PWGSC EGD Environmental Services. Any spills on land that exceed the limits outlined in Appendix I, shall be immediately reported to the Provincial Emergency Program (PEP). All marine spills will immediately be reported to PEP.

Environmental Incident Reports will be documented for all spills. These reports will be maintained by EGD Environmental Services location of the incident.

Notification and Reporting requirements are illustrated in the Environmental Spill or Incident Flow Chart in Appendix III.

4.0 Emergency Contact Numbers

PWGSC Esquimalt Graving Dock Contacts

Contact Person	Company/Organization	Phone Number
Dave Latoski	EGD Operations Manager	(250) 889-5808 (c)
Bob Desmarais	EGD Yard Supervisor	(250) 888-0141 (c)
Wyatt Wright	EGD Pumphouse Supervisor	(250) 213-5154 (c)
Jack Gale	EGD Crane Supervisor	(250) 213-9683 (c)
Kim Wilson	EGD Risk Management	(250) 213-6540 (c)
Daryl Lawes	EGD Environmental Coordinator	(250) 213-7242 (c)
Melissa Piasta	EGD Environmental Officer	(250) 888-7357 (c)
Alanna Morbin	EGD Environmental Officer	(250) 889-3566 (c)

User Contacts

Company	Office #	After Hrs. Contact	After Hrs. #
Victoria Shipyards Ltd.	(250) 380-1602	Malcolm Barker	(250) 727-2912 (h)
Jenkins Marine	(250) 383-6440	John Jenkins	(250) 478-2605 (h)
Esquimalt Drydock Company	(250) 386-4172	Joe Sansalone	(604) 202-5454 (c)
Hazco (formerly PWWS)	(250 380-0436	Peter Lehman	(250) 380-8143 (h)
Intercon Marine	(250) 389-0391	Tom Whyte	(250) 480-8064 (c)
Nanaimo Shipyard	(250) 753-1151	Ron Van Wachem	(250) 753-4751 (h)

Other Stakeholder Contacts

Organization	Phone Number
DND Emergency Response (Call for all level 3 land and waterborne spills)	911 (from PWGSC government phones)
Port Operations and Emergency Services Branch – DND	Working Hrs: 363-2160 or VHF Channel 10 After Working Hrs: 911 or VHF Channel 10
QHM Pollution Control – Office Only	Bob Pope: 363-5428 (Pollution Control Officer) Lyle Fairly: 363-2911(A/Pollution Control Officer Dave Buchanan: 363-5429 (A/ Pollution Control Officer)
Environment Canada Spill Reporting line	(604) 666-6100
Canadian Coast Guard Emergency Line	24 hr Emergency 1-800-889-8852 (604) 666-6011or Maritime Communication and Traffic Services (MCTS) VHF Channel 12

	Senior Response Officer (Victoria) (250) 363-3806
BC Provincial Emergency Program (PEP) Spill Reporting/Emergency Coordination Line	(800) 663-3456
Burrard Clean	24 hr Emergency (604) 294-9116 Non-Emergency (604) 294-6001 Fax (604) 294-6003
Canadian Forces Sailing Association	(250) 385-2646
Songhees First Nations Office	(250) 386-1043

5.0 Training

PWGSC EGD employees will receive appropriate spill response training. Training will include, but is not limited to:

- Policy, Legislation and Liabilities
- Basics of Spill Response
- Spill Prevention Strategies
- Resources Available at the EGD
- Hands on Exercises

Users of the Esquimalt Graving Dock will ensure that their employees receive appropriate spill response training.

6.0 Records

The controlled copy of this plan is held with the EGD Environmental Services. Uncontrolled copies will be distributed as requested.

Spill response training records for EGD personnel will be documented and retained on file with EGD Environmental Services.

Appendix I

Responding to a Spill on Land

Responding to a Spill on Land

For all spills on land (including the wharves or in the Graving Dock), every effort shall be made to prevent the spill from reaching the marine environment. This can be achieved by placing absorbent material (e.g. sock/boom, pad, bagged universal absorbent) on the spill and also between the spill and the water.

Level 1:

If there is a land based spill, and it is within the capability of the generator or discoverer to respond to the spill, the generator/discoverer will proceed to clean up the spill using the appropriate PPE and spill supplies. The waste shall be properly labeled and disposed of in accordance with EGD policy. The waste shall not be abandoned or disposed of in the garbage or a dumpster. Once the spill has been cleaned up, the responder will immediately report the spill to their supervisor and to PEP if applicable (refer to Appendix I for reportable quantities on land). An Environmental Incident Report, or information for a report, will also be submitted to Environmental Services for tracking purposes.

Level 2:

If there is a land based spill and the generator/discoverer requires assistance with clean up, the generator/discoverer will immediately notify the Incident Commander and Environmental Services. The Incident Commander or Environmental Services will determine if the spill is within the capability of PWGSC staff and resources. Dock employees will stand by and await further direction from the Incident Commander or Environmental Services. If within PWGSC capability clean up will commence using appropriate PPE and spill supplies. The waste will be properly labeled and disposed of in accordance with EGD policy. The waste shall not be abandoned or disposed of in the garbage or a dumpster. Once the spill has been cleaned up, the responder will report the spill to PEP if applicable (refer to Appendix I for reportable quantities on land). An Environmental Incident Report, or information for a report, will also be submitted to Environmental Services for tracking purposes.

Level 3:

If there is a land based spill, and the Incident Commander and/or Environmental Services have deemed the spill not within the capability of PWGSC staff/resources, the DND Fire Department will be called in to assist or manage the spill. PWGSC personnel and resources may still be utilized during cleanup, therefore; dock employees will stand by and await further direction from the Incident Commander or Environmental Services. Once the spill has been cleaned up, PWGSC Environmental Services will report the spill to PEP if applicable (refer to Appendix I for reportable quantities on land). Environmental Services for tracking purposes will also file a report. An Environmental Incident Report, or information for a report, will also be submitted to Environmental Services for tracking purposes.

Reportable Quantities for Land Spills
Federal Regulations for the Transportation of Dangerous Goods

Substance Spilled	***Reportable Limit***
Explosives of Class 1 as defined in section 2.9 of the Federal Regulations	Any amount that could pose a danger to public safety or is greater than 50kg
Gases of Class 2 as defined in section 2.13 of the Federal Regulations	Any quantity that could pose a danger to public safety or any sustained release of 10 minutes or more
Flammable liquids of Class 3 as defined in section 2.18 of the Federal Regulations	200 L
Flammable solids of Class 4 as defined in section 2.20 of the Federal Regulations	25 kg
Products or substances that are oxidizing substances of Division 1 of Class 5 as defined in section 2.23 and 2.24 (a) of the Federal Regulations	50 kg or 50 L
Products or substances that are organic peroxides that contain the bivalent "-O-O-" structure of Division 2 of Class 5 as defined in sections 2.23 and 2.24 (b) of the Federal Regulations	1 kg or 1 L
Products or substances that are toxic and substances of Division 1 of Class 6 as defined in section 2.26 and 2.27 (a) of the Federal Regulations	5 kg or 5L
Infectious Substances defined in sections 2.26 and 2.27 (b) of the Federal Regulations	Any amount
Radioactive materials of Class 7 as defined by section 2.37 of the Federal Regulations and section 20 of the Packaging and Transport of Nuclear Substances Regulations	Any amount or any emission that is: (*a*) 10 mSv/h on the external surface of a package that is being transported under exclusive use, 2 mSv/h on the surface of the conveyance, and 0.1 mSv/h at a distance of 2 m from the surface of the conveyance; and (*b*) 2 mSv/h on the external surface of a package that is not being transported under exclusive use, 0.1 mSv/h at a distance of 1 m from the package, 2 mSv/h on the surface of the conveyance, and 0.1 mSv/h at a distance of 2 m from the surface of the conveyance.
Corrosive products or substances of Class 8 as defined by section 2.40 of the Federal Regulations	5 kg or 5 L

Miscellaneous products or substances of Class 9 as defined by section 2.43 of the Federal Regulations	25 kg or 25 L

Appendix II

Responding to a Spill on Water

Responding to a Spill on Water

For spills on water it is often difficult to determine the source. The priority is to determine the size of the spill and the direction it is moving. A solid boom is the most effective means of containing a spill on water. The only readily available boom material at EGD is permanently in the water providing containment for the Dock main discharge port. If necessary, this boom may be disconnected and moved to contain a spill on the water as an intern measure. In addition, absorbent booms and pads may be place on the water to absorb oil.

In the event of the discovery of a minor spill or sheen on the water, the alert will be made by two-way VHF radio on Channel 4 and Channel 10. Dock employees will stand-by and await further direction from the Incident Commander or Environmental Services.

Level 1:

If there is a spill that reached the marine environment, and it is within the capability of the generator or discoverer to respond to the spill, the generator/discoverer will proceed to clean up the spill using the appropriate PPE and Spill Kits (Hydrocarbon). The waste shall be properly labeled and disposed of in accordance with EGD policy. The waste shall not be abandoned or disposed of in the garbage or a dumpster. Once the spill has been cleaned up, the responder will immediately report the spill to their supervisor and to Environmental Services regardless of size. Environmental Services will report the spill to PEP. An Environmental Incident Report will also be submitted by the generator/discoverer to Environmental Services for tracking purposes. An Environmental Incident Report template can be located in Appendix II.

Level 2:

If there is a spill that reaches the marine environment, and the generator/discoverer requires assistance with clean up, the generator/discoverer will immediately notify the Incident Commander and Environmental Services (Contact numbers are located in Appendix III). The Incident Commander or Environmental Services will determine if the spill in within the capability of PWGSC staff and resources. If within PWGSC capability, clean up will commence using appropriate PPE, permanent boom, and spill response resources. The waste will be properly labeled and disposed of in accordance with EGD policy. The waste shall not be abandoned or disposed of in the garbage or a dumpster. Once the spill has been cleaned up, the responder will immediately report the spill to Environmental Services (if not previously notified). Environmental Services will report the spill to PEP. An Environmental Incident Report will also be submitted by the generator/discoverer to Environmental Services for tracking purposes. An Environmental Incident Report template can be located in Appendix II.

Level 3:

If there is a spill that reaches the marine environment and the Incident Commander and/or Environmental Services have deemed the spill not within the capability of PWGSC staff/resources,

DND Pollution Control, the Canadian Coast Guard, or an external contractor will be immediately notified and brought in to assist or manage the spill. PWGSC personnel and resources may still be utilized during cleanup. Once the spill has been cleaned up, PWGSC Environmental Services will report the spill to PEP. Environmental Services will also file a report internally for tracking purposes. Environmental Services, the Incident Commander, or Environment Canada may investigate the incident.

Oil Spills on Water

Environmental Impacts

The environmental implications of an oil spill are dependent on a number of variables including the product spilled, the quantity spilled, the location of the spill, and the habitat or wildlife impacted.

Spilled oil and certain cleanup operations can threaten different types of marine habitats and animals in different ways. For example, exposed sandy, gravel or cobble beaches are usually cleaned by manual techniques. Although oil can soak into sand and gravel, few organisms live full-time in this habitat, so the risk to animal life or the food chain is less that in other habitats, such as tidal flats.

Sheltered beaches have very little wave action to encourage natural dispersion. If the cleanup effort is not timely, oil may remain stranded on these beaches for years. Tidal flats are broad, low-tide zones, usually containing rich plant, animal, and bird communities. Deposited oil may seep into the muddy bottoms of these flats, creating potentially harmful effects on the ecology of the area. Finally, salt marshes host a variety of plants, bird and mammal life. Marsh vegetation; especially the root systems are easily damaged by fresh light oils.

In open water, marine organisms such as fish and whales have the ability to swim away from a spill by going deeper in the water or further out to sea. However, marine animals that live close to shore have a higher risk of being adversely affected as a result of an oil spill. Further, if one species in a food chain is adversely affected as a result of contamination, the entire food chain suffers.

Properties of Various Oil Types

Oil Type	*Representative Oils*	*Diagnostic Properties*	*Physical/Chemical Properties*
Light volatile oils	Distillate fuel, and most light crude oils	Highly fluid, usually transparent but can be opaque, strong odour, rapid spreading, can be rinsed from plant sample by simple agitation	• May be flammable • High rate of evaporative loss of volatile components • Assumed to be highly toxic to marine biota when fresh • Tend to form unstable emulsions • May penetrate sediments
Non-sticky oils	Medium to heavy paraffin-based refined and crude oils	Moderate to high viscosity, waxy or oily feel, can be rinsed from surfaces by low pressure water flushing	• Generally removable from surfaces • Penetration of substrates variable • Toxicity variable • Includes water in oil emulsions
Heavy sticky oils	Residual fuel oil; medium to heavy asphalt and mixed base crudes	Typically opaque brown or black, sticky or tarry, viscous, cannot be rinsed from plant by agitation	• High viscosity • Hard to remove from surfaces • Tend to form stable emulsions • High specific gravity and potential for sinking after weathering • Low substrate penetration • Low toxicity (biological effects due to smothering) • Will interfere with many types of recovery equipment
Non-fluid oils (at ambient temperature)	Residual and heavy crude oils (all types); asphalt	Tarry or waxy lumps	• Non-spreading • Cannot be recovered from water surfaces using most conventional clean-up equipment • Cannot be pumped without preheating or slurring • Initially relatively nontoxic • May melt and flow when stranded in sun

Reference: QHM Pollution Contingency Plan, Department of National Defence, December 2000.

Note: One of the most common substances spilled is dirty bilge water, which can be spilled during pumping operations. Bilge water is composed of a wide variety of substances, the majority of which include seawater, freshwater and numerous petroleum products (e.g. lubricants and fuels).

Estimating the Size of a Spill

When oil is spilled a working estimate of the volume of a spill on the water surface can be made by visual assessment of its surface area and thickness. When making a visual estimate of quantity, consideration should be given to slick thickness which can vary considerably even in a single slick. In general, dark brown or black patches indicate higher concentrations of oil, while coloured or silvery bands, such as those often seen at slick edges indicate extremely thin areas. The following table summarizes the appearance of oil on water as it is related to thickness.

Thickness (μm)*	Quantity (L/km^2)	Appearance
0.04	40	Barely visible under very good light conditions
0.08	90	Visible as a silvery sheen on water
0.15	175	First trace of colour may be observed
0.3	350	Bright bands of colour
1.0	1200	Colours begin to turn dull
2.0	2300	Colours are much darker
1000	10 x 10^6	Dark brown, black; emulsions may be present

Reference: QHM Pollution Contingency Plan, Department of National Defence, December 2000.

*1000 μm = 1.0 mm

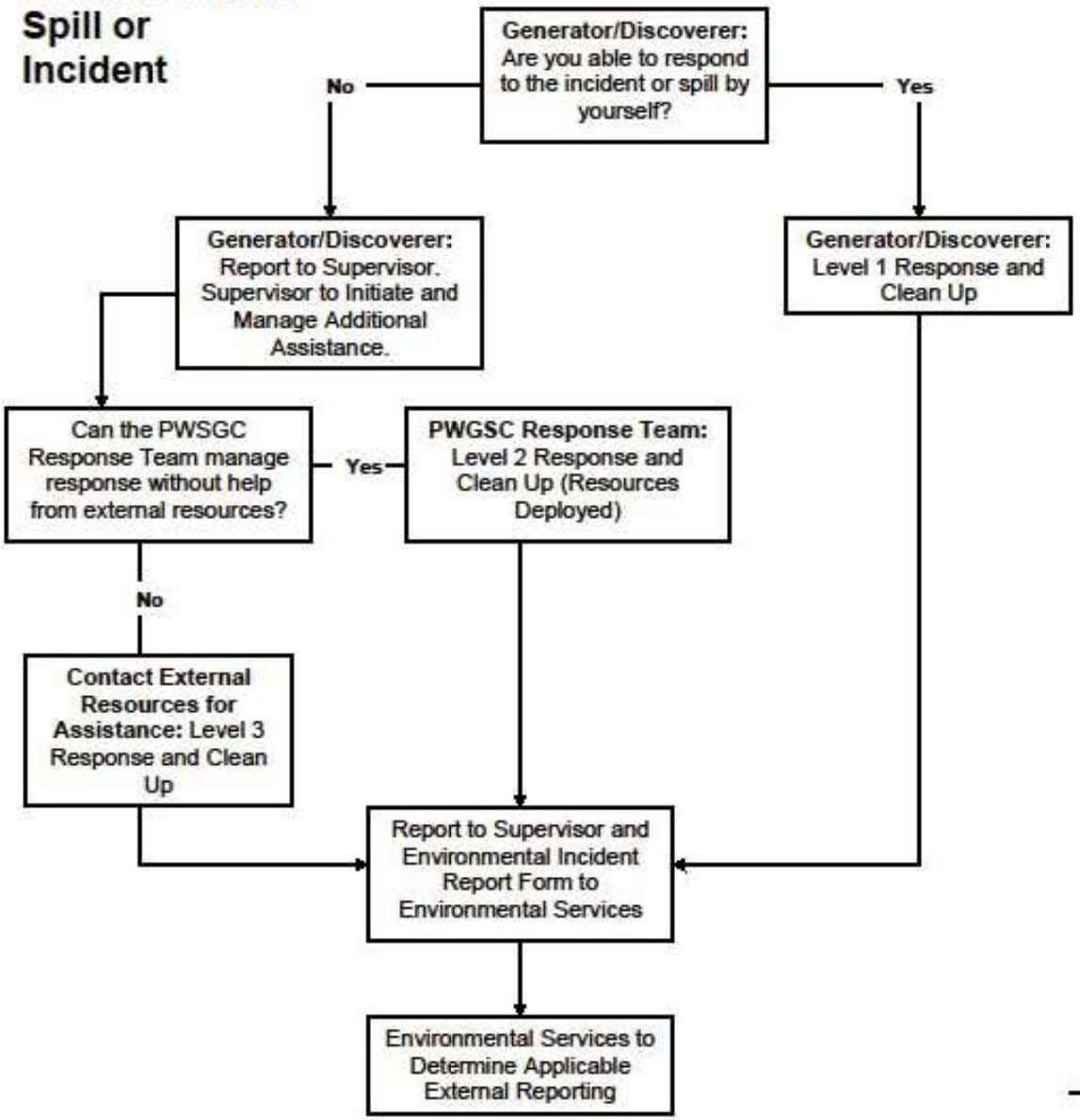
Fate of Spilled Oil

When oil is spilled on water, the slick itself can be affected by a number of weathering processes including oxidation, evaporation, spreading, emulsification, dissolution, biodegradation, and sedimentation. Weathering is a series of chemical and physical changes that cause spilled oil to break down and become heavier than water. Winds, waves, and currents may result in natural dispersion, breaking a slick into droplets which are then distributed throughout the water.

Appendix III

Environmental Spill or Incident Flow Chart

Environmental Spill or Incident



CONTACTS

Level 1:
Supervisor
Environmental Services

Level 2:
Supervisor
Environmental Services

Level 3:
EGD Commissionaires
(250) 363-3874

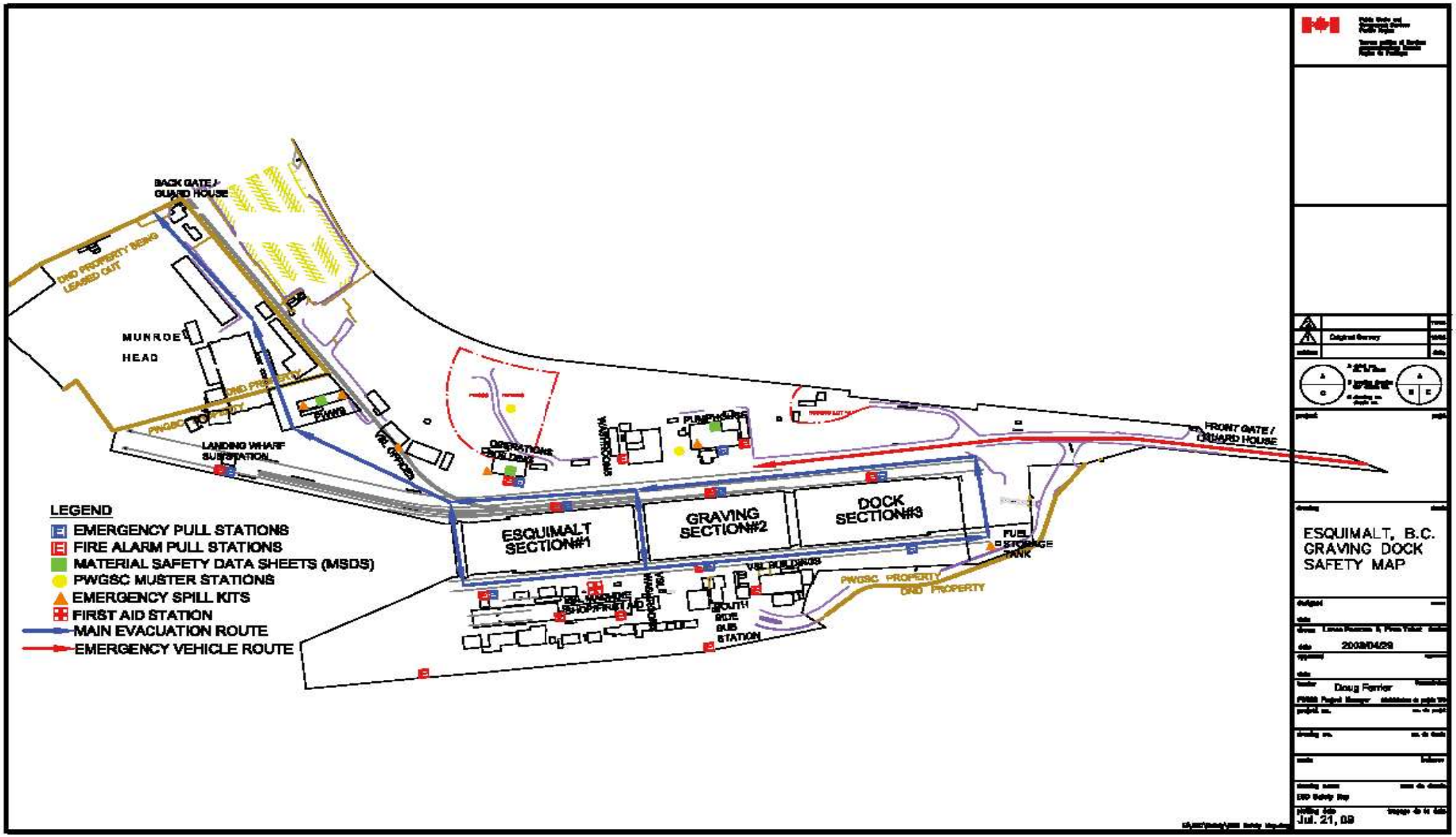
DND POESB/QHM
(250) 250-363-2160
VHF Channel 10

Provincial Emergency Program
(800) 663-3456

Canadian Coast Guard
(800) 889-8852
VHF Channel 12

Appendix IV

Site and Location Map



ESQUIMALT, B.C.
GRAVING DOCK
SAFETY MAP

2008/04/29

Doug Ferrier

Jul. 21, 09

APPENDIX H

FUELLING AND OIL TRANSFER POLICY

Keystone Environmental
Knowledge-Driven Results

Esquimalt Graving Dock
Fueling and Oil Transfer Policy

From time to time, bulk transfer of oil and fuel to or from vessels takes place at the Esquimalt Graving Dock (EGD) facility. Oil spills pose a significant risk to the environment, economy, and infrastructure at the EGD.

Scope: This policy applies to all vessel fueling operations involving trucks and barges, as well as bulk oil transfers of greater than 10 tonnes (10,000 litres) per day involving vessels berthed at the EGD. It applies to fueling of vessels in the drydock, but not bulk oil transfers involving dry-docked ships.

Oil, as described in the *Canada Shipping Act*, is considered petroleum in any form, including crude oil, fuel oil, sludge, oil refuse and refined products.

Requirements: The following must be adhered to when transferring bulk fuel/oil to or from vessels at the EGD:

1. Transfer operations must comply with the requirements outlined in the *Canada Shipping Act*, *Oil Pollution Prevention Regulations Part IV – Transfer Operations*.

2. An **Oil Transfer Checklist** must be completed and signed by both the representatives from the transfer vehicle (tank, truck or barge) and the vessel. This checklist must be received and signed by an EGD Representative prior to fuel/oil transfer.

3. For berthed vessels, a containment boom must be securely in place so that the areas of operations involved in the oil transfer process are completely surrounded. The containment boom must be structurally sound and have a minimum stand off of 5 feet from the sides of the vessel (this standoff may be adjusted to meet short term needs as long as potential spills from the dock, transfer hoses, decks and vents can be contained). *Users may deploy their own containment boom, have boom provided by a third party, or rent the Esquimalt Graving Dock boom.*

4. For transfers involving vessels in the Graving Dock, there must be a Pumphouse Operator present to shut down the auxiliary drydock pumps if a spill occurs. If no operator is on site, the drains and trenches on the dock floor should be covered, blocked or otherwise isolated from the tunnels leading to the auxiliary pumps.

Fuel transfer will not be allowed to commence without the permission of an Esquimalt Graving Dock Supervisor and completion of the **Oil Transfer Checklist**. The **Oil Transfer Checklist** can be obtained from the Front Gate Commissionaires or Pumphouse Operator. It must be filled out and submitted to the Pumphouse Operator or Front Gate Commissionaires prior to transfer.

Further details on safe transfer procedures can be found in the **Tank Truck to Marine Vessel-Oil Transfer Manual** (http://www.pacific.ccg-gcc.gc.ca/er/oiltransfer/index_e.htm).

May 29, 2007

Example Scenarios

Fuelling a Vessel at a Jetty

1. Agent/User arranges fuel for vessel.
2. Agent/User notifies Esquimalt Graving Dock Supervisor of fuelling plan.
3. A containment boom is secured around the vessel.
4. Fuel truck arrives at Front Gate.
5. Front Gate Commissionaire provides Oil Transfer Checklist. Commissionaire notifies the Pumphouse Operator of the operation, and to expect a submitted checklist.
6. Truck meets with the responsible vessel representative.
7. The checklist is filled out and signed by both parties.
8. Checklist is taken to the Pumphouse, signed as received by Pumphouse Operator, and filed. Copy is provided to the vessel or truck representative if requested.
9. Transfer takes place.
10. Truck leaves property.
11. Containment boom is retrieved.

Containment boom around vessel during fueling operations

Transfer of Lube Oil (> 10,000 litres) from a Berthed Vessel.

1. Shipyard prepares to transfer 10,000 litres of lube oil from a vessel to dockside tanks/totes.
2. Shipyard notifies Esquimalt Graving Dock Supervisor of transfer.
3. A containment boom is secured around the vessel.
4. The responsible personnel on the vessel and the shore fill out the Oil Transfer Checklist (this may be the same company if they are responsible for both ends of transfer).
5. Checklist is taken to the Pumphouse, signed as received by Pumphouse Operator, and filed. Copy is provided to the vessel or truck representative if requested.
6. Transfer takes place.
7. Containment boom is retrieved.

ESQUIMALT GRAVING DOCK
OIL TRANSFER CHECKLIST

OIL TRANSFER LOCATION (circle): South Jetty North Landing Wharf Graving Dock (Section 1 2 3)
TANK/TRUCK/BARGE COMPANY NAME: _____
VESSEL NAME: _____

RESPONSE PERSONNEL INFORMATION:
Vessel (Name, Phone): _____
Tank, Truck or Barge (Name, phone): _____

INSTRUCTIONS FOR COMPLETION: No vessel berthed at the Esquimalt Graving Dock is to begin loading or discharging oil until this form is completed in its entirety, and submitted to the Pumphouse Operator. For dry-docked vessels, this checklist needs to be completed for fuelling operations only. Transfer must not proceed unless affirmative answers are provided for each applicable checklist question. If the Pumphouse Operator is not on Duty, please provide the completed form to the Front Gate Commissionaires.

QUESTIONS	**VESSEL**		**TANK, TRUCK or BARGE**	
	Yes	**No**	**Yes**	**No**
Is there a written spill procedure plan?				
Is there immediately available cleanup and containment material?				
Are sufficient/qualified personnel available to deal with an emergency?				
Is there an effective deck watch and adequate supervision ashore?				
Have procedures for *oil* transfer handling been agreed to?				
Is there an agreed upon communication system?				
Agree on units of volume measure (gallons, litres)				
Have emergency shutdown procedures been agreed to?				
Are transfer hoses in good condition, tested and properly rigged?				
Are scuppers plugged and drip tray positioned?				
Are unused connections blanked?				
Are safety/smoking requirements being observed?				
Berthed Vessels				
Is the vessel securely moored? (Vessel at a Jetty)				
Is there a sufficient containment boom in place to contain a spill or release? (Vessel at a Jetty)				

DATE/TIME	**PRODUCT**	**QUANTITIY TO BE LOADED**	**DESCRIPTION OF RECEIVING TANK**	**CAPACITY OF RECEIVING TANK**	**RATE**	**PUMPING PRESSURE (psi)**

DECLARATION
We have checked all the items on this checklist and have satisfied ourselves that the entries we have made are correct to the best of our knowledge.

VESSEL REPRESENTATIVE
NAME: _____
SIGNATURE: _____
DATE: _____

TANK, TRUCK, BARGE REPRESENTATIVE
NAME: _____
SIGNATURE: _____
DATE: _____

EGD REPRESENTATIVE SIGNATURE: _____ DATE: _____

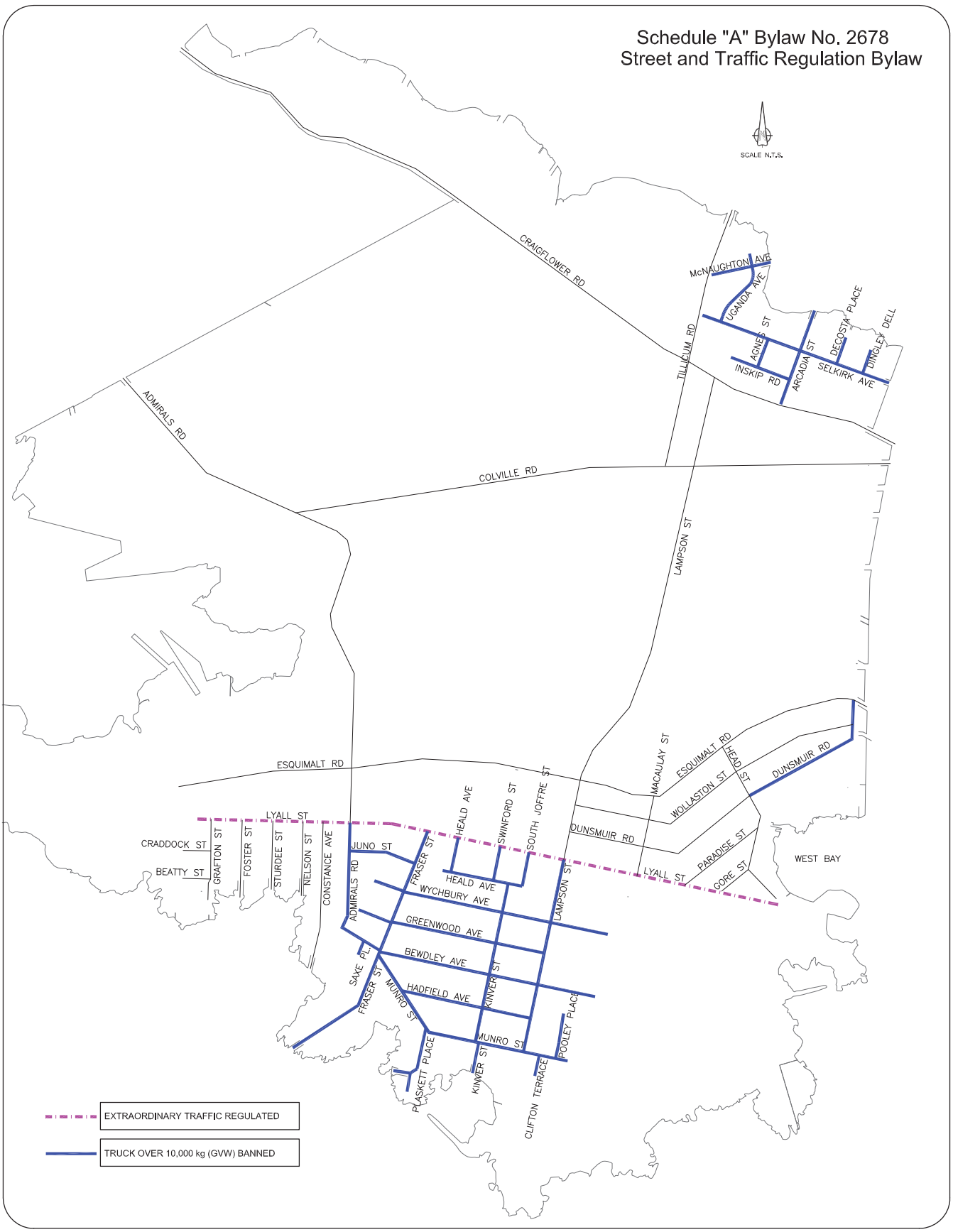
In case of emergency contact the Commissionaires immediately
(250) 363-3784

APPENDIX I

TOWNSHIP OF ESQUIMALT TRUCK ROUTES

Keystone Environmental
Knowledge-Driven Results

Schedule "A" Bylaw No. 2678
Street and Traffic Regulation Bylaw



SECTION 4
A CONNECTED COMMUNITY — TRANSPORTATION

Transportation issues, whether within Esquimalt or as part of the regional network are critical to our community's ongoing sustainability. This section sets out a variety of transportation issues within our community, including roads, parking, public transit, cycling and walking, and how we connect to the regional network.

- To improve mobility and access for local travel and to adjacent municipalities.
- To minimize intrusion of major traffic flows into neighbourhoods.
- To promote the safe use of the road network by pedestrians and bicyclists.
- To improve the network and infrastructure for safe cycling;
- To provide convenient routing for transit service, together with good local access routes for pedestrians to transit service, particularly in higher density areas, parks and recreation facilities.
- To avoid or mitigate the negative impacts of parking on aesthetics, livability, and the environment.
- To ensure the continued availability of sufficient parking.

4.1 Roads

Esquimalt's road system serves a variety of purposes and users. In addition to allowing residents to move between their homes, places of work, shopping and recreational facilities, it is also part of a larger regional network, which provides for the movement of private and commercial vehicles, as well as DND traffic.

4.1.2 Roads Policies

a) Major Roads and Residential Collector Roads are shown on "Schedule B". All roads not highlighted on "Schedule B" are designed to serve local traffic only.

b) Craigflower Road and Esquimalt Road will continue to serve as the municipality's principal east/west through-traffic routes. Through-traffic will be encouraged to use these routes rather than local streets.

c) Encourage multi-modal street design and accessibility for pedestrians, cyclists, transit users and motorists.

d) All roads, including all major collector roads, should become bicycle-accommodating.

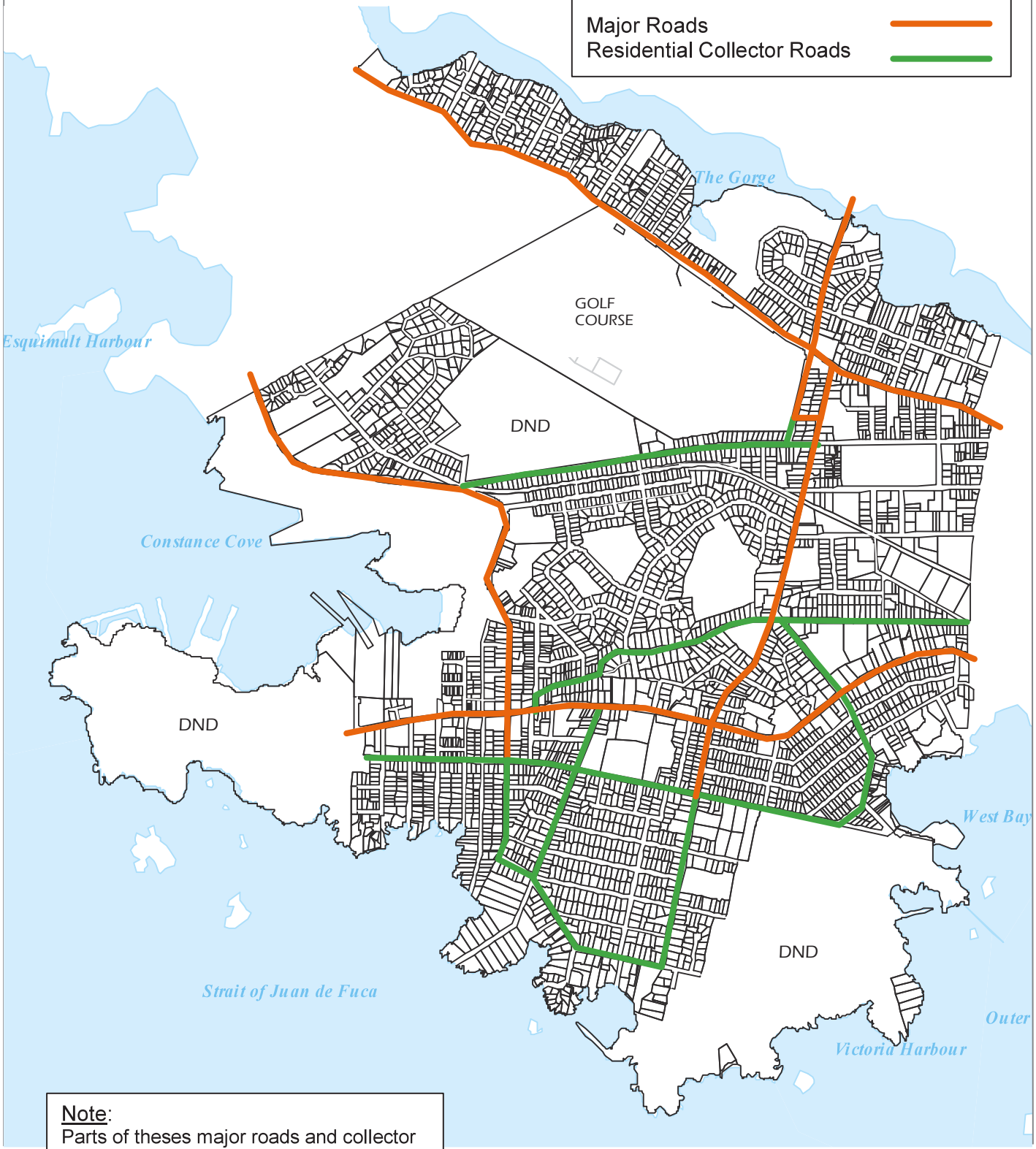
e) The Township is pursuing potential funding from other levels of government in order to assist with improvements to Craigflower Road.

f) Major and local roads within Esquimalt are considered to be a "community resource" for the benefit of all users of the road. They increase opportunities for personal

Corporation of the Township of Esquimalt
OFFICIAL COMMUNITY PLAN

Schedule B_1
ROAD NETWORK

Major Roads
Residential Collector Roads



Note:
Parts of theses major roads and collector roads are also part of the Bicycle Network [see Cycling Routes map]. Cycling is a recognized form of transportation and is permitted on all municipal roads.

APPENDIX C

REGULATORY CORRESPONDENCE

Keystone Environmental
Knowledge-Driven Results

August 4, 2016

Fisheries Protection Program
Fisheries and Oceans Canada
219 – 800 Burrard Street
Vancouver, BC V6C 0B9

Dear DFO:

Re: 14-HPAC-00210 Construction Schedule
Esquimalt Graving Dock South Jetty Reconstruction Project
Esquimalt, BC
Project No. 13024

Public Works and Government Services Canada (PWGSC) and Defence Construction Canada will begin construction of the South Jetty Pier beginning as early as October 2016, and completed as late as July 31, 2020. Keystone Environmental Ltd. has been retained by PWGSC to provide environmental support throughout the project.

Keystone Environmental is requesting confirmation from the Fisheries Protection Program (FPP) on the following in advance of tendering the project:

1. The estimated completion data for the construction of the South Jetty has been revised to July 31, 2020. Does this change the recommendations by FPP in the May 13, 2014 letter 14-HPAC-00210 (attached) that no formal approval from FPP is required?
2. The marine contractors will request to work throughout the year, including during outside of the least risk windows for fish:
   - Can works occur during October 1 to November 30?
   - Can works occur during February 16 to June 30?

Anticipated works related to the construction of the South Jetty include:

- Pile driving
- Concrete pouring
- Intertidal excavation to install headwalls

Suite 320
4400 Dominion Street
Burnaby, British Columbia
Canada V5G 4G3

Telephone: 604 430 0671
Facsimile: 604 430 0672
info@KeystoneEnviro.com
KeystoneEnviro.com

Environmental Consulting
Engineering Solutions
Assessment & Protection

The contractor will be required to install mitigation measures and supply a full-time qualified environmental monitor during in-water works. In addition, Keystone Environmental will perform spot checks to confirm compliance with the Environmental Management Plan.

Please contact us with any questions.

Sincerely,

Keystone Environmental Ltd.

Original signed by

Warren Appleton, R.P.Bio.
Project Manager

\\10.0.0.8\Common\13000-13099\13024 PWGSC\Report\13024 160804 DFO Notification Letter.docx

ATTACHMENT:

- 14-HPAC-00210 – Implementation of Mitigation Measures to Avoid and Mitigate Serious Harm to Fish

14-HPAC-00210 – IMPLEMENTATION OF MITIGATION MEASURES TO AVOID AND MITIGATE SERIOUS HARM TO FISH

Keystone Environmental
Knowledge-Driven Results

Fisheries and Oceans Canada | Pêches et Océans Canada

Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC, V9T 6N7

Your file *Votre référence*

May 13, 2014

Our file *Notre référence*
14-HPAC-00210

Cliff Rhodes, Portfolio Director
Public Works and Government Services Canada
219-800 Burrard Street
Vancouver, BC, V6C 0B9

VIA E-MAIL: Cliff.Rhodes@pwgsc-tpsgc.gc.ca

Dear Mr. Rhodes:

Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish.

The Fisheries Protection Program (the Program) of Fisheries and Oceans Canada received your proposal on February 26, 2014.

Your proposal has been reviewed to determine whether it is likely to result in serious harm to fish which is prohibited under subsection 35(1) of the *Fisheries Act*.

Our review consisted of:

- Request for Review form and attached Figures and Photos

We understand that you propose to:

- Demolish the existing South Jetty pier
- Dredge and remediate contaminated sediments
  - 5,225 m2 intertidal coarse sediment and bedrock
  - 6,893 m2 subtidal unconsolidated sediment
- Construct a new South Jetty pier
- Remove existing sheet pile containment wall

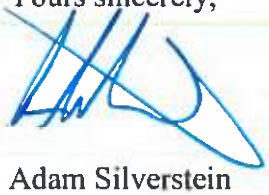
Provided that the mitigation measures identified in your Request for Review form are incorporated into your plans, the Program is of the view that your proposal will not result in serious harm to fish. No formal approval is required from the Program under the *Fisheries Act* in order to proceed with your proposal.

If your plans have changed or if the description of your proposal is incomplete, or changes in the future, you should consult our website (http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html) or consult with a qualified environmental consultant to determine if further review is required by the Program.

Please notify this office at least 10 days before starting your project. A copy of this letter should be kept on site while the work is in progress.

If you have any questions, please contact Byron Nutton at our Nanaimo office at 250-756-7221, by fax at 250-756-7229, or by email at byron.nutton@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with the Program.

Yours sincerely,



Adam Silverstein
Manager, Regulatory Reviews
Fisheries Protection Program

Keystone Environmental
Knowledge-Driven Results

August 12, 2016

Fisheries Protection Program
Fisheries and Oceans Canada
219 – 800 Burrard Street
Vancouver, BC V6C 0B9

Dear FPP:

Re: 14-HPAC-00210 Construction Schedule
Esquimalt Graving Dock South Jetty Reconstruction Project
Esquimalt, BC
Project No. 13024

Public Works and Government Services Canada (PWGSC) will begin construction of the South Jetty Pier beginning as early as October 2016, and completing as late as July 31, 2020. Keystone Environmental Ltd. has been retained by PWGSC to provide environmental support throughout the project.

On February 26, 2014, a Request for Review (RfR) was submitted by PWGSC to the Fisheries Protection Program (FPP) to determine if a Fisheries Act Authorization was required for the Esquimalt Graving Dock South Jetty Redevelopment / Waterlot Underpier Phase 2 Remediation Project. Phase 2 involves the demolition of the existing south jetty, dredging and remediation of contaminated sediments (5,225 m^2 intertidal course sediment and bedrock; 6,893 m^2 subtidal unconsolidated sediment), construction of a new South Jetty pier, and removal of the existing sheet pile containment wall (RfR attached**)**. FPP concluded that provided the mitigation measures identified in the Request for Review were followed, no serious harm to fish would occur and no formal approval from FPP was required (**14-HPAC-00210 -** see attached). The application included completing some works outside of the least risk windows for fish.

During the Phase 1 works, which involved dredging and rock placement within the EGD waterlot and nearby areas, work outside of the summer (July 1 – October 1) or winter (December 1 – February 15) windows was not recommended based on the potential for contaminant desorption from re-suspended sediments potentially caused by dredging. Portions of the Phase 2 works are already complete (sheet pile installation, dredging, cap placement, pier removal) and were allowed to be performed by FPP outside of the least risk windows. Rational provided by PWGSC included:

Suite 320
4400 Dominion Street
Burnaby, British Columbia
Canada V5G 4G3

Telephone: 604 430 0671
Facsimile: 604 430 0672
info@KeystoneEnviro.com
KeystoneEnviro.com

- Dredging was performed within a contained in isolated work cell;
- A very low probability of negative interactions was anticipated with the implementation of Best Management Practices (BMP) and Environmental Management Plan (EMP) and associated Water Quality Monitoring Plan (WQMP) with stop work provisions because:
  - Significant salmon spawning streams do not drain into Esquimalt Harbour, reducing the likelihood of returning spawners being present;
  - Herring spawns typically do not occur in Esquimalt Harbour;
- Hay and McCarter, 1999, indicate there is a low probability of herring spawning if works do not occur between March and mid-April. Herring observations are absent since 1993. Modelling by Anchor further demonstrated that even if a silt curtain or TRB were absent, TSS concentrations were orders of magnitude less than concentrations where acute lethality occurs (see RfR 2014 attached). Further, pile driving was not expected to exceed 30 kPa 1m from the source (RfR 2014).
- If salmon were present, they would unlikely be caught up by the dredging bucket, would not have access through the sheet piling wall or within the temporary resuspension barrier (TRB), and water quality criteria in the WQMP would be monitored for compliance.
- Monitoring for herring and herring eggs on equipment would also occur. If found, equipment would remain inactive until the eggs hatch.
- Pressure waves from pile driving were not expected to exceed 30 kPa more than 1m away from pile driving activities.

PWGSC is proceeding with the construction of the South Jetty component. Keystone Environmental is requesting confirmation from FPP on the following in advance of tendering the project:

1. The estimated completion date for the construction of the South Jetty has been revised to July 31, 2020. Does this change the recommendations by FPP in the May 13, 2014 letter 14-HPAC-00210 (attached) that no formal approval from FPP is required?
2. The marine contractors will request to work throughout the year. It is understood these work windows are intended to provide times of least risk to sensitive fisheries resources that may occupy/use the area. Salmon migrating to spawning areas may be present in October and November and spawning herring may be present from the end of February to June. PWGSC is seeking confirmation that works may occur, subject to successful implementation of BMPs, outside of the least risk windows for fish:
   - Can works occur during October 1 to November 30?
   - Can works occur during February 16 to June 30?

   Anticipated works related to the construction of the South Jetty include:
   - Pile driving
   - Concrete pouring
   - Intertidal excavation to install headwalls

The contractor will be required to install mitigation measures and supply a full-time qualified environmental monitor during in-water works. In addition, Keystone Environmental will perform spot checks to confirm compliance with the EMP.

Please contact us with any questions.

Sincerely,

Keystone Environmental Ltd.

Original signed by

Warren Appleton, R.P.Bio.
Project Manager

\\key-fs2012\Common\13000-13099\13024 PWGSC\Report\13024 160812 DFO Notification Letter.docx

ATTACHMENT:

- 14-HPAC-00210 – Implementation of Mitigation Measures to Avoid and Mitigate Serious Harm to Fish

14-HPAC-00210 – IMPLEMENTATION OF MITIGATION MEASURES TO AVOID AND MITIGATE SERIOUS HARM TO FISH

Keystone Environmental
Knowledge-Driven Results

Fisheries and Oceans Canada | Pêches et Océans Canada

Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC, V9T 6N7

Your file *Votre référence*

May 13, 2014

Our file *Notre référence*
14-HPAC-00210

Cliff Rhodes, Portfolio Director
Public Works and Government Services Canada
219-800 Burrard Street
Vancouver, BC, V6C 0B9

VIA E-MAIL: Cliff.Rhodes@pwgsc-tpsgc.gc.ca

Dear Mr. Rhodes:

Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish.

The Fisheries Protection Program (the Program) of Fisheries and Oceans Canada received your proposal on February 26, 2014.

Your proposal has been reviewed to determine whether it is likely to result in serious harm to fish which is prohibited under subsection 35(1) of the *Fisheries Act*.

Our review consisted of:

- Request for Review form and attached Figures and Photos

We understand that you propose to:

- Demolish the existing South Jetty pier
- Dredge and remediate contaminated sediments
  - 5,225 m2 intertidal coarse sediment and bedrock
  - 6,893 m2 subtidal unconsolidated sediment
- Construct a new South Jetty pier
- Remove existing sheet pile containment wall

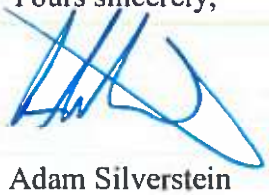
Provided that the mitigation measures identified in your Request for Review form are incorporated into your plans, the Program is of the view that your proposal will not result in serious harm to fish. No formal approval is required from the Program under the *Fisheries Act* in order to proceed with your proposal.

If your plans have changed or if the description of your proposal is incomplete, or changes in the future, you should consult our website (http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html) or consult with a qualified environmental consultant to determine if further review is required by the Program.

Please notify this office at least 10 days before starting your project. A copy of this letter should be kept on site while the work is in progress.

If you have any questions, please contact Byron Nutton at our Nanaimo office at 250-756-7221, by fax at 250-756-7229, or by email at byron.nutton@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with the Program.

Yours sincerely,



Adam Silverstein
Manager, Regulatory Reviews
Fisheries Protection Program

Request for Review

A) Contact information

Name of Business/Company:

Public Works and Government Services Canada

Name of Proponent:

Cliff Rhodes, Portfolio Director

Mailing address:

219-800 Burrard St.

City/Town:

Vancouver

Province/Territory:

British Columbia

Postal Code:

V6Z 0B9

Tel. No. :

(250) 363-0572

Fax No.:

(604) 775-6806

Email:

Cliff.Rhodes@pwgsc-tpsgc.gc.ca

Select additional contact:
Contractor/Agency/Consultant *(if applicable):*

Public Works and Government Services Canada
Contact: Andrew Mylly

Mailing address:

219-800 Burrard St.

City/Town:

Vancouver

Province/Territory:

British Columbia

Postal Code:

V6Z 0B9

Tel. No. :

(604) 666-9684

Fax No.:

(604) 775-6645

Email:

Andrew.Mylly@pwgsc-tpsgc.gc.ca

Is the Proponent the main/primary contact? ○ Yes ◉ No

If no, please enter information for the primary contact or any additional contact.

Andrew Mylly
Public Works and Government Services Canada
(604) 666-9684
Andrew.Mylly@pwgsc-tpsgc.gc.ca

B) Description of Project

If your project has a title, please provide it.

Esquimalt Graving Dock South Jetty Redevelopment / Waterlot Underpier Phase 2 Remediation Project

Is the project in response to an emergency circumstance*? ○ Yes ◉ No

Does your project involve work in water? ◉ Yes ○ No

If yes, is the work below the High Water Mark*? ◉ Yes ○ No

What are you planning to do? Briefly describe all project components you are proposing in or near water.

This Request for Review (RFR) outlines the second of two phases of work for the Esquimalt Graving Dock Waterlot Sediment Remediation Project (Figures 1 & 2, Appendix 1). Phase 1 work consisted of enclosing the work area to be remediated in Phase 2 within a sheetpile wall (Photographs 1-3, Appendix 2) to manage contaminant migration, dredging open-water areas of the surrounding waterlot (Photograph 4, Appendix 2) and application of engineered capping to manage residual contamination. This RFR details proposed Phase 2 works which include demolition of the timber piled portions of the South Jetty, redriving of the sheet pile wall, dredging and remediation of contaminated under-pier sediments (in two stages, Photographs 5 & 6, respectively, Appendix 2), placement of engineered capping (sand and rock armour) over dredged areas and reconstruction of the South Jetty pier with a steel pile and concrete structure.

How are you planning to do it? Briefly describe the construction materials, methods and equipment that you plan to use.

Public Works and Government Services Canada (PWGSC) plans to demolish and reconstruct the timber piled portions of the EGD South Jetty at the Esquimalt Graving Dock (EGD) facility in Constance Cove, Esquimalt Harbour, Vancouver Island. PWGSC also plans to remediate contaminated sediment within the South Jetty under-pier area as part of Phase 2 of the Esquimalt Graving Dock Waterlot Sediment Remediation project. Phase 2 will include the following activities:

- re-driving of sheet-pile wall (installed in Phase 1; Photographs 1-3, Appendix 2);
- demolition of timber piled portions of the South Jetty (Photographs 5-6, Appendix 2);
- dredging/excavating under-pier sediments;
- off-site disposal of contaminated marine sediments at a suitable licensed disposal facility;
- pile driving;
- installation of pre-cast and cast-in-place concrete, both above and below the HHWM;
- placement of rock armouring and sand; and,
- reconstruction of demolished marine terminal structures.

At the under-pier area, of the South Jetty (Phase 2), sand and armour rock will be placed over dredged areas where necessary to stabilize the slope and mitigate against erosion of materials by propwash forces and manage undisturbed (missed-inventory) contamination. Undisturbed (missed-inventory) contamination may be present following the dredging due to technical feasibility constraints (e.g., contamination is too deep to for removal adjacent to existing structures or areas inaccessible for excavation). Where coarse substrates (cobble/boulder) currently exist similar materials will be used to replace removed substrate resulting in no anticipated changes to substrate type. In areas of soft sediment (fine grained silt/sand) some placement of armour rock (cobble/boulder) may occur.

The following activities are proposed to facilitate the work described:

1. Demolition of the South Jetty and associated utilities:
   - The timber piles will be removed by either vibration or choking. Removal of existing South Jetty deck and catwalk will be conducted by general demolition methods;
   - driving of the existing steel sheet pile wall (which currently surrounds the South Jetty further into bottom sediment (to 0 m chart datum);
2. Installation of a Temporary Resuspension Barrier (TRB) around the perimeter of the Phase 2 Stage 1 and subsequent Stage 2 dredge areas;
3. Dredging/excavation to remove contaminated sediments from the South Jetty under-pier area and to create room for the construction of a concrete retaining wall at the east approach structure:
   - mechanical dredges and land-based excavators would be used, as appropriate;
4. Dredged sediment/excavated material will be directly loaded to sealed haul barges and transported to an off-site off-loading area for road transport to a permitted upland disposal facility;
5. Sand and armour rock will be placed over dredged areas where necessary to stabilize the slope and mitigate against erosion of materials by propwash forces and manage un-disturbed (missed inventory) contamination:
   - once armouring activities are complete, the steel sheet pile wall will be removed through vibratory methods, where possible;

6.Reinforced concrete pile plugs (connection of piles to cap beams), pre-cast concrete cap beams, pre-cast utilidor sections, and pre-cast fender panels (includes grouting) will be installed in the intertidal area. Installation of pre-cast concrete beams (for deck support, includes grouting), formwork, rebar and concrete for cast-in-place deck slab above the HHWM;
7. Intertidal area granular sub-base foundation will be placed and compacted for concrete retaining wall at east approach, as well as formwork, rebar and concrete for cast-in-place retaining wall at east approach;
8. South Jetty under-deck stormwater drainage pipework, fenders, mooring bollards, wharf ladders, utility kiosks, and miscellaneous deck hardware will be installed;
9. Removal and reinstatement of the tug boat facility with new piles at the east approach of the South Jetty; and,
10. Subsequent to remediation, no further action is anticipated to be required to maintain the habitat quality of dredged areas.

Include a site plan (figure/drawing) showing all project components in and near water.

Are details attached? (•) Yes ( ) No

Identify which work categories apply to your project.

- [ ] Aquaculture Operations
- [ ] Aquatic Vegetation Removal
- [ ] Beaches
- [ ] Berms
- [ ] Blasting / Explosives
- [ ] Boat Houses
- [ ] Boat Launches / Ramps
- [ ] Breakwaters
- [ ] Bridges
- [ ] Cable Crossings
- [ ] Causeways
- [ ] Culverts
- [ ] Dams
- [ ] Dewatering / Pumping
- [ ] Docks
- [x] Dredging / Excavation
- [ ] Dykes
- [ ] Fishways / Ladders
- [ ] Flow Modification (hydro)
- [ ] Groundwater Extraction
- [ ] Groynes
- [ ] Habitat Restoration
- [ ] Ice Bridges
- [ ] Log Handling / Dumps
- [ ] Log Removal
- [ ] Moorings
- [ ] Open Water Disposal
- [x] Piers
- [ ] Riparian Vegetation Removal
- [ ] Seismic Work
- [x] Shoreline Protection
- [ ] Stormwater Management Facilities
- [ ] Surface Water Taking
- [ ] Tailings Impoundment Areas
- [ ] Temporary Structures
- [ ] Turbines
- [ ] Water Control Structures
- [ ] Water Intakes / Fish Screens
- [ ] Water Outfalls
- [ ] Watercourse Realignment
- [ ] Weirs
- [x] Wharves
- [ ] Wind Power Structures
- [ ] Other Please Specify

Was your project submitted for review to another federal or provincial department or agency? (•) Yes ( ) No

If yes, indicate to whom and associated file number(s).

Phase 1: DFO Authorization No. 11-HPAC-PA3-00016; CEAR Reference No. 11-01-59873; NWPA Approval 8200-2003-500198 (8200-03-8256.3); DFO SARA permit: License # XSHAB 1 2013 - Amendment 1 File Number: SARA 292. Phase 1 of the project was also reviewed by DND, EC and TC. DND was a Responsible Authority for Phase 1 work.

C) Location of the Project

Coordinates of the proposed project Latitude [ ] N Longitude [ ] W

OR UTM zone [10 U] ; [468364] Easting

[5364815] Northing

Include a map clearly indicating the location of the project as well as surrounding features.

Name of Nearest Community (City, Town, Village): Esquimalt

Municipality, District, Township, County, Province: Esquimalt, Capital Regional District, British Columbia

Name of watershed (if applicable): n/a

Name of watercourse(s) or waterbody(ies) near the proposed project: Constance Cove within Esquimalt Harbour

Provide detailed directions to access the project site:

From Swartz Bay Ferry Terminal:

Head south on Ferry Ramp toward Patricia Bay Hwy
Continue onto Patricia Bay Hwy
Take exit 7 for McKenzie Avenue W toward Nanaimo/Sooke
Merge onto McKenzie Ave
Turn left onto Glanford Ave
Continue onto Carey Rd
Turn right onto Tillicum Rd
Turn right onto Colville Rd
Continue across Admirals Rd

Access via Admirals Road. Contact Site Representative prior to arrival to arrange for a Visitor's Pass. Provide Photo ID to security Gate.
825 Admirals Rd. Esquimalt, BC V9A 2P1

D) Description of the Aquatic Environment

Identify the predominant type of aquatic habitat where the project will take place.

(•) Estuary (Estuarine) ( ) Lake (Lacustrine) ( ) On the ba

Provide a detailed description of biological and physical characteristics of the proposed project site.

[Note: The above radio buttons do not properly display on the version of Adobe Acrobat used to prepare this application. This is a marine project.]

The Project Area is in the Coastal Douglas Fir Biogeoclimatic Zone. Constance Cove is approximately 0.5 km wide at its entrance, sheltered and subject to the marine tidal regime of Esquimalt Harbour, BC (Figure 1, Appendix 1). The tidal heights in the Project Area beneath the South Jetty are HHW+3.5 m, LLW+0.1 m and Mean tide +1.9 adjacent open water areas are typically at depths of 12 m below chart datum (CRA, 2010). There is a net drift of water out of Constance Cove from east to west across the area of the EGD Waterlot at velocities up to 0.12 m/s (mean 0.05 m/s).

The Phase 2 project area (Figure 2, Appendix 1) has already been significantly altered (and compensated for in Phase 1) with the installation of the Sheet Pile Wall as authorized by DFO. The majority of intertidal area in the Project Area has been altered from natural conditions: terrain in the South Jetty under-pier area consists of wood pilings, exposed cobble, woody debris and a concrete wall in the intertidal zone. Variable subtidal substrate types exist in the South Jetty under-pier area. Silt with shell fragments and some cobble is present under the western extent of the South Jetty Silt and shell fragments, as well as gravel/cobble/boulders, exist under the middle

and eastern portion of the South Jetty (Archipelago, 2009). In areas around the South Jetty, coarse grained sediments and fill were encountered overlying upper marine sediments, Victoria clay and till (Golder, 2011). Debris noted in the South Jetty under-pier area includes anchor chains, scrap metal, old collapsed sheet pile wall, sunken wooden deck structures (possibly old fire wall) and a number of old timber piles (Archipelago, 2009).

Marine ecological features of the South Jetty were limited, at the time of assessment, to encrusting/attached biota. Barnacles and encrusting sponges were ubiquitous on pilings, cobbles and boulders (Archipelago, 2009). No attached flora was observed on the South Jetty structures or under-pier substrate.

Subtidal surveys indicated that plumose anemones (Metridium senile, M. farcimen) and crabs (family Cancridae) were the most widespread and abundant fauna observed within the Project Area, in particular under the South Jetty. Cancridae crabs and plumose anemones (M. senile) were abundant at the western end of the South Jetty with reduced abundance towards the eastern end. Other species observed included hydroids, tunicates, anemones (Urticina spp.), giant rock scallop (Crassadoma gigantea), nudibranchs, coonstripe shrimp (Pandalus danae), red rock crab (Cancer productus), decorator crab, northern kelp crab (Pugettia producta), spiny pink sea star (Pisaster brevispinus), and purple urchins (Strongylocentrotus purpuratus) (Archipelago, 2009; Golder, 2009).
In the areas adjacent to the South Jetty, benthic invertebrates were limited in abundance compared to other contaminated harbour sites (Je et al., 2003). The Capital Regional District (CRD) Harbours Atlas indicated the presence of burrowing sea cucumbers in the eastern extent of the Project Area and along the South Jetty, and plumose anemones throughout the Project Area (CRD, 2010). EGD records noted that several octopus and squid have been previously observed in the adjacent area (dry dock).

Fish observed near the South Jetty (via underwater video) included an unidentified goby (possibly Lepidoglobus lepidus or Rhinogobiops nicholsii), unidentified sculpin and a juvenile rockfish (Sebastes sp.). EGD records indicate that Pacific herring (Clupea pallasii), chinook salmon (Oncorhynchus tshawytscha), coho salmon (O. kisutch), unidentified salmonid species (Oncorhynchus spp.), starry flounder, lingcod (Ophiodon elongates) and perch (genus/species unknown) have also been previously noted in the adjacent area (dry dock).

Although marine mammals (mainly seals and rare occurrences of sea lions) have been observed within the Project Area, habitat use appears to be transitory and proposed works are not thought to impact marine mammal habitat use in the area, with the exception of potential noise disturbances mitigated through Best Management Practices as outlined below. Stellar Sea Lions have become a more common sight in Constance Cove over the last few years and will be monitored in future operations.

Include representative photos of affected area (including upstream and downstream area) and clearly identify the location of the project.

E) Potential Effects of the Proposed Project

Have you reviewed the Pathways of Effects (PoE) diagrams (http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html) that describe the type of cause-effect relationships that apply to your project?

(•) Yes ( ) No

If yes, select the PoEs that apply to your project.

- [ ] Addition or removal of aquatic vegetation
- [ ] Change in timing, duration and frequency of flow
- [ ] Cleaning or maintenance of bridges or other structures
- [x] Dredging
- [x] Excavation
- [ ] Fish passage issues
- [ ] Grading
- [ ] Marine seismic surveys
- [ ] Organic debris management
- [ ] Placement of marine finfish aquaculture site
- [x] Placement of material or structures in water
- [ ] Riparian Planting
- [ ] Streamside livestock grazing
- [x] Structure removal
- [ ] Use of explosives
- [x] Use of industrial equipment
- [ ] Vegetation Clearing
- [ ] Wastewater management
- [ ] Water extraction

Will there be changes (i.e., alteration) in the fish habitat*? (●) Yes ( ) No ( ) Unknown

If yes, provide description.

Benthic invertebrates and fish that occur beneath the South Jetty may be destroyed or damaged during dredging. During the deconstruction of South Jetty, pilings will be removed along with any attached invertebrates and invertebrate habitat. This will cause a temporary loss of biota and habitat until the new pilings are installed and recolonize.

Surveys conducted following Phase 1 indicated under-pier habitat to have limited to no habitat value for fish due to enclosure by the sheet pile wall. The existing contaminated subtidal and intertidal sediments in the South Jetty under-pier area will be removed and replaced with clean sand filter material and armour rock. This area is expected to recolonize to a level and condition at or better than currently exists.

The footprint would be: 6,893 m^2 of subtidal unconsolidated sediment and 5,225 m^2 of intertidal coarse sediment and bedrock (12,118 m^2 total; Figure 2, Appendix 1).

Will the fish habitat alteration be permanent*? (●) Yes ( ) No ( ) Unknown

Is there likely to be destruction or loss of habitat used by fish? ( ) Yes (●) No ( ) Unknown

What is the footprint (area in square meters) of your project that will take place below the high water mark*? 12,118 m^2 (see above)

Is your project likely to change water flows or water levels? ( ) Yes (●) No ( ) Unknown

If your project includes withdrawing water, provide source, volume, rate and duration. n/a

If your project includes water control structure, provide the % of flow reduction. n/a

If your project includes discharge of water, provide source, volume and rate. n/a

Will your project cause death of fish? ( ) Yes ( ) No (●) Unknown

If yes, how many fish will be killed (for multi-year project, provide average)? What species and lifestages?

No fish are intended to be killed for this project; however, fish could become trapped within the Temporary Re-suspension Barrier during dredging operations. Given the area enclosed area is very large and provides areas of refuge during operations, any fish loss is anticipated to be minimal.

Are there aquatic species at risk (http://www.sararegistry.gc.ca/species/aquatic_e.cfm) present? If yes, which ones?

No aquatic SAR confirmed present. Species Potentially Present: Canary Rockfish, cutthroat trout, Stellar Sea Lions, Harbour Porpoise

What is the time frame of your project?

The construction will start on 04/15/2015 and end by March 2017

If applicable, the operation will start on MM/DD/YYYY and end by MM/DD/YYYY

If applicable, provide schedule for the maintenance

n/a

If applicable, provide schedule for decommissioning

n/a

Are there additional effects to fish and fish habitat that will happen outside of the time periods identified above? ( ) Yes (●) No

(If yes, provide details)

Have you considered and incorporated all options for redesigning and relocating your project to avoid negative effects to fish and fish habitat?

(•) Yes ( ) No

If yes, describe.

Redevelopment considered several different design options with the final chosen design retaining the original site footprint.

Anchor QEA LLC (Anchor) was retained by PWGSC to develop a number of remedial alternatives to address sediment contamination associated with historical operations at the EGD facility. Four (4) remediation alternatives consisting of a combination of remedial approaches to capture the range of potential remediation costs were developed by Anchor at the project level prior to Phase 1 work. Phase 2 work is based on selection of specific project alternatives at the Phase 1 project review stage. These remediation options included:

Alternative 1: Maximum Sediment Removal (infrastructure removal of entire South Jetty structure): This option consisted of removal of all contaminated sediments in the open water areas (Phase 1) and under the South Jetty (Phase 2), which would necessitate complete removal of the South Jetty (including timber piling and steel piling areas) to allow unrestricted access. Contaminated sediment would be removed throughout the project area, except where setbacks from existing structures preclude removal (e.g., near the dry dock mouth and along the North Landing Wharf). A new South Jetty structure would be constructed following remediation.

Alternative 2: Maximum Practicable Sediment Removal (infrastructure removal of South Jetty timber pilings, but not steel pilings): this option consisted of mechanical dredging of the open water areas (Phase 1) and South Jetty timber and steel piling areas (Phase 2). Contaminated sediment would be removed throughout the project area, except where setbacks from existing structures preclude removal (e.g., near the dry dock mouth and along the NLW). The timber piling areas of the South Jetty structure would be reconstructed following remediation. This alternative included two options:

Alternative 2A: Remediation of open water areas and South Jetty sediments as one phase, concurrent with demolition and reconstruction of South Jetty timber piling area; or,

Alternative 2B: Remediation of open water areas as part of Phase 1, and mechanical dredging of contaminated sediment located beneath the South Jetty in Phase 2 at a later date in conjunction with reconstruction of the South Jetty. Alternative 2B included the installation of a temporary sheet pile wall around the South Jetty as part of Phase 1 to help prevent recontamination of previously dredged areas, until Phase 2 underpier remediation is undertaken.
Alternative 2B was the option selected during the initial project review stage. Phase 1 work has been completed under a previous DFO authorization and should not be considered as part of this review process.

Have you consulted DFO's Measures to Avoid Harm to Fish and Fish Habitat (http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html) to determine which measures apply to your project?

(•) Yes ( ) No

Will you be incorporating applicable measures into your project? (•) Yes ( ) No

If yes, identify which ones. If No, identify which ones and provide reasons.

Time work in water to respect timing windows to protect fish, including their eggs, juveniles, spawning adults and/or the organisms upon which they feed.
Plan activities near water such that materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, or other chemicals do not enter the watercourse.
Develop a response plan to be implemented immediately in the event of a sediment release or spill of a deleterious substance and keep an emergency spill kit on site.
Ensure that building material used in a watercourse has been handled and treated in a manner to prevent the release or leaching of substances into the water that may be deleterious to fish.
Retain a Qualified Environmental Professional (QEP) to ensure applicable permits for relocating fish are obtained; and, where appropriate, to capture fish trapped within an isolated/enclosed area at the work site and safely relocate them to an appropriate location in the same waters.
Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks, invasive species and noxious weeds.

Whenever possible, operate machinery on land above the high water mark, on ice, or from a floating barge in a manner that minimizes disturbance to the banks and bed of the waterbody.
Wash, refuel and service machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water.
A QEP will be retained to conduct site monitoring throughout the duration of the project.

Have you considered and incorporated additional best practices and mitigation measures recommended in relevant guidelines to avoid negative effects to fish and fish habitat?

○ No ◉ Yes

If Yes, include a list of the guidelines being used to avoid negative effects to fish and fish habitat.

All works will adhere to the EGD Environmental Best Management Practices and Environmental Policy. The EGD facility has an ISO 14001 certified EMS.

The following measures are to be implemented to mitigate effects to fish and fish habitat:
• a qualified Environmental Monitor will be on-site during project activities (refer to Environmental Assessment [Golder, 2012a; G3 Consulting Ltd. (G3), 2014a] for environmental monitoring responsibilities);
• prior to dredging, the perimeter of the dredge area (i.e., South Jetty under-pier area) will be identified and enclosed with a sheet pile wall and silt curtain/temporary resuspension barrier (TRB), so that work occurs within the confines of the Project Area (Photographs 1-3, Appendix 2);
• work will be conducted in a manner (i.e., isolated work cell) that does not result in the deposit of a deleterious substance into waters frequented by fish;
• dredging will take place during the marine/estuarine fisheries winter work window for the Victoria area (July 1 to October 1 and December 1 to February 15; DFO, 2010), when practicable. Subject to agreement by applicable regulatory agencies and the implementation of appropriate controls, some work may occur outside of these windows and with a qualified professional on-site to monitor work. Work timing windows are discussed further in the environmental assessment document (Golder, 2012a) and in Section E.13 (below);
• where kelps are present, "No Dredge Zones" will be identified, within the Project Area, and delineated to avoid direct impacts from dredging activities;
• where possible, in keeping with the aims of the remediation, removed hard substrates (e.g., boulders and cobbles) will be replaced with similar substrate types to support recolonization by marine biota;
• follow water quality mitigation measures outlined in the Phase 2 Environmental Management Plan (G3, 2014b);
• work activities will cease, and DFO will be contacted, if aggregations of herring (e.g., herring spawn) and/or salmonids (e.g., smolts or spawning adults) are observed within the confined work area; and,
• openings in the sheet pile wall, at the South Jetty, have been included in the proposed design. These openings will mitigate potential changes in currents under the South Jetty by allowing water exchange and movement.

When modifying the sheet pile wall and South Jetty pilings by pile driving:
• the use of vibrational pile driving where practical and feasible is preferred over impact pile driving as the latter is associated with louder sound pressure levels underwater. The use of "vibro-hammers" for pile installation minimizes the effects on fish by decreasing the anticipated noise levels;
• concurrent multiple underwater noise generating activities will be minimized when practicable (e.g., avoiding multiple pile driving activities at the same time). Where multiple underwater noise generating activities are planned they will be sequenced when possible to minimize construction duration;
• underwater noise will be monitored in accordance with the following:
• The sound from the installation will not exceed 30 kPa at a distance of 1 to 2 m outside of sheet pile wall; or,
• if the sound level exceeds 30 kPa at a threshold distance of 1 to 2 m outside of sheet pile wall, efforts will be made to modify the impact to the sheet pile to reduce the intensity of the sound generated.

DFO previously granted a Section 32 Authorization (for destruction of fish by means other than fishing) pursuant to the Fisheries Act for Phase 1 work (11-HPAC-PA3-00016). Compensation for the disturbance to fish habitat has already been implemented as part of Phase 1 work and in accordance with DFO requirements (DFO, 2010).

Are there any relevant best practices or mitigation measures that you are unable to incorporate? ○ Yes ◉ No

(If yes, identify which ones.)

Can you follow appropriate Timing Windows (http://www.dfo-mpo.gc.ca/pnw-ppe/timing-periodes/index-eng.html) for all your project activities below the High Water Mark*?

○ Yes ◉ No

(If no, provide explanations.)

Subject to agreement by applicable regulatory agencies and the implementation of appropriate controls, some work will need to occur outside of these windows to accommodate the construction schedule and sequencing which is driven in part by operational considerations at the EGD. The Project Area is located in DFO Area 19 – Victoria, for which the Marine/Estuarine Timing Windows are as follows:
• Summer Window: July 1 – October 1; and,
• Winter Window: December 1 – February 15.

These work windows are intended to provide times of least risk to sensitive fisheries resources that may occupy/use the area. Salmon migrating to spawning areas may be present in October and November and spawning herring may be present from the end of February to June.

Summary of Potential Risks:
Based on the results of an assessment of the potential for contaminant desorption from re-suspended sediments potentially caused by dredging outside either the summer (July 1 – October 1) or winter (December 1 – February 15) windows conducted as a part of Phase 1 work, it was determined that work outside of the work windows was not recommended for Pilgrim Cove or the mouth of the graving dock.
It is considered that the Phase 2 work, as proposed (contained within an isolated work cell), represents a low risk in the context of sensitive species given the very low probability of negative interaction and the consequence of such an unlikely interaction would be mitigated by the implementation of Best Management Practices (BMP) and Environmental Management Plan (EMP) and associated Water Quality Monitoring Plan (WQMP) with stop work provisions (G3, 2014b).
• Esquimalt Harbour does not have significant salmon spawning streams draining into it. Returning spawners would therefore not have a significant presence in Esquimalt Harbour. Mill Stream supports salmon spawning and is located approximately 3.5 km NW of the project area.
• Esquimalt Harbour is not a known common area of herring spawn.
Based on long-term records of herring spawning timing in the Strait of Georgia (Hay and McCarter, 1999), the likelihood of herring spawning on project equipment is relatively low if work ceases prior to the beginning of March and does not re-commence prior to mid-April. Moreover, herring have not been observed spawning near the project area since 1993.
Direct mortality due to suspended solids is not expected even in the absence of a silt curtain/TRB as the TSS concentrations in the plume modelling by Anchor (Golder, 2012a) were several orders of magnitude lower than concentrations at which acute lethality occurs (i.e., acute lethality 96h LC50, in salmonids occurs at TSS concentrations in the order of 10,000 mg/L to 30,000 mg/L depending on the species; Servizi and Martens, 1987; Servizi and Gordon, 1990). TSS and Turbidity data collected during Phase 1 would be used to revise TSS and turbidity water quality standards if more conservative values are found to be required. Sound generated by sheet pile installation/lowering and/or removal is not expected to exceed the specified level of 30 kPa at a distance of 1 m from the source.

Summary of Mitigation Measures:
If salmon were to migrate through the Project Area:
• they would tend to occupy the mid-water column and are unlikely to be caught in the dredge bucket, within the Phase 2 project area;
• they are likely to migrate past the area being actively dredged because it will be contained by a sheet piling wall and within a temporary resuspension barrier (TRB); and,
• the impacts of any suspended sediments from dredging will be contained within the site by a silt curtain/TRB and will be monitored for conformance with water quality thresholds, as outlined in the WQMP for the project (G3, 2014c).
The work area will be monitored for aggregations of herring and/or presence of eggs on equipment such that the equipment can be inactivated until the eggs hatch and the larvae disperse into the water column.
During sheet pile wall activities and dredging of areas beneath the South Jetty, harmful effects to migrating salmon in October and November are not expected provided the following mitigation measures are applied:
• dredging is conducted while the sheet piling wall and TRB are in place;
• a qualified environmental monitor is on site during all work;
• the WQMP, which includes TSS/turbidity criteria and monitoring protocols for dredging and barge dewatering, as well as a decision

framework for managing these activities, is adhered to; and,
• underwater noise generation is monitored during sheetpile wall installation and the installation method is modified if the decision threshold is exceeded.

What residual effects to fish and fish habitat do you foresee after taking into account the avoidance and mitigation measures described above?

No residual negative effects are anticipated after mitigation is applied. Areas to be dredged are generally of low habitat quality as a result of sediment contamination and debris, which the EGD Waterlot Remediation Project seeks to address. This low habitat quality has resulted in a low abundance and diversity of benthic invertebrates. The habitat characteristics on the margin of the Project Area are more amenable to colonization and these areas are better colonized by organisms that live outside of the sediment, typically in association with hard substrates rather than in association with contaminated sediments. In total, approximately 12,118 m2 of intertidal and subtidal substrate beneath the South Jetty are currently enclosed by the sheet pile wall. This habitat is currently largely shaded by the overlying deck and structural supports of the jetty. The Sheet Pile Wall will be removed at the end of the project which would enable and promote the ecological development of the area and create a net positive effect to fish and fish habitat. Fish habitat would be further improved by removal of contaminated substrates and replacement with clean filter material and armour rock. Existing pile structures will be replaced and provide surfaces for encrusting organisms.

F) Signature

I, Andrew Mylly (print name) certify that the information given on this form is to the best of my knowledge, correct and completed.

Signature

12/02/2014
Date

Information about the above-noted proposed work or undertaking is collected by DFO under the authority of the *Fisheries Act* for the purpose of administering the fisheries protection provisions of the *Fisheries Act*. Personal information will be protected under the provisions of the *Privacy Act* and will be stored in the Personal Information Bank DFO-PPU-680. Under the *Privacy Act*, Individuals have a right to, and on request shall be given access to any personal information about them contained in a personal information bank. Instructions for obtaining personal information are contained in the Government of Canada's Info Source publications available at www.infosource.gc.ca or in Government of Canada offices. Information other than "personal" information may be accessible or protected as required by the provision of the *Access to Information Act*.

**All definitions are provided in Section G of the Guidance on Submitting a Request for Review*

Guidance on Submitting a Request for Review

This document explains the requirements for a Request for Review by DFO under the fisheries protection provisions of the *Fisheries Act*. To determine whether you should request a review, follow the steps for proponent Self-Assessment on DFO's Projects Near Water webpage (http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html).

Incomplete Requests for Review will be returned to the applicant without review by DFO. All information requested must be provided. If you attach documents to your application with additional information, you must still provide appropriate summaries in the spaces provided on the application document or your application will be considered incomplete.

Section A: Contact Information

Provide the full legal name of the proponent and primary mailing address for the proponent. When the proponent is a company, identify the full legal registered name of the company.

If applicable, also provide the contact information of the duly authorized representative of the proponent. Please note that a copy of correspondence to Contractor/Agency/Consultant will also be sent to the Proponent.

Section B: Description of Project

This information is meant to provide background about the proposed project. All components of the proposed project in or near water, must be described.

Proponents should provide information about all appropriate phases of the project, i.e., the construction, operation, maintenance and closure phases for the proposed project.

All details about the construction methods to be used, associated infrastructure, permanent and temporary structures, building materials to be used, machinery and equipment to be used must also be provided. For example, the construction of p**ermanent structures** may require the construction of temporary structures such as temporary dikes, in conjunction with other associated activities like the withdrawal of water, land clearing, excavation, grading, infilling, blasting, dredging, installing structures, draining or removing debris from water. Similarly, the equipment and materials to be used may include hand tools, backhoes, gravel, blocks or armor stone (provide the average diameter), concrete (indicate if pre-cast or poured in-water), steel beams or wood.

When physical structures in or near water are proposed, provide the plan and specifications of those works which would require a review.

Section C: Location of the Project

The purpose for this information is to describe and illustrate the location of the proposed project, and to provide geographical and spatial context. The information should also facilitate an understanding of how the project will be situated in relation to existing structures.

The details to be provided must include:

- Coordinates of the project (e.g., Latitude and Longitude or Universal Transverse Mercator Grid coordinates);
- A map(s), site plan, or diagrams indicating the high water mark and the location, size and nature of proposed and existing structures (e.g., floating or fixed), landmarks and proposed activities. In a marine setting, it may be helpful to depict the approximate location of the proposed development on a nautical chart or showing the relation of the site to sea marks or other navigational aids. These plans, maps or diagrams should be at an appropriate scale to help determine the relative size of the proposed structures and activities, the proximity to the watercourse or waterbody and the distance from existing structures;
- The community nearest to the location of the proposal as means to provide a general reference point. When possible, proponents should use geographical names recognized by the Geographical Names Board of Canada (http://www.nrcan.gc.ca/earth-sciences/geography-boundary/geographical-name/11680).
- If available, provide aerial photographs or satellite imagery of the water source(s) and waterbody(ies);
- Names of the watershed(s), water source(s) and/or waterbody(ies) likely to be affected by the proposal; and
- Brief directions to access the proposed project site.

Section D: Description of the Aquatic Environment

Proponents must describe the environmental context and aquatic resources present at the proposed site. The information must identify the current state of the fish and fish habitat prior to the carrying on of the project.

It is important to include information about the fish species present, the biological, chemical, physical features present (habitat characteristics), and the fish life-cycle functions (fish characteristics).

The spatial scope for assessing fish and fish habitat should encompass the direct physical footprint of the project, and the upstream and downstream areas affected.

As an example, the following is a non-exhaustive and non-prescriptive list of some common attributes which may characterize the aquatic environment:

- Type of water source or watercourse (groundwater, river, lake, marine, estuary, etc.);
- Characteristics of the water source or waterbody could include:
  - Substrate characterization - describe the types of substrate (e.g., bedrock, boulder, cobble, gravel etc.), identify the predominant substrate type (e.g., 80% cobble, 20% gravel etc.) and provide maps of the substrate;
  - Aquatic and riparian vegetation characterization - identify the prevalent types of vegetation (e.g. rooted, submerged, emergent, etc.), identify the relative abundance of the vegetation (e.g., 10% cattails, 80% grass, 10% sedge) , indicate the predominant vegetation (e.g., by species or types) and identify the vegetation densities (e.g., type of vegetation/area);
  - Flow characterization - specify if the flow is controlled or if it is natural, identify if the flow is permanent or intermittent, identify the current and tide (marine environment) etc.;
  - Physical waterbody characterization - identify the average depth of water for water bodies, identify bathymetry of water bodies, provide bathymetric maps where available, channel width (determine the width of the channel from the high water mark), slope ;
  - Water quality characterization - (e.g., annual or average pH, salinity, alkalinity, total dissolved solids, turbidity, temperature etc.);
  - Biological water quality characterization - (e.g., benthic macro-invertebrates, zooplankton, phytoplankton, etc.)
- Fish species characterization - identify the fish species (including molluscs, crustaceans, etc.) known or suspected to be in the area, predator prey relationships etc. Identify what source of information was used and to determine the presence of fish in that area; and
- Estimate the fish abundance - estimate the number of fish present, estimate the year class for each species etc.

There are many different methods and attributes available to characterize fish and fish habitat. Proponents must describe all sources of information used, all fish and environment sampling techniques used, all modelling techniques used and all other approaches used to define the fish and fish habitat. Proponents are encouraged to use recognized fisheries inventory methods such as those approved by DFO or provinces and territories, or scientifically defensible methodologies and techniques whenever possible.

Whenever possible, proponents should support descriptions of the aquatic environment with the use of detailed drawings, such as plans or maps and photographs of the habitat features. In an offshore marine setting, photos may not be useful to depict the proposed development site. Instead describe and/or sketch the specific features of the sea floor which may include the presence of submarine features such as canyons, cliffs, caverns, etc.

Section E: Potential Effects of the Proposed Project

The objective of this section is to identify all anticipated effects on fish and fish habitat likely to be caused by the project. Proponents should consider all mitigation or avoidance techniques.

The description must include qualitative and/or quantitative information about the predicted/potential effects to fish species and fish habitat. Some examples of likely effects may include mortality to fish, changes to the life stages of fish affected, area of habitat loss, change to flow, changes to habitat function, reduction in prey availability etc.

The spatial scope of the aquatic effects assessment would include the direct physical "footprint" of the proposed project, and any areas

indirectly affected, such as downstream or upstream areas. This may also include areas in or on the water, on the shoreline, coast or bank(s) (i.e., in the riparian zone).

The assessment must include the following attributes:

- Identification of all fish species affected by the proposed project ;
- Identification of the type of fish habitat affected (e.g., spawning habitat - gravel and cobble, feeding and rearing areas - side channel slough, small tributaries, etc.), estimate of the affected area (e.g., square meters or hectares);
- Of the affected fish, identify the life stages affected (e.g., juvenile, yearling, adult etc.);
- Description of the effect (e.g., mortality to fish from entrapment, delayed migration of spawning adults, reduction in prey availability, etc.)
- Probability of the effect - this is the likelihood of the effect occurring (e.g., probability of fish strike from turbines for specific fish sizes, probability of sediment plume within a distance from source, etc., or qualitative assessment: low, medium, high)
- Magnitude of the effect - this is the intensity or severity of the effect (e.g., total number of fish affected, or qualitatively assessment: low, medium, high).
- Geographic extent of the effect - this is the spatial range of the effect (e.g., localized to 100m from the work, channel reach or lake region, entire watershed etc.); and
- Duration of the effect - this is the temporal period for which the effect will persist (e.g., duration of delay to fish migration in hours, days, months or years).

The information to be provided must also describe the methods and techniques used to conduct the assessment. As much as possible, methods and techniques used should be scientifically defensible.

The schedule should, at minimum, identify the proposed start and end dates for carrying out each proposed activity, and where applicable, identify the respective phase of the proposal; i.e., the construction, operation, maintenance and closure phases. In some cases, in order to provide additional context, it may be relevant to identify other information such as the expected life span of permanent and temporary structures.

Proponents must provide comprehensive information about all best available measures and standards that are proposed to avoid or mitigate potential serious harm.

Residual serious harm to fish is any serious harm to fish remaining after the consideration of the application of proposed measures or standards to avoid or mitigate serious harm.

It is important to clearly describe and quantify residual serious harm because DFO will use this information as part of its decision making on whether an authorization is required under subsection 35(2)(*b*) of the *Fisheries Act*.

Section F: Submission and Signature

The proponent must sign the application. A signed original of the Request for Review must be provided to the regional DFO office, even if an electronic copy was sent by email. Should the review of your project indicate that residual serious harm to fish is likely, the information provided in the Request for Review document can be referred to in the subsequent Application for an Authorization under Paragraph 35(2)(*b*) of the *Fisheries Act*.

Section G: Definitions

Emergency circumstance: If your project must be conducted in response to an emergency, you may apply for an Emergency Authorization. The emergency situations are:

- The project is required as a matter of national security
- The project is being conducted in response to a national emergency where special temporary measures are being taken under the federal *Emergencies Act*
- The project is required to address an emergency that poses a risk to public health or safety or to the environment or property.

Fish habitat: Means spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes.

High Water Mark: The usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to leave a mark on the land.

Permanent alteration to fish habitat: An alteration of fish habitat of a special scale and a duration that limits or diminishes the ability of fish to use as spawning grounds for nursery or rearing, or as food supply, or as a migration corridor in order to carry out one or more of their life processes.

Appendices

Appendix 1: Figures
Appendix 2: Photographs
Appendix 3: Literature Sources

Appendix 1

Figures

Figure 1: Esquimalt Graving Dock Waterlot Sediment Remediation Project Area Map
(adapted from Golder, 2012a; Reference Department of Natural Resources. All rights reserved.
Projection: Transverse Mercator Datum: NAD83 Coordinate system: UTM Zone 10).

G3 Consulting Ltd.

Innovation & Excellence in Environmental Science

Figure 2: Satellite image of Esquimalt Graving Dock and surrounding area.

Appendix 2

Photographs

Appendix 2: EGD Phase 2 Work Photographs

Photo 1: View along the South Jetty sheet pile wall and piles (north side). At the conclusion of Phase 2 the temporary sheet pile wall will be removed.

Photo 2: Top view of a sheet pile wall join currently installed around the South Jetty.

Photo 3: View from water at the north-west end of the jetty looking east. The sheet pile wall surrounds the existing jetty.

Photo 4: Showing a clamshell dredger. Dredged material would be loaded onto a barge. Dredge water to be pumped to a secondary sealed holding barge for treatment (not shown).

Photo 5: Phase 2 - Stage 1 work area (looking west). Concrete and asphalt would be removed, contaminated under-pier soils and sediments remediated and the pier reconstructed.

Photo 6: Phase 2 - Stage 2 work area (looking east). Concrete and asphalt would be removed, contaminated under-pier soils and sediments remediated and the pier reconstructed.

Appendix 3

Literature Sources

LITERATURE SOURCES

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C3

ESQUIMALT GRAVING DOCK

DECISION LETTER

DFO (2014)

Number of Pages: 2

Fisheries and Oceans Canada | Pêches et Océans Canada

Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC, V9T 6N7

Your file *Votre référence*

May 13, 2014

Our file *Notre référence*
14-HPAC-00210

Cliff Rhodes, Portfolio Director
Public Works and Government Services Canada
219-800 Burrard Street
Vancouver, BC, V6C 0B9

VIA E-MAIL: Cliff.Rhodes@pwgsc-tpsgc.gc.ca

Dear Mr. Rhodes:

Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish.

The Fisheries Protection Program (the Program) of Fisheries and Oceans Canada received your proposal on February 26, 2014.

Your proposal has been reviewed to determine whether it is likely to result in serious harm to fish which is prohibited under subsection 35(1) of the *Fisheries Act*.

Our review consisted of:

- Request for Review form and attached Figures and Photos

We understand that you propose to:

- Demolish the existing South Jetty pier
- Dredge and remediate contaminated sediments
  - 5,225 m2 intertidal coarse sediment and bedrock
  - 6,893 m2 subtidal unconsolidated sediment
- Construct a new South Jetty pier
- Remove existing sheet pile containment wall

Provided that the mitigation measures identified in your Request for Review form are incorporated into your plans, the Program is of the view that your proposal will not result in serious harm to fish. No formal approval is required from the Program under the *Fisheries Act* in order to proceed with your proposal.

If your plans have changed or if the description of your proposal is incomplete, or changes in the future, you should consult our website (http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html) or consult with a qualified environmental consultant to determine if further review is required by the Program.

Please notify this office at least 10 days before starting your project. A copy of this letter should be kept on site while the work is in progress.

If you have any questions, please contact Byron Nutton at our Nanaimo office at 250-756-7221, by fax at 250-756-7229, or by email at byron.nutton@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with the Program.

Yours sincerely,

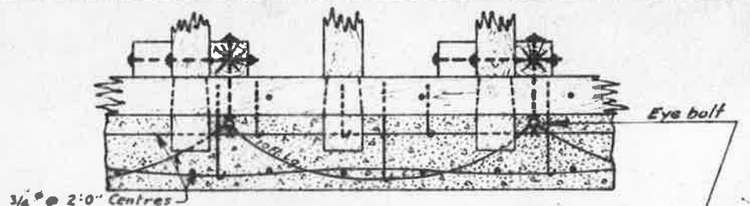
Adam Silverstein
Manager, Regulatory Reviews
Fisheries Protection Program

D1

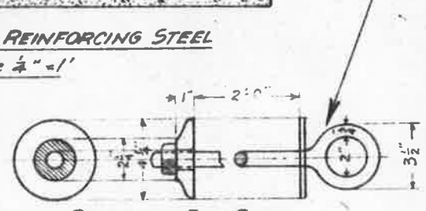
ESQUIMALT GRAVING DOCK

TIMBER CRIB DETAILS AND LANDING WHARF (1926)

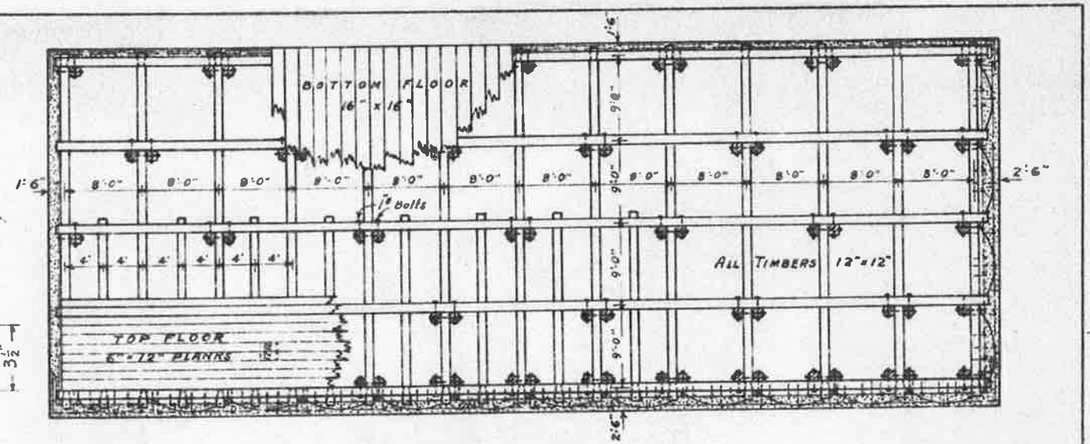
Number of Pages: 3



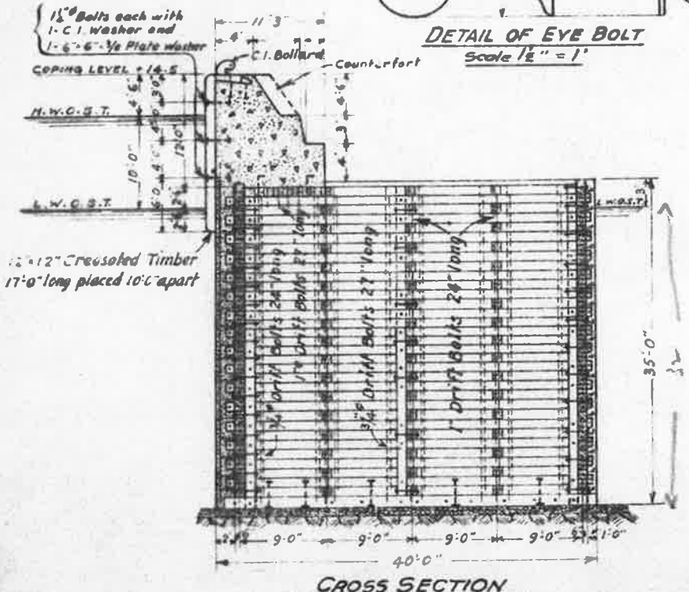
DETAIL SHOWING REINFORCING STEEL
Scale ¼" = 1'



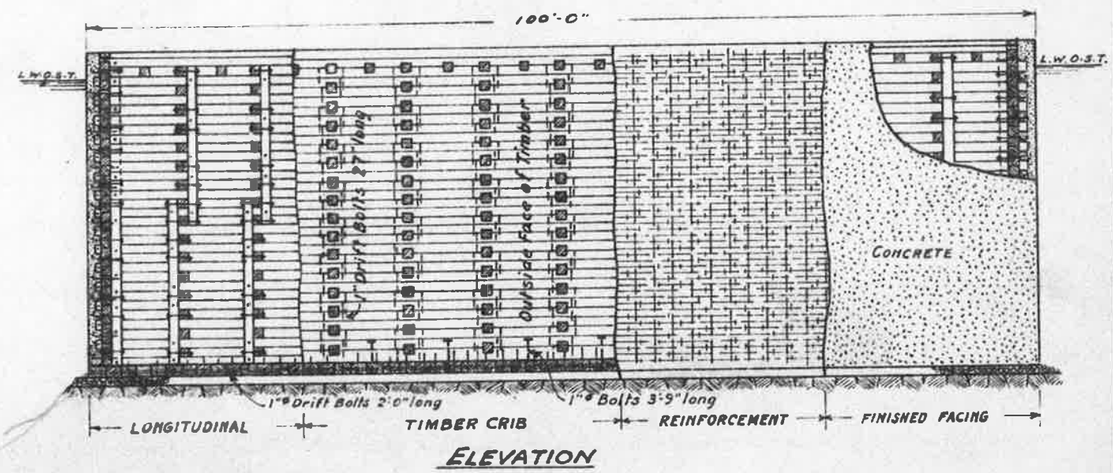
DETAIL OF EYE BOLT
Scale 1½" = 1'



PLAN OF OUTER END CRIB
Scale 1/16" = 1'

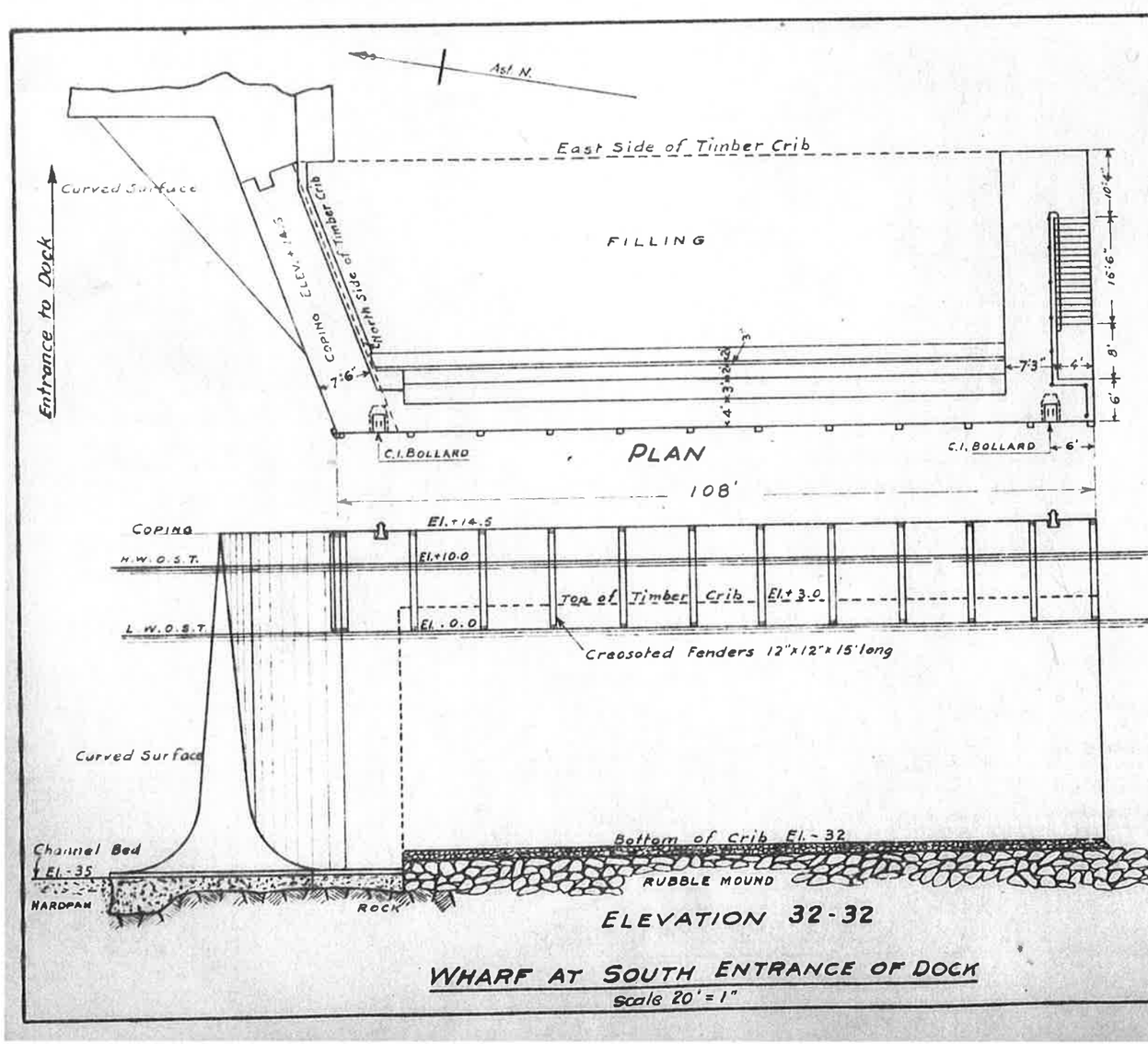


CROSS SECTION
Showing Superstructure



ELEVATION

LANDING WHARF
PLAN AND DETAILS OF CRIBS



WHARF AT SOUTH ENTRANCE OF DOCK

Scale 20' = 1"

ESQUIMALT GRAVING DOCK 32

REDUNDANT
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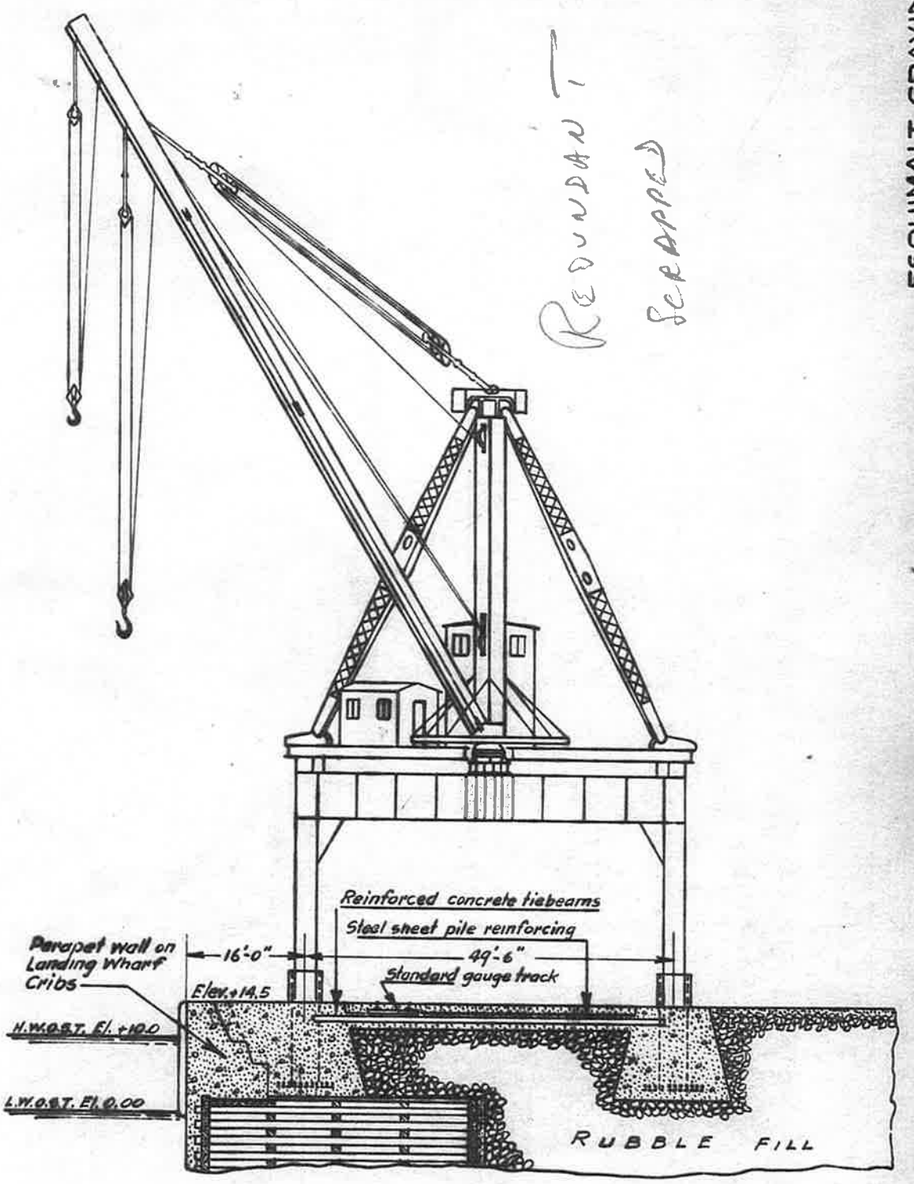


CROSS SECTION 29-29

THROUGH LANDING WHARF, SHOWING 100 TON DERRICK

Scale:- 20' = 1"

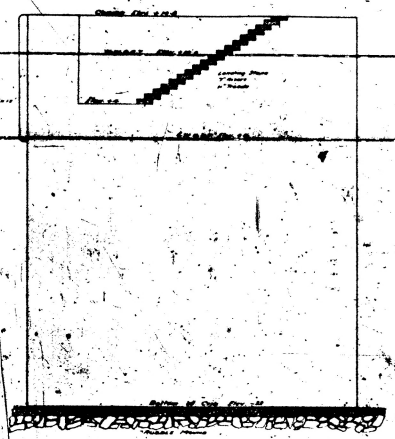
D2

ESQUIMALT GRAVING DOCK

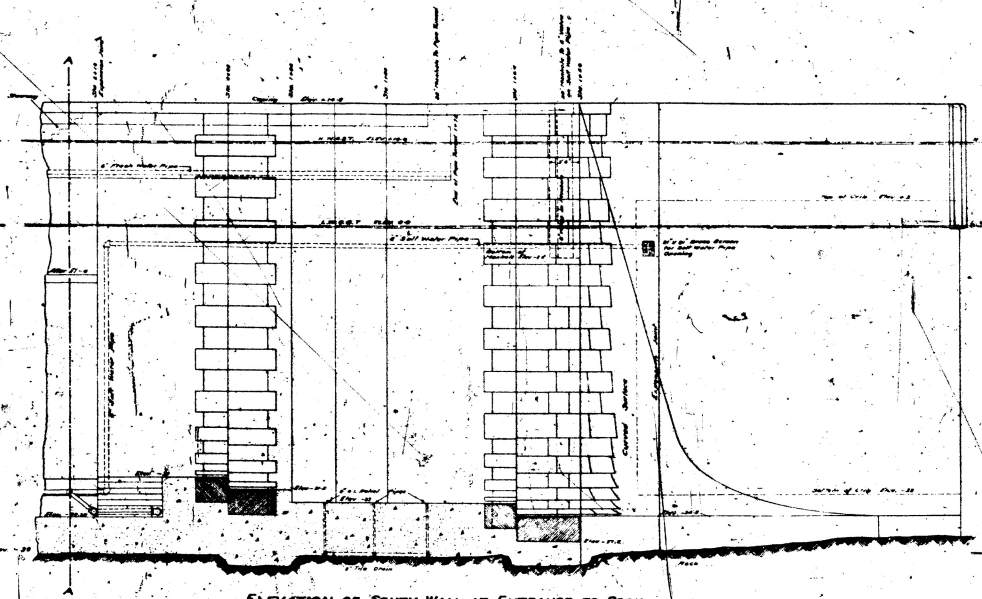
NEW DRY DOCK (1928)

Number of Pages: 10

SECTION THROUGH A.A

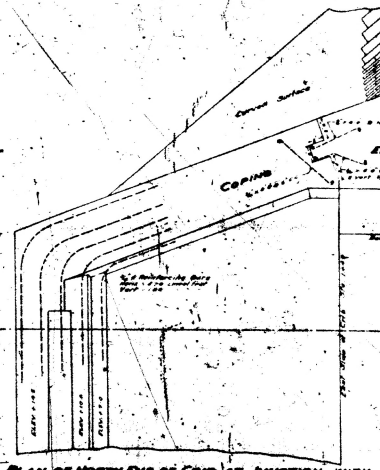


REAR VIEW OF CRIB SHOWING STEPS

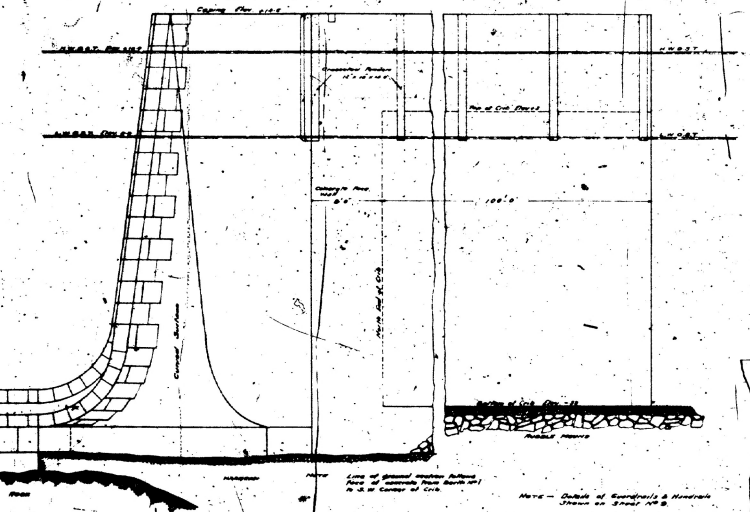


ELEVATION OF SOUTH WALL AT ENTRANCE TO DOCK

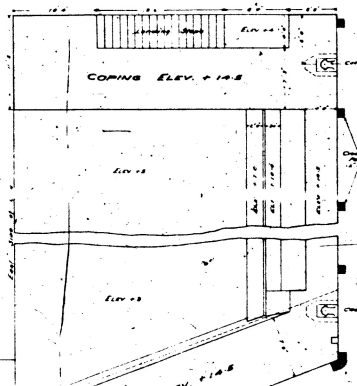
SCALE 1/8" = 1'

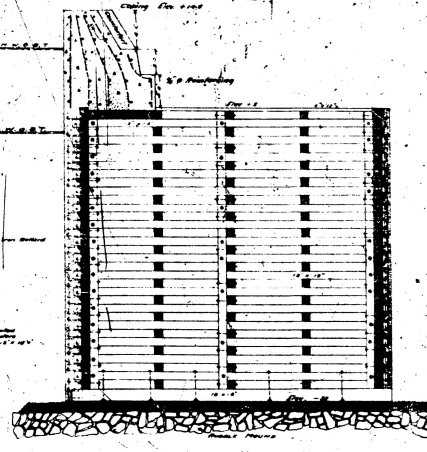


PLAN OF NORTH END OF CRIB AT JUNCTION WITH SOUTH WALL OF DOCK SHOWING REINFORCING

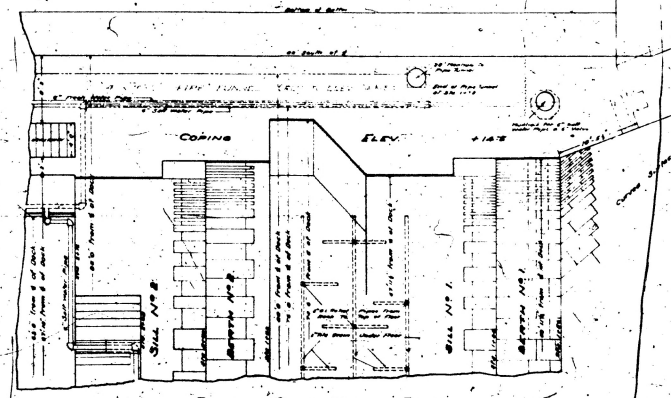


LOOKING EAST PARALLEL TO ℄ OF DOCK





SECTION OF CRIB AT B.B.



PLAN OF SOUTH WALL AT ENTRANCE TO DOCK

SCALE - 1/8" = 1'

CHANNEL BED
ELEV. -35'

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NEW ESQUIMALT DRY

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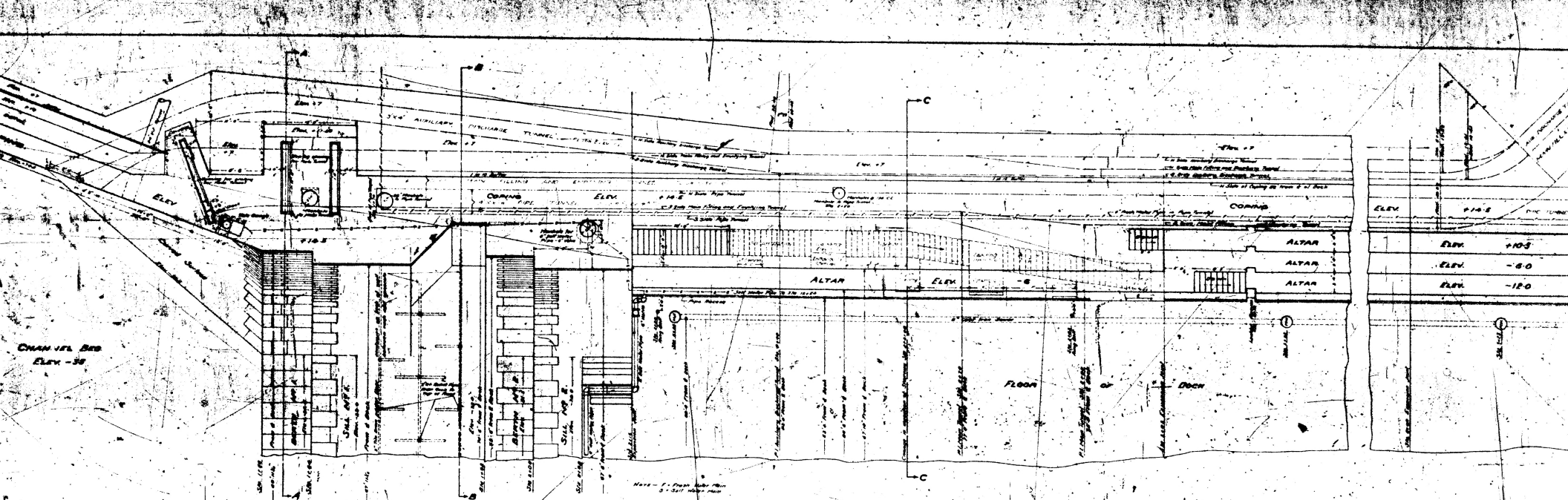
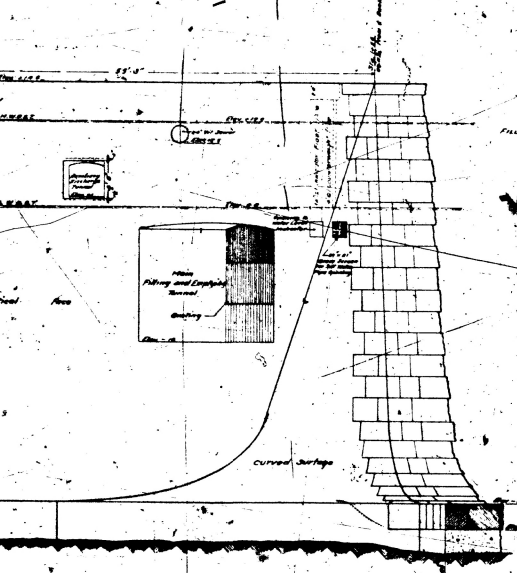
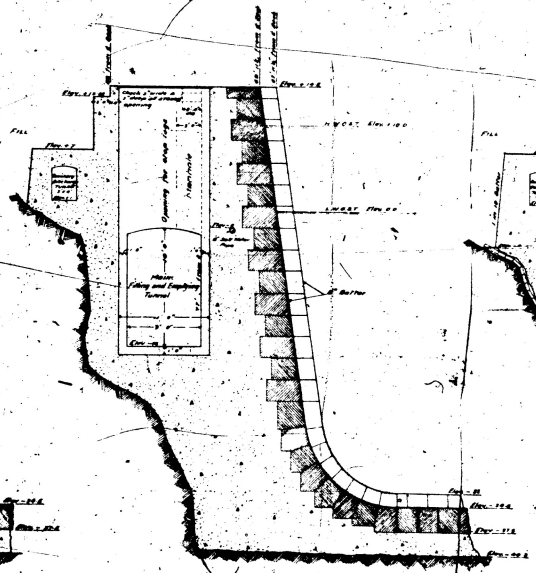


PLAN

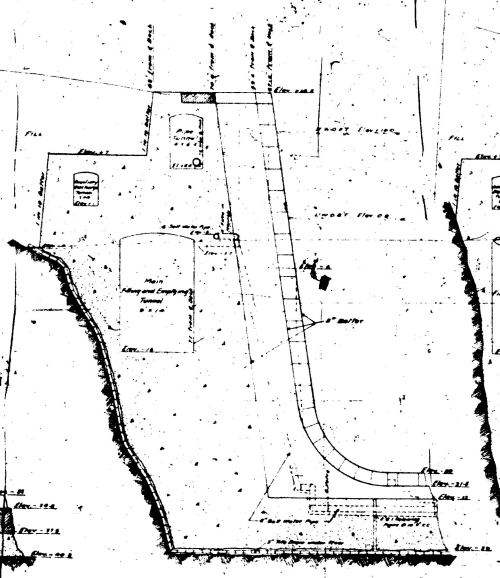
SCALE - 1/8" = 1'



ION OF LANDING WHARF AT ARNOTT WITH DOCK ENTRANCE

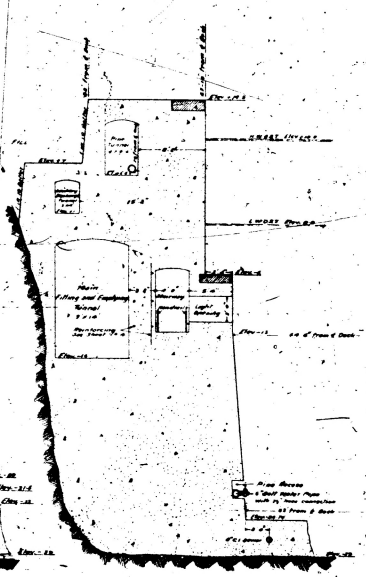


SECTION THROUGH A-A.

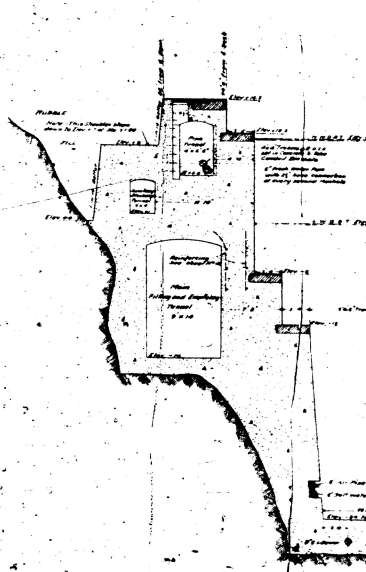


SECTION THROUGH B-B.

SCALE - 1/4" = 1'



SECTION THROUGH C-C.



TYPICAL SECTION SHOWING MAN-HO

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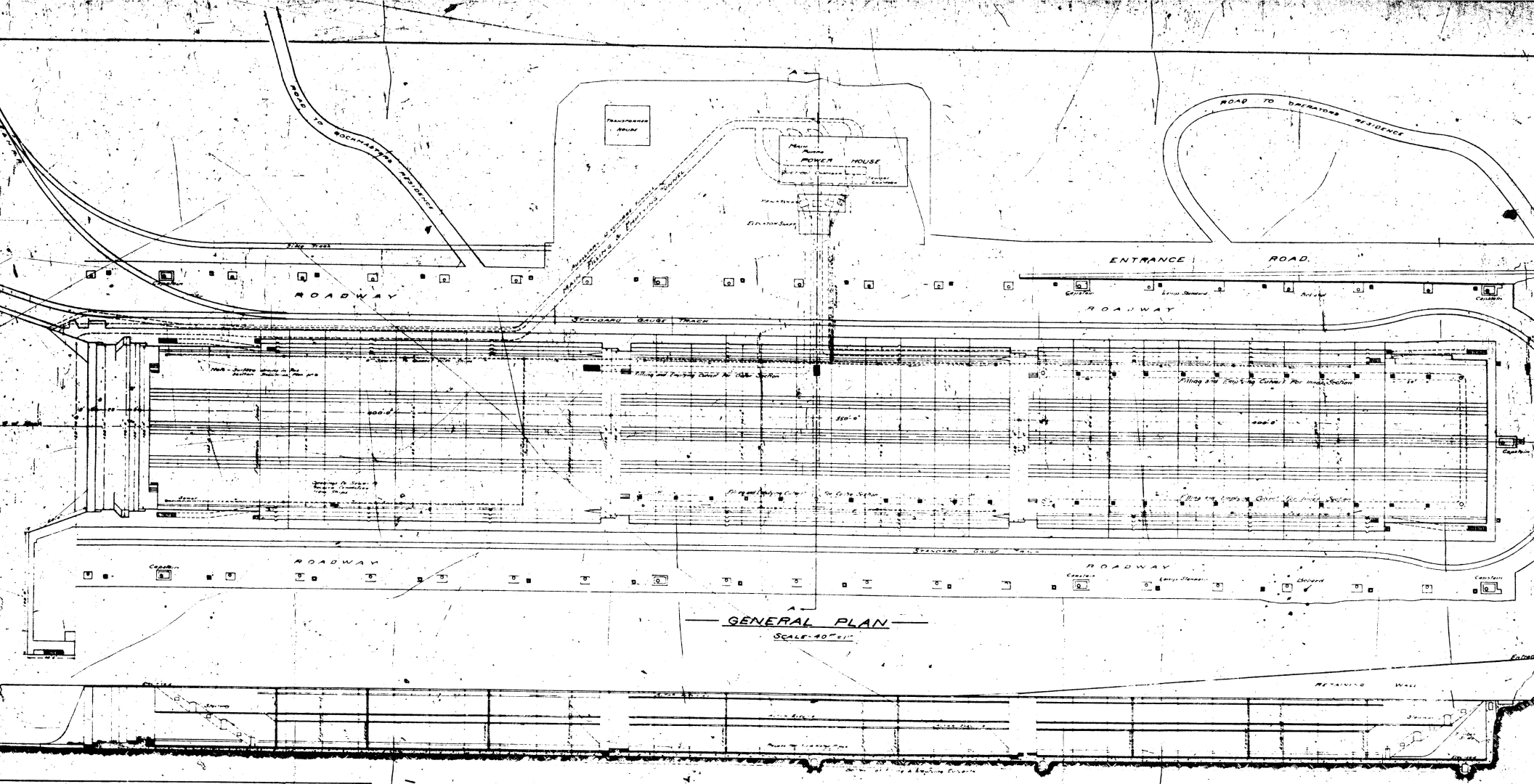


GENERAL PLAN

SCALE-40'=1"

LONGITUDINAL SECTION LOOKING NORTH

SCALE-40'=1"

INDEX

No 1. General Plan. Elevation & Cross Section Scale-1"=40'

2. Plan & Sections Of North Side Of Dock At Berths N° 1 & 2 Scale-½"=1'

3. Plan & Sections Of South Side Of Dock At Berths N° 1 & 2. Also Wing Crib. Scale-½"=1'

4. Plans & Sections Showing Outlet Of Main Filling & Emptying Tunnel - Reinforcing Between Main Tunnel & Stairway. Scale-½"&¼"=1'

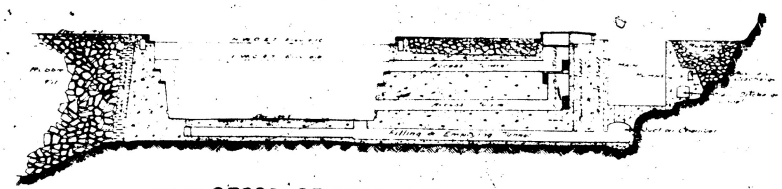
5. Plan & Sections Showing Reinforcing Around Filling & Emptying Tunnel For Outer Basin Scale-½"=1'

6. General Plan Of Pump House Substructure & Elevator Shaft. Scale-½"=1'

7. Part Sectional Plan Showing Sewers & Filling & Emptying Tunnels Entering Pump House. Also Plans & Sections Of Elevator Shaft. Scale-¼"=1'

8. Section At Station 7+75 From Dock To Pump House. - Section Through Suction Chamber Looking North. Scale-½"=1'

9. Large Scale Plans & Sections Of Dock & Landing Wharf. Scale-1"=20'



CROSS SECTION THROUGH A-A

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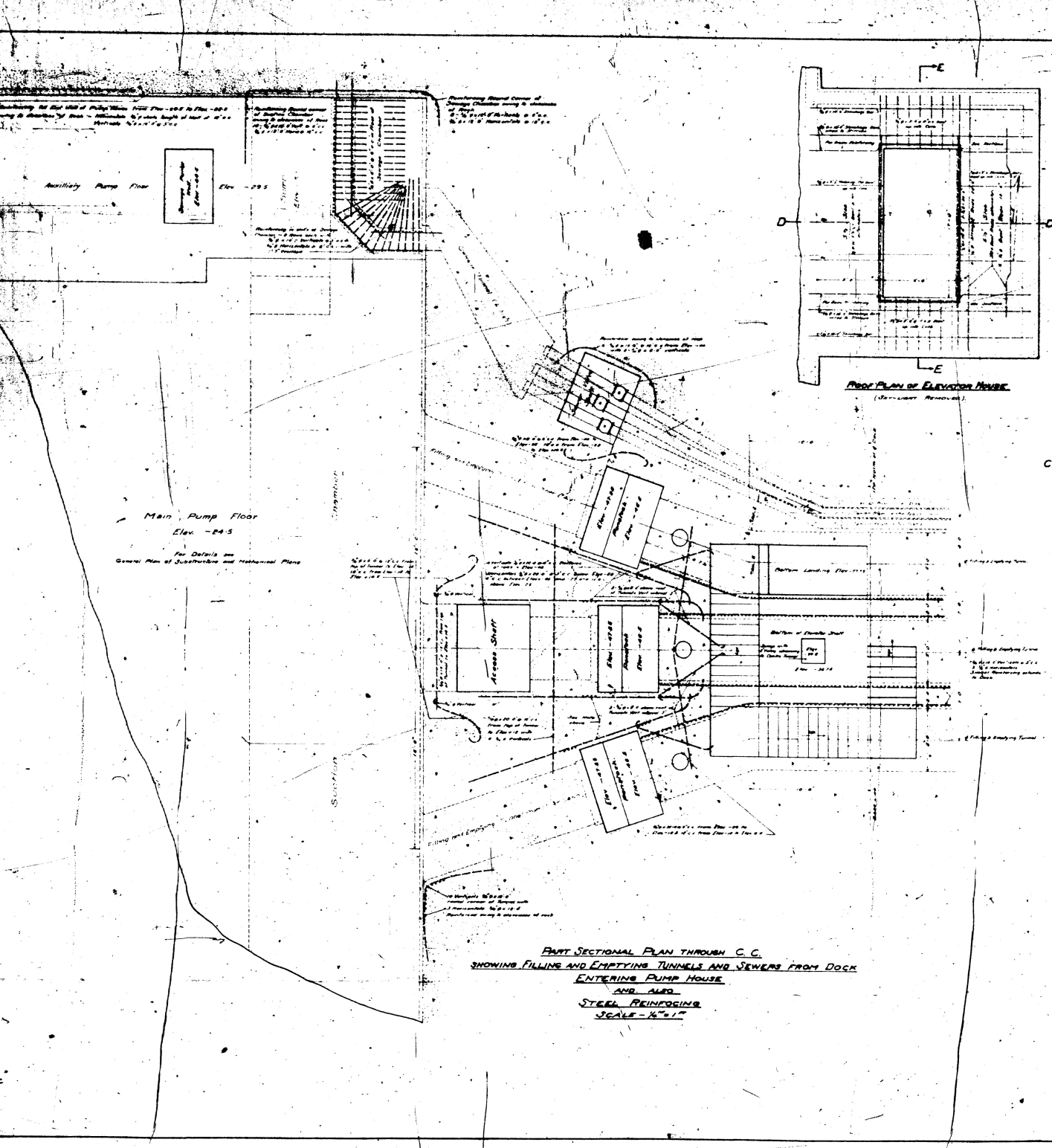
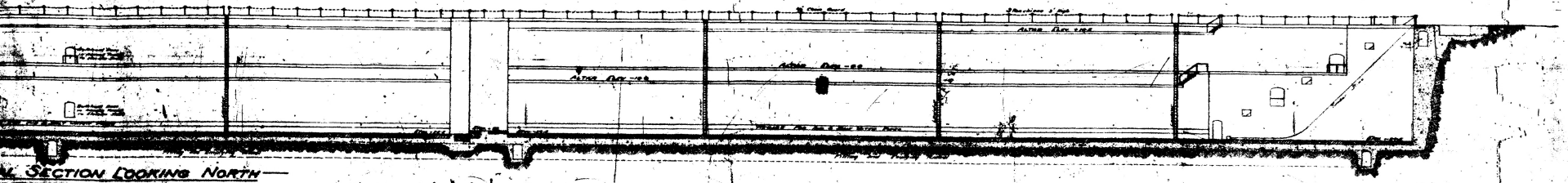

Auxiliary Pump Floor
Elev. -29.5
Main Pump Floor
Elev. -24.5
For Details see
General Plan of Substructure and Mechanical Plans
Access Shaft
Pumping Elev. -14.0
Pumping Elev. -14.0
Pumping Elev. -14.0
Bottom Landing Elev. -17.0
Bottom of Elevator Shaft
Elev. -27.5
Filling & Emptying Culvert
Filling & Emptying Culvert
Filling & Emptying Culvert
Elev. -19.0
Elev. -19.0
Elev. -19.0



N. SECTION LOOKING NORTH
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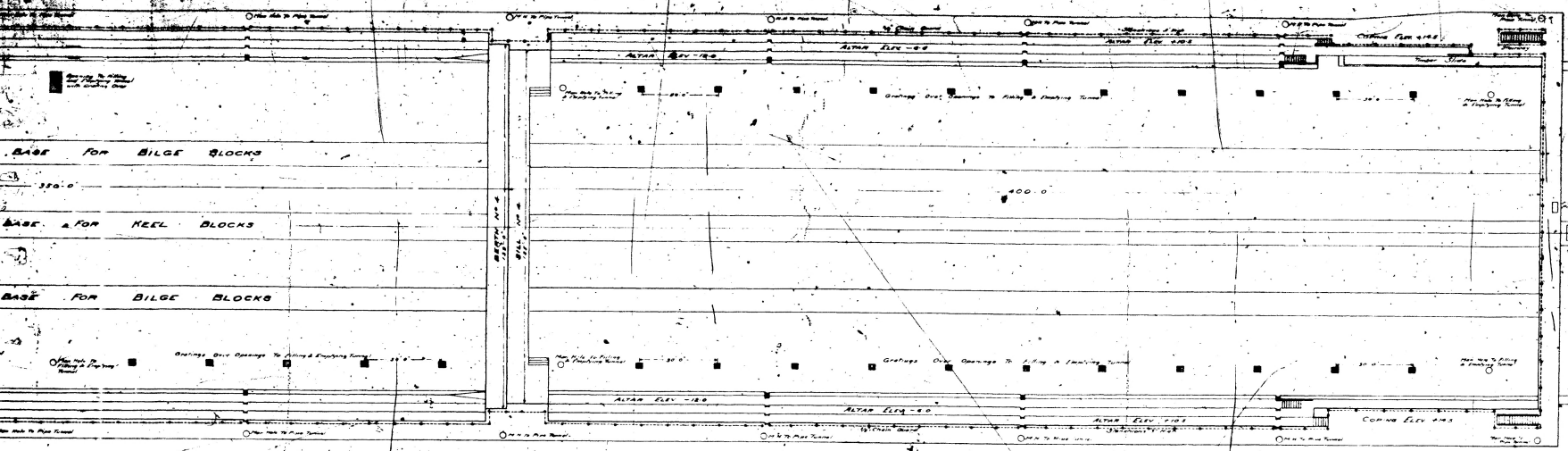

PLAN OF DOCK
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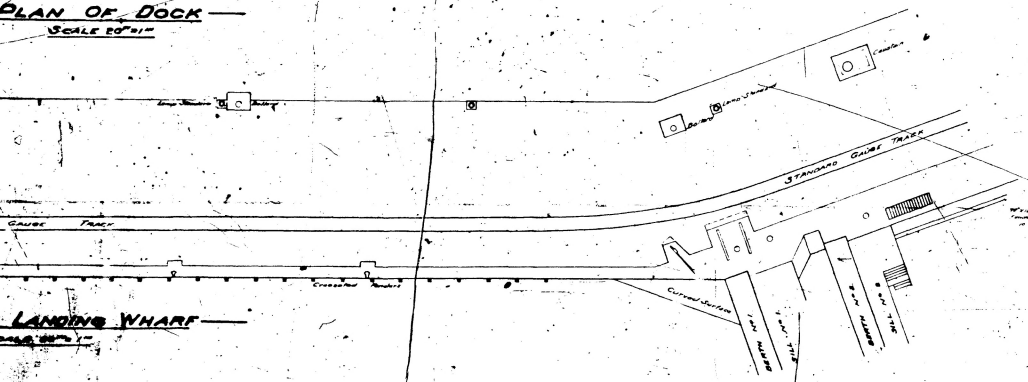
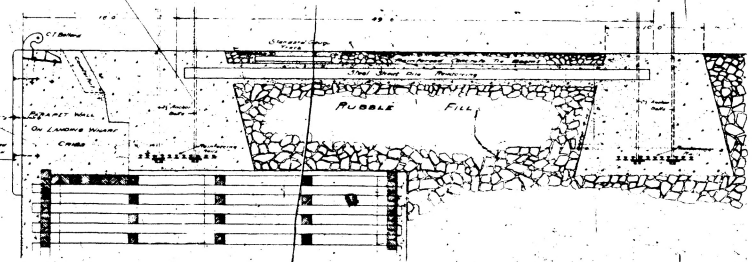


LANDING WHARF



CROSS SECTION THROUGH LANDING WHARF
SHOWING FOUNDATION FOR 100 TON DERRICK
SCALE 8'=1"

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NEW ESQUIMALT DRY

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GENERAL CONTRACTORS
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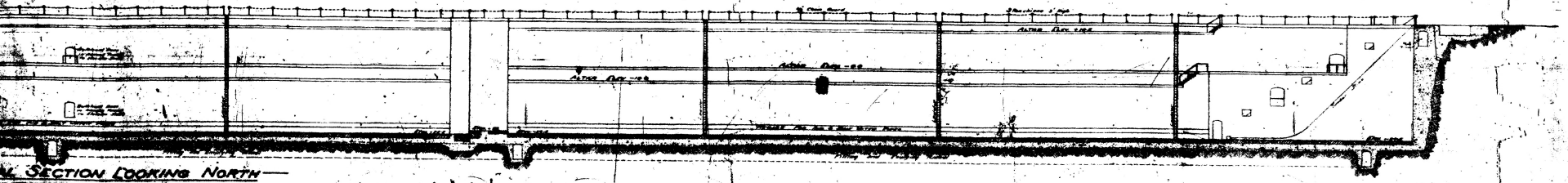

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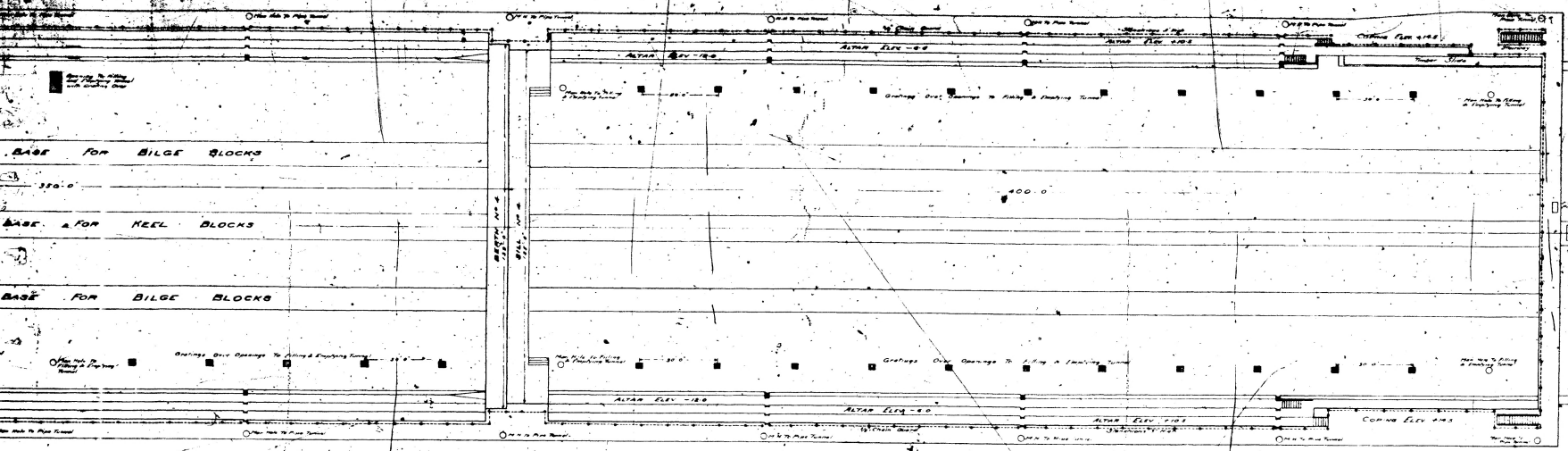
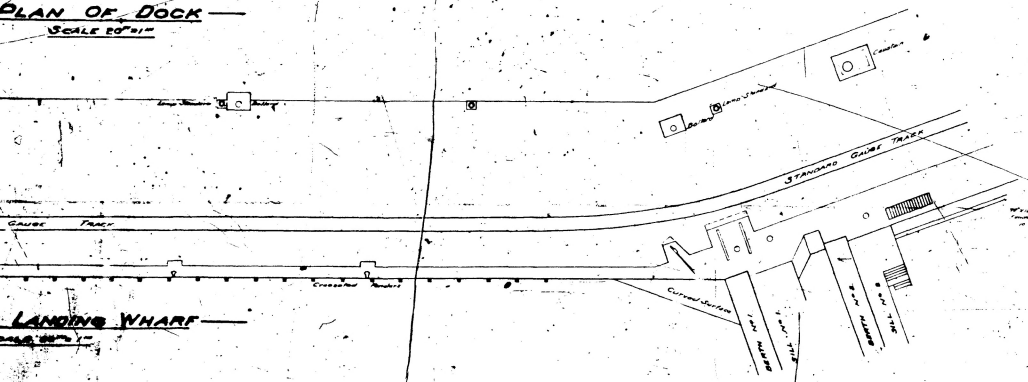
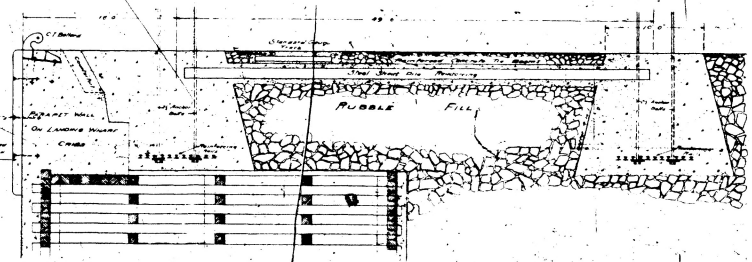


PLAN OF DOCK
SCALE 20'=1"



LANDING WHARF



CROSS SECTION THROUGH LANDING WHARF
SHOWING FOUNDATION FOR 100 TON DERRICK
SCALE 8'=1"

"BC040950"

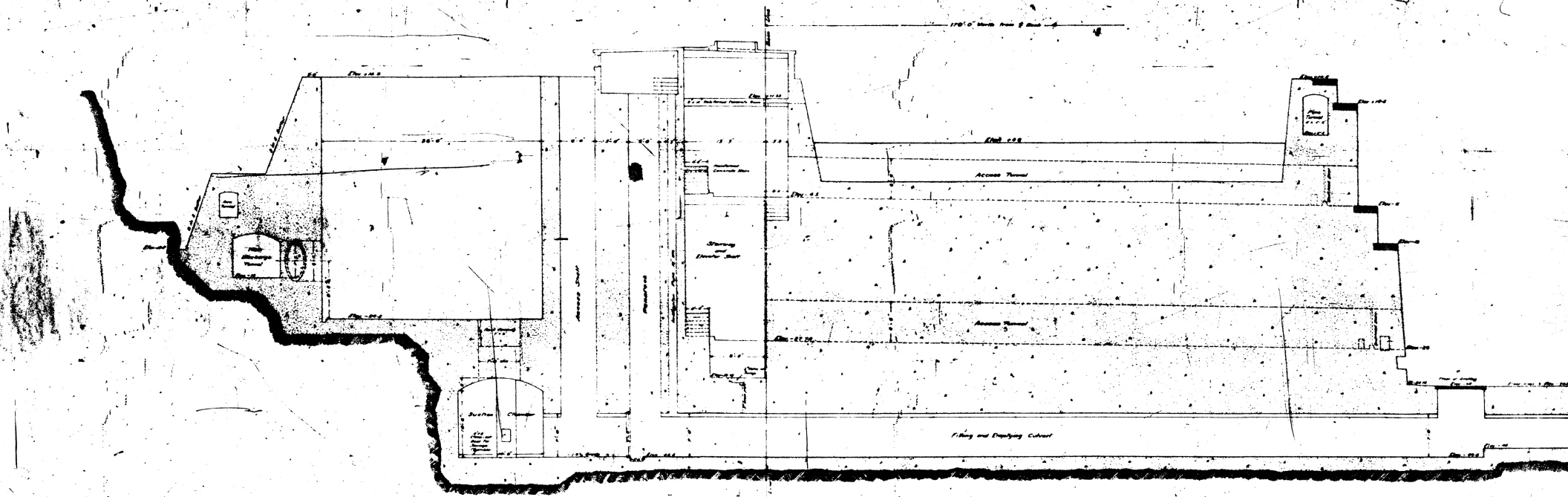
P.W.C.

NEW ESQUIMALT DRY

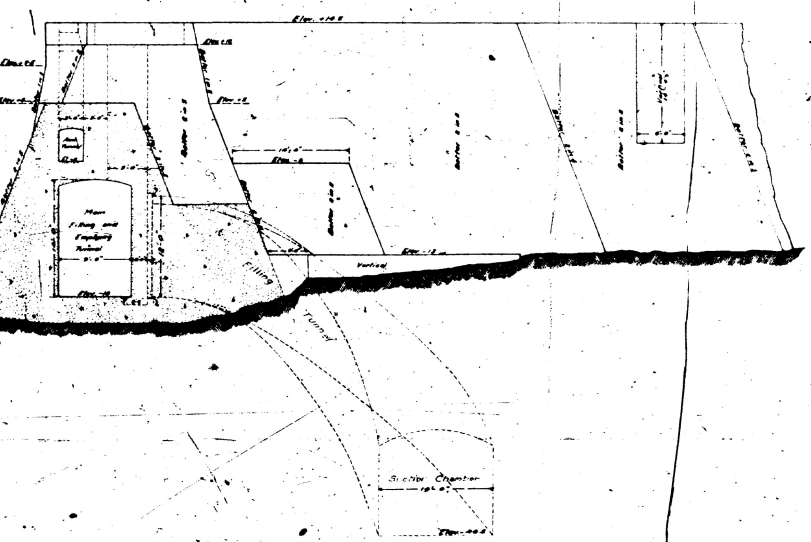
FINAL PLAN AS CONSTR

P. LYALL & SONS CONSTRUCTION CO. LTD.
GENERAL CONTRACTORS
1926

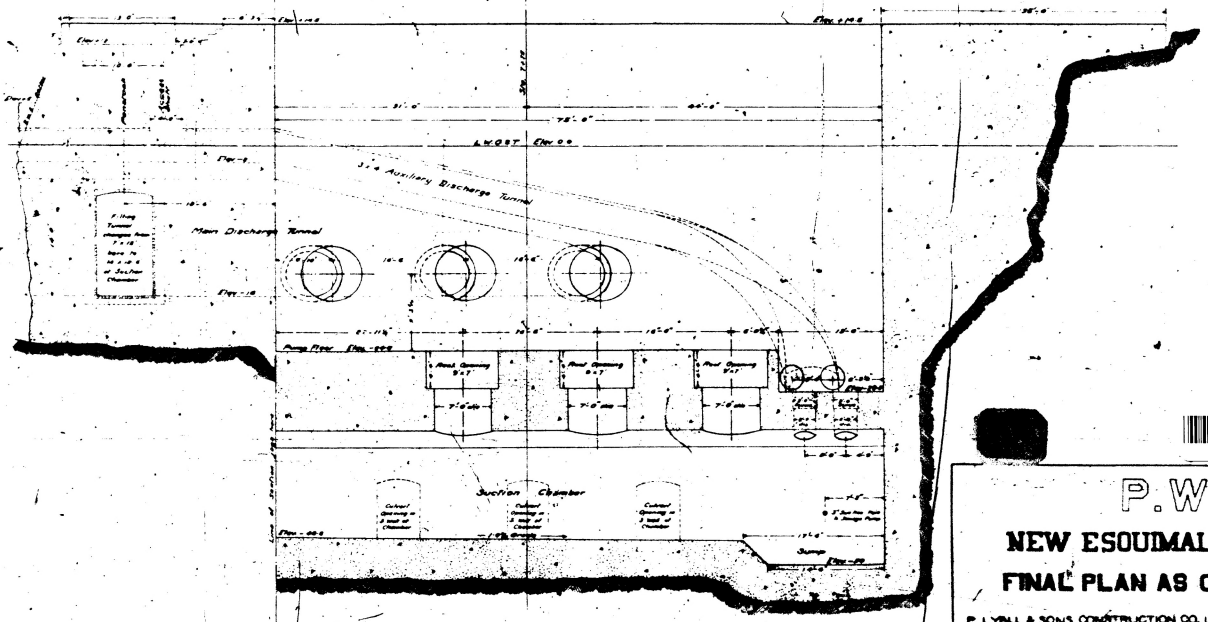
SHE



SECTION AT STA. 7+75
SCALE - 1/8" = 1'-0"



WEST ELEVATION - SECTION AT CONSTRUCTION JOINT
See Sheet No 6



SECTION THROUGH A-A LOOKING NORTH
See Sheet No 6

BC040951

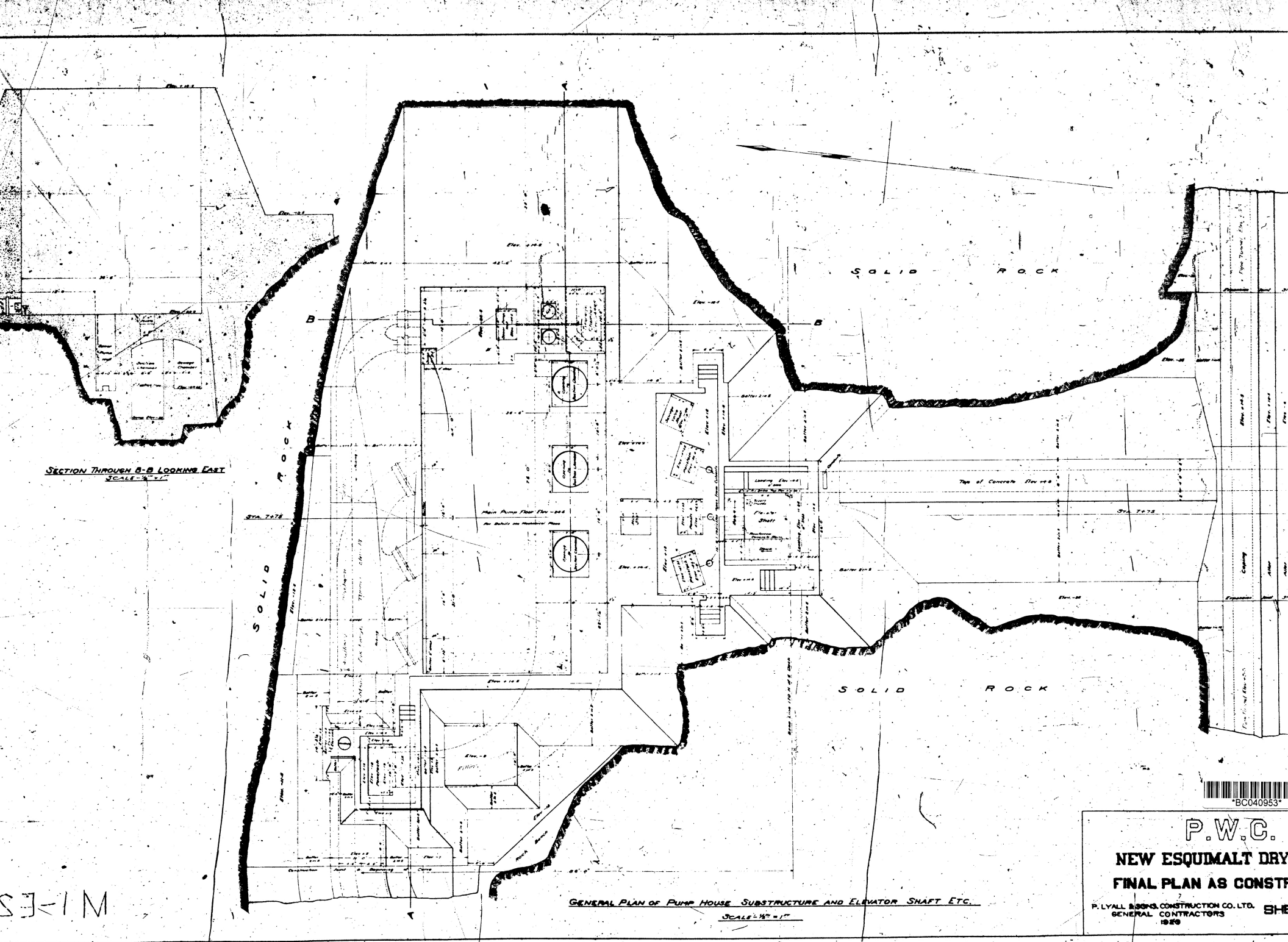
P.W.C.

NEW ESQUIMALT DRY D

FINAL PLAN AS CONSTRU

P. LYALL & SONS CONSTRUCTION CO. LTD.
GENERAL CONTRACTORS
1928

SHEE



SECTION THROUGH B-B LOOKING EAST
SCALE: 1/4" = 1'

GENERAL PLAN OF PUMP HOUSE SUBSTRUCTURE AND ELEVATOR SHAFT ETC.
SCALE: 1/4" = 1'

BC040953

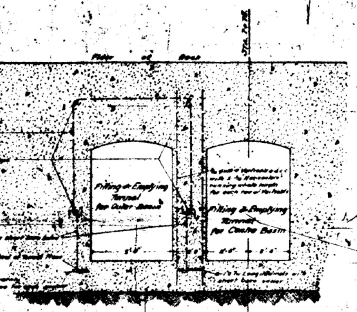
P.W.C.

NEW ESQUIMALT DRY

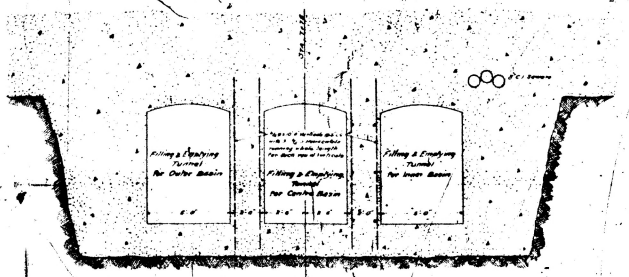
FINAL PLAN AS CONSTR

P. LYALL & SONS CONSTRUCTION CO. LTD.
GENERAL CONTRACTORS
1929

SHE



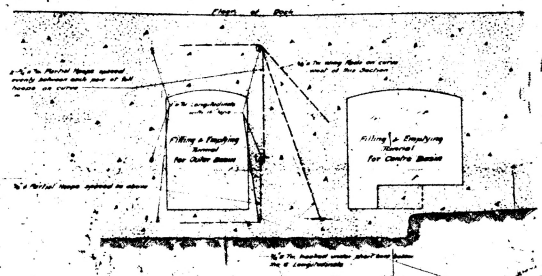
SECTION THROUGH D.D.



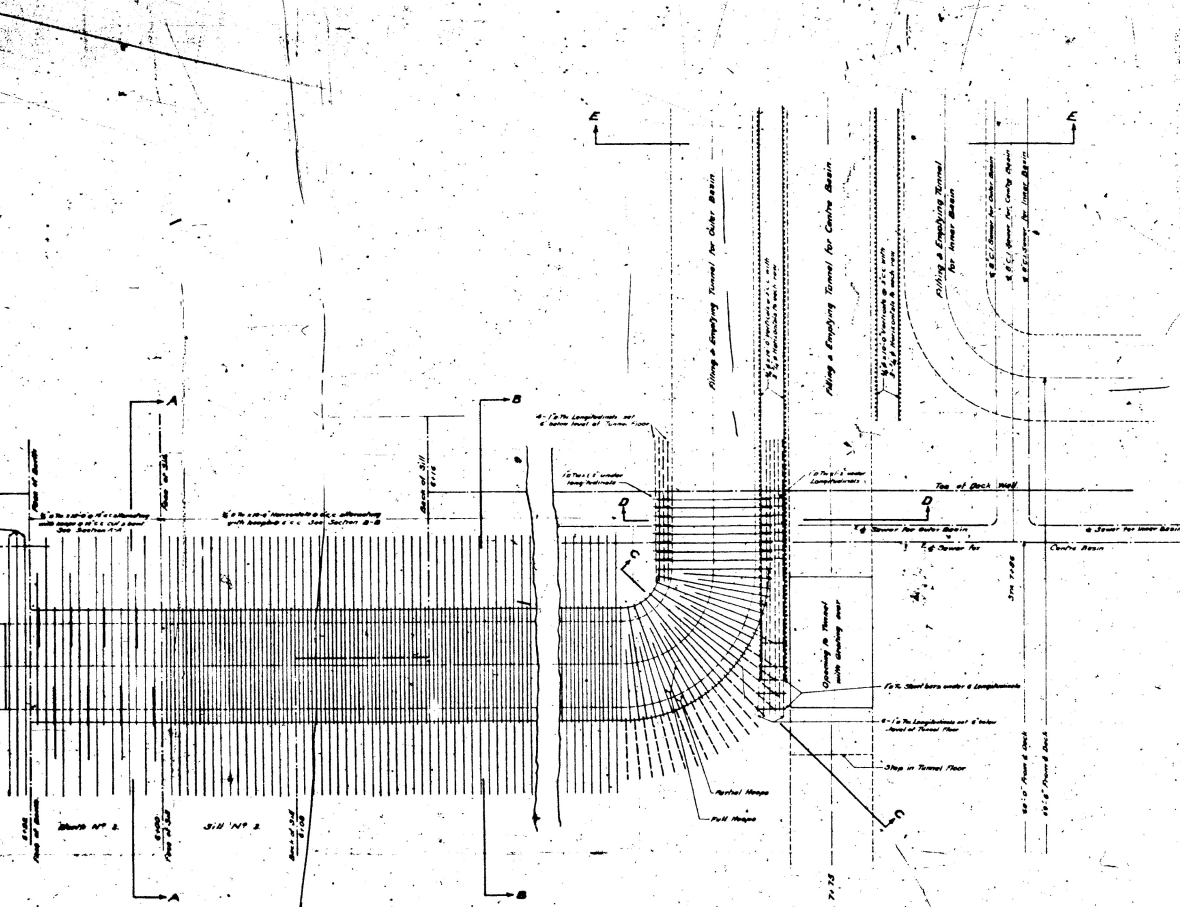
SECTION THROUGH E.E.

Similar Reinforcing Extends To Penstocks

(See Sheet No 7)

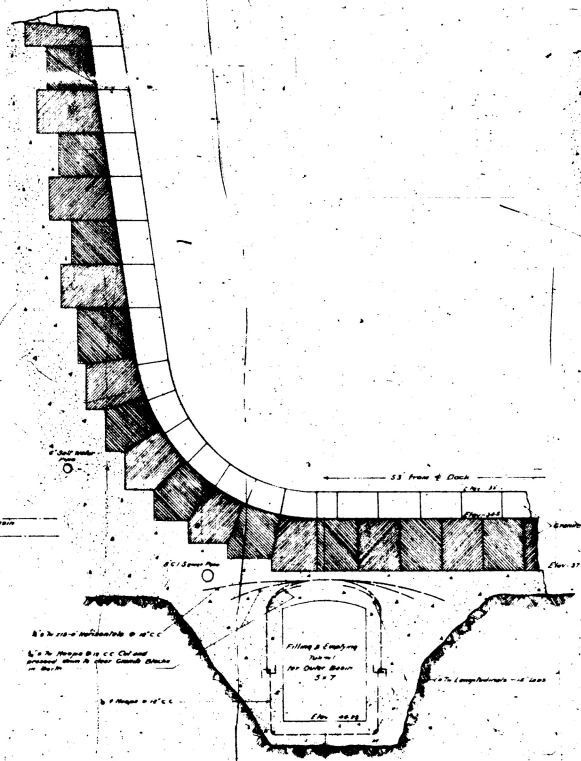


SECTION THROUGH C.C.



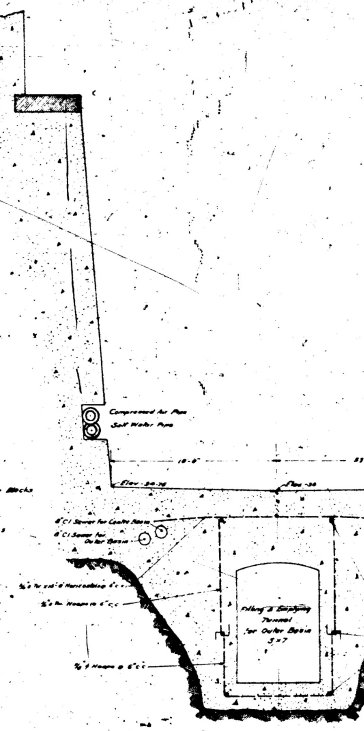
SECTIONAL PLAN AT TOP OF REINFORCING

SCALE - 1/4" = 1'



SECTION THROUGH A.A.

SCALE - 1/4" = 1'



SECTION THROUGH B.B

P.W.C.

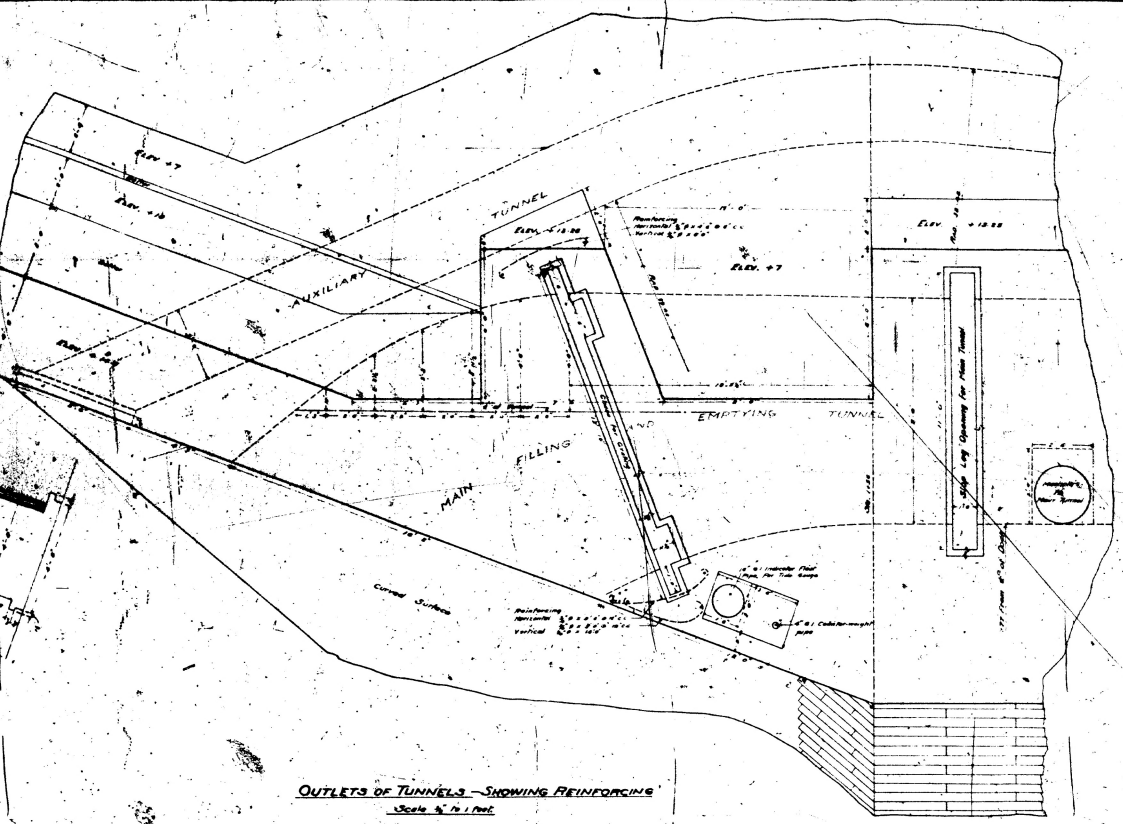
NEW ESQUIMALT DR

FINAL PLAN AS CONST

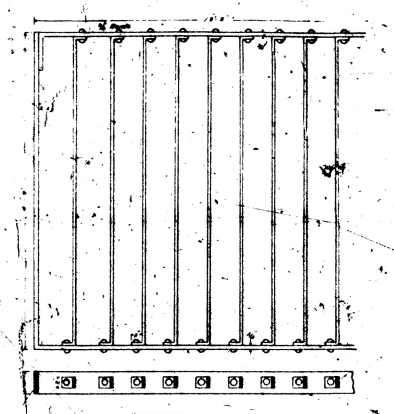
P. LYALL & SONS CONSTRUCTION CO. LTD.
GENERAL CONTRACTORS
1920

SH

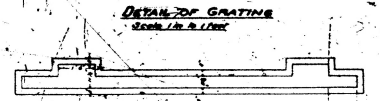
BC040954



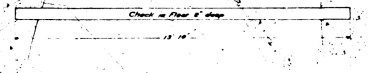
OUTLETS OF TUNNELS — SHOWING REINFORCING
Scale ½" to 1 Foot.



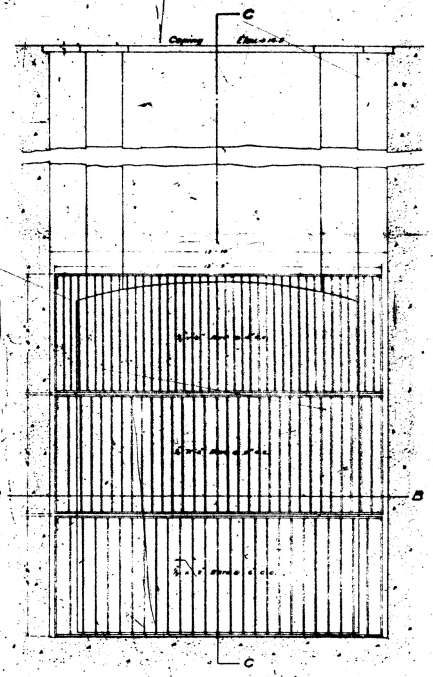
DETAIL OF GRATING
Scale 1½ to 1 Foot



PLAN OF CHASE AT COPING

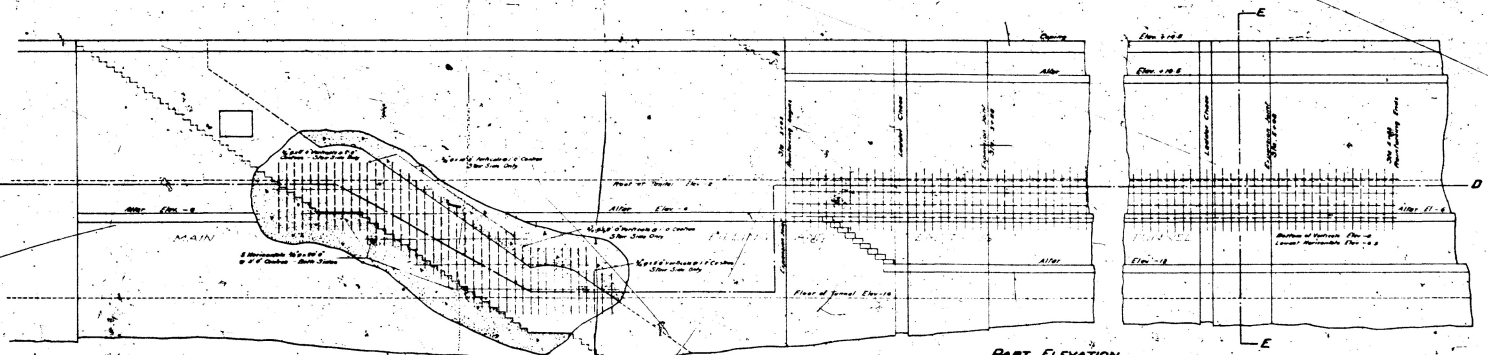


SECTION THROUGH B.B.
Scale ½ to 1 Foot.

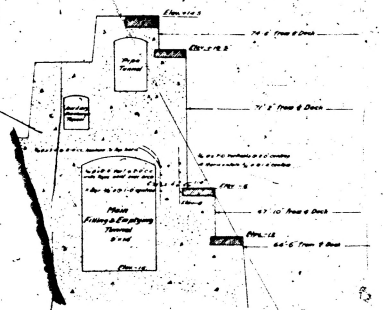


SECTION THROUGH A.A.
Scale ½ to 1 Foot.

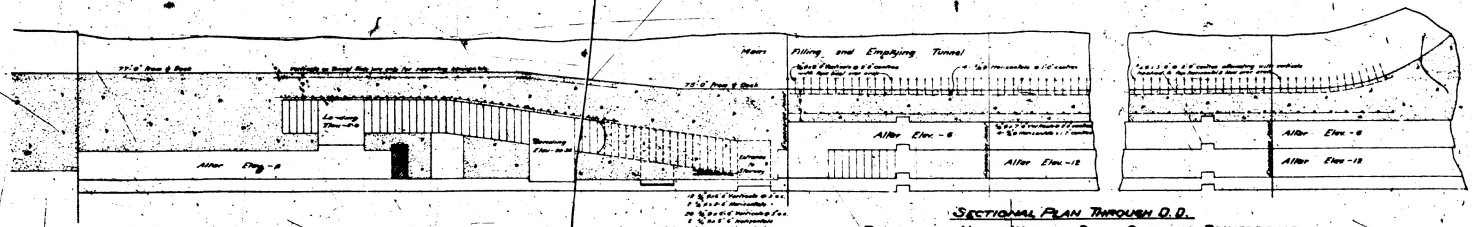
SECTION C.



PART ELEVATION



SECTION THROUGH E.E.



SECTIONAL PLAN THROUGH O.O.
PORTION OF NORTH WALL OF DOCK, SHOWING REINFORCING
Scale ½ to 1 Foot

P.W.C.

NEW ESQUIMALT DRY

FINAL PLAN AS CONSTR

P. LYALL & SONS CONSTRUCTION CO. LTD.
GENERAL CONTRACTORS
1926

SHE

BC040955

D3

ESQUIMALT GRAVING DOCK

IMPROVEMETNS TO GRAVING DOCK

CONTRACT NO.3 (1985)

Number of Pages: 74

PUBLIC WORKS CANADA

PACIFIC REGION

PROJECT NO. PR100772

ESQUIMALT GRAVING DOCK
ESQUIMALT B.C.

IMPROVEMENTS TO GRAVING DOCK
CONTRACT NO. 3

KER, PRIESTMAN & ASSOCIATES LTD.
consulting engineers

300-2659 Douglas Street, Victoria, B.C. V8T 4M3
Telephone (604) 388-6676 Telex 049-7449

FILE NO 25125 DATE MAY 1984

"BC041438"
NOV 6 1985

LIST OF DRAWINGS

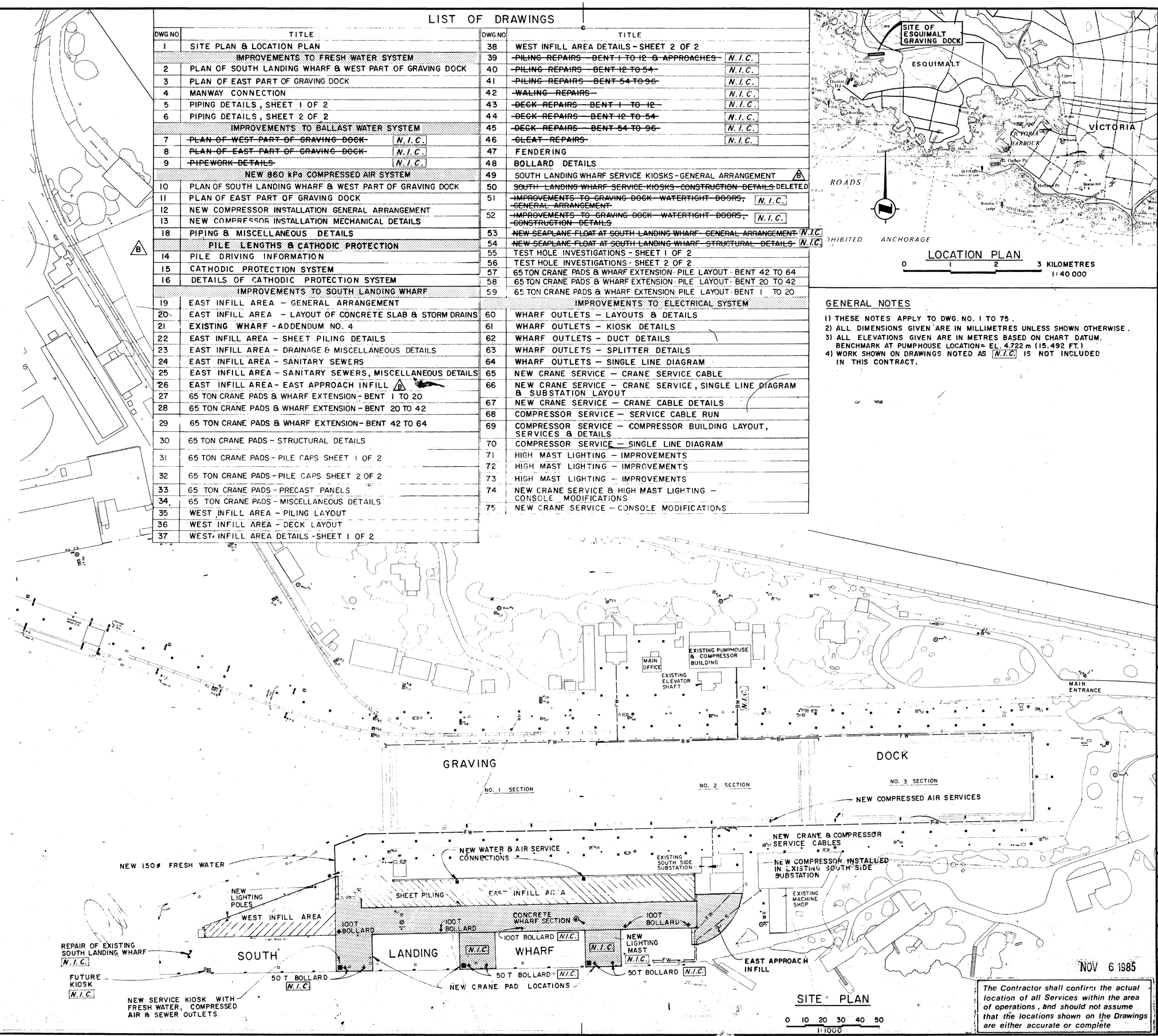
DWG NO	TITLE
1	SITE PLAN & LOCATION PLAN
	IMPROVEMENTS TO FRESH WATER SYSTEM
2	PLAN OF SOUTH LANDING WHARF & WEST PART OF GRAVING DOCK
3	PLAN OF EAST PART OF GRAVING DOCK
4	MANWAY CONNECTION
5	PIPING DETAILS, SHEET 1 OF 2
6	PIPING DETAILS, SHEET 2 OF 2
	IMPROVEMENTS TO BALLAST WATER SYSTEM
7	~~PLAN OF WEST PART OF GRAVING DOCK~~ N.I.C.
8	~~PLAN OF EAST PART OF GRAVING DOCK~~ N.I.C.
9	~~PIPEWORK DETAILS~~ N.I.C.
	NEW 860 kPa COMPRESSED AIR SYSTEM
10	PLAN OF SOUTH LANDING WHARF & WEST PART OF GRAVING DOCK
11	PLAN OF EAST PART OF GRAVING DOCK
12	NEW COMPRESSOR INSTALLATION GENERAL ARRANGEMENT
13	NEW COMPRESSOR INSTALLATION MECHANICAL DETAILS
18	PIPING & MISCELLANEOUS DETAILS
	PILE LENGTHS & CATHODIC PROTECTION
14	PILE DRIVING INFORMATION
15	CATHODIC PROTECTION SYSTEM
16	DETAILS OF CATHODIC PROTECTION SYSTEM
	IMPROVEMENTS TO SOUTH LANDING WHARF
19	EAST INFILL AREA – GENERAL ARRANGEMENT
20	EAST INFILL AREA – LAYOUT OF CONCRETE SLAB & STORM DRAINS
21	EXISTING WHARF - ADDENDUM NO. 4
22	EAST INFILL AREA – SHEET PILING DETAILS
23	EAST INFILL AREA - DRAINAGE & MISCELLANEOUS DETAILS
24	EAST INFILL AREA - SANITARY SEWERS
25	EAST INFILL AREA – SANITARY SEWERS, MISCELLANEOUS DETAILS
26	EAST INFILL AREA - EAST APPROACH INFILL B
27	65 TON CRANE PADS & WHARF EXTENSION - BENT 1 TO 20
28	65 TON CRANE PADS & WHARF EXTENSION - BENT 20 TO 42
29	65 TON CRANE PADS & WHARF EXTENSION - BENT 42 TO 64
30	65 TON CRANE PADS - STRUCTURAL DETAILS
31	65 TON CRANE PADS - PILE CAPS SHEET 1 OF 2
32	65 TON CRANE PADS - PILE CAPS SHEET 2 OF 2
33	65 TON CRANE PADS - PRECAST PANELS
34	65 TON CRANE PADS - MISCELLANEOUS DETAILS
35	WEST INFILL AREA - PILING LAYOUT
36	WEST INFILL AREA - DECK LAYOUT
37	WEST INFILL AREA DETAILS - SHEET 1 OF 2

DWG NO	TITLE
38	WEST INFILL AREA DETAILS - SHEET 2 OF 2
39	~~PILING REPAIRS – BENT 1 TO 12 & APPROACHES~~ N.I.C.
40	~~PILING REPAIRS – BENT 12 TO 54~~ N.I.C.
41	~~PILING REPAIRS – BENT 54 TO 96~~ N.I.C.
42	~~WALING REPAIRS~~ N.I.C.
43	~~DECK REPAIRS – BENT 1 TO 12~~ N.I.C.
44	~~DECK REPAIRS – BENT 12 TO 54~~ N.I.C.
45	~~DECK REPAIRS – BENT 54 TO 96~~ N.I.C.
46	~~CLEAT REPAIRS~~ N.I.C.
47	FENDERING
48	BOLLARD DETAILS
49	SOUTH LANDING WHARF SERVICE KIOSKS - GENERAL ARRANGEMENT B
50	~~SOUTH LANDING WHARF SERVICE KIOSKS CONSTRUCTION DETAILS~~ DELETED
51	~~IMPROVEMENTS TO GRAVING DOCK WATERTIGHT DOORS, GENERAL ARRANGEMENT~~ N.I.C.
52	~~IMPROVEMENTS TO GRAVING DOCK WATERTIGHT DOORS, CONSTRUCTION DETAILS~~ N.I.C.
53	~~NEW SEAPLANE FLOAT AT SOUTH LANDING WHARF GENERAL ARRANGEMENT~~ N.I.C.
54	~~NEW SEAPLANE FLOAT AT SOUTH LANDING WHARF STRUCTURAL DETAILS~~ N.I.C.
55	TEST HOLE INVESTIGATIONS - SHEET 1 OF 2
56	TEST HOLE INVESTIGATIONS - SHEET 2 OF 2
57	65 TON CRANE PADS & WHARF EXTENSION PILE LAYOUT BENT 42 TO 64
58	65 TON CRANE PADS & WHARF EXTENSION PILE LAYOUT BENT 20 TO 42
59	65 TON CRANE PADS & WHARF EXTENSION PILE LAYOUT BENT 1 TO 20
	IMPROVEMENTS TO ELECTRICAL SYSTEM
60	WHARF OUTLETS – LAYOUTS & DETAILS
61	WHARF OUTLETS – KIOSK DETAILS
62	WHARF OUTLETS – DUCT DETAILS
63	WHARF OUTLETS – SPLITTER DETAILS
64	WHARF OUTLETS – SINGLE LINE DIAGRAM
65	NEW CRANE SERVICE – CRANE SERVICE CABLE
66	NEW CRANE SERVICE – CRANE SERVICE, SINGLE LINE DIAGRAM & SUBSTATION LAYOUT
67	NEW CRANE SERVICE – CRANE CABLE DETAILS
68	COMPRESSOR SERVICE – SERVICE CABLE RUN
69	COMPRESSOR SERVICE – COMPRESSOR BUILDING LAYOUT, SERVICES & DETAILS
70	COMPRESSOR SERVICE – SINGLE LINE DIAGRAM
71	HIGH MAST LIGHTING – IMPROVEMENTS
72	HIGH MAST LIGHTING – IMPROVEMENTS
73	HIGH MAST LIGHTING – IMPROVEMENTS
74	NEW CRANE SERVICE & HIGH MAST LIGHTING – CONSOLE MODIFICATIONS
75	NEW CRANE SERVICE – CONSOLE MODIFICATIONS

LOCATION PLAN
0 1 2 3 KILOMETRES
1:40 000

GENERAL NOTES

1) THESE NOTES APPLY TO DWG. NO. 1 TO 75.
2) ALL DIMENSIONS GIVEN ARE IN MILLIMETRES UNLESS SHOWN OTHERWISE.
3) ALL ELEVATIONS GIVEN ARE IN METRES BASED ON CHART DATUM. BENCHMARK AT PUMPHOUSE LOCATION= EL. 4.722 m (15.492 FT.)
4) WORK SHOWN ON DRAWINGS NOTED AS N.I.C. IS NOT INCLUDED IN THIS CONTRACT.



SITE PLAN
0 10 20 30 40 50
1:1000

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER, PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

LEGEND

EXISTING SERVICES SHOWN THUS – – FW 150 GS – –
PROPOSED SERVICES SHOWN THUS — FW 150 GS —
SERVICE IDENTIFICATION — FW 150 GS —
SERVICE CODE AS PER LIST
PIPE DIA. IN mm
PIPE MATERIAL

FW - FRESH WATER
BW - BALLAST WATER
A - COMPRESSED AIR
S - SEWER
D - DRAIN

677

revisions		date
B	AS BUILT	JULY 1985
A	CRANE PADS 283 DELETED	SEPT. 11/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
SITE PLAN & LOCATION PLAN

"BC041435"

designed P.M. / conçu
date APRIL 1984
drawn R.N. / dessiné
date APRIL 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number PR 100772 / no. du projet
drawing no. 1 OF 75 - B / no. du dessin

PWC A1

NOTES
1) FOR GENERAL NOTES & LEGEND, SEE DWG NO. 1

PARKING

STONE WALL

FW 75 CU

FW 65

WATERMAINS LOCATED IN EXISTING MANWAYS

FW 200 DI

SEE ADJOINING DWG NO 3

GRAVING DOCK

NO. 1 SECTION

NO. 2 SECTION

MANWAY CONNECTION SEE DWG. NO. 4

TEE WITH VICTAULIC CAP FOR FUTURE EXTENSION

FW 150 GS

CONNECT TO EXISTING PIPE

WATERMAIN LOCATED IN EXISTING MANWAY

FW150 PVC

FLUSH HYDRANT SEE DETAIL 2/5

65 ø SERVICE OUTLET SEE DETAIL 4/5

RAMP

65 ø SERVICE OUTLET-SEE DETAIL 3/5

RETAINING WALL

FW 150 PVC

SERVICE TAKEOFFS SEE DETAIL 2/6

SEE DETAIL 1/6

EAST INFILL AREA

BURIED SECTION (TYPICAL)

FW150 DI

WEST INFILL AREA

NEW CONCRETE WHARF

FUTURE EXTENSION

SUSPENDED SECTION (TYPICAL)

FUTURE TEE WITH BLIND FLANGE FOR FUTURE EXTENSION

FW 150 PVC (FUTURE)

150 ø BLIND FLANGED OUTLET FOR FUTURE EXTENSION SEE DWG No. 6

SOUTH LANDING WHARF

NEW CRANE PAD

N.I.C.

EXISTING METERING CHAMBER REMAINS, WITH MODIFICATIONS TO CHAMBER

FW

32 m ±

2-65 ø OUTLETS TYPICAL - SEE DETAIL 6/6

FUTURE SERVICE KIOSK NO.1

SERVICE KIOSK NO.2

SERVICE KIOSK NO.3 N.I.C.

SERVICE KIOSK NO.4 N.I.C.

NOTE
ALL PIPEWORK UNDER WHARF INSULATED AS PER SPECIFICATIONS

C ALL FW PIPE CHANGED TO PVC

EXISTING SERVICES IN CRANE PAD LOCATION TO BE ABANDONED

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

PLAN
1 : 500

revisions		date
C	AS BUILT	JULY 1985
B	75ø WATER TO S. SUBSTATION	DEC 1984
A	CRANE PADS 2&3 DELETED	SEPT. 11/84

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

project / projet
BC041436
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO FRESH WATER SYSTEM
PLAN OF SOUTH LANDING WHARF & WEST PART OF GRAVING DOCK

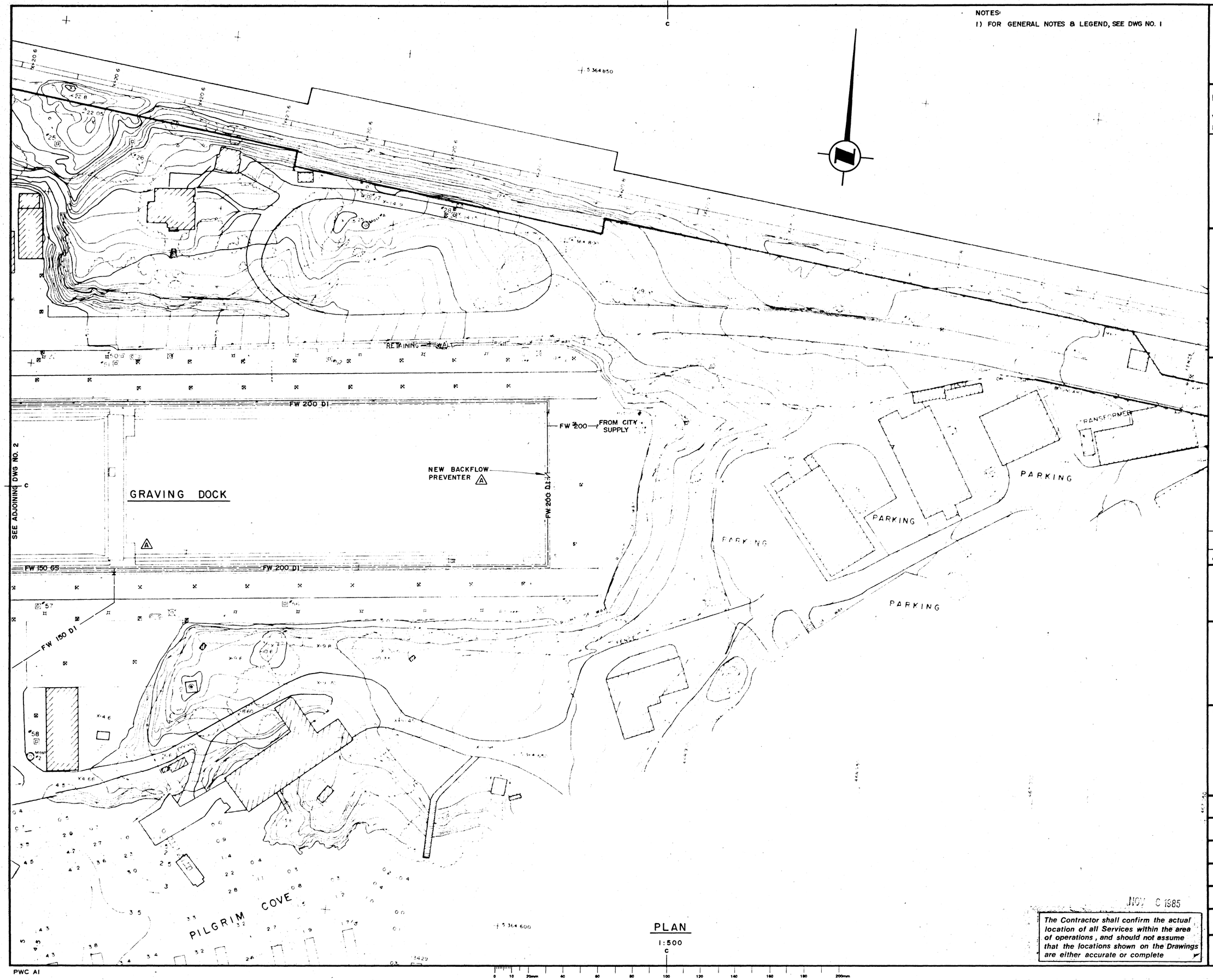
designed TB / conçu
date MARCH 1984
drawn DG / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no du projet
PR 100772

drawing no. / no du dessin
2 OF 75 - C

PWC A1

NOTES:
1) FOR GENERAL NOTES & LEGEND, SEE DWG NO. 1



PLAN
1:500
C

0 10 20mm 40 60 80 100 120 140 160 180 200mm

NOV 0 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

PWC AI

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
PETER MALONE

revisions		date
A	AS BUILT	JULY 26/85

A detail no. no. du détail
B location drawing no. aur dessin no
C drawing no. dessin no

project / projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing / dessin

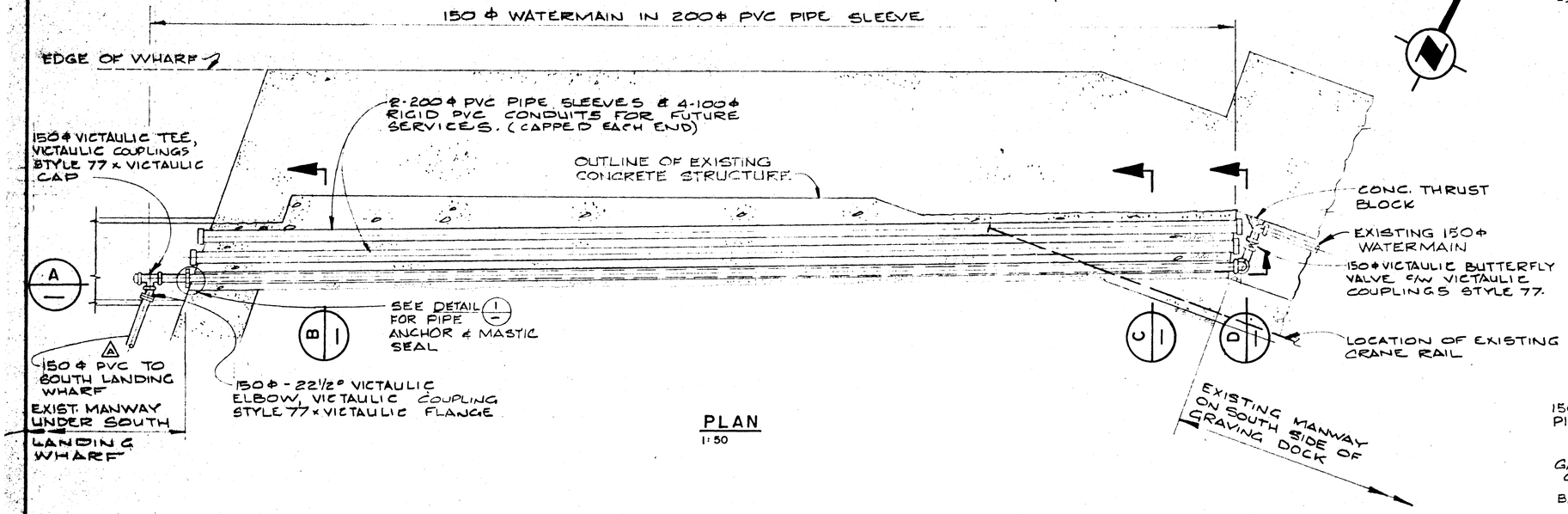
IMPROVEMENTS TO FRESH WATER SYSTEM

PLAN OF EAST PART OF GRAVING DOCK

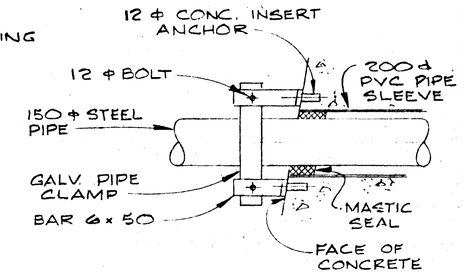
BC041437

designed PM / conçu
date MARCH 1984
drawn DG / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no du projet
PR 100772
drawing no. / no du dessin
3 OF 75 A

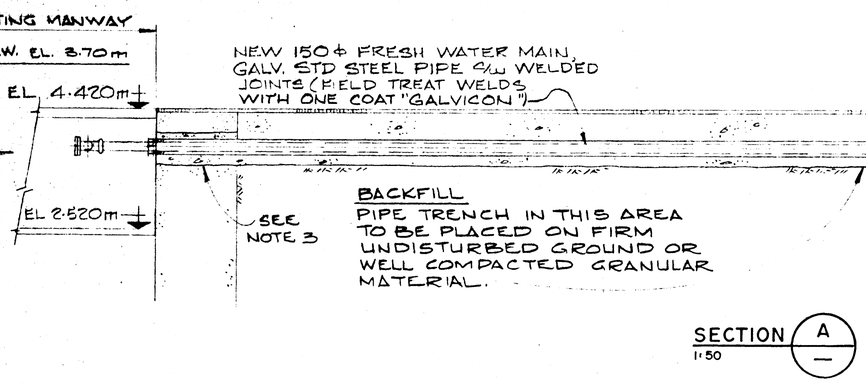
NOTES:
1) FOR GENERAL NOTES & LEGEND SEE DWG NO. 1
2) FOR LOCATION, REFER TO DWG NO. 2
3) SURFACES TO BE ROUGHENED, DRY & FREE OF LOOSE MATERIAL BEFORE CONCRETE IS PLACED. A BONDING/WATERPROOFING AGENT, "VANDEX" OR APPROVED EQUAL, SHALL BE USED ON JOINTS AS DIRECTED BY ENGINEER.

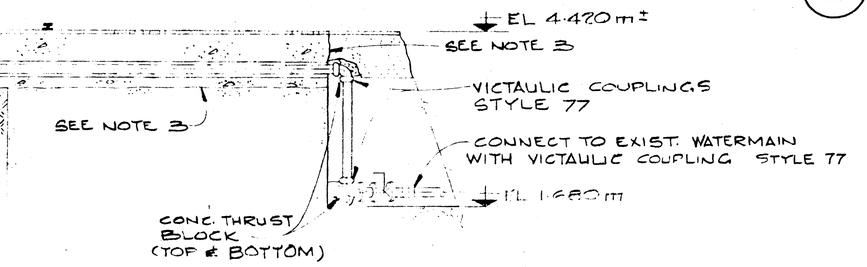


PLAN
1:50

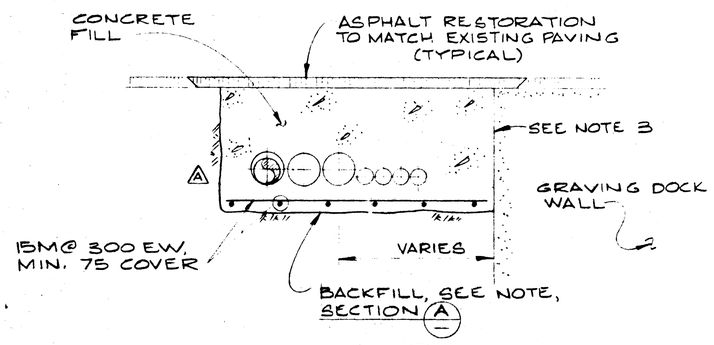


DETAIL 1 — PIPE ANCHOR AT WEST END
1:10

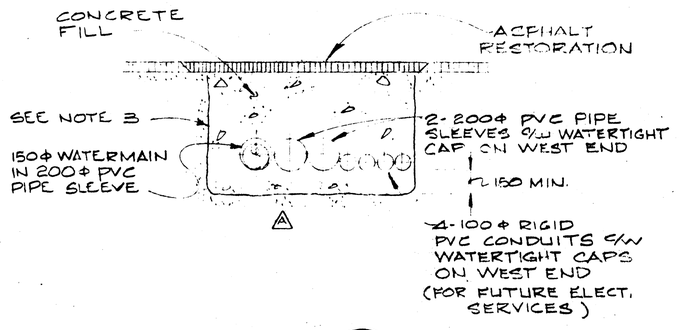




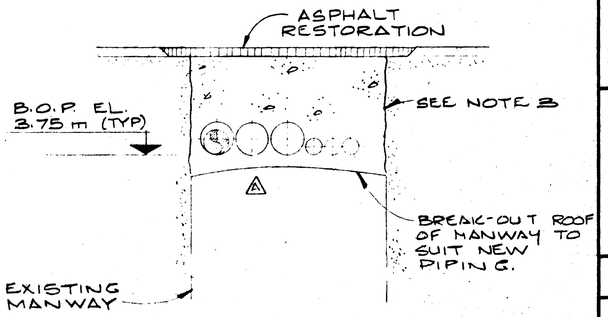
SECTION A
1:50



SECTION B — PIPE TRENCH IN BACKFILL
1:20



SECTION C — PIPE TRENCH IN EXISTING CONCRETE
1:20



SECTION D
1:20

NOV 6 1985

The Contractor ... [redacted]

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MADONE

revisions		date
A	AS-BUILT	JULY 24/85

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

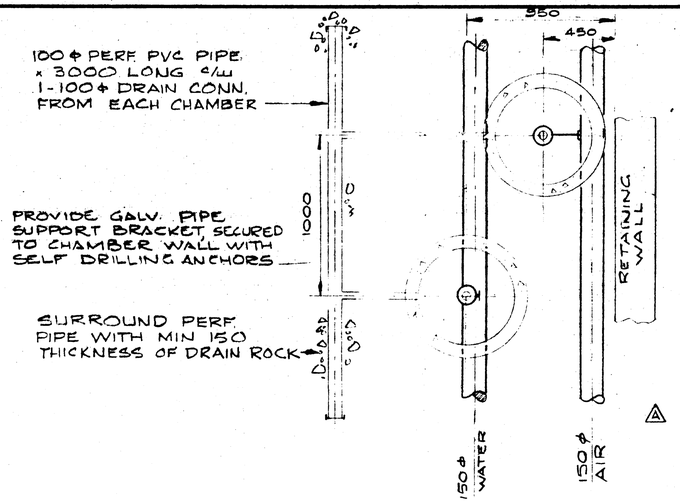
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B C
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO FRESH WATER SYSTEM
MANWAY CONNECTION

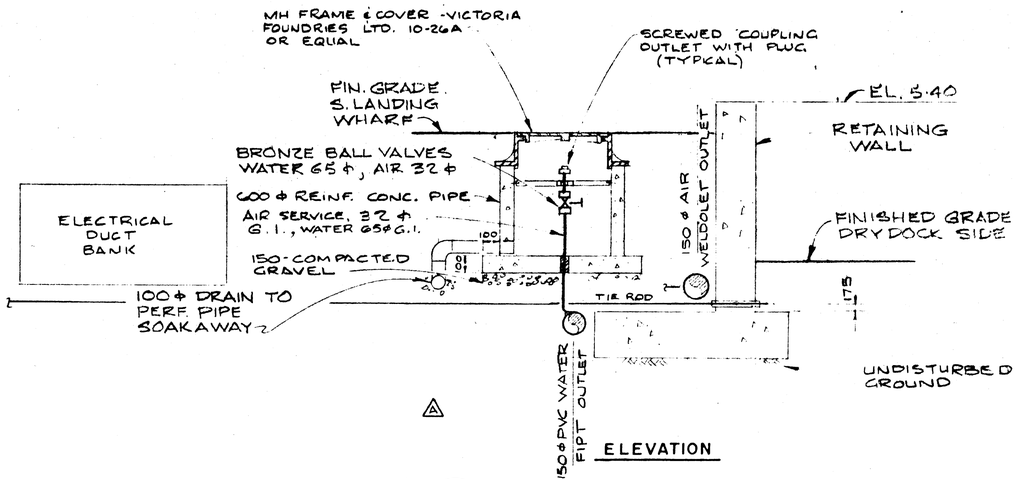
BC041439

designed PM / conçu
date MARCH 1984
drawn DG / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
4 OF 75 A

PWC A1

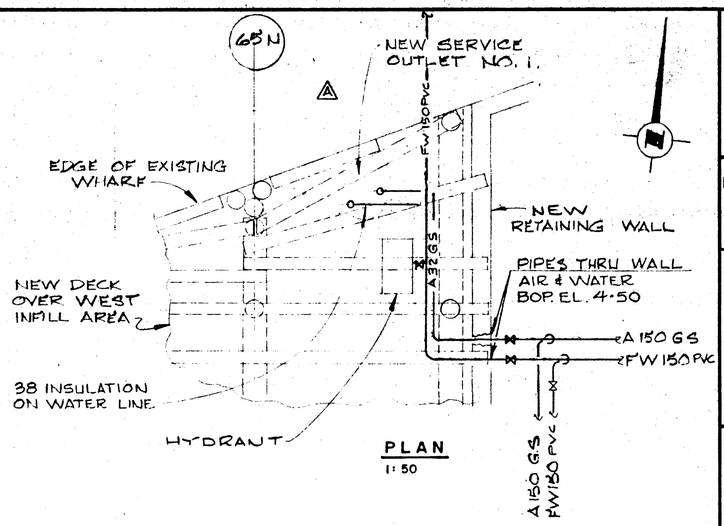


PLAN

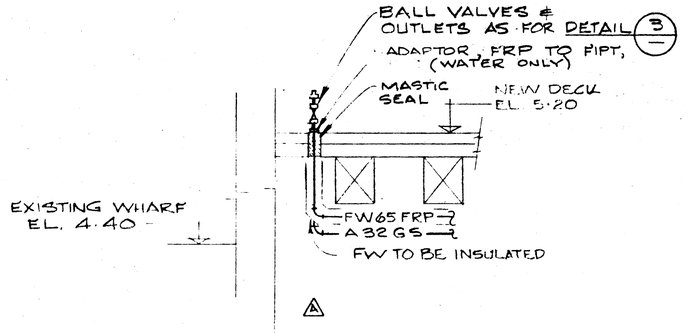


ELEVATION

DETAIL 3 / 2,10 — 1:20 — SERVICE OUTLETS NO. 2 & 3

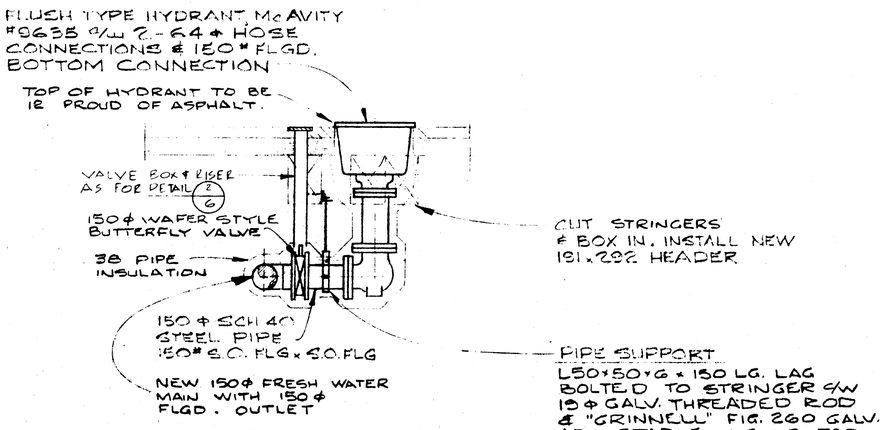


PLAN
1:50



ELEVATION
1:20

DETAIL 4 / 2,10 — SERVICE OUTLET NO. 1



DETAIL 2 / 2 — 1:20 — HYDRANT INSTALLATION ON NORTH SIDE OF SOUTH LANDING WHARF

NOTES:
1) FOR GENERAL NOTES & LEGEND, SEE DWG. NO. 1.

NOV 6 1985

"BC041440"

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
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VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

A	AS-BUILT	JULY 26/85
revisions		date

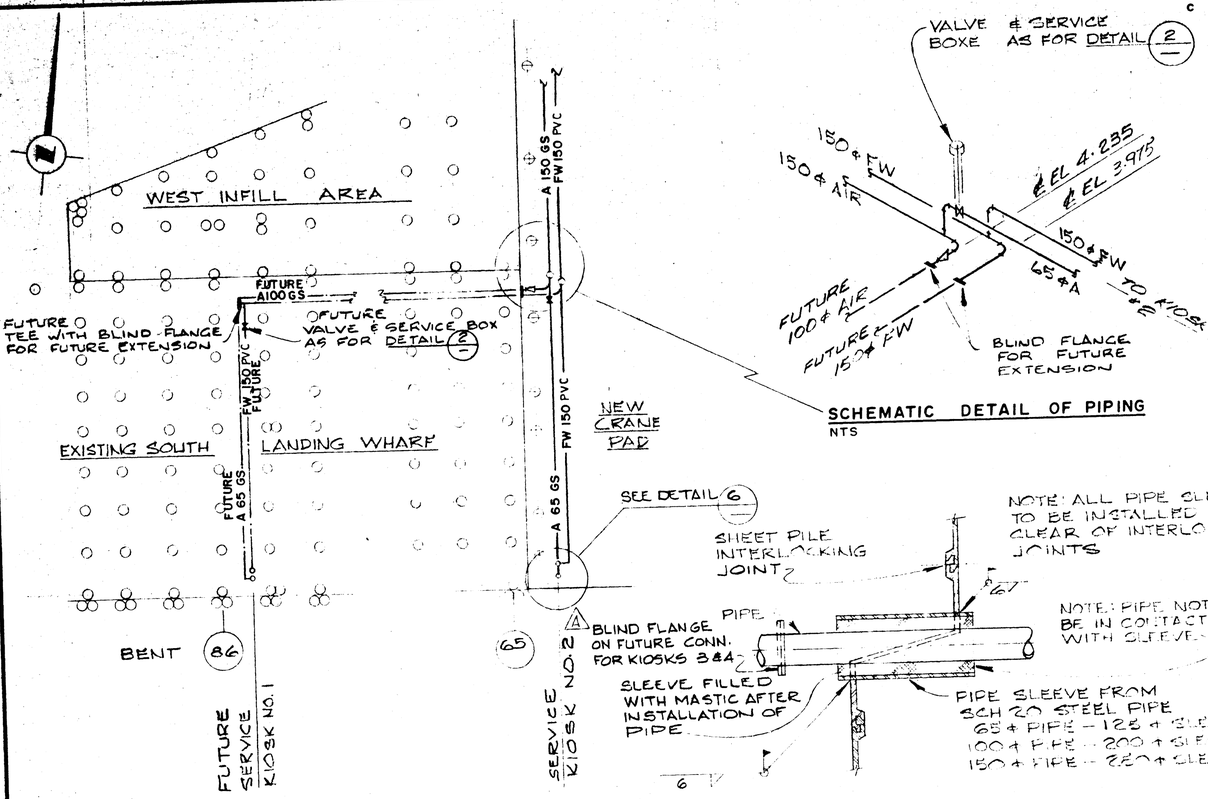
A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B C
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO FRESH WATER & COMPRESSED AIR SYSTEMS
PIPING DETAILS
SHEET 1 OF 2

designed TB — conçu
date MARCH 1984
drawn DG — dessiné
date MARCH 1984
reviewed — examiné
date
approved — approuvé
date
Tender — Soumission
PWC Project Manager — Administrateur de projets TPC
project number — no. du projet
drawing no. — no. du dessin
5 OF 75 (A)

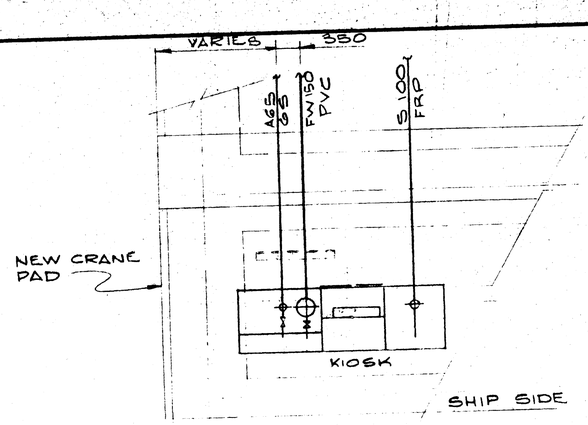
PWC A1

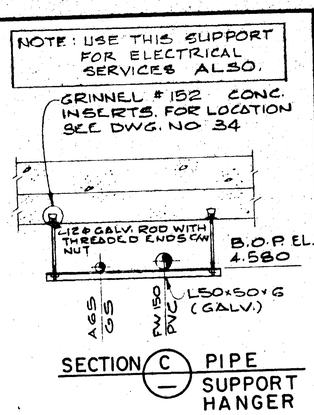


C PLAN OF SERVICE CONNECTIONS TO KIOSKS NO.1 & 2
1:200

SCHEMATIC DETAIL OF PIPING
NTS

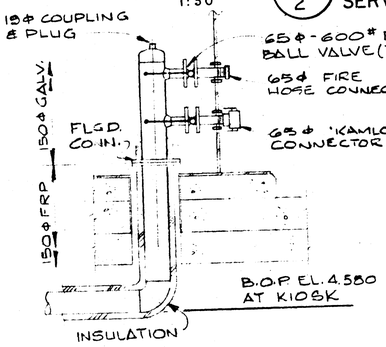
DETAIL 1 — TYPICAL PIPE SLEEVE THROUGH SHEET PILING
1:10



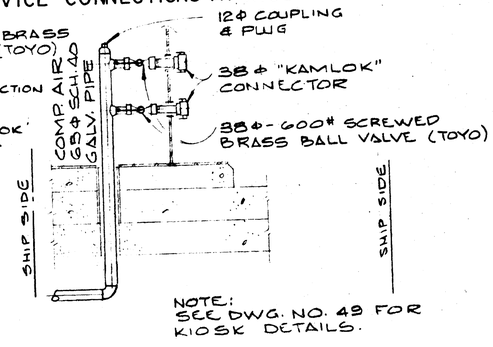


SECTION C — PIPE SUPPORT HANGER

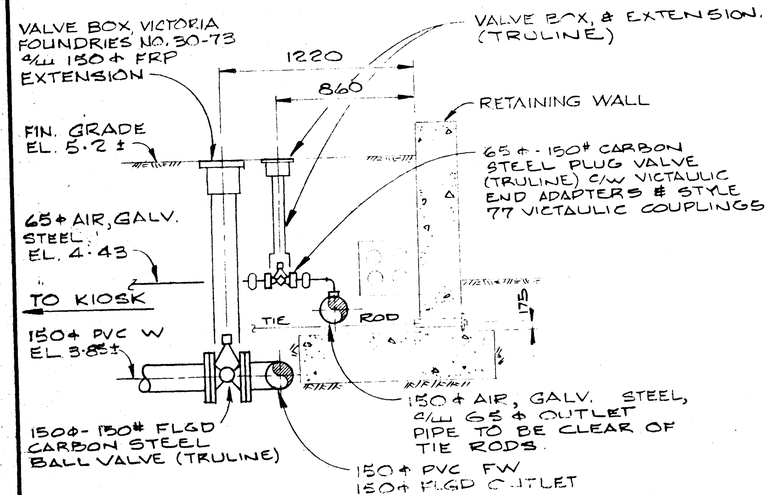
C DETAIL 6/2 — PLAN OF COMPRESSED AIR & FRESH WATER SERVICE CONNECTIONS AT KIOSK 2
1:50



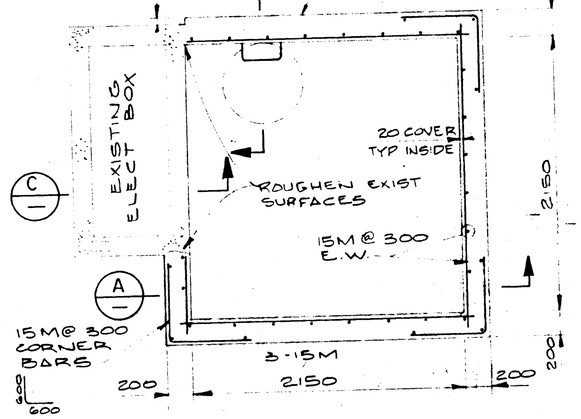
C SECTION A — 150ø FRESH WATER (TYP)
1:20



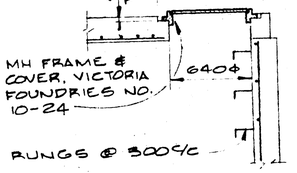
C SECTION B — 65ø COMPRESSED AIR (TYPICAL)
1:20

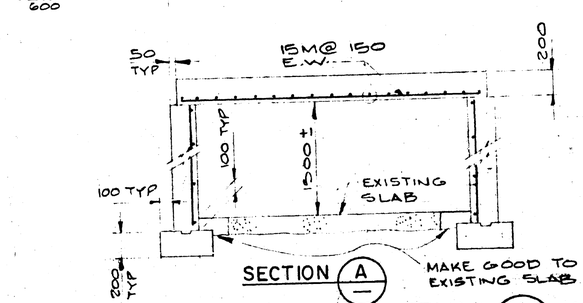


C DETAIL 2 — SERVICE TAKE-OFFS FOR KIOSKS NO. 3 & 4
1:20



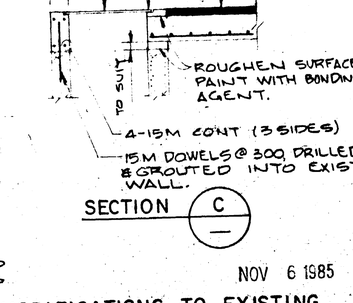
SECTION B — MANHOLE





SECTION A

NOTE
EXISTING METER & PIPING UNTOUCHED

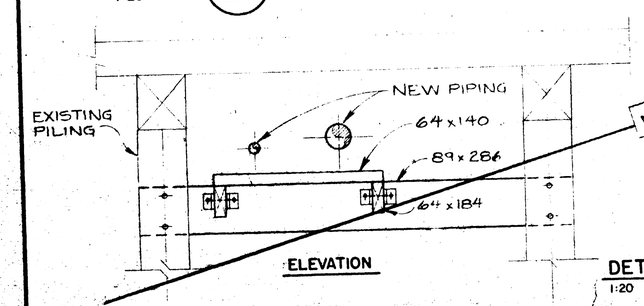


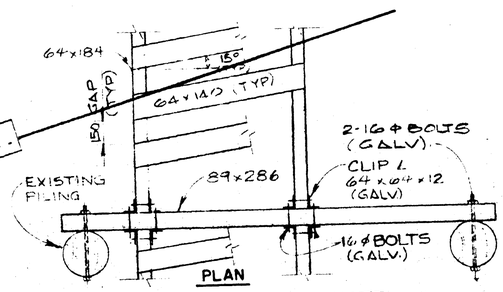
SECTION C

C DETAIL 4/2 — MODIFICATIONS TO EXISTING METERING CHAMBER
1:25

NOV 6 1985

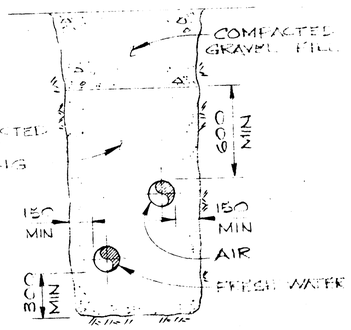
NOTE
1) FOR GENERAL NOTES & LEGEND SEE DWG. NO. 1





DETAIL 5 — PIPE PROTECTION FOR PIPING UNDER WHARF
1:20

NOTE:
TYPICAL ALSO FOR ELECT. DUCTS.



DETAIL 3 — TYPICAL PIPE BEDDING
1:20

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

"BC041441"

revisions		date
C	AS-BUILT	JULY 1985
B	75ø WATER TO S. SUB-STATION	DEC 1984
A	CRANE PADS 283 DELETED	SEPT. 11/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B C
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO FRESH WATER & COMPRESSED AIR SYSTEMS
PIPING DETAILS
SHEET 2 OF 2

designed PM / conçu
date MARCH 1984
drawn DG / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR100772
drawing no. / no. du dessin
6 OF 75- C

PWC A1

NOTES

1) FOR GENERAL NOTES & LEGEND, SEE DWG NO. 1

PARKING

STONE WALL

EXISTING PUMPING STATION FOR CONNECTIONS TO EXISTING PUMP, SEE DWG NO. 9

EXISTING PIPING TO BE REMOVED & NEW PIPING INSTALLED AS DETAILED ON DWG NO. 9

EXISTING TUNNEL

BW 200 ERPE

BW 65 FRP

BW 65 FRP

INSTALL OUTLETS AS PER DETAIL 1/9

INSTALL NEW SERVICE LEADS IN EXISTING PIPE GALLERY

65

100

GRAVING DOCK

SEE ADJOINING DWG NO 8

PLAN
1:500

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
PETER MADOME

revisions | | date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project *BC041442* projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing dessin

IMPROVEMENTS TO BALLAST WATER SYSTEM

PLAN OF WEST PART OF GRAVING DOCK
(NOT IN CONTRACT 3)

designed TB conçu
date MARCH 1984
drawn DG dessiné
date MARCH 1984
reviewed examiné
date
approved approuvé
date
Tender Soumission
PWC Project Manager 84/05/17 Administrateur de projets TPC

project number no. du projet
PR 100772

drawing no. no. du dessin
7 OF 75

PWC A1

NOTES

1) FOR GENERAL NOTES & LEGEND, SEE DWG NO. 1

EXISTING PIPE GALLERY

BW 65 FRP

INSTALL 65ϕ OUTLET SEE DETAIL 1/9

GRAVING DOCK

SEE ADJOINING DWG NO 7

RETAINING WALL

RIGHT OF WAY

FENCE

LIGHT

TRANSFORMER

PARKING

PILGRIM COVE

PLAN
1:500

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

PWC AI

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
PETER MALONE

revisions | | date

A detail no. no. du détail
B location drawing no. sur dessin no
C drawing no. dessin no

project "BC041443" projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B C
CONTRACT NO. 3

drawing dessin

IMPROVEMENTS TO BALLAST WATER SYSTEM

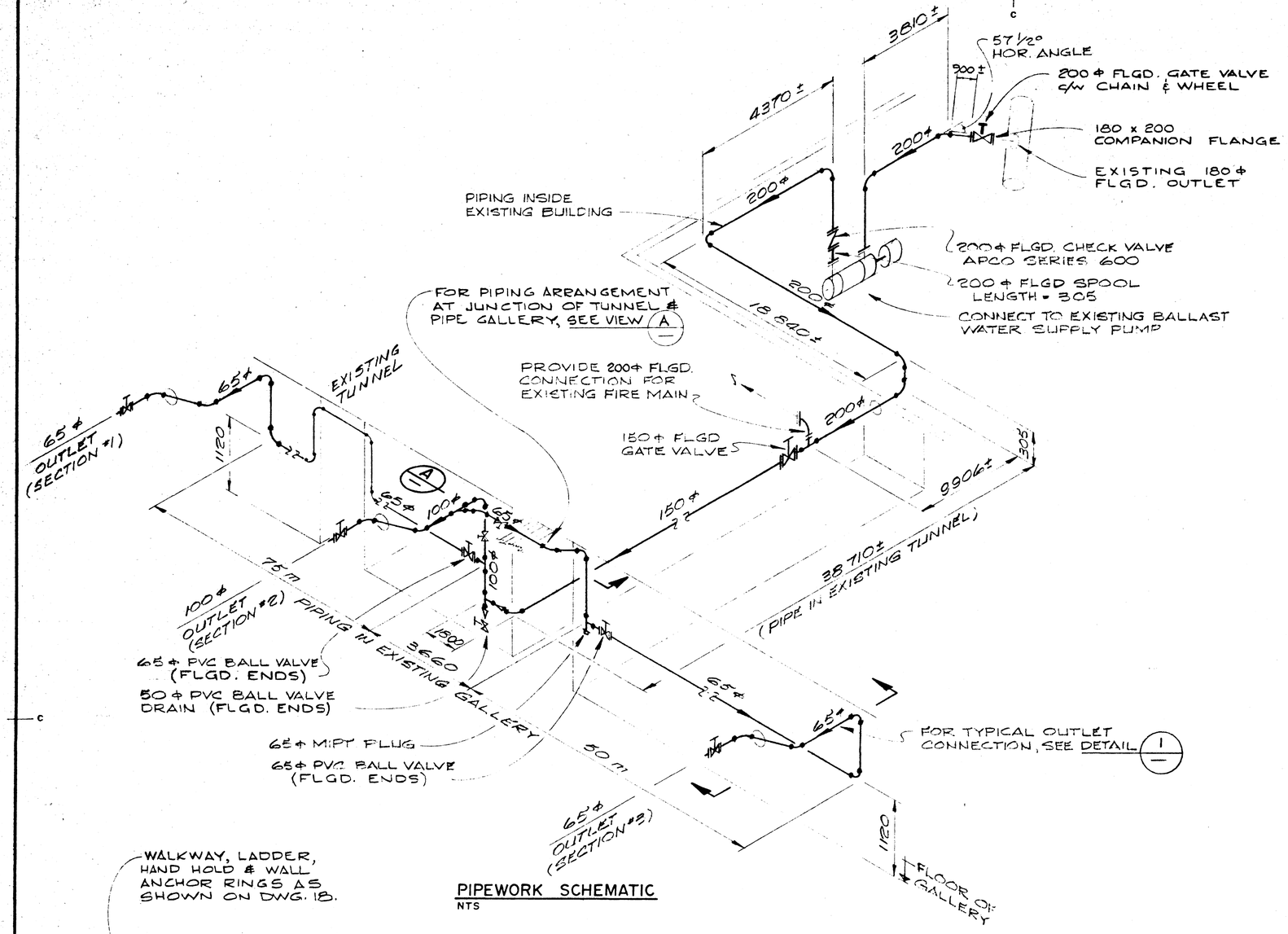
PLAN OF EAST PART OF GRAVING DOCK
(NOT IN CONTRACT 3)

designed TB conçu
date MARCH 1984
drawn DG dessiné
date MARCH 1984
reviewed examiné
date
approved approuvé
date
Tender Soumission
PWC Project Manager Administrateur de projets TPC

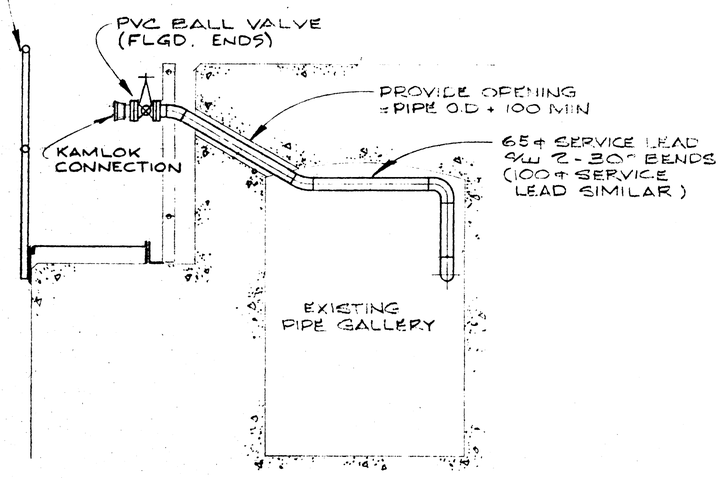
project number no. du projet
PR 100772

drawing no. no. du dessin
8 OF 75

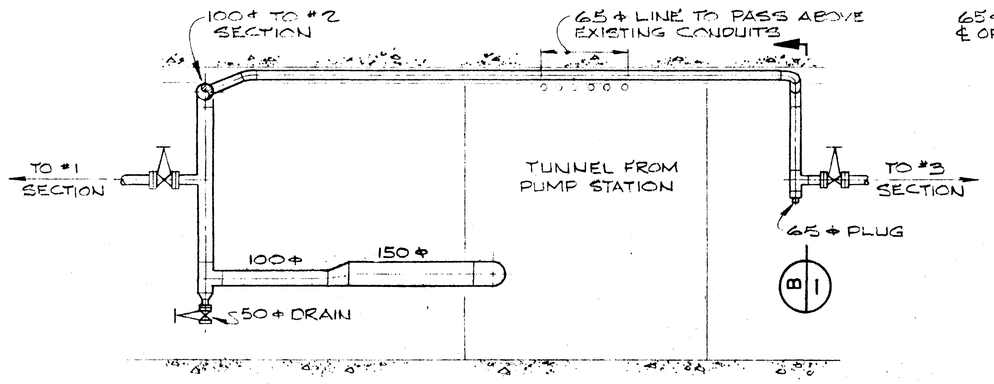
NOTES
1) FOR GENERAL NOTES & LEGEND, SEE DWG NO 1

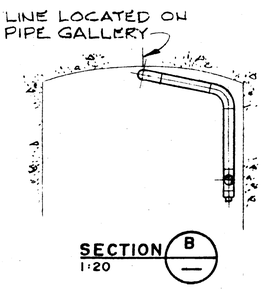


PIPEWORK SCHEMATIC
NTS



DETAIL 1 (1:20) 7,8 TYPICAL OUTLET





SECTION B (1:20)

VIEW A (1:20) PIPEWORK ARRANGEMENT AT JUNCTION OF TUNNEL & PIPE GALLERY

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER ALAN ONE

revisions | date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project *"BC041444"* projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO.3

drawing dessin

IMPROVEMENTS TO BALLAST WATER SYSTEM
PIPEWORK DETAILS
(NOT IN CONTRACT 3)

designed TB conçu
date MARCH 1984
drawn DG dessiné
date MARCH 1984
reviewed examiné
date
approved approuvé
date
Tender Soumission
PWC Project Manager Administrateur de projets TPC

project number no. du projet
PR 100772

drawing no. no. du dessin
9 OF 75

PWC A1

NOTES
1) FOR GENERAL NOTES & LEGEND, SEE DWG NO. 1

PARKING

STONE WALL

EXISTING PUMPHOUSE & COMPRESSOR BUILDING

NEW TELECOM CABLE

GRAVING DOCK

NO. 1 SECTION

NO. 2 SECTION

3 OUTLETS @ 35 m± TYPICAL FOR 3 SECTIONS OF GRAVING DOCK

WALKWAY SEE DETAIL 2/18

SEE DETAIL 1/18

65 ø

100 ø

A 150 GS

NEW TELECOM CABLE

32 ø SERVICE CONNECTION SEE DETAIL 4/5

32 ø SERVICE CONNECTION SEE DETAIL 3/5

RETAINING WALL

SERVICE TAKEOFFS SEE DETAIL 2/6

BURIED SECTION (TYPICAL)

SUSPENDED SECTION (TYPICAL)

NEW COMPRESSOR INSTALLED IN EXISTING SOUTH SUB-STATION

SEE DETAIL 1/6

A65 GS

FUTURE EXTENSION

WEST INFILL AREA

EAST INFILL AREA

NEW CONCRETE WHARF

100 ø BLIND FLANGE FOR FUTURE EXTENSION

FUTURE A 100 GS N.I.C.

FUTURE A 65 GS N.I.C.

SOUTH LANDING WHARF

NEW CRANE PAD

NEW CRANE PAD N.I.C.

NEW CRANE PAD N.I.C.

2-38 ø CONNECTIONS TYPICAL - SEE DETAIL 6/6

FUTURE SERVICE KIOSK NO. 1

SERVICE KIOSK NO. 2

SERVICE KIOSK NO. 3 N.I.C.

SERVICE KIOSK NO. 4 N.I.C.

SEE ADJOINING DWG NO 11

PLAN
1:500

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

PWC A1

Public Works Canada / Travaux publics Canada

KER, PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

"BC041445"

revisions		date
C	AS - BUILT	JULY 26/85
B	AIR TO GRAVING DOCK	DEC 1984
A	CRANE PADS 2&3 DELETED	SEPT. 11/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.

CONTRACT NO. 3

drawing / dessin
NEW 860 kPa COMPRESSED AIR SYSTEM

PLAN OF SOUTH LANDING WHARF & WEST PART OF GRAVING DOCK

designed TB / conçu
date MARCH 1984
drawn DG / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
84/05/15

project number / no. du projet
PR 100772

drawing no. / no. du dessin
10 OF 75 - C

NOTE

1) FOR GENERAL NOTES & LEGEND, SEE DWG. NO. 1

SEE ADJOINING DWG. NO. 10

GRAVING DOCK

NO. 2 SECTION

NO. 3 SECTION

OUTLET SEE DETAIL 1/18

WALKWAY SEE DETAIL 2/18

65 ø 65 ø 100 ø 65 ø

A 150 GS

RETAINING WALL

RIGHT OF WAY

NEW TELECOM CABLE

FENCE

LIGHT

BOUNDARY

TRANSFORMER

PARKING

PILGRIM COVE

PLAN
1:500

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

PWC AI

Public Works Canada / Travaux publics Canada

KER, PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT

FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

"BC041446"

revisions		date
A	AS BUILT	JULY 26/85

A detail no. no. du détail
B location drawing no sur dessin no
C drawing no dessin no

project / projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.

CONTRACT NO. 3

drawing / dessin

NEW 860 kPa COMPRESSED AIR SYSTEM

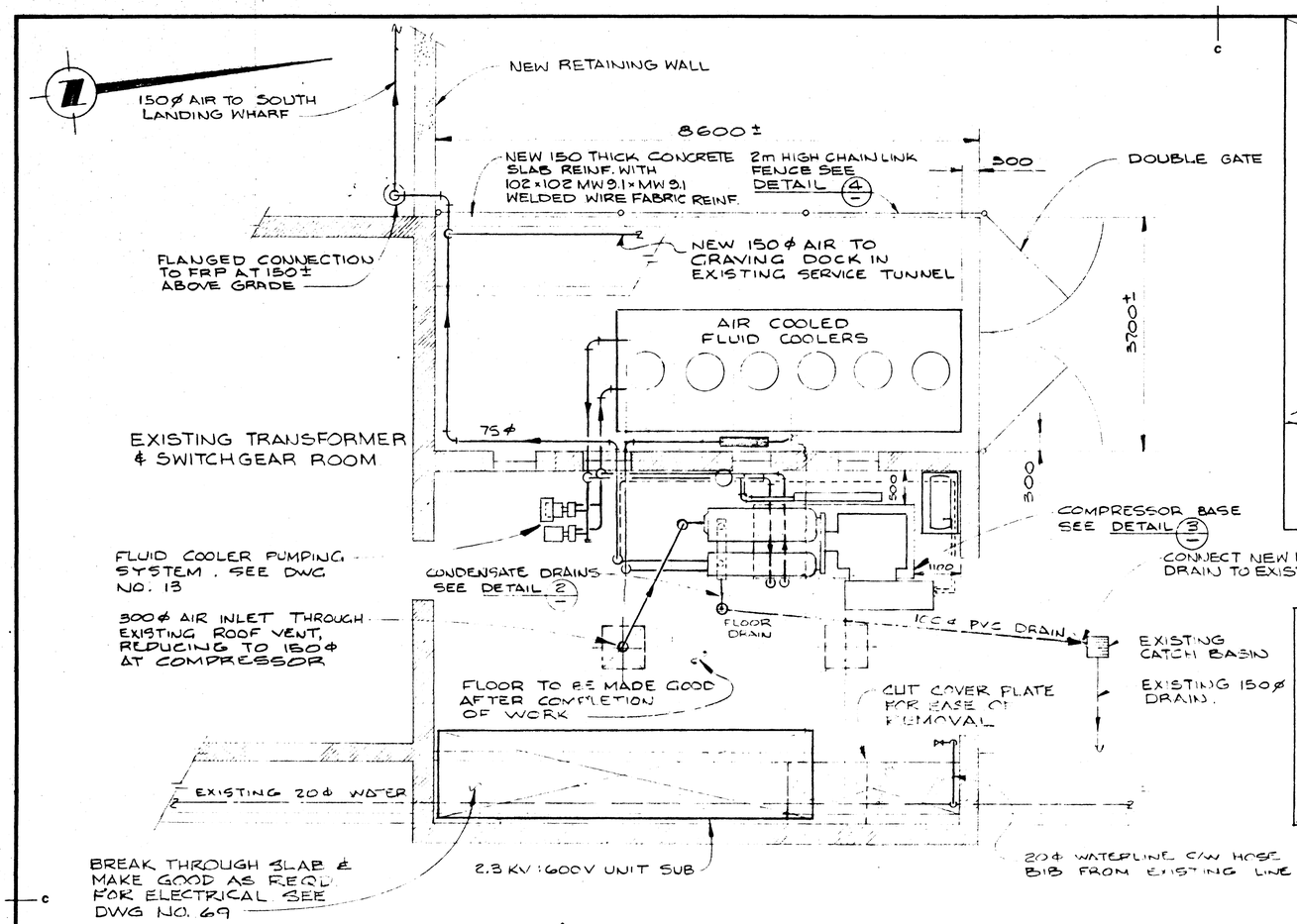
PLAN OF EAST PART OF GRAVING DOCK

designed	TB	conçu
date	MARCH 1984	
drawn	DG	dessiné
date	MARCH 1984	
reviewed		examiné
date		
approved		approuvé
date		

Tender / Soumission
PWC Project Manager — Administrateur de projets TPC — 87/8/15

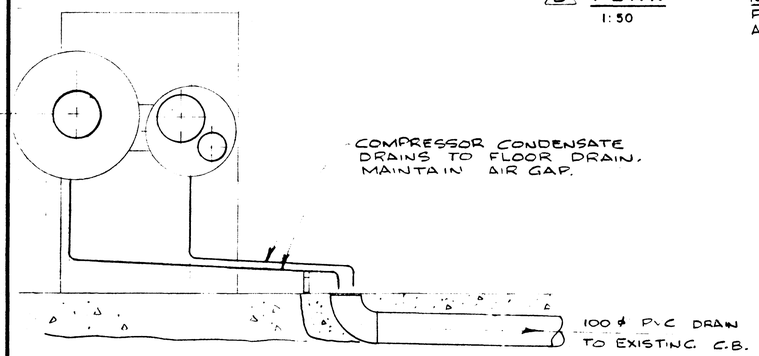
project number / no. du projet: PR100772

drawing no. / no. du dessin: 11 OF 75 A

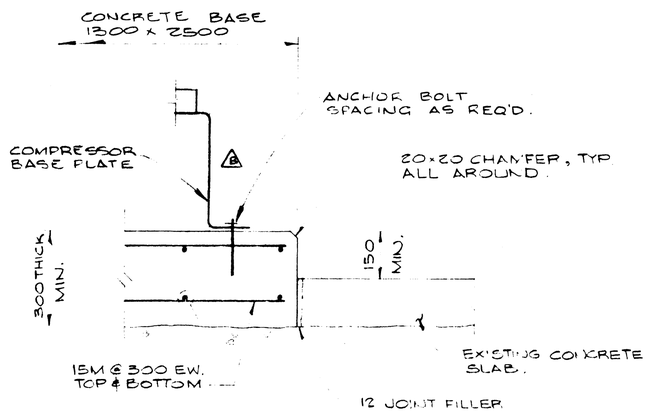


B PLAN
1:50

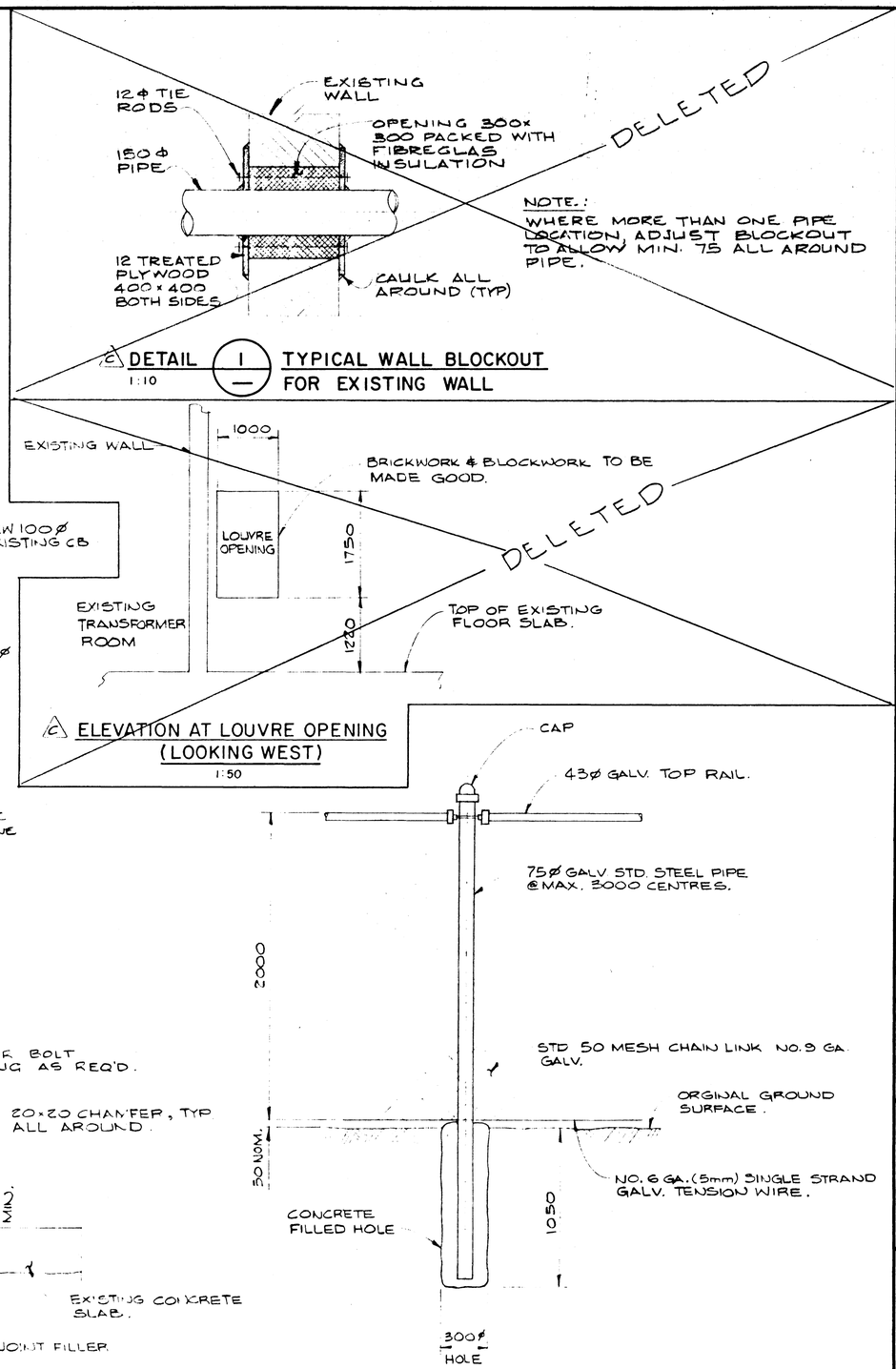
NOTE:
FOR COMPRESSOR PIPING SCHEMATIC AND OTHER DETAILS, SEE DWG NO. 13



B DETAIL 2 CONDENSATE DRAIN
1:10



DETAIL 3 CONCRETE BASE FOR COMPRESSOR
1:10



DETAIL 4 TYPICAL FENCE
1:20

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER, PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

May 31/84

BC041447

revisions		date
C	AS BUILT	OCT 1985
B	COMPRESSOR INSTALL'N	DEC 1984
A	REVISED AS PER ADDENDUM 4	SEPT. 12/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

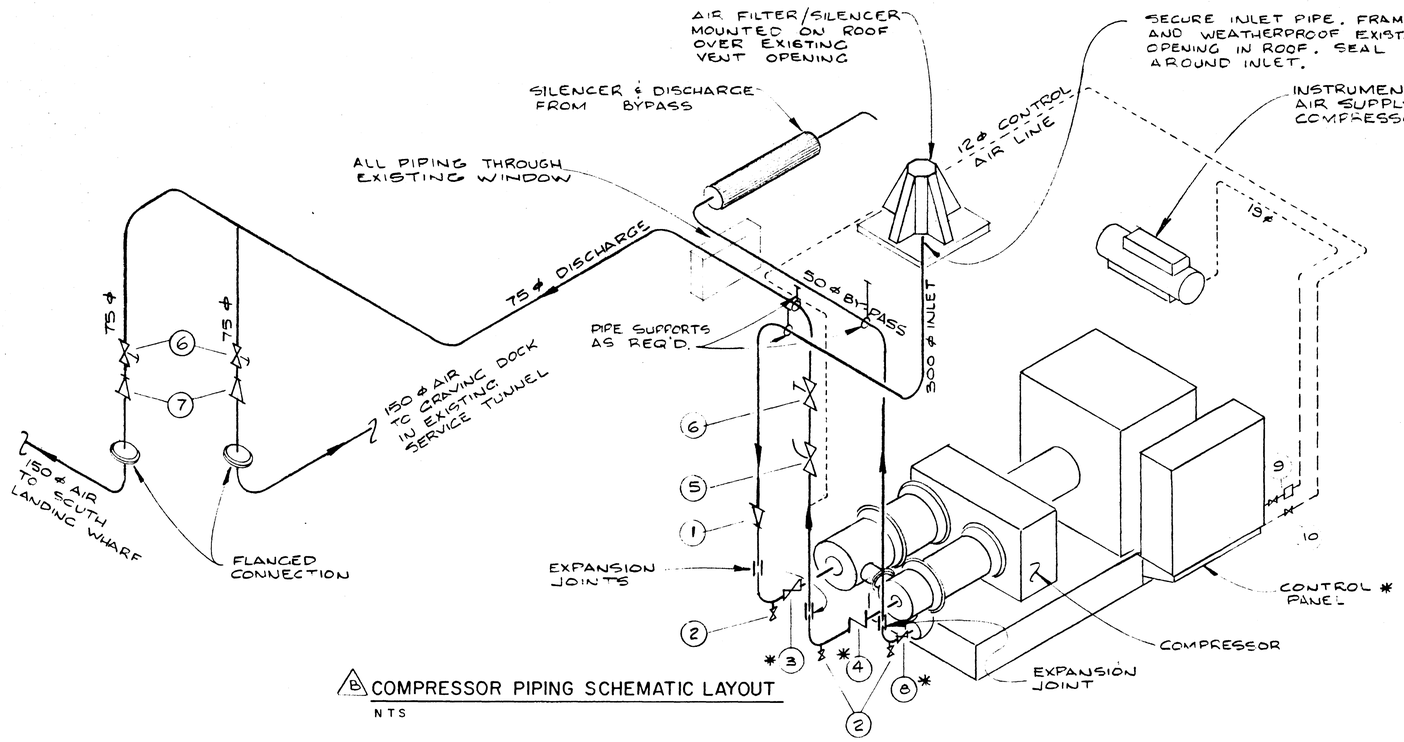
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B C

CONTRACT NO. 3

drawing / dessin
NEW 860 kPa COMPRESSED AIR SYSTEM
NEW COMPRESSOR INSTALLATION
GENERAL ARRANGEMENT

designed PM / conçu
date MAY 1984
drawn GHP / dessiné
date MAY 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
12 OF 75-C

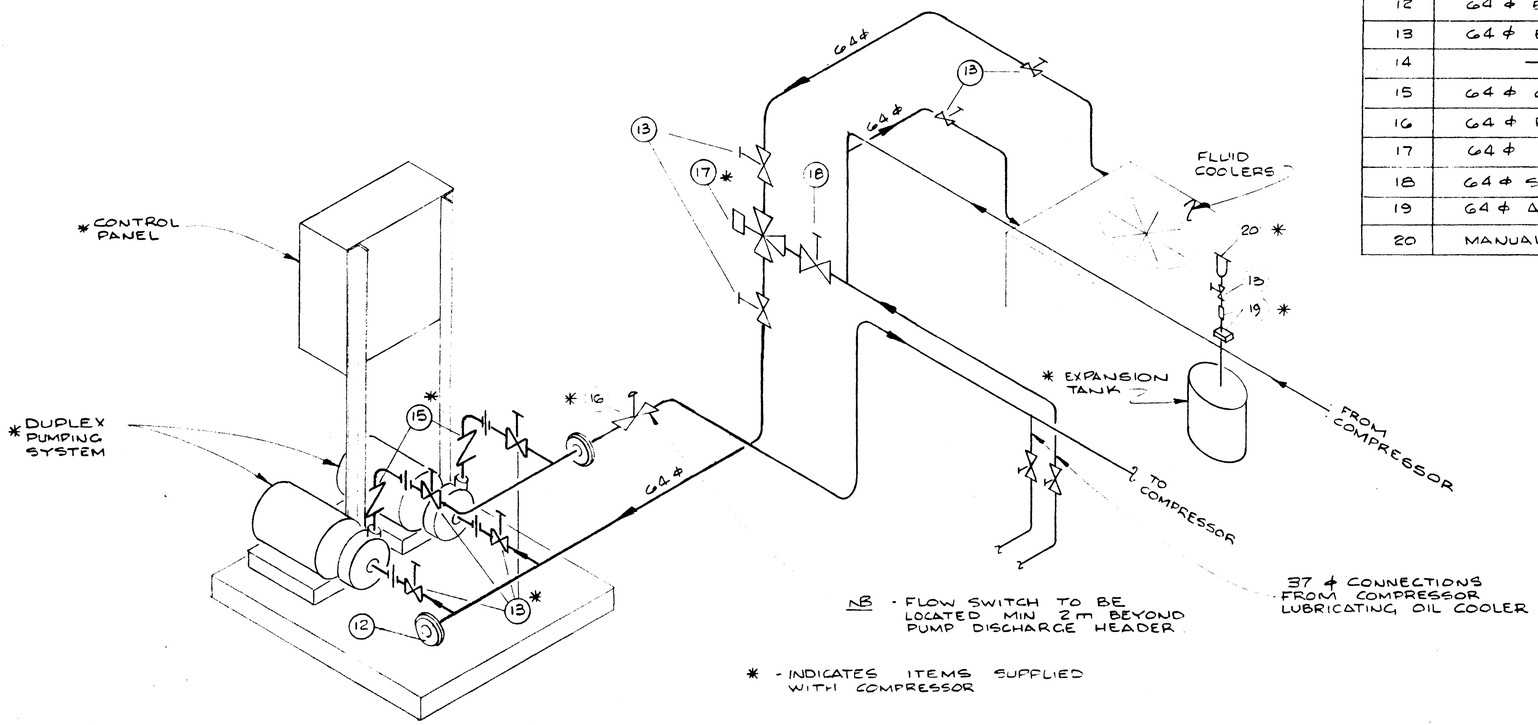
PWC AI



B COMPRESSOR PIPING SCHEMATIC LAYOUT

NTS

ITEM	DESCRIPTION
1	300 x 150 REDUCER
2	12 ϕ CONDENSATE DRAIN VALVE
3	150 ϕ THROTTLE VALVE
4	75 ϕ CHECK VALVE
5	75 ϕ SAFETY VALVE
6	75 ϕ BALL VALVE
7	75 x 150 INCREASER
8	50 ϕ BYPASS VALVE
9	19 ϕ AIR FILTER & GLOBE VALVE
10	12 ϕ GLOBE VALVE
12	64 ϕ BLIND FLANGE
13	64 ϕ BALL VALVE
14	—
15	64 ϕ CHECK VALVE
16	64 ϕ FLOW SWITCH
17	64 ϕ 3-WAY VALVE
18	64 ϕ SHUT OFF BALANCING VALVE
19	64 ϕ AIR PURGE & AUTOMATIC AIR BLEED
20	MANUAL FILL POINT & AIR BLEED



NB - FLOW SWITCH TO BE LOCATED MIN 2m BEYOND PUMP DISCHARGE HEADER

* - INDICATES ITEMS SUPPLIED WITH COMPRESSOR

B FLUID COOLER PUMPING SYSTEM SCHEMATIC LAYOUT

NTS

NOV 6 1985

PWC A1

Public Works Canada / Travaux publics Canada

KER, PRIESTMAN & ASSOCIATES LTD.
consulting engineers.
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

BC041448

revisions		date
B	AS BUILT	OCT 1985
A	REDRAWN	DEC 1984

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B C

CONTRACT NO. 3

drawing / dessin
NEW 860 kPa COMPRESSED AIR SYSTEM

NEW COMPRESSOR INSTALLATION

MECHANICAL DETAILS

designed / conçu
date
drawn / dessiné
date
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
13 OF 75 - B

PILE LAYOUT - BENT

PILE NO.	PILE LENGTH (m)	PILE TIP ELEVATION (m)
A-1	30.14	-25.69
B-1	31.36	-26.91
C-1	32.68	-28.23
D-1	33.99	-29.54
E-1	35.77	-31.32
F-1	37.49	-33.04
G-1	37.20	-32.75
H-1	38.30	-34.70
I-1	39.01	-35.41
F-1.5	36.60	-32.15
H-1.5	39.64	-36.04
A-2	29.11	-24.66
B-2	30.84	-26.39
C-2W	33.35(B)	-27.49
C-2E	38.92(B)	-33.05
D-2W	36.46(B)	-30.43
D-2E	42.02(B)	-36.02
E-2W	36.31(B)	-30.30
E-2E	42.51(B)	-36.48
F-2	36.01	-31.56
G-2	37.04	-32.59
H-2	38.64	-35.04
I-2	38.66	-35.06
F-2.5	36.48	-31.98
H-2.5	39.21	-35.56
A-3	27.88	-23.43
B-3	30.35	-25.90
C-3	30.32	-25.87
D-3	33.94	-29.49
E-3	34.69	-30.24
F-3	35.85	-31.40
G-3	36.81	-32.36
H-3	38.94	-35.34
I-3	39.20	-35.60
F-3.5	36.77	-32.32
H-3.5	39.25	-34.80
B-4N	31.63(B)	-25.55
B-4S	32.07(B)	-25.97
C-4N	19.26(B)	-13.82
C-4S	38.82(B)	-32.86
D-4W	33.73(B)	-28.57
D-4E	40.62(B)	-34.39
E-4W	43.84(B)	-38.08
E-4E	42.14(B)	-35.53
F-4N	41.92(B)	-35.32
F-4S	38.39(B)	-31.97
G-4N	44.53(B)	-37.80
G-4S	38.42(B)	-32.77
H-4N	43.60(B)	-36.61
H-4S	41.97(B)	-36.22
I-4N	43.32(B)	-37.49
I-4S	44.95(B)	-39.04
B-5N	30.22(B)	-24.22
B-5S	33.73(B)	-27.54
C-5N	33.15(B)	-27.00
C-5S	34.65(B)	-28.42
D-5W	34.19(B)	-29.02
D-5E	37.89(B)	-32.61
B-6	27.13	-22.68
C-6N	32.73(B)	-26.60
C-6S	32.23(B)	-26.12
D-6W	32.18(B)	-26.08
D-6E	37.57(B)	-32.26
B-7	26.86	-22.41
C-7	30.88	-26.43
D-7	29.62	-25.17
B-8	27.61	-23.16
C-8	27.59	-23.11
D-8W	35.28(B)	-27.42
D-8E	35.72(B)	-29.74
B-9	28.29	-23.84
C-9	27.89	-23.44
D-9W	40.82(B)	-34.58
D-9E	31.74(B)	-26.06
B-10	32.48	-28.03
C-10	28.46	-24.01
D-10	30.38	-25.93
B-11	37.07	-32.62
C-11W	36.99(B)	-32.84
C-11E	16.51(B)	-11.51
D-11W	38.60(B)	-32.47
D-11E	33.12(B)	-27.27
B-12	35.36	-30.91
C-12	30.46	-26.01
D-12	32.05	-27.60

(B) - Denotes Batter Pile

PILE LAYOUT - BENT

PILE NO.	PILE LENGTH (m)	PILE TIP ELEVATION (m)
B-13	19.82	-15.37
C-13	30.96	-26.53
D-13	32.86	-28.41
B-14	27.99	-23.54
C-14W	16.72(B)	-11.71
C-14E	34.88(B)	-29.19
D-14W	31.07(B)	-25.33
D-14E	36.79(B)	-31.02
B-15	28.89	-24.83
C-15	32.25	-27.90
D-15	34.68	-30.23
B-16N	29.70(B)	-23.73
B-16S	31.43(B)	-25.37
C-16N	33.40(B)	-27.24
C-16S	33.01(B)	-28.02
D-16W	31.11(B)	-26.03
D-16E	38.40(B)	-32.28
B-17N	29.21(B)	-23.26
B-17S	32.04(B)	-25.95
C-17N	31.17(B)	-25.12
C-17S	33.17(B)	-27.02
D-17W	31.10(B)	-26.02
D-17E	36.88(B)	-31.63
B-18	28.96	-24.51
C-18N	36.70(B)	-30.37
C-18S	34.42(B)	-28.20
D-18W	31.48(B)	-25.71
D-18E	36.93(B)	-31.94
B-19	30.90	-26.45
C-19	35.01	-30.56
D-19	35.65	-31.20
B-20	31.47	-27.02
C-20	35.50	-31.05
D-20W	47.97(B)	-41.36
D-20E	32.83(B)	-27.00
B-21	31.48	-27.03
C-21	34.23	-29.78
D-21W	41.08(B)	-34.82
D-21E	34.25(B)	-28.34
B-22	32.61	-28.36
C-22	34.59	-29.94
D-22	37.11	-32.66
B-23	31.95	-27.50
C-23W	43.25(B)	-36.88
C-23E	30.69(B)	-24.97
D-23W	42.61(B)	-36.27
D-23E	32.91(B)	-26.22
B-24	33.59	-29.14
C-24	35.96	-31.51
D-24	40.12	-35.67

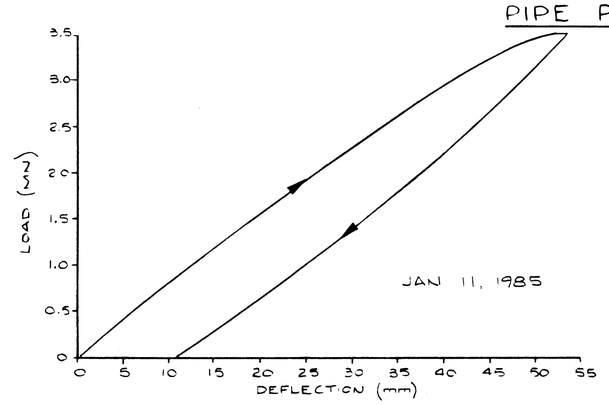
(B) - Denotes Batter Pile

PILE LAYOUT - BENT

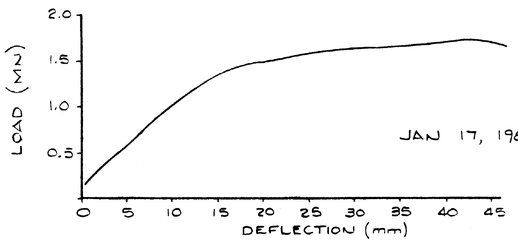
PILE NO.	PILE LENGTH (m)	PILE TIP ELEVATION (m)
B-25	30.38	-25.93
C-25	35.79	-31.34
D-25	39.54	-35.09
B-26	33.18	-28.73
C-26W	31.69(B)	-25.91
C-26E	43.36(B)	-37.29
D-26W	35.12(B)	-29.17
D-26E	41.90(B)	-35.90
B-27	31.01	-26.56
C-27	35.00	-30.55
D-27	38.26	-33.83
B-28N	27.72(B)	-21.85
B-28S	31.53(B)	-25.46
C-28N	30.15(B)	-24.15
C-28S	34.40(B)	-28.18
D-28W	33.03(B)	-27.89
D-28E	38.89(B)	-32.74
B-29N	35.42(B)	-29.15
B-29S	30.53(B)	-24.51
C-29N	28.95(B)	-23.01
C-29S	34.99(B)	-28.74
D-29W	30.83(B)	-25.76
D-29E	34.91(B)	-29.72
B-30	28.05	-23.60
C-30N	28.48(B)	-22.57
C-30S	32.65(B)	-26.52
D-30W	28.88(B)	-23.25
D-30E	36.48(B)	-31.50
B-31	27.37	-22.92
C-31	30.35	-25.90
D-31	30.32	-25.87
B-32	27.86	-23.41
C-32	26.82	-22.37
D-32W	36.24(B)	-30.23
D-32E	27.12(B)	-21.58
B-33	26.43	-21.70
C-33	27.52	-23.07
D-33W	31.51(B)	-25.74
D-33E	26.06(B)	-20.57
B-34	27.43	-22.98
C-34	28.11	-23.66
D-34	23.28	-18.83
B-35	29.08	-24.63
C-35W	25.52(B)	-20.06
C-35E	24.87(B)	-19.44
D-35W	27.13(B)	-21.59
D-35E	25.84(B)	-20.36

(B) - Denotes Batter Pile

PIPE PILE TEST RESULTS

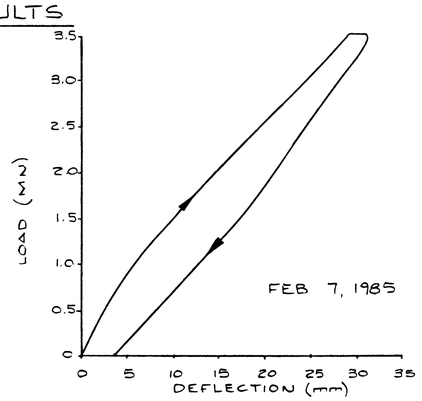


COMPRESSION

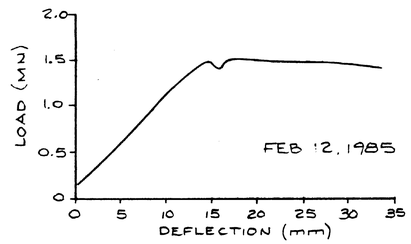


TENSION

LOAD TESTS OF PILE ON LINE H BETWEEN LINES 1 AND 2



COMPRESSION



TENSION

LOAD TESTS OF SPECIAL TEST PILE DRIVEN BETWEEN LINES B AND C, LINES 24 AND 25 (PILE LENGTH = 31.5 m, TIP ELEVATION = -26.3 m)

LOAD TEST NOTES

1) METHOD OF TENSION TESTING 'CONSTANT RATE OF PENETRATION' TO ASTM D1143-74 AT REVERSE RATE OF 1.25 mm/ MINUTE UP TO FAILURE.

2) METHOD OF COMPRESSION TEST TO ASTM D1143-74 TO MAXIMUM LOAD OF 3.5 MN .

3) DISPLACEMENTS ARE AVERAGE READINGS OF TWO GAUGES (L.V.D.T) MOUNTED ONE EACH SIDE OF THE TEST PILE. RESULTS ARE AN AVERAGE EXCEPT WHERE ONE GAUGE WAS DISTURBED DURING TEST.

4) FIELD NOTE - PENETRATION RATE FOR JAN 17 TEST WAS HIGH AND UNEVEN. SOILS CONSULTANT RECOMMENDED AN ADHESION OF 12 kPa BASED ON THIS TEST (LETTER DATED FEB 5, 1985)

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

BC041449

revisions		date
A	AS-BUILT	JULY 1985

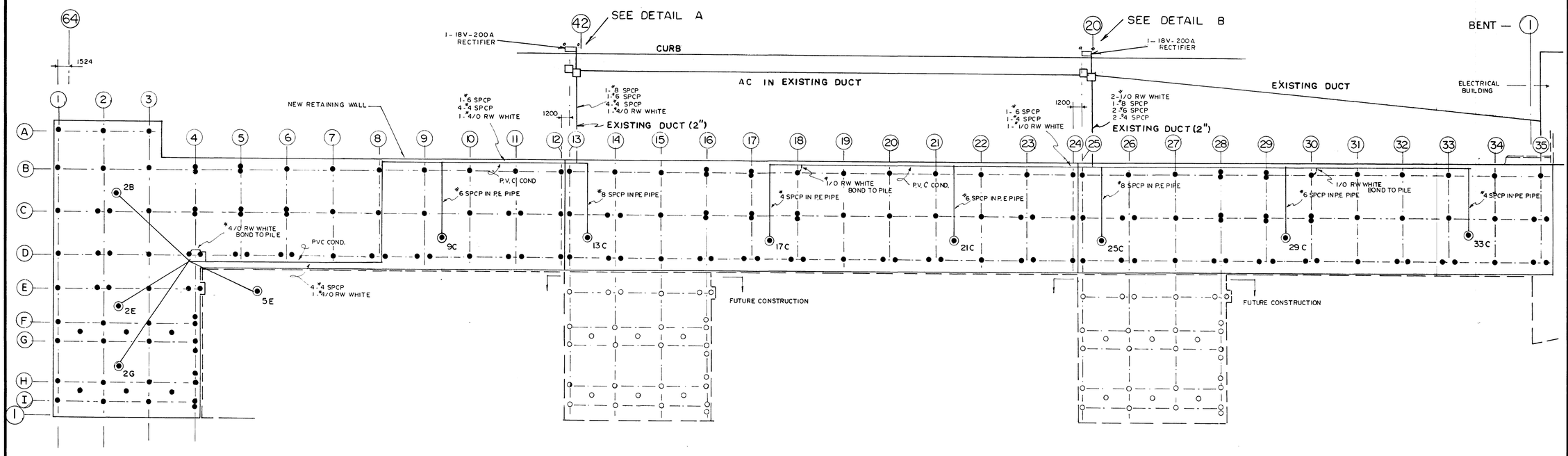
A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS & WHARF EXTENSION
PILE DRIVING INFORMATION

designed PM / conçu
date JULY 1985
drawn RN / dessiné
date JULY 1985
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR100772
drawing no. / no. du dessin
14 OF 75 A

PWC AI

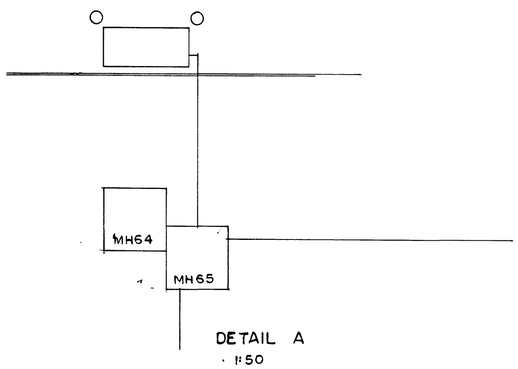


PLAN

1 : 300

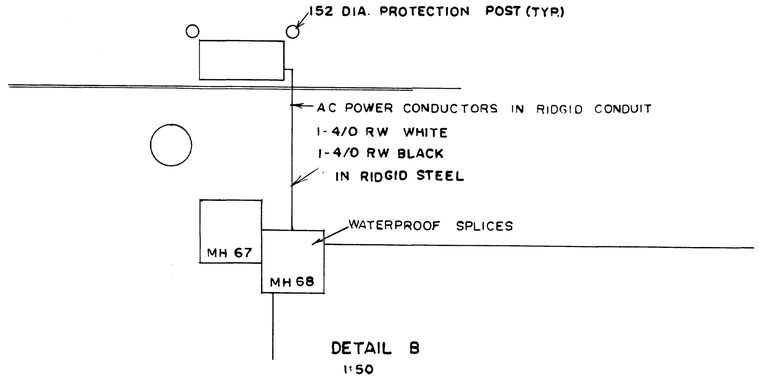
LEGEND

- LEAD SILVER ANODES
- STEEL PIPE PILE
- FUTURE PIPE PILE



DETAIL A

1:50



DETAIL B

1:50

Public Works Canada / Travaux publics Canada

revisions | | date

A detail no. / no. du détail
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

project / projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS

CONTRACT NO. 3

drawing / dessin

CATHODIC PROTECTION SYSTEM

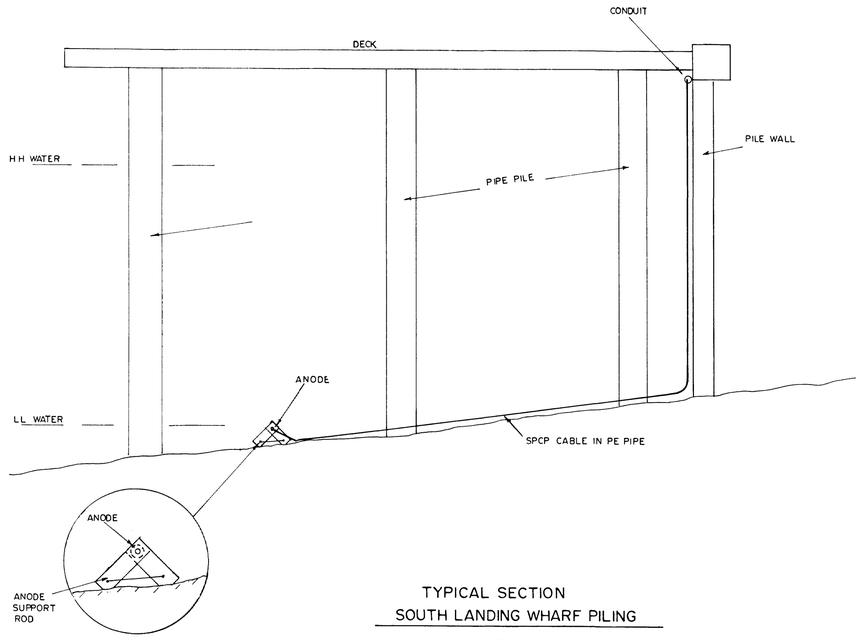
BC036962

designed	W. L. H	conçu
date	85 / 10 / 07	
drawn	G.V.D	dessiné
date	85 / 10 / 15	
reviewed		examiné
date		
approved		approuvé
date		
Tender		Soumission
PWC Project Manager		Administrateur de projets TPC

project number / no. du projet: PR. 100772

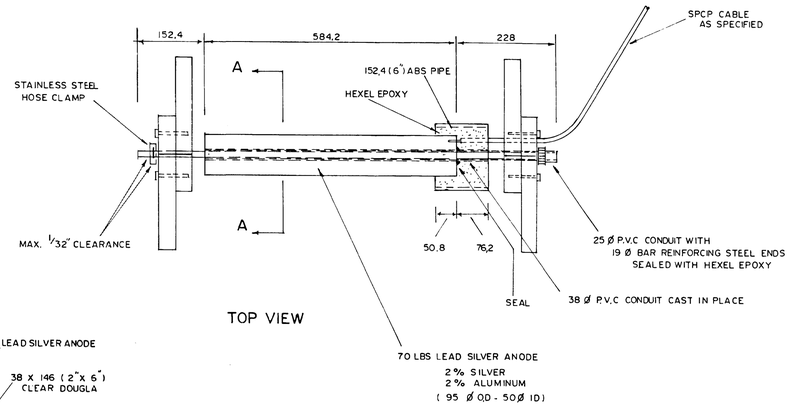
drawing no. / no. du dessin: 15 OF 75

PWC A1

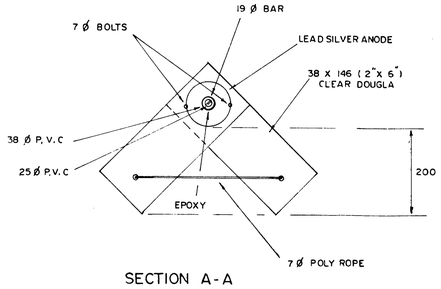


TYPICAL SECTION
SOUTH LANDING WHARF PILING

SCALE : N.T.S



TOP VIEW



SECTION A-A

DETAILS
ANODE ASSEMBLY

SCALE : 1 : 75

Public Works Canada / Travaux publics Canada

revisions | | date

A detail no. / no. du détail
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

project / projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS

CONTRACT NO. 3

drawing / dessin

DETAILS

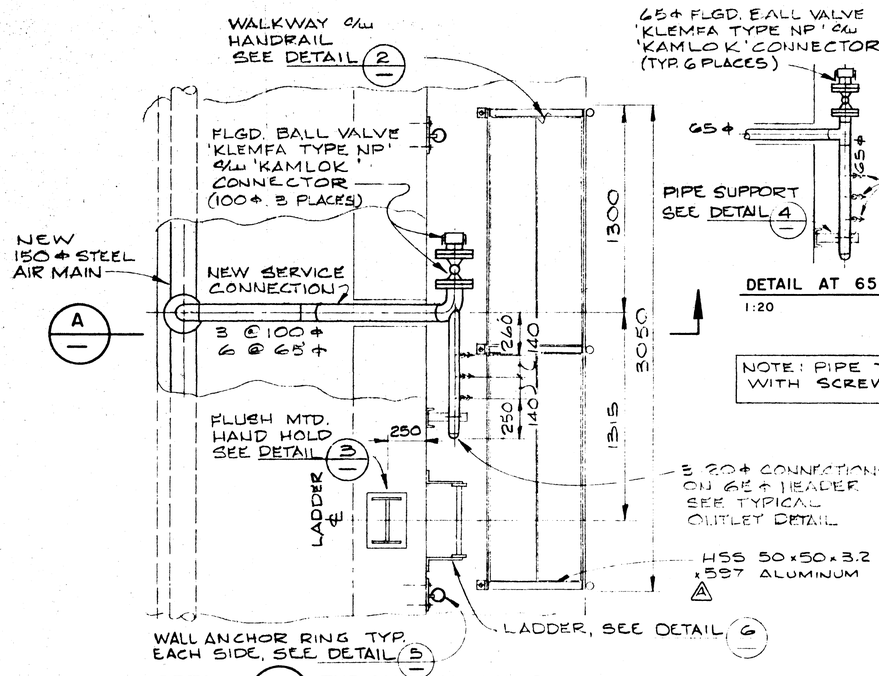
CATHODIC PROTECTION SYSTEM

BC036963

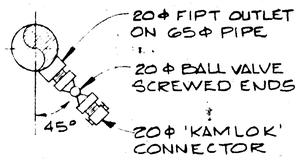
designed W.L.H / conçu
date 85/10/07
drawn G.V.D / dessiné
date 85/10/15
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR. 100772
drawing no. / no. du dessin
16 OF 75

PWC A1

NOTES
1) FOR GENERAL NOTES & LEGEND SEE DWG. NO. 1
2) ALL ALUMINUM TO BE T6061-T6 OR 5454 ALLOY



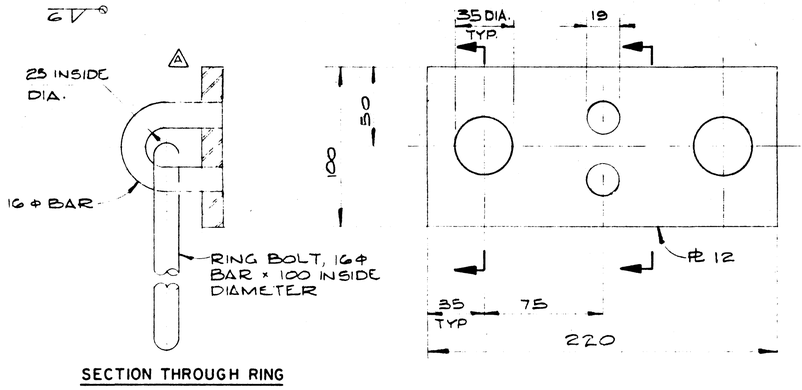
DETAIL 1 TYPICAL WALKWAY & SERVICE CONNECTION
1:20 10, 11



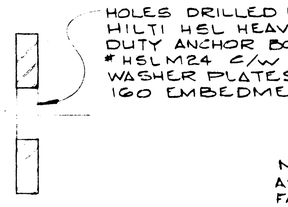
DETAIL AT 65ϕ BRANCH
1:20

TYPICAL OUTLET DETAIL
1:5

NOTE: PIPE TO BE GALV. STEEL WITH SCREWED FITTINGS



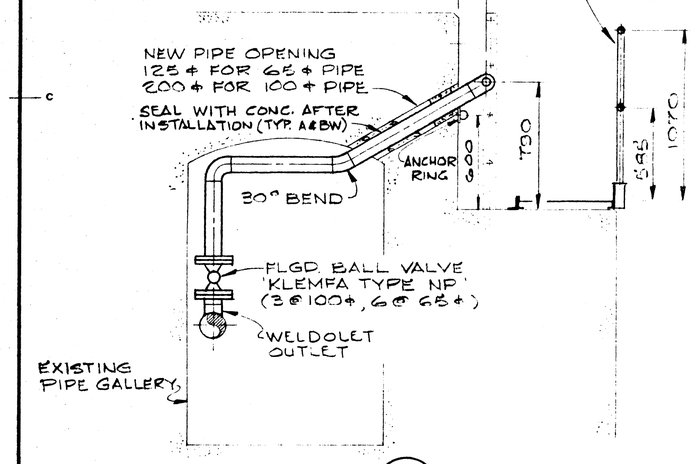
SECTION THROUGH RING



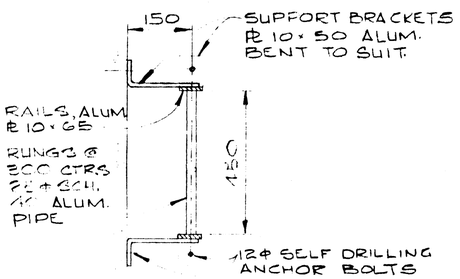
SECTION THROUGH PLATE

NOTE:
ASSEMBLY HOT DIPPED GALV. AFTER FABRICATION

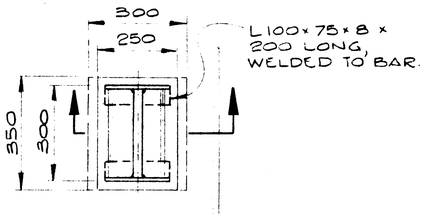
DETAIL 5 WALL ANCHOR RING
1:2 — 18 REQUIRED



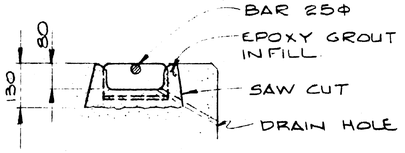
SECTION A
1:20



DETAIL 6 LADDER
1:10



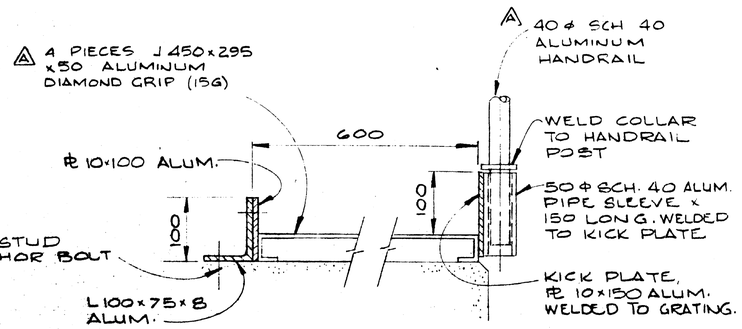
PLAN



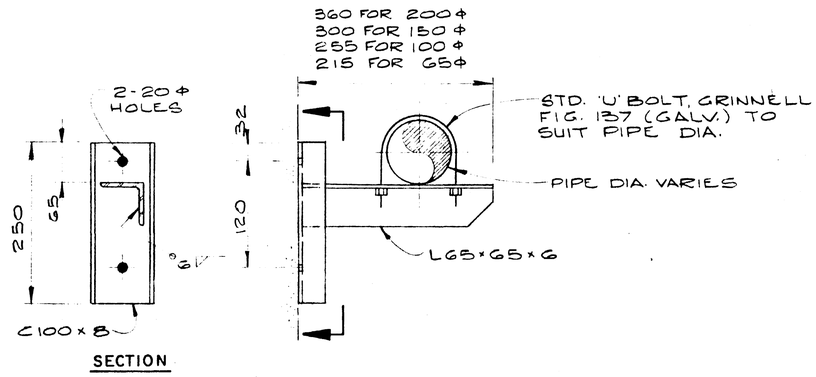
SECTION

NOTE:
HOT DIPPED GALV. AFTER FABRICATION

DETAIL 3 HAND HOLD
1:10 —



DETAIL 2 WALKWAY & HANDRAIL SUPPORT
1:5 9, 18



SECTION

NOTE:
BRACKET, HOT DIPPED GALV. AFTER FABRICATION

DETAIL 4 TYPICAL PIPE SUPPORT BRACKET
1:5 —

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

revisions		date
A	AS BUILT	JULY 26/85

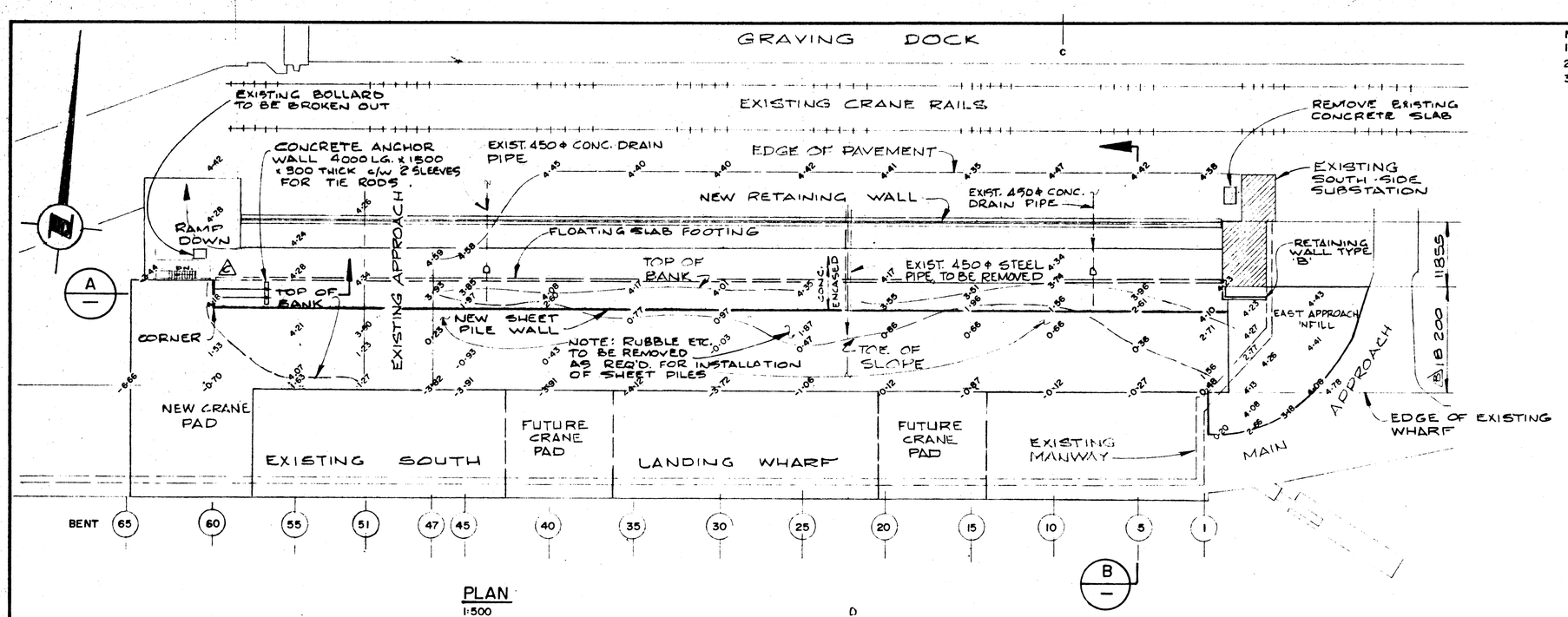
A detail no. no. du détail
B location drawing no. sur dessin no
C drawing no. dessin no

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B C
CONTRACT NO. 3

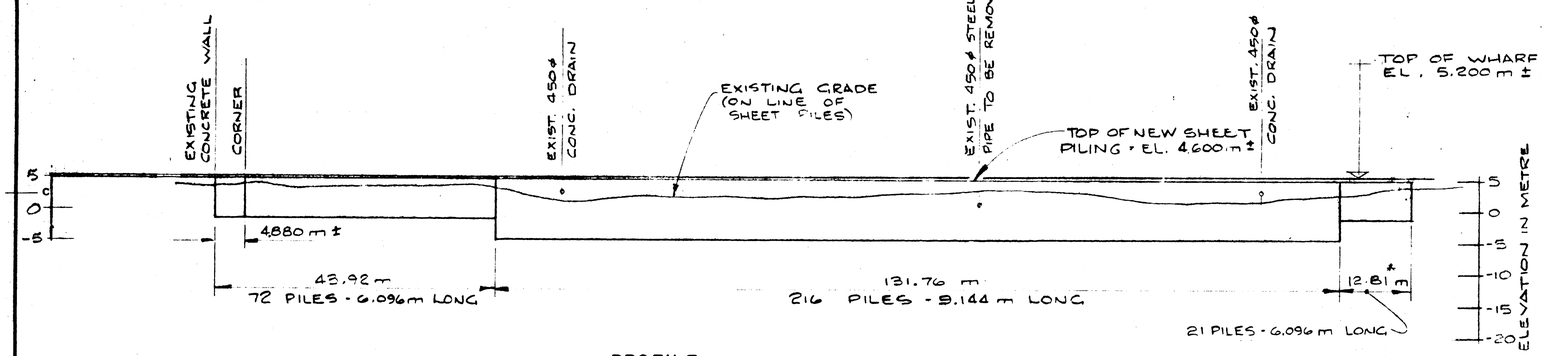
drawing / dessin
NEW 860 kPa COMPRESSED AIR SYSTEM
PIPING & MISCELLANEOUS DETAILS
"BC041450"

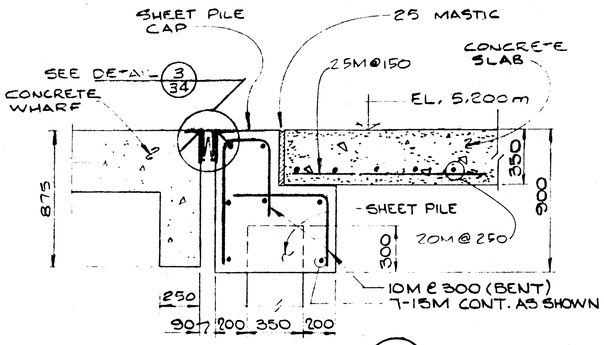
designed TB — concu
date MARCH 1984
drawn DG — dessiné
date MARCH 1984
reviewed — examiné
date
approved — approuvé
date
Tender — Soumission
PWC Project Manager — Administrateur de projets TPC
project number PR 100772
drawing no. 18 OF 75 — no. du dessin

PWC A1

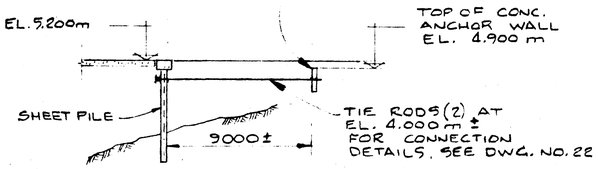


PLAN
1:500

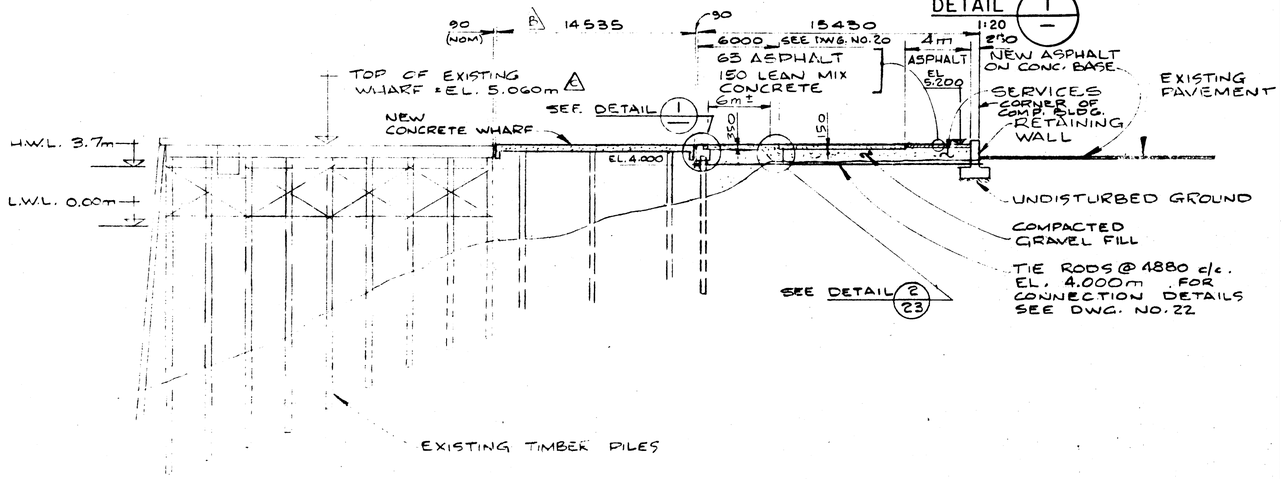




PROFILE
1:500 HOR & VERT



SECTION A
1:200



SECTION B BENT 5
1:200

SHEET PILE SCHEDULE	
PILES SUPPLIED BY OWNER : (CAPPCO K141Z)	121 @ 18.288 m 29 @ 6.096 m 2 @ 12.192 m 1 CORNER @ 12.192 m
PILES REQUIRED	OBTAIN FROM
72 @ 6.096 m *	29 @ 6.096 m 2 @ 12.192 m 13 @ 18.288 m
21 @ 6.096 m	CONTRACTOR TO PURCHASE
1 CORNER @ 6.096 m	1 CORNER @ 12.192 m
216 @ 9.144 m	108 @ 18.288 m

NOTES
1) FOR GENERAL NOTES & LEGEND, SEE DWG NO 1
2) EXISTING GRADE SPOT ELEVATION IN METRES SHOWN THUS 0.15
3) EXISTING TIMBER PILES AND EXISTING APPROACHWAY TO BE REMOVED FROM INFILL AREA.

NOV 6 1985

The Contractor shall confirm the actual location of all services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

revisions		date
C	AS BUILT	JULY 26/85
B	CRANE PADS 2&3 DELETED. DIMENSIONS ADDED	SEPT. 11/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
EAST INFILL AREA
GENERAL ARRANGEMENT

"BC041451"

designed PM / conçu
date MARCH 1984
drawn GHP / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC

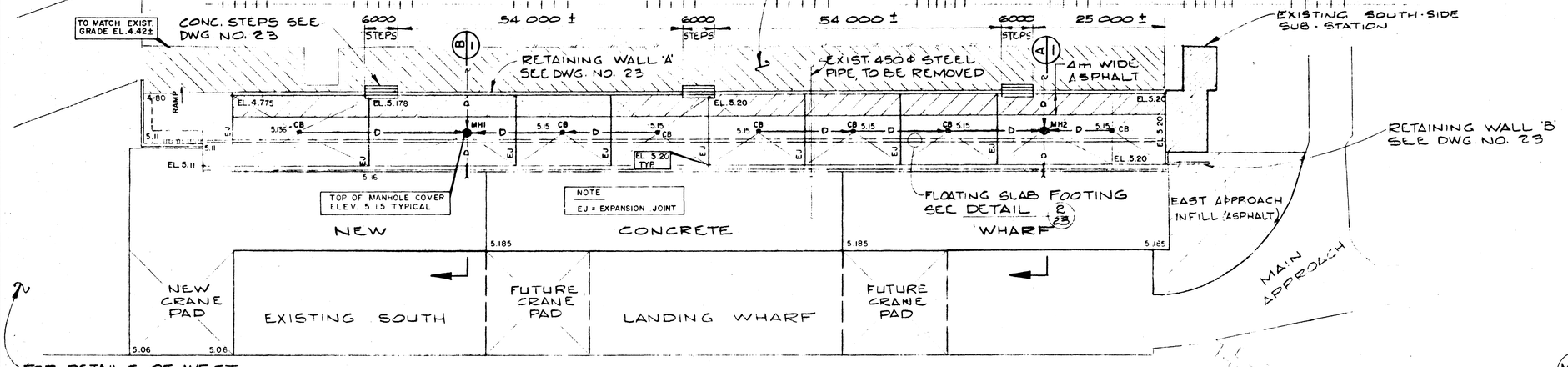
project number / no. du projet
PR 100772
drawing no / no. du dessin
19 OF 75-E

PWC AI

NOTES
1) FOR GENERAL NOTES & LEGEND, SEE DWG. NO. 1

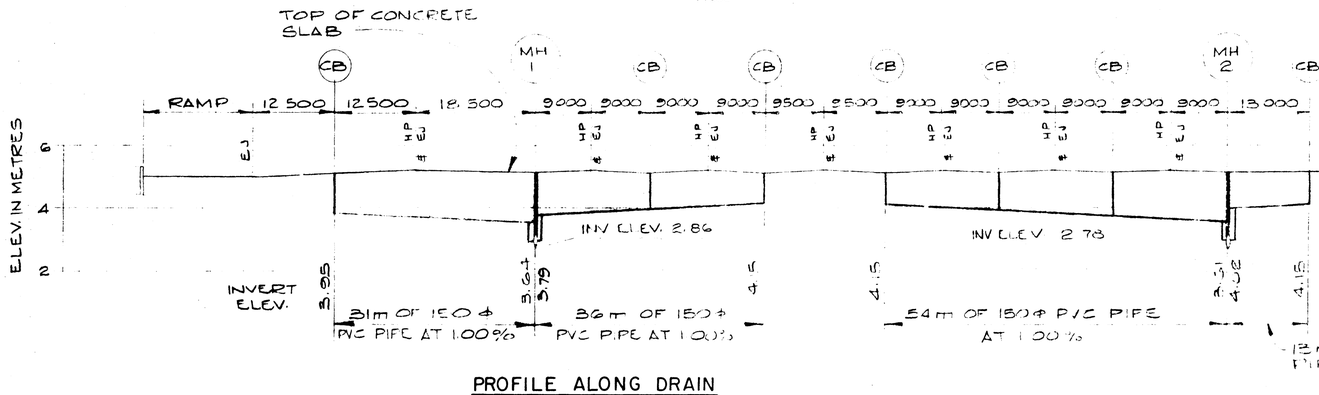
GRAVING DOCK

NEW 65 ASPHALT AND 150 LEAN MIX CONCRETE BASE TO TIE IN WITH EXISTING

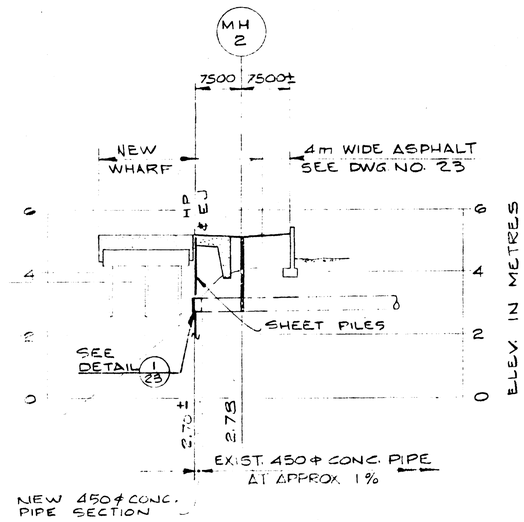


FOR DETAILS OF WEST INFILL AREA SEE DWG. NO. 35 & 36

PLAN A
1:500

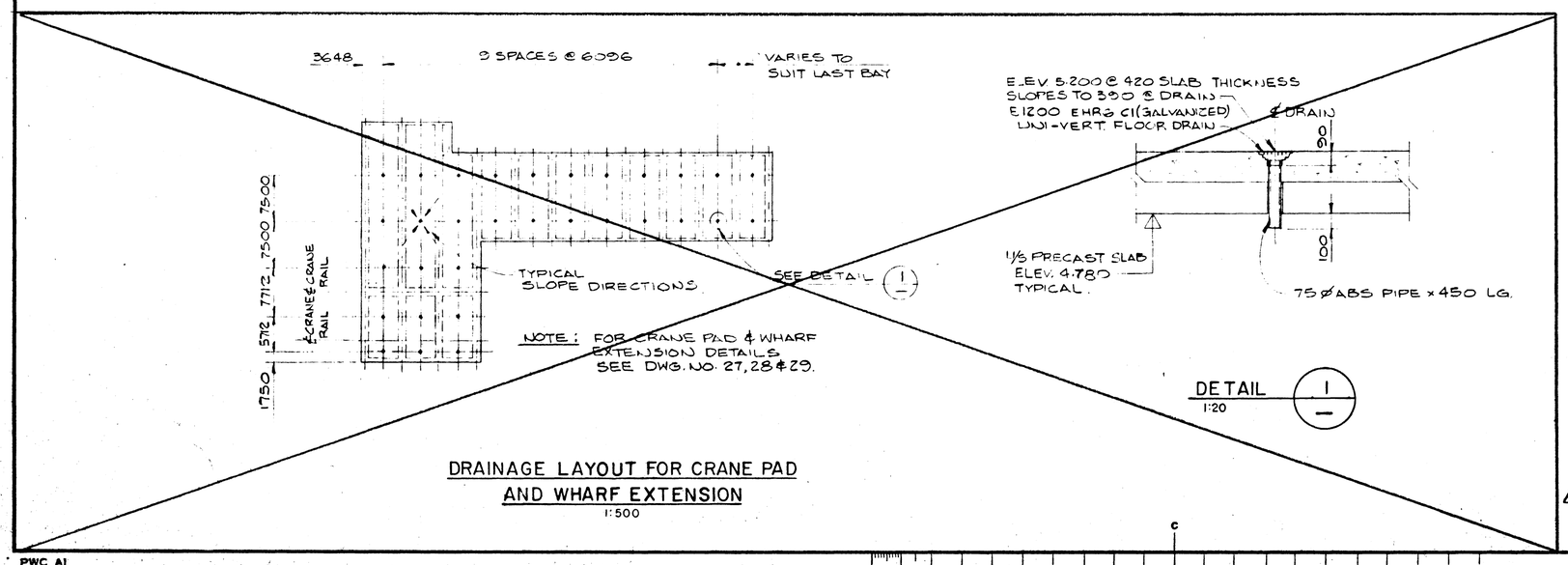


PROFILE ALONG DRAIN
HORIZ. 1:500
VERT. 1:100



SECTION A / — HORIZ. 1:500 VERT. 1:100

SECTION B / — SIMILAR



DETAIL 1 / —
1:20

DRAINAGE LAYOUT FOR CRANE PAD AND WHARF EXTENSION
1:500

NOV 6 1985

PWC A1

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

"BC041452"

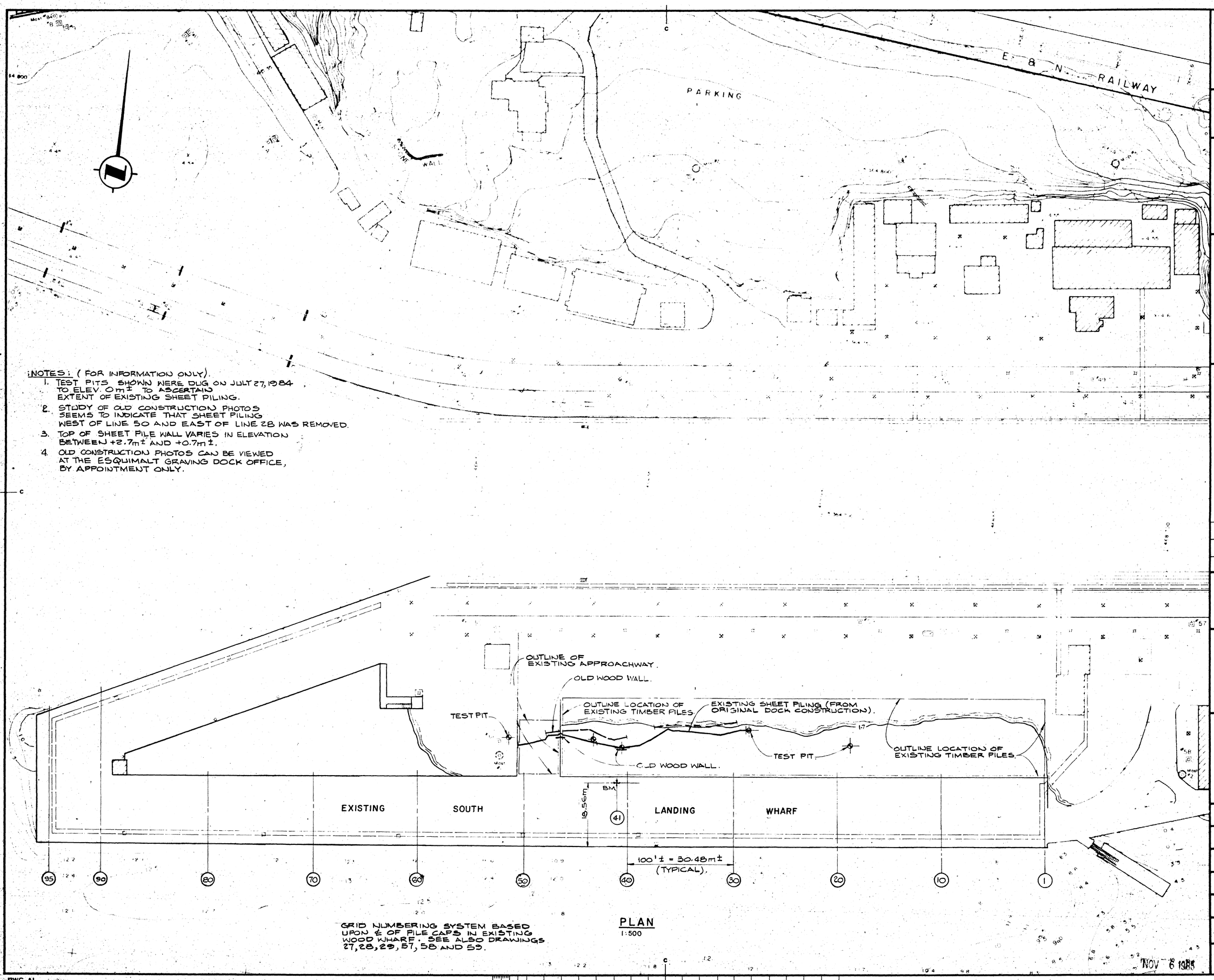
revisions		date
C	AS BUILT	JULY 26/85
B	CRANE PADS 2&3 DELETED	SEPT. 11/84

A detail no. no. du détail
B location drawing no. sur dessin no
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
EAST INFILL AREA
LAYOUT OF CONCRETE SLAB AND STORM DRAINS

designed PM / conçu
date MARCH 1984
drawn GHP / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
20 OF 75- C



NOTES: (FOR INFORMATION ONLY).

1. TEST PITS SHOWN WERE DUG ON JULY 27, 1984 TO ELEV. 0m± TO ASCERTAIN EXTENT OF EXISTING SHEET PILING.
2. STUDY OF OLD CONSTRUCTION PHOTOS SEEMS TO INDICATE THAT SHEET PILING WEST OF LINE 50 AND EAST OF LINE 28 WAS REMOVED.
3. TOP OF SHEET PILE WALL VARIES IN ELEVATION BETWEEN +2.7m± AND +0.7m±.
4. OLD CONSTRUCTION PHOTOS CAN BE VIEWED AT THE ESQUIMALT GRAVING DOCK OFFICE, BY APPOINTMENT ONLY.

GRID NUMBERING SYSTEM BASED UPON ℄ OF PILE CAPS IN EXISTING WOOD WHARF. SEE ALSO DRAWINGS 27, 28, 29, 57, 58 AND 59.

PLAN
1:500

Public Works Canada / Travaux publics Canada

KER, PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER
C. J. GRANT
BRITISH COLUMBIA

BC041453

revisions		date
B	AS BUILT	JULY 28/85
A	RE-ISSUED UNDER ADDENDUM 4	SEPT. 12/84

A detail no / no. du détail
B location drawing no / sur dessin no
C drawing no / dessin no

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.

CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
EXISTING WHARF
ADDENDUM NO. 4

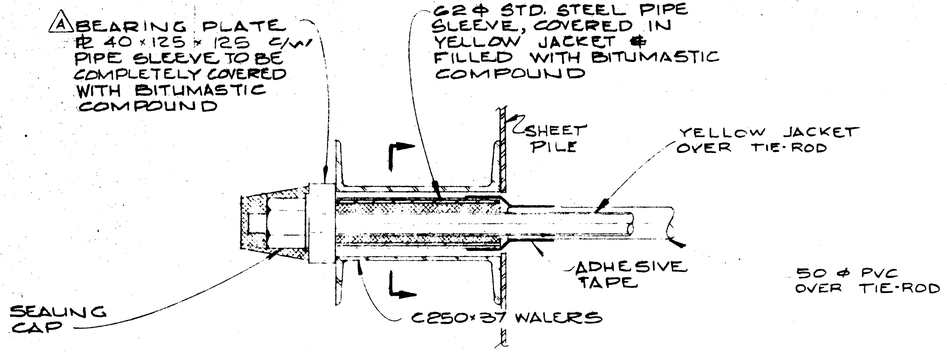
designed C.J.G. / conçu
date JULY 1984
drawn H.C.G. / dessiné
date JULY 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
21 OF 75 - B

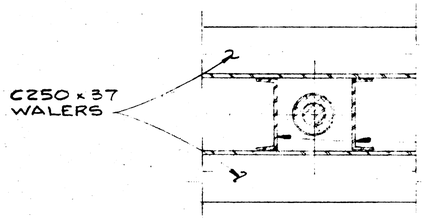
NOV - 8 1985

PWC AI

NOTES

1) FOR GENERAL NOTES & LEGEND SEE DWG.NO. 1



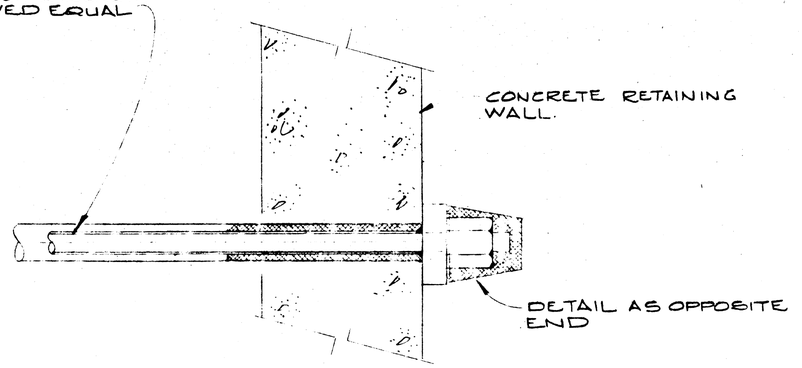


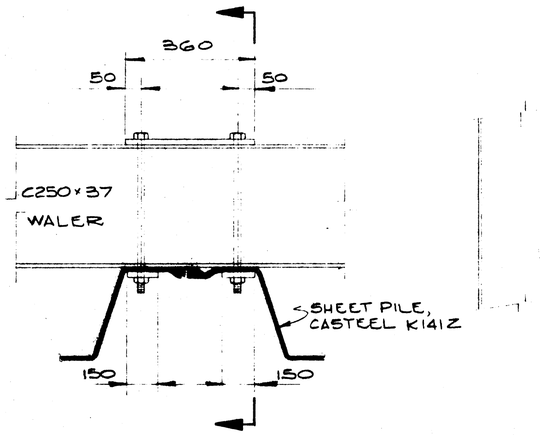
SECTION

ADDITIONAL C 100 x 8 AT PLATE LOCATIONS

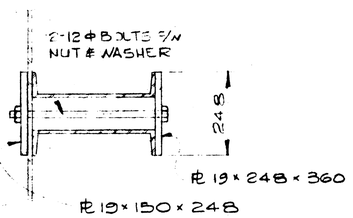
TYPICAL DETAIL OF TIE ROD & PROTECTIVE COATING (B)
1:5

TIE-ROD
NO. 4 (1" ϕ) "DYWIDAG" HIGH STRENGTH THREADBAR OR APPROVED EQUAL

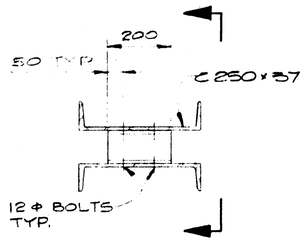


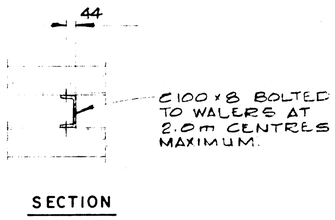


DETAIL 1 — TYPICAL PILE CONNECTION
1:10



SECTION

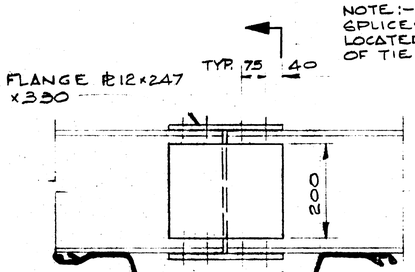




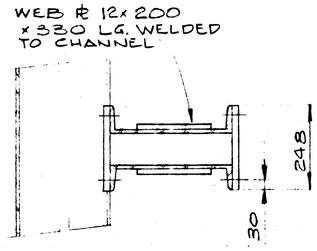
SECTION

DETAIL 3 — TYPICAL WALER CHANNEL SPACER
1:10

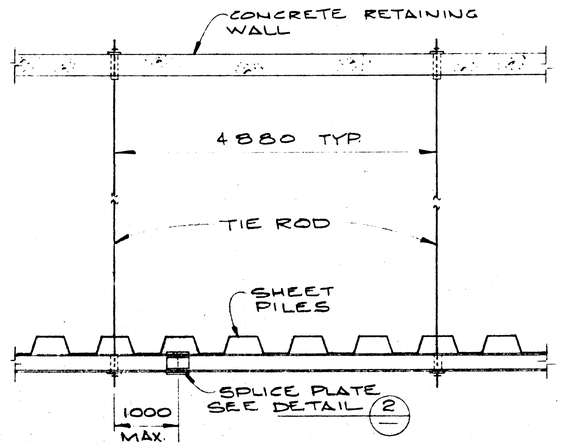
NOTE:- SPLICES TO BE LOCATED WITHIN 1.0m OF TIE RODS.



DETAIL 2 — TYPICAL SPLICE PLATE
1:10



SECTION



PLAN OF TYPICAL TIE ROD & SPLICE PLATE LOCATIONS
1:50

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

"BC041454"

revisions		date
B	AS BUILT	JULY 26/85
A	BEARING PLATE SIZE AMENDED	SEPT. 11/84

A detail no. no. du détail
B location drawing no. sur dessin no
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

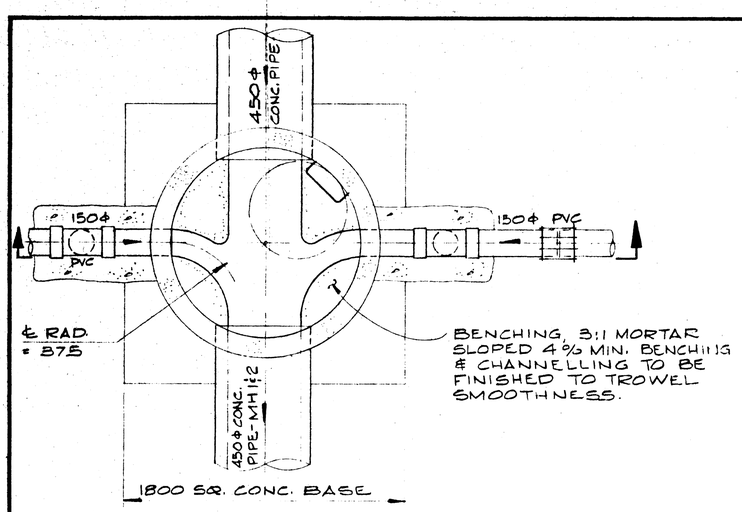
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
EAST INFILL AREA
SHEET PILING DETAILS

designed / conçu — P.M. — date MARCH 1984
drawn / dessiné — G.H.P. — date MARCH 1984
reviewed / examiné — date
approved / approuvé — date
Tender / Soumission — PWC Project Manager / Administrateur de projets TPC — 84/05/15

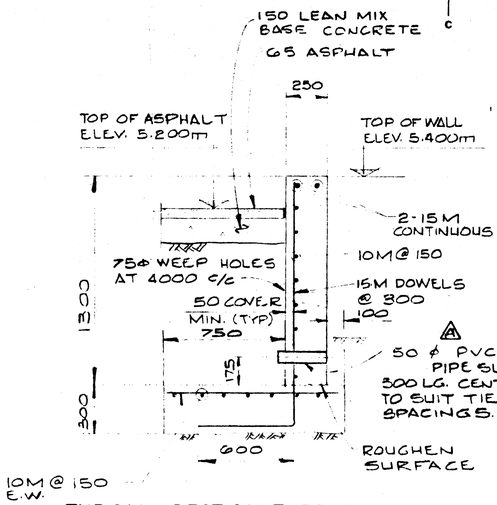
project number / no. du projet — PR 100772

drawing no. / no. du dessin — 22 OF 75-(B)

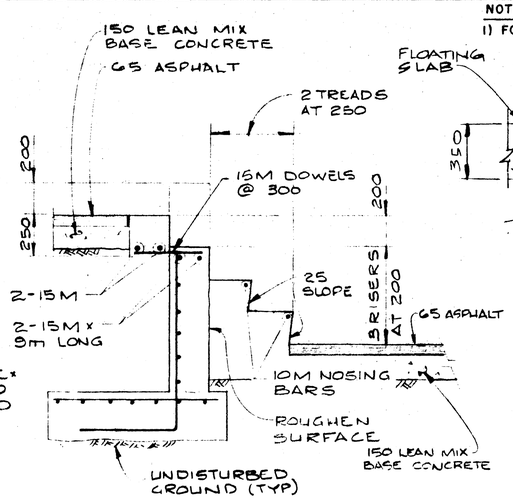
PWC AI



PLAN OF INSPECTION MANHOLE
1:20

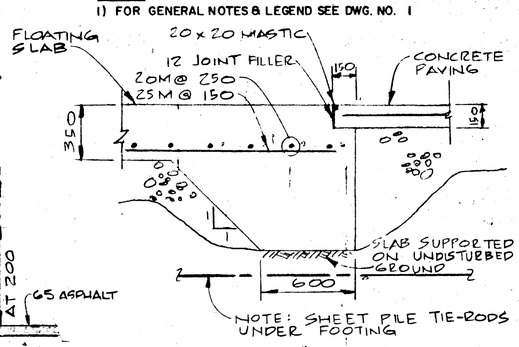


TYPICAL SECTION THROUGH RETAINING WALL 'A'
1:20 (SEE DWG. 20)

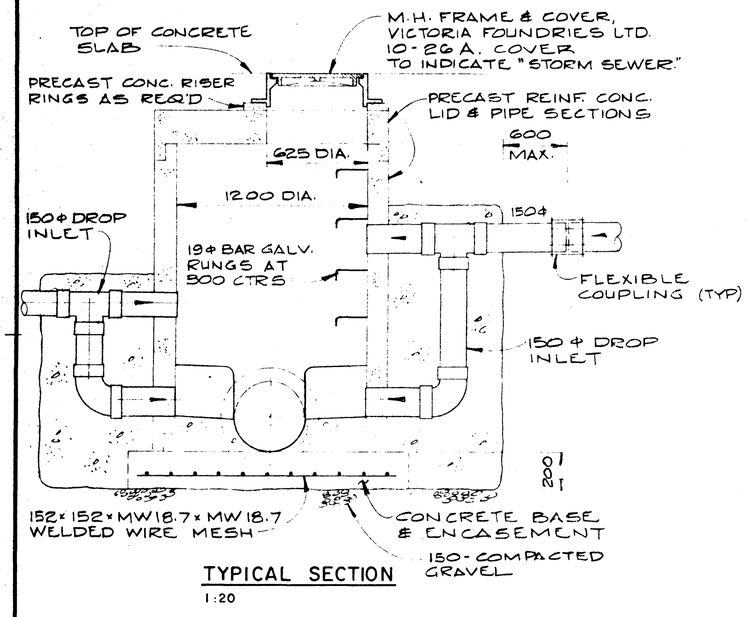


TYPICAL SECTION THROUGH STEPS
1:20

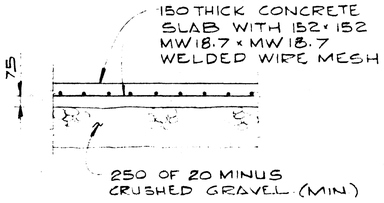
NOTES
1) FOR GENERAL NOTES & LEGEND SEE DWG. NO. 1



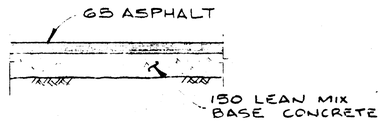
DETAIL 2/19 FLOATING SLAB FOOTING
1:20



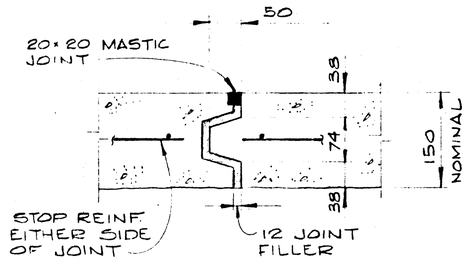
TYPICAL SECTION
1:20



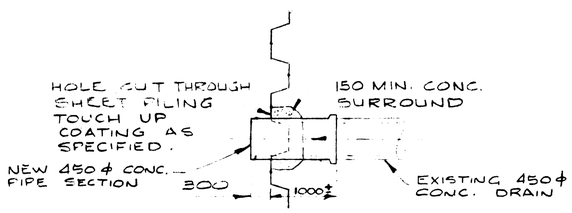
TYPICAL SECTION THROUGH 150 CONCRETE SLAB
1:20



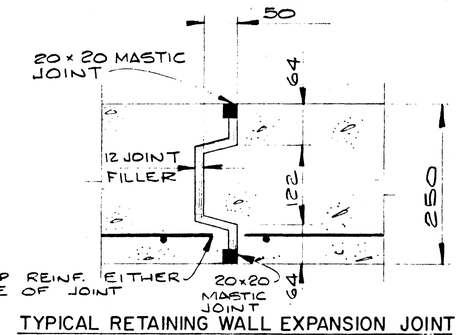
TYPICAL SECTION THROUGH ASPHALT PAVING
1:20



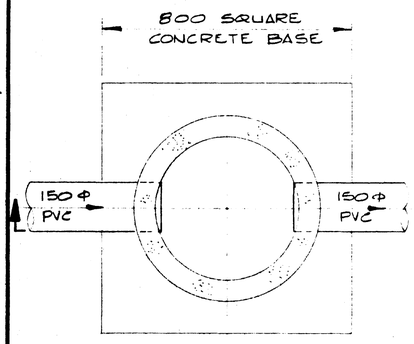
TYPICAL SLAB EXPANSION JOINT
1:5



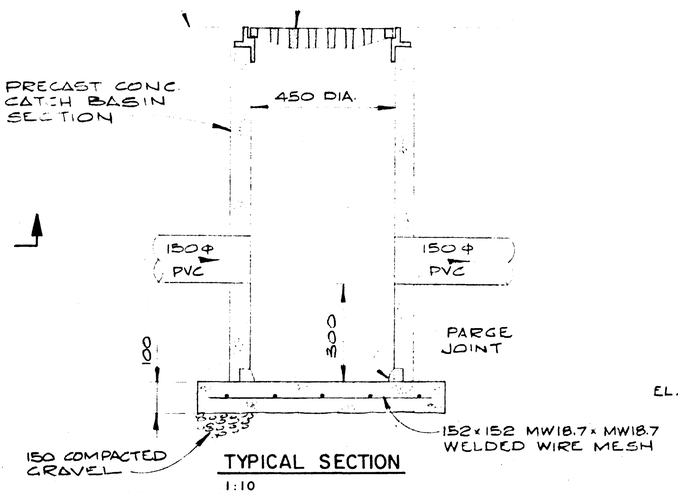
DETAIL 1/20 OUTFALL
1:50



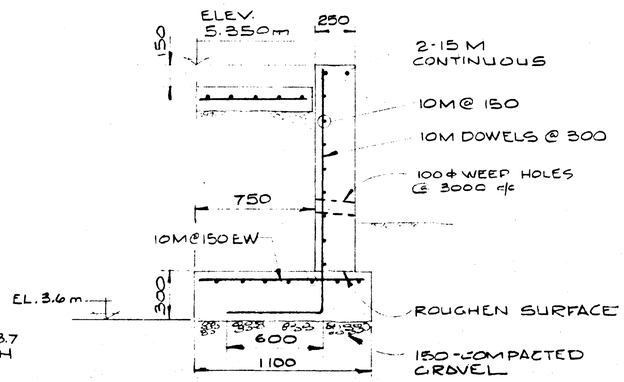
TYPICAL RETAINING WALL EXPANSION JOINT AT 18m ± CENTRES



PLAN OF TYPICAL CATCH BASIN
1:10



TYPICAL SECTION
1:10



TYPICAL SECTION THROUGH RETAINING WALL 'B'
1:20 (SEE DWG. 20)

NOV 6 1985

PWC A1

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

BC041455

revisions		date
A	AS-BUILT	JULY 26/85

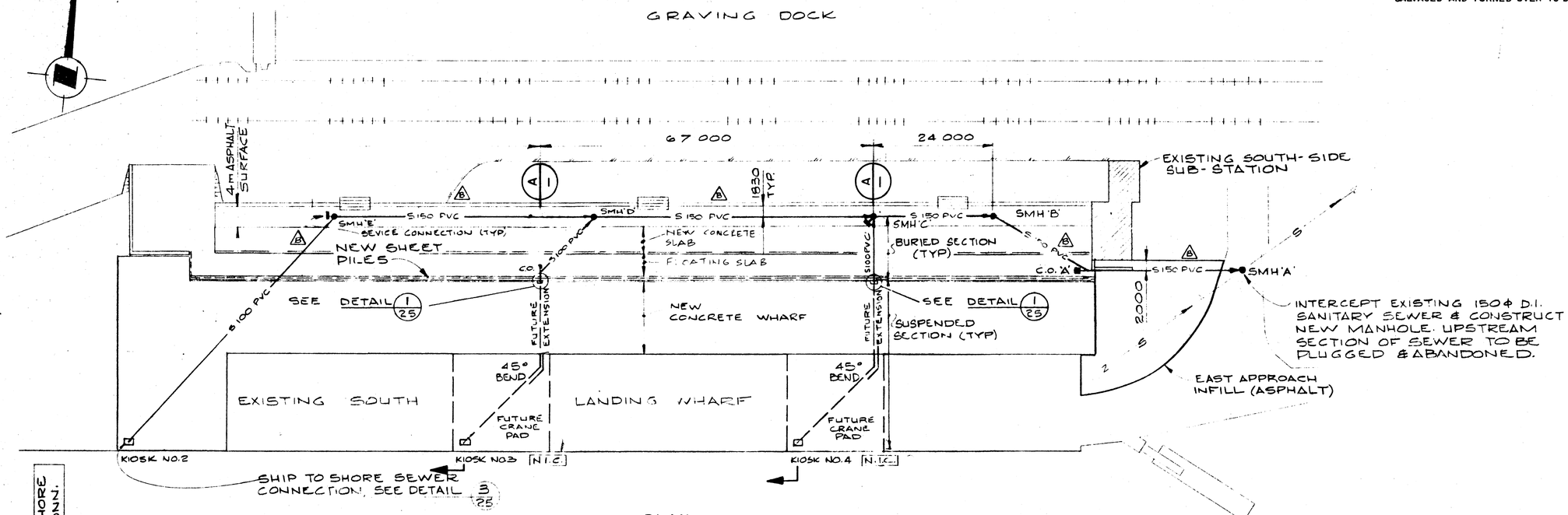
A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

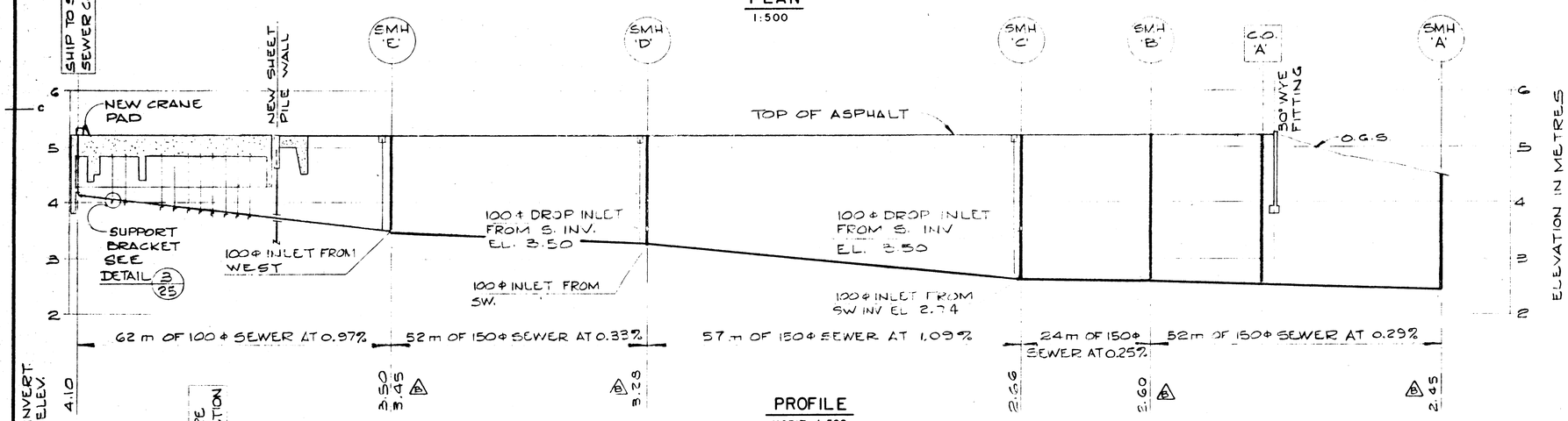
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
EAST INFILL AREA
DRAINAGE & MISCELLANEOUS DETAILS

designed P.M. / conçu
date MARCH 1984
drawn G.H.P. / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
23 OF 75 A

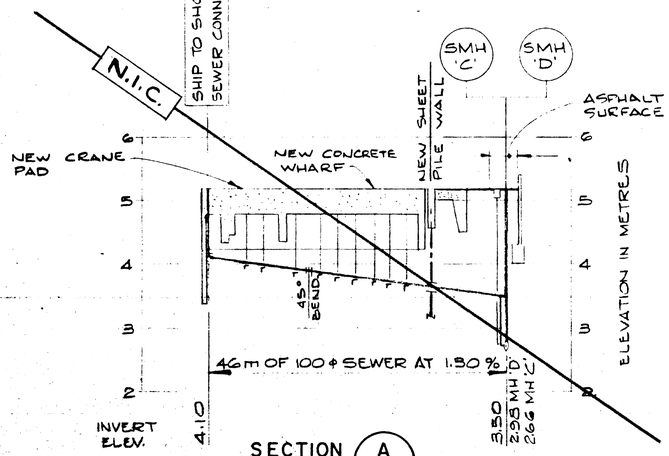
NOTES
1) FOR GENERAL NOTES & LEGEND, SEE DWG. NO. 1
2) ALL SEWER PIPE & FITTINGS TO BE PVC UNLESS SHOWN OTHERWISE
3) EXISTING SEWER PIPE & FITTINGS IN MANWAY TO BE SALVAGED AND TURNED OVER TO DOCK PERSONNEL.



PLAN
1:500



PROFILE
HORIZ. 1:500
VERT. 1:50



SECTION A
HORIZ. 1:500
VERT. 1:50

NOV 6 1985

PWC A1

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

revisions		date
B	AS BUILT	JULY 2/85
A	CRANE PADS 2 & 3 DELETED	SEPT. 11/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project projet
BC041456

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC

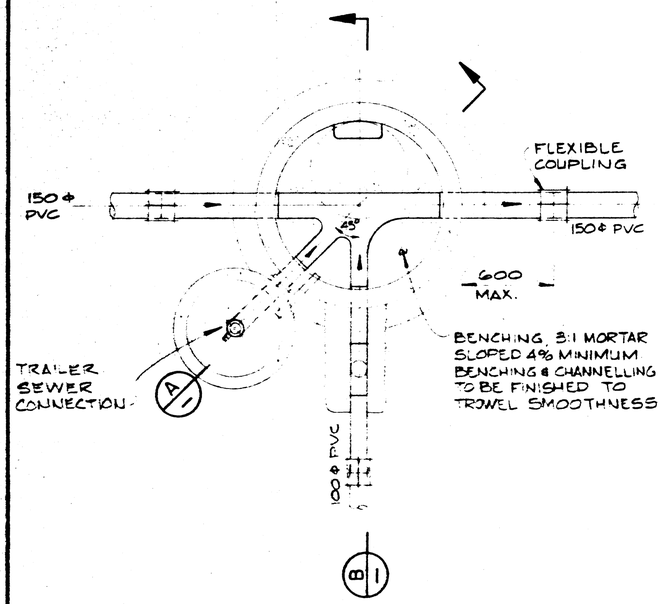
CONTRACT NO. 3

drawing dessin

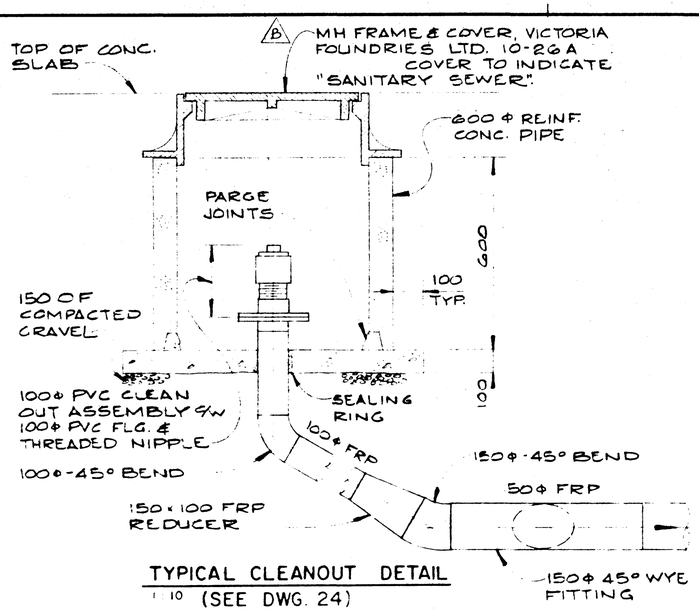
IMPROVEMENTS TO SOUTH LANDING WHARF

EAST INFILL AREA
SANITARY SEWERS

designed TB conçu
date MARCH 1984
drawn GHP dessiné
date MARCH 1984
reviewed examiné
date
approved approuvé
date
Tender Soumission
PWC Project Manager Administrateur de projets TPC
project number no. du projet
PR 100772
drawing no. no. du dessin
24 OF 75- B

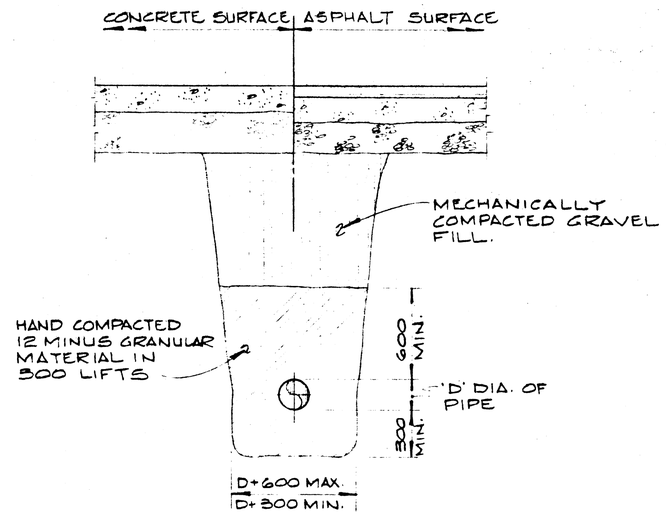


PLAN OF SEWER MANHOLE
1:20

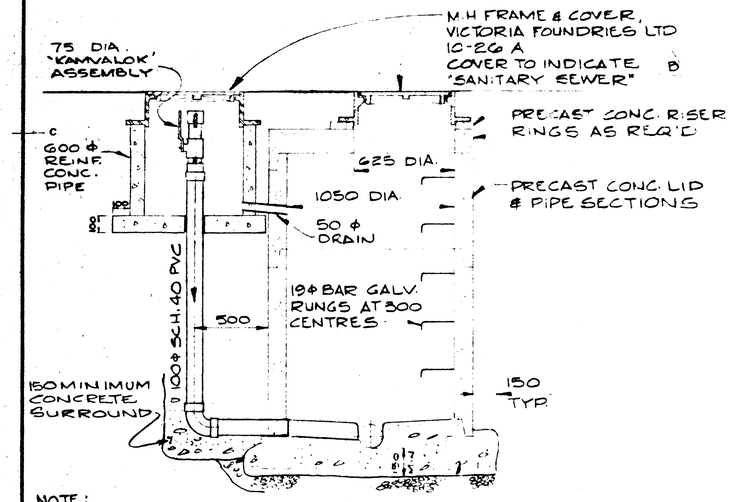


TYPICAL CLEANOUT DETAIL
1:10 (SEE DWG. 24)

NOTES
1) FOR GENERAL NOTES & LEGEND SEE DWG. NO. 1



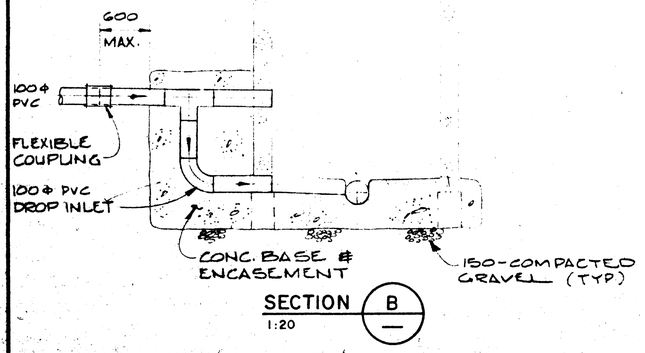
TYPICAL TRENCH DETAIL
1:20



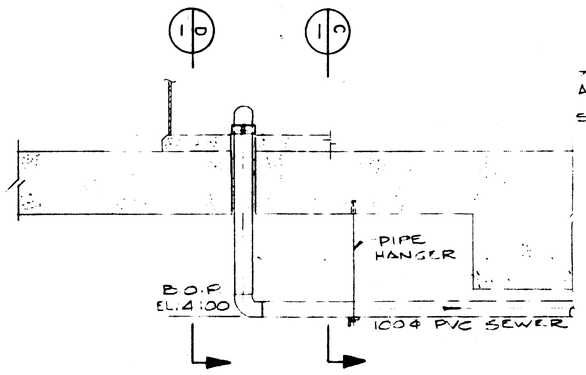
NOTE:
TRAILER SEWER CONN. TYPICAL FOR MH C, D & E ONLY.

BOTTOM RING SUPPORTED TEMPORARILY ON CONC. BLOCKS & SET LEVEL WITH PIPE SPRING LINE

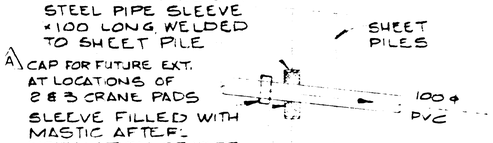
SECTION A
1:20



SECTION B
1:20

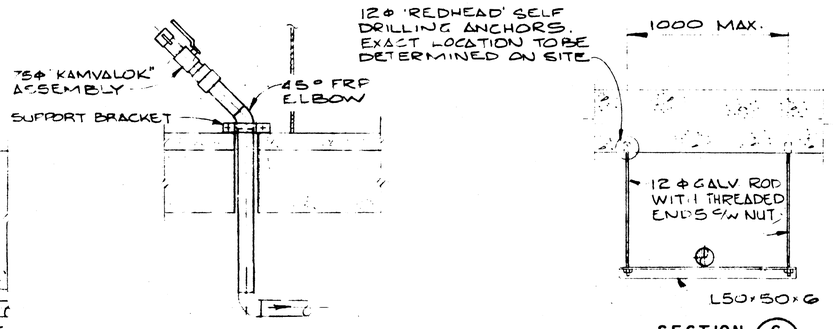


B NOTE
ALL PIPE CHANGED TO PVC



NOTE:
1) ENSURE PIPE SLEEVES ARE INSTALLED CLEAR OF INTERLOCKING JOINTS.
2) COAT PIPE SLEEVES WITH TAR AFTER INSTALLATION.

DETAIL 1/24 PIPE SLEEVE
1:20



SECTION D
1:20

SECTION C
1:20

NOTE:-
HANGER & SUPPORT BRACKET TO BE HOT DIPPED GALVANIZED AFTER FABRICATION.

B DETAIL 3/24 SHIP TO SHORE SEWER CONNECTION & TYPICAL PIPE SUPPORT HANGER
1:20

NOV 6 1985

PWC A1

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF — PETER MALONE — REGISTERED — COLUMBIA

"BC041457"

revisions		date
B	AS-BUILT	JULY 16/85
A	CAP ADDED ON DETAIL 1	SEPT. 11/84

A detail no. no. du détail
B location drawing no sur dessin no
C drawing no dessin no.

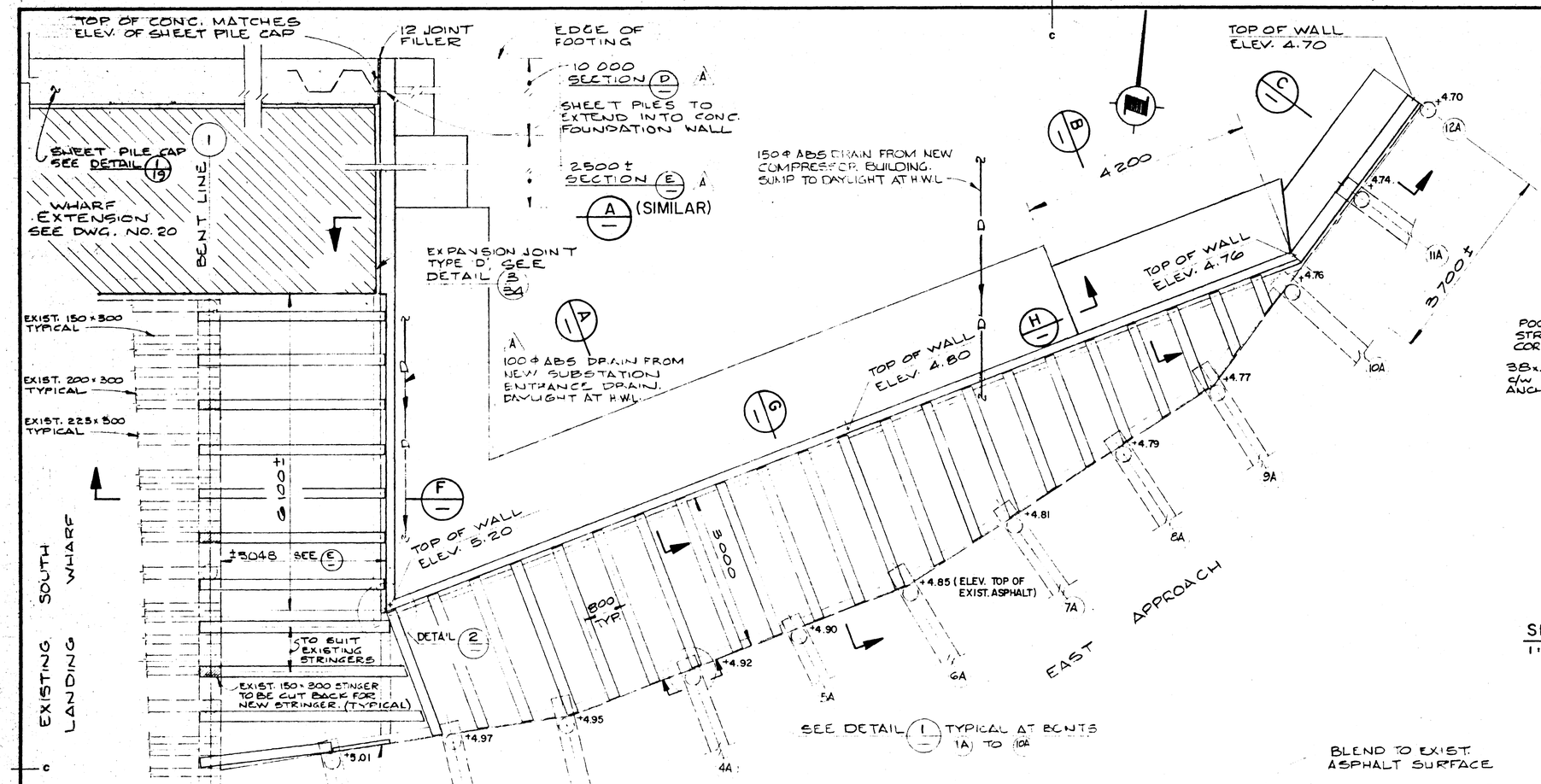
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
EAST INFILL AREA
SANITARY SEWERS
MISCELLANEOUS DETAILS

designed	T B	conçu
date	MARCH 1984	
drawn	GHP	dessiné
date	MARCH 1984	
reviewed		examiné
date		
approved		approuvé
date		
Tender		Soumission
PWC Project Manager		Administrateur de projets TPC

project number / no. du projet: PR 100772

drawing no. / no. du dessin: 25 OF 75-B

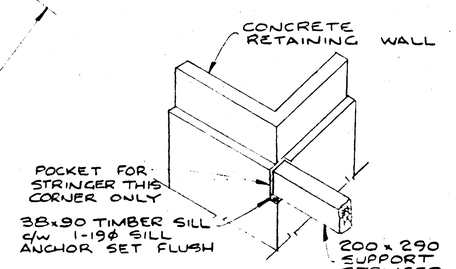


PLAN
1:50

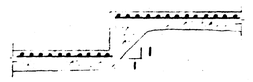
NOTES

1) FOR GENERAL NOTES & LEGEND, SEE DWG.NO. 1

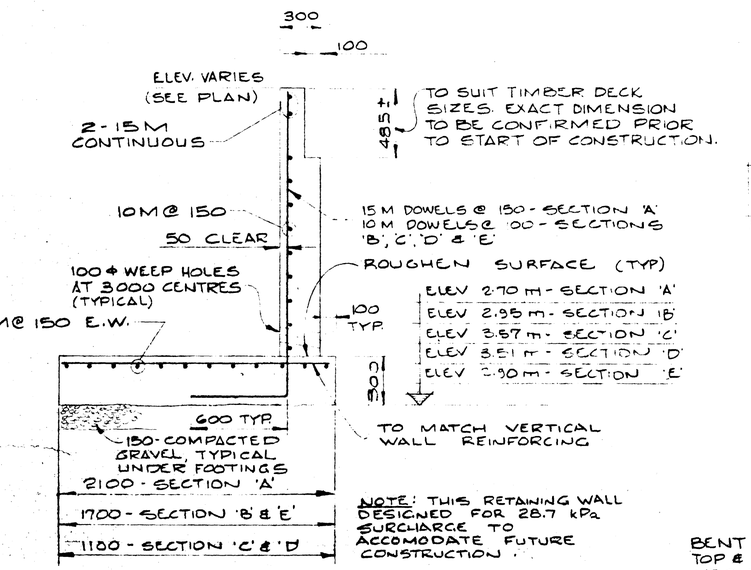
The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete



DETAIL 2
N.T.S.

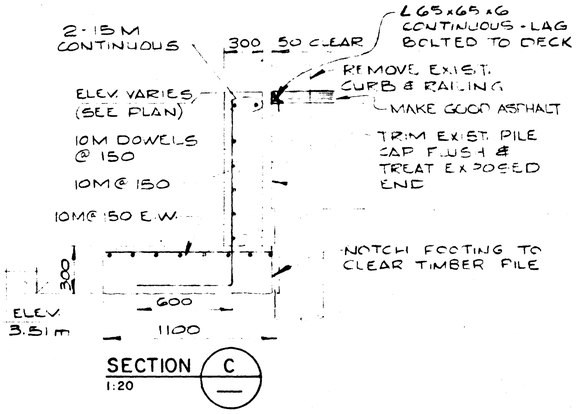


SECTION H — TYPICAL AT CHANGE IN FOOTING ELEVATION
1:50

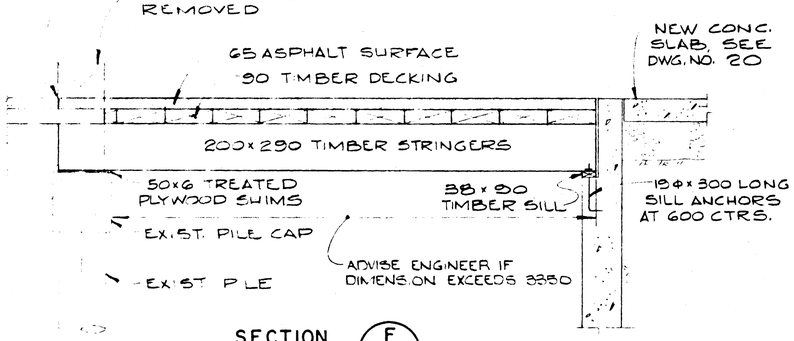


NOTE: THIS RETAINING WALL DESIGNED FOR 28.7 kPa SURCHARGE TO ACCOMODATE FUTURE CONSTRUCTION.

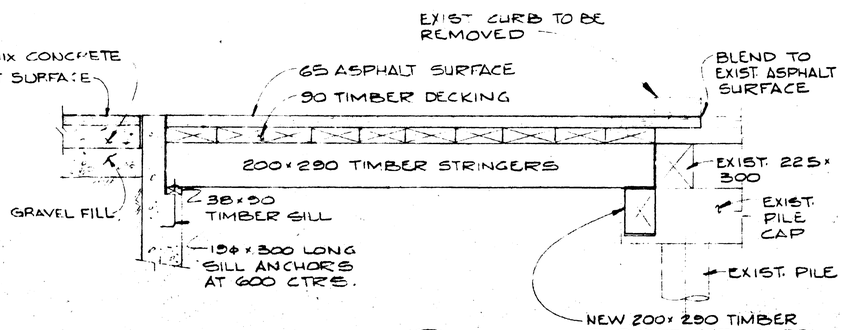
A SECTION A B D E
1:20



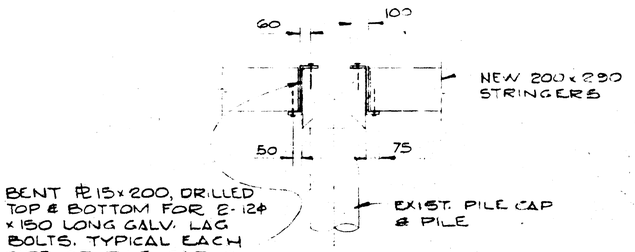
SECTION C
1:20



SECTION F
1:20



SECTION G
1:20



DETAIL 1 — SUPPORT BRACKET FOR NEW DECK STRINGERS
1:20

INOV. 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT — 14

"BC041458"

revisions		date
A	AS BUILT	JULY 25/85

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
EAST INFILL AREA

EAST APPROACH INFILL

designed C.J.G. / conçu
date MARCH 1984
drawn G H P / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no. du projet
PR100772

drawing no. / no. du dessin
26 OF 75 — A

PWC A1

10 SPACES @ 6096 = 60960
SEE DWG 59 FOR PILING LAYOUT

600 | 1435

FOR EXPANSION JOINT TYPE 'D' SEE DETAIL 3/34

TYPE 1+3 BEAM SEE KEY PLAN.

B 50-PRECAST PANELS TYPE 2-D (5 PER BAY) 6096 TYPICAL

EXPANSION JOINT TYPE 'D' SEE DETAIL 3/34

SHEET PILE CAP SEE DETAIL 1/15

TYPE 4 BEAM SEE KEY PLAN.

E/32

FOR RETAINING WALL TYPE 'B' DETAILS SEE DWG. NO. 23

S/30 SIM.

T/30

U/30

432

A

B

400±

FOR DETAILS SEE BEAM ABOVE. (SECT T/30 & U/30)

14535

1600 TYPICAL

LOCATION OF NEW 100T BOLLARD SEE DETAIL 1/48

FOR EXPANSION JOINT TYPE 'D' SEE DETAIL 3/34

1000 (TYP)

OUTLINE OF EXISTING WOOD WHARF.

B 10-PRECAST PANELS TYPE 2 (1 PER BAY)

3 NEW TIMBER PILES TO REPLACE 2 EXISTING PILES, REMOVE EXISTING PILES TO CLEAR NEW STEEL BATTER PILES.

D/33

P/30

PRECAST PANEL TYPE 1. (5 PER BAY, TOTAL 15)

FOR EXPANSION JOINT TYPE 'B' SEE DETAIL 3/34

N.I.C.

FOR COMPRESSION STRUT DETAILS SEE DWG NO. 52.

C/33

2 NEW TIMBER PILES TO REPLACE ONE EXISTING PILE, REMOVE EXISTING PILE TO CLEAR NEW STEEL BATTER PILE.

M/30

SOUTH FACE OF EXISTING WOOD CURB.

50T BOLLARD

FOR FENDER DETAILS & LOCATIONS SEE DWG NO. 47.

15 GRID LINE AS PER EXISTING WHARF

20

LOCATION FOR NEW 50T BOLLARD SEE DETAIL 5/34

34500

c

FOR EXPANSION JOINT TYPE 'C' SEE DETAIL 3/34

P/30 SIM.

3048 TYP.

B/31

CRANE FUTURE RAIL

CRANE FUTURE RAIL

CRANE FUTURE RAIL

7925

3500

1500

1180

2600

1500

PRECAST PANEL TYPE 5 (ONE REQ'D).

A/31

PRECAST PANELS TYPE 3 (4 REQ'D).

SLOT 150 x 950

300 ø PIPE SLEEVE

25 ø ELECTRICAL CONDUIT

350

250

600

150

150 ø PIPE SLEEVE

1524

1240

100 ø PIPE SLEEVE.

PRECAST PANEL TYPE 3A 19488 (ONE REQ'D).

304 ø TYPICAL

PLAN 1:125

SECTION A
1:20

FLOOR SLAB REINFORCING.

8-25M CONT.

400

15M @ 400 TYPICAL STIRRUPS.

15M @ 300 E.W.

4-25M CONT.

3-25 M

885 ±

6-25M CONT.

SECTION B
1:20

1300 (TYP)

EXTRA 15M x 2000 LG.

FOR REINFORCING DETAILS SEE SECTION A

25 GAP (TYP)

1250 NTS

300

3-25M, H2E

3-15 M BENT

400 / 1500

8-25M-H2E

6-15M STIRRUPS EACH END SEE PILE DETAIL DWG 57

SYMM. ABOUT ℄

6-25M-H2E BENT, TOP & BTM EACH SIDE OF PILE (A) (TOTAL 24 BARS)

NOTES:

1.) ALL PILES ARE TO BE 559 mm DIAMETER STEEL PIPE PILES WITH 9.5 mm WALL. PILES TO BE FITTED WITH INSIDE CAST ALLOY STEEL CUTTING SHOE.

2.) BATTER PILES TO BE AT ANGLES AS INDICATED ON DWG. NO. 57

3.) ALL PILES TO BE DRIVEN TO REFUSAL ON ROCK.

CONCRETE BEAM DIMENSIONS TAKEN FROM SOUTH END OF BEAM.

20 000 (NOMINAL)* MATCH LINE

* ACTUAL DIMENSION TO VARY TO SUIT NORTH FACE OF EXISTING WOOD WHARF. SEE DWG NO. 34.

34 500

4725 | 12495 | 21640

2135 | 10060 | 17070 | 27280 | 32920

TYPE 1+3

TYPE 1.

TYPE 3

14 535 (NOMINAL)*

STEEL PILE (TYP.)

TYPE 4

NOTE: SEE DWG. NO. 31 FOR DETAILS OF BEAM TYPES.

KEY PLAN FOR PILE & PILE-CAP LAYOUT
1:2000

NOV 6 1985

PWC AI

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. J. GRANT

"BC041459"

revisions		date
B	AS BUILT	MAY 21/85
A	CRANE PAD DELETED	SEPT. 11/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

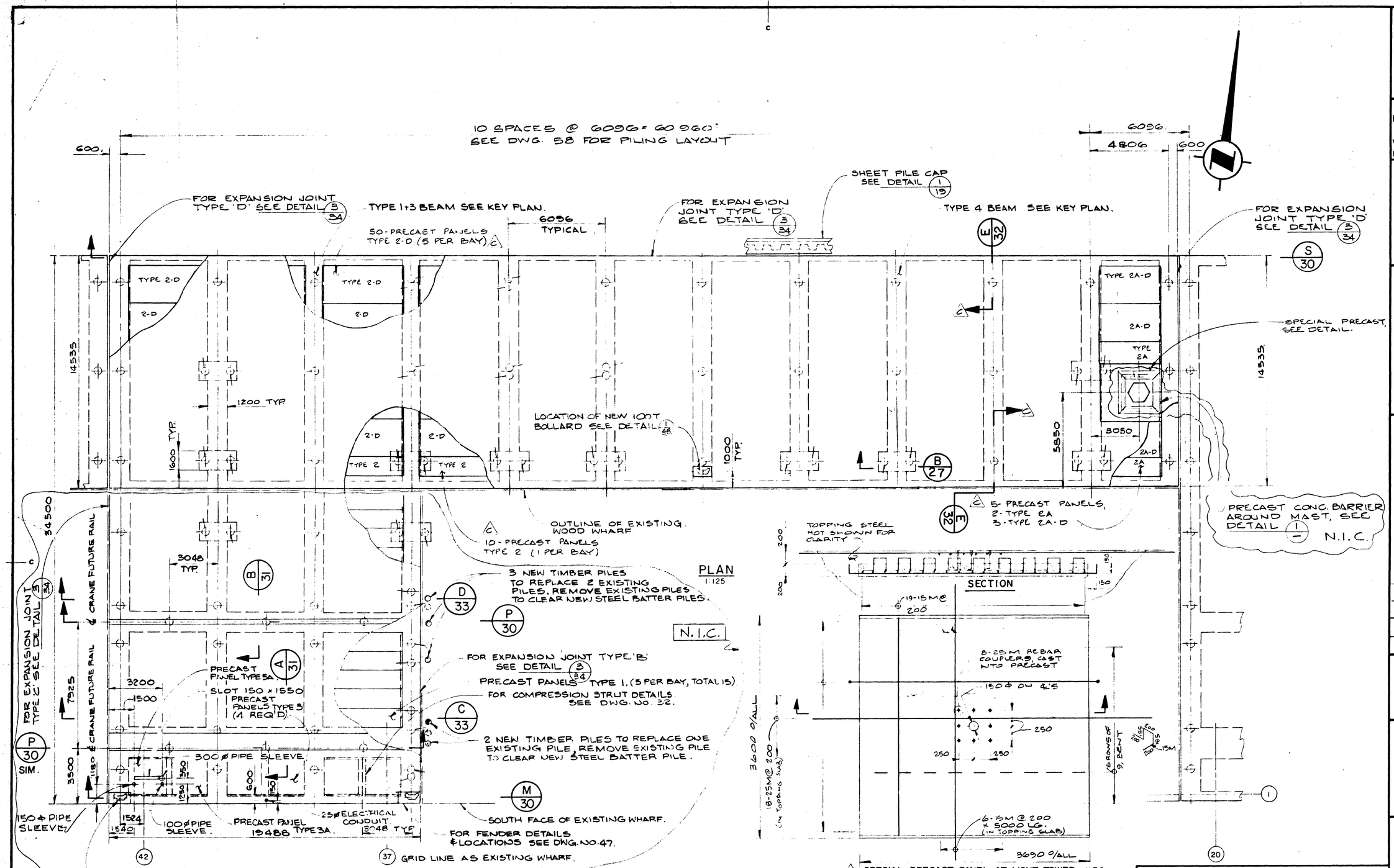
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS & WHARF EXTENSION
BENT 1 TO 20 (PAD NO. 3)

designed C.J.G. / conçu
date APRIL 1984
drawn H.C.G. / dessiné
date APRIL 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no. du projet
PR100772

drawing no. / no. du dessin
27 OF 75 - (B)



Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

"BC041460"

revisions		date
C	AS BUILT	MAY 31/85
B	DIMENSIONS	SEPT. 17/84
A	CRANE PAD DELETED	SEPT. 12/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

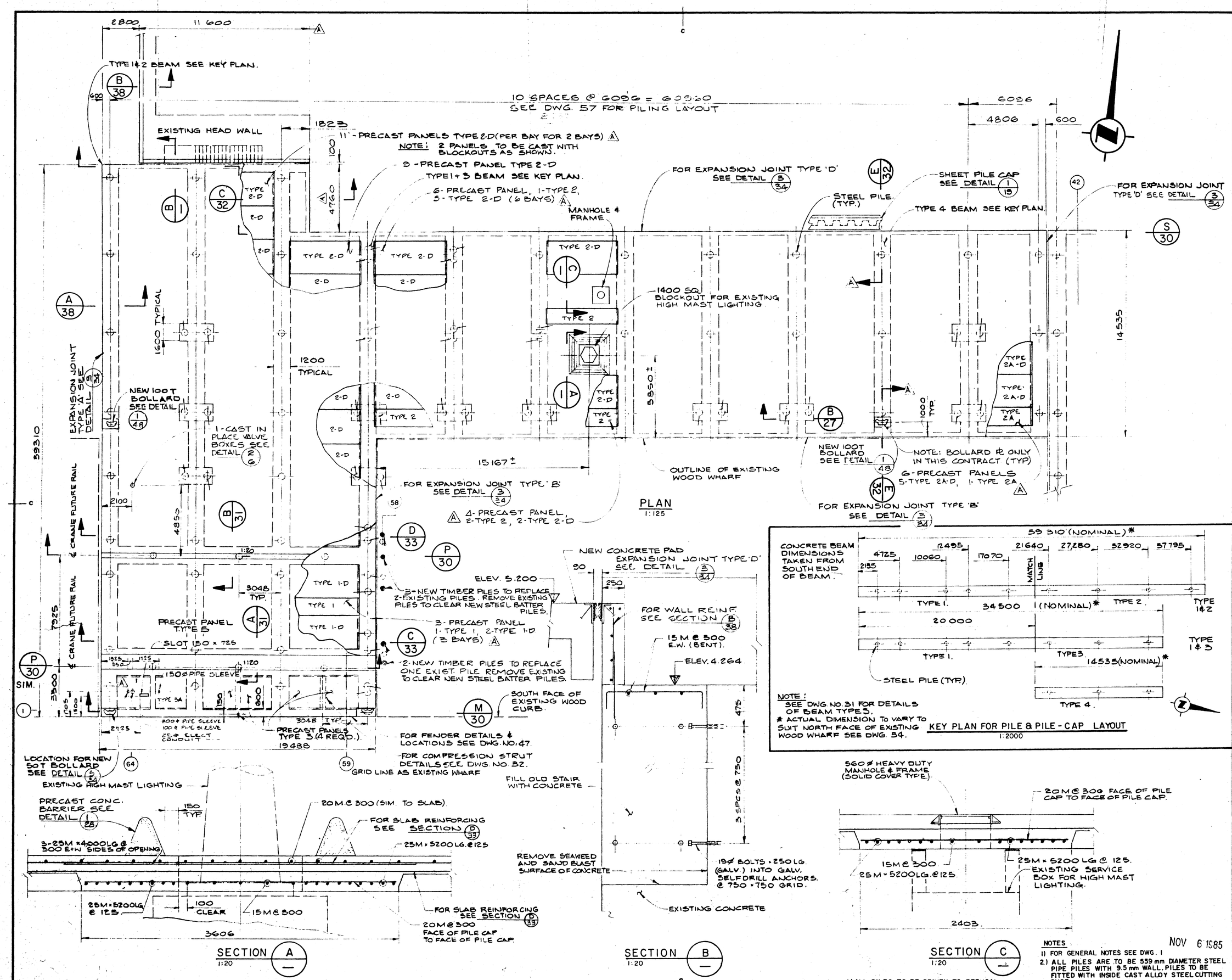
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS & WHARF EXTENSION
BENT 20 TO 42 (PAD NO. 2)

designed	C.J.G.
date	APRIL 1984
drawn	H.C.G.
date	APRIL 1984
reviewed	
date	
approved	
date	
Tender	Soumission
PWC Project Manager	Administrateur de projets TPC

project number / no. du projet: **PR100772**

drawing no. / no. du dessin: **28 OF 75-C**

PWC AI



NOTES

1) FOR GENERAL NOTES SEE DWG. 1
2.) ALL PILES ARE TO BE 559 mm DIAMETER STEEL PIPE PILES WITH 9.5 mm WALL. PILES TO BE FITTED WITH INSIDE CAST ALLOY STEEL CUTTING SHOE
3.) BATTER PILES - SEE DWG 59

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. J. GRANT

BC041461

revisions		date
A	AS BUILT	MAY 31/85

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3.

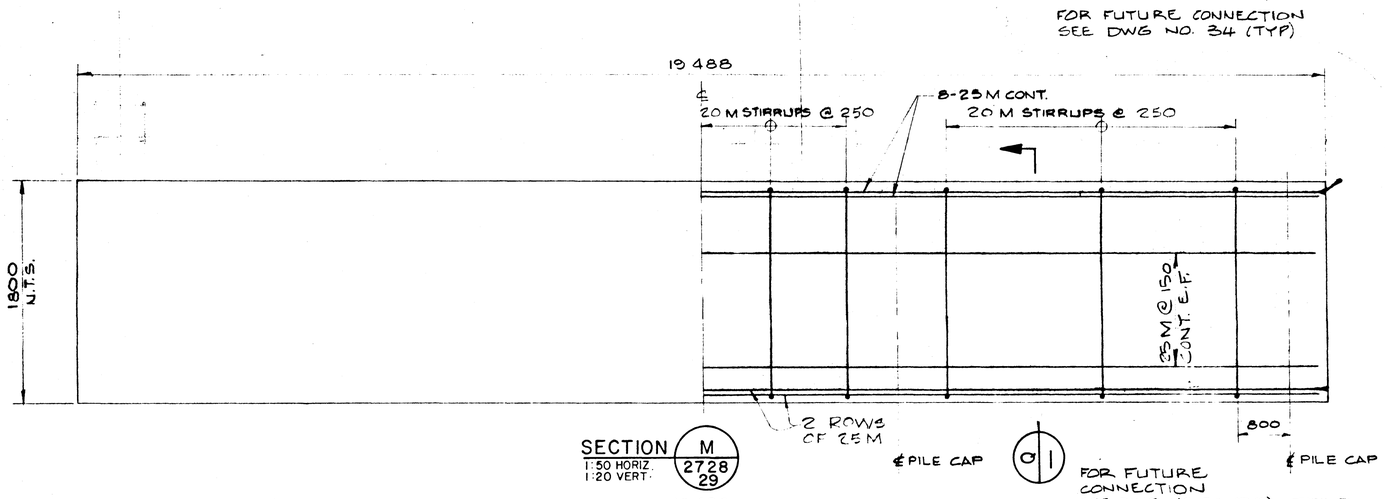
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS & WHARF EXTENSION
BENT 42 TO 64 (PAD NO. 1)

designed	C.J.G.
date	APRIL 1984
drawn	H.C.G.
date	APRIL 1984
reviewed	
date	
approved	
date	
Tender	Soumission
PWC Project Manager	Administrateur de projets TPC

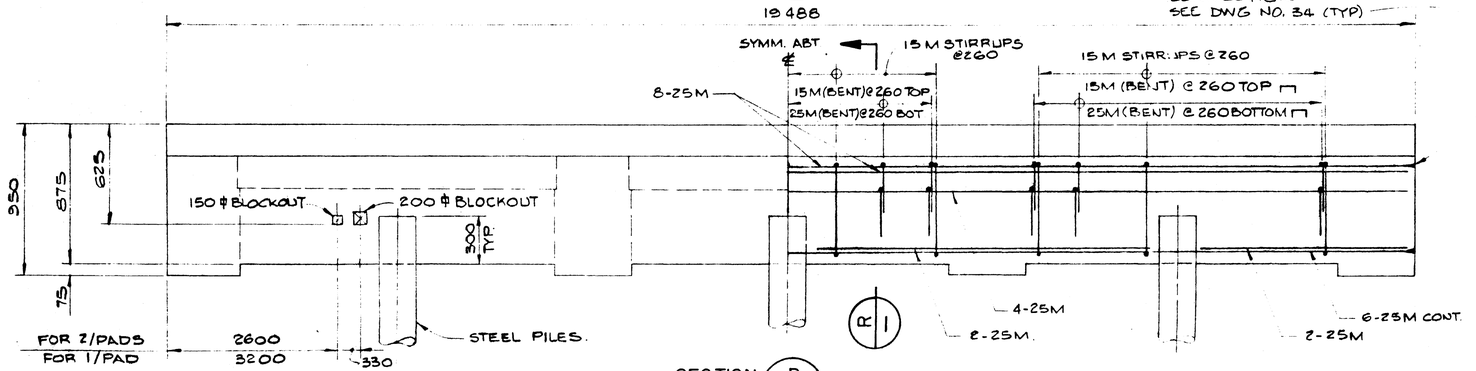
project number / no. du projet: PR100772

drawing no. / no. du dessin: 29 OF 75 A

PWC AI



SECTION M 2728 29
1:50 HORIZ.
1:20 VERT.



SECTION P 27 28 29
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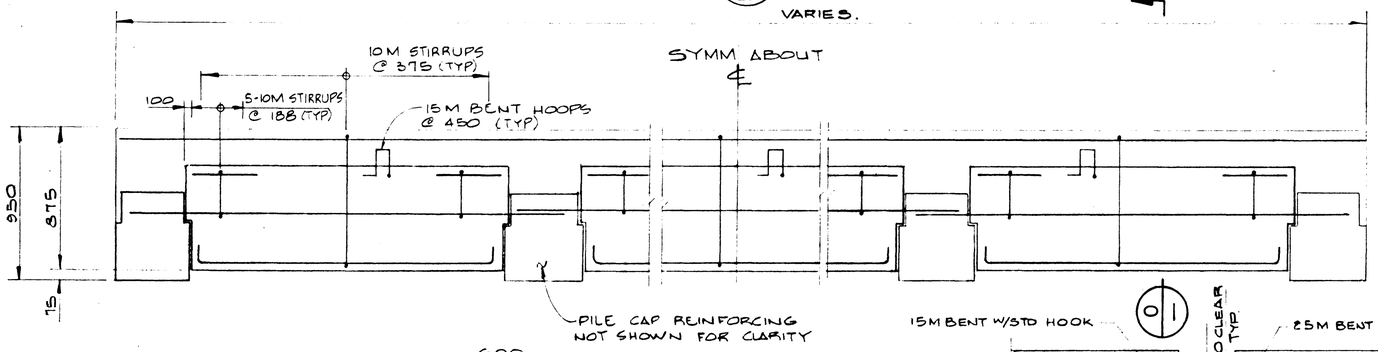
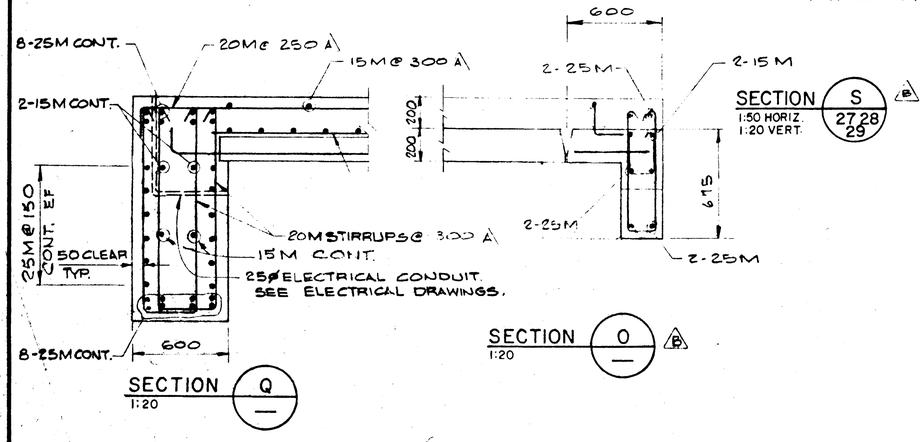
1:20 VERT.

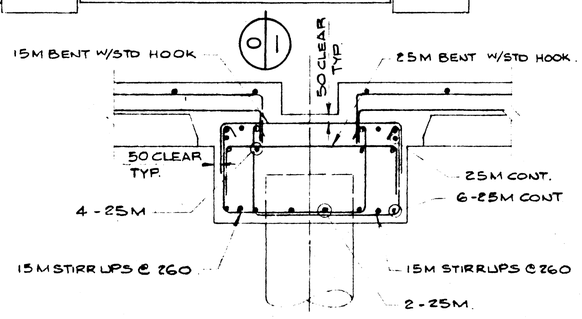




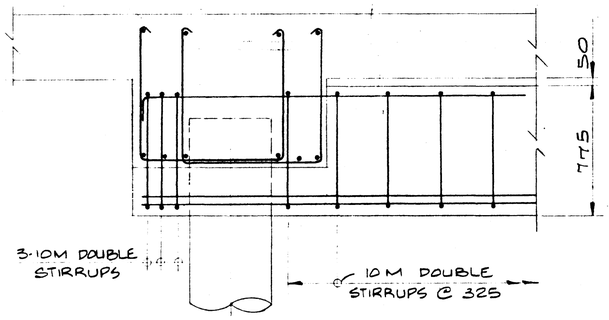
SECTION Q
1:20

SECTION S 27 28 29
1:50 HORIZ.
1:20 VERT.

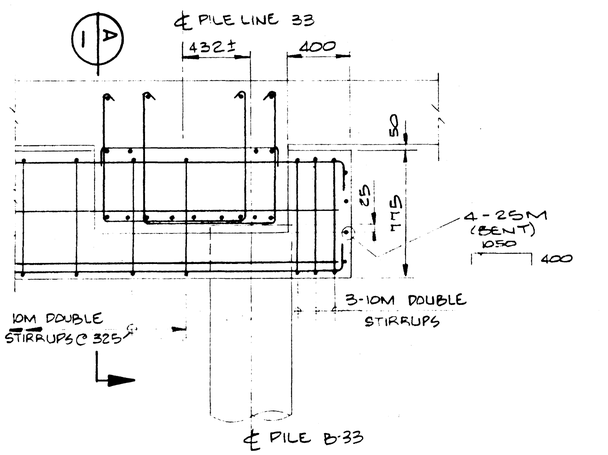
SECTION O
1:20



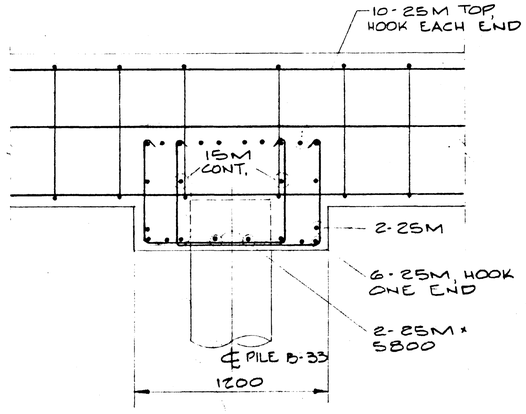
SECTION R
1:20



B SECTION T 27 SPREADER BEAM
1:20



B SECTION U 27 SPREADER BEAM
1:20



B SECTION A
1:20

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

"BC041462"

revisions		date
B	AS BUILT	MAY 31/85
A	REBAR CORRECTED - SECT. 'Q'	SEPT. 12/48

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS
STRUCTURAL DETAILS

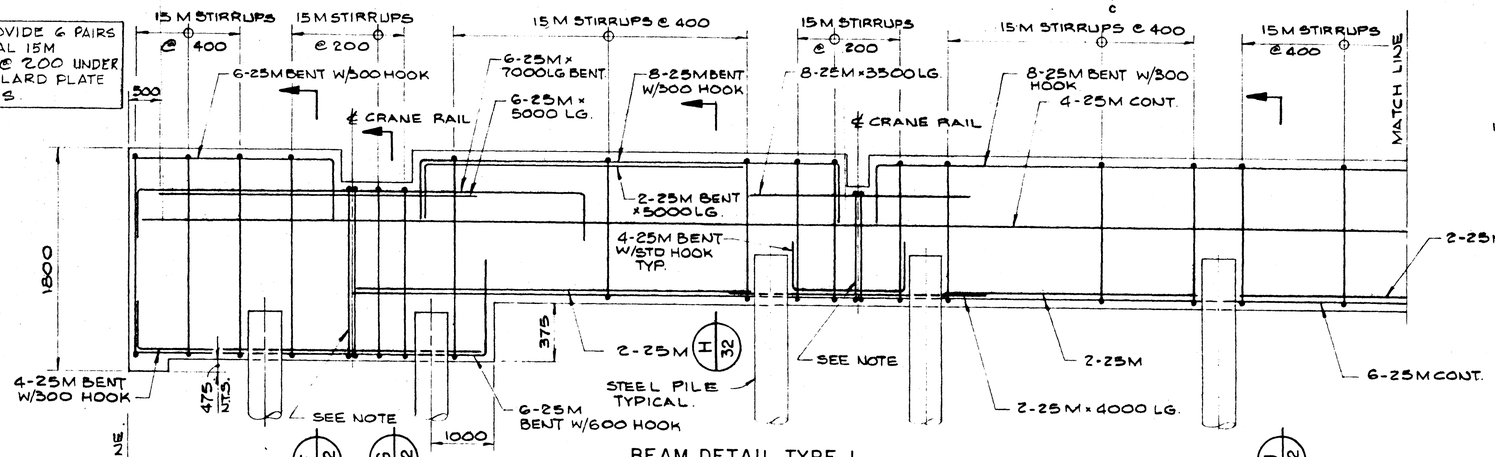
designed C.J.G. / conçu — date APRIL 1984
drawn H.C.G. / dessiné — date APRIL 1984
reviewed / examiné — date
approved / approuvé — date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC — 84/05/15

project number / no. du projet
PR100772

drawing no. / no. du dessin
30 OF 75 - B

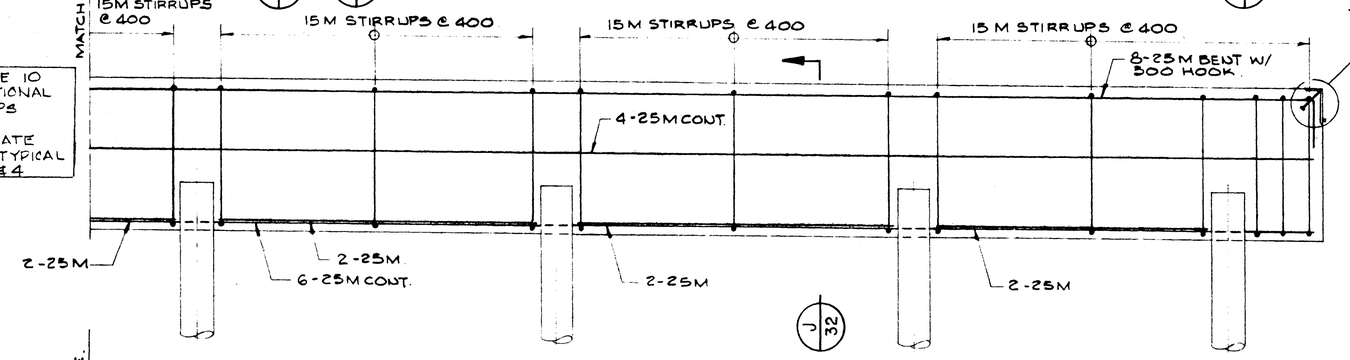
PWC AI

NOTE: PROVIDE 6 PAIRS ADDITIONAL 15M STIRRUPS @ 200 UNDER 50 T. BOLLARD PLATE LOCATIONS.

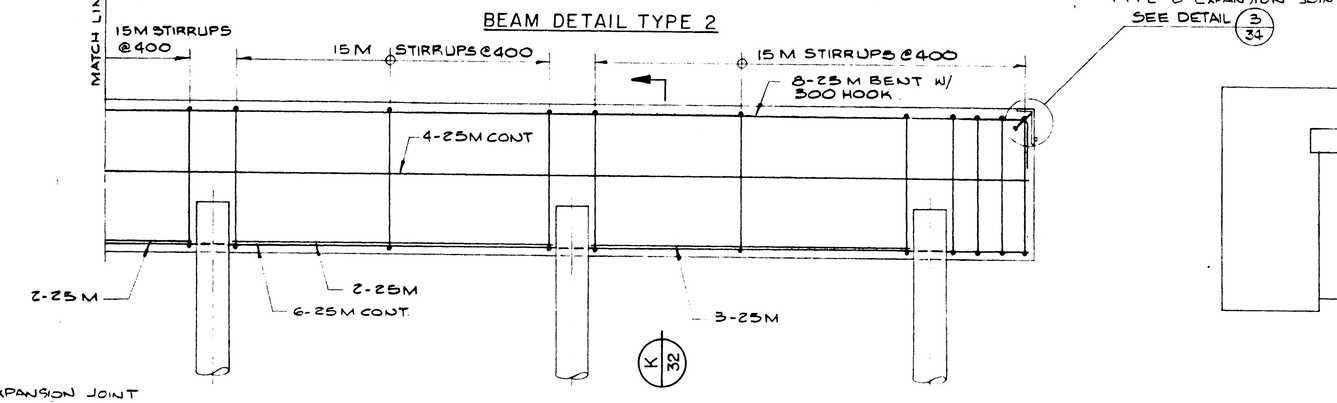


BEAM DETAIL TYPE 1

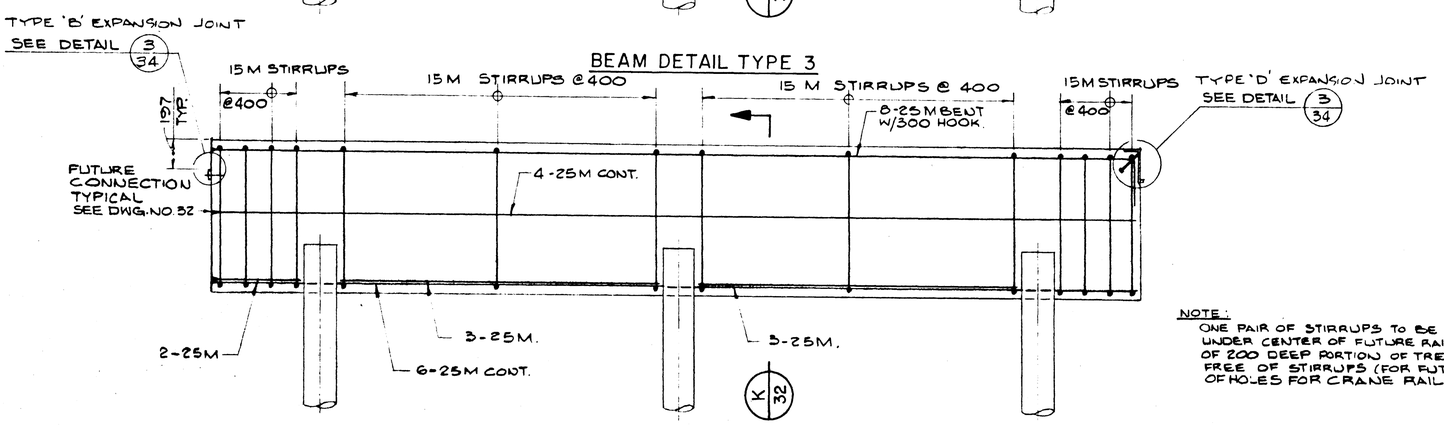
NOTE: PROVIDE 10 PAIRS OF ADDITIONAL 25M STIRRUPS UNDER 100 T. BOLLARD PLATE LOCATIONS - TYPICAL TYPES 2, 3 & 4



BEAM DETAIL TYPE 2

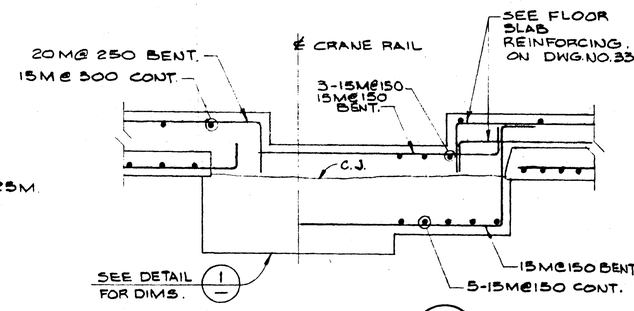


BEAM DETAIL TYPE 3

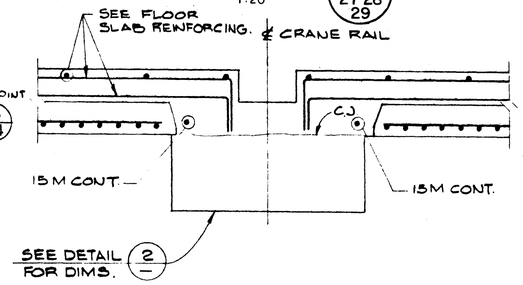


BEAM DETAIL TYPE 4

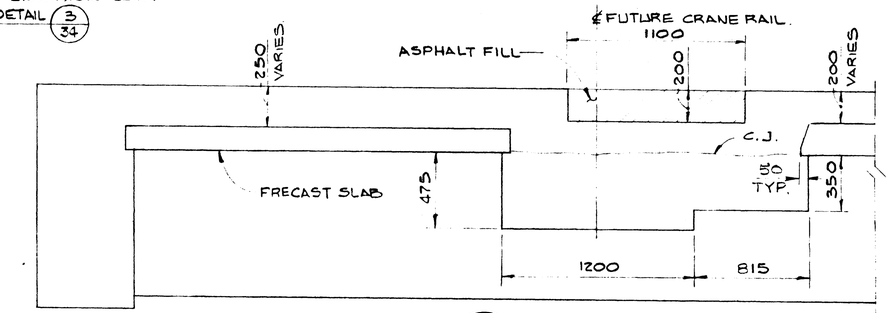
1:50 HORIZ. (TYP.)
1:20 VERT. (TYP.)



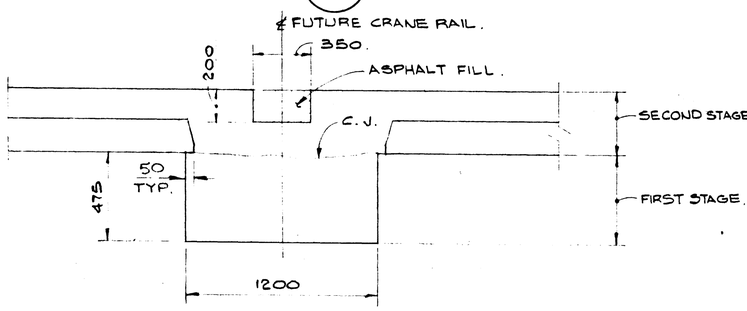
SECTION A (27 28 29) 1:20



SECTION B (27 28 29) 1:20



DETAIL (1/—) 1:20



DETAIL (2/—) 1:20

NOTE:
ONE PAIR OF STIRRUPS TO BE POSITIONED UNDER CENTER OF FUTURE RAIL REMAINDER OF 200 DEEP PORTION OF TRENCH TO BE FREE OF STIRRUPS (FOR FUTURE DRILLING OF HOLES FOR CRANE RAIL BOLTS.

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD. consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. J. GRANT

"BC041463"

revisions	date
A AS BUILT	JULY 26/85

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS
PILE CAPS
SHEET 1 OF 2

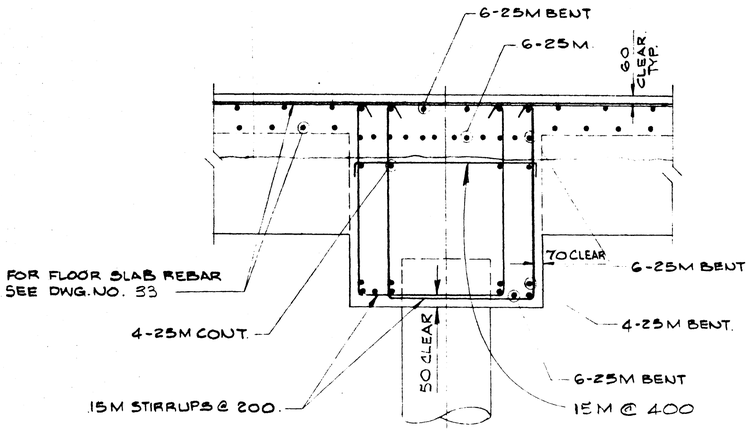
designed	C.J.G.
date	APRIL 1984.
drawn	H.C.G.
date	APRIL 1984.
reviewed	
date	
approved	
date	

Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
5-4/05/15

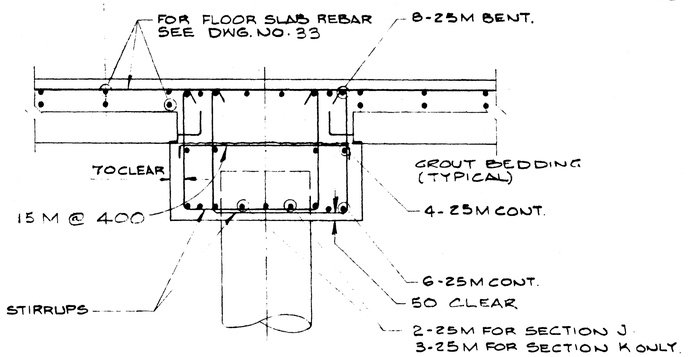
project number / no. du projet: PR100772

drawing no. / no. du dessin: 31 OF 75 (A)

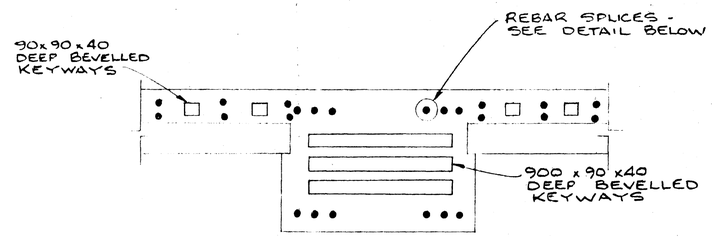
PWC A1



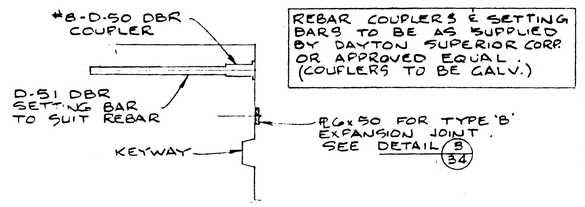
SECTION F / 31
1:20



SECTION J / K — 31
1:20

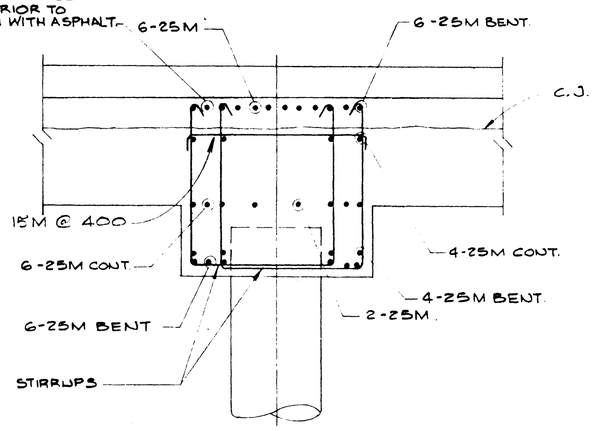


KEYWAY LOCATIONS ON SOUTH FACE OF WHARF EXTENSION
1:20

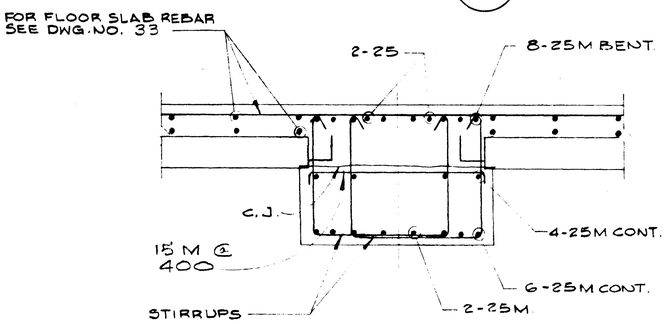


TYPICAL CONNECTION TO FUTURE WHARF EXTENSION (NOT IN CONTRACT)
1:10

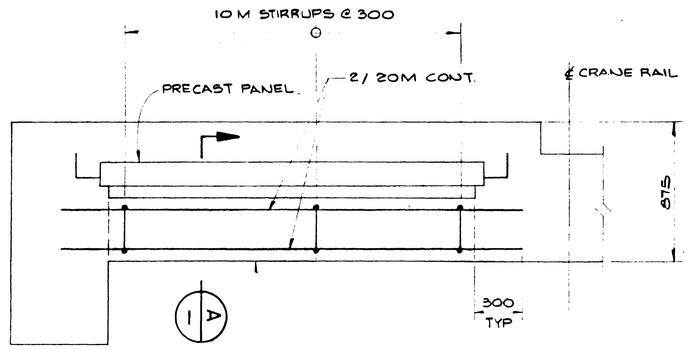
NOTE:
SPRAY PAINT LOCATION OF 25M REBAR ON SURFACE OF CONCRETE PRIOR TO FILLING TRENCH WITH ASPHALT.



SECTION G / 31
1:20

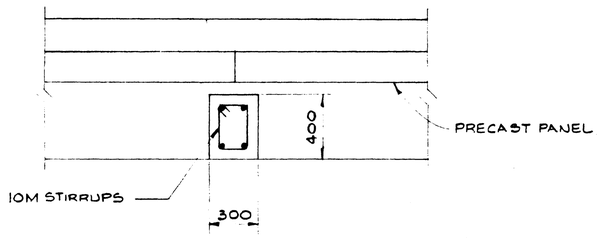


SECTION H / 31
1:20



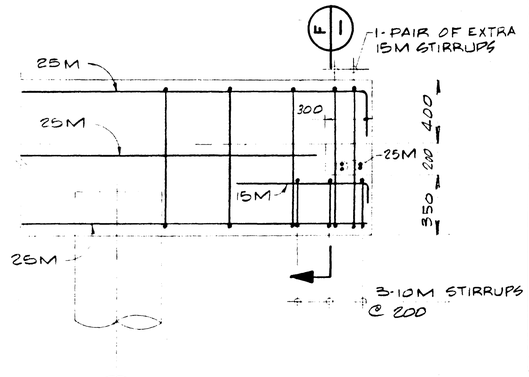
FOR LOCATION OF COMPRESSION STRUTS SEE DWG. NO. 27, 28 & 29.

ELEVATION

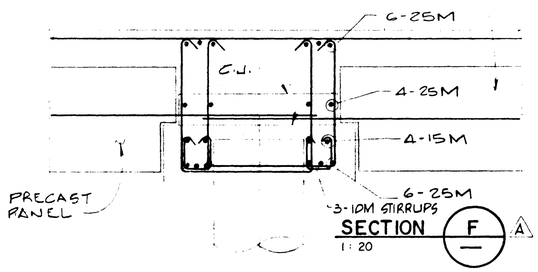


SECTION A / —

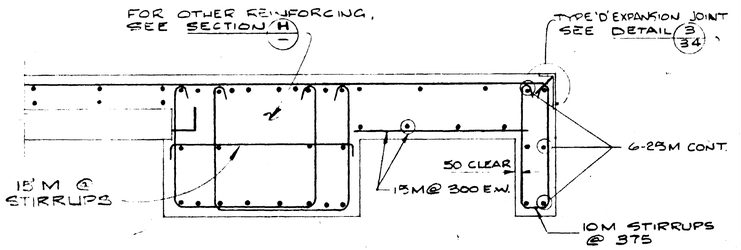
COMPRESSION STRUT DETAIL
1:20



SECTION E / 27, 28, 29 — PRECAST EDGE BEAM AT PILE CAP
1:20



SECTION F / — (A)
1:20



SECTION C / 29
1:20

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

"BC041464"

revisions		date
A	AS BUILT	MAY 31/85

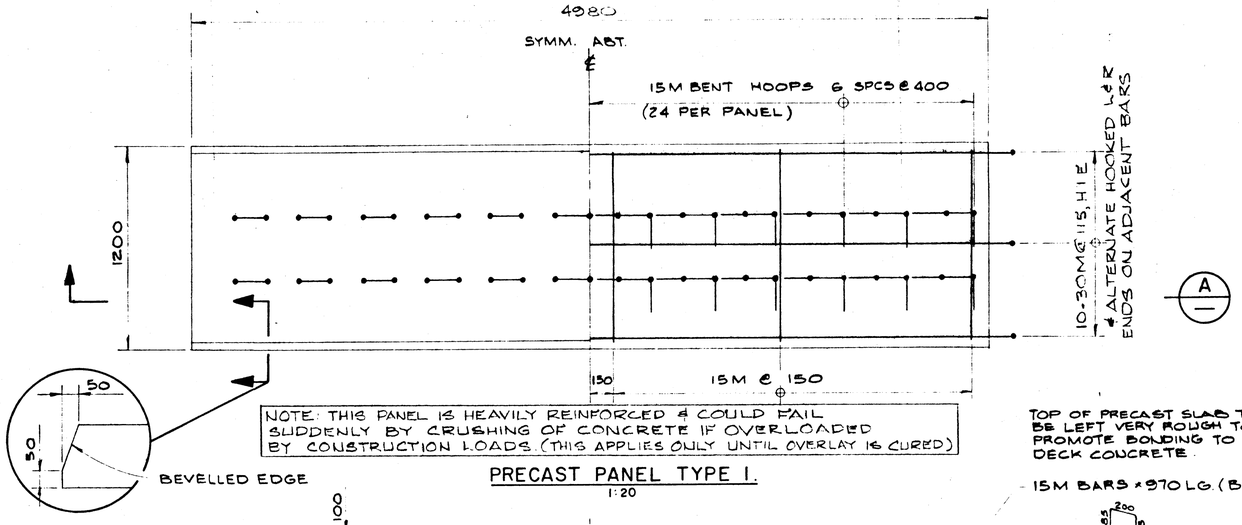
A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO.3

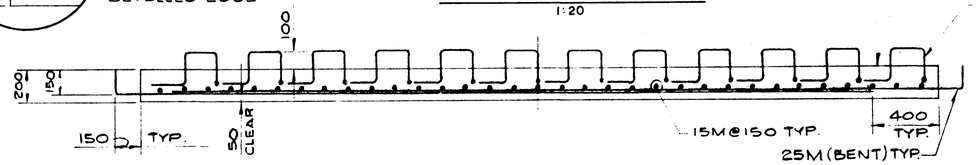
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS
PILE CAPS
SHEET 2 OF 2

designed C.J.G. — conçu
date APRIL 1984.
drawn H.C.G. — dessiné
date APRIL 1984.
reviewed — examiné
date
approved — approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR100772
drawing no. / no. du dessin
32 OF 75 (A)

PWC A1



PRECAST PANEL TYPE 1.
1:20



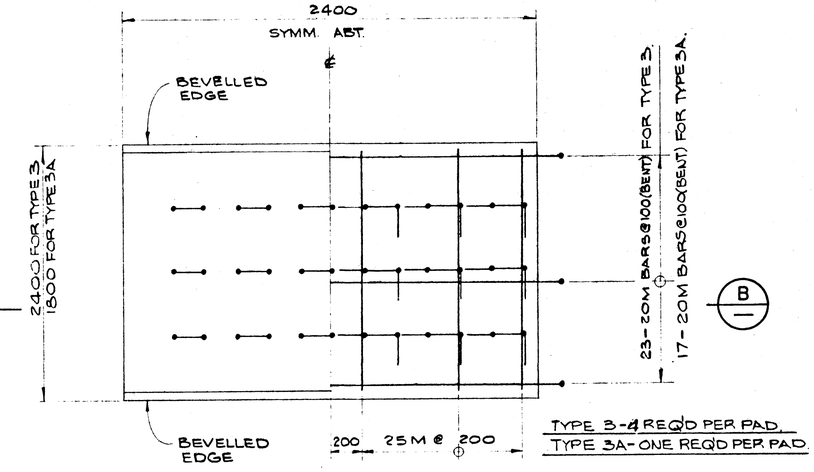
TOP OF PRECAST SLAB TO BE LEFT VERY ROUGH TO PROMOTE BONDING TO DECK CONCRETE.

15M BARS × 970 LG. (BENT).

NOTE: FOR DRAIN HOLE LOCATIONS SEE DWG. 130 20, AND FOR ALL PRECAST LOCATIONS SEE DWG NO. 27, 28 & 29.

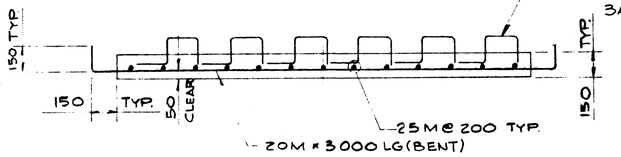
APPLY BONDING COMPOUND "CONCRESIVE 1001-LPL" TO TOP OF TOP & SIDES OF PRE-CAST PANELS IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS TYPICAL ALL PRE CAST PANELS

SECTION A
1:20

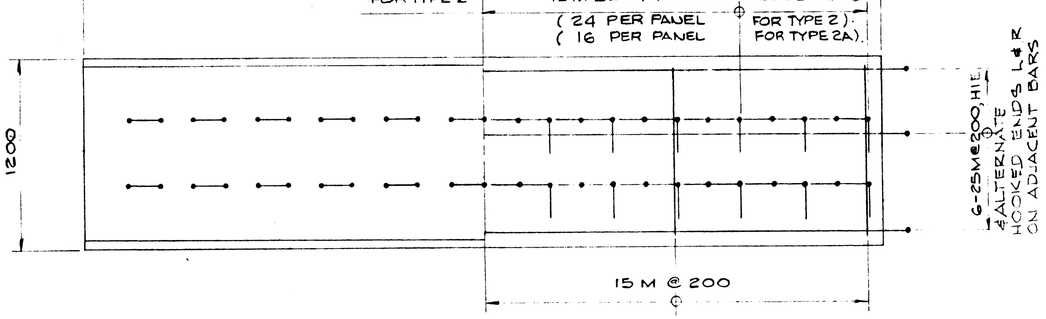


TYPE 3-4 REQ'D PER PAD.
TYPE 3A- ONE REQ'D PER PAD.

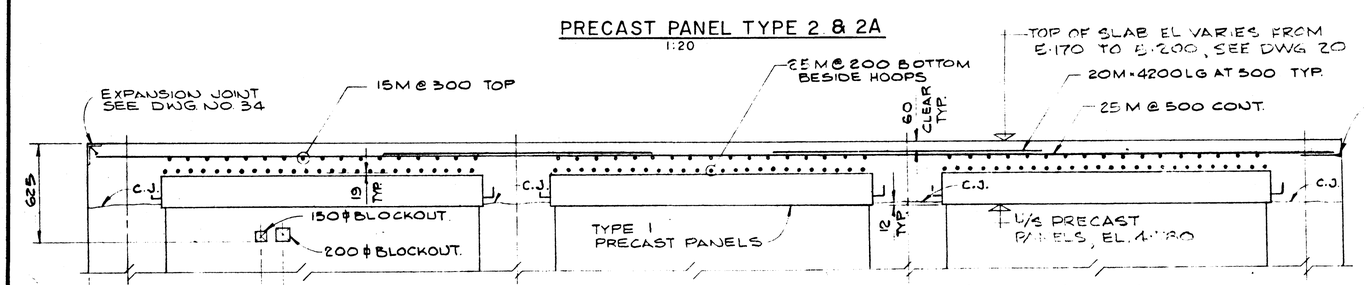
PRECAST PANEL TYPE 3 & 3A
1:20



SECTION B TYPICAL
1:20



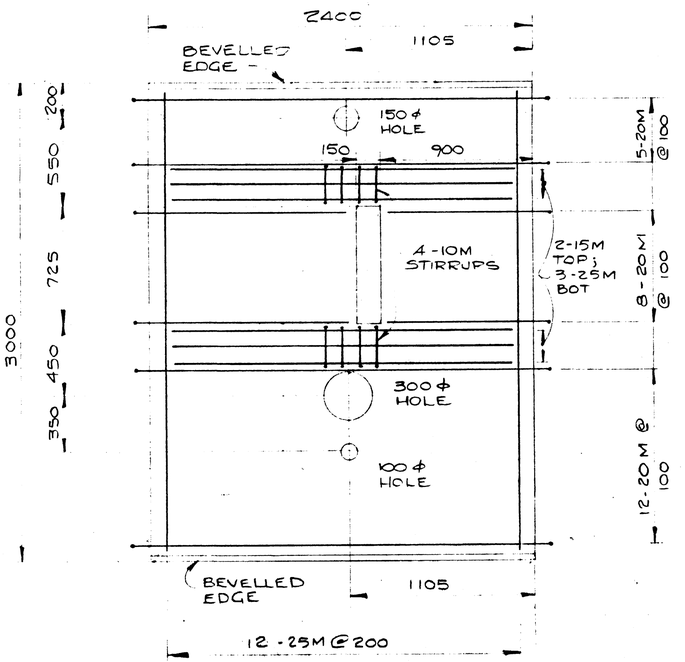
PRECAST PANEL TYPE 2 & 2A
1:20



SECTION C FLOOR SLAB TYPE 1.
1:50 HORIZ. 1:20 VERT. — 27 28 29

SECTION D FLOOR SLAB TYPE 2.
1:50 HORIZ. 1:20 VERT. — 27 28 29

NOTE
TYPE 4 PRECAST PANEL NOT USED



NOTE: 15M BENT BARS NOT SHOWN FOR CLARITY.

B

PRECAST PANEL TYPE 5
1:20

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT — 13

revisions		date
B	AS BUILT	JULY 26/85
A	REBAR SIZE ADDED - PANELS	SEPT. 12/84

A detail no. / no. du détail; B location drawing no. / sur dessin no.; C drawing no. / dessin no.

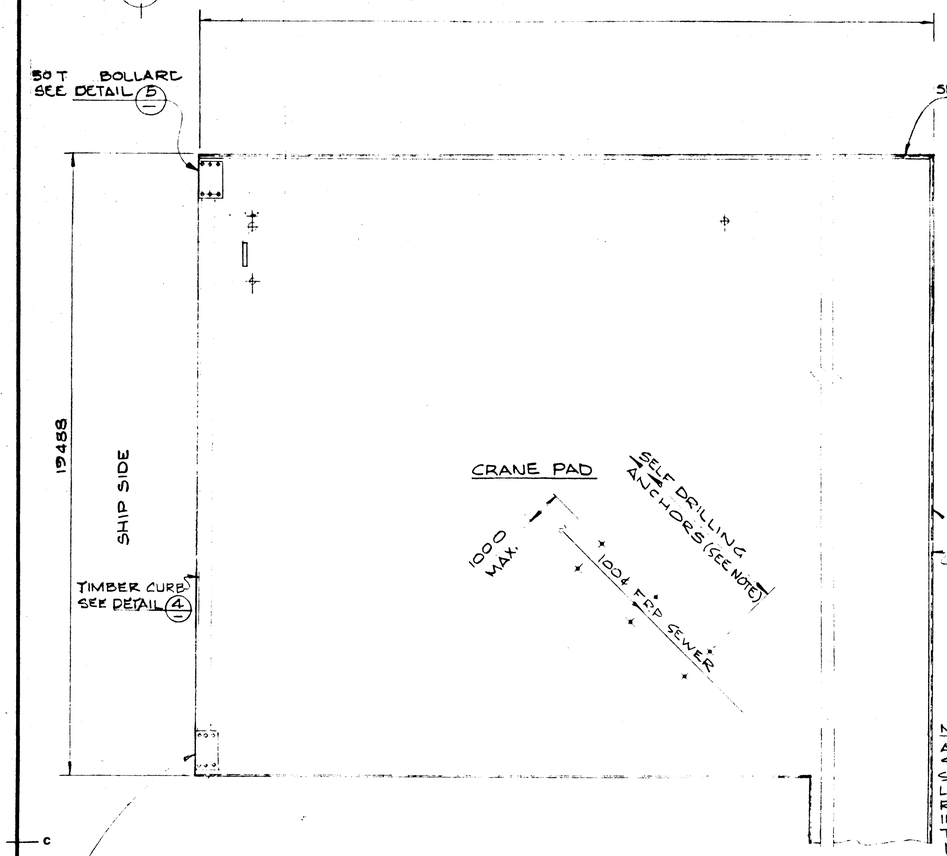
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS
PRECAST PANELS

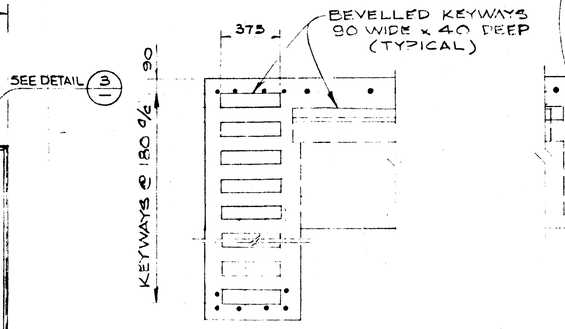
BC041465

designed C.J.G. / conçu
date APRIL 1984
drawn H.C.G. / dessiné
date APRIL 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projet TPC
project number / no. du projet
PR100772
drawing no. / no. du dessin
33 OF 75 — B

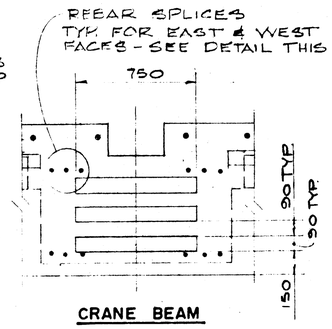
PWC A1



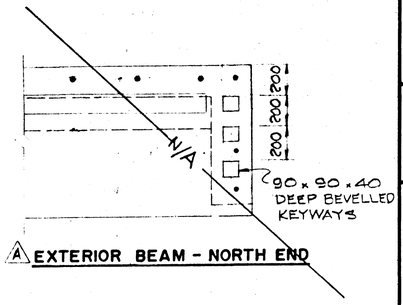
PLAN
1:100



EXTERIOR BEAM- SOUTH END

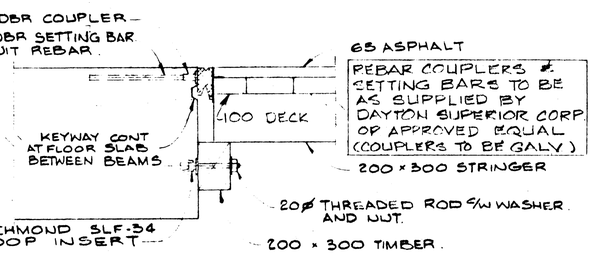


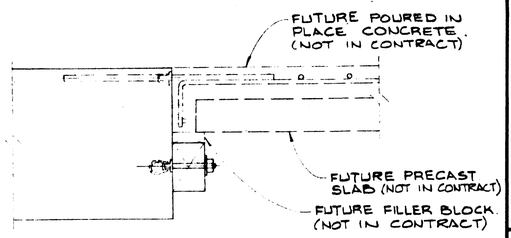
CRANE BEAM



A EXTERIOR BEAM - NORTH END

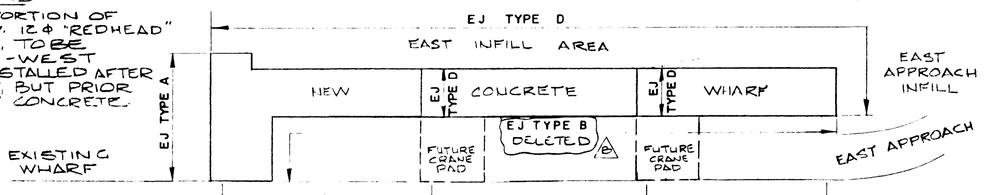
KEYWAY LOCATION ON EAST FACE OF CRANE PADS





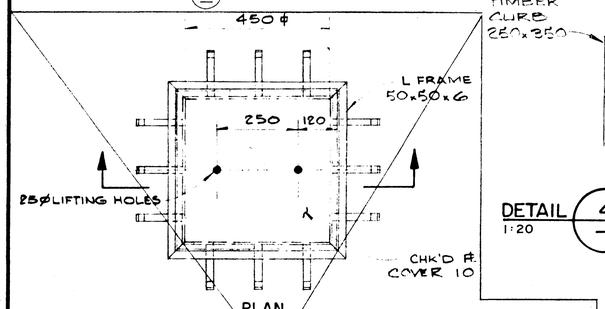
TYPICAL CONNECTION OF CRANE PAD TO EXISTING WHARF
1:20

TYPICAL CONNECTION TO FUTURE CRANE PAD EXTENSION (NOT IN CONTRACT)
1:20



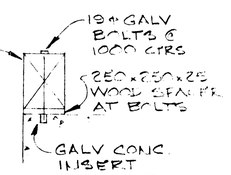
NOTE:- SELF DRILLING ANCHORS
ANCHORS FOR DIAGONAL PORTION OF SEWER LINE TO BE GALV. 12ϕ "REDHEAD" SELF DRILLING ANCHORS, TO BE LOCATED TO AVOID EAST-WEST REINFORCING & TO BE INSTALLED AFTER INSTALLATION OF PRECAST, BUT PRIOR TO POURING OF OVERLAY CONCRETE. MAX. SPACING 2400.

50T BOLLARD
SEE DETAIL 5

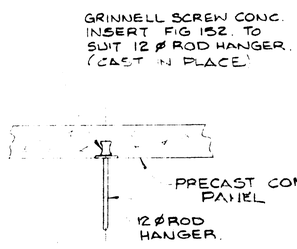


DETAIL 1 — COVER & FRAME FOR SEWER CONNECTION
1:20

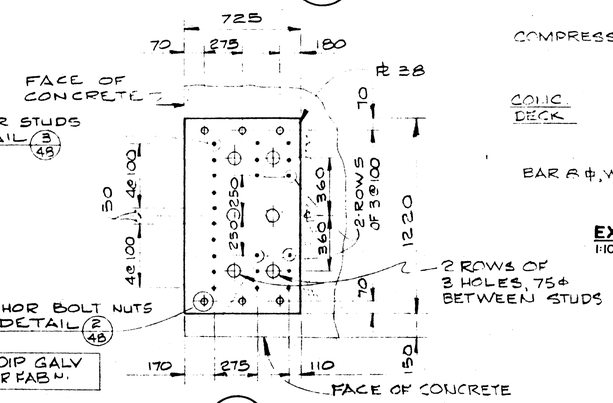
HOT DIP GALVANIZE AFTER FABRICATION



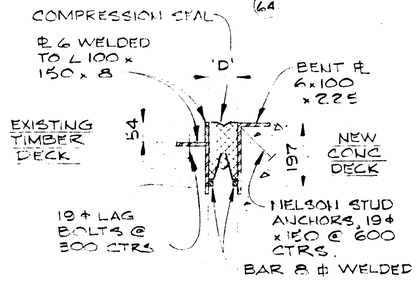
DETAIL 4 — TIMBER CURB
1:20



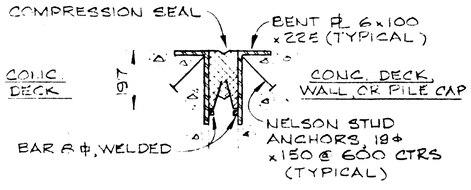
DETAIL 2
1:20



DETAIL 5 — 50 TONNE BOLLARD MOUNTING BASE PLATE
1:20

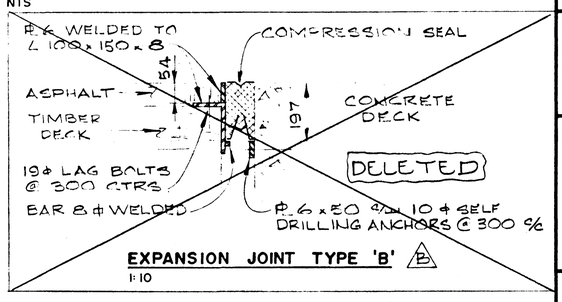


EXPANSION JOINTS TYPE 'A'
1:10



EXPANSION JOINT TYPE 'D'
1:10

LOCATION PLAN
NTS



EXPANSION JOINT TYPE 'B'
1:10

NOTE:
1) COMPRESSION SEALS TO BE 'WATSON BOWMAN WA 600.
DIMENSION 'D' (TEMPERATURE AT TIME OF INSTALLATION = 10°C)
EAST-WEST JOINTS, 'D' = 87 mm
NORTH-SOUTH JOINTS, 'D' = 90 mm
A 2) EXPANSION JOINT TO BE INSTALLED IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS.

DETAIL 3 27,28 29 — TYPICAL EXPANSION JOINTS

NOV 6 1985

PWC.AI

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

BC041466

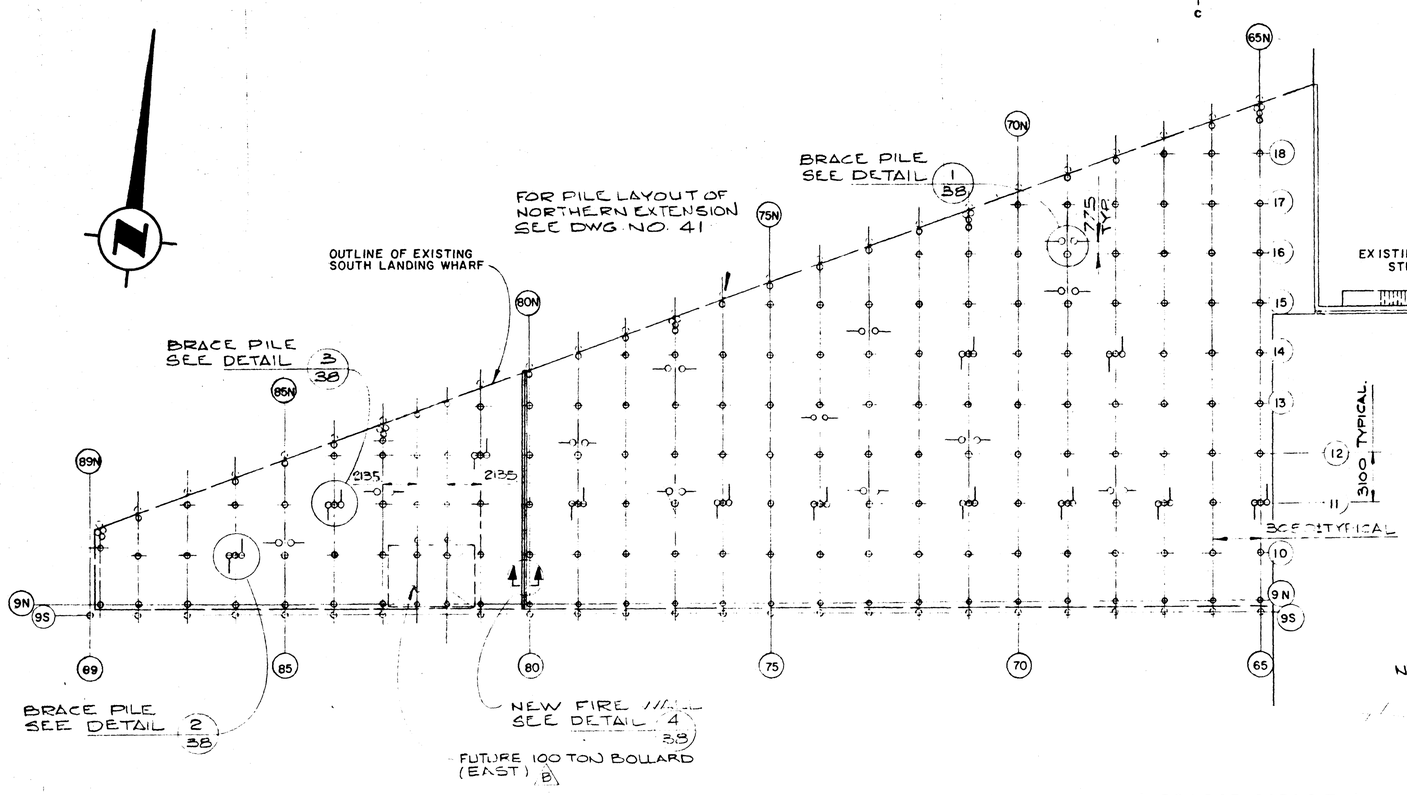
revisions		date
B	AS BUILT	JULY 26/85
A	CRANE PADS 283 DELETED	SEPT. 12/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3.

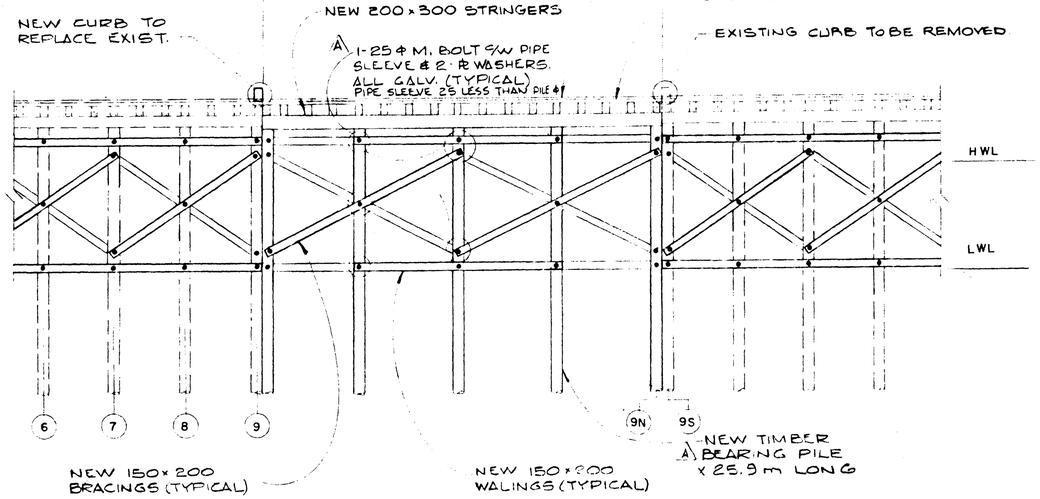
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS
MISCELLANEOUS DETAILS

designed C.J.G.	conçu
date APRIL 1984.	
drawn H.C.G.	dessiné
date APRIL 1984.	
reviewed	examiné
date	
approved	approuvé
date	
Tender	Soumission
PWC Project Manager	Administrateur de projets TPC
project number PR100772	no. du projet
drawing no. 34 OF 75 B	no. du dessin



PILING PLAN OF WEST INFILL AREA (H20 LOAD CAPACITY)

1:200



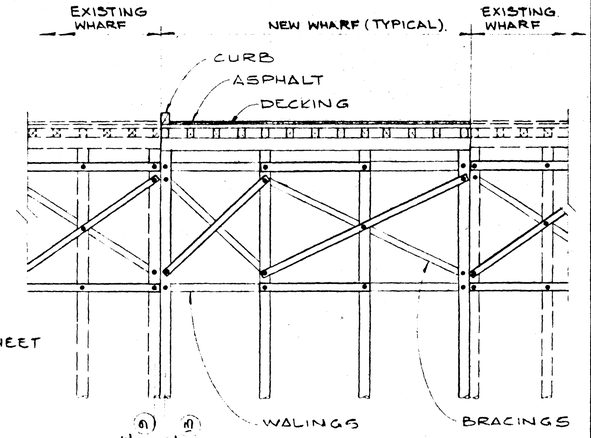
TYPICAL CROSS SECTION AT WEST INFILL AREA (LOOKING EAST)

1:100

NOTE:

1) TOP & BOTTOM WALINGS (SHOWN ON FAR SIDE) TO LAP TO NORTH SIDE OF PILING ON LINE 9N ON NORTH & TO SOUTH SIDE OF PILING ON LINE 9S. BOLTS FROM WALING UPGRADING OF EXISTING WHARF TO GO THROUGH THE NEW WALINGS.

A 2). SPLICE PILE CAPS AT PILE WITH 1200 LONG CORBEL OF SAME CROSS SECTION AS PILE CAP. STRINGERS & CAPS TO BE FACED SZE. ATTACH STRINGERS TO CAPS WITH 19ϕ DRIFT PINS.

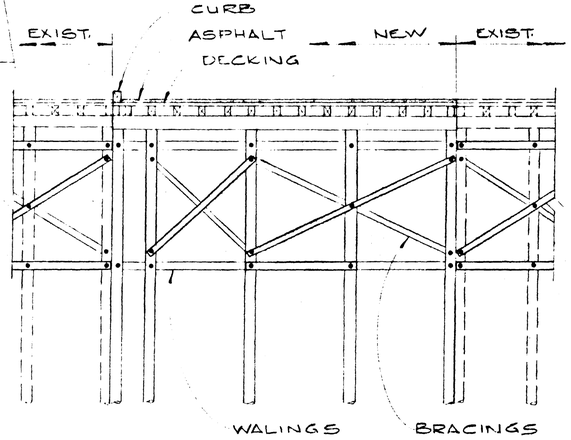


NOTE: BATTER PILES NOT SHOWN FOR CLARITY.

BRACING DETAIL - TYPE 1 (LOOKING EAST)

SIMILAR TO GRID LINE 82.

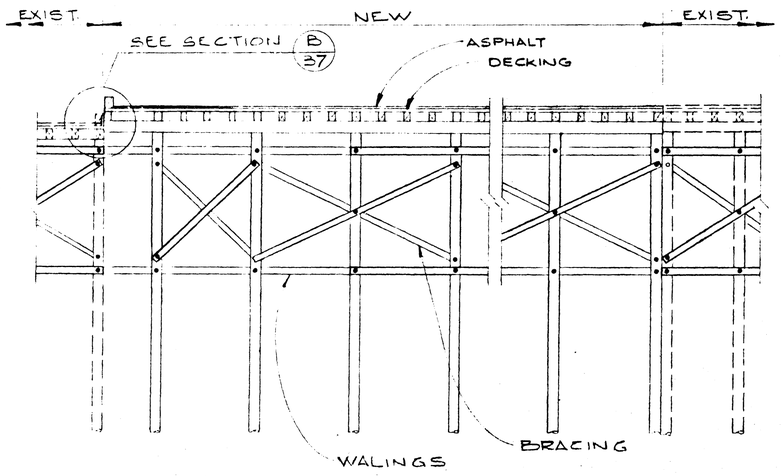
1:100



BRACING DETAIL - TYPE 2 (LOOKING EAST)

SIMILAR TO GRID LINE 84.

1:100



BRACING DETAIL - TYPE 3 (LOOKING EAST)

SIMILAR TO GRID LINE 67.

1:100

NOTES:

1) FOR GENERAL NOTES SEE DWG NO. 1

NOV. 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

"BC041467"

revisions		date
B	AS BUILT	JULY 26/85
A	REVISED AS PER ADDENDUM 3,4	SEPT. 12/84

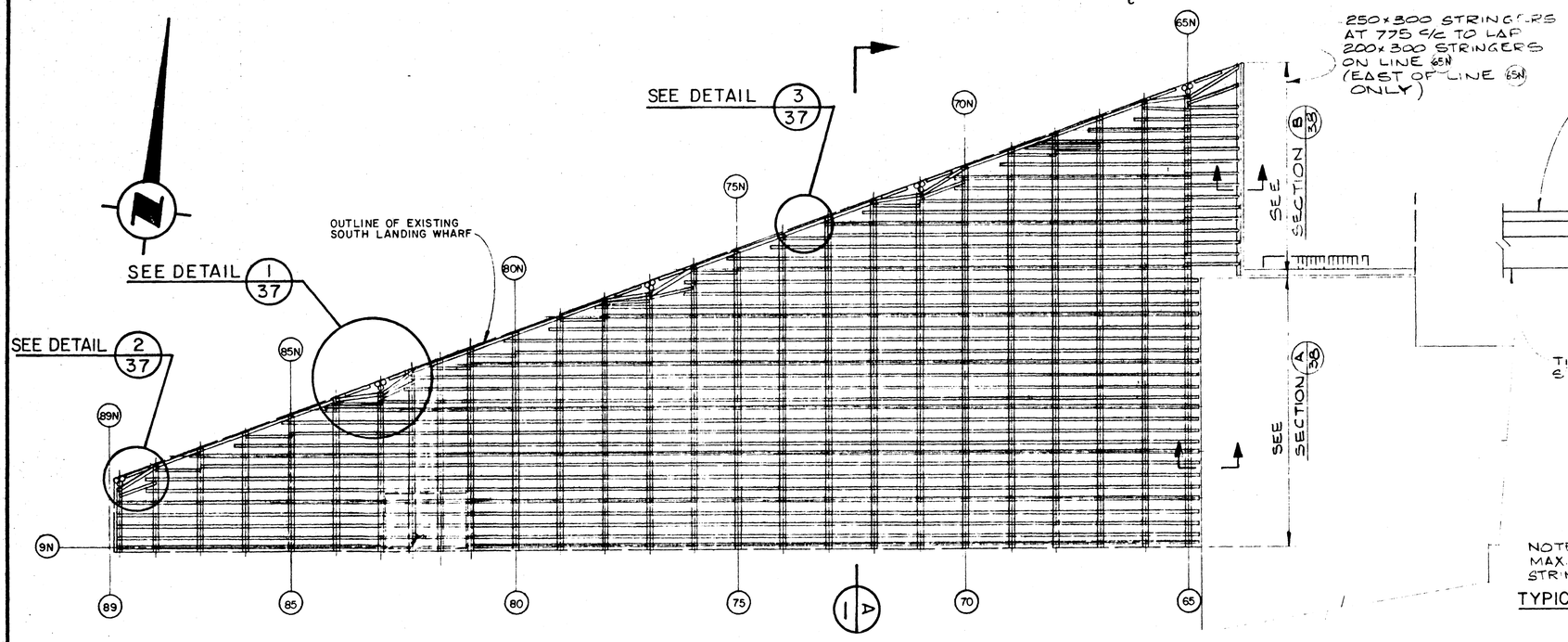
A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

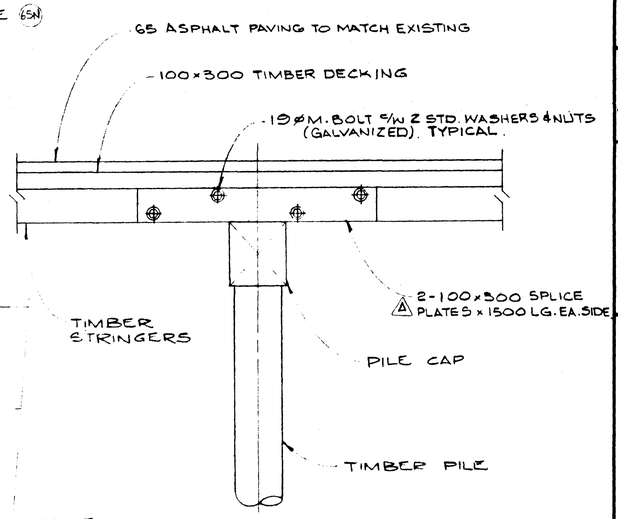
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
WEST INFILL AREA
PILING LAYOUT

designed C.J.G. / conçu
date MARCH 1984
drawn H.C.G. / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
35 OF 75 - B

PWC A1

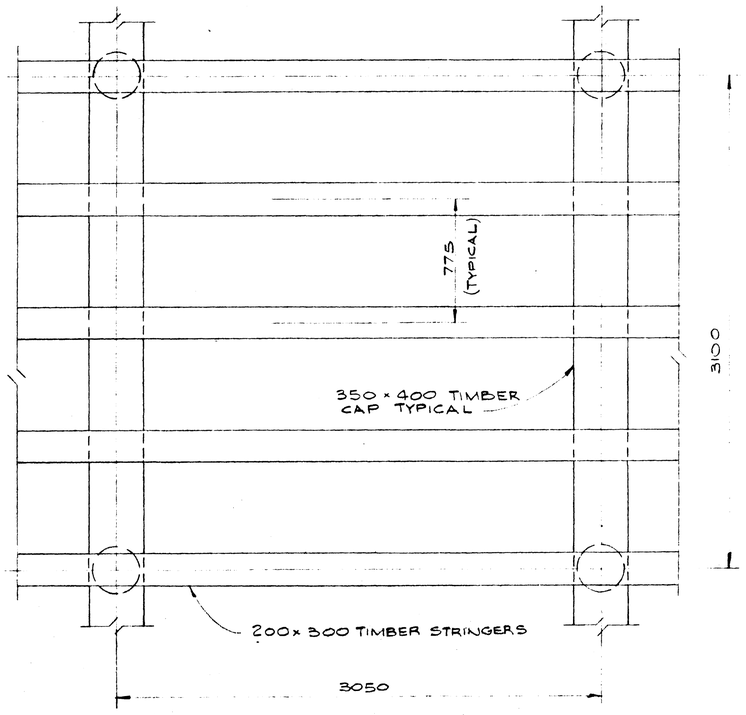


STRINGER PLAN OF WEST INFILL AREA
1:200

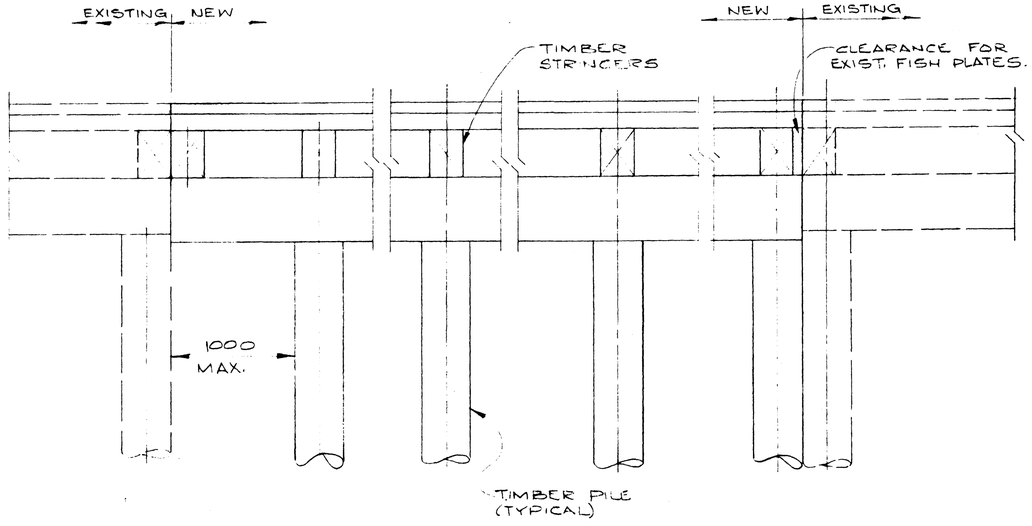


NOTE:
MAX. TWO OUT OF EVERY THREE ADJACENT STRINGERS TO BE SPLICED ON ANY SINGLE PILE CAP.

TYPICAL SECTION AT SPLICE CONNECTION
1:20



TYPICAL PLAN (PER BAY)
1:20
(UNLESS SHOWN OTHERWISE)



SECTION A
1:20

NOTES:
1) FOR GENERAL NOTES SEE DWG NO. 1

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

BC041468

revisions		date
B	AS BUILT	JULY 26/85
A	REVISED AS PER ADDENDUM 3	SEPT. 12/84

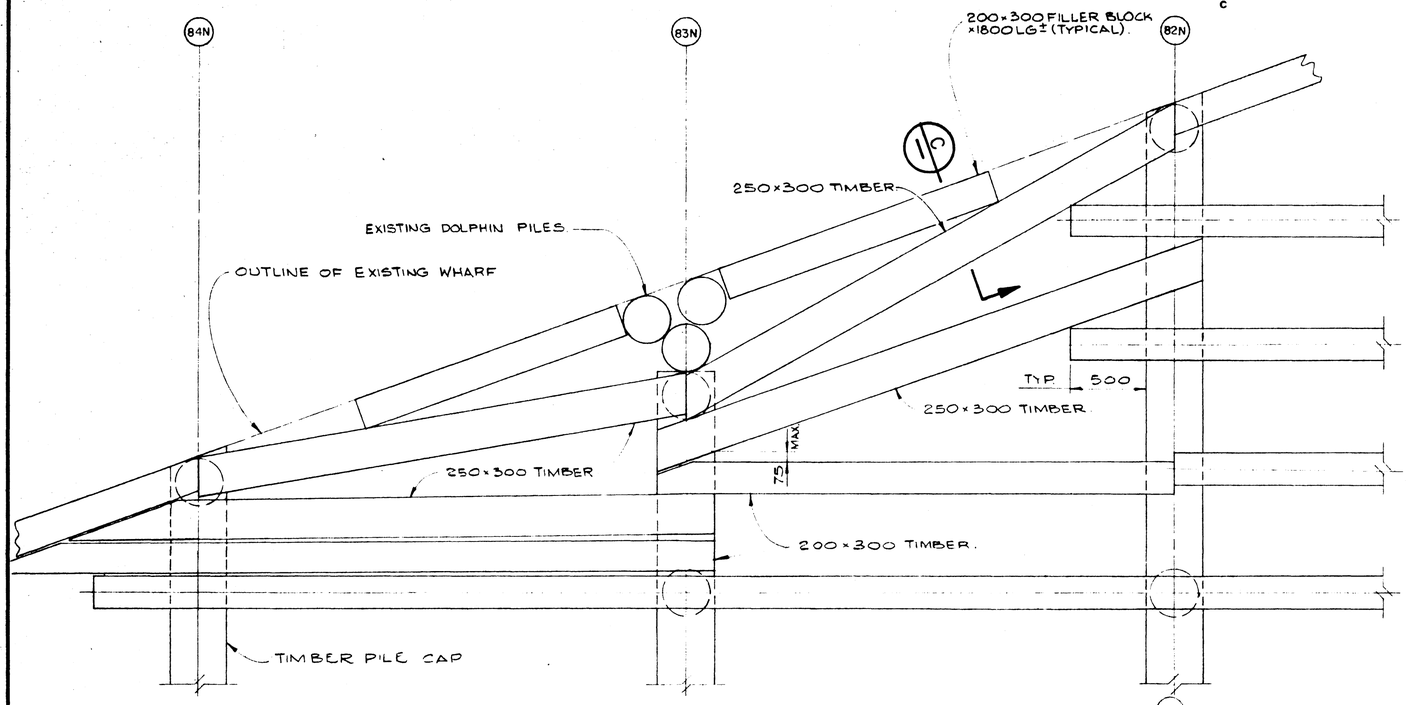
A detail no. / no. du détail
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
WEST INFILL AREA
DECK LAYOUT

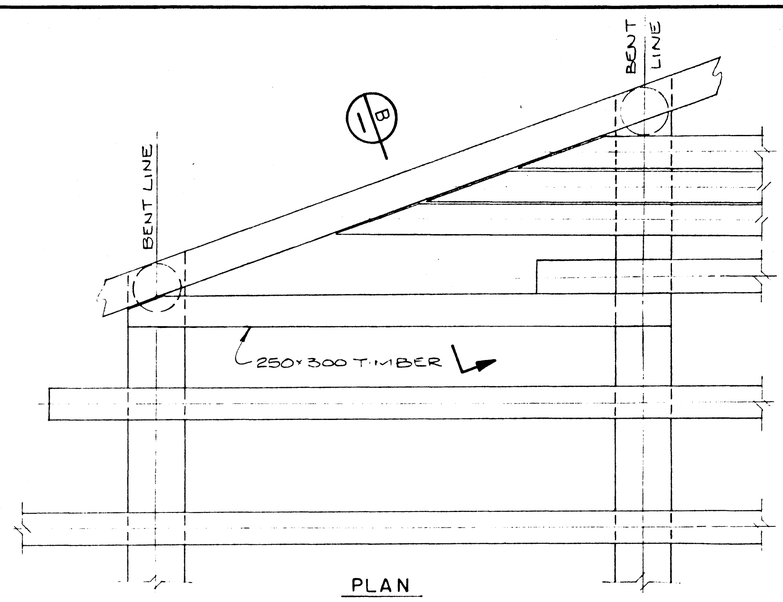
designed C.J.G. / conçu
date MARCH 1984
drawn H.C.G. / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
36 OF 75-B

PWC A1



PLAN

DETAIL 1 / 36
1:20

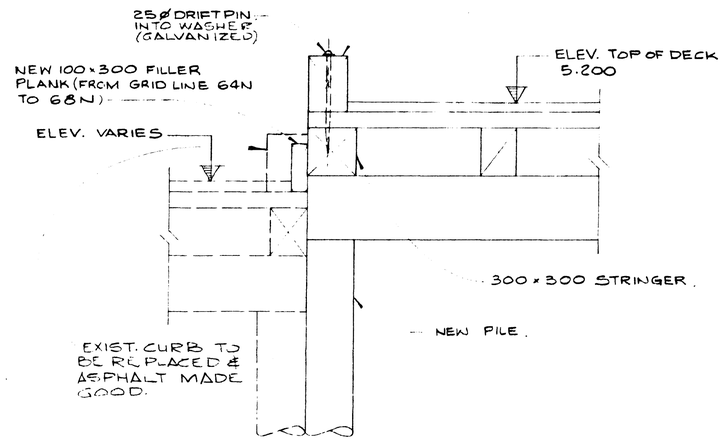


PLAN

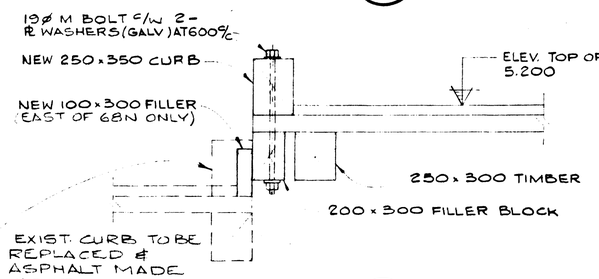
DETAIL 3 / 36
1:20

TYPICAL UNLESS SHOWN OTHERWISE

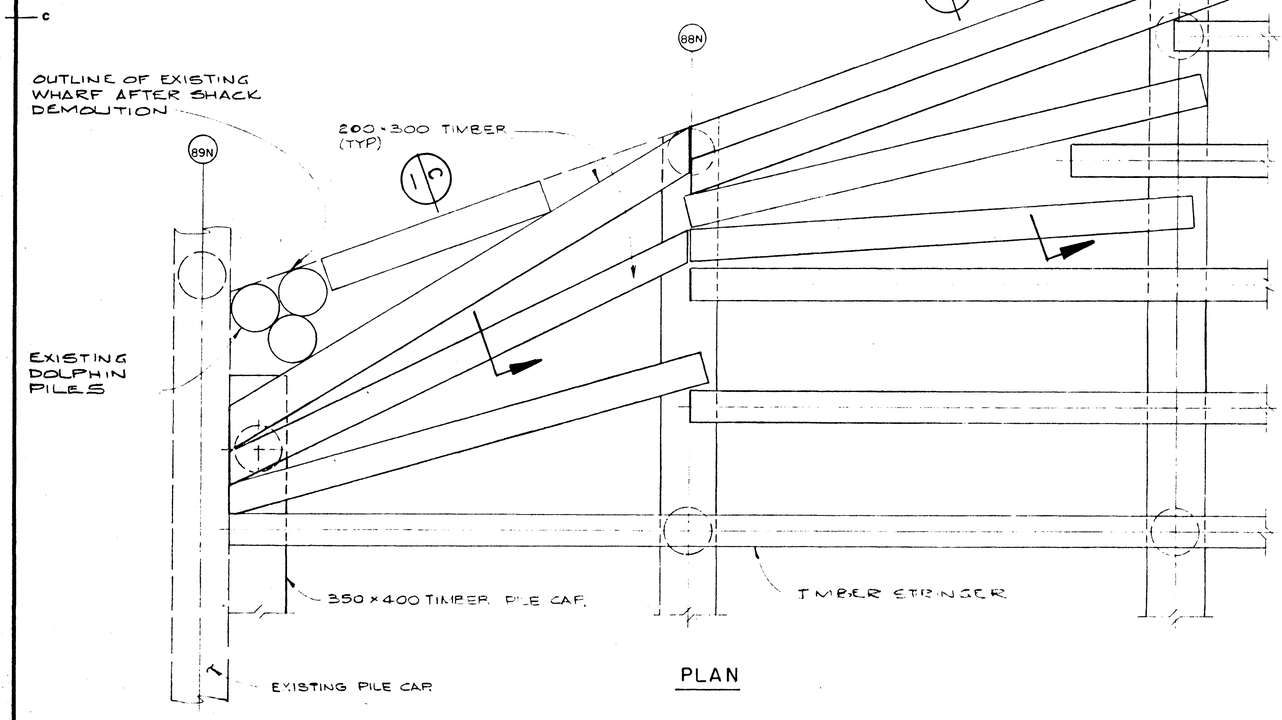
NEW 250×350 CURB



SECTION B
1:20



SECTION C
1:20



PLAN

DETAIL 2 / 36 A
1:20

NOTES:
1) FOR GENERAL NOTES SEE DWG NO. 1

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. GRANT

"BC041469"

revisions		date
A	AS BUILT	JULY 26/85

A detail no. / no. du détail
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
WEST INFILL AREA
DETAILS
SHEET 1 OF 2

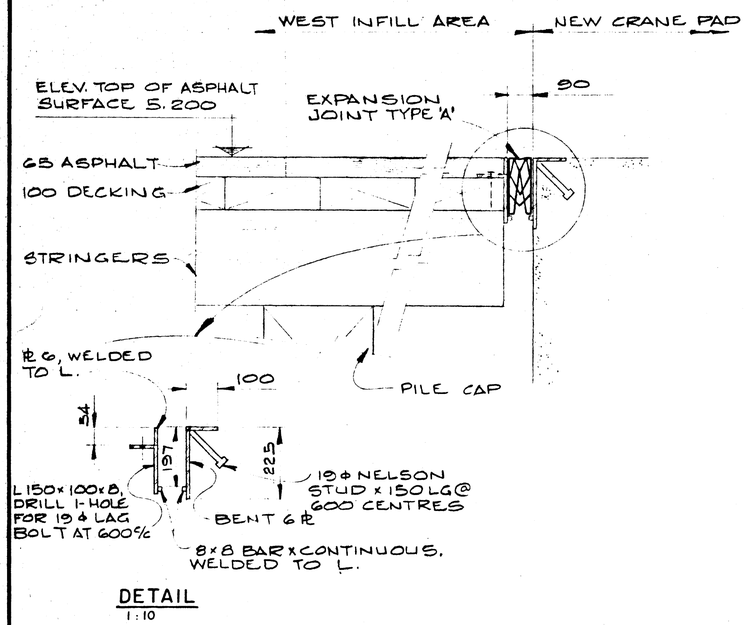
designed C.J.G. / conçu
date MARCH 1984
drawn H.C.G. / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no. du projet
PR 100772

drawing no. / no. du dessin
37 OF 75 A

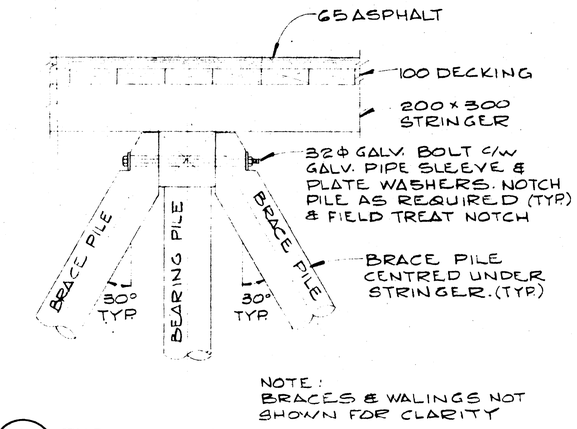
PWC-A1

NOTES
1) FOR GENERAL NOTES & LEGEND SEE DWG. NO. 1

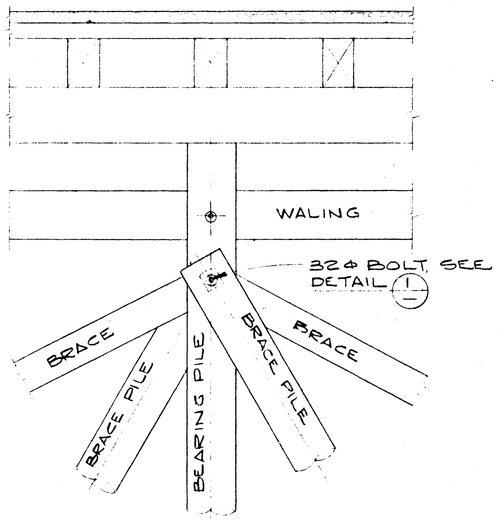


DETAIL
1:10

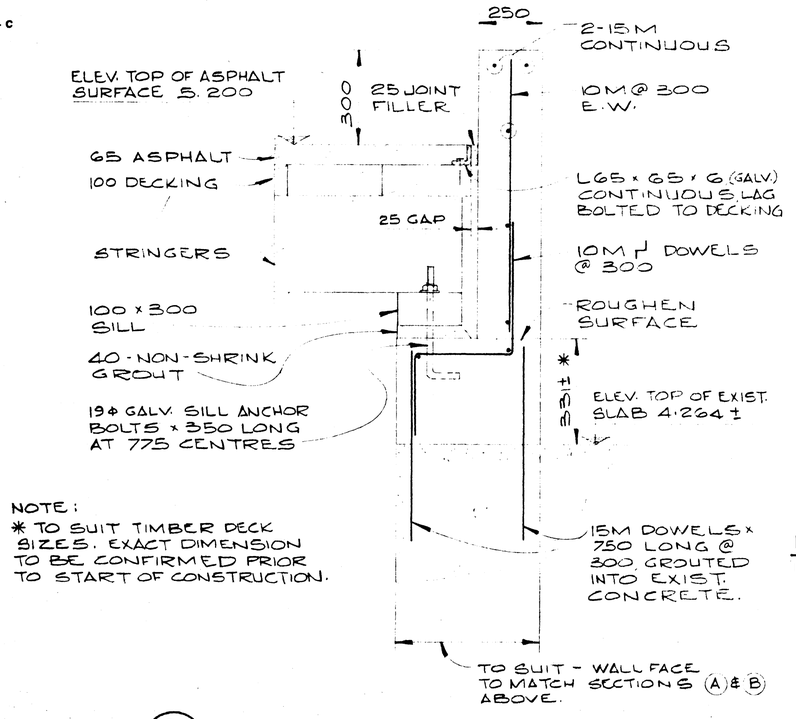
SECTION (A) EXPANSION JOINT DETAIL
1:10 (36)



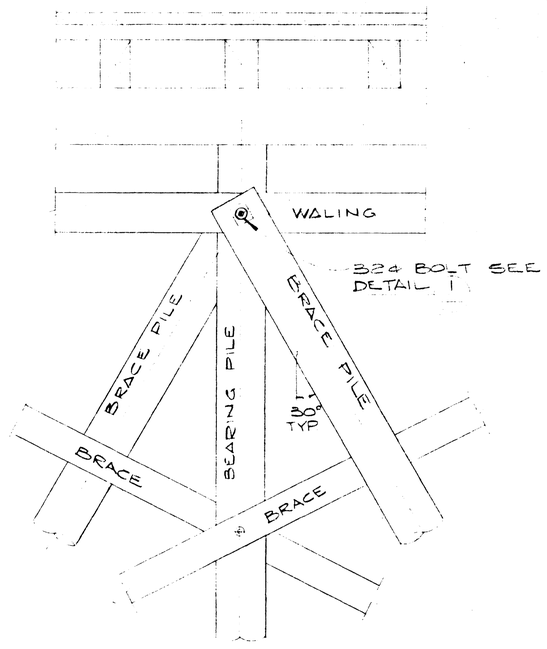
DETAIL (1) TYPICAL EAST-WEST BRACING PILE DETAIL
1:20 (35)



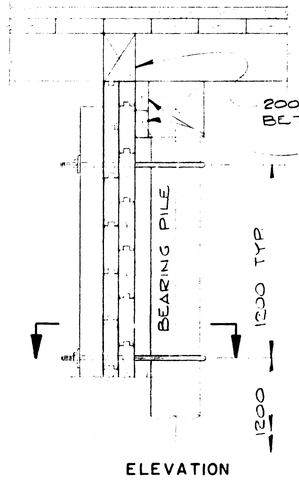
DETAIL (3) NORTH-SOUTH BRACING PILE DETAIL ALONG
1:20 (35) BENT LINE (11) AND AS REQUIRED



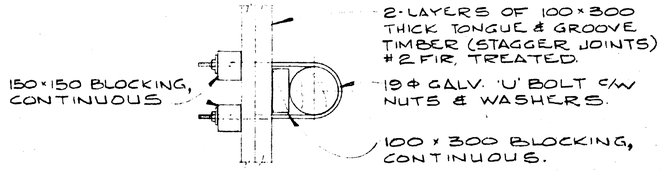
SECTION (B) BEARING WALL DETAIL - TYPICAL OVER EXISTING
1:10 (36) CONCRETE SLAB



DETAIL (2) NORTH-SOUTH BRACING PILE DETAIL ALONG
1:20 (35) BENT LINE (10) AND AS REQUIRED



ELEVATION



SECTION
1:20

DETAIL (4) TYPICAL FIREWALL
1:20 (35)

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. J. GRANT

"BC041470"

revisions		date
A	AS BUILT	JULY 26/85

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

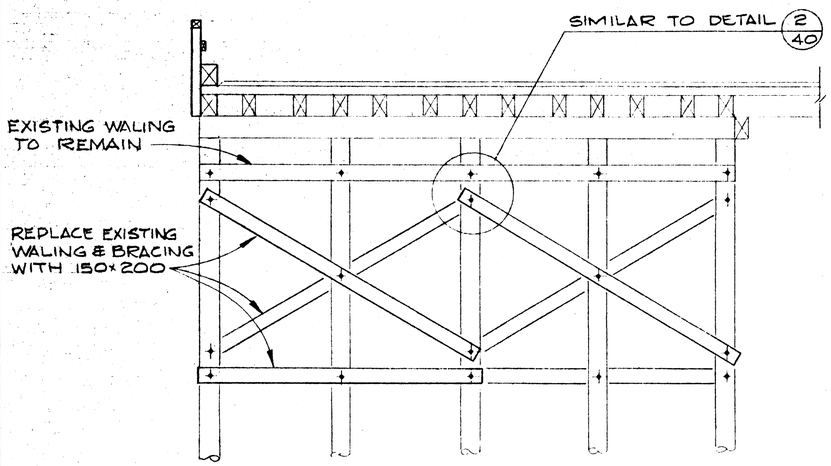
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
WEST INFILL AREA
DETAILS
SHEET 2 OF 2

designed CJG / conçu
date MARCH 1984
drawn GHP / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC 89/05/11

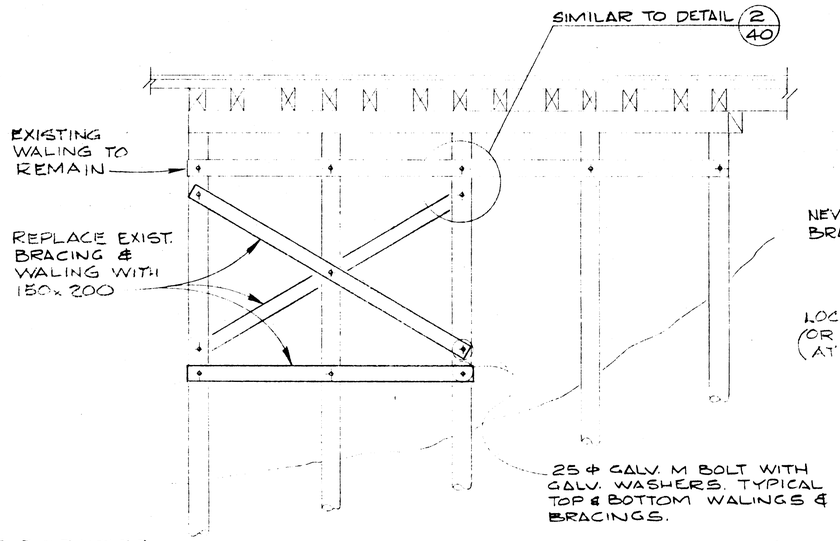
project number / no. du projet
PR 100772

drawing no. / no. du dessin
38 OF 75 (A)

PWC A1

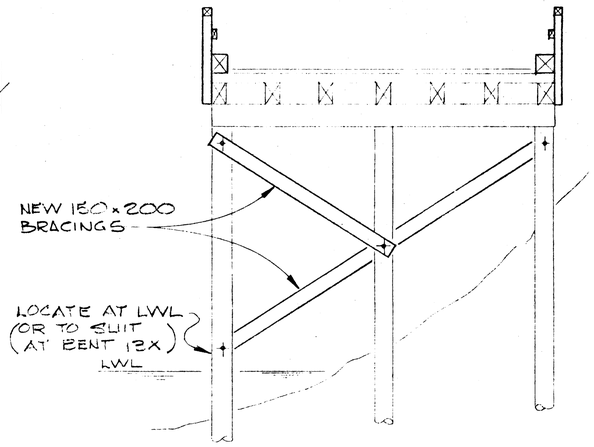


REPAIRS AT BENT 1A & 3A
1:50

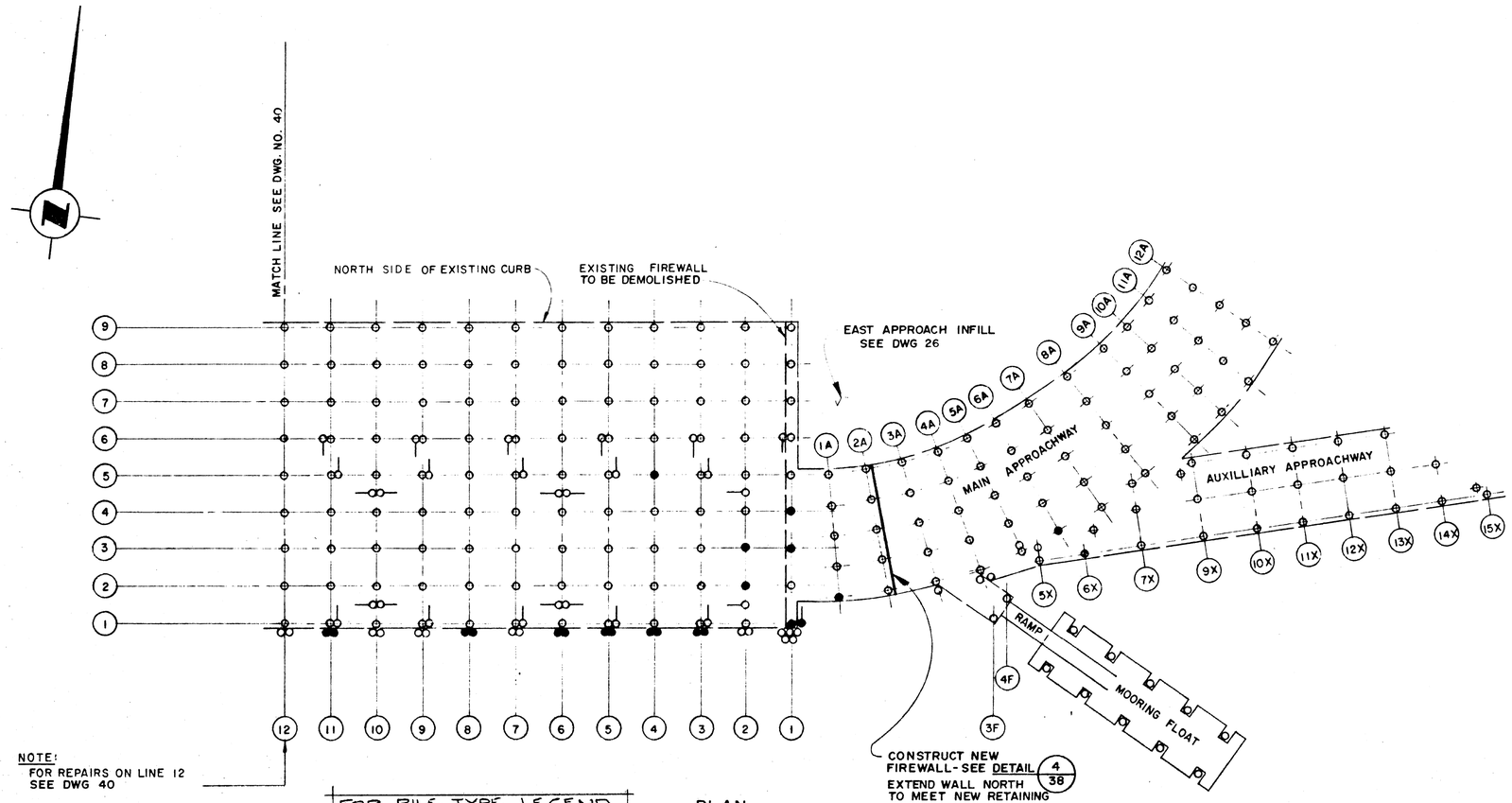


NOTE:-
ANY EXISTING BOLT HOLES IN PILES NOT RE-USED FOR NEW BRACING TO BE PLUGGED WITH TIGHT CREOSOTED WOOD PLUG.

REPAIRS AT BENT 4A, 5A, 6A & 7A
1:50



REPAIRS AT BENT 9X, 10X, 11X, & 13X, BENT 7X SIMILAR
1:50



NOTE:
FOR REPAIRS ON LINE 12 SEE DWG 40

FOR PILE TYPE LEGEND SEE DWG. NO. 41

PLAN
1:200

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete.

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C.J. GRANT

BC041471

revisions | | date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin

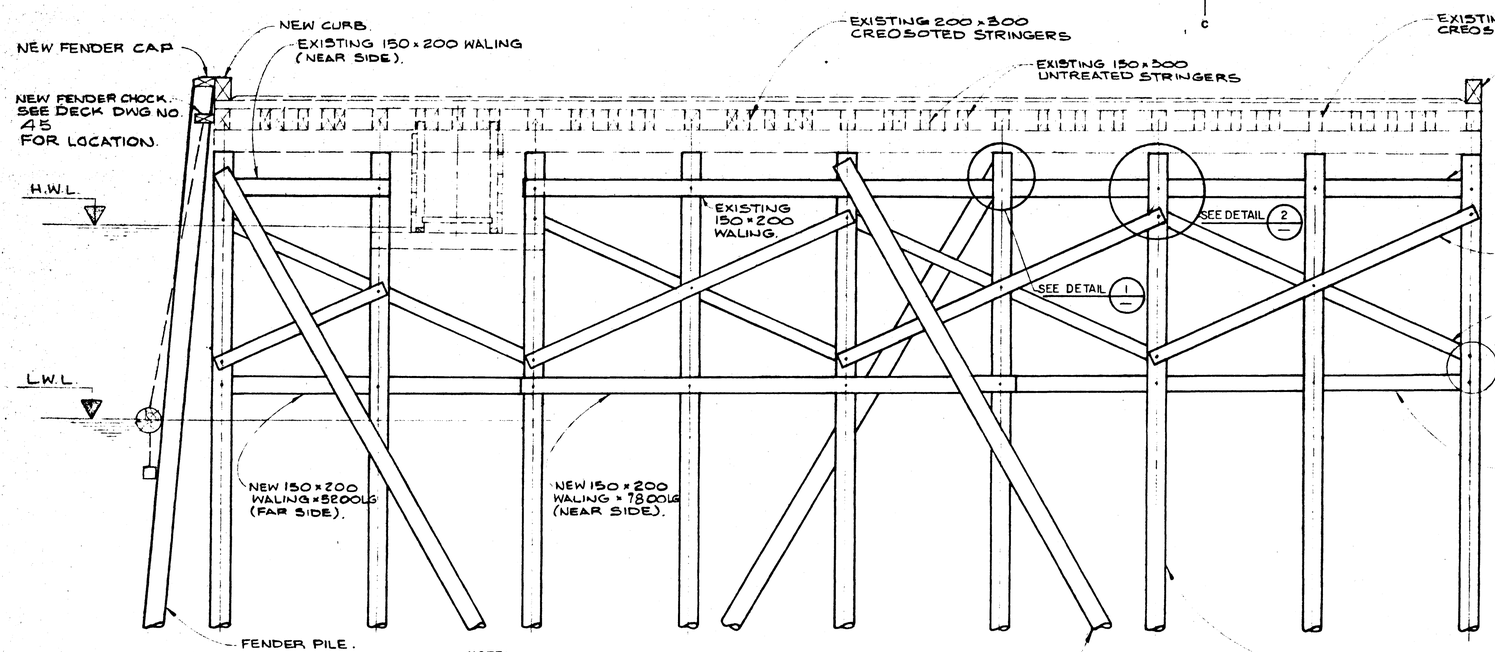
IMPROVEMENTS TO SOUTH LANDING WHARF
PILING REPAIRS BENT (1) TO (12) & APPROACHES
(NOT IN CONTRACT)

designed C.J.G. / conçu
date MARCH 1984
drawn H.C.G. / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no. du projet
PR 100772

drawing no. / no. du dessin
39 OF 75

PWC A1

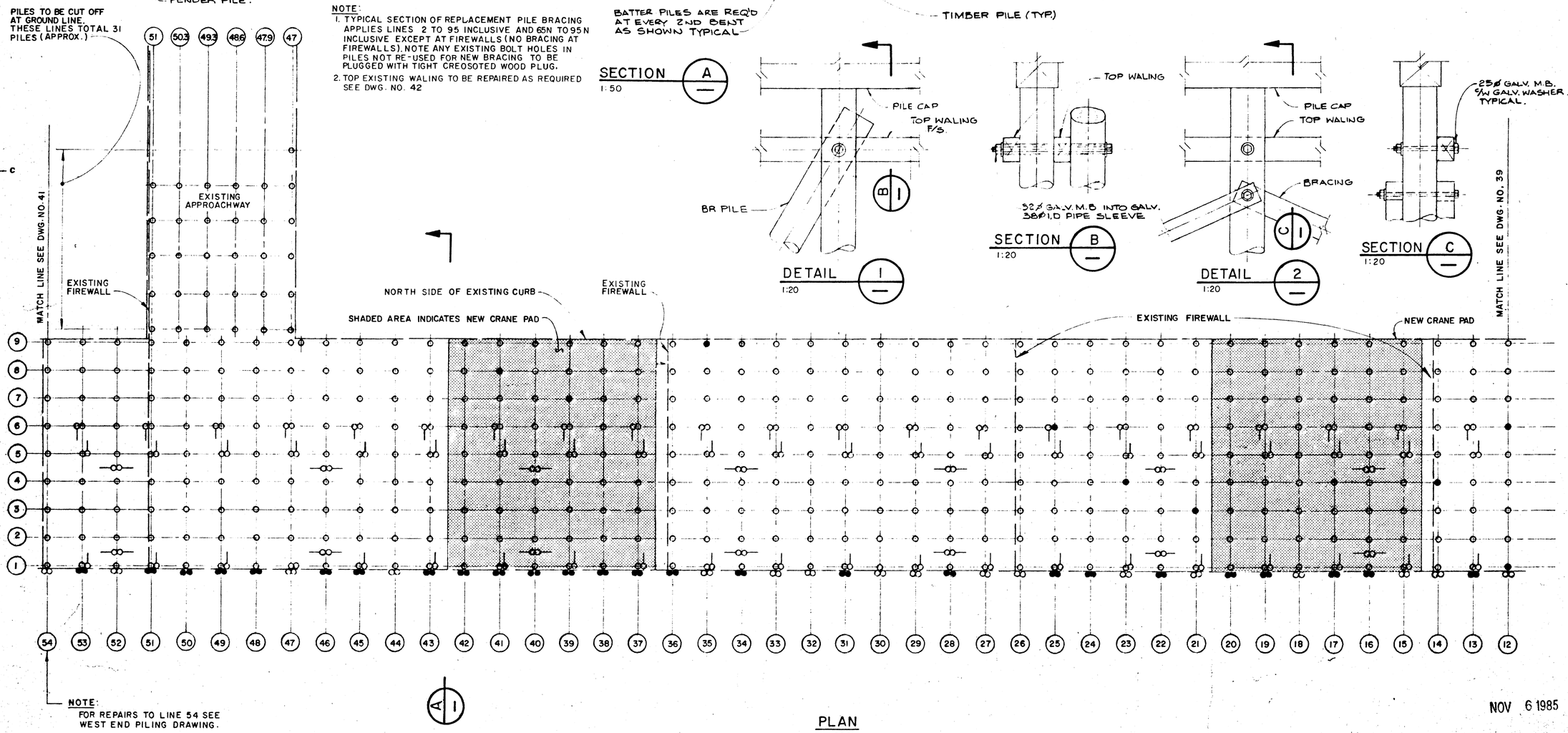


NOTE:
1. TYPICAL SECTION OF REPLACEMENT PILE BRACING APPLIES LINES 2 TO 95 INCLUSIVE AND 65N TO 95N INCLUSIVE EXCEPT AT FIREWALLS (NO BRACING AT FIREWALLS). NOTE ANY EXISTING BOLT HOLES IN PILES NOT RE-USED FOR NEW BRACING TO BE PLUGGED WITH TIGHT CREOSOTED WOOD PLUG.
2. TOP EXISTING WALING TO BE REPAIRED AS REQUIRED SEE DWG. NO. 42

BATTER PILES ARE REQ'D AT EVERY 2ND BENT AS SHOWN TYPICAL

SECTION A — 1:50

NOTES:
1. ALL NEW TIMBER TO BE TREATED BEFORE INSTALLATION.
2. SEE DRAWING NO. 41 FOR EXPLANATION OF SYMBOLS.
3. LIST OF EXISTING PILES TO BE REPLACED - CENTER ONLY.
   PILES - 12-1*, 12-6, 14-4, 21-3, 23-4, 25-6, 34-9, 35-9, 39-7, 41-1 BR, 41-8.
   (TOTAL - 11 PILES.)
   (NOTE: PILE 40-8 WAS REPLACED WITH NEW PILE IN PILE TESTING PROGRAM).
4. FENDER PILES - PAIRS AT LINES 13, 16, 17, 19, 20, 22, 24, 25, 28, 31, 34, 36 TO 43 INCL., 45, 46, 48 TO 51 INCL., 53. (TOTAL 52 PILES).



NOTE:
FOR REPAIRS TO LINE 54 SEE WEST END PILING DRAWING.

PLAN — 1:200

NOV 6 1985

The Contractor shall confirm the actual location of all services within the area of operations. The Owner does not warrant that the locations shown are either accurate or complete.

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

BC041472

revisions		date

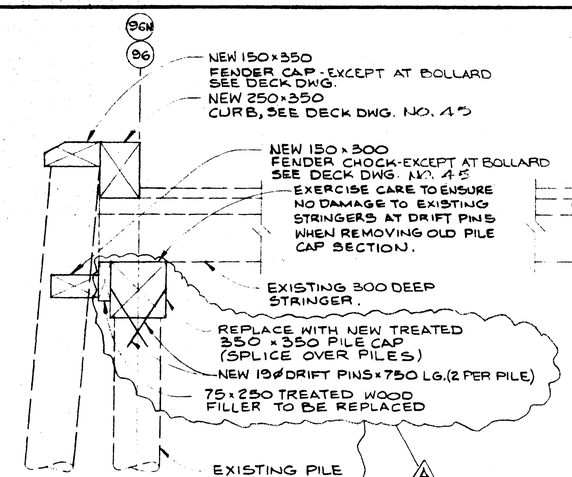
A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
PILING REPAIRS
BENT (12) TO (54)
(NOT IN CONTRACT)

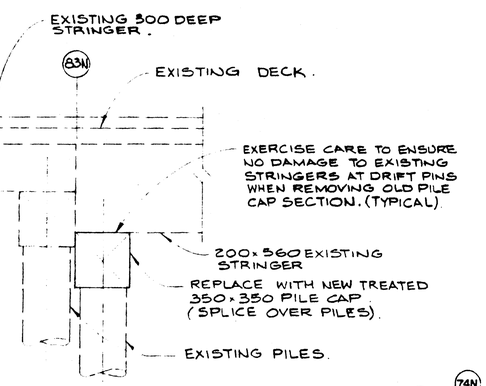
designed / conçu	C.J.G.
date	MARCH 1984
drawn / dessiné	H.C.G.
date	MARCH 1984
reviewed / examiné	
date	
approved / approuvé	
date	
Tender / Soumission	
PWC Project Manager / Administrateur de projets TPC	
project number / no. du projet	PR 100772
drawing no. / no. du dessin	40 OF 75

PWC A1



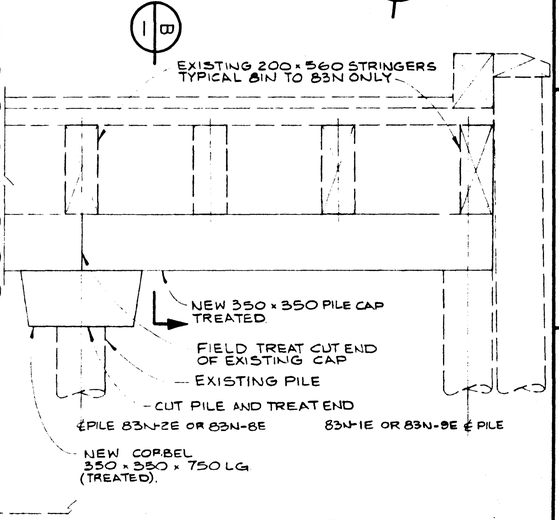
TYPICAL SECTION AT LINE 96 & 96N
1:20

SEE TYPICAL SECTION AT LINE 83N

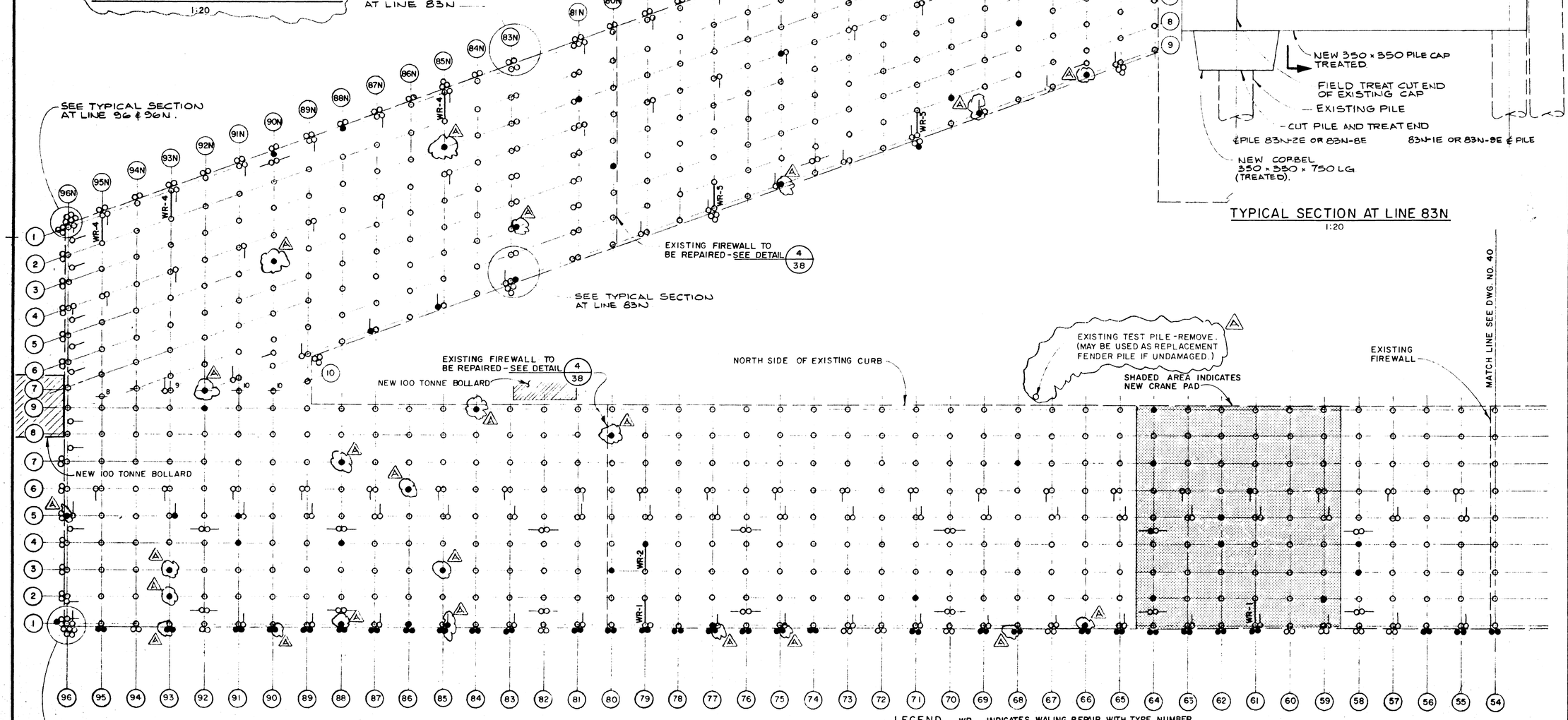


SECTION B
1:20

NOTES:
1. ALL NEW TIMBER TO BE TREATED BEFORE INSTALLATION.
2. FOR REPAIRS TO PILE CAPS AT PILE TEST LOCATIONS SEE DECK REPAIR DRAWINGS.
3. LIST OF EXISTING PILES TO BE REPLACED-WEST END ONLY SOUTH SIDE.
PILES-58-3, 58-4, 58-2, 61-6BR, 62-4#, 62-5, 64-2, 64-4.5WBR, 64-7, 64-9#, 66-1, 68-7, 71-2, 77-1, 79-4, 80-3, 80-8, 84-9#, 85-1BR, 85-3, 86-1, 86-6, 88-1, 88-4, 88-7, 91-4, 91-5, 92-9, 93-2#, 93-3, 93-5BR, 96-5 (TOTAL 31 PILES).
SOUTH SIDE FENDER PILES-96-1FIW-SEE PLAN, ALL PAIRS OF PILES LINE 54 TO 95 INCLUSIVE EXCEPT PAIRS AT LINES 57 TO 60, 67, 70, 72, 73, 82, 92, 94 (TOTAL 63 PILES).
NORTH SIDE. - 65N-4, 66N-9, 68N-6, 69N-9BR, 70N-8, 75N-1BR, 75N-4, 75N-9#, 77N-1BR, 80N-6, 81N-3E, 83N-7E, 83N-9E, 85N-3, 85N-9BR, 87N-9BR, 88N-1, 90N-1, 90N-5, 92N-9. (TOTAL 20 PILES).
NORTH SIDE FENDER PILES.-PAIRS AT 68N, 69N, 71N, 73N PLUS 77N-1F3, SEE PLAN, (TOTAL 9 PILES).
SUB TOTAL-ALL PILES (INCLUDING FENDER PILES THIS SHEET ONLY = 123 PILES.



TYPICAL SECTION AT LINE 83N
1:20



PLAN
1:200

LEGEND WR- INDICATES WALING REPAIR WITH TYPE NUMBER AS SHOWN ON DRAWING 42. (I.E. WR-1)

- ● INDICATES PILES TO BE REPLACED WITH TIMBER PILES 75' LG. (FENDER PILES TO BE 65' LG.) SEE LISTS. PILE CAP NOT TO BE DAMAGED DURING PILE REMOVAL.
- ⊙10 INDICATES N-S GRID NUMBER
- E INDICATES EAST
- W INDICATES WEST
- F FENDER PILE
- BR BRACE PILE
- # INDICATES ALREADY REMOVED IN TESTING PROGRAM, REPLACEMENT PILE REQUIRED.

EXAMPLE - 64-4.5WBR — BRACE PILE (WEST SIDE) BETWEEN E-W LINES 4 AND 5.
N-S GRID NO. 64

NOV 6 1985

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Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

revisions	date
A WORK DONE UNDER CONTRACT 3 SHOWN	

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project projet
"BC041473"

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

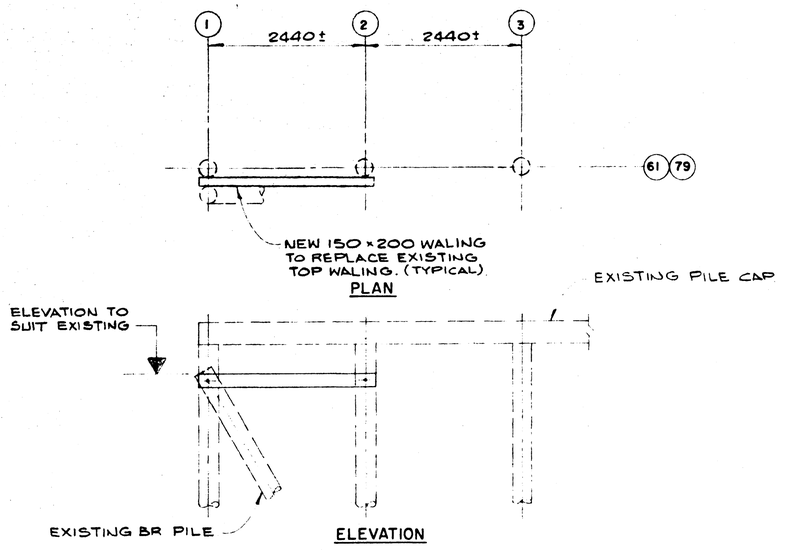
drawing dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
PILING REPAIRS BENT (54) TO (96)
(NOT IN CONTRACT EXCEPT AS NOTED)

designed C.J.G. conçu
date MARCH 1984
drawn H.C.G. dessiné
date MARCH 1984
reviewed examiné
date
approved approuvé
date
Tender Soumission
PWC Project Manager Administrateur de projets TPC

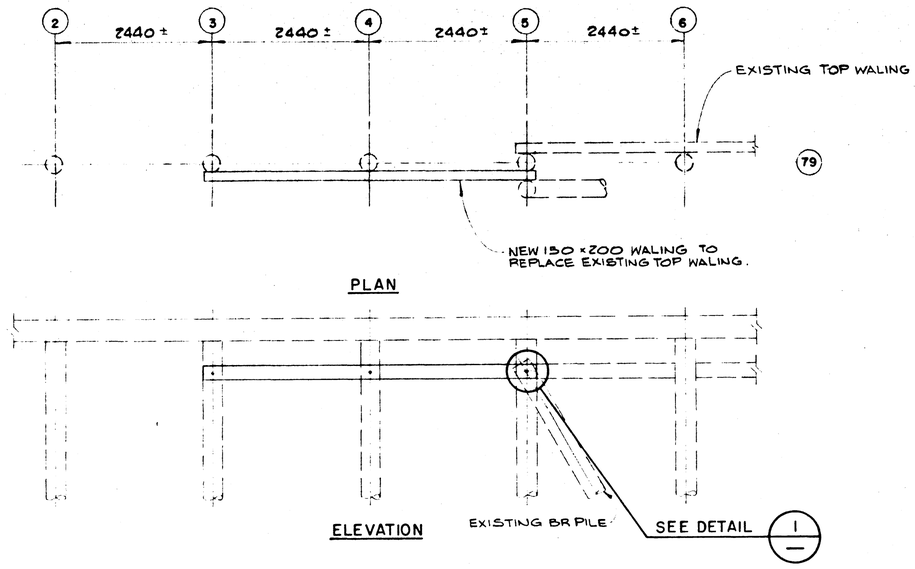
project number no. du projet
PR 100772

drawing no. no. du dessin
41 OF 75 A

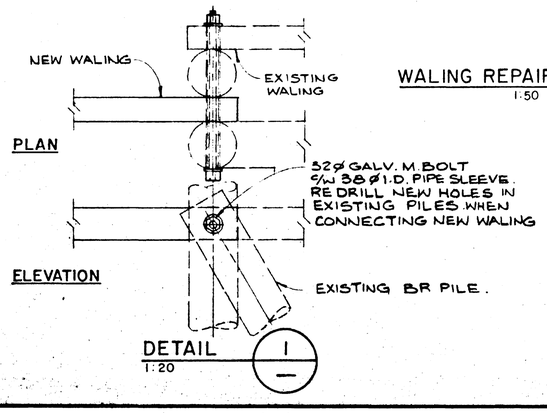
PWC A1



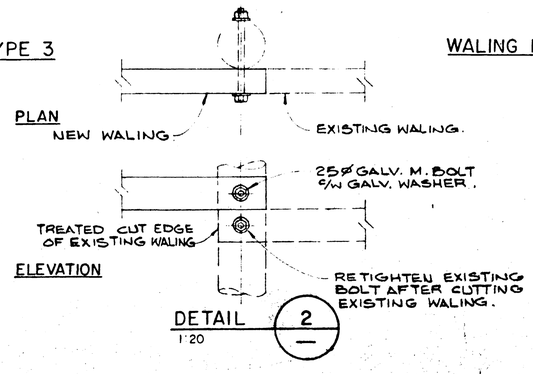
WALING REPAIR TYPE 1.
1:50



WALING REPAIR TYPE 2.
1:50



WALING REPAIR TYPE 3
1:50



WALING REPAIR TYPE 4
1:50

WALING REPAIR TYPE 5
1:50

NOV 6 1985

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Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. GRANT

BC041474

revisions | date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3.

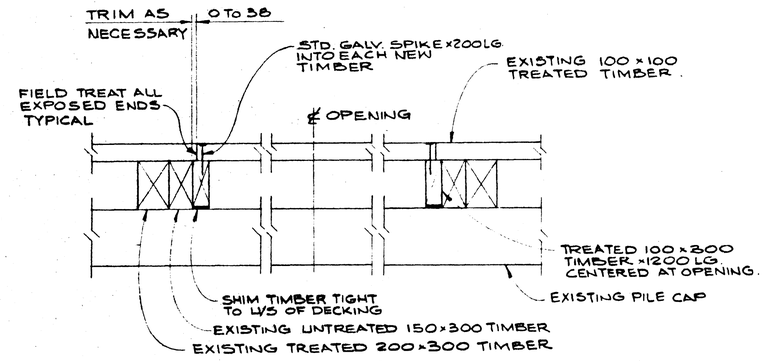
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
WALING REPAIRS
(NOT IN CONTRACT)

designed C.J.G.	conçu
date MAR. 1984.	
drawn H.C.G.	dessiné
date MAR. 1984.	
reviewed	examiné
date	
approved	approuvé
date	
Tender	Soumission
PWC Project Manager	Administrateur de projets TPC
date 89/11/15	

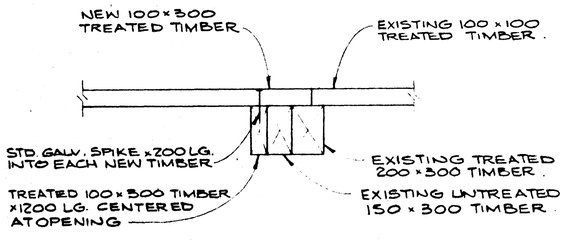
project number / no. du projet: PR100772

drawing no. / no. du dessin: 42 OF 75

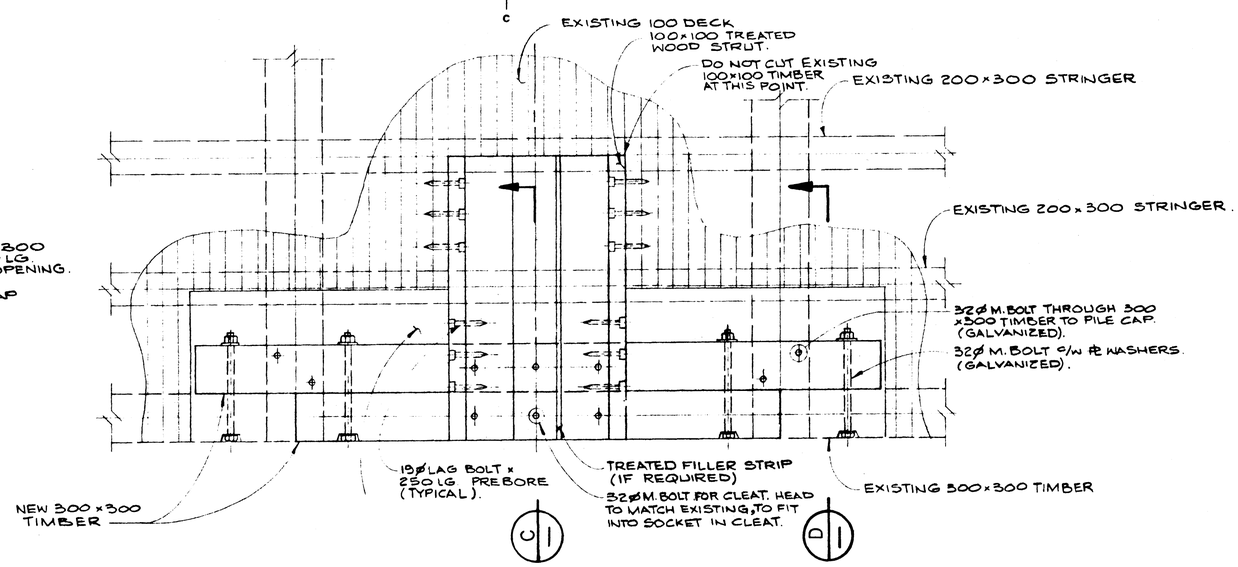
PWC A1



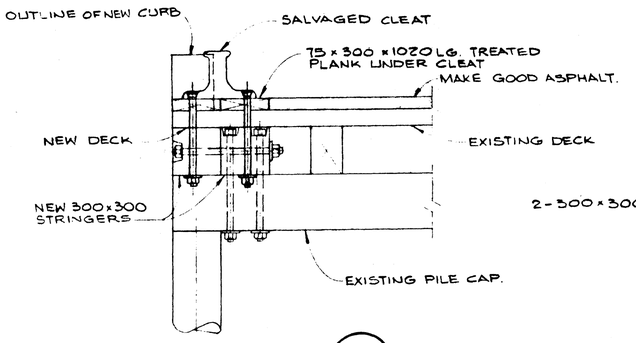
SECTION A 44
1:20



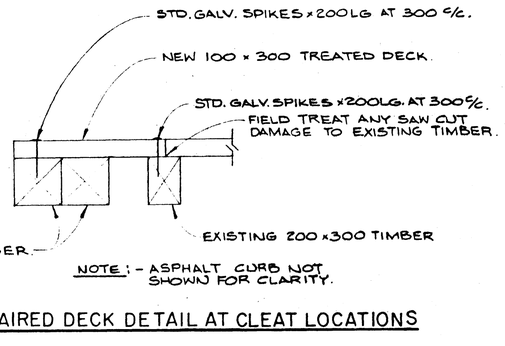
SECTION B 44
1:20



SOUTH SIDE CLEAT DETAIL
1:20

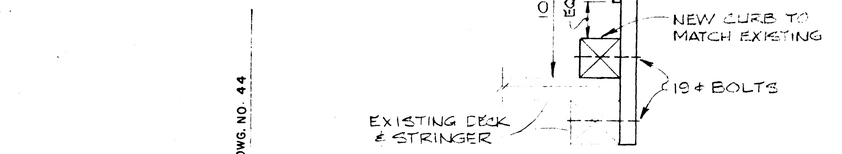


SECTION C 1
1:20



NOTE: - ASPHALT CURB NOT SHOWN FOR CLARITY.

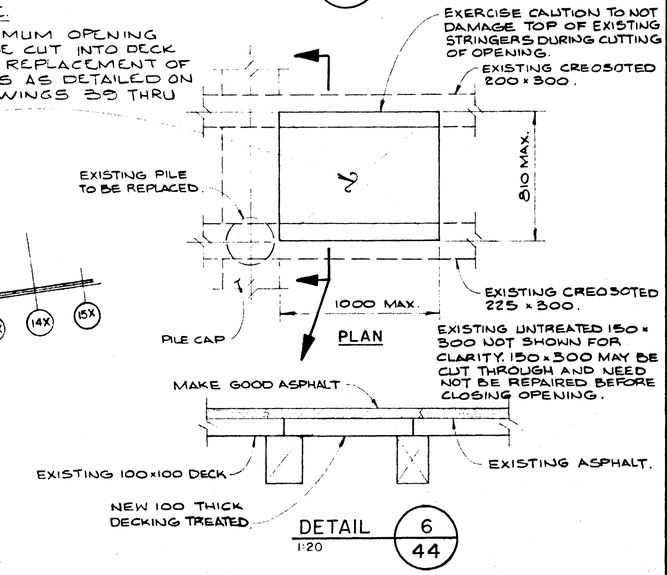
REPAIRED DECK DETAIL AT CLEAT LOCATIONS



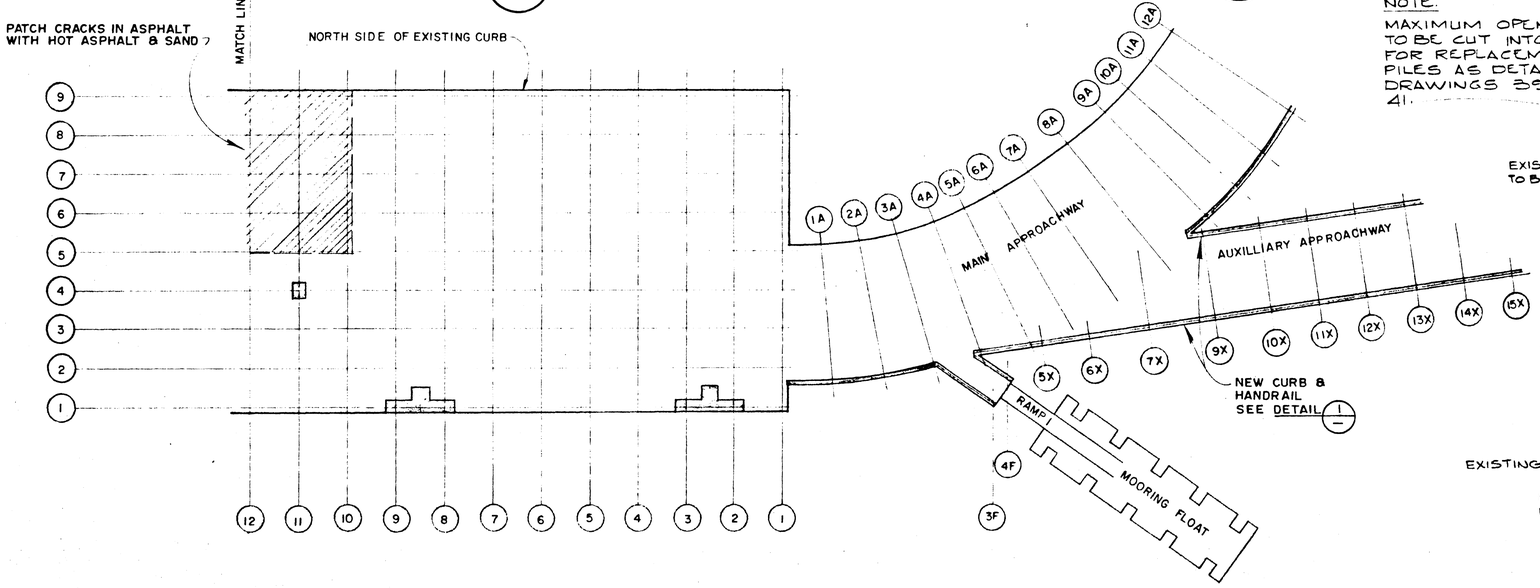
DETAIL 1 — NEW CURB & HANDRAIL
1:20

SECTION C
1:20

SECTION D
1:20



DETAIL 6 44
1:20



PLAN
1:200

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

"BC041475"

revisions		date

A detail no. / no. du détail
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
DECK REPAIRS
BENT (1) TO (12)
(NOT IN CONTRACT)

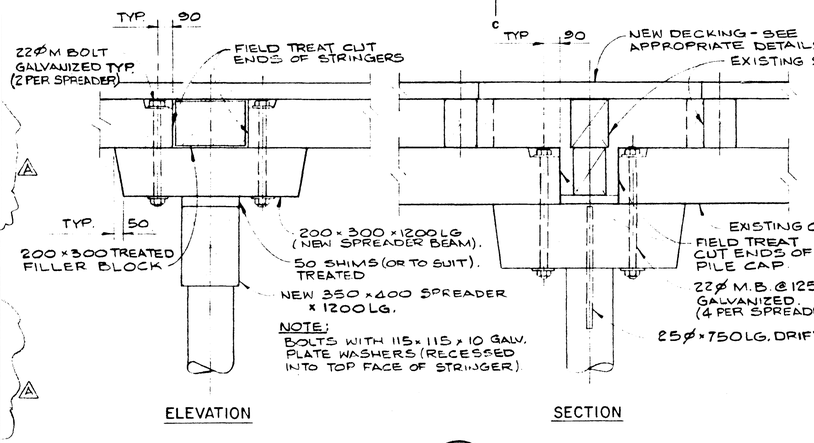
designed C.J.G. / conçu
date MARCH 1984
drawn H.C.G. / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR100772
drawing no. / no. du dessin
43 OF 75

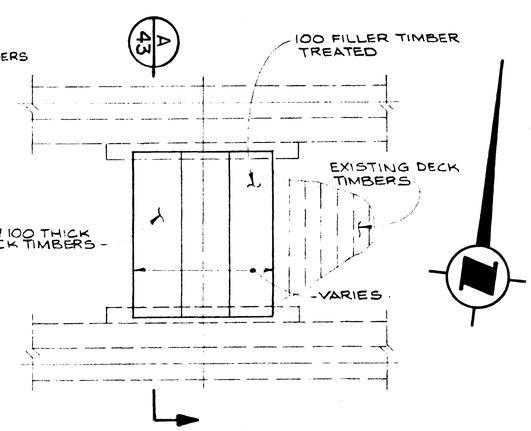
PWC AI

DECK REPAIRS FROM PILE TESTING PROGRAM

GRID LOCATION	PILE CAP AND STRINGER REPAIR		DECK REPAIR	
	DETAIL	COMMENT	DETAIL	COMMENT
11-4	1		2	
24-7	1		2	
31-4	1		2	
40-8	1	SEE NOTE 1.	3	SEE NOTE 1.
49-4	1		2	
59-4	1	SEE NOTE 1.	2	SEE NOTE 1.
62-4	N/A	CAP & STRINGER UNCUT	6 (DWG 43)	SEE NOTE 1.
71-4	1		2	
81-8	1		2	
91-4	1		4	
92N-5	SIM. 1	SKEWED	SIM. 2	SKEWED
93-2	N/A	CAP & STRINGER UNCUT	5	

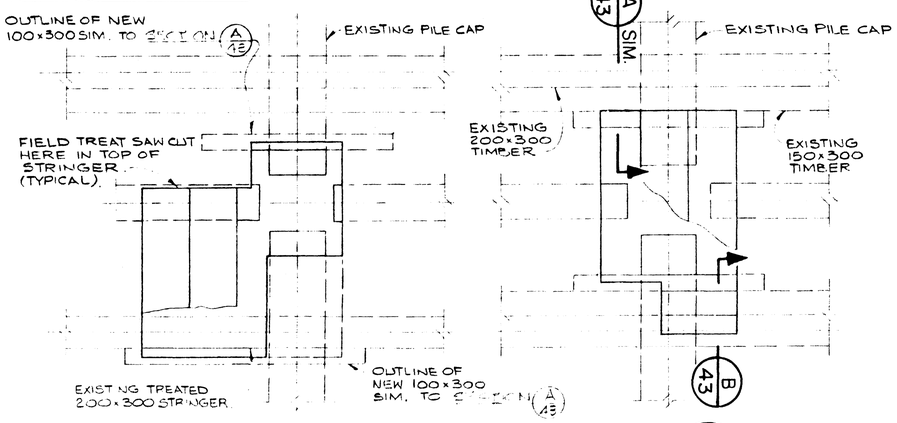
NOTE:
1. THIS REPAIR MAY BE DELETED IF A CONCRETE CRANE PAD IS TO BE CONSTRUCTED AT THIS PORTION OF WHARF





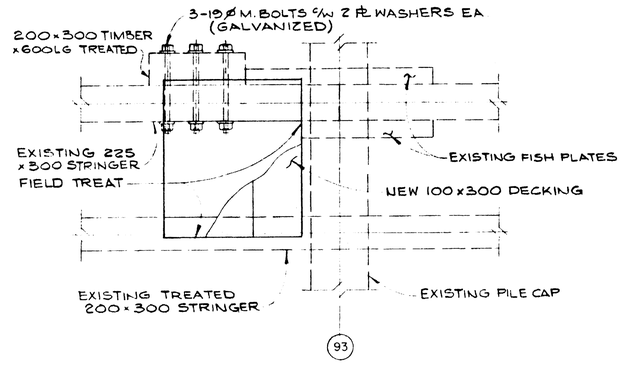
DETAIL 1 / 1:20

DETAIL 2 / 1:20 — TYPICAL DECK OPENING

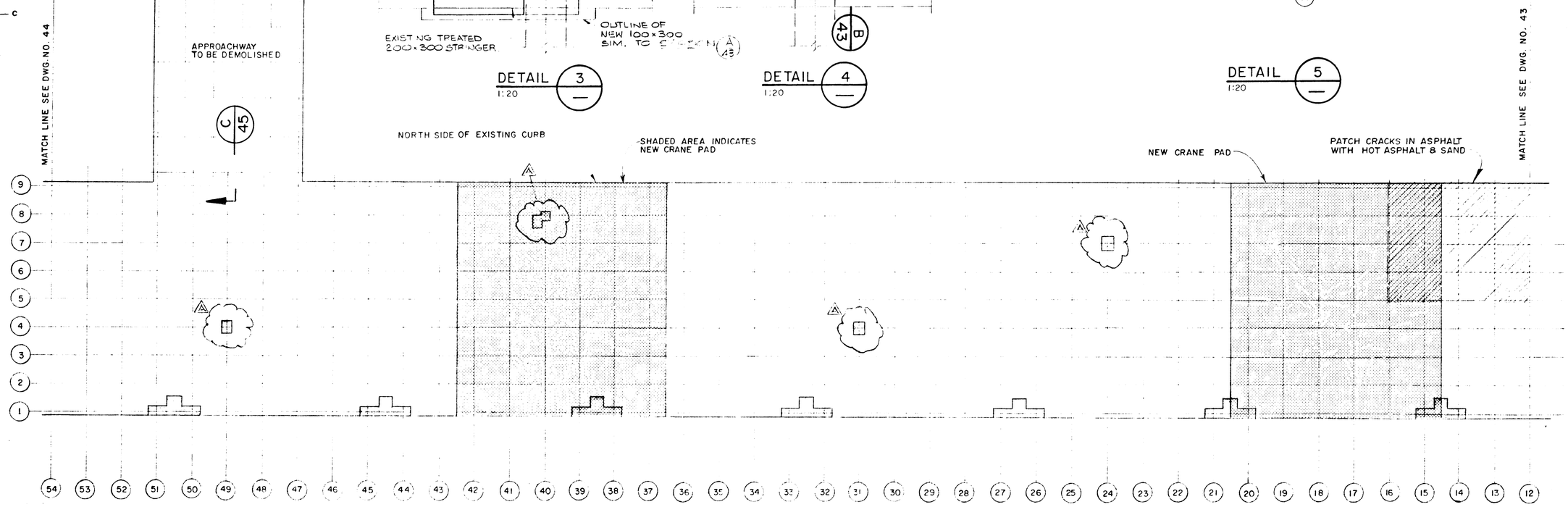


DETAIL 3 / 1:20

DETAIL 4 / 1:20



DETAIL 5 / 1:20



PLAN
1:200

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

"BC041476"

revisions		date
A	WORK DONE UNDER CONTRACT AS SHOWN	

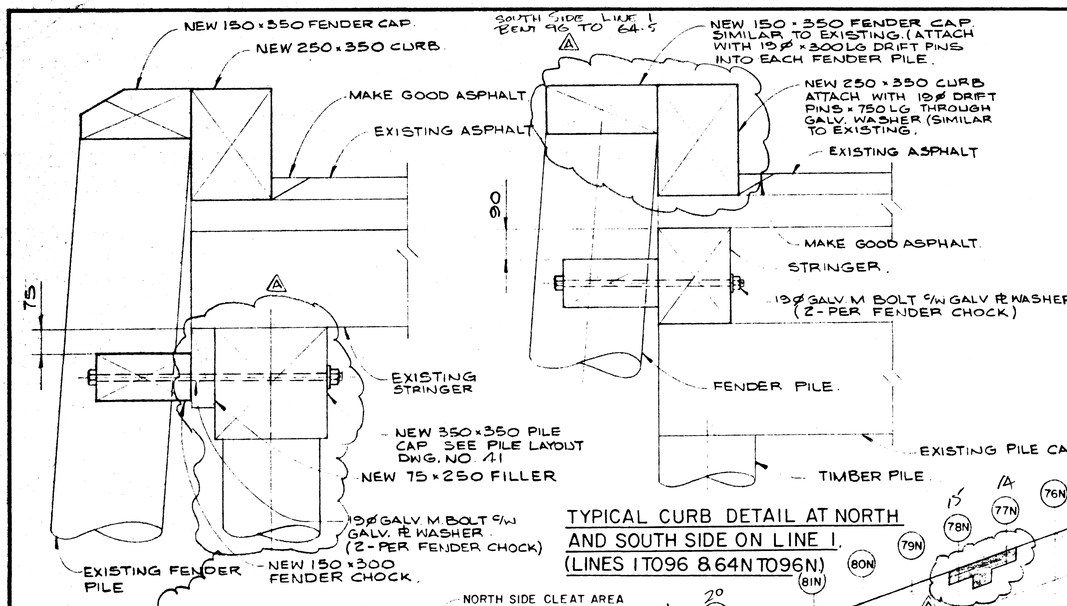
A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
DECK REPAIRS BENT (12) TO (54)
(NOT IN CONTRACT EXCEPT AS NOTED)

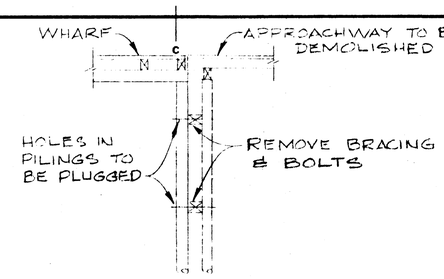
designed	C.J.G.	conçu
date	MARCH 1984	
drawn	H.C.G.	dessiné
date	MARCH 1984	
reviewed		examiné
date		
approved		approuvé
date		
Tender		Soumission
PWC Project Manager		Administrateur de projets TPC
project number	PR 100772	no. du projet
drawing no.	44 OF 75 A	no. du dessin

PWC AI



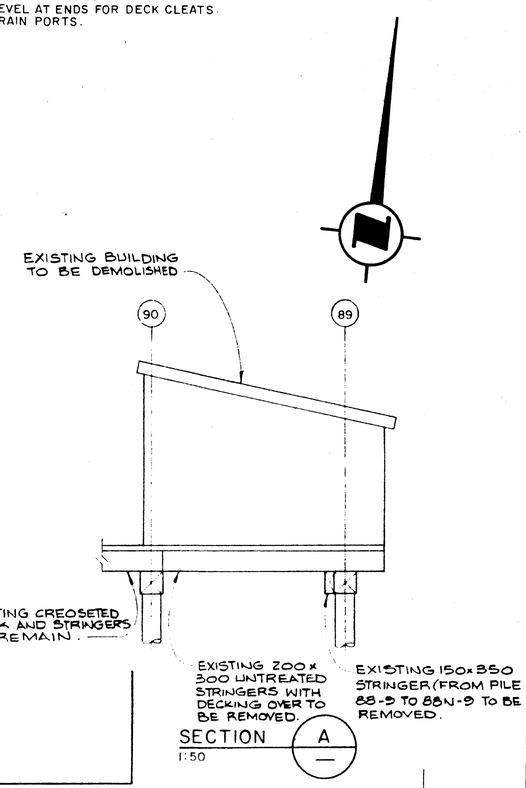
TYPICAL CURB DETAIL AT DECK ON LINE 96 & 96N (LINE 1 NORTH TO LINE 1 SOUTH.)

TYPICAL CURB DETAIL AT NORTH AND SOUTH SIDE ON LINE 1. (LINES 1 TO 96 & 64N TO 96N.)

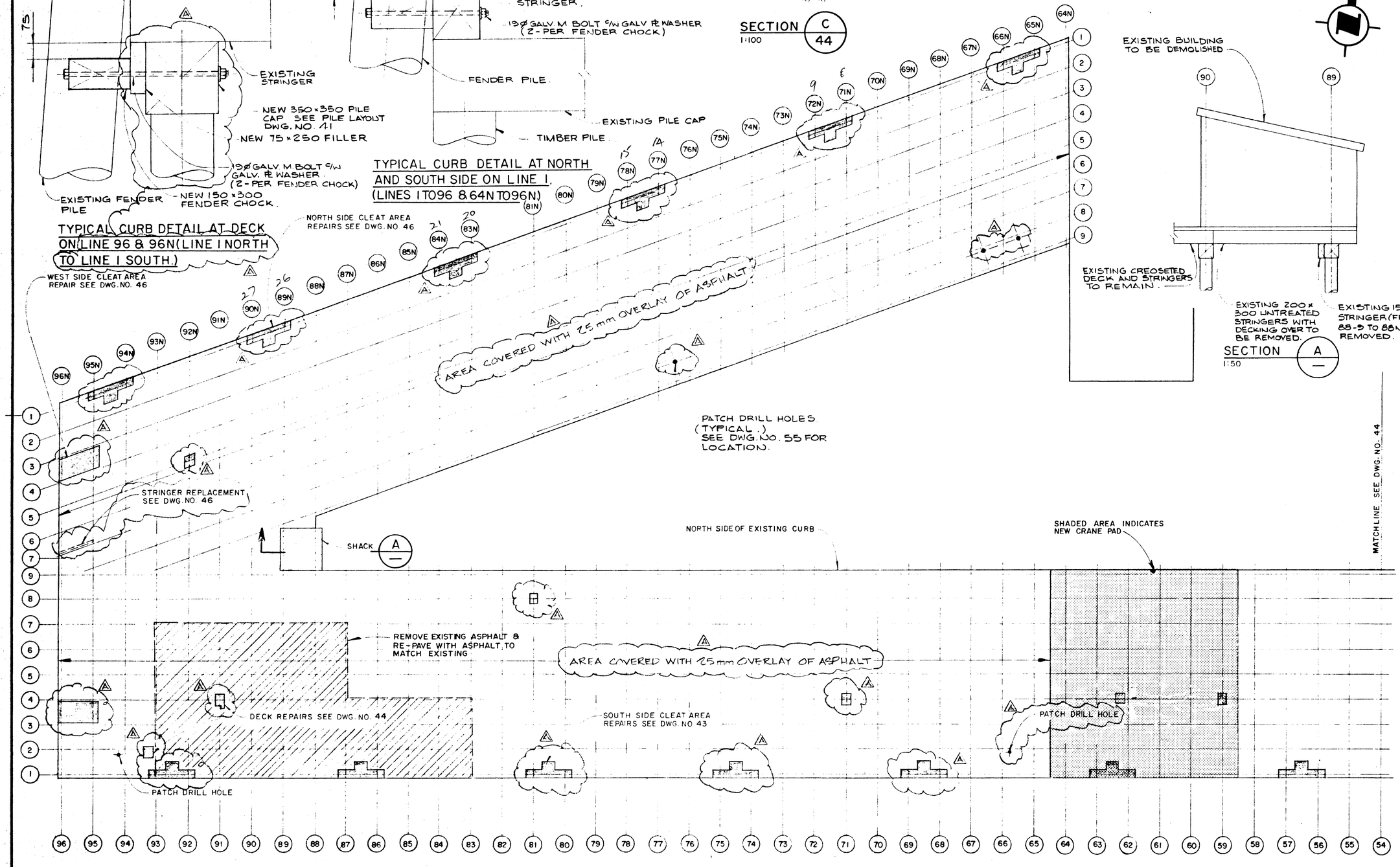


SECTION C / 44
1:100

NOTES:
1. NEW CURB TO BE SIMILAR IN CONFIGURATION TO EXISTING INCLUDING THE FOLLOWING ITEMS:
   A. - BEVEL AT ENDS FOR DECK CLEATS.
   B. - DRAIN PORTS.



SECTION A / —
1:50



NOTES

1. CLEAT REPAIRS AT 14.5-1, 20.5-1, 38.5-1, 62.5-1 MAY BE DELETED IF CONCRETE CRANE PADS TO BE CONSTRUCTED.
2. FENDER CHOCKS NOT TO BE REMOVED AND REPLACED ARE AS FOLLOWS. LINE 1 BETWEEN 4-5, 22-23, 24-25, 28-29, 34-35, 35-36, 36-37, 40-41, 42-43, 52-53, 59-60, 65-66, 84-85, 88-89.

PLAN
1:200

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete.

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. J. GRANT

revisions		date
A	WORK DONE UNDER CONTRACT 3 SHOWN	

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

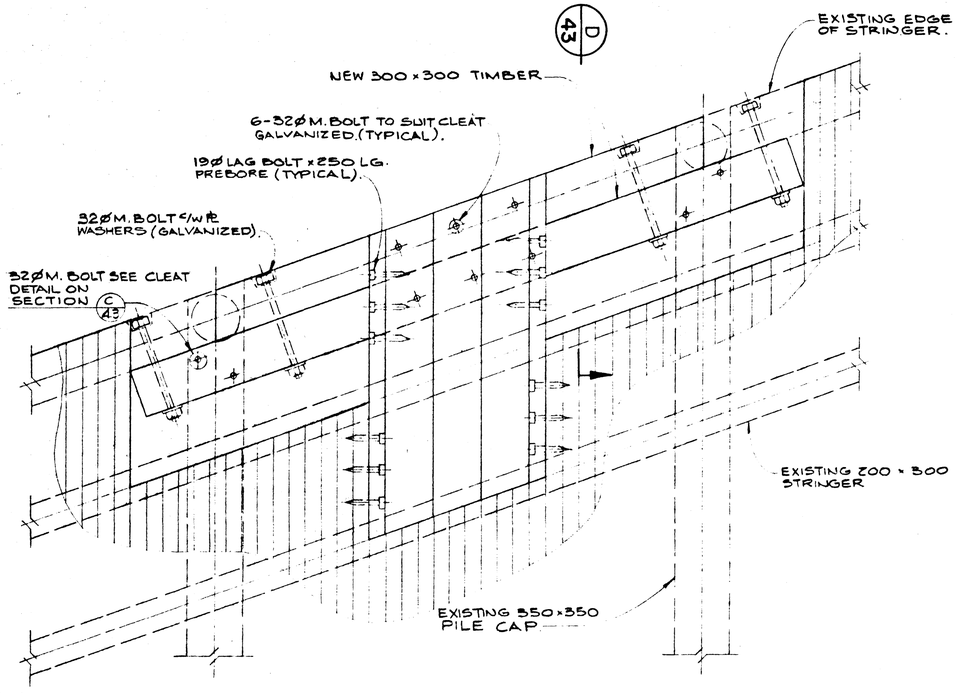
project *BC041477* projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3.

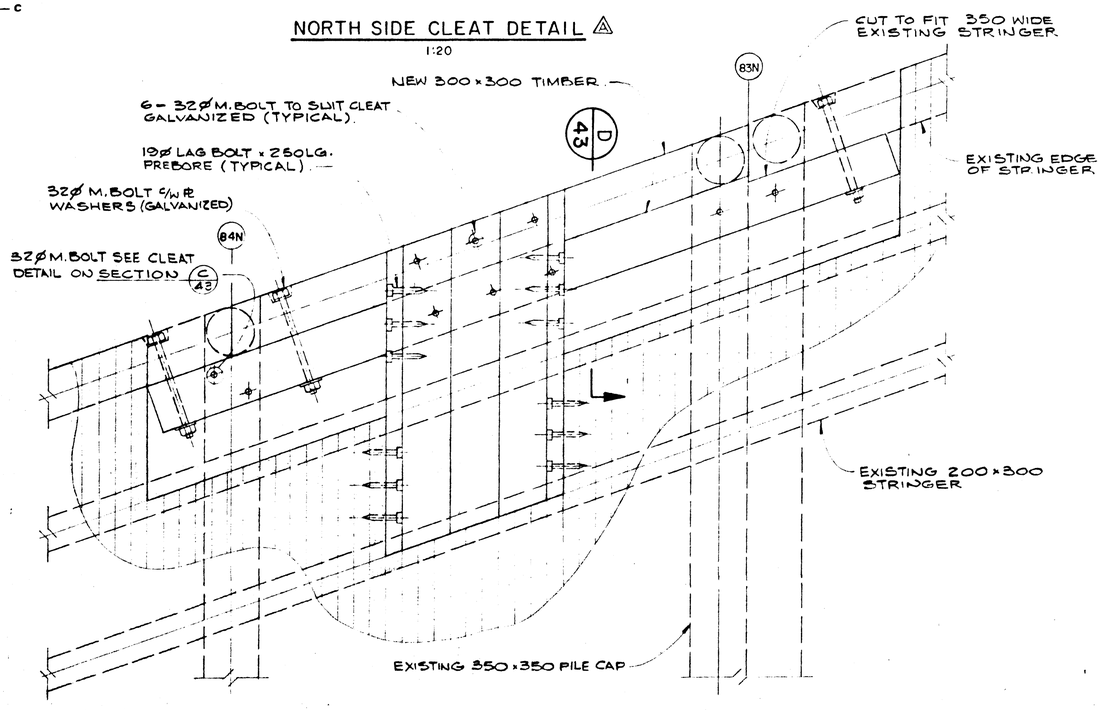
drawing dessin

IMPROVEMENTS TO SOUTH LANDING WHARF
DECK REPAIRS
BENT (54) TO (96)
(NOT IN CONTRACT EXCEPT AS NOTED)

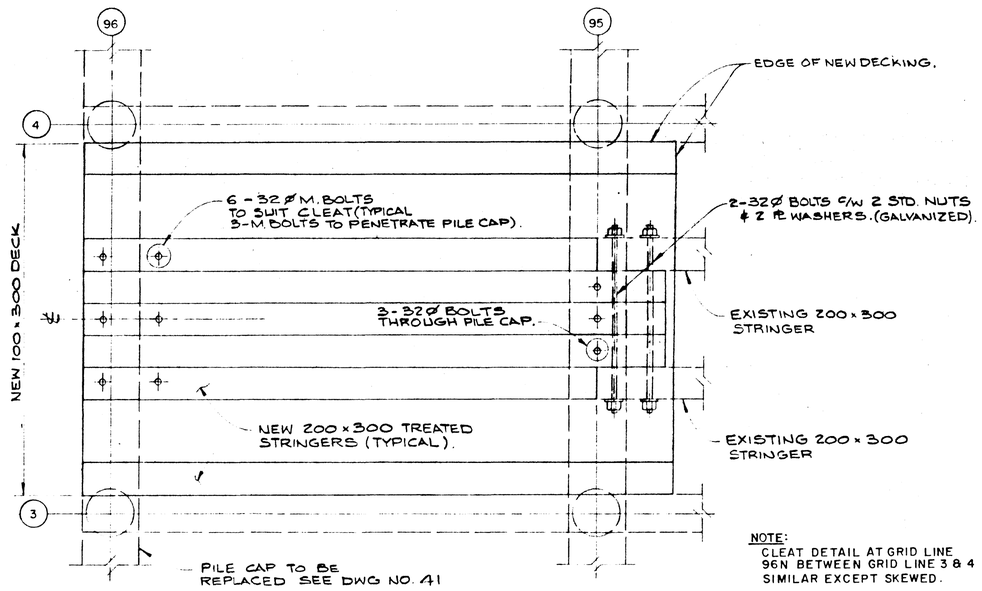
designed C.J.G.	conçu
date MARCH 1984	
drawn H.C.G.	dessiné
date MARCH 1984	
reviewed	examiné
date	
approved	approuvé
date	
Tender	Soumission
PWQ Project Manager	Administrateur de projets TPC
project number	no. du projet
PR 100772	
drawing no.	no. du dessin
45 OF 75	A



NORTH SIDE CLEAT DETAIL ⚠
1:20

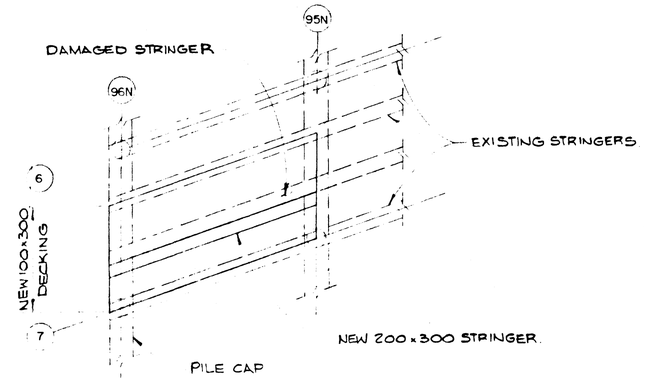


NORTH SIDE CLEAT DETAIL AT GRID LINE 83N. ⚠
1:20



NOTE:
CLEAT DETAIL AT GRID LINE 96N BETWEEN GRID LINE 3 & 4 SIMILAR EXCEPT SKEWED.

CLEAT DETAIL AT GRID LINE 96-BETWEEN 3 & 4. ⚠
1:20



STRINGER REPLACEMENT DETAIL ⚠
1:50

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT.
FILE NO. 25125

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. GRANT

"BC041478"

A	WORK DONE UNDER CONTRACT 3	
revisions		date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS. ESQUIMALT, B.C. CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF CLEAT REPAIRS

(NOT IN CONTRACT 3)

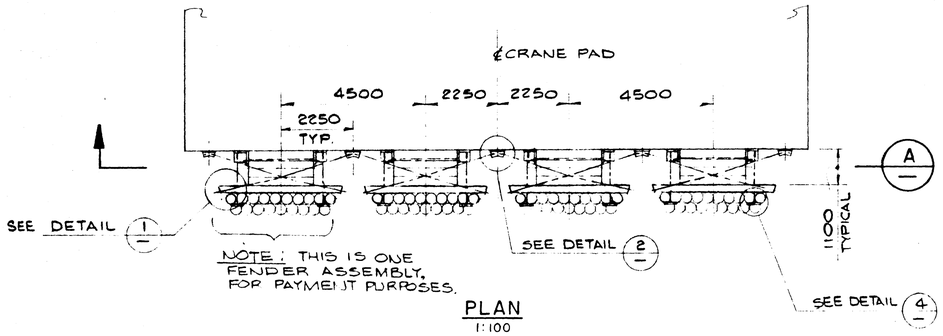
designed C.J.G. / conçu — date MARCH 1984
drawn H.C.G. / dessiné — date MARCH 1984
reviewed / examiné — date
approved / approuvé — date
Tender / Soumission — PWC Project Manager / Administrateur de projets TPC — 89.01.15

project number / no. du projet: **PR100772**

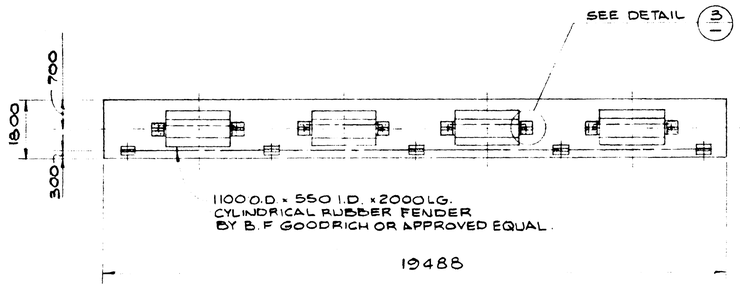
drawing no. / no. du dessin: **46 OF 75 A**

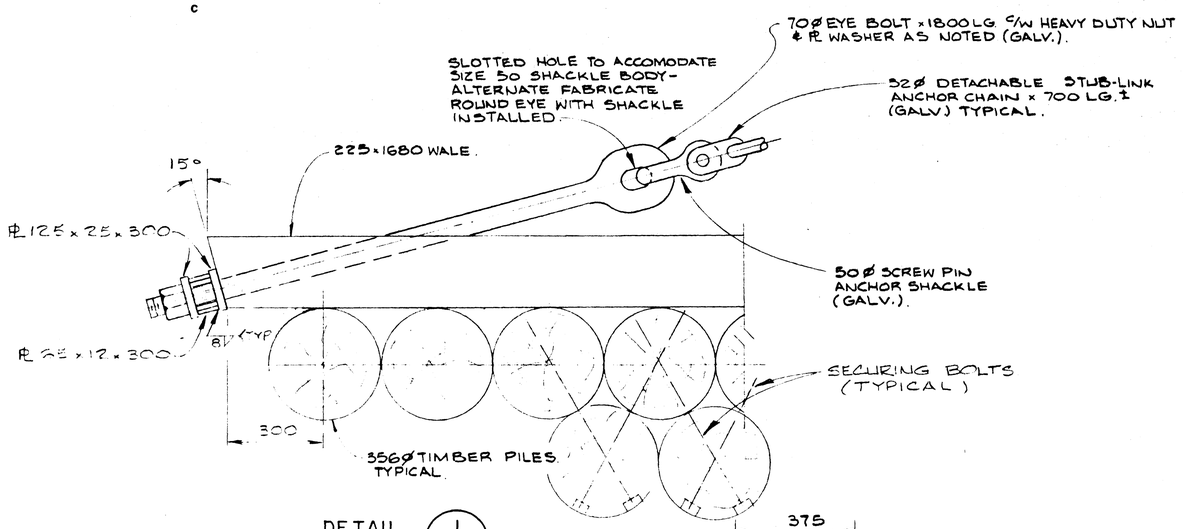
PWC A1

✳ NOTE: BOLTS ONLY INSTALLED FOR FUTURE FENDERING

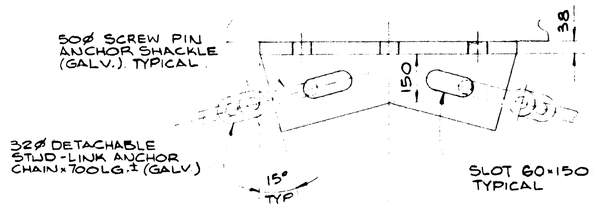


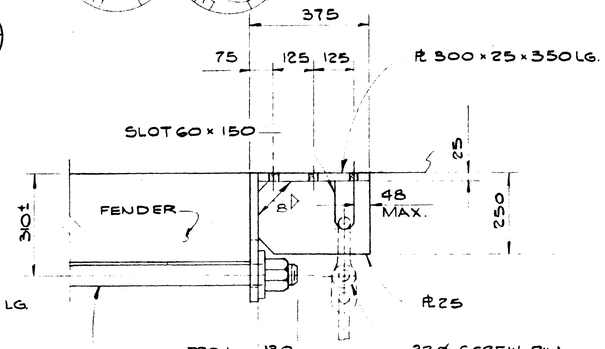
PLAN
1:100

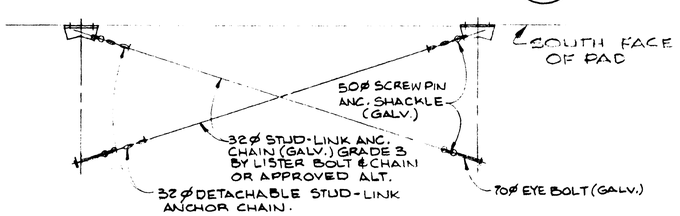




DETAIL 1
1:10

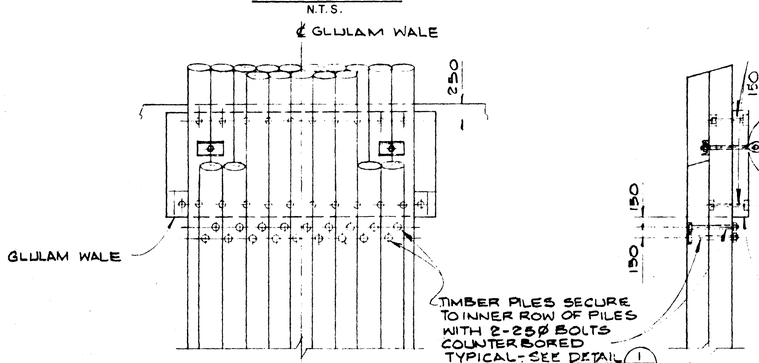






SECTION A
1:100

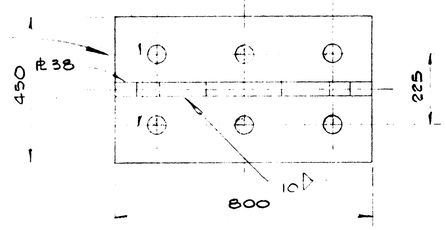
BRACING LAYOUT AT EACH FENDER
N.T.S.

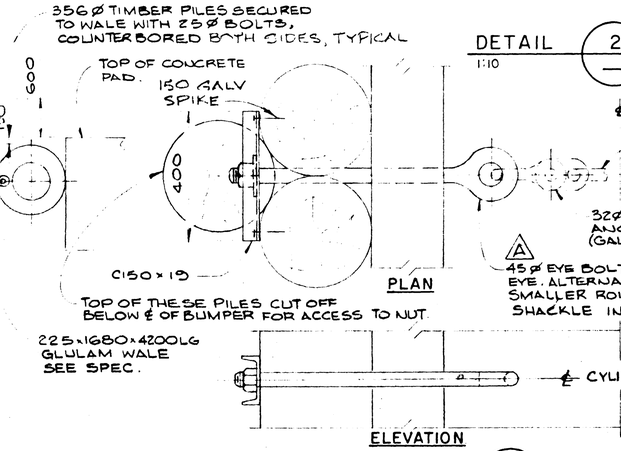


⚠A BOLTING LAYOUT FOR FENDER PILES
1:50

6-HOLES FOR 5/8ø ANCHOR BOLTS

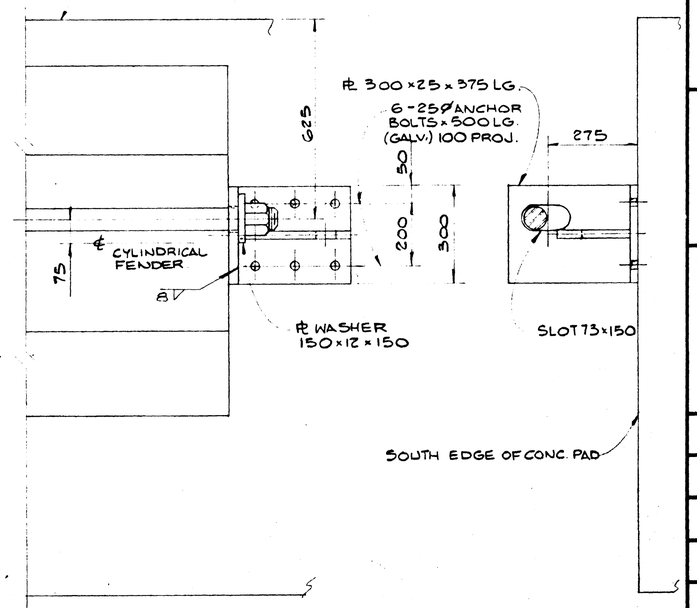
ANCHOR BOLTS 5/8ø x 600 LONG (GALV) 100 PROJECTION (EMBED HEAD OF BOLT IN CONC.)





DETAIL 2
1:10

DETAIL 4
1:10



DETAIL 3
1:10

NOTES:
1.) FOR GENERAL NOTES SEE DWG. NO. 1
2.) ALL STEEL TO BE GALVANIZED (HOT DIPPED).

NOV 6 1985

PWC A1

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

revisions		date
A	BOLTS ONLY INSTALLED FOR FUTURE FENDERING	OCT 22/85

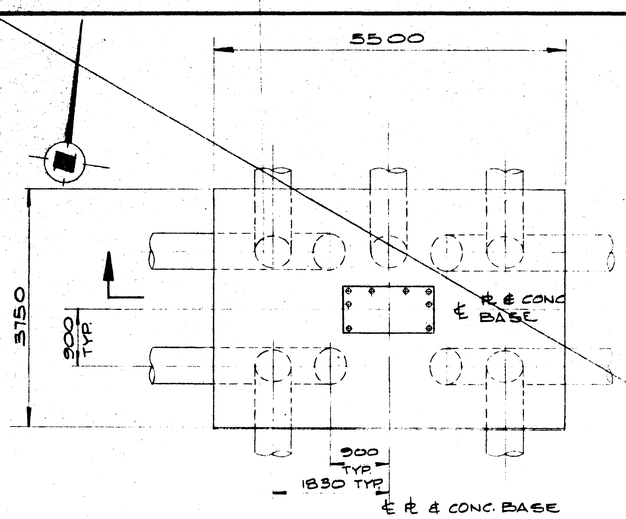
A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO.3

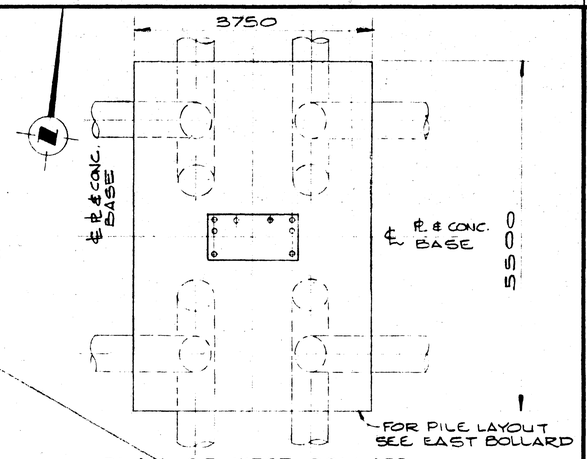
drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF FENDERING

BC041479

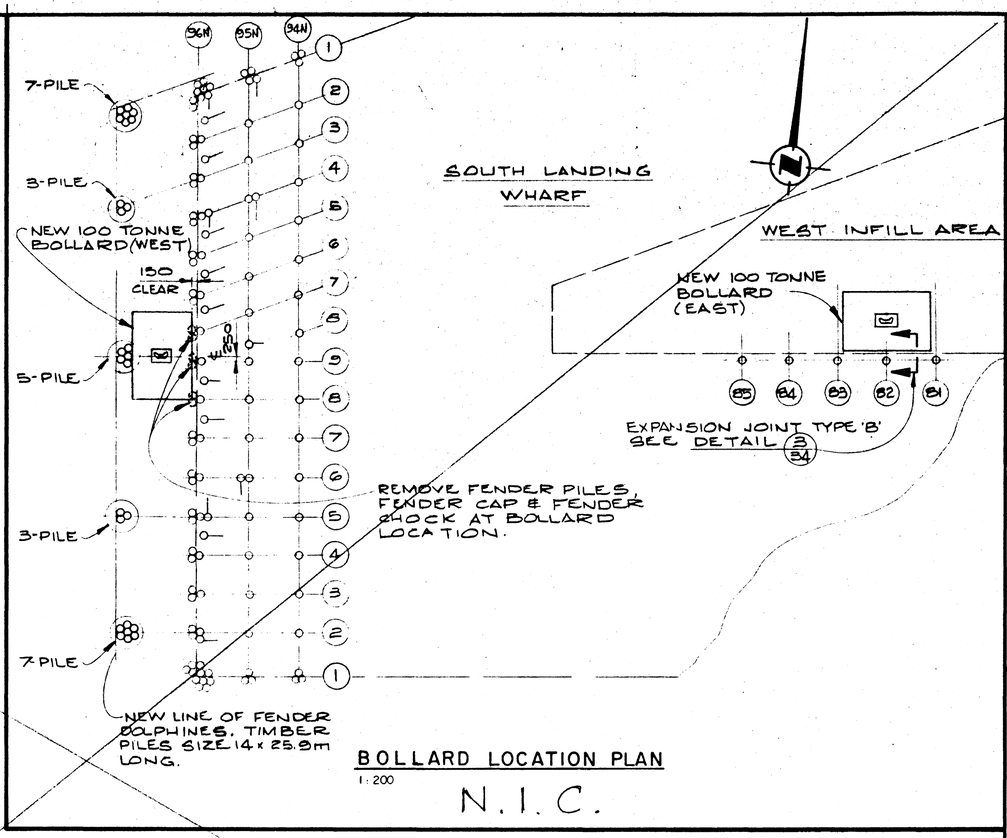
designed C.J.G. / conçu
date APRIL 1984.
drawn H.C.G. / dessiné
date APRIL 1984.
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number PR100772 / no. du projet
drawing no. 47 OF 75 A / no. du dessin



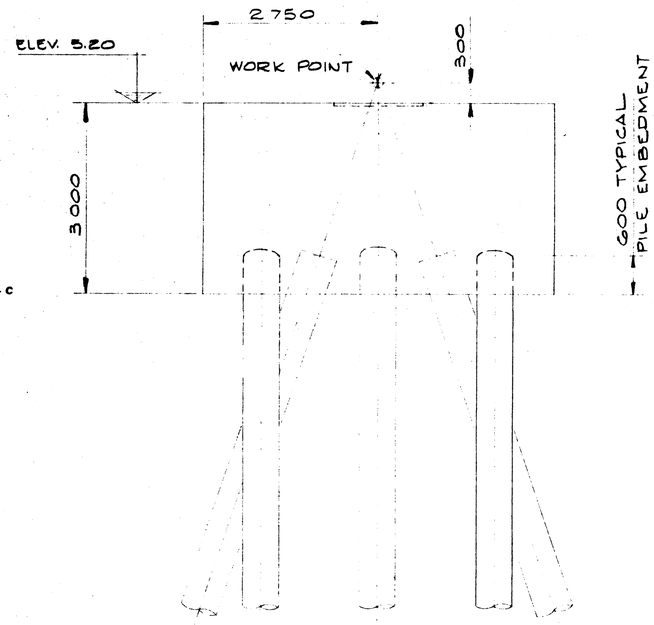
PLAN OF EAST BOLLARD
1:50
N.I.C.



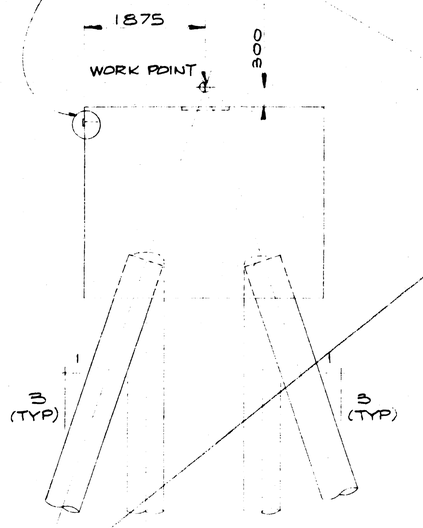
PLAN OF WEST BOLLARD
1:50
N.I.C.



BOLLARD LOCATION PLAN
1:200
N.I.C.

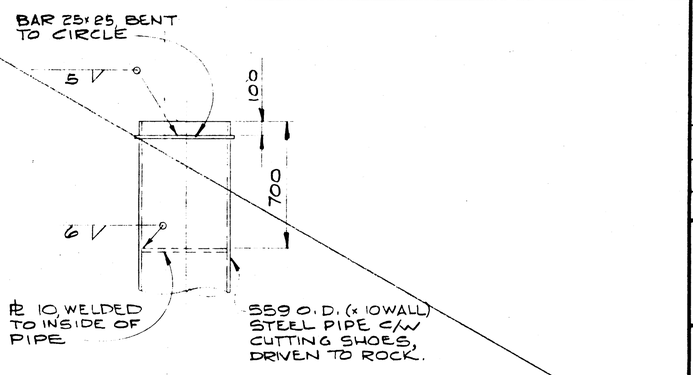


TYPICAL ELEVATION
1:50
N.I.C.

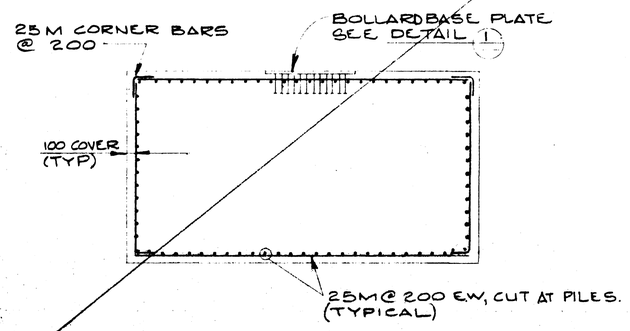


TYPICAL SIDE VIEW
1:50
N.I.C

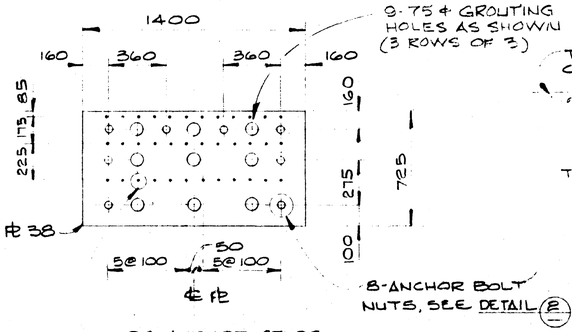
℄ FOR EXPANSION JOINT TYPE 'B', EAST BOLLARD ONLY.



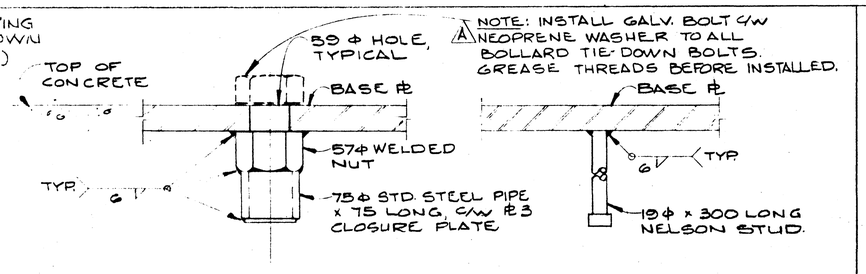
N.I.C. TYPICAL PILE CAP DETAIL
1:20



N.I.C.
SECTION A TYPICAL
1:50



PLAN
1:20



DETAIL 2 — ANCHOR BOLT NUT
1:5

DETAIL 3 — ANCHOR STUD
1:5

NOTE:- COMPLETE UNIT, HOT DIPPED GALVANIZED AFTER FABRICATION

DETAIL 1 — BOLLARD MOUNTING - 100 T BASE PLATE

NOTES
1) FOR GENERAL NOTES SEE DWG. 1

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

revisions		date
B	AS BUILT	JULY 26/85
A	BOLT NOTE ADDED TO DETAIL '1'	SEPT. 12/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

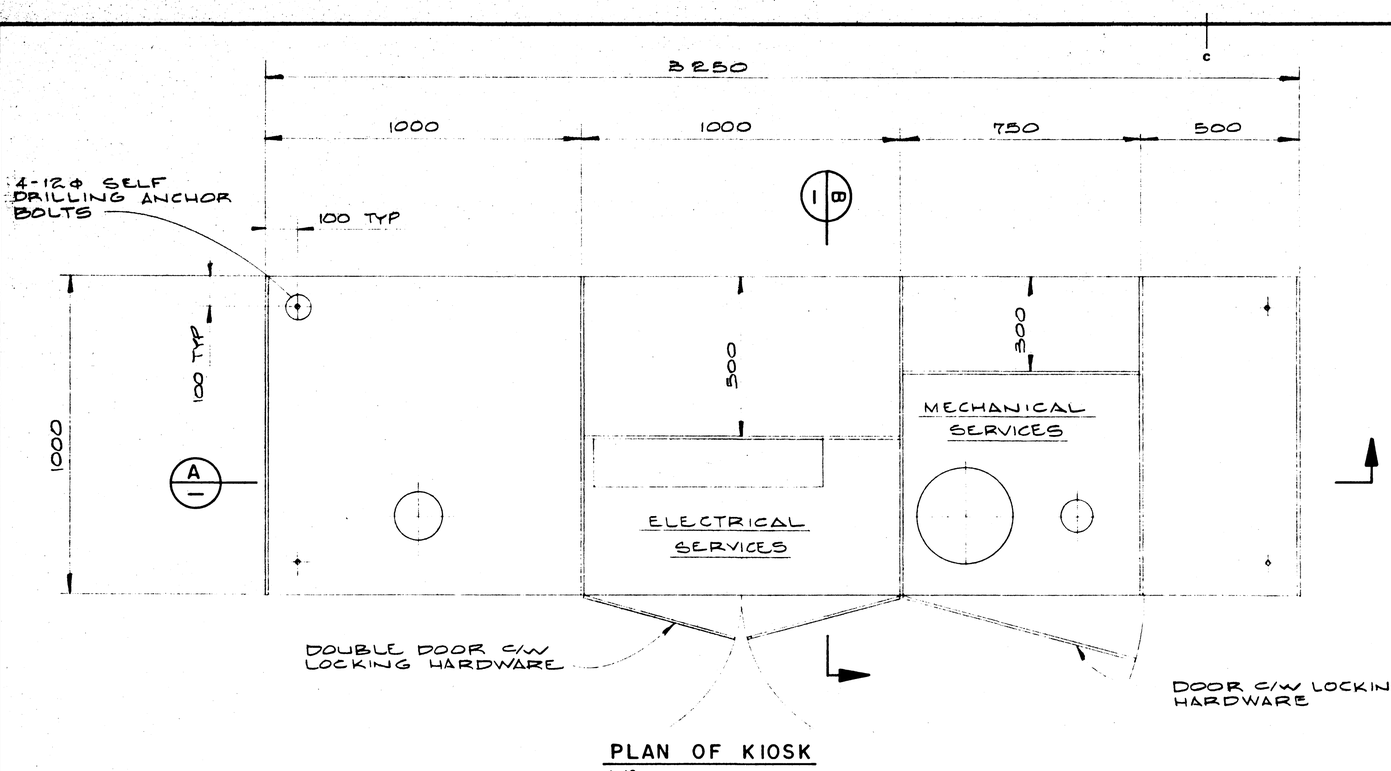
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
BOLLARD DETAILS

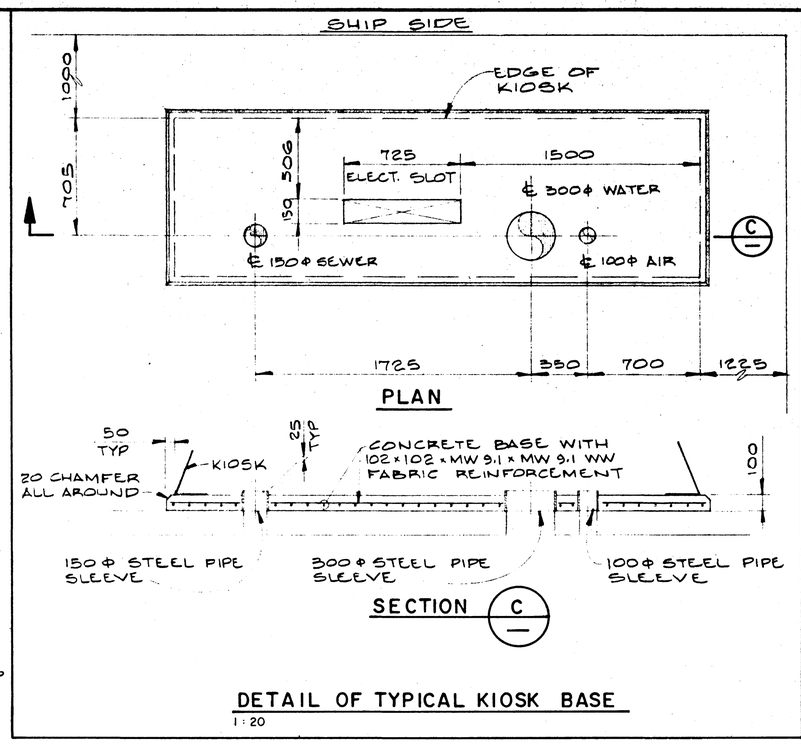
"BC041480"

designed CJG / conçu
date APRIL 1984
drawn GHP / dessiné
date APRIL 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100 772
drawing no. / no. du dessin
48 OF 75 - B

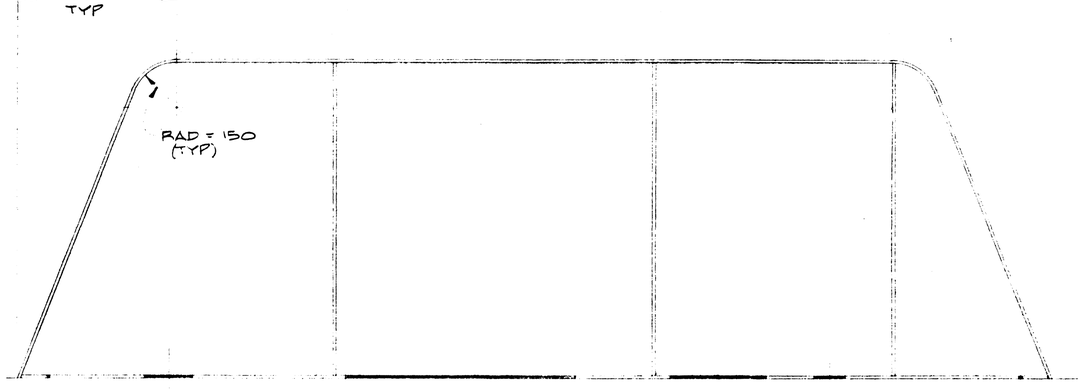
PWC A1



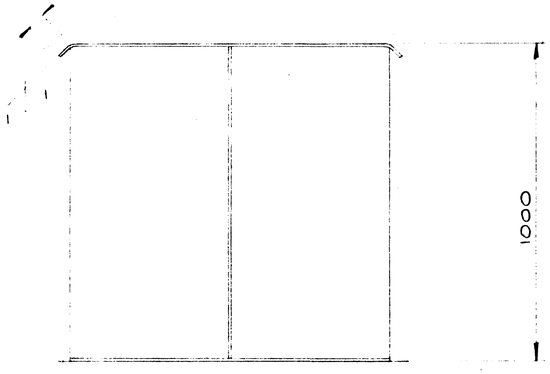
PLAN OF KIOSK
1:10



DETAIL OF TYPICAL KIOSK BASE
1:20



SECTION A
1:10



SECTION B
1:10

NOTES:- KIOSK FABRICATION

1) KIOSK TO BE FABRICATED FROM 10 mm (3/8") THICK GALVANIZED M.S. PLATE, EXCEPT DOORS WHICH SHALL BE FROM 6 mm (1/4") THICK PLATE.
2) KIOSK TO BE ALL WELDED CONSTRUCTION.
3) ALL CUTS, WELDS ETC TO BE TOUCHED UP WITH 2-COATS OF GALVACON AFTER FABRICATION.
4) OPENINGS FOR PIPES & CABLES FROM LOCKABLE CABINET TO SHIP SIDE OF CABINET TO BE CUT ON SITE.

NOTES

1) FOR GENERAL NOTES SEE DWG NO. 1
2) FOR LOCATION OF FUTURE KIOSKS SEE DWG NO'S. 2, 27 & 29. FOR LOCATION OF KIOSK NO. 2 SEE DWG NO. 29.
3) ONE KIOSK REQUIRED IN THIS CONTRACT.

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

revisions		date
B	KIOSK REDRAWN, AS BUILT.	JULY 25/85

A detail no. / no. du détail
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

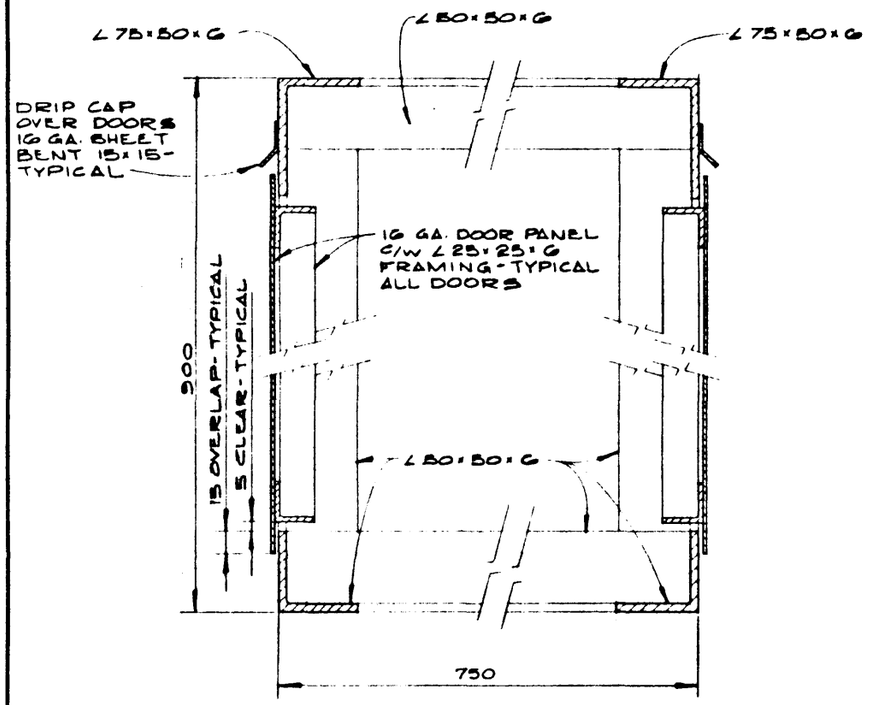
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing / dessin
SOUTH LANDING WHARF SERVICE KIOSK
GENERAL ARRANGEMENT

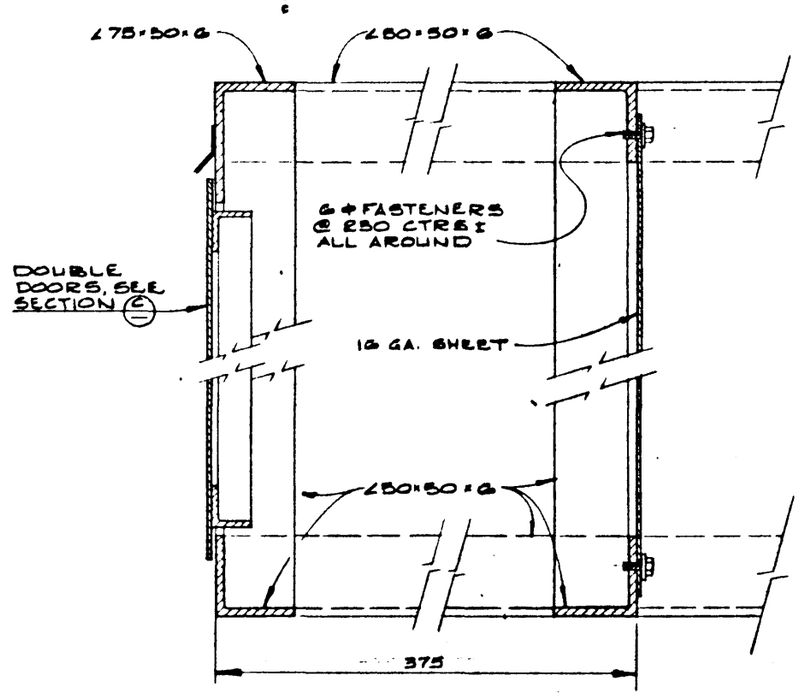
"BC041481"

designed P.M. / conçu
date MARCH 1985
drawn GHP / dessiné
date JULY 1985
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
49 OF 75 - B

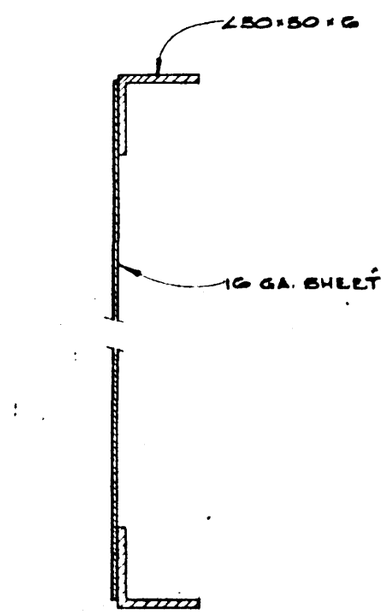
PWC A1



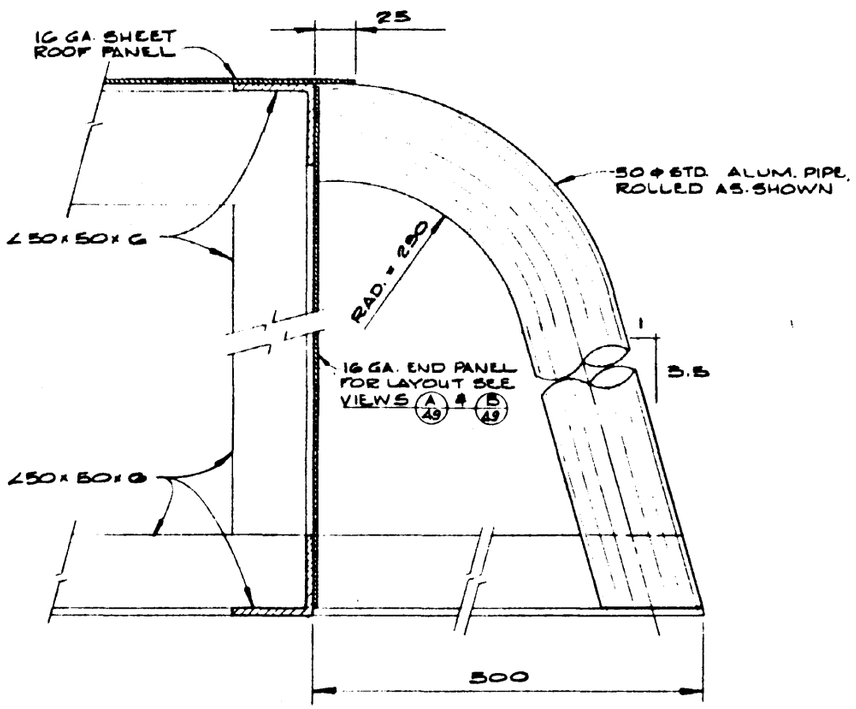
SECTION C 49 — TYPICAL FRAMING FOR MECHANICAL COMPARTMENT
1:2



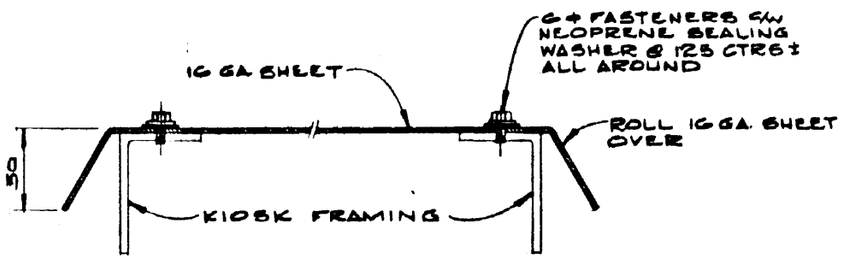
SECTION D 49 — TYPICAL FRAMING FOR ELECTRICAL COMPARTMENT
1:2



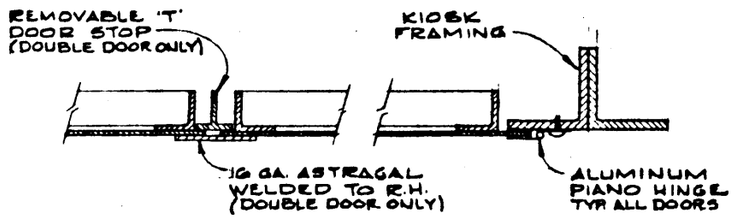
SECTION E 49
1:2



SECTION F 49 — END PANEL & EXTENSION FRAMING
1:2



DETAIL 1 49 — TYPICAL ROOF PANEL
1:2



DETAIL 2 49 — TYPICAL DOOR DETAILS
1:2

NOTES

1) FOR GENERAL NOTES & LEGEND, SEE DWG. NO. 1
2) KIOSKS TO BE FABRICATED FROM ALUMINUM. ALL WELDED CONSTRUCTION UNLESS SHOWN OTHERWISE.

THIS DRAWING REDUCED TO ONE HALF ORIGINAL SIZE

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA

BC040523

revisions | date

A detail on no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

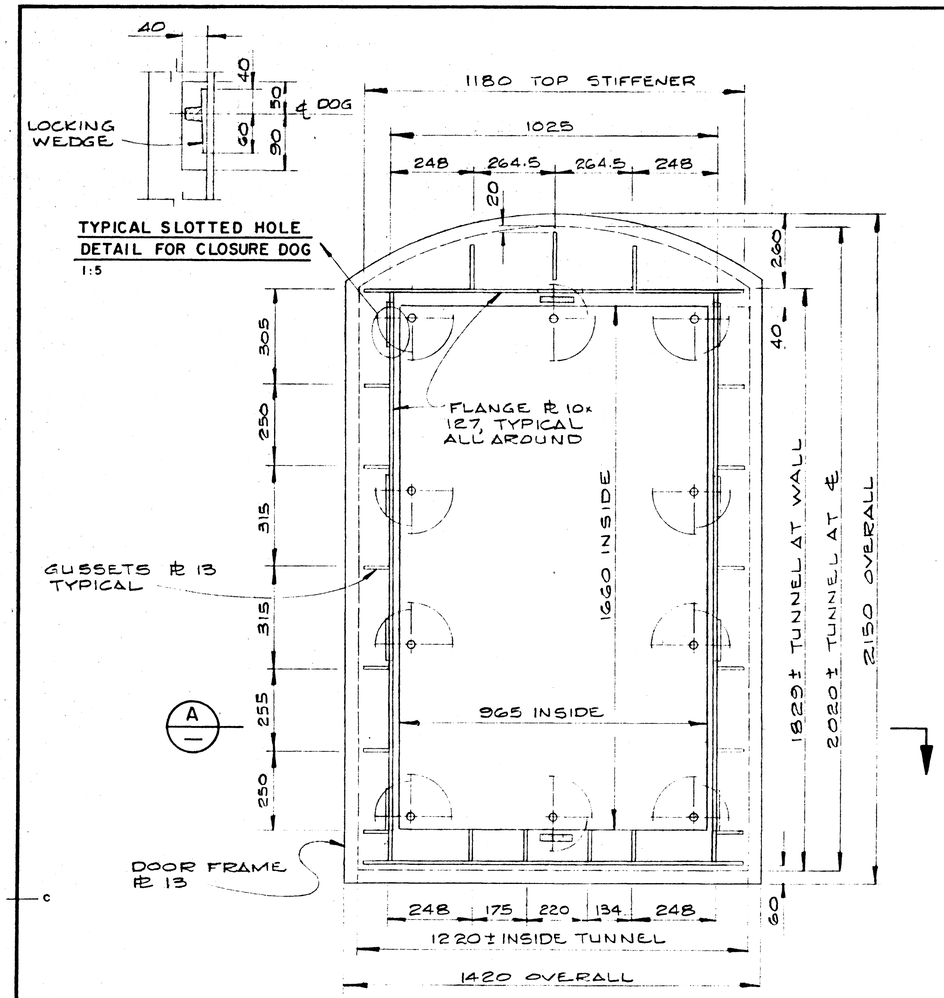
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
SOUTH LANDING WHARF SERVICE KIOSKS
CONSTRUCTION DETAILS

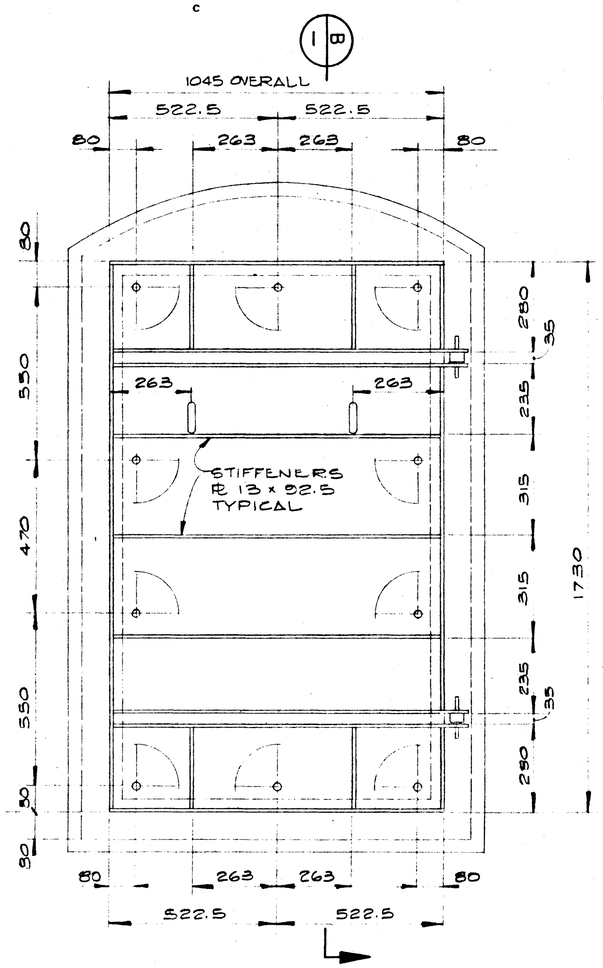
designed / conçu: T.B. — date: MARCH 1984
drawn / dessiné: G.H.P. — date: MARCH 1984
reviewed / examiné — date
approved / approuvé — date
Tender / Soumission — PWC Project Manager / Gestionnaire de projet TPC
project number / no. du projet: PR 100772
drawing no / no. de dessin: 50 OF 75

PWC A1

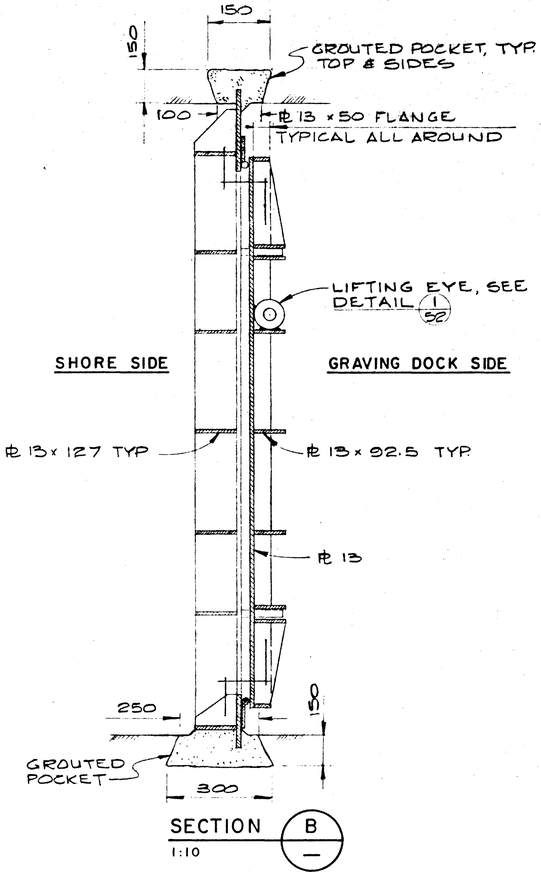
NOTES
1) FOR GENERAL NOTES & LEGEND SEE DWG. NO. 1
2) DOOR & FRAME TO BE FABRICATED FROM A-690 STEEL PLATE
3) 2 - DOOR & FRAME ASSEMBLIES REQUIRED. ALL WELDED CONSTRUCTION.



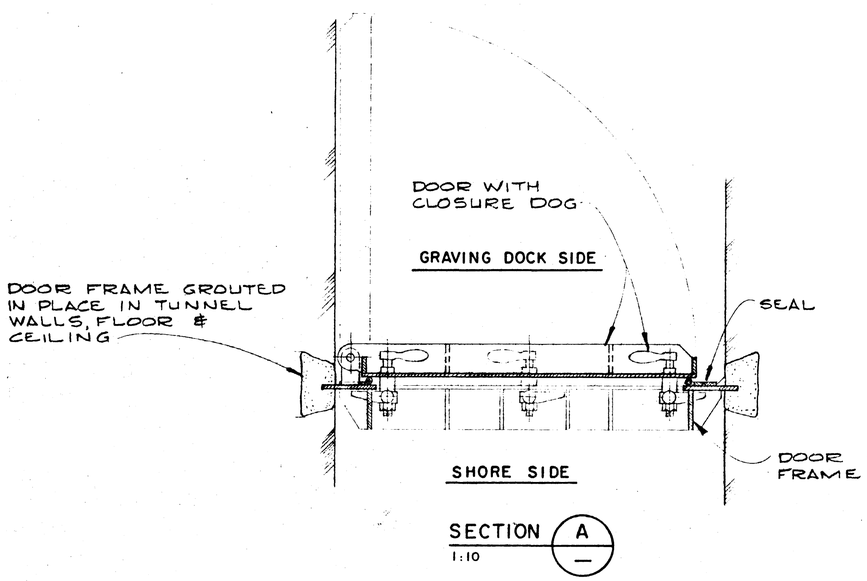
ELEVATION ON FRAME - VIEWED FROM INSIDE OF TUNNEL
1:10



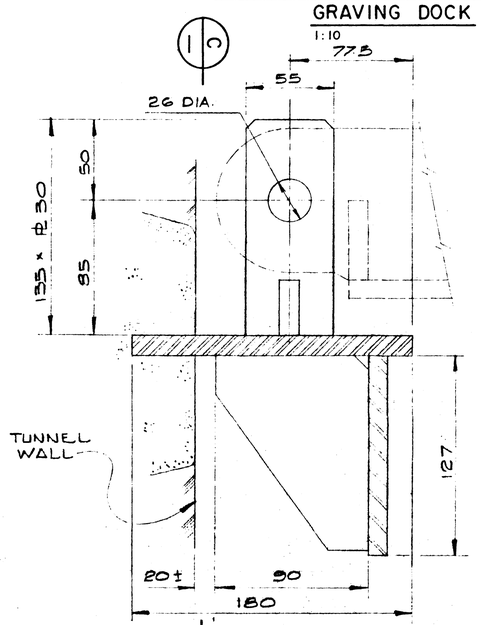
ELEVATION ON DOOR-VIEWED FROM GRAVING DOCK
1:10



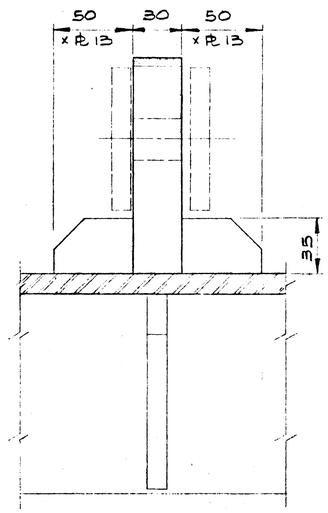
SECTION B
1:10



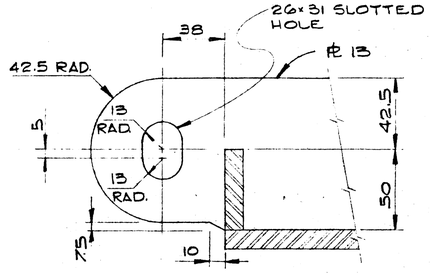
SECTION A
1:10



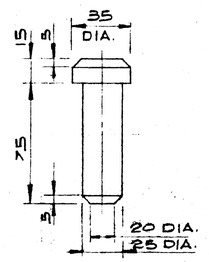
PLAN ON FRAME AT HINGE PLATE



SECTION C



PLAN ON DOOR AT HINGE PLATE



DETAIL OF HINGE PIN

TYPICAL HINGE DETAILS
1:2

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER A. ALONE

revisions | | date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

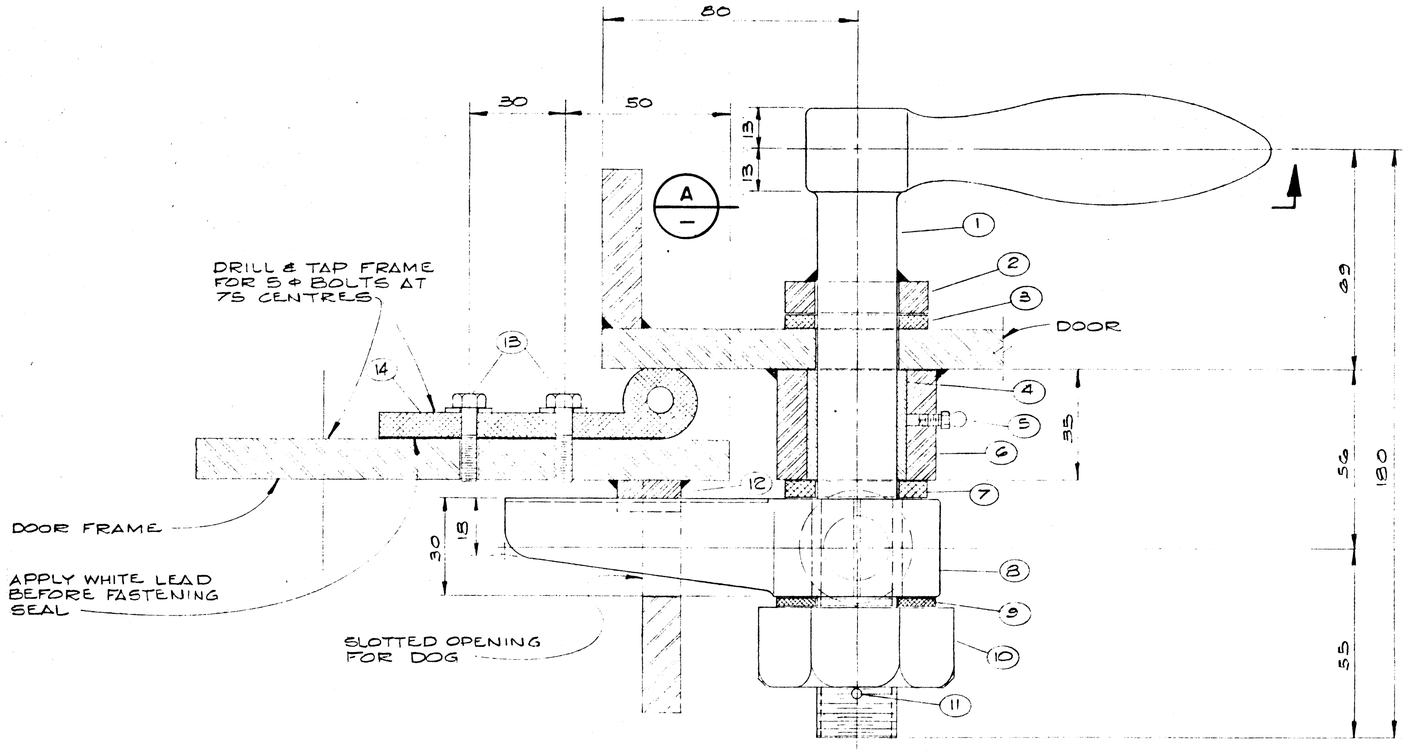
project "BC041482" projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO.3

drawing / dessin
IMPROVEMENTS TO GRAVING DOCK
WATERTIGHT DOORS
GENERAL ARRANGEMENT
(NOT IN CONTRACT 3)

designed T.B. / conçu
date MARCH 1984
drawn G.H.P. / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
51 OF 75

PWC AI

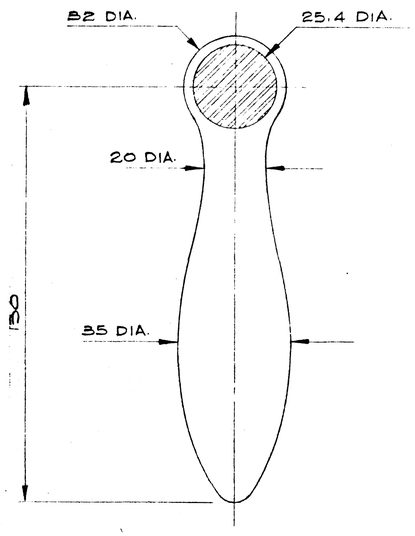


TYPICAL CLOSURE DOG - 10 REQD PER DOOR
FULL SIZE

LIST OF MATERIALS PER DOOR	
ITEM NO.	DESCRIPTION
1	25.4 DIA. FORGED ST. ST. 316 SHAFT & HANDLE. ALL AS DETAILED.
2	10 × 45 O.D. ST. ST. 316 COLLAR, WELDED TO SHAFT.
3	4 × 45 O.D. TEFLON WASHER
4	3.6 WALL ALEMITE BUSHING FOR 25.4 DIA. SHAFT
5	STANDARD BRONZE GREASE NIPPLE
6	50 O.D. × 35 LONG ST. ST. 316 BOSS, WELDED TO DOOR. I.D. TO SUIT BUSHING.
7	5.2 × 45 O.D. TEFLON WASHER
8	FORGED STEEL HANDLE & DOG. ALL AS DETAILED.
9	3 × 50 O.D. ST. ST. 316 WASHER
10	25.4 DIA. HEAVY HEX. NUT.
11	3.6 DIA. HOLE FOR COTTER PIN
12	STEEL LOCKING WEDGE WELDED TO FRAME. ALL AS DETAILED.
13	5 DIA. ST. ST. 316 STD. HEX. BOLT ϕW WASHER
14	NEOPRENE SEAL AS SUPPLIED BY GOODRICH #2697
15	4.76 DIA. STD. STEEL LOCK PIN. 2 REQ'D PER HANDLE

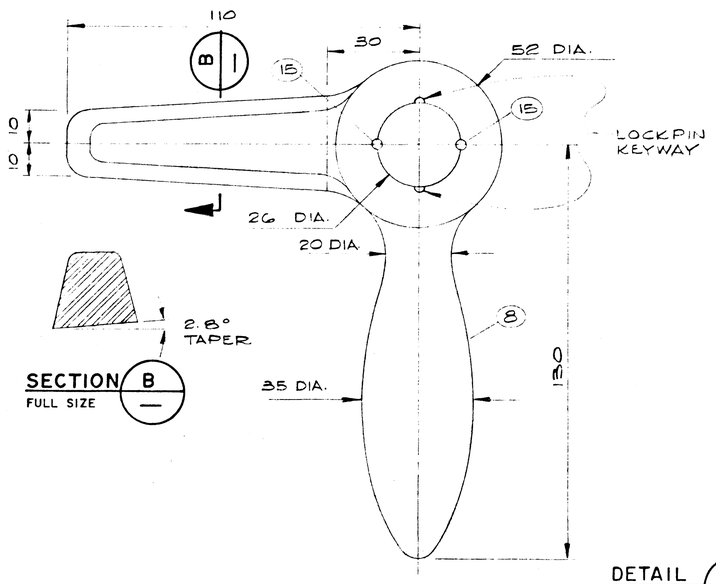
NOTE

1) FOR GENERAL NOTES & LEGEND, SEE DWG. NO. 1

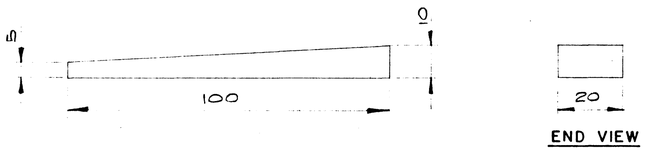


SECTION A — A
FULL SIZE

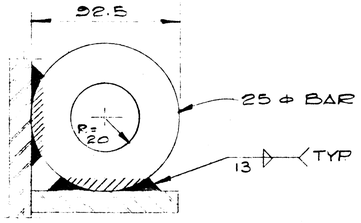
HANDLE & SHAFT



TYPICAL HANDLE & DOG
FULL SIZE



TYPICAL LOCKING WEDGE - 10 REQD PER DOOR
FULL SIZE



DETAIL 1 / 51 — TYPICAL LIFTING EYE
1:2
2 REQD PER DOOR

NOV 6 1985

PWC A1

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

revisions | date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project "BC041483" projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing / dessin

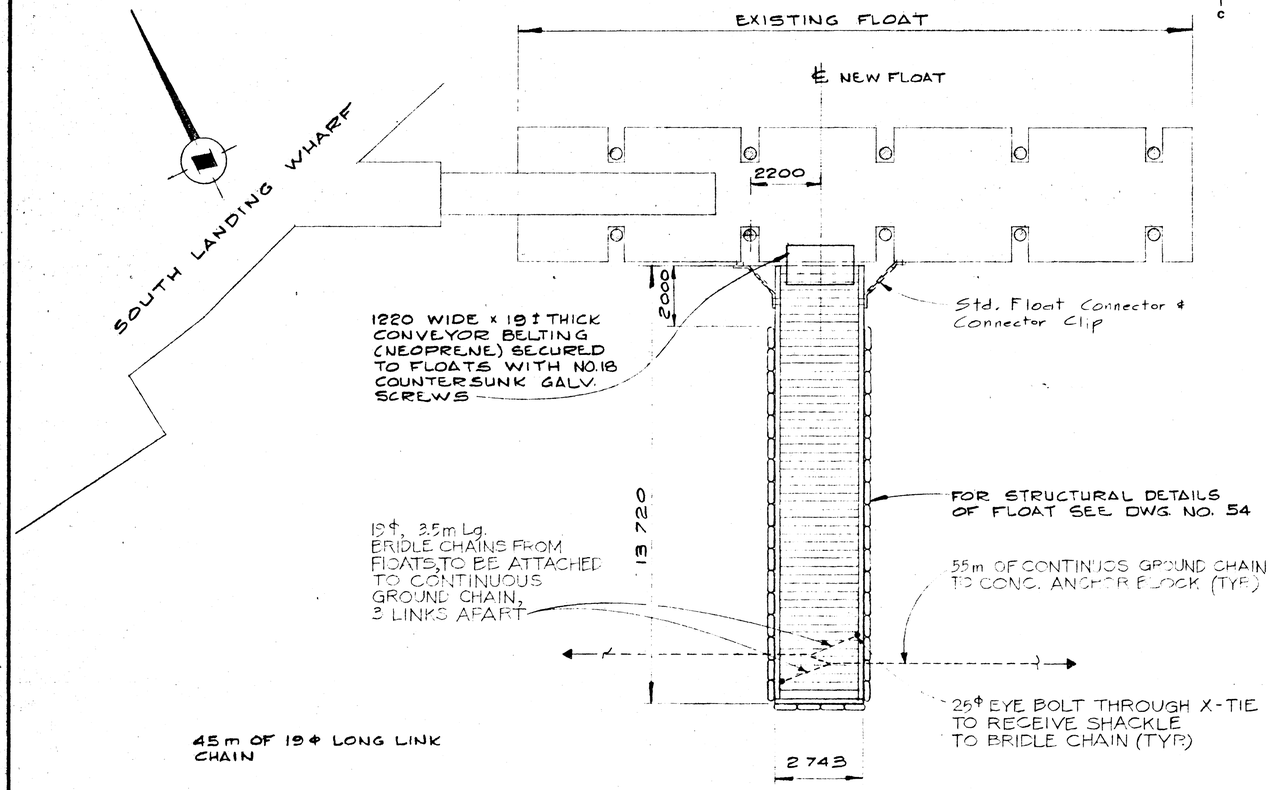
IMPROVEMENTS TO GRAVING DOCK

WATERTIGHT DOORS CONSTRUCTION DETAILS
(NOT IN CONTRACT 3)

designed T.B. / conçu
date MARCH 1984
drawn G.H.P. / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC

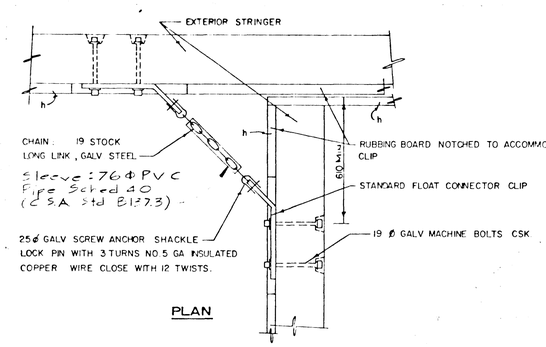
project number / no. du projet
PR 100772

drawing no. / no. du dessin
52 OF 75

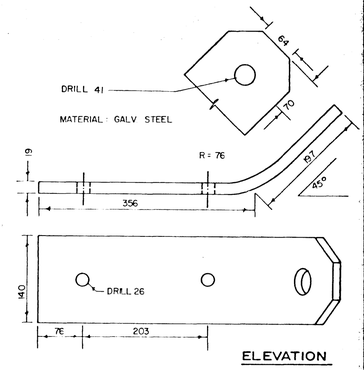


PLAN
1:100

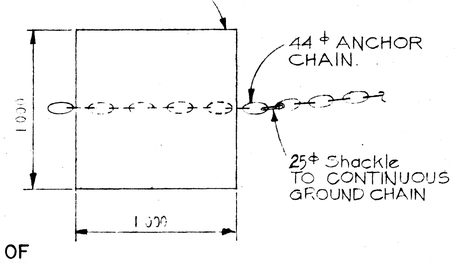
NOTES
1) FOR GENERAL NOTES & LEGEND, SEE DWG. NO. 1



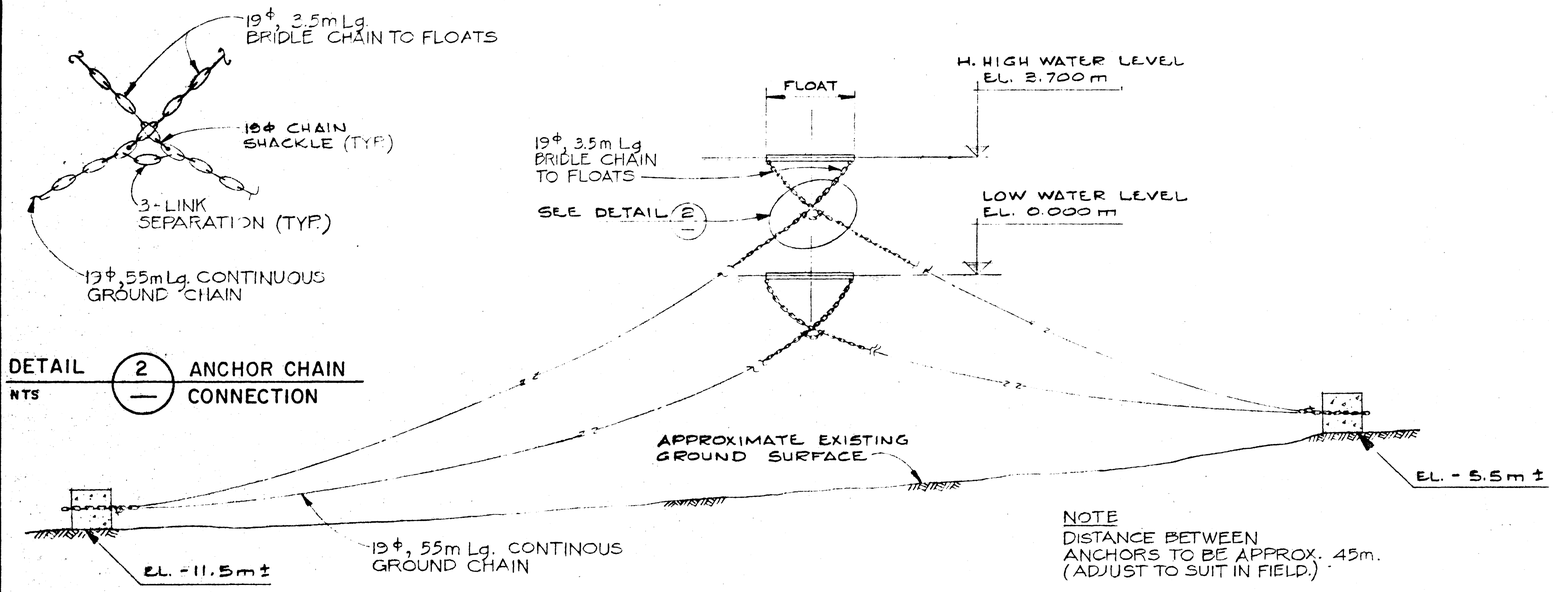
TYP. FLOAT CONNECTOR
N.T.S



STD. FLOAT CONNECTOR CLIP
N.T.S



PLAN OF DETAIL (1) CONCRETE ANCHOR BLOCK
1:20



DETAIL (2) ANCHOR CHAIN CONNECTION
NTS

ELEVATION - MOORING SYSTEM LAYOUT
1:100

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete.

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MALONE

revisions | | date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

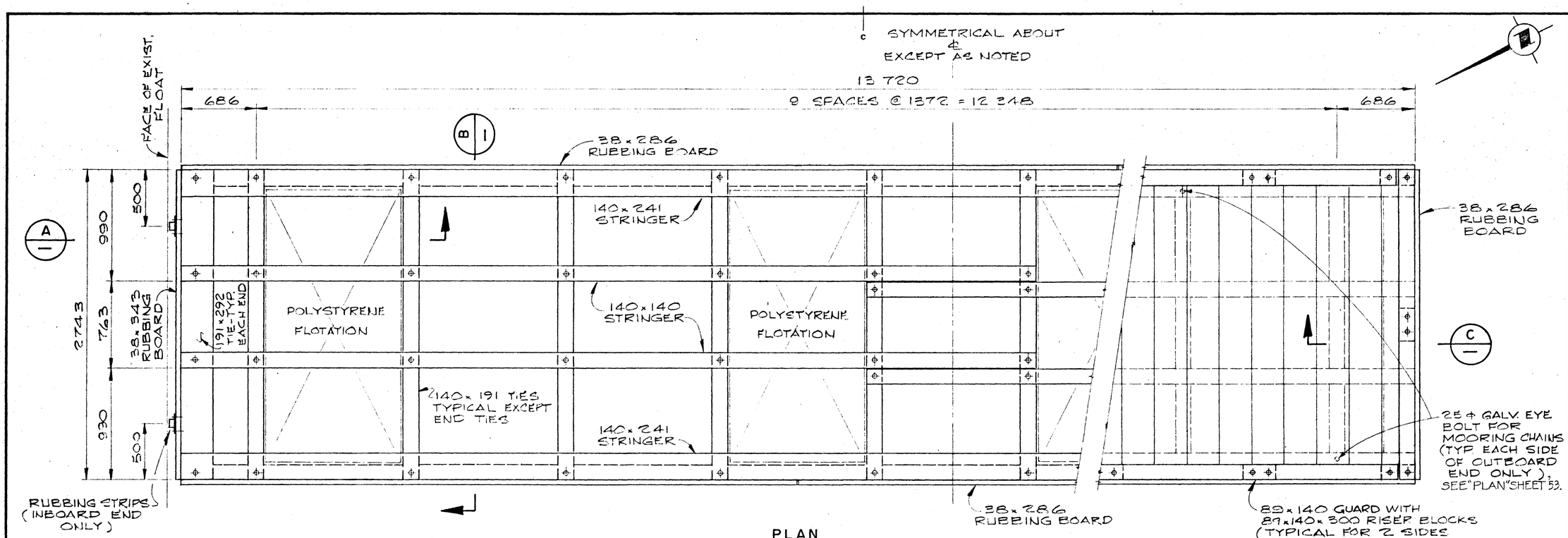
project / projet "BC041484"
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO.3

drawing / dessin
NEW SEAPLANE FLOAT AT SOUTH LANDING WHARF
GENERAL ARRANGEMENT
(NOT IN CONTRACT 3)

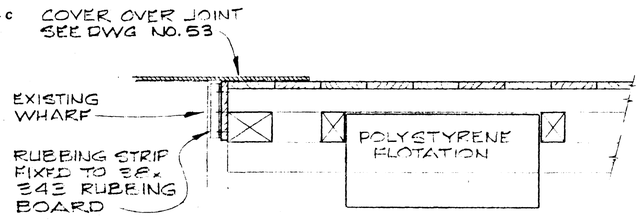
designed TB / conçu
date MARCH 1984
drawn GHP / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no. du projet
PR 100772
drawing no. / no. du dessin
53 OF 75

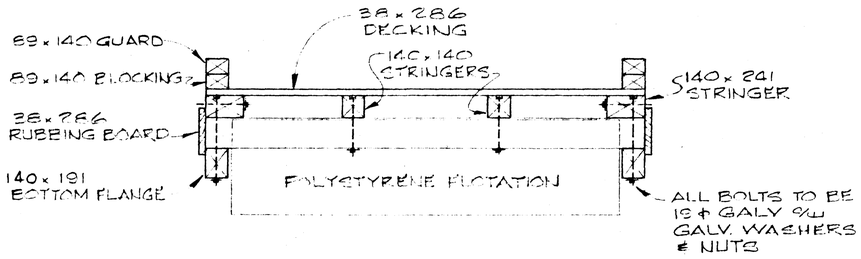
PWC A1



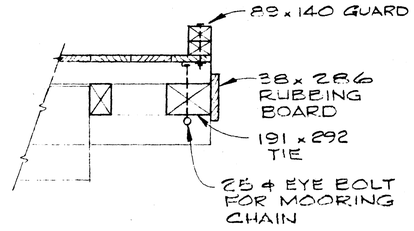
PLAN
1:20



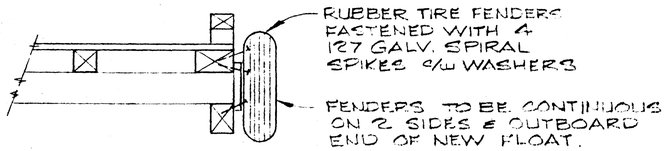
SECTION A
1:20



SECTION B (TYPICAL)
1:20



SECTION C
1:20



DETAIL 1 TYPICAL FENDER INSTALLATION
1:20

NOV 6 1985

The Contractor shall confirm the actual location of all Services within the area of operations, and should not assume that the locations shown on the Drawings are either accurate or complete.

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PETER MACORE

revisions | date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

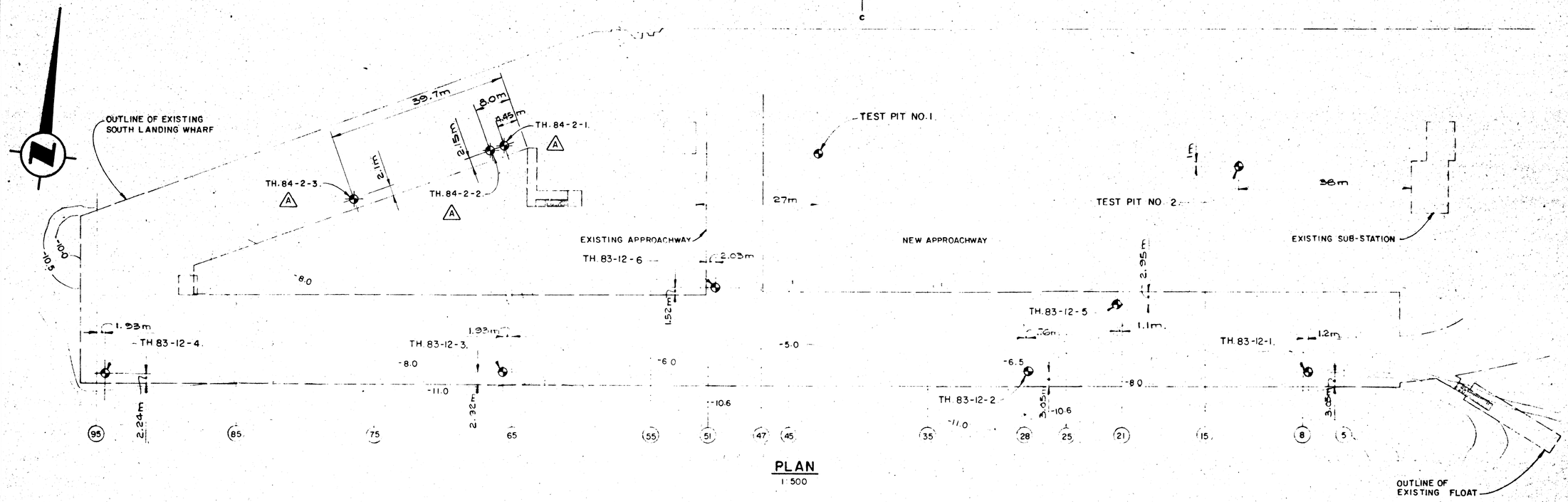
project / projet
"BC041485"
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC
CONTRACT NO. 3

drawing / dessin
NEW SEAPLANE FLOAT AT SOUTH LANDING WHARF
STRUCTURAL DETAILS
(NOT IN CONTRACT 3)

designed T B / conçu
date MARCH 1984
drawn DG / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de Projets TPC

project number / no. du projet
PR 100772
drawing no. / no. du dessin
54 OF 75

PWC A1



PLAN
1:500

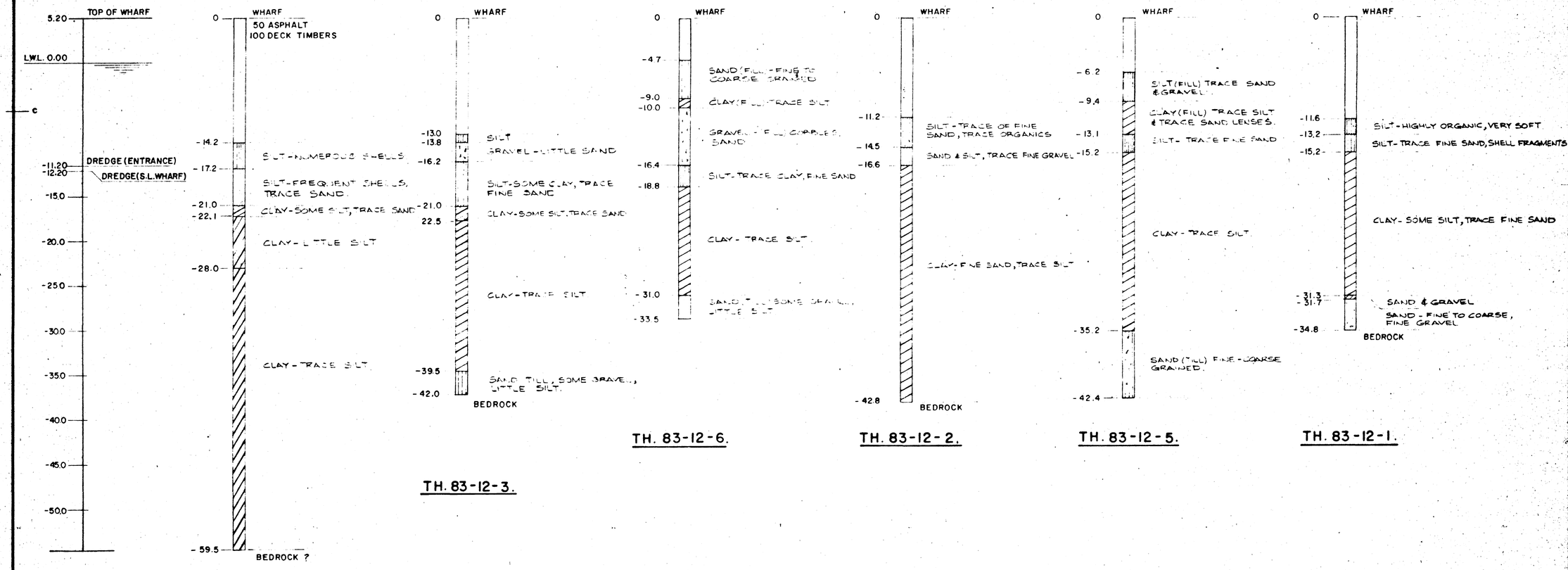


CHART DATUM

NOTES
1) REFER TO DWG. 1 FOR GENERAL NOTES.
2) ELEVATIONS ON TEST HOLES ARE DEPTHS BELOW WHARF ELEVATION (5.20m CHART DATUM). TO TIE IN WITH HARDY ASSOCIATES REPORT. REFER TO CHART DATUM SCALE FOR DREDGING ELEVATIONS.
3) TEST HOLE DATA OBTAINED FROM HARDY ASSOCIATES (1978) LTD. REPORT, REF. VG 03286.

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25126

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. J. GRANT

"BC041486"

revisions		date
A	AS BUILT	JULY 22/85

A detail no. / no. du détail
B location drawing no. / no. du dessin
C drawing no. / no. du dessin

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
TEST HOLE INVESTIGATIONS
SHEET 1 OF 2

designed C.J.G.	concu
date APRIL, 1984.	
drawn H.C.G.	dessiné
date APRIL, 1984.	
reviewed	examiné
date	
approved	approuvé
date	
Tender / Soumission	
PWC Project Manager	Administrateur de projets TPC
project number / no. du projet	PR 100772
drawing no. / no. du dessin	55 OF 75 A

PWC A1

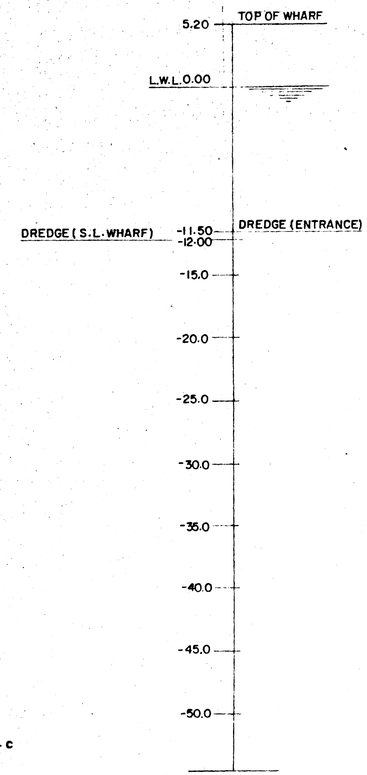
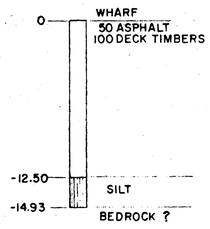
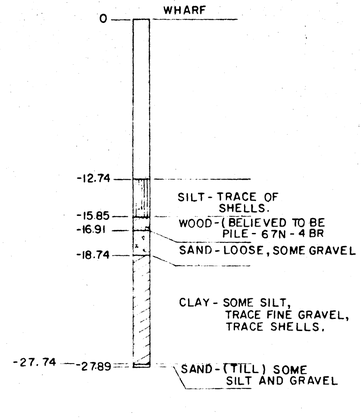


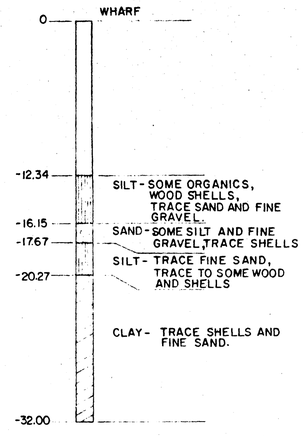
CHART DATUM



TH. 84-2-1.



TH. 84-2-2.



TH. 84-2-3.

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. GRANT

BC041487

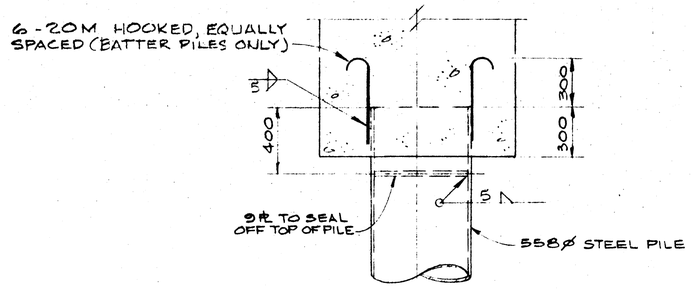
A	AS BUILT	JULY 26/85
revisions		date

A detail no. / no. du détail
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

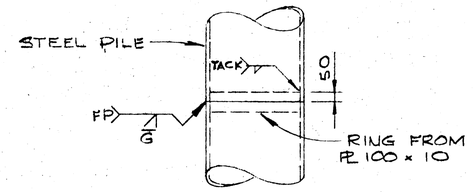
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3.

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
TEST HOLE INVESTIGATIONS
SHEET 2 OF 2

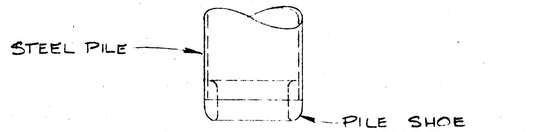
designed	C.J.G.	conçu
date	APRIL 1984.	
drawn	H.C.G.	dessiné
date	APRIL 1984.	
reviewed		examiné



PILE CAP



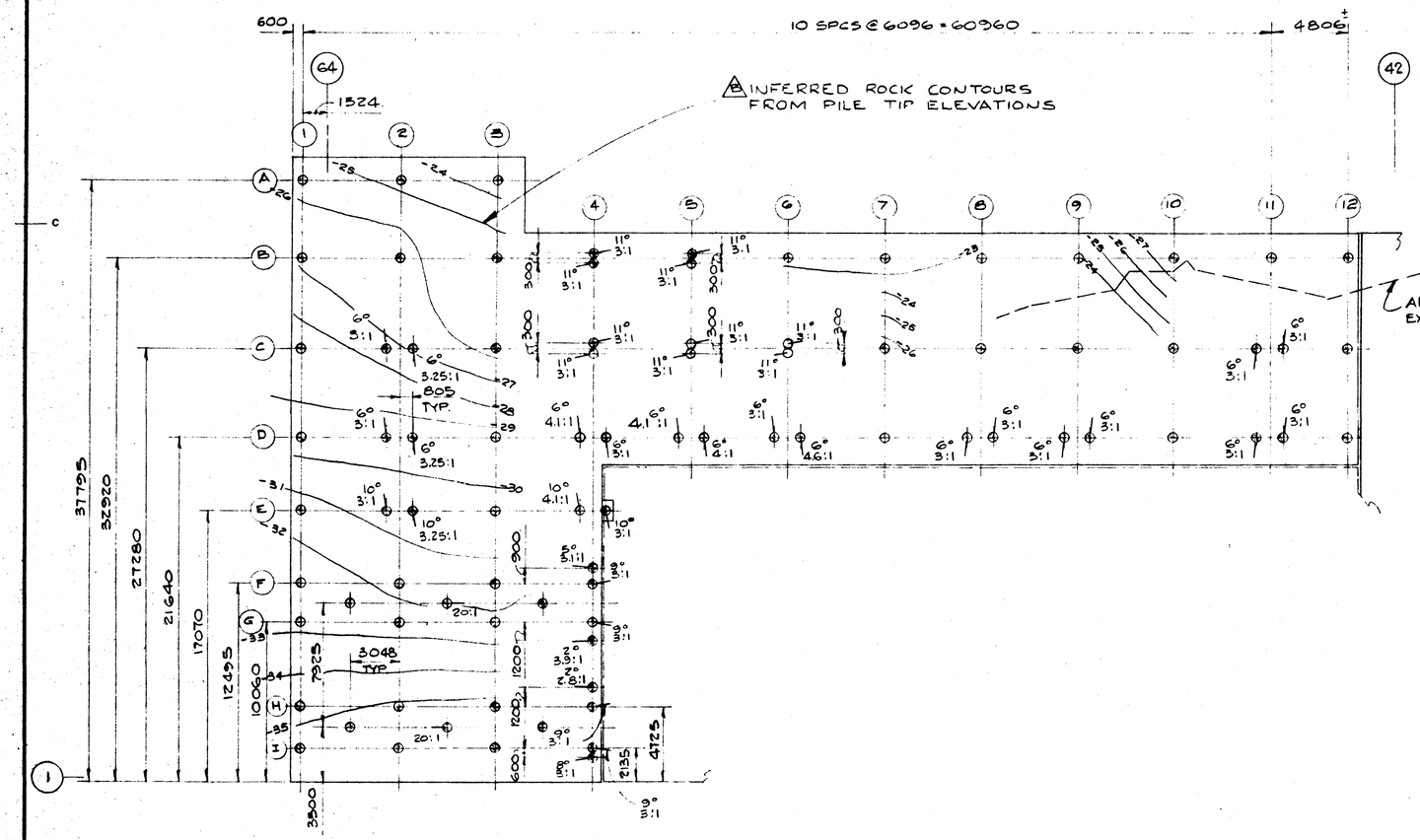
PILE SPLICE



PILE SHOE

PILE DETAILS - TYPICAL DWG 57, 58 & 59

1:20



PLAN

1:200

LEGEND:

⊘ — INDICATES NEW PILE LOCATIONS.

⊘ — INDICATES NEW BATTER PILE LOCATIONS.

EXAMPLE:

INDICATES DEGREES OF BEVEL 10°
SLOPE OF PILE 3:1

NOTES:

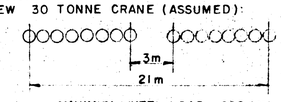
1.) UNIFORMLY DISTRIBUTED LIVE LOAD ; 28.7 kPa (600 PSF).

2.) UNIFORMLY DISTRIBUTED DEAD LOAD (INCLUDING PRECAST) : 13.2 kPa (275 PSF)

3.) HIGHWAY LOADING: HS20.

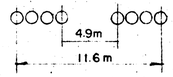
4.) CRANE: (NOTE CRANE RAIL BEAMS DESIGNED FOR FUTURE CRANE OF 7.925 m (26') GAUGE, UTILIZING THE WORST CASE OF THE FOLLOWING 3 CRANES. THE FOLLOWING LOADINGS WITHOUT 15% IMPACT INCLUDED IN DESIGN.)

A) NEW 30 TONNE CRANE (ASSUMED):



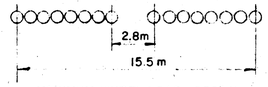
MAXIMUM WHEEL LOAD = 260 kN

B) EXISTING 25 TON CRANE



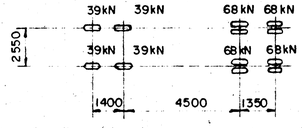
MAXIMUM WHEEL LOAD = 320 kN

C) EXISTING 50 TON CRANE



MAXIMUM WHEEL LOAD = 258 kN

5.) SPECIAL TRUCK LOADING, 65 TON RUBBER TIRED CRANE



a). LOADS DO NOT INCLUDE 15% IMPACT USED IN DESIGN.

b.) LOADING APPLIED ANYWHERE ON DECK.

6.) SPECIAL CRANE OUTRIGGER LOAD:

LOAD OF 530 kN (118.5*) APPLIED AT ONE POINT, SOUTH OF NORTH CRANE RAIL ONLY. LOAD DOES NOT INCLUDE 15% IMPACT USED IN DESIGN. LOAD APPLIED ON 715 mm DIAMETER OUTRIGGER, WITHOUT ANOTHER VEHICLE WITHIN 2m.

7.) EARTHQUAKE LOAD 13% OF DEAD LOAD.

8.) SHIP IMPACT FORCES:

FENDER FORCES ARE FOR SHIPS WITH THE FOLLOWING CHARACTERISTICS

a.) DEAD WEIGHT TONNAGE.	40,000
b.) LENGTH OVERALL	213 m
c.) DEPTH	16.8 m
d.) DRAFT (LIGHT)	4.6 m
f.) VELOCITY OF APPROACH NORMAL TO BERTH FACE	0.15 m/SEC.
g.) ANGLE OF APPROACH	5°
h.) BENT RADIUS OF BOARD AT LOAD LINE.	85 m

FORCE ON WHARF at FENDER LOCATION (TONNES) BASED ON FENDER SIZE SPECIFIED ON DWG. NO. 47

BERTHING LOCATION	F1	F2	F3	F4	TOTAL FORCE ON WHARF
BETWEEN F2 & F3	50	70	70	50	240
AT F3	0	55	80	55	190
AT F2	55	80	55	0	190
AT F4	0	10	70	110	190
AT F1	110	70	10	0	190
LONGITUDINAL FORCE TO BE 30% LATERAL FORCE ON WHARF.					

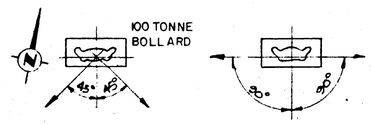
F1 IS RUBBER FENDER AT WEST SIDE OF GROUP.

F4 IS RUBBER FENDER AT EAST SIDE OF GROUP.

9.) MOORING FORCES:

MOORING FORCES ARE FOR SHIPS WITH THE FOLLOWING CHARACTERISTICS.

a.) TONNAGE	40,000
b.) LENGTH OVERALL	213 m
c.) DEPTH	16.8 m
d.) DRAFT (LIGHT)	4.6 m
f.) DESIGN WIND PRESSURE	0.58 kN/m²
g.) GUST FACTOR	2.0



HORIZONTAL LINE ANGLE RANGES.
MAXIMUM VERTICAL ANGLE 30° TO HORIZONTAL.

PILES DESIGNED FOR ALL BOLLARDS TO BE LOADED CONCURRENTLY, INCLUDING ADDITIONAL 50 TONNE UNITS IN AREA OF FUTURE WORK, AT SOUTH FACE OF DOCK. APPROXIMATE LOCATIONS ARE GRID LINES 3, 9, 25, 31, 47 & 53.

10. BATTER PILE DESIGN BASED ON TENSION PILE ADHESION VALUES SUPPLIED BY HARDY & ASSOCIATES.
CLAY ADHESION : 11.5 kPa
SILT ADHESION : 0 kPa AT TOP OF LAYER
11.5 kPa AT BOTTOM OF LAYER

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

BC041488

revisions		date
B	AS BUILT	JUNE 11/85
A	EXISTING SHEET PILES ADDED	SEPT. 12/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

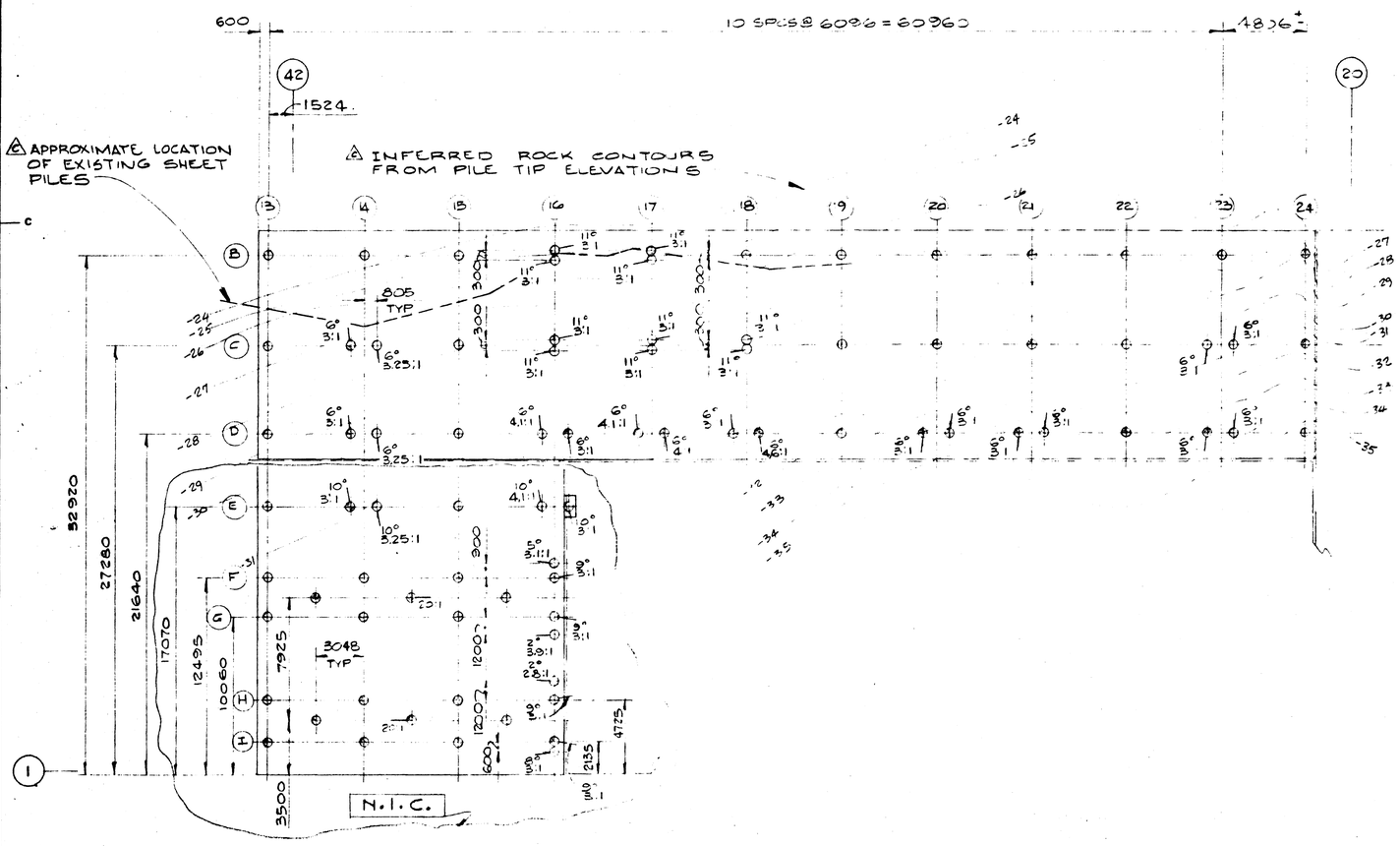
drawing / dessin

IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS & WHARF EXTENSION
PILE LAYOUT
BENT 42 TO 64

designed C.J.G. / conçu
date MAY 1984.
drawn H.C.G. / dessiné
date MAY 1984.
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR100772
drawing no. / no. du dessin
57 OF 75-B

PWC A1

NOTE:
1.) FOR GENERAL NOTES ON PILES SEE DWG. NO. 57.



PLAN
1:200

LEGEND:

● — INDICATES NEW PILE LOCATIONS.
◐ — INDICATES NEW BATTER PILE LOCATIONS.

EXAMPLE:

INDICATES DEGREES OF BEVEL 10°.
SLOPE OF PILE 3:1

NOV 6 1985

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD.
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO 25125

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — C. J. GRANT

"BC041489"

revisions		date
C	AS BUILT	JUNE 11/85
B	DIMENSIONS	SEPT 17/84
A	CRANE PAD DELETED	SEPT. 12/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

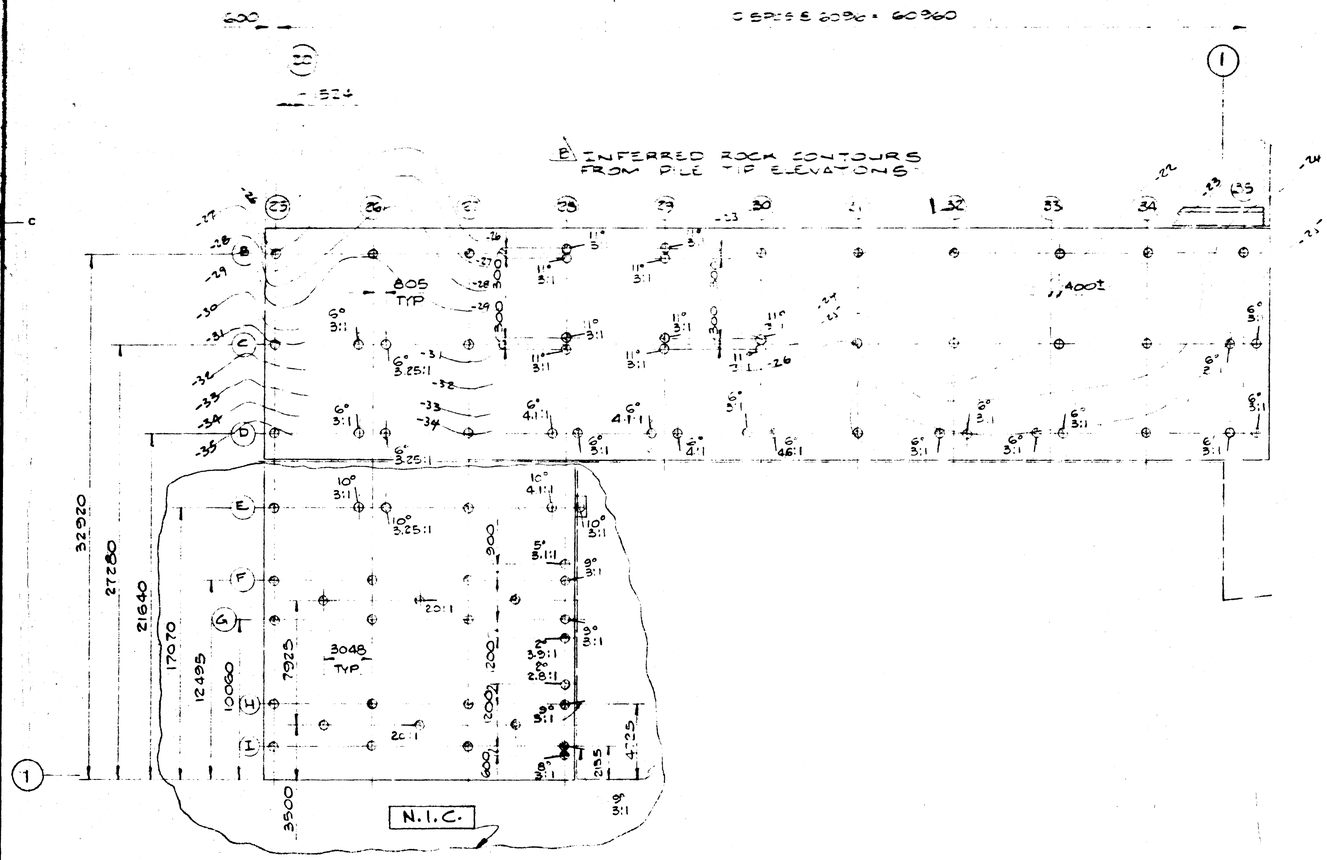
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS & WHARF EXTENSION.
PILE LAYOUT
BENT 20 TO 42.

designed C.J.G. / conçu
date MAY 1984
drawn H.C.G. / dessiné
date MAY 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no. du projet
PR100772
drawing no. / no. du dessin
58 OF 75-A

NOTE:
1) FOR GENERAL NOTES ON PILES SEE DWG. NO. 57.



PLAN
1:200

LEGEND:

● – INDICATES NEW PILE LOCATIONS.
⊘ – INDICATES NEW BATTER PILE LOCATIONS.

EXAMPLE:

INDICATES DEGREES OF BEVEL 10°
SLOPE OF PILE 3:1.

NOV. 6 1985

PWC AI

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA J. GRANT

"BC041490"

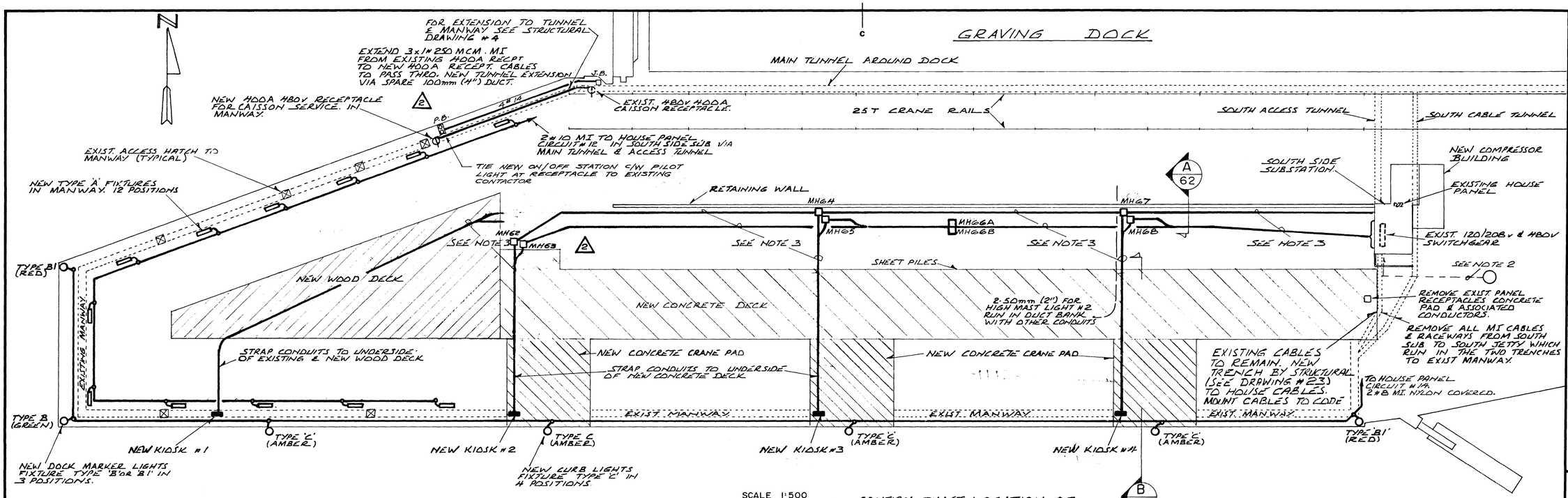
B	AS BUILT	June 11/85
A	CRANE PAD DELETED	SEPT. 12/84
revisions		date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.
CONTRACT NO. 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF
65 TON CRANE PADS & WHARF EXTENSIONS
PILE LAYOUT
BENT 1 TO 20

designed C.J.G. / conçu
date MAY 1984
drawn H.C.G. / dessiné
date MAY 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR100772
drawing no. / no. du dessin
59 OF 75

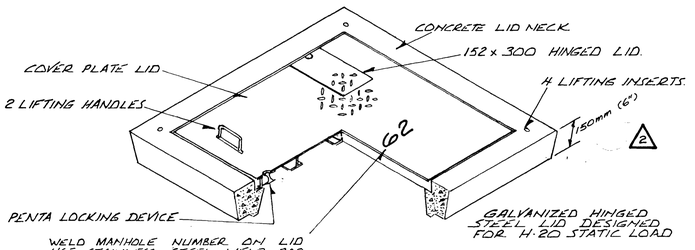


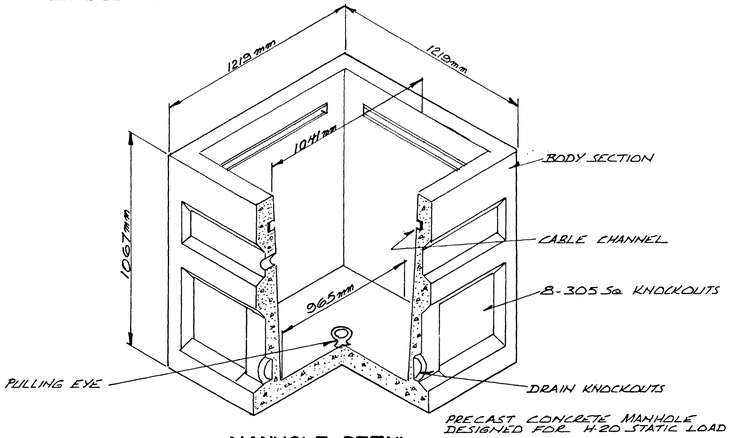
SCALE 1:500

CONFIRM EXACT LOCATION OF CRANE PADS & KIOSKS WITH STRUCTURAL

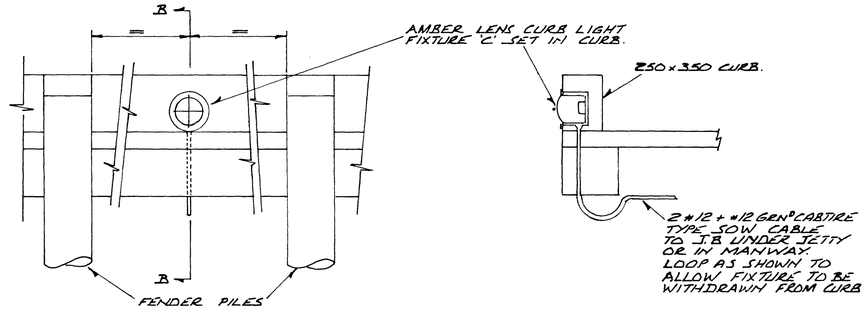
NOTES

1. REMOVE ALL EXISTING OUTLETS, RECEPTACLES LIGHTING & WIRING LOCATED IN THE MANWAY. 100A & 400A RECEPTACLES TO BE TURNED OVER TO GRAVING DOCK.
2. SERVICE TO SEWAGE PUMP STATION TO REMAIN. INFORM DOCK YARD STAFF IF SERVICE IS INTERRUPTED
3. DUCTS FROM SUBSTATION TO MANHOLES TO BE THICK WALL RIGID PVC. CONDUITS ENCASED IN CONCRETE. DUCTS FROM MANHOLES TO KIOSKS TO BE F.R.E. ENCASED IN CONCRETE IN INFILL AREA. & SUSPENDED UNDER NEW DECK AREA.





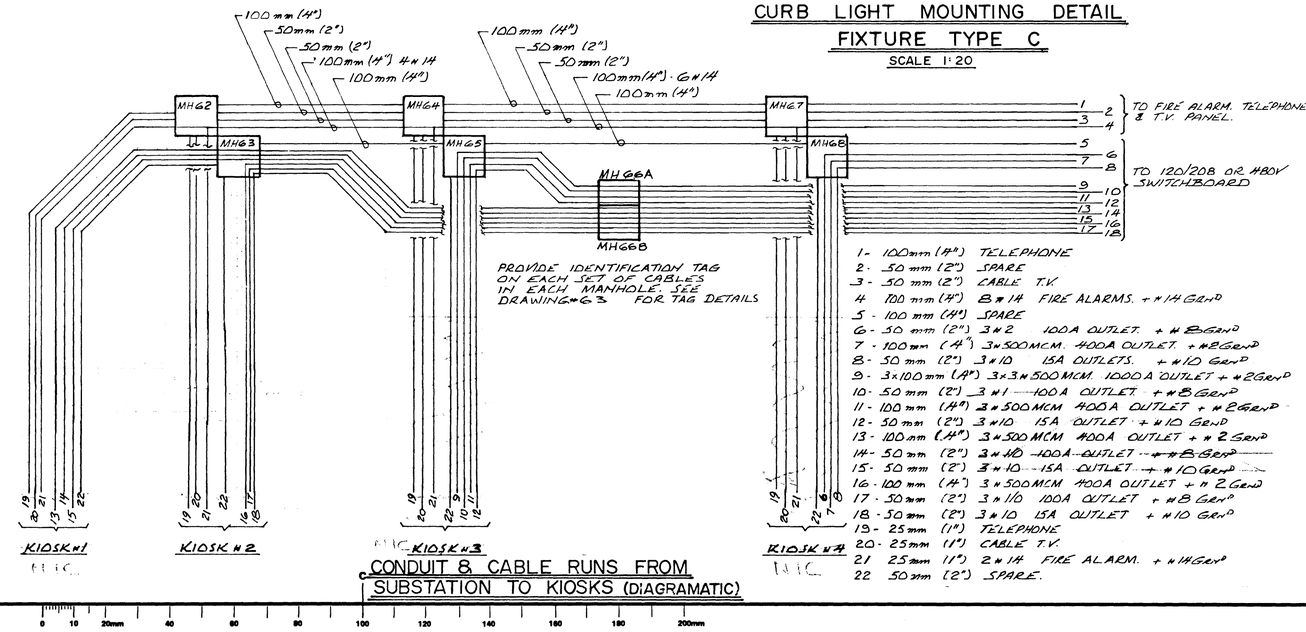
MANHOLE DETAIL
N.T.S.



ELEVATION

SECTION B-B

CURB LIGHT MOUNTING DETAIL
FIXTURE TYPE C
SCALE 1:20



1 - 100mm (4") TELEPHONE
2 - 50 mm (2") SPARE
3 - 50 mm (2") CABLE T.V.
4 100 mm (4") 8 # 14 FIRE ALARMS. + # 14 GRN°
5 - 100 mm (4") SPARE
6 - 50 mm (2") 3 # 2 100A OUTLET. + # 8 GRN°
7 - 100 mm (4") 3 # 500 MCM. 400A OUTLET. + # 2 GRN°
8 - 50 mm (2") 3 # 10 15A OUTLETS. + # 10 GRN°
9 - 3 x 100 mm (4") 3 x 3 # 500 MCM. 1000A OUTLET + # 2 GRN°
10 - 50 mm (2") 3 # 1 100A OUTLET + # 8 GRN°
11 - 100 mm (4") 3 # 500 MCM 400A OUTLET + # 2 GRN°
12 - 50 mm (2") 3 # 10 15A OUTLET + # 10 GRN°
13 - 100 mm (4") 3 # 500 MCM 400A OUTLET + # 2 GRN°
14 - 50 mm (2") 3 # 4 400A OUTLET + # 8 GRN°
15 - 50 mm (2") 3 # 10 15A OUTLET + # 10 GRN°
16 - 100 mm (4") 3 # 500 MCM 400A OUTLET + # 2 GRN°
17 - 50 mm (2") 3 # 1/0 100A OUTLET + # 8 GRN°
18 - 50 mm (2") 3 # 10 15A OUTLET + # 10 GRN°
19 - 25 mm (1") TELEPHONE
20 - 25 mm (1") CABLE T.V.
21 25 mm (1") 2 # 14 FIRE ALARM. + # 14 GRN°
22 50 mm (2") SPARE.

CONDUIT & CABLE RUNS FROM SUBSTATION TO KIOSKS (DIAGRAMATIC)

0 10 20mm 40 60 80 100 120 140 160 180 200mm

PWC AI

Public Works Canada / Travaux publics Canada

PACIFIC REGION

revisions		date
2.	AS BUILT PER RICKETTS - SEWELL SET OF DWGS.	12/11/85
1	ISSUED FOR CONSTRUCTION	21/1/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B. C.

CONTRACT NO. 3

drawing / dessin
WHARF OUTLETS
LAYOUT & DETAILS

BC037005

designed B. D. WRIGHT / conçu
date April 84

drawn B. D. WRIGHT / dessiné
date April 84

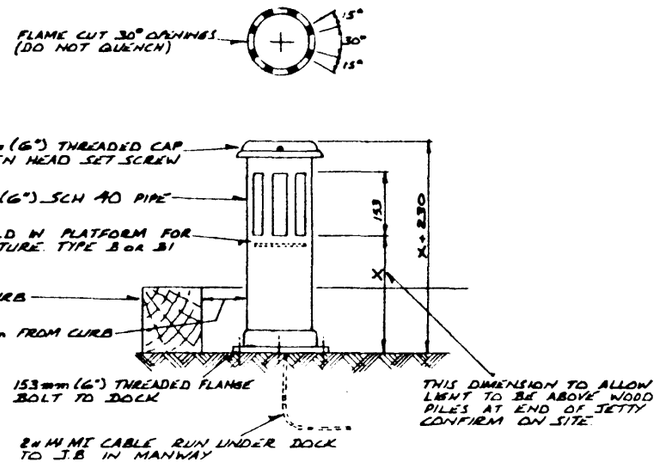
reviewed R. P. SCHELLE / examiné
date May 84

approved A. DERAGOPIAN / approuvé
date

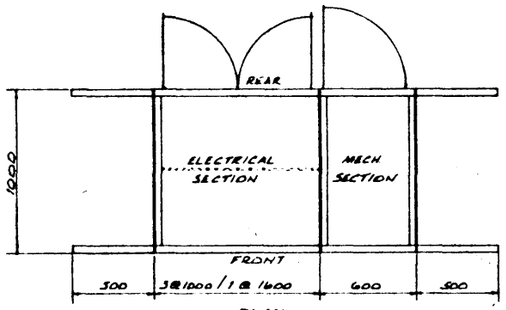
Tender D HARRIS / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no. du projet
PR 100772

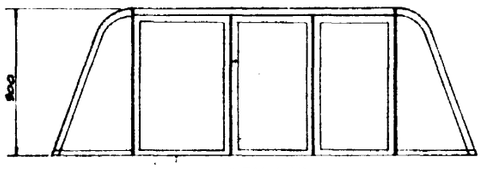
drawing no. / no. du dessin
60 OF 75



DOCK MARKER LIGHT
NTS



PLAN



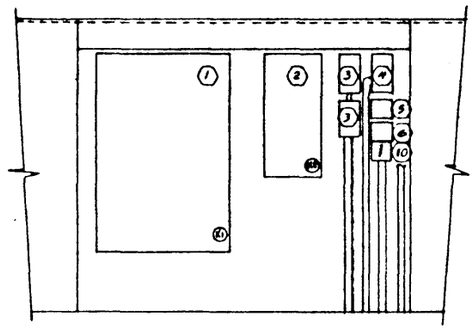
ELEVATION

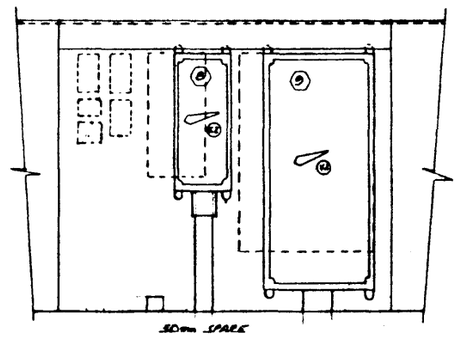
KIOSK DETAILS
SCALE 1:20

SEE STRUCTURAL DRAWINGS FOR DETAILS

HEAVY DUTY WEATHERPROOF SOCKETS
FABRICATED FROM GALVANIZED STEEL
WHITE EPOXY ACRYLIC FINISH
CLEAR ACRYLIC LAMP ENCLOSURE
120V 40W RAPID START C/F BALLAST

FIXTURE TYPE A
N.I.C

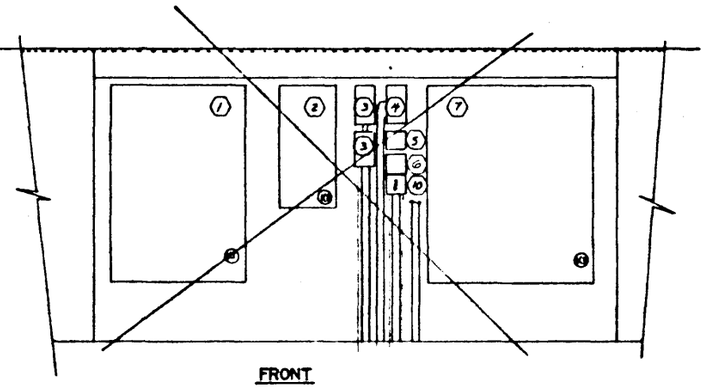


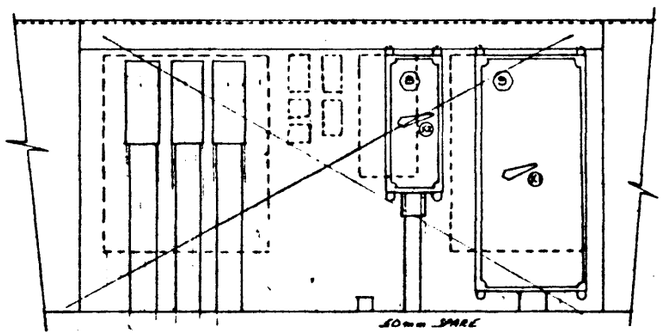


REAR

LAYOUT KIOSK #2 #

SCALE 1:10





REAR

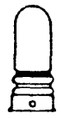
LAYOUT KIOSK #3 N.I.C.

SCALE 1:10

KIOSK EQUIPMENT LEGEND

1. 480V 400A SPLITTER
2. 208V 100A SPLITTER
3. 2 x 120V 15A RECEPTACLE
4. 2 - TELEPHONE OUTLET JACKS SUPPLIED BY B.C. TEL.
5. CABLE T.V OUTLET
6. FIRE ALARM JACK. SELF SHORTING WITH 1 NO & 1 NC CONTACT
7. ~~480V 100A SPLITTER~~ N.I.C.
8. 100A 2P CIRCUIT BREAKER (CROUSE HINDS # DUS 150 TT100 3)
9. 400A 3P CIRCUIT BREAKER (CROUSE HINDS # DUS 440 TT400 3)
10. FIRE ALARM END OF LINE RESISTOR
11. KEY INTERLOCK

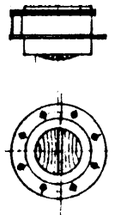
NOTES
1. ALL COMPONENTS TO BE WEATHER PROOF
2. ALL RECEPTACLES & JACKS TO BE CORROSION RESISTANT
3. CIRCUIT BREAKERS TO HAVE MOISTURE TREATMENT



MARINE TYPE INCANDESCENT
CAST ALUMINUM CORROSION RESISTANT
GASKETED BODY
GLASS GLOBE RED OR GREEN
65W ARI 8000 HR TRAFFIC LAMP

TYPE B1 RED GLOBE
TYPE B GREEN GLOBE

FIXTURE TYPE B & B1



MARINE TYPE INCANDESCENT
CAST BRASS GASKETED WEATHERPROOF
IMPACT RESISTANT GLASS LENS SHALLOW
SPREAD LIGHT TYPE
65W ARI 8000 HR TRAFFIC LAMP
WITH AMBER LENS OR AMBER LAMP

FIXTURE TYPE C

THIS DRAWING REDUCED TO ONE HALF ORIGINAL SIZE

Public Works Canada / Travaux publics Canada

PACIFIC REGION

Robert Fremlin & Associates Ltd

BC040531

PROFESSIONAL ENGINEER

1	ISSUED FOR CONSTRUCTION	21/3/94
revisions		date

A detail no. / no. de détail
B location drawing no. / no. dessin no.
C drawing no. / dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B. C.

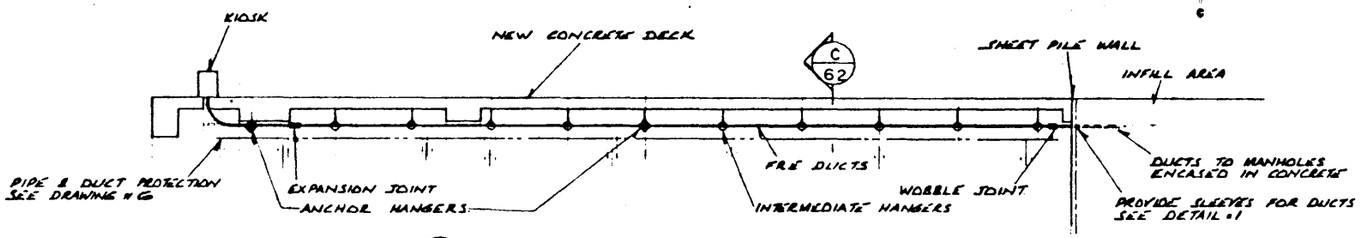
CONTRACT NO. 3

drawing / dessin
WHARF OUTLETS

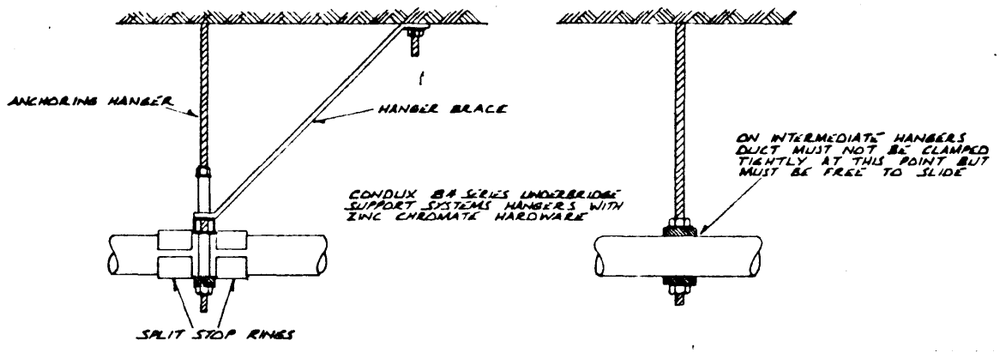
KIOSK DETAILS

designed B D WRIGHT
date Mar 94
drawn B D WRIGHT
date Mar 94
reviewed R P SCHELLE
date MAY 94
approved A. DERAGOPIAN
date
Tender D. HARRIS
PWC Project Manager
Superintendent
Administrateur de projet TPC
project number / no. de projet
PR 100772
drawing no. / no. de dessin
61 OF 75

PWC A1

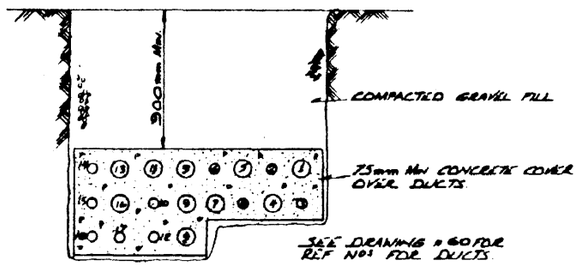


SECTION B/60 ELEVATION OF DUCTS UNDER DECK
SCALE 1:125

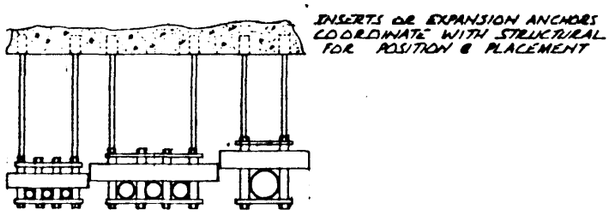


ANCHOR HANGER — INTERMEDIATE HANGER

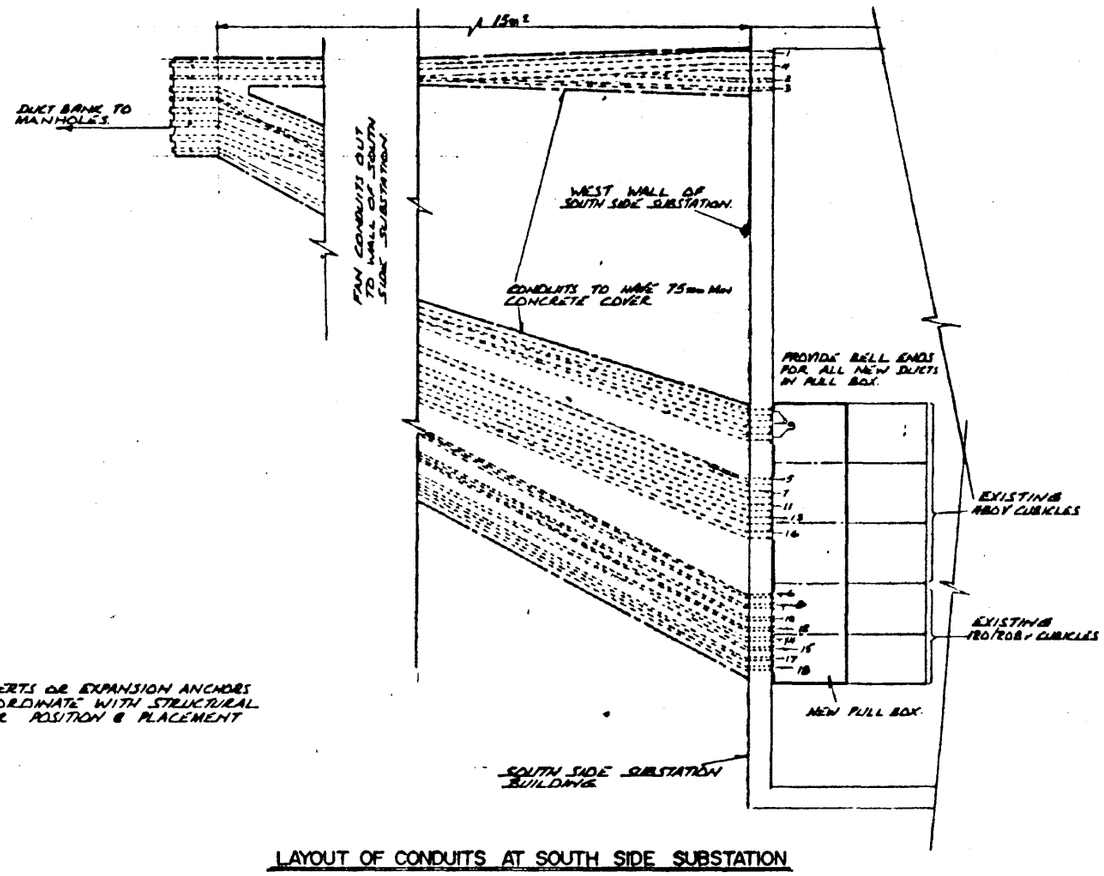
HANGER DETAILS
NTS



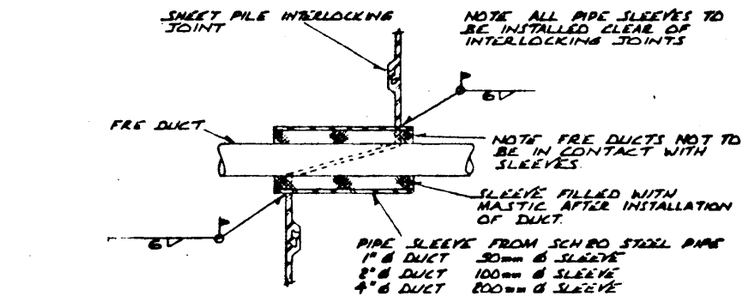
SECTION A/60 DUCT BANK DETAIL
SCALE 1:20



SECTION C/62 ELEVATION OF DUCTS UNDER DECK
SCALE 1:10



LAYOUT OF CONDUITS AT SOUTH SIDE SUBSTATION
SCALE 1:50



DETAIL 1/60 TYPICAL PIPE SLEEVE THROUGH SHEET PILING
SCALE 1:10

THIS DRAWING REDUCED TO ONE HALF ORIGINAL SIZE

Public Works Canada / Travaux publics Canada
PACIFIC REGION

BC040532

PROFESSIONAL ENGINEER PROVINCE OF B.C. R.P. SCHELLE

revisions		date
1	ISSUED FOR CONSTRUCTION	91/5/16

A detail no. / no. du détail
B location drawing no. / no. du dessin de l'emplacement
C drawing no. / no. du dessin

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B. C.

CONTRACT NO. 3

drawing / dessin
WHARF OUTLETS

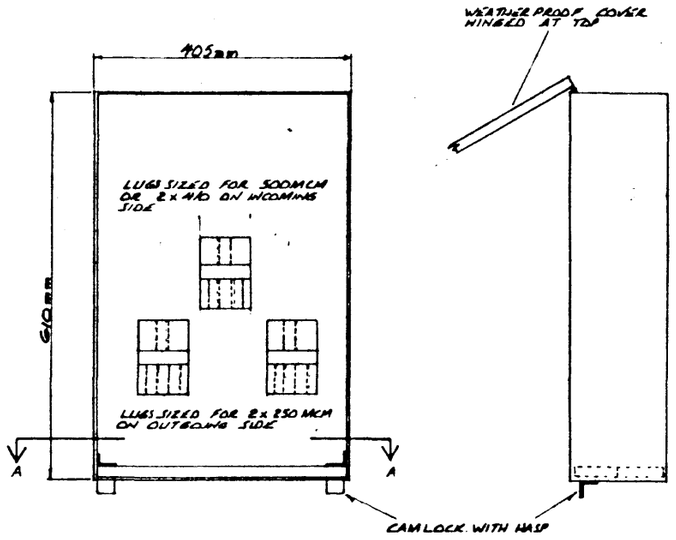
DUCT DETAILS

designed	B.D. WRIGHT	design
date	APRIL 84	
drawn	B.D. WRIGHT	drawn
date	APRIL 84	
reviewed	R.P. SCHELLE	checked
date	MAY 84	
approved	A. DERAGOPIAN	approved
date		
Tender	D. HARRIS	Soumission
PWC Project Manager		Gestionnaire de projets TPC

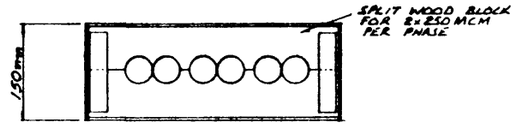
project number / no. du projet
PR 100772

drawing no. / no. du dessin
62 OF 75

PWC A1



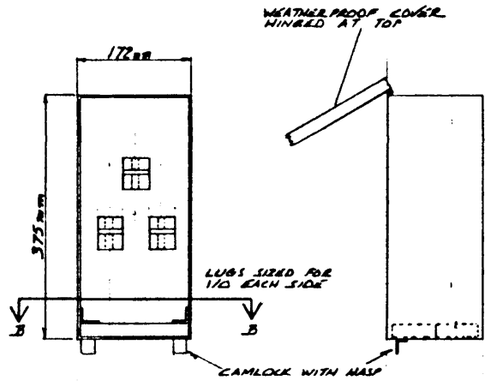
FRONT ELEVATION (LESS COVER) SIDE ELEVATION



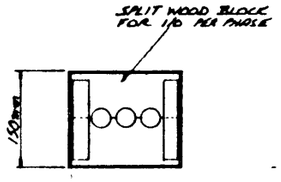
SECTION A A

400A 480V SPLITTER DETAIL

SCALE 1:5



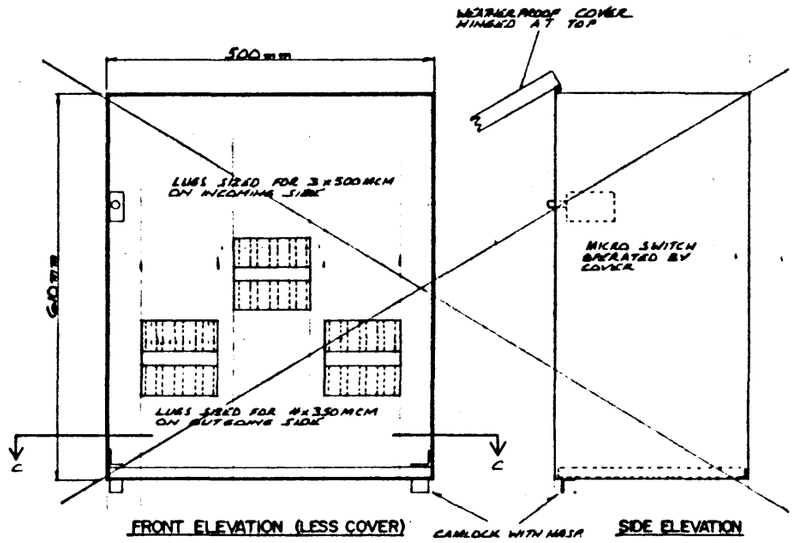
FRONT ELEVATION (LESS COVER) SIDE ELEVATION



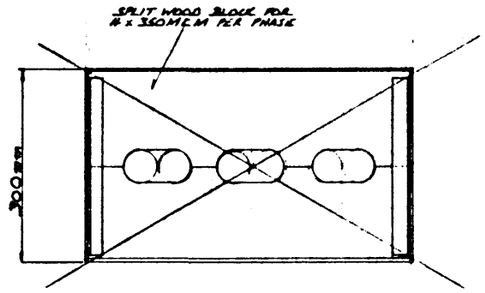
SECTION B B

100A 208V 2P SPLITTER DETAIL

SCALE 1:5



FRONT ELEVATION (LESS COVER) SIDE ELEVATION



SECTION C C

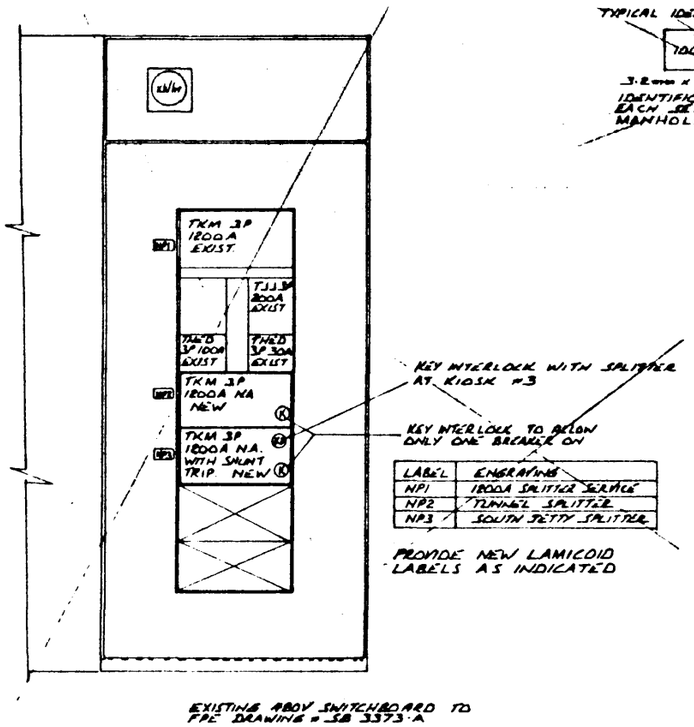
1000A 480V SPLITTER DETAIL

SCALE 1:5

N.I.C.

NOTES:

1. SPLITTER BOXES TO BE WEATHERPROOF FABRICATED FROM HEAVY GAUGE DOUBLE GALVANIZED STEEL
2. TERMINAL LUGS TO BE COPPER WITH TIN FINISH
3. COVERS TO BE KEY INTERLOCKED WITH ASSOCIATED CIRCUIT BREAKER. SEE DRAWING # 6M
4. PROVIDE GROUND LUG IN EACH SPLITTER



EXISTING 480V SWITCHBOARD TO PPE DRAWING # SB 3373 A

MODIFICATION TO EXISTING 480V CUBICLE IN SOUTH SIDE SUBSTATION

NTS

N.I.C.

TYPICAL IDENTIFICATION

KIOSK # 3
1000A 480V A.S.

3.2mm x 12mm x 62mm BRASS

IDENTIFICATION TAG TO BE ON EACH SET OF CABLES IN EACH MANHOLE

THIS DRAWING REDUCED TO ONE HALF ORIGINAL SIZE

Public Works Canada / Travaux publics Canada

PACIFIC REGION

Robert Bruce Wallace & Associates Ltd

BC040533

PROFESSIONAL ENGINEER R. P. SCHELLE BRITISH COLUMBIA

revisions		date
1	ISSUED FOR CONSTRUCTION	89/06

project: ESQUIMALT GRAVING DOCK IMPROVEMENTS ESQUIMALT, B.C.

CONTRACT NO. 3

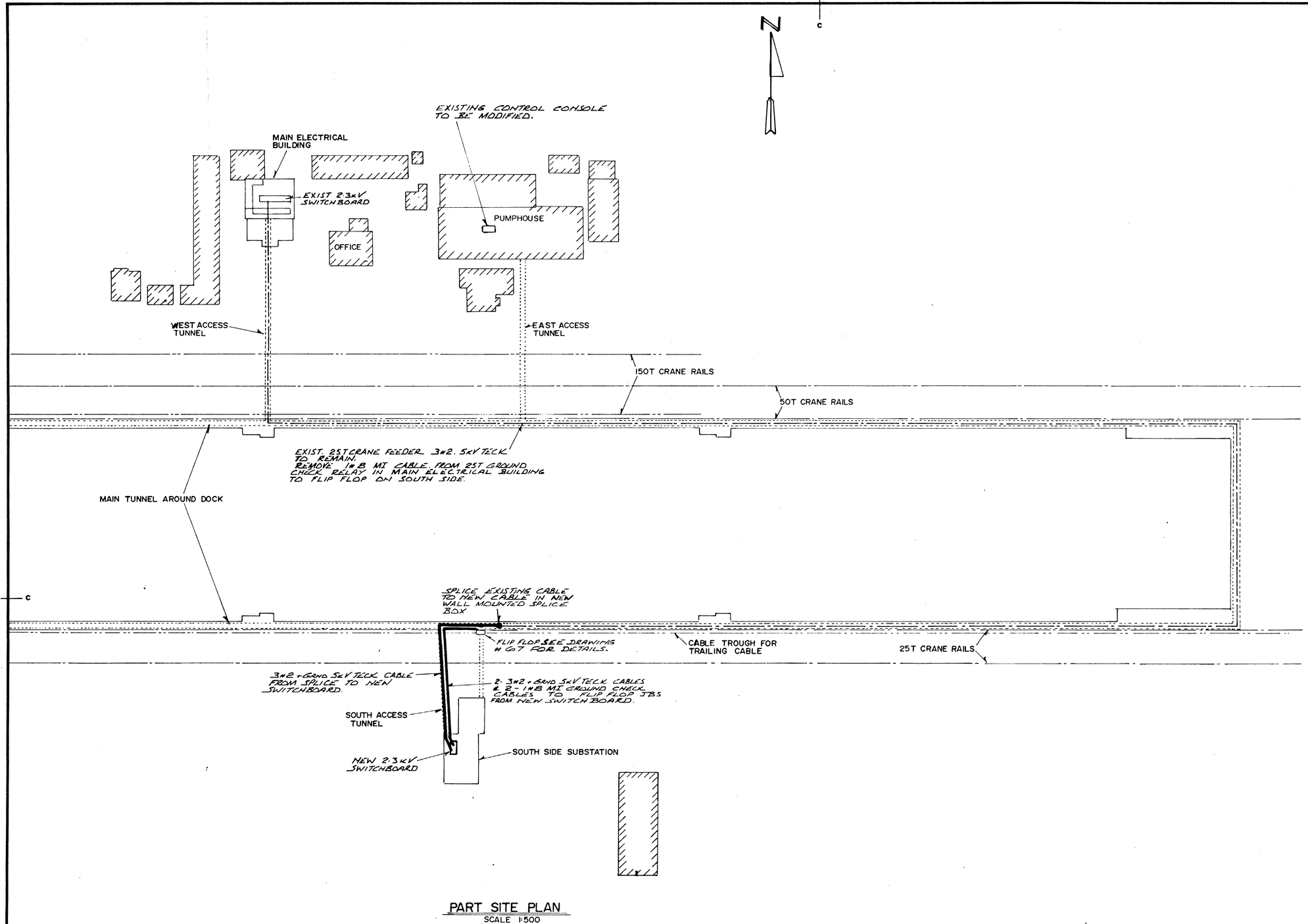
drawing: WHARF OUTLETS

SPLITTER DETAILS

designed B.D.WRIGHT
date APRIL 89
drawn B.D.WRIGHT
date APRIL 89
reviewed R.P.SCHELLE
date MAY 89
approved A. DERAGOPIAN
date
Tender D.HARRIS
project number PR100772

drawing no 63 OF 75

PWC A1



PART SITE PLAN
SCALE 1:500

PWC A1

Public Works Canada / Travaux publics Canada

PACIFIC REGION

Robert Freundlich & Associates Ltd.
CONSULTING ENGINEERS
60 BASTION SQUARE, VICTORIA, B.C. V8W 1J2
TELEPHONE (604) 386-6721

revisions		date
1	ISSUED FOR CONSTRUCTION	2/9/84

A detail no. no. du détail
B location drawing no. sur dessin no
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.

CONTRACT NO. 3

drawing / dessin
NEW CRANE SERVICE

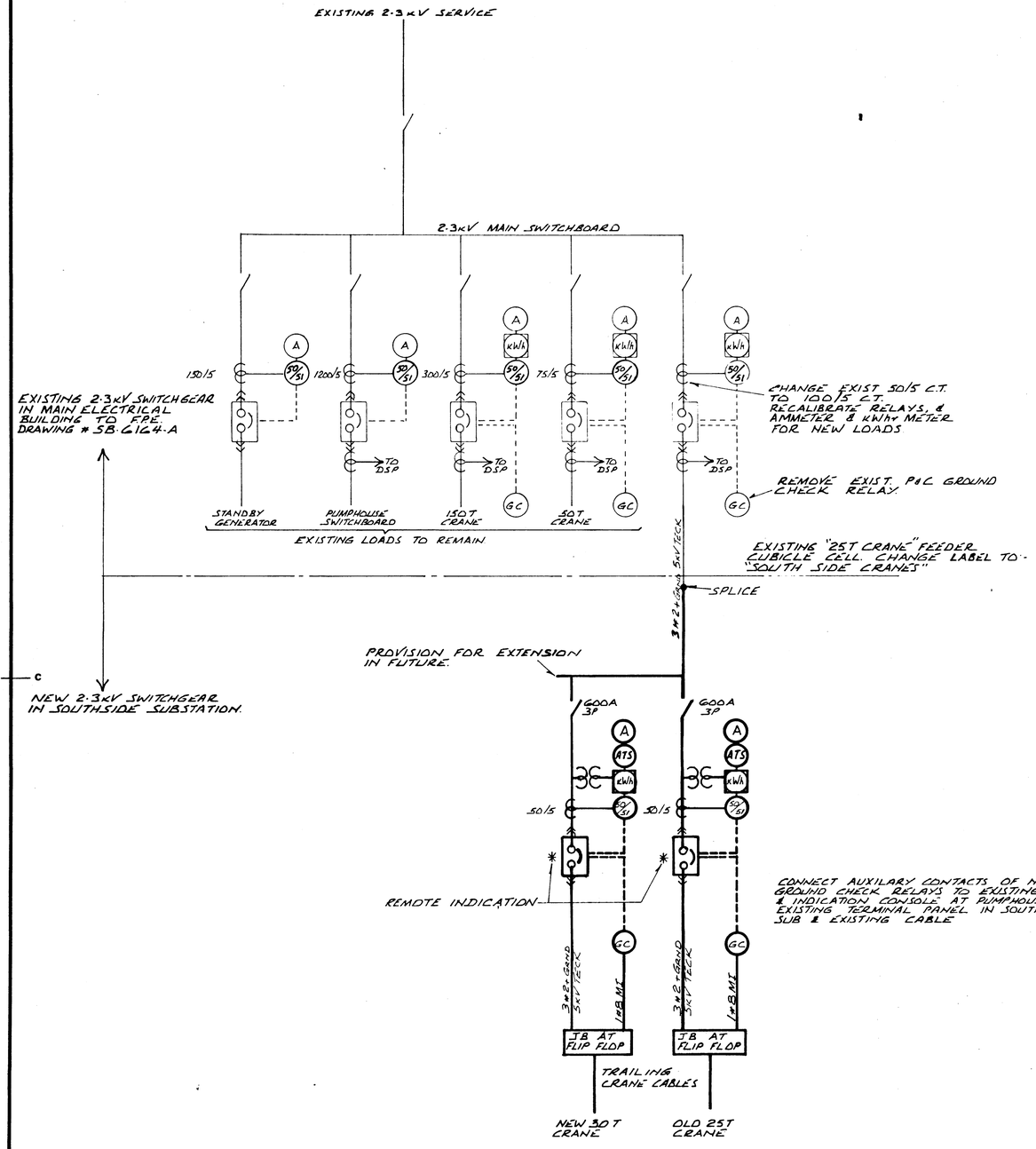
CRANE SERVICE CABLE

"BC039930"

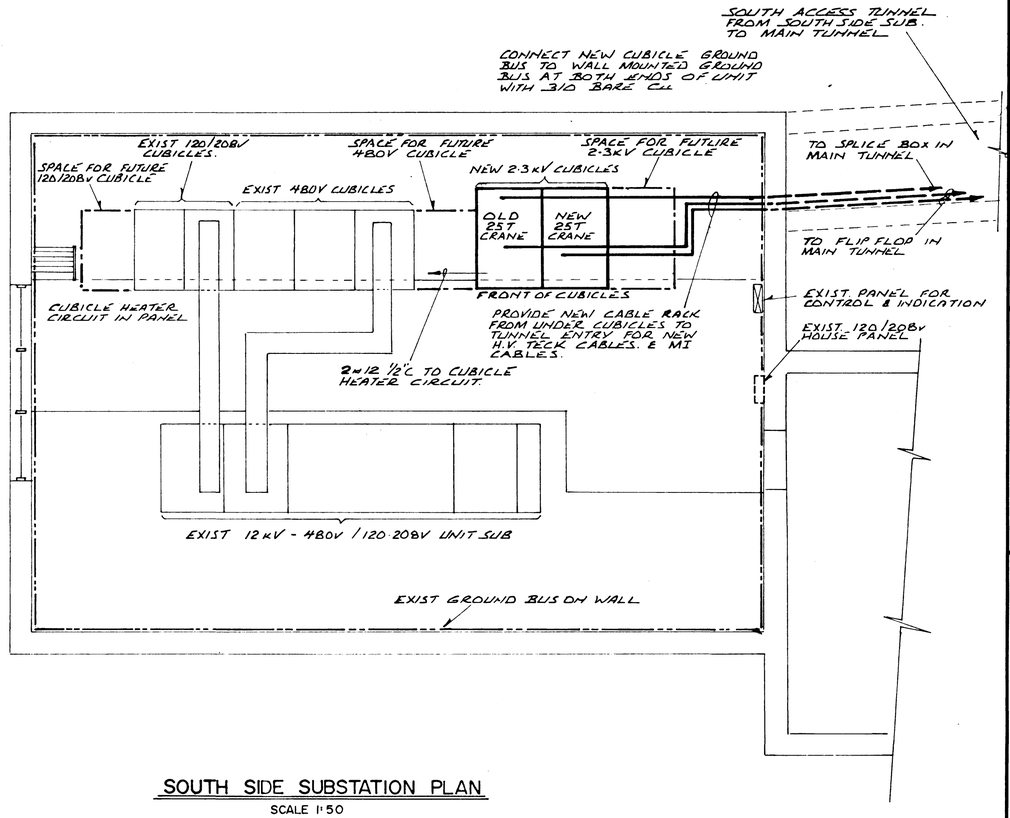
designed B.D.WRIGHT — conçu
date APRIL 84
drawn B.D.WRIGHT — dessiné
date APRIL 84
reviewed R.P. SCHELLE — examiné
date MAY 84
approved A. DERAGOPIAN — approuvé
date
Tender D. HARRIS — Soumission
PWC Project Manager — Administrateur de projets TPC

project number / no. du projet
PR 100772

drawing no. / no. du dessin
65 OF 75



SINGLE LINE DIAGRAM



SOUTH SIDE SUBSTATION PLAN

SCALE 1:50

LEGEND

A	AMMETER
ATS	AMMETER TEST/SELECTER SWITCH
kWh	KILO WATT HOUR METER
50/51	2 PHASE OVERCURRENT & 1 GROUND OVER CURRENT RELAY
GC	GROUND CHECK RELAY (P&C # 2A31-1)
1	HV ISOLATION / DISCONNECT SWITCH
	LOW OIL CIRCUIT BREAKER
	CURRENT TRANSFORMER
	POTENTIAL TRANSFORMER
DSP	SELECTIVE GROUND TRIP UNIT.
	EXISTING
	NEW

Public Works Canada / Travaux publics Canada

PACIFIC REGION

Robert Freundlich & Associates Ltd.
CONSULTING ENGINEERS
60 BASTION SQUARE, VICTORIA, B.C. V8W 1J2
TELEPHONE (604) 386-5721

"BC039931"

revisions		date
1	ISSUED FOR CONSTRUCTION	21/9/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS ESQUIMALT, B. C.

CONTRACT NO. 3

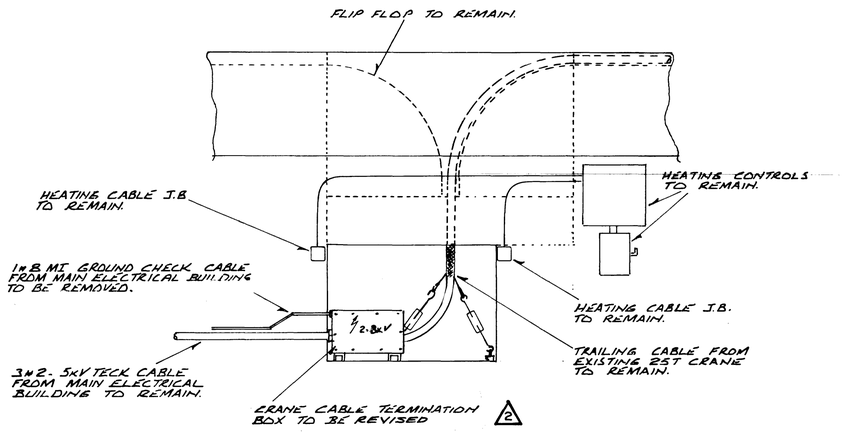
drawing / dessin
NEW CRANE SERVICE

CRANE SERVICE, SINGLE LINE DIAGRAM & SUBSTATION LAYOUT

designed B. D. WRIGHT / conçu
date April 84
drawn B. D. WRIGHT / dessiné
date April 84
reviewed R. P. SCHELLE / examiné
date May 84
approved A. DERAGOPIAN / approuvé
date
Tender D. HARRIS / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
66 OF 75

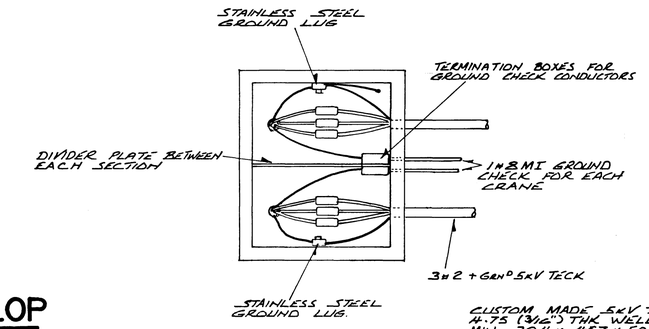
PWC A1

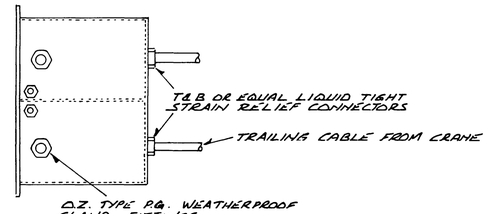
0 10 20mm 40 60 80 100 120 140 160 180 200mm



ELEVATION FROM TUNNEL
SCALE 1:25

EXISTING CABLE TERMINATION DETAIL AT FLIP FLOP





CUSTOM MADE 5kV TERMINATION BOX. 4.75 (3/16") THK WELDED STEEL WITH MIN. 304 x 457 x 508 mm (12"x18"x20") INSIDE DIMS. EACH SECTION. HOT DIP GALVANIZED & YELLOW PAINT FINISH. CSW BOLT ON SINGLE COVER PLATE. NEOPRENE GASKET, & 2.3kV DANGER SIGN ON COVER

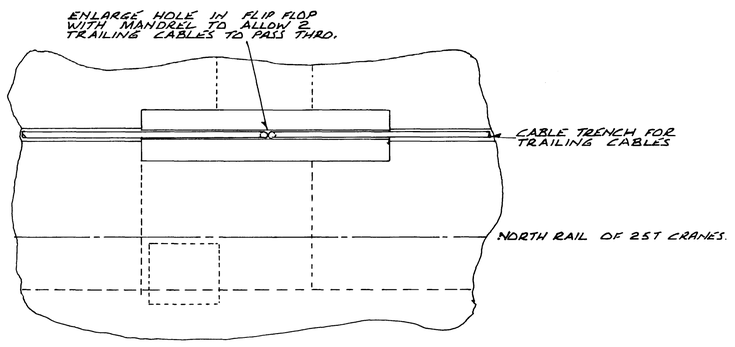
NEW CRANE CABLE TERMINATION BOX DETAIL

SCALE 1:10

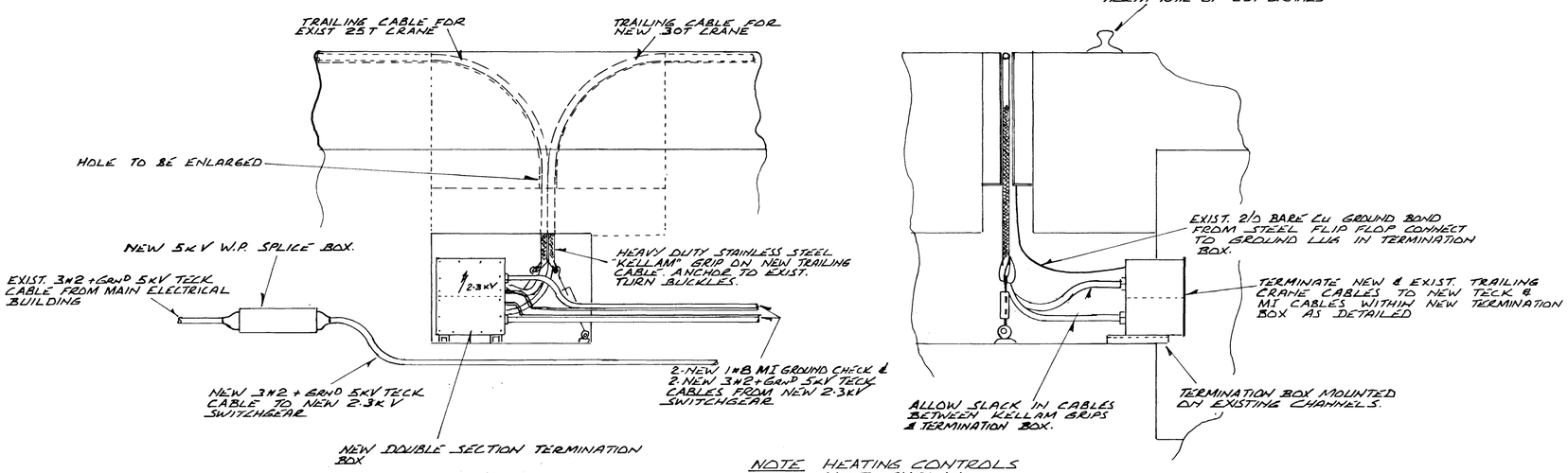
NOTE

REVISE ORIGINAL 5kV TERMINATION BOX

2



PLAN
SCALE 1:25



NOTE HEATING CONTROLS NOT SHOWN.

PROPOSED ELEVATION FROM TUNNEL
SCALE 1:25

SECTION THROUGH FIP FLOP
SCALE 1:25

NEW CABLE TERMINATION DETAILS AT FLIP FLOP

revisions		date
2	AS BUILTS PER RICKETTS - SEWELL SET OF DWGS.	18/11/85
1	ISSUED FOR CONSTRUCTION	21/9/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS ESQUIMALT, B.C.

CONTRACT NO. 3

drawing / dessin
NEW CRANE SERVICE

CRANE CABLE DETAILS

BC037012

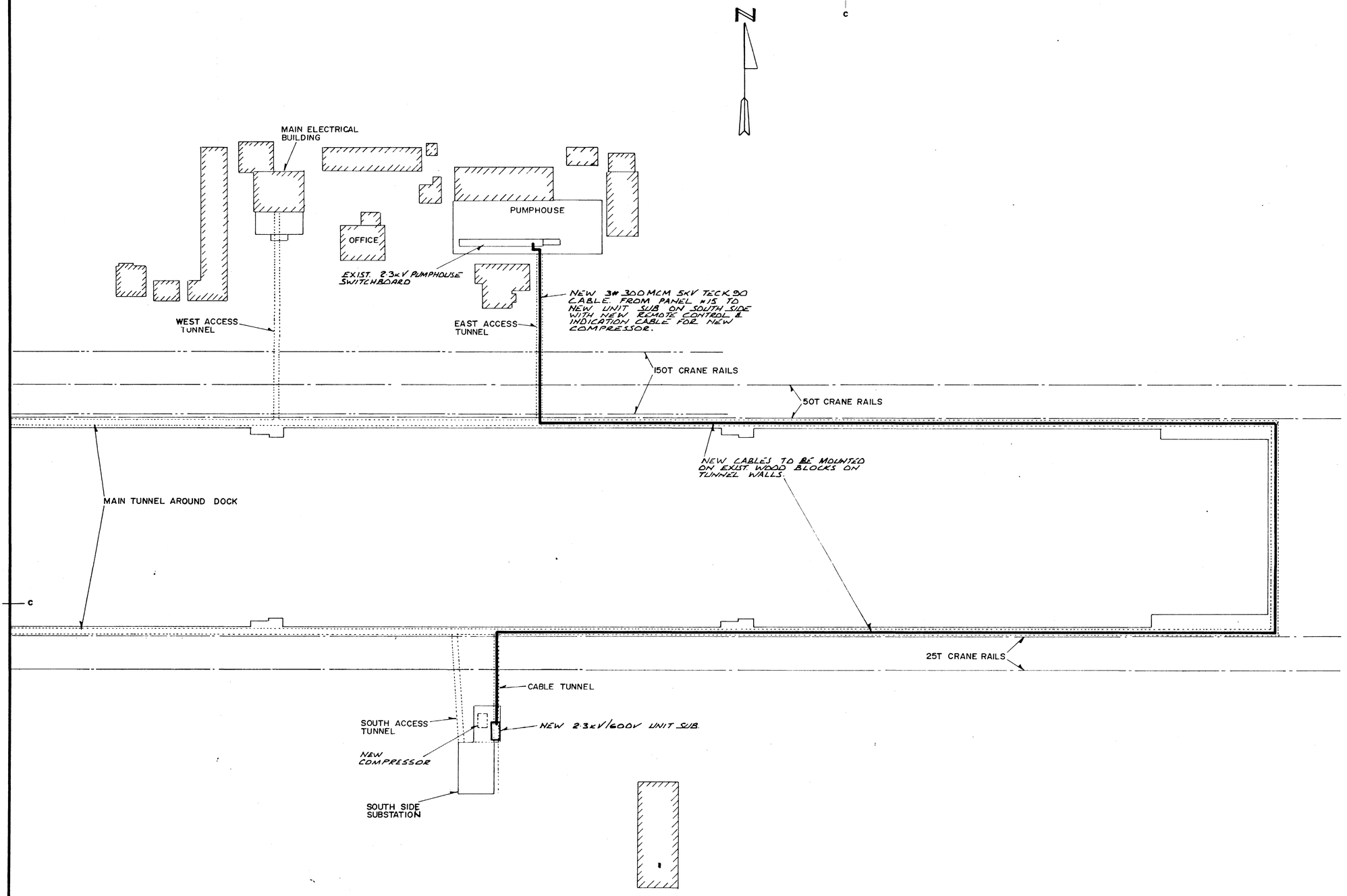
designed B.D.WRIGHT / conçu
date APRIL 84
drawn B.D.WRIGHT / dessiné
date APRIL 84
reviewed R.P.SCHELLE / examiné
date MAY 84
approved A.DERAGOPIAN / approuvé
date
Tender D.HARRIS / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no. du projet
PR 100772

drawing no. / no. du dessin
67 OF 75

Public Works Canada / Travaux publics Canada
PACIFIC REGION

PWC A1



PART SITE PLAN

SCALE 1:500

PWC A1

C

0 10 20mm 40 60 80 100 120 140 160 180 200mm

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PACIFIC REGION

Robert Freundlich & Associates Ltd.
CONSULTING ENGINEERS
60 BASTION SQUARE, VICTORIA, B.C. V8W 1J2
TELEPHONE (604) 386-6721

revisions	date
1 ISSUED FOR CONSTRUCTION	21/3/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.

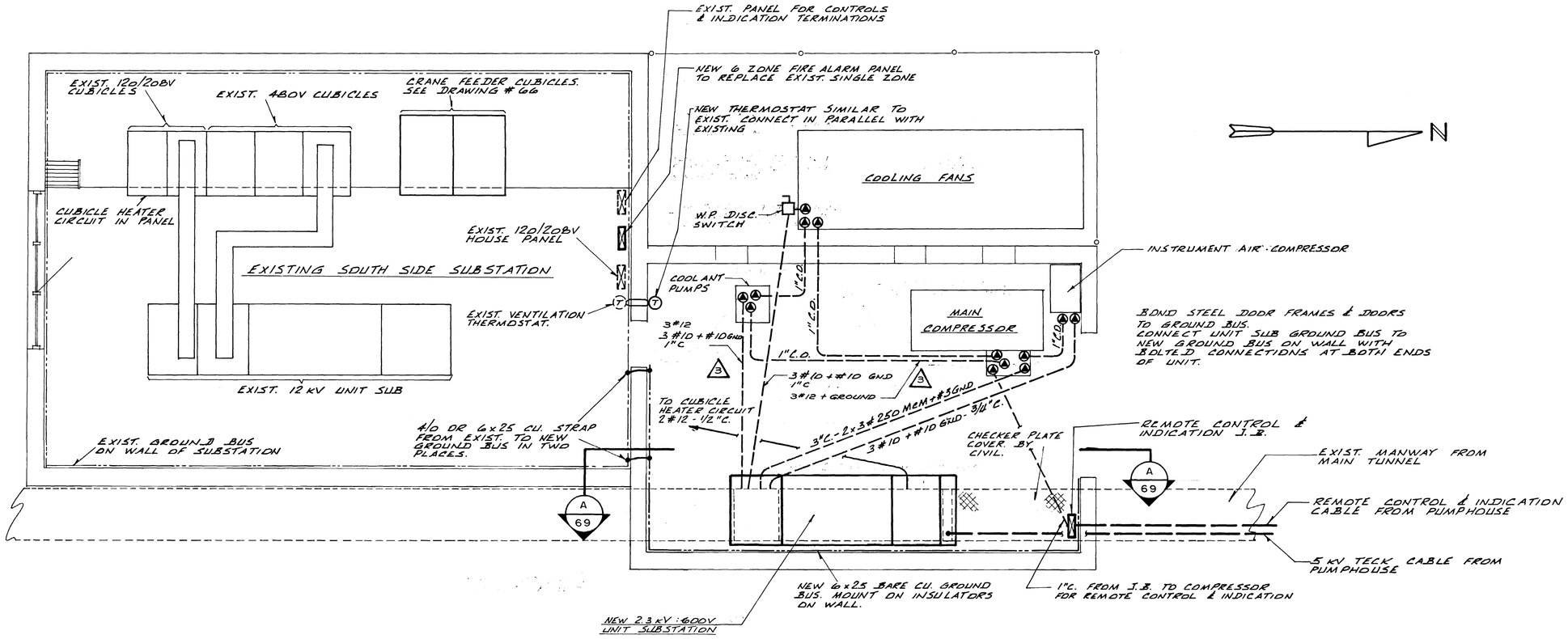
CONTRACT NO. 3

drawing / dessin
COMPRESSOR SERVICE

SERVICE CABLE RUN

BC039932

designed B.D.WRIGHT / conçu
date APRIL 84
drawn B.D.WRIGHT / dessiné
date APRIL 84
reviewed R.P.SCHELLE / examiné
date MAY 84
approved A. DERAGOPIAN / approuvé
date
Tender D. HARRIS / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
68 OF 75



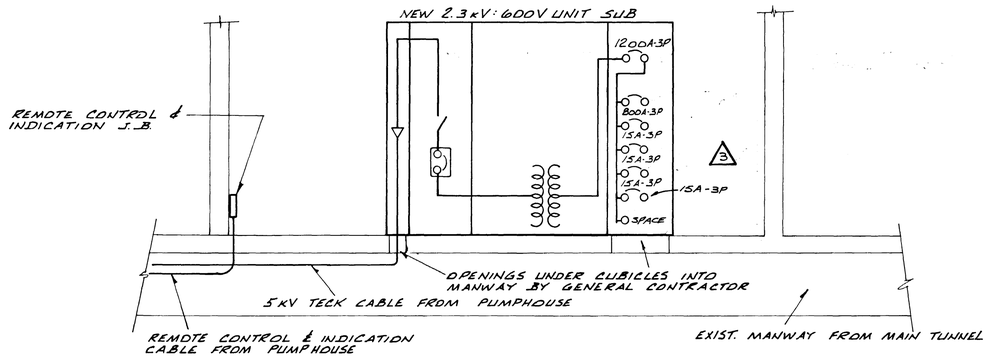
NOTE: 1" C.D. BETWEEN COOLING FANS, COOLANT PUMPS, MAIN COMPRESSOR, AND INSTRUMENT AIR COMPRESSOR, IS FOR INTERLOCK & CONTROL WIRING. COORDINATE WITH MECHANICAL CONTRACTOR FOR INSTALLATION.

SOUTH SIDE SUBSTATION & COMPRESSOR BUILDING LAYOUT

SCALE 1:50

LEGEND

- ---- WIRING IN FLOOR OR UNDERGROUND
- ——— WIRING ON SURFACE OR ABOVE GROUND



A / 69 SECTION
SCALE 1:50

LOCATION OF OPENINGS & CONDUIT CONNECTIONS FOR ELECTRICAL EQUIPMENT INSTALLATIONS SHALL BE FROM APPROVED SHOP DRAWINGS.

revisions		date
3	AS BUILTS PER RICKETTS -SEWELL SET OF DWGS	18/11/85
2	NEW COMPRESSOR INSTALLATION	JAN. 3/85
1	ISSUED FOR CONSTRUCTION	21/3/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

Public Works Canada / Travaux publics Canada

PACIFIC REGION

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — R. P. SCHELLE

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS ESQUIMALT, B.C.

CONTRACT NO. 3

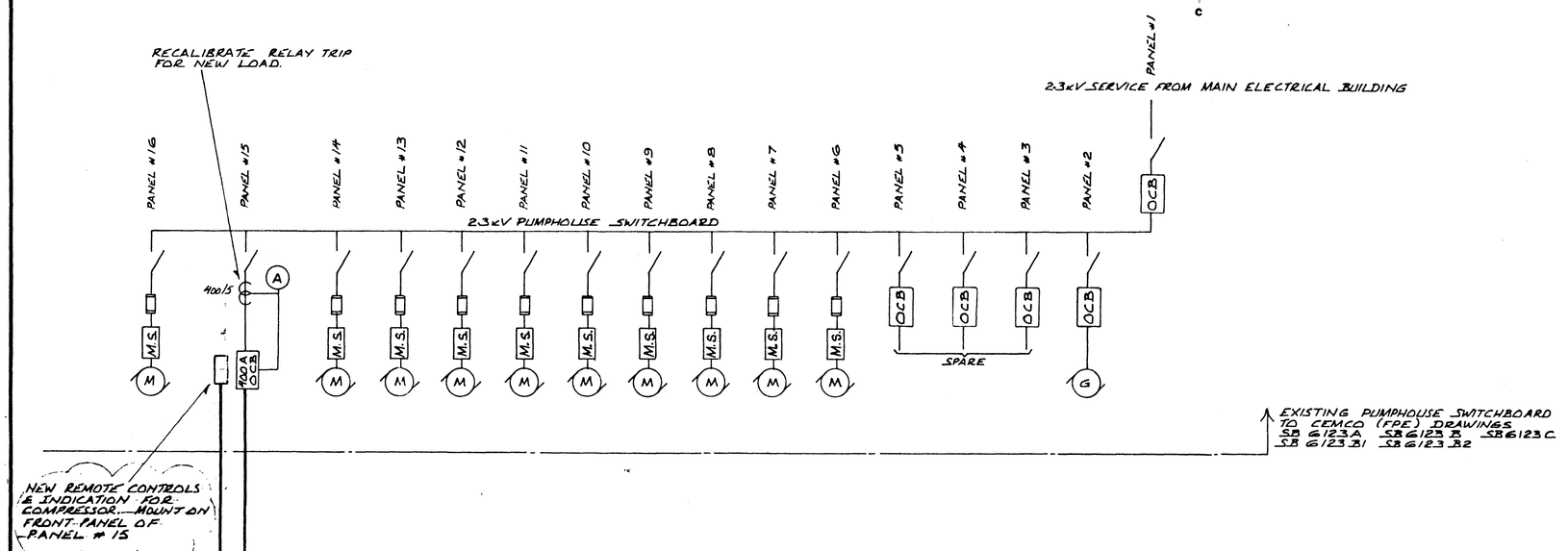
drawing / dessin
COMPRESSOR SERVICE

COMPRESSOR BUILDING LAYOUT, SERVICES & DETAILS

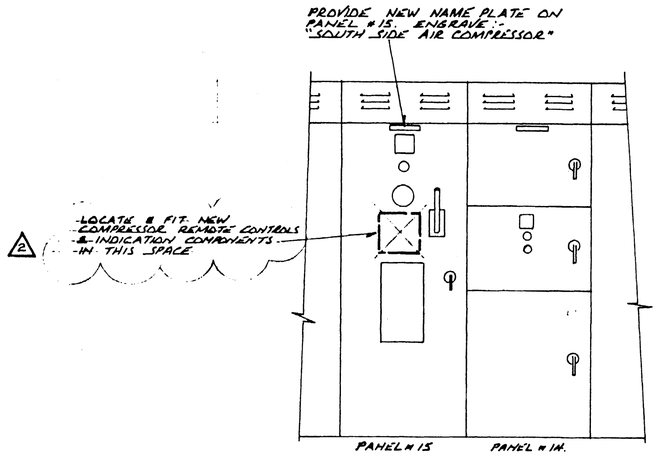
BC037014

designed B.D.WRIGHT / conçu
date JUNE 84
drawn B.D.WRIGHT / dessiné
date JUNE 84
reviewed R.P.SCHELLE / examiné
date JUNE 84
approved A.DERAGOPIAN / approuvé
date
Tender D. HARRIS / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
69 OF 75

PWC AI



SINGLE LINE DIAGRAM



PART FRONT ELEVATION OF PUMPHOUSE SWITCHBOARD

NTS

LEGEND

- (50/51) 2 PHASE OVERCURRENT & 1 GROUND OVER CURRENT RELAYS
- (26) TEMPERTURE RELAY
- (27) UNDER VOLTAGE RELAY
- (GR) GROUND FAULT RELAY WITH FIELD ADJUSTABLE PICK UP & TIME DELAY.
- H.V ISOLATION / DISCONNECT SWITCH
- LOW OIL CIRCUIT BREAKER
- CAP 140 CAPACITOR STORAGE TRIP UNIT
- CURRENT TRANSFORMER
- POTENTIAL TRANSFORMER
- FIRE ALARM HEAT DETECTOR
- F FIRE ALARM PULL STATION
- FIRE ALARM END OF LINE RESISTOR
- FIRE ALARM GONG
- RECEPTACLE 15A 120V DUPLEX
- $ SWITCH.
- NEW
- EXISTING.

FOR REFERENCE ONLY DEC 77

Public Works Canada / Travaux publics Canada

PACIFIC REGION

Robert Leonelich & Associates Ltd.

revisions		date
3	AS BUILTS PER RICKETTS-SEWELL SET OF DWGS	18/11/85
2	NEW COMPRESSOR INSTALLATION.	JAN. 3/85
1	ISSUED FOR CONSTRUCTION	21/3/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS ESQUIMALT B.C.

CONTRACT NO. 3

drawing / dessin
COMPRESSOR SERVICE

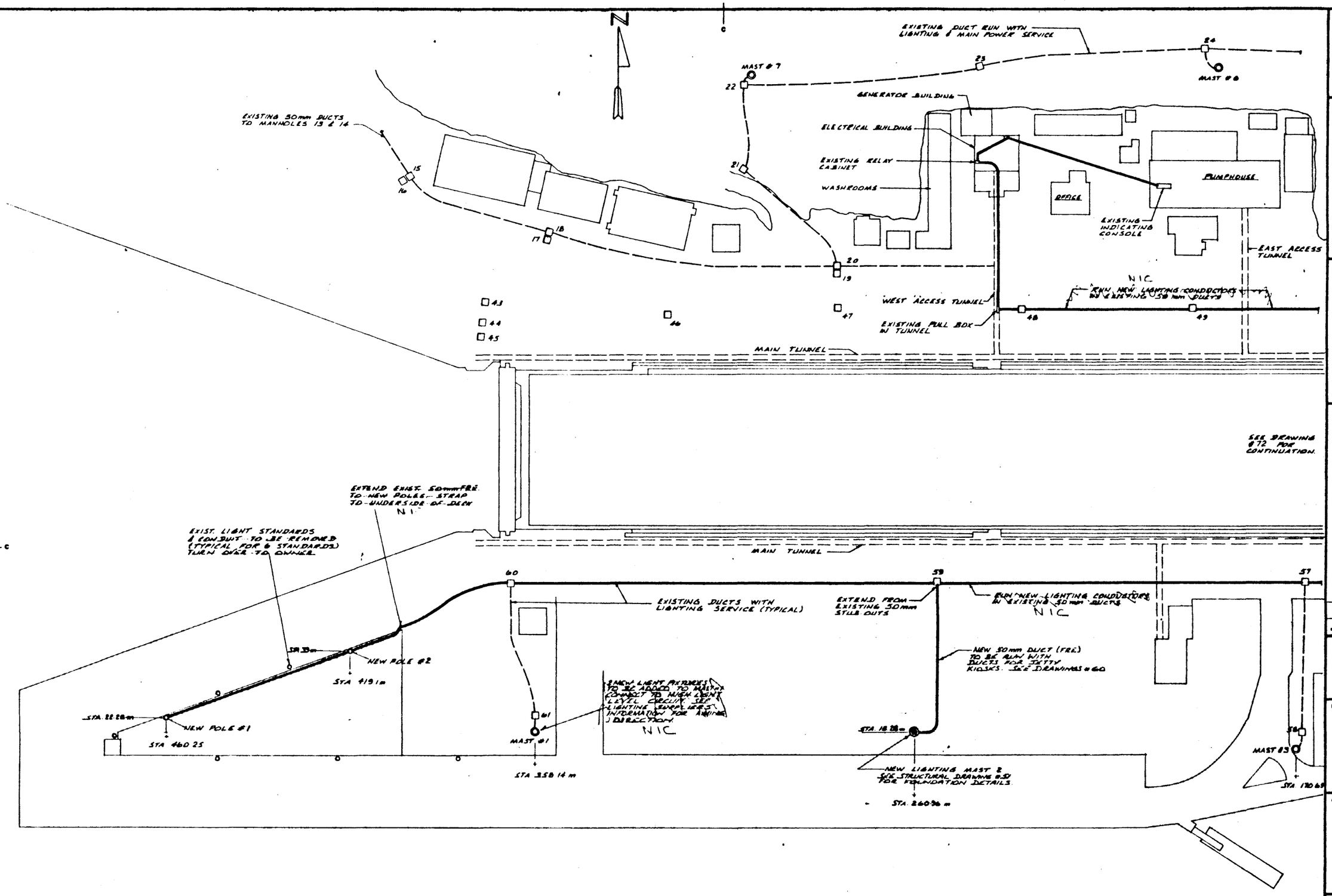
SINGLE LINE DIAGRAM

BC040626

designed B.D. WRIGHT / conçu
date APRIL 84
drawn B.D. WRIGHT / dessiné
date APRIL 84
reviewed R.P. SCHELLE / examiné
date MAY 84
approved A. DERAGOPIAN / approuvé
date
Tender D. HARRIS / Soumission
PWC Project Manager / Administrateur de projets TPC

project number / no. du projet
PR 100772

drawing no. / no. du dessin
70 OF 75



SCALE 1:500

THIS DRAWING REDUCED TO ONE HALF ORIGINAL SIZE

PWC A1

Public Works Canada / Travaux publics Canada

PACIFIC REGION

Robert Freundlich & Associates Ltd.

BC040540

1	ISSUED FOR CONSTRUCTION	88/10/04
revisions		date

A detail no. au dessin
B location drawing no. sur dessin no
C drawing no. dessin no

project / projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B. C.

CONTRACT NO. 3

drawing / dessin

HIGH MAST LIGHTING IMPROVEMENTS

designed B.D. WRIGHT — consp.
date APRIL 88

drawn R.F. LIMA — dessiné
date APRIL 88

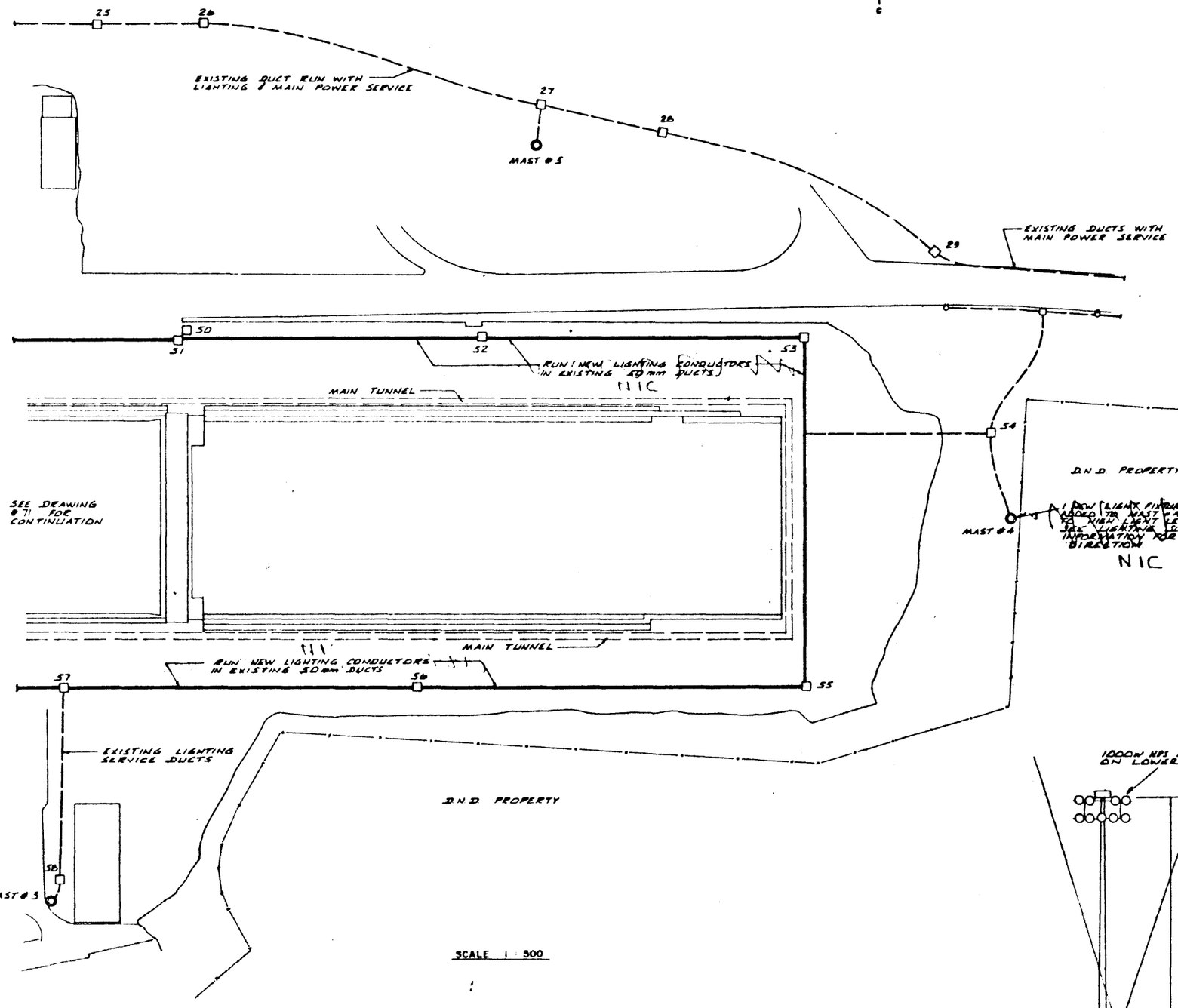
reviewed R.P. SCHELLE — examiné
date MAY 88

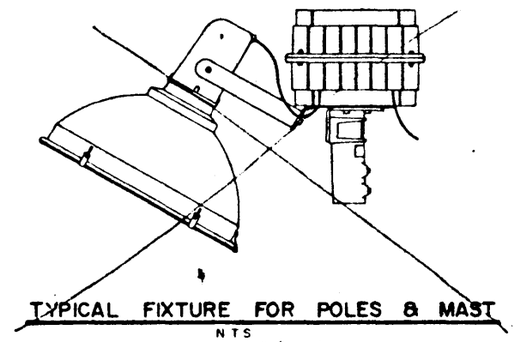
approved A. DERAGOPIAN — approuvé
date

Tuesday D. HARRIS — Bureau/agence
chief, project manager — chef, gérant de projets PWC

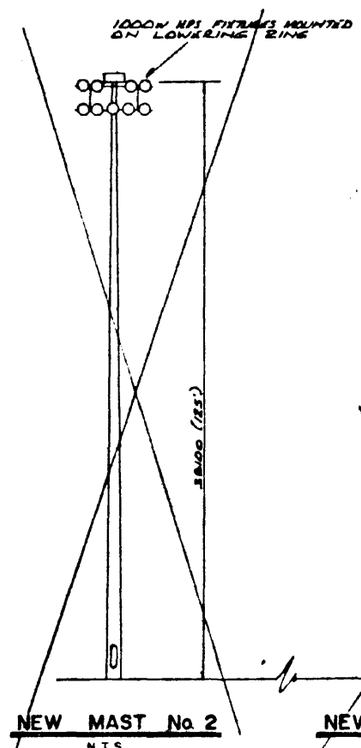
project number / no. du projet
PR 100772

drawing no. / no. du dessin
71 OF 75

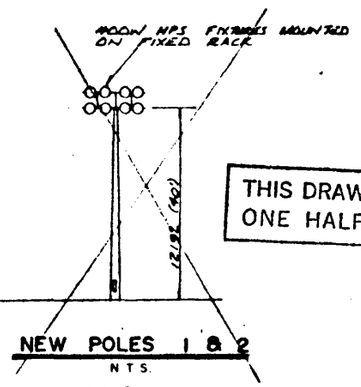




TYPICAL FIXTURE FOR POLES & MAST
NTS
N I C



NEW MAST No 2
NTS
N I C



NEW POLES 1 & 2
NTS
N I C

THIS DRAWING REDUCED TO ONE HALF ORIGINAL SIZE

Public Works Canada / Travaux publics Canada
PACIFIC REGION

Robert Ireland Lich & Associates Ltd.

BC040541

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA

1	ISSUED FOR CONSTRUCTION	88/Nov
revisions		date

A detail no. du détail
B location drawing no. dessin no
C drawing no. dessin no

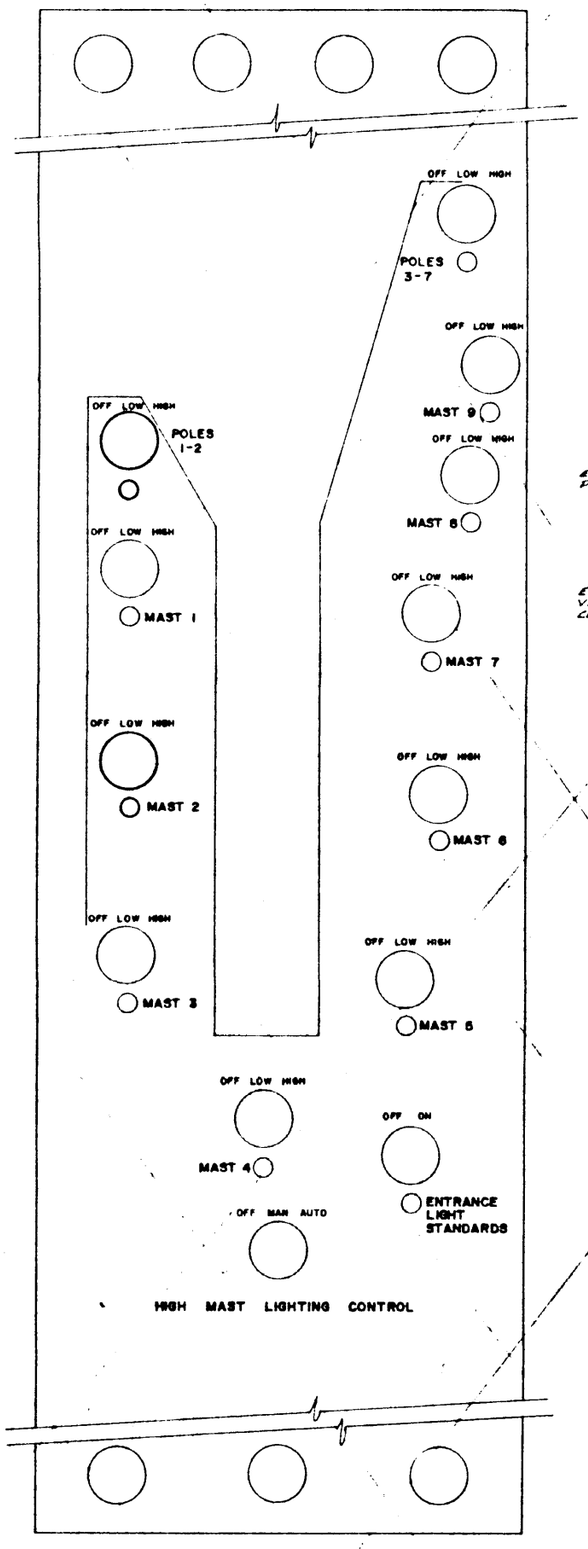
project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.

CONTRACT NO. 3

drawing / dessin
HIGH MAST LIGHTING IMPROVEMENTS

designed B D WRIGHT
date APRIL 88
drawn R F LIMA
date APRIL 88
checked R P SCHELLE
date MAY 88
approved A DERAGOPIAN
date
Tender D HARRIS
PWC Project Manager
Soumission
Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
72 OF 75

PWC A1

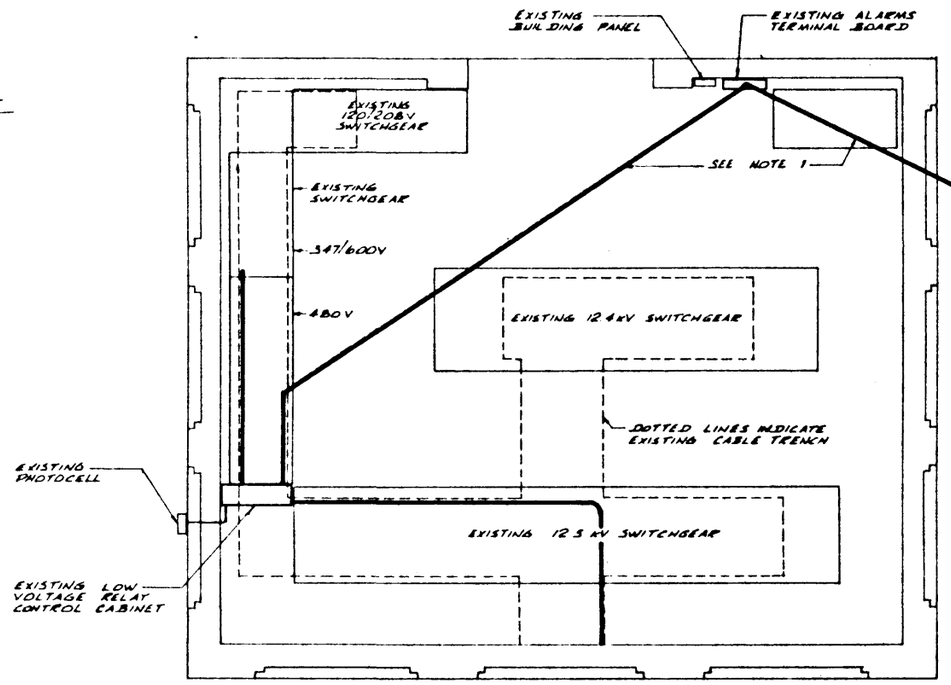


NEW PLATE FOR EXISTING CONTROL CONSOLE IN PUMPHOUSE

N T S

(NOTE: CHANGE OF EXISTING MAST NUMBERING TO NEW NUMBERS)

N I C



MAIN ELECTRICAL BUILDING FLOOR PLAN

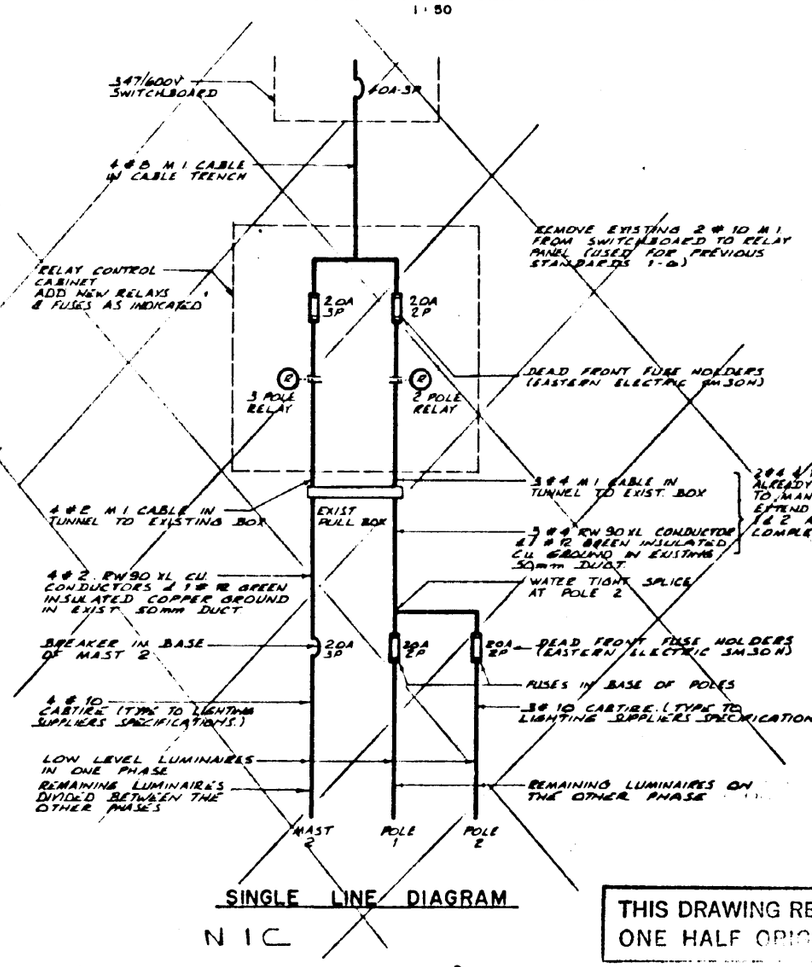
1 : 50

ELECTRICAL SCHEDULE			
MAST	FEEDER SIZE (RW 90 CU COND.)	PHASE DISTRIBUTION: LOW LEVEL LAMPS	PHASE DISTRIBUTION: REMAINING LAMPS
NEW — POLES 1-2	#4	C	A
POLES 3-7	#4	A	C
ENTRANCE STANDARDS	#4	B	
MAST 1	#2	A	B C
NEW — MAST 2	#2	B	A C
MAST 3	#2	C	A B
MAST 4	#4	A	B C
MAST 5	#4	B	A C
MAST 6	#4	C	A B
MAST 7	#4	A	B C
MAST 8	#4	B	A C
MAST 9	#4	C	A B

NOTES:

1. INSTALL NEW 4 PAIR CONTROL CABLE IN EXISTING CONDUIT
   - USE 1 PAIR OF NEW CABLE FOR MAST 2
   - USE SAME PAIR FOR EXISTING CABLE FOR POLES 1 & 2
   - LEAVE REMAINING 3 PAIR OF NEW CABLE AS SPARE

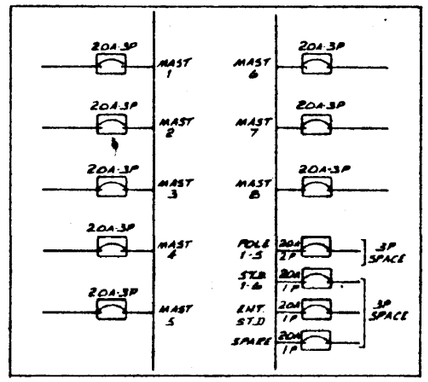
N I C



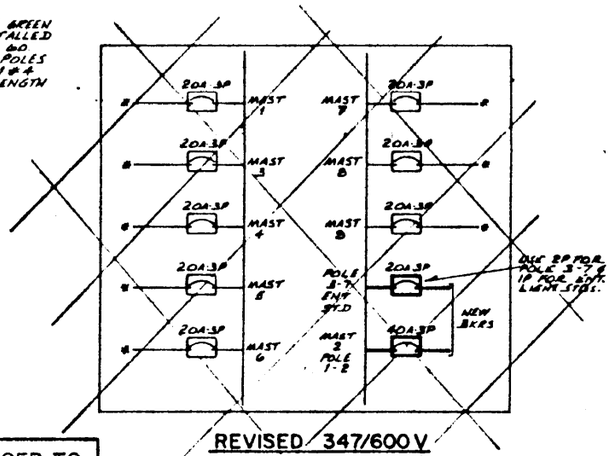
SINGLE LINE DIAGRAM

N I C

THIS DRAWING REDUCED TO ONE HALF ORIGINAL SIZE



EXISTING 347/600V AREA LIGHTING BREAKERS



REVISED 347/600V AREA LIGHTING BREAKERS

LABELLING IS THE ONLY CHANGE TO THESE BREAKERS.

N I C

Public Works Canada / Travaux publics Canada

PACIFIC REGION

Robert Hamilton & Associates Ltd

BC040542

PROFESSIONAL ENGINEER — B. D. WRIGHT — PROVINCE OF BRITISH COLUMBIA

no.	revisions	date
1	ISSUED FOR CONSTRUCTION	89/04/28

A drawing no. du dessin
B Amalthea drawing no. leur dessin no.
C drawing no. dessin no.

project / projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS ESQUIMALT, B. C.

CONTRACT NO. 3

drawing / dessin

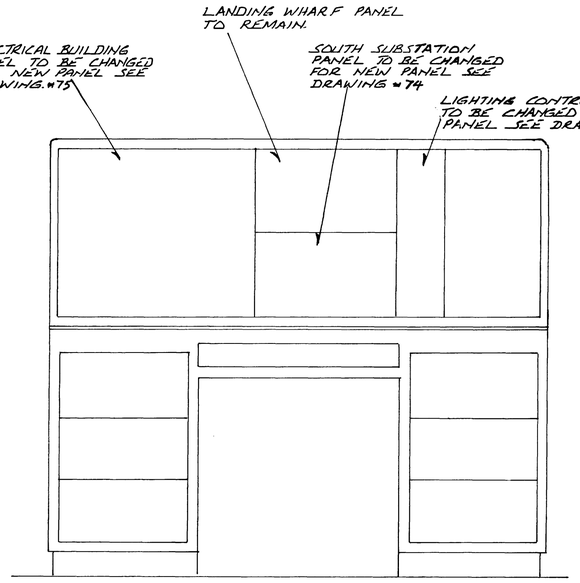
HIGH MAST LIGHTING IMPROVEMENTS

designed B.D WRIGHT	conçu
date April 89	
drawn R F LIMA	dessiné
date April 89	
reviewed R.P SCHELLE	examiné
date May 89	
approved A. DERAGOPIAN	approuvé
date	
Tender D. HARRIS	Soumission
PWC Project Manager	Administrateur de projets TPC

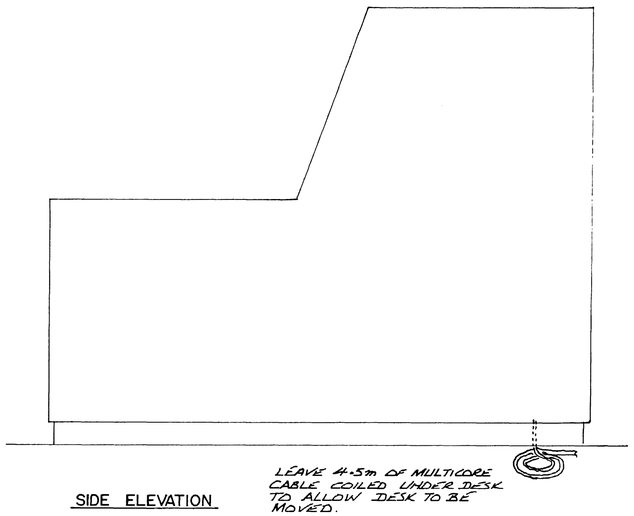
project number / no. du projet: PR 100772

drawing no. / no. du dessin: 73 OF 75

PWC A1



FRONT ELEVATION

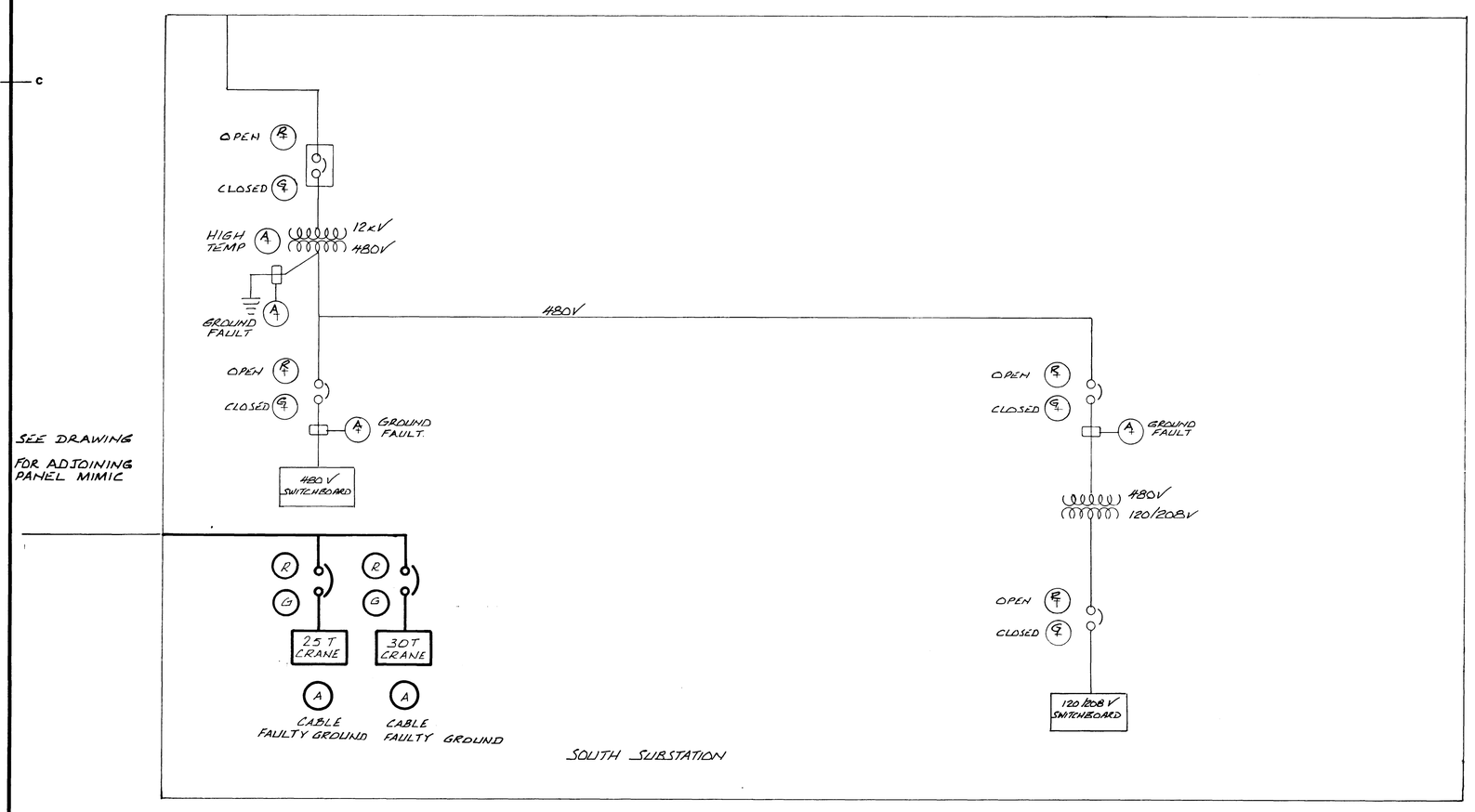


SIDE ELEVATION

ALARMS & INDICATION CONSOLE

SCALE 1:10

NOTE: SEE 'AS BUILT' BY GLENAIRE ELECTRONICS (2)



MIMIC DIAGRAM FOR CONSOLE

SCALE 1:1

GLENARE ELECTRONICS LTD
DRAWING NUMBERS
SD9073-01-03-AA-SH1 & 2
TO BE MODIFIED TO INCORPORATE CHANGES.

CHANGES SHOWN IN HEAVY LINES FOR CLARITY. NEW MIMIC DIAGRAM PANEL TO HAVE ONE LINE THICKNESS.

Public Works Canada / Travaux publics Canada

PACIFIC REGION

revisions		date
2	AS BUILT PER GLENAIRE ELECTRONICS DWG	18/11/85
1	ISSUED FOR CONSTRUCTION	2/9/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet

ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, B.C.

CONTRACT NO. 3

drawing / dessin

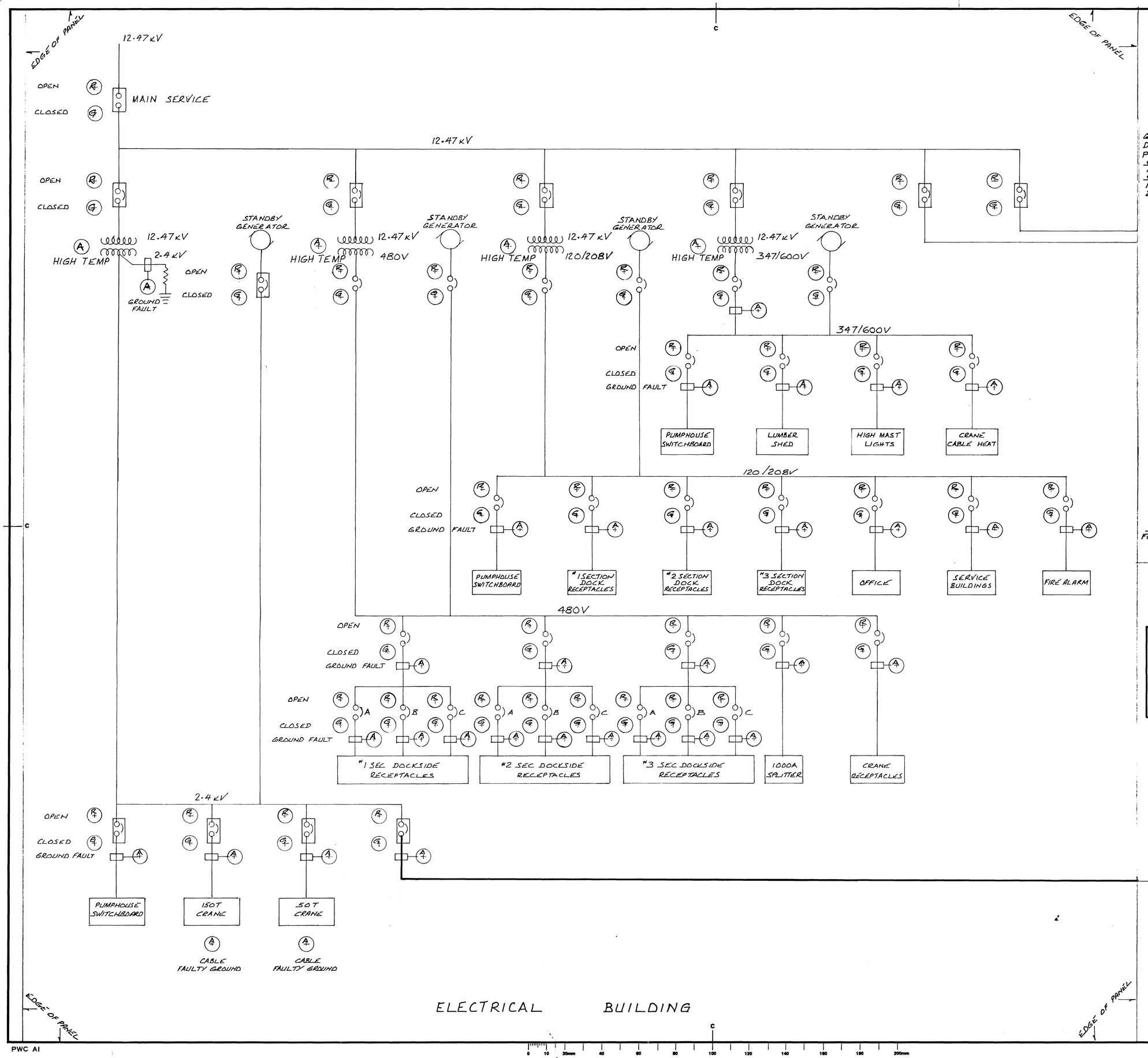
NEW CRANE SERVICE & HIGH MAST LIGHTING CONSOLE MODIFICATIONS

"BC037019"

designed B.D.WRIGHT / conçu
date APRIL 84
drawn B.D.WRIGHT / dessiné
date APRIL 84
reviewed R.P SCHELLE / examiné
date MAY 84
approved A.DERAGOPIAN / approuvé
date
Tender D.HARRIS / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
74 OF 75

PWC AI

0 10 20mm 40 60 80 100 120 140 160 180 200mm



GLENARE ELECTRONICS LTD DRAWING NUMBERS. PP9073-01-02 SHT 1. TO SHT 5. SHT 1, 3, 4, 5 CAN BE REUSED WITHOUT CHANGE SHT 2 TO BE MODIFIED TO INCORPORATE CHANGE TO 2.4 kV SECTION OF MIMIC.

SEE DRAWING # 74 FOR ADJOINING PANEL MIMIC

CHANGES SHOWN IN HEAVY LINES FOR CLARITY. NEW MIMIC DIAGRAM PANEL TO HAVE ONE LINE THICKNESS.

ELECTRICAL BUILDING

PWC AI

Public Works Canada / Travaux publics Canada

PACIFIC REGION

revisions		date
2	AS BUILTS PER RICKETTS 181, -3EWELL SET OF DWGS (NO CHANGES)	11/85
1	ISSUED FOR CONSTRUCTION	2/6/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS ESQUIMALT, B.C.

CONTRACT NO. 3

drawing / dessin
NEW CRANE SERVICE CONSOLE MODIFICATIONS

"BC037020"

designed B.D.WRIGHT / conçu
date APRIL 84
drawn B.D.WRIGHT / dessiné
date APRIL 84
reviewed R.P. SCHELLE / examiné
date MAY 84
approved A. DERAGOPIAN / approuvé
date
Tender D. HARRIS / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no. / no. du dessin
75 OF 75

D4a

ESQUIMALT GRAVING DOCK

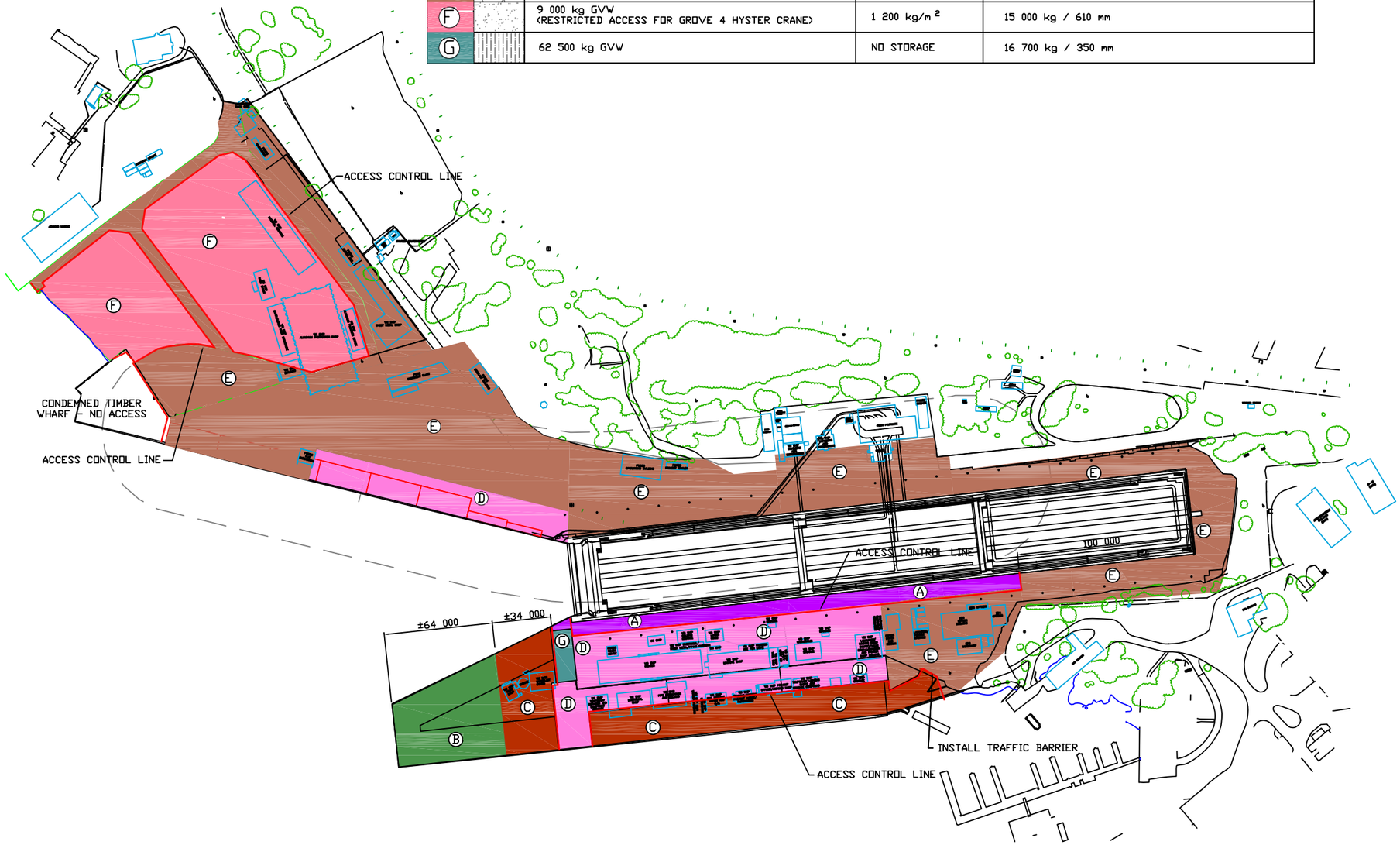
LOAD RATING LAYOUT

KM ENGINEERING (2005)

Number of Pages: 1

		VEHICLE	STORAGE	CONCENTRATED LOAD WITH MINIMUM BEARING LENGTH
A		9 000 kg GVW + UNLOADED HYSTER AND GROVE CRANES AT TIDES HIGHER THAN 2.4m ; 62 500 kg GVW OTHERWISE	NO STORAGE	16 700 kg FOR OUTRIGGER ON CONCRETE WALL
B		8 400 kg GVW NO HYSTER AND GROVE ACCESS	650 kg/m^2	10 000 kg / 350 mm
C		9 000 kg GVW NO HYSTER AND GROVE ACCESS	900 kg/m^2	5 500 kg / 400 mm
D		62 500 kg GVW	2 870 kg/m^2	5 500 kg / 400 mm
E		62 500 kg GVW	4 780 kg/m^2	16 700 kg / 350 mm
F		9 000 kg GVW (RESTRICTED ACCESS FOR GROVE 4 HYSTER CRANE)	1 200 kg/m^2	15 000 kg / 610 mm
G		62 500 kg GVW	NO STORAGE	16 700 kg / 350 mm

GRID NORTH



Public Works and Government Services Canada Pacific Region
Travaux publics et Services gouvernementaux Canada Région du Pacifique

KM Engineering Group Inc.
Consulting Engineers KM 17-2004
5062 West Saanich Road, Victoria, B.C. V8E 2E7
TEL: (250) 920-7979 FAX: (250) 920-7911

revisions | date

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet

ESQUIMALT GRAVING DOCK
LOAD RATING

drawing / dessin

LOAD RATING LAYOUT

designed mak / conçu
date 04.11.18
drawn gw / dessiné
date 05.03.17
approved / approuvé
date
tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project no. / no. du projet
drawing no. / no. du dessin

SK 2

D4b

ESQUIMALT GRAVING DOCK

LOAD RATING REPORT

KM ENGINEERING (2005)

Number of Pages: 45

EGD Surface Load Rating Letter Report

Project #: 860157

Prepared for:

PWGSC

Prepared by:

KM Engineering Group Inc.

Report Date:

March 20th, 2005

KM Engineering Group Inc.

Consulting Engineers

Our reference: km10-04
PWGSC Project #: 860157

March 18, 2005

Public Works and Government Services Canada
641 – 800 Burrard Street,
Vancouver, British Columbia
V6Z 2V8

Attention: Chris Henoch, P.Eng.
Project Manager

Chris,

Re: EGD Facility Load Rating
Final Letter Report

KM Engineering Group Inc. were retained by PWGSC to ascertain the loading capacity of the surface areas surrounding the dock at the Esquimalt Graving Dock. KM Engineering retained Klohn Crippen Consultants Ltd. as geotechnical sub-consultants. The project terms of reference required evaluation of the loading capacity to be based on construction documentation and previous investigations undertaken by various consultants on behalf of PWGSC. Additional filed investigation was excluded.

Site Layout and Details

The original graving dock construction was completed in 1927. The current layout as shown on the attached drawing SK 1 consists of the following areas:

- **The Graving Dock** is approximately 360m by 45m and is oriented with the long axis in the east / west direction and the entrance on the west side.
- **The Munro Head Area** is situated north west of the graving dock and consists of asphalt and concrete paved surfaces on sand and gravel fill overlaying silt over soft clays.
- **The West Timber Wharf Area** is located to the south / east of Munro Head. The wharf is severely deteriorated and condemned.

Mahomed Kathrada, P. ENG., B.Sc. Eng (Natal) TEL: (250) 920-7979 • FAX: (250) 920-7911
5062 West Saanich Rd, Victoria, BC V9E 2E7 email: kmengineering@shaw.ca

- **The North Landing Wharf Area** is at the north entrance of the dock, to the east of Munro Head. The area is assumed to be an extension of the north side laydown area with 50mm asphalt topping on a 150mm unreinforced concrete slab on rock fill over bed rock. The west end of the south side, adjoining the west timber wharf, is retained by 6 timber cribs each 10.7m high, 12.2m wide and 30.5m long with a concrete facing and 3.5m high mass concrete parapets. Mass concrete entrance retaining walls of 4.88m and 3.66m thickness adjoin the timber cribs. Details of the backfill and bearing conditions at the timber cribs and concrete walls is provided in the attached "Surface Load Rating" report by Klohn Crippen and the "Seismic Evaluation of South Jetty & North Entrance Wall" report dated October 2002 by Klohn Crippen. A sketch of the concrete retaining walls, extracted from an earlier report, is attached.
- **The North Side Laydown Area** is to the north of the graving dock. The paving area consists of 50mm asphalt topping on a 150mm unreinforced concrete slab on rock fill over bed rock. The dock face retaining wall is of mass concrete with service tunnels and varies in cross section along the length of the wall. Sketches of representative cross sections of the north wall of the dock, extracted from an earlier report by Klohn Crippen, are attached. The sections were verified with the original construction drawings and "as-built" section drawings available.
- **The East End Laydown Area** is at the east end of the dock and is similar to the north side laydown area.
- **The South Side Laydown Area** is to the south of the dock with a mass concrete retaining wall with service tunnels on the dock face and a steel sheet pile wall at the south side of the retained fill. The paving area consists of 50mm asphalt topping on a 150mm unreinforced concrete slab. The slab bears on rock fill over bed rock for approximately 100m from the east end, and on full retaining wall depth granular fill and organic clays for the remainder of the area. Sketches of the wall sections considered to represent the south wall of the dock, extracted from an earlier report by Klohn Crippen, are attached. The sections were verified with the original construction drawings and "as-built" section drawings available.
- **The South Timber Cribs** retain the west end of the south side laydown area fill. The cribs are similar to the north landing wharf area cribs.
- **The Steel Piled Jetty and Crane Pad** lie to the south of the steel sheet pile wall. The deck was constructed in 1985 and is constructed of reinforced pre-cast and cast-in-place concrete.
- **The West Timber Jetty** is at the south entrance of the dock. The jetty includes an in-fill area which was constructed in 1985.
- **The South Timber Jetty** lies to the south of the steel piled jetty.

Load Capacity Evaluation

KM Engineering Group Inc. (KM) carried out the evaluations of the mass concrete retaining walls, the sheet pile wall and the slab adjacent to the sheet pile wall using in-house developed spread sheets and commercial retaining wall and frame analysis software. Klohn Crippen Consultants Ltd. (KC) carried out evaluations of all the soils and structural analyses for the slabs-on-grade and the cribs. Loadings considered were vehicle loads to a maximum of highway rated vehicle loads (CL625 Truck with gross vehicle load of 63,500kg), pad loads for cranes operated by PWGSC, uniform loads to a maximum of 4870 kg per m^2 and static soil and hydrostatic pressures on retaining structures. Rail mounted crane loads directly over the retaining walls increased the stability of the walls and were thus excluded in the evaluations. Areas inside existing buildings, foundations for the buildings and seismic induced soil loads were not included in the evaluation as they were considered outside the terms of reference for the project.

Design procedures and assumptions made in the evaluations are provided below:

- **The Munro Head Area:** Reference material consisted of "as-built" drawings by Stantec Consulting Ltd and various geotechnical and environmental investigation reports. KC determined subgrade moduli and carried out settlement and bearing capacity analyses for highway and crane pad loadings.
- **The West Timber Wharf Area:** Not evaluated
- **The North Landing Wharf Area:** Reference material consisted of the original construction drawings and photos, CWMM 1980 crane foundation drawings and KC report "Seismic Evaluation of South Jetty & North Entrance Wall" dated October 2002. The reference material indicates a zero tidal lag at the cribs and retaining walls; sand and gravel backfill at the cribs; rock fill over bed rock, varying from 9.9m at the west end to 4.5m at the east or entrance end, behind the concrete walls; the cribs bear on native till at elevation -10m with the most easterly crib and the concrete wall bearing on bedrock at elevation -10.5m. Concrete below the fill elevation is assumed to be poured against the rock cut with zero hydrostatic pressure between the rock and concrete, although no bond resistance is assumed.
  KM carried out overturning, sliding, bearing pressure and concrete stress analyses of the concrete walls for the different thicknesses and varying backfill heights with a soil friction angle of 34° and a friction factor of 0.6.
  KC carried out overturning, sliding, bin pressure and soil slip circle analyses of the cribs with soil friction angle between 35° to 40 ° and a friction factor of 0.49.
- **The North Side Laydown Area:** Reference material consisted of the original construction drawings and photos, Hardy Associates (1978) Ltd. report dated January 1979; KC report "Site Investigation and Liquefaction Assessment" dated June 2002 and KC report "Seismic Evaluation of Graving Dock Structures and Tunnels" dated October 2002. The reference material indicates approximately 4m of wedge shaped rock fill over bed rock behind the concrete walls with a gully at the location of the tunnel leading to the pump house; the concrete wall bearing on bedrock at elevation -10.5m; concrete below the fill elevation poured against the rock cut. Zero hydrostatic pressure is assumed between the rock and concrete, although no bond resistance is assumed.
  KM carried out overturning, sliding, bearing pressure and concrete stress analyses of the concrete walls for the different concrete cross sections with a soil friction angle of 34° and a friction factor of 0.6.
  KC determined subgrade moduli and carried out slab bending, settlement and bearing capacity analyses for highway and crane pad loadings.
- **The East End Laydown Area:** Similar to the north side laydown area.
- **The South Side Laydown Area:** The area extending from the east end wall to about 100m west is as per the north side laydown area.
  For the area west of the 100m point, soil loads are assumed over the full height of the dock wall. For this area KM also carried out a slab capacity check of the 350mm thick slab and of the sheet pile retaining wall, assuming the slab and sheet piles are in good condition.
- **The South Timber Cribs:** Similar to north landing wharf area cribs.
- **The Steel Piled Jetty and Crane Pad:** Design criteria listed on the Ker, Priestman and Associates Ltd. "as-built" drawings of 1985 are to be accepted as the load ratings.
- **The West Timber Jetty:** Evaluation reports "South Jetty Load Ratings" by Westmar Consultants, dated October 2003 and July 2004 are to be accepted as the load ratings.
- **The South Timber Jetty:** Similar to west timber jetty.

Load Capacity Evaluation Results and Comments

Results of the load capacity analyses by KM Engineering Group Inc. and Klohn Crippen Consultants Ltd. and load capacity ratings extracted from drawings and or reports by Ker, Priestman & Associates Ltd., Stantec Consulting Ltd. and Westmar Consultants is provided below and shown on the attached drawing SK2. Surface load ratings are based on evaluation of typical representative details. Dock retaining wall evaluation is based on a drained dock, which results in the most adverse loading conditions.

In the evaluation of the mass concrete retaining walls, the analyses indicates that nominal uniform load surcharge and vehicle or point loads do not significantly affect the stability of the walls. New construction criteria, which requires a "safety" factor of 1.25 to 1.5 with a dead load reduction factor of 0.85, was considered in the evaluation of the walls. However, as all the walls could not satisfy this criterion, Commentary K of the 1995 National Building Code of Canada "Structural Evaluation and Upgrading " procedures for evaluation of existing structures were also used. Based on the evaluation procedures, the limiting "safety" factor for the south wall was determined as 1.18 with a dead load reduction factor equivalent to 1.0. The absolute minimum "safety" factor permitted by the National Building Code (NBC) for any structure is 1.13 when the dead load reduction factor is equivalent to 1.0. It is noted that structures often support higher loads than those determined by the permissible "safety" factors of NBC, but the risk of failure under these higher loads increases to unacceptable levels for life safety considerations.

For the surface ratings, local voids and other deficiencies may be present where the area rating may not be satisfied. However, as these deficiencies are not likely to cause "Life Safety" failures and determination of the deficient areas is not practical, they have not been considered.

- **The Munro Head Area:** Areas with the 200mm thick concrete slabs-on-grade and the drive lane with 75mm thick asphalt on 600mm built-up material are capable of supporting highway rated vehicle loads and PWGSC operated crane pad loads. The areas with 50mm thick asphalt on 100mm crushed gravel, which makes up the general area, is inadequate to support high frequency loading by highway rated vehicles. A 9,000 kg GVW vehicle rating is recommended for the latter area with the requirement to use a minimum 600mm x 600mm spreaders below the crane pads. The soft clays underlying the area will cause excessive settlements at the maximum considered uniform loading of 4,780 kg/m^2. A uniform loading of 1,200 kg/m^2 is recommended to limit settlement to acceptable values.
- **The West Timber Wharf Area:** Not rated.
- **The North Landing Wharf Area:** The overall area is rated to carry highway rated vehicle loads and PWGSC operated crane pad loads. The overall area is also rated to support the maximum considered uniform loading of 4,780 kg/m^2 except in the area adjacent to the mass concrete retaining walls where the maximum uniform loading capacity is 2,870 kg/m^2. The localized reduced uniform load rating is based on the stability of the mass concrete retaining wall, for which the factor of safety is 1.26.
- **The North Side Laydown Area:** The area is rated to carry highway rated vehicle loads, PWGSC operated crane pad loads and the maximum considered uniform loading of 4,780 kg/m^2. The factors of safety for the mass concrete wall exceeded that for new construction. Sections of the wall modified in 2000 were considered stable for the rated loading based on a design summary memo from Chris Peterson, P.Eng, the design engineer for the modifications. The memo states that the modification increased the wall safety by a factor of 1.3 over the typical wall section. Sea water intrusion behind the wall and concrete cracking in the reduced wall sections at the main drainage tunnel elevations may impact future stability if not controlled. The sea water intrusion to

greater depths will lower the stability factor of safety, which may still be acceptable if the intrusion does not extend to the bottom of the walls and full hydrostatic is not mobilized. However the concrete cracking may lead to rapid deterioration and failure thus the wall sections should be regularly monitored and repaired if required by grout injection or similar methods.

- **The East End Laydown Area:** The area is rated to carry highway rated vehicle loads, PWGSC operated crane pad loads and the maximum considered uniform loading of 4,780 kg/m^2. The factors of safety for the mass concrete wall exceeded that for new construction.
- **The South Side Laydown Area:** The area extending from the east end wall to about 100m west is rated to carry highway rated vehicle loads, PWGSC operated crane pad loads and the maximum considered uniform loading of 4,780 kg/m^2. The factors of safety for this section of the mass concrete wall exceeded that for new construction.
  For the area west of the 100m point and extending 10m south of the dock wall, the stability of the mass concrete dock retaining wall controls the load rating. The factor of safety is 1.17 for a zero load rating at the design tide elevation of 2.85m. The factor of safety further reduces to 1.08 at the tide table extreme high tide elevation of 3.38m. For highway rated vehicle loading with no storage, the wall meets the National Building Code criteria at the mean high tide elevation of 2.4m. Highway rated vehicle traffic (fully loaded CL 625 trucks) must therefore be restricted during periods of tide elevations greater than 2.4m and no storage is to be allowed between the crane rails. Further, during the higher tide elevations, the Grove crane should be operated with the load end outriggers located adjacent to the wall coping stone. As the impact of point loads is minimal, vehicle access for a maximum 9,000 kg GVW and the unloaded PWGSC cranes, all of which effectively have point load effects, have been approved for unrestricted access. All the above restrictions are only applicable if the dock is drained.
  To mitigate the extreme high tide operation restrictions, additional investigation of the backfill at the dock south retaining wall may be undertaken or the wall may be tied with tie-back or rock anchors. The additional investigation would entail geotechnical field investigations and hopefully be able to determine higher soil stability properties of the fill than that used in the current analysis, although it is doubt full as the soil values used are already on the high end.
  The area beyond the 10m south line is rated to carry a maximum uniform load of 2,870 kg/m^2 and unrestricted vehicle operation.
- **The South Timber Cribs:** The cribs are adequate to support highway rated vehicle loads, PWGSC operated crane pad loads and the maximum considered uniform loading of 4,780 kg/m^2. However, as combined crane rail loads and uniform loading cannot be supported together, the uniform load rating has been reduced to zero.
- **The Steel Piled Jetty and Crane Pad:** Design loading specified by Ker, Priestman and Associates Ltd. is for highway rated vehicle loads and a maximum uniform loading of 2,870 kg/m^2. Analysis by KM, based on the KPA drawings, has shown that the suspended slabs and beams are also adequate to support PWGSC operated crane pad loads.
- **The West Timber Jetty:** Westmar Consultants have rated the extreme westerly 60m of the jetty area for a maximum 8,400 kg GVW vehicle and a maximum uniform loading of 650 kg/m^2, with no access allowed for the PWGSC operated cranes; the balance of the original jetty area for a maximum 9,000 kg GVW vehicle and a maximum uniform loading of 900 kg/m^2, with no access allowed for the PWGSC operated cranes; and the infill jetty area for a maximum 14,000 kg GVW vehicle and a maximum uniform loading of 1,130 kg/m^2, with access for the PWGSC operated cranes limited to unloaded travel only. KM has reduced ratings of the infill area to the values of the jetty areas to the north and south of the infill area to simplify management of load restrictions.

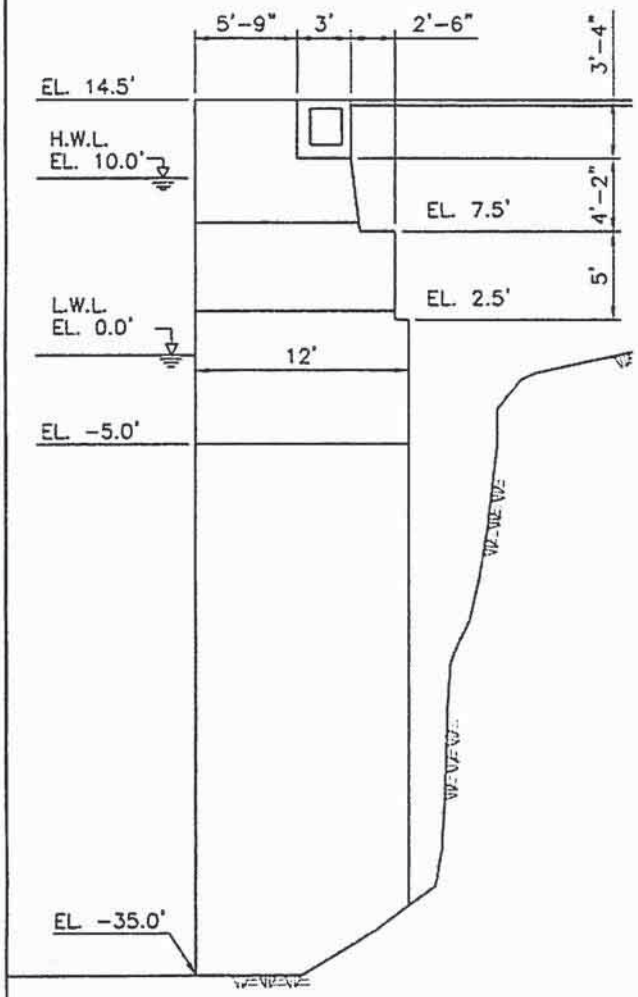
- **The South Timber Jetty:** Westmar Consultants have rated the area for a maximum 9,000 kg GVW vehicle and a maximum uniform loading of 900 kg/m^2, with no access allowed for the PWGSC operated cranes.

The load ratings are additionally shown on drawing SK3 where the load rating is shown together with access control markings and suitable signage to manage load restrictions.

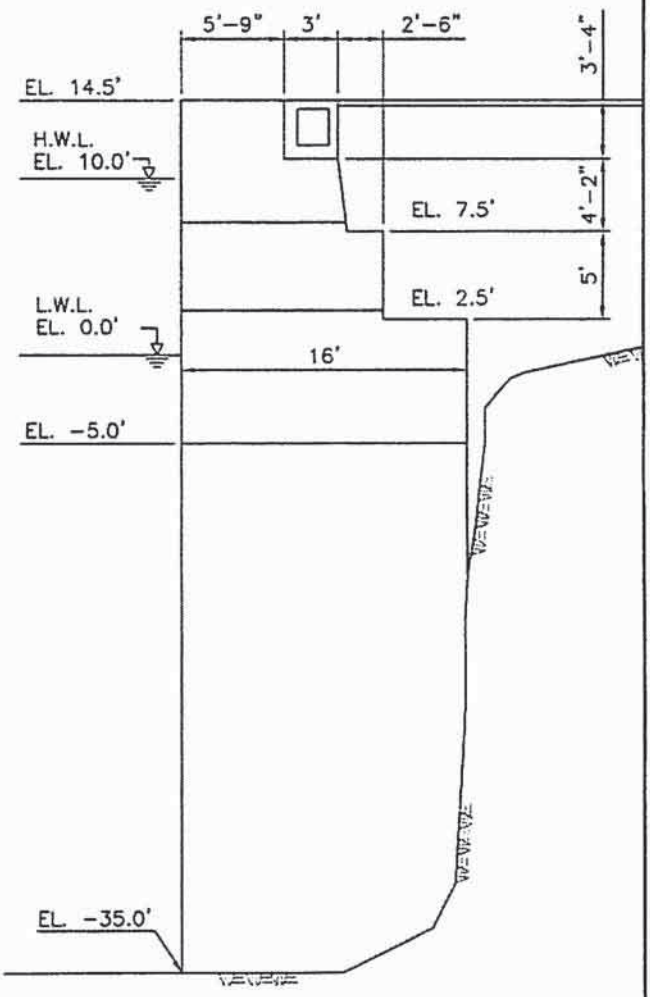
We trust this meets with your requirements.

Sincerely,

Mahomed Kathrada, P.Eng.



STA. 0+55 TO 1+25



STA. 1+25 TO 2+03

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TO BE READ WITH KLOHN-CRIPPEN REPORT DATED _____

SCALE: 5 0 5 10 FEET

CLIENT

Public Works and Government Services Canada
Travaux publics et Services Gouvernementaux Canada

KLOHN CRIPPEN

PROJECT

SEISMIC EVALUATION OF SOUTH JETTY & NORTH ENTRANCE WALL

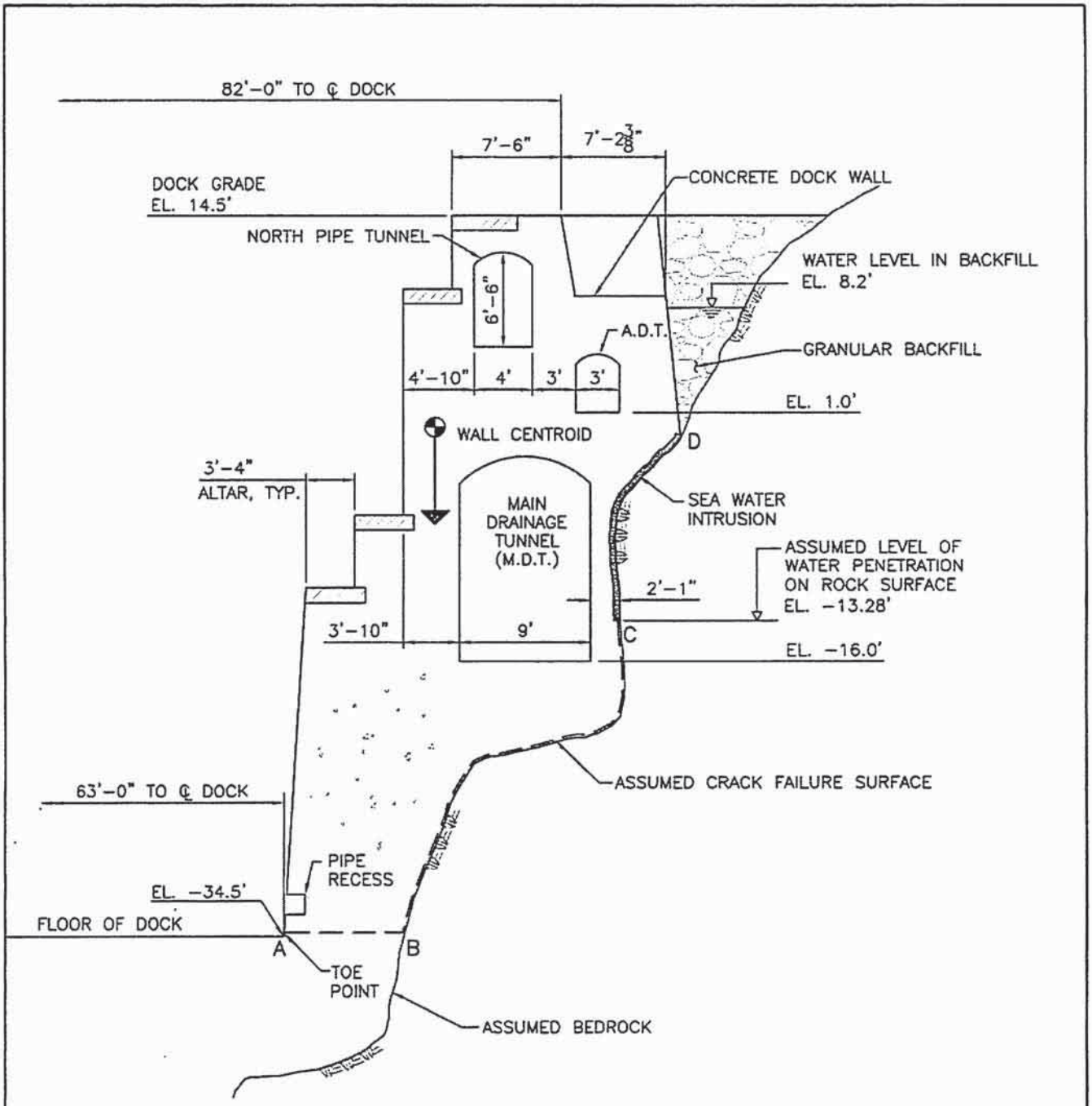
TITLE

NORTH ENTRANCE WALL TYPICAL SECTIONS

PROJECT No. PP1428

FIG. No. FIGURE 12

10 SEP 02 USER: Pwan k:\1428 EQ\ South Jetty Seismic Study\400drawings\Fig12.dwg TIME: 13:48



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SCALE 5 0 5 10 FEET

CLIENT

Public Works and Government Services Canada
Travaux publics et Services Gouvernementaux Canada

KFA Klohn Crippen Associates CONSULTANTS

PROJECT

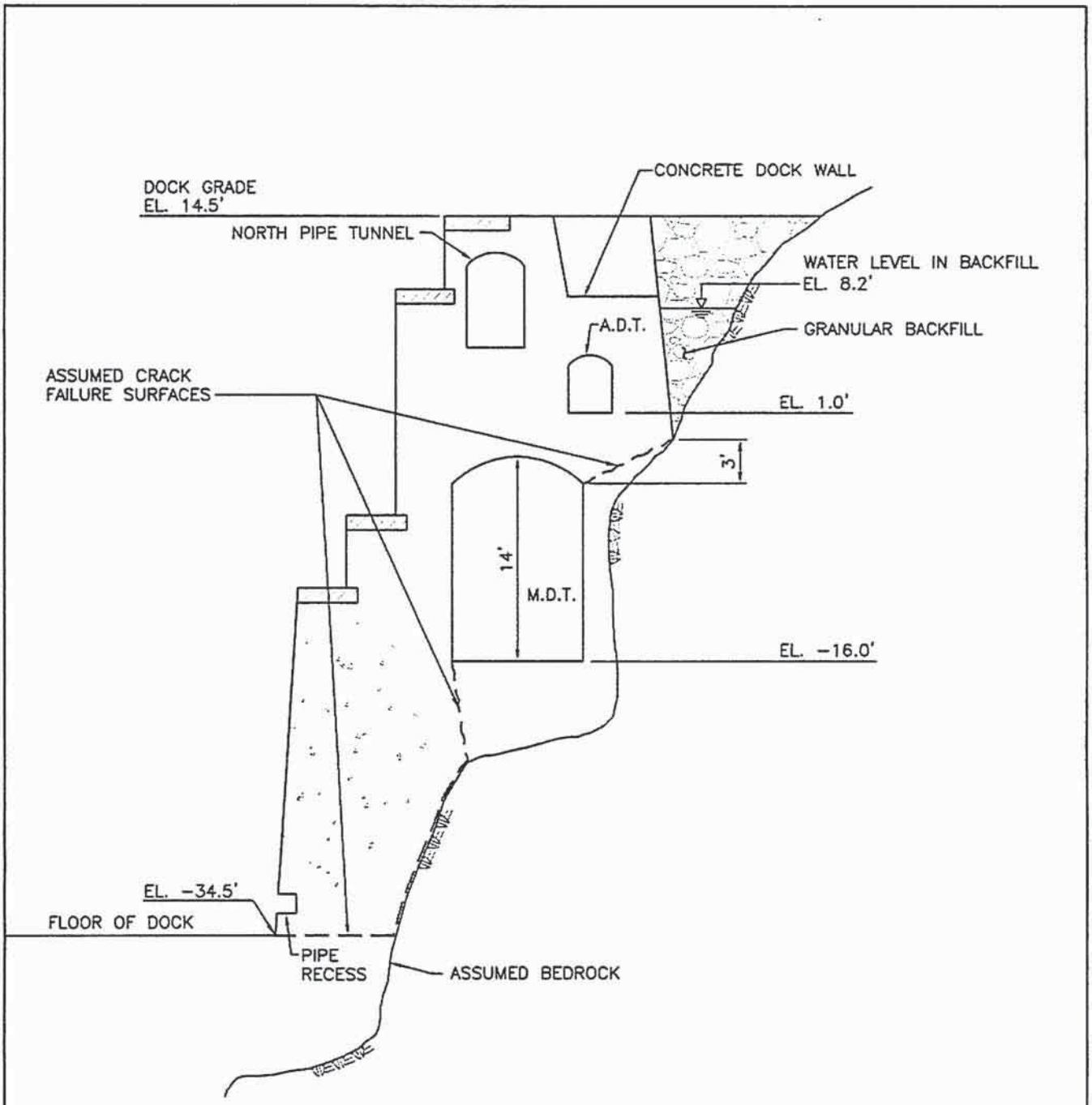
SEISMIC EVALUATION OF ESQUIMALT GRAVING DOCK AND TUNNELS

TITLE

NORTH WALL SECTION 1
FAILURE MODE 1

PROJECT No PP1393

FIG. No. FIGURE 6



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PROJECT

SEISMIC EVALUATION OF ESQUIMALT GRAVING DOCK AND TUNNELS

TITLE

NORTH WALL SECTION 1
FAILURE MODE 2

PROJECT No. PP1393

FIG. No. FIGURE 7

3/14/2002 USER: Pharr
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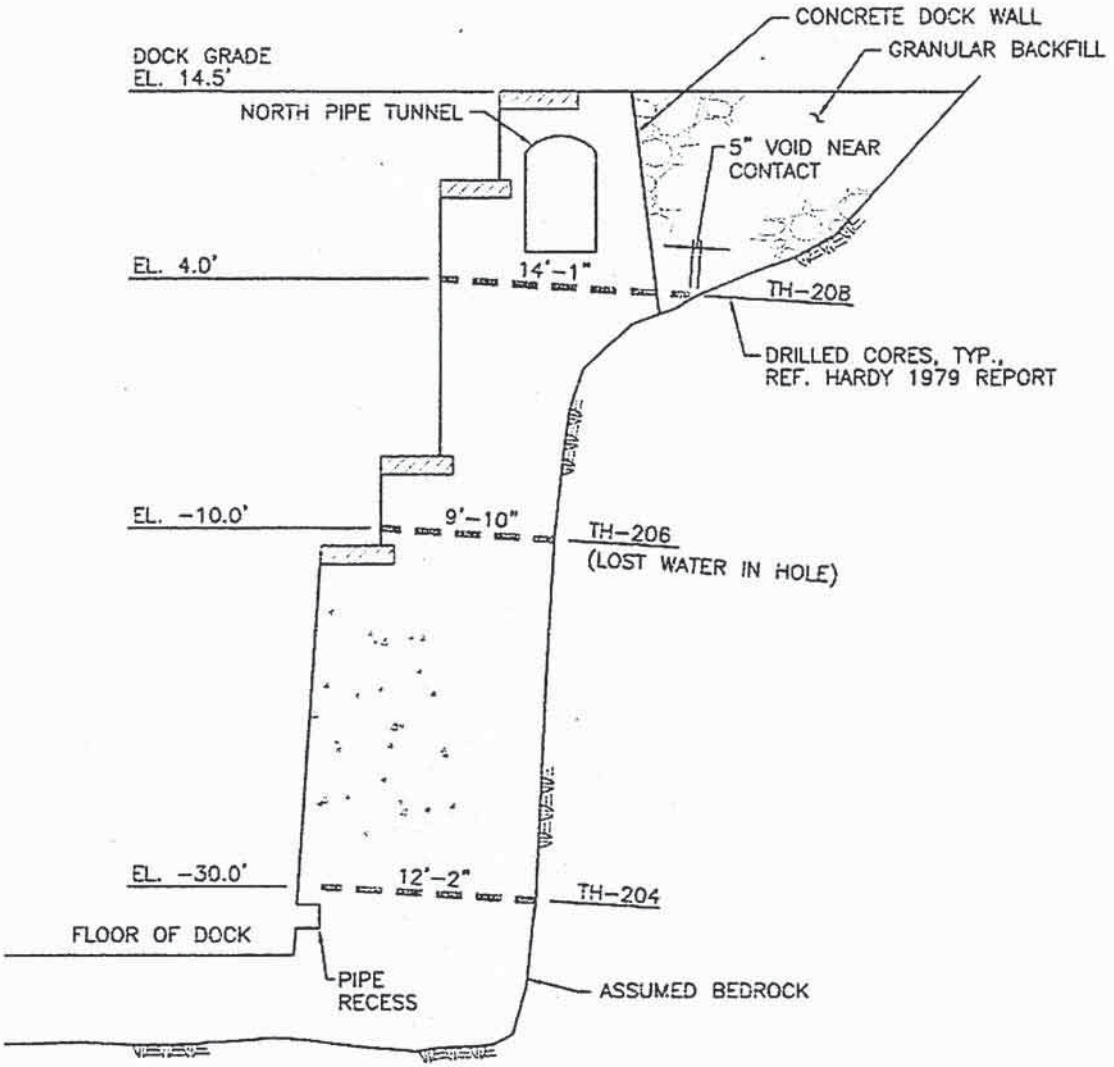
K:\1393 ESQ South Jetty Seismic Study\400drawings\Vsg7.dwg



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PROJECT

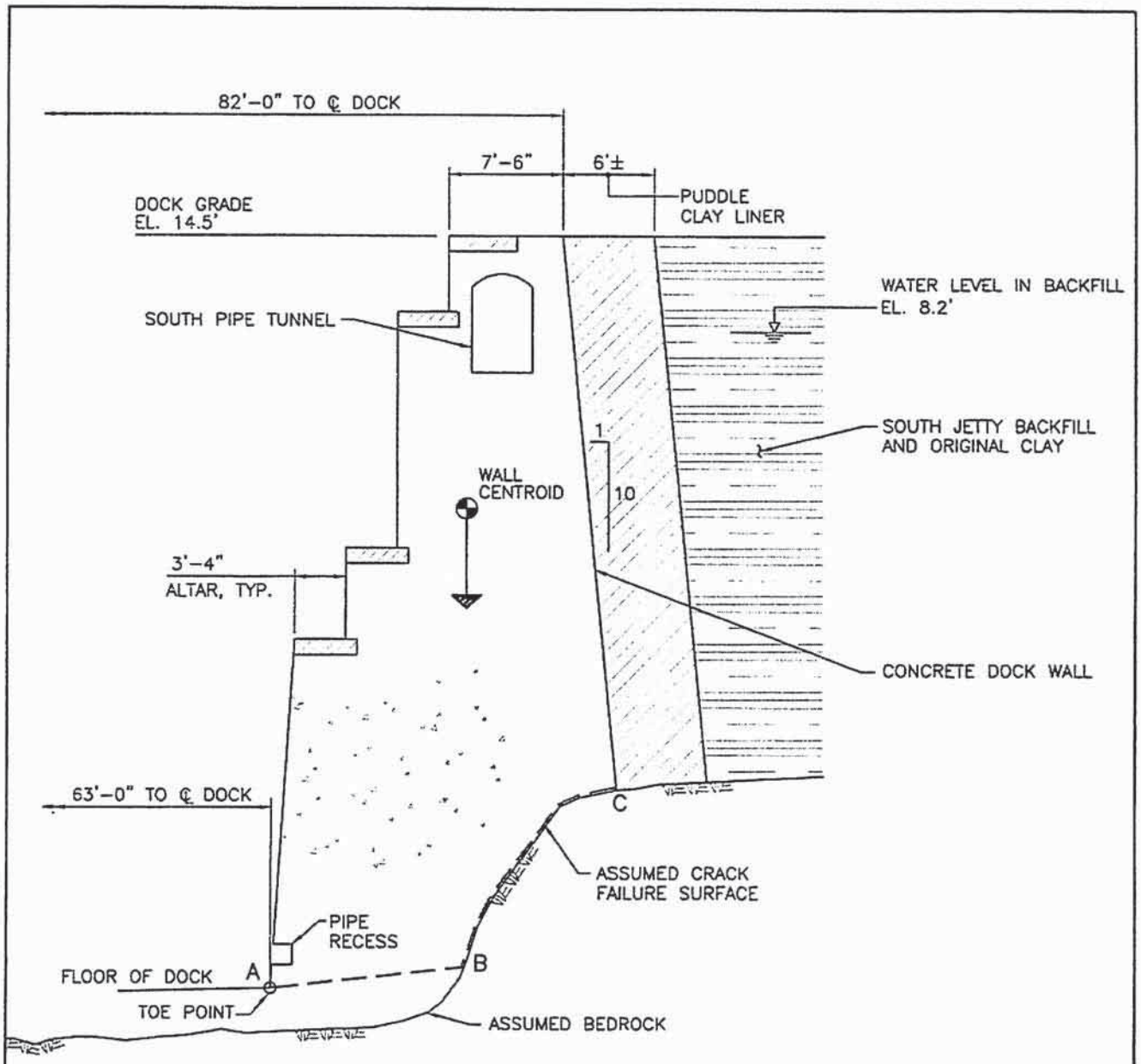
SEISMIC EVALUATION OF
ESQUIMALT GRAVING DOCK AND TUNNELS

TITLE

NORTH WALL SECTION 4

PROJECT No. PP1393

FIG. No. FIGURE 11



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PROJECT

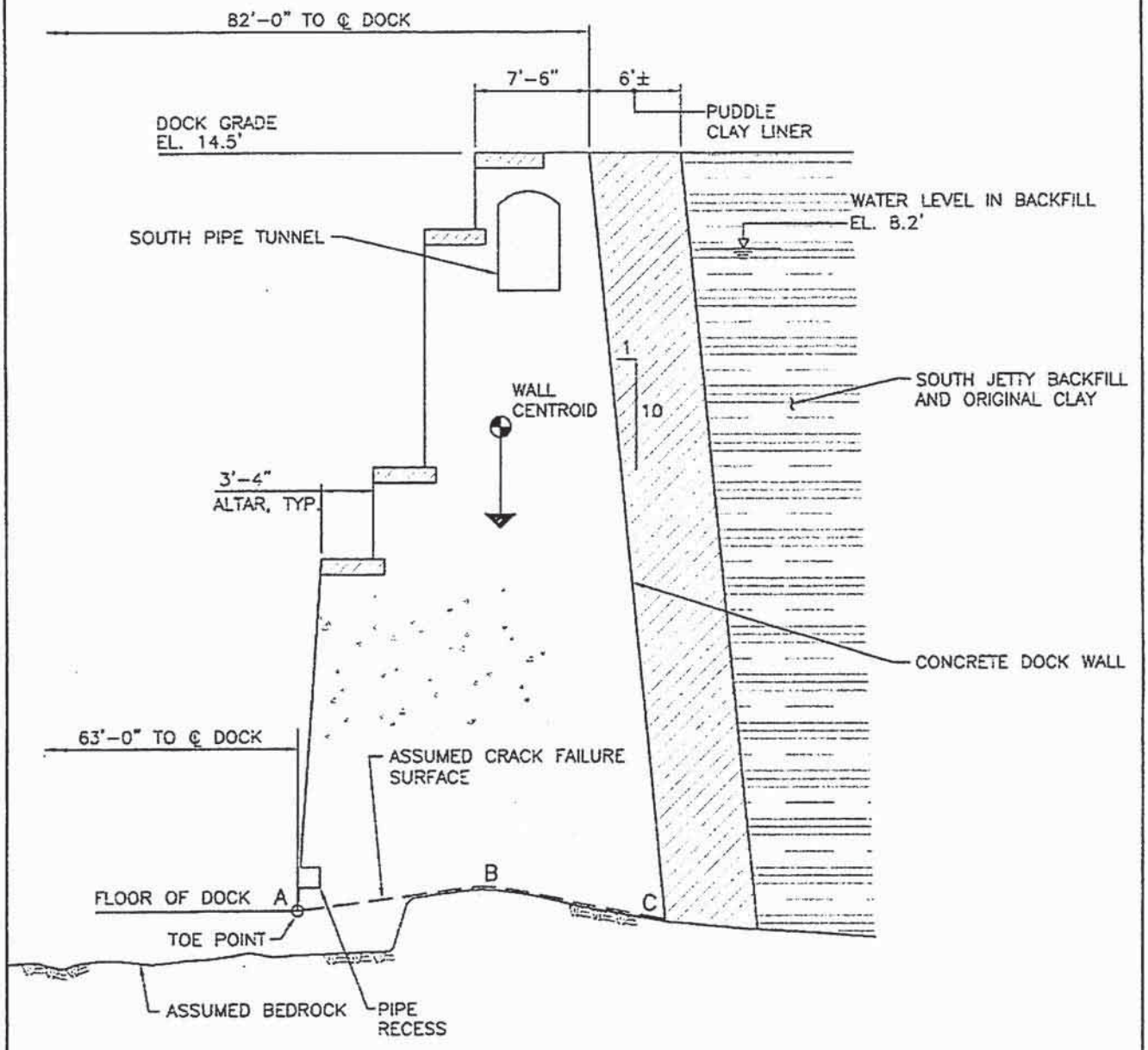
SEISMIC EVALUATION OF ESQUIMALT GRAVING DOCK AND TUNNELS

TITLE

SOUTH WALL SECTION 1
(15-15)

PROJECT No. PP1393

FIG. No FIGURE 12



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PROJECT

SEISMIC EVALUATION OF ESQUIMALT GRAVING DOCK AND TUNNELS

TITLE

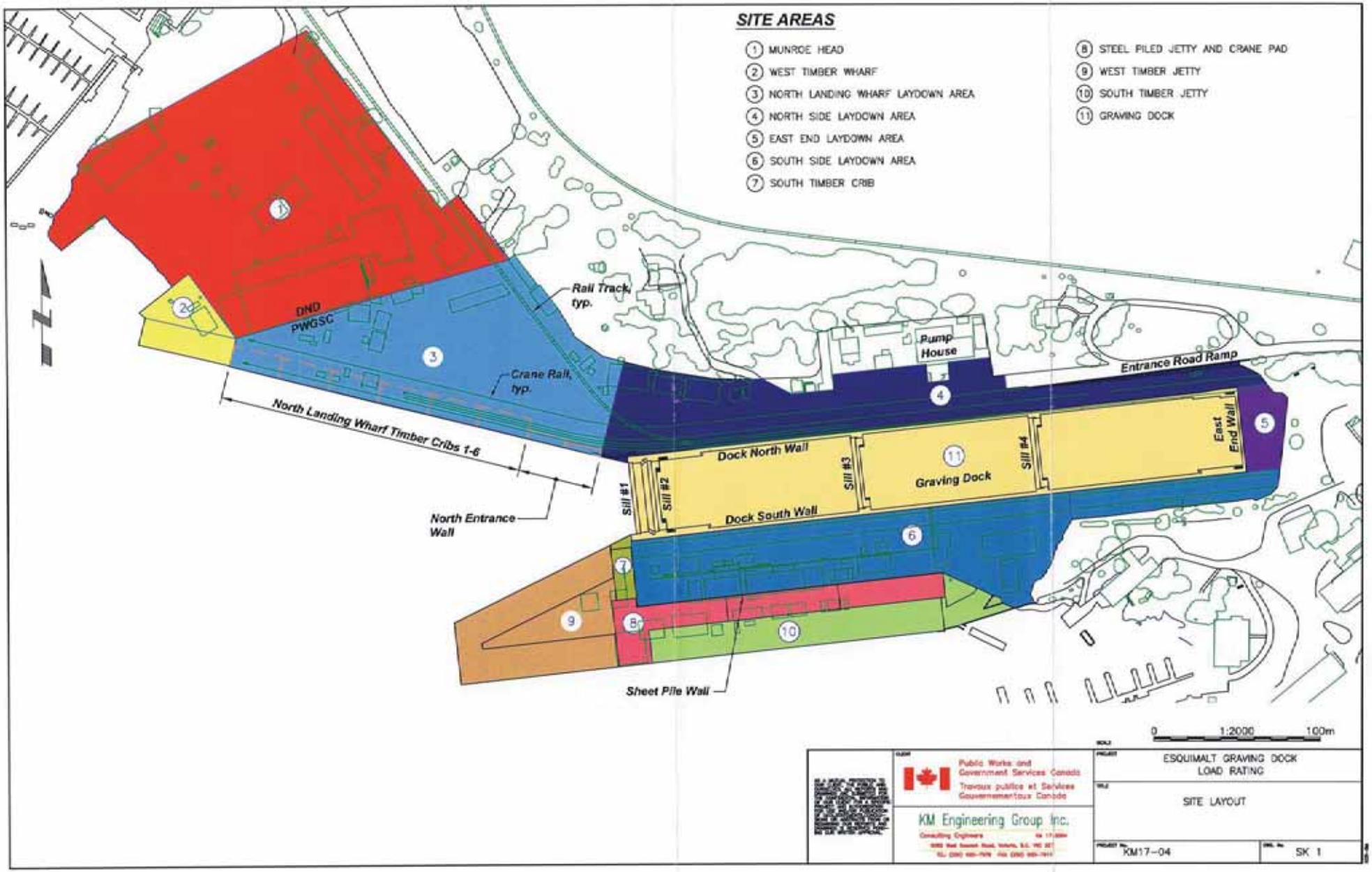
SOUTH WALL SECTION 2

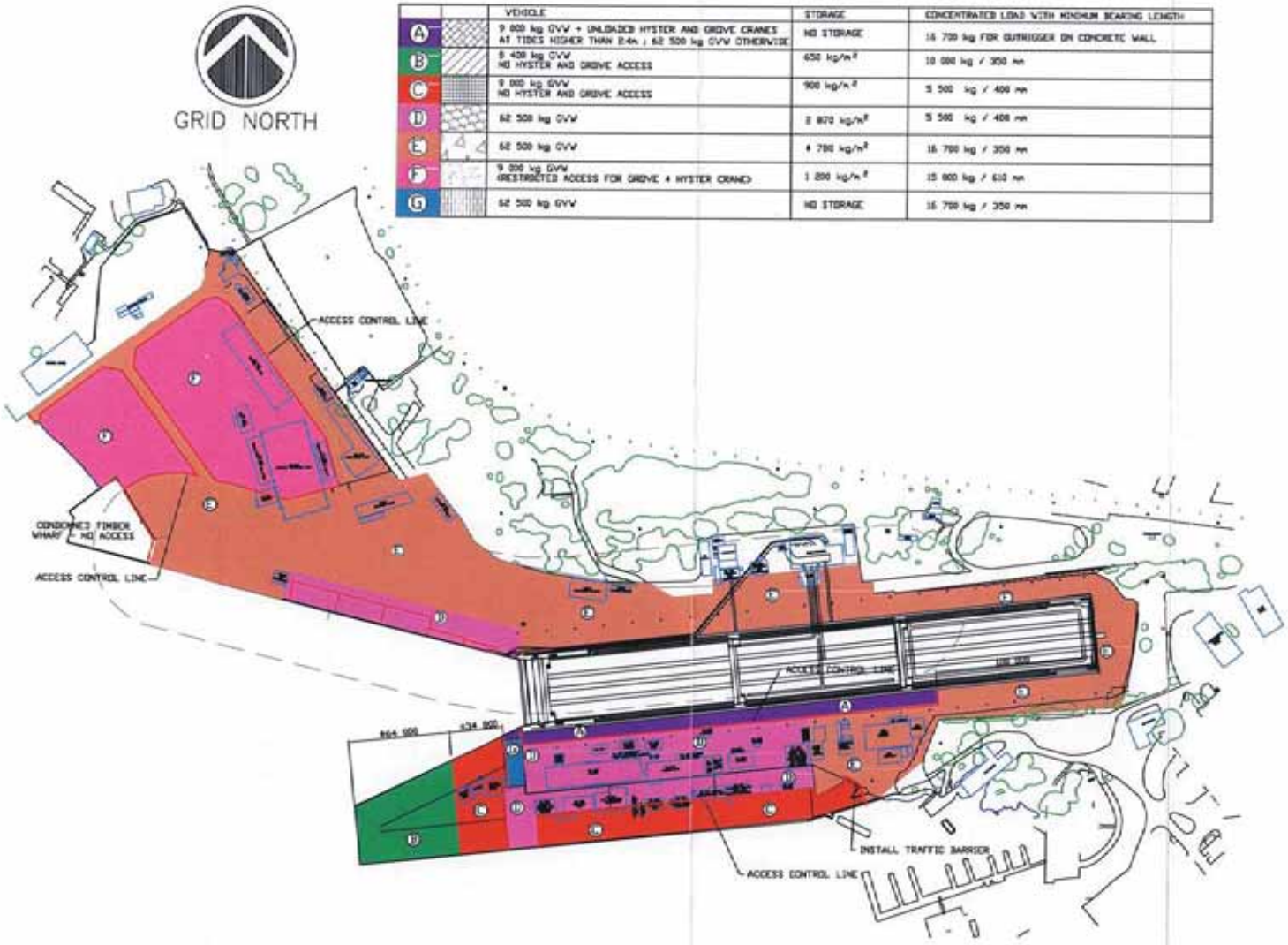
(17-17)

KFA Klohn Crippen Associates CONSULTANTS

PROJECT No. PP1393

FIG No. FIGURE 13


SITE AREAS
1 MUNROE HEAD
2 WEST TIMBER WHARF
3 NORTH LANDING WHARF LAYDOWN AREA
4 NORTH SIDE LAYDOWN AREA
5 EAST END LAYDOWN AREA
6 SOUTH SIDE LAYDOWN AREA
7 SOUTH TIMBER CRIB
8 STEEL PILED JETTY AND CRANE PAD
9 WEST TIMBER JETTY
10 SOUTH TIMBER JETTY
11 GRAVING DOCK
DND
PWGSC
Rail Track, typ.
Crane Rail, typ.
North Landing Wharf Timber Cribs 1-6
North Entrance Wall
Pump House
Entrance Road Ramp
Dock North Wall
Sill #1
Sill #2
Sill #3
Sill #4
Graving Dock
East End Wall
Dock South Wall
Sheet Pile Wall
0 1:2000 100m
Public Works and Government Services Canada
Travaux publics et Services Gouvernementaux Canada
KM Engineering Group Inc.
ESQUIMALT GRAVING DOCK
LOAD RATING
SITE LAYOUT
KM17-04
SK 1



		VEHICLE	STORAGE	CONCENTRATED LOAD WITH MINIMUM BEARING LENGTH
A		9 800 kg GVW + UNLOADED HYSTER AND GROVE CRANES AT TIDES HIGHER THAN 2.4m ; 62 500 kg GVW OTHERWISE	NO STORAGE	16 700 kg FOR OUTRIGGER ON CONCRETE WALL
B		5 400 kg GVW NO HYSTER AND GROVE ACCESS	650 kg/m²	10 000 kg / 350 mm
C		9 000 kg GVW NO HYSTER AND GROVE ACCESS	900 kg/m²	5 500 kg / 400 mm
D		62 500 kg GVW	2 870 kg/m²	5 500 kg / 400 mm
E		62 500 kg GVW	4 780 kg/m²	16 700 kg / 350 mm
F		9 200 kg GVW (RESTRICTED ACCESS FOR GROVE & HYSTER CRANE)	1 200 kg/m²	15 600 kg / 610 mm
G		62 500 kg GVW	NO STORAGE	16 700 kg / 350 mm

KM Engineering Group Inc.

ESQUIMALT GRAVING DOCK
LOAD RATING

LOAD RATING LAYOUT

04.11.15

05.03.17

SK 2

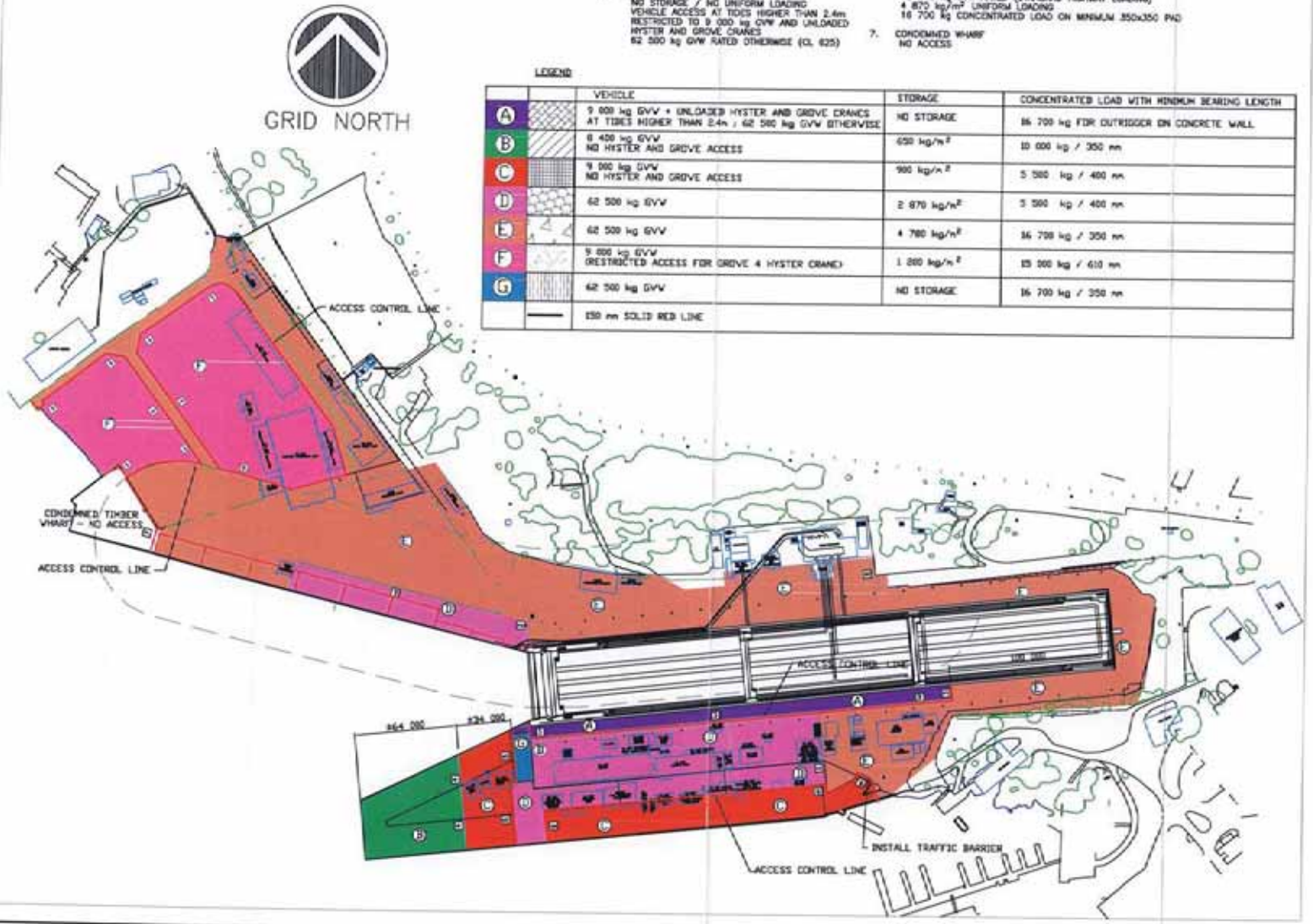
SIGNS

SIGNS TO FACE OUTWARDS FROM RESTRICTED AREA
SIGN TO BE WHITE WITH RED BORDER AND TEXT

1. RESTRICTED ENTRY AND LOADING.
   9 000 kg GVW RATED
   LIMITED USE BY HYSTER AND GROVE CRANES
   USE 610x610 PADS ON OUTRIGGERS
   1 200 kg/m² UNIFORM LOADING
2. RESTRICTED LOADING
   2 870 kg/m² UNIFORM LOADING
3. RESTRICTED ENTRY AND LOADING
   NO STORAGE / NO UNIFORM LOADING
   VEHICLE ACCESS AT TIDES HIGHER THAN 2.4m
   RESTRICTED TO 9 000 kg GVW AND UNLOADED
   HYSTER AND GROVE CRANES
   62 500 kg GVW RATED OTHERWISE (CL 625)
4. RESTRICTED ENTRY AND LOADING
   5 400 kg GVW RATED
   550 kg/m² UNIFORM LOADING
   5 500 kg CONCENTRATED LOAD ON MINIMUM 400x400 PAD
5. RESTRICTED ENTRY AND LOADING
   9 000 kg GVW RATED (NO ACCESS TO HYSTER AND GROVE CRANES)
   900 kg/m² UNIFORM LOADING
   5 500 kg CONCENTRATED LOAD ON MINIMUM 400x400 PADS
6. ACCESS AND LOAD RESTRICTIONS
   MAXIMUM LIMITS FOR UNRESTRICTED AREAS
   62 500 kg GVW RATED (STANDARD HIGHWAY LOADING)
   4 870 kg/m² UNIFORM LOADING
   16 700 kg CONCENTRATED LOAD ON MINIMUM 350x350 PAD
7. CONDEMNED WHARF
   NO ACCESS

LEGEND

		VEHICLE	STORAGE	CONCENTRATED LOAD WITH MINIMUM BEARING LENGTH
A		9 000 kg GVW + UNLOADED HYSTER AND GROVE CRANES AT TIDES HIGHER THAN 2.4m ; 62 500 kg GVW OTHERWISE	NO STORAGE	16 700 kg FOR OUTRIGGER ON CONCRETE WALL
B		6 400 kg GVW NO HYSTER AND GROVE ACCESS	650 kg/m²	10 000 kg / 350 mm
C		9 000 kg GVW NO HYSTER AND GROVE ACCESS	900 kg/m²	5 500 kg / 400 mm
D		62 500 kg GVW	2 870 kg/m²	5 500 kg / 400 mm
E		62 500 kg GVW	4 780 kg/m²	16 700 kg / 350 mm
F		9 000 kg GVW (RESTRICTED ACCESS FOR GROVE 4 HYSTER CRANE)	1 200 kg/m²	15 000 kg / 610 mm
G		62 500 kg GVW	NO STORAGE	16 700 kg / 350 mm
		150 mm SOLID RED LINE		



KM Engineering Group Inc.
Consulting Engineers

ESQUIMALT GRAVING DOCK
LOAD RATING

LOAD RATING LAYOUT AND SIGNAGE

SK 3

KLOHN CRIPPEN

File No. P01557A01 - 200

March 16th, 2005

KM Engineering Group Inc.
5062 West Saanich Road,
Victoria, B.C.
V9E 2E7

Mr. Mahomed Kathrada, P.Eng.

Dear Mr. Kathrada:

Esquimalt Graving Dock,
Surface Load Rating – Final Report

Please find enclosed our final sealed report on Surface Load Rating, for the Esquimalt Graving Dock (EGD) located at Esquimalt, B.C. The report presents the engineering analyses performed and key results. In response to review comments on the draft report, the final report includes (in Section 5.2) an assessment of vehicle loading in the Munroe Head Lot Areas. Figure 1, "Division of Surface Load Areas", shows an artificial subdivision of the dock surface areas for analysis and reporting purposes. The areas covered by this report are:

Zone 1: Munroe Head;
Zones 4A, 4B and 4C: North Landing Wharf Laydown Area;
Zones 5A and 5B: North Side Laydown Area;
Zone 6: East End Laydown Area;
Zone 7: South Side Laydown Area;
Zone 8: South Jetty Fill Area; and,
Zone 10: Timber Crib.

Our primary conclusions are as follows:

- Our structural analyses indicate that the typical pavement structure, with 50 mm asphalt paving overlying 150 mm unreinforced concrete slab, used in most areas around the EGD site, is able to carry the maximum loading from the 20T Grove Crane outrigger pads, but some localized slab cracking may occur at the bottom surface. The effect of wheel loading by the Hyster crane, ambulance, DND fire truck, or general highway vehicles is less severe. We understand that similar vehicles and cranes have operated daily on the pavement for many years with no substantial cracking observed, although cracks may have been concealed under the asphalt

paving. It is reasonable to conclude that a limited amount of cracking in an unreinforced concrete slab is acceptable from a performance perspective, as long as sub-soil bearing capacity is not exceeded.

- Bearing capacity analyses for the 20T Grove Crane outrigger pads indicate that the factor of safety (FOS) is adequate for areas with the typical pavement structure, i.e., with 150 mm concrete slab and 50 mm asphalt paving. In Munroe Head and other areas with no concrete slab, the bearing capacity factor of safety is less than unity. Square 610 mm timber spreader pads should be placed beneath the 20T Crane outrigger pads to increase the FOS to 1.5 when the crane is operated in areas with no concrete slab, such as the Lot Areas at Munroe Head; we understand that the 20T Crane currently carries spreader pads of this size for crane leveling purposes anyway.

- The existing asphalt pavement structure at the Munroe Head Lot Areas does not meet the design guidelines for low volume and local roadways; the pavement should be considered as similar to a walkway or driveway. In order to avoid long-term degradation, we recommend that the 20T Grove Crane, Hyster Crane and other loading trucks should be restricted from using the Lot Areas (except where 610mm square timber spreader pads are used for the 20T Grove Crane). The use of a DND Fire Truck or Ambulance should be acceptable on the Lot Area pavement structure, on the reasonable assumption that such use would be infrequent.

- A ground surcharge loading of 48 kPa (about 1000 psf) has been used throughout this report as a target value for load rating purposes. The estimated settlements for 48 kPa area-wide loading are in the order of 25 mm to 150 mm in the North Landing Wharf and Munroe Head areas, and down to about 10 mm to 50 mm in the Graving Dock north and east laydown areas. Differential settlements can be taken as 50% of the settlement estimates. In Zone 6, settlements are acceptable under 48 kPa surcharge. The estimated settlements in all the other zones, especially Zones 1 and 4, will not meet the target 12 mm settlement criterion under 48 kPa surcharge. Without any further refinement of the settlement analysis, Zones 1/4/5/7/8 will likely suffer significant differential settlements under 48 kPa surcharge, which may damage the pavement structures and underground utilities. Therefore, we recommend that these areas should only be subjected to minimal long-term surcharge loading, e.g. about 12 kPa (250 psf).

- In order to refine the settlement predictions, we recommend that a 10 m long by 10 m wide, 2.5 m to 3.0 m high test fill be constructed in a deep fill zone behind the North Landing Wharf, with monitoring of settlement over a 6-week period. This may allow re-evaluation of allowable surcharge loading for the North Landing Wharf and Munroe Head zones, and by inference the other zones.

- The six timber cribs at the North Landing Wharf (NLW) Zones 4A-4B-4C, and the single crib at the South Jetty (SJ) Zone 10, have adequate local static stability, cope wall stability and internal crib strength, even with 48 kPa surcharge load behind and above the cribs. Static stability for the North Entrance Wall, adjacent to the NLW cribs, is beyond the scope of this report. Global slip circle stability for the NLW cribs generally meets conventional factor of safety requirements, but the FOS under the 48 kPa surcharge loading is only 1.4. Global stability for the SJ crib with 48 kPa surcharge gives a minimum FOS of 1.3 at low tide; or a FOS of 1.1 with 30T crane loading and no surcharge. The single crib analysis neglects any three-dimensional effects of the loading and the geometry of the south jetty fill zone, which would increase the factor of safety. We believe that these FOS values are acceptable for relatively infrequent loadings combined with low tide level. However, we recommend that the 30T gantry crane should not be operated in the SJ timber crib area when other ground surcharge loading is present.

Please call me at (604) 251-8439 if you have any queries on this report.

Yours very truly,

KLOHN CRIPPEN CONSULTANTS LTD.

Geoff Cooper, P.Eng.
Manager, Ports & Harbours

Encls.

Prepared By: Geoff Cooper, P.Eng.
Manager, Ports & Harbours

Structural Review By: Dirk Duivestein, P.Eng.

Geotechnical Review By: Steven Ahlfield, P.Eng.
Manager, Geotechnical Division

Disclaimer of Responsibility to Third Parties

This report is an instrument of service of Klohn Crippen Consultants Ltd (KC) and has been prepared for the exclusive use of KM Engineering Group Inc. and Public Works and Government Services Canada (PWGSC). The contents of this report may not be relied upon by any other party without the express written permission of KC. The contents of this report reflect KC's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. KC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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1. INTRODUCTION

KM Engineering Group Inc. has been retained by Public Works and Government Services Canada (PWGSC) to develop a load rating layout and field signage at the Esquimalt Graving Dock (EGD). As part of this project, KM Engineering has subcontracted Klohn Crippen (KC) to perform the following scope of work:

- Evaluate the effect of vehicle loads from the specified heaviest loaded vehicles on the pavement structures. Alternately, assess the adequacy of soil bearing capacity under the pavement by load-distribution through the pavement thickness;
- Estimate settlements and differential settlements under area-wide loading; and,
- Evaluate the strength and stability of the six timber cribs at the North Landing Wharf (NLW) and single timber crib at the South Jetty (SJ).

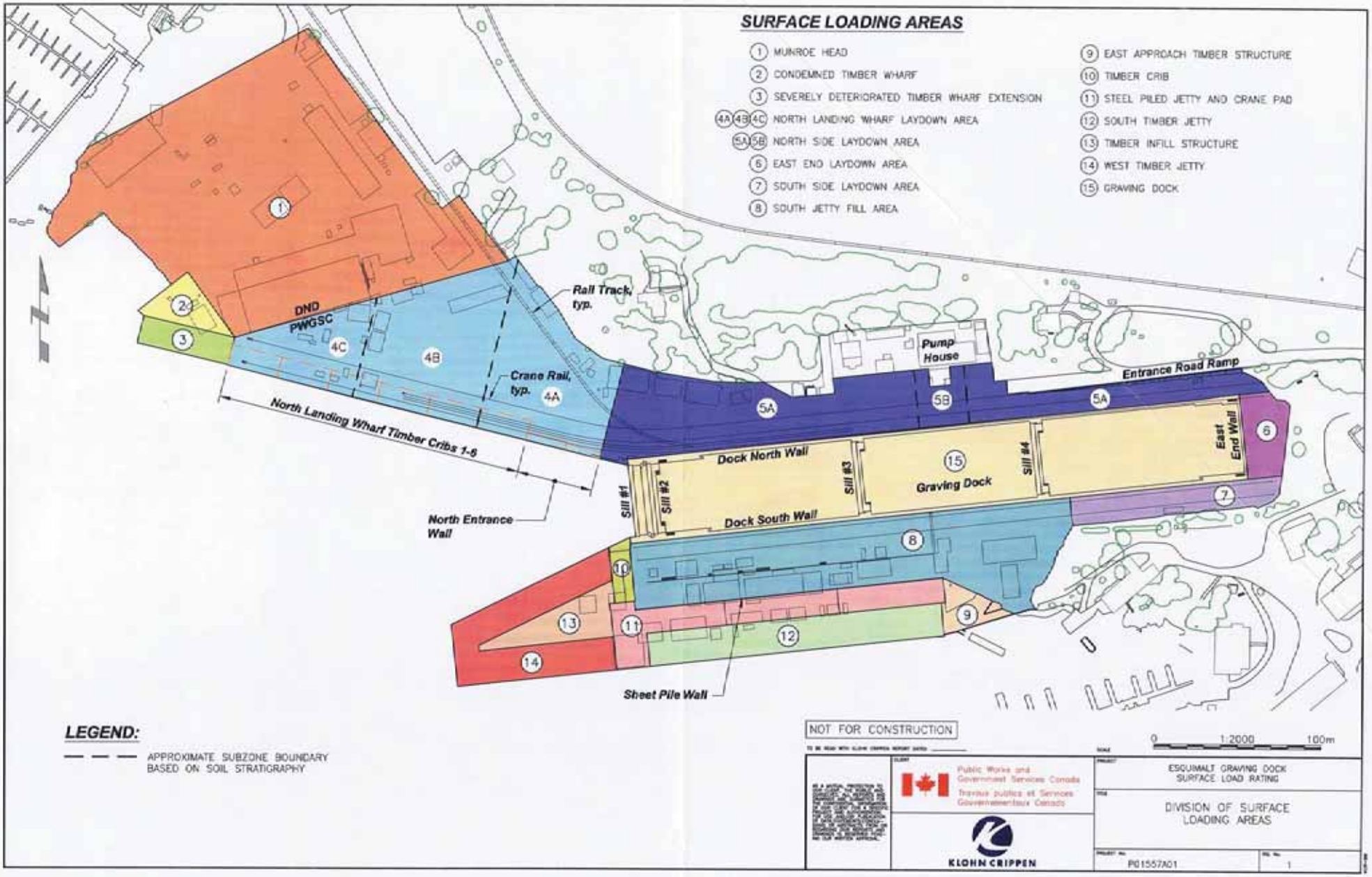
As noted in our proposal of September 3rd, 2004, our scope excludes the following items:

- Any work related to the Timber Piled Wharves/Decks, the South Jetty Structure (i.e., concrete deck and crane pad on steel piles) and the adjoining Sheet Piled Wall Structure;
- Any work related to the structural strength or stability of the Graving Dock Side Walls and End Walls, North Entrance Retaining Wall, Main Access Road Retaining Wall, Crane Beams and Service Tunnels; and,
- Any field investigations, field trips, or meetings in Victoria.

For this project we have subdivided the potential surface loading areas into several zones. The zones covered under our scope of this project are listed in **Table 1** below, and are shown in the attached **Figure 1**.

Table 1 – Surface Loading Areas

Zone	Description
1	Munroe Head
4A, 4B and 4C	North Landing Wharf Laydown Area
5A and 5B	North Side Laydown Area
6	East End Laydown Area
7	South Side Laydown Area
8	South Jetty Fill Area
10	Timber Crib


SURFACE LOADING AREAS
1 MUNROE HEAD
2 CONDEMNED TIMBER WHARF
3 SEVERELY DETERIORATED TIMBER WHARF EXTENSION
4A 4B 4C NORTH LANDING WHARF LAYDOWN AREA
5A 5B NORTH SIDE LAYDOWN AREA
6 EAST END LAYDOWN AREA
7 SOUTH SIDE LAYDOWN AREA
8 SOUTH JETTY FILL AREA
9 EAST APPROACH TIMBER STRUCTURE
10 TIMBER CRIB
11 STEEL PILED JETTY AND CRANE PAD
12 SOUTH TIMBER JETTY
13 TIMBER INFILL STRUCTURE
14 WEST TIMBER JETTY
15 GRAVING DOCK
DND
PWGSC
Rail Track, typ.
Crane Rail, typ.
North Landing Wharf Timber Cribs 1-6
North Entrance Wall
Pump House
Entrance Road Ramp
Dock North Wall
Dock South Wall
Graving Dock
Sill #1
Sill #2
Sill #3
Sill #4
East End Wall
Sheet Pile Wall
LEGEND:
APPROXIMATE SUBZONE BOUNDARY BASED ON SOIL STRATIGRAPHY
NOT FOR CONSTRUCTION
0 1:2000 100m
Public Works and Government Services Canada
Travaux publics et Services Gouvernementaux Canada
KLOHN CRIPPEN
ESQUIMALT GRAVING DOCK
SURFACE LOAD RATING
DIVISION OF SURFACE LOADING AREAS
P01557A01
1

2. SITE AND SUBSOIL CONDITIONS

The subsoil conditions for the different zones were interpreted based on the information from the original EGD construction drawings, various Klohn Crippen reports, and reports by others. Unless otherwise noted, we understand that in most areas, the pavement structure comprises surficial asphalt paving of 50 mm typical thickness overlying an un-reinforced concrete slab of 150 mm typical thickness.

2.1 Relevant Reports and Drawings

The following relevant reports, site investigation logs and drawings were reviewed for this project:

- Original EGD construction drawings (incomplete).
- R.M. Hardy & Associates Ltd., "Report on Stability of Timber Cribs Proposed 150 Tonne Travelling Crane Esquimalt Graving Dock, Esquimalt, B.C." 1978.
- R.M. Hardy & Associates Ltd., "Stability of Timber Cribs Proposed 150 Tonne Travelling Crane, Esquimalt Graving Dock, Esquimalt, B.C." January 31, 1979.
- SRK-Robinson Inc., "Environmental Investigation of Signal Hill and Munroe Head, Esquimalt Harbour" November 23, 1993.
- GeoViro Engineering Ltd., "Phase III Contaminated Site Investigation of DVD Munroe Head Land Parcel, Esquimalt Harbour, B.C." March 1996.
- A compilation of existing geotechnical information for the Esquimalt Graving Dock prepared by Golder Associates, for PWGSC, January 2000.
- Golder Associates, "Geotechnical Assessment, North Landing Wharf, Esquimalt Graving Dock, Esquimalt, B.C." January 17, 2002.
- Klohn Crippen Consultants, "Esquimalt Graving Dock and South Landing Wharf, Site Investigation and Liquefaction Assessment" June 25, 2002.
- Klohn Crippen Consultants, "Esquimalt Graving Dock North Landing Wharf Cribs and Laydown Area Renewal Phase 1 (Study)" September 2002.
- Seacor Environmental Inc., "Subsurface Environmental Investigation and Remedial Options Assessment, Munroe Head Property, Esquimalt, B.C." October 21, 2002.
- Klohn Crippen Consultants, "Esquimalt Graving Dock Seismic Evaluation of South Jetty and North Entrance Wall" October 25, 2002.
- Klohn Freundlich Associates, "Esquimalt Graving Dock Seismic Evaluation of Graving Dock Structure and Tunnels" October 25, 2002.
- Stantec, Munroe Head Subdivision Record Drawings, Esquimalt, B.C., September 2003 (and Design Brief dated 18 Sept 2003).

- Golder Associates, "Archaelogical Assessment Proposed Site Redevelopment, Munroe Head, Esquimalt, B.C." October 2, 2003.
- Golder Associates, "Geotechnical Investigation Proposed Site Redevelopment, Munroe Head, Esquimalt, B.C." October 3, 2003.
- Golder Associates, "Supplemental Site Investigation and Quantitative Risk Assessment at Munroe Head, Esquimalt Harbour, B.C." October 10, 2003.

2.2 Zone 1 - Munroe Head

The Munroe Head area is generally underlain by sand and gravel fill and rockfill (cobbles and boulders), which overlies bedrock or a discontinuous native silt/clay layer underlain by bedrock. The area at the north and the east abandoned rail grade area are underlain by a shallow layer of sand and gravel fill overlying firm silt which in turn is underlain by a soft clay layer. A shallow north-south trending bedrock zone, with bedrock depth ranging from 0.5 m to about 2.2 m, exists near the middle of the Munroe Head area, as confirmed by test pits conducted by Golder (2003). The bedrock level in the area to the south and adjacent to the North Landing Wharf laydown area may be deeper than 15 m to 20 m.

The pavement structure in Munroe Head was recently reconstructed, with the pavements generally comprising 50 mm asphalt paving overlying 100 mm crushed gravel over most areas, 75 mm asphaltic paving overlying 150 mm crushed gravel followed by 450 mm select granular subbase at roadways, and 200 mm thick concrete slab overlying 150 mm crushed gravel at the 150t Crane laydown area in the south (Lot 11) as indicated on the Stantec (2003) record drawings.

2.3 Zone 4 - North Landing Wharf Laydown Area

The North Landing Wharf laydown area is bounded by the North Entrance Wall at the south-east end and six Timber Cribs along the wharf face. Very little site investigation data exists for the area towards the north of the North Entrance Wall and timber crib area. The bedrock generally dips from the east to the west and from north to south, with depths up to about 30 m at the south-west area near where timber crib number 5 is located.

The North Entrance Wall lies between the north sidewall of the graving dock proper, and the six timber cribs at the North Landing Wharf. It was initially built using tremied (underwater) concrete in 1926, and was subsequently reconstructed in 1942 again with tremie concrete, cast on the prepared bedrock surface, with the concrete placed against intact rock for a large part of the wall height as indicated on CWMM drawing 3793-02.

The North Entrance Wall is a large gravity retaining wall, apparently varying in thickness from 4.9 m (16 ft) at the west end, reducing to 3.7 m (12 ft) at the east end. The wall supports the front rail of the 150t crane, the rear rail being generally pile-supported or on rock. We believe that granular backfill (sand, gravel and rockfill) was placed behind the North Entrance Wall on intact bedrock.

Each of the six identical timber cribs is 10.7 m (35 ft) high, 12.2 m (40 ft) wide and 30.5 m (100 ft) long. The bases were solid-formed from 457 mm square timbers, whereas the external walls used 305 mm timbers. Concrete facing was attached to all four exterior walls of each crib, presumably to aid strength and durability. The facing is generally 0.3 m thick, except at the front wall, which has 0.6 m thick facing. Interior crosswalls used interlaced 305 mm square timbers leaving 305 mm gaps between each layer. Each crib has 48 cells (12 longitudinally by 4 laterally), each cell being 2.4 m long by 2.7 m wide.

The timber cribs are founded generally on a gravel bed, underlain by till which is in turn underlain by bedrock. The proven depth to bedrock from the base of the crib varies from about 4.3 m to 8.5 m, but remains unproven between Sta. 1+52.4 m (5+00 ft) and 2+37.7 m (7+80 ft). In that zone, a depression, possibly a buried channel, exists in the rock surface. Apparently, silt and clay in the seabed was dredged to nominal foundation elevation -10 m (-33 ft), surfaced with a leveling course of broken stone, and the timber cribs were then floated into position and sunk onto the prepared bed. However, the eastern portion of Crib 1 is founded directly on bedrock. According to the photographic record, the cribs were then filled with sand and gravel, and with sand alone, using a floating crane and material imported on a scow.

A concrete parapet, or cope wall, was cast on top of the front edge of the cribs. The area behind and on top of the cribs was filled with mixed cobbles, sand and gravel, and then paved to a general dock elevation of +4.42 m (+14.5 ft). The parapet wall is apparently founded on large longitudinal timbers bearing directly on the top timbers of each crib.

The forward row of piles, supporting the seaward rail of the 150t crane, were installed through the bottom (457 mm square) timbers of the cribs to bedrock. The approximate thickness of these bottom timbers was confirmed by the penetration of the various investigative drill holes. The eight piles driven through each crib were positioned to avoid the timber crosswalls.

2.4 Zones 5, 6, 7 and 8 - Adjacent to Graving Dock Walls

The north, east and southeast sides of the dry dock were excavated into rock, and the mass concrete retaining walls were subsequently cast against rock for most of their height. As a result, relatively shallow backfills exist at the north, east and southeast portions of the dry dock retaining walls. The fill or rockfill comprises fine to coarse, subangular to subrounded sand and gravel, with trace silt and occasional cobbles and boulders.

In Zone 5, north of the north graving dock wall, the bedrock level undulates along an east-west section, and may range in depth from about 0.3 m to 9.0 m, with a "gully" to about 17.5 m depth in the area adjacent to the tunnels leading to the Pump House. In Zones 6 and 7, the bedrock level ranges from about 0.3 m to 1.8 m and 1.2 m to 5.8 m, respectively.

In Zone 8 south of the south graving dock wall, a 2 m wide puddle clay fill was placed against the rear face of the dock wall as a hydraulic seal to bedrock. The puddle clay comprises firm to stiff clay of intermediate plasticity (CI) with interlayers of silt, sand and gravel. The original EGD construction drawings indicate that "rubble fill" or rockfill was placed against the puddle clay on the south side. The rockfill was underlain by soft to firm native silt and clay which overly the bedrock or a thin layer of till underlain by the bedrock. The bedrock depth increases from east to west and from north to south.

2.5 Zone 10 - Timber Crib at South Jetty

This single timber crib, similar to those used in the North Landing Wharf construction during the same period, was likely towed in place, sunk and filled with sand, gravel, and rockfill. The crib is believed to have been founded on a gravel bed, underlain by till, which is in turn underlain by bedrock. The estimated depth to bedrock from the base of the crib varies from about 6 m to 14 m.

We believe that this single crib is similar to those installed at the North Landing Wharf. The only significant difference is that about 3.65 m (12 ft) depth of toe fill is present in front of the single crib, presumably placed to reduce the unrestrained design length for the timber piles at the West Jetty and Infill Structure, whereas the North Landing Wharf timber cribs have no toe fill above base level. This toe fill would provide some passive resistance to sliding of the crib under backfill and surcharge loading conditions.

3. SUBGRADE MODULUS

Subgrade modulus values are required as input to structural analyses to assess the effect of loading from the heaviest envisaged vehicle on the pavement structure. PWGSC have stipulated that the vehicle types to be considered include the 20 Ton Grove Mobile Crane, Hyster Mobile Crane, ambulance, DND fire truck, or highway vehicle loading as specified by the Canadian Highway Bridge Design Code CAN/CSA-S6-00. The load data for the 20T Grove Crane and the Hyster Crane were provided by KM Engineering's e-mail dated October 18th, 2004. These load data are summarized as follows:

20T Grove Crane: Front axle load = 10,100 kg; rear axle load = 9,000 kg; maximum outrigger pad load = 16,700 kg.
Hyster Crane: Front axle load = 8,400 kg; rear axle (single wheel) load = 5,300 kg.

The wheel/outrigger pad layouts for each crane were field measured by our Geoff Cooper on October 20th, 2004. A copy of the sketches showing the crane layouts and dimensions is included in **Appendix I**. From this data, and from comparison with the other stipulated vehicle/wheel loads, we have determined that the outrigger pad reaction from the fully loaded 20T Grove Crane is the critical load case for the dock surface areas dealt with in this report.

The subgrade modulus values for the different zones were calculated based on the soil conditions and field investigation test data. The estimated subgrade modulus values for both the 20T Crane and the Hyster Crane are summarized in **Table 2** below.

Table 2 - Estimated Subgrade Moduli At Base of Concrete Pavement Slab

Zone	Subgrade Modulus – 20T Grove Crane (kN/m^3)	Subgrade Modulus – Hyster Crane (kN/m^3)
1	76,842	122,248
4A	76,842	122,248
4B	76,842	122,248
4C	76,842	122,248
5A	86,610	137,788
5B	86,610	137,788
6	86,610	137,788
7	21,490	34,188
8	57,306	91,168
10	57,306	91,168

4. STRUCTURAL ANALYSIS OF THE CONCRETE PAVEMENT

A structural analysis has been carried out to assess the likely performance of the existing concrete pavement structure using "beam on elastic foundation" theory, with computer modelling. The subgrade modulus values used in the structural slab analyses are described in Section 3 of this report. As mentioned in that section the outrigger pad load from the fully loaded 20T Grove Crane was found to be the critical load case when compared to the other specified vehicle loads. However, we have also evaluated the effect of the Hyster Crane wheel loads on the concrete pavement structure for comparison purposes.

Background drawings of the graving dock indicate that, in most areas adjacent to the EGD, the pavement structure generally comprises a 150 mm (6 in) thick unreinforced concrete slab, with 50 mm (2 in) asphalt surfacing. The recent remediation of the Munroe Head lots and access roads generally used asphalt and base course pavement construction of varying thickness; the load carrying capacity of those areas is discussed elsewhere is this report. In the 150t Crane laydown area, just behind the west end of the North Landing Wharf, the recent remediations included unreinforced concrete slab construction, with no asphalt overlay. However, the slab thickness is variously shown as 200 mm or 240 mm on the as-built Stantec Drawings, depending on which drawing is referenced. In lieu of more exact information, we have based our structural slab assessment on the more representative pavement structure of 150 mm concrete grade slab with 50 mm asphalt overlay.

A 3-D computer model was developed to evaluate slab behaviour under outrigger pad loading. The model comprises a 6.0 m by 6.0 m slab area, using shell elements on elastic ground springs. Each shell element is 0.05 m by 0.05 m square, and 150 mm thick. The total number of shell elements is therefore 14,400. Each corner (node) of each shell element has a ground spring defined by multiplying the subgrade modulus by the contributing area to the node. In order to mimic slab continuity, the model's edges allow vertical translation, but are otherwise fixed. Crane pad loadings are defined as uniformly distributed pressure loading on shell elements, with 45-degree load distribution assumed through the 50 mm thick asphalt overlay; this degree of distribution is appropriate for slab flexural checks. Therefore, the typical 350 mm by 350 mm outrigger pad for the 20T Grove Crane would form a structural loading area of 450 mm by 450 mm at the top surface of the concrete slab.

In the absence of any concrete test data, the compressive strength of the existing concrete is assumed to be 25 MPa. Note that our Oct 2002 report titled "Esquimalt Graving Dock Seismic Evaluation of Graving Dock Structure and Tunnels" deduced that 30 MPa is an appropriate strength to use for design checks for the 1925-era dock walls and floor slab,

so assuming 25 MPa concrete compressive strength for dockside grade slabs is reasonable.

Five different load cases were analyzed, as follows;

1) One outrigger pad (20T Grove Crane) at slab centre with minimum value springs;
2) One outrigger pad (20T Grove Crane) at slab centre with maximum value springs;
3) The Hyster Crane rear axle at slab centre with minimum value springs;
4) The Hyster Crane rear axle at slab centre with maximum value springs; and,
5) One outrigger pad (20T Grove Crane) at slab edge with minimum value springs.

The first four load cases are representative of the typical slab loading conditions experienced at the dry dock, because the surface areas are large (tending to infinite), and individual slab sections are constrained between adjacent slabs and/or dock walls. Therefore, the simplistic free-edge assumption in load case 5 does not actually occur anywhere at the EGD, so it is presented for reference only.

The moment demands (M_d) from the computer analyses were compared to the cracking moment capacity (M_c) of the unreinforced concrete slab. The flexural C/D (Capacity/Demand) ratios and maximum slab deflections (d_{max}) were then derived and are summarized in **Table 3** below. Shear demands were also compared with slab shear capacity, based on load distribution down to mid-plane of the concrete slab, and were found to be in the range from 1.5 to 2.0.

Table 3 – Structural Capacity/Demand Ratios for 150mm Concrete Grade Slab

		Flexural Cracking at Bottom Surface		Flexural Cracking at Top Surface		
Load/Spring Case	**M_c (kNm/m)**	**M_d (kNm/m)**	**C/D ratio**	**M_d (kNm/m)**	**C/D ratio**	**d_{max} (mm)**
20T at slab centre, min. spring value	4.50	26.5	0.17	2.89	1.56	1.62
20T at slab centre, max. spring value	4.50	21.5	0.21	3.16	1.42	0.77
Hyster at slab centre, min. spring value	4.50	12.7	0.35	1.54	2.92	0.63
Hyster at slab centre, max. spring value	4.50	10.1	0.45	1.55	2.90	0.30
20T at slab edge, min. spring value	4.50	45.4	0.10	21.0	0.21	4.41

At the bottom surface of the slab (in soil contact), the C/D ratios for bending moments indicate that under all conditions cracks would likely form at specified maximum crane pad loading. However, at the top of the slab, the C/D ratios indicate there would be no cracking when the slab is centrally loaded. The area of high (bottom) moment demand is very localized under the outrigger pad, so cracking would also be expected to be localized. The fact that the existing concrete slabs have been in place for many years at the EGD, with apparently acceptable structural performance, indicates that extreme pad loadings are not often repeated in the same location. Note that our analysis ignores the potentially beneficial effect of slab arching.

These results are supported by a published study on concrete slabs on grade ("Load-Carrying Capacity for Concrete Slabs on Grade"; by Shentu, Jiang, and Hsu; Journal of Structural Engineering, Jan. 1997). The study compared the results from a finite element analysis with actual test results for a number of circular slabs on grade. The top surface cracks, which form at some distance away from the pad, developed at loading levels 5 times larger than the loads that would initiate bottom cracking directly under the pad. The results in Table 3 illustrate similar behaviour. The JSE report also indicated that bottom cracks will tend to be very localized and radial in shape, whereas top cracks (if they were to occur) will tend to be circumferential in shape.

In conclusion, when the 20T Crane outrigger pad loading is located in the middle regions of the grade slabs, localized bottom cracking may occur, but this is still acceptable in terms of overall structural performance of the concrete slab. Since flexural cracking at the top surface is unlikely under these loadings, the overall structural integrity of the slab is assured. If the crane pads are ever placed at an unsupported edge of the slab system, then a significant amount of cracking might develop at both the top and bottom surfaces, which could lead to degradation and damage of the slab.

5. BEARING CAPACITY ASSESSMENT

5.1 Analysis for 20t Grove Crane Loading

Bearing capacity analyses using conventional techniques developed for shallow foundations were carried out for the maximum outrigger pad load applied by the 20T Grove Crane. This type of analysis is not considered appropriate for the Hyster Crane loading as the loads are applied by the tires rather than stiff plates. Analyses were performed for two types of pavement structures: the 200 mm thick pavement comprising 50 mm asphalt paving and 150 mm concrete slab, and the 50 mm thick asphalt pavement with sub-base (most common pavement structure in the Munroe Head area). Results of the bearing capacity analysis are presented in **Table 4** below.

Table 4 - Results of Bearing Capacity Analysis

Case	Loading Type	Pavement Thickness (mm)	q_r (kPa)	q_{ult} (kPa)	Pad size required (mm)	FOS	Pavement Type
1	20T Grove Crane	200	291	413	Outrigger	1.42	Asphalt + Concrete
2	20T Grove Crane	50	809	350	Outrigger	0.43	Asphalt
3	20T Grove Crane	50	325	473	610x610	1.46	Asphalt

Note: q_r is the applied bearing pressure due to the maximum outrigger pad load of the 20T Grove Crane and q_{ult} is the ultimate soil bearing capacity.

The results indicate that areas with 200 mm thick pavement, i.e. all zones except Munroe Head, will have adequate soil bearing capacity to sustain the outrigger pad load, with factors of safety (FOS) greater than 1.4. However, the area with only 50 mm thick pavement, i.e. Munroe Head, will not have adequate soil bearing capacity to support the outrigger loads directly (FOS less than 1.0). The analyses show that the 20T Grove Crane can be used in the Munroe Head area only if 610 mm by 610 mm square timber pads are placed under each of the crane outrigger pads to distribute the loads. In this case the FOS will increase to about 1.5.

5.2 Analysis for Other Loads in Munroe Head Lot Areas

Table 4 indicates a FOS of less than unity for the 20t Mobile Crane outrigger pads when applied at the Lot Areas at Munroe Head, but greater than unity when 610mm square

spreader pads are used. However, Table 4 does not indicate whether this pavement can carry the Hyster Crane, DND Fire Truck, Ambulance or other highway traffic.

The Lot Areas at Munroe Head were constructed in the Fall of 2003. Stantec's record Drawings 852944-603 and 605 show a pavement structure of 50mm Asphalt Paving on 100mm of Crushed Gravel (particle size 25mm minus) for the Lot Areas. Stantec's Design Brief dated 18 Sept 2003 said that "Lot areas (which are not part of the roads and laydown area) will be graded and paved with 100mm of crush and 50mm of asphalt to finish the site and control runoff". No design loading was specified by Stantec for the Lot Areas; their design brief implies that no specific design loading was envisaged, or stipulated by the Owner (PWGSC).

The current standards or guidelines on pavement structure by the Ministry of Transportation (MoT, Technical Circular T-01/04 "Pavement Structure Design Guidelines," February 2004), and Master Municipal Construction Documents Association of B.C. (MMCDA, "Design Guidelines for Sustainability – Draft", 2003), are as follows:

- MoT pavement design standards for low volume and subdivision roads are: 50 mm asphalt pavement, 225 mm of 25 mm crushed base course, and 150 mm select granular sub-base (SGSB) on coarse grained subgrades (USCS classification: GW/GP/GM/GC/SW/SP/SM/SC).
- MMCDA design guidelines on minimum pavement structure for asphaltic concrete (AC) for local roadways with subgrade soil with USCS classification or SC or better are: 50 mm AC surface course, 75 mm base course, and 150 mm sub-base. The MMCDA guidelines for sidewalk, walkways and driveways are: 50 mm of asphaltic concrete, overlying 75 mm of base course.

It appears that the existing asphalt pavement structure at the Munroe Head Lot Areas does not meet the design guidelines for low volume and local roadways; the pavement should be considered as similar to a walkway or driveway. Thus, the Lot Areas may be susceptible to long-term degradation, depending on the extent/duration of use of heavier vehicles.

Therefore, we recommend that the 20T Grove Crane, Hyster Crane and other loading trucks should be restricted from using the Lot Areas (except where 610mm square timber spreader pads are used for the 20T Grove Crane). The use of a DND Fire Truck or Ambulance should be acceptable on the Lot Area pavement structure, on the reasonable assumption that such use would be infrequent.

6. SETTLEMENT

Potential locations for materials or equipment storage are Zones 1, 4, 5 and 6. Zones 7, 8 and 10 are unlikely to be used as heavy storage areas because these areas are either currently occupied by industrial buildings and other structures, e.g. warehouses, or are in the path of critical traffic routes, e.g. fire trucks, cranes, etc. Therefore, there is no need to assess settlements in Zones 7, 8 and 10.

Settlement analyses were carried out to estimate the potential settlements in Zones 1, 4, 5, 6 under sustained area-wide loading, and loading in a 10 m by 10 m area to simulate local loading from storage of materials. We have assumed a "target" loading of 48 kPa applied to the various zones where materials may be stored. This 48 kPa loading may be conservative, but is considered appropriate for this type of mixed-use waterfront facility. The surface load is assumed to be uniformly distributed.

The soil profile varies considerably across the site and often within each area. The settlement analyses were based on a general soil profile for each zone; variations in the settlements will occur due to vertical and lateral differences in the subsoil characteristics. For example, there is a shallow bedrock zone trending approximately north-south near the middle of Zone 1 where settlements could be less than the adjacent areas.

In some areas, the settlement is mainly in the loose fill, and settlement will occur over a few days or perhaps weeks. In other areas a portion of the settlement will occur due to consolidation of fine-grained soils that will occur over several years. Determination of short-term versus long-term settlement and variations within each area is not possible with the current subsurface data.

Settlements were estimated by selecting an equivalent elastic modulus for both the granular and fine-grained soils based on the existing drill hole data. There is considerable uncertainty in selection of the equivalent elastic modulus, particularly for the loose rock fill based on Becker penetration tests.

The estimated settlements are summarized in **Table 5** overleaf. KM Engineering indicated in an email dated October 20th, 2004 that the permanent pavement settlement allowance is on the order of 12 mm, and no restriction on temporary settlement as long as there is no permanent damage to existing surface finishes. Table 5 shows that the estimated settlements are in the order of 25 mm to 150 mm in the North Landing Wharf and Munroe Head areas, and down to about 10 mm to 50 mm in the Graving Dock north and east laydown areas. With exception of Zone 6, the estimated settlements in all the other zones, especially Zones 1 and 4, will not meet the target 12 mm settlement criterion.

The accuracy of settlement estimates due to variations in soil stratigraphy and properties that cannot be determined from site investigations is conventionally in the range of 50% to 200%. Locally, the settlements will vary with variations in soil properties, soil stratigraphy, and intensity or duration of material or equipment loading. The rate of settlement will be the highest in areas underlain by granular fill materials, and the lowest in areas with reasonably thick layer(s) of fine-grained soils, where long-term settlement will occur. Differential settlements can be taken as 50% of the settlement estimates, and can be assumed to occur from the centre to the edge of each zone. Structures including pavements, buried utilities and existing structures may be affected by the differential settlements, as the differential settlements may cause tensile and compressive stresses, as well as bending moments, depending on the settlement patterns. Local drainage may also be affected by the settlement patterns.

Settlement estimates can be refined by conducting a full-scale load test in one of the areas likely to be used for materials storage, such as the deep fill section at the North Landing Wharf. The load test could be comprised of 2.5 to 3 m of granular fill over a 10 m by 10 m area to replicate 48 kPa loading. Settlements would be monitored using settlement plates placed on the existing pavement surface prior to fill placement. Settlements would be monitored on a weekly basis during and after fill placement until the settlement rate stabilizes; likely on the order of 6 weeks. This test fill would allow recalibration of the soil model for the granular fill / rockfill. A similar test fill could also be constructed in an area underlain by deep fine-grained soil. In this case, the test fill duration may have to be increased to the order of 6 months to evaluate time-dependent settlement.

Table 5 - Estimated Settlements

Zone	Estimated Settlement due to 48 kPa Area-Wide Surface Loading (mm)	Estimated Settlement due to 48 kPa Surface Loading on a 10 m x 10 m area (mm)
1	25 to 125 (range)	25 to 75 (range)
4A	75	50
4B	100	65
4C	150	75
5A	25	20
5B	50	40
6	5 to 10 (range)	5 to 10 (range)

7. STATIC STABILITY OF SIX TIMBER CRIBS AT NORTH LANDING WHARF AND SINGLE CRIB AT SOUTH JETTY

The general arrangement and framing of the seven timber cribs at EGD is outlined in Sections 2.3 and 2.5 of this report. For timber crib sketches and modeling notes, refer also to our previous reports, "Esquimalt Graving Dock North Landing Wharf Cribs and Laydown Area Renewal Phase 1 (Study)" of September 2002, and "Esquimalt Graving Dock Seismic Evaluation of South Jetty and North Entrance Wall" of October 2002. For stability analysis purposes, the applied forces and criteria include:

(a) Weight of timber crib structure, concrete facing, concrete parapet and crib fill;
(b) Active soil pressure from retained fill at all 7 cribs;
(c) Passive soil pressure from toe fill for single crib at the South Jetty only;
(d) Tidal elevation varies from LWL = 0.00 m, to HWL = +3.00 m;
(e) No scour undercutting at the North Landing Wharf Cribs, since scour remediation was performed recently;
(f) No scour undercutting at the South Jetty Crib, since a substantial toe fill is present;
(g) Base friction coefficient = 0.49; rear wall/soil friction = 0.49; and
(h) Target uniform ground surcharge loading of 48 kPa (either above the cribs, behind the cribs, or both above and behind the cribs), and its effect on lateral soil pressures.

Note that for stability analysis purposes for these large crib structures, the effect of vehicle wheel loading or outrigger pad loading is far less than the effect of the target uniform ground surcharge loading, so the latter has been used for crib stability analyses. Mooring and berthing forces are negligible when compared with lateral soil loading, and can therefore be ignored for these analyses.

7.1 Tidal Lag

Tidal variation at this location ranges from elevation 0.0 m at LWL to approximately +3.0 m (10 ft) at HWL. It is common for tidal lag to occur at waterfront facilities even in granular fill materials. At the EGD the fill inside the cribs, and behind them, is granular and relatively free draining. The Hardy report (1978) took the conservative view that up to 1.52 m (5 ft) tidal lag may occur, despite test pit evidence to the contrary from their field investigations. Field measurements made by Klohn Crippen, during caisson drilling at the North Landing Wharf in September 2001, indicated no measurable difference between the water level inside the drilled caisson and at the waterside. Therefore, based on field evidence, our stability calculations assume zero tidal lag.

7.2 Assumed Ground Surcharge

"Design" surcharge values to reflect operational use at wharves usually vary between 29 kPa (600 psf) and 48 kPa (1000 psf), depending on client/user requirements. For the EGD cribs and laydown areas directly behind them, the "design" value for applied surcharge is not stated on any of the EGD drawings. In lieu of any historical criteria or other data at EGD, we have applied a "target" surcharge of 48 kPa for the EGD crib structures. The surcharge is assumed to be evenly distributed, but also as patch loadings to determine the likely worst condition. A value of 48 kPa is conservative, but still appropriate for this type of mixed-use waterfront facility.

7.3 Soil-Structure Friction

Base friction for large wharf structures is dependent on the method of construction and materials used. Sources (Bowles, Canadian Foundation Engineering Manual, and NAVFAC DM7.2 of May 1982) indicate that the angle of friction between timber/piling and soil should be taken as $\frac{3}{4}\phi$. The internal friction angle, ϕ, of the mixed sand and gravel under and behind the cribs likely ranges from 35° to 40°. Therefore, the base or wall friction angle, δ, may range from 26° to 30°. Relatively little is known about the quality or roughness of the timbers used to form the base of the cribs. Conservatively, therefore, we have taken the coefficient of friction for our stability calculations as $\tan \delta = \tan 26° = 0.49$. For static analyses, the cribs have been modeled as two-dimensional rigid structures. The 3 internal longitudinal walls have been modeled as a single wall of equivalent total thickness for convenience. Lateral cross walls and end walls have been accounted for in the 2-D models.

7.4 Results of Crib Local Stability Analyses

The local Factors of Safety (FOS) against sliding (and overturning) across the base of the crib under various static loading conditions are summarized in **Table 6**. In all cases "failure" would be initiated by sliding action prior to overturning. The minimum Factor of Safety (FOS) against sliding is 1.88 for the six cribs at the North Landing Wharf, or 2.84 for the single crib at the South Jetty. For both locations, the critical loading case is with the 48 kPa ground surcharge applied behind the crib only, not above it. Tidal elevation makes little difference to the sliding FOS results. The South Jetty crib results are significantly safer than the corresponding values calculated for the North Landing Wharf cribs, primarily due to the presence of the toe fill in front of the South Jetty crib.

The FOS for the concrete parapet wall alone, against sliding across the top of the crib, was reported by Hardy report (1978) to be greater than 3.50 for static conditions. Our calculations show that the FOS against parapet sliding reduces to 1.37 for the static case if 48 kPa ground surcharge is included; this is still an acceptable result for temporary loading conditions at an existing structure.

7.5 Results of Crib Global Static Stability Analyses

The global Factors of Safety (FOS) for the timber cribs under static conditions, with and without 48 kPa surcharge loading, are summarized in **Table 6**. The minimum FOS is 1.4 for the six cribs at the North Landing Wharf, and 1.3 for the single crib at the South Jetty. For both locations, the critical loading case is with the 48 kPa ground surcharge applied above and behind the cribs. The FOS for the NLW timber cribs is slightly lower than the conventional factor of safety requirements (FOS of 1.5). The South Jetty timber crib results are conservative because the assumed surcharge load of 48 kPa applied is likely infrequent and therefore conservative for the single crib area. The FOS of 1.3 is probably acceptable for this infrequent, area-wide loading condition at low tide for the South Jetty timber crib area.

We have also analyzed global slope stability of the South Jetty crib under the loading of the 30t level-luffing gantry crane (in lieu of wheel loads for the 30t crane at EGD, we used representative loads from the 30T crane at CFB Esquimalt), without any ground surcharge present. The FOS is 1.4 at high tide level and 1.1 at low tide level. This analysis neglects the three-dimensional effects of the loading and the geometry of the South Jetty area, which would increase the factor of safety. The crane has likely been operated in this area many times, and there are no indications of significant deformations or cracking in the dock walls. Therefore, we conclude that the global stability FOS for the 30t gantry crane loading case is likely acceptable. However, the 30t gantry crane should not be operated in the South Jetty timber crib area when surcharge loading is also present.

Table 6 - Timber Cribs, Static Stability, Key Results

Case Description	Tide Level	Global Stability FOS	Local Sliding FOS	Local Overturning FOS	Crib Toe Pressure (kPa)	Crib Heel Pressure (kPa)
Six Cribs at North Landing Wharf						
Static (with no surcharge)	LWL	1.50[i]	2.68	7.04	232	148
Static (with 48 kPa surcharge behind cribs only)	LWL	1.40[i]	1.92	4.65	272	124
Static (with 48 kPa surcharge above and behind cribs)	LWL	1.40[i]	2.39	5.66	320	172
Static (with 48 kPa surcharge above cribs only)	LWL	1.49[i]	3.36	8.68	280	196
Static (with no surcharge)	HWL	About 1.50[i]	2.81	7.55	191	129
Static (with 48 kPa surcharge behind cribs only)	HWL	1.40[i]	1.88	4.56	231	104
Single Crib at South Jetty						
Static (with no surcharge)	LWL	1.55	4.02	7.36	205	176
Static (with 48 kPa surcharge behind cribs only)	LWL	-	2.84	4.85	244	152
Static (with 48 kPa surcharge above and behind cribs)	LWL	1.30	3.30	5.86	292	200
Static (with 48 kPa surcharge above cribs only)	LWL	-	4.69	9.00	253	224
Static (with 30t Gantry Crane loading only)	LWL	1.10	-	-	-	-
Static (with no surcharge)	HWL	2.48	4.47	7.95	164	156
Static (with 48 kPa surcharge behind cribs only)	HWL	1.85[ii]	2.94	4.79	203	132
Static (with 30t Gantry Crane loading only)	HWL	1.40	-	-	-	-

Notes:

i) Global static FOS based on worst stratigraphy (clay layer); typical FOS on rock fill foundation at North Landing Wharf is about 2.20 or higher.

ii) FOS for static condition with 48 kPa surcharge above and behind cribs.

7.6 Results of Bin Pressure Analyses

Internal pressures are developed by the presence of sand and gravel fill materials within the relatively small cells of the timber cribs. Established methodologies (Janssen, Reimbert) are available to calculate lateral bin pressures for static load cases. Overpressure factors, to account for pressure increases that may occur in silos during filling/emptying operations, are not required for this type of analysis.

Each crib has four rows of twelve cells. The front row of cells is critical to crib performance since any rupture of the front face would allow release of retained materials into the ocean. If the front face were to collapse, then the parapet wall would likely also fail, and the dock grade surface would become unstable and suffer distress. For analysis purposes we have made several assumptions, based on information available:

(a) Timber type and grade assumed equal to, or better than, Douglas Fir Grade No.2;
(b) Strength of the concrete facing is ignored since its reinforcement and method of attachment are unknown;
(c) Connections between front face timbers and cross-wall timbers are not fully detailed on existing drawings (but some notching of timbers is implied), so we have assumed a notched connection supplemented by iron spikes giving a resilient connection; and
(d) Soil/timber wall friction angle is taken as 26 degrees.

Calculated maximum bin pressures for the static load case:

- With no ground surcharge, p_{bin} = 11.1 kPa; or,
- With 48 kPa ground surcharge, p_{bin} = 24.6 kPa.

For static conditions, with or without the surcharge, our calculations indicate that the front wall timbers have adequate strength to resist the applied bin pressures.

8. CONCLUSIONS AND RECOMMENDATIONS

Our structural analyses indicate that the typical pavement structure, with 50 mm asphalt paving overlying 150 mm unreinforced concrete slab, used in most areas around the EGD site, is able to carry the maximum loading from the 20T Grove Crane outrigger pads, but some localized slab cracking may occur at the bottom surface. The effect of wheel loading by the Hyster crane, ambulance, DND fire truck, or general highway vehicles is less severe. We understand that similar vehicles and cranes have operated daily on the pavement for many years with no substantial cracking observed, although cracks may have been concealed under the asphalt paving. It is reasonable to conclude that a limited amount of cracking in an unreinforced concrete slab is acceptable from a performance perspective, as long as sub-soil bearing capacity is not exceeded.

Bearing capacity analyses indicate that the factor of safety (FOS) is adequate for areas with the typical pavement structure, i.e., with concrete slab. In Munroe Head and other areas with no concrete slab, the bearing capacity factor of safety is less than unity. Square 610 mm timber spreader pads should be placed beneath the 20T Crane outrigger pads to increase the FOS to 1.5 when the crane is operated in areas with no concrete slab, such as the Lot Areas at Munroe Head; we understand that the 20T Crane currently carries spreader pads of this size for crane leveling purposes anyway.

The existing asphalt pavement structure at the Munroe Head Lot Areas does not meet the design guidelines for low volume and local roadways; the pavement should be considered as similar to a walkway or driveway. In order to avoid long-term degradation, we recommend that the 20T Grove Crane, Hyster Crane and other loading trucks should be restricted from using the Lot Areas (except where 610mm square timber spreader pads are used for the 20T Grove Crane). The use of a DND Fire Truck or Ambulance should be acceptable on the Lot Area pavement structure, on the reasonable assumption that such use would be infrequent.

The estimated settlements under 48 kPa surcharge loading are in the order of 25 mm to 150 mm in the North Landing Wharf and Munroe Head areas, and down to about 10 mm to 50 mm in the Graving Dock north and east laydown areas. With exception of Zone 6, the estimated settlements in all the other zones, especially Zones 1 and 4, will not meet the target 12 mm settlement criterion. The conventional accuracy of settlement estimates variations in soil properties, soil stratigraphy, and intensity or duration of material is typically assumed to range from 50% to 200% of the estimated values. Differential settlements are generally assumed as 50% of the settlement estimates and assumed to occur from the centre to the edge of each zone. Estimation of soil properties, particularly the loose rockfill, based on the existing Becker penetration test data is subject to

considerable uncertainty. The settlement estimates could be refined by conducting a full-scale load test to represent the area-wide loading considered herein.

On the basis of the analysis performed to date, we find that Zones 1/4/5/7/8 will likely suffer significant differential settlements under 48 kPa surcharge, which may damage the pavement structures and underground utilities. In order to derive an allowable surcharge loading for these areas, the following approximate methodology can be used:

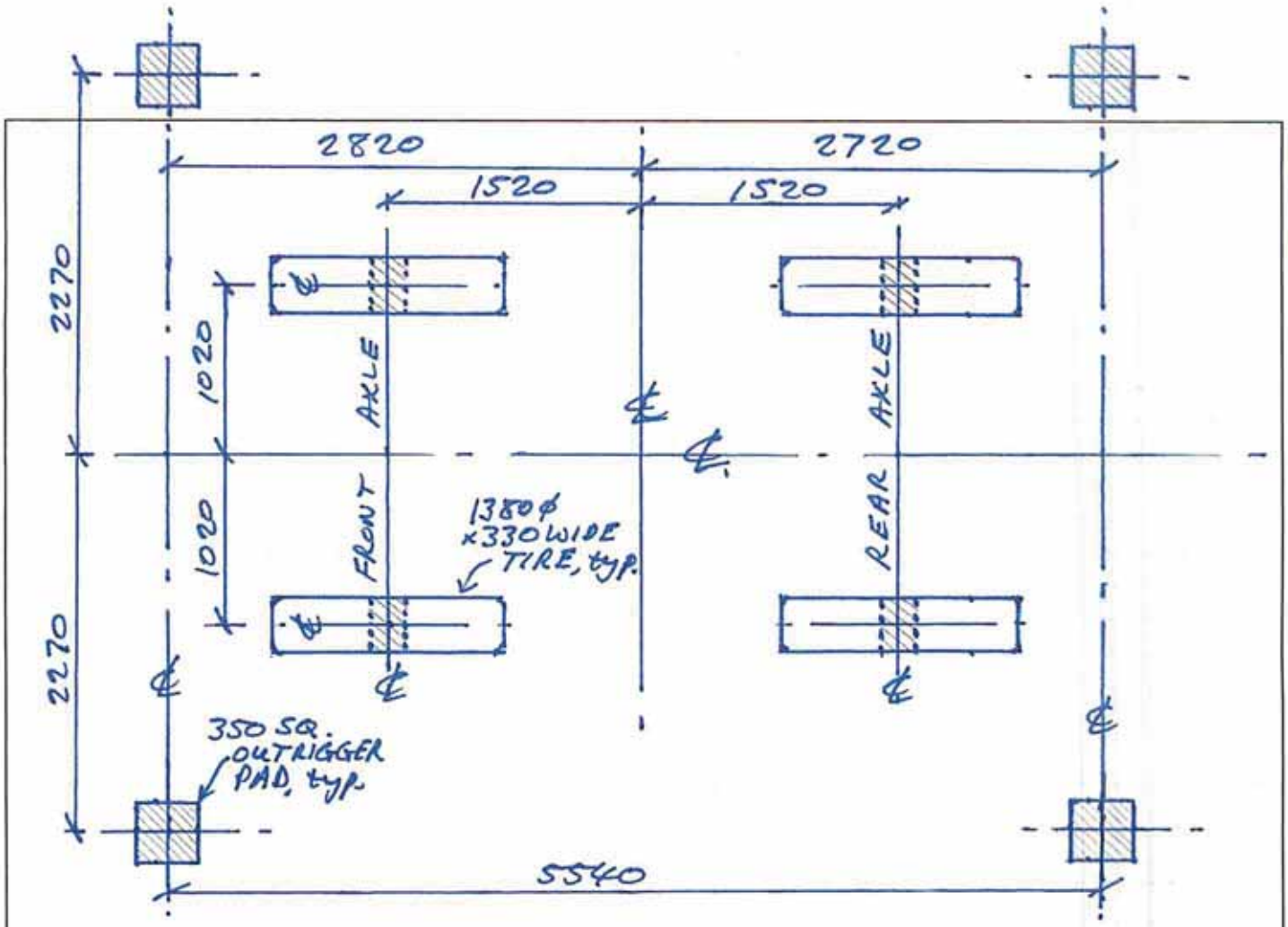
- Take the representative average settlement as about 100 mm (25 mm to 150 mm range per the settlement calculation results);
- Take 50% of this as differential settlement = 50mm;
- Make the reasonable assumption that settlements are roughly proportional to applied loading if other conditions remain the same;
- In order to achieve the 12mm criterion, estimate the allowable surcharge as (12mm/50mm) * 48 kPa = 12 kPa.

Therefore, we recommend that these areas should only be subjected to minimal long-term surcharge loading, e.g. about 12 kPa (250 psf).

The six timber cribs at the North Landing Wharf (NLW) and the single crib at the South Jetty (SJ) have adequate local static stability, cope wall stability and internal crib strength, even with 48 kPa surcharge load behind and above the cribs. Static stability for the North Entrance Wall, adjacent to the NLW cribs, is beyond the scope of this report. Global stability for the NLW meets conventional factor of safety requirements (FOS of 1.5) for low tide level and no surcharge, but is slightly lower (FOS of 1.4) under the 48 kPa surcharge loading. The NLW stability analysis is relatively insensitive to tide level. However, the SJ global stability factor of safety is more sensitive to tide level. Global slip circle stability, without surcharge gives FOS of 1.6 and 2.5 for low and high tide levels, respectively. Global slip circle stability, with 48 kPa surcharge gives FOS of 1.3 and 1.8 for low and high tide levels, respectively. We believe that a factor of safety of 1.3 is acceptable for this infrequent, area-wide loading at the South Jetty timber crib area. Stability analysis for the SJ timber crib under representative 30t gantry crane loading gives FOS of 1.4 and 1.1 at high and low tide levels, respectively. This analysis neglects the three-dimensional effects of the loading and the geometry of the south jetty fill zone, which would increase the factor of safety. The crane has likely been operated in this area over the years and there are no indications of significant deformations. We recommend that the 30t gantry crane should not be operated in the SJ timber crib area when surcharge loading is also present.

APPENDIX I

20T GROVE MOBILE CRANE AND HYSTER CRANE WHEEL/OUTRIGGER LAYOUT



20 TON GROVE MOBILE CRANE WHEEL/OUTRIGGER LAYOUT

NOTES:

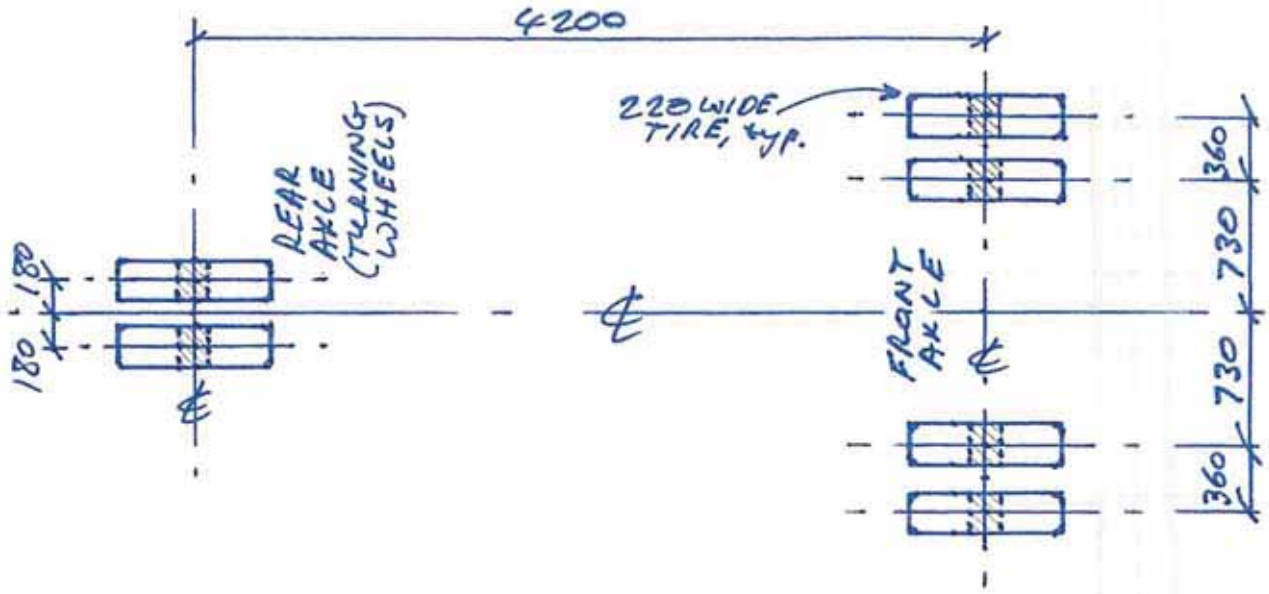
1) 600mm SQ x 70mm THK. TIMBER PADS ARE USED UNDER OUTRIGGERS PURELY FOR HEIGHT/LEVEL CONTROL ONLY.

2) 4 NO. 2520mm x 880mm x 30mm THK. STEEL PLATES ARE USED (1 AT EACH OUTRIGGER) WHEN CRANE OPERATES ON SOUTH LANDING WHARF TIMBER JETTIES.

3) ALL DIMENSIONS ARE APPROXIMATE FIELD MEASUREMENTS

KLOHN CRIPPEN

PROJECT SURFACE LOAD	NO. P0155 7A01
DETAILS RATING @ ESQUIMALT GRAVING DOCK.	
ENG. L. Cooper	CHK.
DATE Oct 20/04.	SHEET 1 OF 2



HYSTER MOBILE CRANE
WHEEL LAYOUT

NOTES:

1) ALL DIMENSIONS ARE APPROXIMATE FIELD MEASUREMENTS.

KLOHN CRIPPEN	PROJECT SURFACE LOAD NO. P0155 7A01
	DETAILS RATING @ ESQUIMALT GRAVING DOCK
	ENG. G. Cooper CHK.
	DATE Oct 20/04 SHEET 2 OF 2

D5

ESQUIMALT GRAVING DOCK

ELECTRICAL MASTER DRAWING (2011)

Number of Pages: 2

REFERENCE DRAWINGS		REF. No.
	FPE SR 155-W1, REV. 4 (1990)	1
	FPE SB 6165-W1, REV. 1 (1985)	2
DUPLICATE REFERENCE →	FPE SB 6165-W1, REV. 1 (1985)	3
	FPE-SR-242-W1, REV. 2 (1985)	4
EMD E2	MAIN SUBSTATION 1-LINE	5
EMD E76	4SS2 FRONT ARRANGEMENT	6
EMD E77	2SS2 FRONT ARRANGEMENT	7
EMD E4305	480V GFM SYSTEM	8
EMD E6	STANDBY SYSTEM 1-LINE	9
EMD E1	NUMBERING SYSTEM	10
EMD E3	PUMPHOUSE 1-LINE	11

GENERAL NOTES:

1. THIS DRAWING IS DERIVED FROM PWGSC PROJECT NO. 845398 AS-BUILT DRAWING NO. E5 OF 21, REV. 2.
2. UNLESS NOTED OTHERWISE, ALL BREAKERS ARE 3-POLE. FOR ADDITIONAL BREAKER DETAILS, SEE SWITCHBOARD FRONT ARRANGEMENT DRAWINGS AND PANEL SCHEDULES.
3. FOR FEEDER GROUND FAULT TRIP PRIORITIES, SEE SWITCHBOARD FRONT ARRANGEMENT DRAWINGS.
4. 52-4 IS NOT SHOWN ON THIS DRAWING PER REF. 1.
5. STANDARD PWGSC FONT SIZE OF 2.5mm IS NOT IMPLEMENTED ON EMD DRAWINGS BY SPECIAL PERMISSION.
6. FOR SYMBOLS AND ABBREVIATIONS, SEE ESD'S.

TEMPORARY NOTES:

1. VERIFY INTERNAL DISTRIBUTION.
2. VERIFY No. OF PARALLEL CABLES.
3. VERIFY CT RATIO.
4. VERIFY I.C. RATING OF 52-4SS1-3.
5. VERIFY P.T. SOURCE.
6. INVESTIGATE IF SWITCH RATING IS ADEQUATE.
7. VERIFY 2 OR 3 CT'S.
8. P&C 2A31-1 PER ELITE-307
9. CHANGE NAMEPLATE
10. VERIFY BREAKER TRIP UNIT RATING.
11. FIELD VERIFY.
12. CONFIRM METER NUMBERS AND IDENTIFY BREAKER.
13. FAULT LEVEL TO COME.
14. VERIFY IF SPARES ARE CONNECTED TO SECTION #3 BUS OR THE MAIN BUS.
15. VERIFY CONNECTION

rev.	revisions	date
6	INCLUDED STANDBY GENERATOR LOADS ELECTRICAL SAFETY UPGRADE DESIGN CRITERIA	14 FEB 2011
5	BY RFA: 112.5 SS-1 ANF RATING ADDED; BREAKER 4SS2-18 CT ADDED, 4SS2-23 WOSK #3 SPLITTER WAS A RECEPTACLE	6 JULY 2007
4	BY RFA: UPDATED FAULT LEVELS PER ELITE STUDY OF 2 OCT 2006	16 NOV 2006
3	BY RFA: ADDED CABLE No'S; REMOVED LEGEND	15 AUG 2005
2	BY RFA: AS-BUILT PER F&I MARK-UPS (PWGSC #846354, RFA# 237-20307).	27 MAY 2005
1	BY RFA: CABLE NUMBERS FOR JM4 & 5 UPDATED AS TENDERED (PWGS No. 846354) ISSUED FOR 2004 HV MAINTENANCE TENDER; 208V JETTY MOUNTS 1-5 FEEDER No.'S WERE 4SS2	7 OCT 2004

Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

Pacific Region

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4396 WEST SAANICH ROAD, SUITE 130
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FAX: (250) 386-2844

project / projet
ESQUIMALT GRAVING DOCK
ESQUIMALT, B.C.

ELECTRICAL MASTER DRAWING

drawing / dessin
SOUTH SIDE SUBSTATION SINGLE LINE DIAGRAM

designed: M. K. ÇANÇAR | G. PETERSON
drawn: P. PARANPAN
approved:
tender: Soummission
PWGSC Project Manager: Administrateur de projets TPSGC
project no. / no. du projet: —
drawing no. / no. du dessin: EMD E5 REV.6

Plot Date: JULY 23, 2012 1:04 PM Plotted by: MUNZHO
File Name: D:\EMD E5 (SOUTH SUB) REV 6.DWG

NOTES:

1. UNLESS NOTED OTHERWISE, ALL BREAKERS ARE 3-POLE. FOR ADDITIONAL BREAKER DETAILS, SEE SWITCHBOARD FRONT ARRANGEMENT DRAWINGS AND PANEL SCHEDULES.
2. GENERATOR AND TRANSFORMER STAR POINTS ARE EXTENDED WITH INSULATED CONDUCTORS FOR SINGLE POINT GROUNDING AT ATS.
3. NORMAL POWER CIRCUITS ARE INDICATED IN BLACK AND SHOWN IN SIMPLIFIED FORM FOR INFORMATION ONLY. FOR DETAILS AND FUTURE UPDATES, SEE REF. 1 THROUGH 4.
4. FOR OPERATING PROCEDURES, SEE REF. 5. DOUBLE LINE SQUARE FRAMES INDICATE EQUIPMENT REQUIRING MANUAL ACTION BY THE OPERATOR FOR STANDBY OPERATION.
5. EQUIPMENT LISTED IN SQUARE FRAMES MAY BE PROVIDED WITH STANDBY POWER BASED ON OPERATOR'S ASSESSMENT AND GENERATOR BASE LOAD. FOR FULL DETAILS, SEE RESPECTIVE SINGLE-LINE DIAGRAMS AND GENERATOR OPERATING PROCEDURES.
6. STANDARD PWGSC FONT SIZE OF 2.5mm IS NOT IMPLEMENTED ON EMD DRAWINGS BY SPECIAL PERMISSION.

REFERENCE DRAWINGS		REF. No.
EMD E2	MAIN SUBSTATION 1-LINE	1
EMD E3	PUMPHOUSE 1-LINE	2
EMD E4	NORTH LANDING WHARF SUBSTATION 1-LINE	3
EMD E5	SOUTH SIDE SUBSTATION 1-LINE	4
EMD E7	600kW GENERATOR OPERATING PROCEDURES	5
	SIMPOWER 12894-171 THRU 176	6
	ELITE (DWG No. TO COME)	7
	ASCO GS F940DA-146221	8

TEMPORARY NOTES:

1. FIELD VERIFY.
2. VERIFY I.C. RATING.
3. VERIFY METERING CIRCUITS.
4. (NOT USED.)
5. VERIFY 1-PHASE TRANSFOMER WITH SECONDARY SWITCH.

Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

Pacific Region

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FAX: (250) 386-2844

revisions		date
6	BY PWGSC DM: ADDED SHOP MARKUPS.	12 SEP 2012
5	BY RFA: AS-BUILT OF GUARDHOUSE FEEDER; REMOVED TEMPORARY NOTE 4.	19 DEC 2006
4	BY RFA: REMOVED NOTE 7; AS BUILT - REMOVED TEMPORARY NOTE 6.	14 NOV 2006
3	BY RFA: ADDED BREAKER NO'S TO 65A; TEMPORARY NOTE 6 ADDED FOR REMOVAL OF GARAGE FROM STANDBY SYSTEM	20 JAN 2006
2	BY RFA: GENERAL UPDATE; COMBINED WITH "OPERATING" DIAGRAM	15 AUG 2005
1	BY RFA: ADDED NGR FOR T6SP2-1; ISSUED FOR 2004 HV MAINTENANCE TENDER	7 OCT 2004

A detail no. / no. du détail
B location drawing no. / numéro du dessin
C drawing no. / dessin no.

project / projet

ESQUIMALT GRAVING DOCK
ESQUIMALT, B.C.

ELECTRICAL MASTER DRAWING

drawing / dessin

STANDBY POWER SYSTEM SINGLE-LINE DIAGRAM

designed	M. K. ÇANÇAR	contrôlé
date		
drawn	J.O. / A.S. / P.P.	dessiné
date		
approved		approuvé
date		
AS BUILT		Soumission
PWGSC Project Manager		Administrateur de projets TPSGC
project no.	—	no. du projet
drawing no.	EMD E6	no. du dessin REV.6

Plot Date: September 18, 2012 12:42 PM Plotted by MACNO
File Name: U:\VF_DOCUMENTS_BACKUP\CN_PROJECTS\STAND E6 (STANDBY SLD) REV 6.DWG

D6a

ESQUIMALT GRAVING DOCK

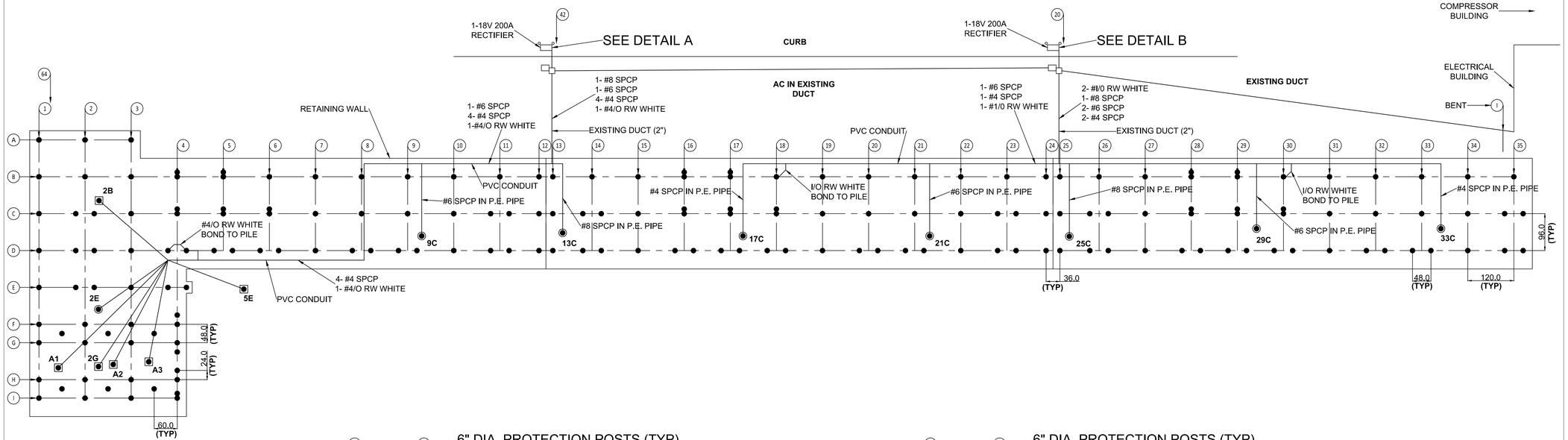
CATHODIC PROTECTION SYSTEM WIRING DETAILS

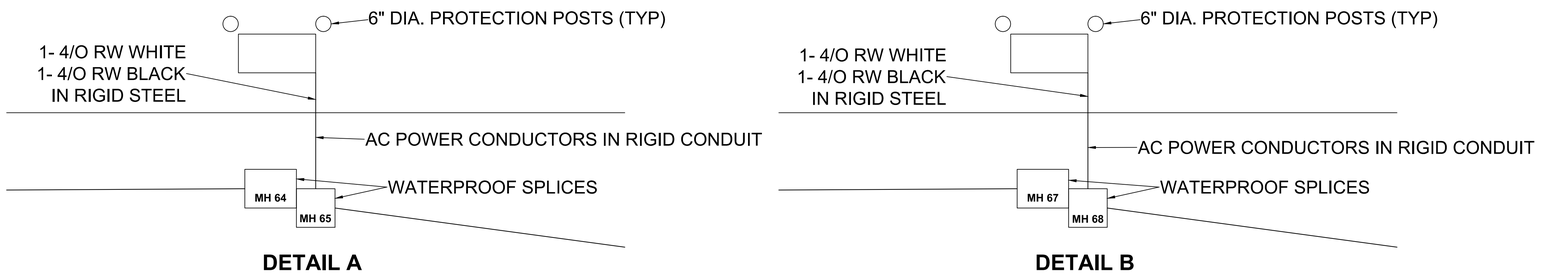
Number of Pages: 1

NOTES

1. THIS DRAWING (CAD .DWG) WAS CREATED IN MARCH 2014 USING THE ORIGINAL HAND-DRAWN CONSTRUCTION DRAWING FROM 1985 AS A REFERENCE. THE ORIGINAL 1985 CONSTRUCTION DRAWING WAS PROJECT NO. PR.100772, SHEET 15 OF 75, "ESQUIMALT GRAVING DOCK IMPROVEMENTS, CONTRACT NO.3."
2. ALL DIMENSIONS INCLUDED FOR PILINGS RELATIVE TO ONE ANOTHER ARE APPROXIMATIONS MADE FROM MEASUREMENTS TAKEN UNDERNEATH THE JETTY
3. ALL LOCATIONS OF LEAD SILVER ANODES SHOWN ARE APPROXIMATIONS
4. RECTIFIER DETAIL DRAWINGS ARE NOT TO SCALE AND ONLY TO BE REFERENCED AS A COMPONENTS LIST
5. MEASUREMENTS WERE TAKEN IN IMPERIAL UNITS (INCHES) FROM UNDERSIDE OF DOCK; ORIGINAL DRAWING IS BELIEVED TO BE DONE IN METRIC UNITS
6. DRAWING DOES NOT INCORPORATE ADDITIONS TO THE PHYSICAL STRUCTURE OF THE DOCK SINCE THE ORIGINAL DRAWING WAS COMPLETED
7. LEAD SILVER ANODES 2E, 2G, 9C, 13C, 17C, 21C, 25C, 24C, & 33C WERE REPLACED WITH LIKE AND KIND ANODES BY CORROSION SERVICES LTD. DURING MAY 1999 AND JULY 2006
8. THREE MIXED-METAL ANODES WERE INSTALLED DURING OCTOBER 2012 AT LOCATIONS 5E, 2B, & 2G BY CORROSION SERVICES LTD.
9. MIXED-METAL ANODES USED TO REPLACE EXISTING LEAD SILVER ANODES ARE SIZED TO MATCH THE OUTPUT AND DESIGN LIFE OF THE EXISTING LEAD SILVER ANODES
10. MIXED METAL ANODES WERE ADDED TO THE CATHODIC PROTECTION SYSTEM AT LOCATIONS A1, A2, & A3 BY CORROSION SERVICES LTD. DURING MAY 2014

LEGEND	
◉	LEAD SILVER ANODES
◉	MIXED-METAL ANODES
●	STEEL PIPE PILE





DETAIL A

DETAIL B

NOT TO SCALE

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS
Région de Pacifique

REV	DESCRIPTION/DESCRIPTION	DATE
2	BY PWGSC (EH): CATHODIC PROTECTION UPGRADE TO SOUTH JETTY BY CORROSION SERVICES LTD.; UPDATES TO THE STYLE OF ANODES USED THROUGHOUT SOUTH JETTY	05/2014
1	BY PWGSC (EH): HAND DRAWN SCAN OF PDF CONVERSION TO CAD BY PWGSC ELECTRICAL SHOP FOR FUTURE ANODE ADDITIONS	03/2014

Client/client

ESQUIMALT GRAVING DOCK

ESQUIMALT, BC

Project title/Titre du projet

ESQUIMALT GRAVING DOCK SOUTH JETTY CATHODIC PROTECTION

Consultant Signature Box Only

Designed by/Concept par

Drawn by/Dessine par
ERIC HARROP 2014/03/13

PWGSC Project Manager/Administrateur de Projets TPSGC
JOE LEZETC

PWGSC, Regional Manager, Architectural and Engineering Services/ Gestionnaire régionale, Services d'architectural et de génie, TPSGC

Drawing title/Titre du dessin

ELECTRICAL WIRING & DETAILS

Project No./No. du projet	Sheet/Feuille	Revision no./ Le Révision no.
PR. 100772	15 OF 75	2

Plot Date: June 19, 2014 3:25 PM
Plotted by: Harropf
C:\DOCUMENTS AND SETTINGS\HARROPF\DESKTOP\DRAWING\CATHODIC PROTECTION SYSTEM REV 2.DWG

PWGSC – B1 – 1000X707

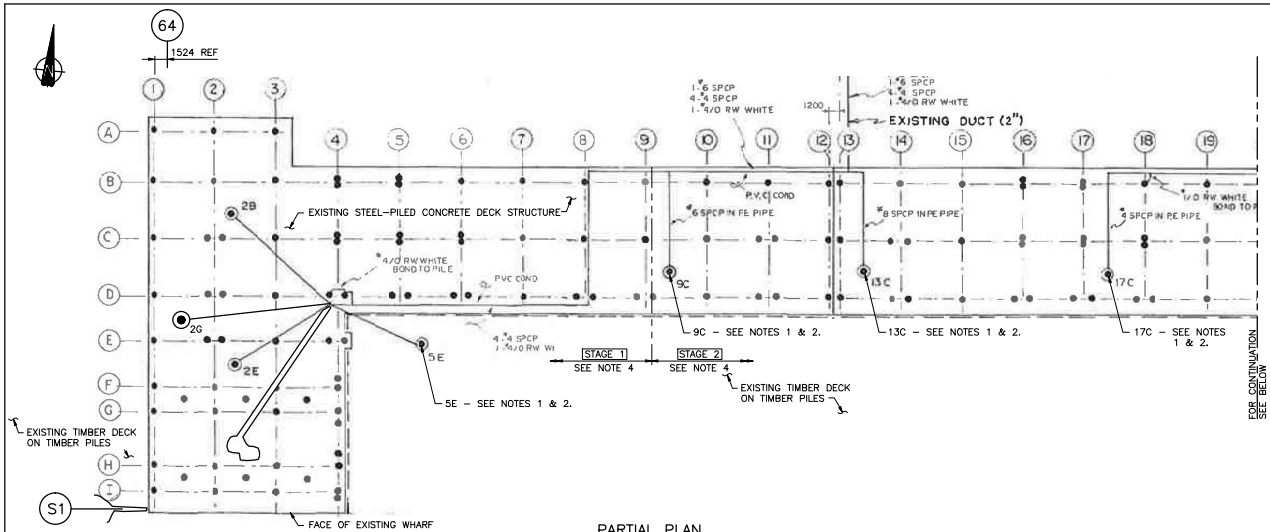
DM5XXXXXX

D6b

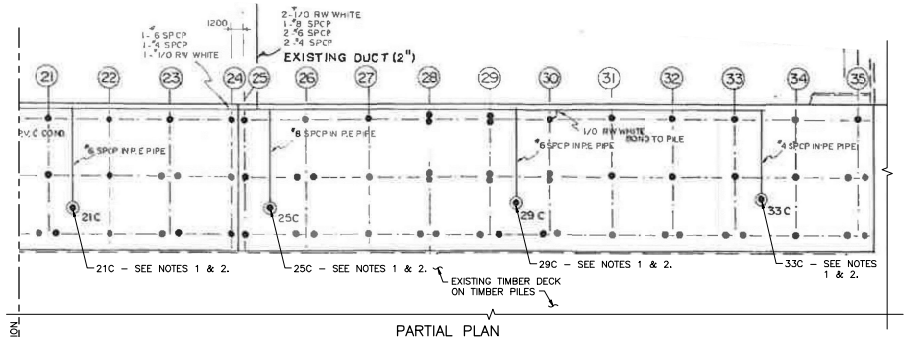
ESQUIMALT GRAVING DOCK

MODIFICATIONS TO CATHODIC PROTECTION

Number of Pages: 1



PARTIAL PLAN
1:250



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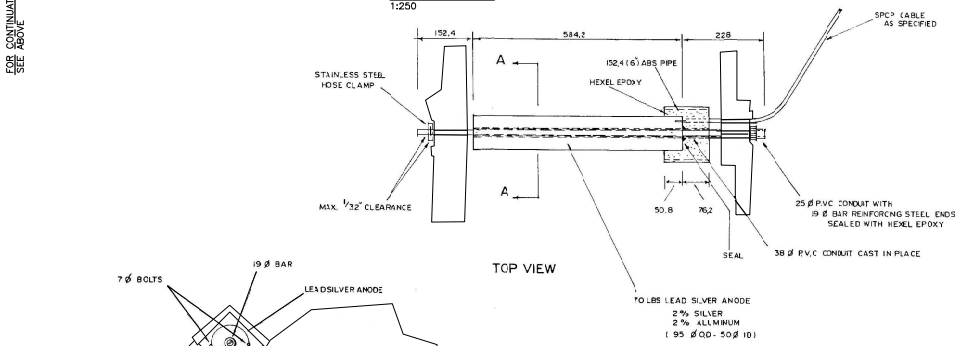
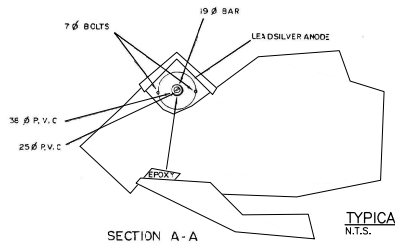
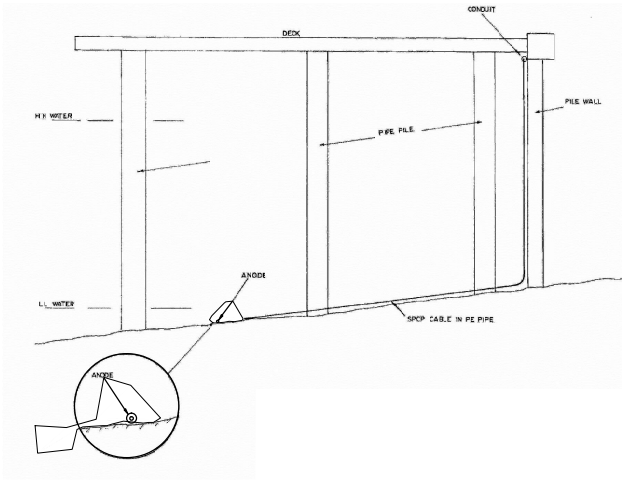
1:250





TYPICAL ANODE ASSEMBLY DETAILS
N.T.S.



TYPICAL SECTION
N.T.S.

HOLD FOR POTENTIAL UPGRADE OF EXISTING ICCP SYSTEM

LEGEND:

- LEAD SILVER ANODE
- EXISTING STEEL PIPE PILE

NOTES:

1. TEMPORARILY REMOVE, STORE AND REINSTATE ANODES TO ORIGINAL LOCATION AFTER DREDGING AND ENGINEERED CAPPING WORK ARE COMPLETED.
2. DO NOT DAMAGE THE INSULATION ON THE ANODE CABLE DURING REMOVAL AND REINSTATING.
3. DETAILS TAKEN FROM ESQUIMALT GRAVING DOCK IMPROVEMENTS, PROJECT NUMBER PR.100772 DRAWINGS 15 AND 16 OF 75. SUPPLIMENTED BY FIELD INFORMATION FROM S&W RECORD DRAWINGS S15 (REFERENCE DRAWINGS).
4. REFER TO SPECIFICATION SECTION 02 41 13 FOR STAGE 1/STAGE 2 REQUIREMENTS.

CORROSION TESTING REQUIREMENTS:

1. INSPECT AND TEST THE ICCP SYSTEM AFTER PARTIAL AND COMPLETE REINSTATEMENT (I.E. AT COMPLETION OF STAGE 1 WORK AND AT COMPLETION OF STAGE 2 WORK) TO CONFIRM THAT THE REINSTATED ICCP SYSTEM PROVIDES THE SAME LEVEL AS PREVIOUSLY EXISTED.

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada
REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

Klohn Crippen Berger

E	REVISED 99% INTEGRATED DESIGN	2014/03/31
D	REVISED 99% INTEGRATED DESIGN	2014/03/28
C	PRELIM 99% INTEGRATED DESIGN	2013/12/18
B	95% INTEGRATED DESIGN	2013/08/23
A	80% INTEGRATED DESIGN	2013/03/15
Revision / Revision	Description/Description	Date/Date

Client/client
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

SOUTH JETTY WHARF DEVELOPMENT

Consultant Signature Only

Designed by/Concept par
GEOFF COOPER

Drawn by/Dessiné par
ARNIE RST

PWGSC Project Manager/Administrateur de Projets TPSGC
JAMIE LeBLANC

Regional Manager, Architectural and Engineering Services
Regional Manager, Environmental Services

Drawing title/Titre du dessin
SOUTH JETTY MODIFICATIONS TO CATHODIC PROTECTION SYSTEM

Project No./No. du projet	Sheet/	Revision no./
R.026729.002 R.018400.002	E11 OF XX	E

PWGSC – A1 – 841X594

0 10 20 30 40 50 60 70 80 90 100mm

DMS XXXXXX

D6c

ESQUIMALT GRAVING DOCK

CATHODIC PROTECTION MAINTENANCE SURVEY
(2014)

Number of Pages: 26

January 30th, 2014

Esquimalt Graving Dock
825 Admirals Rd.
Victoria, B.C.
V9A 2P1

Attention: Mr. Joe Lezetc
Electrical Department

Re: Cathodic Protection Maintenance
Esquimalt Graving Dock - South Landing Wharf
Victoria, B.C.

The annual inspection for the above noted facility was completed on December 11th, 2013. Please find attached our report, including rectifier, current and potential data as well as a drawing showing the dock structure and the protection system. A summary of the survey results is as follows.

1. Protection Criteria

Please see Appendix I of the survey report for the National Association of Corrosion Engineers (NACE) Protection Criteria, Standard SPO169-2007. Note that for saltwater environments a silver-silver chloride reference electrode is generally used with an equivalent potential of 800 millivolts negative.

2. Survey Results

2.1. Rectifier Operation: The impressed current system includes two 18 volt, 200 amp rectifiers. The rectifiers were inspected and found to be operating normally: the west unit at 7.6 volts producing 57.5 amps with a circuit resistance of 0.132 ohms, the east unit at 7.1 volts producing 50.5 amps with a circuit resistance of 0.141 ohms.

The systems should be left on at all times except during dock work or other unusual conditions. Monthly or quarterly checks on system output should be undertaken with a total target current level of approximately 100 amps. Changes greater than 15% in output should be reported to Corrosion Service Company.

2.2. Status of Protection: As the data shows in Appendix III, potential measurements meet the equivalent NACE No. 1 Protection Criterion at most test locations. A significant exception however, is at west end of the dock in rows 1 - 4, Bents G – I (see Appendix V drawing) were protection levels are significantly diminished and do not meet the required NACE Protection.

Based on an initial visual inspection we conclude that the reduced protection levels may result from a mechanical short to the new sheet pile wall through tie-back structures anchored to the existing pile cap. To restore proper protection to the pile structure we recommend follow-up review and investigation and repair/upgrade work as required.

Aside from the above scope of work regular checks on system outputs and a complete maintenance survey by year end are also recommended.

We trust this information is to your satisfaction and note your invoice for the survey work and this report will be sent directly from our Toronto office. If you have questions or require additional copies of the report please contact the undersigned at our Annacis Island office.

Yours truly,

Corrosion Service Company Limited

Ross Armstrong
Branch Manager
NACE Certified, No. 6520

Encl.

CORROSION SERVICE

CP System	MAINTENANCE SURVEY

CATHODIC PROTECTION MARINE PILES

Esquimalt Graving Dock South Landing Wharf

PUBLIC WORKS CANADA

Prepared for: Public Works Canada
825 Admirals Road
Victoria, B.C. V9A 2P1

Prepared By: _____

Ross Armstrong
Branch Manager
NACE Certified No. 6520

Date: December 2013

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REPORT SUMMARY

The survey and inspection work for the subject systems was completed on December 11th, 2013. A summary of the findings is as follows.

1. Protection Criteria

Please see Appendix I of the report for the National Association of Corrosion Engineers (NACE) protection criteria, Standard SPO169-2007. For saltwater environments a silver-silver chloride reference electrode is generally used with an equivalent potential of 800 millivolts negative.

2. Survey Results

2.1 Rectifier Operation: The impressed current system includes two 18 volt, 200 amp rectifiers. The rectifiers were inspected and found to be operating normally: the west unit at 7.6 volts producing 57.5 amps with a circuit resistance of 0.132 ohms, the east unit at 7.1 volts producing 50.5 amps with a circuit resistance of 0.141 ohms.

The systems should be left on at all times except during dock work or other unusual conditions. Monthly or quarterly checks on system output should be undertaken with a total target current level of approximately 100 amps. Changes greater than 15% in output should be reported to Corrosion Service Company.

2.2. Status of Protection: As the data shows in Appendix III, potential measurements meet the equivalent NACE No. 1 Protection Criterion at most test locations. A significant exception however, is at west end of the dock in rows 1 - 4, Bents G – I (see Appendix V drawing) where protection levels are significantly diminished and do not meet the required NACE Protection.

Based on an initial visual inspection we conclude that the reduced protection levels at the west end of dock may result from a mechanical short to the new sheet pile wall through tie-back structures anchored to the existing pile cap. To restore proper protection to the pile structure we recommend follow-up review and investigation and repair/upgrade work as required.

Aside from the above scope of work regular checks on system outputs and a complete maintenance survey by year end are also recommended.

1.0 BACKGROUND

1.1 A cathodic protection system was installed at the subject site in 1986. Cathodic protection is provided to the South Landing Wharf including the piling supports and the sheet pile wall. The installation was completed by Ricketts-Sewell Electric Ltd. of Victoria.

1.2 Since that time the system has performed well. Rectifier outputs have been allowed to decline as structure polarization has generally maintained protection levels at reduced current levels.

1.3 To improve protection levels in some areas several new lead silver anodes were installed in May 1999. The anode installation has provided a more balanced current discharge and as a result system outputs have been reduced.

1.4 During July 2006 two new 50lb. lead silver anodes were installed for the west rectifier. Other work included replacement of failed conduit straps as well as cleaning and coating of some bond connections.

1.5 The last complete survey was undertaken in December of 2012. At that time protection levels were found to be complete on most accessible piles and complete to near complete on the sheet pile wall.

1.6 During October 2012 three replacement Mix Metal Oxide (MMO) anodes were installed for the West Rectifier. The anodes are sized to match the output and design life of the existing lead silver anodes.

1.7 This report covers the 2013 maintenance survey of the above noted systems conducted by Corrosion Service Company Limited.

2.0 PURPOSE

2.1 To determine the status of the anodes, rectifiers and associated wiring.

2.2 To measure rectifier outputs, bond, ground and anode lead drains. To inspect cables and other provisions for condition and operation.

2.3 To make adjustments and undertake minor repairs to the system to achieve optimum performance.

2.4 To determine the level and extent of protection being achieved throughout dock structure.

2.5 To report on the survey results and to make recommendations for maintaining complete protection.

3.0 PROCEDURE

3.1 Survey Equipment

- Simpson model 400 multimeters,
- T & R or Neilson Copper Sulphate Electrodes,
- CCPL-3 silver-silver chloride electrode
- Swain model Sea Clip D.C. ammeter

3.2 The rectifiers were inspected. Voltage and current readings were recorded and total circuit resistance was calculated. To check meter accuracy, readings were taken with an external meter.

3.3 For the dock facility, structure-to-water constant on potential readings were recorded for as many of the accessible piles and sheet pile wall as possible (See Appendix IV).

3.4 Negative and anode leads were measured for current drains.

3.5 All data was tabulated and analyzed in the preparation of this report.

4.0 DISCUSSION OF RESULTS

4.1 Status of Facilities

4.11 **Rectifiers**: The impressed current system includes two 18 volt, 200 amp rectifiers. The rectifiers were inspected and found to be operating normally: the west unit at 7.6 volts producing 57.5 amps with a circuit resistance of 0.132 ohms, the east unit at 7.1 volts producing 50.5 amps with a circuit resistance of 0.141 ohms.

The systems should be left on at all times except during dock work or other unusual conditions. Monthly or quarterly checks on system output should be undertaken with a total target current level of approximately 100 amps. Changes greater than 15% in output should be reported to Corrosion Service Company Limited.

4.12 **Anodes**: Current readings were recorded for individual anodes and for negative bond connections. As the data shows all anodes for both systems are producing satisfactory current outputs.

4.2 Status of Protection

4.21 Protection Criterion

For interpretation of potential data see Appendix I: National Association of Corrosion Engineers (NACE) Protection Criteria, standard SPO169-2007. For saltwater environments a silver-silver chloride electrode is generally used with an equivalent referenced potential of 800 millivolts negative.

Note that polarized potentials cannot be measured for the dock structure, as protective current from the rectifiers cannot be interrupted during the potential measurement. To minimize IR drop reading error, potential measurements are recorded in close proximity to pile surfaces at locations remote from the anodes. In highly conductive electrolytes, such as saltwater, voltage drops other than those across the structure to electrolyte boundary are expected to be very low and as such should not add significant error to potential measurements.

4.22 Dock Structure

As the data shows, protection levels are generally similar to the last survey in 2012 (see Appendix IV), and at most test locations, potential measurements meet the equivalent NACE No. 1 Protection Criterion. . A significant exception however, is at west end of the dock in rows 1 - 4, Bents G – I (see Appendix V drawing) where protection levels are significantly diminished and do not meet the required NACE Protection. Based on an initial visual inspection we conclude that reduced protection levels at the west end of dock may result from a mechanical short to the new sheet pile wall through tie-back structures anchored to the existing pile cap. To restore proper protection to the pile structure we recommend follow-up review and investigation and repair/upgrade work as required.

5.0 RECOMMENDATIONS

5.1 Monthly or quarterly checks on system output should be undertaken with a target total target current level of approximately 100 amps. Changes greater than 15% in output should be referred to CSCL. ror review.

5.2 At the first opportunity investigate the apparent short and reduced protection levels at the west end of the dock.

5.3 Undertake a complete maintenance survey by year end.

Appendix I
Protection Criteria

APPENDIX I

CATHODIC PROTECTION CRITERIA

From National Association of Corrosion Engineers (NACE)
Standard SPO169-2007

1. A negative (cathodic) potential of at least 850 mV with the cathodic protection applied. This potential is measured with respect to a saturated copper-copper sulphate electrode contracting the electrolyte. Voltage drops other than those across the structure to electrolyte boundary must be considered for valid interpretation of this voltage measurement. "Consideration" is understood to mean the application of sound engineering practice in determining the significance of voltage drops by methods such as the following:

    - Measuring or calculating the voltage drop(s).
    - Reviewing the historical performance of the cathodic protection system.
    - Evaluating the physical and electrical characteristics of the structure and its environment.
    - Determining whether or not there is physical evidence of corrosion.

2. A negative polarized potential of at least 850 mV measured with respect to a saturated copper-copper sulphate electrode contacting the electrolyte

3. A minimum of 100 mV of cathodic protection between the structure and a stable reference electrode contacting the electrolyte. The formation or decay of polarization can be measured to satisfy this criterion.

ALTERNATE REFERENCE ELECTRODES

Other standard reference electrodes may be substituted for the saturated copper/copper sulphate reference electrode. Two commonly used reference electrodes are listed below along with their voltage equivalent (at 25ºC [77ºF]) to –850 mV referred to a saturated copper/copper sulphate reference electrode.

1. Saturated KCL calomel reference electrode: -780 mV; and
2. Saturated silver/silver chloride reference electrode used in 25 ohm-cm seawater: -800 mV.

Appendix II
Rectifier Data

APPENDIX II-1
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

RECTIFIER "A" PERFORMANCE DATA (West Rectifier, Near Bent 42)
Model No: CSOWTZ 18-200EPZ, Serial No. 86C1051
Note: AF: As Found, AL: As Left, Set: System Activated

DATE	TIME	BY	STATUS	TAP	VOLTS	AMPS	OHMS	HOURS
07-13-06	9:30	RJA	AF	CBF4	8.0	62.0	0.129	32263
			Meter Check		7.8	62.5	0.125	
12/13/07	11:00	RJA	AF/AL	CBF4	8.0	60.0	0.133	40998
			Meter Check		7.4	56.0	0.133	
12/16/08	10:30	RJA	AF/AL	CBF4	8.0	60.0	0.133	49842
			Meter Check		7.8	60.5	0.129	
12/16/09	10:30	RJA	AF/AL	CBF4	8.0	55.0	0.145	58295
			Meter Check		7.9	54.0	0.146	
12/09/10	10:30	RJA	AF/AL	CBF4	8.0	48.0	0.167	66674
			Meter Check		8.3	41.5	0.200	
12/07/11	11:15	RJA	AF/AL	CBF4	7.5	50.0	0.150	74950
			Meter Check		8.3	37.8	0.220	
03-10-12	10:00	RJA	AF	CBF4	8.3	34.5	0.241	82145
			AL		8.1	60.0	0.135	
11/12/12	09:00	RJA	AF/AL	CBF4	8.0	60.0	0.133	n/a
			Meter Check		7.8	60.8	0.128	
12/11/13	11:30	RJA	AF/AL	CBF4	8.0	60.0	0.133	n/a
			Meter Check		7.6	57.5	0.132	

APPENDIX II-2
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

RECTIFIER "B" PERFORMANCE DATA (East Rectifier, Near Bent 20)
Model No: CSOWTZ 18-200EPZ, Serial No. 86C1052
Note: AF: As Found, AL: As Left, Set: System Activated

DATE	TIME	BY	STATUS	TAP	VOLTS	AMPS	OHMS	HOURS
12-13-07	10:30	RJA	AF/AL	CBF3	7.5	50.0		15570
			Meter Check		7.1	49.0	0.145	
12-16-08	10:45	RJA	AF/AL	CBF3	7.5	50.0		15570
			Meter Check		7.3	51.5	0.141	
12-16-09	11:00	RJA	AF/AL	CBF3	7.5	50.0		15570
			Meter Check		7.4	52.0	0.141	
12-09-10	11:00	RJA	AF/AL	CBF3	7.5	50.0		n/a
			Meter Check		7.6	52.0	0.146	
12/07/11	11:00	RJA	AF/AL	CBF3	7.5	50.0		n/a
			Meter Check		7.2	49.0	0.147	
12/11/12	09:30	RJA	AF/AL	CBF3	7.5	50.0		n/a
			Meter Check		7.4	52.5	0.140	
12/11/13	11:30	RJA	AF/AL	CBF3	7.5	50.0	0.150	n/a
			Meter Check		7.1	50.5	0.141	

Appendix III
Anode Data

APPENDIX III-1
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

ANODE TO STRUCTURE CURRENT DATA - RECTIFIER A (West Rectifier)

SURVEY DATE	12/07/11	11/03/12		12/11/12	12/11/13
SURVEY BY	R.J.A.	R.J.A.		R.J.A.	R.J.A.
CURRENT	37.8 Amps	34.5	60.1	60.8	57.5
Anode Cable #					
1	0.0	0.0	12.0	11.4	10.7
2	12.5	7.5	5.5	5.9	10.8
3	0.0	0.0	11.4	10.9	9.4
4	0.0	0.0	10.3	10.4	8.9
5	11.1	12.1	9.5	9.8	9.5
6	14.8	13.9	11.3	11.1	11.6
Anode Total	38.4	33.5	60.0	59.5	60.9
Negative Cable	37.9			60.0	

APPENDIX III-2
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

ANODE TO STRUCTURE CURRENT DATA - RECTIFIER B (East Rectifier)

SURVEY DATE	12-07-11	12/11/12	12/11/13
SURVEY BY	R.J.A.	R.J.A.	R.J.A.
CURRENT	49.0 Amps	60.8	50.5
Anode Cable #			
1	11.0	11.2	10.8
2	10.1	10.6	10.1
3	9.7	10.4	9.6
4	9.8	10.3	10.6
5	10.4	10.1	9.4
Anode Total	51.0	52.6	50.5
Negative Cable (Structure Bond)			
1	27.0	29.3	
2	23.0	22.8	
Total	50.0	52.1	

Appendix IV

Potential
Survey Data

APPENDIX IV-1
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

PILE-TO-WATER POTENTIAL MEASURMENTS, MILLIVOLTS NEGATIVE
Readings to Silver-Silver Chloride Reference Electrode
Except Where Noted All Measurments Recorded In Water At 1 Meter Depth

SURVEY DATE	12/16/09	12/09/10	12/07/11	12/11/12	12/11/13
SURVEY BY	R.J.A	R.J.A	R.J.A	R.J.A	R.J.A
CURRENT	106 Amps	94 Amps	87 Amps	113 AMPS	108 AMPS
Pile Location					
W1					
W2					
W3					
W4					
W5					
W6					
W7					
W8					
W9					
W10	843	828		820	
W11	833	843	840	840	
W12	828	816	830	960	820
W13	812	816	846	815	814
W14	805	790	823	821	809
W15	783	785	804	800	
W16	805	800	890	800	880
W17	865	800	900	870	870
W18	800	863	900	865	
W19	825	863	909	858	790
W20	870	823	909	790	813
W21	865	775	800	811	
W22					
W23	870	810	817	860	
W24	870	858	845	861	
W25	922	858	860	903	930
W26	926	842	900	903	940
W27	926	860	912	953	940
W28	956	907	930	950	968
W29	986	915	912	963	1000
W30	983	915	915	948	980
W31	998	956	951	980	1027
W32	997	990	960	946	1030
W33	950	990	961	923	1040

APPENDIX IV-2
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

PILE-TO-WATER POTENTIAL MEASURMENTS, MILLIVOLTS NEGATIVE
Readings to Silver-Silver Chloride Reference Electrode
Except Where Noted All Measurments Recorded In Water At 1 Meter Depth

SURVEY DATE	12/16/09	12/09/10	12/07/11	12/11/12	12/11/13
SURVEY BY	R.J.A	R.J.A	R.J.A	R.J.A	R.J.A
CURRENT	106 Amps	94 Amps	87 Amps	113 AMPS	108 AMPS
Pile Location					
A1	1037	1020	1033	1067	960
A2	992	980	1010	1036	894
A3	964	826	1021	953	
B1	1047	1000	1049	1094	950
B2	1034	970	1017	1063	1102
B3	992	956	1001	1020	
B4					
B5					
B6					
B7					
B8					
B9					
B10	998	986		988	
B11	1000	1010	950	1012	952
B12	1009	965	1075	970	940
B13	984	963	970	980	924
B14	968	932	946	970	890
B15	937	963	1000	950	
B16	959	930	925	1060	940
B16 WEST	959	923	985	1057	943
B17	1028	1054	985	1050	1085
B17 WEST	1028	1065	1140	1050	1080
B18	1108	1040	1100	1070	1750
B19	946	920	983	956	880
B20	962	945	935	963	940
B21	1020	993	960	1017	
B22	1010	990	1020	1030	
B23	1012	970	1063	1047	
B24	1030	958	1050	1037	1035
B25	1030	990	1044	1046	1050
B26	1077	1082	1076	1067	1000
B27	1077	1089	1098	1043	1065

APPENDIX IV-3
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

PILE-TO-WATER POTENTIAL MEASURMENTS, MILLIVOLTS NEGATIVE
Readings to Silver-Silver Chloride Reference Electrode
Except Where Noted All Measurments Recorded In Water At 1 Meter Depth

SURVEY DATE	12/16/09	12/09/10	12/07/11	12/11/12	12/11/13
SURVEY BY	R.J.A	R.J.A	R.J.A	R.J.A	R.J.A
CURRENT	106 Amps	94 Amps	87 Amps	113 AMPS	108 AMPS
Pile Location					
B28	1098	1106	962	1058	1086
B28 WEST	1098	1105	970	1058	1086
B29	1200	1209	1040	1153	1236
B29 WEST	1200	1208	1042	1070	1240
B30	1150	1161	1057	1100	1080
B31	1141	1106	1057	1054	1124
B32	1151	1146	1037	1023	1100
B33					
B34					
C1	1090	1037	1100	1165	1070
C2	1092	1010	1057	1170	1028
C2 WEST	1047	1005	1057	1100	1000
C3	1047	956	1000	1030	938
C4	1000	957			
C5					
C6					
C7					
C8	974	944	931	940	870
C9	967	1040	1023	964	902
C10	1116	1120	1237	1040	1080
C11	1145	1170	1180	1116	1060
C11 WEST	1145	1199	1200	1120	1075
C12	1112	1140	1110	1060	1050
C13	1122	1150	1120	1060	1060
C14	1105	1142	1167	1059	1050
C14 WEST	1085	1123	1150	1093	1045
C15	1028	1040	1053	1045	970
C16	1010	993	1060	1014	960
C16 WEST	1010	987	1058	1012	960
C17	1075	1058	1127	1080	1130
C17 WEST	1082	1075	1125	1095	1135
C18	1175	1220	1290	1174	1230

APPENDIX IV-4
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

PILE-TO-WATER POTENTIAL MEASURMENTS, MILLIVOLTS NEGATIVE
Readings to Silver-Silver Chloride Reference Electrode
Except Where Noted All Measurments Recorded In Water At 1 Meter Depth

SURVEY DATE	12/16/09	12/09/10	12/07/11	12/11/12	12/11/13
SURVEY BY	R.J.A	R.J.A	R.J.A	R.J.A	R.J.A
CURRENT	106 Amps	94 Amps	87 Amps	113 AMPS	108 AMPS
Pile Location					
C18 WEST	1175	1215	1273	1173	1230
C19	1052	1026	1286	1040	995
C20	1034	1000	1285	1119	992
C21	1108	1072	1100	1180	1150
C22	1085	1142	1062	1090	1226
C23	1085	1069	1184	1075	1050
C23 WEST	1060	1072	1144	1080	1051
C24	1080	1054	1140	1088	1129
C25	1090	1062	1123	1085	1085
C26	1175	1128	1130	1137	1132
C26 WEST	1175	1133	1197	1128	1145
C27	1124	1117	1180	1137	1114
C28	1117	1125	1163	1096	1154
C28 WEST	1119	1122	1160	1096	1155
C29	1243	1220	1260	1234	1310
C29 WEST	1243	1240	1270	1280	1323
C30	1198	1222	1310	1275	1230
C30 WEST	1198	1223	1242	1186	1230
C31	1122	1121	1146	1116	1150
C32	1207	1208	1270	1205	1140
C33	1198	1258	1246	1216	1070
C34	1088	1097	1107	1100	1085
D1	1111	994	1091	1160	1024
D2	1069	987	1020	1132	980
D2 WEST	1068	966	1021	1105	980
D3	1040	947	1012	1056	1010
D4	1036	938	998	1063	904
D4 WEST	1020	936	1002	1010	840
D5					
D5 WEST					
D6					
D6 WEST					
D7					

APPENDIX IV-5
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

PILE-TO-WATER POTENTIAL MEASURMENTS, MILLIVOLTS NEGATIVE
Readings to Silver-Silver Chloride Reference Electrode
Except Where Noted All Measurments Recorded In Water At 1 Meter Depth

SURVEY DATE	12/16/09	12/09/10	12/07/11	12/11/12	12/11/13
SURVEY BY	R.J.A	R.J.A	R.J.A	R.J.A	R.J.A
CURRENT	106 Amps	94 Amps	87 Amps	113 AMPS	108 AMPS
Pile Location					
D8	935	940	930	930	860
D8 WEST	935	945	950	923	830
D9	985	1010	967	963	910
D9 WEST	985	1012	991	970	916
D10	1165	1040	990	1094	1042
D11	1130	1100	1196	1100	1046
D11 WEST	1130	1110	1165	1042	1048
D12	1143	1109	1170	1126	1114
D13	1150	1130	1240	1136	1109
D14	1130	1154	1238	1024	1142
D14 WEST	1130	1160	1150	1027	1138
D15	1033	1142	1240	1069	980
D16	1064	1140	1240	1070	985
D16 WEST	1070	1206	1150	1085	965
D17	1063	1188	1070	1058	1006
D17 WEST	1060	1110	1070	1060	1010
D18	1087	1022	1162	1140	1042
D18 WEST	1087	1018	1107	1135	1043
D19	1050	1062	1130	1202	1000
D20	1059	1057	1133	1170	1040
D20 WEST	1059	1066	1090	1202	1030
D21	1146	1037	1093	1118	1114
D21 WEST	1143	1056	1090	1122	1120
D22	1214	1053	1095	1118	1249
D23	1127	1140	1190	1120	1080
D23 WEST	1127	1163	1090	1220	1074
D24	1167	1111	1158	1200	1140
D25	1160	1112	1157	1176	1130
D26	1210	1222	1220	1181	1238
D26 WEST	1200	1208	11219	1121	1233
D27	1130	1213	1289	1122	1140

APPENDIX IV-6
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

PILE-TO-WATER POTENTIAL MEASURMENTS, MILLIVOLTS NEGATIVE
Readings to Silver-Silver Chloride Reference Electrode
Except Where Noted All Measurments Recorded In Water At 1 Meter Depth

SURVEY DATE	12/16/09	12/09/10	12/07/11	12/11/12	12/11/13
SURVEY BY	R.J.A	R.J.A	R.J.A	R.J.A	R.J.A
CURRENT	106 Amps	94 Amps	87 Amps	113 AMPS	108 AMPS
Pile Location					
D28	1130	1130	1184	1190	1116
D28 WEST	1130	1139	1156	1170	1116
D29	1240	1140	1158	1224	1228
D29 WEST	1237	1271	1276	1225	1240
D30	1190	1259	1299	1183	1185
D30 WEST	1190	1187	1232	1171	1202
D31	1192	1195	1223	1180	1120
D32	1163	1101	1170	1132	1154
D32 WEST	1163	1210	1181	1137	1160
D33	1167	1140	1070	1153	1220
D33 WEST	1167	1158	1205	1156	1210
D34	1070	1058	1080	1070	1054
E1	1107	992	1050	1149	1011
E2	1072	973	1020	1090	910
E2 WEST	1055	968	1020	1086	869
E3	1030	952	980	1050	808
E4	1016	937	970	1020	815
E4 WEST	1016	933	965	1020	900
F1	1100	960	1021	1110	890
F2	1050	958	1018	1094	800
F3	1062	935	970	1060	790
F4	1040	940	994	1034	726
F4 WEST	1039	943	992	1040	740
MF1	1040	950	1009	1082	870
MF2	1085	934	960	1030	880
MF3	1102	900	954	975	810
G1	1100	956	1023	1096	723
G2	1092	953	1017	1070	730
G3	1060	937	989	1030	720
G4	1043	941	993	1030	760
G4 WEST	1045	940	994	1050	860

APPENDIX IV-7
PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK
SOUTH LANDING WHARF PILING

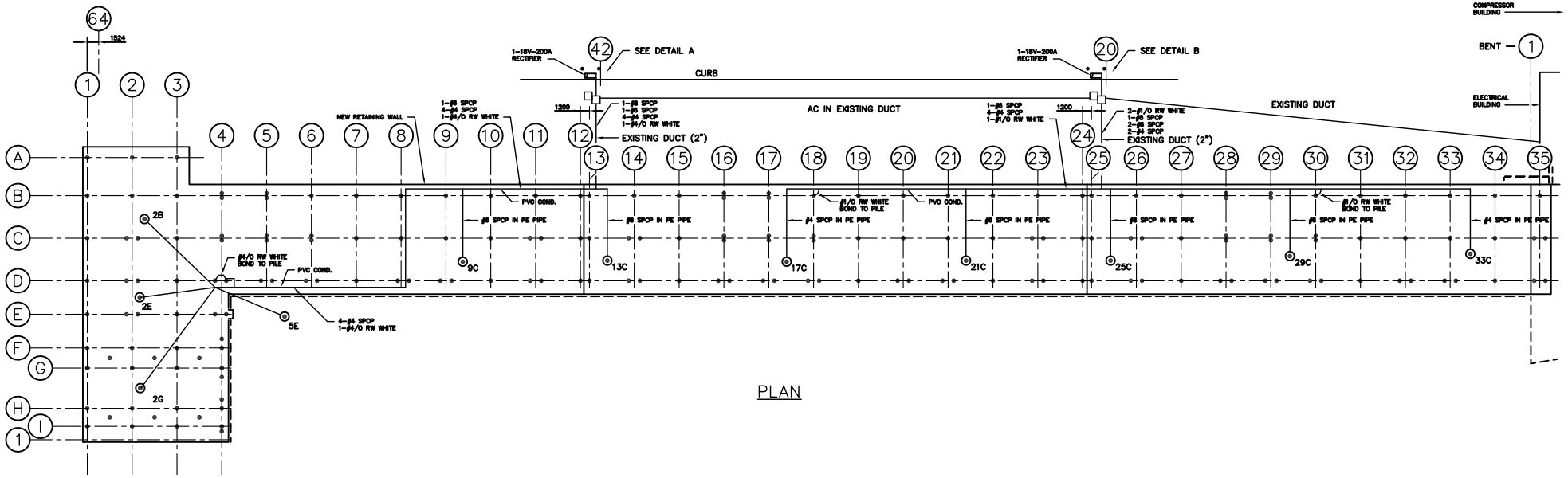
PILE-TO-WATER POTENTIAL MEASURMENTS, MILLIVOLTS NEGATIVE
Readings to Silver-Silver Chloride Reference Electrode
Except Where Noted All Measurments Recorded In Water At 1 Meter Depth

SURVEY DATE	12/16/09	12/09/10	12/07/11	12/11/12	12/11/13
SURVEY BY	R.J.A	R.J.A	R.J.A	R.J.A	R.J.A
CURRENT	106 Amps	94 Amps	87 Amps	113 AMPS	108 AMPS
Pile Location					
H1	1105	964	1020	1023	790
H2	1100	954	1029	1032	782
H3	1040	944	940	1060	740
H4	1050	950	1007	1074	633
H4 WEST	1045	946	1002	1080	710
MH1	1055	962	1026	1030	732
MH2	1040	950	930	1075	740
MH3	1045	975	999	1080	
I1	1132	964	1020	HT	700
I2	1117	958	1030	HT	764
I3	1040	942	1036	HT	740
I4	1040	944	1006	HT	680
I4 WEST	1037	947	1015	1085	645

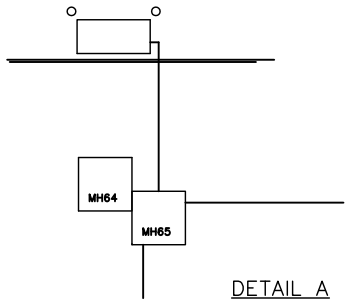
Appendix V

System Drawing

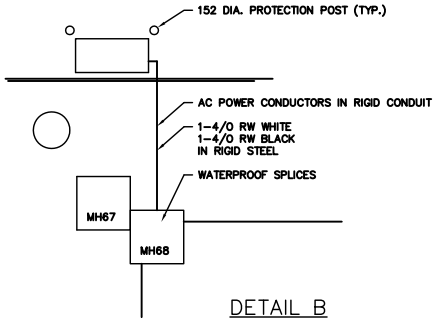
WEST COAST CORROSION PREVENTION LTD.
Corrosion Protection in Soil and Water
Petroleum – Municipal – Marine
SURVEY, BRITISH COLUMBIA



PLAN



DETAIL A



DETAIL B

LEGEND

- LEAD SILVER ANODES
- STEEL PIPE PILE

No.	REVISION	DATE	BY
03	MMO Anodes 5E, 2B & 2G replaced Oct 2012	08/01/06	RA
02	Anodes 2E & 2G replaced July 2006	08/01/06	RA
01	Anodes 9C & 17C replaced May 1999	04/05/00	RA

FOR: PUBLIC WORKS CANADA
ESQUIMALT GRAVING DOCK IMPROVEMENTS
CATHODIC PROTECTION SYSTEM

redrawn on cad from dwg. 15 of 75
proj. no. PR. 100772

DWG. No. BPWV0253
SCALE: N.T.S.
DWG. BY: J.V.V. DATE: 6/16/94
SRV'D BY: DATE:

D6d

ESQUIMALT GRAVING DOCK

CATHODIC PROTECTION STUDY (2016)

Number of Pages: 8

Facility Owner:

Public Works Canada

Prepared for:

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Revision Table:

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September 21, 2016

Herold Engineering Ltd.
1051 Vancouver St.
Victoria, B.C. V8V 4T6

Attention: Kate Ulmer, P.Eng
Associate

Re: Cathodic Protection Design Review
Esquimalt Graving Dock (EGD)
South Jetty Wharf Development
Victoria, B.C.

As requested we have undertaken a cathodic protection (cp) study for the above noted facility. In the following sections we provide background information on corrosion and cathodic protection, review the construction details of the proposed and existing wharf structures, examine cathodic protection design options and provide a cp system recommendation complete with initial cost estimate. Details are as follows.

1. Study Scope

The study scope covers initial review and pricing of cathodic protection for the EGD South Jetty Wharf Development project. For corrosion mitigation it is understood the subject structures will be provided a high quality coating (epoxy or similar) from the pile cap through to the mudline complimented by cathodic protection. In summary, we have assumed the cathodic protection should be designed to provide a minimum 20 year service life and for a more detailed discussion of system design life and related considerations see section 3.3 below.

2. Corrosion & Cathodic Protection Background

2.1. Marine Corrosion & Cathodic Protection

Cathodic protection is an effective method of eliminating corrosion in marine environments. In the inter-tidal zone the level of protection is dependent on the elevation above low tide. Typically, cathodic protection is totally effective to the mid tide level and below including seabed penetrations. Through the upper tidal zone protection levels decrease and above high tide there is no effect. For marine applications then, an ideal corrosion protection system includes cathodic protection used in conjunction with a structure coating, which is installed in at least the inter-tidal zone. Cathodic protection of the submerged portion of the marine structures in addition to the lower half of the tidal zone can be achieved by sacrificial anodes or an impressed current system. Details of these types of systems are as follows.

2.2. Sacrificial Cathodic Protection

"Sacrificial" type cathodic protection utilizes the inherent nature of reactive metals such as aluminum, zinc or magnesium to provide energy for the protection system. Through electrolysis the energy becomes available when potential difference between dissimilar metals (the anode material verses the ferrous metal of the dock structure) is configured in an electrical circuit and the anode material is consumed. This electrochemical energy source is similar to a battery.

Aluminum and zinc are common sacrificial anodes. Both are widely used in marine applications and although zinc provides better performance under more variable conditions, the consumption rate by weight is approximately three times that of aluminum often making it the less economical choice. In summary for the purposes of cost comparison we have chosen a standard 96kg. aluminum anode assembly which has proven to be reliable as well as cost effective to purchase and install. Advantages of sacrificial systems include:

- Relatively simple design and installation,
- Easier and less costly to protect smaller, physically remote or isolated structures,
- Generally most cost effective option for smaller current requirement systems,
- System material is easy and inexpensive to manufacture and replace,
- No AC power required, so no operational costs and reduced maintenance costs,
- Reduced or absent structure continuity bond requirements,
- Minimal or absent complication relating to interference effects on un-bonded foreign structures such as vessels, barges, etc. berthed at the terminal.

2.3. Impressed Current Cathodic Protection

Impressed current cathodic protection is provided by a combination of rectifier power supply, impressed current anodes and coupling conductors and hardware. To power the electrolysis reaction these systems convert A.C. to D.C. power. General configurations often include one or more rectifier power supplies and cast iron or mixed metal oxide anode assemblies System advantages include:

- The capital cost of an equal life system is generally lower for larger current requirement systems with a breakeven point in the range of approximately 100 amps. In summary, below this value capital costs for a sacrificial system are lower whereas above this value capital costs increasing favour the use of impressed current systems.
- It is easier to adjust for losses in anodes or additions to the dock structure,
- After the anodes are consumed, usually only the anodes and anode cables need replacement,
- Extra system capacity can protect new structures or provide extended service life.

3. Subject Facility Review

3.1. Facility Description

Select sheets from the provided drawing package for project #R.026729.002, were used as references for the subject review. Cathodic protection is to be provided to the following structures at the marine facility including:

- West Jetty: Wharf replacement structure, including 102 - 762mm diameter coated steel piles. Also 14 – 762mm diameter steel displacement control piles with bedrock anchors.
- South Jetty: Wharf replacement structure, including 100 - 762mm & 914mm diameter coated steel piles.
- Existing South Jetty Dock Structure: The existing pile structure is to be retained including approximately 170 coated steel piles and 200 linear meters of coated sheet pile wall (SPW). In summary, these structures are provided cathodic protection and for more details see the following section.

3.2. Status of Facility

We understand the existing coated steel South Jetty Dock is to be retained. The structure dates from the 1980's and has been provided impressed current cathodic protection (cp) since 1986. The cp system was originally designed and installed by Coproco Corrosion Control, now Corrosion Service, and over the years our company has generally undertaken annual maintenance surveys with some upgrades and repairs completed as required. The original system had a nominal 20 year design life and includes two (2) DC 18V-200A rectifier units complete with seabed placed anode assemblies. The anodes were a 50lb., 2% lead silver type and over the last 10 years as they have failed a Mixed Metal Oxide (MMO) replacement has been installed, such that approximately 2/3 of the original anodes have now been replaced. The last maintenance inspection of the systems dates from 2014 and at that time the systems were found to be operating normally at a total output of approximately about 120 Amps. Finally note that on-going South Jetty Remediation Project has meant that the systems have been off since early 2015 with the anodes and some cabling removed. At this time we are uncertain of the status of these components or the system re-installation-commissioning plans.

In summary for many years the existing cp systems have generally provided satisfactory corrosion protection, however due to system age, limited maintenance work and what we expect may be significant damage due to the Remediation Project, more significant repairs/upgrades will likely to be required in the short to medium term. Finally, if we assume the cathodic protection system service life for both the existing and new pile structures should be similar then we conclude that replacement of the existing cp systems is likely the preferred approach within an overall design concept for the Wharf Development project.

3.3. CP Design, Redundancy and Facility Service Life

As noted above, the design life for the cathodic protection is a minimum twenty years although for the subject structures there is some additional protective capacity based on conservative design estimates and likely reduced, longer term polarization requirements. This may provide either longer service life or more protective capacity for scenarios such as structure additions.

In regard to service life it has been our experience that marine cp systems experience considerable time related deterioration as they approach and exceed 20 years of service and more typically develop significant protection deficiencies as a result of aging cables, bonds and hardware rather than fully consumed anodes. For this reason, regular annual maintenance surveys are recommended and become increasingly important as the marine structures age.

4. System Design Considerations

4.1. Current Requirement

A critical design consideration for providing proper cathodic protection is current requirement. Current requirement calculations are based on unit density recommendations outlined in NACE (National Association of Corrosion Engineers) SP0176-2007. To determine overall system current requirements, the subject structures were inventoried with estimates made for surface area seawater exposures and seabed penetrations. Note that for seawater exposures initial current requirements are higher than mean requirements as a result of structure polarization effects. In Table 1 we summarize our assumptions and estimates and indicate expected overall current requirements for the subject new and existing EGD South Jetty structures[2].

Table 1 Cathodic Protection Design Calculations Summary

Ref.	Esquimalt Graving Dock Facility	Structure Description	Coating Quality Estimate	Total Exposure (Sea/Mud) Surface Area (meter)^2	Required Current Density (mA/meter^2)						Total Required Current (A)	
					Initial[1]			Average[1]			Initial	Average
					Sea	Mud	Rock	Sea	Mud	Rock		
2.	**West Jetty Wharf**	116-762mm Piles	90%	12,936	15	30	2	9	30	2	337	321
3.	**South Jetty Wharf**	100-762/914 mm Piles	90%	9,348	15	30	n/a	9	30	n/a	290	280
	Existing Dock Structure	170 Piles & 200m of SPW	Assumed to be High	Uncertain	n/a						200[2]	120[2]

1: NACE (National Association of Corrosion Engineers) SP0176-2007 Recommended Current Densities, De-rated For Coating Completeness

2: Current Requirements Based on Operational History

4.2. Current Requirement Assumptions and Estimates

As noted above in the summary table a coating quality estimate of 90% complete is used for the new pile structures. As compared to for example, pipeline soil applications this estimate may seem low, however there are several factors which account for this including:

- A conductive, dense electrolyte (seawater) which more readily exposes coating holidays, thinness and other deficiencies,
- Accelerated coating deterioration and much more likely damage due to harsh environmental conditions including seawater and atmospheric/weather exposures, marine life growth, mechanical impacts, etc.,
- Difficult environmental conditions for field handling and field coating applications.

To account for these factors we have de-rated the design estimate coating quality by 10% which is based on considerable empirical experience in marine applications. In addition note that mud exposed surfaces are assumed to be uncoated but have a lower current requirement ($30mA/M^2$) than bare pile surfaces exposed to seawater (un-derated). Note also that the new piles typically have very deep Toe (driven) elevations, typically -20 to -50 meters which greatly increases surface areas where reduced polarization effects occur. The net result is much less difference between initial and mean current requirements as compared to other dock structure applications. Finally note that current requirement estimates for the existing dock structures are based on recent operational values including an expected initial value for depolarization.

In summary and as indicated in the table above the total initial current requirement for both the new and existing pile structures is in the range of 830 Amps while the average requirement is approximately 720 Amps. In summary, this overall current requirement is relatively high and in the absence of other considerations would typically move a cost based design decision strongly in favour of impressed current type systems.

4.3. Structure Continuity

For cathodic protection to be effective sacrificial systems generally require at least some electrical continuity within and in some cases between structures whereas impressed current systems normally require the entire dock structure to be electrically continuous. Depending on the cp system type and the continuity status of the dock structure required bonding work may be minimal in scope and cost or be very significant.

Based on our review of the provided drawings, continuity between piles and/or individual bents can likely be provided through bonding of or within the rebar cage of the prefabricated pile cap/beams. Subsequent bonding between bents can then be made by connecting to the topping slabs, if possible, or independently after construction (details to be confirmed).

4.4. Interference Effects

As noted above for impressed current cp systems to be effective proper electrical continuity must be provided. An additional consideration is interference effects to electrically foreign structures, which can include vessels and barges berthed at the dock facility. In summary berthed vessels may pick up current from the terminal impressed current system(s) and without a return ground path the current can discharge back to the electrolyte (seawater) which may result in accelerated corrosion. This risk is usually be mitigated through vessel cp systems, grounding through shore power services or other paths and/or as can be provided through intentional bonding provisions.

5. Conclusions and Recommendations

Cathodic protection is widely used in many industries and is accepted as a cost effective method of corrosion control. Based on a number of considerations we conclude that an impressed current type cathodic protection system is the preferred option for the subject dock structures. Specific technical and cost considerations include:

- Relatively high overall initial and mean current requirements in the range of DC 800 – 700 amps respectively (see Table 1 above). This results from the relatively large number of piles, approaching 400 as well as the very deep Toe elevations for many of the new piles.
- With a current requirement in the range of 800 Amps, a very large number of sacrificial anodes would be required for a 20 year design life, including 1 to 4 anodes installed on each pile depending on size and other considerations. Although technically feasible, the very large number of required anodes, may make the installation impractical and more costly.
- Although bonding requirements for an impressed current system are more comprehensive than for sacrificial, the cost for this work (scope to be confirmed) will likely be relatively modest, particularly if incorporated in to the dock construction work (see above).
- The cost for a technically equivalent, equal life system likely favours the impressed current option.

5.1. Comparative Cost Estimates

The following lump sum costs are for technically equivalent, 20 year systems delivered on a design build basis. The systems would protect all existing and new piles including the SPW and the pricing is inclusive of all costs for cp materials, labour, sub-contracts and expenses including a design package (drawings and specification), project supervision, construction inspection and system commissioning complete with reporting. Our estimates reflect recent prices charged by British Columbia suppliers and contractors for similar industrial projects in B.C. and we expect the estimates to be accurate within +/-20% pending clarification of design details, project scope, timing, etc.

- Sacrificial System: Inclusive costs for a complete sacrificial system amount to approximately $XXXXXX. This includes XXX 96 kg. sacrificial anodes, all installation labour and services complete with project supervision, system commissioning and reporting etc. as detailed above. Note that depending the continuity status of the dock structures some relatively minor additional bond work may be required.

- Impressed Current System: Inclusive costs for a complete impressed current system amounts to approximately $XXXXXX including all materials (rectifiers, anodes, cabling, etc.) all installation labour and services complete with project supervision, system commissioning and reporting etc.

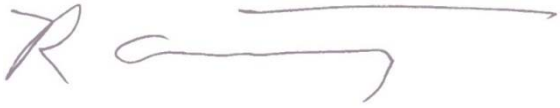
In summary and as can be seen, the costs for a technically equivalent, 20 year system favour the impressed current option. On this basis, as well as technical considerations as noted above we recommend the use of an impressed current type system for protection of all new and existing pile structures for the subject South Jetty Wharf Development project.

We trust this information is to your satisfaction. If you have questions or require further information please contact the undersigned at our Annacis Island office.

Yours truly,

CORROSION SERVCICE COMPANY LTD.

David Coskin, EIT
Systems Specialist
NACE Certified No. 54488



Ross Armstrong
B.C. Regional Branch Manager
NACE Certified No. 6520

D7

ESQUIMALT GRAVING DOCK

SUPPLEMENTARY TEST HOLE INVESTIGATION

GOLDER (2010)

Number of Pages: 399

March 3, 2010

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Esquimalt Graving Dock Waterlot - Supplementary Test Hole Investigation for Remedial Action Plan/Risk Management Plan

Submitted to:
Public Works and Government Services Canada
641 - 800 Burrard Street
Vancouver, BC
V6Z 2V8

REPORT

A world of capabilities delivered locally

Report Number: 09-1475-5008

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3 Copies - Public Works and Government Services Canada
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Golder Associates

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1.0 INTRODUCTION

1.1 Site Description

The Esquimalt Graving Dock (EGD) is located on the north shore of Constance Cove in Esquimalt Harbour, at 825 Admirals Road in the Township of Esquimalt, British Columbia. The EGD Waterlot covers an approximate surface area of 5.5 hectares (ha). The EGD facility is bounded by the Esquimalt and Nanaimo (E&N) Railway and the Songhees Indian Reserve to the north, the Department of National Defence (DND) Munroe Head Property to the northwest, and the DND Naden Base to the east and southeast. The Canadian Forces Sailing Association (CFSA) is located on the northwest tip of the Waterlot.

The EGD facility is operated and managed by Public Works and Government Services Canada (PWGSC) and constitutes federal Crown-owned property. Esquimalt Harbour is administered by the DND and is governed by the *Canada Marine Act*, Transport Canada's Natural and Man Made Harbour Regulations and local policies and procedures. The Harbour Authority is the Queen's Harbour Master, Canadian Forces Base (CFB) Esquimalt.

Constance Cove and Esquimalt Harbour have a long history of naval and industrial activity, dating back to the mid-1800s. In 1921, PWGSC began construction of the Esquimalt Graving Dock (EGD) at Skinner Cove, a natural marine basin on the north shore of Constance Cove. The Dry Dock was developed by blasting and excavating bedrock, with the blast rock used as fill in portions of the Dry Dock. Construction was carried out within a cofferdam system. The EGD was operational by 1926 and became one of the largest solid-bottom dry docks in the world.

The EGD facility structures bounding the Waterlot include the North Landing Wharf (NLW), the Dry Dock and the South Jetty (or South Landing Wharf). To the west of the NLW is the Munroe Head foreshore area.

1.2 Project Background

PWGSC has retained Anchor QEA L.L.C. (Anchor) of Seattle, Washington and Golder Associates Ltd. (Golder) to prepare a Remedial Action Plan (RAP) / Risk Management Plan (RMP) for the Esquimalt Graving Dock Waterlot. The current preferred remedial alternative for the Waterlot involves the dredging of contaminated sediments to the full extent practicable (Anchor RAP/RMP, 2009). This includes dredging contaminated sediments adjacent to sensitive infrastructure; the North Landing Wharf, Dry Dock entrance and South Jetty.

Golder has previously provided a preliminary assessment of the potential geotechnical and infrastructure stability constraints associated with the proposed remedial dredging of the Waterlot, issued in two technical memorandums:

- "Geotechnical Review of Remedial Options for Esquimalt Graving Dock" dated July 6, 2009; and,
- "Infrastructure Stability Considerations for proposed Esquimalt Graving Dock Waterlot Sediment Remediation" dated June 26, 2009.

These preliminary assessments were based on a review of existing sub-surface information and geotechnical data collected or collated by Golder and Klohn Crippen Berger Ltd. (KCB) as part of previous studies at EGD (which were mainly focused on the upland area of the facility). The preliminary assessments also referred to shallow sub-surface data available from Golder's sediment coring program in the Waterlot, which was carried out as part of the environmental investigation.

The available information was reviewed in the context of the conceptual remedial alternatives being considered for the Waterlot. The potential constraints associated with the proposed remediation were primarily related to the dredging of sediments up to or adjacent to sensitive structures, as identified above. It was recommended that a program of sub-surface investigation be carried out within the Waterlot to provide further information with which to assess the potential constraints identified and provide a better understanding of the possible cost associated with the remedial dredging.

1.3 Objective and Scope of Work

As identified above, the current preferred remedial alternative for the Waterlot involves dredging contaminated sediments adjacent to sensitive infrastructure.

As part of the remedial alternatives evaluation and costing being carried out by Anchor, sheet piling was identified (conceptually) as a potential method which may facilitate dredging up to structures where potential undermining or de-stabilising was a concern. Due to the potential for shallow bedrock or till-like material, it was considered necessary to obtain additional data on sub-surface stratigraphy to assess the feasibility of sheet piling and to further assess concerns regarding potential undermining or de-stabilising of structures.

To refine the remedial alternatives evaluation and to provide geotechnical data for the future detailed design phase of the remediation, Golder recommended that a program of sub-surface investigation be carried out. The objective of the investigation was to further assess Waterlot stratigraphy and associated soil/sediment material and *in-situ* properties, and to assess sub-marine slopes along the NLW and around the South Jetty.

The scope of work identified by Golder is detailed in our workplan titled “Revised Workplan for a Supplementary Borehole Investigation” dated September 30, 2009 (reference P/09/373). In summary, the scope of work included a program comprising:

- Sonic drilling through the open timber and steel pipe piled section of the South Jetty;
- Sonic, mud rotary drilling and cone penetration testing (CPT) within the Waterlot from a barge; and,
- Geotechnical laboratory testing.

As part of the marine based drilling program, Golder included seven CPT locations to support the South Jetty rehabilitation project which, is being assessed by KCB on behalf of PWGSC. This work was undertaken in accordance with Golder Change Order Request dated October 1, 2009 (reference E/09/372).

Sonic drilling through the South Jetty was carried out in conjunction with the environmental detailed site investigation, as detailed in Golder’s “Draft Detailed Site Investigation, Esquimalt Graving Dock Waterlot” report, which is currently being finalised.

This report provides a factual account of the geotechnical scope of work undertaken and presents the results of the field investigation and laboratory analyses.

2.0 AVAILABLE SUBSURFACE INFORMATION

2.1 Previous Studies

The following reports were referred to in reviewing the potential geotechnical and infrastructure stability considerations, assessing sub-surface stratigraphy and determining the scope of additional investigation required at the Waterlot to support the assessment of engineering design considerations for the remedial dredging:

- Westmar Consultants Inc., 2007, "Structural Condition Inspection and Report for: Esquimalt Graving Dock South Jetty – Bent Nos. 65S to 96S": report dated December 2007.
- Klohn Freundlich Associates Consultants, 2004, "Esquimalt Graving Dock, Seismic Retrofit of Caisson Gates and Sills (Final Report)": report dated March 2004.
- Klohn Crippen Consultants Ltd., 2002a, "North Landing Wharf Cribs and Laydown Area Renewal, Phase 1 (Study), Final Report": report dated September 2002.
- Klohn Crippen Consultants Ltd., 2002b, "Esquimalt Graving Dock and South Landing Wharf, Site Investigation and Liquefaction Assessment, Final Report": report dated June 2002b.
- Hay & Company Consultants Inc., 2001, "Report on Condition of South Jetty Wharf, Esquimalt Graving Dock, Esquimalt, BC": report dated June 2001.
- Golder Associates Ltd., 2001, "Field Investigation Program, North Landing Wharf, Esquimalt Graving Dock, Esquimalt, BC", report dated November 13, 2001.
- Golder Associates Ltd., 2000, "Compilation of Existing Geotechnical Information, Esquimalt Graving Dock, Esquimalt, BC." PWGSC Project #846348.

Relevant test hole locations and information from the above reports are shown on Figure 1 and data included in cross-sections where applicable.

2.2 Published Geology

The bedrock geology in the area of the Esquimalt Graving Dock, and over a large portion of Greater Victoria, is mapped as Wark Gneiss, which is a complex of metamorphic rocks including massive and gneissic metadiorite, metagabbro, and amphibolite (Muller, 1983)[1]. Metamorphosed granitic rocks of the Saltspring Intrusions occur near the southern boundary of the Waterlot based on the geologic mapping of Muller, which suggests that the inferred intrusive contact between the Wark Gneiss and the Saltspring Intrusions crosses the point of land between Pilgrim Cove and Lang Cove in a roughly east-west direction.

[1] Muller, J.E., 1983, "Geology, Victoria west of sixth meridian, British Columbia": Geological Survey of Canada, Map 1553A.

During the glacial advances of the Late Pleistocene epoch, the weathered surface of the bedrock, along with fault zones or zones with closely spaced joints oriented parallel to the direction of ice movement, were eroded by the glaciers, leaving a surface of strong, unweathered rock with highly irregular topography (Nasmith and Buck, 1998)[2]. Many of the valleys and depressions in the bedrock surface were subsequently infilled with glacial and post-glacial sediments that range in thickness from less than three metres to more than 30 m.

In the project area, bedrock is exposed at surface immediately north of the pumphouse and North Landing Wharf, where it slopes steeply toward the south and the southwest, respectively. Bedrock was excavated to construct the pumphouse, and the north wall and floor of the dry dock. A ridge of exposed bedrock occurs along the south shore of Pilgrim Cove, located south of the east end of the South Jetty.

In the Greater Victoria area, the bedrock is directly overlain by discontinuous deposits of basal till and/or poorly sorted till-like glacial deposits (ablation till and redeposited till) of silt, sand, gravel, and clay, which may contain cobbles and boulders and is collectively referred to as *Vashon Till.* The Vashon Till was deposited during the Fraser Glaciation (the last of at least three glacial advances of the Late Pleistocene), which began about 20,000 years ago and ended about 12,000 years ago. At the peak of the Fraser Glaciation, the ice filled the Strait of Juan de Fuca to the Pacific Ocean (Nasmith and Buck, 1998). In much of the Greater Victoria area, the Vashon Till is generally less than a few metres in thickness, but the Vashon Till may be underlain by older glacial and inter-glacial deposits of the Late Pleistocene, which may include the *QuadraSediments* (*i.e.,* Quadra Sand) and *Dashwood Drift* (Clague, 1979).

The glacial soils and bedrock are overlain by widespread deposits of fine-grained soils known locally as "Victoria Clay", which have infilled many of the bedrock valleys and depressions. The Victoria Clay consists of *Capilano*-aged glaciomarine sediments, which were deposited near the end of the Fraser Glaciation between about 12,000 and 13,000 years ago, at a time when the sea level was approximately 70 m higher than present (Nasmith and Buck, 1998). The Victoria Clay comprises a mixture of silt and clay, with lesser quantities of fine sand and coarser-grained materials carried and deposited by floating ice.

Isostatic rebound of the land due to retreat of the glaciers caused the Victoria Clay to be uplifted which resulted in the height of the ground surface relative to sea level being as much as 50 m higher than present levels (Nasmith and Buck, 1998). Where the water table dropped below the surface of the exposed Victoria Clay, sub-aerial weathering and desiccation occurred, resulting in the formation of a generally stiff to hard crust that typically has a characteristic tan to brown colour due to oxidation (locally referred to as the "brown Victoria Clay"). The upper part of the crust may be cross-cut by closely spaced fissures. Depending on the depth of the underlying bedrock, the weathered crust of the Victoria Clay, which is typically 2 to 5 m thick, may be underlain by the "grey Victoria Clay", which is typically composed of firm, grey, silty clay that has undergone minimal subaerial weathering and/or oxidation.

During the early part of the Holocene epoch, gradual sea level rise allowed scattered beach deposits to develop on the surface of the Victoria Clay along historic shorelines that moved as the sea level changed. Inundation of the surface of the Victoria Clay allowed deposition of more recent, Holocene-aged "marine mud" typically comprising fine-grained mixtures of silt, clay, fine sand, and marine detritus.

[2] Nasmith, H.W. and Buck, G.F., 1998. "The Engineering Geology of the Greater Victoria Area, British Columbia" in Urban Geology of Canadian Cities, P.F. Karrow and O. White, Editors, Geological Association of Canada, Special Paper 42; p. 21-38.

3.0 INVESTIGATION METHODOLOGY

The first phase of the supplementary borehole investigation program consisted of ten (10) sonic boreholes (GBH09-01 to GBH09-10 inclusive) within the timber pile-supported section of the South Jetty that were drilled between August 25 and September 3, 2009.

This was followed by a phased marine subsurface investigation of the Waterlot using barge-supported drilling as follows:

- Drilling of seven (7) sonic boreholes (GBH09-11, 12, 15 and GBH09-18 to 21 inclusive) between October 14 and 16, 2009. During that period, the planned sonic boreholes in the North Landing Wharf area could not be completed due to an unscheduled ship requiring berthing along the NLW.
- Drilling of one mud-rotary borehole (GBH09-23) from October 19 to 20, 2009.
- Pushing of fourteen (14) electric piezo-cone penetration test (CPT) soundings at locations selected by Golder (GCPT09-01 through 11, inclusive, as well as GCPT09-02B which was the second attempt to get through a gravel fill layer) from October 21 to 23, 2009 and from October 2 to 3, 2009. This included an additional logged mud-rotary Borehole GBH09-24 required to drill through the gravel fill layer that caused premature cone penetration refusal at GBH09-02B.
- Pushing of seven (7) CPT soundings at locations selected by Klohn-Crippen Berger (KCPT09-101 through 107 inclusive) from October 28 to 30, 2009 and from November 2 to 3, 2009, including an additional logged mud-rotary Borehole GBH09-17 that was carried out to assess if very shallow refusal at KCPT09-107 was due to dense native soils or coarse-grained fill materials (as was encountered at GCPT09-02B). During this period, GCPT09-08 and GCPT09-09 were re-pushed (identified as GCPT09-08B and 09B) due to equipment problems that compromised some of the data in the original soundings.
- Drilling of one mud-rotary borehole through the South Jetty (GBH09-22) on November 4, 2009.
- Drilling of three (3) sonic boreholes (GBH09-13, 14, 16) and pushing of four (4) CPT soundings (GCPT09-03 through 06, inclusive) between November 10 and 13, 2009.

The locations of the test holes for the investigation are plotted on the site plan on Figure 1; a list of the UTM coordinates, mudline elevations, maximum depth of penetration, and bottom of hole elevations for each test hole are provided in the attached Table 1. Test holes in the Waterlot along the perimeter of the South Jetty and directly in front of the NLW, were located as close to each of the structures as was considered practical, which resulted in the test holes being, on average, about 7 m from the edge of the structures.

The drill rigs used in this investigation were supplied and operated by Mud Bay Drilling Co. Ltd. of Surrey, BC. The barge was supplied and operated by Spectrum Marine Ltd. of Richmond, BC. Cone penetration testing was carried out by ConeTec Investigations Ltd. of Richmond, BC. All field work was carried out under the full-time inspection of members of Golder's geotechnical and/or geo-environmental staff, who located the test holes in the field, determined mudline elevations, monitored changes in tide levels, visually examined and logged the subsurface conditions encountered, and collected soil samples for detailed examination and laboratory testing of geotechnical and/or chemical parameters. Upon completion of drilling, the boreholes were backfilled with bentonite grout.

The field methodology used for each type of test hole (sonic and mud rotary boreholes and CPTs) is outlined in Sections 3.1 to 3.3. The various methods used to assess the locations and mudline elevations of the test holes are described in Section 3.4. An outline of the various geotechnical laboratory tests carried out on samples obtained from the boreholes is provided in Section 3.5.

3.1 Sonic Drilling

Five (5) sonic boreholes on the South Jetty (GBH09-05 through 09, inclusive) and one borehole at Munroe Head (GBH09-11) were drilled specifically for environmental sampling of the upper strata and were terminated before till-like glacial deposits or bedrock. Five (5) sonic boreholes on the South Jetty (GBH09-01 to 04 inclusive and GBH09-10), and two boreholes in the Waterlot (GBH09-12 and 18), were drilled for combined environmental and geotechnical purposes; the remainder of the boreholes were drilled solely for geotechnical purposes.

The objective of the geotechnical sonic boreholes was to assess the depth to till and bedrock. Till or bedrock were encountered at all geotechnical sonic boreholes except for GBH09-01 and 20, which were both terminated at depths of approximately 48 m to 50 m below mudline, within very dense glacial deposits interpreted to be basal till. Two of the originally planned sonic boreholes along the NLW (one in front of NLW Timber Crib #5 and one in the northeast corner of the Dry Dock entrance) were to be carried out during the last week of the drilling program, but wind storms on November 9 and 13 resulted in rough seas that prevented safe deployment of the barge and drill rig. Test Hole GBH09-13 was to have been drilled adjacent to GCPT09-05, but was instead drilled and logged as a pilot hole (*i.e.,* "drill-out") for GCPT09-04, in which the CPT probe was broken while pushing into the top of a layer of rock fill.

The sonic boreholes drilled through the South Jetty were advanced using a small track-mounted sonic rig (DB 320 Mini Sonic Rig). The sonic boreholes drilled from the barge during the marine investigation were advanced using a full size truck-mounted sonic rig. Sediment/soil cores were recovered using an approximately 10 cm (four-inch) outer-diameter core barrel which is vibrated into the ground. Before extracting the core barrel, an approximately 15 cm (six-inch) outer-diameter casing is advanced to the core barrel tip depth to maintain a cased borehole. Recovered cores were then extruded from the core barrel into an approximately 150 mm diameter polyethylene liner. In sonic boreholes drilled for environmental purposes, core barrels and lengths of casing were decontaminated with soap and water and a high pressure rinse prior to advancing each new borehole.

Poor recovery of the very soft near-surface sediments occurred at all of the sonic boreholes drilled at the west end of the South Jetty (GBH09-01, GBH09-03 and GBH09-05 to 08 inclusive), where the greatest thickness of these sediments were encountered. The use of both an open-faced bit and a "flapper" bit were attempted with limited success. At GBH09-03, an apparent cobble became jammed in the "flapper" bit, which may have damaged the bit and prevented it from opening sufficiently on a subsequent run, which resulting in poor core recovery. At GBH09-02, an apparent plug of wood in the bit prevented recovery in the top 4 m of core.

3.2 Mud Rotary Drilling

Mud rotary Boreholes GBH09-22 and 23 were advanced to depths of 12.8 and 14.6 m below mudline, respectively, to obtain relatively undisturbed samples of unconsolidated marine sediments and Victoria Clay. Sampling was carried out using a piston tube sampling apparatus, which consists of a 76 mm diameter thin-walled steel tube that is lowered to the bottom of the borehole, with the bottom of the piston blocking the bottom of the tube and keeping drilling mud and slough out of the tube. The tube is pushed hydraulically into the soil or sediment below the bottom of the borehole while the piston stays in contact with the top of the resulting sample.

Mud rotary Boreholes GBH09-17 and GBH09-24 were advanced at KCPT09-107 and GCPT09-24, respectively, as "drill-outs", since the CPT at both locations encountered refusal at shallow depths.

In all of the mud rotary boreholes, Standard Penetration Testing (SPT) was carried out at selected depths to obtain disturbed soil/sediment samples for stratigraphic identification, and to obtain SPT 'N' values[3] for assessing the relative density of granular soils or the consistency of stiff to hard fine-grained soils. The SPTs were carried out using an automatic trip hammer that maximizes the driving efficiency of the hammer.

3.3 Cone Penetration Testing

Electronic piezocone penetration test (CPT) soundings were carried out to provide detailed characterization of the soil stratigraphy and provide near-continuous measurement of parameters that can be used to interpret soil properties used in geotechnical design.

The CPT soundings were carried out using a cone penetrometer with a 500 bar (50 MPa) capacity cone tip (except for KCPT09-101 which was carried out using a 100 MPa capacity cone tip) with a 10 cm^2 tip area and a tip area ratio of 0.8. The penetrometer was equipped with a pore pressure filter element located directly behind the shoulder of the cone (U2 location). Saturation and assembly of the cone penetrometer was carried out in the field by the CPT technician from ConeTec. Baseline voltage readings were taken at atmospheric pressure on the barge. Measurements of the cone tip resistance (q_c), sleeve friction (f_s), and dynamic pore pressure response (u) were recorded at 0.05 m intervals during penetration at a relatively constant rate of approximately 0.02 m/s.

Profiles with depth below mudline of corrected cone tip resistance (q_t), sleeve friction (f_s), friction ratio ($R_f = f_s/q_t$), dynamic pore pressure response (u), and soil behaviour type normalized for overburden pressure (SBTn) from each CPT sounding are provided in Appendix D. Profiles for GCPT09-02, 08, 09 have not been included as these soundings were replaced by GCPT09-02B, 08B, 09B, respectively. An apparent problem with the equipment electronics appears to have compromised some of the pore pressure data in GCPT09-07 and in GCPT09-08, 09 (replaced by GCPT09-08B, 09B carried out after the problem had been corrected). This may have also affected the f_s baseline reading in GCPT09-02B, resulting in unusually low f_s readings and R_f values in that sounding. In GCPT09-01, the pore pressure data above a depth of approximately 16.5 m appears to exhibit a sluggish response that may have been caused by less than 100% saturation of the filter element, and the resulting pore pressure data between approximately 4 m and 16 m depth below mudline are lower than they should be, based on other CPT pore pressure data from other sounding locations.

Note that the soil behaviour types indicated in the last column of the CPT plots indicates the type of soil response to cone penetration rather than actual soil composition. The SBTn descriptions provided on the CPT profile sheets in Appendix D are based on the classification system developed by Robertson (1990), which is included in Appendix D. Estimates of total and effective overburden stresses used to normalize the CPT data are based on the software used by ConeTec and have not been reviewed by Golder. Use of the normalized system avoids the tendency for Soil Behaviour Type descriptions of fine-grained soils to become gradually coarser-grained with increasing depth below about 15 to 20 m, which occurs with the commonly used non-normalized classification system. However, there is a tendency for near-surface soils to be described as being significantly coarser-grained than actual (*e.g.,* plastic silts described as sands) due to very low overburden pressures.

Both normalized and non-normalized classification systems based on tip resistance and friction ratio tend to classify the very stiff silty clay in the crust of the Victoria Clay deposit as a sand/silt mixture, rather than as a very stiff fine-grained soil.

[3] SPT 'N' = the number of blows of a 63.5 kg hammer dropped from a height of 0.76 m to drive an open split spoon sampler a distance of 0.3 m

3.3.1 Pore Pressure Dissipation Testing

A pore pressure dissipation test was conducted within the glacial deposits encountered at most CPT locations. Dissipation tests were conducted to assess the equilibrium piezometric pressure at the test depth, and to differentiate fine-grained till-like soils from coarser-grained granular materials. Once cone penetration is halted, the dynamic pore pressures (u) generated during penetration will increase or decrease with time (depending on whether u is above or below the background pressure at that depth), until u is in apparent equilibrium with the background pressure. The rate of the change in u with time also provides information on the coefficient of consolidation of the soil, which is a function of soil permeability. Generally, equilibrium pressures were only achieved where the penetrometer was able to adequately penetrate soils that were sufficiently permeable for the equilibrium pressure to be reached in a relatively short period of time.

The dissipation curves are included in Appendix E, and the interpreted piezometric levels at locations where equilibrium conditions appear to have been achieved are listed in Table E-1.

3.4 Surveying of Test Hole Locations and Mudline Elevations

Surveying of test hole and mudline elevations was conducted by the Focus Corporation. The horizontal location of the holes in the jetty deck that were used to allow boreholes to be advanced through the deck, and the elevation of the jetty deck were surveyed at each of the 10 sonic boreholes locations at the South Jetty. The approximate elevation of the mudline was calculated using the measured distance between the surveyed deck and the mudline, which was determined using a weighted tape measure.

Reference points for the marine investigation test holes along the perimeter of the South Jetty and the NLW were surveyed in advance by Andy Blaine Consulting and were marked with a survey pin and flagging on the edge of the structure. The actual locations of the drill casing were determined by measuring the perpendicular offset distance between the survey pin and the drill casing, as well as the offset distance parallel to the structure (if necessary), using a tape measure. The horizontal coordinates of the boreholes were determined by plotting the surveyed reference points on the AutoCAD base plan and applying the offset distances measured in the field. The elevation of the mudline was obtained by measuring the vertical distance between the survey pin and the water level using a tape measure, and assessing the depth of the mudline below the water at the same point in time using a weighted tape. This method was also used to determine the mudline elevations of GBH09-11 and 12 located offshore of Munroe Head. However, the horizontal locations of these boreholes were estimated using a hand-held GPS which has an approximate horizontal positional accuracy of +/- 3.0 m.

For the marine investigation holes where the barge was anchored farther away from the structures, the horizontal coordinates of the drill casing and the elevation of the barge deck were measured using an RTK GPS unit that typically achieved a positional accuracy of approximately +/- 2.0 to 3.0 cm. The approximate elevation of the mudline was calculated using the measured distance between the surveyed barge deck and the mudline, which was determined using a weighted tape measure.

In addition to the limitations on the accuracy of the surveyed reference points and the taped measurements, the accuracy of the borehole locations and mudline elevations obtained using these methods is affected by potential deviations from plumb of the drill casing between the jetty deck or the barge deck and the mudline, as well as deviations from plumb of the tape measure through the water column. Furthermore, the weighted tape can be expected to sink some unknown distance into the very soft sediments below the surface of the sediments during measurement of the mudline.

3.5 Geotechnical Laboratory Testing

Geotechnical index tests are used to assess the geotechnical characteristics of soils and for soil classification purposes. Laboratory testing was carried out at Golder's materials testing facility in Victoria. The following index tests were carried out on selected geotechnical samples recovered from the sonic and mud rotary boreholes:

- Water content measurements;
- Liquid and plastic limit (Atterberg limits) determinations;
- Grain size distribution analyses (sieves with hydrometer tests for the fine-grained fraction); and,
- Bulk density determinations from tube samples.

A tabulated summary of the index test results is provided in Appendix I.

Direct shear testing of test specimens obtained from two tube samples of marine sediments was carried out at Golder's laboratory in Burnaby, BC. Three individual specimens cut from each tube sample were consolidated under saturated conditions to vertical effective stresses of 30, 60 and 120 kPa (normal to the horizontal plane of shearing), prior to shearing at a rate that is intended to be slow enough to maintain drained conditions. The results of the direct shear tests are provided in Appendix C.

4.0 SUBSURFACE CONDITIONS

4.1 General

Detailed descriptions of the subsurface conditions encountered at the locations of the boreholes advanced during the 2009 investigation (GBH09-series holes) are presented in the Record of Boreholes in Appendix A. The results of laboratory index testing (water contents, Atterberg limits, and bulk densities) are also provided on the Record of Borehole sheets, and grain size distributions of selected samples are provided in Appendix B. The results of direct shear tests carried out on relatively undisturbed tube samples are provided in Appendix C.

Data acquired during the Cone Penetration Test (GCPT and KCPT) soundings are provided in Appendix D, which includes profiles with depth below mudline of various CPT parameters for each sounding, including tip resistance (q_t), sleeve friction (f_s), friction ratio (R_f), dynamic pore pressure (u), and soil behaviour type normalized for overburden pressure (SBTn). The results of pore pressure dissipation tests are provided in Appendix E. Profiles with elevation of undrained shear strengths (s_u) interpreted from the CPT data are provided in Appendix F.

Detailed descriptions of the subsurface conditions encountered at the locations of the vibra-core sampling carried out by Golder in 2009 (SC09-series holes) are presented in the Record of Sediment Cores in Appendix G. Grain size distributions of selected geotechnical samples from the sediment cores are provided in Appendix H. It should be noted that the "depths" indicated on the laboratory results for the grain size distributions for the sediment cores represent distances along the length of the core and not actual depths below mudline. The actual depths below mudline for each of the test results are indicated in the Table in Appendix I.

Compiled geotechnical laboratory index test results from all hole locations (GBHs and SCs) are provided in Appendix I, which include bulk densities, water contents and Atterberg limits, plasticity and liquidity indices, and soil composition (proportions of gravel and sand-sized particles, fines contents, and clay-size fractions).

General descriptions of the subsurface conditions encountered during the investigation are provided in the following sections.

4.2 Stratigraphy

The stratigraphic units encountered during the South Jetty and Waterlot investigations carried out in 2009 were generally consistent with the geologic units described in Section 2.1, and are summarized below, in order of increasing depth (note that not all of the units described below were encountered at each test hole location):

- **Unconsolidated Sediments:** comprising very soft organic silt to organic clayey silt and/or very loose sandy silt, generally black or grey and black in colour and typically containing shells and/or fibrous organics. This surficial stratigraphic unit is inferred to represent the top of the Holocene (post-glacial) marine deposits ("marine mud"), and part of the same geologic unit as the underlying Upper Fine-Grained Marine Sediments. These materials are referred to as Unconsolidated Sediments due to their very loose, saturated *in-situ* condition, and are inferred to have been deposited recently.

- **Upper Fine-Grained Marine Sediments:** comprising soft to firm mixtures of silt, clay, and fine sand typically ranging from silty clay to clayey silt to sandy silt, with varying quantities of shells, and generally minor organic content. These materials are generally grey in colour and exhibit properties similar to that of consolidated fine-grained sediments, and are interpreted to represent Holocene deposits of "marine mud".

- **Upper Coarse-Grained Marine Sediments:** comprising generally loose to compact granular soils ranging from silty sand to silty sand and gravel and sand to sandy gravel, with varying quantities of shells. These are inferred to be beach deposits derived from erosion of exposed glacial deposits.

- **Victoria Clay:** comprising generally firm to stiff, grey silty clay with minor quantities of sand and gravel, includes an upper very stiff "crust" of brown to mottled grey and brown silty clay, in some but not all of the test holes.

- **Glacial Deposits**, generally comprising dense to very dense, typically well-graded mixtures of sand, silt, gravel, and clay in varying proportions; may also contain cobbles and potential boulders. Inferred to represent glacial till.

- **Bedrock**, comprising strong to very strong meta-diorite and amphibolite of the Wark Gneiss, which may be highly fractured.

Fill materials, typically comprising sand/gravel mixtures or broken rock, were encountered at surface or underlying the Unconsolidated Sediments at a few borehole locations (refer to Section 4.2.2). Materials such as angular gravel and cobbles and wood timbers were encountered within the Unconsolidated Sediments and/or within the Upper Fine-Grained Marine Sediments at some locations. These materials may have been deposited onto or into the soft surface of the marine mud at the time of construction of the Graving Dock and subsequently covered by later sediments.

Typical stratigraphic cross-sections (Sections A-A' through I-I') that illustrate the inferred variations in the depth and elevation of the stratigraphic units are provided on the attached Figures 2a through 2i. The locations of the cross-sections are shown on Figure 1.

The interpreted elevations of the top of each of the stratigraphic units described above and their estimated thicknesses as estimated from boreholes and CPT soundings from this investigation are summarized in Table 2. Where the Unconsolidated Sediments are underlain by Upper Fine-Grained Marine Sediments, a gradual

transition in soil properties was typically observed between the two units rather than an abrupt boundary or contact. The thickness of the Unconsolidated Sediments and the depth/elevation of the top of the Upper Fine-Grained Marine Sediments should, therefore, be considered to be approximate. The variation in elevation of the top of the Victoria Clay, and the top of the Glacial Deposits, are shown on Figures 3a and 3b, respectively. It should be recognized that the depth, thickness, composition, and density/stiffness of the various soil layers can be expected to vary from that encountered at the test hole locations.

More detailed descriptions of the physical properties of each of the soil units identified above are provided in the following sub-sections.

4.2.1 Unconsolidated Sediments

The surficial Unconsolidated Sediments are composed of silt with varying amounts of sand and marine shells, and minor clay, gravel, fibrous organics and wood debris, and materials of anthropogenic origin. The surficial sediments tend to be black or mixed black and grey in colour, probably due to the presence of significant quantities of decayed organic matter.

The grain size distributions obtained from selected samples from this unit are plotted together on Figure 4a. Note that the reported “sand” and “gravel” proportions may represent similarly sized shell fragments or mixtures of mineral particles and shell fragments. Fines contents (silt and clay sized particles) varied from about 75% to 95% (average 85%), with clay-sized fractions (% finer than 0.002 mm) in the range of 8% to 13% (average 10%). The gradation of the surficial sediments was observed to be very similar to that of the underlying Upper Fine-Grained Marine Sediments; however, the organic content of the Unconsolidated Sediments sediments generally appears to be higher than the underlying marine sediments. Measured Total Organic Carbon (TOC = mass of organic carbon / total dry mass) values in the range of 1.0 to 4.0% (mean of 2.1%) were measured from selected samples obtained from this unit.

Measured water contents, Atterberg limits, and plasticity and liquidity indices from samples of this material are provided in Table 3. The sediments in this unit have relatively high water contents, plastic and liquid limits, and plasticity indices, which are inferred to be due to the presence of fine, organic, colloidal materials. The position of the measured Atterberg limits on the Unified Soil Classification System (USCS) plasticity chart (refer to Figure 5) indicates that these sediments can be classified as organic soils of high plasticity (OH). There is some overlap in the ranges of index properties of this stratigraphic unit with that of the underlying Upper Fine-Grained Marine Sediments; however, the surficial sediments have higher plasticity and higher liquidity, on average, than the underlying grey marine sediments.

Table 3: Water Contents and Atterberg Limits (Unconsolidated Sediments)

	Range	Median	Mean +/-Std Dev
Water Content* (w)	82 – 152 %	108%	111+/-22 %
Plastic Limit (PL)	30 – 53 %	38%	39+/-7 %
Liquid Limit (LL)	53 – 134 %	81%	80+/-25 %
Plasticity Index (LL-PL)	23 – 80 %	42%	41+/-18%
Liquidity Index* (w-LL)/(LL-PL)	0.7 to 3.0	2.0	2.0+/-0.8

*Note: Measured water contents and liquidity indices may be lower than *in-situ* values due to drainage of excess water from recovered samples.

A bulk density of 1476 kg/m^3 was determined from a core sample of the Unconsolidated Sediments, with a corresponding water content of 120%.

The consistency of the surficial sediments can be described as very soft or very loose, to semi-fluid. Measured liquidity indices were generally well above 1.0 for samples recovered from the top 1.2 m thickness of the sediments, indicating that the water content of the material (even after removal of excess water) is above the limit at which it behaves like a viscous fluid. The one sample tested that had a liquidity index of less than unity (indicating that the sample was in a plastic state) came from a depth of approximately 4.2 m below mudline at GBH09-01. The trend of decreasing liquidity index with depth below mudline is consistent in both the surficial Unconsolidated Sediments and the fine-grained Upper Marine Sediments.

The sleeve friction (f_s) measured within the surficial sediments in CPT soundings tended to be very low to negligible (less than 2 kPa). Despite the fine-grained nature of the sediments, pore water pressures (u) measured during cone penetration matched the hydrostatic pressure profile. The hydrostatic pore water pressures, negligible sleeve friction, high liquidity index determinations, and visual observations of recovered samples, suggest that the surficial fine-grained sediments have not consolidated into a cohesive soil.

The approximate thicknesses of the Unconsolidated Sediments encountered at the borehole locations and interpreted from the CPT data are tabulated in Table 2. At test hole locations within the Waterlot and below the South Jetty to the south of the existing sheet pile wall, the estimated thickness of the Unconsolidated Sediments ranges from 0.5 m to 2.0 m. The thickness of the Unconsolidated Sediments under the western portion of the South Jetty was estimated to be 4.4 m at GBH09-01 and 3.4 m at GBH09-07. The lack of recovery of the upper 2.3 m to 4.6 m of sediments at GBH09-03, 05, 06 and 08, located in the same general area, may also indicate relatively thick Unconsolidated Sediments in this area, where mudline elevations are significantly higher than other areas of the Waterlot (perhaps due to a lack of historic dredging under the jetty structure).

4.2.2 Fill Materials

Fill materials, typically comprising sand/gravel mixtures with variable fines contents, or broken rock fill, were encountered at surface or underlying the Unconsolidated Sediments at some borehole locations, as summarised below.

The thickest fills observed during the investigation consisted mainly of broken rock encountered in Boreholes GBH09-11 and 12 (at least 11.0 m thick and 4.9 m thick, respectively) at Munroe Head. Layers of broken rock fill were also encountered at GCPT09-03/GBH09-14 and GCPT09-04/GBH09-13 in front of NLW Timber Crib #3 and at GBH09-16 in front of the North Entrance Wall at the dry dock entrance. Broken rock fills were also likely encountered at CPT location GCPT09-05 in front of the NLW Timber Crib #5, where a shallow CPT refusal required a drill-out. A thin layer of broken rock fill was also encountered at GCPT09-02B/GBH09-24 on the north side of the South Jetty.

Thick granular fill materials (extending to 7.5 m below mudline) comprising sand to gravely sand to sandy gravel, were encountered at GBH09-02 along the south side of the South Jetty. A 1.3 m thick layer of gravel was also encountered overlying Upper Fine-Grained Marine Sediments at GBH09-09 on the southeast side of the South Jetty.

Angular gravel to cobbles was encountered within silts at GBH09-07 and 08 under the South Jetty in the vicinity of Section C-C'. Wood material, inferred to be part of a timber pile, was also encountered within clayey silt (inferred to belong to the Upper Marine Sediments deposit).

4.2.3 Upper Fine-Grained Marine Sediments

The Unconsolidated Sediments and fill materials (where encountered) are underlain by soft to firm, fine-grained sediments that are generally grey in colour. These sediments are primarily composed of silt-sized particles, with lesser amounts of sand (mainly fine-grained) and clay-sized particles, marine shells and shell fragments of varying sizes, and minor organics. Based on soil plasticity, these sediments are classified as ranging from silty clay to clayey silt (plastic soils) to sandy silt (non-plastic). Upward fining of sediment particle size was observed in some boreholes, with non-plastic sandy silt grading into plastic fine-grained silt at some locations. At a few locations, the fine-grained sediments contained angular gravel, which likely represents materials incorporated into the sediments during construction of the Graving Dock.

The laboratory grain size distributions of selected samples from this unit are plotted together on Figure 4b. Note that the reported "sand" and "gravel" proportions may include shell fragments as well as mineral particles. Fines contents of 62% to 97% (median of 88%) were measured, with clay-size fractions (% finer than 0.002 mm) ranging from 4% to 35% (median of 12%). TOC values in the range of 0.6 to 1.3% (mean of 1.0%) were measured from selected samples in this unit.

Measured water contents and Atterberg limits results (reported for plastic soils only) from samples of this material are listed in Table 4 below. Based on the Atterberg Limits results, the fines content of these sediments tends to exhibit intermediate to high plasticity despite generally having low clay-size fractions, probably due to the presence of fine organic colloidal materials. Measured liquidity indices tend to decrease with increasing depth below mudline, but were generally above unity for samples recovered from up to about 2 m depth below mudline, and generally below unity for samples recovered from depths greater than about 2 m below mudline.

Table 4: Water Contents and Atterberg Limits (Upper Fine-Grained Marine Sediments)

	Range	Median	Mean +/-Std Dev
Water Content (w)	23 – 76 %	51%	48+/-15 %
Plastic Limit (PL)	16 – 34 %	26%	25+/-5 %
Liquid Limit (LL)	32 – 63 %	46%	45+/-7 %
Plasticity Index (LL-PL)	11 – 35 %	20%	20+/-5%
Liquidity Index* (w-LL)/(LL-PL)	0.4 to 2.3	1.2	1.2+/-0.5

*Note: Lower end of the range of Liquidity Indices may not be representative due to sand and shell content, which can reduce measured water contents but is removed for Atterberg limits testing.

The measured Atterberg limits are plotted on the Unified Soil Classification System (USCS) plasticity chart on Figure 5. The results indicate a high degree of variability in the relationship between plasticity index and liquid limit for this stratigraphic unit, but the results generally straddle the "A-Line", which is indicative of sediments with variable clay and organic contents. Sediments with higher clay contents and negligible organic contents tend to plot higher on the chart (higher plasticity indices relative to their liquid limits) and above the A-Line, while sediments with higher organic contents plot further to the right on the chart (higher liquid limit) and tend to plot below the A-Line.

The upper end of the range of index properties for the Upper Fine-Grained Marine Sediments overlaps with the index properties of the overlying Unconsolidated Sediments, and the lower end of the range overlaps with the underlying Victoria Clay unit. However, the water contents, plastic and liquid limits, and liquidity indices measured from samples of the Fine-Grained Upper Marine Sediments are, on average, intermediate between the overlying and underlying units.

Bulk densities in the range of 1590 to 2050 kg/m^3 (mean of 1760 kg/m^3) were measured from tube samples and core samples of these sediments; the measured densities increased with decreasing water content.

The consistency of the marine mud can be described as very soft to soft, becoming firm with depth. Undrained shear strengths interpreted from CPT data generally increase with depth, typically in the range of 10 to 35 kPa. Peak undrained shear strengths measured by field vane in the Klohn Crippen Borehole DH02-02 ranged from 13 to 27 kPa, and remoulded strengths ranged from 4 to 6 kPa (sensitivity to strength loss of 3 to 5).

Pore water pressures (u) measured during cone penetration of this unit were typically close to hydrostatic pressures, indicating a relatively high permeability for the fine-grained nature of the sediments, likely due to a generally low clay content and relatively narrow gradation. Consequently, undrained shear strengths measured in these sediments are likely to be only applicable to very rapid loading scenarios.

Drained strength parameters are considered to be more representative for scenarios where load is applied over a period of hours to days. Direct shear tests were carried out on specimens cut from two tube samples of the Upper Fine-Grained Marine Sediments recovered from GBH09-22 and 23. The peak horizontal shear strengths measured at vertical effective stresses of 30, 60 and 120 kPa, for each of these tube samples, are plotted on Figure 6. Peak friction angles of 35 and 38 degrees were determined from the samples which had measured coarse-grained particle (“sand” and “gravel” sized) contents of 18% and 26%, respectively, and clay-sized contents of 35% and 4%, respectively. An apparent cohesion intercept (strength at zero normal stress) of 2 to 3 kPa was determined from the peak strength envelope, corresponding to the 30 to 120 kPa range of normal stresses.

The approximate thickness of the Upper Fine-Grained Marine Sediments unit encountered at the borehole locations and interpreted from the CPT data is tabulated in Table 2. The thickness of this unit ranged from 0.5 m to 5.6 m (average of 2.9 m) where encountered at the boreholes and CPT soundings in front of the NLW Timber Crib Nos. 3 and 5, below the South Jetty, and off-shore of the west end of the South Jetty. These sediments were not encountered at Boreholes GBH09-12 at Munroe Head, or at Boreholes GBH09-15 through 19 near the mouth of the Dry Dock, or at GBH09-04, GBH09-21 and GCPT09-11 at the east end of the south side of the South Jetty. This deposit was encountered under the south side of the South Jetty at GBH09-02, GBH09-22, GBH09-09, and GBH09-10, however, it does not appear to have been encountered further south at GCPT09-09B and GCPT09-10 and KCPT09-102 and 103 where the mudline is located at lower elevations at or beyond the toe of the submarine slope. Past dredging operations may have removed the soft to firm sediments from those locations.

4.2.4 Upper Coarse-Grained Marine Sediments

The Upper Coarse-Grained Marine Sediments, comprising mixtures of sand, silt and gravel, with variable shell contents, and minor clay contents, were encountered underlying the Upper Fine-Grained Marine Sediments or the Unconsolidated Sediments at some test hole locations (refer to Table 2). This deposit was encountered in various test holes along Section C-C’ (refer to Figure 2c) and Section I-I’ (refer to Figure 2i), and appears to extend across the Waterlot from the area of the intersection of Sections C-C’ and I-I’ to GBH09-14 in front of NLW Timber Crib #3. The sediments encountered within this unit in this area are inferred to have been derived locally from glacial deposits located at higher elevations to the northeast, which would likely have been exposed above sea level some time after deposition of the Victoria Clay (Section 2.1).

Similar deposits were also encountered overlying the Victoria Clay at borehole locations along the south side of the South Jetty east of Section D-D’ (GBH09-10, 09, 04), and in Pilgrim Cove at KCPT09-101 and SC09-134 and 135A.

The composition of this unit varies widely from sand and silt, to silty sand, to silty sand and gravel, to gravelly sand with some silt, to sandy gravel, with varying shell contents. The grain size distributions determined from selected samples from this unit are plotted together on Figure 4e. Note that the reported "sand" and "gravel" proportions may include shell fragments as well as mineral particles. Measured "sand" contents were in the range of 40% to 59% (median of 54%), fines contents were in the range of 12% to 49% (median of 21%), and "gravel" contents in the range of 3% to 39% (median of 22%).

4.2.5 Victoria Clay

Glaciomarine sediments known locally as "Victoria Clay" are composed of silty clay with minor sand and gravel, and may contain marine shells and/or lenses of fine sand to silty fine sand. The grain size distributions determined from selected samples from this unit are plotted together on Figure 4d. Clay-size fractions (% finer than 0.002 mm) determined from the hydrometer test results were 43% and 49%, which is significantly higher than the test results from samples of the overlying marine mud (Unconsolidated Sediments). Sand, gravel and possibly cobbles were encountered within the silty clay near the base of the deposit at some locations (*e.g.,* GBH09-04 and GBH09-20 and GCPT09-11 near the east end of the South Jetty and at GCPT09-03 and GCPT09-04, opposite NLW Timber Crib #3.

Measured water contents, Atterberg limits, and plasticity and liquidity indices from samples of this material are listed in Table 5 below. The Victoria Clay at the Site has relatively low plastic limits that are consistently below 20%, as compared to the overlying marine muds that have plastic limits that are generally above 20%. Typical water contents (26% to 36%) and typical liquidity indices (0.4 to 1.0) in the Victoria Clay deposit are also significantly lower than the typical ranges for the overlying marine muds (w = 33% to 63% and I_L = 0.7 to 1.7). Two tests indicated water contents in excess of 38% and liquidity indices in excess of 0.9, both of which were located at the top of the deposit where water induced softening has likely occurred.

Table 5: Water Contents and Atterberg Limits (Victoria Clay)

	Range	Median	Mean +/-Std Dev
Water Content (w)	18 – 45 %	32%	31+/-5 %
Plastic Limit (PL)	14 – 20 %	17%	17+/-2 %
Liquid Limit (LL)	29 – 47 %	36%	36+/-5 %
Plasticity Index (LL-PL)	14 – 28 %	19%	19+/-4%
Liquidity Index (w-LL)/(LL-PL)	0.2 to 1.2	0.8	0.7+/-0.3

The measured Atterberg limits are plotted on the Unified Soil Classification System (USCS) plasticity chart on Figure 5. The relation between plasticity index and liquid limit for the Victoria Clay follows a consistent line parallel to and well above the A-Line, with measured liquid limits consistently less than 50%, thereby indicating classification as clay of low plasticity (CL) according to the USCS system.

The estimated elevations of the top of the Victoria Clay at test holes from the current investigation are plotted in plan view on Figure 3a. The surface of the deposit was encountered as deep as El. -18.5 m Geodetic west of the west of the South Jetty and south of the NLW Timber Crib No. 5, but rises gradually in an east-northeast direction. This geologic unit was encountered at all borehole and CPT locations except for:

- GBH09-15 through GBH09-18 near the mouth of the Dry Dock, where the top of glacial deposits were encountered at elevations in the range of -14.3 m to -12.6 m Geodetic (above the shallowest Victoria Clay in that area); and,

- GBH09-12 at Monroe Head, where the top of glacial deposits were encountered at El. -15.2 m Geodetic (above the top of the Victoria Clay at GCPT09-06 and GBH09-14).

The approximate thickness of the Victoria Clay encountered at the borehole locations and interpreted from the CPT data is tabulated in Table 2. The thickness ranges from 3.8 m at KCPT09-101 at the end of the floating dock in Pilgrim Cove, to greater than 36 m at KCPT09-104, at the southwest end of the South Jetty.

The Victoria Clay has a firm to stiff consistency and is generally grey in colour where unweathered (*i.e.,* "grey Victoria Clay" (Nasmith and Buck, 1998). An upper weathered crust of very stiff silty clay, which is generally brown to mottled grey and brown in colour, was encountered at all test holes in the area of the west end of the South Jetty, as far east as Section C-C'.

The thickness of the weathered crust at these locations ranges from about 2 m to 4 m. The lowest water contents and liquidity indices were measured in samples of Victoria Clay obtained mainly from the middle of the crust, where undrained shear strengths interpreted from CPT data tend to increase to a peak in excess of 150 kPa, before decreasing abruptly to less than 75 kPa below the bottom of the crust. A bulk density of 2143 kg/m^3 was measured from a tube sample obtained from the middle of the crust at GBH09-23, with a corresponding water content of 20%.

Bulk densities ranging from 1870 to 1960 kg/m^3 were measured from tube and core samples of the grey Victoria Clay. Undrained shear strengths interpreted from CPT data generally decreased with increasing depth below the crust, reaching a minimum strength typically in the range of 40 kPa to 60 kPa before increasing with depth to the bottom of the deposit. Peak undrained shear strengths measured by field vane methods in Klohn Crippen Borehole DH02-04 ranged from 44 to 78 kPa; remoulded strengths ranged from 9 to 53 kPa (sensitivity of 6 to 1.5).

The bottom of the crust can be inferred from the CPT data at GCPT09-09B along Section D-D'. No crust is apparent in the test holes located east of Section D-D', where the top of the Victoria Clay was encountered at elevations above -15 m Geodetic. It is possible that the clay crust was either eroded from this area, or may have been removed by previous dredging. The top of the grey Victoria Clay at GBH09-10, 09 and 04 (and inferred from the data at KCPT09-101) is overlain by silty sand with variable gravel content, which is inferred to be part of the Upper Coarse-Grained Marine Sediments. The grey Victoria Clay at GCPT09-09B, 10, 11, GCPT09-102 and 103 and GBH09-21, is directly overlain by the Unconsolidated Sediments, which suggests that past dredging activities south of the jetty likely extended down to and possibly into the Victoria Clay. The Victoria Clay crust was also absent in test holes along the NLW at Sections G-G' and H-H'. At all of these locations, the Victoria Clay appears to be overlain by the Upper Marine Sediments.

4.2.6 Glacial Deposits

Glacial Deposits were encountered underlying the Victoria Clay at all test holes that fully penetrated the clay. Grain size distributions of selected samples from this unit are plotted together on Figure 4e.

The Glacial Deposits typically comprise very dense, well-graded silty sand to sand and silt, trace gravel to gravelly (clasts tending to be sub-angular to sub-rounded), trace to some clay, which is consistent with typical ground moraine deposits of the Vashon Till. These deposits can be expected to include occasional cobbles and potential boulders. CPT penetration refusal at measured tip resistances in excess of 30 MPa typically occurred abruptly at the inferred top of this deposit. Due to the significant fines contents and very dense state of packing, the fine-grained till-like soils are expected to have relatively low hydraulic conductivities.

At a few locations (*e.g.,* GBH09-02, 03, 10, 20), the surface of the Glacial Deposits consisted of a relatively thin layer of compact to dense sand to gravelly sand. The cone penetrometer was able to penetrate into this surficial layer where it was encountered, with measured tip resistances generally in the range of 10 to 30 MPa (at GCPT09-06 and 10 and KCPT09-101 and 106). Coarser-grained layers of dense to very dense, well-graded sand and gravel to sandy gravel, trace silt to silty, with cobbles, were also encountered between layers of finer-grained till-like deposits. These deposits are inferred to potentially have higher hydraulic conductivities than the till-like materials.

The estimated elevations of the top of the Glacial Deposits at test holes in the current investigation are plotted in plan view on Figure 3b. In the vicinity of the mouth of the Dry Dock, this deposit was encountered at elevations ranging from -12.6 m Geodetic at GBH09-18 (underlying Unconsolidated Sediments) to -14.3 m Geodetic at GBH09-16 (underlying 1.4 m of rock fill) to -13.6 m at GBH09-15 (underlying Unconsolidated Sediments). At GBH09-17, the Glacial Deposits were encountered at approx. El. -14.3 m Geodetic underlying sandy gravel interpreted as the Upper Coarse-Grained Marine Sediments. West of GBH09-17 and GBH09-15, the surface of the Glacial Deposits is inferred to slope steeply to the southwest, and south of GBH09-17 and 18, the surface slopes steeply to the south. Excavation of bedrock and overlying soils during dry dock construction is interpreted to have extended some distance west of the outer caisson berth along the North Entrance Wall. A relatively flat "bench" was likely developed in this area by excavation into the surface of the Glacial Deposits.

The top of the Glacial Deposits were encountered at El. -12.5 m Geodetic at KCPT09-101 at the end of the floating dock in Pilgrim Cove. It appears that the surface of this deposit dips steeply westward from this point, to -25.0 m Geodetic at GBH09-21, to around -27 m Geodetic at GBH09-04 and KCPT09-102. The location of the bedrock outcrop to the south of Pilgrim Cove, and the steeply northward dipping mudline to the south of KCPT09-102, suggests that the surface of the Glacial Deposits probably rises to the south of KCPT09-102.

The approximate thickness of the Glacial Deposits at the sonic borehole locations where this unit was fully penetrated, are tabulated in Table 2. The thickness of the unit ranges from about 0.5 to 0.6 m at GBH09-03 and GBH09-19 on the north side of the South Jetty, to about 14 m at GBH09-02 on the south side of the jetty and greater than 22 m at GBH09-20, where bedrock was not encountered before the borehole was terminated at El. - 63.6 m Geodetic. The thicknesses of till-like materials encountered during Golder's 2009 investigations are significantly greater than reported in previous studies, particularly along the south side of the South Jetty. Previous boreholes by others in the vicinity of the over-water portion of the South Jetty were drilled using mud rotary boreholes where soils samples would have been collected using a 51 mm diameter SPT sampler that may have encountered refusal in the very dense till materials. Accordingly, glacial till may have previously been misidentified as bedrock.

4.2.7 Bedrock

Bedrock was encountered underlying the Glacial Deposits at all borehole locations where that unit was fully penetrated. The bedrock surface elevations interpreted from the borehole information are tabulated in Table 2. Materials recovered from just below the bedrock surface in the sonic boreholes typically consisted of angular cobble, gravel and sand-sized rock fragments, interpreted to be the result of drilling disturbance (no water was used during sonic drilling through the Glacial Deposits or into the bedrock). This zone has been identified as "probable BEDROCK" on the Record of Boreholes in Appendix A, and may correspond to the zone of highly fractured bedrock. During drilling there was little or no recovery on the last core run within bedrock. At GBH09-02, no sample was recovered from what is inferred to be the top of the bedrock,

Within the Waterlot, bedrock was encountered as shallow as El. -14.6 m Geodetic at GBH09-18 in the southeast corner of the area of the mouth of the Dry Dock, and -15.5 m Geodetic at GBH09-16 along the North Entrance Wall. The bedrock is overlain by Glacial Deposits at both of these locations. Based on the original construction drawings for the Dry Dock facility, the original bedrock surface dipped from north to south across the Dry Dock in

the vicinity of Caisson Berths 1 and 2, and bedrock excavation was carried out to construct the floor of the Dry Dock. Bedrock may occur at shallower depths than at the locations where it was encountered during the drilling investigation, and could potentially directly underlie the Unconsolidated Sediments to the north of GBH09-18 and east of GBH09-16.

The bedrock surface appears to slope to the west and south away from the Dry Dock entrance. At the west end of the South Jetty, the bedrock appears to slope steeply to the south, dropping from El. -31.2 m Geodetic at BH09-03 to below El. -57 m Geodetic at GBH09-01 and to at least El. -64 m Geodetic or deeper at GBH09-20.

Along the south side of the NLW, the bedrock surface dips from El. -20.9 m Geodetic at GBH09-15 (in front of Timber Crib #1), to El. -25.5 m at GBH09-14 (in front of Timber Crib #3), to deeper than El. -29 m at GCPT09-5 (in front of Timber Crib #5), but rises up to El. -16.7 m Geodetic at GBH09-12 (just west of the end of the NLW).

At the east end of the South Jetty, bedrock was encountered at El. -31.4 m Geodetic at GBH09-21 located just south of the jetty. Given that bedrock is exposed at surface along the south shore of Pilgrim Cove, the bedrock surface probably continues to slope steeply to the north below the mudline along the south side of Pilgrim Cove.

4.3 Pore Water Pressures

Pore water pressures measured during CPT soundings through the Unconsolidated Sediments and Upper Marine Sediments were generally close to the expected hydrostatic pressure profile generated by the weight of sea water above the mudline and tide levels at the time of testing. Therefore, it is likely that equilibrium pore water pressures in these sediments are tidally controlled.

Groundwater levels within the Glacial Deposits and underlying bedrock were not measured directly by piezometers. However, equilibrium pore water pressures at the top of the Glacial Deposits were measured in CPT dissipation tests at a few locations where adequate penetration into the deposit could be achieved. The measured equilibrium pore water pressures at these locations are listed in Table E-1 in Appendix E, along with the piezometric levels (Geodetic elevation) corresponding to the measured pore water pressures. The difference between the piezometric level and the elevation at which the pore water pressure is measured is equivalent to the height (or “head”) of water that would produce the measured pore water pressure. The head of water that corresponds to the measured pore water pressure depends on the pore water density, which is a function of the pore water salinity. Since the salinity of the pore water within the Glacial Deposits underlying the confining influence of the Victoria Clay deposit is not known, hydraulic heads and resulting piezometric levels were computed for assumed water densities of 1.00 g/cm^3 (fresh water), 1.01 g/cm^3 (brackish water), and 1.02 g/cm^3 (salt water). Since the nearest exposures of the Glacial Deposits above the confining influence of the Victoria Clay occur in the mouth of the Dry Dock and under the NLW, where the soil unit would be in contact with sea water, it would be reasonable to assume salt water to brackish water densities for the measured pressures listed in Table E-1. Accordingly, the interpreted piezometric levels within the top of the Glacial Deposits appear to be within about +/-1 m Geodetic (*i.e.,* close to mean sea level). It is unclear whether the variations between the tidal elevation and the interpreted piezometric levels within the top portion of the Glacial Deposits represent a tidally influenced regime with some time lag in pressure response, or reflects the limitation of the accuracy of the interpretation based on the available data.

5.0 CLOSURE

This report has been provided to support the Waterlot RAP/RMP project. We trust this meets with your requirements and look forward to discussing the report with you.

GOLDER ASSOCIATES LTD.

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Table 1
Summary of Test Hole Locations

Test Hole ID	Test Hole Type	Facility Area	Approximate UTM Coordinates		Approximate Mudline Elevation	Maximum Depth Below	Bottom Elevation
			Northing	Easting	(m Geodetic)	(m)	(m Geodetic)
GBH09-01	Sonic Borehole	South Jetty (Southwest)	5364793.0	468340.2	-8.65	48.46	-57.11
GBH09-02	Sonic Borehole	South Jetty (South Side)	5364804.6	468416.3	-4.48	44.20	-48.68
GBH09-03	Sonic Borehole	South Jetty (Northwest)	5364829.9	468334.1	-9.64	26.37	-36.01
GBH09-04	Sonic Borehole	South Jetty (South Side)	5364820.1	468568.2	-4.31	32.00	-36.31
GBH09-05	Sonic Borehole	South Jetty (Southwest)	5364801.8	468333.1	-9.16	11.43	-20.59
GBH09-06	Sonic Borehole	South Jetty (Southwest)	5364800.7	468308.6	-10.09	10.67	-20.76
GBH09-07	Sonic Borehole	South Jetty (Northwest)	5364840.9	468356.1	-9.64	8.08	-17.72
GBH09-08	Sonic Borehole	South Jetty (Southwest)	5364806.1	468378.3	-9.20	8.53	-17.73
GBH09-09	Sonic Borehole	South Jetty (South Side)	5364814.4	468537.6	-6.15	8.53	-14.68
GBH09-10	Sonic Borehole	South Jetty (South Side)	5364805.7	468476.9	-7.82	34.59	-42.41
GBH09-11	Sonic Borehole	Munroe Head	5365019	468067	-2.85	19.81	-22.66
GBH09-12	Sonic Borehole	Munroe Head	5364981	468131	-10.28	11.28	-21.56
GBH09-13	Sonic Borehole	North Landing Wharf	5364931.1	468251.1	-13.20	6.25	-19.45
GBH09-14	Sonic Borehole	North Landing Wharf	5364938.6	468253.0	-12.93	14.02	-26.95
GBH09-15	Sonic Borehole	North Landing Wharf	5364924.2	468312.9	-12.49	8.53	-21.02
GBH09-16	Sonic Borehole	North Landing Wharf	5364914.0	468352.0	-12.17	3.51	-15.68
GBH09-17	Mud Rotary Borehole	South Jetty (Northwest)	5364876.4	468356.3	-12.76	1.73	-14.49
GBH09-18	Sonic Borehole	South Jetty (Northwest)	5364871.3	468381.2	-12.10	3.66	-15.76
GBH09-19	Sonic Borehole	South Jetty (Northwest)	5364861.6	468362.0	-12.79	10.36	-23.15
GBH09-20	Sonic Borehole	South Jetty (Southwest)	5364781.8	468366.7	-13.90	49.68	-63.58
GBH09-21	Sonic Borehole	South Jetty (South Side)	5364803.6	468571.3	-12.20	22.86	-35.06
GBH09-22	Mud Rotary Borehole	South Jetty (South Side)	5364797	468422	-9.11	12.80	-21.91
GBH09-23	Mud Rotary Borehole	South Jetty (Northwest)	5364829.3	468296.6	-13.83	14.63	-28.46
GBH09-24	Mud Rotary Borehole	South Jetty (Northwest)	5364845.3	468327.0	-13.21	3.58	-16.79
GCPT09-01	Peizo-Cone Penetration Test	South Jetty (Northwest)	5364830.1	468296.3	-13.58	25.00	-38.58
GCPT09-02B	Peizo-Cone Penetration Test	South Jetty (Northwest)	5364845.3	468327.0	-13.21	12.85	-26.06
GCPT09-03	Peizo-Cone Penetration Test	North Landing Wharf	5364938.6	468253.0	-12.93	8.50	-21.43
GCPT09-04	Peizo-Cone Penetration Test	North Landing Wharf	5364931.1	468251.1	-13.20	8.90	-22.10
GCPT09-05	Peizo-Cone Penetration Test	North Landing Wharf	5364950.5	468204.4	-13.60	15.40	-29.00
GCPT09-06	Peizo-Cone Penetration Test	North Landing Wharf	5364933.8	468205.0	-14.33	16.00	-30.33
GCPT09-07	Peizo-Cone Penetration Test	South Jetty (Southwest)	5364774.1	468296.1	-14.04	33.45	-47.49
GCPT09-08B	Peizo-Cone Penetration Test	South Jetty (Southwest)	5364781.5	468370.0	-14.14	26.85	-40.99
GCPT09-09B	Peizo-Cone Penetration Test	South Jetty (South Side)	5364786.5	468421.2	-13.65	24.45	-38.10
GCPT09-10	Peizo-Cone Penetration Test	South Jetty (South Side)	5364795.7	468502.6	-12.32	25.35	-37.67
GCPT09-11	Peizo-Cone Penetration Test	South Jetty (South Side)	5364802.8	468568.4	-12.22	14.20	-26.42
KCPT09-101	Peizo-Cone Penetration Test	South Jetty (South Side)	5364798.6	468621.0	-5.62	7.70	-13.32
KCPT09-102	Peizo-Cone Penetration Test	South Jetty (South Side)	5364786.4	468541.0	-12.62	14.65	-27.27
KCPT09-103	Peizo-Cone Penetration Test	South Jetty (South Side)	5364776.8	468421.3	-13.52	27.10	-40.62
KCPT09-104	Peizo-Cone Penetration Test	South Jetty (Southwest)	5364757.4	468300.0	-13.97	40.35	-54.32
KCPT09-105	Peizo-Cone Penetration Test	South Jetty (Northwest)	5364814.5	468261.0	-13.37	34.90	-48.27
KCPT09-106	Peizo-Cone Penetration Test	South Jetty (Northwest)	5364854.0	468315.5	-13.72	12.35	-26.07
KCPT09-107	Peizo-Cone Penetration Test	South Jetty (Northwest)	5364876.4	468356.3	-12.76	0.70	-13.46

Table 2
Interpreted Stratigraphic Unit Elevations and Approximate Thicknesses

				Stratigraphic Unit:	Unconsolidated Sediments	Fill Materials		Upper Marine Sediments (Fine-Grained)		Upper Marine Sediments (Coarse-Grained)		Victoria Clay		Glacial Deposits		Bedrock
Test Hole ID	Facility Area	Approximate Mudline Elevation (m Geodetic)	Bottom of Hole Elevation (m Geodetic)		Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)
GBH09-01	South Jetty (Southwest)	-8.7	-57.1		4.4			-13.0	4.3	Not Encountered		-17.3	28.0	-45.3	>11.8	below -57.1
GBH09-02	South Jetty (South Side)	-4.5	-48.7		No Recovery to 1.2 m depth	-4.5	8.1	-12.6	2.2	Not Encountered		-14.8	17.4	-32.2	14.0	-46.2 (inferred)
GBH09-03	South Jetty (Northwest)	-9.6	-36.0		No Recovery to 3.1 m depth			-12.7 or higher	at least 4.6	Not Encountered		-17.3 or lower	up to 13.4	-30.7	0.5	-31.2
GBH09-04	South Jetty (South Side)	-4.3	-36.3		1.5	-5.8	0.3	Not Encountered		Not Encountered		-6.1	21.0	-27.2	4.6	-31.7
GBH09-05	South Jetty (Southwest)	-9.2	-20.6		No Recovery to 2.3 m depth		at least 0.3	-11.8	5.6	Not Encountered		-17.4				
GBH09-06	South Jetty (Southwest)	-10.1	-20.8		No Recovery to 4.6 m depth			-14.7 or higher	at least 3.0	Not Encountered		-17.7				
GBH09-07	South Jetty (Northwest)	-9.6	-17.7		3.4	-13.0	0.6	-13.6	0.5	-14.7	1.1	-15.8				
GBH09-08	South Jetty (Southwest)	-9.2	-17.7		No Recovery to 2.4 m depth			-11.6 or higher	at least 3.1	-14.7	1.1	-15.8				
GBH09-09	South Jetty (South Side)	-6.2	-14.7		1.5	-7.6	1.3	-8.9	1.1	-10.0	1.6	-11.6				
GBH09-10	South Jetty (South Side)	-7.8	-42.4		0.5			-8.3	3.6	-11.9	2.0	-13.9	21.8	-35.7	3.1	-38.8
GBH09-11	Munroe Head	-2.9	-22.7		Not Encountered	-2.9	13.1	-16.0	2.2	-18.1	1.5	-19.6				
GBH09-12	Munroe Head	-10.3	-21.6		Not Encountered	-10.3	6.4	Not Encountered		Not Encountered		Not Encountered		Not Encountered		-16.7
GBH09-13/GCPT09-04	North Landing Wharf	-13.2	-19.5		1.8	-15.0	0.8	-15.8	1.2 (est.)	No Recovery		-17 (est.)	5 (est.)	-22.0		
GBH09-14/GCPT09-03	North Landing Wharf	-12.9	-27.0		1.2	-14.2	0.4	-14.6	1.5	-16.1	0.5	-16.6	4.7	-21.3	4.2	-25.5
GBH09-15	North Landing Wharf	-12.5	-21.0		1.1			Not Encountered		Not Encountered		Not Encountered		-13.6	7.3	-20.9
GBH09-16	North Landing Wharf	-12.2	-15.7		0.7	-12.9	1.4	Not Encountered		Not Encountered		Not Encountered		-14.3	1.2	-15.5
GBH09-17/KCPT09-107	South Jetty (Northwest)	-12.8	-14.5		0.5			Not Encountered		-13.2	1.1	Not Encountered		-14.3		
GBH09-18	South Jetty (Northwest)	-12.1	-15.8		0.5			Not Encountered		Not Encountered		Not Encountered		-12.6	2.0	-14.5
GBH09-19	South Jetty (Northwest)	-12.8	-23.1		0.9			Not Encountered		-13.7	0.9	-14.6	5.4	-20.0	0.6	-20.6
GBH09-20	South Jetty (Southwest)	-13.9	-63.6		0.5			-14.4	1.9	Not Encountered		-16.3	25.2	-41.5	>22.1	below -63.6
GBH09-21	South Jetty (South Side)	-12.2	-35.1		1.4			Not Encountered		Not Encountered		-13.6	11.4	-25.0	6.4	-31.4
GBH09-22	South Jetty (South Side)	-9.1	-21.9		1.7			-10.8	3.8	Not Encountered		-14.6				
GBH09-23	South Jetty (Northwest)	-13.8	-28.5		Min. Recovery to 1.2 m depth			-14.2	3.4	Not Encountered		-17.6				
GBH09-24/GCPT09-02B	South Jetty (Northwest)	-13.2	-26.1		1.1	-14.3	0.9	-15.2	1.8 (est.)			-17 (est.)	9 (est.)	-25.9		
GCPT09-01	South Jetty (Northwest)	-13.6	-38.6		0.6			-14.2	3.4	Not Encountered		-17.6	20.8	-38.4		
GCPT09-05	North Landing Wharf	-13.6	-29.0		0.5	-14.1	2.7	-16.8	1.7	Not Encountered		-18.5	10.4	-28.9		
GCPT09-06	North Landing Wharf	-14.3	-30.3		0.5			-14.8	3.7	Not Encountered		-18.5	11.2	-29.7		
GCPT09-07	South Jetty (Southwest)	-14.0	-47.5		0.5			-14.5	3.6	Not Encountered		-18.1	>29.4	below -47.5		
GCPT09-08B	South Jetty (Southwest)	-14.1	-41.0		1.3			-15.4	1.2	Not Encountered		-16.5	24.3	-40.8		
GCPT09-09B	South Jetty (South Side)	-13.7	-38.1		1.2			Not Encountered		Not Encountered		-14.8	23.2	-38.0		
GCPT09-10	South Jetty (South Side)	-12.3	-37.7		2.0			Not Encountered		Not Encountered		-14.3	21.8	-36.1		
GCPT09-11	South Jetty (South Side)	-12.2	-26.4		1.4			Not Encountered		Not Encountered		-13.6	12.6	-26.2		
KCPT09-101	South Jetty (South Side)	-5.6	-13.3		1.0			Not Encountered		-6.6	2.0	-8.6	3.9	-12.5		
KCPT09-102	South Jetty (South Side)	-12.6	-27.3		1.8			Not Encountered		Not Encountered		-14.4	12.6	-27.0		
KCPT09-103	South Jetty (South Side)	-13.5	-40.6		1.5			Not Encountered		Not Encountered		-15.0	25.5	-40.5		
KCPT09-104	South Jetty (Southwest)	-14.0	-54.3		0.7			-14.7	3.4	Not Encountered		-18.0	>36.3	below - 54.3		
KCPT09-105	South Jetty (Northwest)	-13.4	-48.3		1.2			-14.6	3.9	Not Encountered		-18.5	>29.8	below - 48.3		
KCPT09-106	South Jetty (Northwest)	-13.7	-26.1		0.7			-14.4	2.5	Not Encountered		-16.9	7.5	-24.4		

MUNROE HEAD

NORTH LANDING WHARF

WATERLOT

DRY DOCK

SECTION 1

SECTION 2

SECTION 3

SOUTH JETTY

TIMBER PILE-SUPPORTED WHARF

STEEL PILE-SUPPORTED CONCRETE DECK

CRIB #6

CRIB #5

CRIB #4

CRIB #3

CRIB #2

CRIB #1

Gabion Mats

N

S

E

W

LEGEND

GBH09-xx	Sonic or Mud Rotary Borehole (by Golder 2009)
GCPT09-xx / KCPT09-xx	Cone Penetration Test (by Golder 2009)
SC09-xx / DC09-xx	Sediment Core and Diver Core (by Golder 2009)
JP09-xx	Jet Probe (by Golder 2009)
TH-xx	Testholes (by Hardy Associates)
BPT01-xx	Becker Penetration Test (by Golder 2001)
BPT02-xx	Becker Penetration Test (by Klohn Crippen 2002)
BOC01-xx	Becker Open Hole (by Golder 2001)
BOC02-xx	Becker Open Hole (by Klohn Crippen 2002)
AH02-01	Hollow-stem Auger hole (by Golder 2001)
DH02-01	Mud Rotary Borehole (by Klohn Crippen 2002)
SCPT02-xx / CPT02-xx	Cone Penetration Test (by Klohn Crippen 2002)
	Approximate Area of Timber Piling Under Jetty
	Approximate Area of Steel Pile-supported Concrete Deck
5	Cross Section Locations
	Waterlot Boundary

NOTES

1. Bathymetry contours (0.5m intervals) provided by CRA Surveys, February 2009. Elevations (in metres) referenced to Geodetic Datum.
2. Drawing base information provided by Public Works and Government Services Canada

20 0 20
SCALE METRES

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

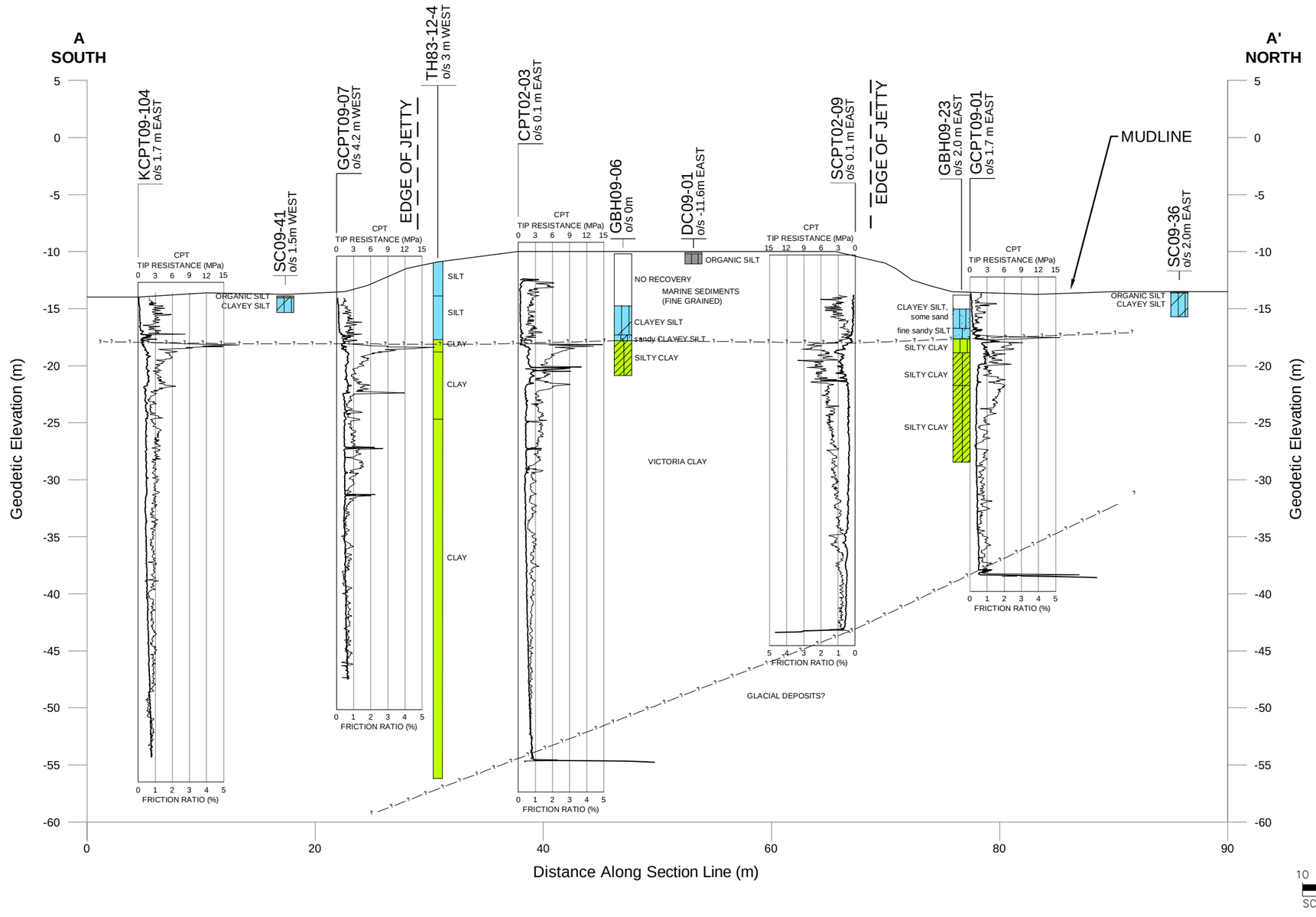
TEST HOLE LOCATION PLAN

Golder Associates
Victoria, BC

PROJECT No. 09-1475-5008			FILE No. P09147550081000-01		
DESIGN	CNW	3 NOV 09	SCALE AS SHOWN	REV.	0
CADD	CLF	11 JAN 09			
CHECK	CNW	2 MAR 10			
REVIEW	JF	2 MAR 10			

FIGURE 1

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot Esq BC (ESQ)\Cad\Drawings\MXD\ Drawing Rev. Fig 1 - P09147550081000-01.dwg Nov 03, 2010 - 1:36pm



LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C

TITLE
STRATIGRAPHIC CROSS-SECTION A-A'

Golder Associates
Victoria, BC

PROJECT	09-1475-5008	FILE No.	S09147550081000-03
DESIGN	CNW	21 SEP 09	SCALE AS SHOWN REV. 0
CADD	TRE	30 DEC 09	
CHECK	CNW	2 MAR 10	
REVIEW	JF	2 MAR 10	

FIGURE 2a

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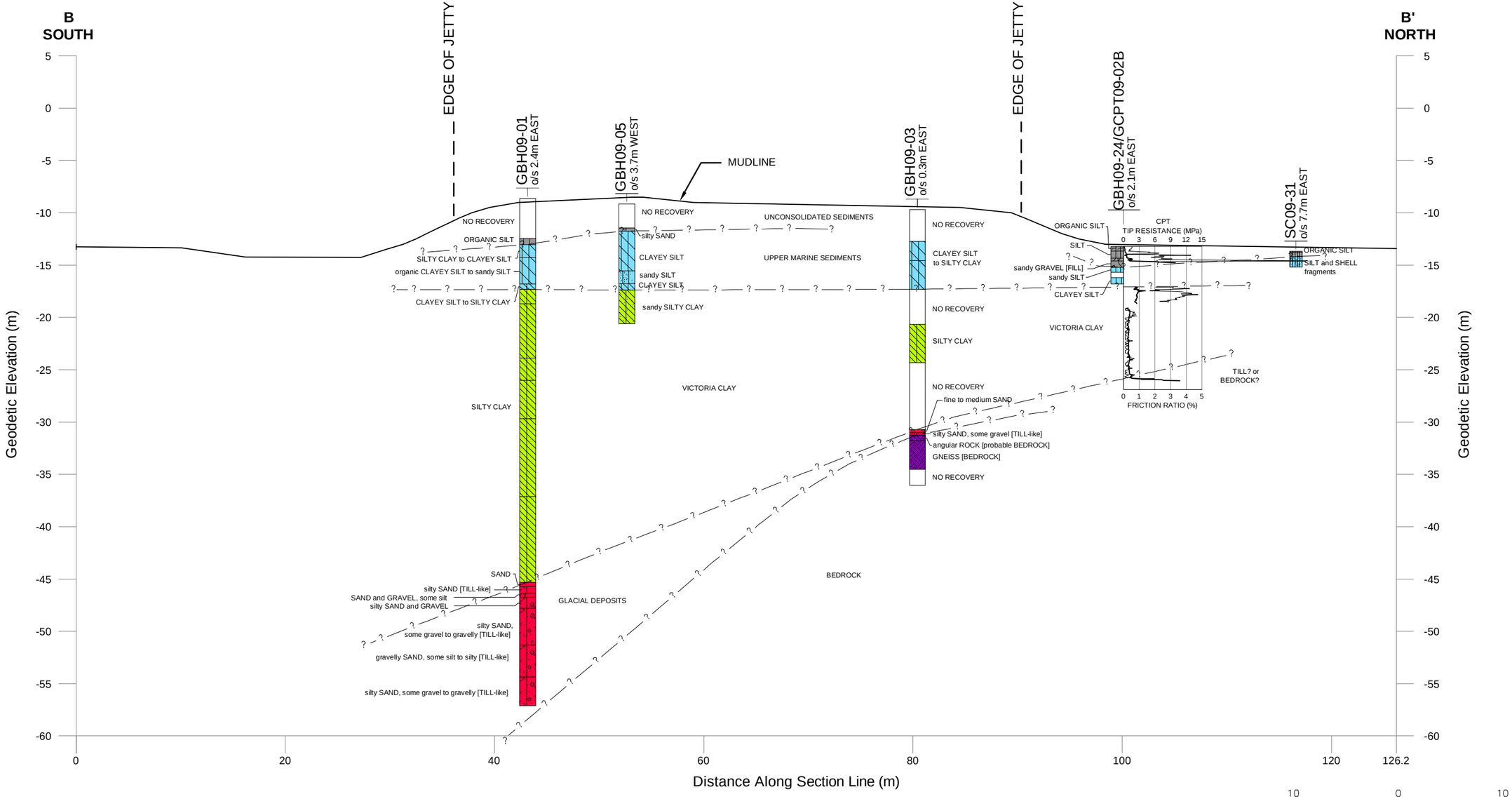


LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

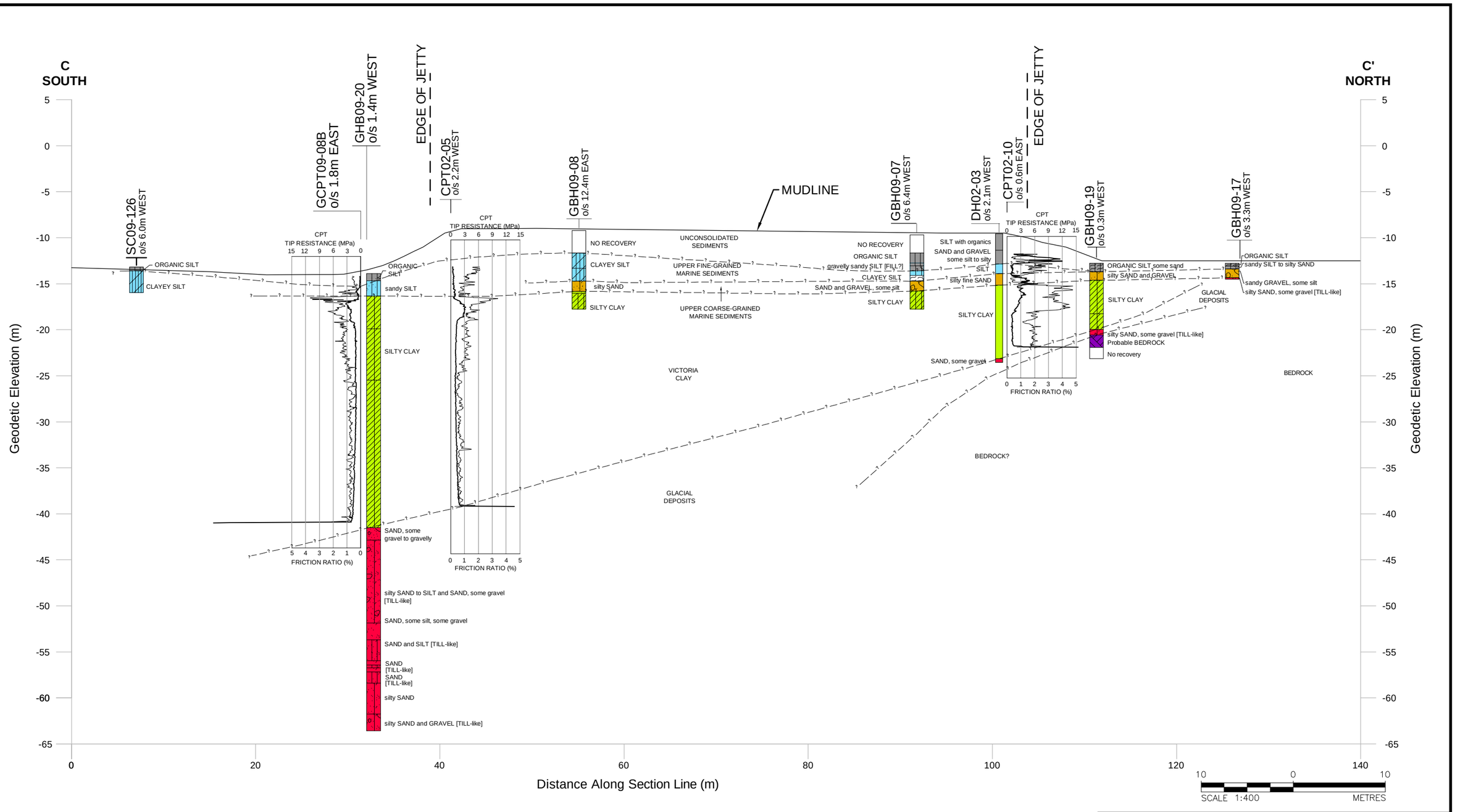
TITLE
STRATIGRAPHIC CROSS-SECTION B-B'

Golder Associates
Victoria, BC

PROJECT No. 09-1475-5008			FILE No. S09147550081000-01	
DESIGN	CNW	21 SEP 09	SCALE AS SHOWN	REV. 0
CADD	TRE	29 DEC 09		
CHECK	CNW	2 MAR 10		
REVIEW	JF	2 MAR 10		

FIGURE 2b

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2b S09147550081000-01 B-B.dwg Mar 03, 2010 - 1:39pm



LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- UPPER MARINE SEDIMENTS (COARSE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

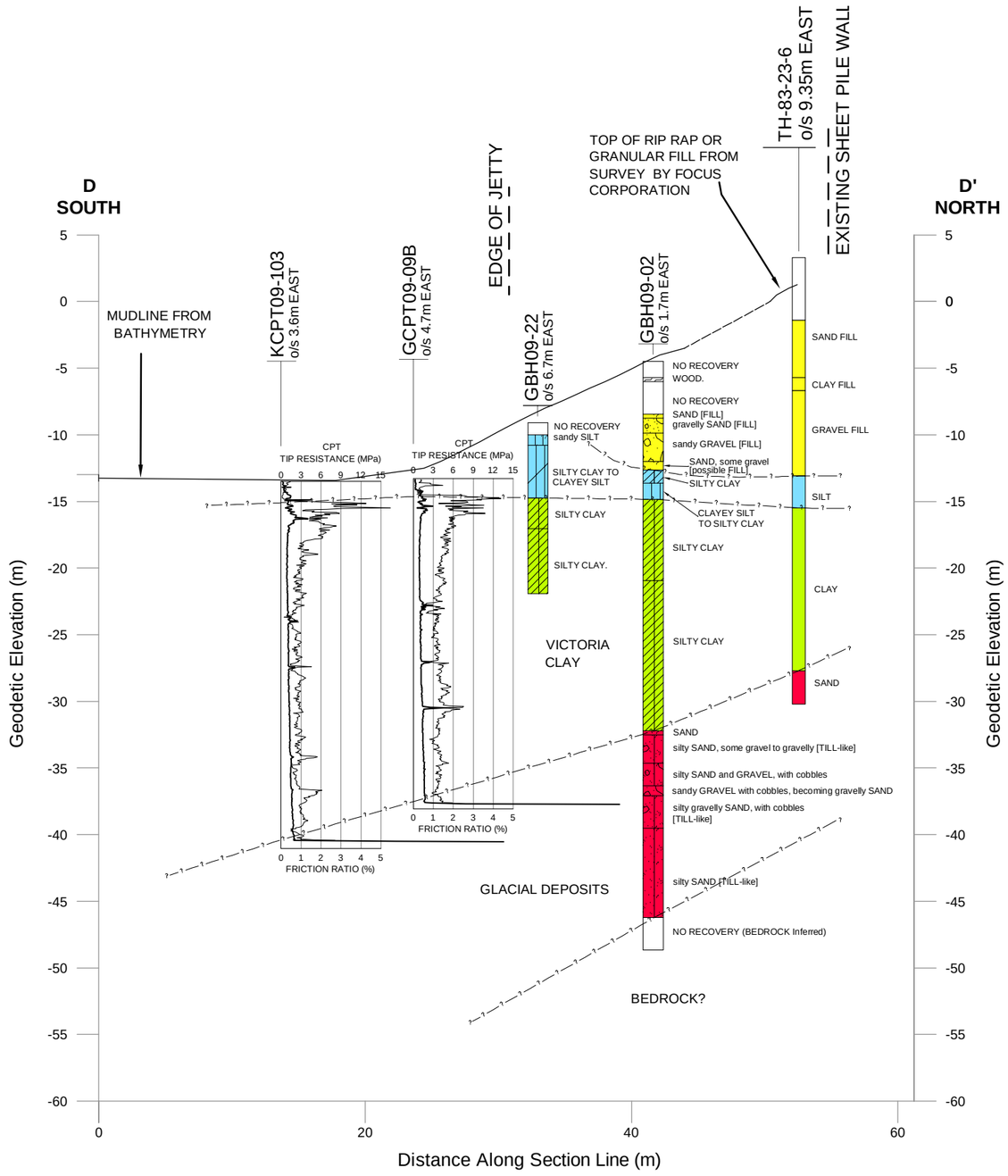
TITLE
STRATIGRAPHIC CROSS-SECTION C-C'

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No S09147550081000-02		
DESIGN	CNW	21 SEP 09	SCALE AS SHOWN	REV.	0
CADD	TRE	29 DEC 09			
CHECK	CNW	2 MAR 10			
REVIEW	JF	2 MAR 10			

FIGURE 2c

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2c S09147550081000-02 C-C.dwg Mar 03, 2010 - 1:05pm



10 0 10
SCALE 1:400 METRES

LEGEND

- UNCONSOLIDATED SEDIMENTS
- GRANULAR AND/OR ROCK FILL
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

1. Mudline profile was derived from bathymetric contours (interval = 0.5 m).
2. Rip Rap elevations from Focus Corportation: 03020056-104TS2.dwg, dated January 15, 2010

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

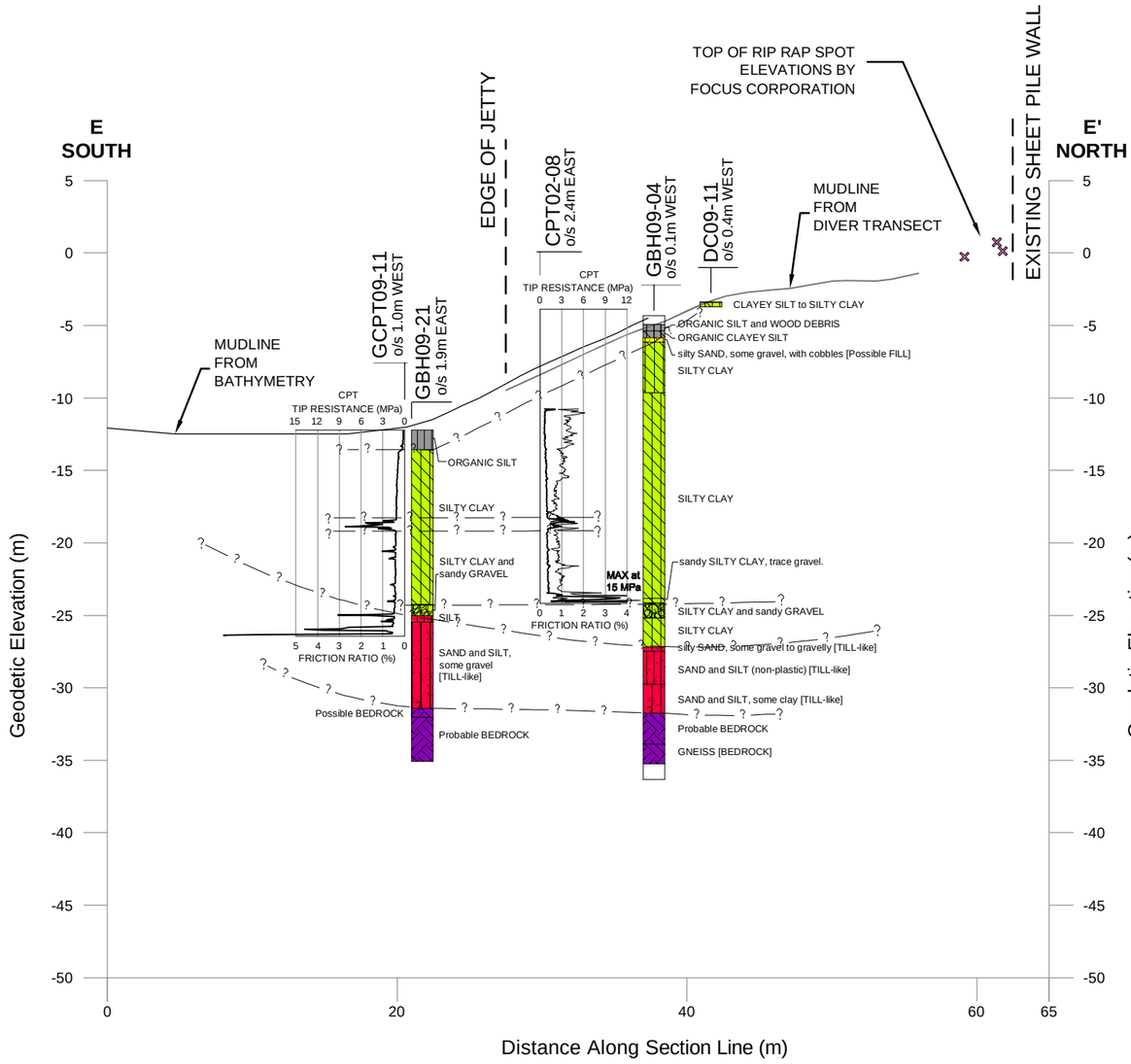
TITLE
STRATIGRAPHIC CROSS-SECTION D-D'

Golder Associates
Victoria, BC

PROJECT No. 09-1475-5008			FILE No S09147550081000-04
DESIGN	CNW	21 DEC 09	SCALE AS SHOWN REV. 0
CADD	JEF	31 DEC 09	
CHECK	CNW	2 MAR 10	
REVIEW	JF	2 MAR 10	

FIGURE 2d

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\ Drawing file: Fig 2d S09147550081000-04 D-D.dwg Mar 03, 2010 - 1:24pm



LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- GRANULAR AND/OR ROCK FILL
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

1. Mudline profile was derived from bathymetric contours (interval = 0.5 m).
2. Rip Rap elevations from Focus Corportation: 03020056-104TS2.dwg, dated January 15, 2010

10 0 10
SCALE 1:400 METRES

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

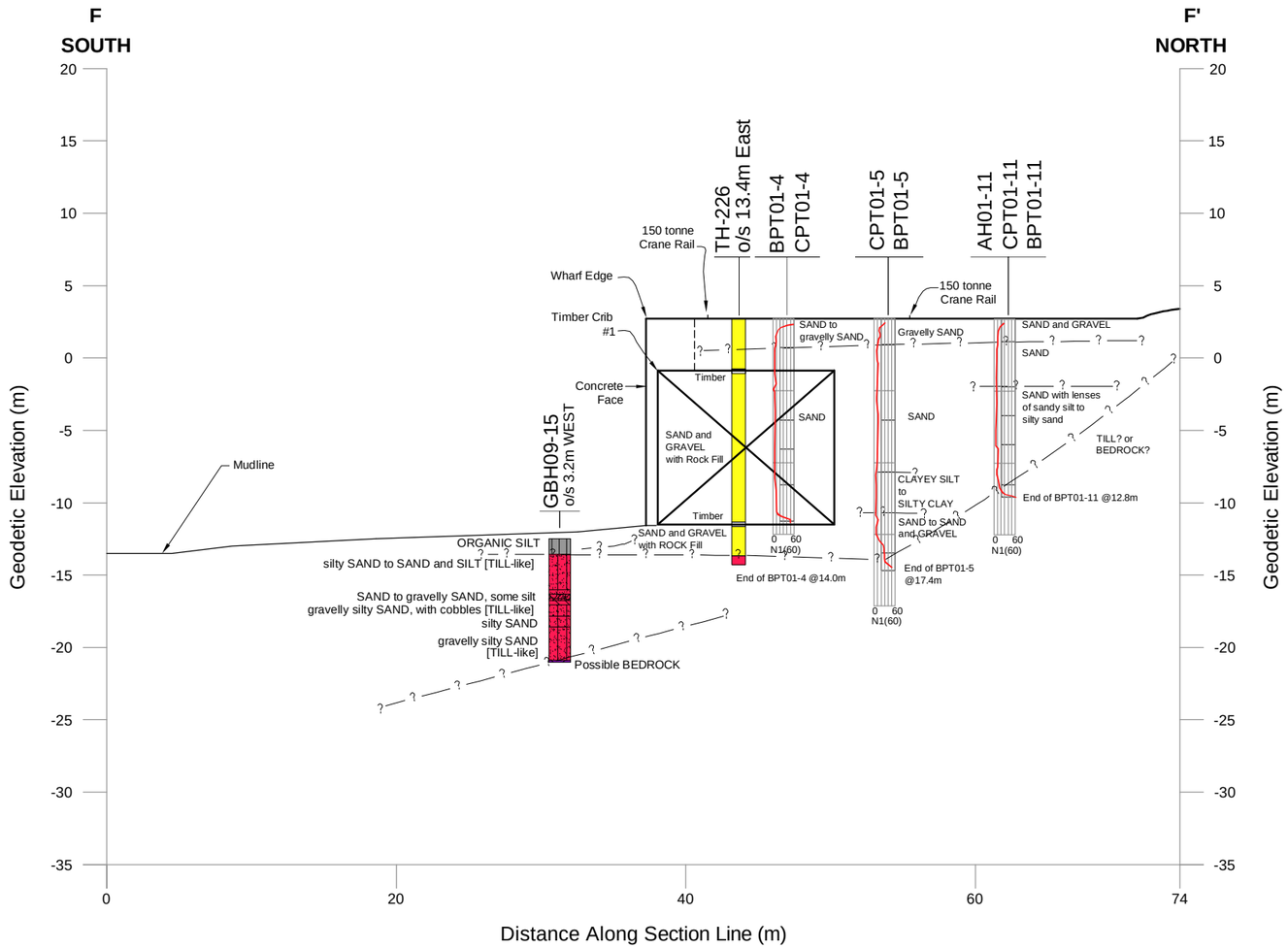
TITLE
STRATIGRAPHIC CROSS-SECTION E-E'

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No S0914755008 1000-05		
DESIGN	CNW	21 SEP 09	SCALE AS SHOWN	REV.	0
CADD	JEF	21 DEC 09			
CHECK	CNW	2 MAR 10			
REVIEW	JF	2 MAR 10			

FIGURE 2e

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2e S0914755008 1000-05 E-E.dwg



LEGEND

- UNCONSOLIDATED SEDIMENTS
- GRANULAR AND/OR ROCK FILL
- GLACIAL DEPOSITS
- BEDROCK
- N1(60) FROM BECKER PENETRATION TEST (BPT)

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

10 0 10
SCALE 1:400 METRES

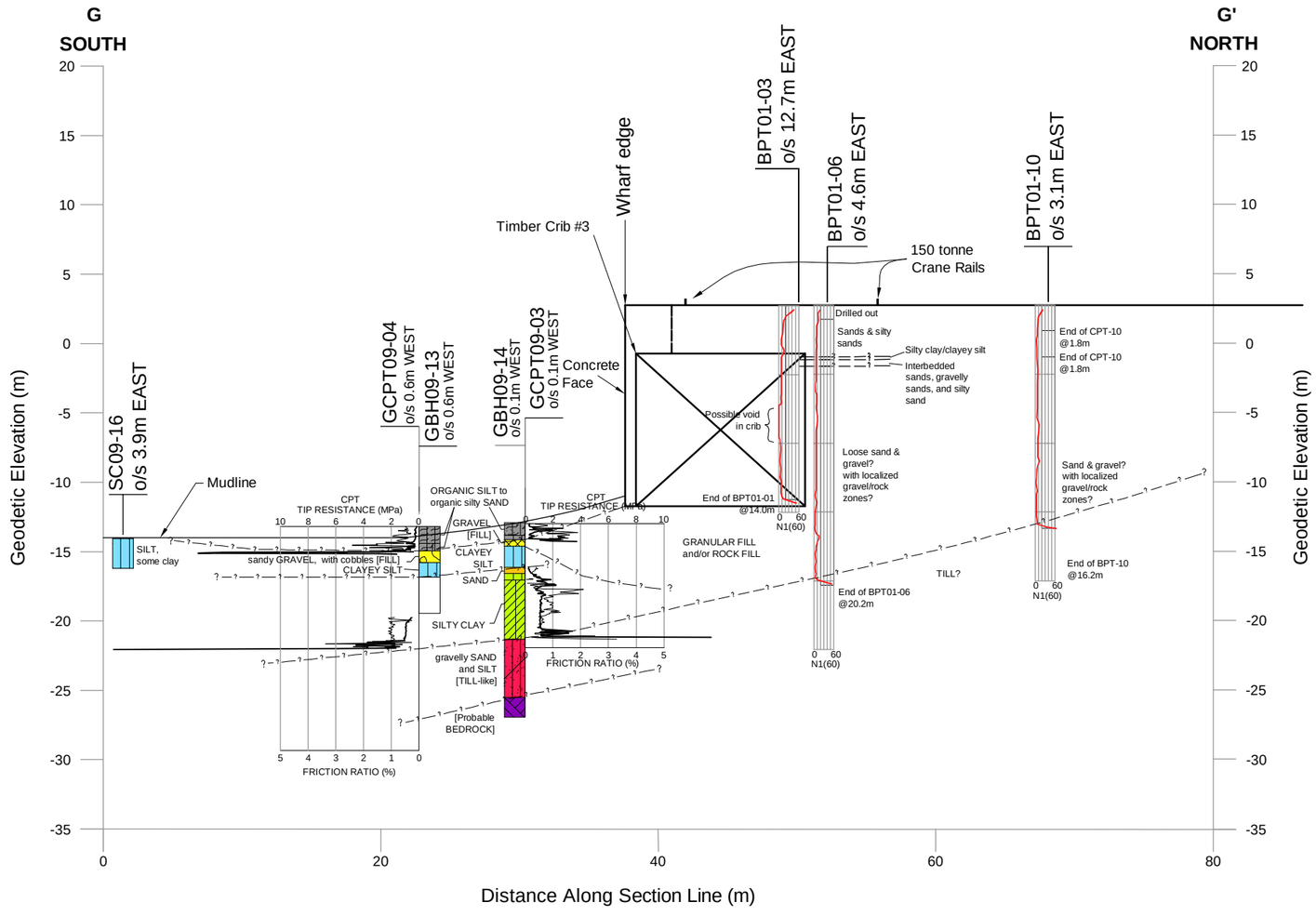
PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
STRATIGRAPHIC CROSS-SECTION F-F'

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No.S09147550081000-06	
DESIGN	CNW	21 SEP 09	SCALE AS SHOWN	REV. 0
CADD	JEF	29 DEC 09		
CHECK	CNW	2 MAR 10	**FIGURE 2f**	
REVIEW	JF	2 MAR 10		

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2f S09147550081000-06 F-F.dwg Mar 03, 2010 - 1:32pm



10 0 10
SCALE 1:400 METRES

LEGEND

- UNCONSOLIDATED SEDIMENTS
- GRANULAR AND/OR ROCK FILL
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- UPPER MARINE SEDIMENTS (COARSE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f
- N1(60) FROM BECKER PENETRATION TEST (BPT)

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

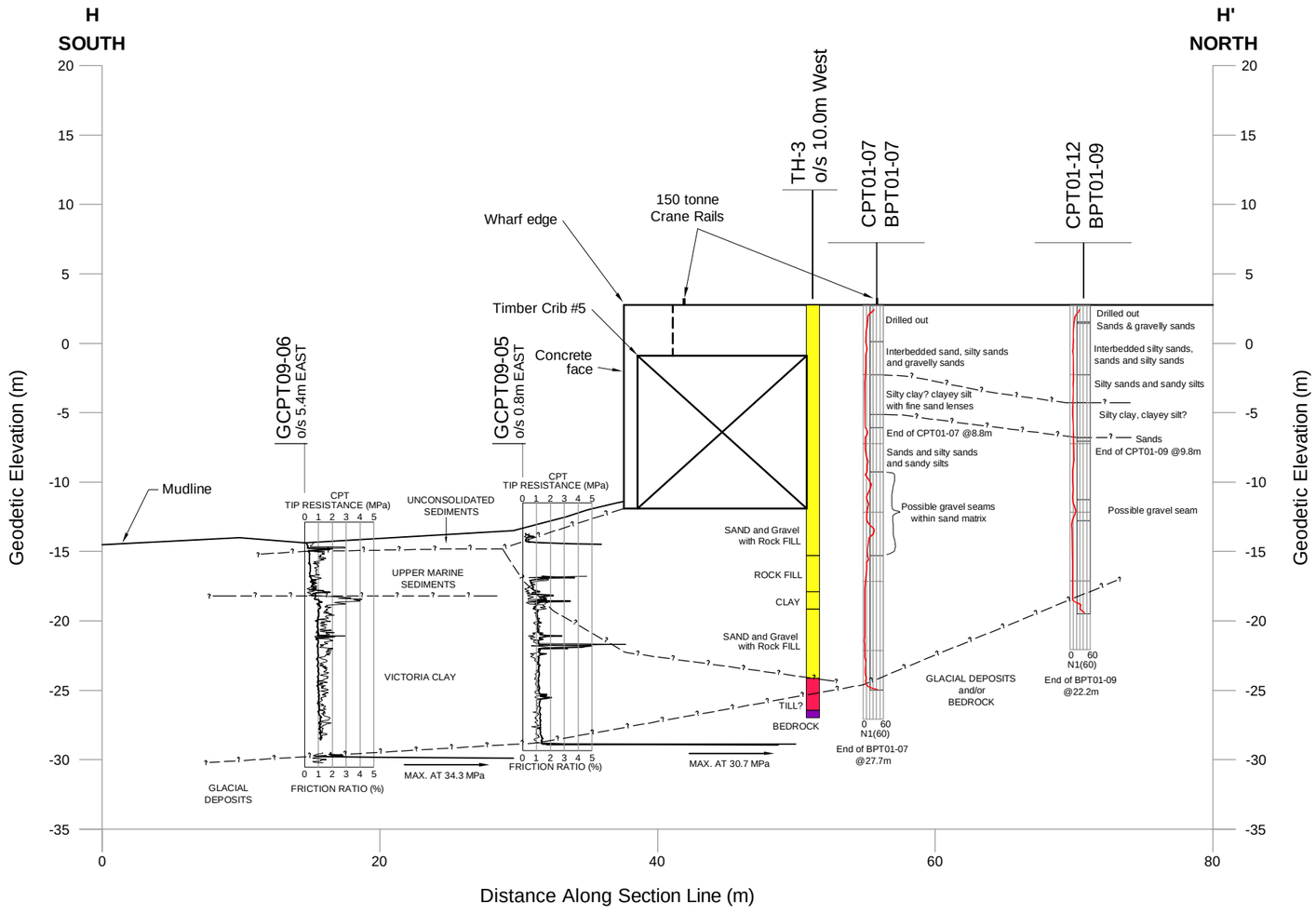
PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
STRATIGRAPHIC CROSS-SECTION G-G'

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No.S09147550081000-08
DESIGN	CNW	16 DEC 09	SCALE AS SHOWN REV. 0
CADD	JEF	29 DEC 09	
CHECK	CNW	2 MAR 10	FIGURE 2g
REVIEW	JF	2 MAR 10	

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2g S09147550081000-08 G-G.dwg Mar 03, 2010 - 1:19pm



10 0 10
SCALE 1:400 METRES

LEGEND

- GRANULAR AND/OR ROCK FILL
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f
- N1(60) FROM BECKER PENETRATION TEST (BPT)

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

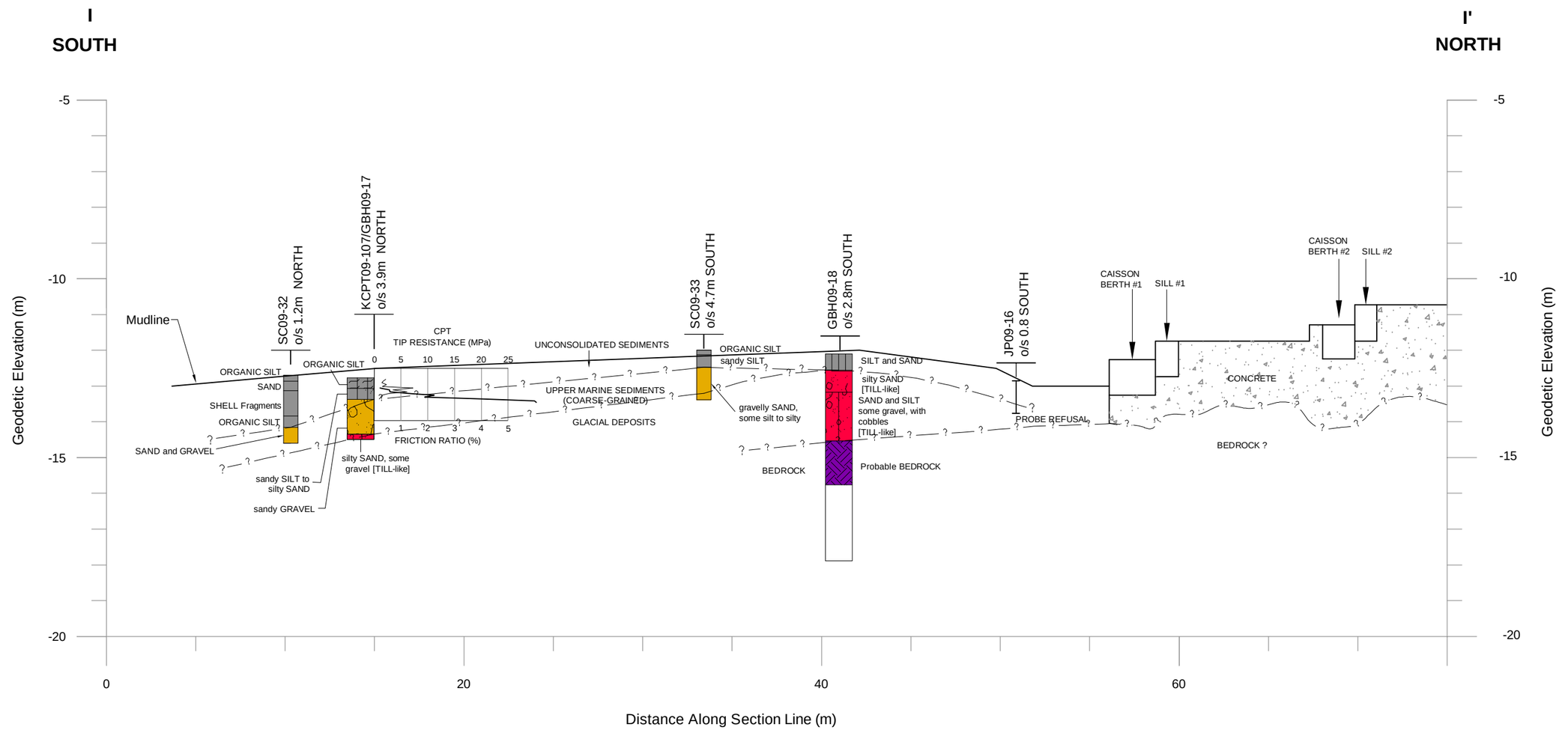
PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
STRATIGRAPHIC CROSS-SECTION H-H'

Golder Associates
Victoria, BC

PROJECT No. 09-1475-5008			FILE No.S09147550081000-07
DESIGN	CNW	16 DEC 09	SCALE AS SHOWN REV. 0
CADD	JEF	29 DEC 09	
CHECK	CNW	2 MAR 10	**FIGURE 2h**
REVIEW	JF	2 MAR 10	

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\PHASE 1000\Fig 2h S09147550081000-07 H-H.dwg Mar 03, 2010 - 1:28pm



5 0 5
SCALE 1:250 METRES
2X VERTICAL EXAGGERATION

LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (COARSE-GRAINED)
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

STRATIGRAPHIC CROSS-SECTION I-I'

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No. S09147550081000-07	
DESIGN	CNW	23 NOV 09	SCALE AS SHOWN	REV. 0
CADD	CLF	29 NOV 09		
CHECK	CNW	2 MAR 10		
REVIEW	JF	2 MAR 10		

FIGURE 2i

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\ Drawing file: Fig. 2i S09147550081000-07 I-I'.dwg Mar 03, 2010 - 1:12pm

N

W E

S

GCPT09-05 -18.5

GCPT09-06 -18.5

GBH09-14 -16.6

GBH09-15 NOT PRESENT

GBH09-16 NOT PRESENT

GBH09-17 NOT PRESENT

GBH09-18 NOT PRESENT

GBH09-19 -14.6

KCPT09-106 -16.9

GCPT09-02B -17.0

GBH09-07 -15.8

GCPT09-01 -17.6

GBH09-03 -17.3

GBH09-23 -17.6

KCPT09-105 -18.5

GBH09-06 -17.7

GBH09-05 -17.4

GBH09-01 -17.3

GBH09-08 -15.8

GBH09-02 -14.8

GBH09-22 -14.6

GBH09-20 -16.3

GCPT09-08B -16.5

GCPT09-09B -14.8

KCPT09-103 -15.0

GCPT09-07 -18.1

KCPT09-104 -18.0

GBH09-10 -13.9

GCPT09-10 -14.3

KCPT09-102 -14.4

GBH09-09 -11.6

GBH09-04 -6.14

GCPT09-11 -13.6

GBH09-21 -13.6

KCPT09-101 -8.6

LEGEND

XX
Testhole (2009 Investigation) with Elevation of Top of Victoria Clay

-15 Inferred Elevation Contours for Top of Victoria Clay (1m Interval)

Waterlot Boundary

NOTES

1. All Elevations (in metres) referenced to Geodetic Datum.
2. Bathymetry contours (0.5m intervals) provided by CRA Surveys, February 2009.
3. Drawing base information provided by Public Works and Government Services Canada
4. Soil unit surface elevations have been interpreted from testhole data at the testhole locations shown. Subsurface elevations between the testholes have been inferred and so may vary from that shown.

30 0 30

SCALE 1:1,500 METRES

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
ELEVATION OF TOP OF VICTORIA CLAY

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No. P091475500 81000-02		
DESIGN	CNW	12 JAN 10	SCALE AS SHOWN	REV. 0	
CADD	CLF	13 JAN 10			
CHECK	CNW	2 MAR 10			
REVIEW	JF	2 MAR 10			

FIGURE 3a

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\PHASE 1000\Fig 3a P091475500 81000-02 Victoria Clay.dwg Mar 03, 2010 - 1:50pm

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\PHASE 1000\Fig 3b P0914755008100-02 Glacial Till.dwg Mar 03, 2010 - 1:52pm

N
W E
S

GCPT09-05 -28.9
GCPT09-06 -29.7
GBH09-14 -21.3
GCPT09-04 -22.0
GBH09-15 -13.6
GBH09-16 -14.3
GBH09-17 -14.3
GBH09-18 -12.6
GBH09-19 -20.0
KCPT09-106 -24.4
GCPT09-02B -25.9
GCPT09-01 -38.4
GBH09-03 -30.7
KCPT09-105 Below -48.3
GBH09-02 -32.2
GBH09-10 -35.7
GCPT09-10 -36.1
GBH09-01 -45.3
GCPT09-09B -38.0
GCPT09-08B -40.8
KCPT09-103 -40.5
GBH09-20 -41.5
GCPT09-07 Below -47.5
KCPT09-104 Below -54.3
GBH09-04 -27.2
GCPT09-11 -26.2
GBH09-21 -25.0
KCPT09-101 -12.5
KCPT09-102 -27.0

LEGEND

XX
Testhole (2009 Investigation) with Elevation Top of Glacial Deposit

-18 Inferred Elevation Contours for Top of Glacial Deposit (5m Interval)

Waterlot Boundary

NOTES

1. All Elevations (in metres) referenced to Geodetic Datum.
2. Bathymetry contours (0.5m intervals) provided by CRA Surveys, February 2009.
3. Drawing base information provided by Public Works and Government Services Canada
4. Soil unit surface elevations have been interpreted from testhole data at the testhole locations shown. Subsurface elevations between the testholes have been inferred and so may vary from that shown.

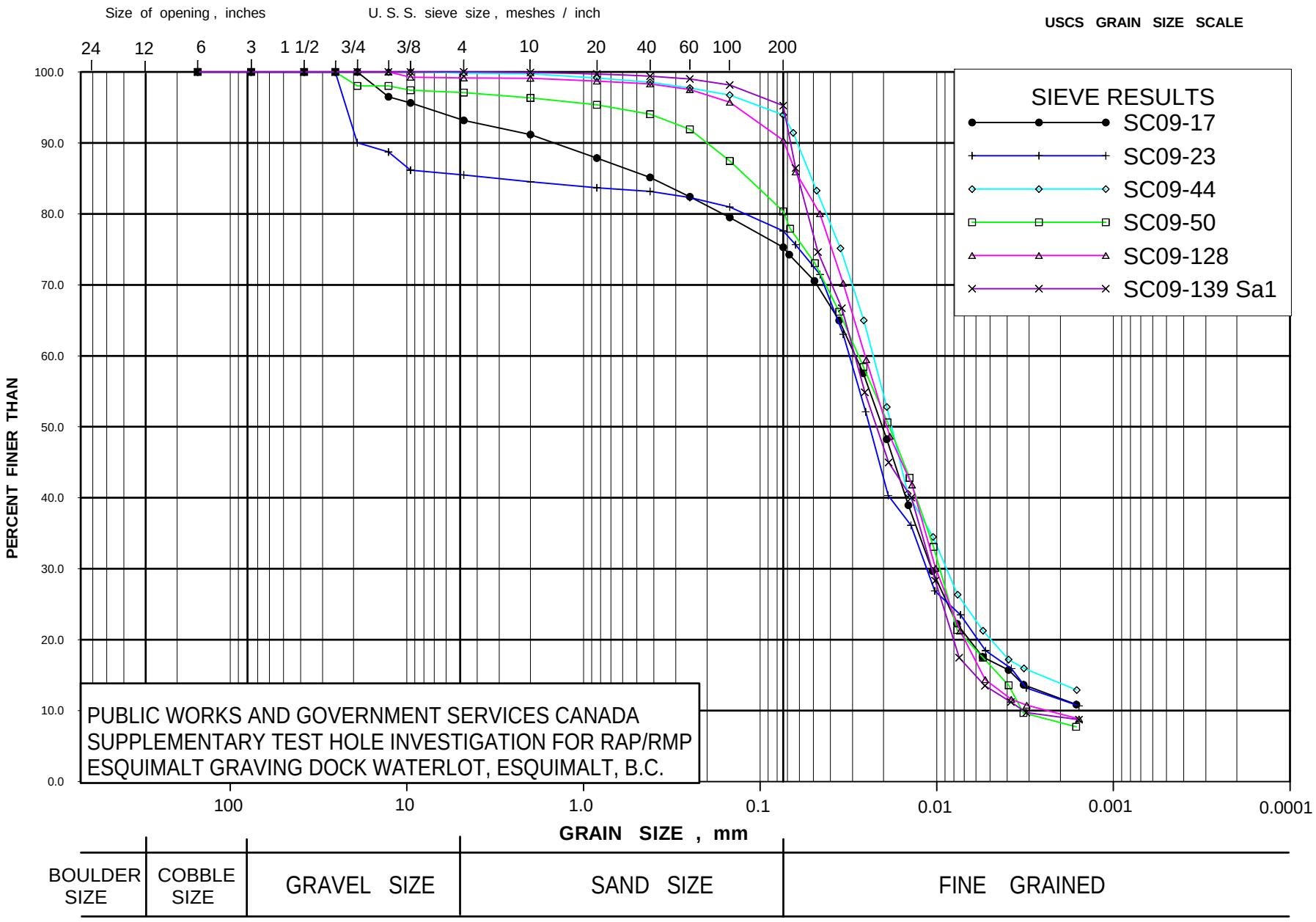
30 0 30
SCALE 1:1,500 METRES

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
ELEVATION OF TOP OF GLACIAL DEPOSITS

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No P0914755008100-02
DESIGN	CNW	12 JAN 10	SCALE AS SHOWN REV. 0
CADD	CLF	13 JAN 10	
CHECK	CNW	2 MAR 10	FIGURE 3b
REVIEW	JF	2 MAR 10	

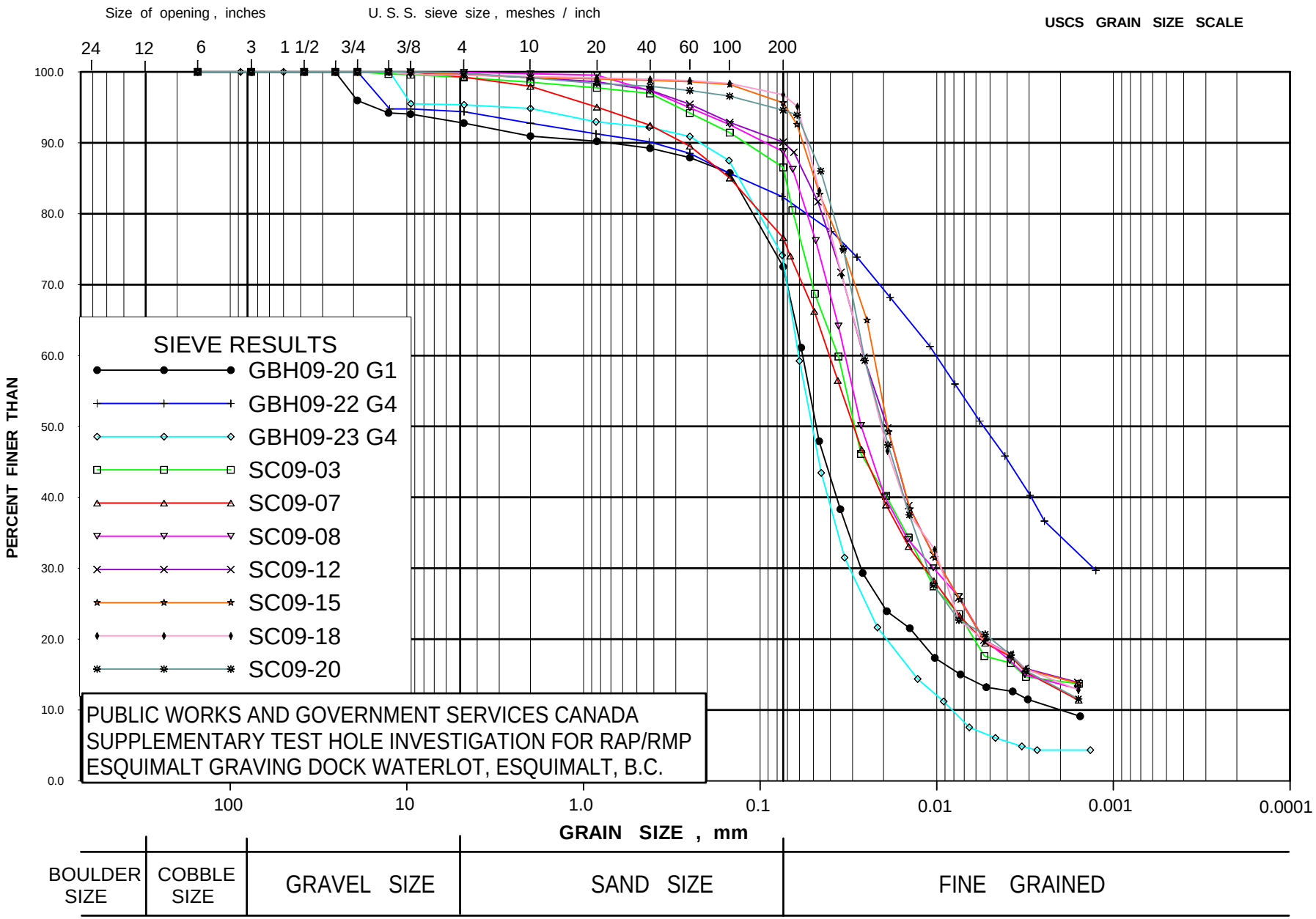


Project No. 09-1475-5008
Drawn DGM
Reviewed CNW
Date 15 Jan 10

Golder Associates

GRAIN SIZE DISTRIBUTIONS
Unconsolidated Sediments

Figure 4a

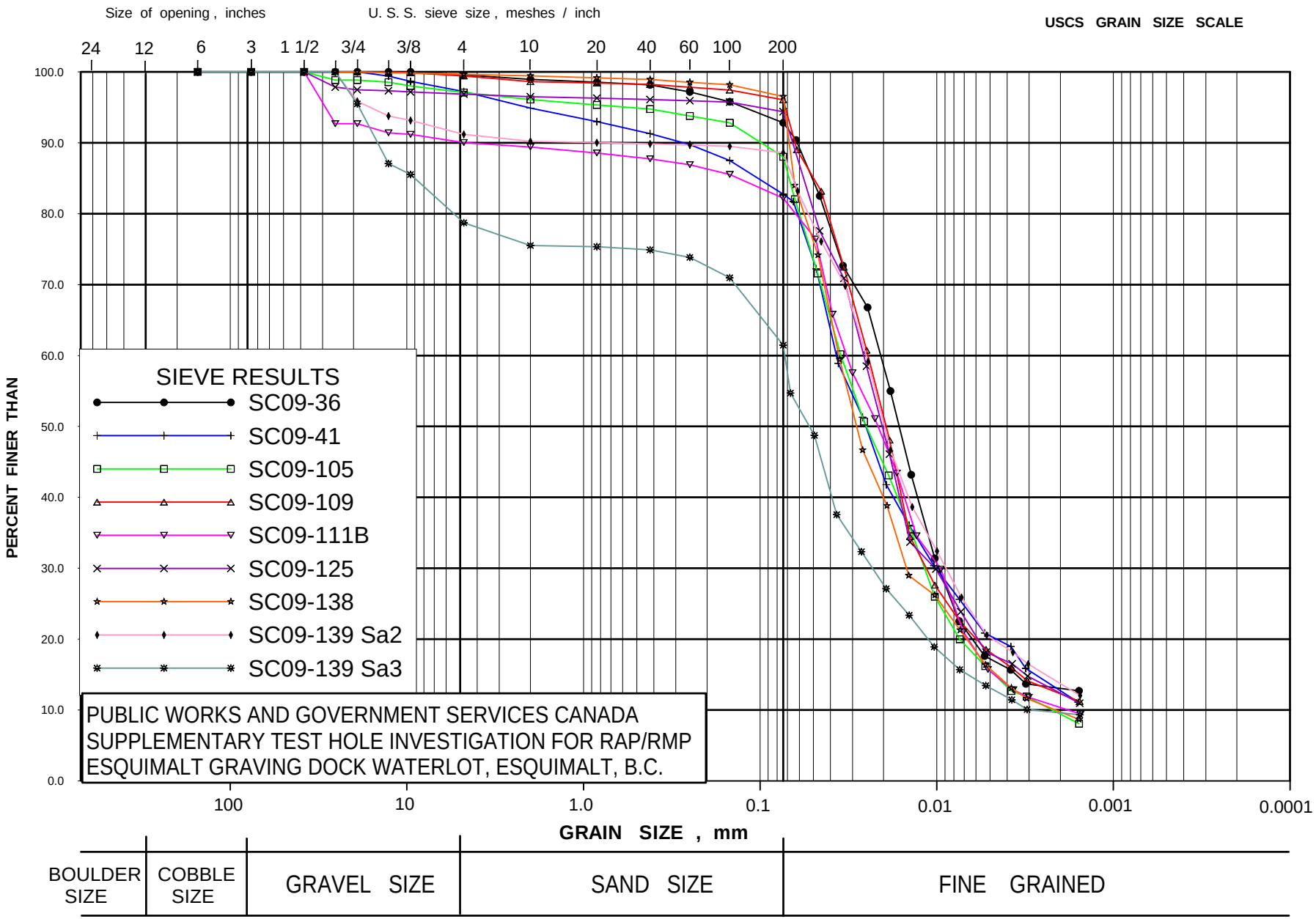


Project No. 09-1475-5008
Drawn DGM
Reviewed CNW
Date 15 Jan 10

Golder Associates

GRAIN SIZE DISTRIBUTIONS
Upper Marine Sediments (Fine Grained)

Figure 4b

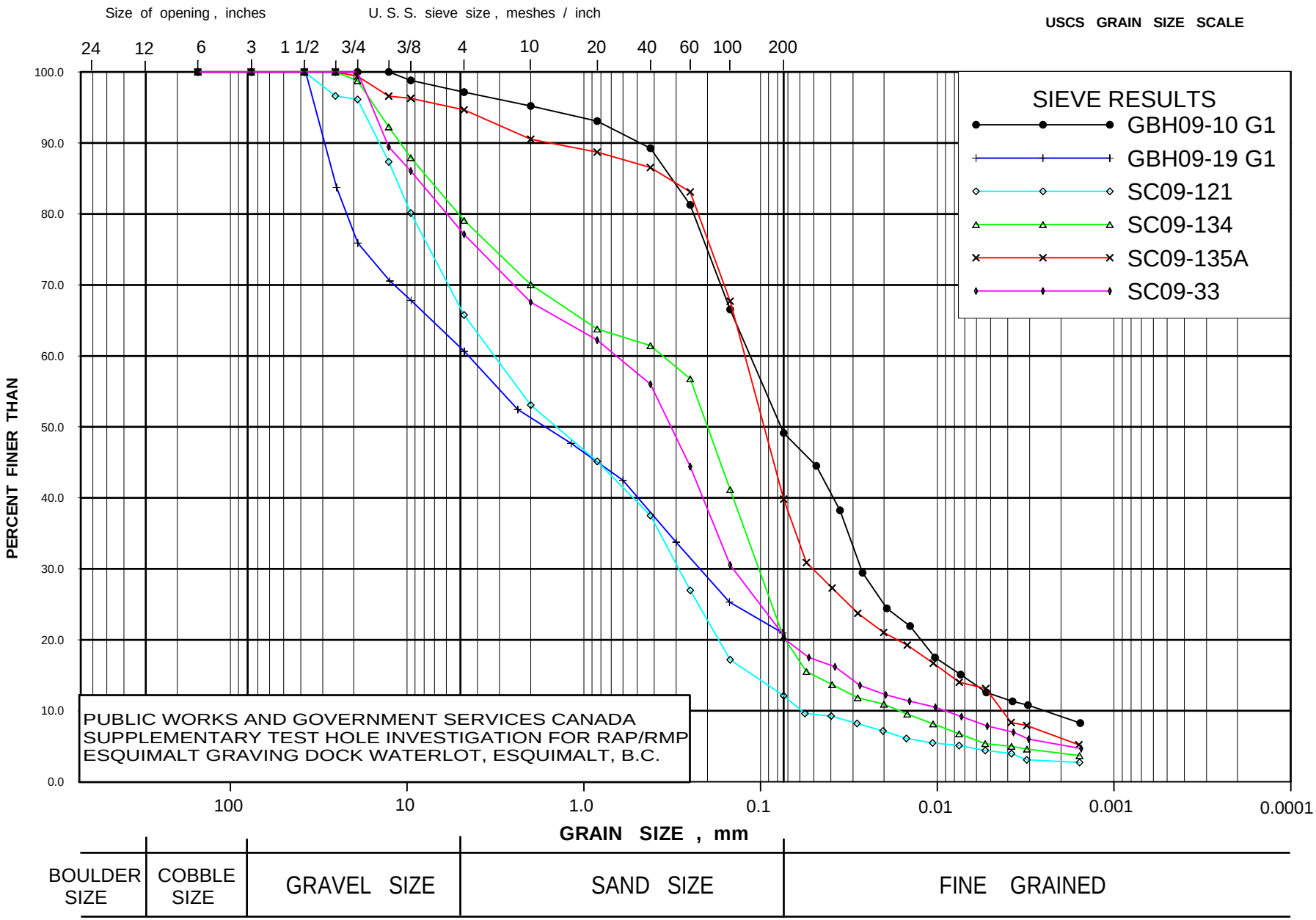


Project No. 09-1475-5008
Drawn DGM
Reviewed CNW
Date 15 Jan 10

Golder Associates

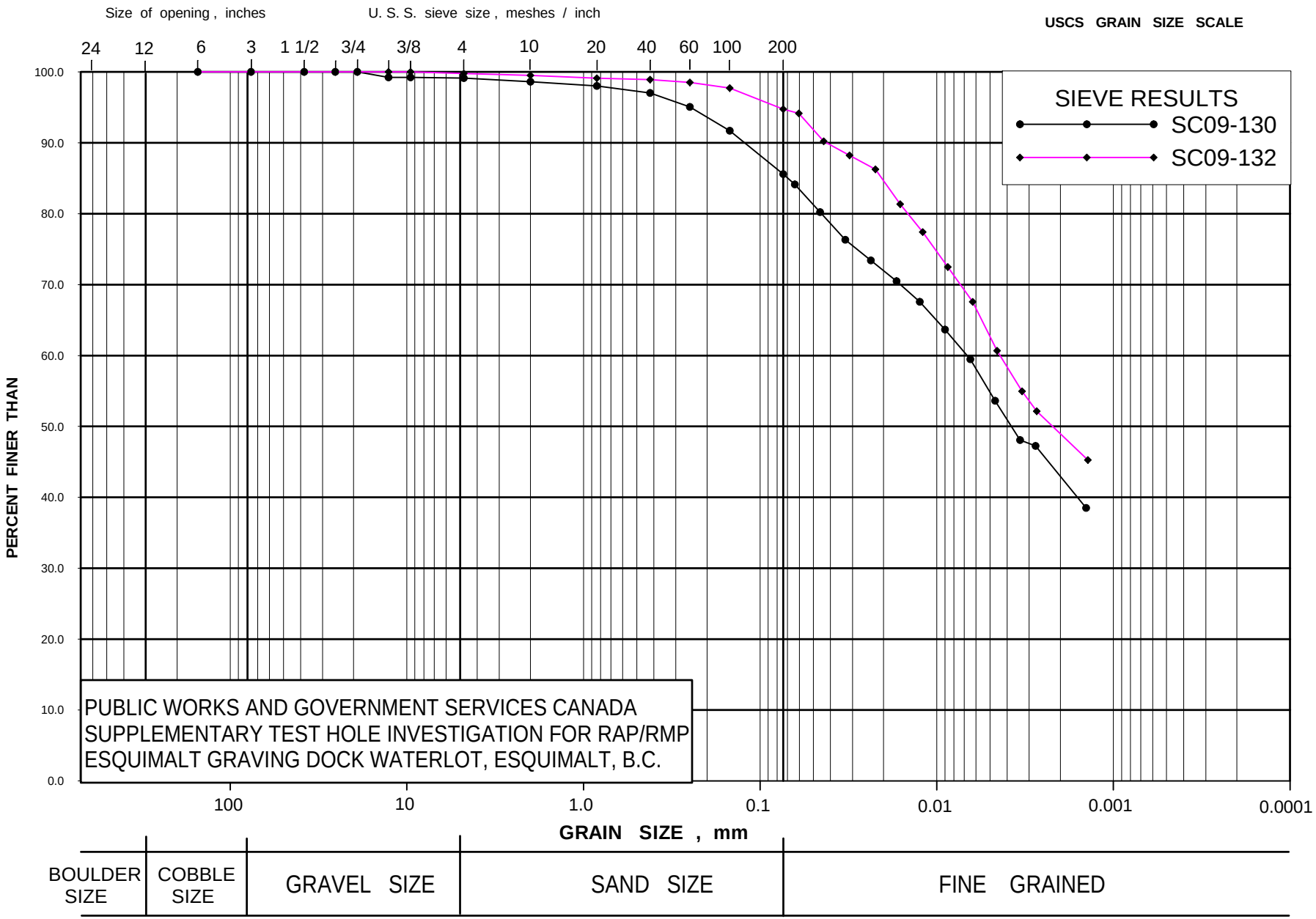
GRAIN SIZE DISTRIBUTIONS
Upper Marine Sediments (Fine Grained)

Figure 4c



Project No. 09-1475-5008 **Drawn** DGM **Reviewed** CNW **Date** 15 Jan 10	Golder Associates	**GRAIN SIZE DISTRIBUTIONS** **Upper Marine Sediments (Coarse Grained)**

Figure 4d

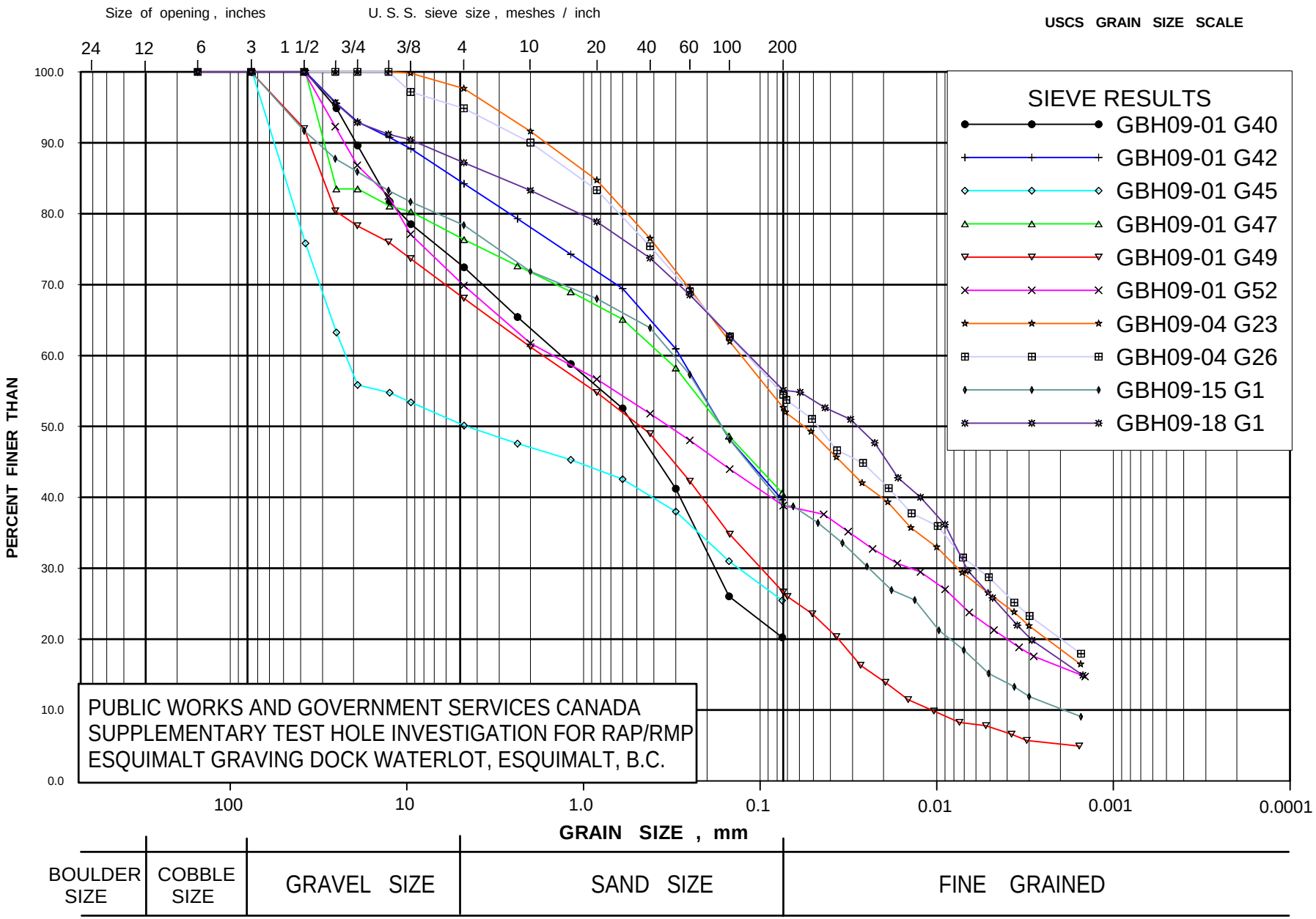


Project No. 09-1475-5008
Drawn DGM
Reviewed CNW
Date 15 Jan 10

Golder Associates

GRAIN SIZE DISTRIBUTIONS
Victoria Clay

Figure 4e

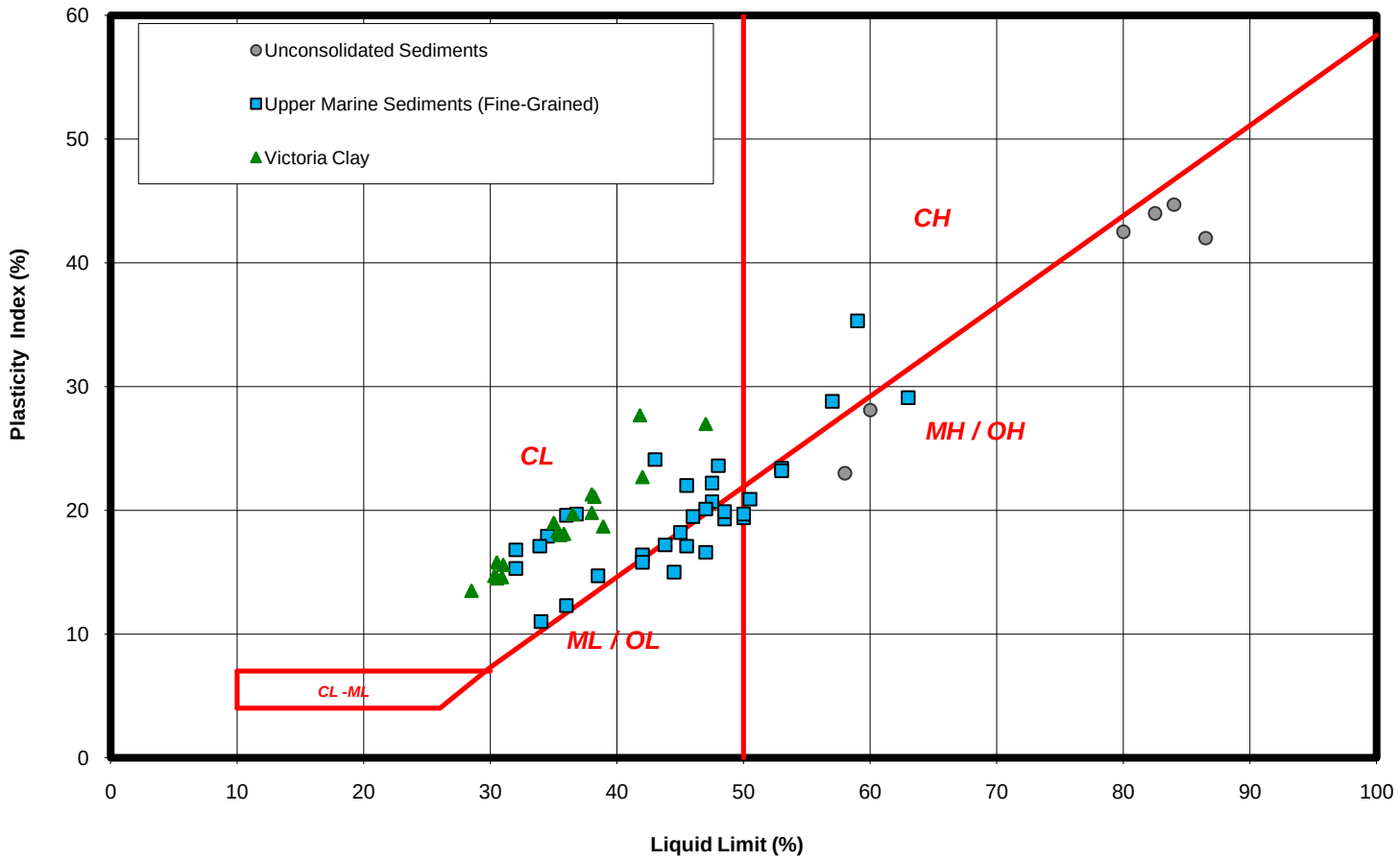


Project No. 09-1475-5008
Drawn DGM
Reviewed CNW
Date 15 Jan 10

Golder Associates

GRAIN SIZE DISTRIBUTIONS
Glacial Deposits

Figure 4f



USCS Classification of Fine-Grained Soils

Fine-Grained - Liquid Limit < 50

CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
OL	Organic silts and organic silt-clays of low plasticity

Fine-Grained - Liquid Limit > 50

CH	Inorganic clays of high plasticity, fat clays
MH	Inorganic silts, micaeous or diatomaceous fine sandy or silty soils, elastic silts
OH	Organic clays of medium to high plasticity, organic silts

PROJECT **PUBLIC WORKS AND GOVERNMENT SERVICES CANADA**
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

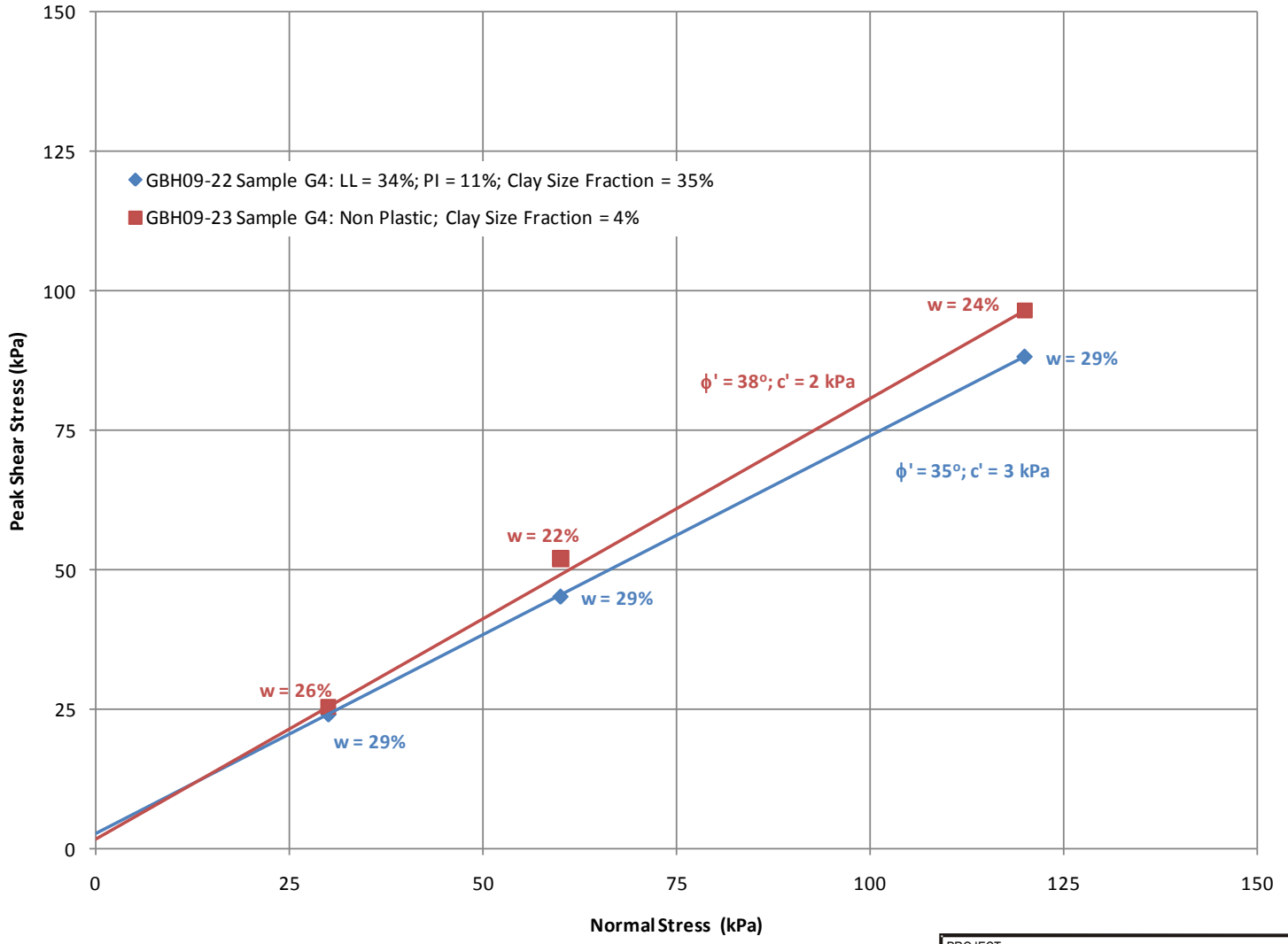
TITLE

Plasticity Chart

Golder Associates

PROJECT No. 09-1475-5008			FILE No.S09147550081000-05
ANALYSIS	CNW	18 JAN 10	SCALE REV.
CADD	SA	18 JAN 10	**FIGURE 5**
CHECK	CNW	1 MAR 10	
REVIEW	JF	2 MAR 10	

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Data\Stability Analyses\Figures



PROJECT **PUBLIC WORKS AND GOVERNMENT SERVICES CANADA**
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

Drained Shear Strengths from Direct Shear Tests

Golder Associates

PROJECT No. 09-1475-5008			FILE No.
ANALYSIS	TM/LL	18 JAN 10	SCALE REV.
CADD	MCS	12 FEB 10	**FIGURE 6**
CHECK	CNW	12 FEB 10	
REVIEW	JF	15 FEB 10	

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Deliverables\Factual Report\Figures

APPENDIX A

Record of Boreholes

GEOTECHNICAL SOIL DESCRIPTION TERMINOLOGY

RELATIVE DENSITY OR CONSISTENCY

RELATIVE DENSITY OF COHESIONLESS SOILS	
Density Description	**SPT N[(1)] (blows/ft)**
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50
(1) Refer to ASTM D 1586 for a definition of N.	

CONSISTENCY OF COHESIVE SOILS		
Consistency	**Undrained Shear Strength (kPa)**	**SPT N[(1)] (blows/ft)**
Very soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30
(1) Refer to ASTM D 1586 for a definition of N. N value ranges in shaded cells may not be representative of consistency of cohesive soils with water contents at or above the liquid limit.		

COMPONENT CLASSIFICATION

Component Definitions by Gradation		
Component	**Particle Size Range**	
	(mm)	**USS Sieve**
Boulders	>300	12 inch
Cobbles	75 to 300	3 to 12 inch
Gravel		3 inch to No. 4
Coarse	19 to 75	0.75 to 3 inch
Fine	4.76 to 19	No. 4 to 0.75 inch
Sand		No. 4 to No. 200
Coarse	2.0 to 4.76	No. 10 to No.4
Medium	0.42 to 2.0	No. 40 to No. 10
Fine	0.075 to 0.42	No. 200 to No. 40
Silt and/or Clay	<0.075	No. 200

Description Terminology Denoting Component Proportions	
Descriptive Term	**Range of Proportion[(1)]**
trace	1 to 10%
some	10 to 20%
…y	20 to 30%
and	>30%
(1) Percentage by weight; does not apply to clay content or organic content	

Cohesive and Organic Soil Descriptions	
Description	**Typical USCS Designation**
CLAYEY SILT	ML, CL-ML
SILTY CLAY	CL
CLAY	CH
Organic SILT to Organic CLAY	OL,OH
PEAT	Pt

SAMPLE TYPE

Log Symbol	Sample Type
AS	auger sample
DO	drive open (SPT split spoon)
CS	chunk/core sample
TP	thin walled, piston
TO	thin walled, open (shelby tube)

LABORATORY TESTS

Log Symbol	Laboratory Test
circle plot (w)	water content
bar plot (w_P,w_L)	Atterberg limits
M	sieve analysis
H	hydrometer analysis
C	consolidation test
DS	direct shear test

GENERAL NOTES

1. Cohesionless soils do not exhibit plastic behavior at any water content. Cohesionless soils can include both coarse-grained and fine-grained particles. Coarse-grained particles are particles that would be retained on the No. 200 USS sieve (0.075 mm), while fine-grained particles are particles that would pass the No. 200 USS sieve (0.075 mm). Cohesionless soils are described in terms of the relative mass proportions of the particle size constituents.

2. Cohesive soils exhibit plastic behavior over a range of moulding water contents, and are classified as (in order of increasing degree of plasticity) CLAYEY SILT, SILTY CLAY, or CLAY, based on Atterberg limits testing, with reference to the plasticity chart in ASTM D 2487. Cohesive soils exhibiting bulk plastic behaviour are generally fine-grained soils but may also contain minor or even major proportions of coarse-grained particles.

3. Organic soils are soils with at least 5% organic content by weight. The behaviour of organic fine-grained soils is similar to that of the mineral soil component. Peat is comprised predominantly of organic matter (> 30% by weight), which may contain minor proportions of mineral soils.

4. Standard Penetration Test (SPT, ASTM D 1586) and Dynamic Cone Penetration Test (DCPT) blow counts shown on the logs are field values and have not been corrected for effective overburden pressure or hammer efficiency.

5. Soil component descriptions on the borehole logs are influenced by the borehole diameter, sampler size, and drilling method. The distribution of soil constituents within a soil formation can be expected to vary from the description on the Record of Borehole sheets, particularly with regards to gravel, cobbles, and boulders.

6. Water levels shown on the Record of Borehole sheets represent water levels observed within the open boreholes at the time of drilling or at the time of standpipe piezometer monitoring. Groundwater levels may vary significantly with time due to annual, seasonal, and special meteorological conditions. Artesian conditions may be present in some soil formations but not apparent during drilling of the formation.

7. Location coordinates shown on the logs are UTM and elevations are to Geodetic vertical datum.

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-01

SHEET 1 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364793 E: 468340.2

DATUM: Geodetic

DRILLING DATE: August 25-26, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-8.65				SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) 20 40 60 80	WATER CONTENT PERCENT Wp — W — Wl; NP - Non-Plastic 25 50 75 100		
0	DB320 Mini-Track Sonic Rig; Sonic with 100 mm diameter core barrel and 150 mm diameter casing	NO RECOVERY		0.00							
				-12.48							
4		Very soft, wet, black, ORGANIC SILT, with wood debris, fibrous organics, shell fragments, hydrogen sulphide-like odour.		3.83	Sa1A	CS					
					G1	CS					
				-13.05	Sa1B	CS					
		Soft, wet, grey, CLAYEY SILT to SILTY CLAY, with shell fragments, hydrogen sulphide-like odour.		4.40	G2	CS					
5					G3	CS					
					Sa2	CS					
				-14.29	G4	CS					
		Soft to firm, wet, grey, organic CLAYEY SILT, trace sand becoming sandy SILT to trace to some clay, with shells.		5.64	G5	CS					
6					Sa3	CS					
					G6	CS					
7					G7	CS					
					Sa4	CS					
8					G8	CS					
				-16.83							
		Firm, wet, grey, CLAYEY SILT to SILTY CLAY, trace sand, with shells.		8.18							
				-17.34	G9	CS					
9		Stiff to very stiff, moist, brown becoming mottled brown and grey, SILTY CLAY.		8.69	G10	CS					
					Sa5	CS					
					G11	CS					
10											
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS/DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-01

SHEET 2 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364793 E: 468340.2

DATUM: Geodetic

DRILLING DATE: August 25-26, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Stiff to very stiff, moist, brown becoming mottled brown and grey, SILTY CLAY. *(continued)*			G12	CS							
					Sa6	CS							
11					G13	CS							
				-19.85 11.20									
					G14	CS							
12					G15	CS							
					G16	CS							
13					Sa7	CS							
					G17	CS							
14		Stiff becoming firm, wet, grey, SILTY CLAY, trace sand, trace gravel.											
15					G18	CS							
					G19	CS							
16					G20	CS							
					Sa8	CS							
17				-26.02 17.37									
					G21	CS							
18					G22	CS							
		Firm, wet, grey, SILTY CLAY.											
19					G23	CS							
					G24	CS							
20		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS/DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-01

SHEET 3 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364793 E: 468340.2

DRILLING DATE: August 25-26, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Firm, wet, grey, SILTY CLAY. *(continued)*			G25	CS		SHEAR STRENGTH Cu, kPa; nat V. + Q - ●; rem V. ⊕ U - ○ (20 40 60 80)	WATER CONTENT PERCENT: Wp — W — Wl; NP - Non-Plastic (25 50 75 100)		
21					Sa9/10	CS					
22					G26	CS					
23					G27	CS					
24					G28	CS					
25											
26						CS					
27					G29	CS					
28					G30	CS					
29		Stiff, moist to wet, grey, SILTY CLAY.		-37.12 28.47	G31	CS					
30		*CONTINUED NEXT PAGE*			G32	CS					

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS/DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-01

SHEET 4 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364793 E: 468340.2

DRILLING DATE: August 25-26, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Stiff, moist to wet, grey, SILTY CLAY. *(continued)*			G33	CS					
31					G34	CS					
32					G35	CS					
					Sa12	CS					
33					G36	CS					
34					G37	CS					
35					G38	CS					
36					G39	CS					
				-45.33							
		Dense to very dense, wet, grey, well-graded gravelly SAND, some silt to silty.		36.68	G40	CS				M	
37				-45.74	Sa13	CS					
		Compact to dense, moist, grey, SAND and SILT, some gravel, trace clay.		37.09	G41	CS					
					G42	CS				M	
				-46.37	G43	CS					
		Dense to very dense, wet, grey, well-graded SAND and GRAVEL, some silt.		37.72							
38				-46.75	G44	CS					
		Very dense, moist, grey, well-graded silty SAND and GRAVEL to silty sandy GRAVEL.		38.10	Sa14	CS					
					G45	CS				M	
39				-47.82							
		Very dense, moist, grey, well-graded SAND and SILT, some gravel to gravelly (fine to coarse, rounded to sub-angular). [TILL-like]		39.17							
40		*CONTINUED NEXT PAGE*									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS/DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-01

SHEET 5 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364793 E: 468340.2

DRILLING DATE: August 25-26, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
40	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very dense, moist, grey, well-graded SAND and SILT, some gravel to gravelly (fine to coarse, rounded to sub-angular). [TILL-like] *(continued)*			G46	CS							
41					Sa15	CS							
					G47	CS						M	
42				-51.32									
		Very dense, moist, grey, well-graded gravelly SAND (fine to coarse, rounded to sub-angular gravel), some silt to silty. [TILL-like]		42.67									
43													
					G48	CS							
44													
					G49	CS						M,H	
45				-54.37									
		Very dense, dry, mottled light and dark green-grey with white inclusions, well-graded gravelly silty SAND, (fine and coarse, angular gravel), trace clay. [TILL-like]		45.72									
46					G50	CS							
					G51	CS							
47					G52	CS						M,H	
					G53	CS							
48				-57.11									
		End of Borehole.		48.46									
49													
50													

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS/DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-02

SHEET 1 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364804.6 E: 468416.3

DATUM: Geodetic

DRILLING DATE: August 27-28, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-4.48				SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) 20 40 60 80	WATER CONTENT PERCENT Wp — W — Wl; NP - Non-Plastic 25 50 75 100		
0	DB320 Mini-Track Sonic Rig; Sonic with 100 mm diameter core barrel and 150 mm diameter casing	NO RECOVERY		0.00							
1				-5.70							
		Black creosote-soaked WOOD.		1.22 -6.00							
				1.52							
2		NO RECOVERY									
3											
				-8.44							
4		Wet, black, well-graded SAND, trace to some gravel, with wood debris and shell fragments, creosote-like odour, hydrocarbon sheen. [FILL]		3.96 -8.75	Sa1/2	CS					
		Wet, grey with black staining, gravelly SAND, trace silt, with shell fragments, hydrocarbon-like odour. [FILL]		4.27	Sa3/4	CS					
5				-9.87							
		Wet, grey, sandy GRAVEL, trace silt with shell fragments, hydrocarbon-like odour. [FILL]		5.39	Sa5	CS					
6											
7					G1	CS					
				-12.00							
		Wet, grey, SAND, some gravel, trace silt, with shell fragments. [possible FILL]		7.52	Sa6	CS					
8					G2	CS					
				-12.63							
		Firm, moist, grey, SILTY CLAY, trace sand, trace gravel, with shell fragments.		8.15	G3	CS					
9					Sa7	CS					
				-13.62	G4	CS					
		Stiff, moist, grey, CLAYEY SILT to SILTY CLAY, trace sand, trace fine gravel.		9.14							
10					G5	CS					
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-02

SHEET 2 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364804.6 E: 468416.3

DRILLING DATE: August 27-28, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Stiff, moist, grey, CLAYEY SILT to SILTY CLAY, trace sand, trace fine gravel. *(continued)*		-14.84 / 10.36									
11					G6	CS							
12					G7 Sa8	CS CS							
13		Stiff becoming firm, moist to wet, grey, SILTY CLAY, trace sand, trace fine gravel.			G8	CS							
14					G9	CS							
15					G10	CS							
16				-20.94 / 16.46									
17					Sa9	CS							
18		Firm to stiff, moist to wet, grey, SILTY CLAY.			G11	CS							
19					G12	CS							
20		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-02

SHEET 3 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364804.6 E: 468416.3

DRILLING DATE: August 27-28, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	--- 20.4 to 20.9 m depth: Contains lenses (3) of fine to medium sand < 25 mm thick.			G13	CS							
21													
22					G14	CS							
23					G15	CS							
24		Firm to stiff, moist to wet, grey, SILTY CLAY. *(continued)*			Sa10	CS							
25					G16	CS							
26		--- Below 25.6 m depth: Contains trace sand.											
27					G17	CS							
28		Compact to dense, wet, grey, SAND, trace silt, trace gravel.		-32.22 27.74 -32.52 28.04	G18	CS							
29		Very dense, moist, grey, well-graded silty SAND, some gravel to gravelly (fine and coarse, sub-rounded to sub-angular). [TILL-like]			G19	CS							
30					G20	CS							
		CONTINUED NEXT PAGE											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-02

SHEET 4 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364804.6 E: 468416.3

DATUM: Geodetic

DRILLING DATE: August 27-28, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing			-34.66							
				30.18	G21	CS					
31		Very dense, dry, grey, well-graded silty SAND and GRAVEL, with cobbles.			Sa11	CS					
				-36.33							
32		Dense to very dense, wet, grey, sandy GRAVEL with cobbles, becoming fine to medium SAND, trace coarse sand, trace fine gravel, becoming well-graded gravelly SAND, trace silt.		31.85	G22	CS					
					G23	CS					
					G24	CS					
				-37.09							
33		Very dense, wet, grey, well-graded gravelly SAND, some silt to silty, with cobbles. [TILL-like]		32.61							
34					G25	CS					
35				-39.53							
		Very dense, moist becoming dry, mottled light/dark grey and olive grey, well-graded silty SAND, trace to some angular gravel, trace clay. [TILL-like]		35.05	G26	CS					
36											
					G27	CS					
37											
					G28	CS					
38											
39											
					G29	CS					
40		*CONTINUED NEXT PAGE*									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-02

SHEET 5 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364804.6 E: 468416.3

DRILLING DATE: August 27-28, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (20 40 60 80) nat V. + Q - ● rem V. ⊕ U - ○	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (25 50 75 100) Wp W Wl NP - Non-Plastic	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
40	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very dense, moist becoming dry, mottled light/dark grey and olive grey, well-graded silty SAND, trace to some angular gravel, trace clay. [TILL-like] *(continued)*			G30	CS							
41													
				-46.24	G31	CS							
42				41.76									
43		NO RECOVERY (BEDROCK Inferred)											
44				-48.68									
				44.20									
		End of Borehole.											
45													
46													
47													
48													
49													
50													

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-03

SHEET 1 OF 3

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364829.9 E: 468334.1

DRILLING DATE: August 31, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-9.64									
0	DB320 Mini-Track Sonic Rig; Sonic with 100 mm diameter core barrel and 150 mm diameter casing			0.00									
1		NO RECOVERY											
2													
3				-12.69									
				3.05									
4		Soft, wet, grey, CLAYEY SILT to SILTY CLAY, trace sand, trace gravel, with shell fragments, wood debris and organics, hydrocarbon-like odour.			Sa1/2	CS							
					G1	CS							
				-14.52									
5				4.88									
6		Soft, wet, grey, CLAYEY SILT to SILTY CLAY, trace to some gravel, trace sand, with shell fragments. --- Rounded cobble recovered from approximately 7.62 m depth.											
7					Sa3	CS							
					G2	CS							
				-17.26									
				7.62									
8													
9		NO RECOVERY											
10													
		CONTINUED NEXT PAGE											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-03

SHEET 2 OF 3

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364829.9 E: 468334.1

DRILLING DATE: August 31, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	NO RECOVERY *(continued)*		-20.61									
11				10.97									
12					G3	CS							
					Sa4	CS							
13		Soft to firm, wet, grey, SILTY CLAY, trace gravel, trace sand.			G4	CS							
14					G5	CS							
				-24.27									
15				14.63									
16													
17		NO RECOVERY											
18													
19													
20		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-03

SHEET 3 OF 3

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364829.9 E: 468334.1

DRILLING DATE: August 31, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	NO RECOVERY *(continued)*		-30.67							
21		Dense to very dense, wet, grey, fine to medium SAND, some silt.		21.03 -30.98	G6	CS					
		Very dense, wet, grey, silty SAND, some gravel. [TILL-like]		21.34 -31.21	G7	CS					
		Dry, grey, coarse gravel to cobble-sized, angular ROCK. [probable BEDROCK]		21.56	G8	CS					
22				-31.74							
		Strong to very strong, GNEISS. [BEDROCK]		22.10	G9	CS					
23											
24					G10	CS					
					G11	CS					
				-34.48							
25		NO RECOVERY		24.84							
26				-36.01							
		End of Borehole.		26.37							
27											
28											
29											
30											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-04

SHEET 1 OF 4

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364820.1 E: 468568.2

DRILLING DATE: September 1, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Mudline		-4.31							
				0.00							
		NO RECOVERY									
				-4.92							
		Soft, wet, black, ORGANIC SILT and WOOD DEBRIS, hydrocarbon-like odour, hydrocarbon sheen.		0.61	Sa1	CS					
1				-5.38							
		Soft to firm, wet, grey, organic CLAYEY SILT, trace to some sand, trace gravel, trace shell fragments, hydrogen sulphide-like odour.		1.07	Sa2/3	CS					
				-5.83							
		Wet, grey, silty SAND, some gravel, with cobbles. [Possible FILL]		1.52							
				-6.14							
2				1.83	G1	CS					
					Sa4	CS					
3					G2	CS					
		Stiff becoming firm, moist, grey, SILTY CLAY, trace sand, trace gravel, with shells.									
4					G3	CS					
					G4	CS					
5				-9.64							
				5.33	G5	CS					
					Sa5	CS					
6											
7					G6	CS					
		Firm, moist, grey, SILTY CLAY, trace sand.									
8											
					G7	CS					
9											
					G8	CS					
10											
		CONTINUED NEXT PAGE									

DB320 Mini-Track Sonic Rig
Sonic with 100 mm diameter core barrel and 150 mm diameter casing

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-04

SHEET 2 OF 4

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364820.1 E: 468568.2

DRILLING DATE: September 1, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing				G9	CS							
11					G10	CS							
12		--- 9.8 to 14.3 m depth: Contains trace gravel.			Sa6	CS							
13					G11	CS							
14		Firm, moist, grey, SILTY CLAY, trace sand. *(continued)*			G12	CS							
15					G13	CS							
16					G14	CS							
17		--- 17.7 m depth: Lens (<15 mm thickness) of fine to medium sand.			G15	CS							
18					G16	CS							
19				-23.82									
		Stiff, moist to wet, grey, sandy SILTY CLAY, trace gravel.		19.51 -24.12	G17	CS							
20		*CONTINUED NEXT PAGE*		19.82									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-04

SHEET 3 OF 4

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364820.1 E: 468568.2

DRILLING DATE: September 1, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Compact, wet, grey, clayey GRAVEL (angular), some sand. *(continued)*			G18	CS						M,H	
					G19	CS							
				-25.19									
21		Firm to stiff, moist to wet, grey SILTY CLAY, trace to some sand.		20.88	G20	CS							
22					G21	CS							
				-27.17									
23		Dense to very dense, moist to wet, grey, silty SAND, some gravel to gravelly (sub-rounded), trace clay. [TILL-like]		22.86	G22	CS							
				-27.47									
				23.16									
24		Very dense, dry, light grey, well-graded SAND and SILT, some clay, trace fine angular gravel. [TILL-like]			G23	CS						M,H	
					G24	CS							
25				-29.76									
				25.45	G25	CS							
26		Very dense, moist, grey, well-graded SAND and SILT, some clay, trace angular gravel. [TILL-like] --- 27.4 m depth: Possible seam of wet gravelly sand.			G26	CS						M,H	
					G27	CS							
27													
					G28	CS							
				-31.74									
				27.43									
28		Wet, grey and green with white veining, coarse sand-sized to gravel-sized to cobble-sized angular rock. [Probable BEDROCK]											
29					G29	CS							
				-33.88									
		Strong to very strong GNEISS. [BEDROCK]		29.57									
30		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-04

SHEET 4 OF 4

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364820.1 E: 468568.2

DRILLING DATE: September 1, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	DB320 Mini-Track Sonic Rig	Strong to very strong GNEISS. [BEDROCK] *(continued)*			G30	CS					
				-35.25							
31		NO RECOVERY		30.94							
				-36.31							
32		End of Borehole.		32.00							
33											
34											
35											
36											
37											
38											
39											
40											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-05

SHEET 1 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364801.8 E: 468333.1

DATUM: Geodetic

DRILLING DATE: September 2, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-9.16									
0	DB320 Mini-Track Sonic Rig; Sonic with 100 mm diameter core barrel and 150 mm diameter casing			0.00									
1		NO RECOVERY											
2				-11.45									
		Loose, wet, grey, silty SAND, trace gravel, with shells, with debris (glass, wood), hydrocarbon-like odour [possible FILL].		2.29 -11.75 2.59	Sa1/2	CS							
3					Sa3	CS							
4		Firm, moist to wet, grey, CLAYEY SILT, trace sand, trace gravel, with shells, hydrogen sulphide-like odour. --- Shell fragments below 4.42 m depth.											
5					Sa4	CS							
6				-15.56									
		Wet, grey, sandy SILT, trace gravel, with shell fragments, hydrogen sulphide-like odour. ---Shell layer 15 cm thick at 6.71 m depth. --- Contains cobbles (15 to 20 cm thick) at 7.26 m depth.		6.40	Sa5	CS							
7				-16.78									
		Firm to stiff, moist, grey, CLAYEY SILT, trace to some sand.		7.62									
8				-17.39	Sa6	CS							
		Very stiff, moist, grey with brown mottle, sandy SILTY CLAY. --- Silt, trace to some sand below 10.97 m depth.		8.23									
9													
10					Sa7	CS							
		CONTINUED NEXT PAGE											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-05

SHEET 2 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364801.8 E: 468333.1

DRILLING DATE: September 2, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	DB320 Mini-Track Sonic Rig	Very stiff, moist, grey with brown mottle, sandy SILTY CLAY. --- Silt, trace to some sand below 10.97 m depth. *(continued)*			Sa7	CS					
11				-20.59							
		End of Borehole.		11.43							
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-06

SHEET 1 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364800.7 E: 468308.6

DATUM: Geodetic

DRILLING DATE: September 2, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-10.09							
0	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	NO RECOVERY		0.00							
				-14.66							
5		Soft, wet, grey, CLAYEY SILT, trace sand, trace coarse rounded gravel, with shells, hydrogen sulphide-like odour.		4.57	Sa1	CS					
7				-17.20							
		Soft to firm, wet, grey, sandy CLAYEY SILT, trace gravel, with shells, hydrogen sulphide-like odour.		7.11	Sa2	CS					
				-17.71							
8		Stiff, moist, blue-grey, SILTY CLAY, trace sand. --- Grey with brown mottle, very stiff below 8.53 m depth.		7.62	Sa3	CS					
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-06

SHEET 2 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364800.7 E: 468308.6

DRILLING DATE: September 2, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10		Stiff, moist, blue-grey, SILTY CLAY, trace sand. --- Grey with brown mottle, very stiff below 8.53 m depth. *(continued)*		-20.76							
		End of Borehole.		10.67							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-07

SHEET 1 OF 1

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364840.9 E: 468356.1

DATUM: Geodetic

DRILLING DATE: September 2, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-9.64							
0	DB320 Mini-Track Sonic Rig; Sonic with 100 mm diameter core barrel and 150 mm diameter casing			0.00							
1		NO RECOVERY									
				-11.62							
2				1.98							
		Very soft, wet, black, ORGANIC SILT with shell fragments, trace sand, hydrogen sulphide-like odour.			Sa1/2	CS					
3				-12.69							
		Soft, wet, grey, SILT, trace sand, trace gravel, hydrogen sulphide-like odour.		3.05	Sa3	CS					
				-12.99							
		Moist to wet, grey, gravelly sandy SILT (angular gravel). [possible FILL]		3.35							
				-13.55							
4		Firm, moist, grey, CLAYEY SILT, trace sand, trace angular gravel with wood debris, creosote and hydrocarbon-like odour.		3.91	Sa4	CS					
				-14.06							
		WOOD DEBRIS (possible timber pile), creosote and hydrocarbon-like odour, sheen.		4.42							
5				-14.67							
		Moist to wet, SAND and GRAVEL, some silt, with shells, hydrocarbon/creosote-like odour.		5.03	Sa5	CS					
6				-15.74							
		Very stiff, moist, grey with brown mottle, SILTY CLAY.		6.10	Sa6	CS					
7											
8				-17.72							
		End of Borehole.		8.08							
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-08

SHEET 1 OF 1

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364806.1 E: 468378.3

DATUM: Geodetic

DRILLING DATE: September 2, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-9.20							
0	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing			0.00							
1		NO RECOVERY									
2				-11.64							
3		Soft to firm, moist, grey and brown, CLAYEY SILT, trace sand, trace to some coarse angular gravel, with shell fragments.		2.44	Sa1	CS					
4				-13.31							
		Firm, moist, grey, CLAYEY SILT, trace sand, trace shell fragments, hydrogen sulphide-like odour.		4.11							
5		--- Angular cobbles (> 15 cm) from 4.27 to 4.57 m depth.			Sa2	CS					
				-14.69							
6		Wet, grey, silty SAND, trace rounded gravel, with shells.		5.49	Sa3/4	CS					
				-15.80							
		Moist, grey and brown, sandy SILTY CLAY, trace gravel with shells.		6.61 -16.01							
7				6.81							
		Moist, brown with grey mottle, SILTY CLAY, trace sand, trace fine rounded gravel.			Sa5	CS					
8				-17.73							
		End of Borehole.		8.53							
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-09

SHEET 1 OF 1

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364814.4 E: 468537.6

DATUM: Geodetic

DRILLING DATE: September 3, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-6.15									
0	DB320 Mini-Track Sonic Rig; Sonic with 100 mm diameter core barrel and 150 mm diameter casing	NO RECOVERY		0.00 -6.61									
		Very soft, wet, black, ORGANIC SILT, trace sand, with wood debris, hydrogen sulphide-like odour, sheen.		0.46									
1		--- Grey-black, soft at 1.27 m depth.			Sa1/2	CS							
				-7.60									
		Loose, wet, grey, GRAVEL, some sand, trace to some silt. [FILL]		1.45	Sa3								
2				-8.89									
		Soft to firm, moist, grey, CLAYEY SILT, trace sand.		2.74	Sa4								
3				-9.35									
		Soft to firm, wet, grey, sandy CLAYEY SILT, with shells, hydrogen sulphide-like odour.		3.20									
				-10.01									
4		Wet, grey, SAND, trace gravel, with shells.		3.86	Sa5								
		--- Shell layer from 3.96 to 4.42 m depth.											
5				-11.64									
		Firm, wet, grey, SILTY CLAY, trace sand, creosote/hydrocarbon-like odour.		5.49	Sa6								
6				-13.01									
		Stiff, moist, grey, SILTY CLAY.		6.86	Sa7								
7				-14.69									
		End of Borehole.		8.53									
8													
9													
10													

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-10

SHEET 1 OF 4

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364805.7 E: 468476.9

DATUM: Geodetic

DRILLING DATE: September 3, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-7.82							
0	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very soft, wet, black, ORGANIC SILT, some sand, with shells and organics, hydrogen sulphide-like odour.		0.00 -8.28	Sa1/2	CS					
1		Soft, wet, grey, CLAYEY SILT, some sand, some gravel, creosote-like odour.		0.46							
2					Sa3						
3				-11.02							
		Soft, wet, grey CLAYEY SILT and SAND, trace gravel, with shells, with wood debris, creosote-like odour.		3.20							
4				-11.92	Sa4						
		Loose, wet, grey, fine SAND and SILT, trace to some clay, trace medium to coarse sand.		4.10	G1					M,H	
5					Sa5						
					G2						
6				-13.92							
		Firm to stiff, moist to wet, grey, SILTY CLAY, trace sand, trace gravel.		6.10	G3						
7					Sa6						
					G4						
8				-15.90							
		Firm, wet, grey, SILTY CLAY, trace sand.		8.08	G5						
9											
10					G6						
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-10

SHEET 2 OF 4

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364805.7 E: 468476.9

DRILLING DATE: September 3, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Firm, wet, grey, SILTY CLAY, trace sand. *(continued)*			Sa7								
11					G7								
12					G8								
13					G9								
				-21.08 13.26									
14		Firm to stiff, wet, grey, SILTY CLAY, trace to some sand, trace to some gravel.			G10								
				-22.30 14.48									
15					G11								
16					G12								
17		Firm, moist to wet, grey, SILTY CLAY, trace sand.			G13								
18					G14								
19					G15								
20		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-10

SHEET 3 OF 4

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364805.7 E: 468476.9

DRILLING DATE: September 3, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Firm, moist to wet, grey, SILTY CLAY, trace sand. *(continued)*			G16						
21					G17						
22					G18						
23				-30.83 23.01	G19						
24					G20						
25		Stiff, moist, grey, SILTY CLAY, trace sand. --- Above 23.9 m and below 26.8 m depth: Contains trace gravel.			G21 Sa8						
26					G22						
27					G23						
28		Compact to dense, wet, grey, well-graded gravelly SAND (fine to coarse gravel).		-35.71 27.89 -36.02	G24						
		Dense, wet, grey, well-graded silty gravelly SAND.		28.19 -36.32	Sa9 G25						
29		Dense, wet, grey, medium to coarse SAND and fine GRAVEL (rounded to sub-angular), trace fine sand, trace silt.		28.50 -37.08	G26						
30		Very dense, wet, light grey, well-graded silty SAND, some gravel, trace clay. [TILL-like]		29.26	G27						
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-10

SHEET 4 OF 4

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364805.7 E: 468476.9

DRILLING DATE: September 3, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very dense, wet, light grey, well-graded silty SAND, some gravel, trace clay. [TILL-like] *(continued)*		-38.30							
		Very dense, moist to dry, grey, silty SAND, some sub-rounded to sub-angular gravel. [TILL-like]		-38.45 30.63	G28 G29						
31		Very dense, dry, light grey to white, fine sandy SILT (non-plastic), some medium to coarse sand, trace to some sub-angular to angular gravel. [TILL-like]		-38.83 31.01	G30						
		Gravel to cobble-sized angular ROCK. [Probable BEDROCK]			G31						
32											
					G32						
33				-40.74 32.92							
		NO RECOVERY.									
34				-42.42 34.59							
		End of Borehole.									
35											
36											
37											
38											
39											
40											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AK/DLS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-11

SHEET 1 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5365019 E: 468067

DATUM: Geodetic

DRILLING DATE: October 14, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-2.85									
0	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing			0.00									
					Sa1	CS							
1		Wet, grey, gravelly SAND to SAND with trace gravel, with shells, with angular cobbles. [FILL]											
					Sa2	CS							
2				-5.14									
				2.29									
3													
4													
5													
6		Angular coarse GRAVEL with angular cobbles, with boulders (inferred) and void spaces (inferred). [FILL]											
7													
8													
9													
10		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-11

SHEET 2 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5365019 E: 468067

DATUM: Geodetic

DRILLING DATE: October 14, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Angular coarse GRAVEL with angular cobbles, with boulders (inferred) and void spaces (inferred). [FILL] *(continued)*		-13.82							
11		Wet, brown, gravelly SAND, some silt. [possible FILL]		10.97							
12		Wet, grey, sandy GRAVEL, trace silt. [possible FILL]		-14.89 12.04							
13				-15.96							
14		Loose, wet, grey-brown, sandy SILT, trace clay, with shells.		13.11	Sa4	CS					
15					Sa5	CS					
16		Wet, grey, silty SAND, trace gravel, with shells.		-18.09 15.24	Sa6	CS					
17				-19.62 16.76							
18		Stiff, wet, grey, SILTY CLAY, trace sand.			Sa7	CS					
19				-22.66							
20		End of Borehole.		19.81							

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-12

SHEET 1 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364981 E: 468131

DRILLING DATE: October 14, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-10.28									
0	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Wet, black, SAND and GRAVEL (angular), some silt, hydrocarbon-like odour. [FILL]		0.00 -10.89	Sa1	CS							
		Firm, wet, mottled light and dark grey, CLAYEY SILT, some sand, trace gravel, with shells, solvent and hydrocarbon-like odour.		0.61 -11.19	Sa2	CS							
1		No Recovery		0.91 -12.11									
2		Wet, grey, silty SAND and GRAVEL, trace clay, with cobbles, solvent and hydrocarbon-like odour. [FILL]		1.83 -12.56	Sa3	CS							
3		Possible BOULDER [FILL]		2.29 -14.39	G1	CS							
4		Coarse GRAVEL with cobbles (sub-rounded to angular). [FILL]		4.11 -15.16	G2	CS							
5		Stiff, moist to wet, grey, SILTY CLAY and well-graded SAND and GRAVEL (sub-rounded to angular), with cobbles, hydrocarbon-like odour. [possible FILL]		4.88 -16.68	G3 Sa4	CS CS							
6													
7		Gravel-sized and cobble-sized angular rock. [Probable BEDROCK]		6.40 -19.73	G4	CS							
8													
9		No Recovery		9.45									
10		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-12

SHEET 2 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364981 E: 468131

DRILLING DATE: October 14, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Truck Mounted Sonic Drill	No Recovery *(continued)*									
11				-21.56							
		End of Borehole.		11.28							
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-13

SHEET 1 OF 1

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364931.1 E: 468251.1

DRILLING DATE: November 11, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-13.20									
0	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very soft, wet, black, ORGANIC SILT, with shells, hydrocarbon-like odour.		0.00 -14.42									
1		Very loose, wet. grey and black, sandy ORGANIC SILT to organic silty SAND, trace gravel, with shells.		1.22 -14.95									
2		Wet, angular GRAVEL, some sand to sandy, trace to some silt, with angular cobbles. [FILL]		1.75 -15.79	G1	CS							
3		Firm, moist to wet, grey, CLAYEY SILT, trace sand, with shell fragments.		2.59 -16.86	G2	CS							
4		No Recovery (core barrel may have been blocked by cobble recovered at end of barrel)		3.66 -19.45									
5													
6													
7		End of Borehole.		6.25									
8													
9													
10													

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-14

SHEET 1 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364938.6 E: 468253

DATUM: Geodetic

DRILLING DATE: November 12, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-12.93									
0	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very loose, wet, black, organic silty SAND, some gravel, with shells, hydrocarbon-like odour.		0.00 -13.84									
1		Soft, wet, grey with black staining, organic CLAYEY SILT, some coarse angular gravel, trace sand.		0.91 -14.15									
		Wet, grey-green, angular GRAVEL. [FILL]		1.22 -14.60	G1	CS							
2		Soft to firm, wet, grey, CLAYEY SILT, trace to some sand, trace gravel, with shells.		1.68 -16.13	G2	CS							
3		Wet, grey, SAND, trace silt, with shells.		3.20 -16.58	G3	CS							
		Soft to firm, wet, grey, SILTY CLAY, trace to some sand, trace gravel.		3.66 -17.04	G4	CS							
4				4.11									
5					G5	CS							
6		Stiff, moist to wet, grey, SILTY CLAY, trace sand, trace gravel, with shells.			G6	CS							
7													
8					G7	CS							
				-21.31									
		Very dense, moist to wet, green-grey, SAND and SILT, some gravel to gravelly, trace clay. [TILL-like]		8.38	G8	CS							
9					G9	CS							
10		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-14

SHEET 2 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364938.6 E: 468253

DRILLING DATE: November 12, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very dense, moist to wet, green-grey, SAND and SILT, some gravel to gravelly, trace clay. [TILL-like] *(continued)*			G10	CS							
11													
12				-25.51	G11	CS							
13		Gravel-sized angular rock. [Probable BEDROCK]		-26.95	G12 G13	CS CS							
14		End of Borehole.		14.02									
15													
16													
17													
18													
19													
20													

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-15

SHEET 1 OF 1

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364924.2 E: 468312.9

DATUM: Geodetic

DRILLING DATE: October 16, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-12.49							
0	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very soft, wet, black, ORGANIC SILT, some gravel, some sand, with organic fibres, with metal debris.		0.00 -13.55							
1		Dense to very dense, moist to dry, grey-brown becoming grey, well-graded silty SAND to SAND and SILT, some gravel to gravelly, trace clay. [TILL-like]		1.07	G1	CS				M, H	
2											
3					G2	CS					
		Dense, moist, brown, fine SAND, some medium to coarse sand, some silt, trace fine gravel.		-15.99 3.51 -16.30	G3	CS					
4		Dense, wet, grey, well-graded gravelly SAND, some silt.		3.81 -16.75	G4	CS					
		Hard, moist, grey, CLAY, trace gravel, with shell fragments, fissured.		4.27 -17.06	G5	CS					
5		Dense, wet, grey, well-graded gravelly silty SAND, with cobbles. [TILL-like]		4.57 -17.82	G6	CS					
		Very dense, moist, grey, well-graded silty SAND, trace gravel, with partings of fine sand, with ~5mm thick seams (2) of silt.		5.33	G7	CS					
6				-18.58							
		Very dense, wet, grey, silty fine SAND to well-graded SAND, with some silt, some gravel to gravelly. [TILL-like]		6.10	G8	CS					
7					G9	CS					
8				-20.87							
		Possible Bedrock		-21.02	G10	CS					
9		End of Borehole.		8.53							
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-16

SHEET 1 OF 1

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364914 E: 468352

DATUM: Geodetic

DRILLING DATE: November 13, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-12.17									
0	Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very loose, wet, black, sandy ORGANIC SILT, some gravel, hydrocarbon-like odour.		0.00									
				-12.93									
1		Wet, green-grey, fine to coarse angular GRAVEL, some medium to coarse sand, trace silt. [FILL]		0.76	G1	CS						M	
2				-14.30	G2	CS						M	
		Very dense, moist to wet, green-grey, well-graded silty SAND, some gravel, trace clay. [TILL-like]		2.13									
3					G3	CS							
				-15.52									
		Gravel-sized angular rock fragments. [Possible BEDROCK]		-15.68	G4	CS							
				3.51									
4		End of Borehole.											
5													
6													
7													
8													
9													
10													

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-17

SHEET 1 OF 1

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364876.4 E: 468356.3

DATUM: Geodetic

DRILLING DATE: November 2, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SAMPLER HAMMER, 64kg; DROP, 762mm

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-12.76				SHEAR STRENGTH Cu, kPa; nat V. +, rem V. ⊕; Q - ●, U - ○ (20 40 60 80)	WATER CONTENT PERCENT: Wp, W, Wl; NP - Non-Plastic (25 50 75 100)		
0	Mud Rotary	Very loose, ORGANIC SILT to sandy ORGANIC SILT.		0.00							
				-13.06							
		Loose becoming compact, wet, grey, sandy SILT becoming silty SAND, trace gravel, with shell fragments and organics (decayed twigs).		0.30							
				-13.37	G1	51 DO					
1		Compact to dense, wet, grey becoming golden brown, sandy GRAVEL (sub-rounded to sub-angular), trace to some silt.		0.61	G2A	51 DO	27				
				-14.33							
		Compact, wet, golden brown, well-graded silty SAND, some sub-angular gravel. [TILL-like]		-14.49	G2B						
2		Note: Soil descriptions above 0.6m depth based on data from KCPT09-107 and SC09-111C		1.73							
		End of Borehole.									
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MCS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-18

SHEET 1 OF 1

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364871.3 E: 468381.2

DRILLING DATE: October 17, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-12.10							
0	DB320 Mini-Track Sonic Rig Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Loose to very loose, wet, dark grey, SILT and SAND, some gravel.		0.00	Sa1	CS					
				-12.56							
		Dense, moist, green-grey, well graded SAND and SILT, some gravel, some clay. [TILL-like]		0.46	Sa2	CS					
1					G1	CS				M, H	
				-13.17							
		Very dense, dry, grey, sandy SILT, some gravel, with cobbles. [TILL-like]		1.07	G2	CS					
2				-14.54							
		Wet, grey, fine to coarse gravel-sized, angular rock fragments, some medium to coarse sand, trace silt. [Probable fractured BEDROCK]		2.44	G3	CS				M	
3				-15.76	G4	CS					
		No recovery		3.66							
4											
5				-17.89							
		End of Borehole.		5.79							
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-19

SHEET 1 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364861.6 E: 468362

DRILLING DATE: October 17, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-12.79							
0	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very soft, wet, black, ORGANIC SILT some sand, trace gravel, with organic fibres, hydrocarbon-like odour.		0.00	Sa1						
				-13.70							
1		Loose to compact, wet, grey, silty SAND and GRAVEL (sub-rounded to angular), with shell fragments.		0.91	Sa2						
				-14.62	G1	CS				M	
2		Stiff to very stiff. SILTY CLAY, trace to some sand, trace gravel.		1.83							
3					G2	CS					
4											
				-17.66							
5		Firm, wet, grey, SILTY CLAY, trace sand, trace gravel.		4.88	G3	CS					
6					G4	CS					
7				-19.95							
		Very dense, moist, green-grey, silty SAND, some gravel, trace clay. [TILL-like]		7.16	G5	CS					
				-20.56	G6	CS					
8		Dry, green-grey, angular, coarse sand-sized to gravel-sized angular rock. [Probable BEDROCK]		7.77	G7	CS					
					G8	CS					
9				-21.93							
		No recovery		9.14							
10											
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-19

SHEET 2 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364861.6 E: 468362

DRILLING DATE: October 17, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10		No recovery *(continued)*		-23.15							
		End of Borehole.		10.36							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-20

SHEET 1 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364781.8 E: 468366.7

DATUM: Geodetic

DRILLING DATE: October 15-16, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-13.90									
0	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very soft, wet, black, ORGANIC SILT, trace sand, with shells and organic fibres, hydrocarbon-like odour.		0.00 -14.35									
1		Soft becoming firm/loose, wet, grey, CLAYEY SILT becoming sandy SILT, trace to some clay, trace gravel, with shells.		0.46									
2					G1	CS						M,H	
				-16.33 2.44									
3													
4		Stiff becoming very stiff, moist, brown, SILTY CLAY, trace sand, trace gravel.			G2	CS							
5					G3	CS							
					G4	CS							
6				-19.87 5.97									
					G5	CS							
7													
					G6	CS							
8		Stiff, wet, grey, SILTY CLAY, trace sand, trace gravel.											
					G7	CS							
9					G8	CS							
10		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-20

SHEET 2 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364781.8 E: 468366.7

DRILLING DATE: October 15-16, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Stiff, wet, grey, SILTY CLAY, trace sand, trace gravel. *(continued)*									
11					G9	CS					
				-25.48 11.58							
12					G10	CS					
13											
14					G11	CS					
15											
					G12	CS					
16		Firm becoming stiff, wet, grey, SILTY CLAY, trace sand.									
17					G13	CS					
18											
					G14	CS					
19											
20		*CONTINUED NEXT PAGE*									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-20

SHEET 3 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364781.8 E: 468366.7

DRILLING DATE: October 15-16, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Firm becoming stiff, wet, grey, SILTY CLAY, trace sand. *(continued)*			G15	CS							
21													
22					G16	CS							
23													
24													
25					G17	CS							
26													
27					G18	CS							
				-41.48									
28		Dense, wet, grey, SAND, some gravel to gravelly, trace silt.		27.58	G19	CS							
29				-42.85									
		Very dense, moist to wet, grey, well-graded silty SAND to SILT and SAND, some gravel, trace clay, with cobbles. [TILL-like]		28.96	G20	CS							
30		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-20

SHEET 4 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364781.8 E: 468366.7

DRILLING DATE: October 15-16, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
30	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very dense, moist to wet, grey, well-graded silty SAND to SILT and SAND, some gravel, trace clay, with cobbles. [TILL-like] *(continued)*									
31					G21	CS					
32					G22	CS					
33											
34					G23	CS					
35											
36					G24	CS					
37					G25	CS					
38				-51.84 37.95							
38		Very dense, wet, grey, SAND, some silt, some gravel.			G26	CS					
39											
39					G27	CS					
40				-53.67 39.78							
40		*CONTINUED NEXT PAGE*									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-20

SHEET 5 OF 5

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364781.8 E: 468366.7

DRILLING DATE: October 15-16, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
40	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very dense, dry to moist, green-grey, SAND and SILT, trace to some gravel, trace clay. [TILL-like] *(continued)*			G28	CS					
41					G29	CS					
42				-55.96							
		Very dense, wet, grey, SAND, trace to some silt.		42.06	G30	CS					
				-56.42							
		Very dense, moist, grey-green, SAND and SILT, trace gravel, trace clay. [TILL-like]		42.52	G31	CS					
43				-56.72							
		Very dense, wet, grey, medium SAND, trace to some silt.		42.82	G32	CS					
				-57.18							
44		Very dense, moist, green-grey, SAND and SILT, trace gravel, trace clay. [TILL-like]		43.28	G33	CS					
				-58.40							
45		Very dense, wet, green-grey, silty fine to medium SAND, trace clay.		44.50	G34	CS					
46											
47					G35	CS					
				-61.75							
48		Very dense, wet, green-grey, silty SAND and GRAVEL, trace clay, with cobbles. [TILL-like]		47.85	G36	CS					
49					G37	CS					
				-63.58							
50		End of Borehole.		49.68							

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-21

SHEET 1 OF 3

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364803.6 E: 468571.3

DRILLING DATE: October 16, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-12.20									
0	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Very soft, wet, black, ORGANIC SILT, trace sand, with organic fibres; hydrocarbon-like odour.		0.00									
1				-13.57									
				1.37									
2					G1	CS							
3													
4					G2	CS							
5		Firm becoming stiff, wet, grey, SILTY CLAY, trace sand, trace gravel. -5.49m to 7.95m depth: contains seams of fine sand <15mm thick.			G3	CS							
6													
7					G4	CS							
8					G5	CS							
9					G6	CS							
10		*CONTINUED NEXT PAGE*											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-21

SHEET 2 OF 3

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364803.6 E: 468571.3

DRILLING DATE: October 16, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Truck Mounted Sonic Drill Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Firm becoming stiff, wet, grey, SILTY CLAY, trace sand, trace gravel. -5.49m to 7.95m depth: contains seams of fine sand <15mm thick. *(continued)*			G7	CS					
11					G8	CS					
12					G9	CS					
				-24.24							
		Stiff, wet, grey, SILTY CLAY and sandy GRAVEL.		12.04	G10	CS					
				-25.00							
13		Compact, moist, grey, SILT, some sand, trace to some gravel, trace clay.		12.80	G11	CS					
				-25.46							
		Very dense, dry to moist, green-grey, SAND and SILT, some gravel. [TILL-like]		13.26	G12	CS					
14				-26.22							
		Very dense, moist to wet, light grey, SAND and SILT, some gravel, trace clay. [TILL-like]		14.02	G13	CS					
					G14	CS					
15					G15	CS					
16					G16	CS					
17					G17	CS					
18											
19					G18	CS					
				-31.40							
		Dry, light grey to white rock flour with sand and gravel-sized rock fragments. [Possible BEDROCK]		19.20							
				-32.01	G19	CS					
20				19.81							
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-21

SHEET 3 OF 3

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364803.6 E: 468571.3

DRILLING DATE: October 16, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	Truck Mounted Sonic Drill: Sonic with 100 mm diameter core barrel and 150 mm diameter casing	Gravel-sized angular rock. [Probable BEDROCK]			G20	CS					
21		Gravel-sized angular rock. [Probable BEDROCK] *(continued)*									
22				-35.06							
23		End of Borehole.		22.86							
24											
25											
26											
27											
28											
29											
30											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-22

SHEET 1 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364797 E: 468422

DATUM: Geodetic

DRILLING DATE: November 4, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SAMPLER HAMMER, 64kg; DROP, 762mm

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-9.11							
0				0.00							
		No recovery									
				-10.02							
1				0.91	G0	DO					
		Loose, wet, grey with black staining, sandy SILT, with decomposed wood fibres.		-10.79							
				1.68							
2					G1	DO					
3					G2	DO					
		Soft to firm, wet, grey, SILTY CLAY to CLAYEY SILT, trace to some sand, trace gravel, with shells.			G3	DO					
		-contains decomposed wood fibres above 2.4m depth									
4											
					G4	TP		Bulk Density=2049 kg/m3		M,H,DS	
5	Mud Rotary				G5	DO					
				-14.60							
				5.49							
6					G6	TP /CS					
		Firm to stiff, moist to wet, grey, SILTY CLAY, trace sand, trace gravel.			G7	DO					
7											
					G8	TP					
				-17.04							
8				7.92							
					G9	DO					
9		Firm, wet, grey, SILTY CLAY.			G10	TP		Bulk Density=1959 kg/m3			
					G11	DO					
10											
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-22

SHEET 2 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364797 E: 468422

DRILLING DATE: November 4, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 762mm

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Mud Rotary	Firm, wet, grey, SILTY CLAY. *(continued)*									
11											
12					G12	TP					
					G13	DO					
				-21.91							
13		End of Borehole.		12.80							
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-23

SHEET 1 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364829.3 E: 468296.6

DATUM: Geodetic

DRILLING DATE: October 19-20, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SAMPLER HAMMER, 64kg; DROP, 762mm

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-13.83							
0	Mud Rotary	Minimal Recovery		0.00	Sa1	DO					
1					G1	DO					
				-15.04							
		Very soft becoming soft, wet, dark grey, CLAYEY SILT, some sand, with shells.		1.22	G2	DO					
2					G3	TP		Bulk Density=1590 kg/m3			
				-16.72							
3		Loose, wet, grey, SILT, some fine sand to sandy, trace clay, with shells.		2.90	G4	TP		Bulk Density=2028 kg/m3		M,H,DS	
				-17.64							
4		Firm becoming very stiff, moist, grey, SILTY CLAY, trace sand, with shells. - Possible coarse gravel or cobble at 4.19 m.		3.81	G5	TP					
					G6	TP					
5				-18.85							
		Very stiff, moist, grey-brown, SILTY CLAY, trace sand.		5.03	G7	DO					
6					G8	TP		Bulk Density=2143 kg/m3			
					G9	DO					
7				-20.82							
		Stiff becoming firm to stiff, wet, grey, SILTY CLAY, trace sand.		7.00	G10	TP					
8					G11	DO					
9											
10											
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-23

SHEET 2 OF 2

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364829.3 E: 468296.6

DRILLING DATE: October 19-20, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 762mm

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Mud Rotary	Stiff becoming firm to stiff, wet, grey, SILTY CLAY, trace sand. *(continued)*			G12	DO					
11											
12											
13											
14				-28.46	G13	DO					
		End of Borehole.		14.63							
15											
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DGM
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

PROJECT No.: 09-1475-5008

RECORD OF BOREHOLE: GBH09-24

SHEET 1 OF 1

LOCATION: Esquimalt Graving Dock - See Location Plan
N: 5364845.3 E: 468327

DATUM: Geodetic

DRILLING DATE: October 21/22, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SAMPLER HAMMER, 64kg; DROP, 762mm

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (25 50 75 100)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Mudline		-13.21							
0	Mud Rotary	Very soft becoming soft, wet, black, ORGANIC SILT.		0.00 -13.66							
		Soft to firm, wet, grey with black banding, SILT.		0.45 -14.32							
1		Stiff, wet, grey, SILTY CLAY, trace sand, trace gravel, with shell fragments. [possible FILL]		1.12 -14.60	G1A	51 DO					
		Compact to dense, wet, grey, angular GRAVEL, some sand to sandy (coarse-grained), trace silt. [FILL]		1.40 -15.21	G1B G2A						
2		Loose, wet, grey, fine sandy SILT, with shell fragements.		2.01 -15.67	G2B	51 DO	6				
		No Recovery		2.46 -16.18							
3		Firm, wet, grey, CLAYEY SILT, trace gravel, with shell fragments. -sand lens at 3.48m depth		2.97 -16.79	G3	51 DO	4				
		Note: Soil descriptions above 1.1m depth based on data from GCPT09-02B and SC09-37.		3.58							
4		End of Borehole.									
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

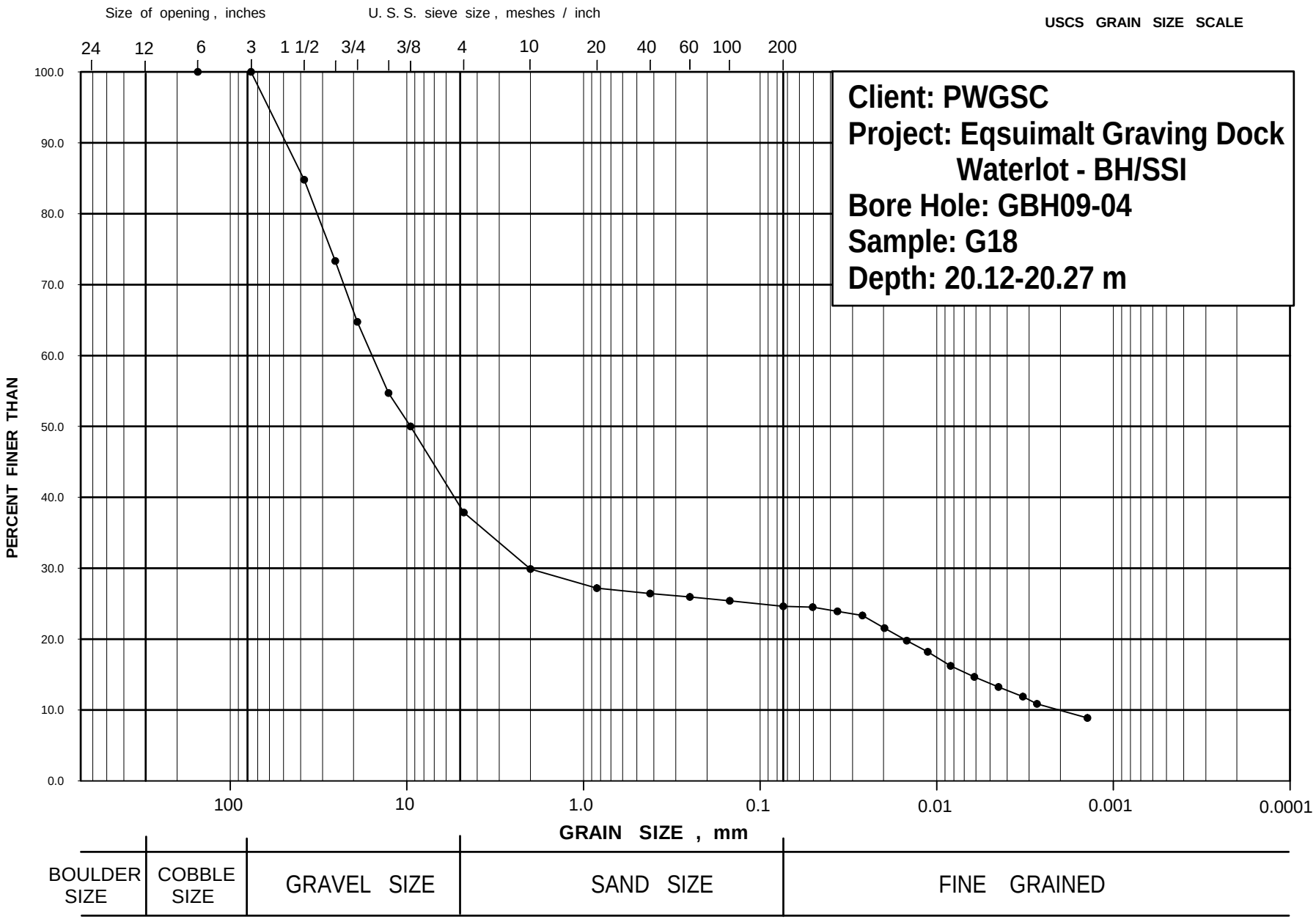
Golder Associates

LOGGED: MCS
CHECKED: MCS/CNW

File:N:\ACTIVE\2009\1475\09-1475-5008 PWGSC WATERLOT BH SSI EGD\VIC DRAFTING\GINT\09-1475-5008 CONVERTED.GPJ Output Form:BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB CFelker 3/1/10

APPENDIX B

Grain Size Distributions (Boreholes)



Project No. 09-1475-5008 **Drawn** DGM **Reviewed** **Date** 30 Oct 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: **TESTED BY:**

Auger Hole	GBH09-04	Sample No.	G18		Depth (m) :	20.12-20.27	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.2	
	Total Weight	1562.6	Before Wash	75.0	Total -200	61.8	
			After Wash	13.4	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"	237.4	15.2			15.2	38.1	84.8
1"	179.5	11.5			11.5	25.4	73.3
3/4"	133.9	8.6			8.6	19.1	64.8
1/2"	156.9	10.0			10.0	12.7	54.7
3/8"	73.7	4.7			4.7	9.52	50.0
#4	189.4	12.1			12.1	4.76	37.9
#10	124.9	8.0			8.0	2.00	29.9
#20			6.7	9.0	2.7	0.840	27.2
#40			1.9	2.5	0.8	0.420	26.4
#60			1.2	1.6	0.5	0.250	26.0
#100			1.4	1.8	0.5	0.149	25.4
#200			2.0	2.6	0.8	0.074	24.6
Pan			61.8	82.4	24.6		

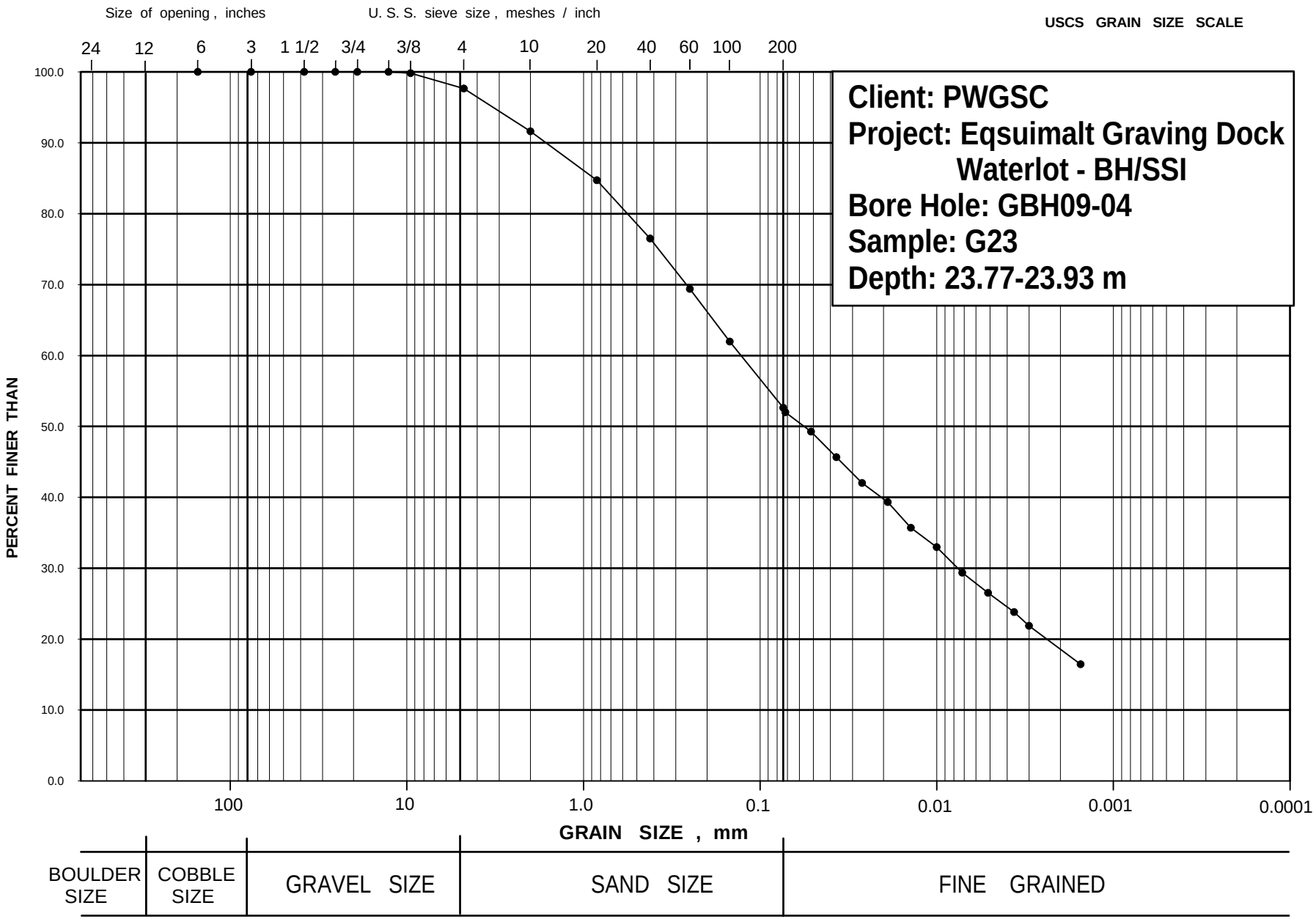
HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	66.0	20.0		-3.77	62.2	0.0504	24.5
1	64.5	20.0		-3.77	60.7	0.0365	23.9
2	63.0	20.0		-3.77	59.2	0.0264	23.3
4	58.5	20.0		-3.77	54.7	0.0198	21.6
8	54.0	20.0		-3.77	50.2	0.0148	19.8
15	50.0	20.0		-3.77	46.2	0.0113	18.2
30	45.0	20.0		-3.77	41.2	0.0084	16.2
60	41.0	20.0		-3.77	37.2	0.0061	14.7
120	37.5	19.5		-3.84	33.7	0.0045	13.3
240	34.0	19.5		-3.84	30.2	0.0033	11.9
360	31.5	19.0		-3.91	27.6	0.0027	10.9
1440	26.5	18.0		-3.91	22.6	0.0014	8.9

Reported by: _____ Reviewed by: _____

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other zones/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

2640 Douglas St. Victoria, BC, V8T 4M1, Tel: 250-881-7372, Fax: 250-881-7470



Project No. 09-1475-5008 **Drawn** DGM **Reviewed** **Date** 30 Oct 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: **TESTED BY:**

Auger Hole	GBH09-04	Sample No.	G23		Depth (m) :	23.77-23.93	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.4	
	Total Weight	857.6	Before Wash	50.1	Total -200	28.8	
			After Wash	21.7	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"		0.0			0.0	25.4	100.0
3/4"		0.0			0.0	19.1	100.0
1/2"		0.0			0.0	12.7	100.0
3/8"	1.6	0.2			0.2	9.52	99.8
#4	18.5	2.2			2.2	4.76	97.7
#10	51.7	6.0			6.0	2.00	91.6
#20			3.8	7.5	6.9	0.840	84.7
#40			4.5	9.0	8.2	0.420	76.5
#60			3.9	7.8	7.1	0.250	69.4
#100			4.1	8.1	7.4	0.149	62.0
#200			5.1	10.2	9.3	0.074	52.6
Pan			28.8	57.5	52.6		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	32.5	20.0		-3.77	28.7	0.0720	52.0
1	31.0	20.0		-3.77	27.2	0.0515	49.3
2	29.0	20.0		-3.77	25.2	0.0370	45.7
4	27.0	20.0		-3.77	23.2	0.0265	42.0
8	25.5	20.0		-3.77	21.7	0.0189	39.3
15	23.5	20.0		-3.77	19.7	0.0140	35.7
30	22.0	20.0		-3.77	18.2	0.0100	33.0
60	20.0	20.0		-3.77	16.2	0.0072	29.4
120	18.5	19.5		-3.84	14.7	0.0051	26.5
240	17.0	19.5		-3.84	13.2	0.0037	23.8
360	16.0	19.0		-3.91	12.1	0.0030	21.9
1440	13.0	18.0		-3.91	9.1	0.0015	16.5

Reported by: _____ Reviewed by: _____

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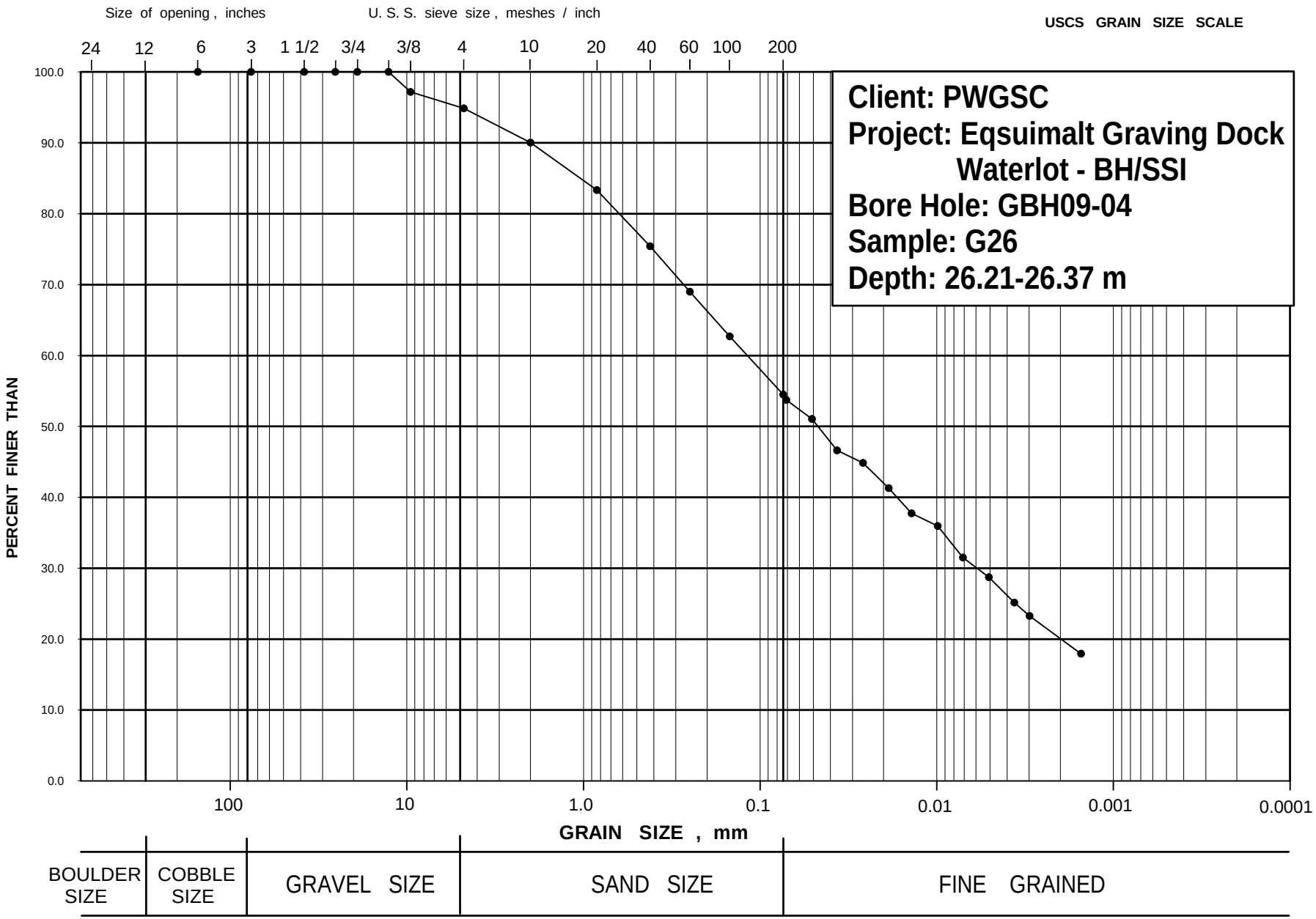

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** **Date** 30 Oct 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: **TESTED BY:**

Auger Hole	GBH09-04	Sample No.	G26		Depth (m) :	26.21-26.37	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.7	
	Total Weight	957.1	Before Wash	50.1	Total -200	30.3	
			After Wash	20.5	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"		0.0			0.0	25.4	100.0
3/4"		0.0			0.0	19.1	100.0
1/2"		0.0			0.0	12.7	100.0
3/8"	26.9	2.8			2.8	9.52	97.2
#4	22.2	2.3			2.3	4.76	94.9
#10	46.3	4.8			4.8	2.00	90.0
#20			3.7	7.4	6.7	0.840	83.3
#40			4.4	8.8	7.9	0.420	75.4
#60			3.6	7.1	6.4	0.250	69.0
#100			3.5	7.0	6.3	0.149	62.7
#200			4.6	9.1	8.2	0.074	54.5
Pan			30.3	60.5	54.5		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	34.0	20.0		-3.77	30.2	0.0712	53.7
1	32.5	20.0		-3.77	28.7	0.0509	51.1
2	30.0	20.0		-3.77	26.2	0.0367	46.6
4	29.0	20.0		-3.77	25.2	0.0261	44.8
8	27.0	20.0		-3.77	23.2	0.0187	41.3
15	25.0	20.0		-3.77	21.2	0.0139	37.7
30	24.0	20.0		-3.77	20.2	0.0099	36.0
60	21.5	20.0		-3.77	17.7	0.0071	31.5
120	20.0	19.5		-3.84	16.2	0.0051	28.7
240	18.0	19.5		-3.84	14.2	0.0036	25.2
360	17.0	19.0		-3.91	13.1	0.0030	23.3
1440	14.0	18.0		-3.91	10.1	0.0015	17.9

Reported by: _____ Reviewed by: _____

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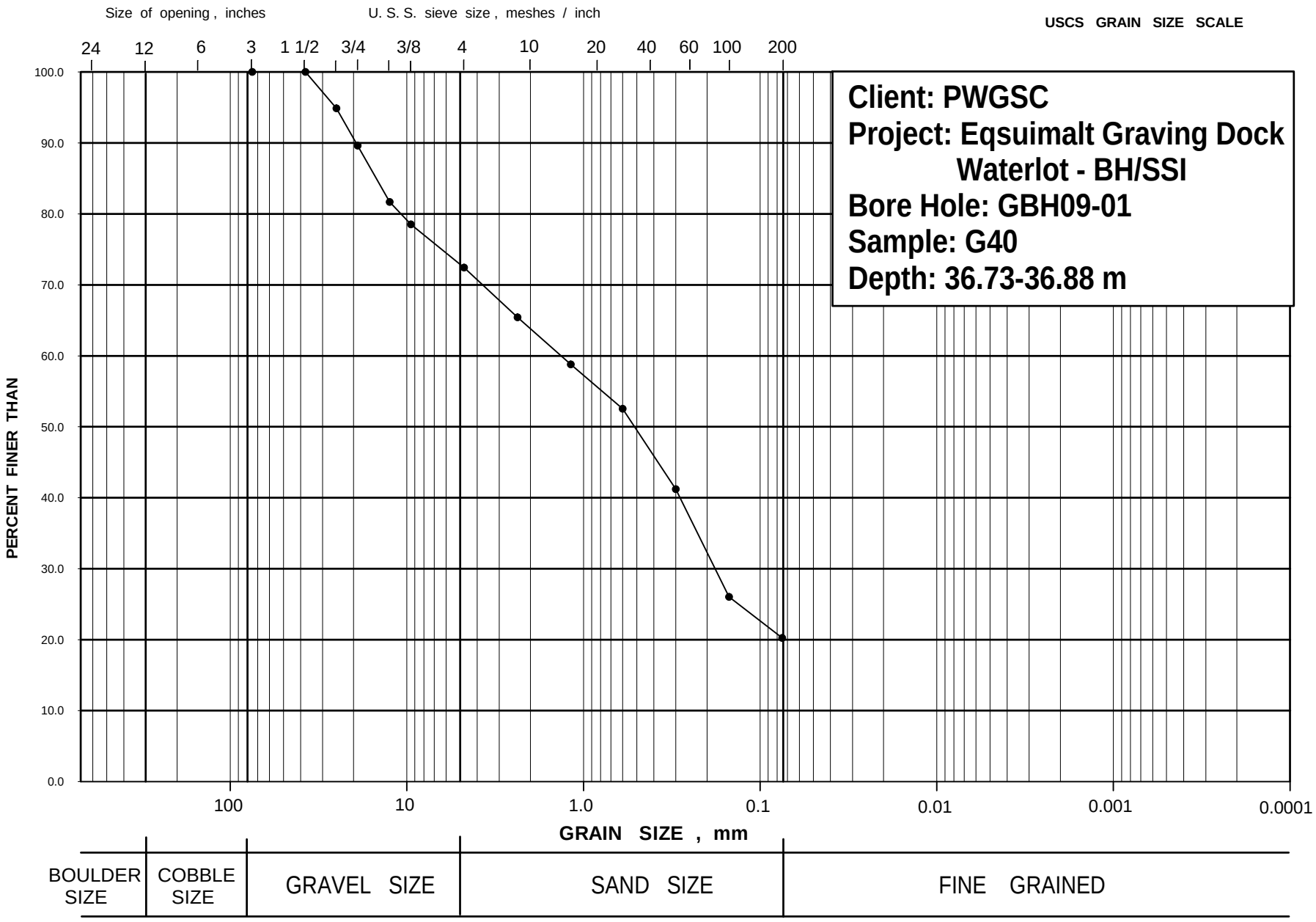

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** **Date** 30 Oct 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: 30-Sep-09 **TESTED BY:** AMB

Auger Hole	GBH09-01	Sample :	G40		Depth :	36.73-36.88	
	1st SIEVING		2nd SIEVING		Wash Sieving		
	Weight before sievir	1266.7	Weight before sieving		Weight after wash		1027.6
	Total weight	1266.7	1/4 Pass #4		Residual #200		17.3
	Pass #4				Minus #200		256.4

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
3"		0.0			0.0	75.0	100.0
1 1/2"		0.0			0.0	37.5	100.0
1"	64.9	5.1			5.1	25.0	94.9
3/4"	66.5	5.2			5.2	19.0	89.6
1/2"	100.5	7.9			7.9	12.5	81.7
3/8"	40.0	3.2			3.2	9.5	78.5
#4	77.3	6.1			6.1	4.75	72.4
#8	88.7	7.0			7.0	2.36	65.4
#16	83.9	6.6			6.6	1.18	58.8
#30	79.2	6.3			6.3	0.6	52.6
#50	143.7	11.3			11.3	0.3	41.2
#100	192.2	15.2			15.2	0.15	26.0
#200	73.3	5.8			5.8	0.075	20.2
Pan	256.4	20.2			20.2		

REMARKS :

Reported by: _____ Reviewed by: _____

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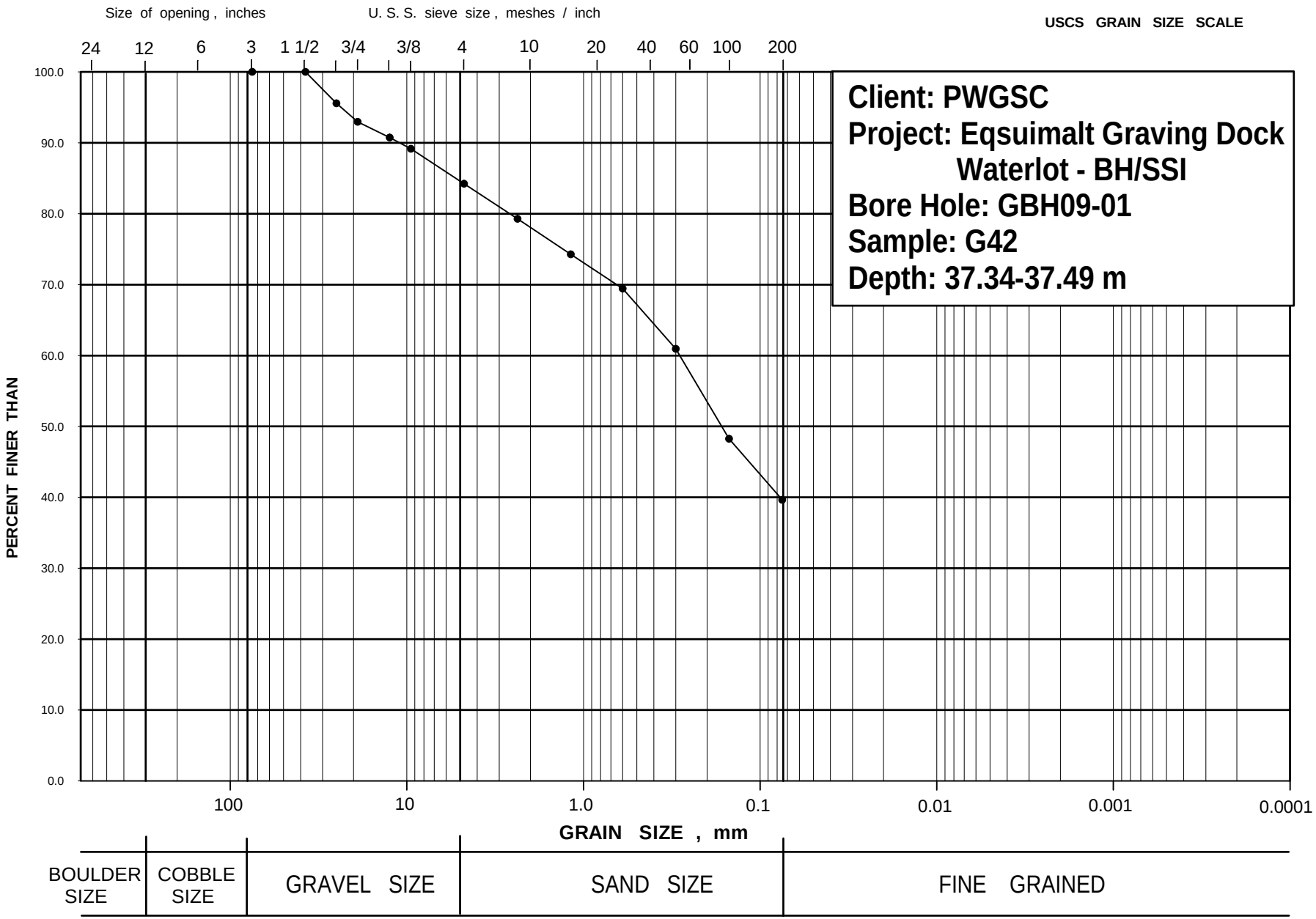

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** **Date** 30 Oct 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: 30-Sep-09 **TESTED BY:** AMB

Auger Hole	**GBH09-01**	**Sample :**	**G42**		**Depth :**	**37.34-37.49**	
	1st SIEVING		**2nd SIEVING**		**Wash Sieving**		
	Weight before sievir	798.6	Weight before sieving		Weight after wash		506.2
	Total weight	798.6	1/4 Pass #4		Residual #200		24.2
	Pass #4				Minus #200		316.6
Sieve (USS)	**Weight Retained**	**% Retained**	**Weight Retained**	**% Retained**	**% Retained of Total**	**Diameter (mm)**	**% Passing**
3"		0.0			0.0	**75.0**	**100.0**
1 1/2"		0.0			0.0	**37.5**	**100.0**
1"	35.3	4.4			4.4	**25.0**	**95.6**
3/4"	20.9	2.6			2.6	**19.0**	**93.0**
1/2"	17.6	2.2			2.2	**12.5**	**90.8**
3/8"	12.7	1.6			1.6	**9.5**	**89.2**
#4	39.5	4.9			4.9	**4.75**	**84.2**
#8	39.5	4.9			4.9	**2.36**	**79.3**
#16	39.9	5.0			5.0	**1.18**	**74.3**
#30	38.7	4.8			4.8	**0.6**	**69.4**
#50	67.8	8.5			8.5	**0.3**	**60.9**
#100	101.3	12.7			12.7	**0.15**	**48.3**
#200	68.8	8.6			8.6	**0.075**	**39.6**
Pan	316.6	39.6			39.6		

REMARKS :

Reported by: _____ Reviewed by: _____

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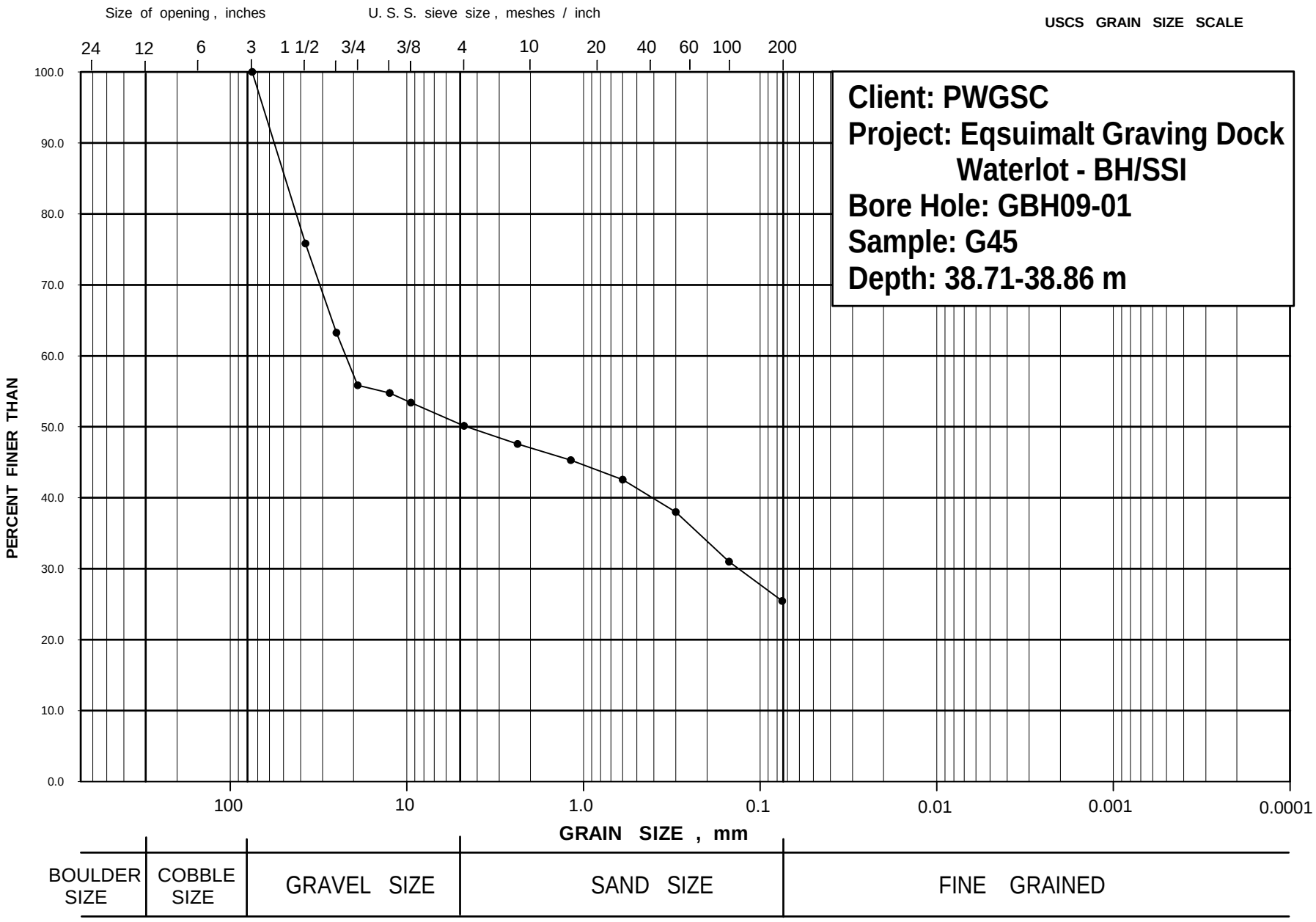

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** **Date** 30 Oct 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: Sept. 30, 2009 **TESTED BY:** AMB

Auger Hole	**GBH09-01**	**Sample :**	**G45**		**Depth :**	**38.71-38.86**	
	1st SIEVING		**2nd SIEVING**		**Wash Sieving**		
	Weight before sievir	1856.7	Weight before sieving		Weight after wash		1412.0
	Total weight	1856.7	1/4 Pass #4		Residual #200		28.2
	Pass #4				Minus #200		472.9

Sieve (USS)	**Weight Retained**	**% Retained**	**Weight Retained**	**% Retained**	**% Retained of Total**	**Diameter (mm)**	**% Passing**
3"		0.0			0.0	**75.0**	**100.0**
1 1/2"	448.7	24.2			24.2	**37.5**	**75.8**
1"	233.3	12.6			12.6	**25.0**	**63.3**
3/4"	137.7	7.4			7.4	**19.0**	**55.9**
1/2"	20.4	1.1			1.1	**12.5**	**54.8**
3/8"	25.1	1.4			1.4	**9.5**	**53.4**
#4	60.6	3.3			3.3	**4.75**	**50.1**
#8	47.4	2.6			2.6	**2.36**	**47.6**
#16	42.4	2.3			2.3	**1.18**	**45.3**
#30	51.0	2.7			2.7	**0.6**	**42.6**
#50	84.9	4.6			4.6	**0.3**	**38.0**
#100	129.8	7.0			7.0	**0.15**	**31.0**
#200	102.5	5.5			5.5	**0.075**	**25.5**
Pan	472.9	25.5			25.5		

REMARKS :

4.4% Moisture

Reported by: _____ Reviewed by: _____

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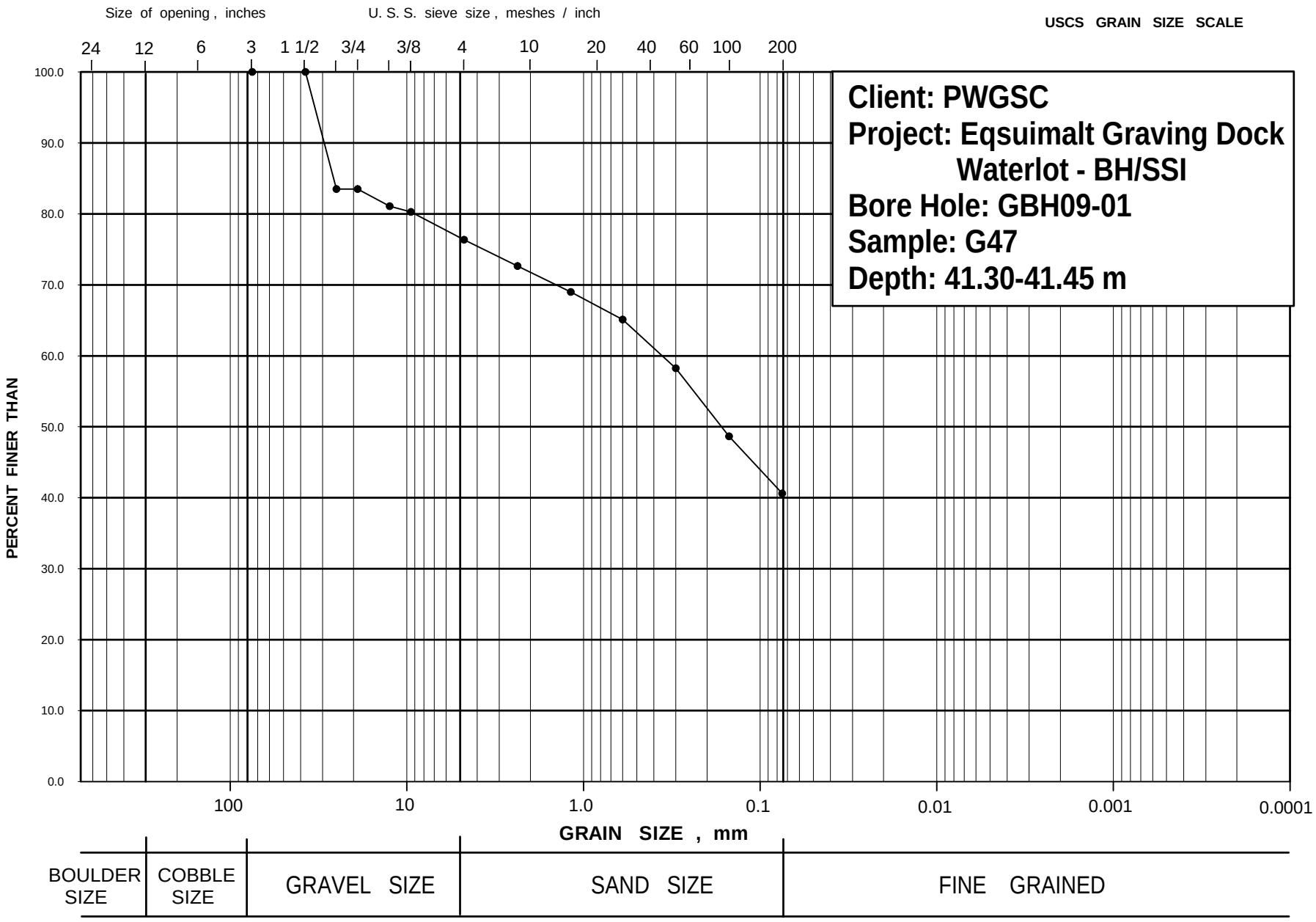

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** **Date** 30 Oct 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: 30-Sep-09 **TESTED BY:** AMB

Auger Hole	GBH09-01	Sample :	G47		Depth :	41.30-41.45	
	1st SIEVING		2nd SIEVING		Wash Sieving		
	Weight before sievir	1163.7	Weight before sieving		Weight after wash		729.5
	Total weight	1163.7	1/4 Pass #4		Residual #200		37.8
	Pass #4				Minus #200		472.0

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
3"		0.0			0.0	75.0	100.0
1 1/2"		0.0			0.0	37.5	100.0
1"	191.9	16.5			16.5	25.0	83.5
3/4"	0.0	0.0			0.0	19.0	83.5
1/2"	28.2	2.4			2.4	12.5	81.1
3/8"	9.5	0.8			0.8	9.5	80.3
#4	45.4	3.9			3.9	4.75	76.4
#8	43.2	3.7			3.7	2.36	72.7
#16	42.5	3.7			3.7	1.18	69.0
#30	45.2	3.9			3.9	0.6	65.1
#50	80.1	6.9			6.9	0.3	58.2
#100	111.5	9.6			9.6	0.15	48.7
#200	93.7	8.1			8.1	0.075	40.6
Pan	472.0	40.6			40.6		

REMARKS :

Reported by: _____ Reviewed by: _____

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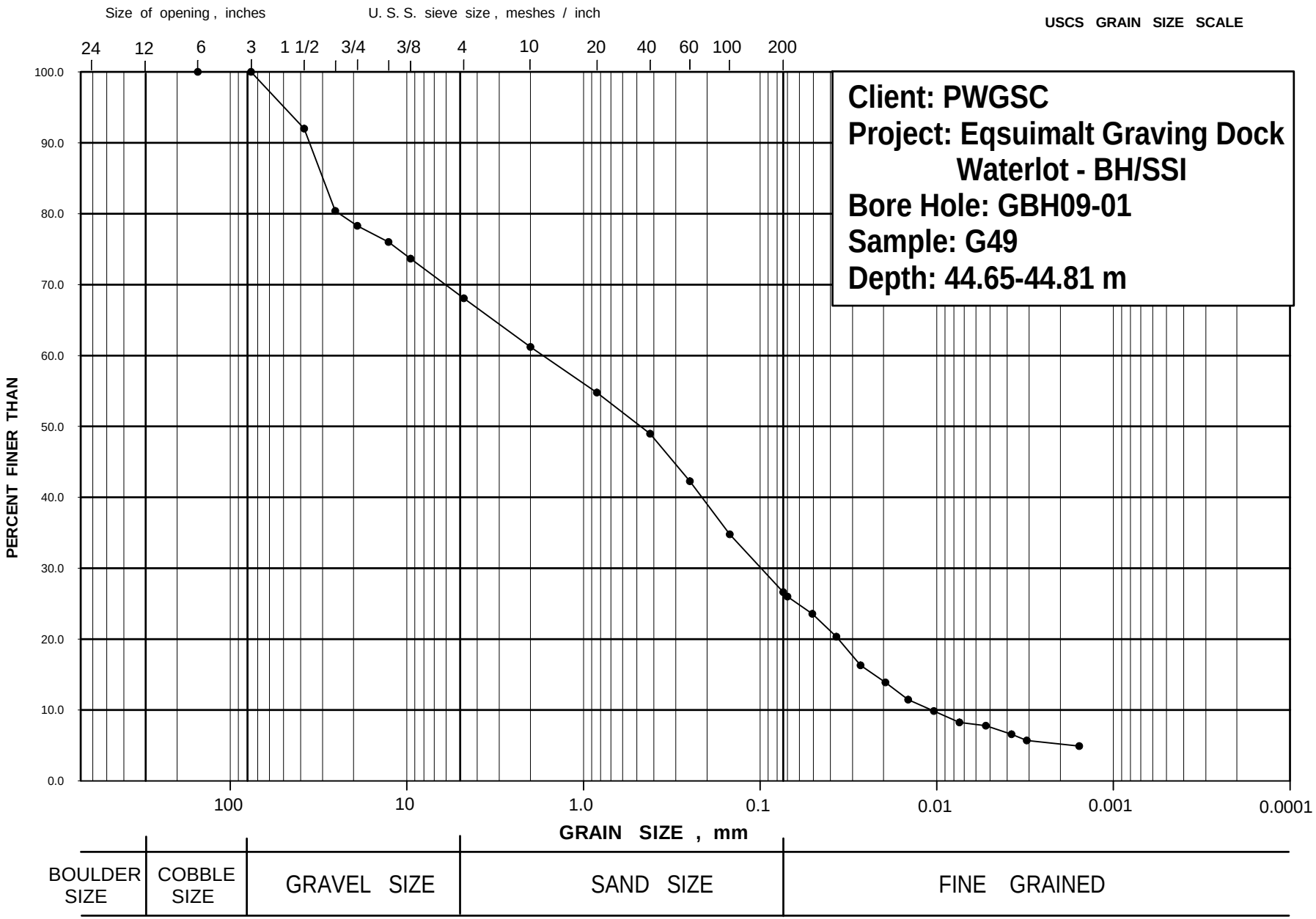

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** **Date** 30 Oct 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: **TESTED BY:**

Auger Hole	GBH09-01	Sample No.	G49		Depth (m) :	44.65-44.81	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	1.5	
	Total Weight	1260.8	Before Wash	75.0	Total -200	32.6	
			After Wash	44.0	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"	100.8	8.0			8.0	38.1	92.0
1"	146.4	11.6			11.6	25.4	80.4
3/4"	26.6	2.1			2.1	19.1	78.3
1/2"	28.7	2.3			2.3	12.7	76.0
3/8"	29.6	2.3			2.3	9.52	73.7
#4	70.6	5.6			5.6	4.76	68.1
#10	86.4	6.9			6.9	2.00	61.2
#20			7.9	10.5	6.4	0.840	54.8
#40			7.1	9.5	5.8	0.420	49.0
#60			8.2	11.0	6.7	0.250	42.3
#100			9.2	12.2	7.5	0.149	34.8
#200			10.0	13.3	8.2	0.074	26.6
Pan			32.6	43.4	26.5		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	36.0	20.0		-3.77	32.2	0.0701	26.0
1	33.0	20.0		-3.77	29.2	0.0507	23.6
2	29.0	20.0		-3.77	25.2	0.0370	20.3
4	24.0	20.0		-3.77	20.2	0.0271	16.3
8	21.0	20.0		-3.77	17.2	0.0195	13.9
15	18.0	20.0		-3.77	14.2	0.0145	11.5
30	16.0	20.0		-3.77	12.2	0.0104	9.9
60	14.0	20.0		-3.77	10.2	0.0074	8.2
120	13.5	19.5		-3.84	9.7	0.0053	7.8
240	12.0	19.5		-3.84	8.2	0.0038	6.6
360	11.0	19.0		-3.91	7.1	0.0031	5.7
1440	10.0	18.0		-3.91	6.1	0.0016	4.9

Reported by: _____ Reviewed by: _____

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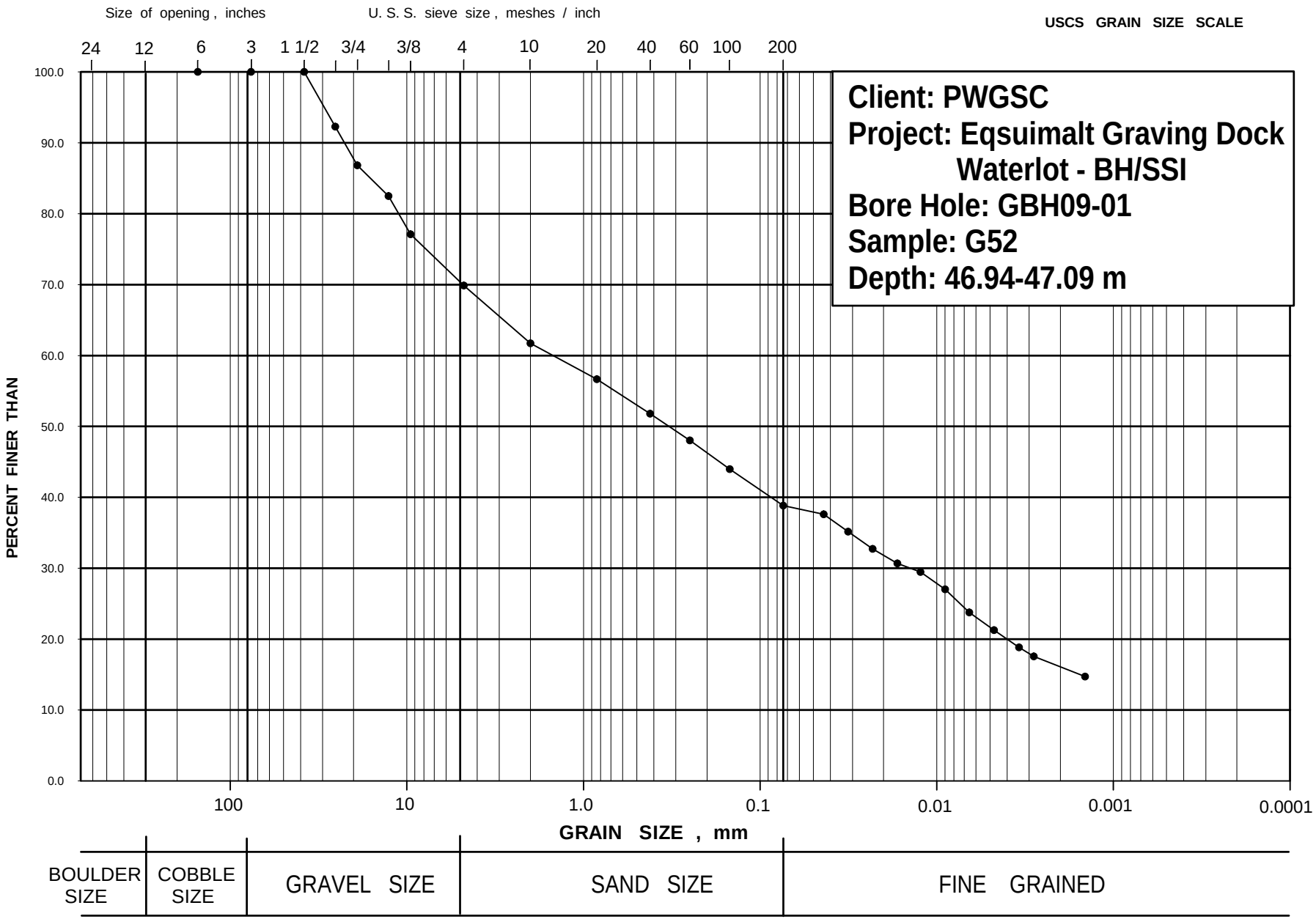

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** **Date** 30 Oct 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: **TESTED BY:**

Auger Hole	GBH09-01	Sample No.	G52		Depth (m) :	46.94-47.09	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.6	
	Total Weight	1069.6	Before Wash	75.0	Total -200	47.1	
			After Wash	28.5	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	82.5	7.7			7.7	25.4	92.3
3/4"	58.5	5.5			5.5	19.1	86.8
1/2"	46.2	4.3			4.3	12.7	82.5
3/8"	57.8	5.4			5.4	9.52	77.1
#4	77.2	7.2			7.2	4.76	69.9
#10	87.3	8.2			8.2	2.00	61.7
#20			6.2	8.2	5.1	0.840	56.7
#40			5.9	7.9	4.9	0.420	51.8
#60			4.6	6.1	3.8	0.250	48.0
#100			4.9	6.6	4.0	0.149	44.0
#200			6.3	8.3	5.1	0.074	38.8
Pan			47.1	62.8	38.8		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	53.0	20.0		-3.77	49.2	0.0597	
1	50.0	20.0		-3.77	46.2	0.0436	37.6
2	47.0	20.0		-3.77	43.2	0.0318	35.2
4	44.0	20.0		-3.77	40.2	0.0231	32.7
8	41.5	20.0		-3.77	37.7	0.0167	30.7
15	40.0	20.0		-3.77	36.2	0.0124	29.5
30	37.0	20.0		-3.77	33.2	0.0090	27.0
60	33.0	20.0		-3.77	29.2	0.0065	23.8
120	30.0	19.5		-3.84	26.2	0.0047	21.3
240	27.0	19.5		-3.84	23.2	0.0034	18.8
360	25.5	19.0		-3.91	21.6	0.0028	17.6
1440	22.0	18.0		-3.91	18.1	0.0015	14.7

Reported by: _____ Reviewed by: _____

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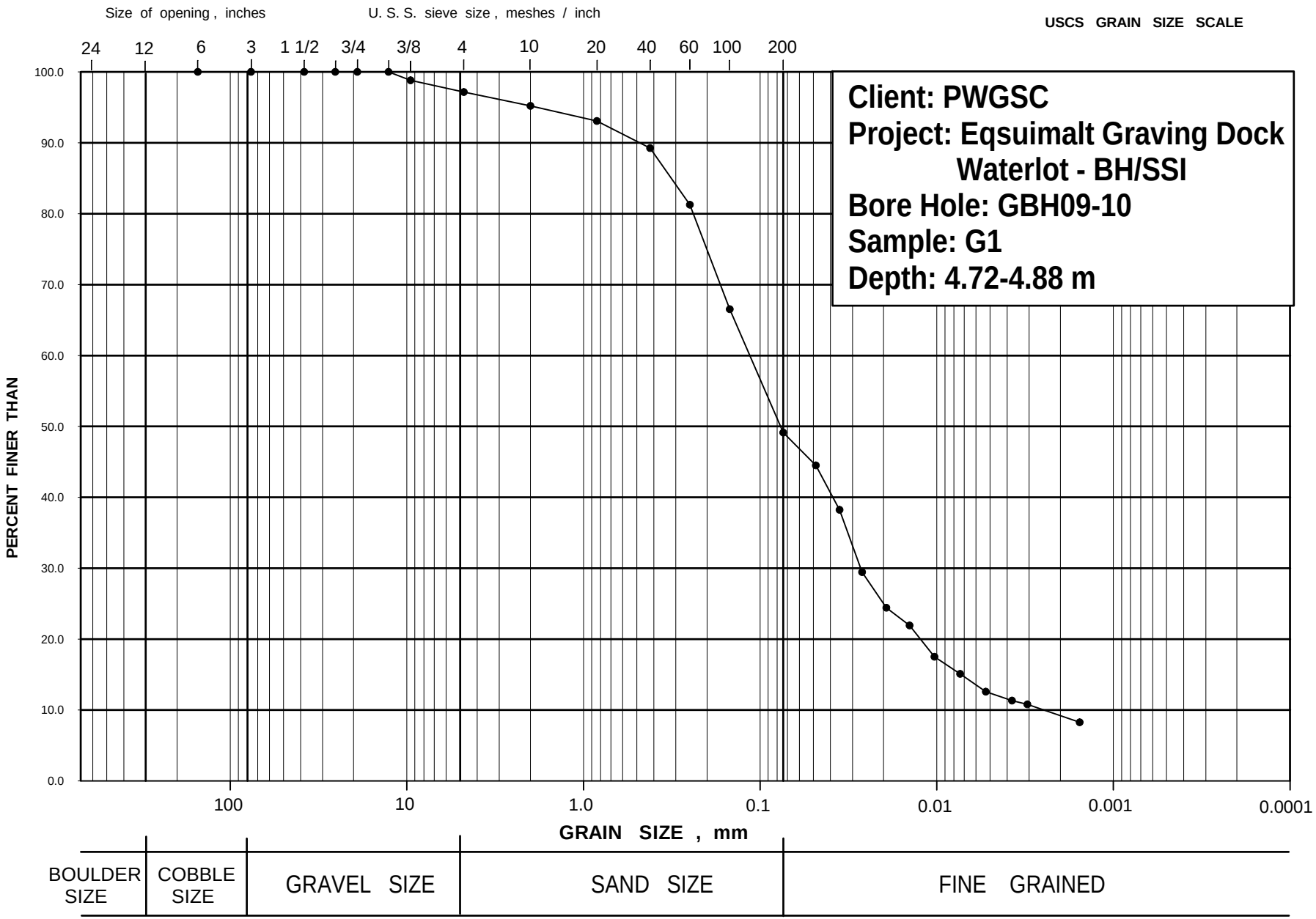

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** CW **Date** 24 Dec 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: **TESTED BY:**

Auger Hole	GBH09-10	Sample No.	G1		Depth (m) :	4.72-4.88	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	2.0	
	Total Weight	626.2	Before Wash	75.0	Total -200	38.7	
			After Wash	38.3	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"		0.0			0.0	25.4	100.0
3/4"		0.0			0.0	19.1	100.0
1/2"		0.0			0.0	12.7	100.0
3/8"	7.5	1.2			1.2	9.52	98.8
#4	10.3	1.6			1.6	4.76	97.2
#10	12.1	1.9			1.9	2.00	95.2
#20			1.7	2.3	2.2	0.840	93.1
#40			3.0	4.0	3.8	0.420	89.3
#60			6.3	8.4	8.0	0.250	81.3
#100			11.6	15.5	14.7	0.149	66.5
#200			13.7	18.3	17.4	0.074	49.1
Pan			38.7	51.6	49.1		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	43.0	18.0		-4.04	39.0	0.0663	
1	39.5	18.0		-4.04	35.5	0.0483	44.5
2	34.5	18.0		-4.04	30.5	0.0356	38.2
4	27.5	18.0		-4.04	23.5	0.0265	29.5
8	23.5	18.0		-4.04	19.5	0.0193	24.4
15	21.5	18.0		-4.04	17.5	0.0143	21.9
30	18.0	18.0		-4.04	14.0	0.0103	17.5
60	16.0	18.5		-3.97	12.0	0.0074	15.1
120	14.0	18.5		-3.97	10.0	0.0053	12.6
240	13.0	18.5		-3.97	9.0	0.0038	11.3
360	12.5	19.0		-3.91	8.6	0.0031	10.8
1440	10.5	19.0		-3.91	6.6	0.0016	8.3

Reported by: _____ Reviewed by: _____

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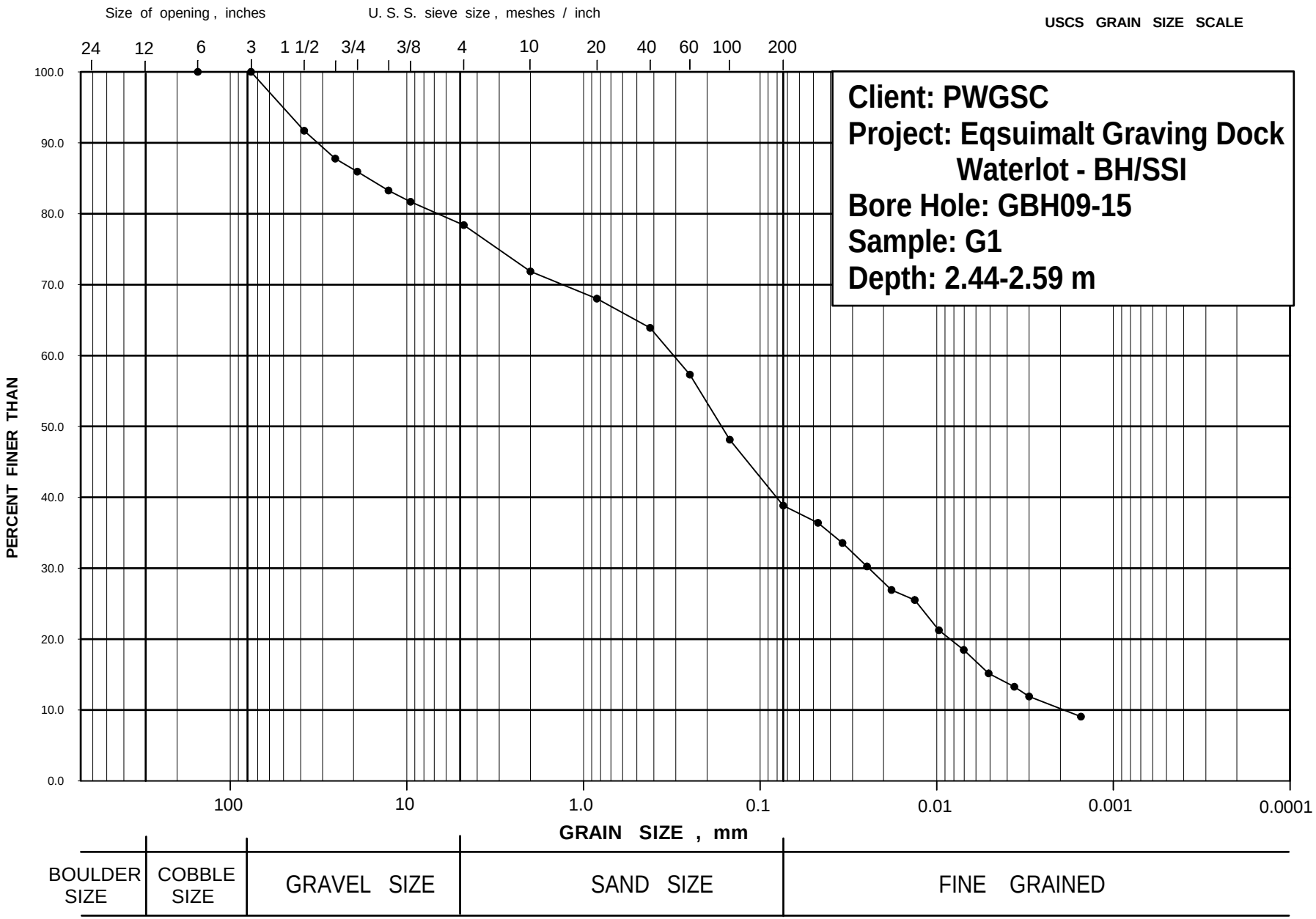

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** CW **Date** 24 Dec 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: **TESTED BY:**

Auger Hole	GBH09-15	Sample No.	G1		Depth (m) :	2.44-2.59	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	1.1	
	Total Weight	2243.8	Before Wash	75.1	Total -200	40.6	
			After Wash	35.6	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"	186.2	8.3			8.3	38.1	91.7
1"	88.1	3.9			3.9	25.4	87.8
3/4"	41.3	1.8			1.8	19.1	85.9
1/2"	59.7	2.7			2.7	12.7	83.3
3/8"	35.6	1.6			1.6	9.52	81.7
#4	74.2	3.3			3.3	4.76	78.4
#10	146.5	6.5			6.5	2.00	71.9
#20			4.0	5.3	3.8	0.840	68.0
#40			4.3	5.7	4.1	0.420	63.9
#60			6.9	9.2	6.6	0.250	57.3
#100			9.6	12.8	9.2	0.149	48.1
#200			9.7	12.9	9.3	0.074	38.8
Pan			40.6	54.1	38.8		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	45.0	18.0		-4.04	41.0	0.0650	38.8
1	42.5	18.0		-4.04	38.5	0.0471	36.4
2	39.5	18.0		-4.04	35.5	0.0342	33.6
4	36.0	18.0		-4.04	32.0	0.0249	30.2
8	32.5	18.0		-4.04	28.5	0.0181	26.9
15	31.0	18.0		-4.04	27.0	0.0133	25.5
30	26.5	18.0		-4.04	22.5	0.0097	21.3
60	23.5	18.5		-3.97	19.5	0.0070	18.5
120	20.0	18.5		-3.97	16.0	0.0051	15.2
240	18.0	18.5		-3.97	14.0	0.0036	13.3
360	16.5	19.0		-3.91	12.6	0.0030	11.9
1440	13.5	19.0		-3.91	9.6	0.0015	9.1

Reported by: _____ Reviewed by: _____

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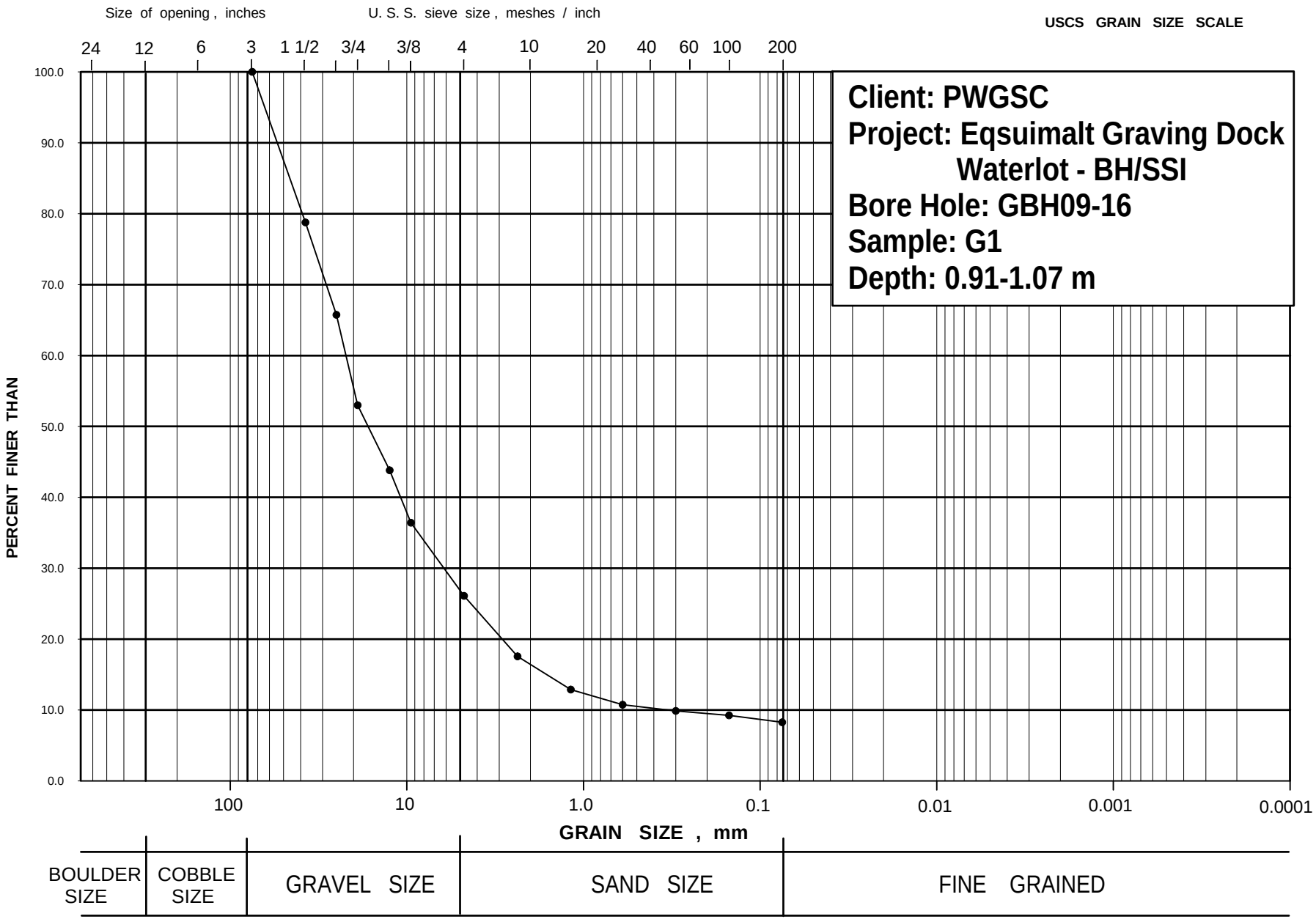

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** CW **Date** 24 Dec 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: 4-Dec-09 **TESTED BY:** AMB

Auger Hole	**GBH09-16**	**Sample :**	**G1**		**Depth (m) :**	**0.91-1.07**
	1st SIEVING		**2nd SIEVING**		**Wash Sieving**	
	Weight before sieving		Weight before sieving		Weight after wash	2008.3
	Total weight	2184.5	1/4 Pass #4		Residual #200	5.8
	Pass #4				Minus #200	182.0

Sieve (USS)	**Weight Retained**	**% Retained**	**Weight Retained**	**% Retained**	**% Retained of Total**	**Diameter (mm)**	**% Passing**
3"		0.0			0.0	**75.0**	**100.0**
1 1/2"	463.7	21.2			21.2	**37.5**	**78.8**
1"	284.4	13.0			13.0	**25.0**	**65.8**
3/4"	279.1	12.8			12.8	**19.0**	**53.0**
1/2"	200.2	9.2			9.2	**12.5**	**43.8**
3/8"	161.4	7.4			7.4	**9.5**	**36.4**
#4	225.8	10.3			10.3	**4.75**	**26.1**
#8	186.4	8.5			8.5	**2.36**	**17.6**
#16	102.2	4.7			4.7	**1.18**	**12.9**
#30	46.3	2.1			2.1	**0.6**	**10.8**
#50	19.2	0.9			0.9	**0.3**	**9.9**
#100	13.9	0.6			0.6	**0.15**	**9.2**
#200	21.0	1.0			1.0	**0.075**	**8.3**
Pan	182.0	8.3			8.3		

REMARKS :

Reported by: _____ Reviewed by: _____

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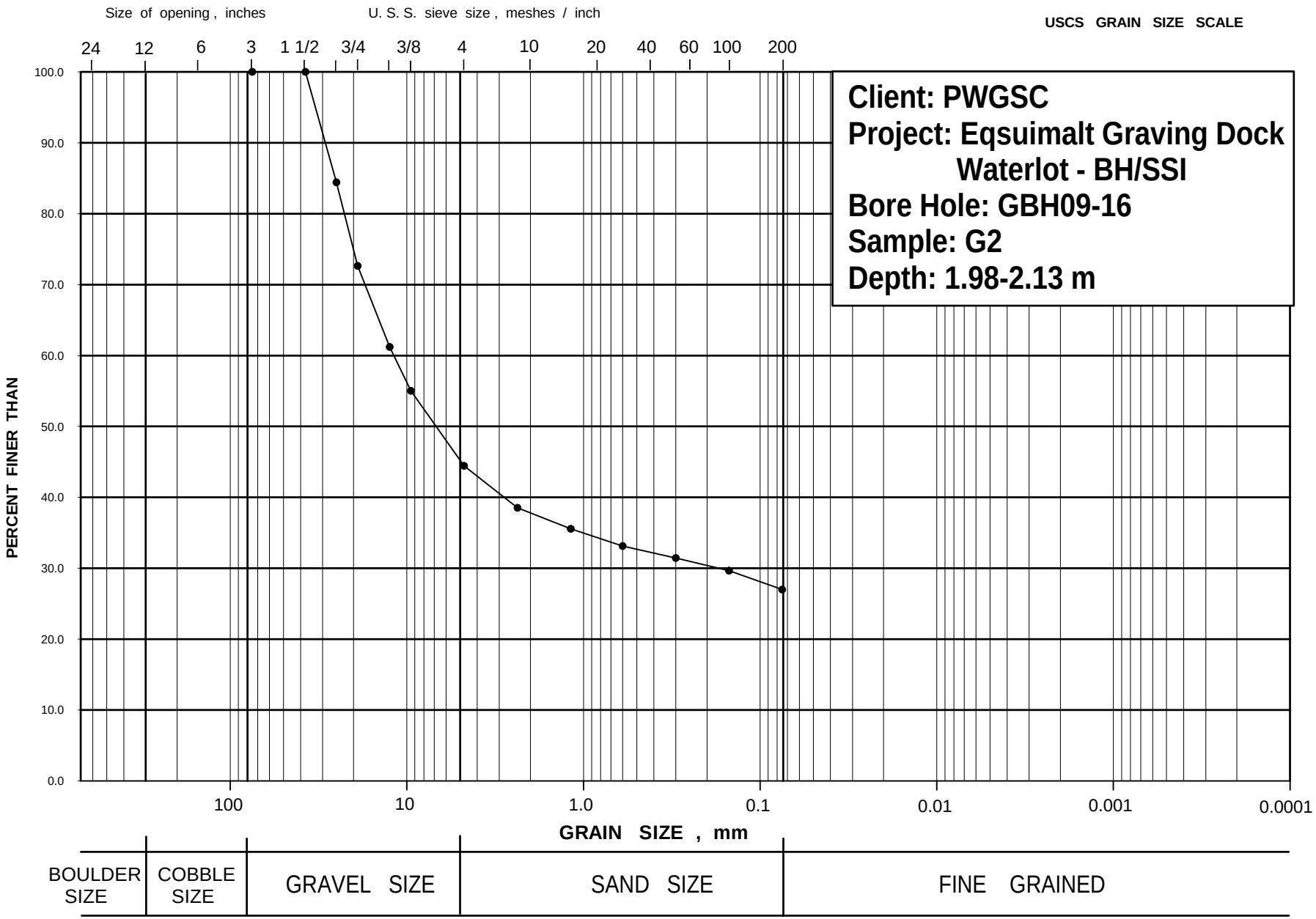

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** CW **Date** 24 Dec 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: 4-Dec-09 **TESTED BY:** AMB

Auger Hole	**GBH09-16**	**Sample :**	**G2**		**Depth (m) :**	**1.98-2.13**
	1st SIEVING		**2nd SIEVING**		**Wash Sieving**	
	Weight before sieving		Weight before sieving		Weight after wash	1468.5
	Total weight	1998.1	1/4 Pass #4		Residual #200	10.3
	Pass #4				Minus #200	539.9

Sieve (USS)	**Weight Retained**	**% Retained**	**Weight Retained**	**% Retained**	**% Retained of Total**	**Diameter (mm)**	**% Passing**
3"		0.0			0.0	**75.0**	**100.0**
1 1/2"		0.0			0.0	**37.5**	**100.0**
1"	311.2	15.6			15.6	**25.0**	**84.4**
3/4"	235.7	11.8			11.8	**19.0**	**72.6**
1/2"	228.5	11.4			11.4	**12.5**	**61.2**
3/8"	123.0	6.2			6.2	**9.5**	**55.0**
#4	212.0	10.6			10.6	**4.75**	**44.4**
#8	117.9	5.9			5.9	**2.36**	**38.5**
#16	59.3	3.0			3.0	**1.18**	**35.6**
#30	48.7	2.4			2.4	**0.6**	**33.1**
#50	33.8	1.7			1.7	**0.3**	**31.4**
#100	35.7	1.8			1.8	**0.15**	**29.6**
#200	53.0	2.7			2.7	**0.075**	**27.0**
Pan	539.9	27.0			27.0		

REMARKS :

Reported by: _____ Reviewed by: _____

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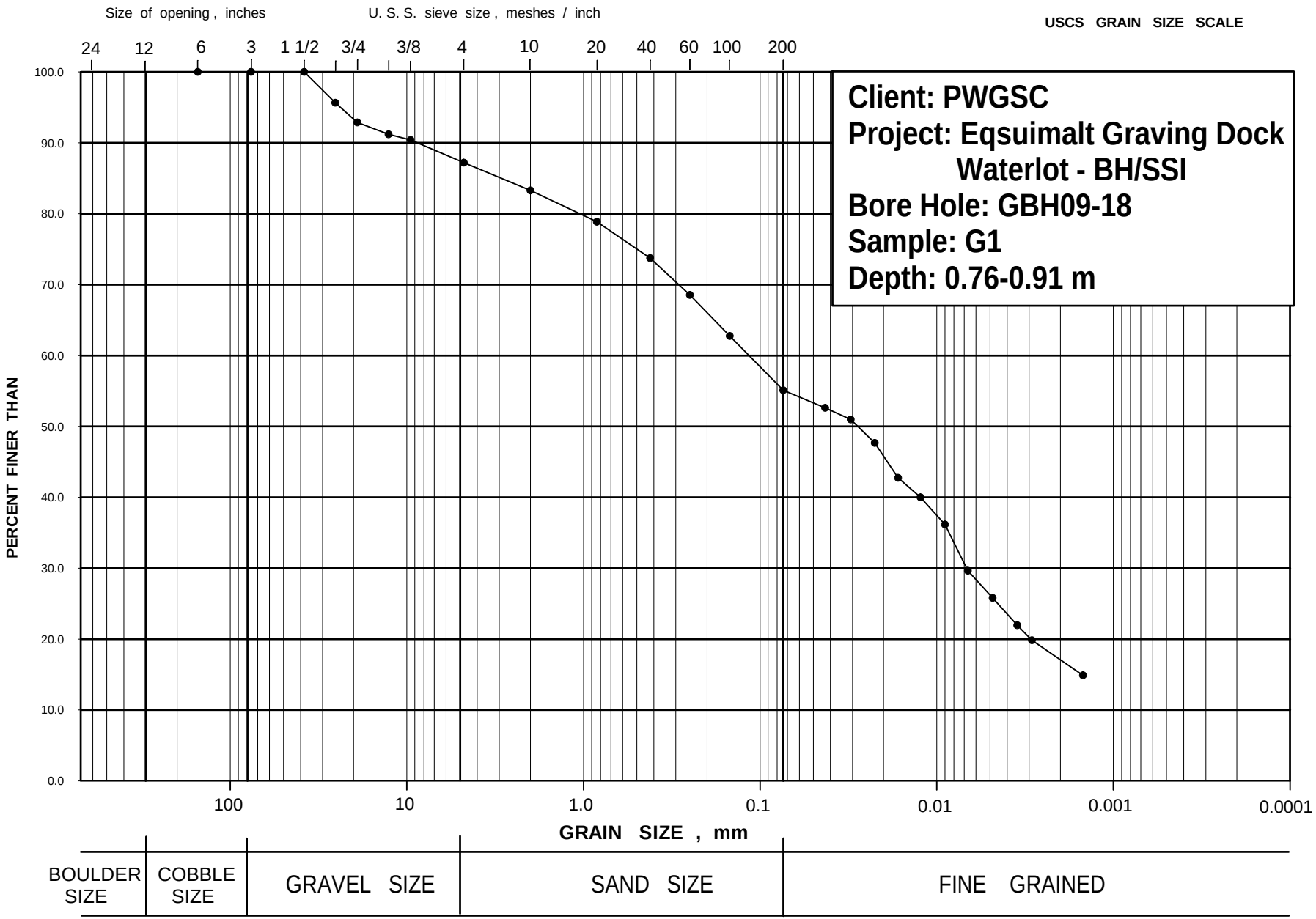

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** CW **Date** 24 Dec 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: **TESTED BY:**

Auger Hole	GBH09-18	Sample No.	G1		Depth (m) :	0.76-0.91	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	1.3	
	Total Weight	2012.5	Before Wash	75.1	Total -200	49.7	
			After Wash	26.7	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	87.3	4.3			4.3	25.4	95.7
3/4"	56.1	2.8			2.8	19.1	92.9
1/2"	33.5	1.7			1.7	12.7	91.2
3/8"	16.2	0.8			0.8	9.52	90.4
#4	64.5	3.2			3.2	4.76	87.2
#10	78.6	3.9			3.9	2.00	83.3
#20			4.0	5.3	4.4	0.840	78.9
#40			4.6	6.1	5.1	0.420	73.8
#60			4.7	6.3	5.2	0.250	68.5
#100			5.2	6.9	5.8	0.149	62.8
#200			6.9	9.2	7.7	0.074	55.1
Pan			49.7	66.2	55.1		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	54.0	18.0		-4.04	50.0	0.0593	54.8
1	52.0	18.0		-4.04	48.0	0.0429	52.6
2	50.5	18.0		-4.04	46.5	0.0308	51.0
4	47.5	18.0		-4.04	43.5	0.0224	47.7
8	43.0	18.0		-4.04	39.0	0.0166	42.8
15	40.5	18.0		-4.04	36.5	0.0124	40.0
30	37.0	18.0		-4.04	33.0	0.0090	36.2
60	31.0	18.5		-3.97	27.0	0.0067	29.7
120	27.5	18.5		-3.97	23.5	0.0048	25.8
240	24.0	18.5		-3.97	20.0	0.0035	22.0
360	22.0	19.0		-3.91	18.1	0.0029	19.9
1440	17.5	19.0		-3.91	13.6	0.0015	14.9

Reported by: _____ Reviewed by: _____

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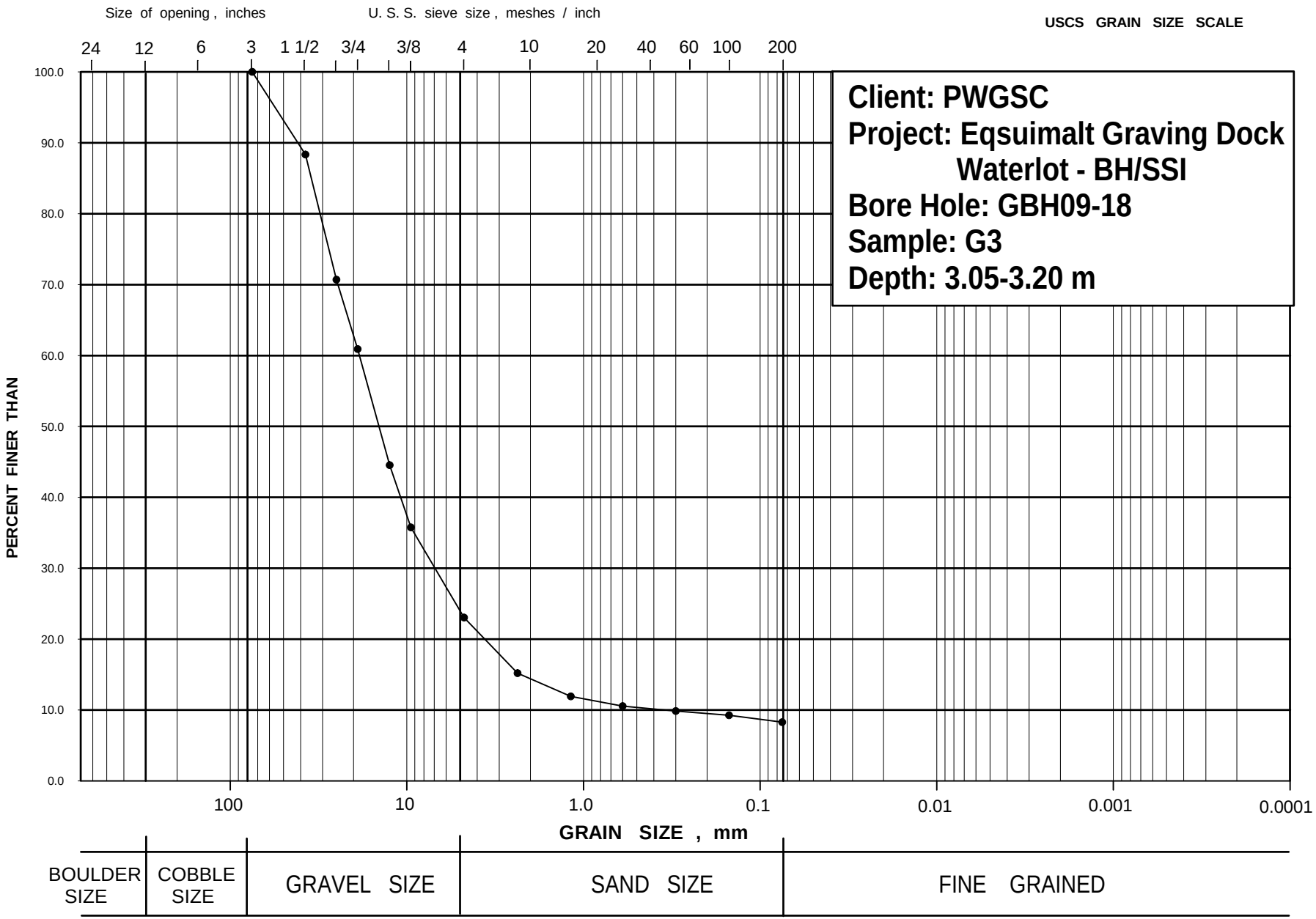

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** CW **Date** 24 Dec 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: 4-Dec-09 **TESTED BY:** AMB

Auger Hole	**GBH09-18**	**Sample :**	**G3**		**Depth (m) :**	**3.05-3.20**
	1st SIEVING		**2nd SIEVING**		**Wash Sieving**	
	Weight before sieving		Weight before sieving		Weight after wash	2294.7
	Total weight	2493.9	1/4 Pass #4		Residual #200	7.0
	Pass #4				Minus #200	206.2

Sieve (USS)	**Weight Retained**	**% Retained**	**Weight Retained**	**% Retained**	**% Retained of Total**	**Diameter (mm)**	**% Passing**
3"		0.0			0.0	**75.0**	**100.0**
1 1/2"	290.5	11.6			11.6	**37.5**	**88.4**
1"	440.0	17.6			17.6	**25.0**	**70.7**
3/4"	244.5	9.8			9.8	**19.0**	**60.9**
1/2"	408.3	16.4			16.4	**12.5**	**44.5**
3/8"	219.0	8.8			8.8	**9.5**	**35.8**
#4	317.0	12.7			12.7	**4.75**	**23.0**
#8	195.6	7.8			7.8	**2.36**	**15.2**
#16	81.4	3.3			3.3	**1.18**	**11.9**
#30	34.1	1.4			1.4	**0.6**	**10.6**
#50	17.3	0.7			0.7	**0.3**	**9.9**
#100	14.9	0.6			0.6	**0.15**	**9.3**
#200	24.5	1.0			1.0	**0.075**	**8.3**
Pan	206.2	8.3			8.3		

REMARKS :

Reported by: _____ Reviewed by: _____

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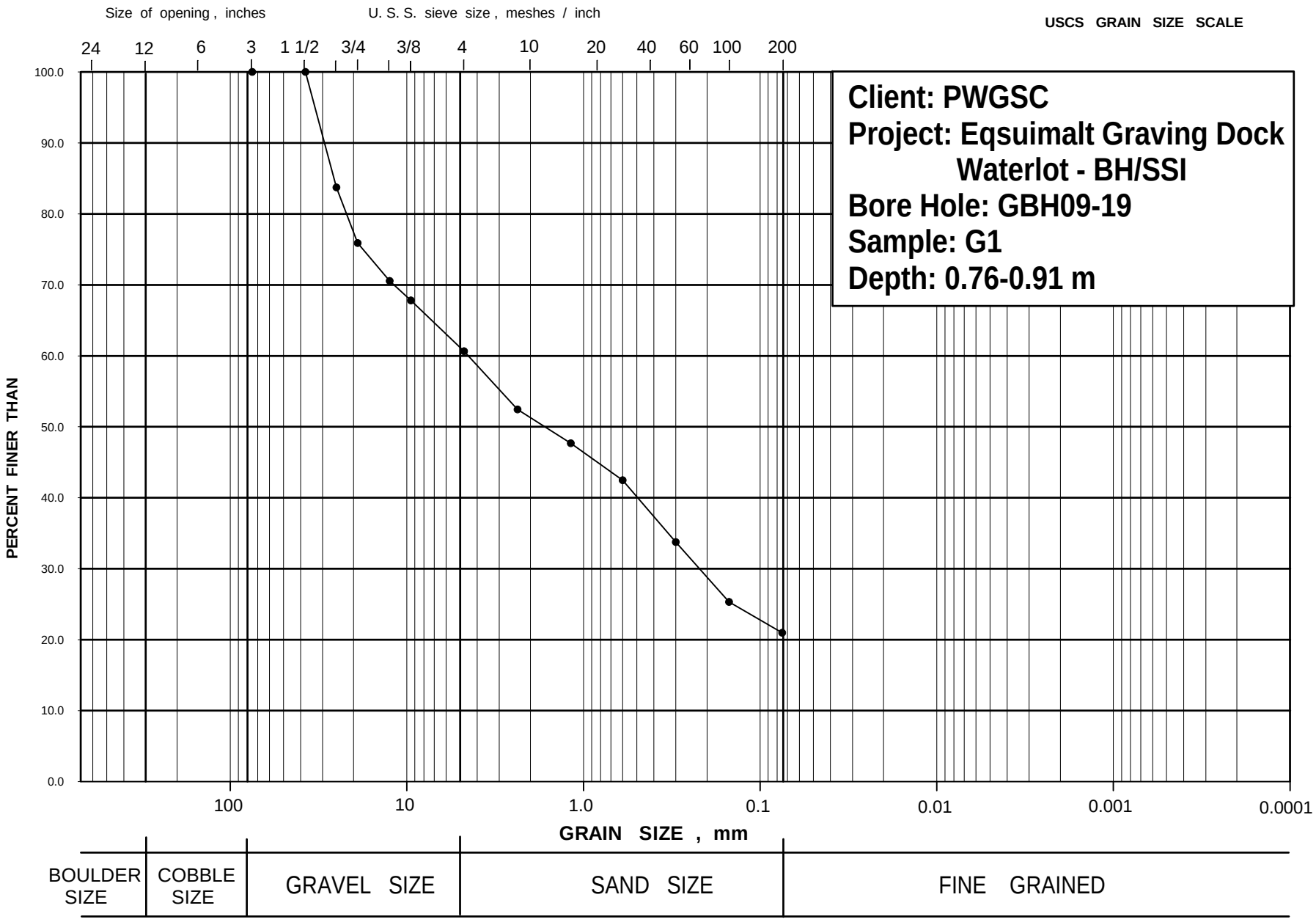

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** CW **Date** 24 Dec 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: 4-Dec-09 **TESTED BY:** AMB

Auger Hole	**GBH09-19**	**Sample :**	**G1**		**Depth (m) :**	**0.76-0.91**
	1st SIEVING		**2nd SIEVING**		**Wash Sieving**	
	Weight before sieving		Weight before sieving		Weight after wash	830.7
	Total weight	1037.4	1/4 Pass #4		Residual #200	11.0
	Pass #4				Minus #200	217.7

Sieve (USS)	**Weight Retained**	**% Retained**	**Weight Retained**	**% Retained**	**% Retained of Total**	**Diameter (mm)**	**% Passing**
3"		0.0			0.0	**75.0**	**100.0**
1 1/2"		0.0			0.0	**37.5**	**100.0**
1"	168.8	16.3			16.3	**25.0**	**83.7**
3/4"	81.4	7.8			7.8	**19.0**	**75.9**
1/2"	55.4	5.3			5.3	**12.5**	**70.5**
3/8"	28.4	2.7			2.7	**9.5**	**67.8**
#4	74.3	7.2			7.2	**4.75**	**60.6**
#8	84.9	8.2			8.2	**2.36**	**52.5**
#16	49.4	4.8			4.8	**1.18**	**47.7**
#30	54.2	5.2			5.2	**0.6**	**42.5**
#50	90.4	8.7			8.7	**0.3**	**33.8**
#100	87.6	8.4			8.4	**0.15**	**25.3**
#200	44.9	4.3			4.3	**0.075**	**21.0**
Pan	217.7	21.0			21.0		

REMARKS :

Reported by: _____ Reviewed by: _____

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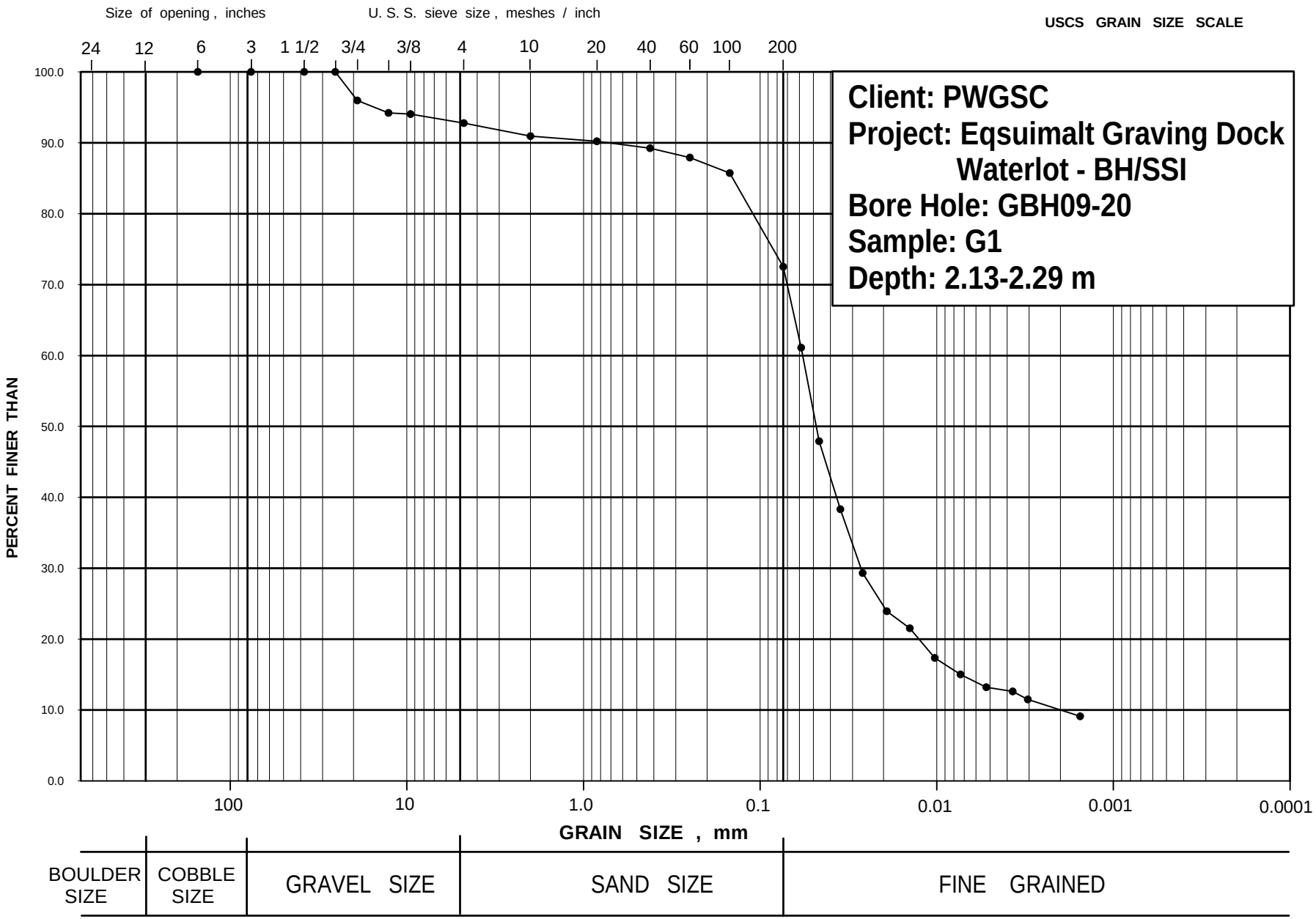

Project No. 09-1475-5008 **Drawn** DGM **Reviewed** CW **Date** 24 Dec 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: Waterlot – BH/SSI

PROJECT NUMBER: 09-1475-5008

DATE SAMPLED: **SAMPLED BY:** DGM

DATE TESTED: **TESTED BY:**

Auger Hole	GBH09-20	Sample No.	G1		Depth (m) :	2.13-2.29	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	4.6	
	Total Weight	694.5	Before Wash	75.0	Total -200	59.8	
			After Wash	19.8	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"		0.0			0.0	25.4	100.0
3/4"	28.0	4.0			4.0	19.1	96.0
1/2"	12.1	1.7			1.7	12.7	94.2
3/8"	1.3	0.2			0.2	9.52	94.0
#4	8.8	1.3			1.3	4.76	92.8
#10	12.7	1.8			1.8	2.00	90.9
#20			0.6	0.8	0.7	0.840	90.2
#40			0.8	1.1	1.0	0.420	89.2
#60			1.1	1.5	1.3	0.250	87.9
#100			1.8	2.4	2.2	0.149	85.7
#200			10.9	14.5	13.2	0.074	72.5
Pan			59.8	79.7	72.5		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	55.0	18.0		-4.04	51.0	0.0586	61.1
1	44.0	18.0		-4.04	40.0	0.0464	47.9
2	36.0	18.0		-4.04	32.0	0.0352	38.3
4	28.5	18.0		-4.04	24.5	0.0263	29.3
8	24.0	18.0		-4.04	20.0	0.0192	23.9
15	22.0	18.0		-4.04	18.0	0.0142	21.5
30	18.5	18.0		-4.04	14.5	0.0103	17.3
60	16.5	18.5		-3.97	12.5	0.0074	15.0
120	15.0	18.5		-3.97	11.0	0.0052	13.2
240	14.5	18.5		-3.97	10.5	0.0037	12.6
360	13.5	19.0		-3.91	9.6	0.0031	11.5
1440	11.5	19.0		-3.91	7.6	0.0015	9.1

Reported by: _____ Reviewed by: _____

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Golder Associates Ltd. - Burnaby Laboratory
4280 Still Creek Drive
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PARTICLE SIZE ANALYSIS OF SOILS

Reference
ASTM D 422-63 (2007)

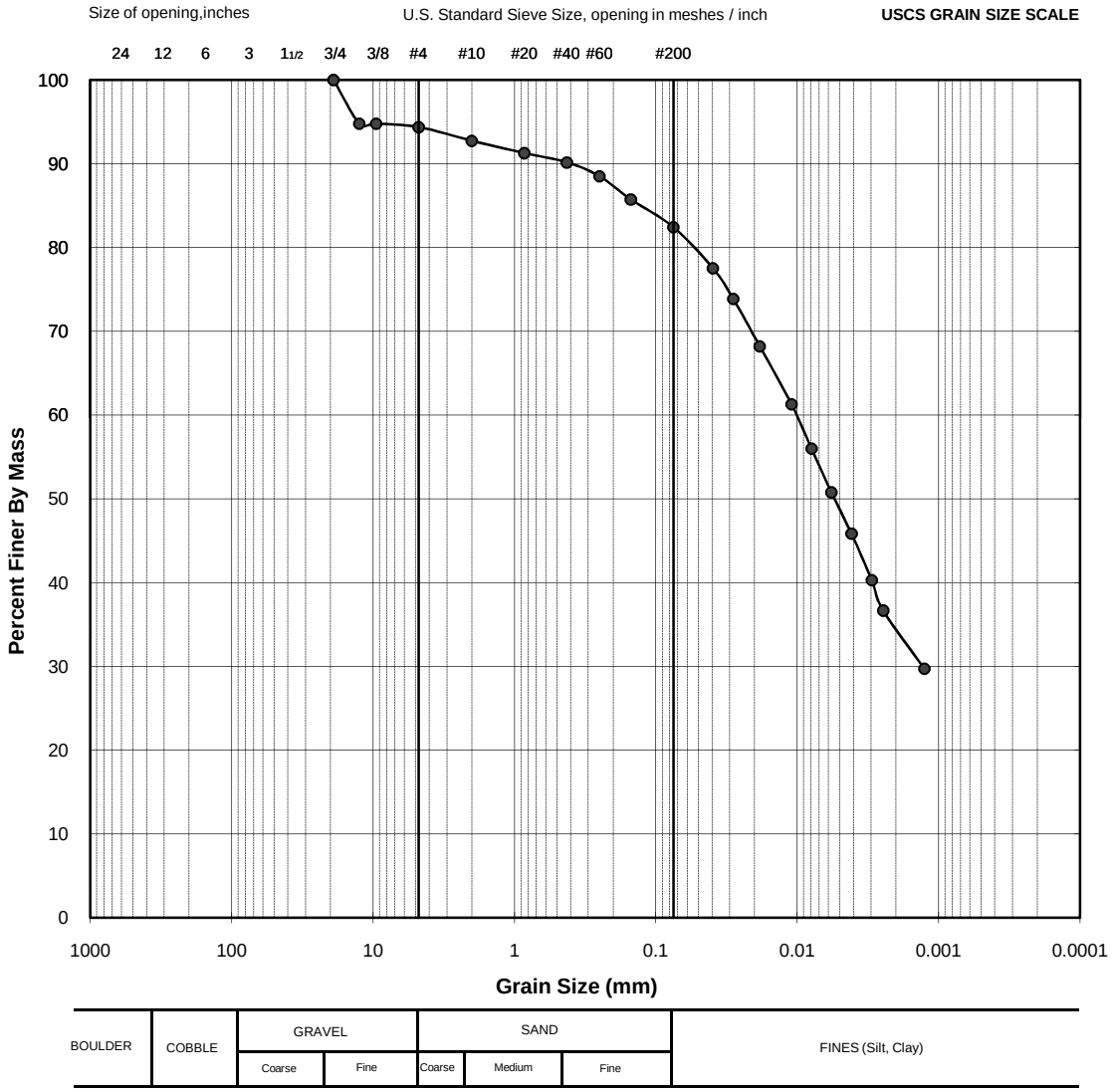
Project No.:	09-1475-5008 / 3000	**Borehole:**	**GBH09-22**
Client:	PWGSC	**Sample No.:**	G4
Project:	Waterlot BH SSI	**Depth (m):**	4.27-4.88
Location:	Esquimalt Graving Dock	**Lab ID No:**	227

Specific Gravity (assumed): 2.70

Other Remarks:

Dispersion Method: Stirring
Dispersion Period (min): 0.00

Sieve Size (USS)	Sieve Size (mm)	% Passing
3.5"	87.50	100.0
3"	75.00	100.0
2"	50.00	100.0
1.5"	37.50	100.0
1"	25.00	100.0
3/4"	19.00	100.0
1/2"	12.50	94.8
3/8"	9.50	94.8
#4	4.75	94.4
#10	2.00	92.7
#20	0.850	91.3
#40	0.425	90.2
#60	0.250	88.5
#100	0.150	85.7
#200	0.075	82.4
-	0.0393	77.5
-	0.0283	73.9
-	0.0184	68.2
-	0.0109	61.3
-	0.0079	56.0
-	0.0057	50.8
-	0.0041	45.8
-	0.0030	40.3
-	0.0025	36.6
-	0.0013	29.7



** The test data given herein pertain to the sample provided only. This report constitutes a testing service only. Interpretation of the data can be provided upon request.*

TM	5/1/2010	LP	January 6,2010
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Laboratory
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

PARTICLE SIZE ANALYSIS OF SOILS

Reference
ASTM D 422-63 (2007)

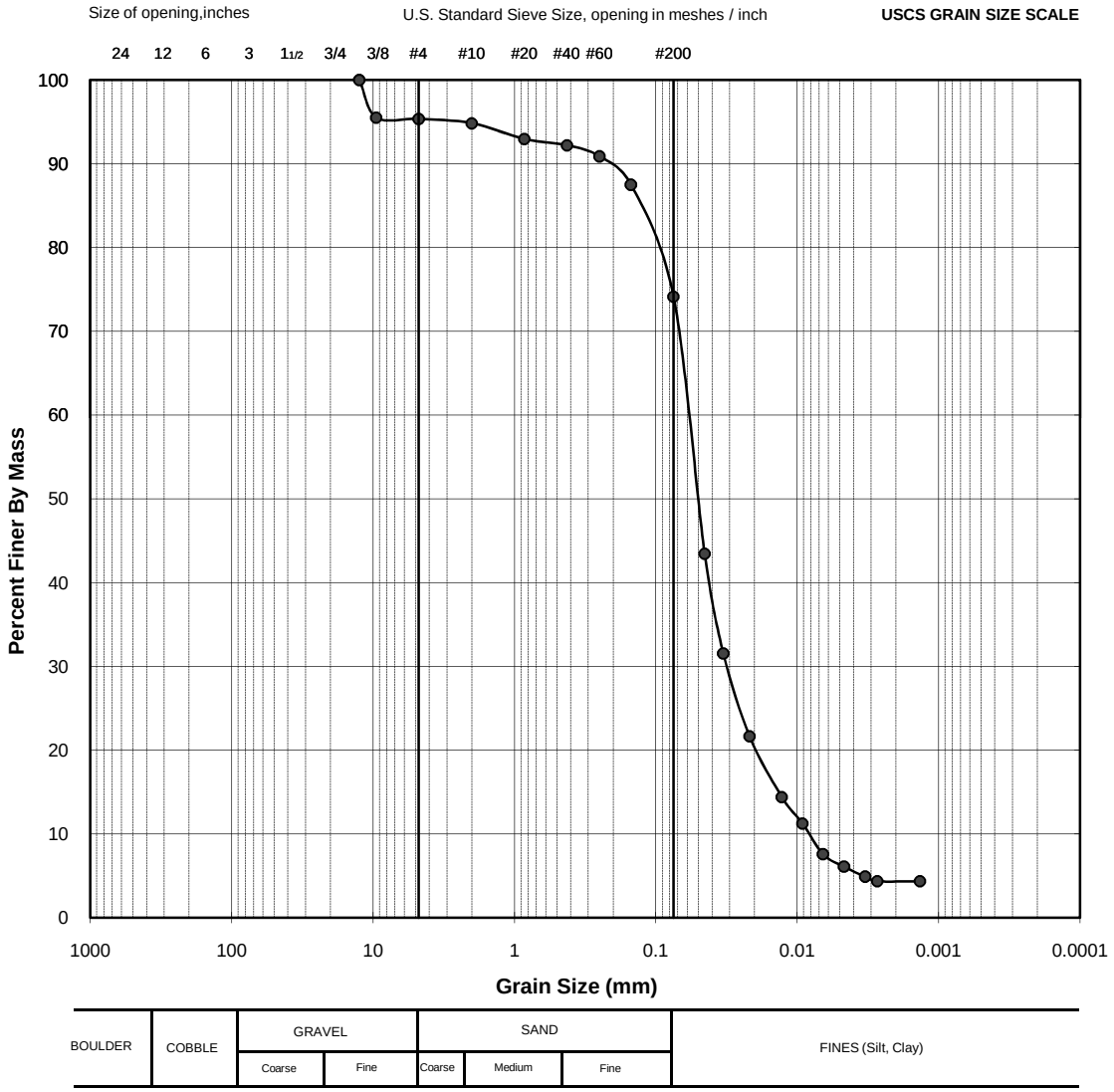
Project No.:	09-1475-5008 / 3000	**Borehole:**	**GBH09-23**
Client:	PWGSC	**Sample No.:**	4
Project:	Waterlot BH SSI	**Depth (m):**	3.05-3.66
Location:	Esquimalt Graving Dock	**Lab ID No:**	227

Specific Gravity (assumed): 2.70

Other Remarks: Material taken from Dtest-2 and Dtest-3 trimmings

Dispersion Method: Stirring
Dispersion Period (min): 0.00

Sieve Size (USS)	Sieve Size (mm)	% Passing
3.5"	87.50	100.0
3"	75.00	100.0
2"	50.00	100.0
1.5"	37.50	100.0
1"	25.00	100.0
3/4"	19.00	100.0
1/2"	12.50	100.0
3/8"	9.50	95.5
#4	4.75	95.4
#10	2.00	94.8
#20	0.850	93.0
#40	0.425	92.2
#60	0.250	90.9
#100	0.150	87.5
#200	0.075	74.1
-	0.0451	43.4
-	0.0333	31.5
-	0.0217	21.6
-	0.0128	14.4
-	0.0092	11.2
-	0.0066	7.6
-	0.0047	6.1
-	0.0033	4.9
-	0.0027	4.3
-	0.0014	4.3



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TM	5/1/2010	LP	January 6,2010
TESTED BY	DATE	CHECKED BY	DATE

APPENDIX C

Direct Shear Test Results

Golder Associates Ltd. - Burnaby Laboratory
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Drained Conditions

Reference
ASTM D 3080-04

Client:	PWGSC	**Sample No.:**	GBH09-22
Project:	Waterlot BH SSI	**Sample Location:**	G4
Location:	Esquimalt Graving Dock	**Depth (m):**	4.27-4.88
Project No.:	09-1475-5008/ 3000	**Lab ID No:**	227

Test Condition:	SATURATED	**Equipment Description:**		GEOTAC DIGISHEAR# 2
Visual Description:	Soft to firm grey silty CLAY	**Normal Load Cell:**	Serial No.:	270986
	Undisturbed sample	**Shear Load Cell:**	Serial No.:	266562
	Peak only	**Vertical LPT:**	Serial No.:	LP-567

Remarks: Area correction not applied to normal and shear stress calculation
Water added to the shear box

Initial Sample Dimensions

Test No.	1	2	3			
Shear box geometry	round	round	round			
Diameter (mm)	63.50	63.50	63.53			
Height (mm)	25.40	25.40	25.48			
Area (cm^2)	31.67	31.67	31.69			
Volume (cm^3)	80.44	80.44	80.75			

Weight Volume Relationships

Sample Type	PEAK	PEAK	PEAK			
Dry Mass (g)	121.6	122.2	120.5			
Initial γ_{wet} (kN/m^3)	19.19	19.27	18.87			
Final γ_{wet} (kN/m^3)	18.40	19.82	19.92			
Initial γ_{dry} (kN/m^3)	14.83	14.90	14.64			
Final γ_{dry} (kN/m^3)	15.07	15.47	15.51			
Initial water content (%)	29.4	29.3	28.9			
Final water content (%)	22.1	28.1	28.4			

Consolidation Results

Normal Stress (kPa)	30	60	120			
t_{90} (Taylor Method) (min)	39.7	25.0	21.2			
Calculated t_{50} (min)	9.3	5.8	4.9			
Change in height ΔH_c (mm)	0.40	0.94	1.44			

Comments:

Test 1 taken 16 cm from top of tube

Test 2 taken 19.8 cm from top of tube

Test 3 taken 17 cm from top of tube

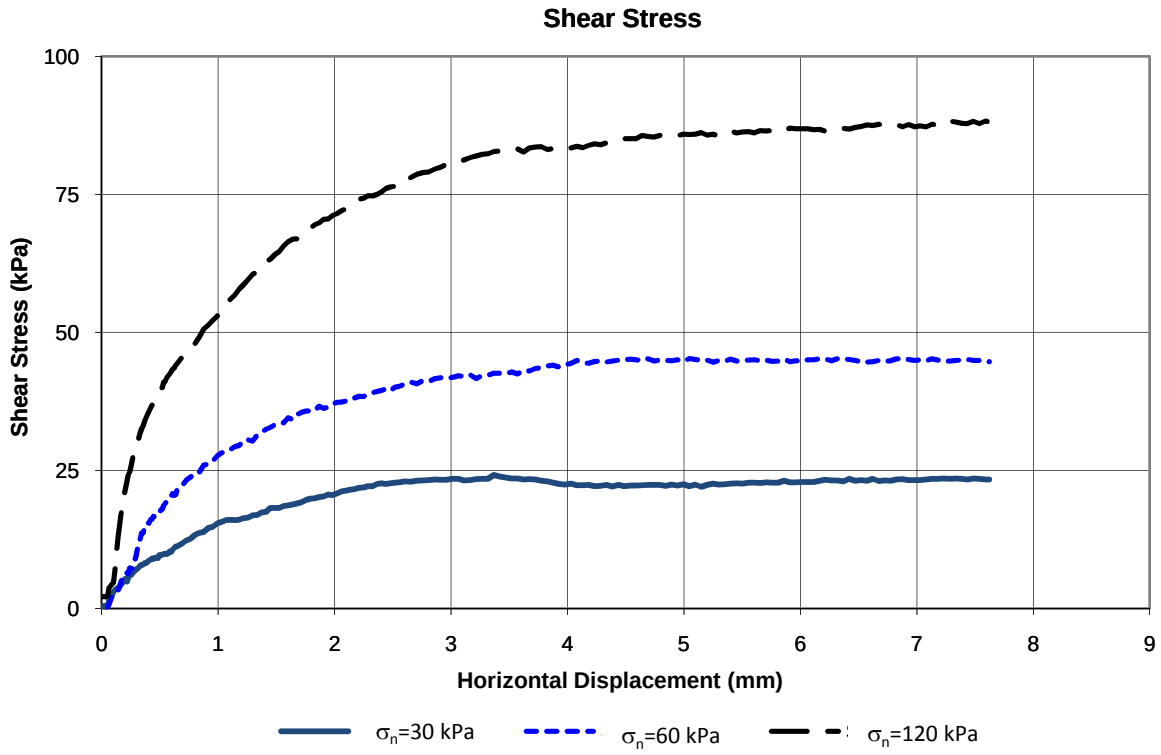
TM/LL	December 28, 2009	ROB	January 26, 2010
TESTED BY	DATE	CHECKED BY	DATE

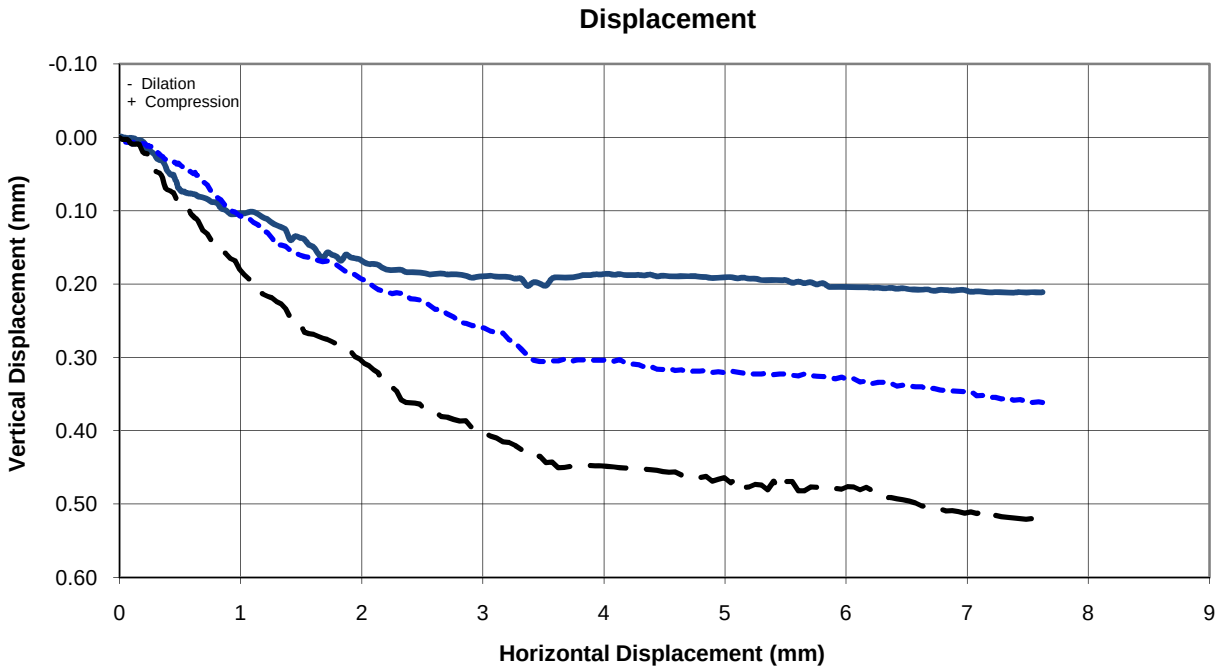
Golder Associates Ltd. - Burnaby Laboratory
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Drained Conditions

Reference
ASTM D 3080-04

Client:	PWGSC	**Sample No.:**	GBH09-22
Project:	Waterlot BH SSI	**Sample Location:**	G4
Location:	Esquimalt Graving Dock	**Depth (m):**	4.27-4.88
Project No.:	09-1475-5008/ 3000	**Lab ID No:**	227





TM/LL	December 28, 2009	ROB	January 26, 2010
TESTED BY	DATE	CHECKED BY	DATE

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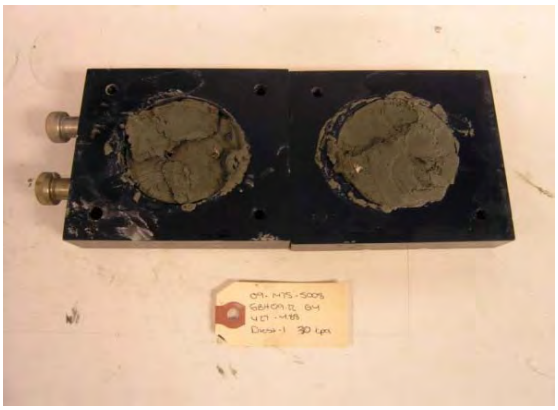
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Drained Conditions

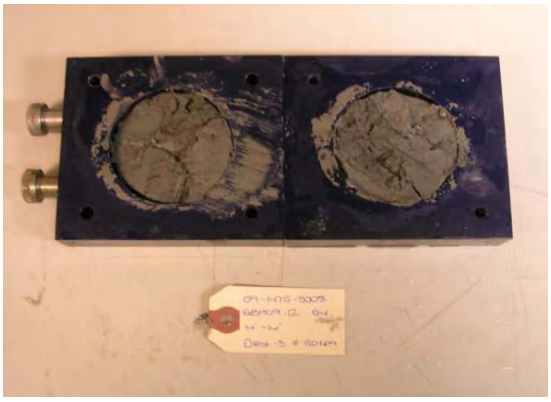
Reference
ASTM D 3080-04

Client:	PWGSC	**Sample No.:**	GBH09-22
Project:	Waterlot BH SSI	**Sample Location:**	G4
Location:	Esquimalt Graving Dock	**Depth (m):**	4.27-4.88
Project No.:	09-1475-5008/ 3000	**Lab ID No:**	227



Test 1 (After Shear)

Test 2 (After Shear)



Test 3 (After Shear)

Remarks:

Atterberg Limit Results

Liquid Limit = 34

Plastic Limit = 23

Plastic Index = 11

$w_{natural}$ (%) = 28.9 to 29.4

Classification = ML/CL

Soft to firm, wet, very dark grey, silty CLAY to clayey SILT, little sand, little marine shells

TM/LL	December 28, 2009	ROB	January 26, 2010
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Laboratory
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Drained Conditions

Reference
ASTM D 3080-04

Client:	PWGSC	**Sample No.:**	GBH09-22
Project:	Waterlot BH SSI	**Sample Location:**	G4
Location:	Esquimalt Graving Dock	**Depth (m):**	4.27-4.88
Project No.:	09-1475-5008/ 3000	**Lab ID No:**	227

Test 1	
Normal Stress , kPa	30
Disp Rate, mm/min	0.0002

Test 2	
Normal Stress , kPa	60
Disp Rate, mm/min	0.0002

Test 3	
Normal Stress , kPa	120
Disp Rate, mm/min	0.0002

Normal Stress , kPa	
Disp Rate, mm/min	

Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm
0.00	0.4	0.000	0.05	0.25	0.006	0.00	2.0	0.000			
0.01	0.4	-0.001	0.06	0.66	0.007	0.01	2.1	0.002			
0.03	0.5	0.001	0.08	1.41	0.007	0.03	2.1	0.003			
0.04	0.3	0.000	0.09	2.22	0.007	0.04	2.1	0.003			
0.05	0.4	0.001	0.10	2.35	0.009	0.05	2.2	0.003			
0.06	1.3	0.001	0.11	2.58	0.007	0.06	3.7	0.003			
0.08	2.0	0.001	0.13	2.93	0.008	0.08	4.1	0.005			
0.09	2.2	0.001	0.14	3.21	0.006	0.09	4.4	0.008			
0.10	2.9	0.001	0.15	3.80	0.008	0.10	4.6	0.009			
0.11	3.4	0.001	0.17	4.68	0.009	0.11	7.0	0.009			
0.13	3.6	0.002	0.18	5.38	0.007	0.13	10.0	0.010			
0.14	3.6	0.003	0.19	6.14	0.008	0.14	12.7	0.009			
0.15	4.0	0.004	0.20	6.10	0.009	0.15	14.9	0.009			
0.17	4.3	0.004	0.22	6.41	0.009	0.17	16.8	0.010			
0.18	4.6	0.004	0.23	6.24	0.012	0.18	18.3	0.015			
0.19	4.8	0.006	0.24	7.37	0.011	0.19	20.0	0.020			
0.20	5.4	0.008	0.25	7.18	0.013	0.20	21.5	0.022			
0.22	4.9	0.018	0.27	7.30	0.012	0.22	22.9	0.022			
0.23	5.6	0.018	0.28	8.37	0.015	0.23	24.1	0.022			
0.24	6.0	0.019	0.29	9.24	0.015	0.24	24.8	0.025			
0.25	6.1	0.019	0.31	10.46	0.019	0.25	26.0	0.026			
0.27	6.6	0.020	0.32	11.63	0.021	0.27	27.2	0.034			
0.28	6.7	0.022	0.33	12.46	0.023	0.28	28.2	0.041			
0.29	7.1	0.024	0.34	13.65	0.025	0.29	29.0	0.046			
0.30	7.1	0.028	0.36	13.68	0.026	0.30	30.1	0.047			
0.32	7.4	0.030	0.37	14.69	0.028	0.32	30.8	0.048			
0.33	7.7	0.031	0.38	14.93	0.030	0.33	31.7	0.049			
0.34	7.9	0.031	0.39	15.54	0.032	0.34	32.5	0.051			
0.36	7.9	0.032	0.41	15.41	0.032	0.36	33.1	0.055			
0.37	8.2	0.036	0.42	16.09	0.034	0.37	33.8	0.064			
0.38	8.2	0.041	0.43	16.13	0.035	0.38	34.6	0.070			
0.39	8.4	0.046	0.44	16.68	0.034	0.39	35.2	0.071			
0.41	8.7	0.048	0.46	16.55	0.034	0.41	35.7	0.072			
0.42	8.8	0.051	0.47	16.49	0.037	0.42	36.4	0.073			
0.43	9.1	0.051	0.48	17.12	0.035	0.43	36.7	0.074			

0.44	9.0	0.051	0.50	17.25	0.037	0.44	37.3	0.075			
0.46	9.1	0.057	0.51	17.84	0.038	0.46	38.1	0.080			
0.47	9.2	0.061	0.52	17.95	0.040	0.47	38.6	0.085			
0.48	9.1	0.069	0.53	18.67	0.041	0.48	39.1	0.087			
0.50	9.7	0.071	0.55	18.99	0.042	0.50	39.6	0.088			
0.51	9.7	0.074	0.56	19.44	0.042	0.51	39.8	0.088			
0.52	9.7	0.074	0.57	19.48	0.045	0.52	40.1	0.089			
0.53	9.8	0.074	0.58	19.67	0.046	0.53	40.9	0.090			
0.55	9.9	0.076	0.60	20.42	0.048	0.55	41.1	0.090			
0.56	9.8	0.076	0.61	20.82	0.050	0.56	41.8	0.094			
0.57	10.0	0.077	0.62	20.45	0.048	0.57	42.1	0.098			
0.58	10.3	0.076	0.64	20.62	0.052	0.58	42.5	0.103			
0.60	10.3	0.077	0.65	21.53	0.052	0.60	43.0	0.106			
0.61	10.6	0.078	0.69	22.10	0.060	0.61	43.3	0.108			
0.62	10.9	0.078	0.72	23.20	0.065	0.62	43.5	0.110			
0.64	11.2	0.079	0.76	23.78	0.076	0.64	44.0	0.111			
0.65	11.3	0.081	0.80	24.59	0.081	0.65	44.4	0.114			
0.69	11.7	0.082	0.84	24.66	0.085	0.69	45.4	0.127			
0.72	12.3	0.084	0.88	25.95	0.095	0.72	46.1	0.131			
0.76	12.6	0.088	0.92	26.12	0.100	0.76	47.1	0.142			
0.80	13.3	0.089	0.95	26.66	0.102	0.80	48.0	0.149			
0.84	13.6	0.097	0.99	27.60	0.107	0.84	49.1	0.151			
0.88	13.8	0.099	1.03	28.19	0.109	0.88	50.6	0.159			
0.92	14.5	0.105	1.07	28.59	0.110	0.92	51.3	0.165			
0.95	14.8	0.105	1.11	28.79	0.116	0.95	52.2	0.168			
0.99	15.3	0.104	1.14	29.30	0.119	0.99	52.9	0.180			
1.03	15.6	0.104	1.18	29.50	0.127	1.03	54.1	0.187			
1.07	16.0	0.102	1.22	30.46	0.130	1.07	55.1	0.193			
1.11	16.1	0.102	1.26	30.56	0.137	1.11	56.0	0.204			
1.14	16.0	0.105	1.30	30.30	0.147	1.14	56.7	0.207			
1.18	16.0	0.109	1.33	31.39	0.147	1.18	57.8	0.214			
1.22	16.3	0.112	1.37	31.95	0.149	1.22	58.7	0.217			
1.26	16.5	0.117	1.41	32.44	0.154	1.26	59.6	0.219			
1.30	16.9	0.120	1.45	32.83	0.157	1.30	60.5	0.224			
1.33	16.9	0.123	1.49	33.26	0.160	1.33	61.0	0.227			
1.37	17.4	0.126	1.53	33.53	0.162	1.37	62.2	0.234			
1.41	17.5	0.140	1.56	33.61	0.164	1.41	62.7	0.247			
1.45	18.2	0.135	1.60	34.54	0.164	1.45	63.3	0.250			
1.49	18.2	0.137	1.64	34.20	0.168	1.49	64.0	0.252			
1.53	18.2	0.139	1.68	35.14	0.169	1.53	64.6	0.266			
1.56	18.6	0.146	1.72	35.53	0.169	1.56	65.6	0.267			
1.60	18.7	0.150	1.75	35.74	0.172	1.60	66.4	0.268			
1.64	18.9	0.158	1.79	35.73	0.174	1.64	66.9	0.271			
1.68	19.0	0.165	1.83	35.83	0.179	1.68	66.9	0.274			
1.72	19.2	0.157	1.87	36.62	0.183	1.72	67.7	0.276			
1.75	19.6	0.160	1.91	36.24	0.184	1.75	68.2	0.279			
1.79	19.9	0.163	1.94	36.48	0.188	1.79	68.9	0.282			
1.83	19.9	0.168	1.98	37.02	0.192	1.83	69.5	0.284			
1.87	20.2	0.160	2.02	37.35	0.195	1.87	69.9	0.287			
1.91	20.3	0.164	2.06	37.40	0.199	1.91	70.5	0.291			
1.94	20.6	0.165	2.10	37.53	0.204	1.94	70.5	0.299			
1.98	20.5	0.167	2.14	38.04	0.207	1.98	71.2	0.302			
2.02	20.8	0.171	2.17	38.15	0.210	2.02	71.5	0.308			

2.06	21.2	0.173	2.21	38.41	0.211	2.06	72.1	0.311			
2.10	21.3	0.173	2.25	38.37	0.213	2.10	72.4	0.317			
2.14	21.5	0.174	2.29	38.83	0.212	2.14	72.7	0.321			
2.17	21.6	0.178	2.33	39.06	0.213	2.17	73.4	0.333			
2.21	21.8	0.181	2.36	39.29	0.215	2.21	74.1	0.336			
2.25	21.9	0.181	2.40	39.45	0.220	2.25	74.3	0.341			
2.29	22.1	0.181	2.44	39.74	0.221	2.29	74.7	0.346			
2.33	22.1	0.181	2.48	39.43	0.222	2.33	74.7	0.358			
2.36	22.5	0.184	2.52	40.05	0.223	2.36	75.0	0.361			
2.40	22.7	0.184	2.56	40.24	0.228	2.40	75.4	0.362			
2.44	22.6	0.184	2.61	40.60	0.234	2.44	76.1	0.362			
2.48	22.7	0.184	2.66	40.98	0.235	2.48	76.3	0.364			
2.52	22.8	0.185	2.71	40.68	0.241	2.52	76.5	0.370			
2.55	22.9	0.187	2.76	41.25	0.245	2.55	77.3	0.372			
2.61	23.0	0.186	2.81	41.09	0.252	2.61	77.3	0.374			
2.66	22.9	0.186	2.86	41.61	0.254	2.66	78.1	0.381			
2.71	23.1	0.187	2.91	41.78	0.257	2.71	78.7	0.381			
2.76	23.2	0.187	2.96	41.75	0.257	2.76	79.0	0.385			
2.81	23.2	0.187	3.01	41.82	0.260	2.81	79.0	0.387			
2.86	23.3	0.189	3.06	42.11	0.264	2.86	79.6	0.387			
2.91	23.3	0.192	3.11	42.02	0.266	2.91	79.9	0.396			
2.96	23.3	0.190	3.17	42.31	0.267	2.96	80.5	0.397			
3.01	23.5	0.190	3.22	41.63	0.276	3.01	80.5	0.403			
3.06	23.5	0.189	3.27	42.18	0.280	3.06	80.9	0.407			
3.11	23.2	0.190	3.32	42.27	0.289	3.11	81.3	0.410			
3.17	23.2	0.190	3.37	42.58	0.298	3.17	81.6	0.415			
3.22	23.4	0.191	3.42	42.60	0.304	3.22	81.9	0.416			
3.27	23.5	0.193	3.47	42.57	0.305	3.27	82.3	0.420			
3.32	23.5	0.193	3.52	42.82	0.306	3.32	82.4	0.426			
3.37	24.1	0.203	3.57	42.48	0.305	3.37	82.8	0.427			
3.42	23.9	0.198	3.62	43.14	0.305	3.42	82.8	0.435			
3.47	23.7	0.199	3.67	42.99	0.303	3.47	83.2	0.435			
3.52	23.5	0.202	3.72	43.49	0.306	3.52	83.3	0.444			
3.57	23.5	0.193	3.78	43.58	0.303	3.57	83.2	0.443			
3.62	23.4	0.191	3.83	43.93	0.304	3.62	82.7	0.450			
3.67	23.4	0.191	3.88	44.04	0.304	3.67	83.4	0.450			
3.72	23.3	0.191	3.93	43.72	0.304	3.72	83.6	0.449			
3.78	23.1	0.190	3.98	44.08	0.304	3.78	83.6	0.448			
3.83	23.0	0.188	4.03	44.38	0.304	3.83	83.1	0.448			
3.88	22.8	0.188	4.08	44.93	0.305	3.88	83.3	0.448			
3.93	22.6	0.187	4.13	44.53	0.303	3.93	83.6	0.448			
3.98	22.4	0.187	4.18	44.39	0.308	3.98	83.3	0.448			
4.03	22.6	0.186	4.23	44.72	0.309	4.03	83.4	0.449			
4.08	22.3	0.187	4.28	44.79	0.310	4.08	83.7	0.449			
4.13	22.3	0.187	4.33	44.61	0.313	4.13	83.5	0.451			
4.18	22.4	0.188	4.39	44.79	0.312	4.18	83.9	0.451			
4.23	22.2	0.188	4.44	44.99	0.316	4.23	84.2	0.451			
4.28	22.2	0.188	4.49	45.06	0.317	4.28	84.0	0.452			
4.33	22.3	0.188	4.54	45.17	0.315	4.33	84.3	0.452			
4.39	22.1	0.187	4.59	45.02	0.318	4.39	84.8	0.453			
4.44	22.4	0.190	4.64	44.92	0.317	4.44	84.9	0.454			
4.49	22.1	0.189	4.69	45.21	0.320	4.49	85.1	0.456			
4.54	22.3	0.190	4.74	44.79	0.319	4.54	85.1	0.457			

4.59	22.2	0.190	4.79	45.00	0.319	4.59	85.1	0.456			
4.64	22.3	0.189	4.84	44.89	0.318	4.64	85.7	0.461			
4.69	22.4	0.190	4.89	44.84	0.320	4.69	85.5	0.459			
4.74	22.4	0.189	4.94	45.01	0.320	4.74	85.4	0.461			
4.79	22.3	0.190	5.00	44.72	0.321	4.79	85.7	0.464			
4.84	22.2	0.191	5.05	45.26	0.319	4.84	85.6	0.462			
4.89	22.4	0.192	5.10	45.08	0.320	4.89	85.7	0.469			
4.94	22.2	0.191	5.15	45.00	0.321	4.94	85.6	0.466			
5.00	22.5	0.191	5.20	45.00	0.322	5.00	85.9	0.464			
5.05	22.1	0.191	5.25	44.54	0.323	5.05	85.8	0.471			
5.10	22.4	0.192	5.30	44.90	0.323	5.10	85.9	0.464			
5.15	22.0	0.191	5.35	44.81	0.321	5.15	86.2	0.478			
5.20	22.4	0.193	5.40	45.15	0.323	5.20	85.7	0.477			
5.25	22.6	0.193	5.45	44.81	0.323	5.25	85.9	0.473			
5.30	22.4	0.195	5.50	44.96	0.323	5.30	85.5	0.474			
5.35	22.5	0.195	5.55	44.96	0.325	5.35	85.8	0.480			
5.40	22.6	0.195	5.61	45.06	0.325	5.40	86.4	0.469			
5.45	22.7	0.195	5.66	44.84	0.323	5.45	86.1	0.481			
5.50	22.6	0.195	5.71	44.99	0.325	5.50	86.3	0.469			
5.55	22.8	0.198	5.76	44.76	0.326	5.55	86.4	0.469			
5.61	22.8	0.197	5.81	44.81	0.326	5.61	86.2	0.482			
5.66	22.7	0.199	5.86	45.13	0.327	5.66	86.5	0.482			
5.71	22.9	0.197	5.91	44.71	0.329	5.71	86.5	0.477			
5.76	22.8	0.201	5.96	44.87	0.327	5.76	86.6	0.477			
5.81	22.7	0.199	6.01	44.75	0.330	5.81	86.8	0.479			
5.86	23.1	0.204	6.06	45.02	0.329	5.86	86.5	0.481			
5.91	22.9	0.204	6.11	45.05	0.333	5.91	87.0	0.479			
5.96	22.9	0.204	6.16	45.22	0.332	5.96	86.9	0.480			
6.01	22.9	0.204	6.22	45.16	0.336	6.01	86.9	0.476			
6.06	22.9	0.204	6.27	44.88	0.334	6.06	86.9	0.477			
6.11	22.9	0.205	6.32	45.21	0.334	6.11	86.7	0.481			
6.16	23.1	0.204	6.37	45.15	0.335	6.16	86.8	0.477			
6.22	23.3	0.205	6.42	45.07	0.339	6.22	86.4	0.482			
6.27	23.2	0.205	6.47	44.89	0.338	6.27	86.7	0.487			
6.32	23.2	0.206	6.52	44.68	0.339	6.32	86.8	0.492			
6.37	23.0	0.205	6.57	44.64	0.340	6.37	86.9	0.491			
6.42	23.4	0.207	6.62	44.67	0.340	6.42	86.8	0.493			
6.47	23.1	0.206	6.67	44.94	0.343	6.47	87.1	0.494			
6.52	23.3	0.207	6.72	44.75	0.342	6.52	87.3	0.496			
6.57	23.1	0.207	6.77	44.85	0.345	6.57	87.6	0.498			
6.62	23.5	0.208	6.83	45.21	0.345	6.62	87.5	0.503			
6.67	23.1	0.207	6.88	45.19	0.346	6.67	87.7	0.504			
6.72	23.2	0.209	6.93	45.09	0.346	6.72	87.5	0.507			
6.77	23.1	0.208	6.98	44.91	0.347	6.77	87.7	0.507			
6.83	23.4	0.208	7.03	45.04	0.347	6.83	87.7	0.510			
6.88	23.4	0.209	7.08	44.84	0.352	6.88	87.2	0.509			
6.93	23.2	0.208	7.13	45.22	0.352	6.93	87.7	0.511			
6.98	23.3	0.208	7.18	44.95	0.355	6.98	87.2	0.512			
7.03	23.2	0.211	7.23	44.73	0.354	7.03	87.4	0.511			
7.08	23.3	0.210	7.28	44.82	0.357	7.08	87.2	0.513			
7.13	23.5	0.211	7.33	44.92	0.355	7.13	87.7	0.511			
7.18	23.5	0.212	7.39	44.95	0.358	7.18	87.6	0.508			
7.23	23.5	0.211	7.44	45.09	0.358	7.23	87.6	0.516			

7.28	23.5	0.211	7.49	44.89	0.360	7.28	88.3	0.517			
7.33	23.5	0.212	7.54	44.92	0.362	7.33	88.1	0.518			
7.39	23.5	0.212	7.59	44.85	0.361	7.39	87.9	0.519			
7.44	23.4	0.211	7.62	44.68	0.362	7.44	87.8	0.520			
7.49	23.5	0.212				7.49	88.2	0.521			
7.54	23.5	0.211				7.54	87.8	0.520			
7.59	23.3	0.212				7.59	88.3	0.523			
7.62	23.4	0.211				7.62	88.2	0.522			

TM/LL	December 28, 2009	ROB	January 26, 2010

Golder Associates Ltd. - Burnaby Laboratory
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Drained Conditions

Reference: ASTM D 3080-04

Client:	PWGSC	**Sample No.:**	GBH09-23
Project:	Waterlot BH SSI	**Sample Location:**	4
Location:	Esquimalt Graving Dock	**Depth (m):**	3.05-3.66
Project No.:	09-1475-5008/ 3000	**Lab ID No:**	227

Test Condition:	SATURATED	**Equipment Description:**		GEOTAC DIGISHEAR# 2
Visual Description:		**Normal Load Cell:**	Serial No.:	270986
	Undisturbed sample	**Shear Load Cell:**	Serial No.:	266562
	Peak only	**Vertical LPT:**	Serial No.:	LP-567

Remarks: Area correction not applied to normal and shear stress calculation
Water added to the shear box

Initial Sample Dimensions

Test No.	1	2	3			
Shear box geometry	round	round	round			
Diameter (mm)	63.53	63.53	63.53			
Height (mm)	25.48	25.48	25.48			
Area (cm^2)	31.69	31.69	31.69			
Volume (cm^3)	80.75	80.75	80.75			

Weight Volume Relationships

Sample Type	PEAK	PEAK	PEAK			
Dry Mass (g)	126.1	135.1	129.1			
Initial γ_{wet} (kN/m^3)	19.29	20.07	19.46			
Final γ_{wet} (kN/m^3)	19.72	20.61	20.10			
Initial γ_{dry} (kN/m^3)	15.32	16.42	15.69			
Final γ_{dry} (kN/m^3)	15.45	16.69	16.12			
Initial water content (%)	26.0	22.3	24.1			
Final water content (%)	27.6	23.5	24.7			

Consolidation Results

Normal Stress (kPa)	30	60	120			
t_{90} (Taylor Method) (min)	0.5	0.2	0.2			
Calculated t_{50} (min)	0.13	0.03	0.03			
Change in height ΔH_c (mm)	0.22	0.42	0.68			

Comments:

TM/LL	January 4, 2010	ROB	January 26, 2010
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Laboratory
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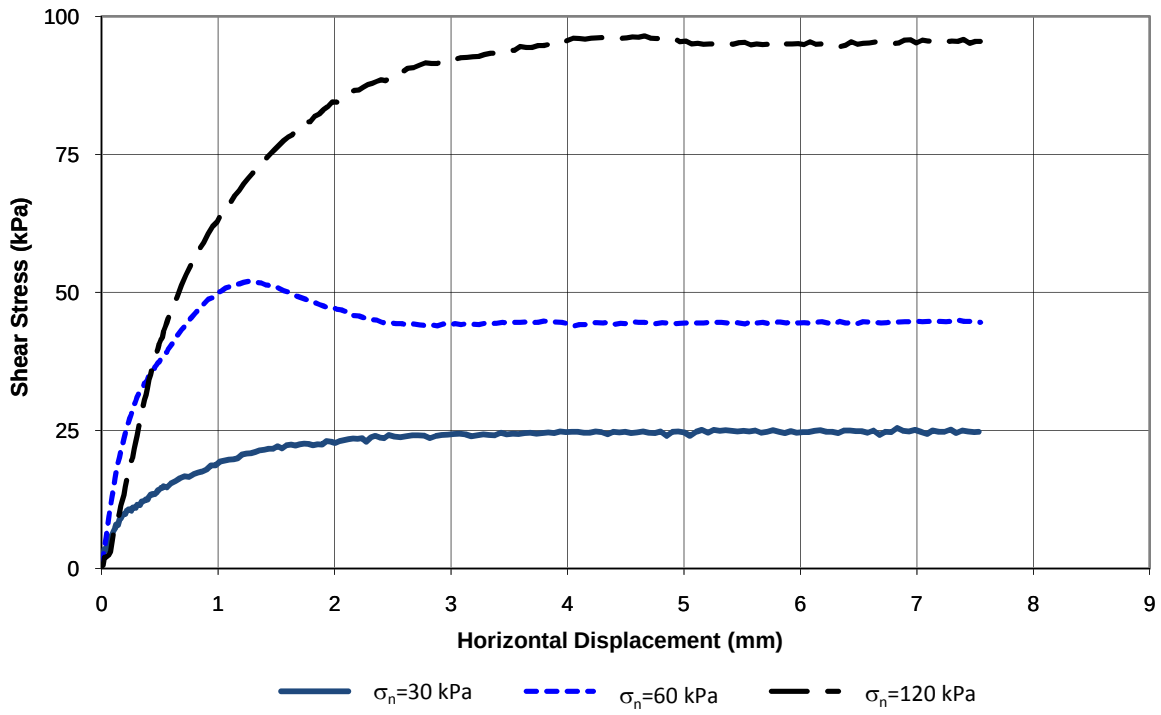
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Drained Conditions

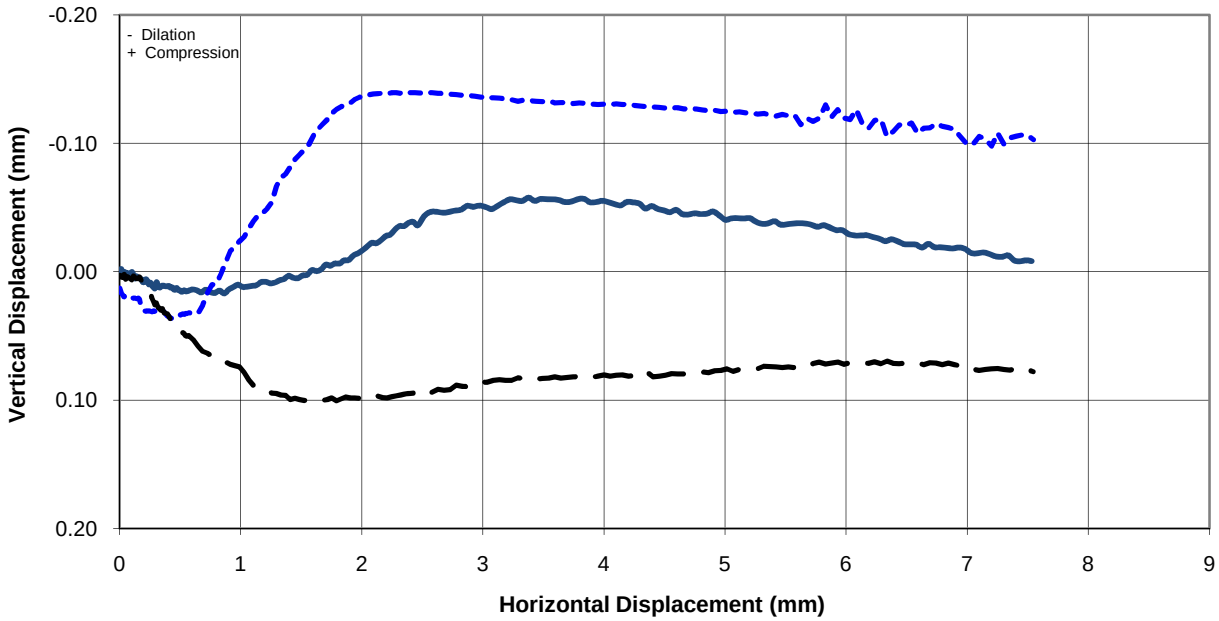
Reference
ASTM D 3080-04

Client:	PWGSC	**Sample No.:**	GBH09-23
Project:	Waterlot BH SSI	**Sample Location:**	4
Location:	Esquimalt Graving Dock	**Depth (m):**	3.05-3.66
Project No.:	09-1475-5008/ 3000	**Lab ID No:**	227

Shear Stress



Displacement



TM/LL	January 4, 2010	ROB	January 26, 2010
TESTED BY	DATE	CHECKED BY	DATE

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Direct Shear Testing of Soils Under Consolidated Drained Conditions

Reference
ASTM D 3080-04

Client:	PWGSC	**Sample No.:**	GBH09-23
Project:	Waterlot BH SSI	**Sample Location:**	4
Location:	Esquimalt Graving Dock	**Depth (m):**	3.05-3.66
Project No.:	09-1475-5008/ 3000	**Lab ID No:**	227

Test 1 (After Shear)

Test 2 (After Shear)

Test 3 (After Shear)

Remarks:

Atterberg Limit Results

Liquid Limit = ---

Plastic Limit = ---

Plastic Index = Non Plastic Soil

$w_{natural}$ (%) = 22.3 to 26.0

Classification = ---

Loose, wet, very dark grey sandy SILT, trace clay, trace seashells.

TM/LL	January 4, 2010	ROB	January 26, 2010
TESTED BY	DATE	CHECKED BY	DATE

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Direct Shear Testing of Soils Under Consolidated Drained Conditions

Reference: ASTM D 3080-04

Client:	PWGSC	**Sample No.:**	GBH09-23
Project:	Waterlot BH SSI	**Sample Location:**	4
Location:	Esquimalt Graving Dock	**Depth (m):**	3.05-3.66
Project No.:	09-1475-5008/ 3000	**Lab ID No:**	227

Test 1	
Normal Stress , kPa	30
Disp Rate, mm/min	0.0004

Test 2	
Normal Stress , kPa	60
Disp Rate, mm/min	0.0004

Test 3	
Normal Stress , kPa	120
Disp Rate, mm/min	0.0004

Normal Stress , kPa	
Disp Rate, mm/min	

Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm
0.00	2.3	0.000	0.00	0.86	0.013	0.00	0.3	0.003			
0.01	2.5	-0.002	0.01	2.16	0.017	0.01	0.6	0.004			
0.03	3.5	0.001	0.03	3.52	0.018	0.03	2.0	0.004			
0.04	3.3	0.000	0.04	5.58	0.020	0.04	2.0	0.002			
0.05	4.0	0.001	0.05	7.73	0.019	0.05	2.2	0.006			
0.06	4.9	0.001	0.06	9.42	0.020	0.06	2.5	0.004			
0.08	5.8	0.002	0.08	11.29	0.020	0.08	3.0	0.004			
0.09	6.1	0.002	0.09	13.07	0.020	0.09	4.9	0.006			
0.10	6.7	0.000	0.10	14.53	0.021	0.10	6.3	0.006			
0.11	7.2	0.002	0.11	16.31	0.021	0.11	7.0	0.003			
0.13	8.0	0.005	0.13	17.58	0.021	0.13	8.3	0.005			
0.14	7.8	0.003	0.14	19.12	0.021	0.14	8.8	0.005			
0.15	8.8	0.005	0.15	20.12	0.021	0.15	10.1	0.005			
0.17	9.0	0.005	0.17	21.35	0.022	0.17	11.4	0.004			
0.18	9.6	0.006	0.18	22.27	0.026	0.18	12.4	0.006			
0.19	9.9	0.008	0.19	23.52	0.029	0.19	13.3	0.009			
0.20	9.8	0.008	0.20	24.47	0.031	0.20	14.8	0.011			
0.22	10.5	0.006	0.22	25.45	0.031	0.22	16.2	0.011			
0.23	10.7	0.007	0.23	26.34	0.031	0.23	17.2	0.013			
0.24	10.7	0.010	0.24	27.16	0.031	0.24	18.3	0.015			
0.25	10.4	0.008	0.25	27.91	0.031	0.25	19.5	0.016			
0.27	11.0	0.011	0.27	28.76	0.031	0.27	20.0	0.020			
0.28	11.1	0.012	0.28	29.64	0.031	0.28	21.7	0.023			
0.29	10.9	0.013	0.29	30.36	0.031	0.29	23.0	0.026			
0.30	11.5	0.008	0.30	31.03	0.031	0.30	24.1	0.024			
0.32	11.5	0.011	0.32	31.69	0.031	0.32	25.6	0.028			
0.33	11.5	0.012	0.33	32.03	0.031	0.33	27.0	0.029			
0.34	12.1	0.011	0.34	32.52	0.030	0.34	28.1	0.030			
0.36	12.2	0.011	0.36	32.82	0.030	0.36	29.4	0.029			
0.37	12.3	0.011	0.37	33.55	0.031	0.37	30.5	0.032			
0.38	12.5	0.011	0.38	33.73	0.033	0.38	31.4	0.032			
0.39	12.4	0.011	0.39	34.25	0.035	0.39	32.6	0.033			
0.41	13.0	0.011	0.41	34.87	0.035	0.41	34.1	0.035			
0.42	13.4	0.012	0.42	35.05	0.036	0.42	35.0	0.037			
0.43	13.3	0.012	0.43	35.50	0.036	0.43	36.0	0.038			

0.44	13.5	0.013	0.44	35.95	0.037	0.44	37.0	0.041			
0.46	13.4	0.014	0.46	36.50	0.036	0.46	37.8	0.041			
0.47	13.7	0.012	0.47	36.81	0.036	0.47	38.9	0.043			
0.48	14.1	0.014	0.48	37.20	0.035	0.48	39.7	0.045			
0.50	14.3	0.014	0.50	37.52	0.034	0.50	40.7	0.047			
0.51	14.5	0.015	0.51	37.95	0.033	0.51	41.4	0.048			
0.52	14.6	0.015	0.52	38.31	0.033	0.52	41.8	0.048			
0.53	14.9	0.014	0.53	38.60	0.033	0.53	43.0	0.048			
0.55	14.7	0.015	0.55	38.88	0.033	0.55	43.7	0.050			
0.56	14.7	0.015	0.56	39.19	0.033	0.56	44.6	0.050			
0.60	15.4	0.014	0.57	39.71	0.032	0.57	45.2	0.050			
0.64	15.8	0.014	0.61	40.80	0.033	0.61	47.6	0.053			
0.67	16.3	0.016	0.65	42.15	0.033	0.65	49.2	0.058			
0.71	16.7	0.014	0.69	43.22	0.026	0.69	51.3	0.062			
0.75	16.5	0.016	0.72	44.11	0.017	0.72	53.2	0.063			
0.79	17.1	0.016	0.76	45.26	0.010	0.76	54.8	0.066			
0.83	17.3	0.015	0.80	46.17	0.009	0.80	56.5	0.066			
0.86	17.5	0.017	0.84	47.06	0.002	0.84	57.8	0.067			
0.90	17.9	0.014	0.88	47.89	-0.008	0.88	59.0	0.071			
0.94	18.7	0.012	0.91	48.77	-0.016	0.91	60.6	0.072			
0.98	18.6	0.010	0.95	49.04	-0.020	0.95	62.0	0.073			
1.02	19.3	0.012	0.99	49.91	-0.024	0.99	62.7	0.074			
1.05	19.5	0.012	1.03	50.28	-0.027	1.03	64.4	0.078			
1.09	19.7	0.011	1.07	50.82	-0.034	1.07	65.7	0.084			
1.13	19.8	0.010	1.11	51.07	-0.039	1.11	66.2	0.089			
1.17	19.9	0.008	1.14	51.39	-0.044	1.14	67.5	0.089			
1.21	20.6	0.008	1.18	51.54	-0.046	1.18	68.5	0.089			
1.24	20.8	0.009	1.22	51.83	-0.049	1.22	69.7	0.092			
1.28	20.9	0.008	1.26	51.98	-0.054	1.26	70.6	0.095			
1.32	21.1	0.007	1.30	51.80	-0.066	1.30	71.6	0.095			
1.36	21.4	0.006	1.33	51.79	-0.073	1.33	72.6	0.096			
1.40	21.5	0.003	1.37	51.69	-0.076	1.37	73.5	0.096			
1.44	21.7	0.005	1.41	51.36	-0.082	1.41	74.2	0.099			
1.47	21.7	0.005	1.45	51.26	-0.087	1.45	75.1	0.099			
1.51	22.1	0.003	1.49	51.15	-0.091	1.49	75.9	0.100			
1.55	21.7	0.002	1.52	50.69	-0.095	1.52	76.7	0.100			
1.59	22.3	-0.001	1.56	50.34	-0.099	1.56	77.5	0.099			
1.63	22.4	-0.001	1.60	50.09	-0.106	1.60	78.1	0.100			
1.66	22.2	-0.002	1.64	49.72	-0.111	1.64	78.5	0.100			
1.70	22.5	-0.006	1.68	49.35	-0.115	1.68	79.5	0.100			
1.74	22.6	-0.005	1.71	49.02	-0.119	1.71	80.2	0.100			
1.78	22.6	-0.007	1.75	48.77	-0.123	1.75	80.8	0.098			
1.82	22.3	-0.006	1.79	48.35	-0.127	1.79	80.9	0.101			
1.85	22.5	-0.009	1.83	48.15	-0.128	1.83	81.9	0.099			
1.89	22.4	-0.009	1.87	47.81	-0.130	1.87	82.3	0.098			
1.93	23.1	-0.013	1.91	47.50	-0.132	1.91	83.0	0.098			
1.97	22.9	-0.014	1.94	47.26	-0.134	1.94	83.6	0.098			
2.01	22.7	-0.017	1.98	47.31	-0.136	1.98	84.5	0.099			
2.04	23.1	-0.020	2.02	46.97	-0.137	2.02	84.5	0.097			
2.08	23.2	-0.023	2.06	46.85	-0.138	2.06	85.1	0.099			
2.12	23.4	-0.022	2.10	46.53	-0.138	2.10	85.7	0.097			
2.16	23.5	-0.025	2.13	45.87	-0.139	2.13	86.3	0.097			
2.20	23.5	-0.028	2.17	45.78	-0.139	2.17	86.6	0.098			

2.24	23.6	-0.029	2.21	45.73	-0.138	2.21	86.7	0.098			
2.27	22.9	-0.033	2.25	45.42	-0.139	2.25	87.2	0.097			
2.31	23.7	-0.036	2.29	45.20	-0.140	2.29	87.7	0.097			
2.35	24.0	-0.036	2.32	45.05	-0.139	2.32	87.9	0.096			
2.39	23.7	-0.038	2.36	44.97	-0.140	2.36	88.2	0.095			
2.43	23.6	-0.039	2.40	44.62	-0.139	2.40	88.5	0.095			
2.46	24.2	-0.036	2.44	44.38	-0.140	2.44	88.3	0.094			
2.51	23.8	-0.043	2.48	44.50	-0.139	2.48	89.1	0.094			
2.57	23.8	-0.047	2.53	44.36	-0.140	2.53	89.7	0.092			
2.62	24.0	-0.047	2.58	44.34	-0.140	2.58	89.8	0.094			
2.67	24.1	-0.046	2.63	43.98	-0.139	2.63	90.6	0.092			
2.72	24.1	-0.047	2.68	44.25	-0.139	2.68	90.7	0.092			
2.77	24.1	-0.048	2.73	44.11	-0.138	2.73	91.2	0.092			
2.82	23.6	-0.048	2.78	43.97	-0.138	2.78	91.6	0.088			
2.87	24.0	-0.051	2.83	44.09	-0.138	2.83	91.5	0.090			
2.92	24.2	-0.051	2.88	43.90	-0.137	2.88	91.5	0.090			
2.97	24.2	-0.052	2.93	44.25	-0.137	2.93	92.0	0.087			
3.02	24.4	-0.051	2.98	44.10	-0.136	2.98	92.1	0.086			
3.07	24.4	-0.049	3.04	44.33	-0.136	3.04	92.2	0.086			
3.12	24.3	-0.052	3.09	44.15	-0.136	3.09	92.5	0.085			
3.17	23.9	-0.054	3.14	44.34	-0.135	3.14	92.5	0.084			
3.23	24.1	-0.057	3.19	44.22	-0.134	3.19	92.7	0.085			
3.28	24.3	-0.056	3.24	44.19	-0.134	3.24	92.8	0.085			
3.33	24.2	-0.055	3.29	44.38	-0.133	3.29	93.1	0.083			
3.38	24.1	-0.058	3.34	44.36	-0.134	3.34	93.3	0.083			
3.43	24.6	-0.055	3.39	44.42	-0.133	3.39	93.3	0.082			
3.48	24.3	-0.057	3.44	44.55	-0.133	3.44	93.6	0.084			
3.53	24.4	-0.057	3.49	44.47	-0.132	3.49	93.9	0.083			
3.58	24.4	-0.057	3.54	44.55	-0.133	3.54	93.9	0.083			
3.63	24.5	-0.056	3.59	44.56	-0.131	3.59	94.6	0.082			
3.68	24.6	-0.054	3.65	44.62	-0.132	3.64	94.4	0.083			
3.73	24.4	-0.055	3.70	44.50	-0.132	3.70	94.4	0.082			
3.78	24.5	-0.057	3.75	44.55	-0.131	3.75	94.7	0.082			
3.84	24.6	-0.057	3.80	44.78	-0.132	3.80	94.7	0.082			
3.89	24.5	-0.054	3.85	44.61	-0.131	3.85	95.0	0.081			
3.94	24.8	-0.054	3.90	44.62	-0.131	3.90	95.2	0.082			
3.99	24.7	-0.055	3.95	44.55	-0.130	3.95	95.1	0.081			
4.04	24.8	-0.054	4.00	44.36	-0.131	4.00	95.6	0.080			
4.09	24.8	-0.053	4.05	43.90	-0.130	4.05	96.1	0.082			
4.14	24.6	-0.052	4.10	44.14	-0.131	4.10	96.0	0.081			
4.19	24.6	-0.054	4.15	44.18	-0.130	4.15	95.9	0.080			
4.24	24.8	-0.054	4.20	44.50	-0.130	4.20	96.1	0.081			
4.29	24.7	-0.053	4.25	44.52	-0.130	4.25	96.1	0.081			
4.34	24.3	-0.049	4.31	44.48	-0.129	4.31	96.1	0.082			
4.39	24.7	-0.051	4.36	44.54	-0.129	4.36	96.0	0.078			
4.44	24.6	-0.049	4.41	44.22	-0.128	4.41	96.1	0.082			
4.50	24.7	-0.048	4.46	44.38	-0.128	4.46	96.0	0.082			
4.55	24.5	-0.046	4.51	44.35	-0.128	4.51	96.1	0.081			
4.60	24.6	-0.048	4.56	44.62	-0.127	4.56	96.3	0.079			
4.65	24.8	-0.045	4.61	44.56	-0.128	4.61	96.2	0.080			
4.70	24.6	-0.045	4.66	44.59	-0.127	4.66	96.4	0.080			
4.75	24.5	-0.046	4.71	44.41	-0.127	4.71	96.1	0.078			
4.80	24.8	-0.045	4.76	44.37	-0.127	4.76	96.0	0.079			

4.85	24.0	-0.045	4.81	44.49	-0.126	4.81	96.0	0.078			
4.90	24.7	-0.047	4.86	44.44	-0.125	4.86	96.0	0.079			
4.95	24.8	-0.044	4.91	44.36	-0.126	4.91	96.0	0.077			
5.00	24.6	-0.041	4.97	44.40	-0.125	4.97	95.4	0.077			
5.05	24.0	-0.042	5.02	44.47	-0.125	5.02	95.5	0.076			
5.10	24.8	-0.042	5.07	44.48	-0.124	5.07	95.0	0.078			
5.16	25.1	-0.041	5.12	44.47	-0.125	5.12	95.1	0.076			
5.21	24.5	-0.042	5.17	44.48	-0.124	5.17	95.0	0.076			
5.26	25.1	-0.039	5.22	44.57	-0.124	5.22	95.0	0.075			
5.31	24.9	-0.037	5.27	44.57	-0.123	5.27	95.0	0.076			
5.36	25.0	-0.038	5.32	44.58	-0.123	5.32	95.0	0.074			
5.41	24.9	-0.039	5.37	44.45	-0.122	5.37	95.3	0.074			
5.46	24.8	-0.037	5.42	44.56	-0.121	5.42	95.0	0.074			
5.51	24.9	-0.037	5.47	44.43	-0.123	5.47	95.2	0.075			
5.56	24.8	-0.038	5.52	44.27	-0.121	5.52	95.3	0.074			
5.61	25.0	-0.038	5.58	44.66	-0.122	5.57	94.8	0.075			
5.66	24.6	-0.038	5.63	44.46	-0.115	5.63	95.0	0.072			
5.71	24.8	-0.037	5.68	44.58	-0.120	5.68	94.9	0.073			
5.77	25.1	-0.035	5.73	44.32	-0.117	5.73	95.0	0.072			
5.82	24.8	-0.036	5.78	44.54	-0.120	5.78	94.7	0.070			
5.87	24.5	-0.034	5.83	44.62	-0.130	5.83	94.4	0.072			
5.92	24.9	-0.032	5.88	44.43	-0.121	5.88	95.0	0.071			
5.97	24.5	-0.032	5.93	44.65	-0.126	5.93	95.0	0.071			
6.02	24.7	-0.029	5.98	44.47	-0.120	5.98	95.1	0.072			
6.07	24.7	-0.028	6.03	44.50	-0.119	6.03	94.9	0.071			
6.12	24.9	-0.028	6.08	44.42	-0.126	6.08	95.4	0.070			
6.17	25.0	-0.029	6.13	44.57	-0.115	6.13	95.0	0.071			
6.22	24.7	-0.027	6.18	44.67	-0.112	6.18	95.0	0.071			
6.27	24.8	-0.026	6.24	44.46	-0.118	6.23	94.9	0.070			
6.32	24.5	-0.024	6.29	44.31	-0.119	6.29	94.7	0.072			
6.37	25.0	-0.025	6.34	44.74	-0.105	6.34	94.5	0.070			
6.43	25.0	-0.024	6.39	44.45	-0.109	6.39	94.8	0.072			
6.48	24.9	-0.022	6.44	44.51	-0.114	6.44	95.4	0.072			
6.53	24.8	-0.021	6.49	44.33	-0.114	6.49	95.0	0.071			
6.58	24.6	-0.021	6.54	44.69	-0.116	6.54	95.1	0.070			
6.63	25.0	-0.019	6.59	44.62	-0.108	6.59	95.2	0.071			
6.68	24.2	-0.022	6.64	44.58	-0.112	6.64	95.4	0.072			
6.73	24.8	-0.019	6.69	44.43	-0.112	6.69	95.2	0.071			
6.78	24.7	-0.019	6.74	44.52	-0.115	6.74	95.1	0.071			
6.83	25.4	-0.019	6.79	44.67	-0.113	6.79	95.0	0.072			
6.88	24.9	-0.018	6.84	44.64	-0.112	6.84	95.2	0.071			
6.93	24.8	-0.019	6.90	44.71	-0.111	6.90	95.7	0.072			
6.98	25.1	-0.018	6.95	44.66	-0.105	6.95	95.7	0.073			
7.03	24.7	-0.015	7.00	44.72	-0.099	7.00	95.2	0.073			
7.09	24.3	-0.014	7.05	44.71	-0.099	7.05	95.7	0.076			
7.14	25.0	-0.015	7.10	44.74	-0.105	7.10	95.6	0.077			
7.19	24.7	-0.014	7.15	44.70	-0.104	7.15	95.6	0.076			
7.24	24.8	-0.012	7.20	44.73	-0.098	7.20	95.4	0.076			
7.29	25.1	-0.012	7.25	44.66	-0.108	7.25	95.4	0.075			
7.34	24.5	-0.013	7.30	44.75	-0.100	7.30	95.5	0.076			
7.39	25.0	-0.009	7.35	44.99	-0.104	7.35	95.4	0.077			
7.44	24.8	-0.008	7.40	44.73	-0.106	7.40	95.8	0.076			
7.49	24.7	-0.009	7.45	44.73	-0.107	7.45	95.1	0.077			

7.53	24.8	-0.008	7.51	44.68	-0.106	7.50	95.5	0.076			
			7.55	44.58	-0.103	7.54	95.5	0.078			

TM/LL	January 4, 2010	ROB	January 26, 2010

APPENDIX D

Cone Penetration Test (CPT) Sounding Profiles

Cone Penetration Tests (CPTU)

The cone penetration tests (CPTU) with pore pressure measurement were carried out by ConeTec using an integrated electronic cone system.

All soundings were performed using compression type cone penetrometers (refer to Figure CPTU). ConeTec has cones of various cross sectional areas and capacities. ConeTec's 5 ton cones have a tip area of 10 cm^2, a friction sleeve area of 150 cm^2 and tip capacity of 500 bar. ConeTec's 10 ton cones have a tip area of 10 cm^2, a friction sleeve area of 150 cm^2 and tip capacity of 1000 bar. ConeTec's 20 Ton cones have a tip area of 15 cm^2, a friction sleeve area of 225 cm^2 and a tip capacity of 1500 bar. ConeTec's Medium Capacity cones (MC375) have a tip area of 15 cm^2, a friction sleeve area of 225 cm^2 and a tip capacity of 375 bar. The compression cones are designed with an equal end area friction sleeve and a tip end area ratio of 0.80. A porewater pressure filter is located directly behind the cone tip. The filter is made of porous plastic and is 5.0 mm thick. Each porewater pressure filters is saturated under vacuum pressure prior to penetration. Porewater pressure dissipation data is recorded at 5-second intervals during pauses in penetration as directed by the field representative.

The cone system is capable of recording the following parameters at varying depth intervals:

Tip Resistance (q_c)
Sleeve Friction (f_s)
Dynamic Pore Pressure (u)
Temperature (T)
Cone Inclination (I)

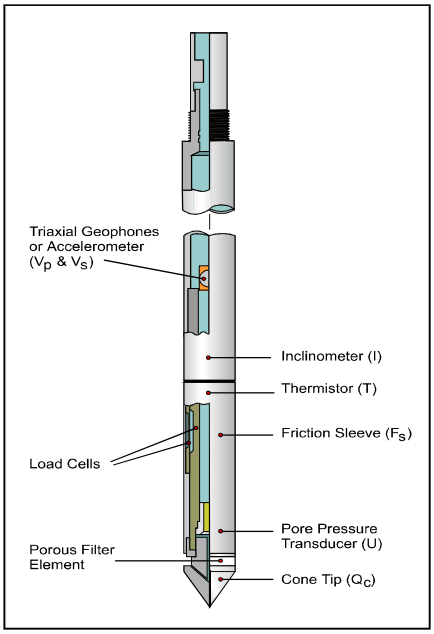


Figure – CPTU

A summary of the cone penetration tests carried out is presented in Table CPTU (Appendix CPTU).

Selected parameters were printed simultaneously on a printer and stored on a floppy disk for future analysis and reference. All cone penetration testing was carried out in accordance with ASTM D-5778-95.

A complete set of baseline readings was taken prior to and at the completion of each sounding to determine temperature shifts and any zero load offsets. Corrections for temperature shifts and zero load offsets can be extremely important, especially when the recorded loads are relatively small. In sandy soils, however, these corrections are generally negligible. Graphical plots of all CPT data are presented in Appendix CPTU.

The inferred stratigraphic profile at each CPT test location is included with this report. The stratigraphic interpretations are based on relationships between cone bearing, q_t, sleeve friction, f_s, and dynamic pore pressure, u. The friction ratio, R_f (100 x f_s/q_t), is a calculated parameter which is used to identify the type of soil and hence gives an indication of its behavior. Generally, soft cohesive soils have high friction ratios, low cone bearing pressures and generate large porewater pressures during penetration. Cohesionless soils have lower friction ratios, high cone bearing pressures and generate little in the way of excess porewater pressure during penetration. The classification of soils is based on correlations summarized by Robertson (1990), as shown in Figure SBT. It is not always possible to clearly identify a soil type based on q_t and f_s alone. Experience, judgment and analyses of porewater pressure generation during penetration and subsequent dissipation tests should be used in arriving at the soil type in these ambiguous situations.

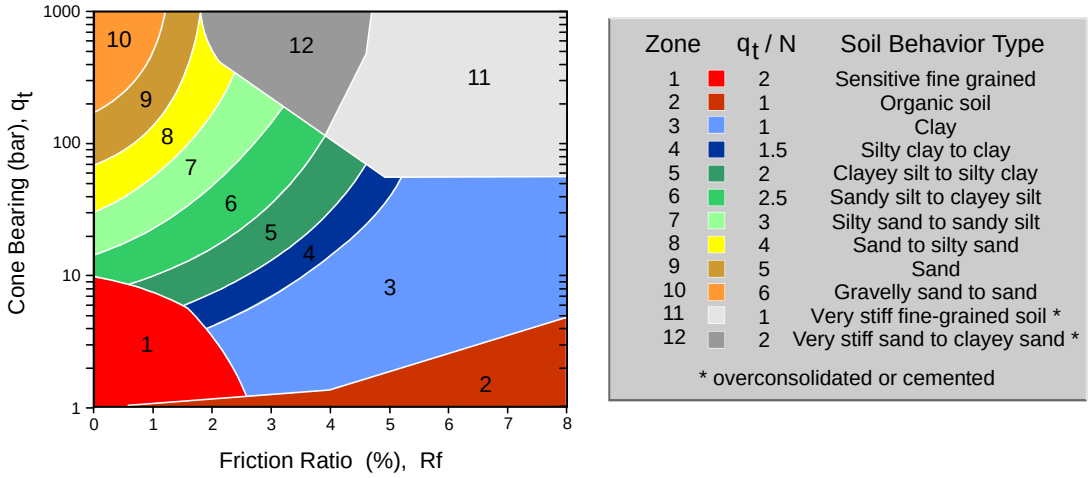
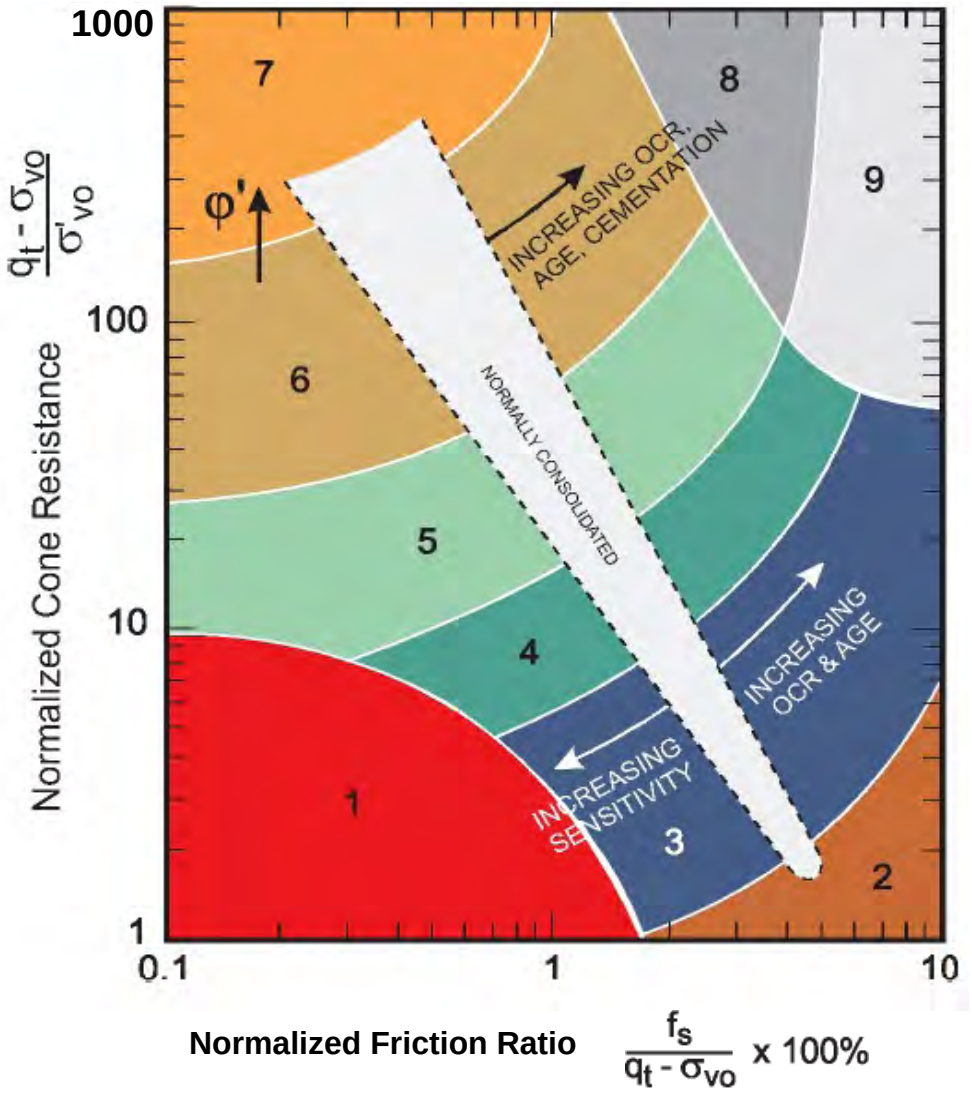


Figure SBT – Non-Normalized Soil Behavior Type Chart, Robertson (1990)

It should be noted that stratigraphic interpretation using CPTU data can also be carried out using a normalized (stress corrected) soil behavior type chart (Robertson, 1990). The Robertson publication emphasizes when normalized stratigraphic interpretation is appropriate.

CPT Soil Behaviour Type Classification

CPT Classification Chart – Normalized



Zone	Soil Behavior Type
1	Sensitive fine-grained
2	Organic soils
3	Clays (silty clay to clay)
4	Silt Mixtures (clayey silt to silty clay)
5	Sand Mixtures (silty sand to sandy silt)
6	Sands (clean sand to silty sand)
7	Gravelly sand to dense sand
8	Very stiff cemented sand to clayey sand
9	Very stiff, over-consolidated fine-grained soil

q_t = cone tip resistance

f_s = sleeve friction

σ_{vo} = total overburden pressure

σ'_{vo} = effective overburden pressure
$= \sigma_{vo} - u_o$

u_o = equilibrium pore water pressure

Robertson, P.K. (1990). "Soil Classification Using the Cone Penetration Test". Canadian Geotechnical Journal, Vol. 27, No. 1, pp. 151 – 158.

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CONETEC

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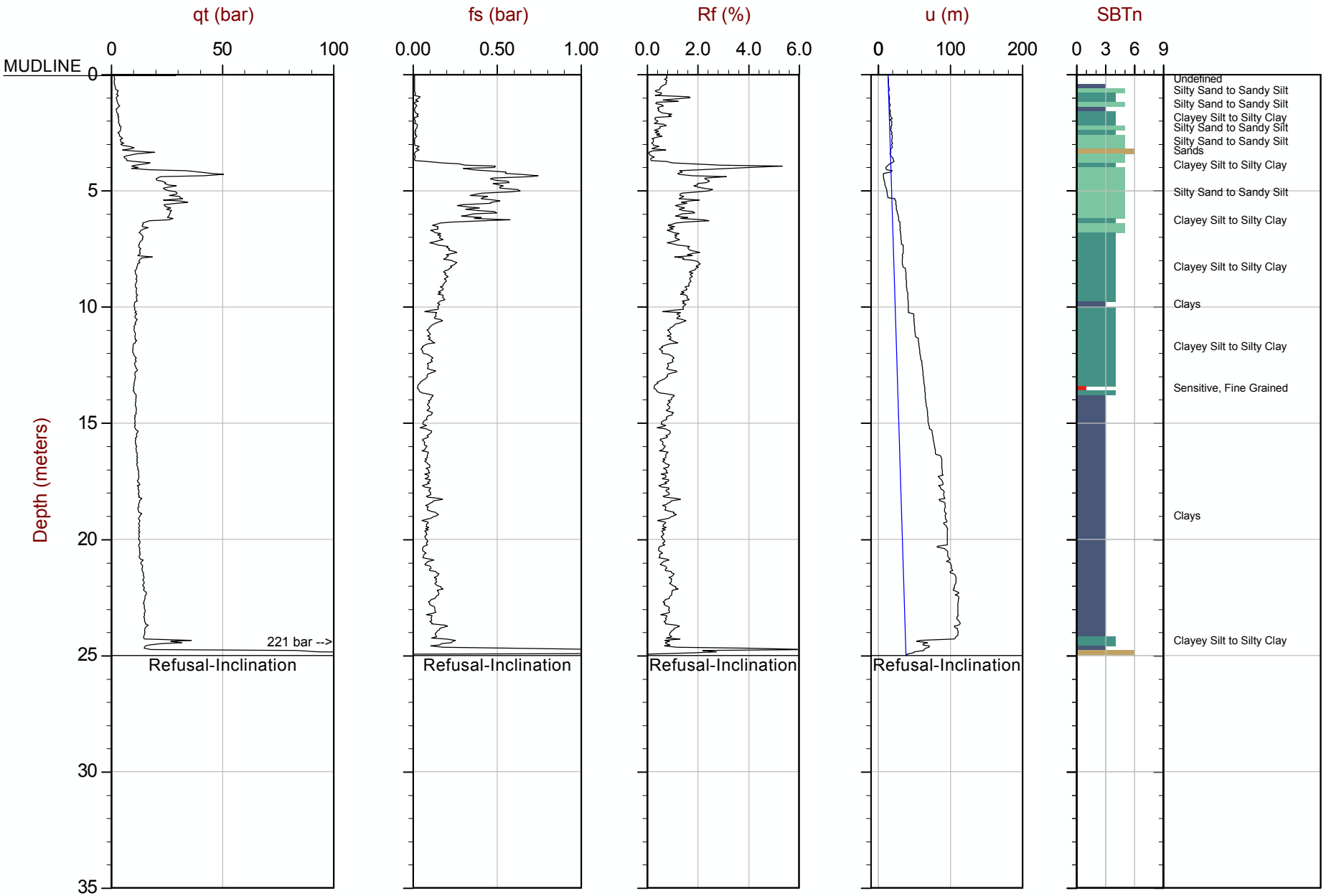

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Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364831m E: 468292m

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Sounding: GCPT09-02B
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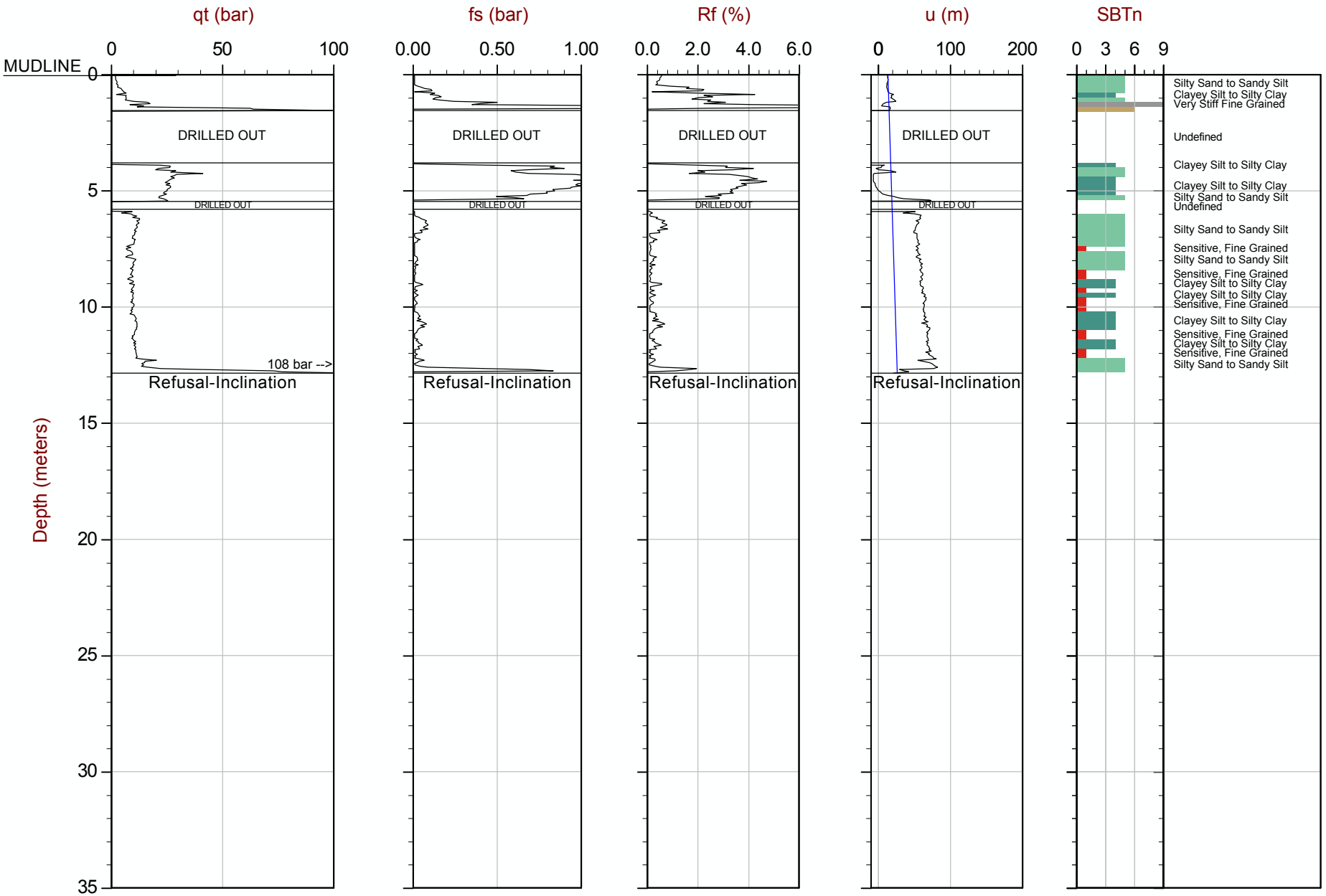

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Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364844m E: 468327m

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Golder

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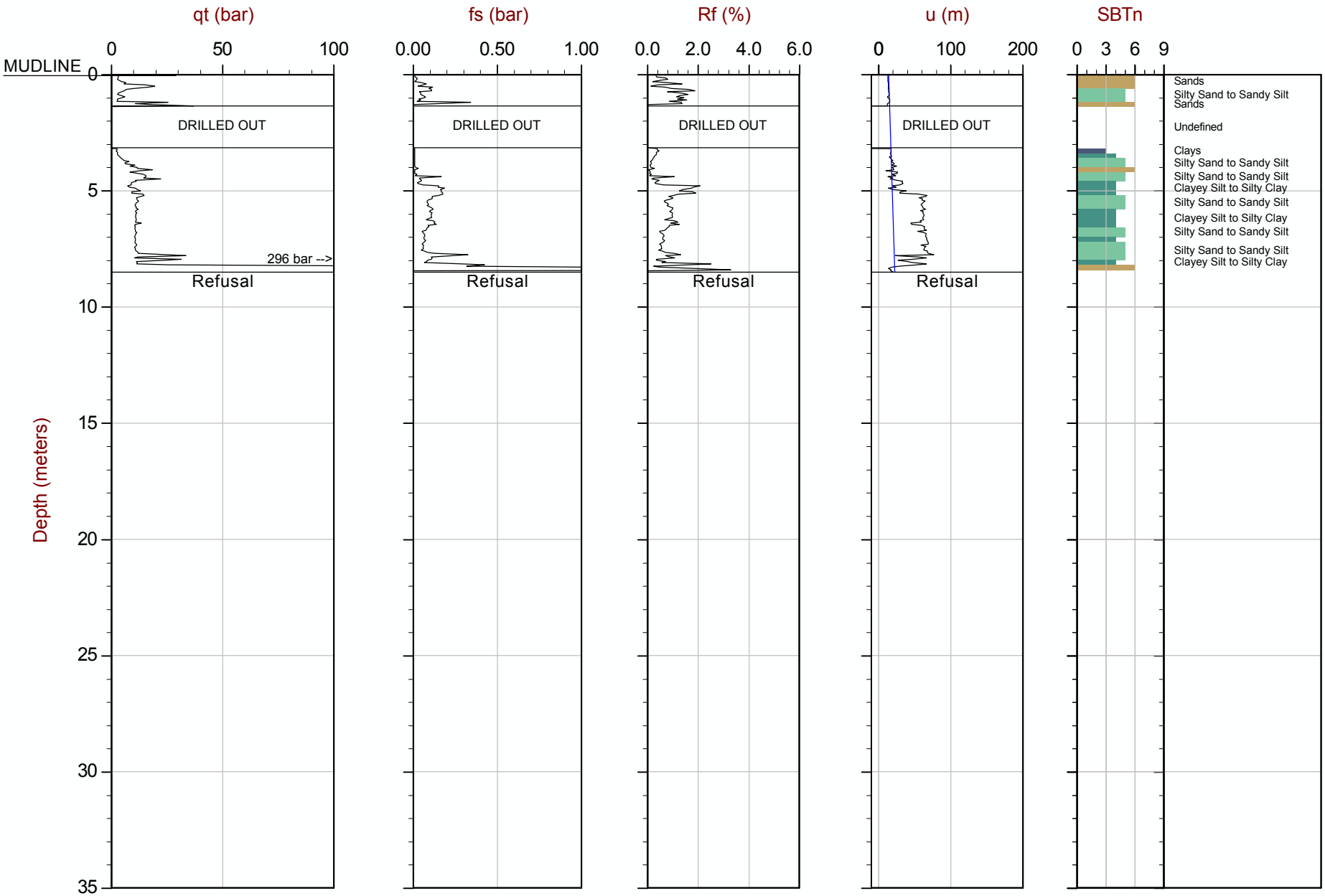

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Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
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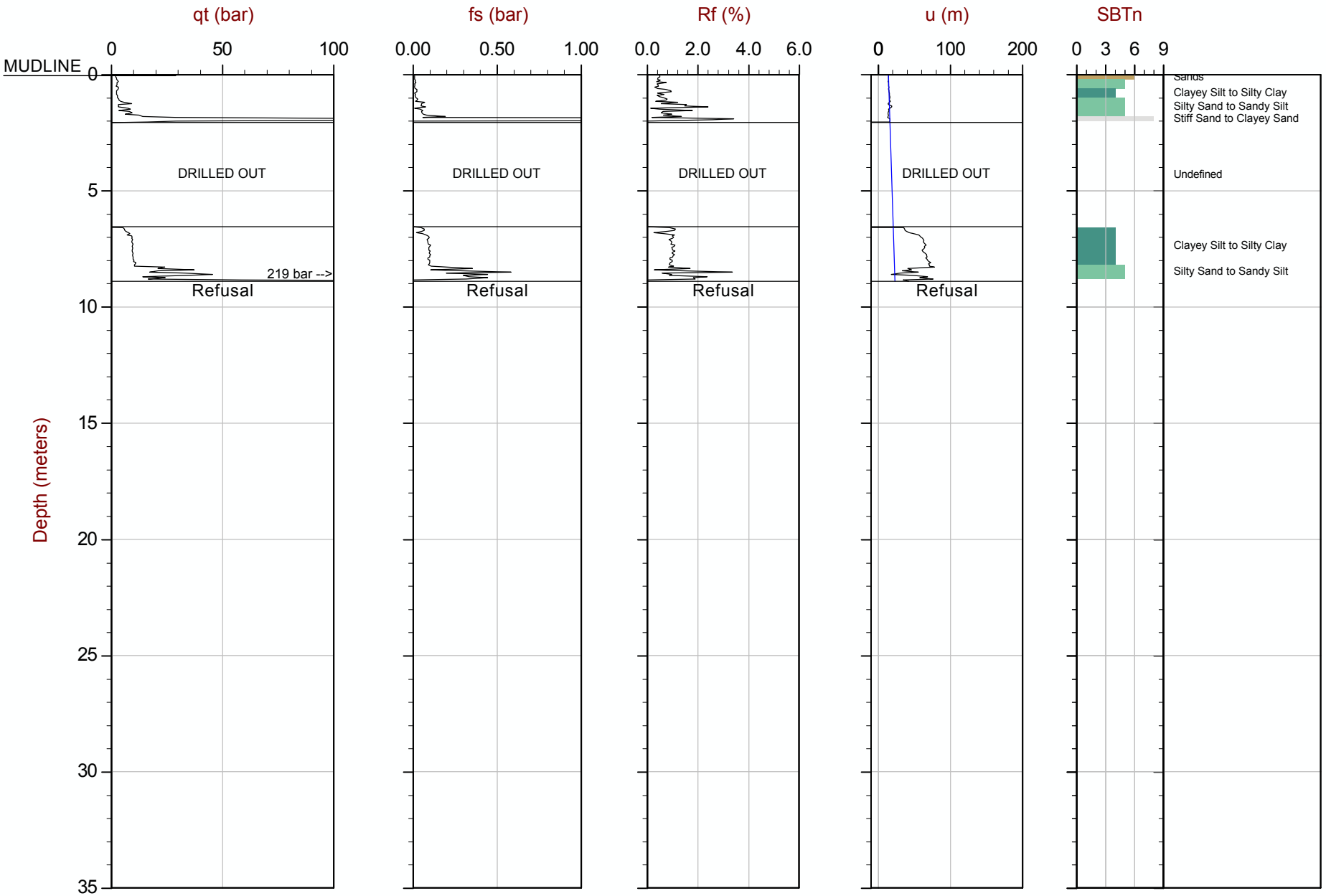

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Avg Int: 0.200 m

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Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
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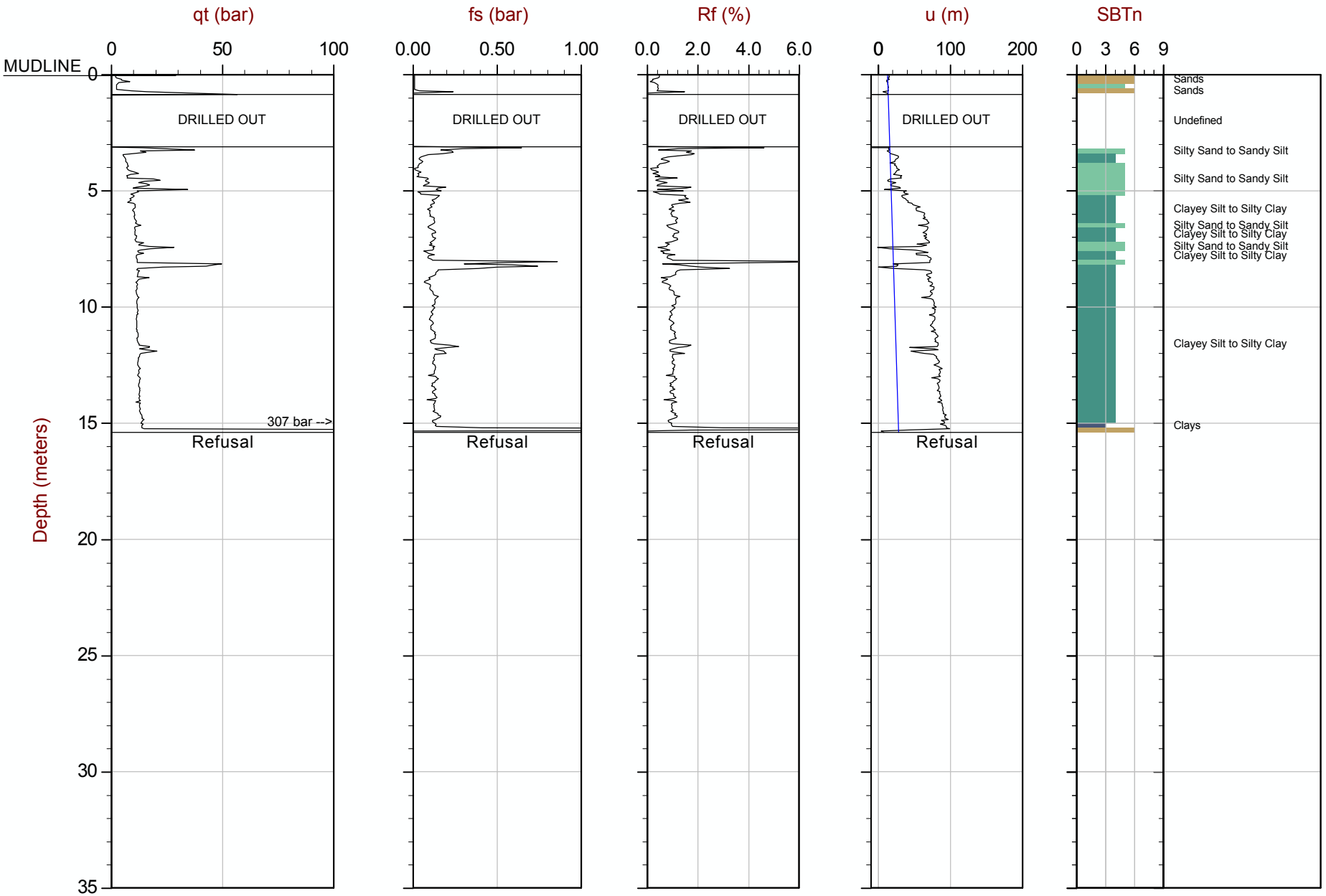

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Avg Int: 0.200 m

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SBT: Lunne, Robertson and Powell, 1997
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Sounding: GCPT09-06
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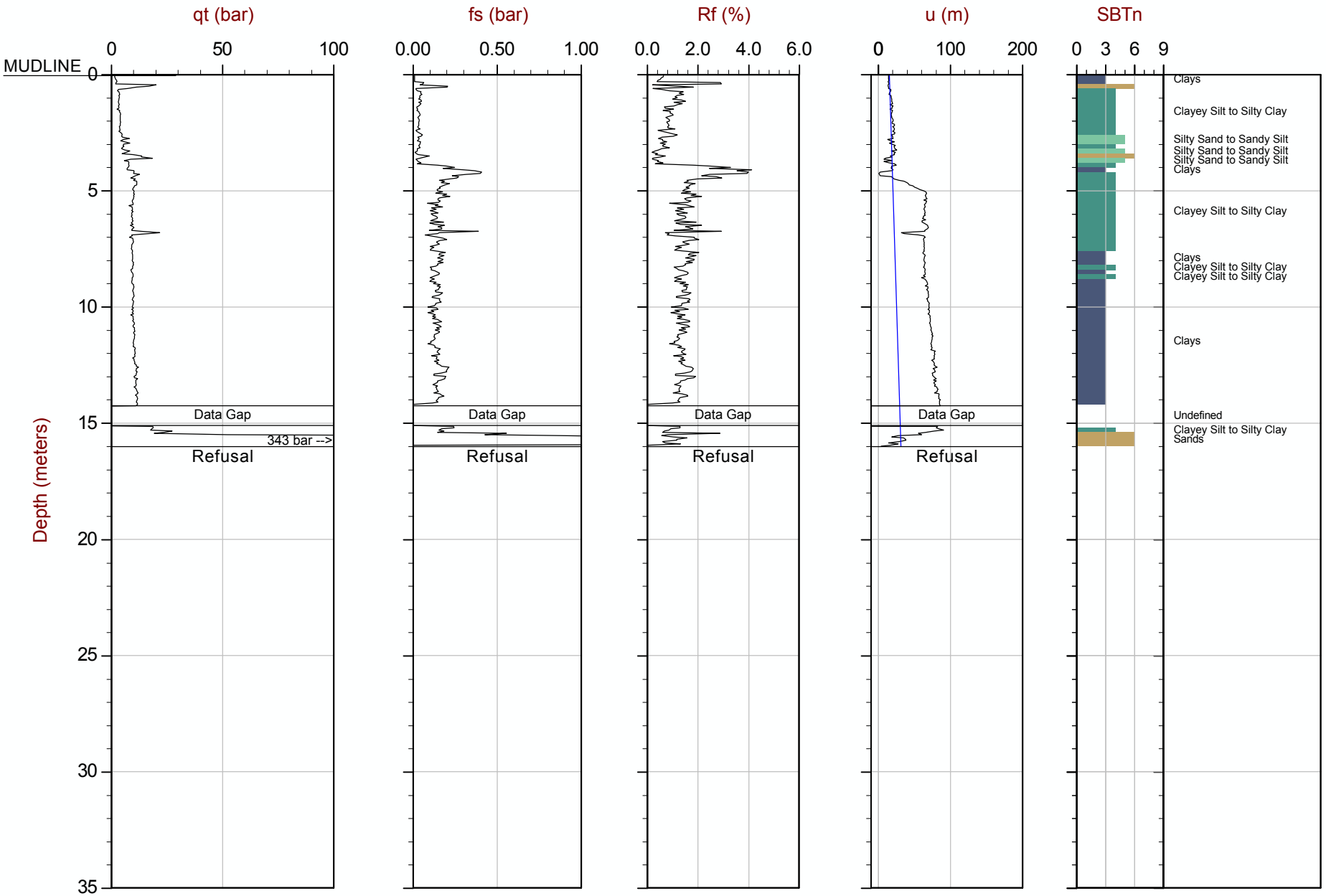

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Avg Int: 0.200 m

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Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
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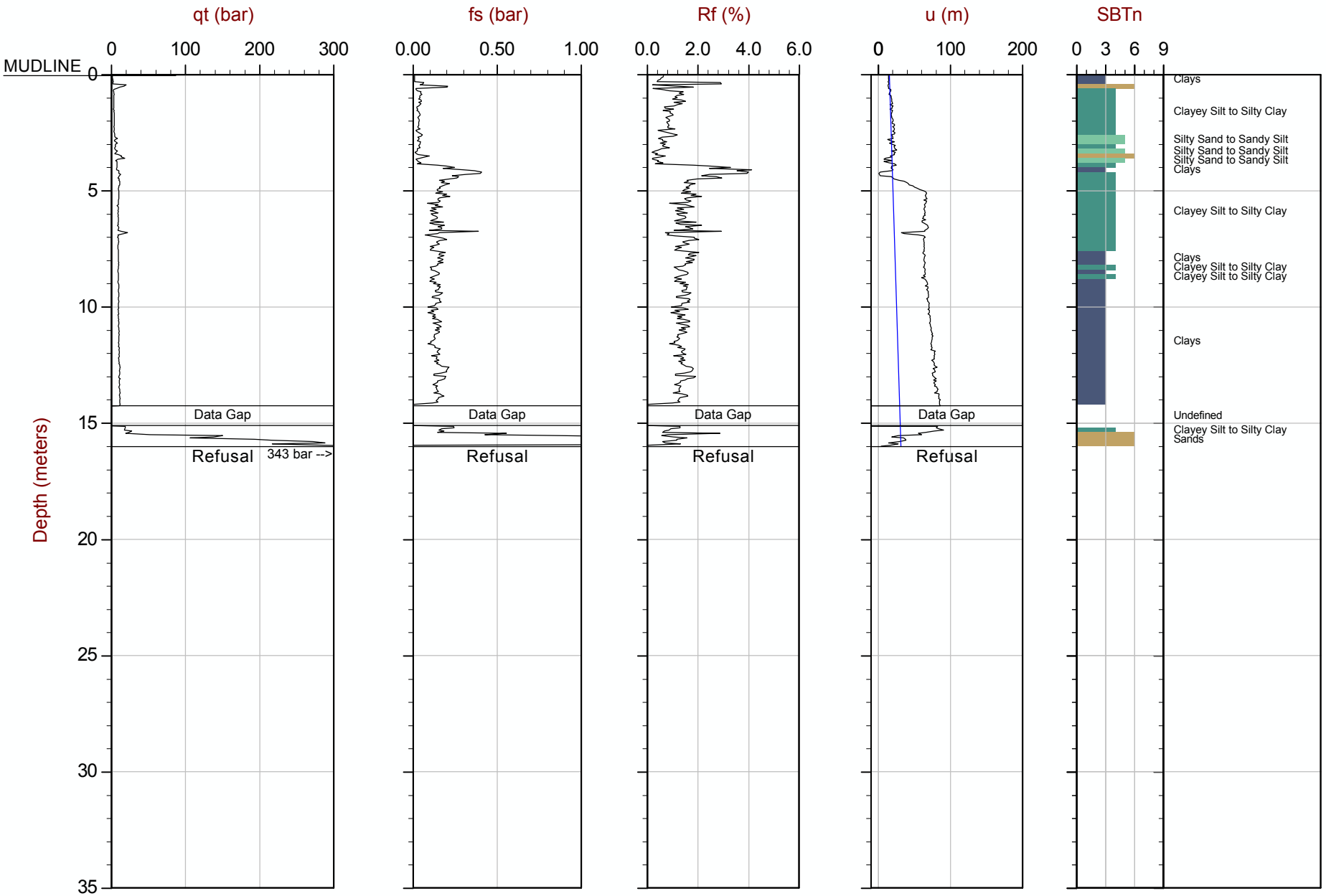

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Page No: 1 of 1

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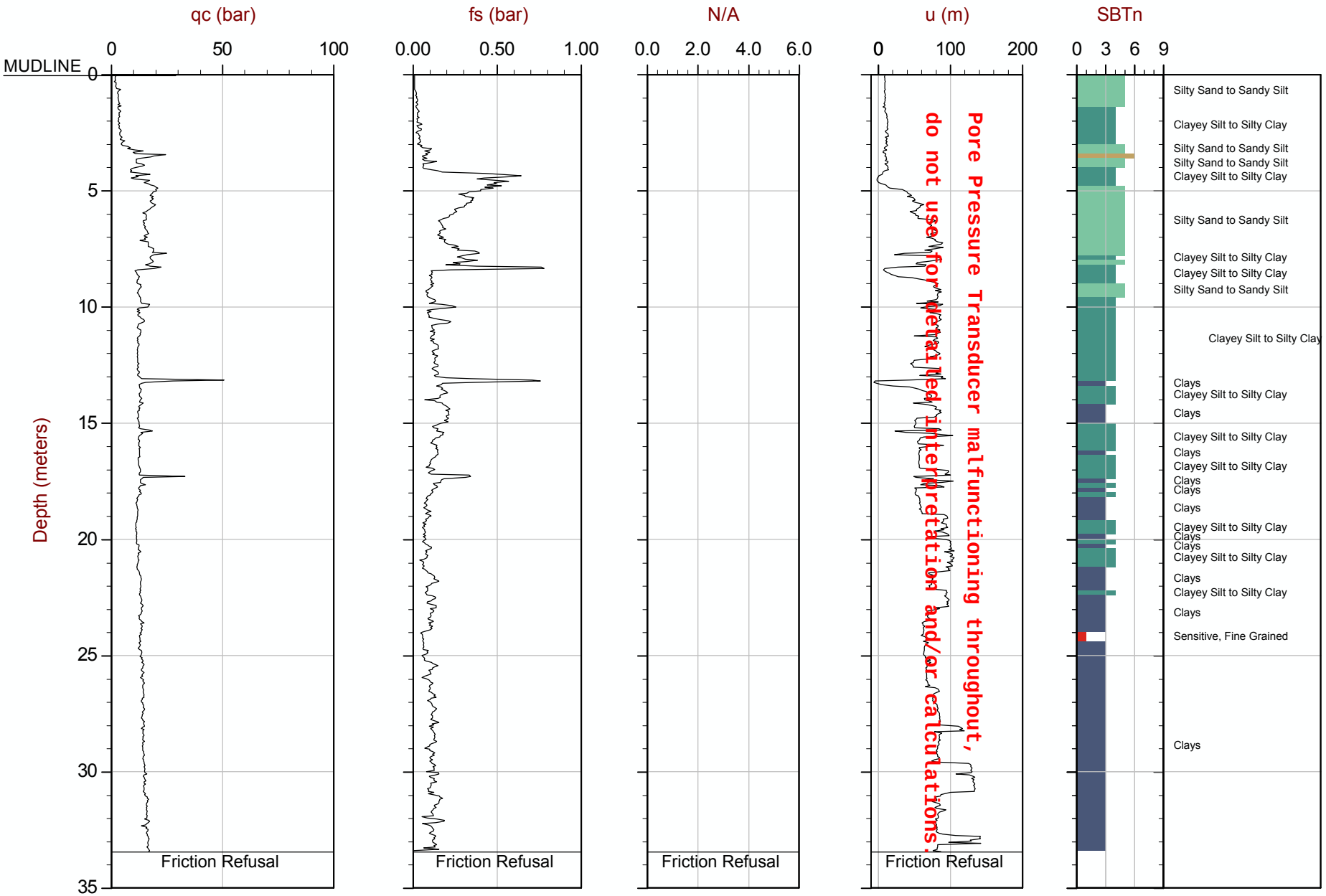

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Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 144CP07.COR
Unit Wt: SBT Chart Soil Zones

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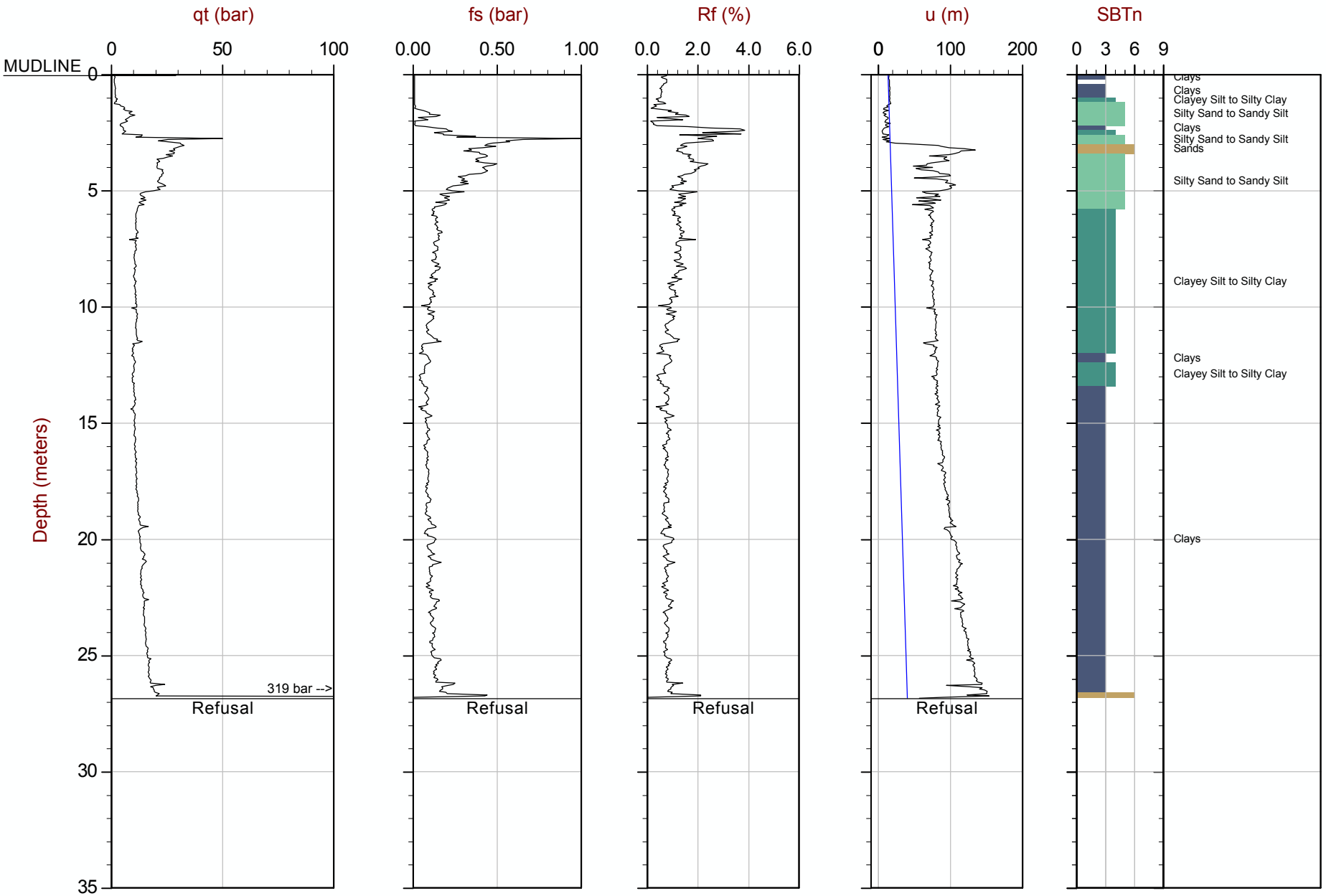

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Avg Int: 0.200 m

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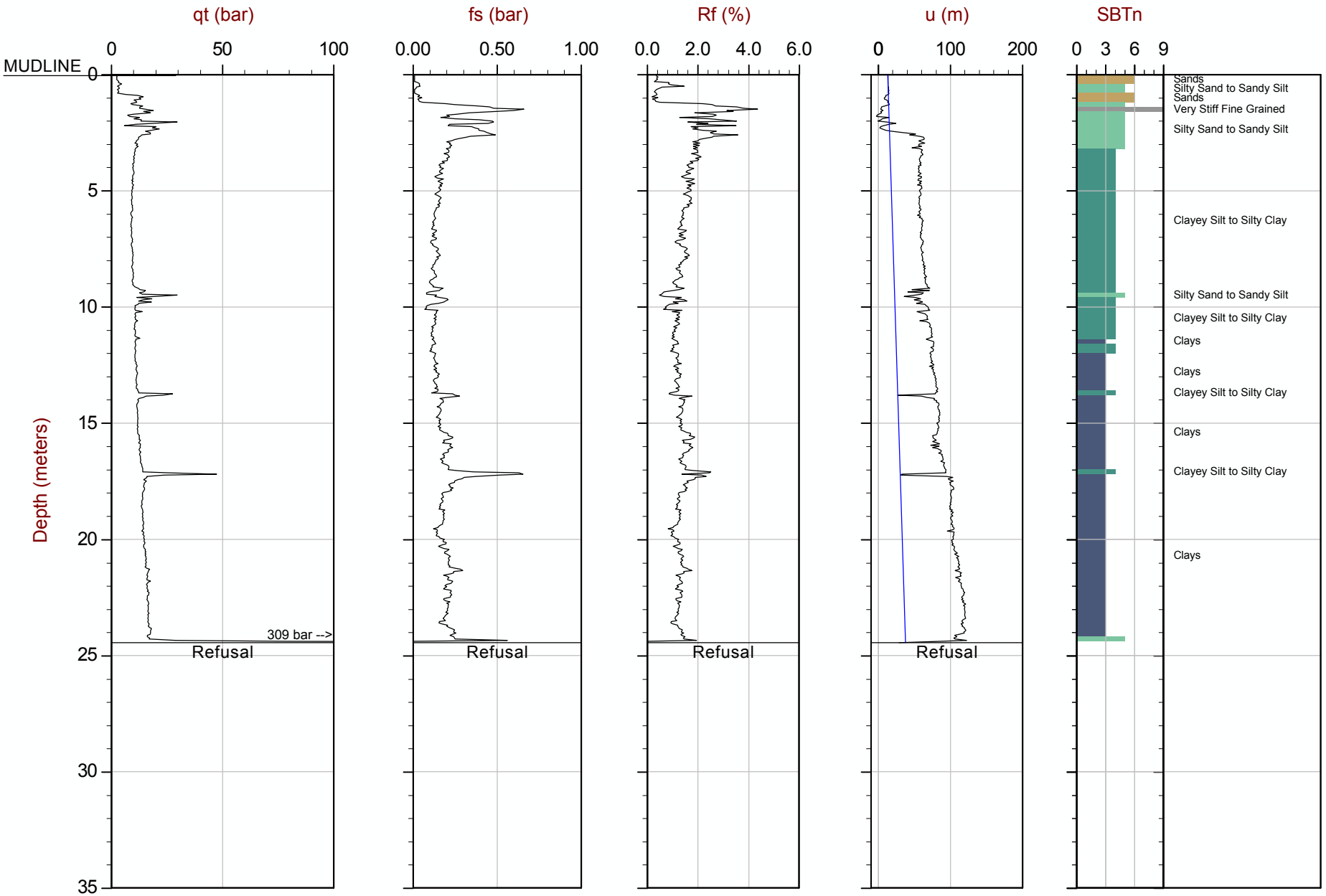

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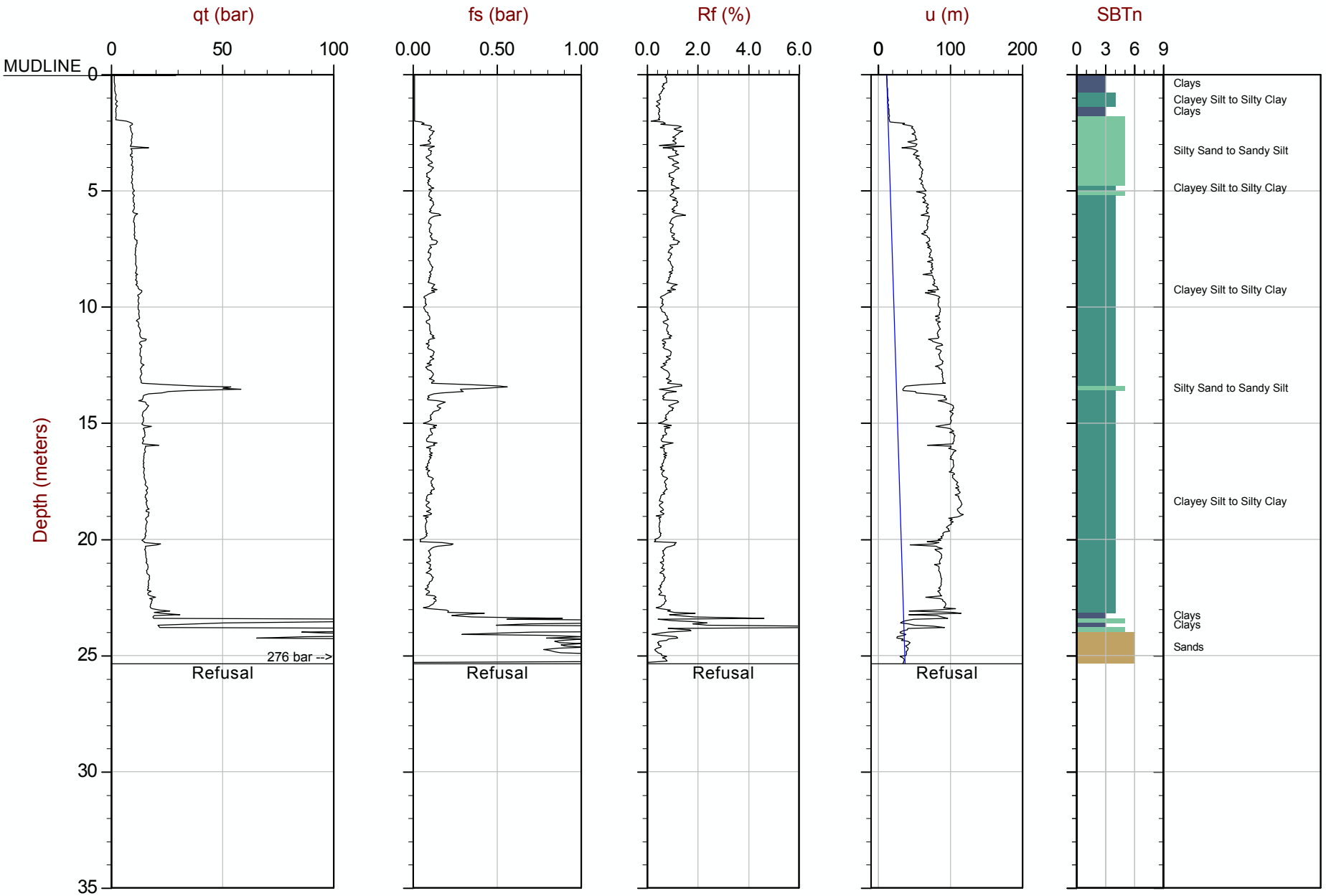

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Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

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Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364799m E: 468501m

CONETEC

Golder

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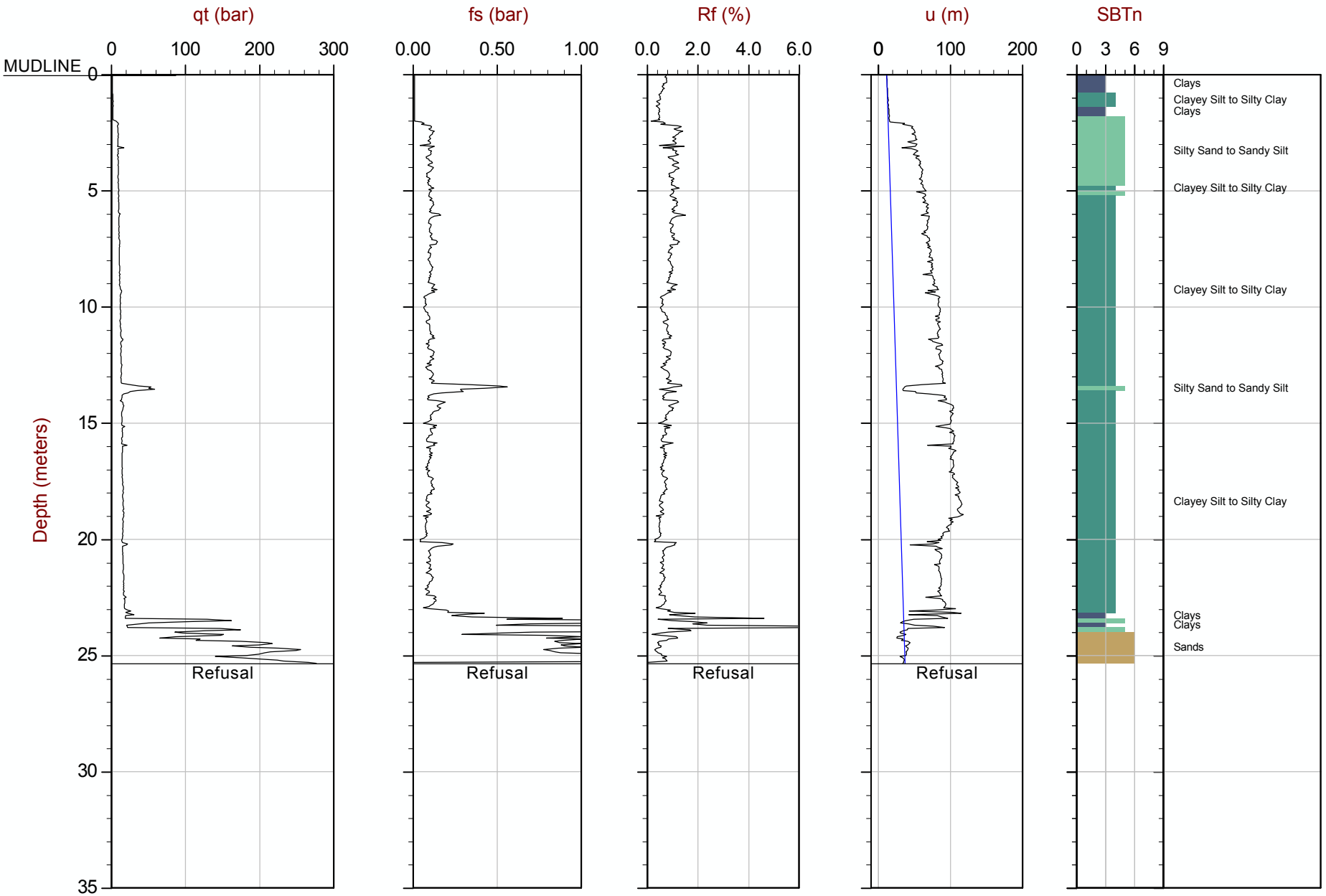

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Avg Int: 0.200 m

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Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364799m E: 468501m

CONETEC

Golder

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Site: Esquimalt Graving Dock

Sounding: GCPT09-11
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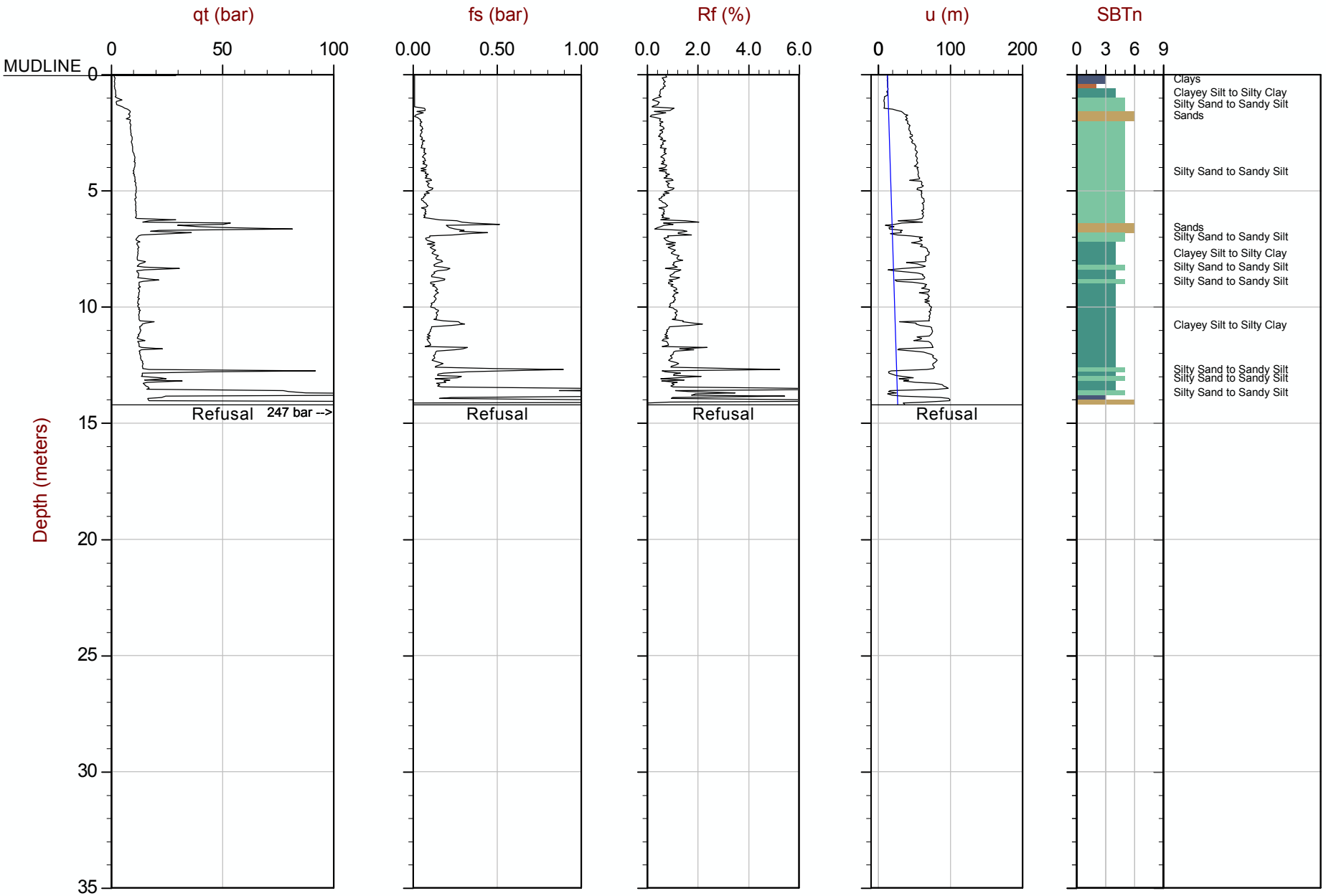

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Avg Int: 0.200 m

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Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364806m E: 468566m

CONETEC

Golder

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Sounding: KCPT09-101
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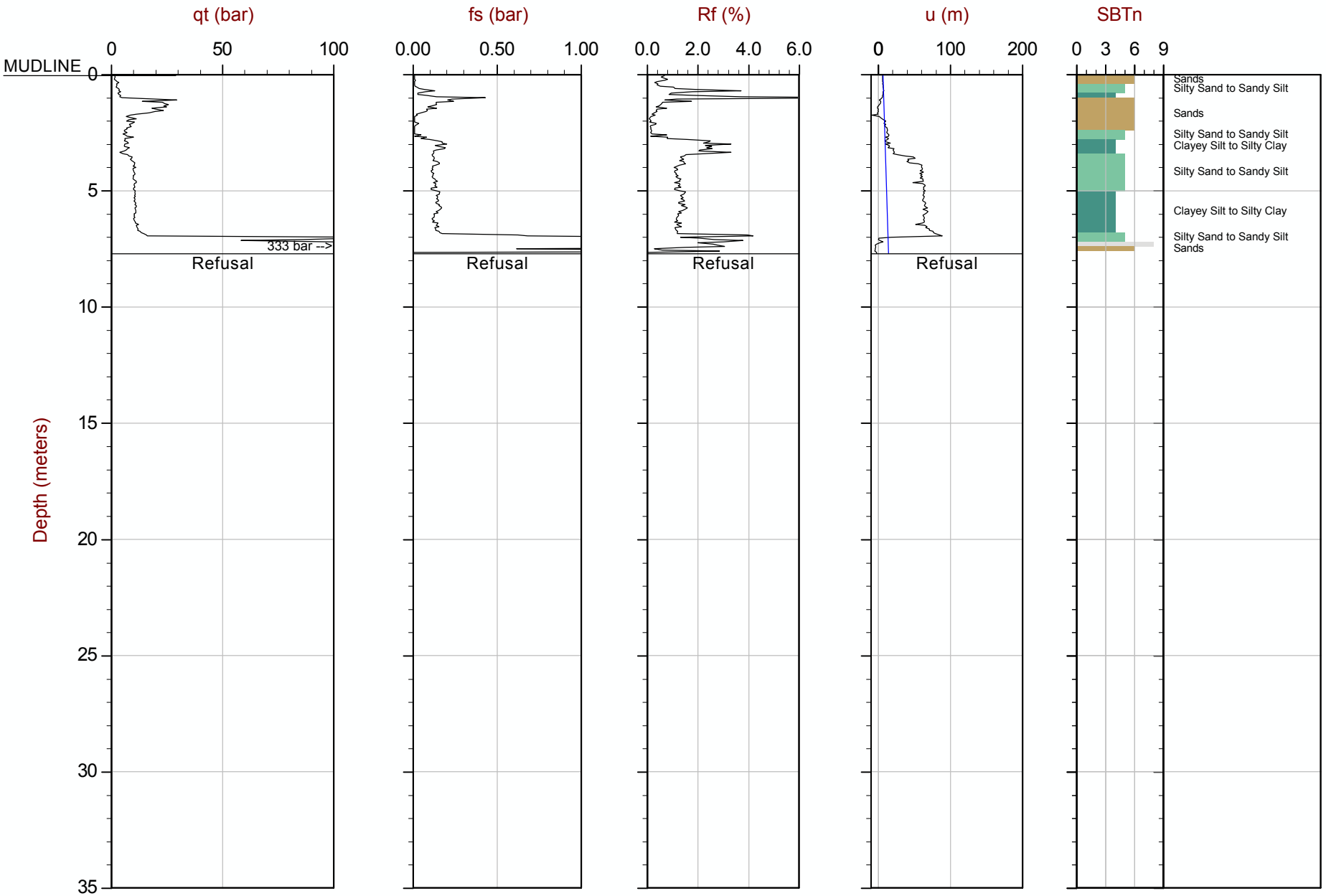

Max Depth: 7.700 m / 25.26 ft
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Avg Int: 0.200 m

File: 144CP101.COR
Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364799m E: 468623m

CONETEC

Golder

Job No: 09-144
Date: 10:28:09 11:32
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Sounding: KCPT09-101
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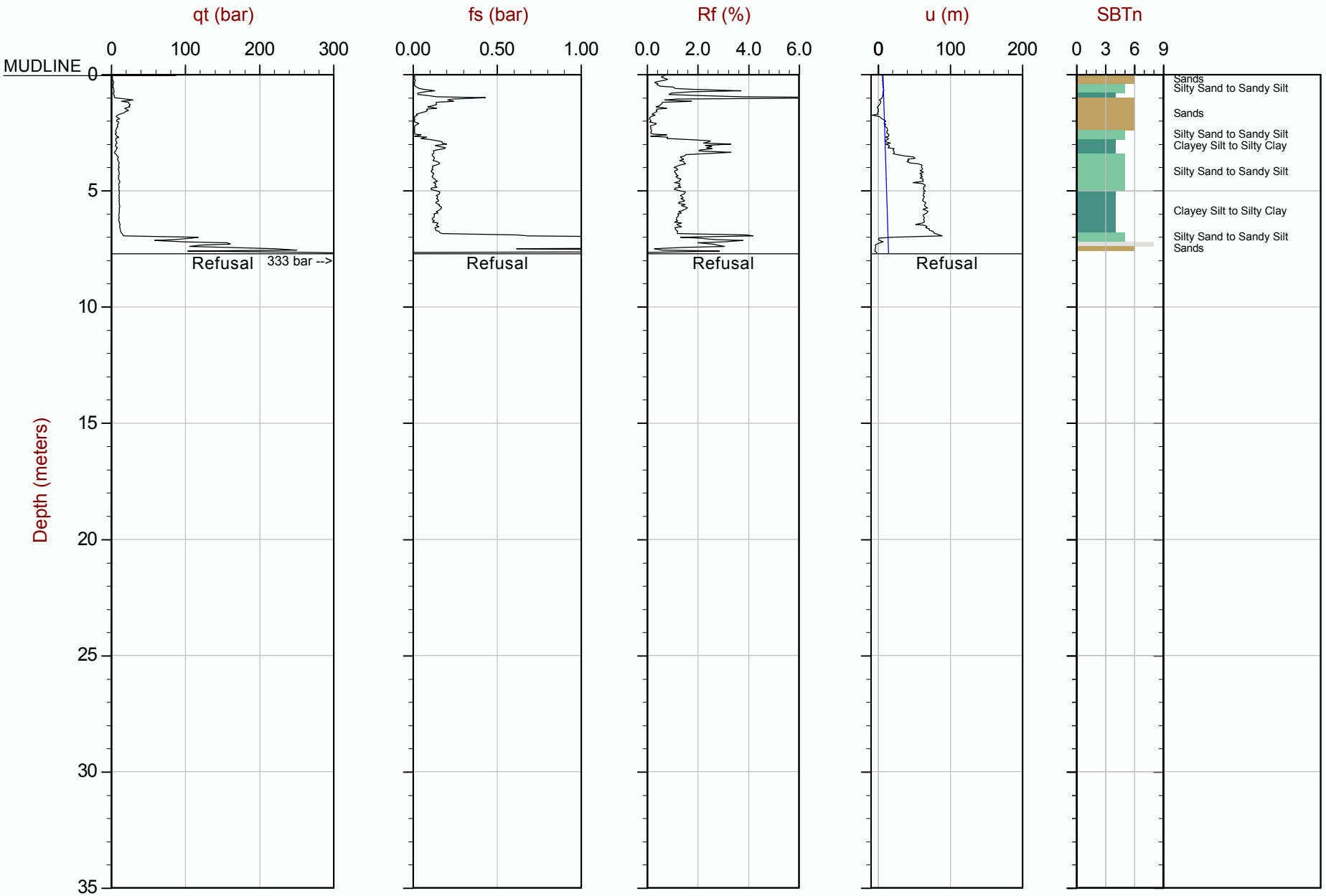

Max Depth: 7.700 m / 25.26 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 144CP101.COR
Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364799m E: 468623m

CONETEC

Golder

Job No: 09-144
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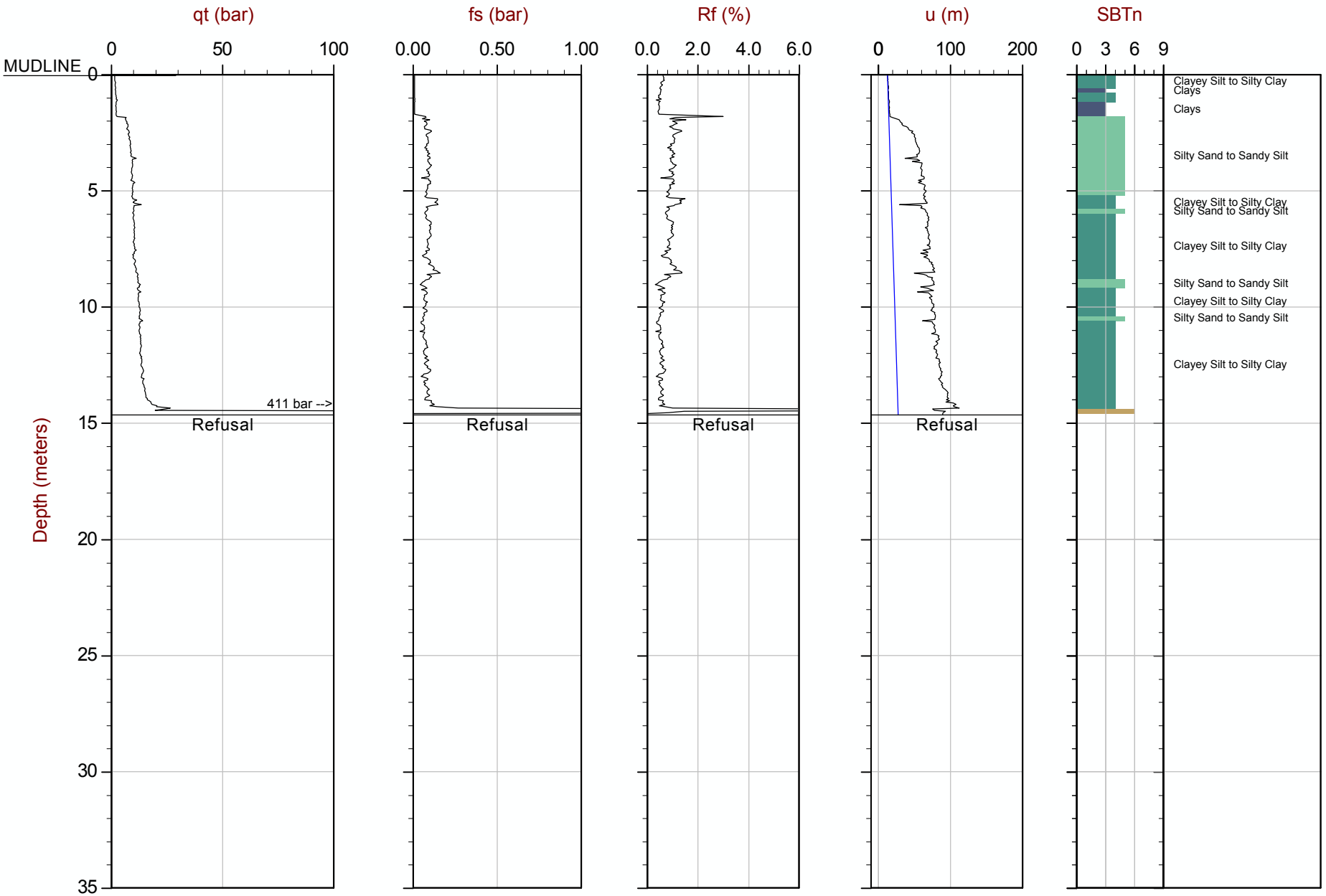
Site: Esquimalt Graving Dock

Sounding: KCPT09-102
Cone: 270:T500F10U500



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Avg Int: 0.200 m

File: 144CP102.COR
Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364789m E: 468542m

CONETEC

Golder

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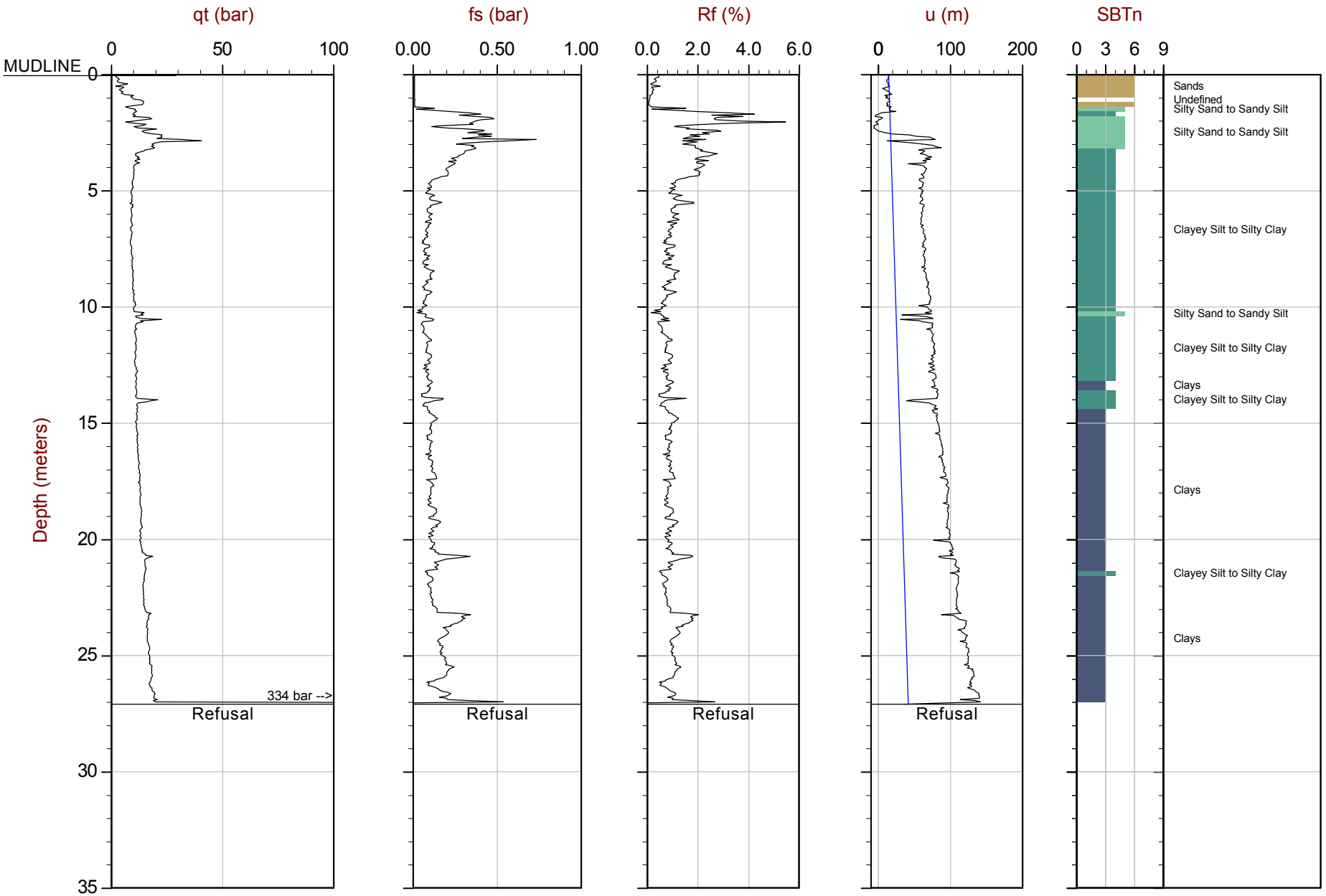

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Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
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CONETEC

Golder

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Sounding: KCPT09-104
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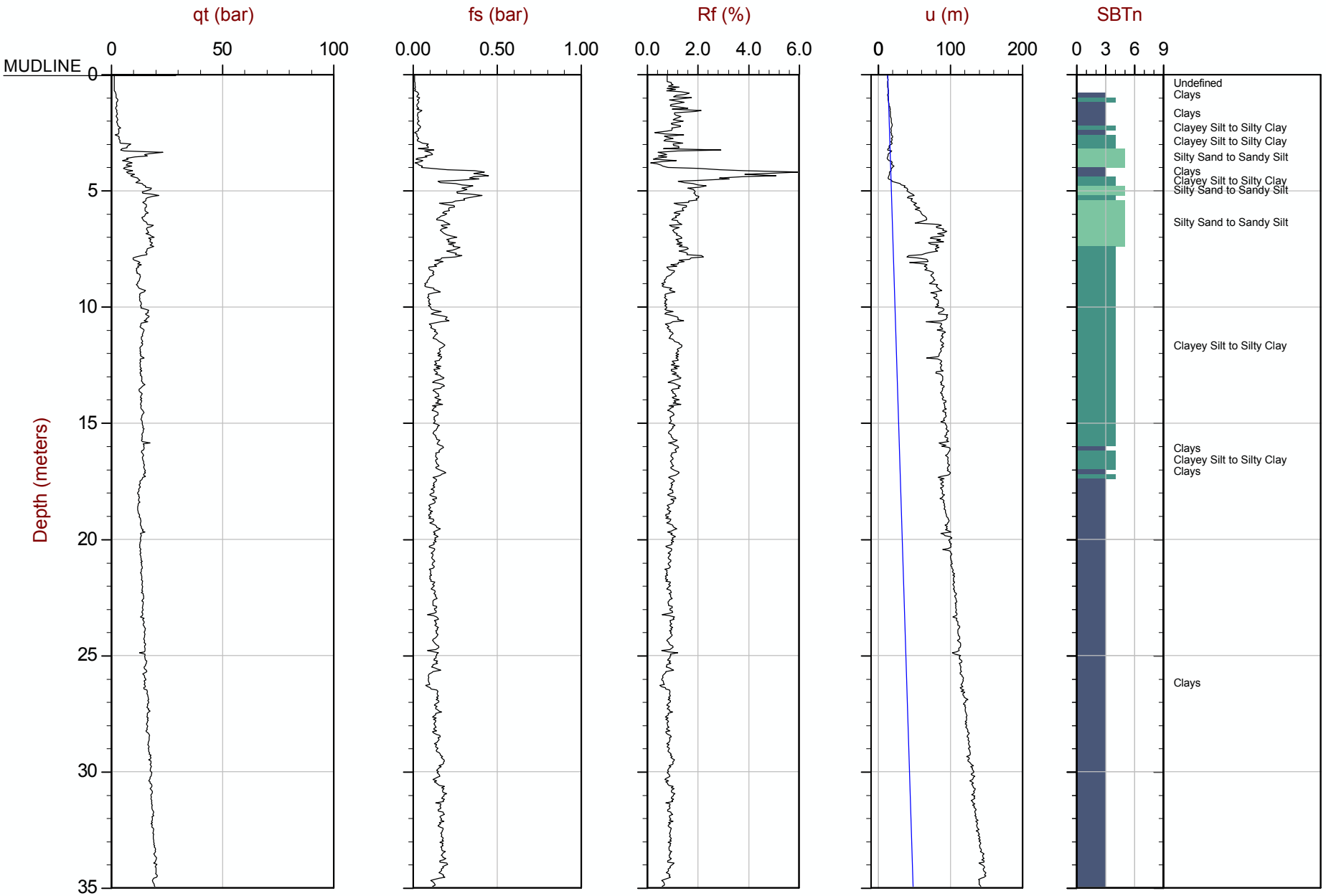

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Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 144CP104.COR
Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364757m E: 468300m

CONETEC

Golder

Job No: 09-144
Date: 10:30:09 09:53
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Sounding: KCPT09-104
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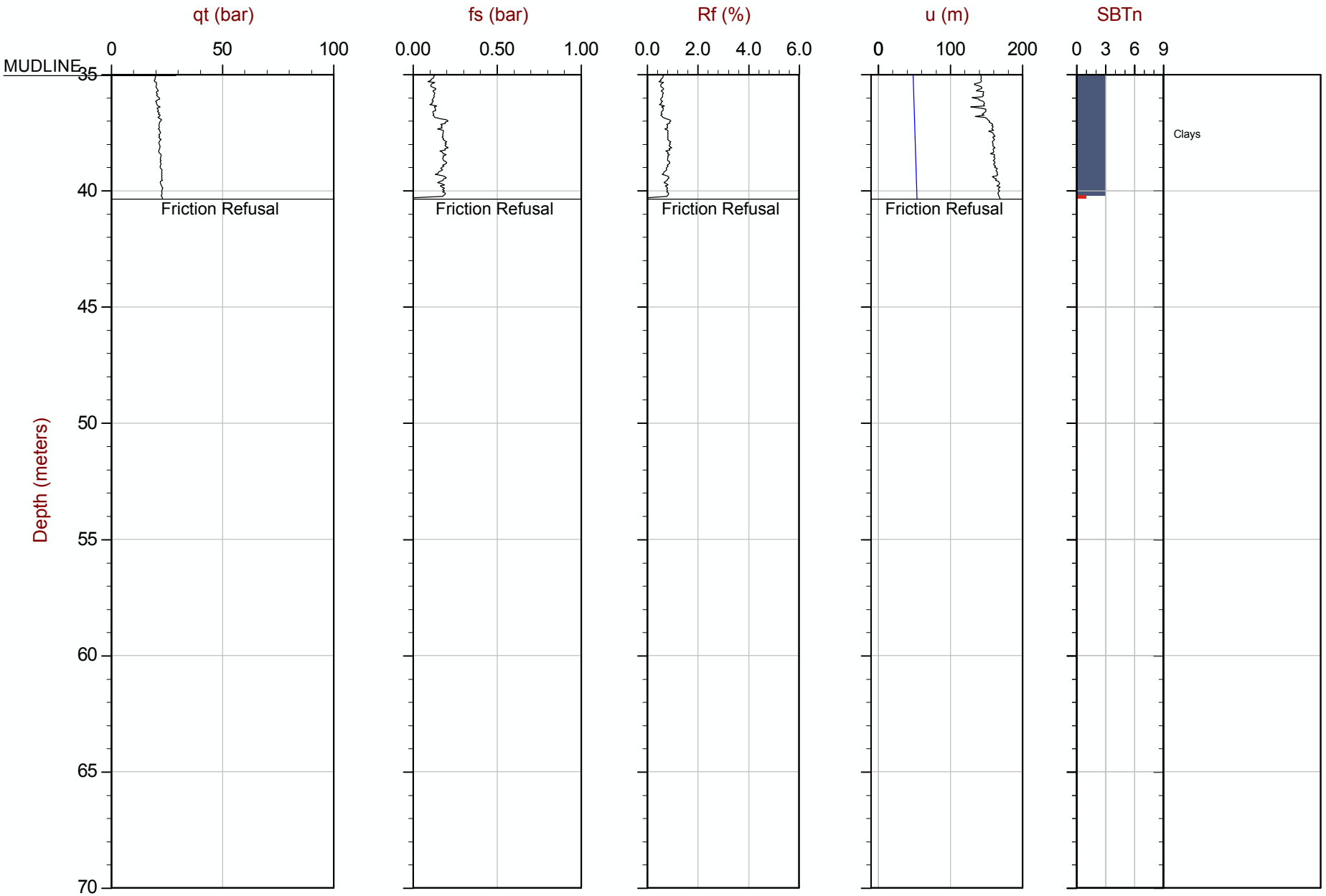


Max Depth: 40.350 m / 132.38 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 144CP104.COR
Unit Wt: SBT Chart Soil Zones

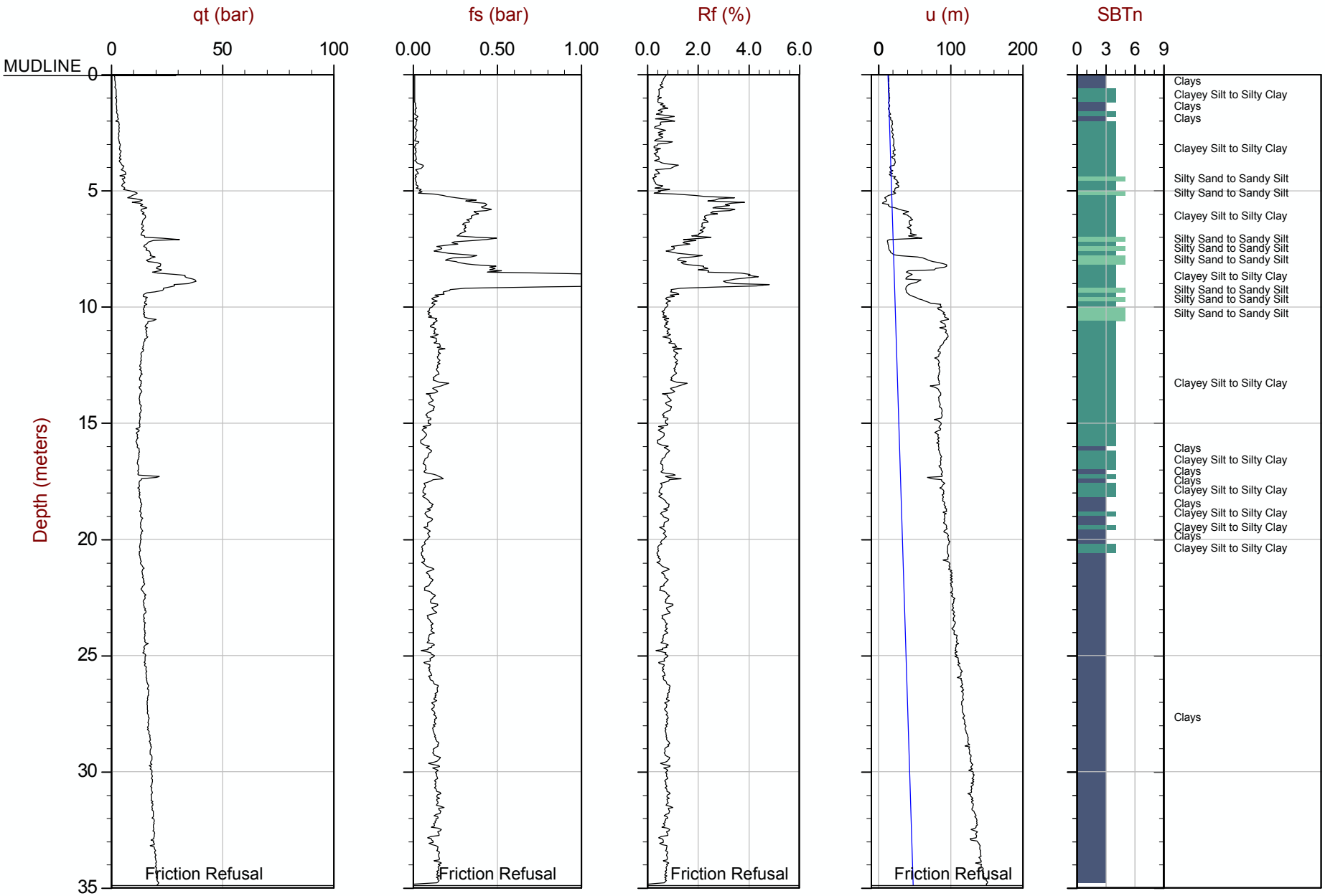
SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364757m E: 468300m

CONETEC

Golder

Job No: 09-144
Date: 10:29:09 13:42
Site: Esquimalt Graving Dock

Sounding: KCPT09-105
Cone: 270:T500F10U500



Max Depth: 34.900 m / 114.50 ft
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Avg Int: 0.200 m

File: 144CP105.COR
Unit Wt: SBT Chart Soil Zones

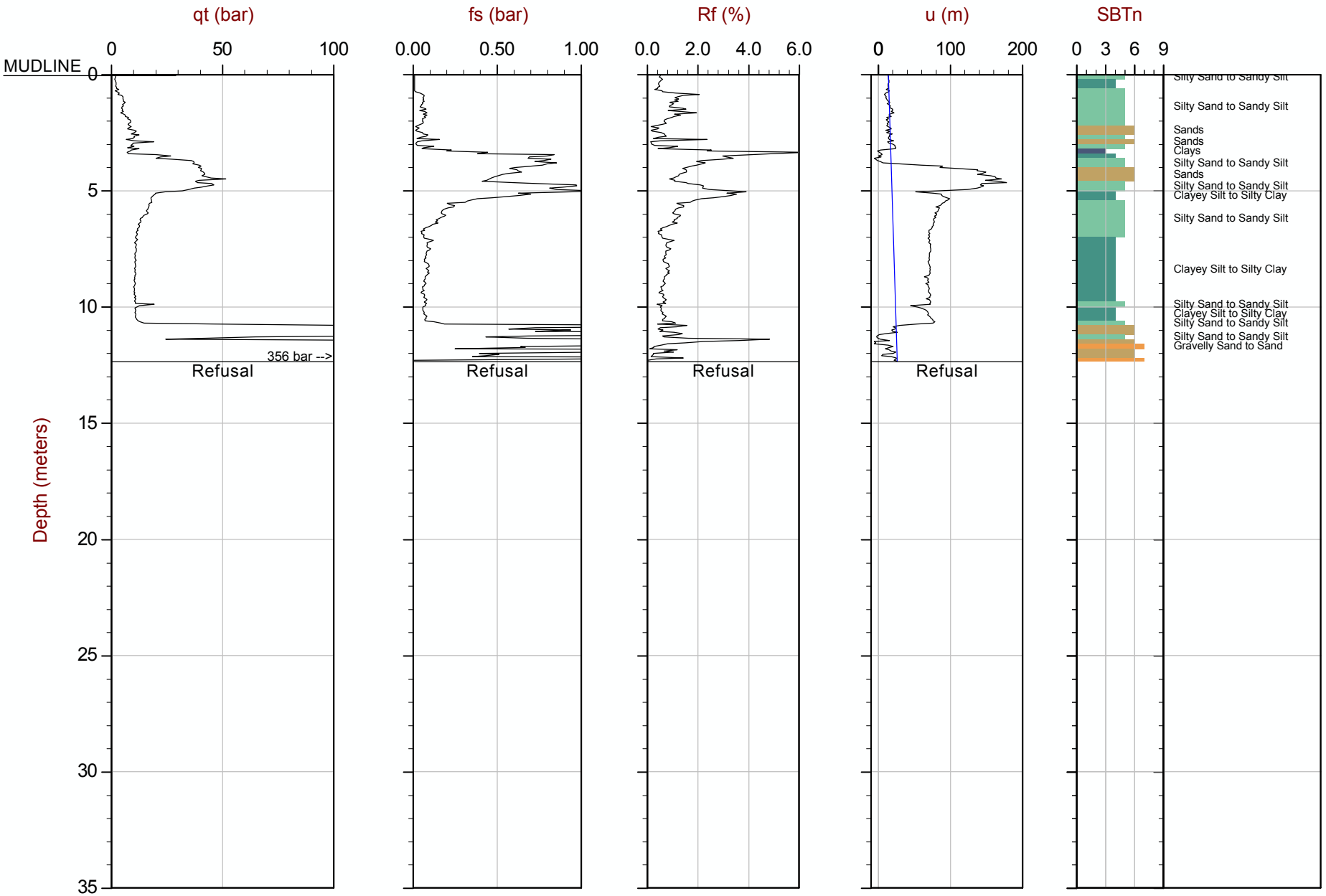
SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364810m E: 468258m

CONETEC

Golder

Job No: 09-144
Date: 11:02:09 10:14
Site: Esquimalt Graving Dock

Sounding: KCPT09-106
Cone: 270:T500F10U500



Max Depth: 12.350 m / 40.52 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 144CP106.COR
Unit Wt: SBT Chart Soil Zones

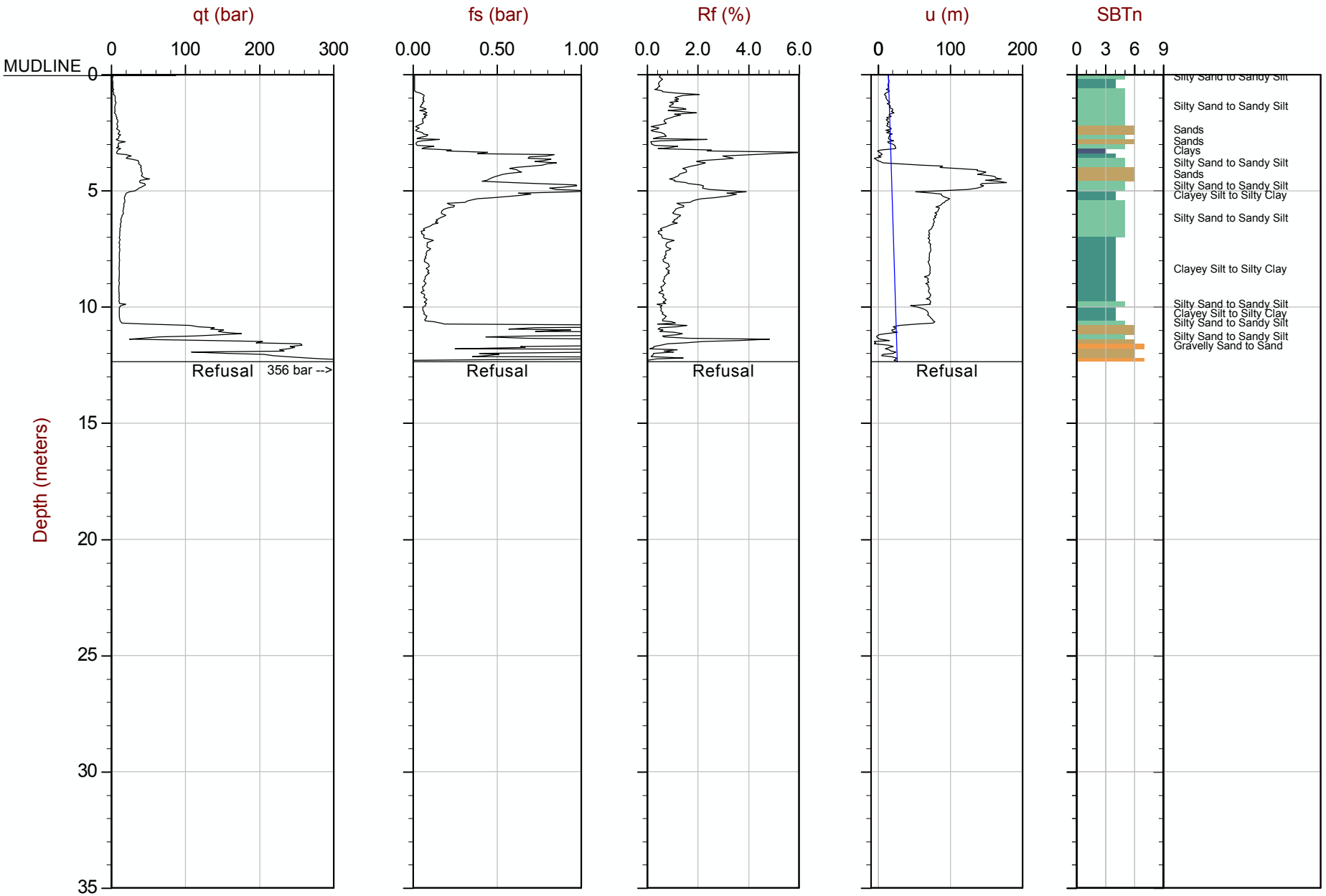
SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364860m E: 468318m

CONETEC

Golder

Job No: 09-144
Date: 11:02:09 10:14
Site: Esquimalt Graving Dock

Sounding: KCPT09-106
Cone: 270:T500F10U500



Max Depth: 12.350 m / 40.52 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 144CP106.COR
Unit Wt: SBT Chart Soil Zones

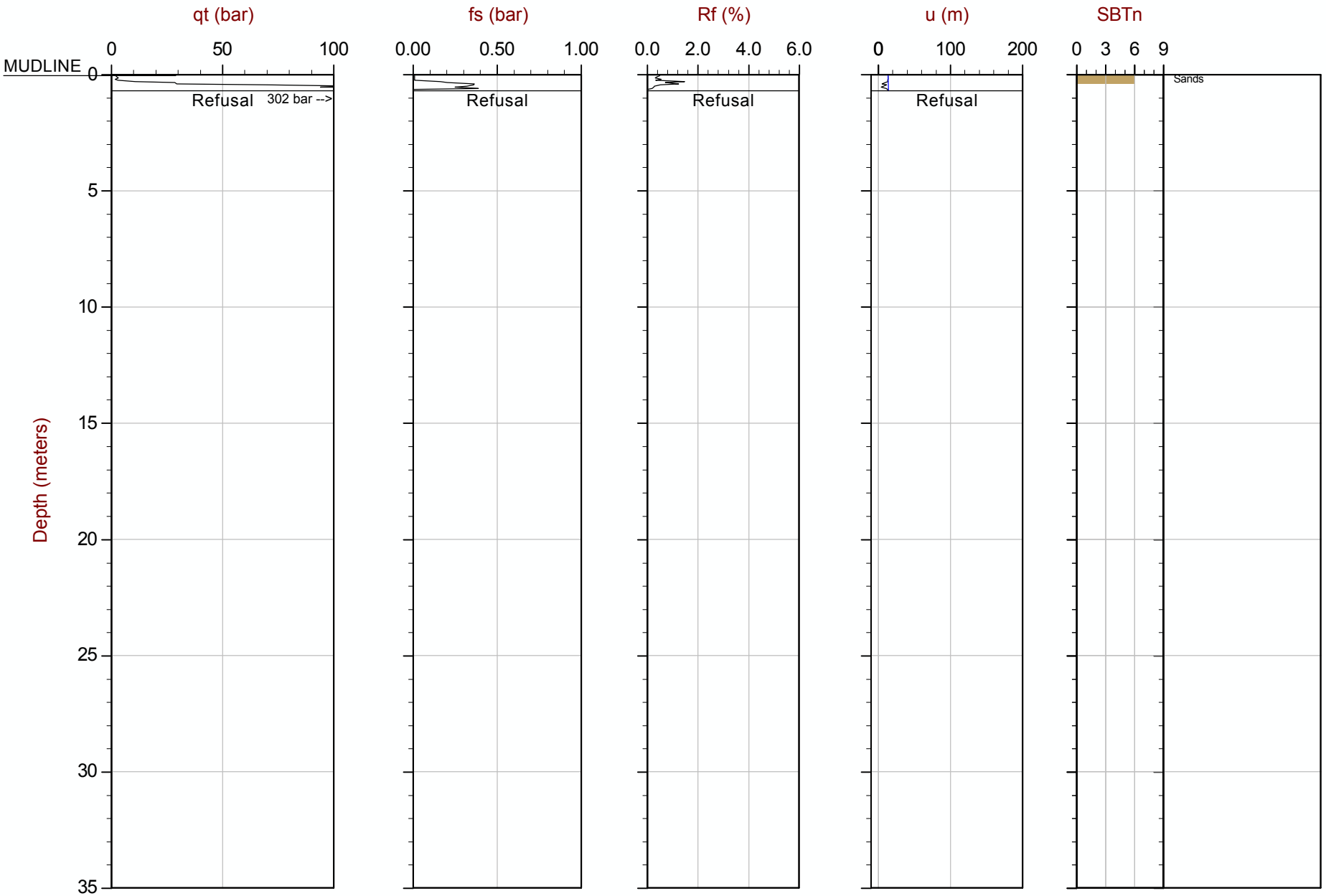
SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364860m E: 468318m

CONETEC

Golder

Job No: 09-144
Date: 11:02:09 13:21
Site: Esquimalt Graving Dock

Sounding: KCPT09-107
Cone: 270:T500F10U500



Max Depth: 0.700 m / 2.30 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 144CP107.COR
Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10U N: 5364879m E: 468356m

APPENDIX E

CPT Pore Pressure Dissipation Test Results

Pore Pressure Dissipation Testing (PPD)

The penetration of the piezocone was halted at specific depths to carry out pore pressure dissipation tests as directed by the field representative. The variation of the penetration pore pressure (u) with time was measured and recorded. All pore pressure data was recorded immediately behind the cone tip at the u_2 location (refer to Figure PTL).

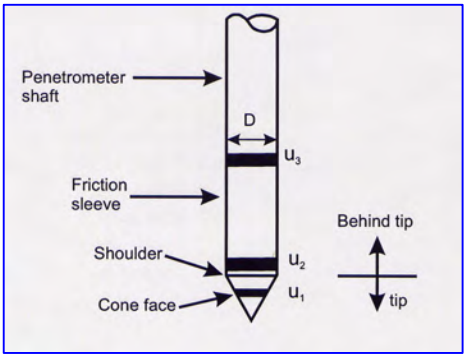


Figure – PTL

Pore pressure dissipation data can be interpreted to provide estimates of :

- equilibrium piezometric pressure
- phreatic surface
- in situ horizontal coefficient of consolidation, c_h
- in situ horizontal coefficient of permeability, k_h

In order to interpret the equilibrium piezometric pressure and/or the phreatic surface, the pore pressure must be monitored until such time as there is no variation in pore pressure with time (refer to Figure PPD). This time is commonly referred to as t_{100}, the point at which 100% of the excess pore pressure has dissipated.

Interpretation of either c_h and k_h from dissipation results can be most easily achieved using either of two analytical approaches: cavity-expansion theory or the strain-path approach. Comparisons of the available solutions and results from field studies suggest that the cavity-expansion method of Torstensson (1977) and the strain-path approaches of Levadous (1980) and Teh (1987) all provide similar predications of consolidation parameters from CPTU dissipation data (Gillespie 1981; Kabir and Lutenegger 1990; Robertson et al. 1991). Robertson et al. (1991) have shown that these methods, although developed for normally consolidated soils, can be equally applied to overconsolidated soils. Furthermore, comparisons of field and laboratory data indicate that the trends in the measured (laboratory) and predicated (CPTU) data

are consistent provided the micro fabric and nature of the soils being tested are taken into consideration (Danziger 1990; Robertson et al. 1991).

A complete reference on pore pressure dissipation tests is presented by Robertson et al. 1991.

The pore pressure dissipation tests are summarized in Table PPD (Appendix PPD).

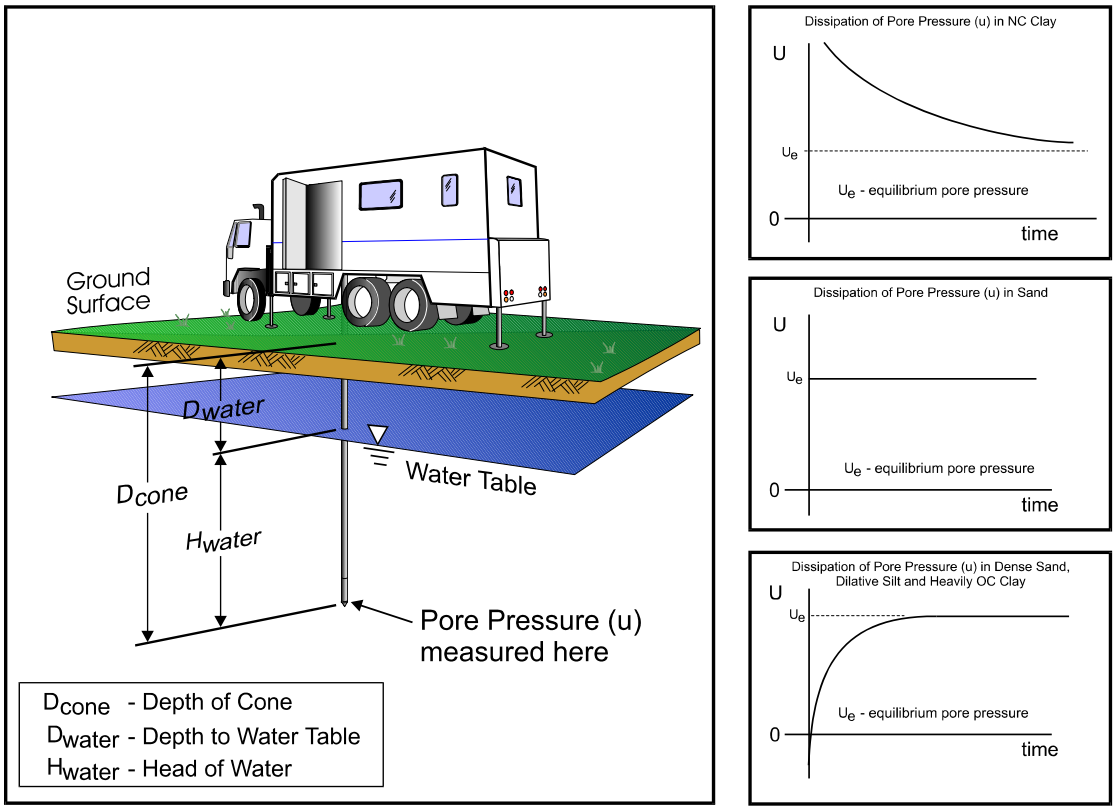


Figure - PPD

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Table E-1 - Equilibrium Pore Water Pressures and Piezometric Levels from CPT Pore Pressure Dissipation Tests

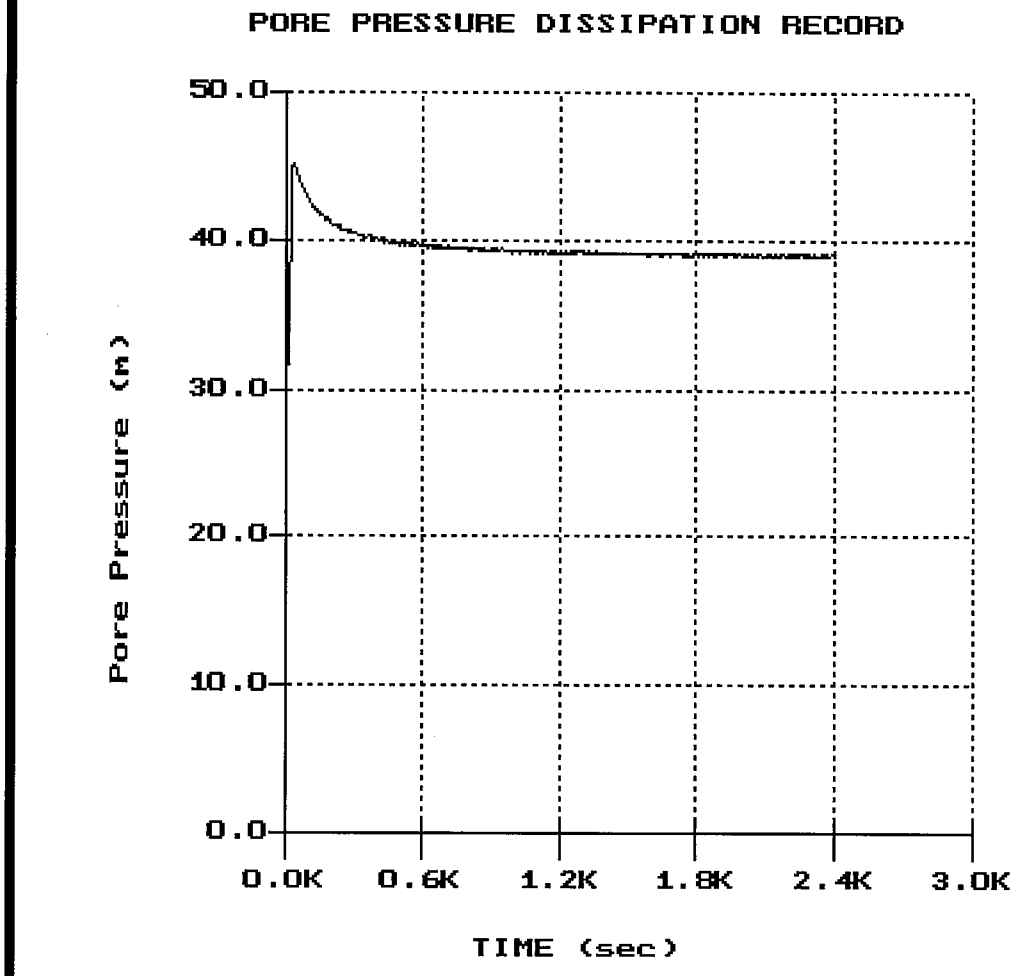
Location	Test Depth (m bml)	Mudline Elevation (m Geodetic)	Test Elevation (m Geodetic)	Measured Equilibrium Pressure (kPa)	Tide Level at Time of Test (m Geodetic)	Fresh Water (density = 1.00 g/cm^3)		Brackish Water (density = 1.01 g/cm^3)		Salt Water (density = 1.02 g/cm^3)	
						Equilibrium Pressure Head (m)	Piezometric Level (m Geodetic)	Equilibrium Pressure Head (m)	Piezometric Level (m Geodetic)	Equilibrium Pressure Head (m)	Piezometric Level (m Geodetic)
GCPT09-01	25.00	-13.58	-38.58	382	0.8	39.0	0.4	38.6	0.0	38.2	-0.4
GCPT09-05	15.40	-13.63	-29.03	286	-0.5	29.2	0.2	28.9	-0.1	28.6	-0.4
GCPT09-06	15.85	-14.33	-30.18	312	-1.3	31.8	1.6	31.5	1.3	31.2	1.0
GCPT09-09b	24.45	-13.65	-38.10	373	0.6	38.0	-0.1	37.6	-0.5	37.3	-0.8
KCPT09-103	27.10	-13.53	-40.63	411	0.6	41.9	1.3	41.5	0.9	41.1	0.4
KCPT09-106	12.35	-13.78	-26.13	263	0.7	26.8	0.7	26.5	0.4	26.3	0.1

Golder

Hole:GCPT09-01
Location:Esquimalt

Cone:227:T500F10U500
Date:10:21:09 09:11

File: 144CP01.PPF
Depth (m): 25.00
(ft): 82.02
Duration : 2400.0s
U-min: 31.23 5.0s
U-max: 45.16 30.0s

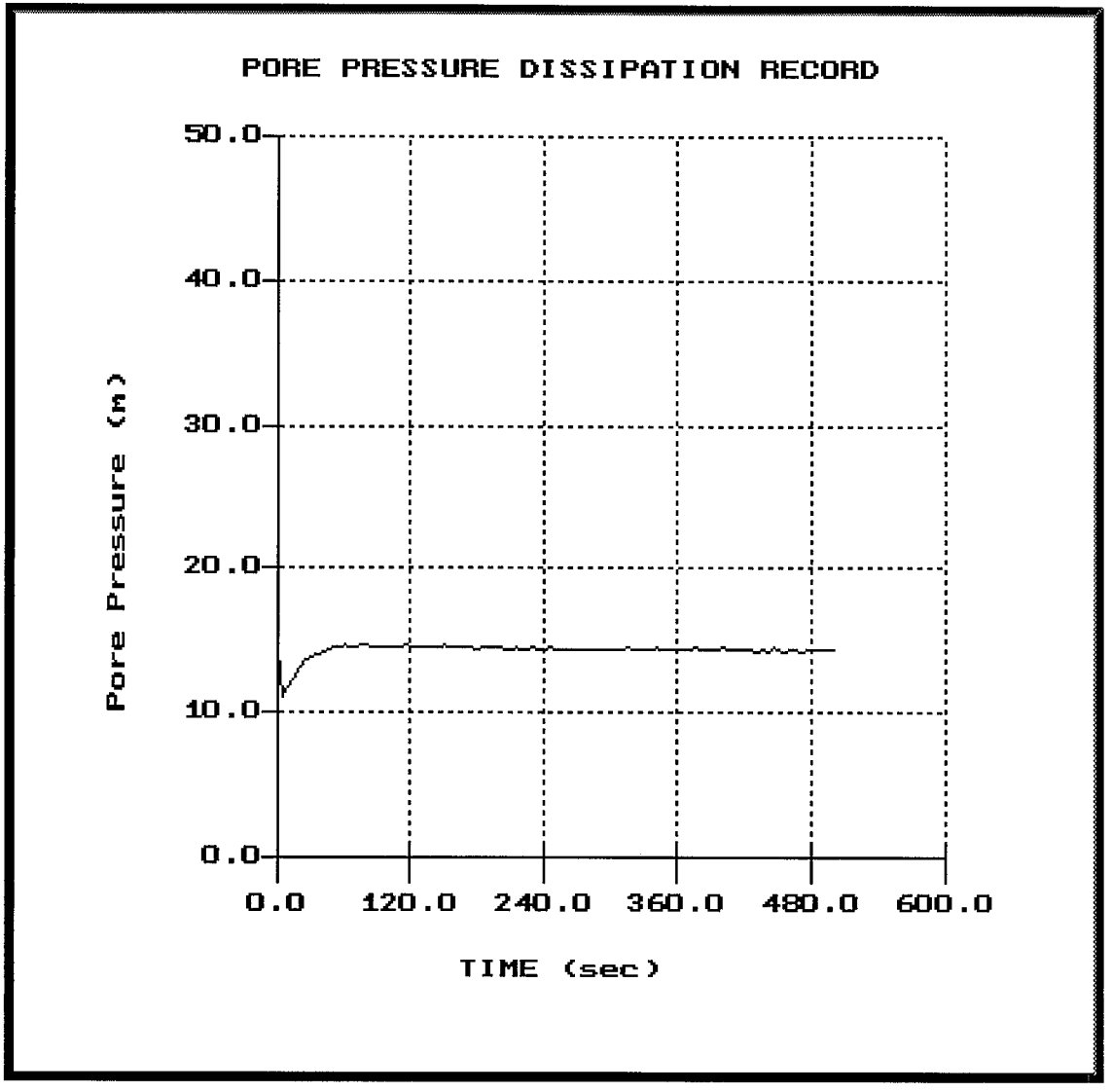


Golder

Hole:GCPT09-02
Location:Esquimalt

Cone:227:T500F10U500
Date:10:21:09 14:24

File: 144CP02.PPF
Depth (m): 1.10
(ft): 3.61
Duration : 500.0s
U-min: 10.91 5.0s
U-max: 14.58 75.0s

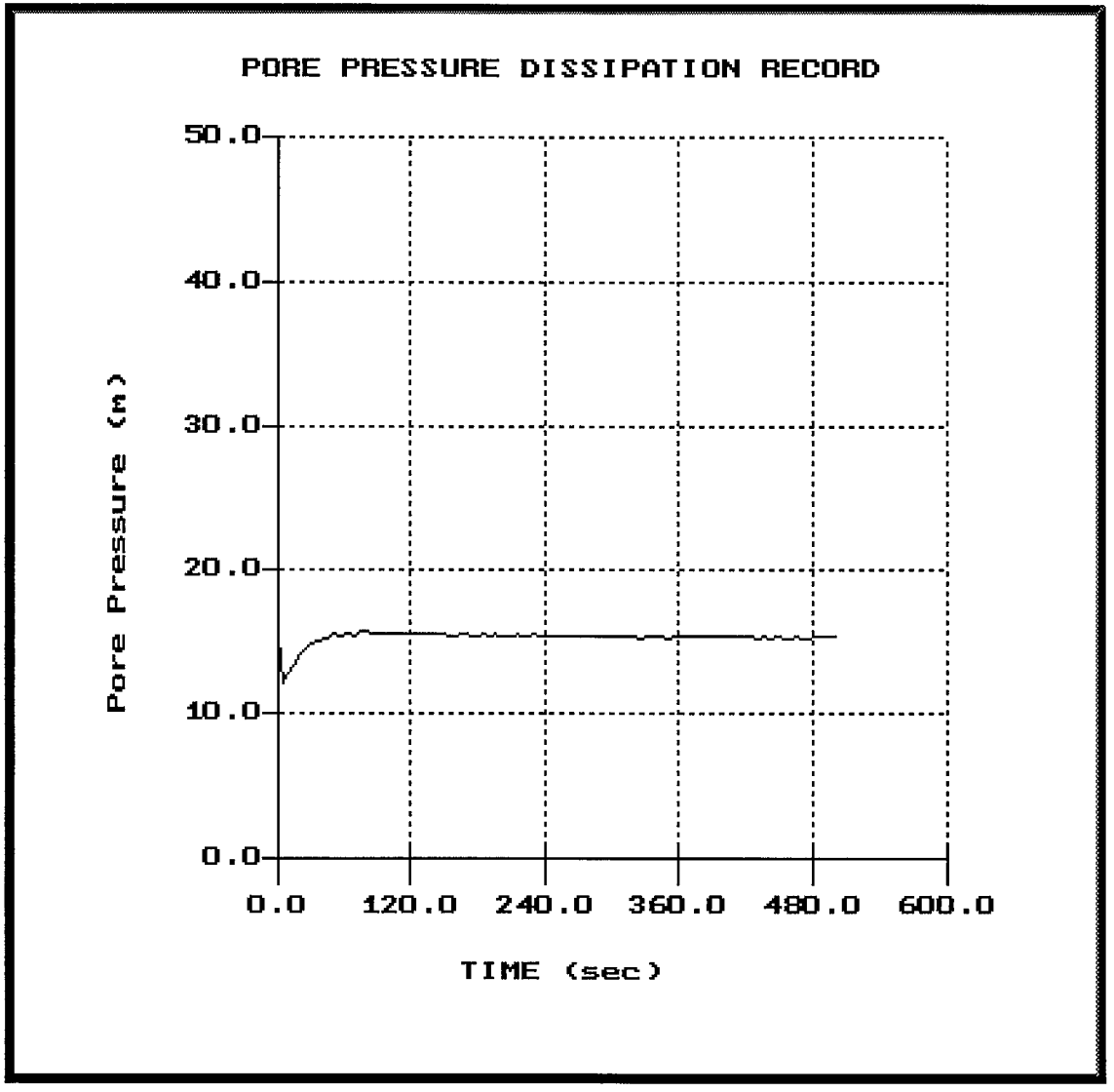


Golder

Hole:GCPT09-02B
Location:Esquimalt

Cone:227:T500F10U500
Date:10:21:09 18:15

File: 144CP02B.PPF
Depth (m): 1.40
(ft): 4.59
Duration : 500.0s
U-min: 11.91 5.0s
U-max: 15.58 75.0s

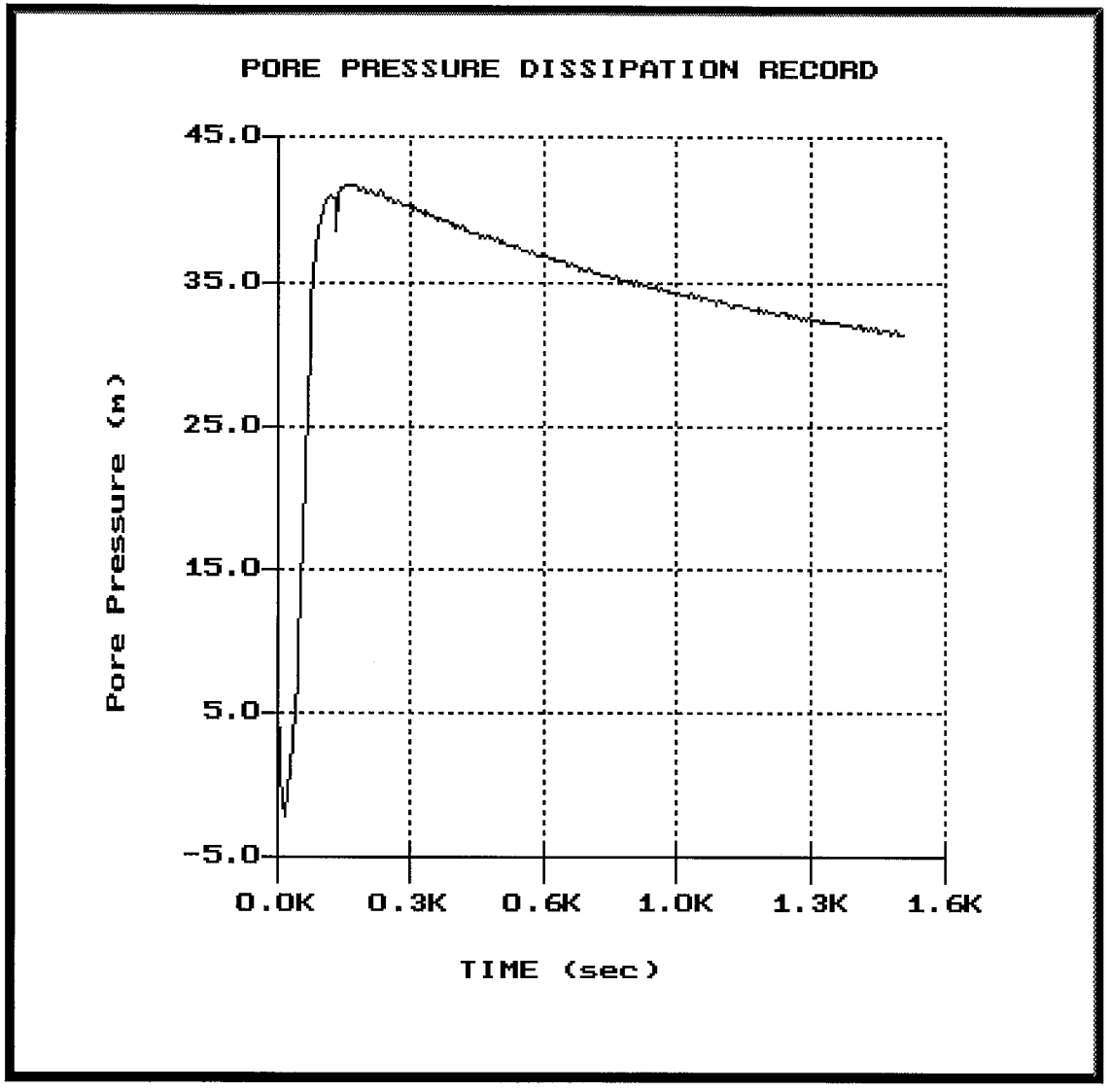


Golder

Hole:GCPT09-02B
Location:Esquimalt

Cone:227:T500F10U500
Date:10:21:09 18:15

File: 144CP02B.PPF
Depth (m): 12.85
(ft): 42.16
Duration : 1500.0s
U-min: -2.27 15.0s
U-max: 41.70 180.0s

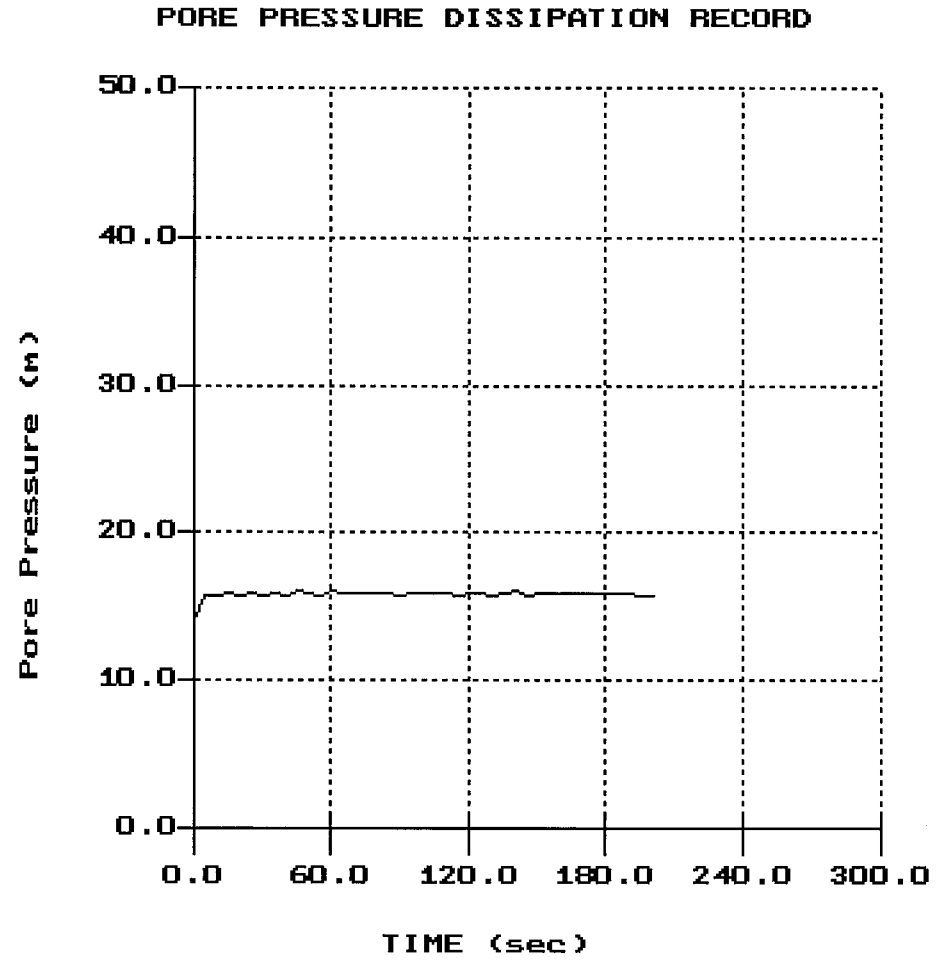


Golder

Hole:GCPT09-03
Location:Esquimalt

Cone:028:T1000F10U500
Date:11:12:09 11:13

File: 144CP03.PPF
Depth (m): 1.35
(ft): 4.43
Duration : 200.0s
U-min: 13.82 0.0s
U-max: 15.94 45.0s

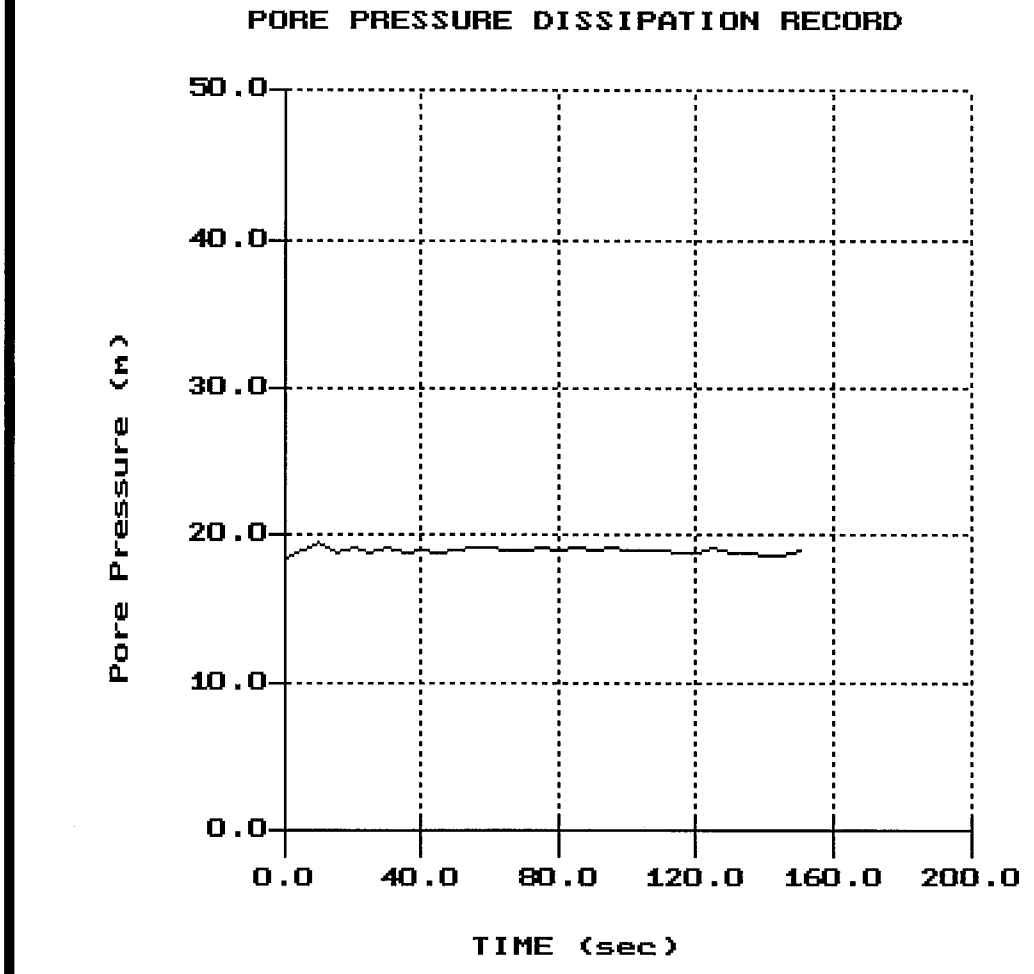


Golder

Hole:GCPT09-03
Location:Esquimalt

Cone:028:T1000F10U500
Date:11:12:09 11:13

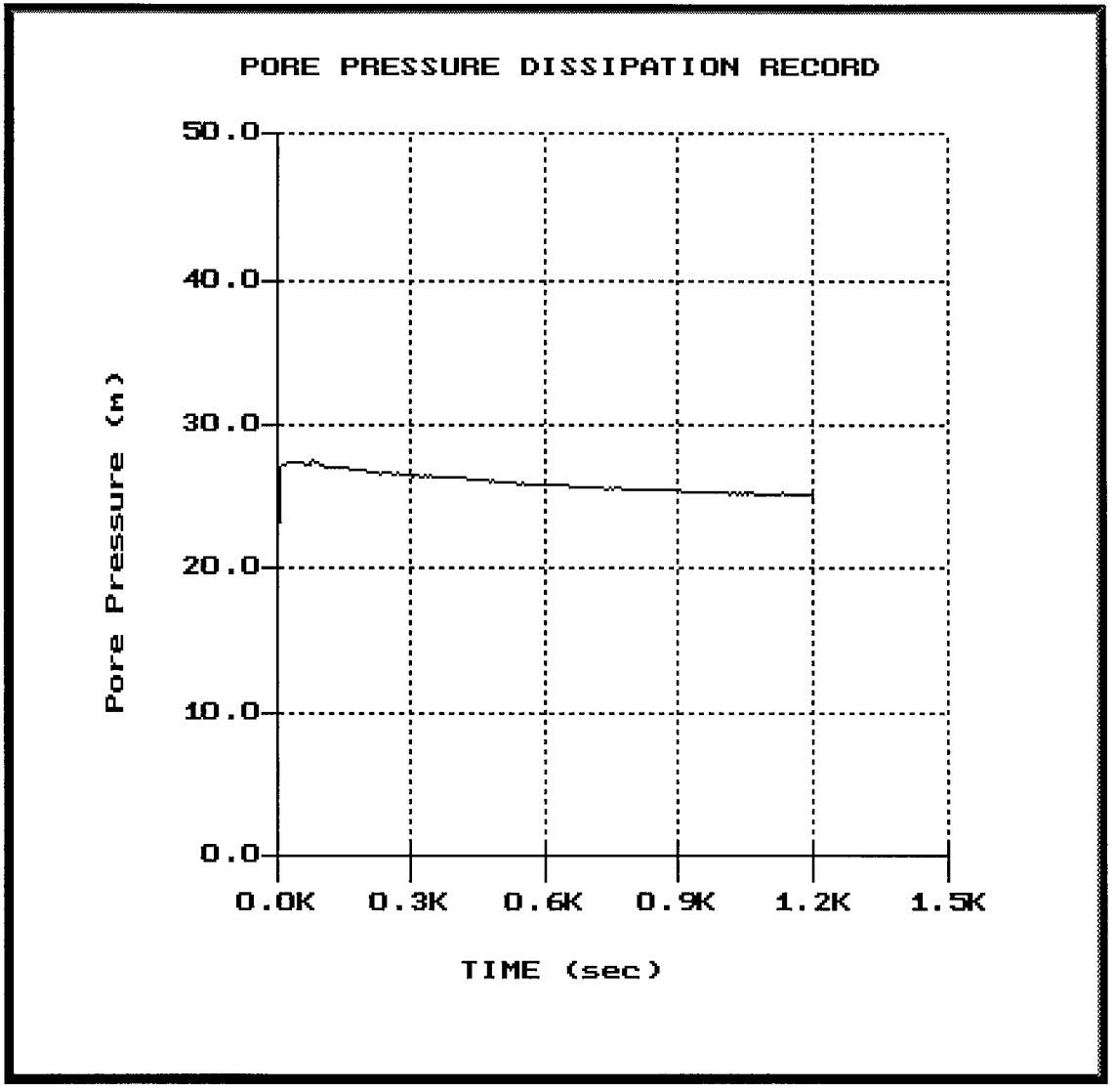
File: 144CP03.PPF
Depth (m): 3.40
(ft): 11.15
Duration : 150.0s
U-min: 18.32 0.0s
U-max: 19.40 10.0s



Golder

Hole:GCPT09-03
Location:Esquimalt

Cone:028:T1000F10U500
Date:11:12:09 11:13



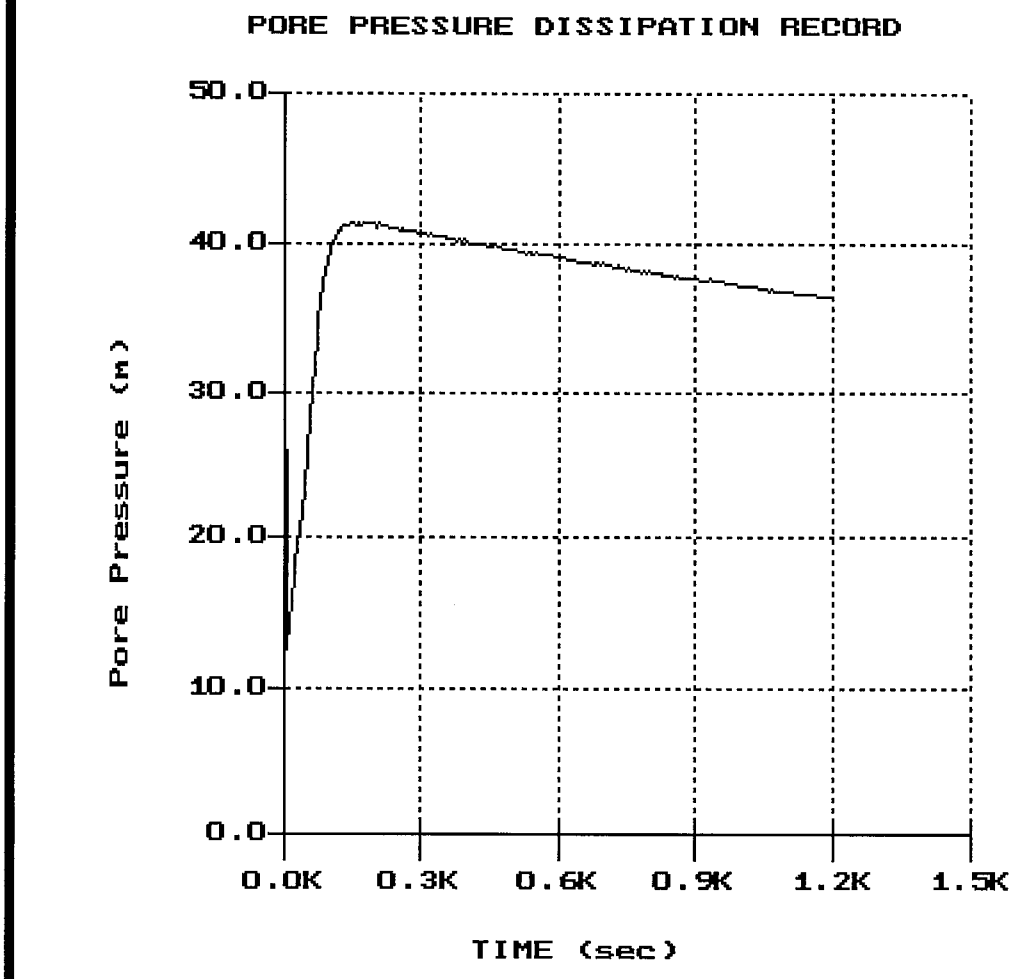
File: 144CP03.PPF
Depth (m): 8.50
(ft): 27.89
Duration : 1200.0s
U-min: 19.03 0.0s
U-max: 27.43 80.0s

Golder

Hole:GCPT09-04
Location:Esquimalt

Cone:270:T500F10U500
Date:11:11:09 10:18

File: 144CP04.PPF
Depth (m): 8.90
(ft): 29.20
Duration : 1200.0s
U-min: 12.50 5.0s
U-max: 41.32 165.0s

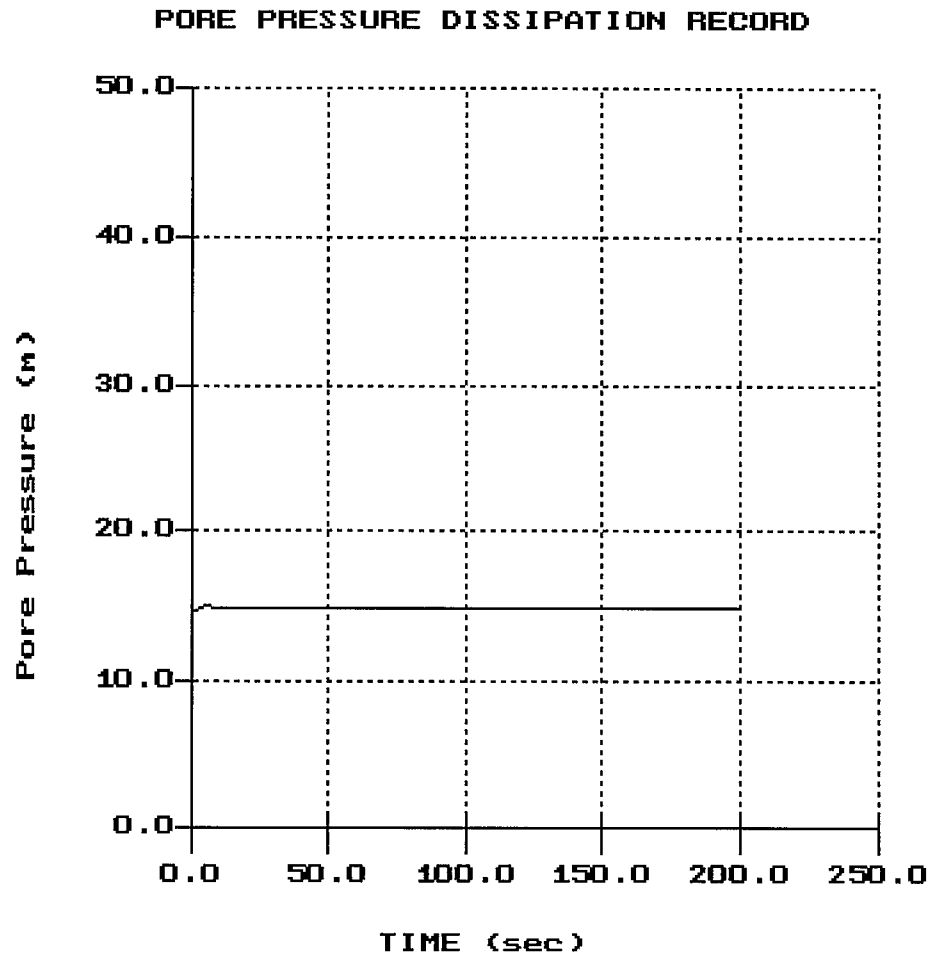


Golder

Hole:GCPT09-05
Location:Esquimalt

Cone:028:T1000F10U500
Date:11:12:09 18:06

File: 144CP05.PPF
Depth (m): 0.85
(ft): 2.79
Duration : 200.0s
U-min: 14.37 0.0s
U-max: 14.85 5.0s

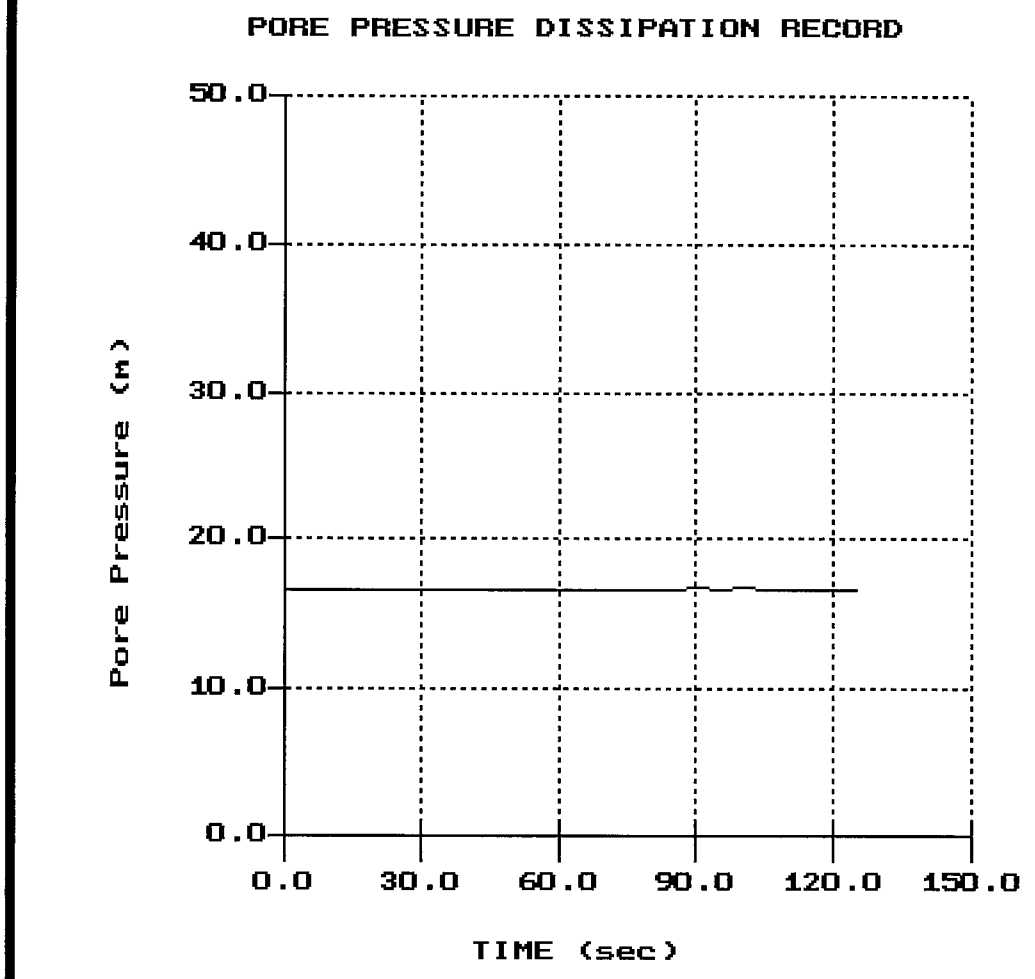


Golder

Hole:GCPT09-05
Location:Esquimalt

Cone:028:T1000F10U500
Date:11:12:09 18:06

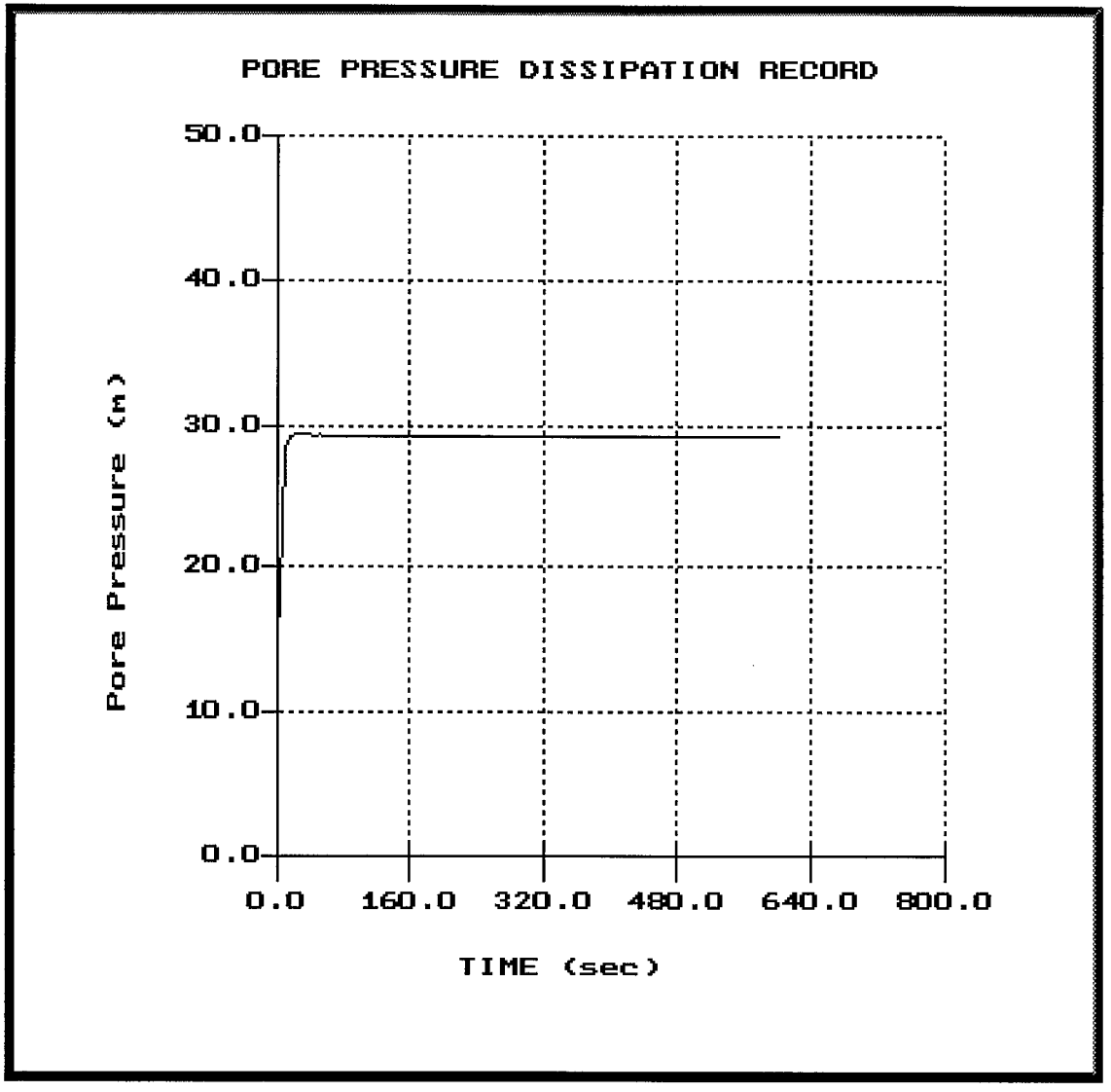
File: 144CP05.PPF
Depth (m): 3.10
(ft): 10.17
Duration : 125.0s
U-min: 16.42 95.0s
U-max: 16.64 90.0s



Golder

Hole:GCPT09-05
Location:Esquimalt

Cone:028:T1000F10U500
Date:11:12:09 18:06

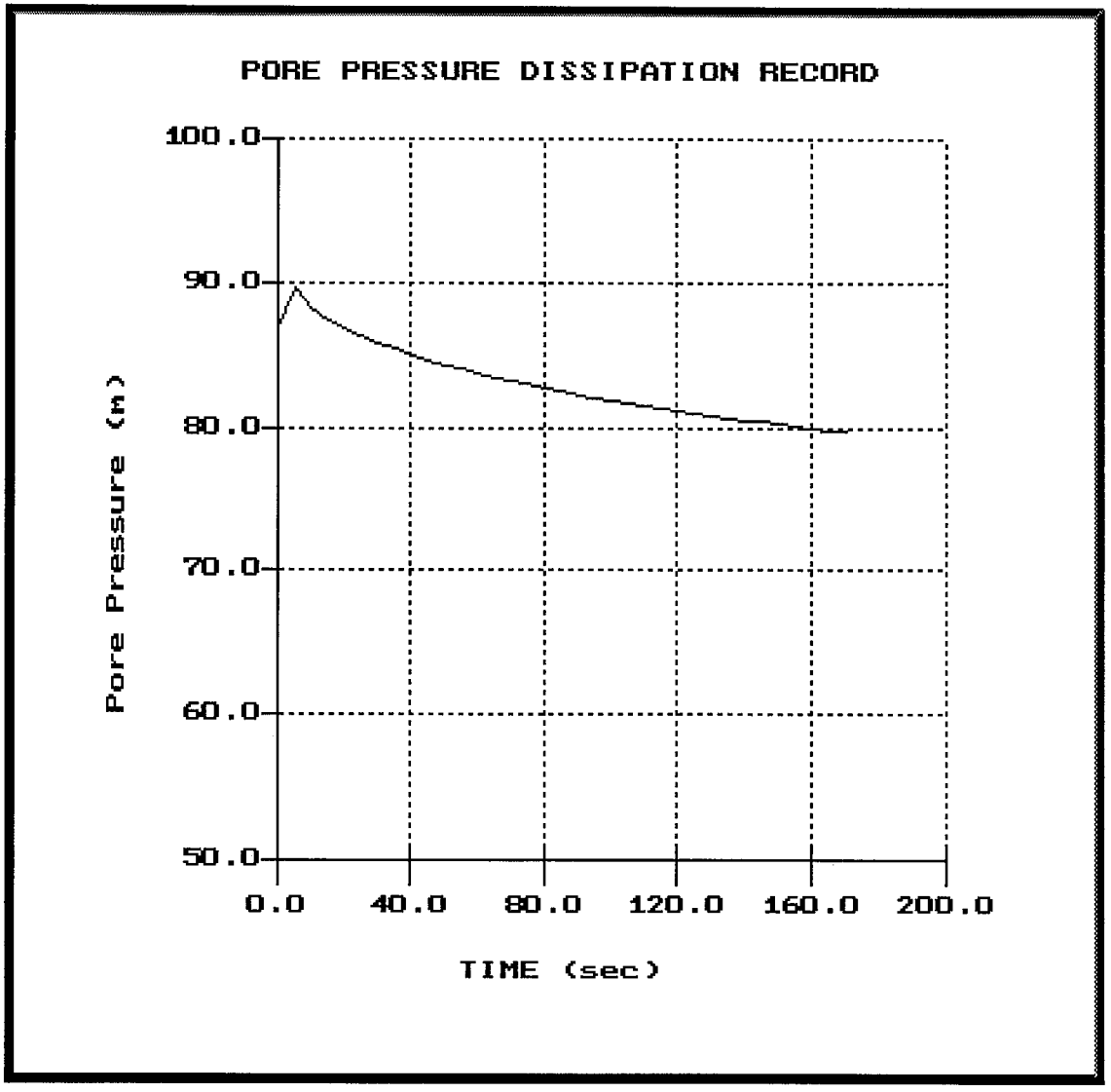


File: 144CP05.PPF
Depth (m): 15.40
(ft): 50.52
Duration : 600.0s
U-min: 14.21 0.0s
U-max: 29.34 25.0s

Golder

Hole:GCPT09-06
Location:Esquimalt

Cone:270:T500F10U500
Date:11:10:09 16:52



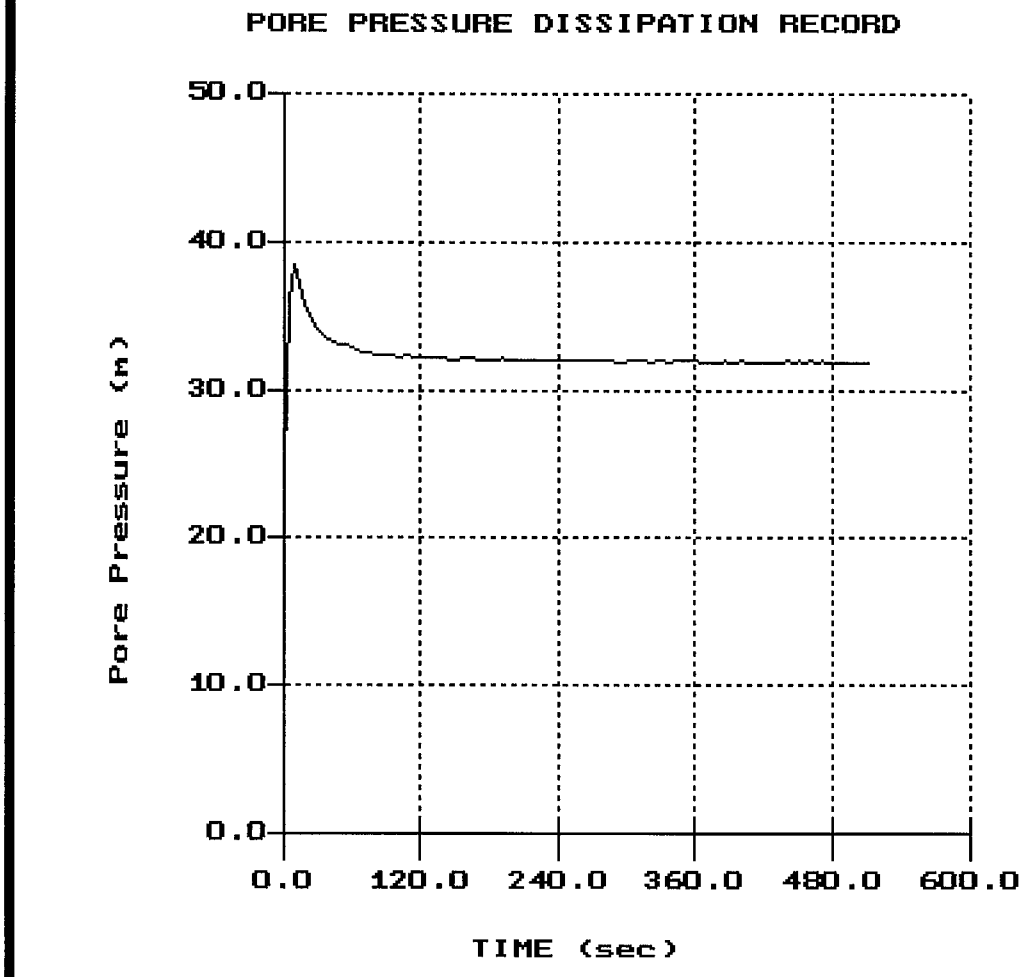
File: 144CP06.PPF
Depth (m): 14.25
(ft): 46.75
Duration : 170.0s
U-min: 79.67 170.0s
U-max: 89.67 5.0s

Golder

Hole:GCPT09-06
Location:Esquimalt

Cone:270:T500F10U500
Date:11:10:09 16:52

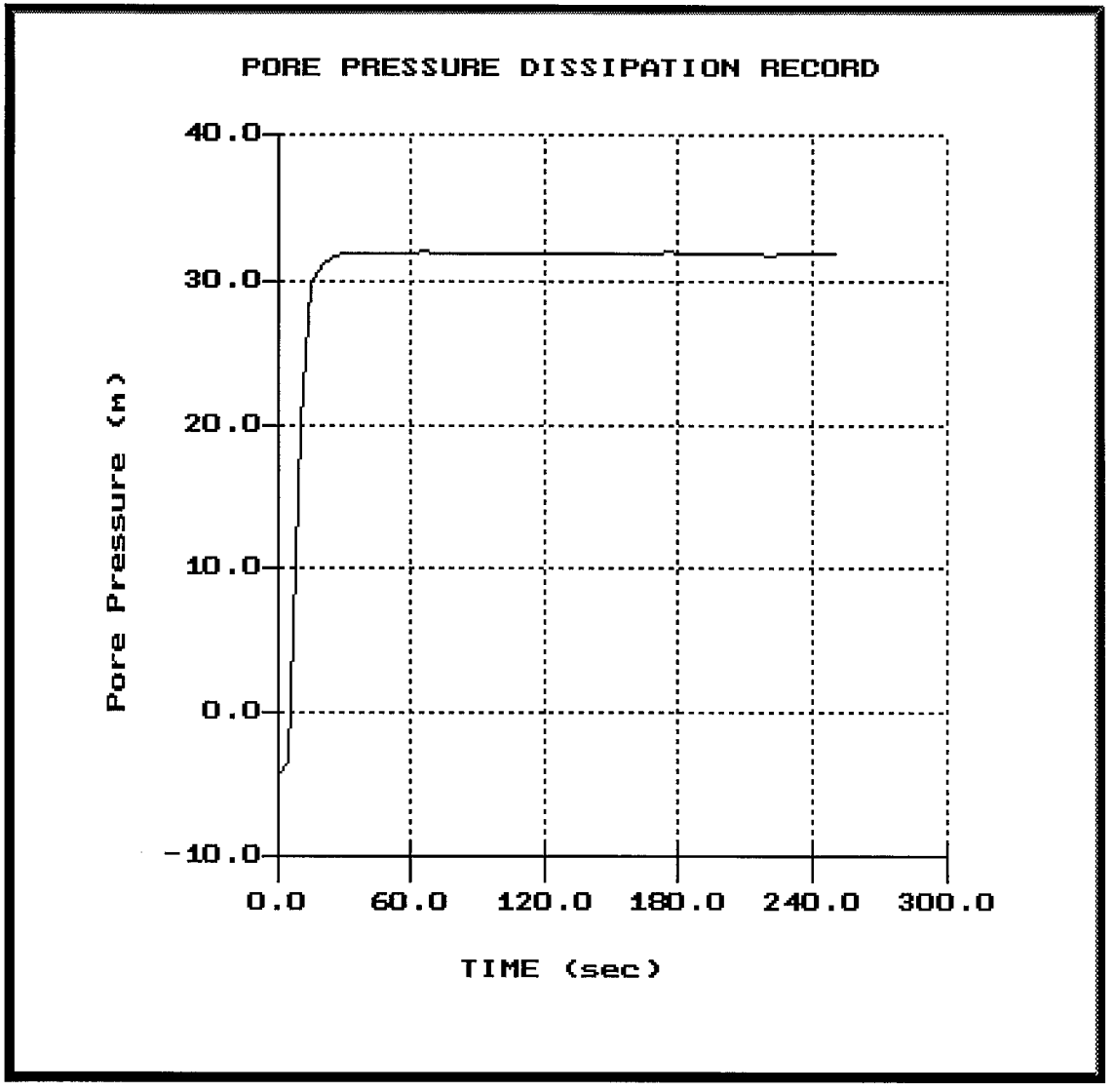
File: 144CP06.PPF
Depth (m): 15.85
(ft): 52.00
Duration : 510.0s
U-min: 24.15 0.0s
U-max: 38.33 10.0s



Golder

Hole:GCPT09-06
Location:Esquimalt

Cone:270:T500F10U500
Date:11:10:09 16:52

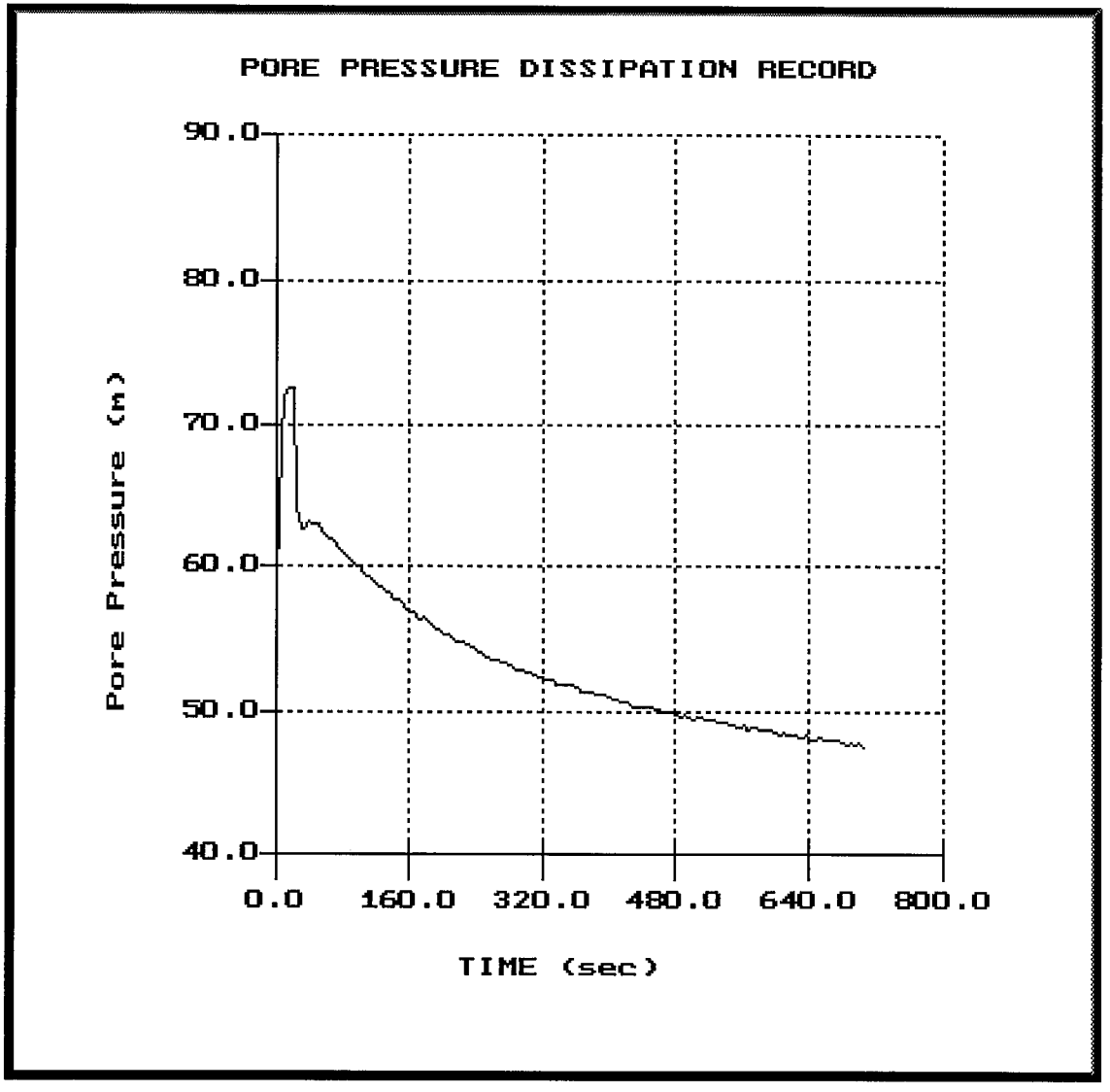


File: 144CP06.PPF
Depth (m): 16.00
(ft): 52.49
Duration : 250.0s
U-min: -4.38 0.0s
U-max: 31.99 175.0s

Golder

Hole:GCPT09-08B
Location:Esquimalt

Cone:270:T500F10U500
Date:10:30:09 14:41



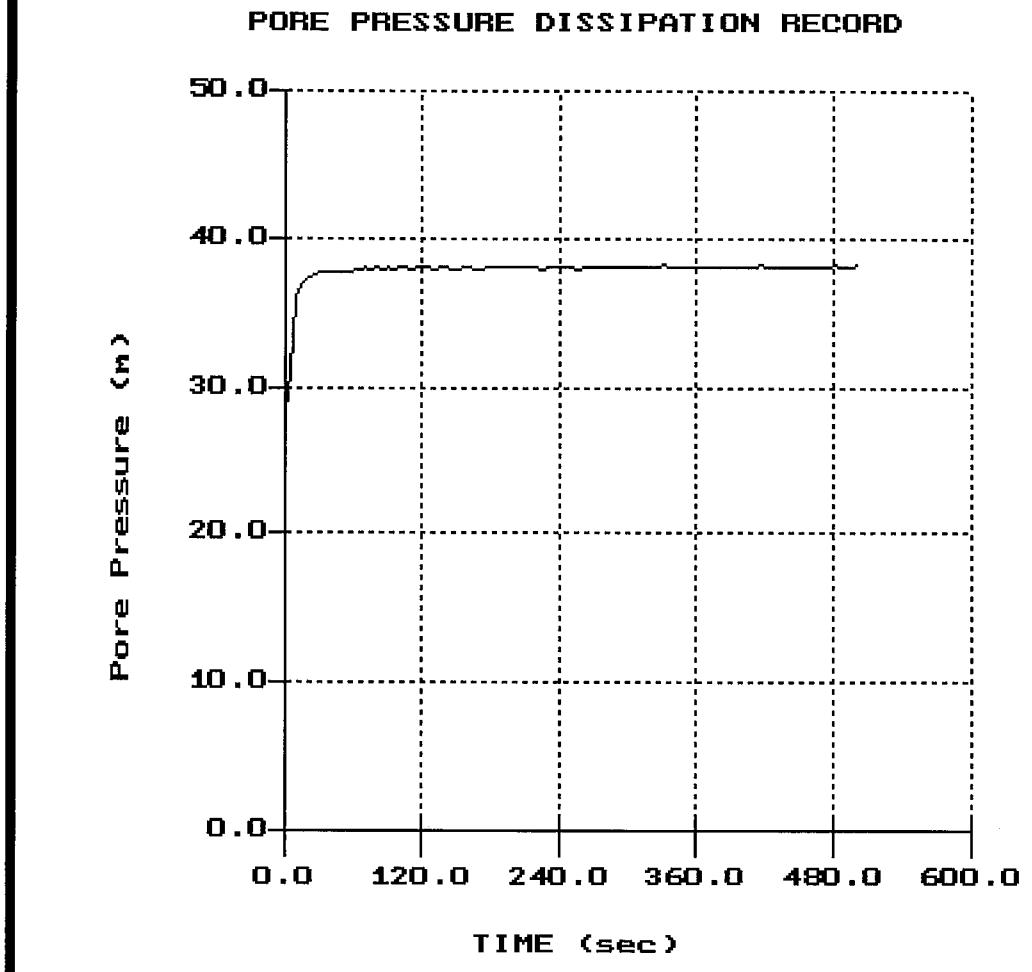
File: 144CP08B.PPF
Depth (m): 26.85
(ft): 88.09
Duration : 705.0s
U-min: 47.55 705.0s
U-max: 72.52 15.0s

Golder

Hole:GCPT09-09B
Location:Esquimalt

Cone:270:T500F10U500
Date:11:03:09 08:26

File: 144CP09B.PPF
Depth (m): 24.45
(ft): 80.22
Duration : 500.0s
U-min: 28.20 0.0s
U-max: 38.14 500.0s

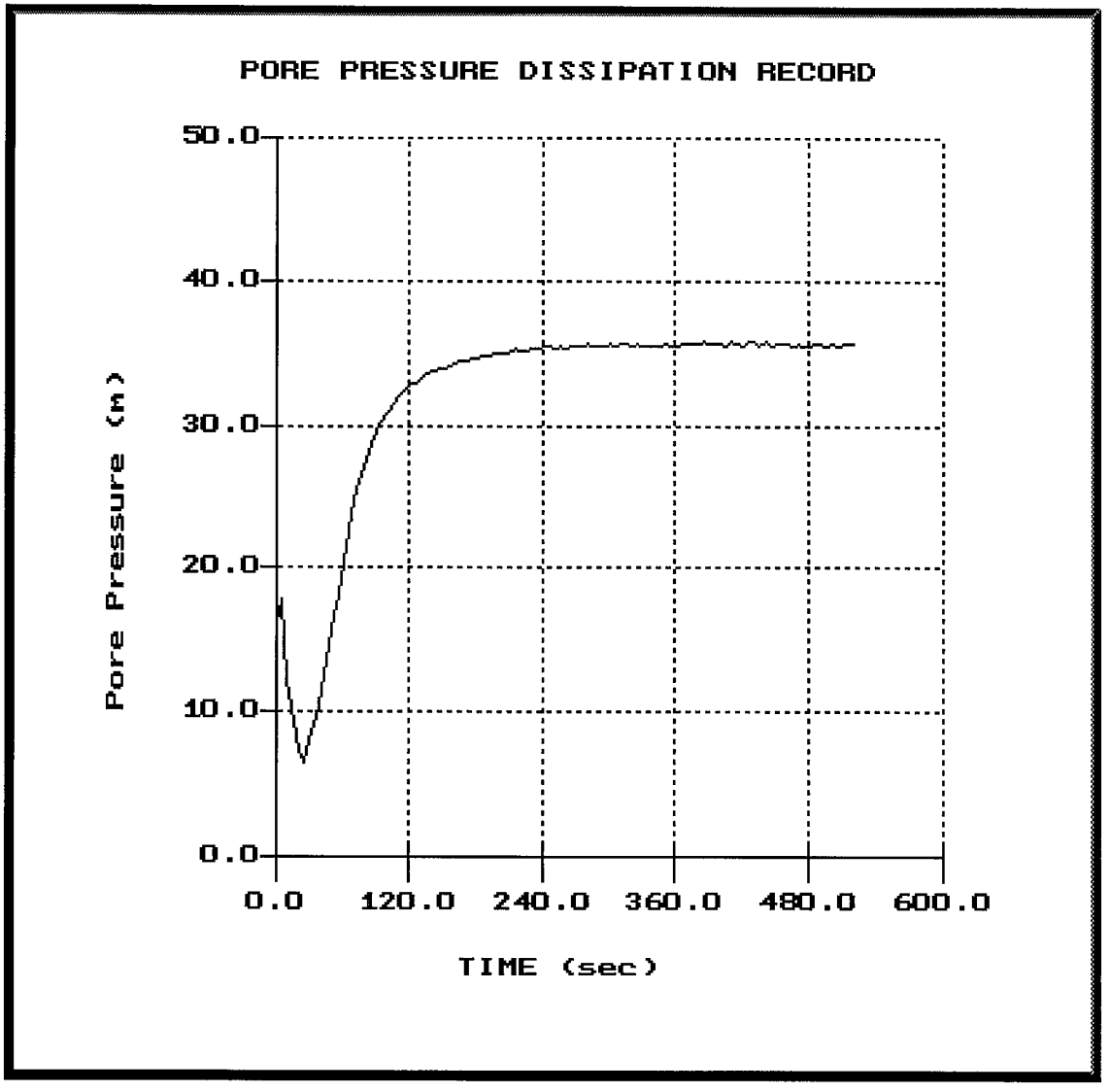


Golder

Hole:GCPT09-11
Location:Esquimalt

Cone:270:T500F10U500
Date:10:22:09 17:08

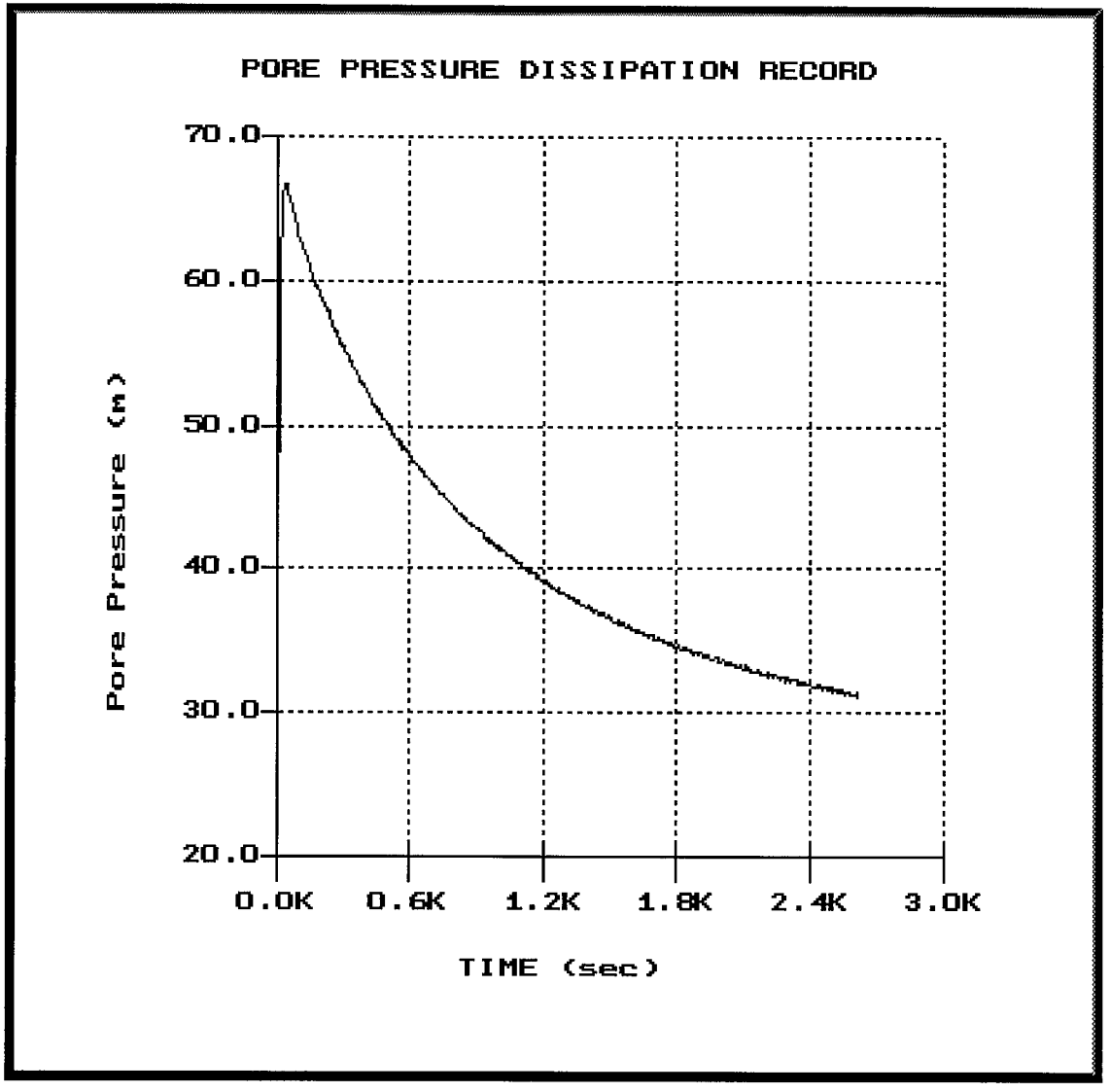
File: 144CP11.PPF
Depth (m): 12.75
(ft): 41.83
Duration : 520.0s
U-min: 6.49 25.0s
U-max: 35.73 430.0s



Golder

Hole:GCPT09-11
Location:Esquimalt

Cone:270:T500F10U500
Date:10:22:09 17:08

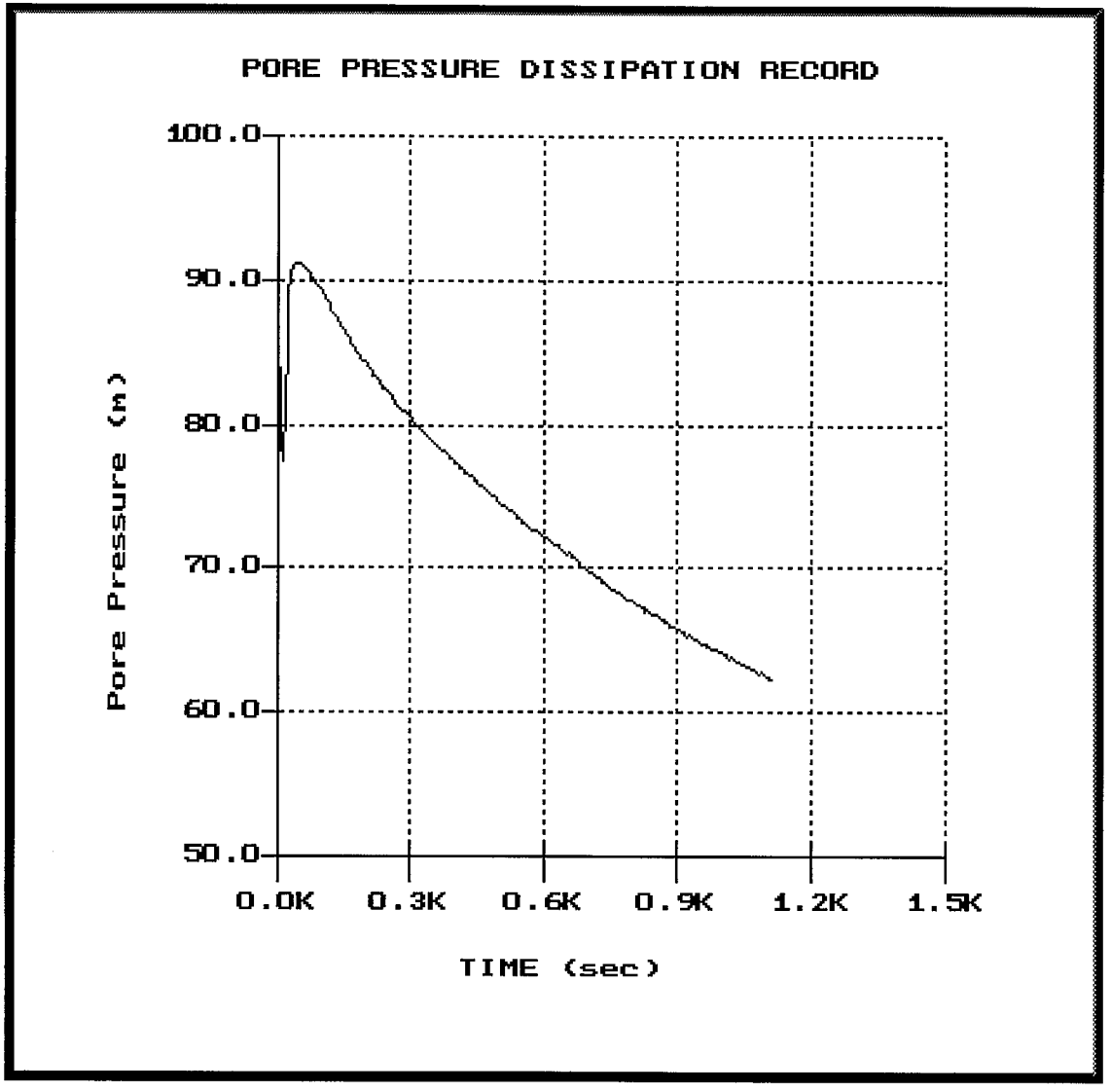


File: 144CP11.PPF
Depth (m): 14.20
(ft): 46.59
Duration : 2610.0s
U-min: 31.02 2610.0s
U-max: 66.74 40.0s

Golder

Hole:KCPT09-102
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 08:46

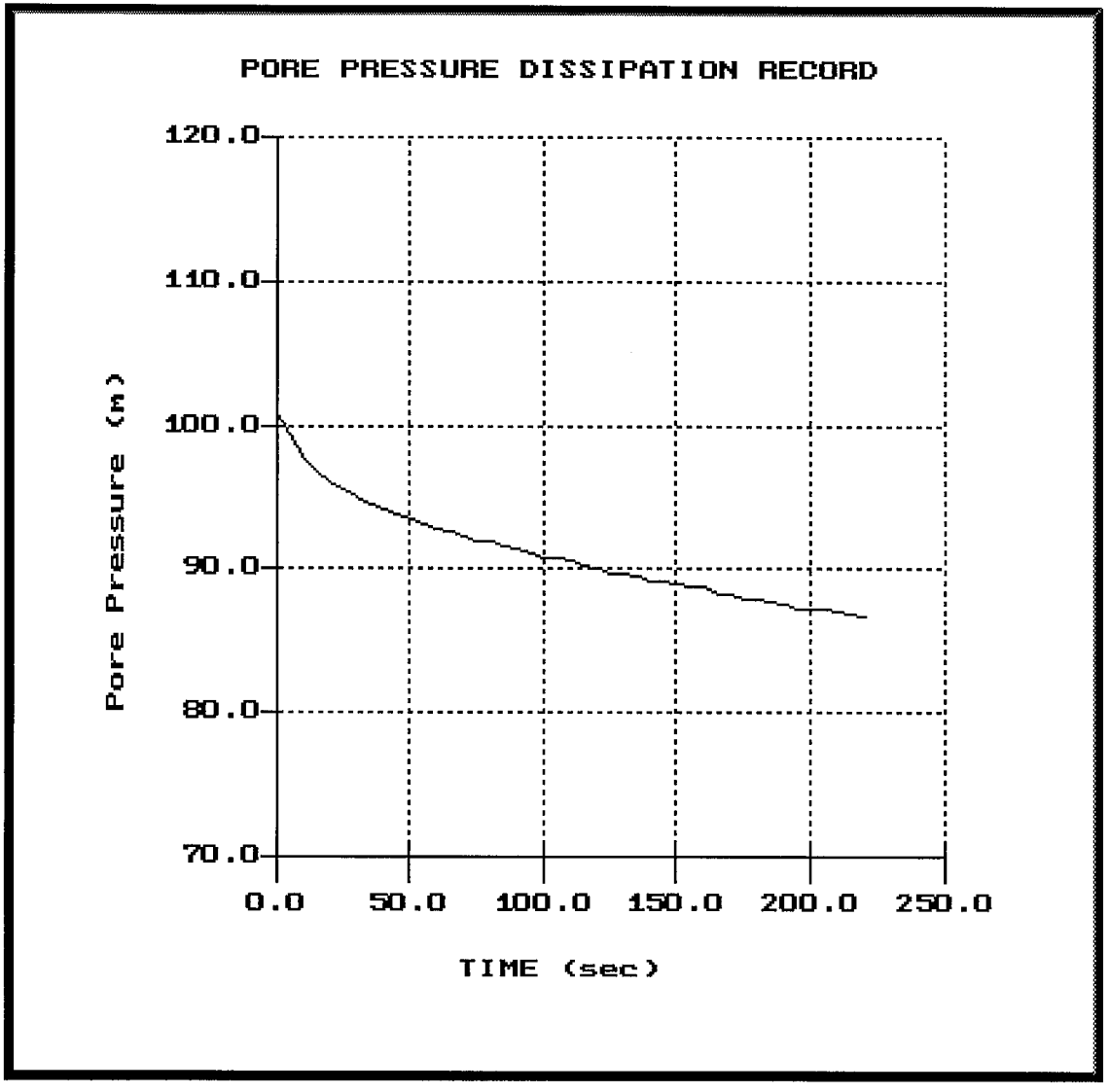


File: 144CP102.PPF
Depth (m): 14.65
(ft): 48.06
Duration : 1110.0s
U-min: 62.17 1105.0s
U-max: 91.23 45.0s

Golder

Hole:KCPT09-103
Location:Esquimalt

Cone:270:T500F10U500
Date:11:03:09 12:21



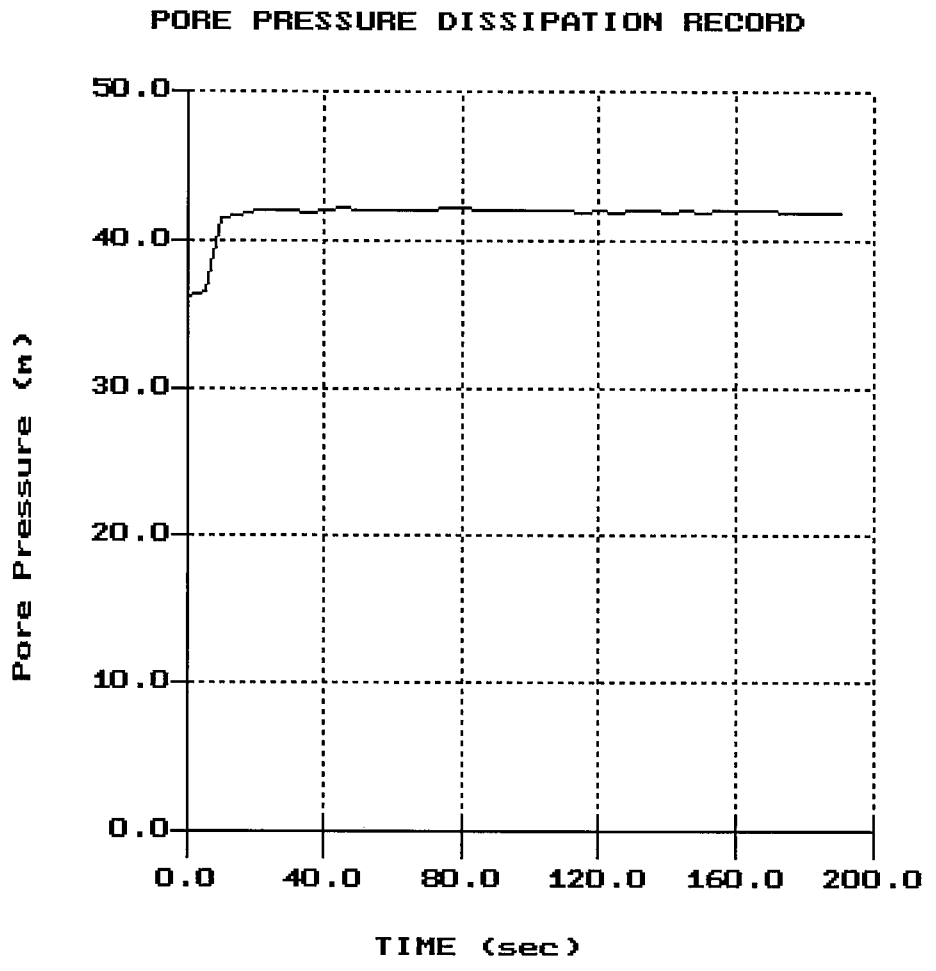
File: 144CP103.PPF
Depth (m): 20.05
(ft): 65.78
Duration : 220.0s
U-min: 86.60 220.0s
U-max: 100.79 0.0s

Golder

Hole:KCPT09-103
Location:Esquimalt

Cone:270:T500F10U500
Date:11:03:09 12:21

File: 144CP103.PPF
Depth (m): 27.10
(ft): 88.91
Duration : 190.0s
U-min: 36.11 0.0s
U-max: 42.14 45.0s

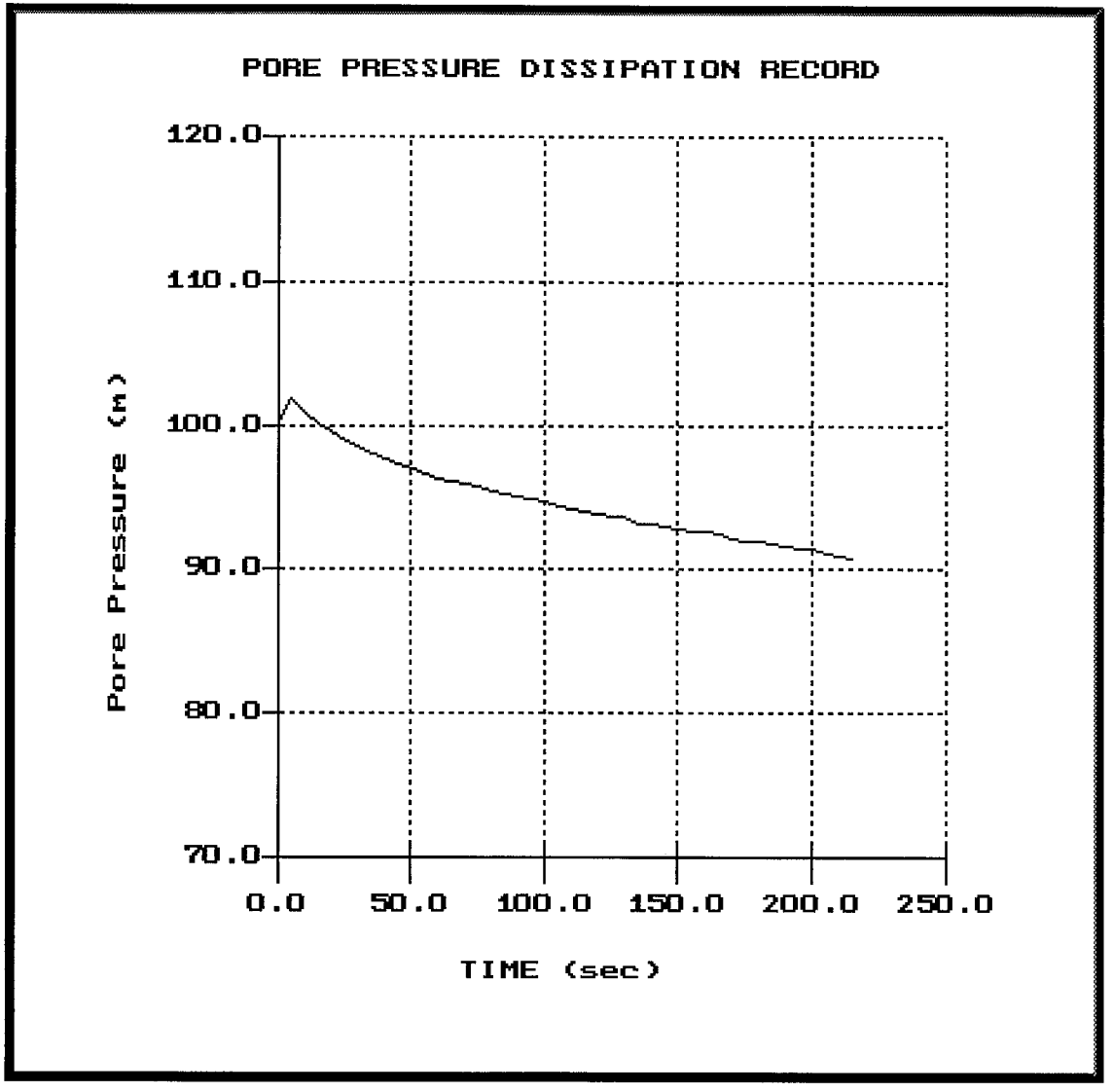


Golder

Hole:KCPT09-104
Location:Esquimalt

Cone:270:T500F10U500
Date:10:30:09 09:53

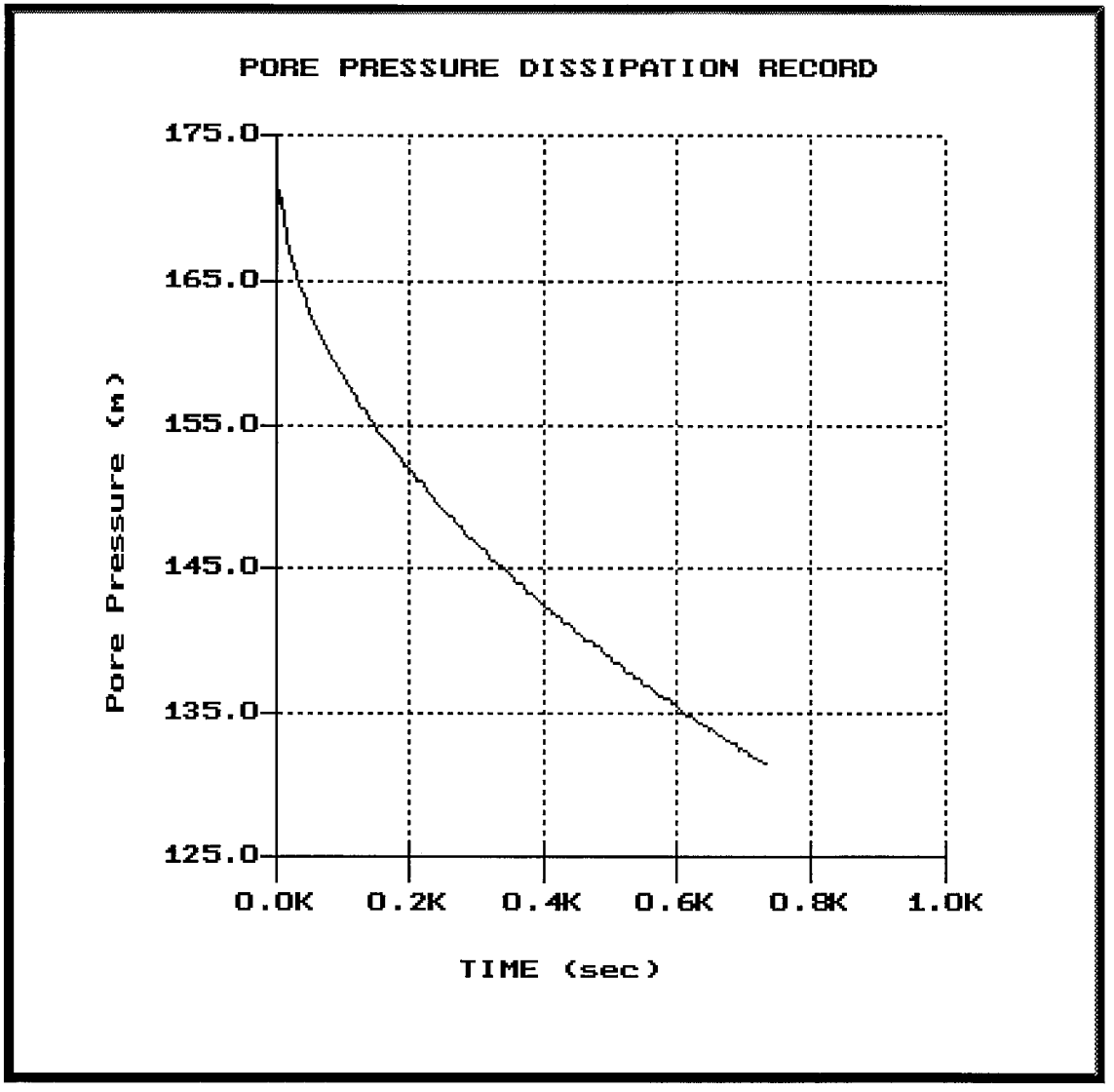
File: 144CP104.PPF
Depth (m): 20.40
(ft): 66.93
Duration : 215.0s
U-min: 90.73 215.0s
U-max: 101.72 5.0s



Golder

Hole:KCPT09-104
Location:Esquimalt

Cone:270:T500F10U500
Date:10:30:09 09:53

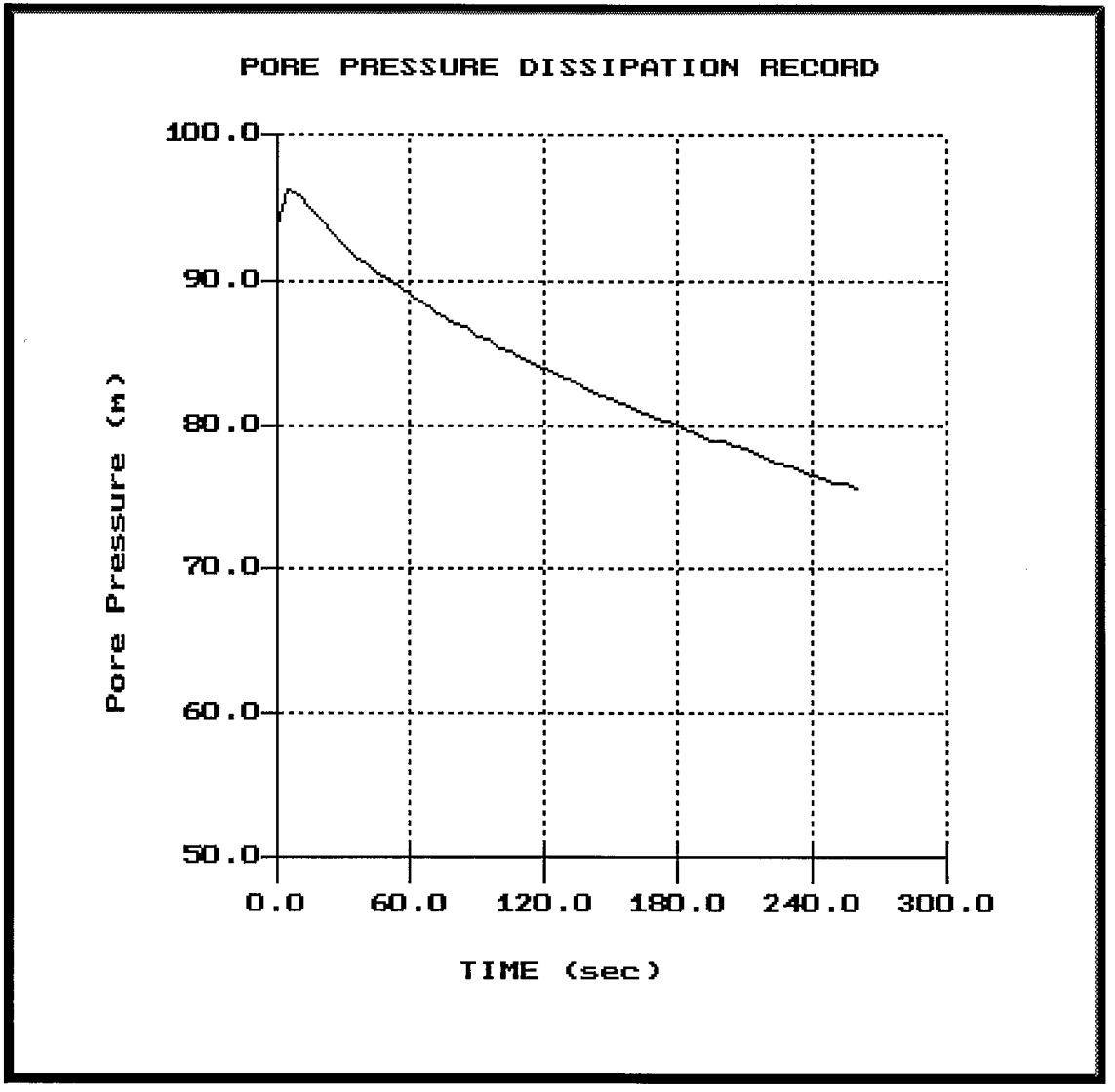


File: 144CP104.PPF
Depth (m): 40.35
(ft): 132.38
Duration : 730.0s
U-min: 131.49 730.0s
U-max: 171.25 5.0s

Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42



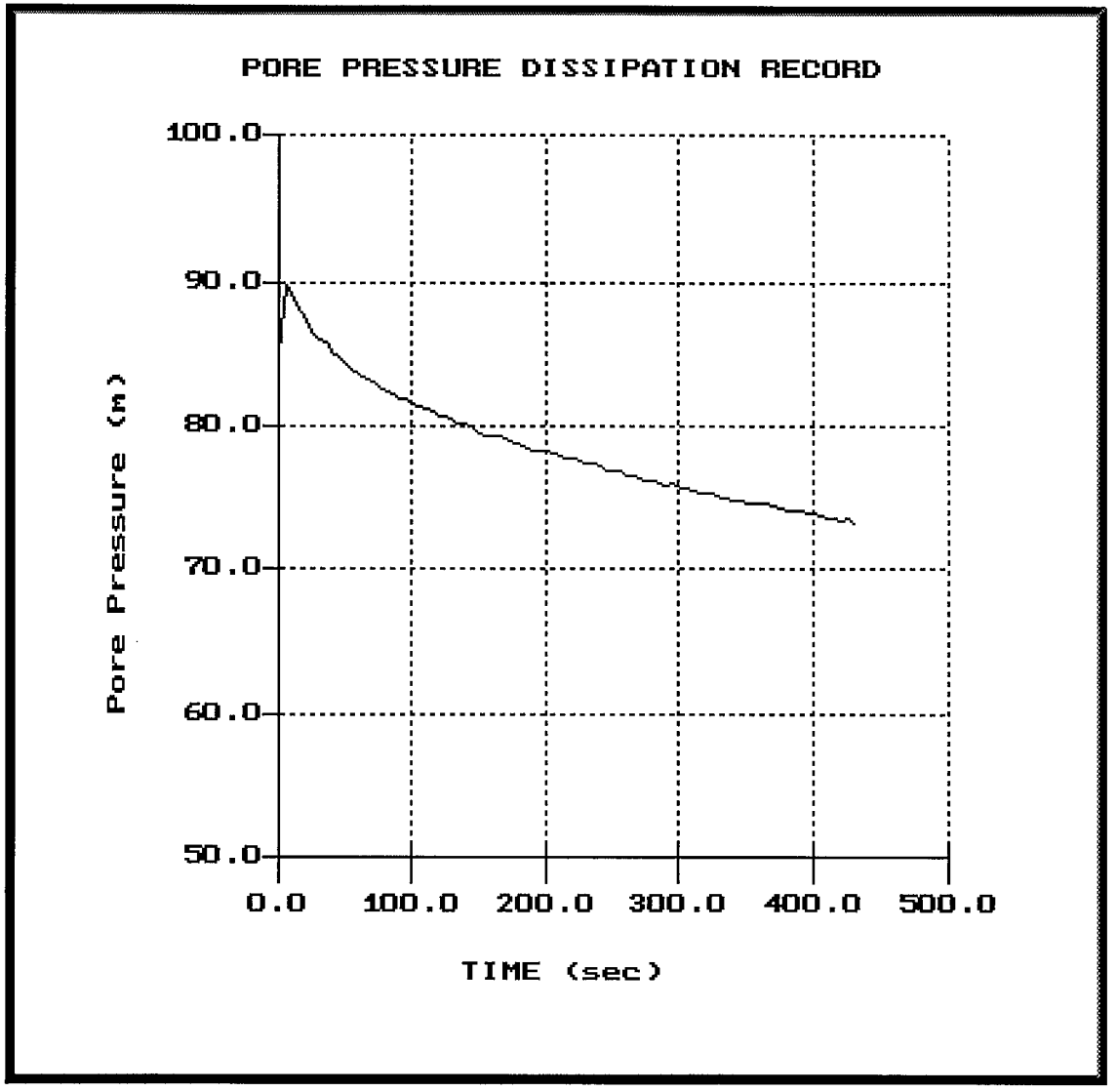
File: 144CP105.PPF
Depth (m): 10.80
(ft): 35.43
Duration : 260.0s
U-min: 75.46 260.0s
U-max: 96.19 5.0s

Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42

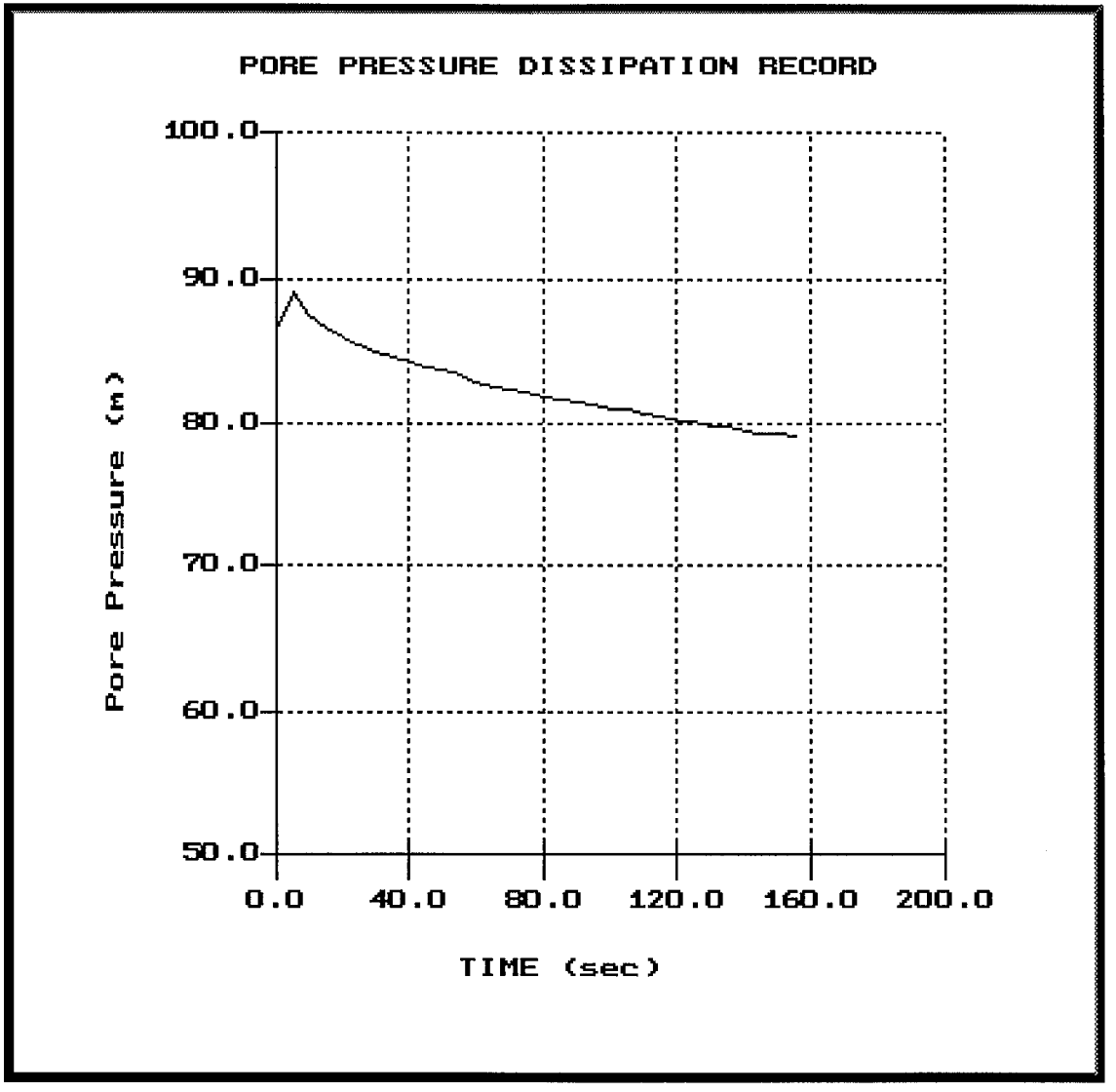
File: 144CP105.PPF
Depth (m): 13.30
(ft): 43.64
Duration : 430.0s
U-min: 73.16 430.0s
U-max: 89.84 5.0s



Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42



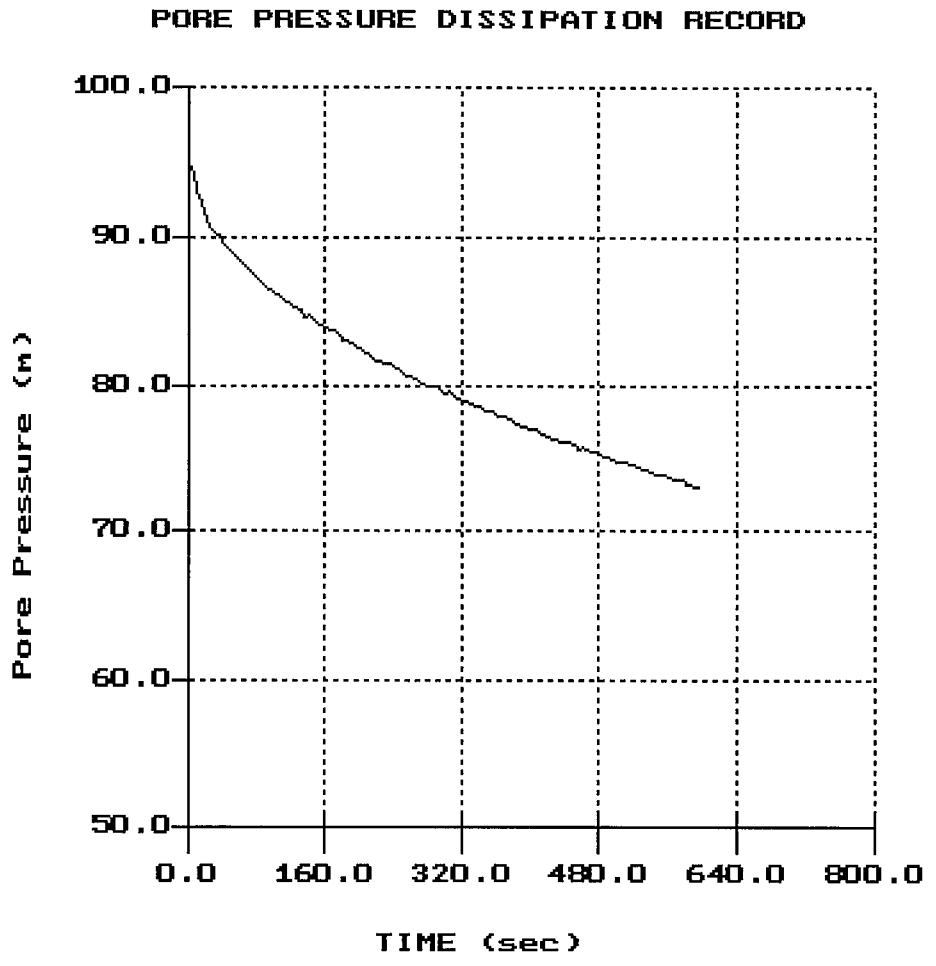
File: 144CP105.PPF
Depth (m): 14.75
(ft): 48.39
Duration : 155.0s
U-min: 78.99 155.0s
U-max: 88.99 5.0s

Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42

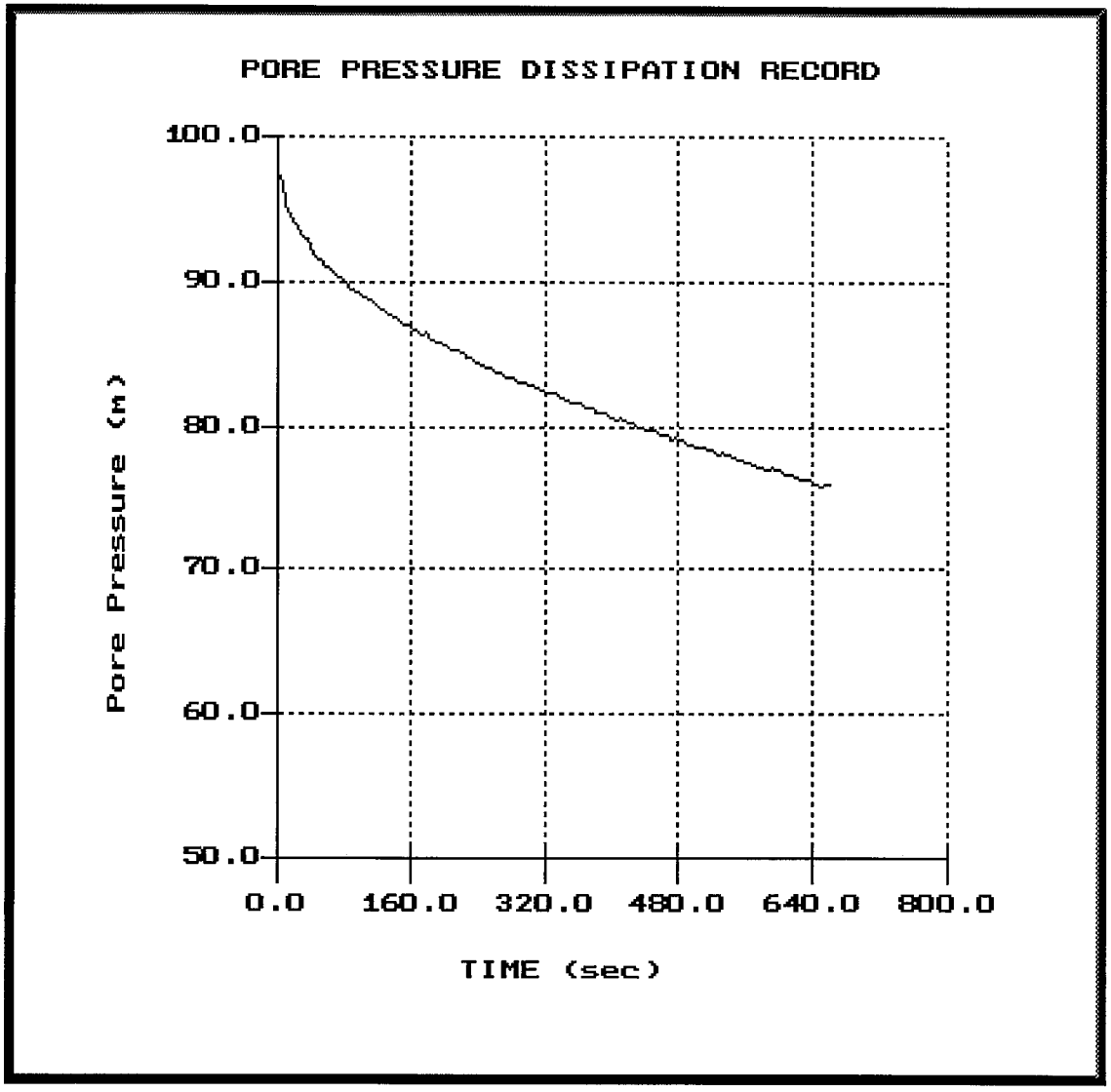
File: 144CP105.PPF
Depth (m): 18.75
(ft): 61.52
Duration : 595.0s
U-min: 72.86 595.0s
U-max: 94.83 0.0s



Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42



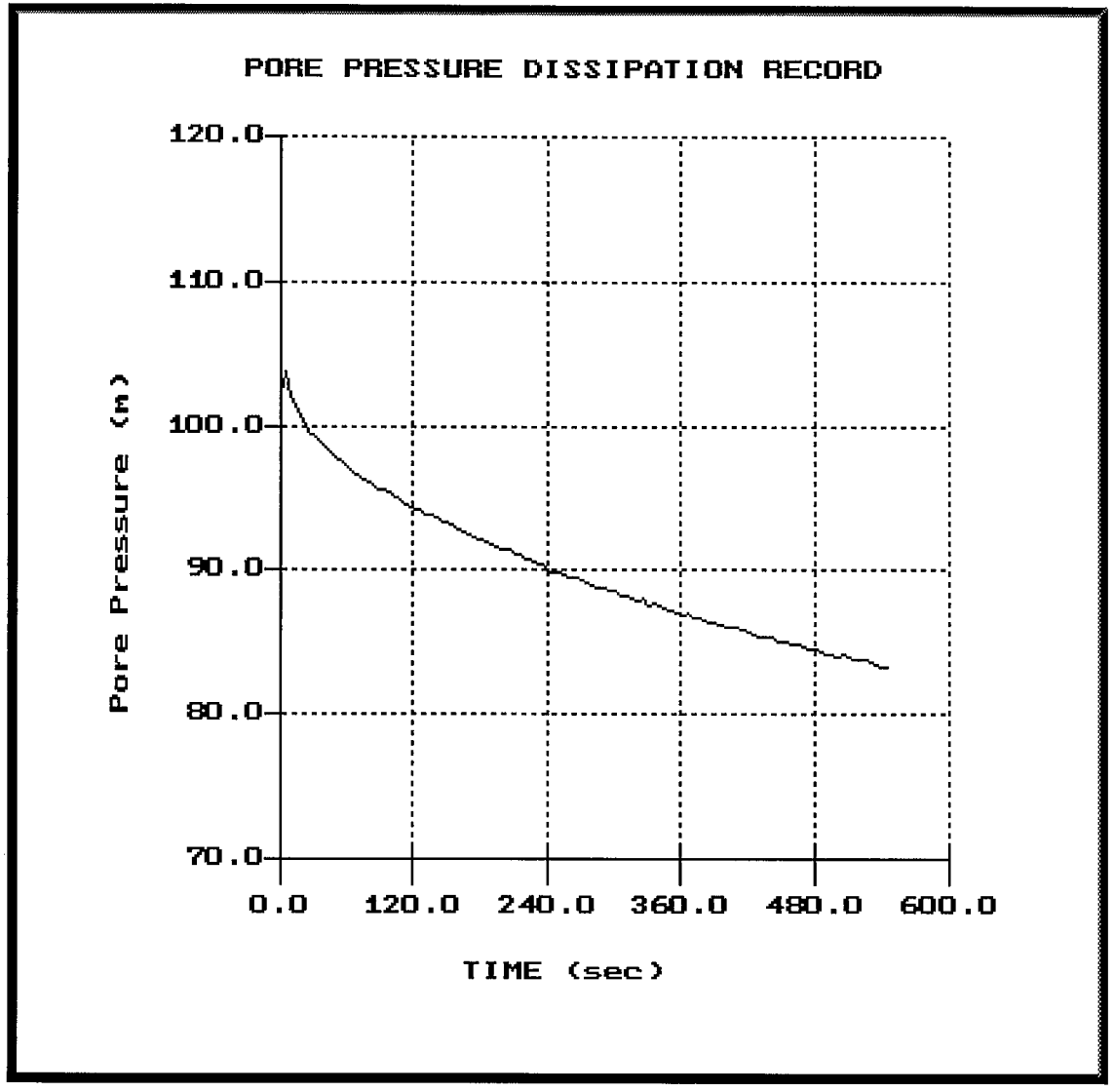
File: 144CP105.PPF
Depth (m): 19.80
(ft): 64.96
Duration : 660.0s
U-min: 75.77 650.0s
U-max: 97.63 0.0s

Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42

File: 144CP105.PPF
Depth (m): 22.80
(ft): 74.80
Duration : 545.0s
U-min: 83.13 540.0s
U-max: 103.75 5.0s

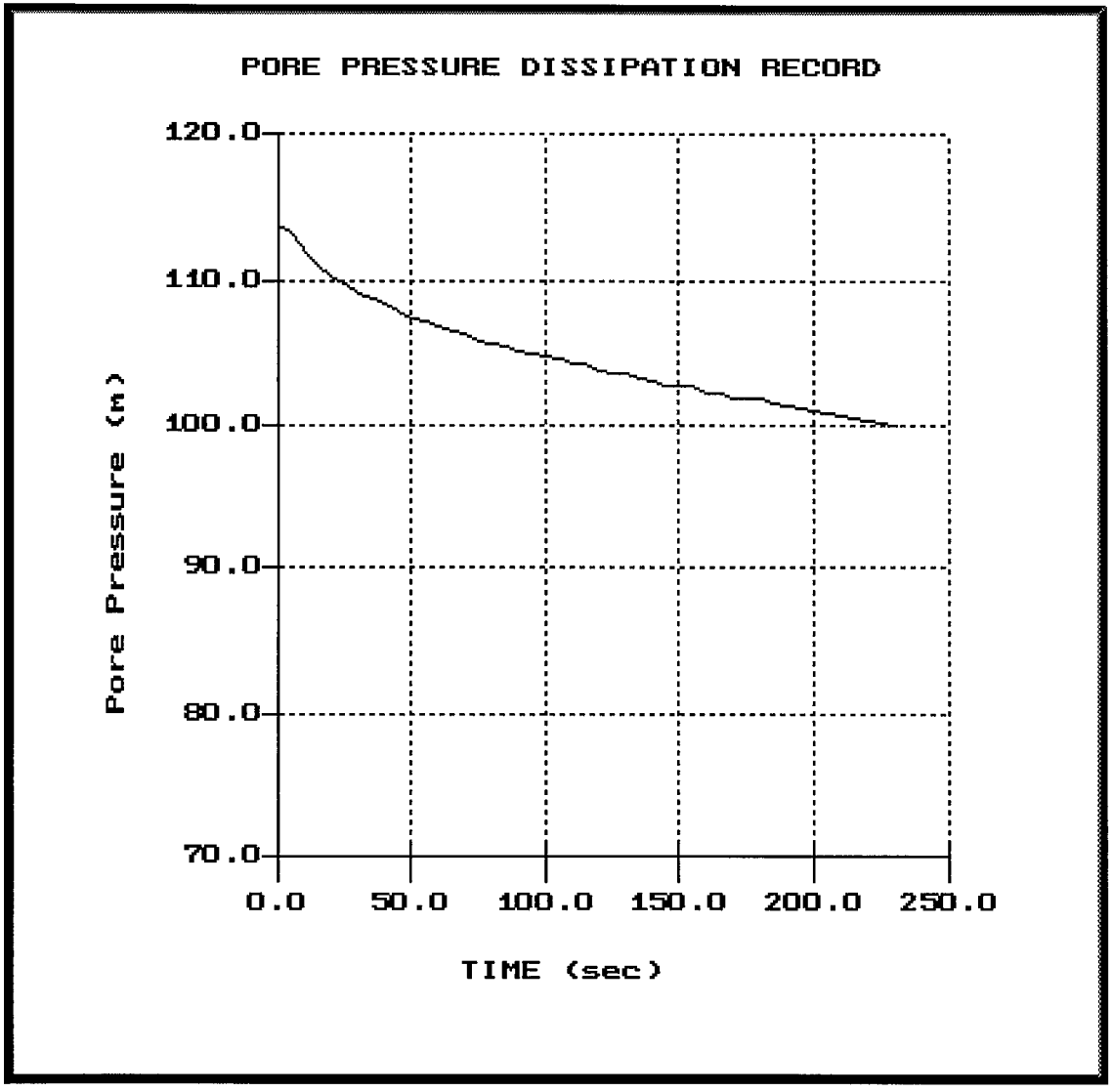


Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42

File: 144CP105.PPF
Depth (m): 25.30
(ft): 83.01
Duration : 230.0s
U-min: 99.84 230.0s
U-max: 113.76 0.0s

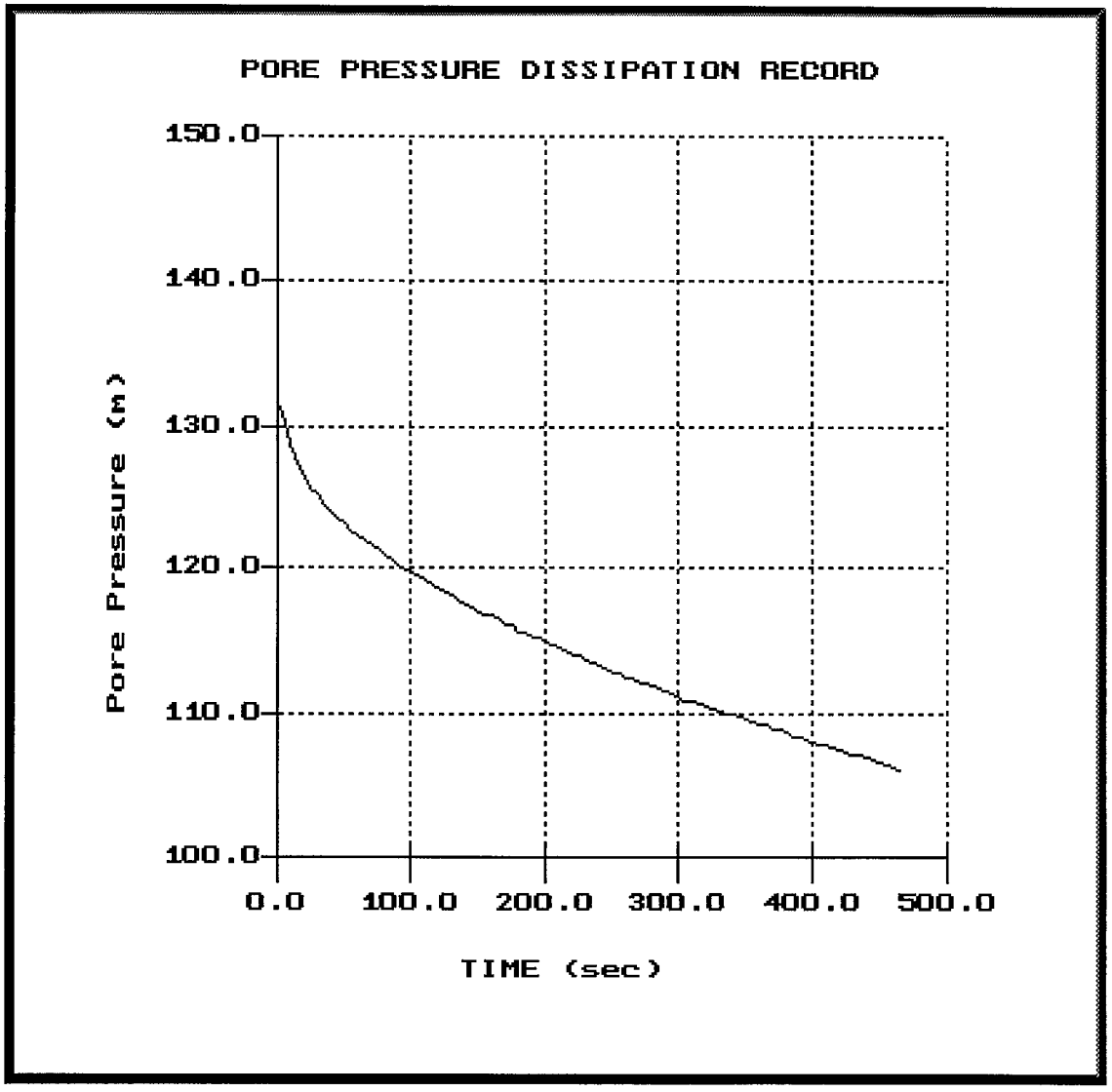


Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42

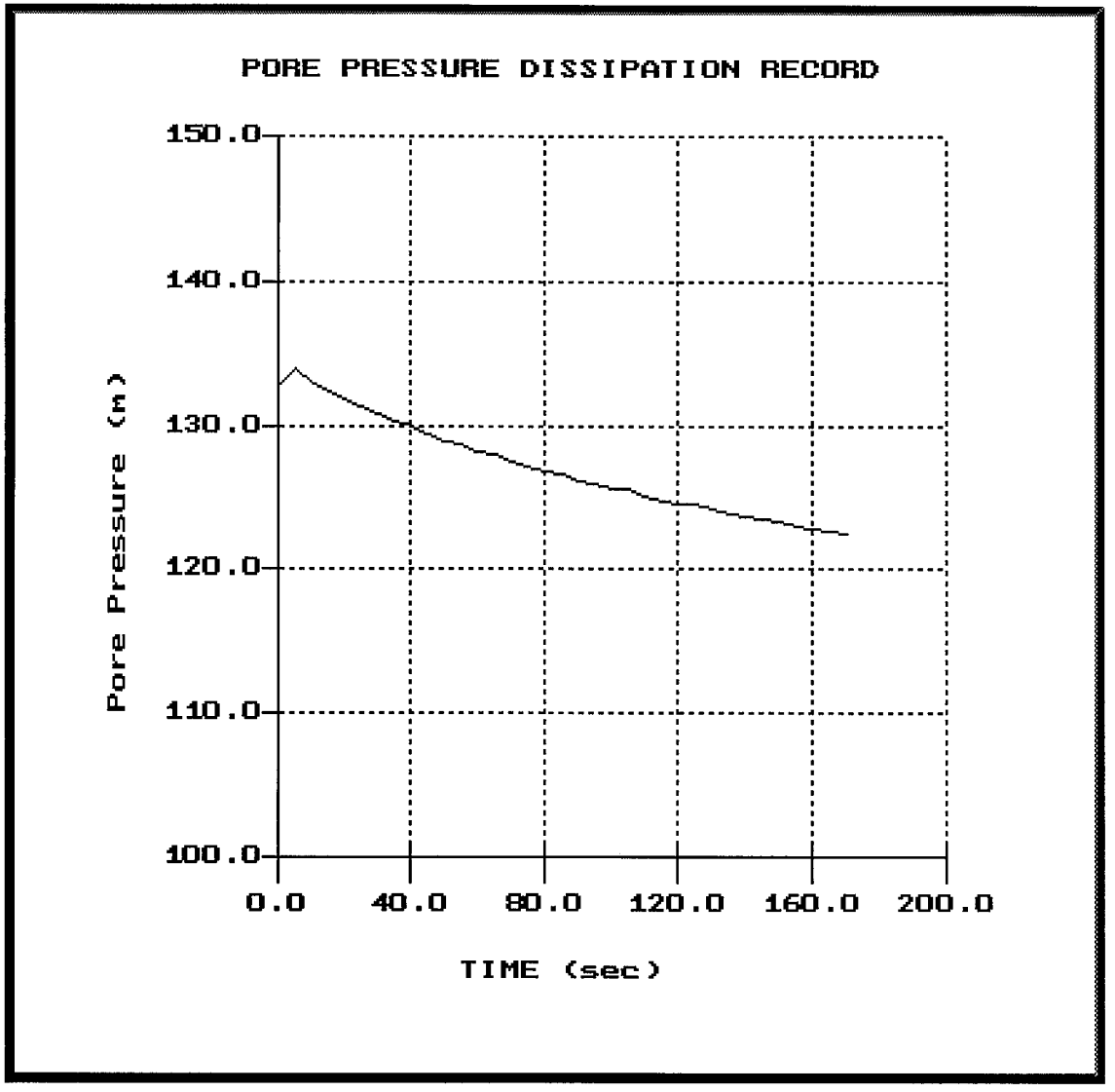
File: 144CP105.PPF
Depth (m): 29.85
(ft): 97.93
Duration : 465.0s
U-min: 106.11 465.0s
U-max: 131.52 0.0s



Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42



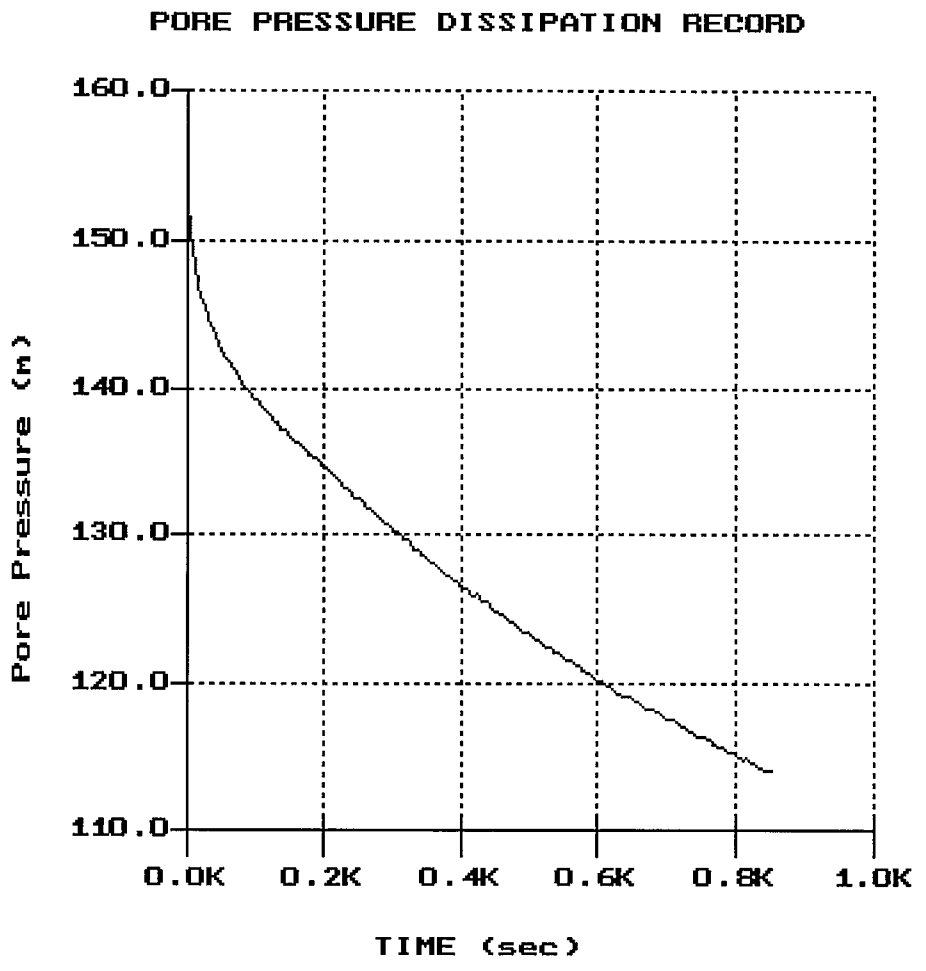
File: 144CP105.PPF
Depth (m): 31.85
(ft): 104.49
Duration : 170.0s
U-min: 122.38 170.0s
U-max: 133.82 5.0s

Golder

Hole:KCPT09-105
Location:Esquimalt

Cone:270:T500F10U500
Date:10:29:09 13:42

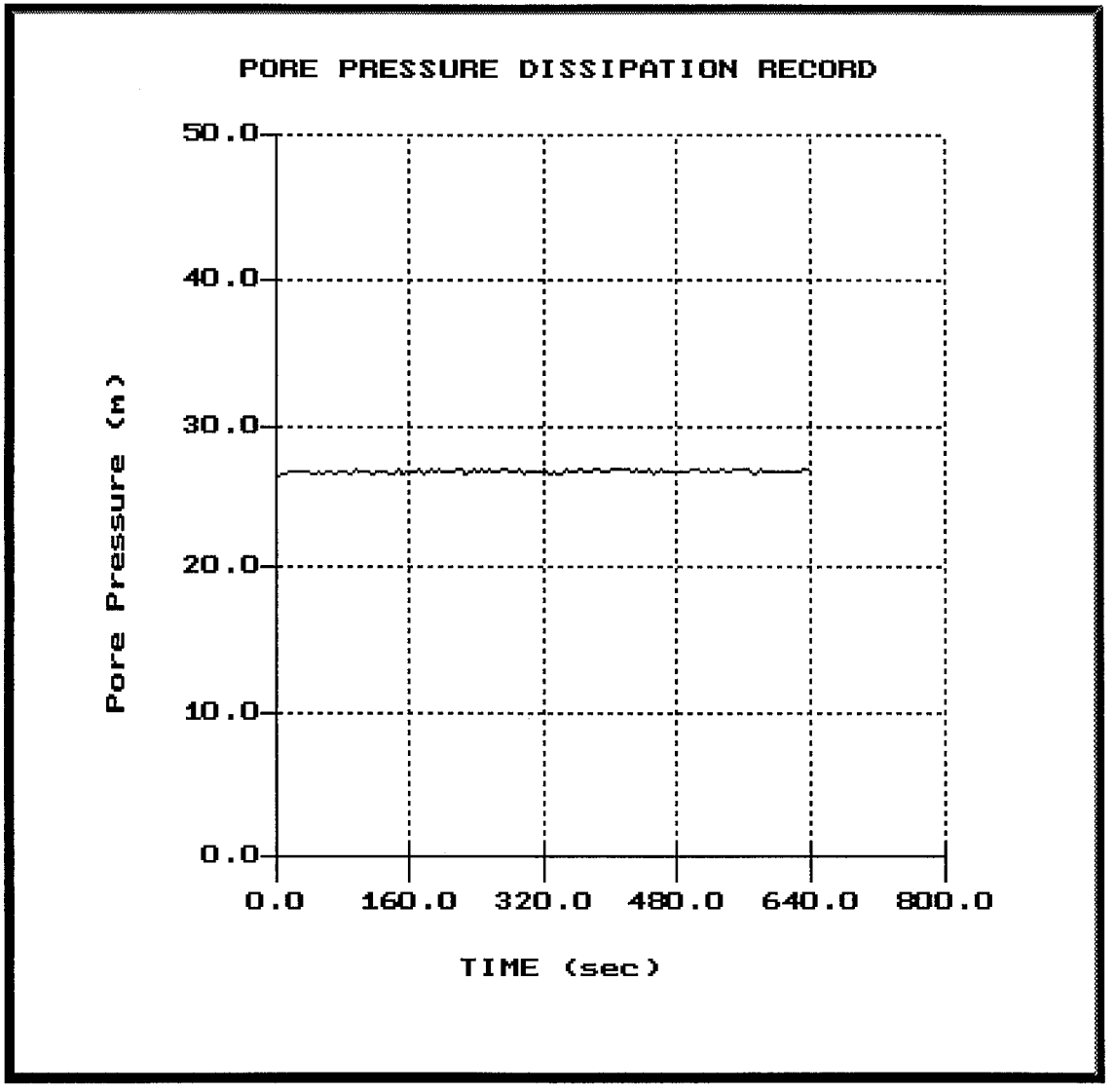
File: 144CP105.PPF
Depth (m): 34.90
(ft): 114.50
Duration : 850.0s
U-min: 113.98 845.0s
U-max: 152.96 0.0s



Golder

Hole:KCPT09-106
Location:Esquimalt

Cone:270:T500F10U500
Date:11:02:09 10:14

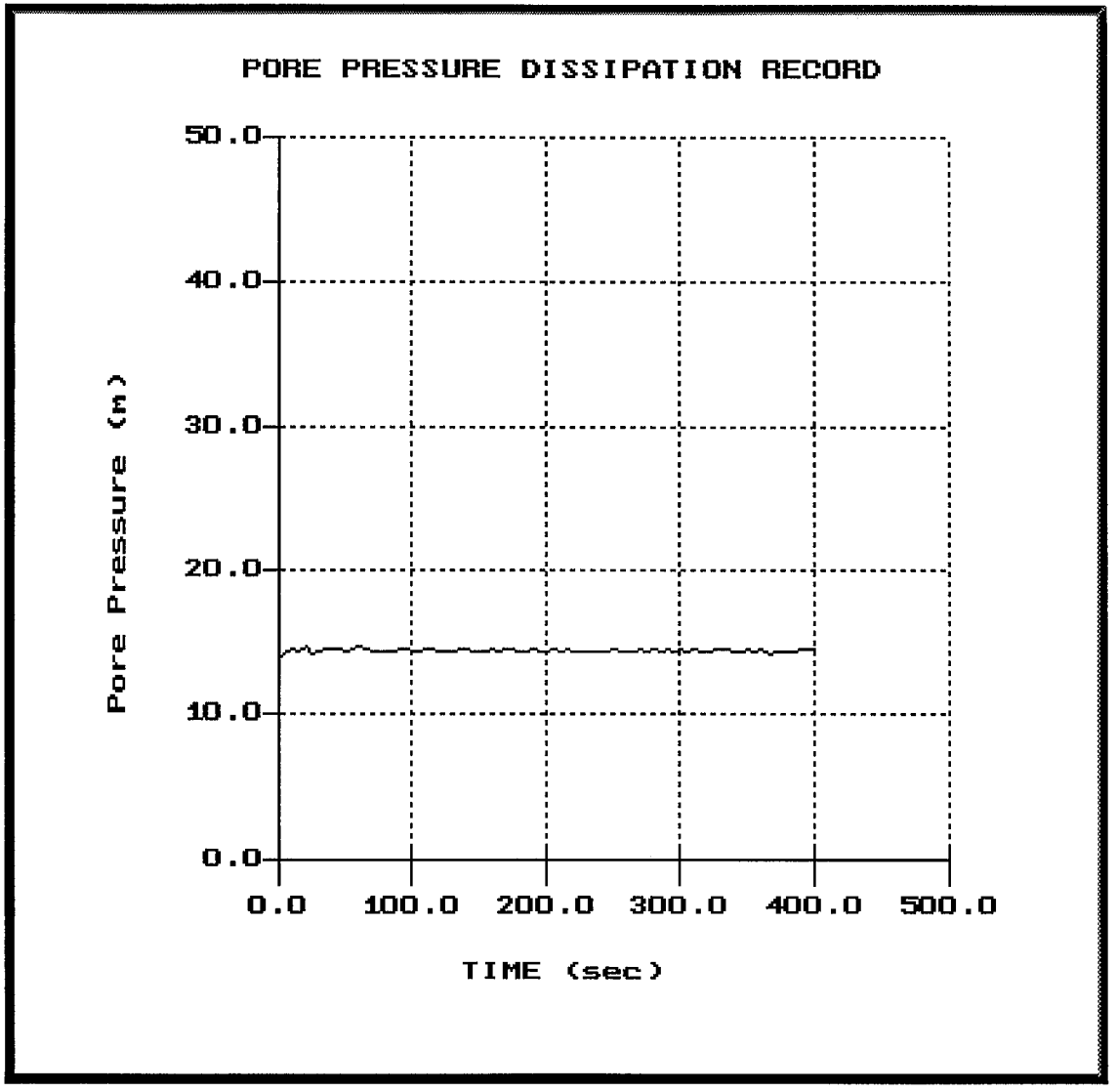


File: 144CP106.PPF
Depth (m): 12.35
(ft): 40.52
Duration : 635.0s
U-min: 26.34 0.0s
U-max: 26.95 420.0s

Golder

Hole:KCPT09-107
Location:Esquimalt

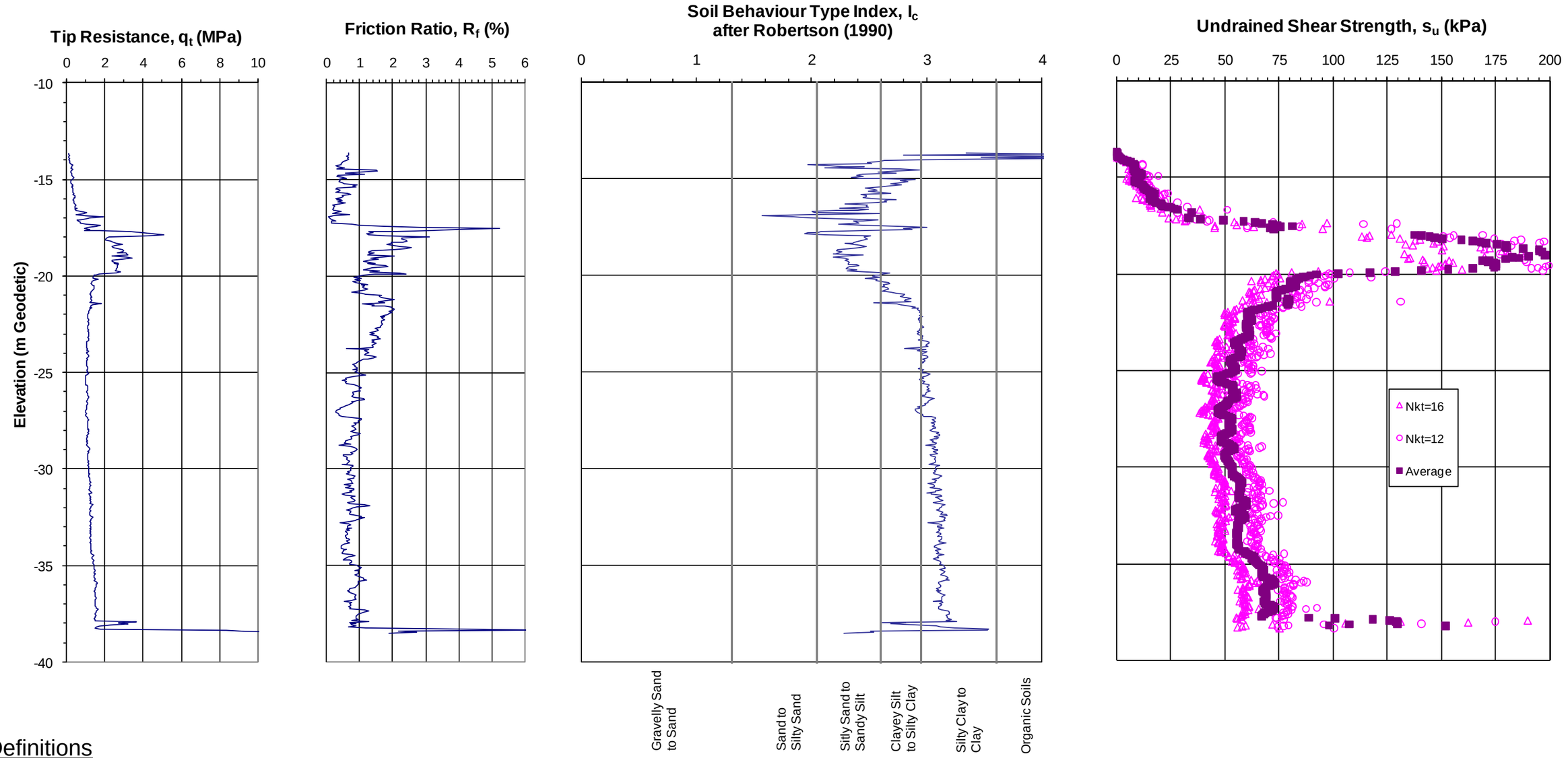
Cone:270:T500F10U500
Date:11:02:09 13:21



File: 144CP107.PPF
Depth (m): 0.70
(ft): 2.30
Duration : 400.0s
U-min: 13.75 0.0s
U-max: 14.51 60.0s

APPENDIX F

Undrained Shear Strengths Interpreted from CPT Data



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

$$\text{where: } Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \;,\; B_q = \frac{u - u_o}{q_t - \sigma_{vo}} \text{ and } F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

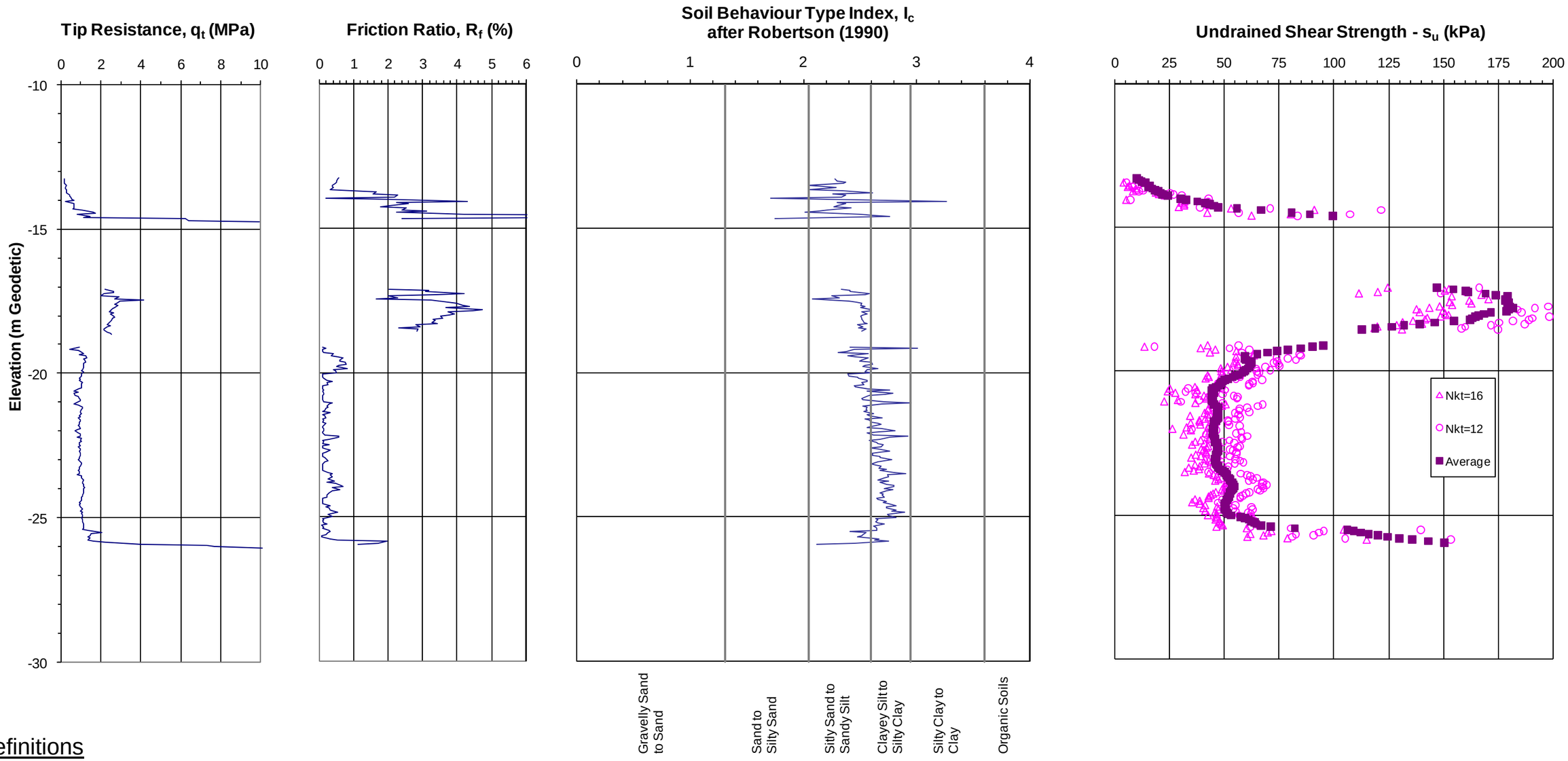
PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE: GCPT09-01 INTERPRETATION: SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-1



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

where: $Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$, $B_q = \frac{u - u_o}{q_t - \sigma_{vo}}$ *and* $F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

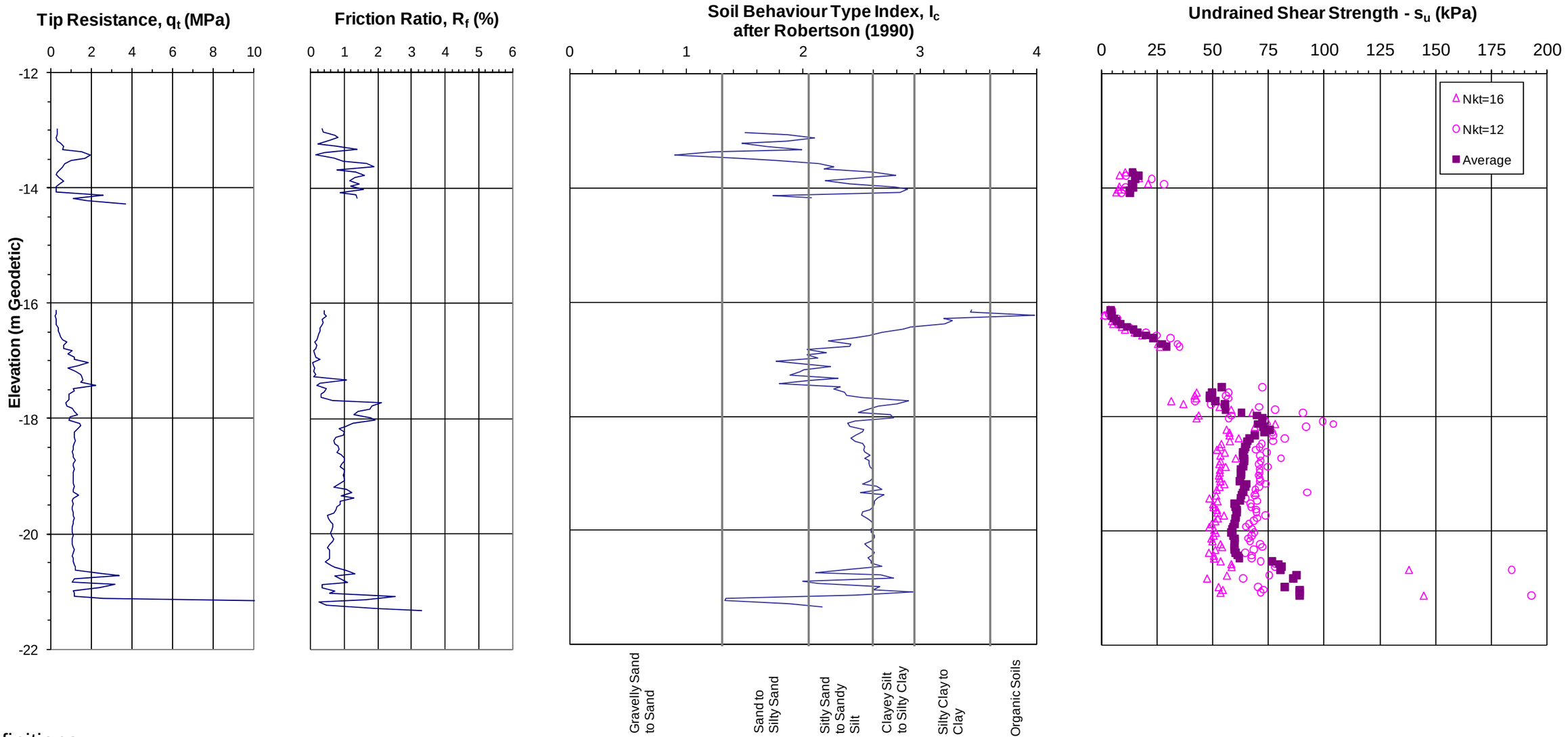
PROJECT **PUBLIC WORKS AND GOVERNMENT SERVICES CANADA**
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
GCPT09-02b INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-2



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

$$\text{where: } Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \;,\; B_q = \frac{u - u_o}{q_t - \sigma_{vo}} \text{ and } F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

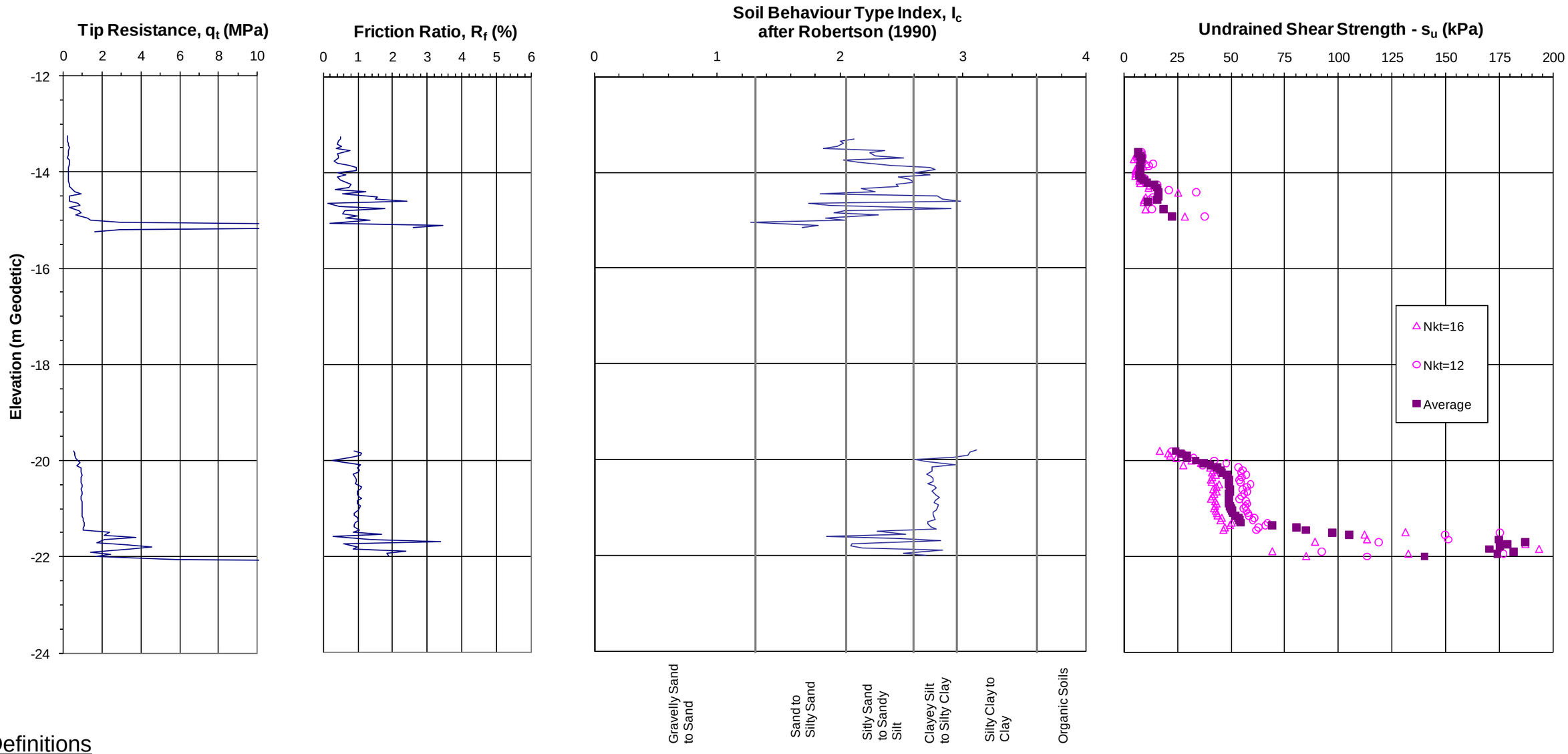
PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE: GCPT09-03 INTERPRETATION: SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-3



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

where: $Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$, $B_q = \frac{u - u_o}{q_t - \sigma_{vo}}$ *and* $F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

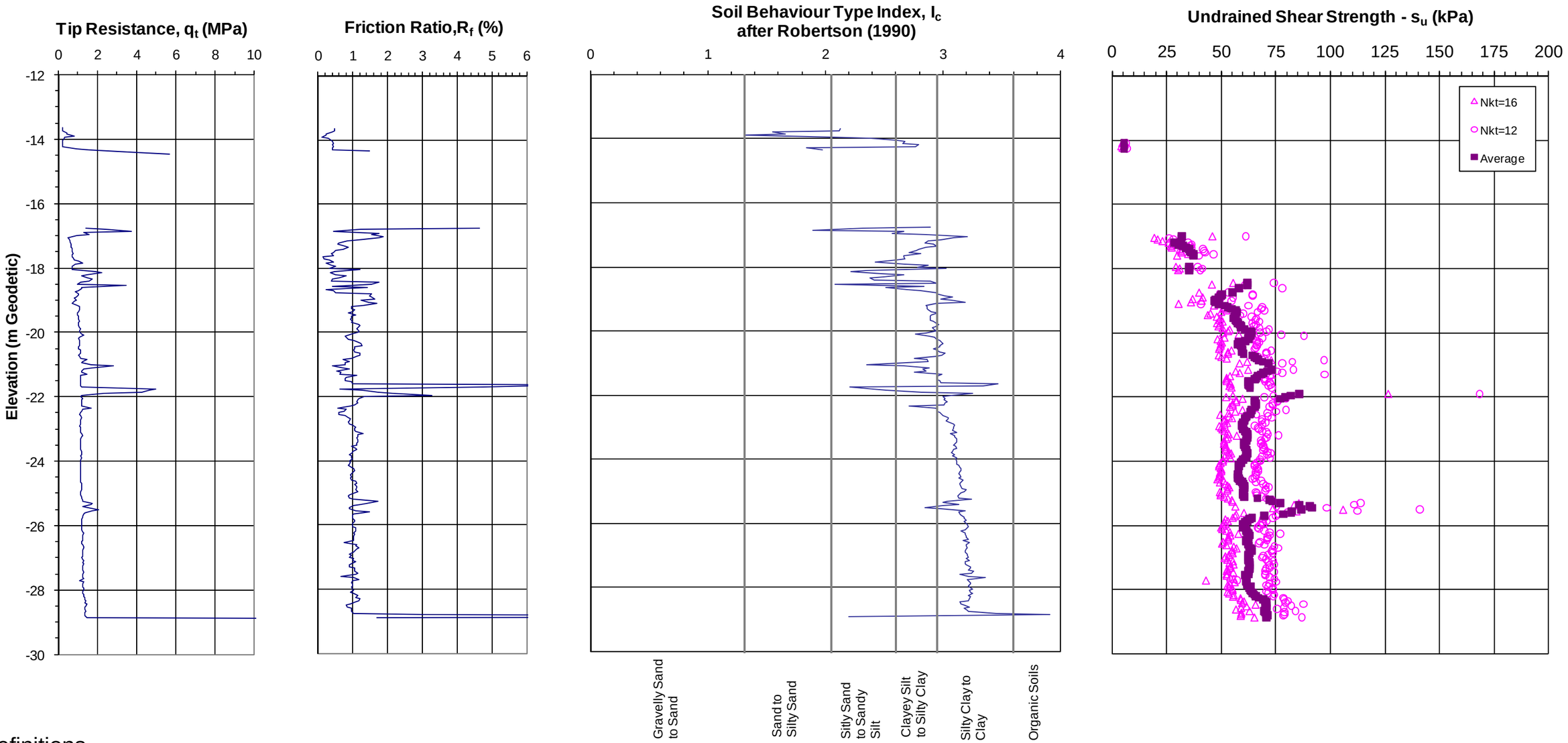
PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE: GCPT09-04 INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-4



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

where: $Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$, $B_q = \frac{u - u_o}{q_t - \sigma_{vo}}$ *and* $F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

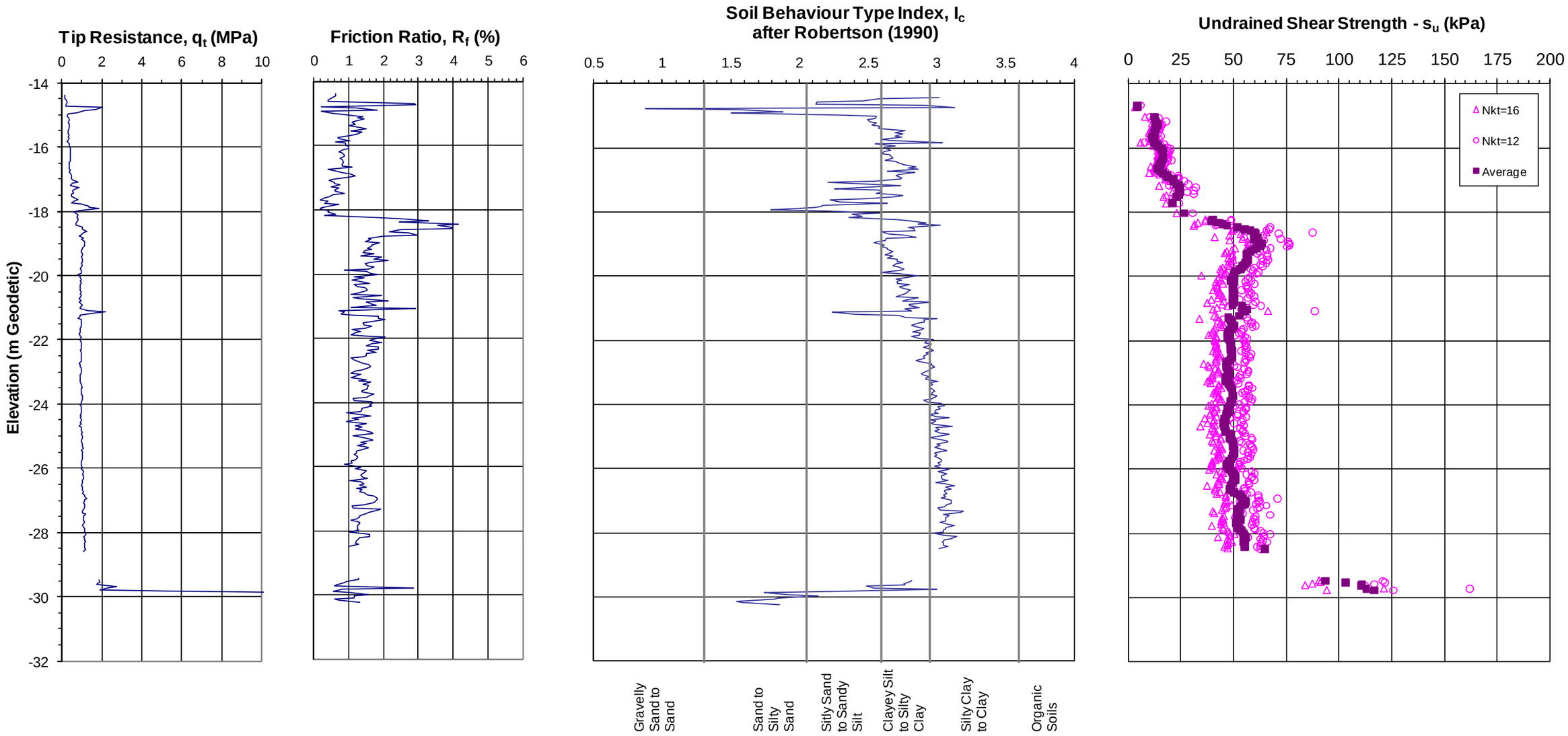
PROJECT **PUBLIC WORKS AND GOVERNMENT SERVICES CANADA**
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
GCPT09-05 INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-5



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

where: $Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$, $B_q = \frac{u - u_o}{q_t - \sigma_{vo}}$ *and* $F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

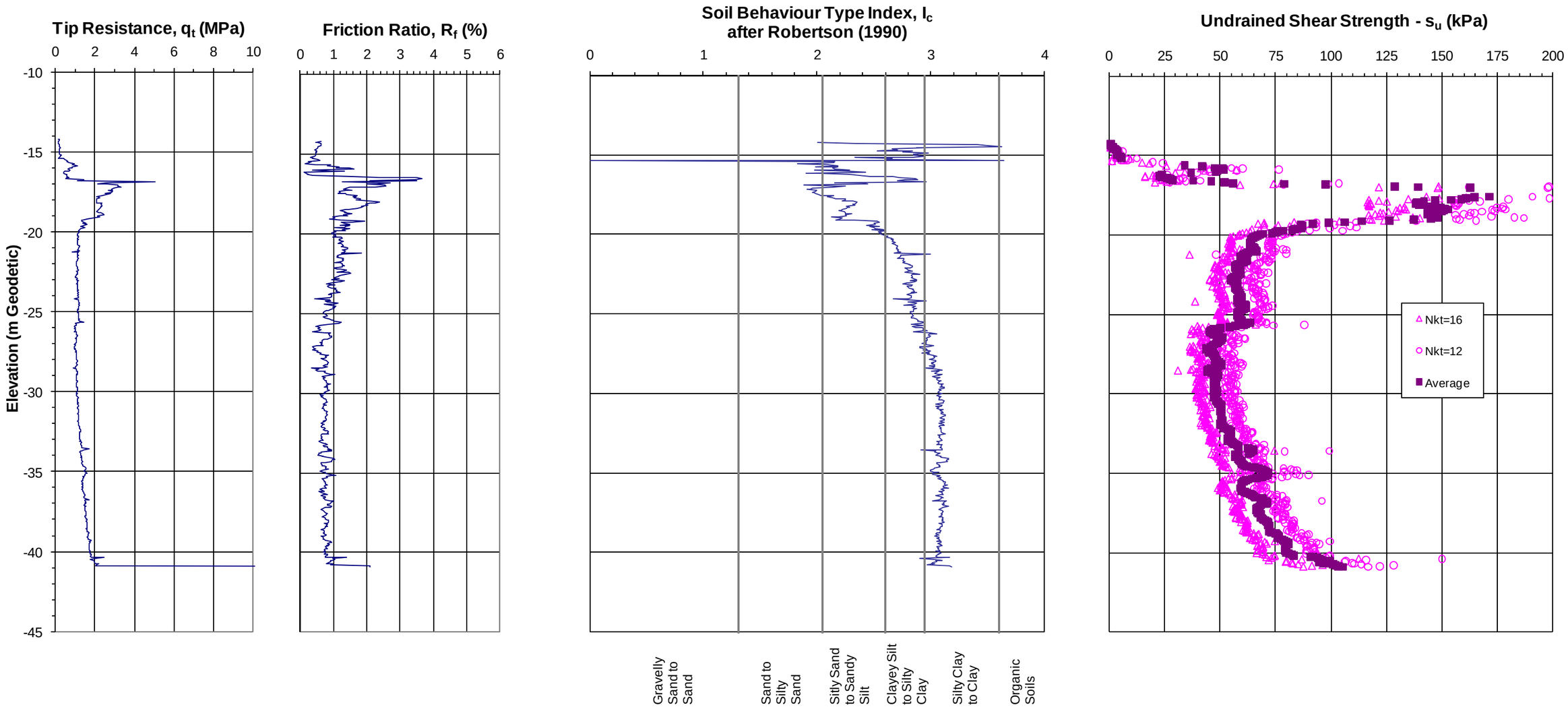
PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE: GCPT09-06 INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-6



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

$$\text{where: } Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \;,\; B_q = \frac{u - u_o}{q_t - \sigma_{vo}} \text{ and } F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

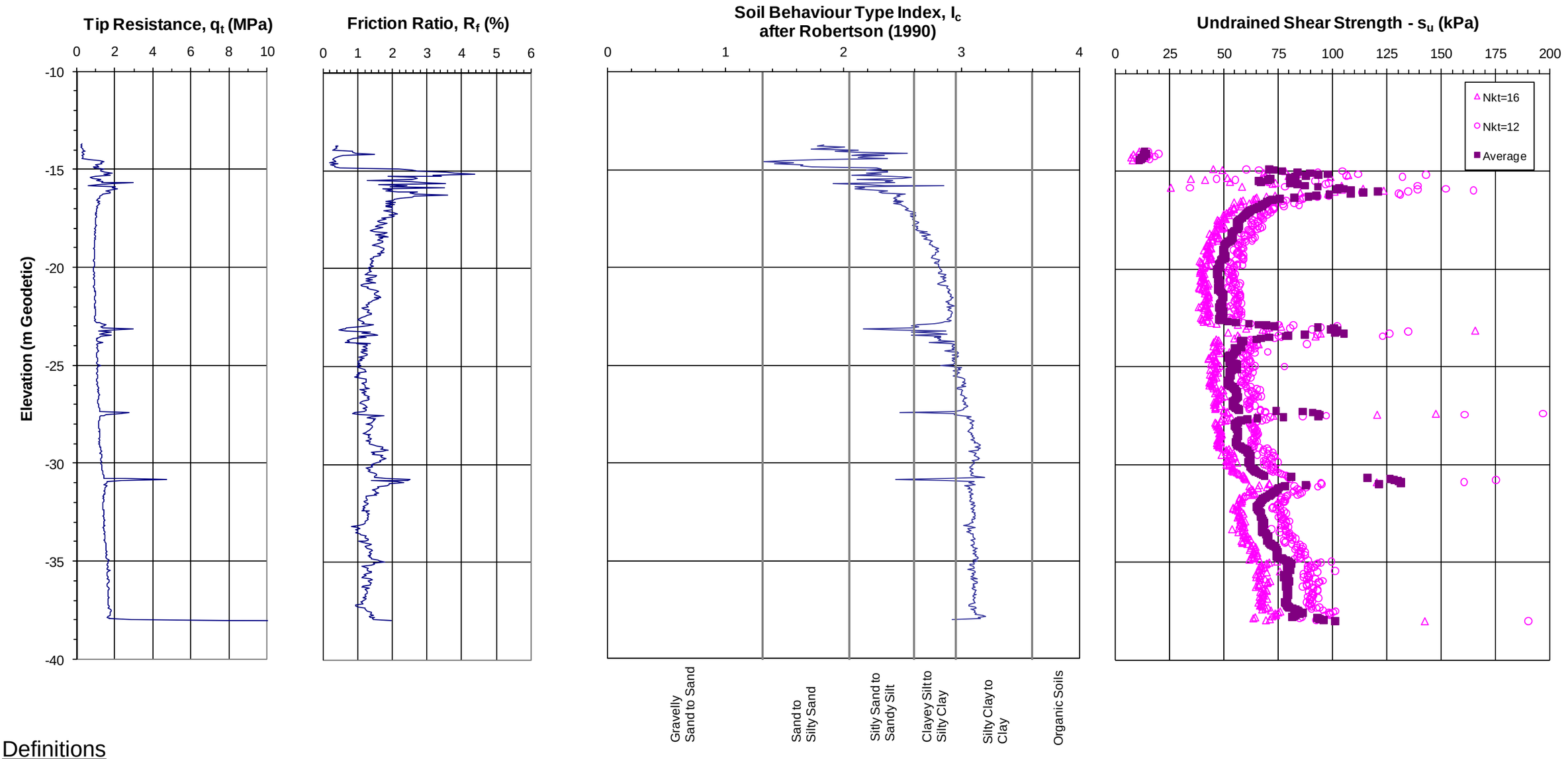
PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE: GCPT09-08b INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-7



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

where: $Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$, $B_q = \frac{u - u_o}{q_t - \sigma_{vo}}$ *and* $F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

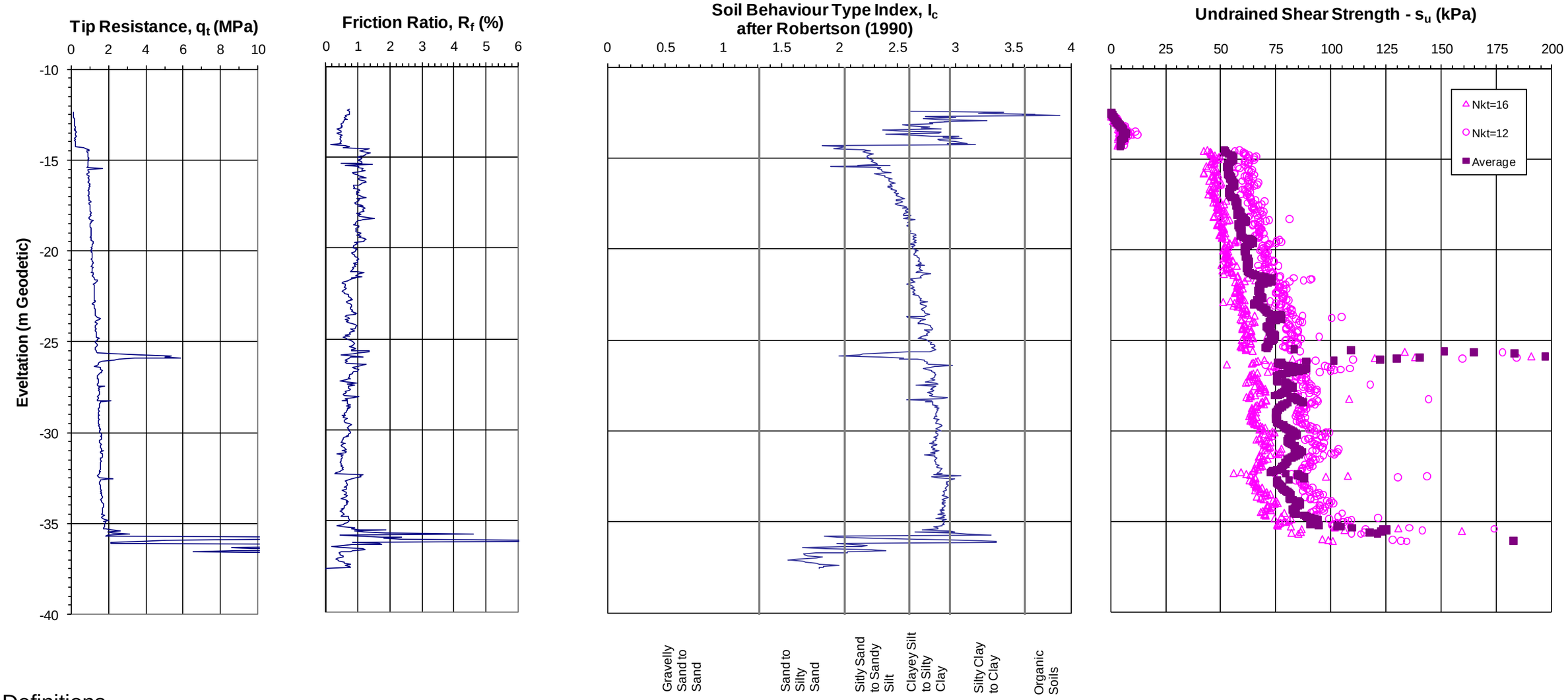
PROJECT **PUBLIC WORKS AND GOVERNMENT SERVICES CANADA**
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
GCPT09-09b INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-8



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

where: $Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$, $B_q = \frac{u - u_o}{q_t - \sigma_{vo}}$ *and* $F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

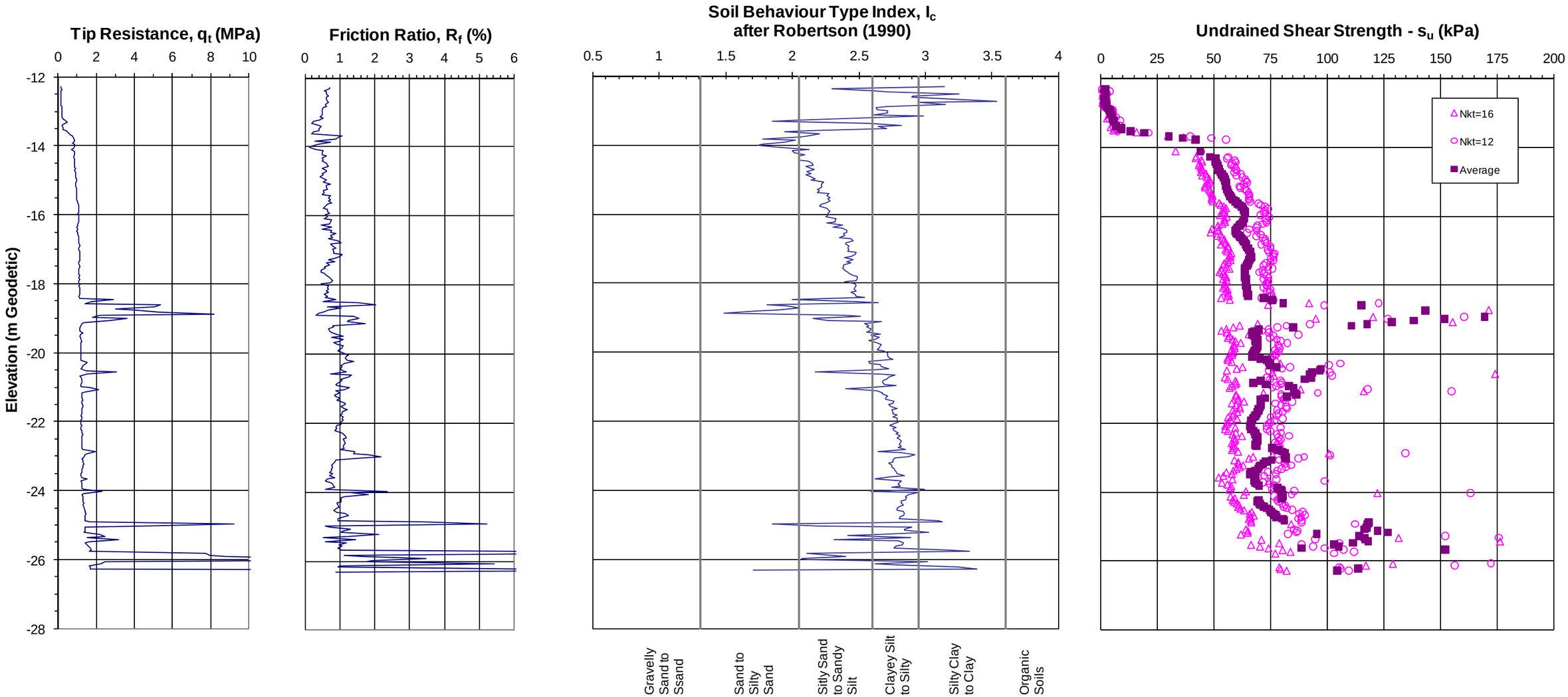
PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE: GCPT09-10 INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-9



Definitions

$R_f = f_s / q_t$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1 - B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

$$\textit{where: } Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \;,\; B_q = \frac{u - u_o}{q_t - \sigma_{vo}} \;\textit{and}\; F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

PROJECT **PUBLIC WORKS AND GOVERNMENT SERVICES CANADA**
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
GCPT09-11 INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	----	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-10

APPENDIX G

Record of Sediment Cores (2009 Vibra-Core Investigation)

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-01

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5365045.6 E: ~468008.0
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 12, 2009 TIME: 15:00
COLLECTION CREW / VESSEL: D.H./N.G./M.S. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 56%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-12.10									
		Very soft, wet, black SILT. Lost during handling.		5.40	3.00	0765-03							
		Soft, wet, black SILT, piece of brittle wood 9cm in lenth at 23cm.				0765-04							
		Lost material due to large angular cobble 12cm in size.		67.90	38.00								
1		Firm, moist, dark grey SILT, some clay, trace shells from 103-105cm and core base.		94.60	53.00	0765-06 0765-05							
2		End of Sediment Core.		187.50	105.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 0765-06 is duplicate of 0765-05.											

Photograph Showing Sediment Core SC09-01.

DEPTH SCALE
1 : 25

LOGGED: A.K./L.M.
CHECKED: R.J.

Golder Associates

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-02

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5365011.6 E: ~467962.3
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 12, 2009 TIME: 13:10
COLLECTION CREW / VESSEL: D.H./N.G./M.S. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 73.9%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.90									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT.											
		Soft, wet, black SILT, trace shell fragments, dark grey below 20cm, piece of concrete with rust stains 20cm in length at 29cm (kept for reference), concrete and brick debris approximately 3cm in length at 36cm.				0749-04							
						0749-05							
				50.10	37.00	0749-07							
1		Moderately firm, moist, dark grey SILT, some clay, trace shell fragments, becoming firm at 108cm.				0749-06							
2		End of Sediment Core.		194.90	144.00								
		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Additional sample collected (0749-07) due to presence of debris below 40cm 0822-01 -TCLP composite (0-20cm+120-140cm).											
3													

Photograph Showing Sediment Core SC09-02.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-03

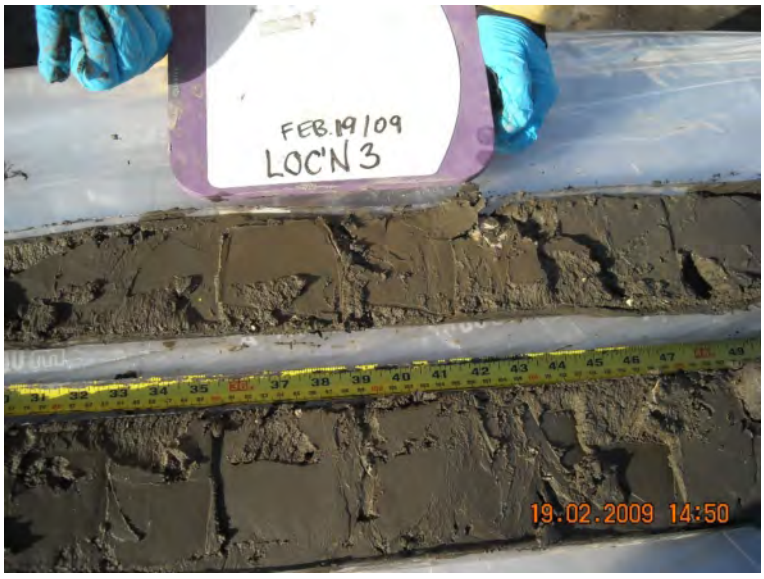
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5365023.8 E: ~468006.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 09:05
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 88.2%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.30									
	Core Catcher (with fins) / Vibra-core	Very soft, wet, dark grey CLAYEY SILT, moderate hydrogen sulphide-like odour.		5.70	5.00	0775-04							
						0775-05 0775-06							
1		Soft, wet, grey CLAYEY SILT, shell fragments, angular gravel at 5-15 cm, pinecone approximately 3cm in length at 101cm, rounded gravel 4cm in size at 122cm.				0775-07							
						0775-08							
2													
		End of Sediment Core.		215.40	190.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected from 120-160cm below mudline. 3.) 0775-06 is a duplicate of 0775-05.											



Photograph Showing Sediment Core SC09-03.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: J.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-04

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5365025.5 E: ~468035.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 13, 2009 TIME: 09:27
COLLECTION CREW / VESSEL: D.H./N.G./M.A. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 95.2%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-10.70									
		Very soft, wet, black SILT, some coarse angular gravel 3-11cm in length.		0.00	0.00	0749-11							
				13.70	13.00	0749-12							
1		Firm, moist, dark grey SILT, some clay, strong hydrogen sulphide-like odour, trace intact shells less than 10cm in length.				0822-02							
						0822-03 0822-04							
2		End of Sediment Core.		203.80	194.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 0822-04 is a duplicate of 0822-03.											

Total Driven Length (TDL): 230.0 cm

Initial Recovered Length (IRL): 219.0 cm

Settled Length (SL): 218.0 cm

Processed Length: 194.0 cm

Photograph Showing Sediment Core SC09-04.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-05

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364988.4 E: ~467996.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 12, 2009 TIME: 12:20
COLLECTION CREW / VESSEL: D.H./N.G./M.S. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 74.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-13.00									
		Very soft, wet, black SILT.		0.00	0.00								
		Soft, wet, black SILT, trace intact shell from 18-24cm, moderately-strong hydrogen sulphide-like odour.		10.70	8.00	0749-01							
				36.10	27.00	0749-02							
1		Moderately firm, moist, dark grey SILT, some clay, slight hydrogen sulphide-like odour, trace shells.				0749-03							
2		End of Sediment Core.		199.20	149.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-05.

DEPTH SCALE
1 : 25

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-06

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364987.9 E: ~468057.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 17, 2009 TIME: 13:30
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 87.1%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.70									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT, strong hydrogen sulphide-like odour, trace shell fragments, intact shells below 7cm.		0.00	0.00	0771-04							
				21.80	19.00	0771-05							
1		Soft, moist, dark grey SILT, some clay, trace shell fragments, intact shells at 142-149cm, becoming firm at 73cm, becoming light grey at 130cm.				0771-06							
2						0771-07							
		End of Sediment Core.		219.30	191.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-06.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-07

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364976.2 E: ~468104.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 17, 2009 TIME: 14:40
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 86.7%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.00									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT trace wood debris at 1-4cm.		0.00	0.00	0771-08							
		Dense SHELLS and firm, wet, black SILT, trace angular gravel.		15.00	13.00	0771-09							
		Soft, moist, dark grey SILT, some clay, becoming firm below 56cm, trace shell fragments throughout, dense, moist, grey, fine grained SAND a 6cm seam at 79-86cm.		35.80	31.00	0771-10							
1						0771-11 0771-12							
		End of Sediment Core.		111.90	97.00								
2													
3													

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.
2.) Geotech sample collected at 50-70cm below mudline
3.) 0771-12 duplicate of 0771-11.

Total Driven Length (TDL): 135.0 cm

Initial Recovered Length (IRL): 117.0 cm

Settled Length (SL): 97.0 cm

Processed Length: 97.0 cm

Photograph Showing Sediment Core SC09-07.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-08

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364963.5 E: ~468039.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 09:35
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 90.4%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.10									
	Core Catcher (with fins) Vibra-core	Very soft, wet, dark grey CLAYEY SILT.				0774-12							
						0775-01							
1		Soft, wet, dark grey CLAYEY SILT, trace shell fragments, becoming firm at 169cm to end of core, black, coal-like debris approximately 7cm in length at 20cm.				0775-02							
2						0775-03							
		End of Sediment Core.		220.10	199.00								BOTTOM
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected from 40-70cm.											Total Driven Length (TDL): 240.0 cm Initial Recovered Length (IRL): 217.0 cm Settled Length (SL): 227.0 cm Processed Length: 199.0 cm

Photograph Showing Sediment Core SC09-08.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-09

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364962.6 E: ~468090.9
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 11, 2009 TIME: 13:57
COLLECTION CREW / VESSEL: D.H./N.G./M.A. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 83.1%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.80 / 0.00	0.00								
0	Core Catcher (with fins) Vibra-core	Soft, wet, dark grey SILT, some clay, trace shells, approximately 30% shell fragments with intact shells at 60-80cm, strong hydrogen sulphide-like odour at 110-188cm, firm, moist, dark grey SILT at 120cm, wood fragments 20cm in length at 170cm.				0755-01							
1						0755-02							
1						0755-03							
2						0755-04							
2		End of Sediment Core.		226.20	188.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-09.

DEPTH SCALE
1 : 25

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-10

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364955.4 E: ~468133.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 16, 2009 TIME: 14:33
COLLECTION CREW / VESSEL: D.H./D.H./N.G. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 85.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.40									
		Very soft, wet, black SILT.				0766-01							
		Soft, wet, dark grey SILT, trace shell, trace clay, strong hydrogen sulphide-like odour below 20cm.				0766-02							
				55.90	48.00								
1	Core Catcher (with fins) Vibra-core	Firm, moist to wet, grey SILT, some clay, trace shell, moderate to strong hydrogen sulphide-like odour.				0766-03							
		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) DRET/TCLP collected here: composite of 0-40cm and 90-110cm of 2 large (250 ml) jars [0767-01 and 0767-02].				0766-04							
2													
		End of Sediment Core.		235.40	202.00								
3													

Total Driven Length (TDL): 260.0 cm

Initial Recovered Length (IRL): 223.0 cm

Settled Length (SL): 202.0 cm

Processed Length: 202.0 cm

Photograph Showing Sediment Core SC09-10.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-11

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364924.7 E: ~468076.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 11, 2009 TIME: 15:25
COLLECTION CREW / VESSEL: M.A./D.H./N.G. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 80.7%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-13.30									TOP
		Very soft, wet, black SILT.											
		Soft, wet, dark grey with black mottling SILT, slight hydrogen sulphide-like odour.				0765-07							
						0765-08							
				37.20	30.00								
1		Moderately firm, moist, dark grey SILT, some clay, trace shells, becoming firm below 140cm.				0765-09							Processed Length (TDL) (IRL) (SL)
2						0765-10							(CTL)
		End of Sediment Core.		220.60	178.00								BOTTOM
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											Total Driven Length (TDL): 244.0 cm Initial Recovered Length (IRL): 197.0 cm Settled Length (SL): 180.8 cm Processed Length: 178.0 cm

Photograph Showing Sediment Core SC09-11.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-12

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364928.2 E: ~468113.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 19, 2009 TIME: 09:45
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 81.3%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.20									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT, slight hydrogen sulphide-like odour.		0.00	0.00	0778-04							
1		Soft, wet, grey SILT, trace shells, strong hydrogen sulphide-like odour, becoming firm below 85cm, wood debris 1-2cm in length at 67cm.		22.10	18.00	0778-05 0778-06 0778-07							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 120-160cm below the mudline. 3.) 0778-06 is a duplicate of 0778-05.				0778-08							
3		End of Sediment Core.		228.80	186.00								

Photograph Showing Sediment Core SC09-12.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./J.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-13

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364925.2 E: ~468150.9
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 11, 2009 TIME: 12:55
COLLECTION CREW / VESSEL: M.A./D.H./N.G. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 84.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.00									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT from 0-4cm, soft, wet, black SILT, hydrogen sulphide-like odour from 3-4cm, becoming grey below 30cm, trace shells at 18-57cm.		0.00	0.00	0755-11							
						0755-12							
1		Firm, moist, grey SILT, some clay, trace shell fragments, slight hydrogen sulphide-like odour, becoming firm below 140cm.		67.20	57.00	0765-01							
2						0765-02							
		End of Sediment Core.		219.30	186.00								
3													

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.
2.) Lost approximately 6cm of clay out of bottom during removal of liner at 6cm
3.) Lost clay material between liner and core catcher shoulder approximately 3cm vertical core length.

Photograph Showing Sediment Core SC09-13.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-14

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364925.5 E: ~468184.9
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 15:15
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 87.3%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.90									
	Core Catcher (with fins) Vibra-core	Soft, wet, black SILT, trace clay below 15cm, trace intact shell, hydrogen sulphide-like odour, becoming grey below 9cm.		0.00	0.00	0773-01							
				24.10	21.00	0773-02							
1		Firm, moist, grey SILT, some clay, trace shells fragments, moderate hydrogen sulphide-like odour, intact shell at 160cm.				0773-03							
2						0773-04							
		End of Sediment Core.		233.70	204.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Total Driven Length (TDL): 245.0 cm

Initial Recovered Length (IRL): 214.0 cm

Settled Length (SL): 201.5 cm

Processed Length: 204.0 cm

Photograph Showing Sediment Core SC09-14.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-15

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364917.4 E: ~468220.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 14:50
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 85.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.50									
	Core Catcher (with fins) Vibra-core	Soft, wet, black SILT, slight hydrogen sulphide-like odour, becoming grey in colour below 11cm.		0.00	0.00	0774-01							
		Soft, moist, grey SILT, black banding at 21-40cm, layer of wet, black, angular GRAVEL, some coarse sand, trace silt at 41-49cm.		24.50	21.00	0774-02							
1		Firm, moist, grey SILT, some clay, trace shell fragments, band of soft, wet, grey SILT at 180-184cm.		61.80	53.00	0774-03							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 130-160cm below the mudline.				0774-04							
		End of Sediment Core.		241.30	207.00								
3													

Total Driven Length (TDL): 260.0 cm

Initial Recovered Length (IRL): 223.0 cm

Settled Length (SL): 207.0 cm

Processed Length: 207.0 cm

Photograph Showing Sediment Core SC09-15.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-16

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364909.2 E: ~468250.3
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 14:15
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 91.1%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.00									
	Core Catcher (with fins) Vibra-core	Soft, wet, grey SILT, trace clay and shells.		7.70	7.00	0774-05							
						0774-06							
1		Firm, moist, grey SILT, some clay, trace shell fragments, strong hydrogen sulphide-like odour below 80cm.				0774-07							
2						0774-08							
		End of Sediment Core.		219.50	200.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-16.

DEPTH SCALE
1 : 25

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

Golder Associates

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-17

SHEET 1 OF 1
DATUM: Geodetic

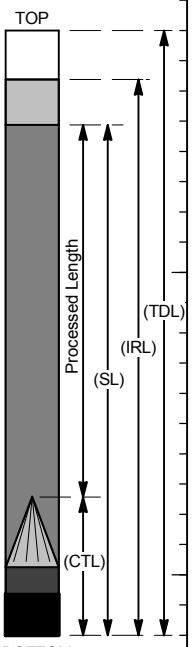
LOCATION:
N: ~5364927.3 E: ~468292.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 17, 2009 TIME: 10:10
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 88.9%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.60									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT, with wood chips and debris.				0770-06							
						0770-07							
1		Soft, wet, black SILT, trace wood debris and shells, barnacle approximately 8cm in length at 27cm, bone fragment approximately 10cm in length at 30cm, becoming firm below 55cm, with strong hydrogen sulphide-like odour, hydrocarbon-like sheen at 97-172cm, increased wood debris and glass fragment at 111-126cm, strong hydrocarbon-like odour at 118cm.				0770-08							
2		Firm, moist, dark grey SILT, some clay, slight hydrogen sulphide-like odour, becoming light grey in colour below 193cm.		193.50	172.00	0770-09							
		End of Sediment Core.		222.70	198.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 45-100cm below the mudline.											

CORE COLLECTION DETAILS



BOTTOM

Total Driven Length (TDL): 244.0 cm

Initial Recovered Length (IRL): 217.0 cm

Settled Length (SL): 198.0 cm

Processed Length: 198.0 cm

Photograph Showing Sediment Core SC09-17.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-18

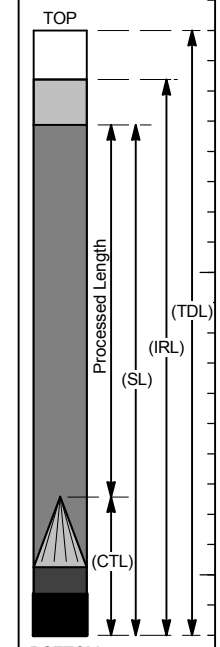
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364891.0 E: ~468107.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 16, 2009 TIME: 14:00
COLLECTION CREW / VESSEL: D.H./D.H./N.G. / Aluminator
COLLECTION ATTEMPT: 2 of 2
INITIAL PERCENT RECOVERY: 84.4%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.80									
	Core Catcher (with fins) Vibra-core	Soft, wet, grey SILT, intact shell approximately 6cm in length at 4cm.		0.00	0.00	0769-03							
				21.30	18.00	0769-04							
1		Firm, moist, grey SILT, some clay, trace shell fragments throughout, strong hydrogen sulphide-like odour at 20cm.				0769-05							
2						0769-06							
		End of Sediment Core.		225.10	190.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 50-90cm below the mudline. 3.) Refusal on first attempt.											



Total Driven Length (TDL): 257.0 cm

Initial Recovered Length (IRL): 217.0 cm

Settled Length (SL): 193.0 cm

Processed Length: 190.0 cm

Photograph Showing Sediment Core SC09-18.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-19

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364909.4 E: ~468156.0
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 13, 2009 TIME: 10:30
COLLECTION CREW / VESSEL: D.H./N.G./M.A. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 85.2%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-14.20									
		Very soft, wet, black SILT.				0823-01							
						0823-02							
1		Soft, wet, dark grey SILT, some clay, trace intact shells and shell fragments, strong hydrogen sulphide-like odour.				0823-03							
				152.60	130.00								
2		Firm, wet, grey SILT, some clay, becoming light grey at 150cm.				0823-04							
				235.90	201.00								
3		End of Sediment Core.											

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.

Total Driven Length (TDL): 263.0 cm

Initial Recovered Length (IRL): 224.0 cm

Settled Length (SL): 224.0 cm

Processed Length: 201.0 cm

Photograph Showing Sediment Core SC09-19.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-20

SHEET 1 OF 1
DATUM: Geodetic

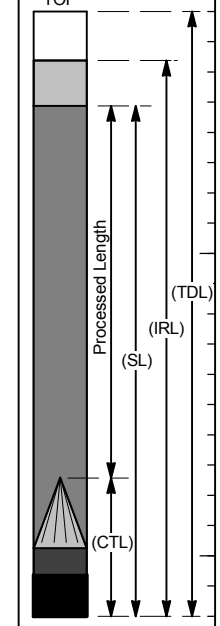
LOCATION:
N: ~5364900.3 E: ~468189.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 19, 2009 TIME: 10:10
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 83%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.00									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT, slight hydrogen sulphide-like odour		0.00	0.00	0777-11 0777-12							
1		Soft, moist, grey CLAYEY SILT, trace shell fragments, intact shell at 190cm, strong hydrogen sulphide-like odour, becoming firm below 70cm.		26.50	22.00	0778-01							
						0778-02							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 40-70cm below mudline. 3.) 0777-12 is a duplicate of 0777-11.				0778-03							
		End of Sediment Core.		238.60	198.00								
3													

Photograph Showing Sediment Core SC09-20.



Total Driven Length (TDL): 259.0 cm

Initial Recovered Length (IRL): 215.0 cm

Settled Length (SL): 216.0 cm

Processed Length: 198.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./J.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-21

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364891.8 E: ~468234.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 13, 2009 TIME: 11:10
COLLECTION CREW / VESSEL: D.H./N.G./M.A. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 79.2%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.90									
	Core Catcher (with fins) Vibra-core	Very soft, wet, dark grey SILT. Soft, wet, dark grey SILT and SHELLS, trace gravel, sub-rounded cobble 8cm in length at 10cm.		2.50	2.00	0823-05							
				20.20	16.00	0823-06							
1		Soft, wet, grey SILT, some clay, trace intact and fragments of shell, strong hydrogen sulphide-like odour, becoming firm below 120cm.				0823-07							
2						0823-08							
		End of Sediment Core.		231.10	183.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Total Driven Length (TDL): 264.0 cm

Initial Recovered Length (IRL): 209.0 cm

Settled Length (SL): 202.0 cm

Processed Length: 183.0 cm

Photograph Showing Sediment Core SC09-21.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-22

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364895.2 E: ~468265.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 13, 2009 TIME: 11:40
COLLECTION CREW / VESSEL: D.H./N.G./M.A. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 83.1%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.00									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT, trace shells, moderate hydrogen sulphide-like odour.		0.00	0.00	0823-09 0823-10							
						0823-11							
1		Soft, wet, grey SILT, some clay, trace intact and fragment shells, strong hydrogen sulphide-like odour, stick less than 5cm in length at 72cm, becoming firm, light grey SILT below 108cm, shell 9cm in length at 173cm.		43.30	36.00	0823-12							
2						0824-01							
3		End of Sediment Core. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 0823-10 is a duplicate of 0823-09.		239.50	199.00								

Photograph Showing Sediment Core SC09-22.

DEPTH SCALE
1 : 25

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-23

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364903.6 E: ~468289.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 19, 2009 TIME: 09:15
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 91.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.10									
	Core Catcher (with fins) / Vibra-core	Very soft, wet, dark grey SILT, trace fine-grained sand, moderate hydrogen sulphide-like odour, black SILT at 10-16cm, degraded woodwaste (pine needles, fibrous material) at 31-38cm, intact shells 6cm in length at 11cm.		0.00	0.00	0776-05							
						0776-06							
1		Soft, wet, grey CLAYEY SILT, trace fine-grained sand and shell fragments, becoming firm at 81cm, intact shell 6cm in length at 101cm.		49.00	45.00	0776-07							
2		Dense, wet, dark grey, silty SAND, trace shell fragments, becoming very dense at 182cm, intact shell 10cm in length at 197cm.		174.30	160.00	0776-08							
3		End of Sediment Core. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected from 0-40cm.		233.10	214.00								

Photograph Showing Sediment Core SC09-23.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./J.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-24

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364896.0 E: ~468313.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 16, 2009 TIME: 11:24
COLLECTION CREW / VESSEL: D.H./D.H./N.G. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 54.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.90									
	Core Catcher (with fins) Vibra-core	Soft, wet, black SILT, trace angular gravel, trace wood pieces at 9cm, moderate hydrogen sulphide-like odour.		0.00	0.00	0768-01							
						0768-02							
1		Dense, wet, grey, coarse and angular, sandy GRAVEL with trace shell fragments.		58.40	32.00	0768-03							
						0768-04							
2		End of Sediment Core.		193.40	106.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-24.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-25

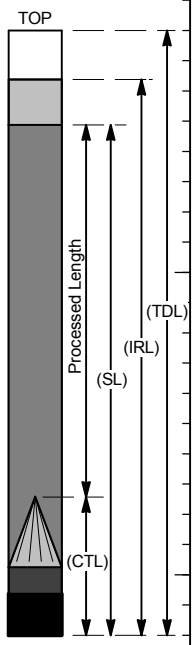
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364902.8 E: ~468343.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 14:50
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 3 of 3
INITIAL PERCENT RECOVERY: %

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.30									
	Core Catcher (with fins) Vibra-core	Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Refusal on all attempts.		0.00	0.00								
1													
2													
3													



Total Driven Length (TDL): 0.0 cm

Initial Recovered Length (IRL): cm

Settled Length (SL): cm

Processed Length: cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED:

CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-26

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364894.6 E: ~468362.3
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 16, 2009 TIME: 16:05
COLLECTION CREW / VESSEL: D.H./D.H./N.G./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 77%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.80									
	Core Catcher (with fins) Vibra-core	Very soft, saturated, black SILT, liquid, trace fine sand.		0.00	0.00								
		Soft, moist, black SILT, trace fine sand, three small worms at 35cm.				0768-11							
1		Dense, wet, black, medium SAND, some angular gravel below 97cm, trace angular cobbles from 90-130cm, trace sand blasting grit.		51.90	40.00	0768-12							
						0769-01							
2		End of Sediment Core.		188.30	145.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) DRET/TCLP collected [0769-02] composite of 0-40cm and 110-130cm.											

Photograph Showing Sediment Core SC09-26.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-27

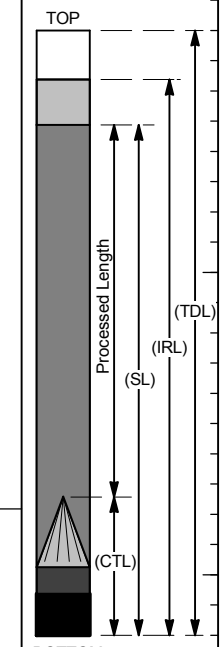
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364870.6 E: ~468152.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 12, 2009 TIME: 16:20
COLLECTION CREW / VESSEL: D.H./N.G./M.S. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 60.6%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-14.20									
		Very soft to soft, wet, black SILT.		0.00	0.00	0749-08							
1		Firm, moist, dark grey SILT, some clay, trace shells, becoming firm from 52cm, intact shells 7cm in length at 95-108cm.		16.50	10.00	0749-09							
						0749-10							
2		End of Sediment Core.		178.20	108.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											



Total Driven Length (TDL): 216.0 cm

Initial Recovered Length (IRL): 131.0 cm

Settled Length (SL): 108.0 cm

Processed Length: 108.0 cm

Photograph Showing Sediment Core SC09-27.

DEPTH SCALE
1 : 25

LOGGED: A.K./L.M.
CHECKED: R.J.

Golder Associates

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-28

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364872.1 E: ~468205.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 19, 2009 TIME: 14:00
COLLECTION CREW / VESSEL: D.H./D.H./N.G. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 88.4%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.10									
	Core Catcher (with fins) Vibra-core	Very soft, wet, dark grey SILT, trace shell fragments.		4.50	4.00	0777-07							
						0777-08							
1		Soft, wet, grey CLAYEY SILT, trace shell fragments, strong hydrogen sulphide-like odour below 90cm, becoming firm at 30cm.				0777-09							
2						0777-10							
		End of Sediment Core.		219.50	194.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Total Driven Length (TDL): 241.0 cm

Initial Recovered Length (IRL): 213.0 cm

Settled Length (SL): 211.0 cm

Processed Length: 1940.0 cm

Photograph Showing Sediment Core SC09-28.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./J.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-29

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364873.5 E: ~468256.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 13, 2009 TIME: 12:50
COLLECTION CREW / VESSEL: D.H./N.G./M.A. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 81.9%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.70									
	Core Catcher (with fins) Vibra-core	Very soft, wet, dark grey SILT, trace shells.		2.40	2.00	0824-02							
		Soft, wet, dark grey SILT, trace clay and shells.		29.30	24.00	0824-03							
1		Soft, wet, grey SILT, some clay, trace shell fragments, hydrogen sulphide-like odour, becoming firm below 44cm.				0824-04							
2						0824-05							
		End of Sediment Core.		228.30	187.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-29.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-30

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364870.5 E: ~468306.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 15:45
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 97.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-13.90									
		Soft, wet, black SILT, moderate hydrogen sulphide-like odour, trace wood debris, pocket of angular gravel at 20-22cm.		0.00	0.00	0773-10							
		Soft, moist, dark grey SILT, trace clay, black banding at 31-35cm, strong hydrogen sulphide-like odour.		22.50	22.00	0773-11							
1		Firm, moist, grey SILTY CLAY, trace shell fragments, intact shell at 72-74cm.		47.00	46.00	0773-12							
2		End of Sediment Core.		120.70	118.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Total Driven Length (TDL): 136.0 cm

Initial Recovered Length (IRL): 133.0 cm

Settled Length (SL): 132.0 cm

Processed Length: 118.0 cm

Photograph Showing Sediment Core SC09-30.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-31

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364865.6 E: ~468328.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 11:25
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 41%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.70									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT, trace wood fibres, moderate hydrogen sulphide-like odour.		9.80	4.00	0774-09							
		Very soft, wet, black SILT, trace wood fibres, moderate hydrogen sulphide-like odour, becoming grey in colour at 11cm.		51.20	21.00	0774-10							
1		Firm, wet, grey SILT and SHELL FRAGMENTS, some clay at 46-60cm, large angular cobble at 35cm.				0774-11							
		End of Sediment Core.		146.30	60.00								
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) No Geotech sample collected due to insufficient volume.											
3													

Photograph Showing Sediment Core SC09-31.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-32

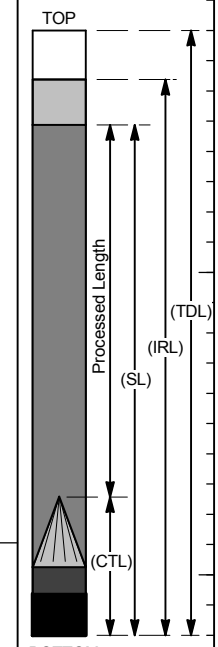
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364872.6 E: ~468350.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 17, 2009 TIME: 09:40
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 95.5%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-13.00									
		Very soft, wet, black SILT, strong hydrogen sulphide-like odour, wood debris 4-10cm in length.		0.00	0.00	0770-01							
		Loose, wet, grey SAND, trace shell fragments.		16.80	16.00	0770-02							
		Dense, moist, SHELL FRAGMENTS, trace coarse sand.		39.80	38.00	0770-03							
1		Dense, moist, SHELL FRAGMENTS, trace coarse sand, pocket of soft, wet, black silt, with white and grey intact shell at 62-73cm, strong hydrogen sulphide-like odour.		64.90	62.00								
		Soft, wet, black SILT, with wood debris, trace shell, strong hydrogen sulphide odour and hydrocarbon-like odour.		121.50	116.00	0770-04							
		Dense, wet, grey, coarse SAND and GRAVEL, trace shell, angular cobble at 150cm.		145.50	139.00	0770-05							
2		End of Sediment Core.		189.50	181.00								
		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											
3													



Total Driven Length (TDL): 220.0 cm

Initial Recovered Length (IRL): 210.0 cm

Settled Length (SL): 181.0 cm

Processed Length: 181.0 cm

Photograph Showing Sediment Core SC09-32.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-33

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364869.2 E: ~468374.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 10:05
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 94.3%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.50									
	Core Catcher (with fins) Vibra-core	Soft, wet, black SILT, trace clay below 12cm, trace shell fragments, slight hydrogen sulphide-like odour, becoming grey below 12cm.		0.00	0.00	0776-01							
		Very soft, wet, grey, sandy SILT.		27.60	26.00	0776-02							
1		Dense, wet, grey SAND and GRAVEL, some shells, intact shell from 53-68cm, trace silt, angular cobbles at 114-130cm.		47.70	45.00	0776-03 0776-04							
2		End of Sediment Core.		137.90	130.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 66-90cm.											

Photograph Showing Sediment Core SC09-33.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./J.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-34

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364842.0 E: ~468179.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 19, 2009 TIME: 11:10
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 89.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface Very soft, wet, grey SILT.		-14.50		0777-03							TOP
						0777-04							
1		Firm, moist, grey SILT, some clay, trace shells, small barnacle at 27cm, soft, wet SILT pocket at 68-72cm, strong hydrogen sulphide-like odour below 80cm.				0777-05							Processed Length (TDL) (IRL) (SL)
2						0777-06							(CTL)
		End of Sediment Core.		227.20	204.00								BOTTOM
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											Total Driven Length (TDL): 245.0 cm Initial Recovered Length (IRL): 220.0 cm Settled Length (SL): 220.0 cm Processed Length: 204.0 cm

Photograph Showing Sediment Core SC09-34.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./J.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-35

SHEET 1 OF 1
DATUM: Geodetic

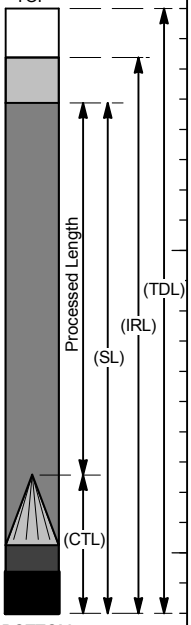
LOCATION:
N: ~5364841.5 E: ~468241.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 19, 2009 TIME: 11:35
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 71.6%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.00									
	Core Catcher (with fins) / Vibra-core	Soft, wet, black SILT, trace fine sand, moderate hydrogen sulphide-like odour, very soft from 0-10cm.		0.00	0.00	0776-09							
1		Firm, moist, grey CLAYEY SILT, trace shell, strong hydrogen sulphide-like odour, rounded small cobble at 127cm.		30.70	22.00	0776-10 0776-11 0776-12							
2		End of Sediment Core. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 0776-11 is a duplicate of 0776-10.		196.90	141.00								
3													

Photograph Showing Sediment Core SC09-35.



Total Driven Length (TDL): 250.0 cm

Initial Recovered Length (IRL): 179.0 cm

Settled Length (SL): 162.0 cm

Processed Length: 141.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./J.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-36

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364848.2 E: ~468294.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 16, 2009 TIME: 12:10
COLLECTION CREW / VESSEL: D.H./D.H./N.G. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 95.4%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.50									
	Core Catcher (with fins) Vibra-core	Soft, wet, black SILT, trace shell fragments, hydrogen sulphide-like odour.		0.00	0.00	0768-05							
				10.50	10.00	0768-06							
1		Firm, moist, grey SILT, some clay, moderate hydrogen sulphide-like odour, becoming very firm below 127cm, intact shells at 109-122cm.				0768-07 0768-08							
2						0768-09							
		End of Sediment Core.		211.70	202.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 110-160cm below mudline. 3.) 0768-08 is a duplicate of 0768-07.											

Photograph Showing Sediment Core SC09-36.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P/J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-37

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364844.0 E: ~468326.3
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 18, 2009 TIME: 11:50
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 78.6%

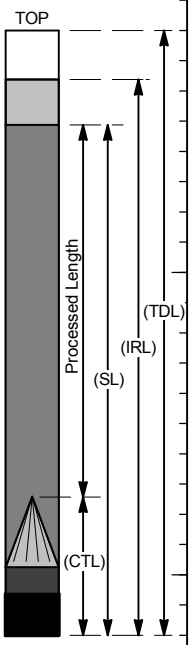
LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.40									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT, trace wood fibres, moderate hydrogen sulphide-like odour, slight hydrocarbon-like sheen.		0.00	0.00	0773-05 0773-06							
		Soft, wet to moist, grey with black banding SILT, trace gravel, slight to moderate hydrogen sulphide-like odour, slight hydrocarbon-like sheen.		28.00	22.00	0773-07							
		Dense, wet, grey SILT, some coarse sand and coarse sub-rounded gravel, trace shell fragments.		75.10	59.00	0773-08							
1		Firm, moist, grey SILT and CLAY, trace coarse angular gravel and shell fragments, pocket of dense, moist, fine grey SAND at 121-134cm.		92.90	73.00	0773-09							
2		End of Sediment Core.		211.20	166.00								
3													

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.
2.) 0773-06 is a duplicate of 0773-05.

Photograph Showing Sediment Core SC09-37.

CORE COLLECTION DETAILS



Total Driven Length (TDL): 243.0 cm

Initial Recovered Length (IRL): 191.0 cm

Settled Length (SL): 188.0 cm

Processed Length: 166.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-38

SHEET 1 OF 1
DATUM: Geodetic

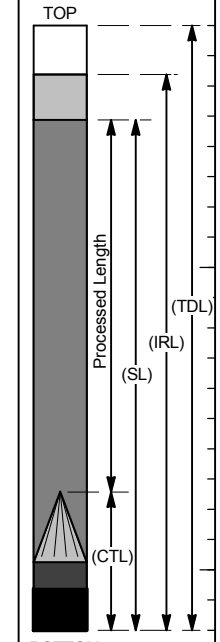
LOCATION:
N: ~5364815.4 E: ~468225.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 13, 2009 TIME: 14:15
COLLECTION CREW / VESSEL: D.H./N.G./M.A. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 80.1%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.40									
	Core Catcher (with fins) Vibra-core	Very soft, wet, dark brown SILT, slight hydrogen sulphide-like odour, whole shell approximately 6cm in size at 15 cm.		0.00	0.00	0824-10							
				18.70	15.00	0824-11							
		Soft, wet, dark brown to dark grey with black banding SILT, moderate hydrogen sulphide-like odour.											
1				76.20	61.00	0824-12							
		Firm, wet, dark grey SILT, some clay, trace shell fragments, strong hydrogen sulphide-like odour.											
2						0825-02 0825-03							
		End of Sediment Core.		227.20	182.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 0825-03 is a duplicate of 0825-02.											

Photograph Showing Sediment Core SC09-38.



Total Driven Length (TDL): 266.0 cm

Initial Recovered Length (IRL): 213.0 cm

Settled Length (SL): 203.0 cm

Processed Length: 182.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-39

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364804.3 E: ~468266.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 16, 2009 TIME: 11:11
COLLECTION CREW / VESSEL: D.H./D.H./N.G. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 90.1%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-13.80									
		Very soft, wet, black SILT.				0766-09							
		Soft, moist to wet, grey SILT, some clay, trace shell fragments, moderate hydrogen sulphide-like odour.				0766-10							
1				88.80	80.00	0766-11							
		Firm, moist, grey SILT, some clay, trace shell fragments, moderate hydrogen sulphide-like odour.				0766-12							
2													
		End of Sediment Core.		214.20	193.00								
3													

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.
2.) Collected samples - 0767-03 and 0767-04 for potential DRET or TCLP analyses.
3.) Core catcher fell out when removing barrel, approximately 14cm bottom of sediments lost.

Total Driven Length (TDL): 243.0 cm

Initial Recovered Length (IRL): 219.0 cm

Settled Length (SL): 194.0 cm

Processed Length: 193.0 cm

Photograph Showing Sediment Core SC09-39.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-40

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364780.0 E: ~468287.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 16, 2009 TIME: 11:50
COLLECTION CREW / VESSEL: D.H./D.H./N.G. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 74%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-13.00									
		Very soft, wet, black SILT, trace hydrocarbon-like sheen.				0766-05							
		Firm, wet, black SILT and SHELL FRAGMENTS (greater than 50% shells).				0766-06							
1		Firm, wet, grey SILT, some clay, trace shell fragments.		71.60	53.00	0766-07							
		Firm, wet, black SILT and SHELL FRAGMENTS.		129.70	96.00	0766-08							
		Firm, moist, grey SILT, some clay, trace shell fragments.		144.60	107.00								
2		End of Sediment Core.		182.40	135.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-40.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-41

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364769.9 E: ~468299.3
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 17, 2009 TIME: 11:25
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 71.6%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-13.90									
		Very soft, wet, black SILT, trace shells, moderate hydrogen sulphide-like odour, becoming soft below 8cm.		0.00	0.00	0770-10							
				16.80	12.00	0770-11							
1		Firm, moist, grey SILT, some clay, trace shell fragments, becoming firm below 90cm.				0770-12							
		End of Sediment Core.		143.90	103.00								
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 35-70cm below mudline.											
3													

Photograph Showing Sediment Core SC09-41.

DEPTH SCALE
1 : 25

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

Golder Associates

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-42

SHEET 1 OF 1
DATUM: Geodetic

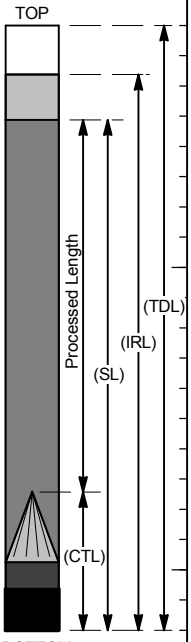
LOCATION:
N: ~5364790.2 E: ~468404.6
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 13, 2009 TIME: 13:40
COLLECTION CREW / VESSEL: D.H./N.G./M.A. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 62.6%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-11.30									
	Core Catcher (with fins) Vibra-core	Very soft, wet, black SILT, no odour, trace hydrocarbon-like sheen.											
		Firm, wet, black SILT with SHELLS, moderate hydrogen sulphide-like odour, trace sheen, tarball approximately 3cm in width at 43cm, sea worm approximately 8cm in length at 17cm.				0824-06							
						0824-07							
1				68.70	43.00	0824-08							
		Soft, wet, black SILT, trace wood debris and shell fragments, hydrocarbon-like sheen, moderate tar-like odour.											
				118.20	74.00	0824-09							
		Firm, moist, dark grey SILT, with some clay, trace shells, moderate hydrogen sulphide-like odour, no sheen.											
		End of Sediment Core.		158.10	99.00								
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) DRET/TCLP collected [0825-01] composite of 0-99cm.											
3													

Photograph Showing Sediment Core SC09-42.



Total Driven Length (TDL): 235.0 cm

Initial Recovered Length (IRL): 147.0 cm

Settled Length (SL): 121.0 cm

Processed Length: 99.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-43

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364778.6 E: ~468364.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 11, 2009 TIME: 11:52
COLLECTION CREW / VESSEL: M.A./D.H./N.G. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 85.6%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-14.30									
		Very soft, wet, black SILT, strong hydrogen sulphide-like odour.		0.00	0.00	0755-05							
		Soft, wet, black SILT, strong hydrogen sulphide-like odour, layer of debris (brick, shell, concrete, wood fibre) at 30-32cm, wood fragments approximately 10cm in length at 60-70cm, wood and intact shells, moderate naphthalene-like odour at 80cm.		17.50	15.00	0755-06 0755-07							
1		Soft, moist, light grey SILT with some clay, becoming firm below 125cm, trace coarse sub-rounded gravel at 140-150cm.		105.10	90.00	0755-08							
2		Firm, moist, dark grey, silty SAND, some shells intact and fragments.		179.90	154.00	0755-09							
		End of Sediment Core. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.		213.80	183.00								
3													

Photograph Showing Sediment Core SC09-43.

DEPTH SCALE
1 : 25

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-44

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364741.3 E: ~468333.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 16, 2009 TIME: 17:06
COLLECTION CREW / VESSEL: D.H./D.H./N.G. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 90%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-13.20									
		Very soft, wet, black SILT, hydrogen sulphide-like odour.		3.30	3.00	0769-07							
		Soft, wet, black-grey SILT, trace shell fragments, moderate hydrogen sulphide-like odour.				0769-08							
1				48.90	44.00	0769-09							
		Firm, moist, grey SILT, some clay, trace shell fragments.											
2						0769-10							
		End of Sediment Core.		215.60	194.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 5-40cm below mudline. 3.) Core catcher fell out when moving core, approximately 25cm bottom of sediments lost.											

Photograph Showing Sediment Core SC09-44.

DEPTH SCALE
1 : 25

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

Golder Associates

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-45

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364800.0 E: ~468495.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 10, 2009 TIME: 15:44
COLLECTION CREW / VESSEL: M.A./D.H./N.G./L.M. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 66.3%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-9.40									
	Core Catcher (with fins) Vibra-core	Firm, wet, black SILT and SHELLS, trace sand, faint asphalt-like odour, trace coarse sub-rounded gravel at 25.5cm.		0.00	0.00	0753-01							
		Soft, wet, grey SILT, trace fine sand, no odour, trace fine to medium sand banding at 34cm.		40.70	27.00	0753-02							
1		Very firm, moist, grey SILT and SHELLS, trace intact shells 5-9cm in length and fragmented shells.		70.90	47.00	0753-03							
		Dense, moist, dark grey, fine to medium grained SAND, some silt, no odour, shell fragments 2-7cm in length at 100-116cm.		120.70	80.00	0753-04							
2		End of Sediment Core.		184.00	122.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Total Driven Length (TDL): 218.0 cm

Initial Recovered Length (IRL): 144.5 cm

Settled Length (SL): 141.0 cm

Processed Length: 122.0 cm

Photograph Showing Sediment Core SC09-45.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./L.M./P.C./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-46

SHEET 1 OF 1
DATUM: Geodetic

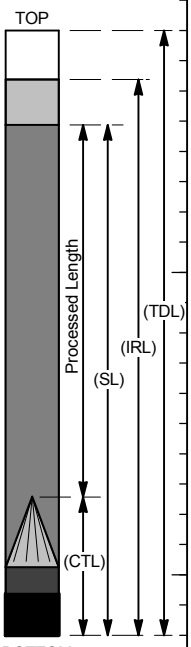
LOCATION:
N: ~5364782.7 E: ~468464.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 11, 2009 TIME: 09:57
COLLECTION CREW / VESSEL: M.A./D.H./N.G./P.C. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 78.7%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-12.80									
		Very soft, wet, black SILT, moderate to strong hydrogen sulphide-like odour.		0.00	0.00	0753-10							
		Loose to dense, moist, dark grey, fine SAND and dense SHELL FRAGMENTS (40-50%).		31.80	25.00								
		Firm, moist, light grey SILT, trace fine sand.		48.30	38.00	0753-11							
1													
		Firm, moist, light grey, sandy SILTY CLAY,well sorted, fine grained sand, fine sand seams between 139-160cm.		102.90	81.00	0753-12							
2		End of Sediment Core.		203.30	160.00								
		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											
3													

Photograph Showing Sediment Core SC09-46.



Total Driven Length (TDL): 244.0 cm

Initial Recovered Length (IRL): 192.0 cm

Settled Length (SL): 183.0 cm

Processed Length: 160.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-47

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364750.9 E: ~468435.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 17, 2009 TIME: 11:40
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 50.6%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-13.90									
				0.00	0.00	0772-01							
		Very soft, wet, black SILT trace wood fibres, moderate hydrogen sulphide-like odour, becoming soft below 28cm.				0772-02							
1		Soft to firm, moist, dark grey-black SILT, trace to some clay, becoming firm, grey SILT below 53cm.		92.90	47.00	0772-03							
		End of Sediment Core.		122.50	62.00								
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) No Geotech sample collected at this location insufficient material.											
3													

Photograph Showing Sediment Core SC09-47.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./D.P.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-48

SHEET 1 OF 1
DATUM: Geodetic

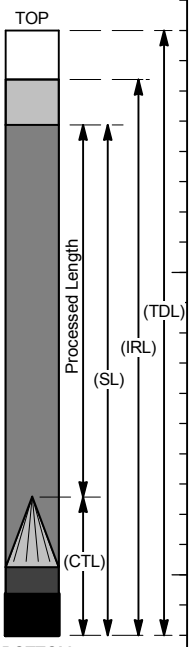
LOCATION:
N: ~5364808.2 E: ~468575.6
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 10, 2009 TIME: 16:24
COLLECTION CREW / VESSEL: D.H./N.G./M.A./L.M. / Pacific GAL
COLLECTION ATTEMPT: 2 of 2
INITIAL PERCENT RECOVERY: 83.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-9.80									
		Firm, wet, black SILT and SHELLS, trace sand, faint asphalt like odour, sub-rounded cobble 8cm in size at 1.7cm.		0.00	0.00	0753-05							
		Soft, wet, grey SILT, trace fine sand, faint hydrogen sulphide-like odour.		31.00	26.00	0753-06							
1		Firm, wet, grey SILT, some shell fragments and clay, wood fragment 6cm in length and plastic at 100cm, sub-rounded cobble 4-5cm in length at 120cm.		95.50	80.00	0753-07							
		Soft, moist, dark grey SILT, trace fine sand with black-grey mottling.		151.60	127.00	0753-08							
2		Stiff, moist, light grey SILTY CLAY, trace shell fragments.		215.90	181.00	0753-09							
		End of Sediment Core.		227.90	191.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-48.



Total Driven Length (TDL): 235.0 cm

Initial Recovered Length (IRL): 197.0 cm

Settled Length (SL): 214.0 cm

Processed Length: 191.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-49

SHEET 1 OF 1
DATUM: Geodetic

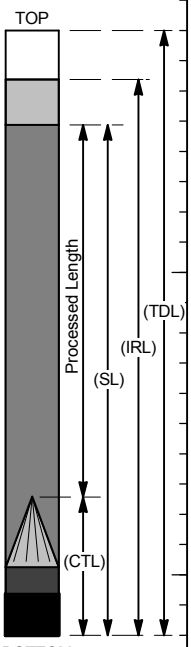
LOCATION:
N: ~5364791.4 E: ~468548.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 11, 2009 TIME: 11:00
COLLECTION CREW / VESSEL: M.A./D.H./N.G. / Pacific GAL
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 83.5%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.20									
	Core Catcher (with fins) Vibra-core			0.00	0.00	0754-01 0754-02							
1		Soft, wet, black SILT, strong hydrogen sulphide-like odour, trace organics, becoming firmer with depth.				0754-03							
				122.20	102.00								
2		Soft to firm, moist, grey SILTY CLAY becoming firm from 142cm to base of core, wood fragment 5cm in length at 142-147cm, fragments and pieces of wire 10cm in length.				0754-04							
				209.60	175.00								
3		End of Sediment Core. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Anchor composite: 0754-05 [0-50cm recovered and 0-59.8cm in-situ]. 3.) 0754-02 is a duplicate of 0754-01.											

Photograph Showing Sediment Core SC09-49.



Total Driven Length (TDL): 234.0 cm

Initial Recovered Length (IRL): 195.5 cm

Settled Length (SL): 194.5 cm

Processed Length: 175.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./L.M.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0004

RECORD OF SEDIMENT CORE: SC09-50

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364775.5 E: ~468489.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: February 17, 2009 TIME: 12:50
COLLECTION CREW / VESSEL: D.H./D.H./M.S. / Aluminator
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 79.8%

LENGTH / DIAMETER:
Barrel = 227cm Liner = 225cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.40									
	Core Catcher (with fins) Vibra-core	Wet, black SILT, hydrocarbon-like sheen on surface. Sediment surface not clearly defined due to volume of water present in sample.		0.00	0.00	0771-01							
1		Wet SILT, trace clay, angular cobbles approximately 8cm at 50-70cm, slight hydrogen sulphide-like odour, angular terracotta fragment approximately 8cm in length at 50cm. Decreasing water content with depth.		62.70	50.00	0771-02							
		Wet, black, SILT, some clay, trace coarse sand.		119.00	95.00	0771-03							
		Wet, grey-black CLAYEY SILT, slight hydrocarbon-like odour, large rock from 131-140cm.		145.40	116.00								
		Moist, grey SILTY CLAY, trace gravel.		176.70	141.00								
2		End of Sediment Core.		190.50	152.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected at 70-100cm below mudline.											

Photograph Showing Sediment Core SC09-50.

DEPTH SCALE
1 : 25

LOGGED: A.K./D.P./J.K.
CHECKED: R.J.

Golder Associates

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-101

SHEET 1 OF 1
DATUM: Geodetic

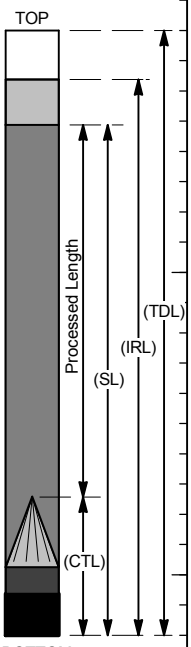
LOCATION:
N: ~5365019.4 E: ~467905.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 23, 2009 TIME: 2:35:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 76.4%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.87									
	Core Catcher (with fins) Vibra-core	Very soft, wet, dark grey-black SILT, moderate hydrocarbon-like odour, fibrous organic matter at 25-28cm.		0.00	0.00	21553-10							
		Firm, moist, grey CLAYEY SILT, trace shell fragments below 50cm, moderate hydrogen sulphide-like odour, intact shell at 50cm, 98-101cm, 152 and 206cm.		39.30	30.00	21553-11							
1						Geotech							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21553-12							
		End of Sediment Core.		281.40	215.00								
3													

Photograph Showing Sediment Core SC09-101.



Total Driven Length (TDL): 311.0 cm

Initial Recovered Length (IRL): 237.5 cm

Settled Length (SL): 215.0 cm

Processed Length: 215.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: M.S./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-102A

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5365092.9 E: ~468007.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 24, 2009 TIME: 10:20:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 3
INITIAL PERCENT RECOVERY: 74%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-11.34									
	Core Catcher (with fins) / Vibra-core	Very soft, wet, dark grey SILT, trace wood and shell fragments, hydrogen sulphide-like odour.		0.00	0.00	21555-09							
		Soft, wet, dark grey SILT, intact shells 8cm in length.		33.80	25.00	21555-10							
1		Loose to soft, wet, light-grey SILT, extensive intact shells and shell fragments throughout, trace rounded gravel and coarse angular gravel.		77.00	57.00	21555-11							
2		End of Sediment Core. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected from Attempt 2 of 3 (SC09-102B) from approximately 56.9-122.3cm.		168.90	125.00								
3													

Photograph Showing Sediment Core SC09-102A.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: P.C./S.A
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-103

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5365042.2 E: ~468013.9
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 27, 2009 TIME: 4:30:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 81.7%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-11.82									
		Very soft, very wet, black SILT, strong hydrogen sulfide odour, trace shells below 50cm, becoming soft and wet below 5cm, wood debris (stick) at 28-36cm, rubber and metal unkown object at 40cm, trace angular gravel at 60-66cm.		0.00	0.00	21557-05							
1		Moderately firm, moist, grey-brown CLAYEY SILT, moderate hydrogen sulfide odour, becoming firm at 89cm, trace shell fragments throughout, trace rounded coarse gravel at 26cm, trace angular gravel at 88cm.		80.80	66.00	21557-06							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21557-07							
		End of Sediment Core.		258.30	211.00								
3													

Total Driven Length (TDL): 293.0 cm

Initial Recovered Length (IRL): 239.5 cm

Settled Length (SL): 211.0 cm

Processed Length: 211.0 cm

Photograph Showing Sediment Core SC09-103.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-104B

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364974.4 E: ~468017.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 24, 2009 TIME: 9:40:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 2 of 2
INITIAL PERCENT RECOVERY: 96.1%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.81									
	Core Catcher (with fins) Vibra-core	Very soft, wet, dark grey SILT, some sand, wood fragments and rootlets throughout, intace shell at 20-27cm.		0.00	0.00	21555-01							
				33.30	32.00								
1		Soft turning to firm at 189cm, moist, brownish-grey CLAYEY SILT, trace sand and shell fragments, intact shells at 130-158cm, trace wood debris at 230-260cm.				21555-02 21555-03							
						21555-04							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21555-03 is a duplicate of 21555-02. 3.) Geotech sample collected from Attempt 1 of 2 (SC09-104A) from 68-92cm.											
		End of Sediment Core.		270.60	260.00								
3													

Photograph Showing Sediment Core SC09-104B.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: P.C./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-105

SHEET 1 OF 1
DATUM: Geodetic

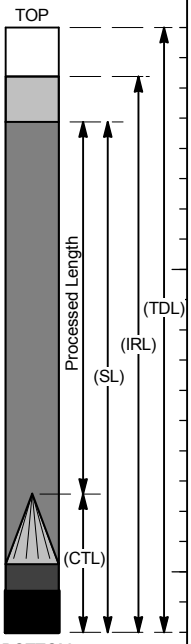
LOCATION:
N: ~5365004.5 E: ~468042.9
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 23, 2009 TIME: 2:55:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 80.2%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES SCN NUMBER	WATER CONTENT PERCENT Wp W WI (10 20 30 40)	GRADATION % GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-11.61									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, dark grey to back SILT, trace sand and shell fragments, intact shells less than 8cm in length, marine organics odour, wet below 11cm.		0.00	0.00	21559-01							
1		Firm, moist, greyish-brown CLAYEY SILT, moderate hydrogen sulphide-like odour, becoming more firm below 200cm, trace shell fragments throughout, intact shell at 86cm, 67cm, 87cm, 102cm, 130cm, and 206cm, shells up to 9cm in length, piece of plastic wire at 60cm.		26.20	21.00	21559-02							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				Geotech							
						21559-03							
		End of Sediment Core.		280.50	225.00								
3													

Photograph Showing Sediment Core SC09-105.



Total Driven Length (TDL): 311.0 cm

Initial Recovered Length (IRL): 249.5 cm

Settled Length (SL): 225.0 cm

Processed Length: 225.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: M.S./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-106

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364979.5 E: ~468083.9
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 28, 2009 TIME: 9:50:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 2 of 2
INITIAL PERCENT RECOVERY: 90.2%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.01									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, trace hydrocarbon-like sheen, slight sewage-like odour, trace rootlets and organics.		0.00	0.00	21560-01							
		Compact, wet, black WOOD DEBRIS and SHELL FRAGMENTS, some silt.		22.20	20.00								
1		Soft, moist to wet, grey-brown, CLAYEY SILT, moderately becoming firm, moist and trace shell fragments below 114cm, coarse angular gravel less than 8cm in length at 78cm.		46.60	42.00	21560-03 21560-02							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21560-03 is a duplicate of 21560-02.				21560-04							
		End of Sediment Core.		246.10	222.00								
3													

Total Driven Length (TDL): 296.0 cm

Initial Recovered Length (IRL): 267.0 cm

Settled Length (SL): 222.0 cm

Processed Length: 222.0 cm

Photograph Showing Sediment Core SC09-106.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-107

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364958.4 E: ~468110.0
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 21, 2009 TIME: 1:30:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 83.8%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 298cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.76									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, trace shell fragments below 20cm, becoming dark grey below 20cm.		0.00	0.00	21551-05 21551-06							
1		Soft, moist, grey CLAYEY SILT, trace shell fragments, firm below 120cm, intact shell at 44cm, 70cm and 90cm, rounded gravel 3m in size at 39cm, moderate hydrogen sulfie-like odour at 125cm.		39.40	33.00	21551-07							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21551-06 is a duplicate of 21551-05.				21551-08							
3		End of Sediment Core.		273.30	229.00								

Total Driven Length (TDL): 314.0 cm

Initial Recovered Length (IRL): 263.0 cm

Settled Length (SL): 229.0 cm

Processed Length: 229.0 cm

Photograph Showing Sediment Core SC09-107.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-108

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364938.0 E: ~468049.6
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 24, 2009 TIME: 11:35:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 97.9%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.94									
	Core Catcher (with fins) Vibra-core	Very soft, wet, dark grey SILT, trace suspected black angular charcoal or crystallized tar.		0.00	0.00	21555-05							
1		Soft, moist, brownish-grey SILT, some clay, intact shell at 68cm.		26.60	26.00	21555-06							
2		Firm to stiff, grey SILT, some clay below 150cm, trace shell fragments throughout, trace wood fiber at 150-253cm, large rounded gravel at 236cm. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.		151.20	148.00	21555-07							
		End of Sediment Core.		258.40	253.00								
3													

Total Driven Length (TDL): 289.6 cm

Initial Recovered Length (IRL): 283.5 cm

Settled Length (SL): 253.0 cm

Processed Length: 253.0 cm

Photograph Showing Sediment Core SC09-108.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: P.C./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-109

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364885.1 E: ~468083.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 24, 2009 TIME: 1:35:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 81.3%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.11									
	Core Catcher (with fins) Vibra-core	Very soft, wet, dark grey SILT, grading to soft SILT with sand.		6.20	5.00	21554-04							
1						21554-05							
		Soft, wet to moist, grey CLAYEY SILT, some fine sand, trace shell fragments up to 4cm in length.				Geotech							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21554-06							
		End of Sediment Core.		258.30	210.00								
3													

Total Driven Length (TDL): 289.6 cm

Initial Recovered Length (IRL): 235.5 cm

Settled Length (SL): 210.0 cm

Processed Length: 210.0 cm

Photograph Showing Sediment Core SC09-109.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: P.C./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-110

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364949.2 E: ~468191.3
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 22, 2009 TIME: 9:32:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 3 of 3
INITIAL PERCENT RECOVERY: 77%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.94									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, trace sand, trace shell fragments, a layer of dense shell fragments at 34cm.		0.00	0.00	21552-12							
		Compact, wet, black, angular GRAVEL and coarse SAND.		51.90	40.00								
1		Moderately firm, moist, grey CLAYEY SILT, trace coarse sand, intact shell at 70cm, trace angular gravel.		70.10	54.00	21576-01							
		Liner in bent stainless steel barrel (no logging or recovery). *		101.30	78.00								
		Very soft, very wet, grey SILT, trace sand and shell fragments, broken shells at 104cm, trace wood debris 10cm in size at 150cm.		132.50	102.00	21576-02							
2		End of Sediment Core.		203.90	157.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) *Segment of core removed with stainless steel barrel, from 78-102cm, due to barrel being bent during core advacement and/or recovery. 3.) Unable to measure Initial Recovered Length (IRL).											

Total Driven Length (TDL): 204.0 cm

Initial Recovered Length (IRL): cm

Settled Length (SL): 157.0 cm

Processed Length: 157.0 cm

Photograph Showing Sediment Core SC09-110.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-111C

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364933.0 E: ~468250.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 20, 2009 TIME: 1:40:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 3 of 3
INITIAL PERCENT RECOVERY: 84.8%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.64									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, trace shell fragments.		0.00	0.00	21548-06							
		Dense, wet, black SHELLS, some silt, trace small (coarse gravel sized) shell fragments, a layer of black angular coarse sand (potential sand blast girt) at 32-40cm.		18.90	16.00	21548-07							
		Soft, wet, black SILT, trace wood debris, 10cm sized angular rock at 68cm.		49.50	42.00	21548-08							
1		Firm, moist, grey CLAYEY SILT, trace shell fragments.		94.30	80.00	21548-09							
		End of Sediment Core.		128.50	109.00								
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected from Attempt 2 of 3 (SC09-111B) from approximately 84.7-176.8cm.											
3													

Photograph Showing Sediment Core SC09-111C.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-112

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364896.6 E: ~468214.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 21, 2009 TIME: 2:45:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 79.9%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 302cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.79									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black-grey SILT, trace shell fragements, intact shell at 14-16cm.		0.00	0.00	21550-08							
1		Soft to firm below 150cm, moist, grey CLAYEY SILT, trace shell fragments, intact shell at 54cm, 132cm and 190cm.		27.50	22.00	21550-09							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21550-10							
3		End of Sediment Core.		286.60	229.00								

Total Driven Length (TDL): 311.0 cm

Initial Recovered Length (IRL): 248.5 cm

Settled Length (SL): 229.0 cm

Processed Length: 229.0 cm

Photograph Showing Sediment Core SC09-112.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-113

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364863.8 E: ~468168.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

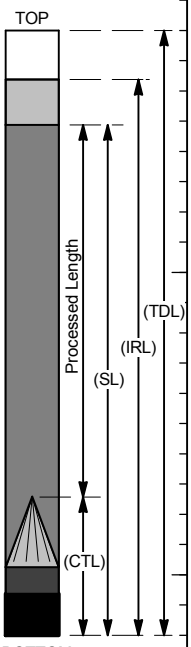
COLLECTION DATE: July 23, 2009 TIME: 9:50:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 95.7%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-14.33									
	Core Catcher (with fins) / Vibra-core	Very soft, very wet, black SILT, trace shell fragment at 0-20cm, intact shells at 20-30cm, trace wood debris.		0.00	0.00	21553-01							
				31.30	30.00								
1						21553-03 21553-02							
		Soft, wet, grey CLAYEY SILT, trace shell fragements, becoming firm at 110cm, trace wood debris at 260cm, intact shell at 90cm, 120cm and 173cm.				21553-04							
2													
		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21553-03 is a duplicate of 21553-02.				21553-05							
		End of Sediment Core.		279.00	267.00								
3													

Photograph Showing Sediment Core SC09-113.

CORE COLLECTION DETAILS



Total Driven Length (TDL): 311.0 cm

Initial Recovered Length (IRL): 297.5 cm

Settled Length (SL): 267.0 cm

Processed Length: 267.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: M.S./S.A
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-114

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364786.7 E: ~468200.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 22, 2009 TIME: 4:46:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 87.3%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp W WI; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-13.84									
		Very soft, wet, black SILT, slightly hydrogen sulphide-like odour, soft below 42cm, grading to dark grey below 46cm.		0.00	0.00	21552-01							
1		Firm, wet, grey CLAYEY SILT, trace shell fragments, moderate hydrogen sulphide-like odour, moist below 103cm, three intact shells pieces approximatly 6cm in length at 142cm, fibrous wood debris approximately 5cm in length at 160cm, intact shells at 220-232cm.		73.30	64.00	21552-02							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21552-03							
3		End of Sediment Core.		285.20	249.00								

Photograph Showing Sediment Core SC09-114.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-115

SHEET 1 OF 1
DATUM: Geodetic

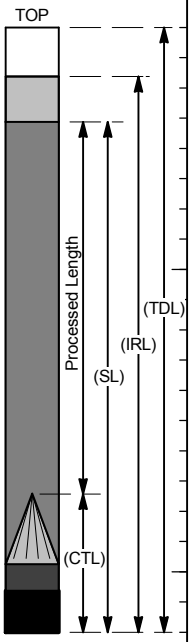
LOCATION:
N: ~5364841.7 E: ~468213.3
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 23, 2009 TIME: 9:20:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 84.9%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.55									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, becoming soft below 14cm.		0.00	0.00	21576-03							
1		Soft, wet, grey CLAYEY SILT, intact shells at 22-38cm 3-9cm in length, becoming moist below 43cm, trace shell fragments, becoming firm at 136cm, moderate hydrogen sulfide-like odour, trace wood debris at 180cm.		25.90	22.00	21576-04							
						21576-05							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21576-06							
		End of Sediment Core.		274.40	233.00								
3													

Photograph Showing Sediment Core SC09-115.



Total Driven Length (TDL): 308.0 cm

Initial Recovered Length (IRL): 261.5 cm

Settled Length (SL): 233.0 cm

Processed Length: 233.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-116

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364880.1 E: ~468288.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 21, 2009 TIME: 9:05:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 87.9%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 302cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.65									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, grading to grey below 22cm, moderate hydrogen sulphide-like odour.		0.00	0.00	21550-01							
1		Firm, moist, grey CLAYEY SILT, trace shell fragments, intact shells approximately 4-6cm in length at 43cm, 180cm and 215-230cm, trace fine sand at 210cm.		36.40	32.00	21550-02							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21550-04 is a duplicate of 21550-03.				21550-04 21550-03							
3		End of Sediment Core.		287.80	253.00								

Photograph Showing Sediment Core SC09-116.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-117

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364919.8 E: ~468329.7
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 21, 2009 TIME: 3:38:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 98.6%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 454cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-12.19									
		Very soft, very wet, black SILT, slight hydrocarbon-like odour.		6.10	6.00	21551-02							
		Dense, moist to wet, black SHELL FRAGMENTS, some silt, shell grading from fine to coarse below 20cm, trace sub-angular and sub-rounded gravel, faint hydrocarbon-like odour.		39.60	39.00	21551-03							
1		Soft, moist, black SANDY SILT grading to dense SILTY SAND below 57cm, suspect sandblast grit from 58-72cm.		79.10	78.00								
		Medium dense, moist, grey GRAVEL, some sand, trace silt, coarse sub-rounded gravel from 79-88cm.		103.40	102.00	21551-04							
		Very firm, moist, grey CLAYEY SILT, horizontal light grey banding.											
2		End of Sediment Core.		137.90	136.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Total Driven Length (TDL): 138.0 cm

Initial Recovered Length (IRL): 136.0 cm

Settled Length (SL): 136.0 cm

Processed Length: 136.0 cm

Photograph Showing Sediment Core SC09-117.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./S.A./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-118B

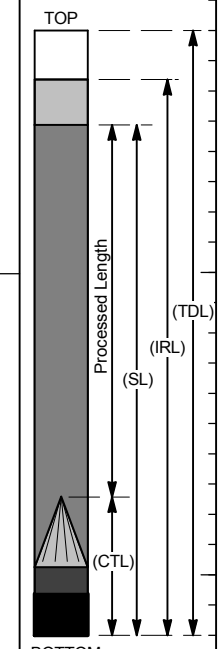
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364904.0 E: ~468374.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 29, 2009 TIME: 8:15:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 2 of 2
INITIAL PERCENT RECOVERY: 92.5%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-12.45 / 0.00	0.00								
		Soft, very wet, black SILT, trace shell fragments, moderate hydrocarbon sulphide-sewage-like odour, becoming moderately firm below 22cm, trace coarse angular gravel, trace organics (sticks, bark) at 22cm, wood debris 7cm in length at 55cm, bone 7cm in length clean cut on one end, socket on other end at 63cm.				21562-02 21562-01							
		Firm, moist, black CLAYEY SILT, becoming grey below 83cm, trace shell fragments.		82.20	76.00	21562-03							
1				100.50	83.00								
		End of Sediment Core.											
2													
3													



Total Driven Length (TDL): 113.0 cm

Initial Recovered Length (IRL): 104.5 cm

Settled Length (SL): 93.0 cm

Processed Length: 93.0 cm

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.
2.) 21562-02 is a duplicate of 21562-01.
3.) Geotech sample collected from Attempt 1 of 2 (SC09-118A) from 12-100cm.

Photograph Showing Sediment Core SC09-118B.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-119A

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364888.5 E: ~468346.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 23, 2009 TIME: 10:38:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 7
INITIAL PERCENT RECOVERY: 50%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 454cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.03									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, trace sand, slight hydrocarbon odour and slight hydrocarbon-like sheen.		0.00	0.00	21553-06							
		Loose, wet, black SILT with well graded gravel, trace sand, hydrocarbon like odour.		40.00	20.00								
1		Loose, wet, black SILT with gravel, trace sand, with pockets of stiff clay, hydrocarbon like odour, angular gravel up to 11cm in size, trace shell fragments at 40cm.		60.00	30.00	21553-07 21553-08							
2		Soft, wet, greyish-black CLAYEY SILT, trace sand, fine to medium gravel and shell fragments, hydrocarbon-like odour, intact shell at 114cm.		194.00	97.00	21553-09							
		End of Sediment Core.		238.00	119.00								
3													

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.
2.) 21553-08 is a duplicate of 21553-07.
3.) Refer also to SC09-119C record, Attempt 3 of 7.

Total Driven Length (TDL): 300.0 cm

Initial Recovered Length (IRL): 150.0 cm

Settled Length (SL): 119.0 cm

Processed Length: 119.0 cm

Photograph Showing Sediment Core SC09-119A.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: M.S./S.A
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-119C

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364878.2 E: ~468352.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 29, 2009 TIME: 11:27:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 3 of 7
INITIAL PERCENT RECOVERY: 88.8%

LENGTH / DIAMETER:
Barrel = 481cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.75									
	Core Catcher (with fins) / Vibra-core	Very sort, very wet, black, saturated-liquified SANDY SILT, fine grained sand, pocket of soft wet black CLAYEY SILT from 8-20cm, faint hydrogen sulphide odour, becoming grey at 35cm.		0.00	0.00	21562-04							
		Loose, very wet, grey, fine to medium grained, Saturated SILTY SAND, trace shell fragments from 65-70cm.		47.30	42.00	21562-05							
1		Compact, moist, grey SAND and GRAVEL, subangular fine gravel less than 2cm in length, trace shell fragments, grading to coarse subangular gravel less than 6cms in length to end of core.		78.80	70.00								
		End of Sediment Core.		123.90	110.00								
2													
3													

Total Driven Length (TDL): 16890.0 cm

Initial Recovered Length (IRL): 150.0 cm

Settled Length (SL): 110.0 cm

Processed Length: 110.0 cm

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.
2.) Refer also to SC09-119A record, Attempt 1 of 7.

Photograph Showing Sediment Core SC09-119C.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-120

SHEET 1 OF 1
DATUM: Geodetic

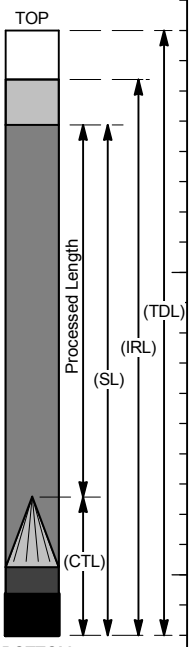
LOCATION:
N: ~5364862.9 E: ~468372.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 29, 2009 TIME: 9:30:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 2 of 2
INITIAL PERCENT RECOVERY: 100%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-12.04									
		Compact, wet, black SHELL FRAGMENTS, trace silt, trace hydrocarbon-like sheen, moderate sewage-like odour.		0.00	0.00	21562-06							
		Soft, wet, grey CLAYEY SILT, trace sub-rounded gravel, trace sand, becoming firm and moist below 53cm, wood debris 12cm in length at 40cm, intact shell at 52.73cm less than 5cm in length, layer of fine shell fragments at 97-100cm.		21.00	21.00	21562-07							
1		Compact, wet, grey, fine grained SAND and SILT, trace sub-angular gravel, becoming loose, very wet below 165cm, intact shells less than 9cm in length at 144cm and 126cm.		104.00	104.00	21562-08							
2		End of Sediment Core.		202.00	202.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-120.



Total Driven Length (TDL): 239.7 cm

Initial Recovered Length (IRL): 239.5 cm

Settled Length (SL): 202.0 cm

Processed Length: 202.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-121

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364862.8 E: ~468342.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

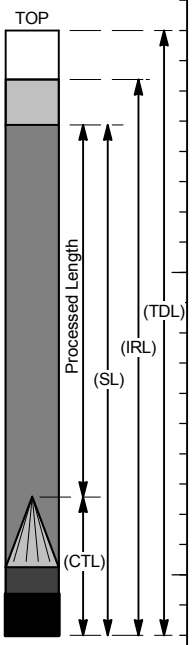
COLLECTION DATE: July 27, 2009 TIME: 12:30:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 79%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-13.08 / 0.00	0.00								
		Soft, very wet, black SILT, trace rootlets, slight hydrocarbon-like sheen, moderate hydrocarbon-like odour (tar-like), wood waste (bark) 6cm in length at 2cm, wood stick 5cm in length at 7cm, trace wood debris below 30cm.				21556-04 21556-05							
1		Soft, wet, grey SILT, some sand, trace shell fragments.		103.80	82.00	21556-06							
		Compcat, wet, grey, fine grained SAND and SHELL FRAGMENTS, trace gravel.		126.60	100.00	Geotech							
2		Compact, moist, grey SILT, trace clay, trace fine grained sand, coarse sub-angular gravel at 160-163cm.		164.60	130.00	21556-07							
3		End of Sediment Core.		232.90	184.00								

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.
2.) 21556-05 is a duplicate of 21556-04.

Photograph Showing Sediment Core SC09-121.



Total Driven Length (TDL): 260.0 cm

Initial Recovered Length (IRL): 205.5 cm

Settled Length (SL): 184.0 cm

Processed Length: 184.0 cm

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-122

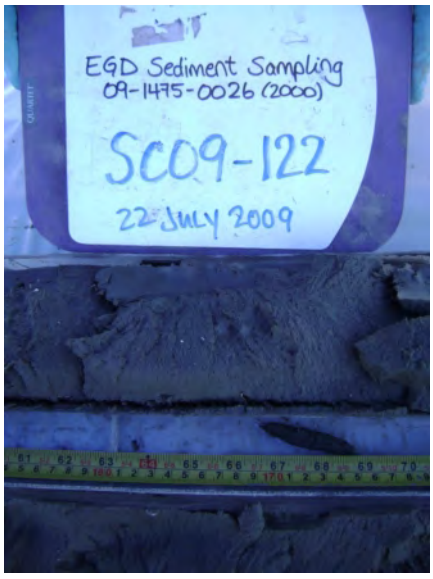
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364837.0 E: ~468302.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 21, 2009 TIME: 9:42:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 96.3%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.95									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, moderate hydrogen sulphide-like odour, layer of fine shell fragments at 14cm, intact shells at 10-18cm.		0.00	0.00	21550-11							
				14.50	14.00								
1		Soft to firm, moist, grey CLAYEY SILT, trace shell fragments from 0-115cm, large intact shell at 270cm, moderate hydrogen sulphide-like odour throughout.				21550-12							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21551-01							
3		End of Sediment Core.		289.70	279.00								



Total Driven Length (TDL): 311.0 cm

Initial Recovered Length (IRL): 299.5 cm

Settled Length (SL): 279.0 cm

Processed Length: 279.0 cm

Photograph Showing Sediment Core SC09-122.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-123

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364793.2 E: ~468244.6
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 22, 2009 TIME: 3:44:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 81.5%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.68									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, faint hydrogen sluphide-like odour, wood debris at 15cm.		0.00	0.00	21552-05							
1		Soft, wet, grey CLAYEY SILT, trace shell debris, moderate hydrogen sulphide-like odour, firm, most, strong hydrogen sulphide-like odour at 92cm to end of core.		27.00	22.00	21552-06							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21552-06 is a duplicate of 21552-05.				21552-07							
		End of Sediment Core.		274.80	224.00								
3													

Total Driven Length (TDL): 311.0 cm
Initial Recovered Length (IRL): 253.5 cm
Settled Length (SL): 224.0 cm
Processed Length: 224.0 cm

Photograph Showing Sediment Core SC09-123.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-124

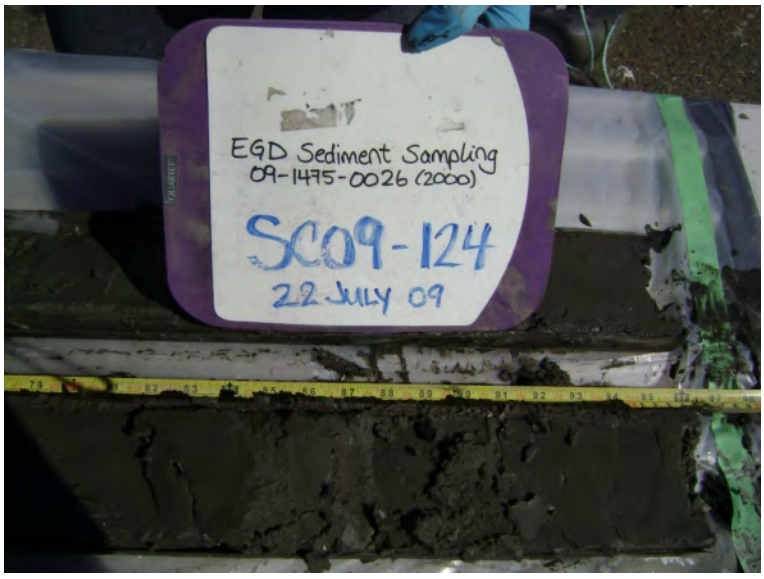
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364732.6 E: ~468278.3
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 21, 2009 TIME: 10:20:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 87.6%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 302cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.38									
	Core Catcher (with fins) Vibra-core	Very, soft, very wet, black SILT, slight hydrogen sulphide-like odour, trace wood debris.		0.00	0.00	21550-05							
1		Firm, moist, grey CLAYEY SILT, trace shell fragments, moderate hydrogen sulphide-like odour, intact shell at 145cm.		20.50	18.00	21550-06							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21550-07							
		End of Sediment Core.		276.30	242.00								
3													



Total Driven Length (TDL): 311.0 cm

Initial Recovered Length (IRL): 272.5 cm

Settled Length (SL): 242.0 cm

Processed Length: 242.0 cm

Photograph Showing Sediment Core SC09-124.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-125

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364713.7 E: ~468352.9
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 23, 2009 TIME: 4:45:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 92.8%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-11.89									
	Core Catcher (with fins) / Vibra-core	Very soft, very wet, dark grey-black SILT, trace sand, trace angular gravel, intact shells 9cm in length at 0cm.		2.20	2.00	21559-04							
1		Soft, moist, greyish-brown CLAYEY SILT, trace shell fragments, moderate hydrogen sulfide-like odour, very soft, wet, greyish-brown disturbed CLAYEY SILT, at 70-82cm and 42-57cm, twigs at 230cm, becoming firm at approximately 155cm.				Geotech							
						21559-05							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21559-06							
		End of Sediment Core.		280.20	260.00								
3													

Total Driven Length (TDL): 311.0 cm

Initial Recovered Length (IRL): 288.5 cm

Settled Length (SL): 260.0 cm

Processed Length: 260.0 cm

Photograph Showing Sediment Core SC09-125.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: M.S./R.P.C
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-126

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364756.5 E: ~468364.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 20, 2009 TIME: 1:00:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 92%

LENGTH / DIAMETER:
Barrel = 308cm Liner = 302cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.18									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, trace shell fragments, grey below 25cm.		0.00	0.00	21548-10							
1		Soft, moist, grey CLAYEY SILT, trace shell fragments, firm below 98cm, some shell fragments at 226cm.		40.20	37.00	21548-11							
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.				21548-12							
						21549-01							
3		End of Sediment Core.		278.30	256.00								

Total Driven Length (TDL): 311.0 cm

Initial Recovered Length (IRL): 286.5 cm

Settled Length (SL): 256.0 cm

Processed Length: 256.0 cm

Photograph Showing Sediment Core SC09-126.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-127

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364779.0 E: ~468354.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 20, 2009 TIME: 10:38:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 84.1%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 300cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.83									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, trace shell fragments, moderate hydrogen sulfide-like odour, trace rootlets.		0.00	0.00	21548-02 21548-01							
1		Soft, wet, black SILT to CLAYEY SILT, trace shell fragments, trace wood waste.		59.50	50.00	21548-03							
2		Firm, moist, grey CLAYEY SILT, trace shell fragments, intact shells at 155-230cm, becoming very firm below 190cm. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21548-02 is a duplicate of 21548-01.		113.00	95.00	21548-04 21548-05							
3		End of Sediment Core.		278.20	234.00								

Photograph Showing Sediment Core SC09-127.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-128

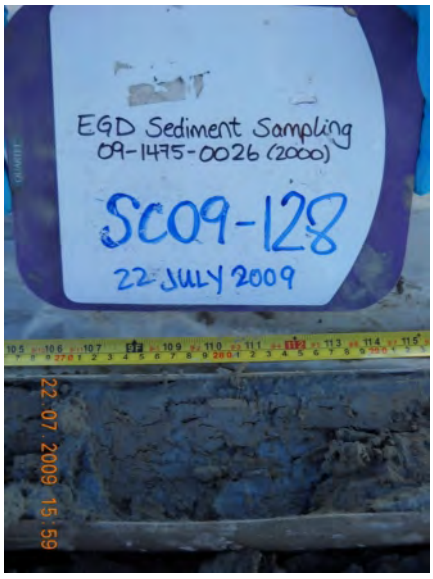
SHEET 1 OF 2
DATUM: Geodetic

LOCATION:
N: ~5364738.4 E: ~468410.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 21, 2009 TIME: 11:20:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 91.6%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 454cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-13.08									
				0.00	0.00	21551-09							
		Very soft, very wet, black SILT, trace shell fragments, strong hydrogen sulphide-like odour.				Geotech							
1				87.30	80.00	21551-10							
		Soft, wet, black and grey CLAYEY SILT, approximately 10cm pockets of very soft, black SILT at 104cm and 119cms.											
				146.30	134.00								
2		Moderately firm, wet, grey CLAYEY SILT with some fine sand and intact shells, a layer of intact shells less than 10cm at 140-190cm, shell fragments at 190-230cm.				21551-11							
				251.10	230.00								
3		Stiff, moist, grey with orange mottled CLAYEY SILT.											
		CONTINUED NEXT PAGE											



Photograph Showing Sediment Core SC09-128.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-128

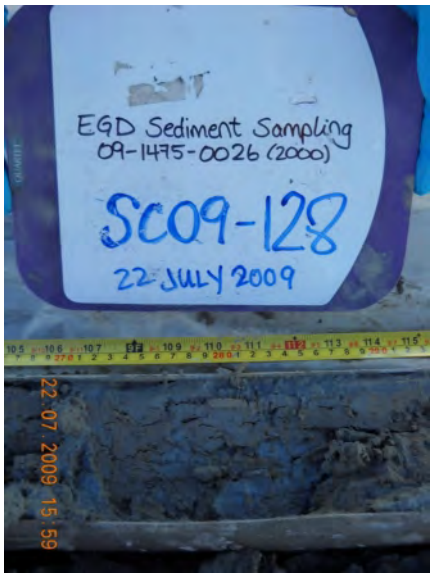
SHEET 2 OF 2
DATUM: Geodetic

LOCATION:
N: ~5364738.4 E: ~468410.5
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 21, 2009 TIME: 11:20:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 91.6%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 454cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
3	Core Catcher (with fins) / Vibra-core	Stiff, moist, grey with orange mottled CLAYEY SILT. *(continued)*				21551-12							
		End of Sediment Core.		355.90	326.00								
4		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											
5													
6													



Photograph Showing Sediment Core SC09-128.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-129

SHEET 1 OF 2
DATUM: Geodetic

LOCATION:
N: ~5364719.8 E: ~468448.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 27, 2009 TIME: 11:05:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 98.6%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-11.01									
		Very soft, wet, dark grey SILT, trace shell fragments with pockets of soft CLAYEY SILT throughout, trace coarse gravel at 20-23cm.		0.00	0.00	21556-08							
1		Moderately firm, moist, dark grey and brown CLAYEY SILT, trace shell fragments, strong hydrocarbon-like odour below 60cm, strong marine decay odour at 30-50cm, intact shell 8 cm in length at 68cm, 87cm, 177cm and 184cm.		30.40	30.00	21556-09							
2						21556-10							
		Firm, moist to wet SILT and SHELL FRAGMENTS, some intact shells.		253.50	250.00								
3		*CONTINUED NEXT PAGE*											

Photograph Showing Sediment Core SC09-129.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-129

SHEET 2 OF 2
DATUM: Geodetic

LOCATION:
N: ~5364719.8 E: ~468448.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 27, 2009 TIME: 11:05:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 98.6%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
3		Firm, moist to wet SILT and SHELL FRAGMENTS, some intact shells. *(continued)*											
	Core Catcher (with fins) / Vibra-core			339.80	335.00	21556-11							
4		Moderately firm, moist, dark grey and brown CLAYEY SILT, trace shell fragments, moderately to strong hydrogen sulphide-like odour.											
		End of Sediment Core.		438.10	432.00								
5													
6		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Photograph Showing Sediment Core SC09-129.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-130

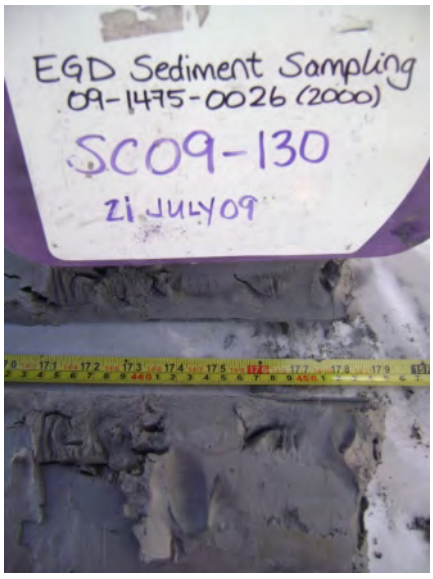
SHEET 1 OF 2
DATUM: Geodetic

LOCATION:
N: ~5364790.0 E: ~468439.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 20, 2009 TIME: 3:02:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 99%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-12.52									
				0.00	0.00								
		Very soft, very wet, black SILT, trace wood debris, moderate hydrogen sulphide-like odour, trace to some intact shell fragments, becoming wet below 50cm, two pieces of coarse rounded gravel 5cm in size.				21549-02							
1		Firm, wet, grey SILT, some intact shells less than 9cm in length, trace to some fine grained sand below 100cm.		75.80	75.00	21549-03							
				121.20	120.00								
2		Firm to very firm, moist, grey CLAYEY SILT, increased CLAY content below 3cm, three pieces of coarse gravel at 435cm.				21549-04 21549-05							
						Geotech							
3		*CONTINUED NEXT PAGE*											



Photograph Showing Sediment Core SC09-130.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-130

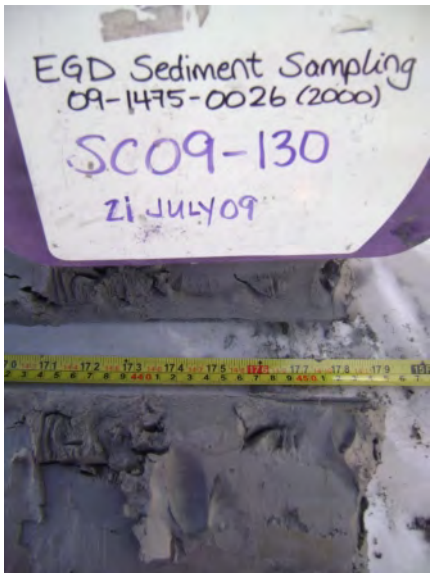
SHEET 2 OF 2
DATUM: Geodetic

LOCATION:
N: ~5364790.0 E: ~468439.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 20, 2009 TIME: 3:02:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 99%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
3	Core Catcher (with fins) Vibra-core	Firm to very firm, moist, grey CLAYEY SILT, increased CLAY content below 3cm, three pieces of coarse gravel at 435cm. *(continued)*				21549-06							
4						21549-07							
		End of Sediment Core.		457.60	453.00								
5													
6		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21549-05 is a duplicate of 21549-04.											



Total Driven Length (TDL): 475.0 cm

Initial Recovered Length (IRL): 474.5 cm

Settled Length (SL): 453.0 cm

Processed Length: 453.0 cm

Photograph Showing Sediment Core SC09-130.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-131

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364755.1 E: ~468478.9
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 27, 2009 TIME: 1:55:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 3
INITIAL PERCENT RECOVERY: 100%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-10.17									
		Very soft, very wet, black SILT, trace organics (rootlets), moderate hydrogen sulphide-like odour, becoming soft and wet at 46cm.		0.00	0.00	21557-01 21557-02							
		Soft, very wet, grey CLAYEY SILT, trace fine sand and shell fragments, pockets of saturated-liquid, grey silt and intact shell 7cm in length at 82cm, lense of coarse, sub-angular gravel less than 6cm in length at 86-93cm.		56.00	56.00	21557-03							
1		Very stiff, moist, grey and brown CLAYEY SILT, trace fine sand banding throughout, trace fine sub-rounded gravel.		93.00	93.00	21557-04							
		End of Sediment Core.		166.00	166.00								
2		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21557-02 is a duplicate of 21557-01.											
3													

Photograph Showing Sediment Core SC09-131.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-132

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364763.5 E: ~468514.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 22, 2009 TIME: 1:05:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 2
INITIAL PERCENT RECOVERY: 87.6%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.92 / 0.00	0.00								
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, trace rootlets and shell fragments, soft below 40cm, moderate hydrogen sulphide-like odour.				21552-09 21552-08							
1													
				125.60	110.00	21552-10							
2		Firm, moist, grey CLAYEY SILT.				Geotech							
						21552-11							
		End of Sediment Core.		260.30	228.00								
3													

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.
2.) 21552-09 is a duplicate of 21552-08.

Total Driven Length (TDL): 275.0 cm

Initial Recovered Length (IRL): 241.0 cm

Settled Length (SL): 228.0 cm

Processed Length: 228.0 cm

Photograph Showing Sediment Core SC09-132.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 [ESQUIMALT GRAVING DOCK]\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-133

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364773.1 E: ~468584.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 24, 2009 TIME: 1:55:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 96.6%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-10.04									
		Soft, wet, black SILT, trace shell fragments up to 6cm in length, trace fibrous organics, strong hydrogen sulphide-like odour.		0.00	0.00	21554-08 21554-07							
		Soft, wet, grey CLAYEY SILT, some sand, trace shell fragments, trace wood debris.		66.30	64.00	21554-09							
1		Firm to stiff, moist, grey CLAYEY SILT.		90.10	87.00	21554-10							
2		End of Sediment Core. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) 21554-08 is a duplicate of 21554-07.		178.10	172.00								
3													

Photograph Showing Sediment Core SC09-133.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: P.C./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-134

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364799.6 E: ~468610.0
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 24, 2009 TIME: 3:25:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 88.7%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-6.36									
	Core Catcher (with fins) / Vibra-core	Very soft, liquid, black SILT.		3.40	3.00								
		Soft, wet, black SILT, trace roolets and decomposing organic material, moderate hydrogen sulphide-like odour, hydrocarbon-like odour.				21554-01							
				55.20	49.00	Geotech							
1		Soft to firm, wet, grey, sandy SILT with shell fragements up to 6cm in length, trace wood fibres, slight hydrogen sulphide-like odour.				21554-02							
				171.40	152.00								
2		Firm, wet to moist, grey, silty, fine SAND, trace intact shells up to 5cm in length, trace wood fibre.				21554-03							
		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											
		End of Sediment Core.		259.30	230.00								
3													

Total Driven Length (TDL): 289.6 cm

Initial Recovered Length (IRL): 257.0 cm

Settled Length (SL): 230.0 cm

Processed Length: 230.0 cm

Photograph Showing Sediment Core SC09-134.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: P.C./S.A.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-135B

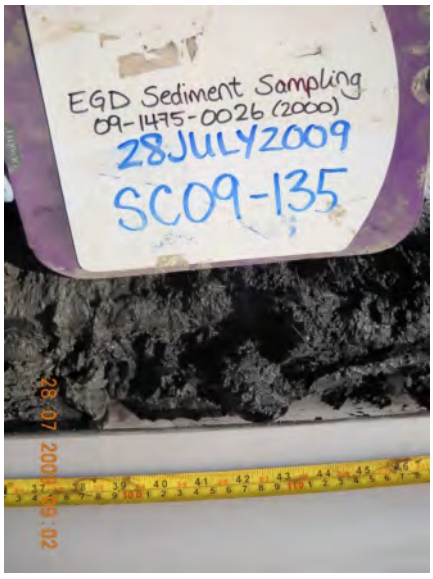
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364805.0 E: ~468663.4
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 27, 2009 TIME: 10:00:00 AM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 2 of 2
INITIAL PERCENT RECOVERY: 92%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES SCN NUMBER	WATER CONTENT PERCENT Wp W WI (10 20 30 40)	GRADATION % GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) Vibra-core	Ground Surface		-4.33									
				0.00	0.00	21556-01							
		Very soft, very wet, black SILT, trace shell fragments and trace rootlets, strong hydrogen sulphide-like odour, glass bottle neck and glass debris at 3cm, becoming soft and wet at 43cm, a layer of some rootlets and organic matter at 68-86cm.				21556-02							
1		Soft, wet, dark grey SILT, some fine sand, trace intact shell, coarse sub-rounded gravel less than 5cm in length at 90cm, very soft, wet, organic inclusions at 105cm.		93.50	86.00								
		Dense, moist, grey SAND, some silt, fine to medium grained sand with shell fragments, trace sub-rounded gravel.		143.50	132.00	21556-03							
2		End of Sediment Core.		179.30	165.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C. 2.) Geotech sample collected from Attempt 1 of 2 (SC09-135A) from 75.8-151.5cm.											



Photograph Showing Sediment Core SC09-135B.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\08-1475-0004 ESQUIMALT GRAVING DOCK\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-136

SHEET 1 OF 1
DATUM: Geodetic

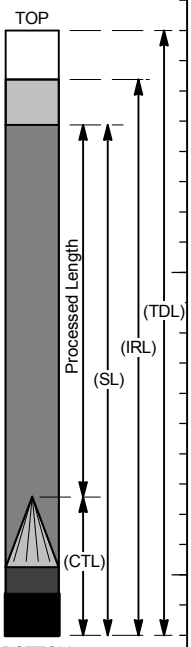
LOCATION:
N: ~5364730.8 E: ~468524.1
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 28, 2009 TIME: 3:45:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 87.2%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-9.89									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, grey SILT, trace fine sand.		0.00	0.00								
		Firm, moist, grey CLAYEY SILT, trace shell fragements, increased CLAY content below 12cm.		10.30	9.00	21560-05							
				25.20	22.00								
1		Soft, moist to wet, grey-brown CLAYEY SILT, trace shell fragments, moderate hydrogen sulphide-like odour, intact shell layer with silt and compact shell fragments less than 10cm in length, wet at 77-121cm, wood waste (small stick) at 161cm, increased firmness, trace fine grained sand and lenses of shell framents below 121cm.				21560-06							
						21560-07							
2		End of Sediment Core.		203.00	177.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

CORE COLLECTION DETAILS



Total Driven Length (TDL): 247.0 cm

Initial Recovered Length (IRL): 215.5 cm

Settled Length (SL): 177.0 cm

Processed Length: 177.0 cm

Photograph Showing Sediment Core SC09-136.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-137

SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364833.5 E: ~468142.2
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 28, 2009 TIME: 3:05:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 80%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0	Core Catcher (with fins) / Vibra-core	Ground Surface		-13.49									
		Very soft, very wet, black SILT, trace shell fragments, sewage-like odour, trace hydrocarbon sheen .		5.00	4.00	21560-11							
1		Soft, moist to wet, grey-brown CLAYEY SILT, trace shell fragments, becoming firm and moist at 80cm to end of core, moderate hydrogen sulphide-like odour throughout, intact shell 5-7cm, at 70cm and 130cm.				21560-12							
2						21561-01							
		End of Sediment Core.		212.50	170.00								
3		Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.											

Total Driven Length (TDL): 240.8 cm

Initial Recovered Length (IRL): 192.5 cm

Settled Length (SL): 170.0 cm

Processed Length: 170.0 cm

Photograph Showing Sediment Core SC09-137.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-138

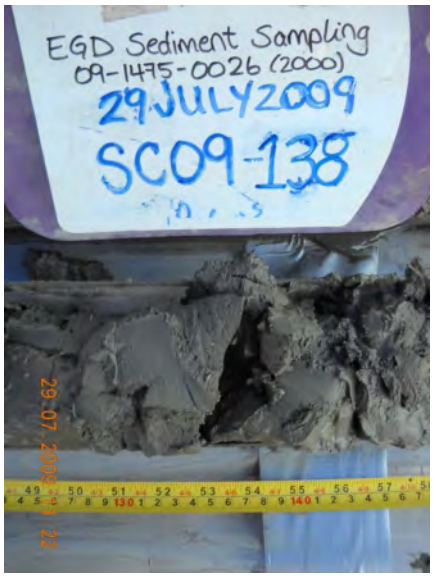
SHEET 1 OF 1
DATUM: Geodetic

LOCATION:
N: ~5364939.4 E: ~468006.8
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 28, 2009 TIME: 2:10:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 75.3%

LENGTH / DIAMETER:
Barrel = 309cm Liner = 301cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-12.62									
	Core Catcher (with fins) Vibra-core	Very soft, very wet, black SILT, trace shell fragments, sewage-rotting organic-like odour.		0.00	0.00	21560-08							
1		Soft, moist, grey-brown CLAYEY SILT, trace shell fragements, becoming firm at 113cm, intact shell 7cm in length at 44cm and 120cm.		21.20	16.00	21560-09 Geotech 21560-10							
2		End of Sediment Core. Note: 1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.		233.70	176.00								
3													



Photograph Showing Sediment Core SC09-138.

DEPTH SCALE
1 : 25

LOGGED: A.K./M.S.
CHECKED: R.J.

Golder Associates

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-139

SHEET 1 OF 2
DATUM: Geodetic

LOCATION:
N: ~5364749.1 E: ~468283.6
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 29, 2009 TIME: 3:20:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 98.9%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
0		Ground Surface		-13.44									
		Very soft, very wet, black SILT, trace shell fragments, slight hydrogen sulfide odour.		0.00	0.00	21562-09							
				18.20	18.00	Geotech							
1	Core Catcher (with fins) / Vibra-core	Firm, moist, grey to brown CLAYEY SILT, trace shell fragments, moderate hydrogen sulphide-like odour, trace woodwaste at 89-110cm, trace intact shell less than 6cm in length at 132cm and 140cm, intact shell less than 8cm in length at 210cm and 295cm.		55.60	55.00	21562-10							
						Geotech							
2						21562-11							
3		*CONTINUED NEXT PAGE*											

Photograph Showing Sediment Core SC09-139.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

PROJECT No.: 09-1475-0026

RECORD OF SEDIMENT CORE: SC09-139

SHEET 2 OF 2
DATUM: Geodetic

LOCATION:
N: ~5364749.1 E: ~468283.6
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

COLLECTION DATE: July 29, 2009 TIME: 3:20:00 PM
COLLECTION CREW / VESSEL: R.S.S. / R.S.S.
COLLECTION ATTEMPT: 1 of 1
INITIAL PERCENT RECOVERY: 98.9%

LENGTH / DIAMETER:
Barrel = 461cm Liner = 453cm Dia. = 10cm
Core Catcher (with fins) =23cm

DEPTH SCALE METRES	COLLECTION RECORD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	Est.* IN-SITU ELEV. (m) / DEPTH (cm)	MEAS. DEPTH (cm)	SAMPLES: SCN NUMBER	WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	GRADATION % GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL LAB. TESTING	CORE COLLECTION DETAILS
3	Core Catcher (with fins) Vibra-core	Firm, moist, grey to brown CLAYEY SILT, trace shell fragments, moderate hydrogen sulphide-like odour, trace woodwaste at 89-110cm, trace intact shell less than 6cm in length at 132cm and 140cm, intact shell less than 8cm in length at 210cm and 295cm. *(continued)*				21562-12 Geotech							
		End of Sediment Core.		371.10	367.00								
4													
5													
6													

Note:
1.) Estimated in situ depths calculated based on initial percent recovery as per depth estimation method applied by Anchor QEA L.L.C.

Photograph Showing Sediment Core SC09-139.

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: A.K./M.S.
CHECKED: R.J.

File:N:\ACTIVE\YEAR 2009\1475\09-1475-0004 (ESQUIMALT GRAVING DOCK)\GINT\COMBINED CORE LOGS.GPJ Output Form:SEDIMENT CORE Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB VWahlstrom 02/03/10

Station ID	Date	Time of Collection	Leadline (m)	Attempt #	RTK ?	Drove Straight?	Drive Penetration (m)	Recovered Length (m)	Initial Percent Recovery (%)	Core Used? [1]	Drive Notes
SC09-101	23July2009	14:35	12.6	1 of 1	Yes	Yes	3.11	2.38	76.4%	E, G	Drove easy, easy retrieval
SC09-102	24July2009	10:20	9.8	1 of 3 (A)	Yes	Yes	2.04	1.51	74.0%	E	Drove straight, refusal at 2.04 m
		10:45	9.9	2 of 3 (B)	Yes	Yes	2.00	1.41	70.3%	G	Drove straight, refusal at 2.00 m
	27July2009	15:45	10.0	3 of 3 (C)	Yes	Yes	2.62	1.23	46.8%	NP	Refusal at 2.62 m, <50% recovery
SC09-103	27July2009	16:30	12.0	1 of 1	Yes	Yes	2.93	2.40	81.7%	E	Easy drive until last 0.5 m
SC09-104	23July2009	15:40	12.9	1 of 2 (A)	Yes	No	n/a	1.30	-	G	May have tipped over during driving
	24July2009	9:40	11.7	2 of 2 (B)	Yes	Yes	2.89	2.93	96.1%	E	Used float pack, drive straight, easy penetration
SC09-105	23July2009	14:55	11.4	1 of 1	Yes	Yes	3.11	2.50	80.2%	E, G	Drove easy, retrieval easy
SC09-106	28July2009	9:20	13.9	1 of 2 (A)	Yes	Yes	unknown	-	-	NP	Catcher inverted on retrieval, unknown amount of material lost
		9:50	14.0	2 of 2 (B)	Yes	Yes	2.96	2.67	90.2%	E	Drove straight, moderate retrieval
SC09-107	21July2009	13:30	13.4	1 of 1	Yes	Yes	3.11	2.63	83.8%	E	Soft bottom, core location on flat bottom at toe of riprap slope
SC09-108	24July2009	11:35	11.4	1 of 1	Yes	Yes	2.89	2.84	97.9%	E	Drove straight, drove easy
SC09-109	24July2009	13:25	12.1	1 of 1	Yes	Yes	2.89	2.36	81.3%	E, G	Drove straight, full penetration
SC09-110	20July2009	14:00	14.0	1 of 3 (A)	Yes	No	<1.0	-	-	NP	Refusal at 0.8 m, no core recovery
		14:25	14.0	2 of 3 (B)	Yes	No	<1.0	-	-	NP	Refusal at 0.7 m, no core recovery
	22July2009	9:32	11.9	3 of 3 (C)	Yes	No	2.0	1.57	77.0%	E	Refusal at approximately 1.0 m in rocky substrate, core barrel damaged
SC09-111	20July2009	11:48	12.6	1 of 3 (A)	Yes	No	1.8	-	-	NP	Hard bottom, drove sideways
		11:55	12.4	2 of 3 (B)	Yes	No	1.8	1.20	66.8%	G	Refusal at 1.8 m, no core recovery
		13:40	13.6	3 of 3 (C)	Yes	Yes	1.74	1.48	84.8%	E	Hard to drive, refusal at 1.74 m
SC09-112	21July2009	14:45	13.9	1 of 1	Yes	Yes	3.11	2.49	79.9%	E	Drove straight and easy, terminated in plastic silt/clay
SC09-113	23July2009	9:50	12.6	1 of 1	Yes	Yes	3.11	2.98	95.7%	E	Drove and retrieved easy
SC09-114	22July2009	16:40	14.2	1 of 1	Yes	Yes	3.11	2.72	87.3%	E	Drove straight, easy, full penetration
SC09-115	23July2009	9:20	12.1	1 of 1	Yes	Yes	3.08	2.62	84.9%	E	Drove and retrieved easy
SC09-116	21July2009	9:05	11.7	1 of 1	Yes	Yes	3.11	2.74	87.9%	E	Soft bottom, easy drive, full penetration
SC09-117	21July2009	15:38	12.5	1 of 1	Yes	Yes	1.38	1.36	98.6%	E	Float package used, refusal
SC09-118	29July2009	7:40	11.6	1 of 2 (A)	Yes	Yes	1.5	1.21	80.3%	G	Drove straight, poor penetration
		8:15	12.1	2 of 2 (B)	Yes	Yes	1.13	1.05	92.5%	E	Drove straight, poor recovery and poor penetration
SC09-119	23July2009	10:25	11.2	1 of 7 (A)	Yes	Yes	~ 3.0	1.50	50.0%	E	Drove easy, easy recovery but possibly tipped over – 2nd attempt required
		12:54	11.6	2 of 7 (B)	Yes	No	~ 2.75	-	-	NP	Tipped over, core catcher is closed
	29July2009	11:27	12.8	3 of 7 (C)	Yes	Yes	1.689	1.50	88.8%	E	Drove straight, refusal in coarse gravel and shell
		12:05	12.7	4 of 7 (D)	Yes	Yes	0.3	-	-	NP	Immediate refusal in coarse gravel
		12:45	13.0	5 of 7 (E)	Yes	Yes	0.33	-	-	NP	Refusal at 0.33 m in coarse material, no recovery
		14:15	13.0	6 of 7 (F)	Yes	Yes	0.47	-	-	NP	Refusal at 0.47 m in coarse material, no recovery
		14:30	13.5	7 of 7 (G)	Yes	Yes	0.70	-	-	NP	Refusal at 0.7 m in clayey silt and medium to coarse gravel

Station ID	Date	Time of Collection	Leadline (m)	Attempt #	RTK ?	Drove Straight?	Drive Penetration (m)	Recovered Length (m)	Initial Percent Recovery (%)	Core Used? [1]	Drive Notes
SC09-120	29July2009	9:10	11.9	1 of 2 (A)	Yes	Yes	< 1.0	-	-	NP	Drove straight, refusal in coarse material, no recovery
		9:30	11.9	2 of 2 (B)	Yes	Yes	2.377	2.40	99.9%	E	Drove straight, good recovery
SC09-121	27July2009	12:30	12.7	1 of 1	Yes	Yes	2.6	2.06	79.0%	E, G	Drove straight, refusal at 10.24 m, ~ 1.8 m short of full penetration
SC09-122	21July2009	9:42	12.0	1 of 1	Yes	Yes	3.11	3.00	96.3%	E	Soft bottom with some hard material, bottom is sloped, slow drive
SC09-123	22July2009	15:44	13.9	1 of 1	Yes	Yes	3.11	2.54	81.5%	E	Drove straight, easy, full penetration
SC09-124	21July2009	10:20	11.6	1 of 1	Yes	Yes	3.11	2.73	87.6%	E	Soft bottom, easy drive
SC09-125	23July2009	16:45	12.3	1 of 1	Yes	Yes	3.11	2.89	92.8%	E, G	Drove easy, easy retrieval
SC09-126	20July2009	13:00	12.9	1 of 1	Yes	Yes	3.11	2.87	92.1%	E	Drove straight, clay in core catcher
SC09-127	20July2009	10:38	12.5	1 of 1	Yes	Yes	3.11	2.62	84.1%	E	Drove straight, easy, clay visible in core catcher
SC09-128	21July2009	11:20	11.7	1 of 1	Yes	Yes	3.93	3.60	91.6%	E, G	Refusal at 10.6 m in very stiff clay
SC09-129	27July2009	11:05	10.7	1 of 1	Yes	Yes	4.39	4.33	98.6%	E	Drove straight and easy, full penetration, easy retrieval
SC09-130	20July2009	15:02	12.8	1 of 1	Yes	Yes	4.74	4.75	99.9%	E, G	Very little headspace, good recovery
SC09-131	27July2009	13:55	12.8	1 of 3 (A)	Yes	Yes	1.90	1.90	100%	E	Drove straight, easy retrieval, refusal at 1.90 m
	28July2009	11:25	13.2	2 of 3 (B)	Yes	No	unknown	-	-	NP	Tipped over, refusal in coarse material (gravel)
		12:00	13.0	3 of 3 (C)	Yes	No	unknown	-	-	NP	Tipped over, damaged core barrel during retrieval
SC09-132	22July2009	10:38	12.1	1 of 2 (A)	Yes	No	unknown	2.41	87.6%	E, G	Tipped over at 2.5 m depth, in plastic silty clay material
		13:05	11.2	2 of 2 (B)	Yes	Yes	unknown	< 2.41	-	NP	Drove straight and slow, plastic clay at depth, hard to retrieve
SC09-133	24July2009	13:55	9.23	1 of 1	Yes	Yes	1.83	1.96	96.6%	E	Drove straight, refusal at 1.83 m
SC09-134	24July2009	15:25	6.18	1 of 1	Yes	Yes	2.896	2.57	88.7%	E, G	Drove straight, alternating ‘easy-hard-easy’ driving
SC09-135	27July2009	9:30	4.2	1 of 2 (A)	Yes	Yes	1.90	1.51	79.2%	G	Refusal at 1.90 m
		10:00	4.1	2 of 2 (B)	Yes	Yes	2.01	1.85	92.0%	E	Refusal at 2.01 m in coarse material
SC09-136	28July2009	15:45	10.1	1 of 1	Yes	Yes	2.47	2.16	87.2%	E	Drove straight, easy retrieval
SC09-137	28July2009	15:05	13.6	1 of 1	Yes	Yes	2.40	1.93	79.9%	E	Drove straight, easy retrieval, refusal at 2.40 m
SC09-138	28July2009	14:10	13.1	1 of 1	Yes	Yes	2.7	2.04	75.4%	E, G	Drove straight, refusal at 2.7 m
SC09-139	29July2009	15:20	13.8	1 of 1	Yes	Yes	4.08	4.04	98.9%	E, G	Collected for Geotech sample

Note:

[1] Core Use codes: E = Environmental; G = Geotechnical; NP = Core not processed

APPENDIX H

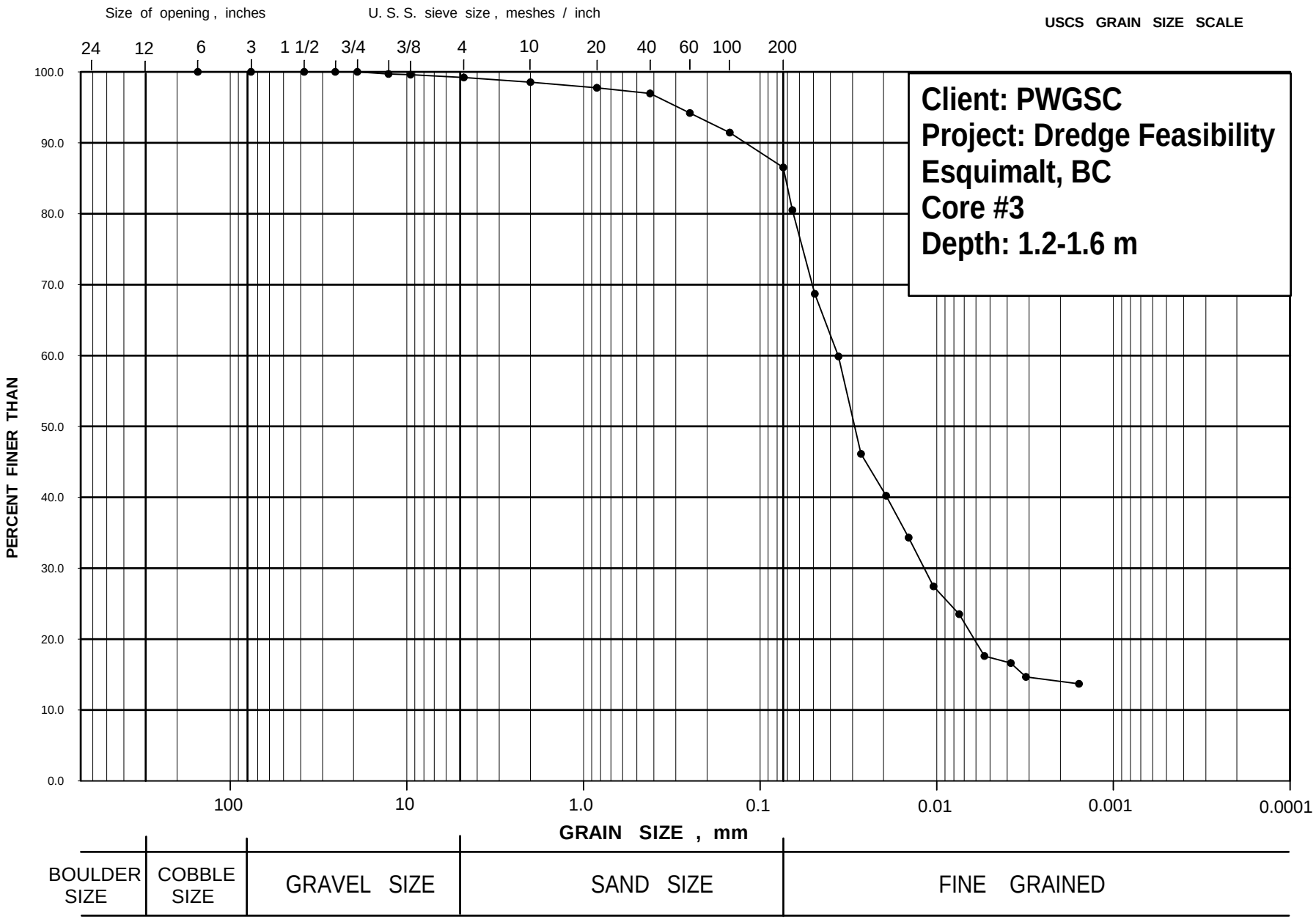
Grain Size Distributions (Sediment Cores)

APPENDIX H
Grain Size Distributions (2009 Vibra-Core Investigation)

Note: The geotechnical sample intervals reported in this appendix are measured depths along the core and are not corrected *in situ* depths as shown on sediment vibra-core logs and in tables.

Corrected *in situ* depths were calculated as per the method developed by Anchor QEA LLC of Seattle, Washington, for other investigations at the Esquimalt Graving Dock. Initial percent recovery was calculated as shown below; the measured depth along a core was then divided by initial percent recovery to obtain a corrected *in situ* depth.

$$\text{Initial Percent Recovery} = \frac{\text{initial recovered core length}}{\text{estimated penetration depth}} \times 100$$



Project No. 09-1475-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

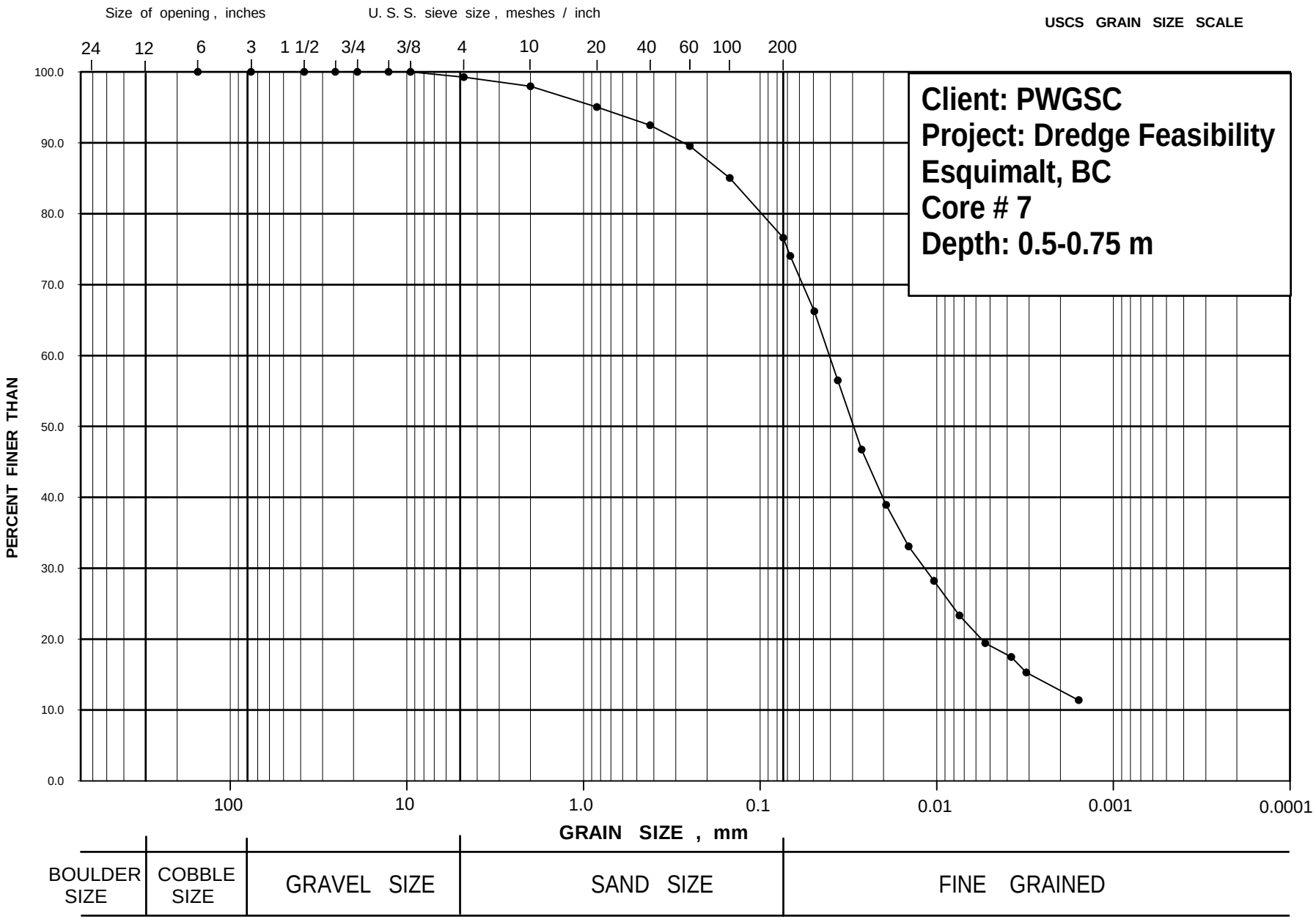
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 3	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	1.2-1.6	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.7	
	Total Weight	329.7	Before Wash	50.0	Total -200	43.9	
			After Wash	6.8	Gs	2.66	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"	1.0	0.3			0.3	12.7	99.7
3/8"	0.3	0.1			0.1	9.52	99.6
#4	1.3	0.4			0.4	4.76	99.2
#10	2.2	0.7			0.7	2.00	98.5
#20			0.4	0.8	0.8	0.840	97.8
#40			0.4	0.8	0.8	0.420	97.0
#60			1.4	2.8	2.8	0.250	94.2
#100			1.4	2.8	2.8	0.149	91.5
#200			2.5	5.0	4.9	0.074	86.5
Pan			43.9	87.8	86.5		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	45.0	18.0		-4.04	41.0	0.0658	80.5
1	39.0	18.0		-4.04	35.0	0.0491	68.7
2	34.5	18.0		-4.04	30.5	0.0360	59.9
4	27.5	18.0		-4.04	23.5	0.0268	46.1
8	24.5	18.0		-4.04	20.5	0.0194	40.2
15	21.5	18.0		-4.04	17.5	0.0144	34.3
30	18.0	18.0		-4.04	14.0	0.0104	27.4
60	16.0	18.0		-4.04	12.0	0.0075	23.5
120	13.0	18.0		-4.04	9.0	0.0054	17.6
240	12.5	18.0		-4.04	8.5	0.0038	16.6
360	11.5	18.0		-4.04	7.5	0.0031	14.7
1440	11.0	18.0		-4.04	7.0	0.0016	13.7
3150							
4590							
5820							
7080							



Project No. 09-1475-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

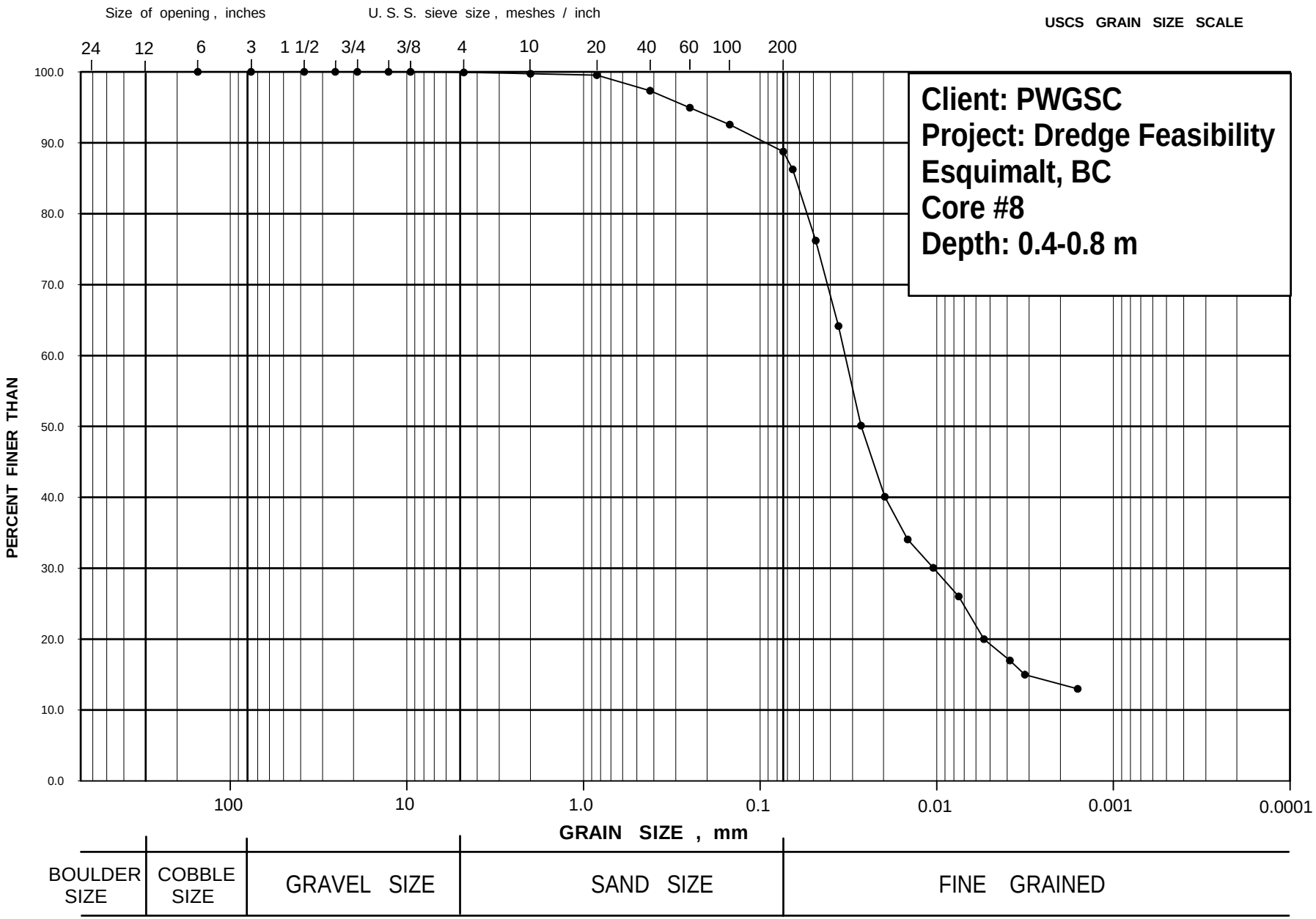
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 7	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.5-0.75 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.6	
	Total Weight	394.0	Before Wash	50.0	Total -200	39.1	
			After Wash	11.5	Gs	2.67	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"						12.7	100.0
3/8"						9.52	100.0
#4	2.9	0.7			0.7	4.76	99.3
#10	5.1	1.3			1.3	2.00	98.0
#20			1.5	3.0	2.9	0.840	95.0
#40			1.3	2.6	2.5	0.420	92.5
#60			1.5	3.0	2.9	0.250	89.5
#100			2.3	4.6	4.5	0.149	85.0
#200			4.3	8.6	8.4	0.074	76.6
Pan			39.1	78.2	76.6		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	42.0	18.0		-4.04	38.0	0.0674	74.1
1	38.0	18.0		-4.04	34.0	0.0494	66.2
2	33.0	18.0		-4.04	29.0	0.0363	56.5
4	28.0	18.0		-4.04	24.0	0.0266	46.7
8	24.0	18.0		-4.04	20.0	0.0194	38.9
15	21.0	18.0		-4.04	17.0	0.0144	33.1
30	18.5	18.0		-4.04	14.5	0.0104	28.2
60	16.0	18.0		-4.04	12.0	0.0074	23.3
120	14.0	18.0		-4.04	10.0	0.0053	19.4
240	13.0	18.0		-4.04	9.0	0.0038	17.5
360	12.0	17.0		-4.16	7.8	0.0031	15.3
1440	10.0	19.0		-4.16	5.8	0.0016	11.4
3150							
4590							
5820							
7080							



Project No. 09-1475-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

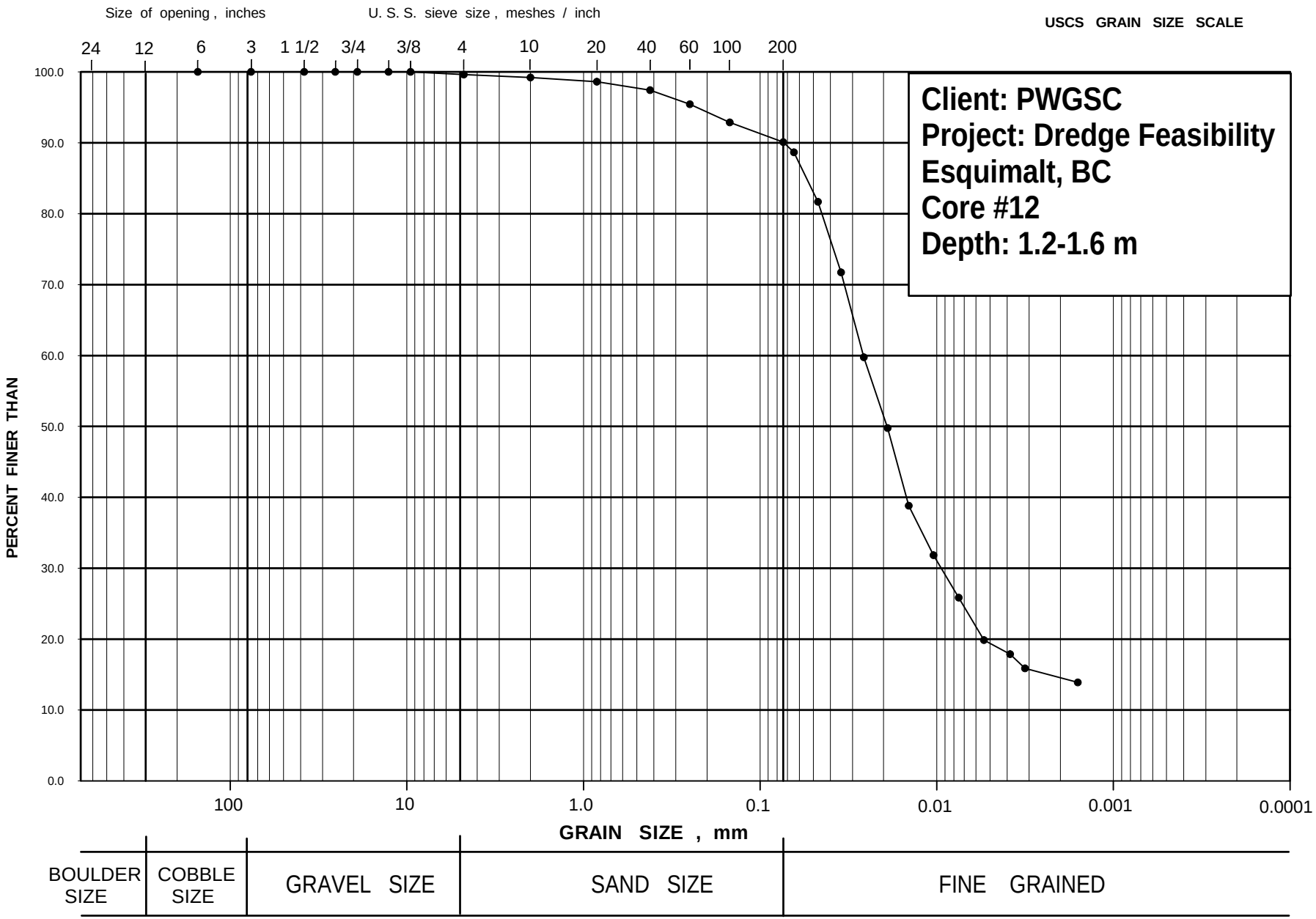
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 8	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.4-0.8 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.4	
	Total Weight	224.8	Before Wash	50.0	Total -200	44.5	
			After Wash	5.9	Gs	2.62	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"	0.0					12.7	100.0
3/8"	0.0					9.52	100.0
#4	0.2	0.1			0.1	4.76	99.9
#10	0.4	0.2			0.2	2.00	99.7
#20			0.1	0.2	0.2	0.840	99.5
#40			1.1	2.2	2.2	0.420	97.3
#60			1.2	2.4	2.4	0.250	94.9
#100			1.2	2.4	2.4	0.149	92.6
#200			1.9	3.8	3.8	0.074	88.8
Pan			44.5	89.0	88.8		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	47.0	18.0		-4.04	43.0	0.0654	86.2
1	42.0	18.0		-4.04	38.0	0.0484	76.2
2	36.0	18.0		-4.04	32.0	0.0360	64.2
4	29.0	18.0		-4.04	25.0	0.0269	50.1
8	24.0	18.0		-4.04	20.0	0.0197	40.1
15	21.0	18.0		-4.04	17.0	0.0147	34.1
30	19.0	18.0		-4.04	15.0	0.0105	30.0
60	17.0	18.0		-4.04	13.0	0.0075	26.0
120	14.0	18.0		-4.04	10.0	0.0054	20.0
240	12.5	18.0		-4.04	8.5	0.0039	17.0
360	11.5	18.0		-4.04	7.5	0.0032	15.0
1440	10.5	18.0		-4.04	6.5	0.0016	13.0
3150							
4590							
5820							
7080							



Project No. 09-1476-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

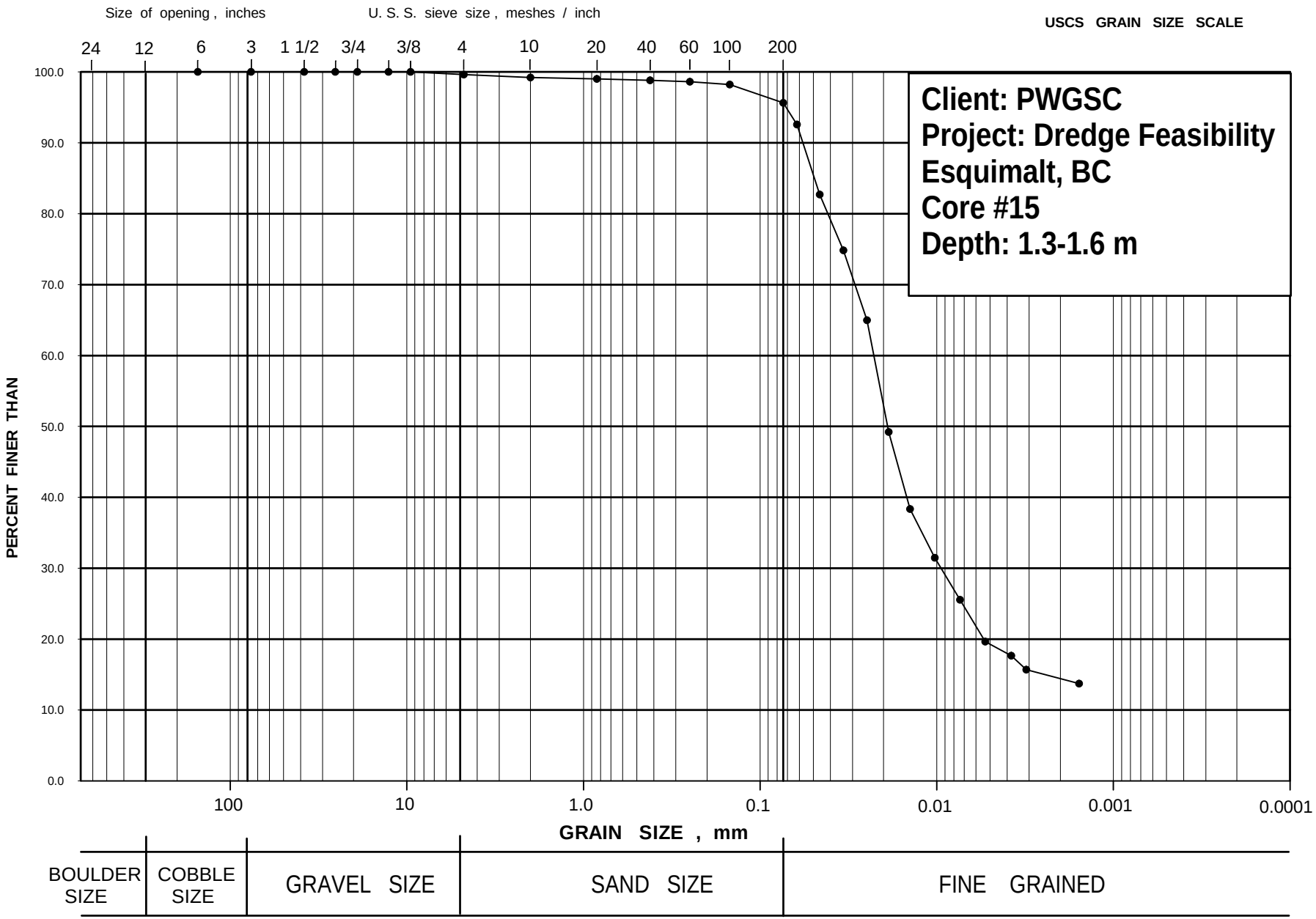
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 15	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	1.2-1.6	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.3	
	Total Weight	289.5	Before Wash	50.1	Total -200	45.5	
			After Wash	4.9	Gs	2.62	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"						12.7	100.0
3/8"						9.52	100.0
#4	1.1	0.4			0.4	4.76	99.6
#10	1.2	0.4			0.4	2.00	99.2
#20			0.3	0.6	0.6	0.840	98.6
#40			0.6	1.2	1.2	0.420	97.4
#60			1.0	2.0	2.0	0.250	95.4
#100			1.3	2.6	2.6	0.149	92.9
#200			1.4	2.8	2.8	0.074	90.1
Pan			45.5	90.8	90.1		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	48.5	18.0		-4.04	44.5	0.0644	88.7
1	45.0	18.0		-4.04	41.0	0.0471	81.7
2	40.0	18.0		-4.04	36.0	0.0348	71.7
4	34.0	18.0		-4.04	30.0	0.0259	59.7
8	29.0	18.0		-4.04	25.0	0.0190	49.8
15	23.5	18.0		-4.04	19.5	0.0144	38.8
30	20.0	18.0		-4.04	16.0	0.0104	31.8
60	17.0	18.0		-4.04	13.0	0.0075	25.9
120	14.0	18.0		-4.04	10.0	0.0054	19.9
240	13.0	18.0		-4.04	9.0	0.0038	17.9
360	12.0	18.0		-4.04	8.0	0.0032	15.9
1440	11.0	18.0		-4.04	7.0	0.0016	13.9
3150							
4590							
5820							
7080							



Project No. 09-1476-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

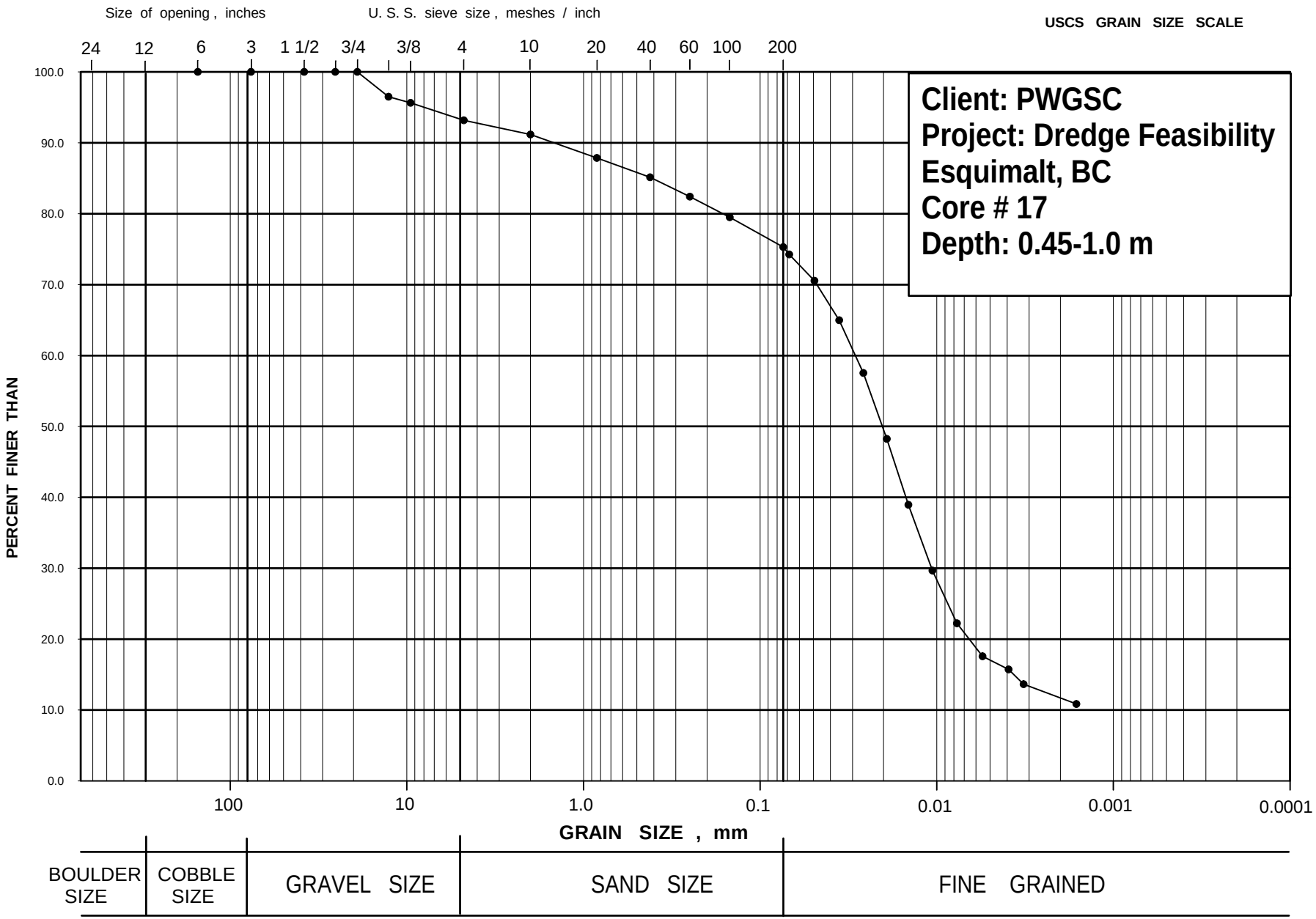
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 15	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	1.3-1.6	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.3	
	Total Weight	289.5	Before Wash	50.1	Total -200	45.5	
			After Wash	4.9	Gs	2.67	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"						12.7	100.0
3/8"						9.52	100.0
#4	1.1	0.4			0.4	4.76	99.6
#10	1.2	0.4			0.4	2.00	99.2
#20			0.1	0.2	0.2	0.840	99.0
#40			0.1	0.2	0.2	0.420	98.8
#60			0.1	0.2	0.2	0.250	98.6
#100			0.2	0.4	0.4	0.149	98.2
#200			1.3	2.6	2.6	0.074	95.6
Pan			45.5	90.8	90.1		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	51.0	18.0		-4.04	47.0	0.0618	92.6
1	46.0	18.0		-4.04	42.0	0.0460	82.7
2	42.0	18.0		-4.04	38.0	0.0337	74.8
4	37.0	18.0		-4.04	33.0	0.0249	65.0
8	29.0	18.0		-4.04	25.0	0.0187	49.2
15	23.5	18.0		-4.04	19.5	0.0142	38.4
30	20.0	18.0		-4.04	16.0	0.0103	31.5
60	17.0	18.0		-4.04	13.0	0.0074	25.6
120	14.0	18.0		-4.04	10.0	0.0053	19.6
240	13.0	18.0		-4.04	9.0	0.0038	17.7
360	12.0	18.0		-4.04	8.0	0.0031	15.7
1440	11.0	18.0		-4.04	7.0	0.0016	13.7
3150							
4590							
5820							
7080							



Project No. 09-1475-0004
Drawn DGM
Reviewed
Date 4 March 09

Golder Associates

GRAIN SIZE DISTRIBUTION

Figure

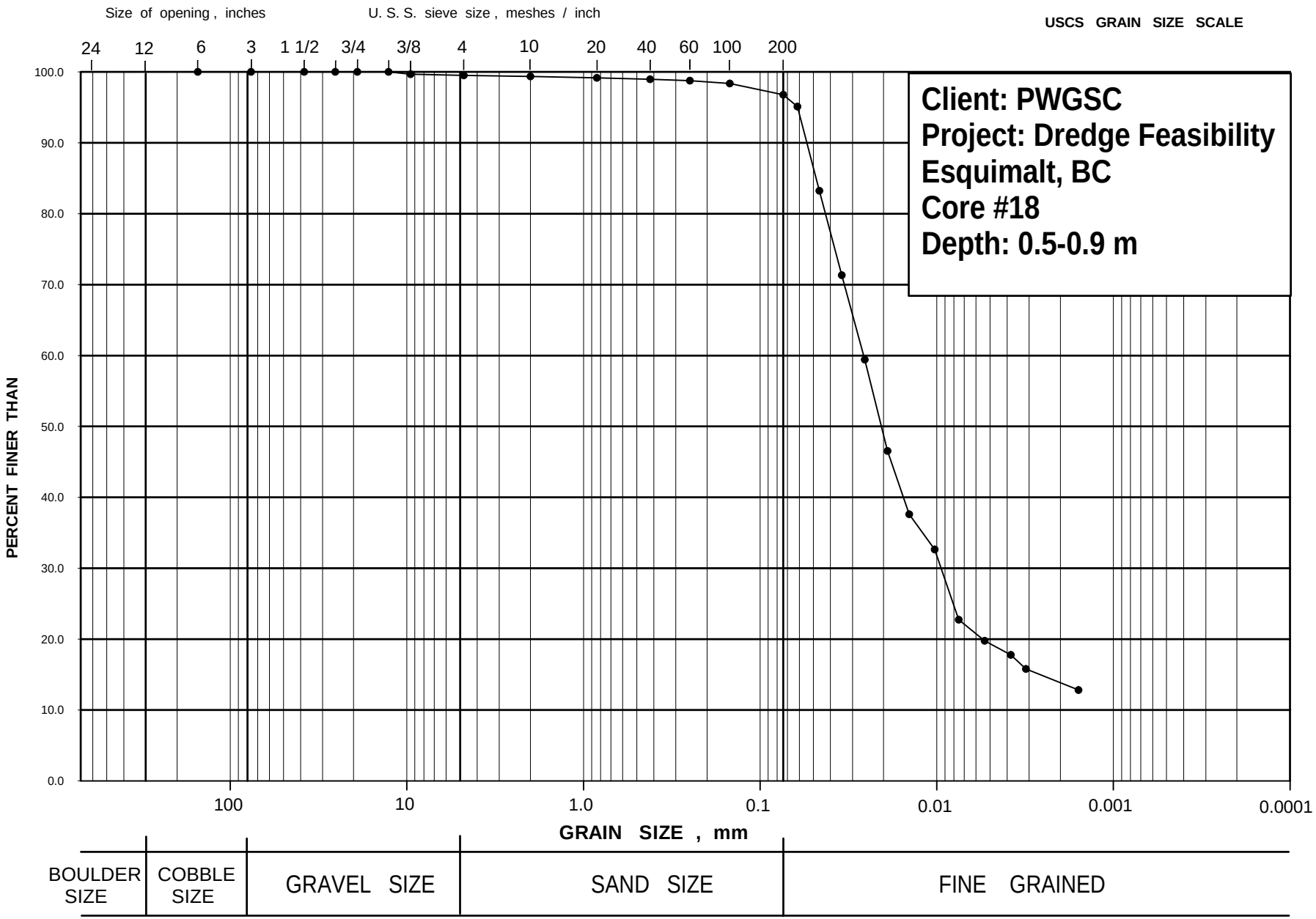
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 17	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.45-1.0 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.4	
	Total Weight	203.6	Before Wash	50.0	Total -200	41.3	
			After Wash	9.1	Gs	2.57	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"	7.1	3.5			3.5	12.7	96.5
3/8"	1.8	0.9			0.9	9.52	95.6
#4	5.0	2.5			2.5	4.76	93.2
#10	4.1	2.0			2.0	2.00	91.2
#20			1.8	3.6	3.3	0.840	87.9
#40			1.5	3.0	2.7	0.420	85.1
#60			1.5	3.0	2.7	0.250	82.4
#100			1.6	3.2	2.9	0.149	79.5
#200			2.3	4.6	4.2	0.074	75.3
Pan			41.3	82.6	75.3		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	44.0	18.0		-4.04	40.0	0.0683	74.3
1	42.0	18.0		-4.04	38.0	0.0492	70.5
2	39.0	18.0		-4.04	35.0	0.0357	65.0
4	35.0	18.0		-4.04	31.0	0.0261	57.5
8	30.0	18.0		-4.04	26.0	0.0192	48.2
15	25.0	18.0		-4.04	21.0	0.0145	39.0
30	20.0	18.0		-4.04	16.0	0.0106	29.7
60	16.0	18.0		-4.04	12.0	0.0077	22.2
120	13.5	18.0		-4.04	9.5	0.0055	17.6
240	12.5	18.0		-4.04	8.5	0.0039	15.7
360	11.5	17.0		-4.16	7.3	0.0032	13.6
1440	10.0	19.0		-4.16	5.8	0.0016	10.9
3150							
4590							
5820							
7080							



Project No. 09-1476-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

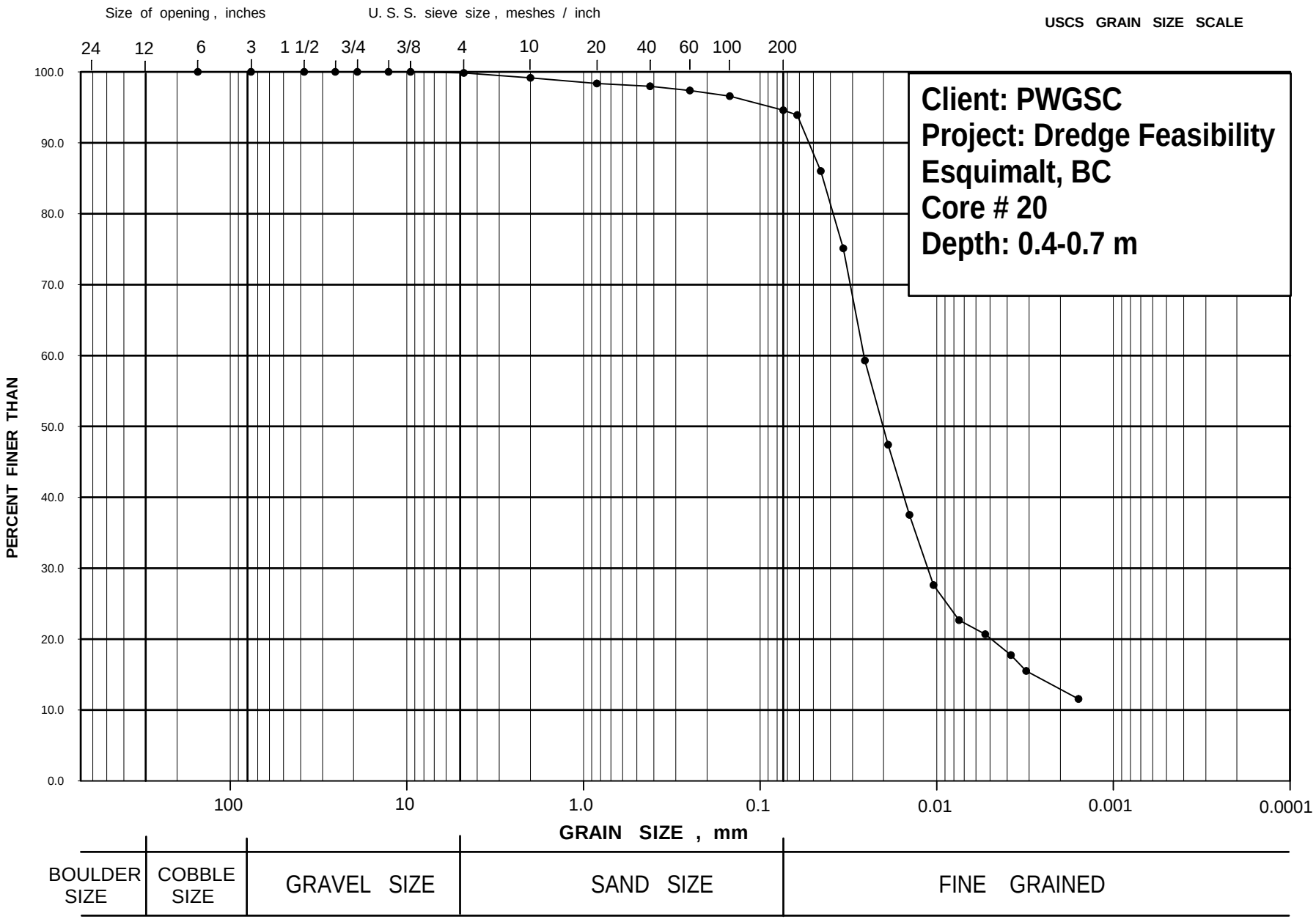
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 18	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.5-0.9 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.3	
	Total Weight	280.7	Before Wash	50.1	Total -200	48.8	
			After Wash	1.6	Gs	2.65	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"						12.7	100.0
3/8"	0.9	0.3			0.3	9.52	99.7
#4	0.5	0.2			0.2	4.76	99.5
#10	0.4	0.1			0.1	2.00	99.4
#20			0.1	0.2	0.2	0.840	99.2
#40			0.1	0.2	0.2	0.420	99.0
#60			0.1	0.2	0.2	0.250	98.8
#100			0.2	0.4	0.4	0.149	98.4
#200			0.8	1.6	1.6	0.074	96.8
Pan			48.8	97.4	96.8		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	52.0	18.0		-4.04	48.0	0.0615	95.1
1	46.0	18.0		-4.04	42.0	0.0462	83.2
2	40.0	18.0		-4.04	36.0	0.0345	71.3
4	34.0	18.0		-4.04	30.0	0.0256	59.4
8	27.5	18.0		-4.04	23.5	0.0190	46.5
15	23.0	18.0		-4.04	19.0	0.0143	37.6
30	20.5	18.0		-4.04	16.5	0.0103	32.7
60	15.5	18.0		-4.04	11.5	0.0075	22.7
120	14.0	18.0		-4.04	10.0	0.0054	19.8
240	13.0	18.0		-4.04	9.0	0.0038	17.8
360	12.0	18.0		-4.04	8.0	0.0031	15.8
1440	10.5	18.0		-4.04	6.5	0.0016	12.8
3150							
4590							
5820							
7080							



Project No. 09-1475-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

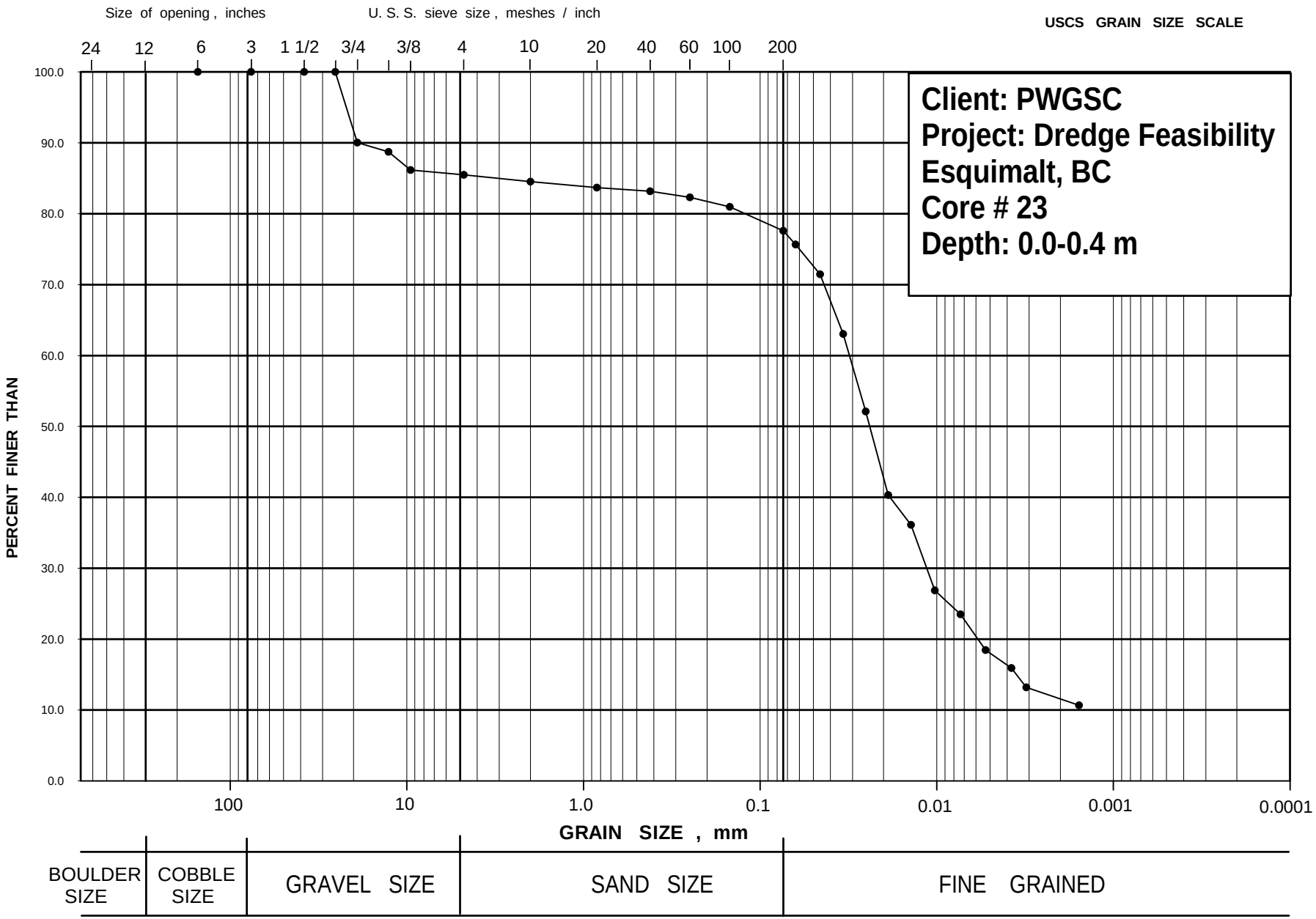
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 20	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.4-0.7 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.2	
	Total Weight	298.7	Before Wash	50.0	Total -200	47.7	
			After Wash	2.5	Gs	2.66	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"						12.7	100.0
3/8"						9.52	100.0
#4	0.4	0.1			0.1	4.76	99.9
#10	2.1	0.7			0.7	2.00	99.2
#20			0.4	0.8	0.8	0.840	98.4
#40			0.2	0.4	0.4	0.420	98.0
#60			0.3	0.6	0.6	0.250	97.4
#100			0.4	0.8	0.8	0.149	96.6
#200			1.0	2.0	2.0	0.074	94.6
Pan			47.7	95.4	94.6		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	51.5	18.0		-4.04	47.5	0.0617	93.9
1	47.5	18.0		-4.04	43.5	0.0454	86.0
2	42.0	18.0		-4.04	38.0	0.0338	75.1
4	34.0	18.0		-4.04	30.0	0.0256	59.3
8	28.0	18.0		-4.04	24.0	0.0189	47.4
15	23.0	18.0		-4.04	19.0	0.0143	37.5
30	18.0	18.0		-4.04	14.0	0.0104	27.6
60	15.5	18.0		-4.04	11.5	0.0075	22.7
120	14.5	18.0		-4.04	10.5	0.0053	20.7
240	13.0	18.0		-4.04	9.0	0.0038	17.7
360	12.0	17.0		-4.16	7.8	0.0031	15.5
1440	10.0	19.0		-4.16	5.8	0.0016	11.6
3150							
4590							
5820							
7080							



Project No. 09-1475-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

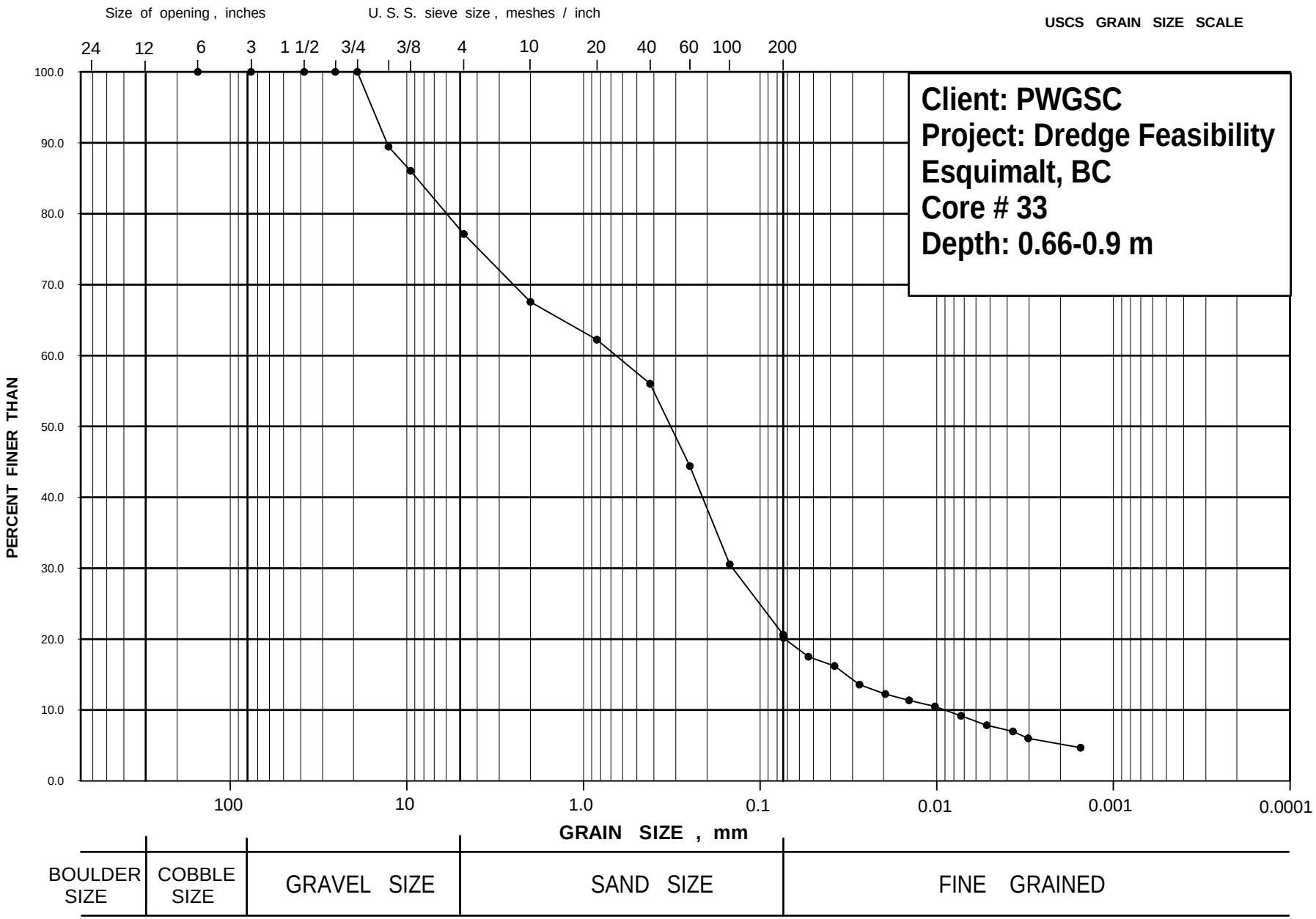
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 23	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.0-0.4	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.3	
	Total Weight	290.1	Before Wash	50.0	Total -200	45.9	
			After Wash	4.4	Gs	2.67	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"	28.9	10.0			10.0	19.1	90.0
1/2"	3.8	1.3			1.3	12.7	88.7
3/8"	7.4	2.6			2.6	9.52	86.2
#4	2.0	0.7			0.7	4.76	85.5
#10	2.8	1.0			1.0	2.00	84.5
#20			0.5	1.0	0.8	0.840	83.7
#40			0.3	0.6	0.5	0.420	83.2
#60			0.5	1.0	0.8	0.250	82.3
#100			0.8	1.6	1.4	0.149	81.0
#200			2.0	4.0	3.4	0.074	77.6
Pan			45.9	91.8	77.6		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	49.0	18.0		-4.04	45.0	0.0631	75.7
1	46.5	18.0		-4.04	42.5	0.0457	71.5
2	41.5	18.0		-4.04	37.5	0.0339	63.0
4	35.0	18.0		-4.04	31.0	0.0253	52.1
8	28.0	18.0		-4.04	24.0	0.0188	40.3
15	25.5	18.0		-4.04	21.5	0.0140	36.1
30	20.0	18.0		-4.04	16.0	0.0103	26.9
60	18.0	18.0		-4.04	14.0	0.0074	23.5
120	15.0	18.0		-4.04	11.0	0.0053	18.5
240	13.5	18.0		-4.04	9.5	0.0038	15.9
360	12.0	17.0		-4.16	7.8	0.0031	13.2
1440	10.5	19.0		-4.16	6.3	0.0016	10.7
3150							
4590							
5820							
7080							



Project No. 09-1475-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

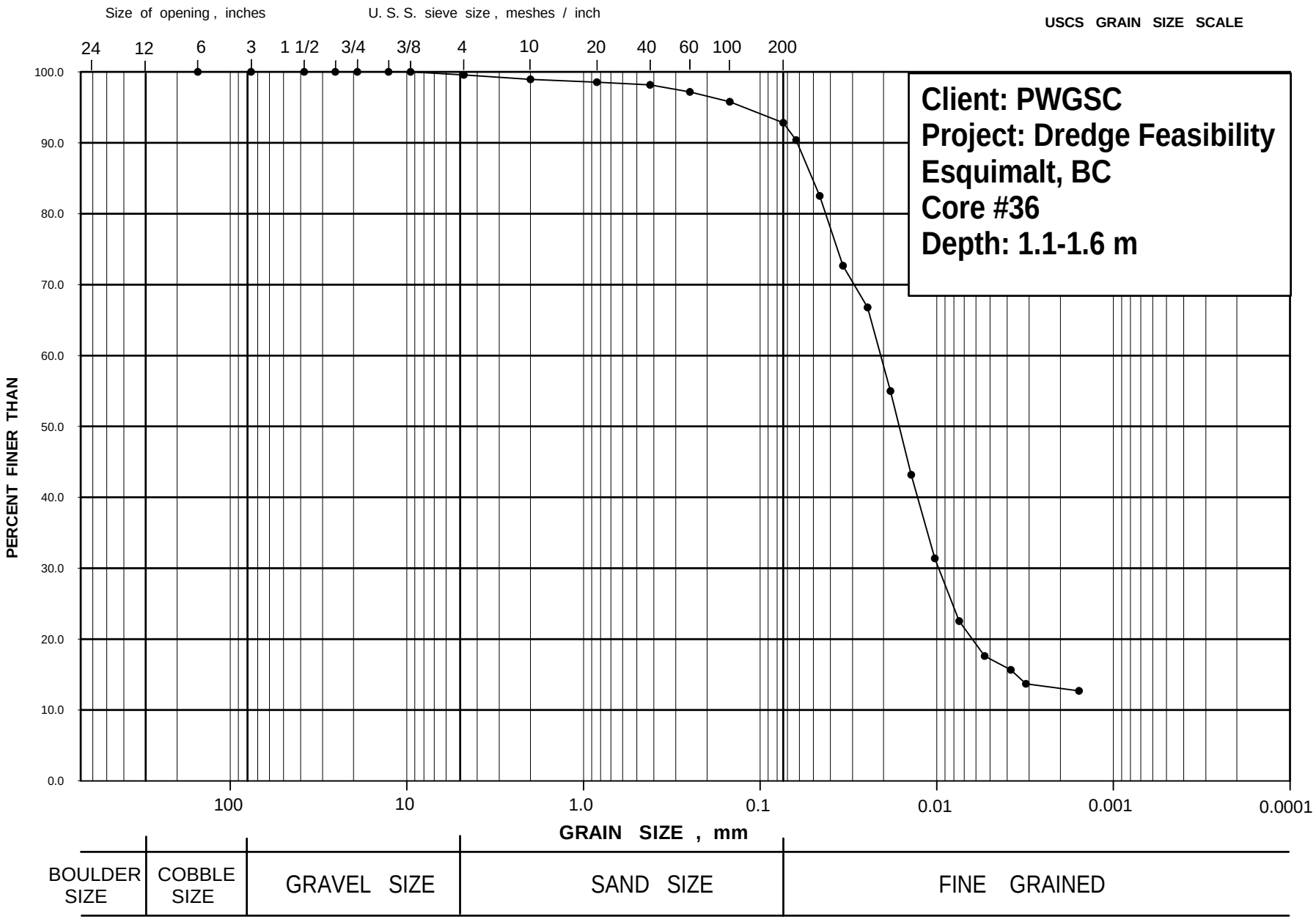
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 33	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.66-0.9 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.8	
	Total Weight	835.5	Before Wash	75.0	Total -200	22.9	
			After Wash	52.9	Gs	2.77	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"	88.0	10.5			10.5	12.7	89.5
3/8"	28.5	3.4			3.4	9.52	86.1
#4	74.5	8.9			8.9	4.76	77.1
#10	80.1	9.6			9.6	2.00	67.6
#20			5.9	7.9	5.3	0.840	62.2
#40			6.9	9.2	6.2	0.420	56.0
#60			12.9	17.2	11.6	0.250	44.4
#100			15.4	20.5	13.9	0.149	30.5
#200			11.0	14.7	9.9	0.074	20.6
Pan			22.9	30.5	20.6		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	27.0	18.0		-4.04	23.0	0.0737	20.2
1	24.0	18.0		-4.04	20.0	0.0532	17.5
2	22.5	18.0		-4.04	18.5	0.0380	16.2
4	19.5	18.0		-4.04	15.5	0.0274	13.6
8	18.0	18.0		-4.04	14.0	0.0196	12.3
15	17.0	18.0		-4.04	13.0	0.0144	11.4
30	16.0	18.0		-4.04	12.0	0.0102	10.5
60	14.5	18.0		-4.04	10.5	0.0073	9.2
120	13.0	18.0		-4.04	9.0	0.0052	7.9
240	12.0	18.0		-4.04	8.0	0.0037	7.0
360	11.0	17.0		-4.16	6.8	0.0030	6.0
1440	9.5	19.0		-4.16	5.3	0.0015	4.7
3150							
4590							
5820							
7080							



Project No. 09-1476-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

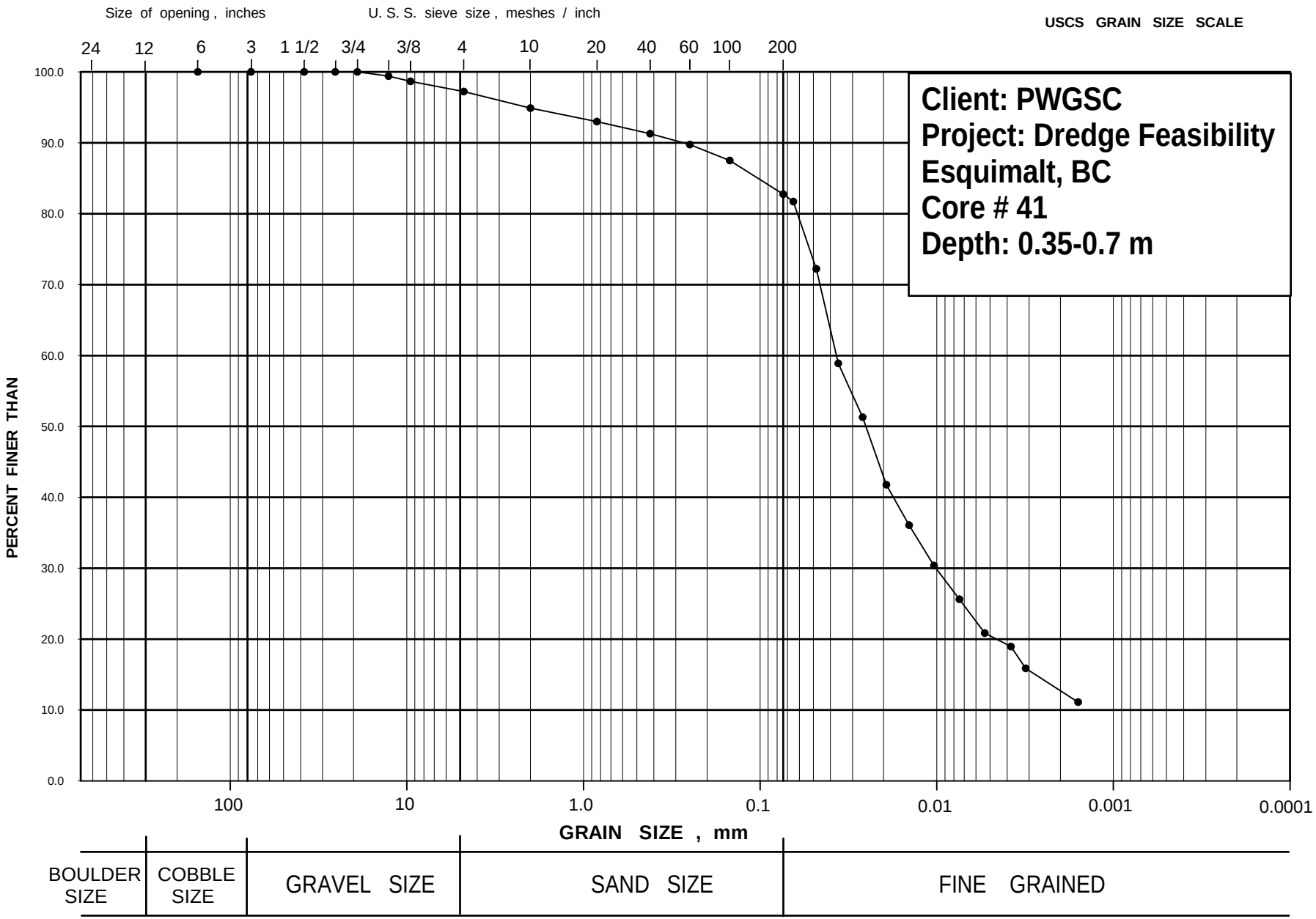
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 36	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	1.1-1.6 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.6	
	Total Weight	306.5	Before Wash	50.1	Total -200	47.0	
			After Wash	3.7	Gs	2.67	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"						12.7	100.0
3/8"						9.52	100.0
#4	1.3	0.4			0.4	4.76	99.6
#10	1.9	0.6			0.6	2.00	99.0
#20			0.2	0.4	0.4	0.840	98.6
#40			0.2	0.4	0.4	0.420	98.2
#60			0.5	1.0	1.0	0.250	97.2
#100			0.7	1.4	1.4	0.149	95.8
#200			1.5	3.0	3.0	0.074	92.8
Pan			47.0	93.8	92.8		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	50.0	18.0		-4.04	46.0	0.0625	90.4
1	46.0	18.0		-4.04	42.0	0.0460	82.5
2	41.0	18.0		-4.04	37.0	0.0340	72.7
4	38.0	18.0		-4.04	34.0	0.0247	66.8
8	32.0	18.0		-4.04	28.0	0.0183	55.0
15	26.0	18.0		-4.04	22.0	0.0140	43.2
30	20.0	18.0		-4.04	16.0	0.0103	31.4
60	15.5	18.0		-4.04	11.5	0.0075	22.5
120	13.0	18.0		-4.04	9.0	0.0054	17.6
240	12.0	18.0		-4.04	8.0	0.0038	15.7
360	11.0	18.0		-4.04	7.0	0.0031	13.7
1440	10.5	18.0		-4.04	6.5	0.0016	12.7
3150							
4590							
5820							
7080							



Project No. 09-1475-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

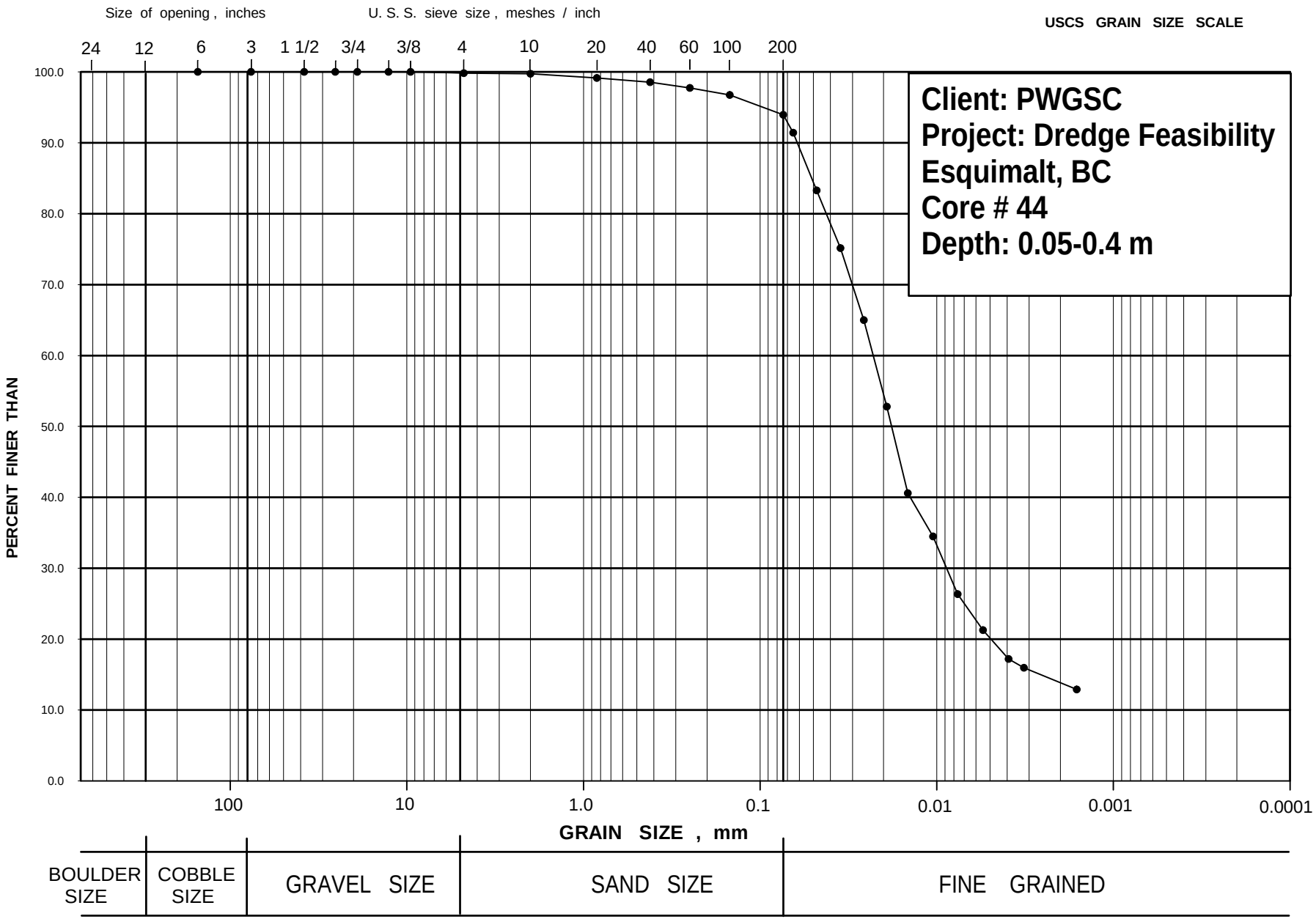
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 41	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.35-0.7 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.2	
	Total Weight	270.2	Before Wash	50.0	Total -200	43.6	
			After Wash	6.6	Gs	2.64	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"	1.6	0.6			0.6	12.7	99.4
3/8"	2.0	0.7			0.7	9.52	98.7
#4	3.9	1.4			1.4	4.76	97.2
#10	6.3	2.3			2.3	2.00	94.9
#20			1.0	2.0	1.9	0.840	93.0
#40			0.9	1.8	1.7	0.420	91.3
#60			0.8	1.6	1.5	0.250	89.8
#100			1.2	2.4	2.3	0.149	87.5
#200			2.5	5.0	4.7	0.074	82.7
Pan			43.6	87.2	82.7		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	47.0	18.0		-4.04	43.0	0.0650	81.7
1	42.0	18.0		-4.04	38.0	0.0481	72.2
2	35.0	18.0		-4.04	31.0	0.0361	58.9
4	31.0	18.0		-4.04	27.0	0.0263	51.3
8	26.0	18.0		-4.04	22.0	0.0193	41.8
15	23.0	18.0		-4.04	19.0	0.0144	36.1
30	20.0	18.0		-4.04	16.0	0.0104	30.4
60	17.5	18.0		-4.04	13.5	0.0074	25.6
120	15.0	18.0		-4.04	11.0	0.0053	20.9
240	14.0	18.0		-4.04	10.0	0.0038	19.0
360	12.5	17.0		-4.16	8.3	0.0031	15.9
1440	10.0	19.0		-4.16	5.8	0.0016	11.1
3150							
4590							
5820							
7080							



Project No. 09-1475-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

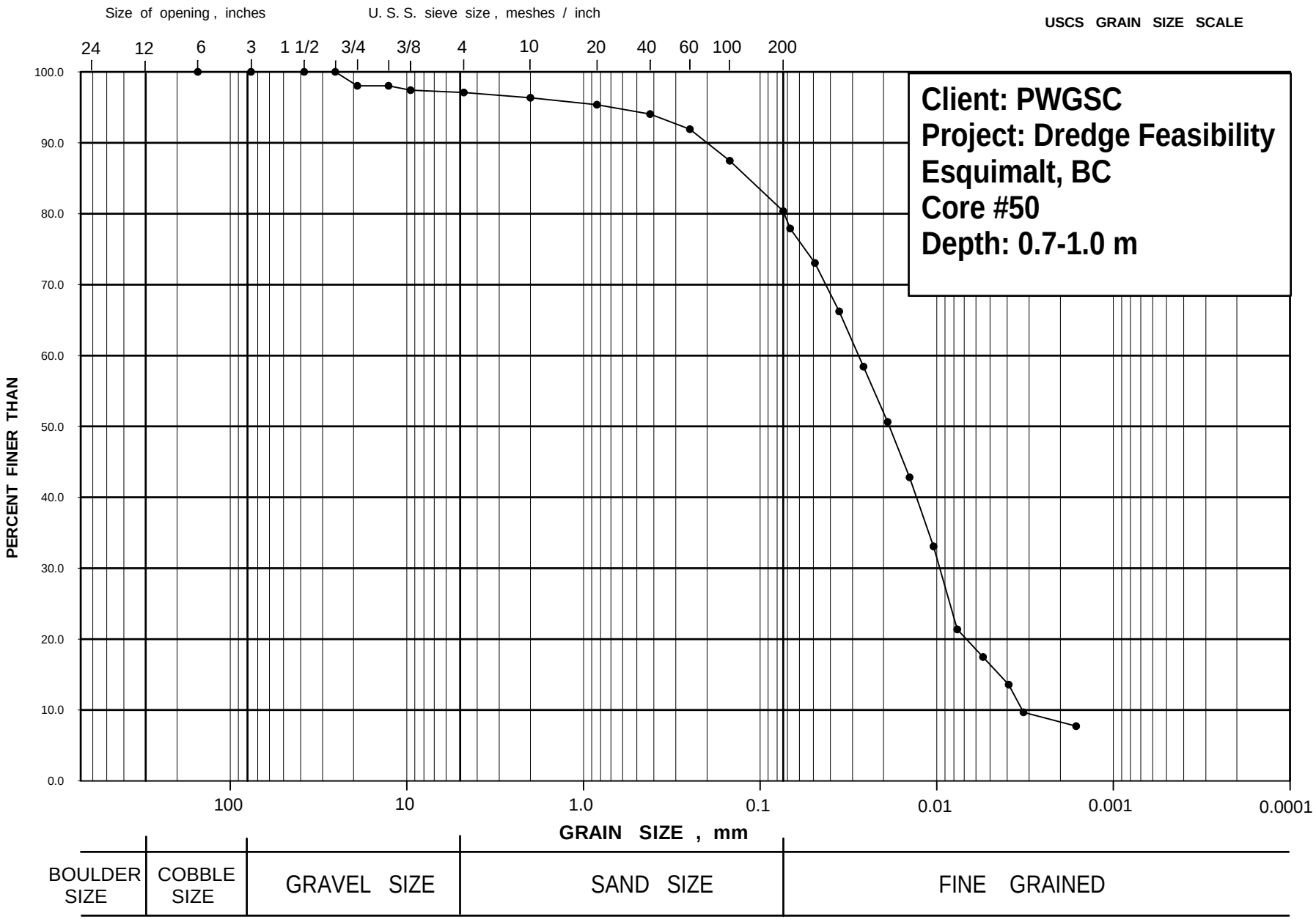
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 44	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.05-0.4 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.3	
	Total Weight	269.0	Before Wash	50.0	Total -200	47.1	
			After Wash	3.2	Gs	2.57	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"						19.1	100.0
1/2"						12.7	100.0
3/8"						9.52	100.0
#4	0.5	0.2			0.2	4.76	99.8
#10	0.2	0.1			0.1	2.00	99.7
#20			0.3	0.6	0.6	0.840	99.1
#40			0.3	0.6	0.6	0.420	98.5
#60			0.4	0.8	0.8	0.250	97.7
#100			0.5	1.0	1.0	0.149	96.7
#200			1.4	2.8	2.8	0.074	94.0
Pan			47.1	94.2	94.0		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	49.0	18.0		-4.04	45.0	0.0651	91.4
1	45.0	18.0		-4.04	41.0	0.0479	83.3
2	41.0	18.0		-4.04	37.0	0.0351	75.2
4	36.0	18.0		-4.04	32.0	0.0259	65.0
8	30.0	18.0		-4.04	26.0	0.0192	52.8
15	24.0	18.0		-4.04	20.0	0.0146	40.6
30	21.0	18.0		-4.04	17.0	0.0105	34.5
60	17.0	18.0		-4.04	13.0	0.0076	26.4
120	14.5	18.0		-4.04	10.5	0.0055	21.3
240	12.5	18.0		-4.04	8.5	0.0039	17.2
360	12.0	17.0		-4.16	7.8	0.0032	15.9
1440	10.5	19.0		-4.16	6.3	0.0016	12.9
3150							
4590							
5820							
7080							



Project No. 09-1476-0004 **Drawn** DGM **Reviewed** **Date** 4 March 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

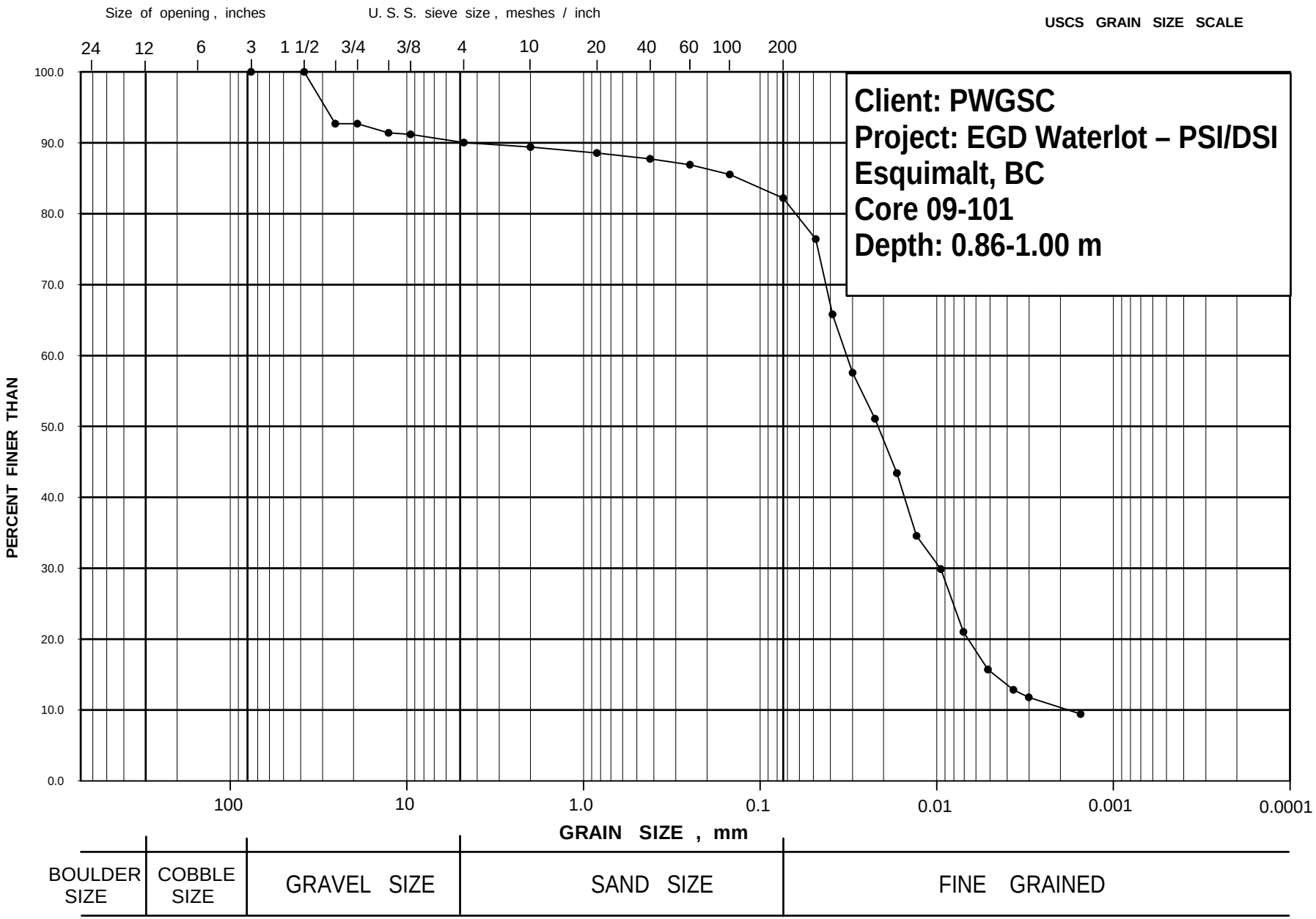
PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	09-1475-0004	**Client :**	PWGSC		**BH :**	Core 50	
Sch#	3600	**Project :**	Dredge Feasibility		**Sample :**		
Lab Work:	DGM	**Location:**	Esquimalt, BC		**Depth :**	0.7-1.0 m	
	1ST SIEVING		**Hydrometer: (Minus #10)**		Residual #200	0.8	
	Total Weight	224.6	Before Wash	50.0	Total -200	41.7	
			After Wash	9.1	Gs	2.60	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"						152.4	100.0
3"						76.2	100.0
1 1/2"						38.1	100.0
1"						25.4	100.0
3/4"	4.4	2.0			2.0	19.1	98.0
1/2"	0.0					12.7	98.0
3/8"	1.4	0.6			0.6	9.52	97.4
#4	0.7	0.3			0.3	4.76	97.1
#10	1.7	0.8			0.8	2.00	96.3
#20			0.5	1.0	1.0	0.840	95.4
#40			0.7	1.4	1.3	0.420	94.0
#60			1.1	2.2	2.1	0.250	91.9
#100			2.3	4.6	4.4	0.149	87.5
#200			3.7	7.4	7.1	0.074	80.4
Pan			41.7	83.4	80.4		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	44.0	18.0		-4.04	40.0	0.0677	77.9
1	41.5	18.0		-4.04	37.5	0.0489	73.0
2	38.0	18.0		-4.04	34.0	0.0357	66.2
4	34.0	18.0		-4.04	30.0	0.0260	58.4
8	30.0	18.0		-4.04	26.0	0.0190	50.6
15	26.0	18.0		-4.04	22.0	0.0143	42.8
30	21.0	18.0		-4.04	17.0	0.0104	33.1
60	15.0	18.0		-4.04	11.0	0.0077	21.4
120	13.0	18.0		-4.04	9.0	0.0055	17.5
240	11.0	18.0		-4.04	7.0	0.0039	13.6
360	9.0	18.0		-4.04	5.0	0.0032	9.7
1440	8.0	18.0		-4.04	4.0	0.0016	7.7
3150							
4590							
5820							
7080							



Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/SA

DATE TESTED: 5-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-101	Sample No.			Depth :	.86-1.0	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.5	
	Total Weight	613.3	Before Wash	50.0	Total -200	48.1	
			After Wash	2.4	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	0.0	0.0			0.0	12.7	100.0
3/8"	0.0	0.0			0.0	9.52	100.0
#4	0.1	0.0			0.0	4.76	100.0
#10	0.4	0.1			0.1	2.00	99.9
#20			0.4	0.8	0.8	0.840	99.1
#40			0.2	0.4	0.4	0.420	98.7
#60			0.2	0.4	0.4	0.250	98.3
#100			0.2	0.4	0.4	0.149	97.9
#200			0.9	1.8	1.8	0.074	96.1
Pan			48.1	96.2	96.1		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	44.0	24.0		-3.17	40.8	0.0648	80.7
1	40.0	24.0		-3.17	36.8	0.0475	72.8
2	35.5	24.0		-3.17	32.3	0.0349	63.9
4	29.0	24.0		-3.17	25.8	0.0259	51.1
8	24.0	24.0		-3.17	20.8	0.0190	41.2
15	20.0	24.0		-3.17	16.8	0.0142	33.3
30	17.0	24.0		-3.17	13.8	0.0102	27.3
60	13.0	24.0		-3.17	9.8	0.0074	19.4
120	11.0	24.0		-3.17	7.8	0.0053	15.5
240	9.0	24.5		-3.08	5.9	0.0038	11.7
360	8.0	25.0		-3.00	5.0	0.0031	9.9
1440	6.5	23.5		-3.00	3.5	0.0016	6.9

Reported by: _____ Reviewed by: _____

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other zones/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

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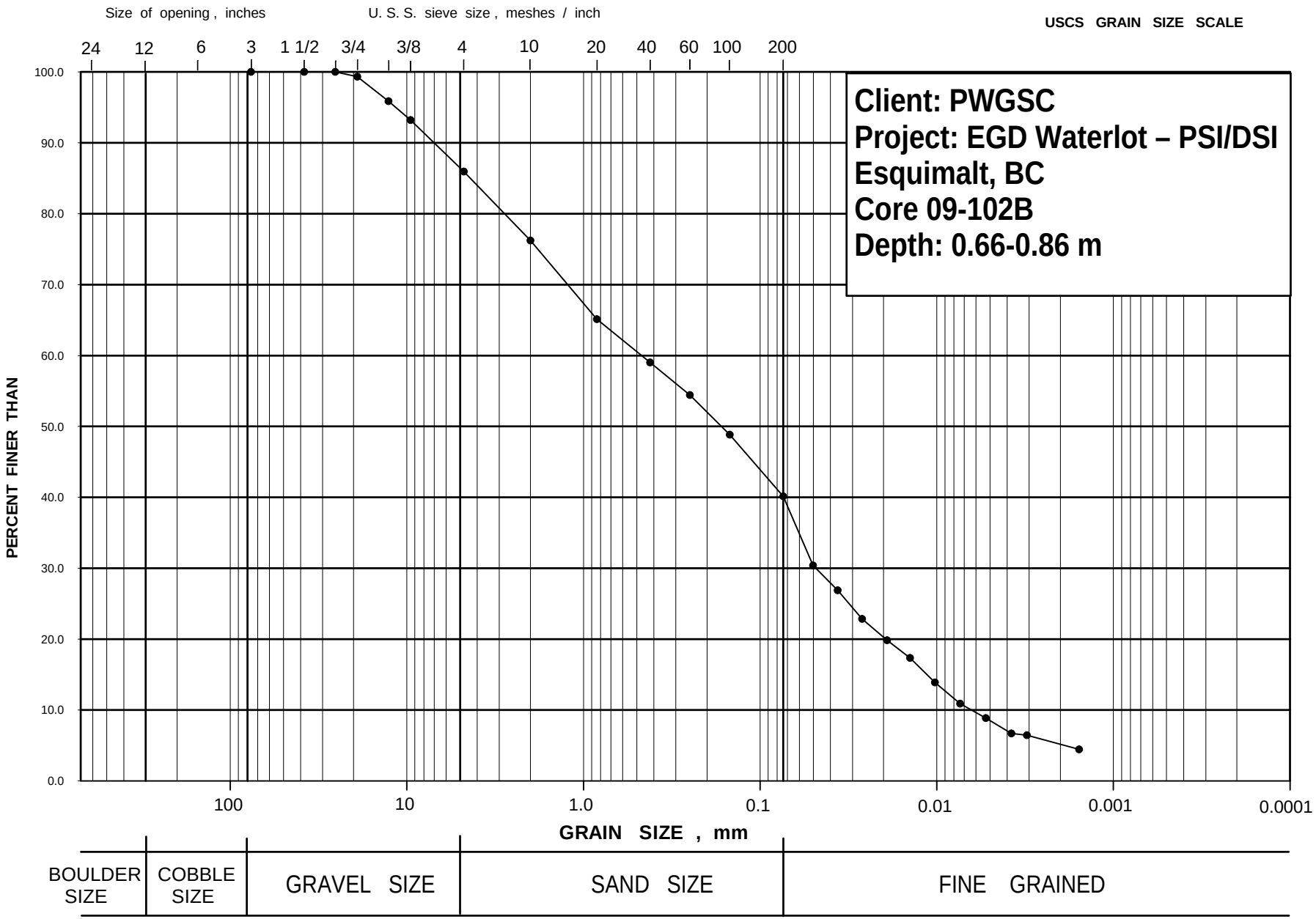

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** PC/SA

DATE TESTED: 4-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-102B	Sample No.			Depth (m) :	0.66-0.86	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	1.0	
	Total Weight	396.7	Before Wash	75.0	Total -200	39.5	
			After Wash	36.5	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	2.7	0.7			0.7	19.1	99.3
1/2"	13.7	3.5			3.5	12.7	95.9
3/8"	10.5	2.6			2.6	9.52	93.2
#4	28.8	7.3			7.3	4.76	86.0
#10	38.6	9.7			9.7	2.00	76.2
#20			10.9	14.6	11.1	0.840	65.1
#40			6.0	8.0	6.1	0.420	59.0
#60			4.5	6.0	4.6	0.250	54.4
#100			5.5	7.3	5.6	0.149	48.8
#200			8.6	11.4	8.7	0.074	40.1
Pan			39.5	52.7	40.2		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	38.0	23.5		-3.25	34.8		
1	33.5	23.5		-3.25	30.3	0.0502	30.4
2	30.0	23.5		-3.25	26.8	0.0364	26.9
4	26.0	23.5		-3.25	22.8	0.0265	22.9
8	23.0	23.5		-3.25	19.8	0.0191	19.8
15	20.5	23.5		-3.25	17.3	0.0142	17.3
30	17.0	24.0		-3.17	13.8	0.0102	13.9
60	14.0	24.0		-3.17	10.8	0.0074	10.9
120	12.0	24.0		-3.17	8.8	0.0053	8.9
240	10.0	23.0		-3.33	6.7	0.0038	6.7
360	9.5	24.5		-3.08	6.4	0.0031	6.4
1440	7.5	23.0		-3.08	4.4	0.0016	4.4

Reported by: _____ Reviewed by: _____

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other zones/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

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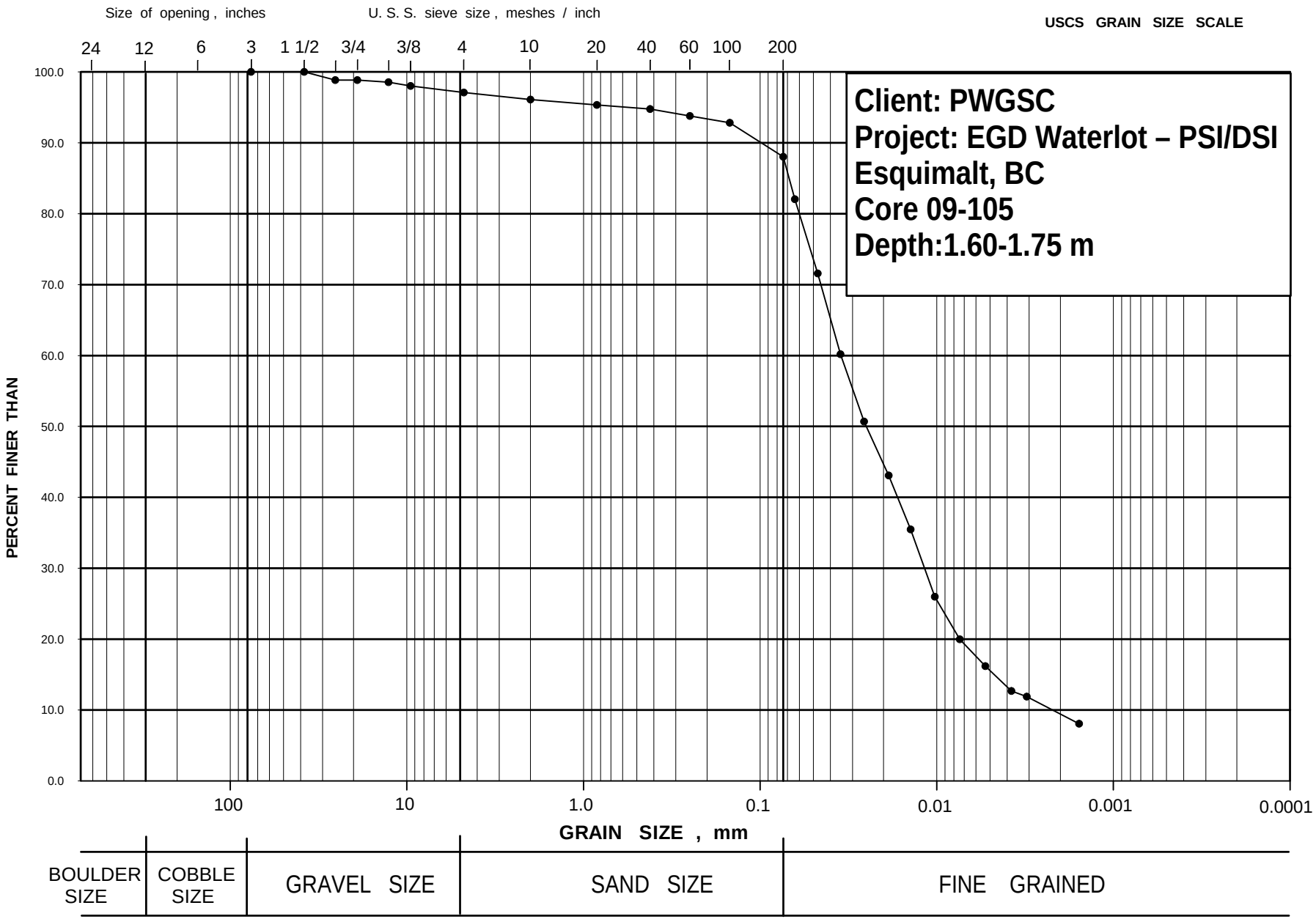

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/SA

DATE TESTED: 6-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-105	Sample No.			Depth (m) :	1.60-1.75	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	1.3	
	Total Weight	716.1	Before Wash	50.0	Total -200	45.8	
			After Wash	5.5	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	8.3	1.2			1.2	25.4	98.8
3/4"	0.0	0.0			0.0	19.1	98.8
1/2"	2.1	0.3			0.3	12.7	98.5
3/8"	3.8	0.5			0.5	9.52	98.0
#4	6.5	0.9			0.9	4.76	97.1
#10	7.2	1.0			1.0	2.00	96.1
#20			0.4	0.8	0.8	0.840	95.3
#40			0.3	0.6	0.6	0.420	94.8
#60			0.5	1.0	1.0	0.250	93.8
#100			0.5	1.0	1.0	0.149	92.8
#200			2.5	5.0	4.8	0.074	88.0
Pan			45.8	91.6	88.0		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	46.5	23.0		-3.33	43.2	0.0635	82.0
1	41.0	23.0		-3.33	37.7	0.0472	71.6
2	35.0	23.0		-3.33	31.7	0.0351	60.2
4	30.0	23.0		-3.33	26.7	0.0258	50.7
8	26.0	23.0		-3.33	22.7	0.0188	43.1
15	22.0	23.0		-3.33	18.7	0.0141	35.5
30	17.0	23.0		-3.33	13.7	0.0103	26.0
60	14.0	22.0		-3.48	10.5	0.0074	20.0
120	12.0	22.0		-3.48	8.5	0.0053	16.2
240	10.0	23.0		-3.33	6.7	0.0038	12.7
360	9.5	23.5		-3.25	6.3	0.0031	11.9
1440	7.5	23.0		-3.25	4.3	0.0016	8.1

Reported by: _____ Reviewed by: _____

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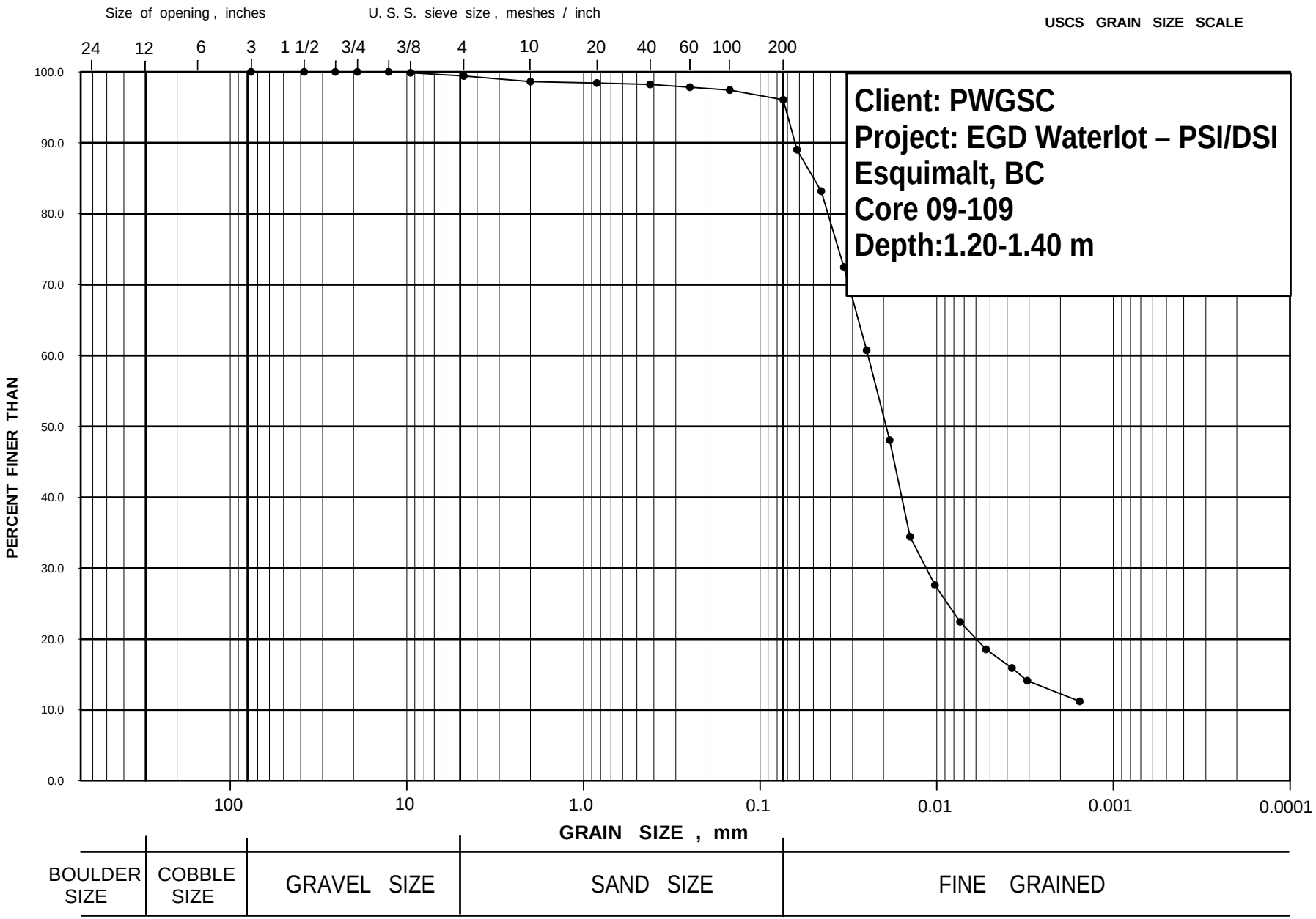

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/SA

DATE TESTED: 6-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-109	Sample No.			Depth (m) :	1.20-1.40	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.3	
	Total Weight	640.8	Before Wash	50.0	Total -200	48.7	
			After Wash	1.6	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	0.0	0.0			0.0	12.7	100.0
3/8"	0.7	0.1			0.1	9.52	99.9
#4	3.0	0.5			0.5	4.76	99.4
#10	5.1	0.8			0.8	2.00	98.6
#20			0.1	0.2	0.2	0.840	98.4
#40			0.1	0.2	0.2	0.420	98.2
#60			0.2	0.4	0.4	0.250	97.8
#100			0.2	0.4	0.4	0.149	97.4
#200			0.7	1.4	1.4	0.074	96.1
Pan			48.7	97.4	96.1		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	49.0	23.0		-3.33	45.7	0.0619	89.0
1	46.0	23.0		-3.33	42.7	0.0451	83.2
2	40.5	23.0		-3.33	37.2	0.0335	72.5
4	34.5	23.0		-3.33	31.2	0.0249	60.8
8	28.0	23.0		-3.33	24.7	0.0185	48.1
15	21.0	23.0		-3.33	17.7	0.0142	34.4
30	17.5	23.0		-3.33	14.2	0.0102	27.6
60	15.0	22.0		-3.48	11.5	0.0074	22.4
120	13.0	22.0		-3.48	9.5	0.0053	18.5
240	11.5	23.0		-3.33	8.2	0.0038	15.9
360	10.5	23.5		-3.25	7.3	0.0031	14.1
1440	9.0	23.0		-3.25	5.8	0.0016	11.2

Reported by: _____ Reviewed by: _____

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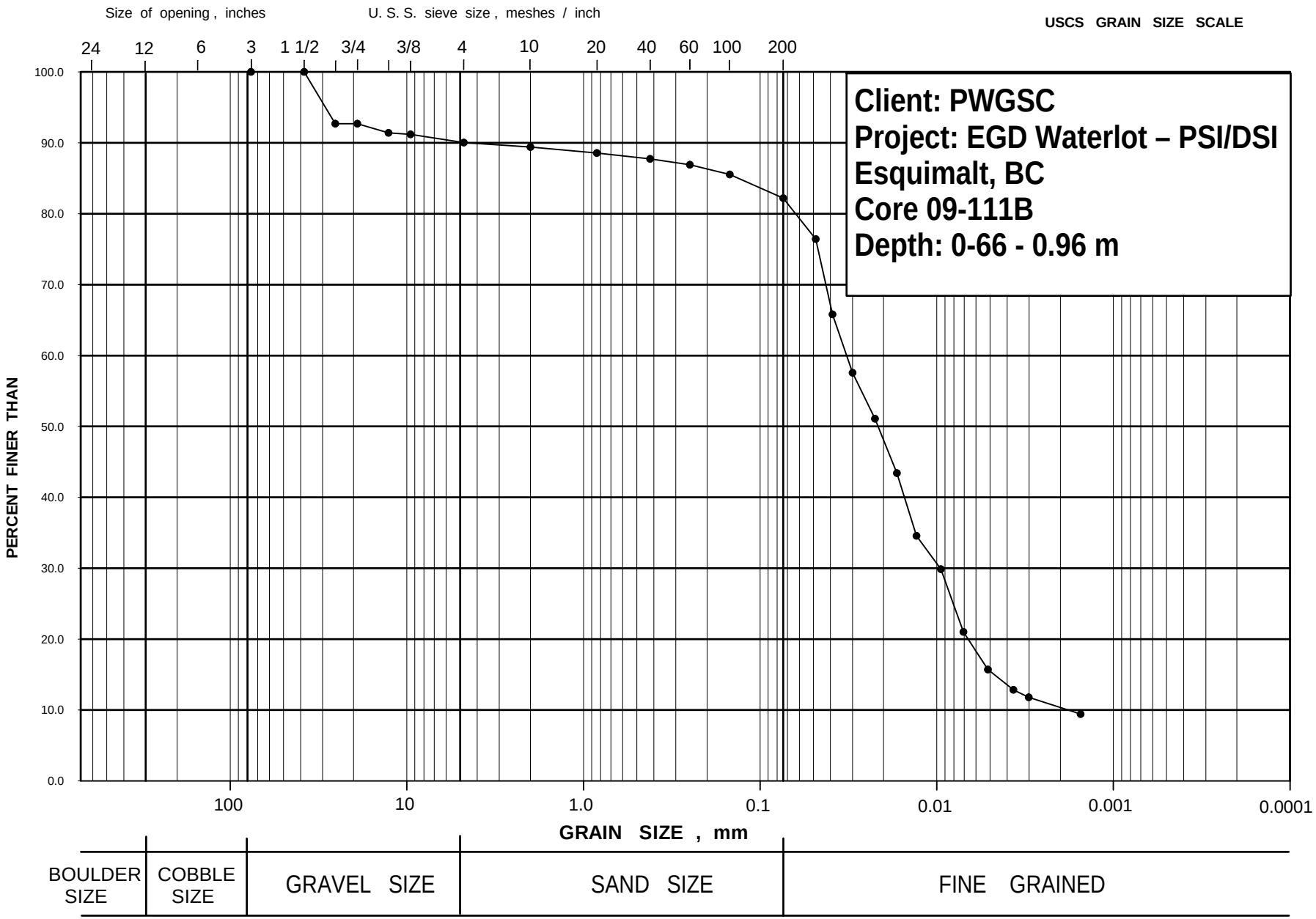

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/SA

DATE TESTED: 5-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-111B	Sample No.			Depth :	0.66-0.96	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.9	
	Total Weight	1058.3	Before Wash	75.0	Total -200	69.0	
			After Wash	6.9	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	77.2	7.3			7.3	25.4	92.7
3/4"	0.0	0.0			0.0	19.1	92.7
1/2"	13.7	1.3			1.3	12.7	91.4
3/8"	2.3	0.2			0.2	9.52	91.2
#4	12.2	1.2			1.2	4.76	90.0
#10	6.8	0.6			0.6	2.00	89.4
#20			0.7	0.9	0.8	0.840	88.6
#40			0.7	0.9	0.8	0.420	87.7
#60			0.7	0.9	0.8	0.250	86.9
#100			1.1	1.5	1.4	0.149	85.5
#200			2.8	3.7	3.3	0.074	82.2
Pan			69.0	91.9	82.2		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	68.0	24.0		-3.17	64.8	0.0484	76.4
1	59.0	24.0		-3.17	55.8	0.0390	65.8
2	52.0	24.0		-3.17	48.8	0.0299	57.6
4	46.5	24.0		-3.17	43.3	0.0224	51.1
8	40.0	24.0		-3.17	36.8	0.0168	43.4
15	32.5	24.0		-3.17	29.3	0.0130	34.6
30	28.5	24.0		-3.17	25.3	0.0095	29.9
60	21.0	24.0		-3.17	17.8	0.0071	21.0
120	16.5	24.0		-3.17	13.3	0.0051	15.7
240	14.0	24.5		-3.08	10.9	0.0037	12.9
360	13.0	25.0		-3.00	10.0	0.0030	11.8
1440	11.0	23.5		-3.00	8.0	0.0015	9.4

Reported by: _____ Reviewed by: _____

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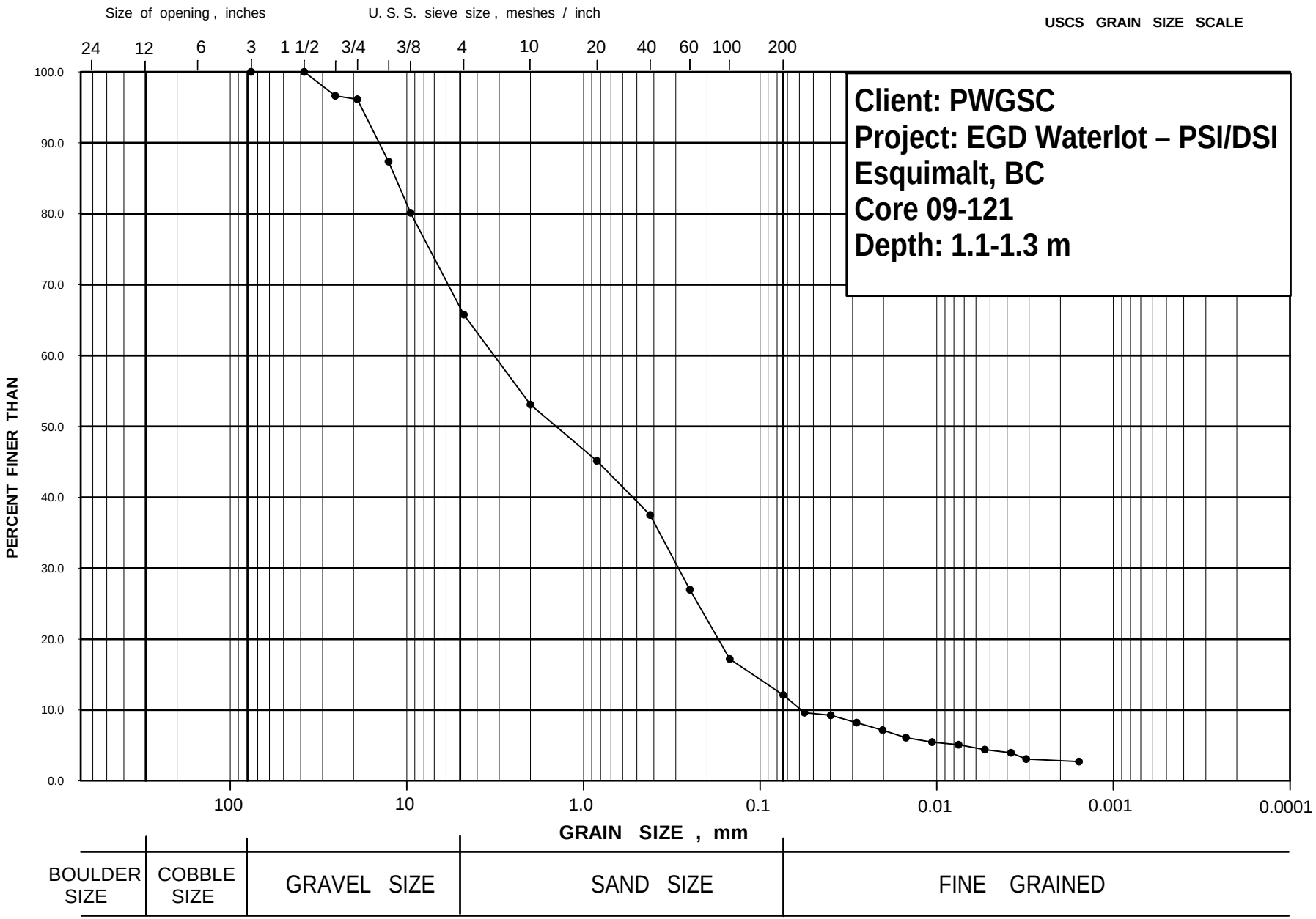

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 27-Jul-09 **SAMPLED BY:** MA-AK

DATE TESTED: 4-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-121	Sample No.			Depth (m) :	1.10-1.30	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.4	
	Total Weight	773.6	Before Wash	75.0	Total -200	17.1	
			After Wash	58.3	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	26.1	3.4			3.4	25.4	96.6
3/4"	3.8	0.5			0.5	19.1	96.1
1/2"	67.9	8.8			8.8	12.7	87.4
3/8"	55.8	7.2			7.2	9.52	80.1
#4	111.3	14.4			14.4	4.76	65.8
#10	98.2	12.7			12.7	2.00	53.1
#20			11.2	14.9	7.9	0.840	45.1
#40			10.8	14.4	7.6	0.420	37.5
#60			14.9	19.9	10.5	0.250	27.0
#100			13.8	18.4	9.8	0.149	17.2
#200			7.2	9.6	5.1	0.074	12.1
Pan			17.1	22.8	12.1		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5		23.5		-3.25	-3.2		
1	17.0	23.5		-3.25	13.8	0.0562	9.6
2	16.5	23.5		-3.25	13.3	0.0398	9.3
4	15.0	23.5		-3.25	11.8	0.0284	8.2
8	13.5	23.5		-3.25	10.3	0.0203	7.2
15	12.0	23.5		-3.25	8.8	0.0149	6.1
30	11.0	24.0		-3.17	7.8	0.0106	5.5
60	10.5	24.0		-3.17	7.3	0.0075	5.1
120	9.5	24.0		-3.17	6.3	0.0054	4.4
240	9.0	23.0		-3.33	5.7	0.0038	4.0
360	7.5	24.5		-3.08	4.4	0.0031	3.1
1440	7.0	23.0		-3.08	3.9	0.0016	2.7

Reported by: _____ Reviewed by: _____

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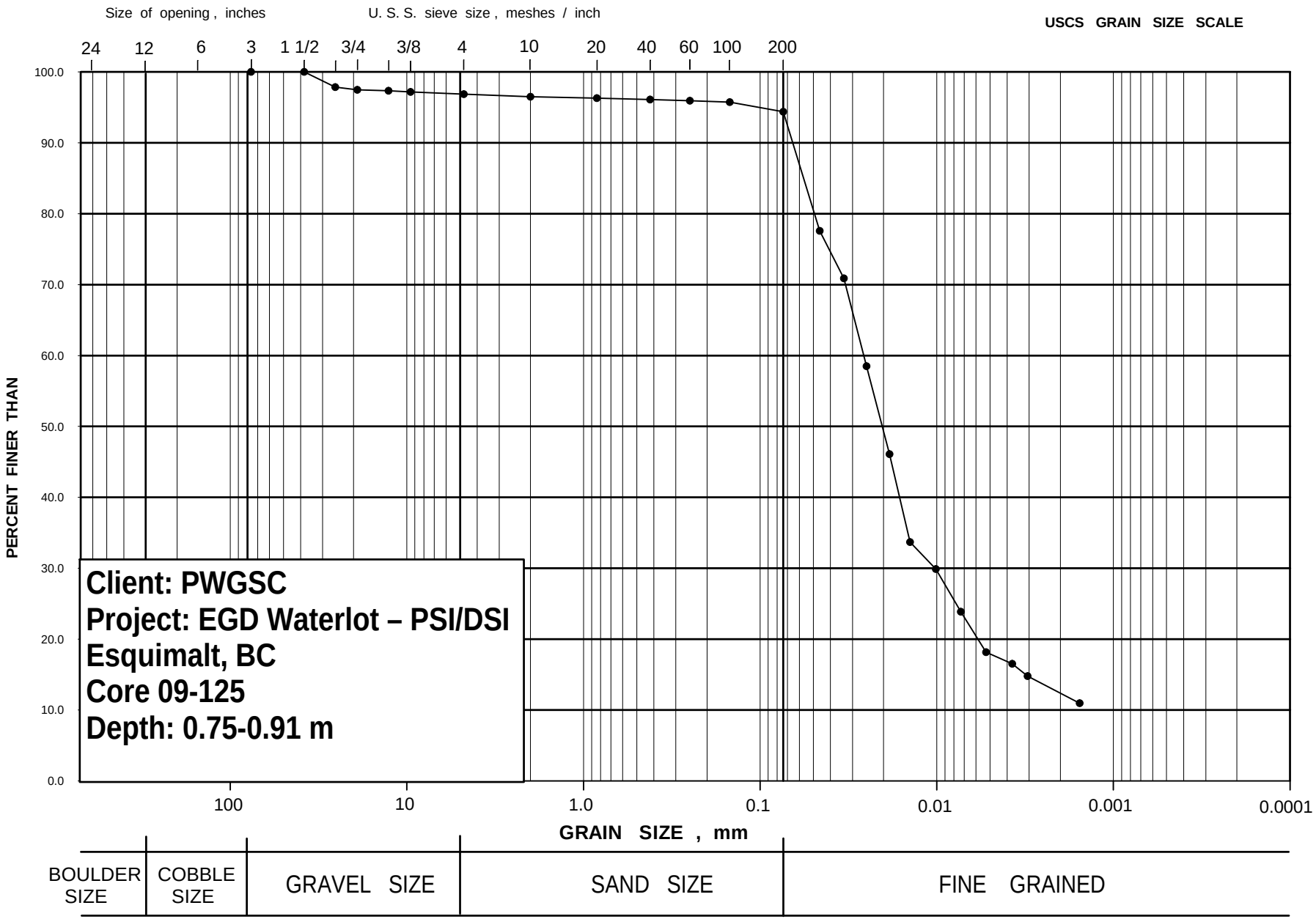

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/RPC

DATE TESTED: 6-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-125	Sample No.			Depth (m) :	0.75-0.91	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.2	
	Total Weight	663.9	Before Wash	50.0	Total -200	48.9	
			After Wash	1.3	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	14.2	2.1			2.1	25.4	97.9
3/4"	2.5	0.4			0.4	19.1	97.5
1/2"	1.0	0.2			0.2	12.7	97.3
3/8"	1.0	0.2			0.2	9.52	97.2
#4	2.1	0.3			0.3	4.76	96.9
#10	2.4	0.4			0.4	2.00	96.5
#20			0.1	0.2	0.2	0.840	96.3
#40			0.1	0.2	0.2	0.420	96.1
#60			0.1	0.2	0.2	0.250	95.9
#100			0.1	0.2	0.2	0.149	95.7
#200			0.7	1.4	1.3	0.074	94.4
Pan			48.9	97.8	94.4		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	50.0	23.0		-3.33	46.7		
1	44.0	23.0		-3.33	40.7	0.0460	77.6
2	40.5	23.0		-3.33	37.2	0.0335	70.9
4	34.0	23.0		-3.33	30.7	0.0250	58.5
8	27.5	23.0		-3.33	24.2	0.0186	46.1
15	21.0	23.0		-3.33	17.7	0.0142	33.7
30	19.0	23.0		-3.33	15.7	0.0101	29.9
60	16.0	22.0		-3.48	12.5	0.0073	23.9
120	13.0	22.0		-3.48	9.5	0.0053	18.1
240	12.0	23.0		-3.33	8.7	0.0037	16.5
360	11.0	23.5		-3.25	7.8	0.0031	14.8
1440	9.0	23.0		-3.25	5.8	0.0016	11.0

Reported by: _____ Reviewed by: _____

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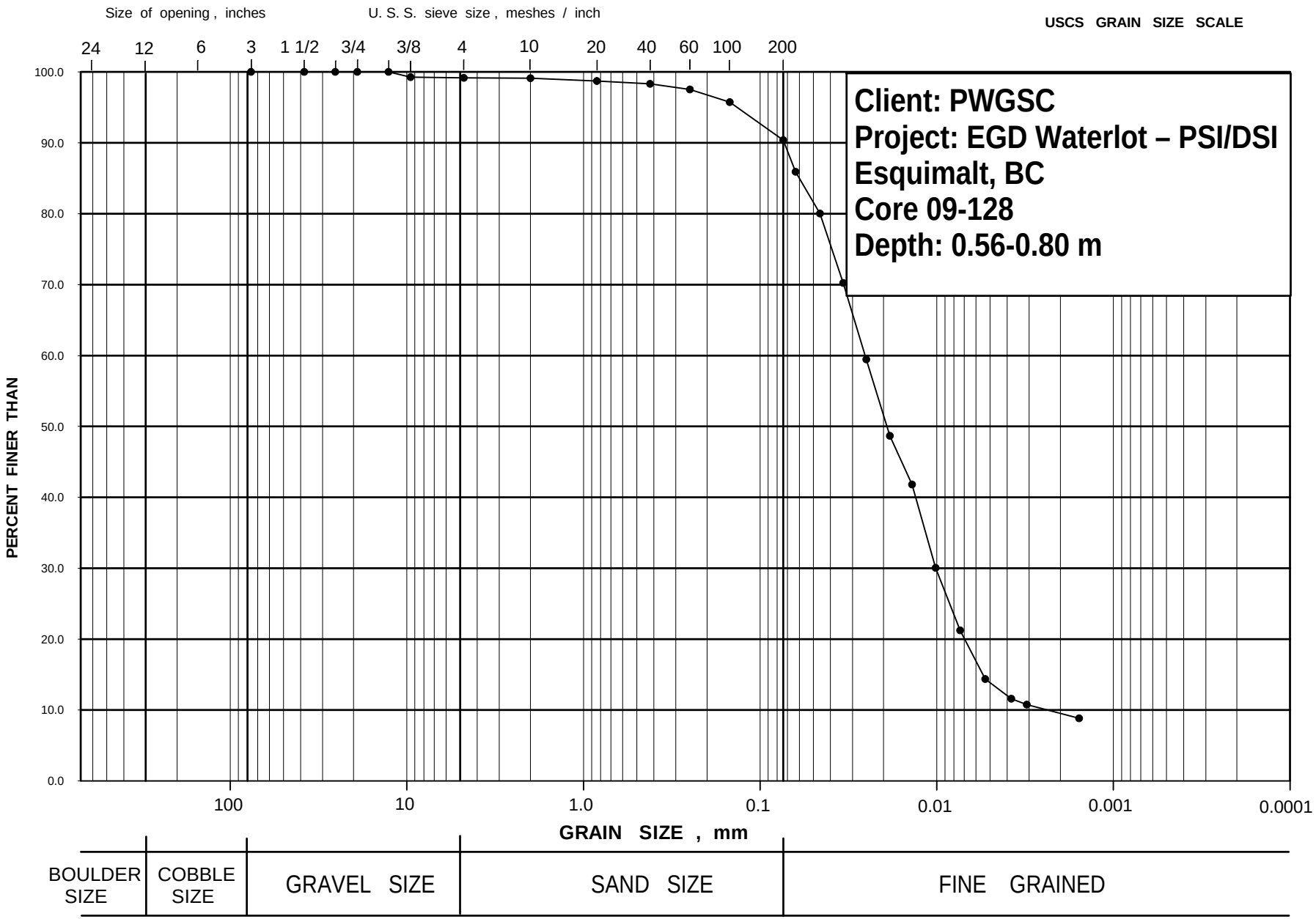

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/SA

DATE TESTED: 5-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-128	Sample No.			Depth :	0.56-.080	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.7	
	Total Weight	288.8	Before Wash	50.0	Total -200	45.6	
			After Wash	5.1	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	0.0	0.0			0.0	12.7	100.0
3/8"	2.1	0.7			0.7	9.52	99.3
#4	0.3	0.1			0.1	4.76	99.2
#10	0.2	0.1			0.1	2.00	99.1
#20			0.2	0.4	0.4	0.840	98.7
#40			0.2	0.4	0.4	0.420	98.3
#60			0.4	0.8	0.8	0.250	97.5
#100			0.9	1.8	1.8	0.149	95.7
#200			2.7	5.4	5.4	0.074	90.4
Pan			45.6	91.2	90.4		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	47.0	24.0		-3.17	43.8	0.0630	85.9
1	44.0	24.0		-3.17	40.8	0.0459	80.0
2	39.0	24.0		-3.17	35.8	0.0339	70.2
4	33.5	24.0		-3.17	30.3	0.0250	59.5
8	28.0	24.0		-3.17	24.8	0.0184	48.7
15	24.5	24.0		-3.17	21.3	0.0138	41.8
30	18.5	24.0		-3.17	15.3	0.0101	30.1
60	14.0	24.0		-3.17	10.8	0.0074	21.2
120	10.5	24.0		-3.17	7.3	0.0053	14.4
240	9.0	24.5		-3.08	5.9	0.0038	11.6
360	8.5	25.0		-3.00	5.5	0.0031	10.8
1440	7.5	23.5		-3.00	4.5	0.0016	8.8

Reported by: _____ Reviewed by: _____

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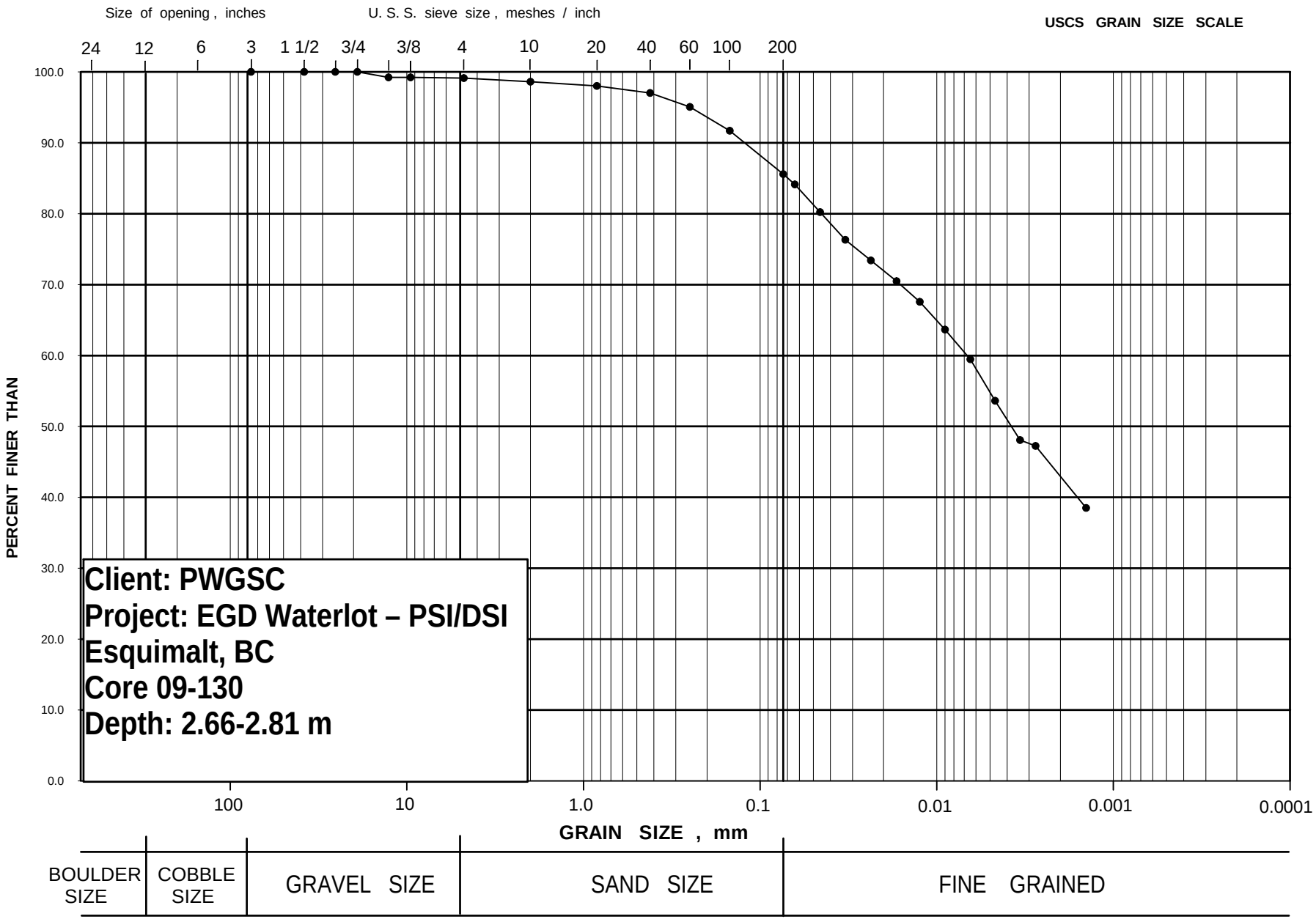

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/RPC

DATE TESTED: 6-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-130	Sample No.			Depth (m) :	2.66-2.81	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.5	
	Total Weight	775.6	Before Wash	50.0	Total -200	43.9	
			After Wash	6.6	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	6.0	0.8			0.8	12.7	99.2
3/8"	0.0	0.0			0.0	9.52	99.2
#4	0.7	0.1			0.1	4.76	99.1
#10	4.1	0.5			0.5	2.00	98.6
#20			0.3	0.6	0.6	0.840	98.0
#40			0.5	1.0	1.0	0.420	97.0
#60			1.0	2.0	2.0	0.250	95.1
#100			1.7	3.4	3.3	0.149	91.7
#200			3.1	6.2	6.1	0.074	85.6
Pan			43.9	87.8	86.6		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	46.5	23.0		-3.33	43.2	0.0635	84.1
1	44.5	23.0		-3.33	41.2	0.0458	80.2
2	42.5	23.0		-3.33	39.2	0.0329	76.3
4	41.0	23.0		-3.33	37.7	0.0236	73.4
8	39.5	23.0		-3.33	36.2	0.0169	70.5
15	38.0	23.0		-3.33	34.7	0.0125	67.6
30	36.0	23.0		-3.33	32.7	0.0090	63.7
60	34.0	22.0		-3.48	30.5	0.0065	59.5
120	31.0	22.0		-3.48	27.5	0.0047	53.6
240	28.0	23.0		-3.33	24.7	0.0034	48.1
360	27.5	23.5		-3.25	24.3	0.0028	47.3
1440	23.0	23.0		-3.25	19.8	0.0014	38.5

Reported by: _____ Reviewed by: _____

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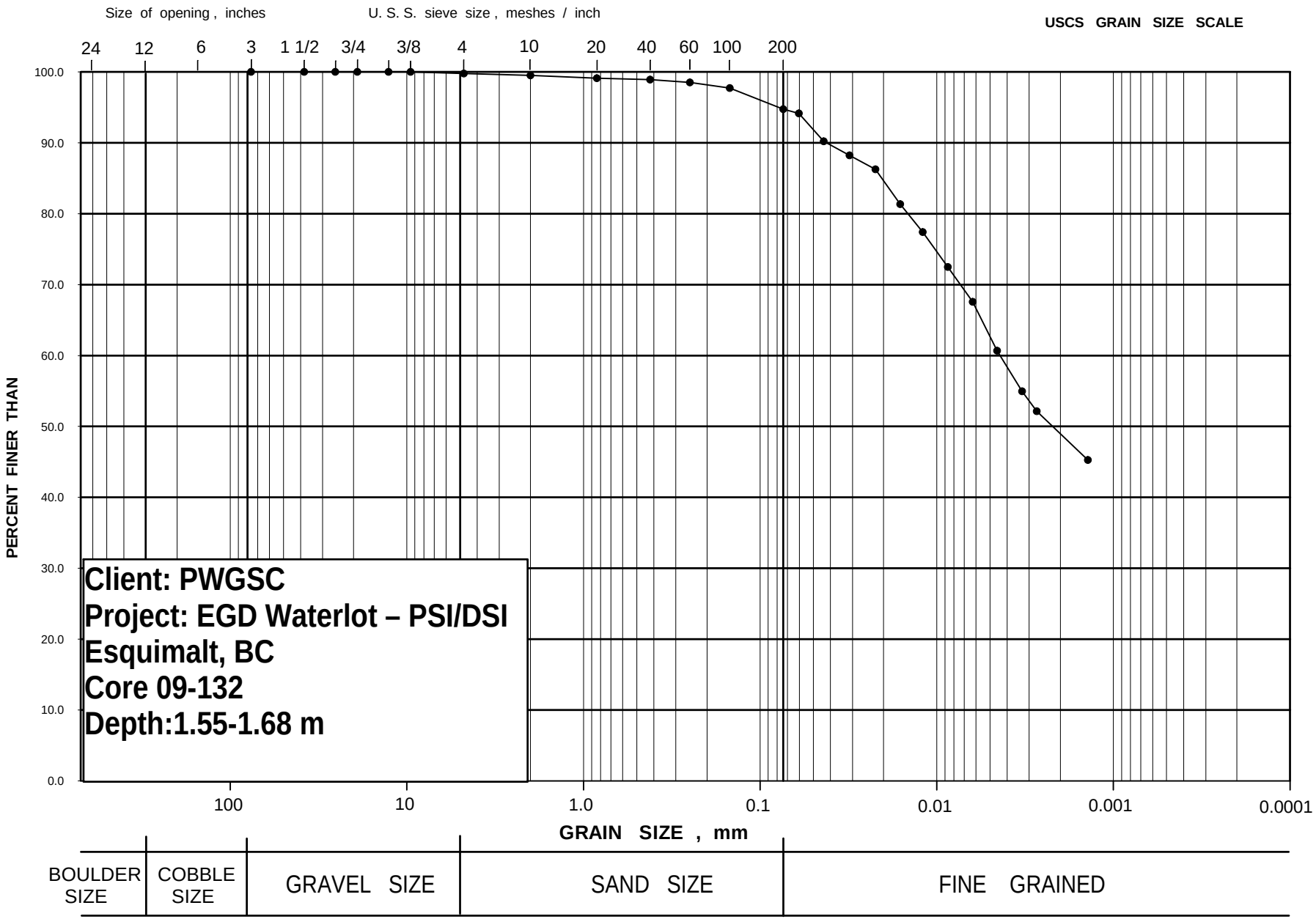

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/SA

DATE TESTED: 5-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-132	Sample No.			Depth :	1.55-1.68	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.4	
	Total Weight	327.7	Before Wash	50.0	Total -200	47.6	
			After Wash	2.8	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	0.0	0.0			0.0	12.7	100.0
3/8"	0.0	0.0			0.0	9.52	100.0
#4	0.7	0.2			0.2	4.76	99.8
#10	0.9	0.3			0.3	2.00	99.5
#20			0.2	0.4	0.4	0.840	99.1
#40			0.1	0.2	0.2	0.420	98.9
#60			0.2	0.4	0.4	0.250	98.5
#100			0.4	0.8	0.8	0.149	97.7
#200			1.5	3.0	3.0	0.074	94.7
Pan			47.6	95.2	94.7		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	51.0	24.0		-3.17	47.8	0.0605	94.1
1	49.0	24.0		-3.17	45.8	0.0437	90.2
2	48.0	24.0		-3.17	44.8	0.0312	88.2
4	47.0	24.0		-3.17	43.8	0.0223	86.3
8	44.5	24.0		-3.17	41.3	0.0161	81.4
15	42.5	24.0		-3.17	39.3	0.0120	77.4
30	40.0	24.0		-3.17	36.8	0.0087	72.5
60	37.5	24.0		-3.17	34.3	0.0063	67.6
120	34.0	24.0		-3.17	30.8	0.0046	60.7
240	31.0	24.5		-3.08	27.9	0.0033	54.9
360	29.5	25.0		-3.00	26.5	0.0027	52.2
1440	26.0	23.5		-3.00	23.0	0.0014	45.3

Reported by: _____ Reviewed by: _____

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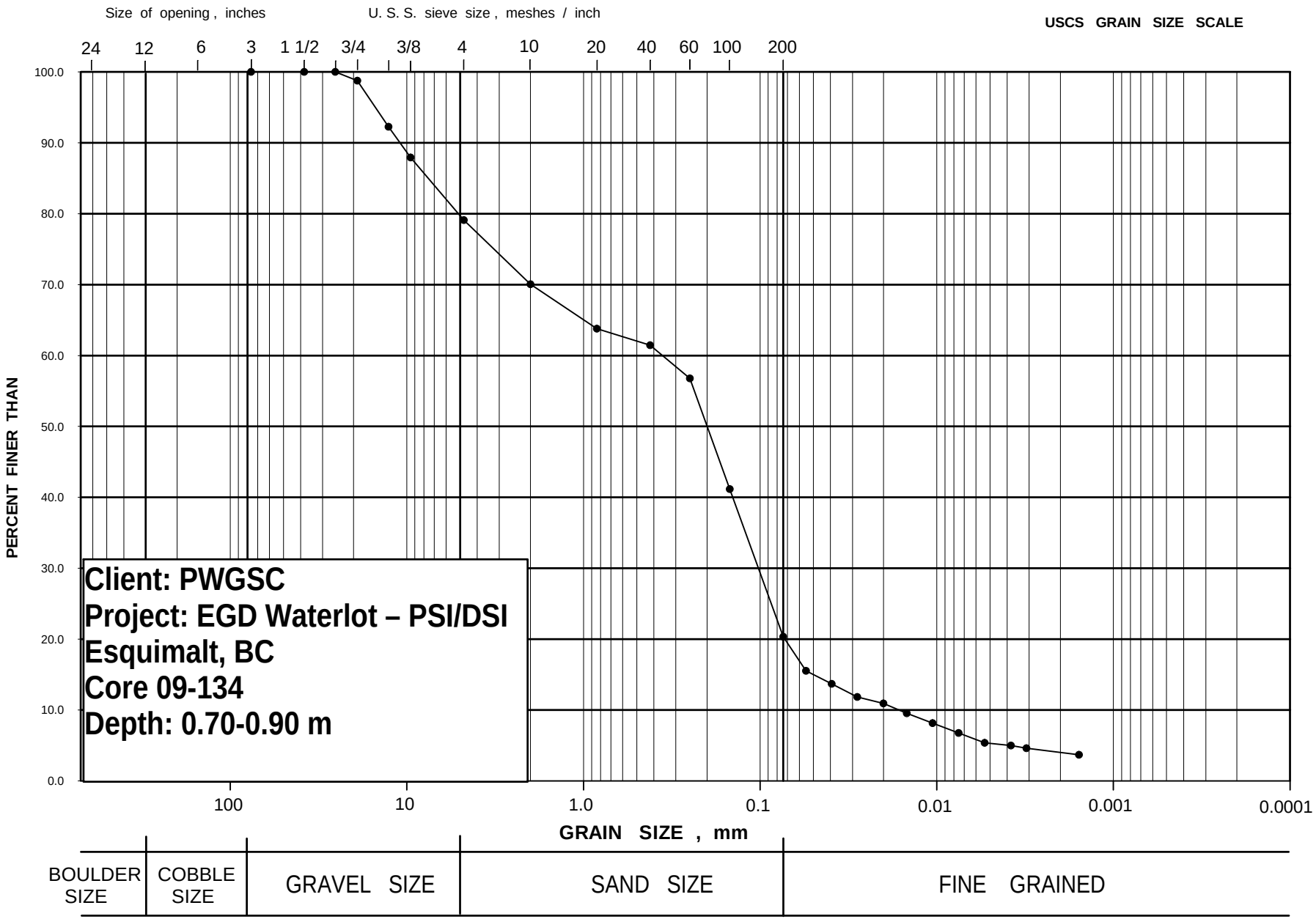

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/SA

DATE TESTED: 5-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-134	Sample No.			Depth (m) :	0.70-0.90	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	1.8	
	Total Weight	564.9	Before Wash	75.0	Total -200	21.8	
			After Wash	55.0	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	6.9	1.2			1.2	19.1	98.8
1/2"	36.8	6.5			6.5	12.7	92.3
3/8"	24.5	4.3			4.3	9.52	87.9
#4	49.9	8.8			8.8	4.76	79.1
#10	51.1	9.0			9.0	2.00	70.0
#20			6.7	8.9	6.3	0.840	63.8
#40			2.5	3.3	2.3	0.420	61.5
#60			5.0	6.7	4.7	0.250	56.8
#100			16.7	22.3	15.6	0.149	41.2
#200			22.3	29.7	20.8	0.074	20.3
Pan			21.8	29.1	20.4		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	25.0	24.0		-3.17	21.8		
1	20.0	24.0		-3.17	16.8	0.0551	15.5
2	18.0	24.0		-3.17	14.8	0.0394	13.7
4	16.0	24.0		-3.17	12.8	0.0282	11.9
8	15.0	24.0		-3.17	11.8	0.0201	10.9
15	13.5	24.0		-3.17	10.3	0.0148	9.5
30	12.0	24.0		-3.17	8.8	0.0106	8.2
60	10.5	24.0		-3.17	7.3	0.0075	6.8
120	9.0	24.0		-3.17	5.8	0.0054	5.4
240	8.5	24.5		-3.08	5.4	0.0038	5.0
360	8.0	25.0		-3.00	5.0	0.0031	4.6
1440	7.0	23.5		-3.00	4.0	0.0016	3.7

Reported by: _____ Reviewed by: _____

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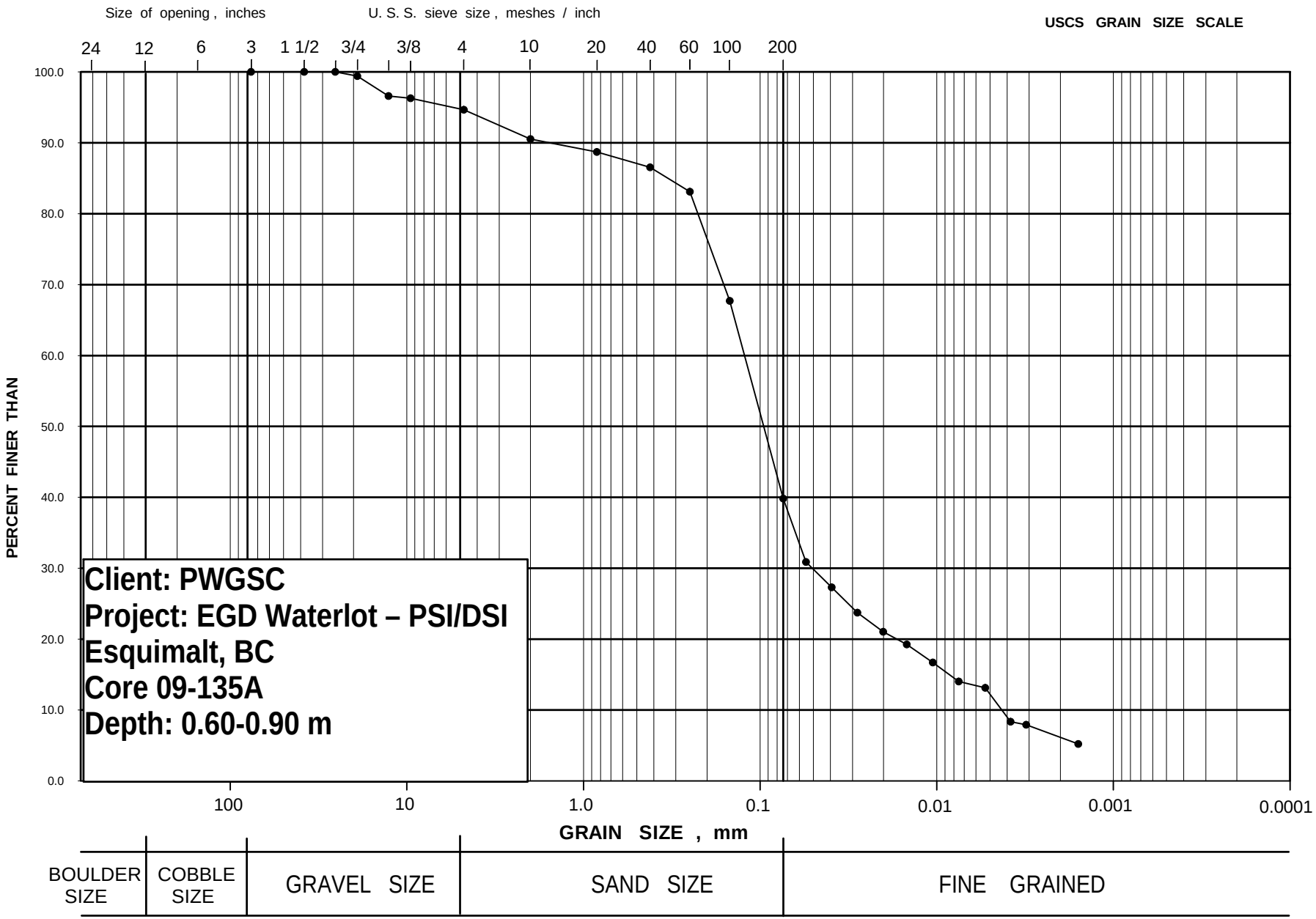

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 27-Jul-09 **SAMPLED BY:** MA-AK

DATE TESTED: 4-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-135A	Sample No.			Depth (m) :	0.60-0.90	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	1.5	
	Total Weight	468.6	Before Wash	50.0	Total -200	22.0	
			After Wash	29.5	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	2.8	0.6			0.6	19.1	99.4
1/2"	13.1	2.8			2.8	12.7	96.6
3/8"	1.5	0.3			0.3	9.52	96.3
#4	7.6	1.6			1.6	4.76	94.7
#10	19.4	4.1			4.1	2.00	90.5
#20			1.0	2.0	1.8	0.840	88.7
#40			1.2	2.4	2.2	0.420	86.5
#60			1.9	3.8	3.4	0.250	83.1
#100			8.5	17.0	15.4	0.149	67.7
#200			15.4	30.8	27.9	0.074	39.8
Pan			22.0	44.0	39.8		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	24.0	23.5		-3.25	20.8		
1	20.5	23.5		-3.25	17.3	0.0550	30.9
2	18.5	23.5		-3.25	15.3	0.0394	27.3
4	16.5	23.5		-3.25	13.3	0.0282	23.7
8	15.0	23.5		-3.25	11.8	0.0201	21.0
15	14.0	23.5		-3.25	10.8	0.0148	19.2
30	12.5	24.0		-3.17	9.3	0.0105	16.7
60	11.0	24.0		-3.17	7.8	0.0075	14.0
120	10.5	24.0		-3.17	7.3	0.0053	13.1
240	8.0	23.0		-3.33	4.7	0.0038	8.4
360	7.5	24.5		-3.08	4.4	0.0031	7.9
1440	6.0	23.0		-3.08	2.9	0.0016	5.2

Reported by: _____ Reviewed by: _____

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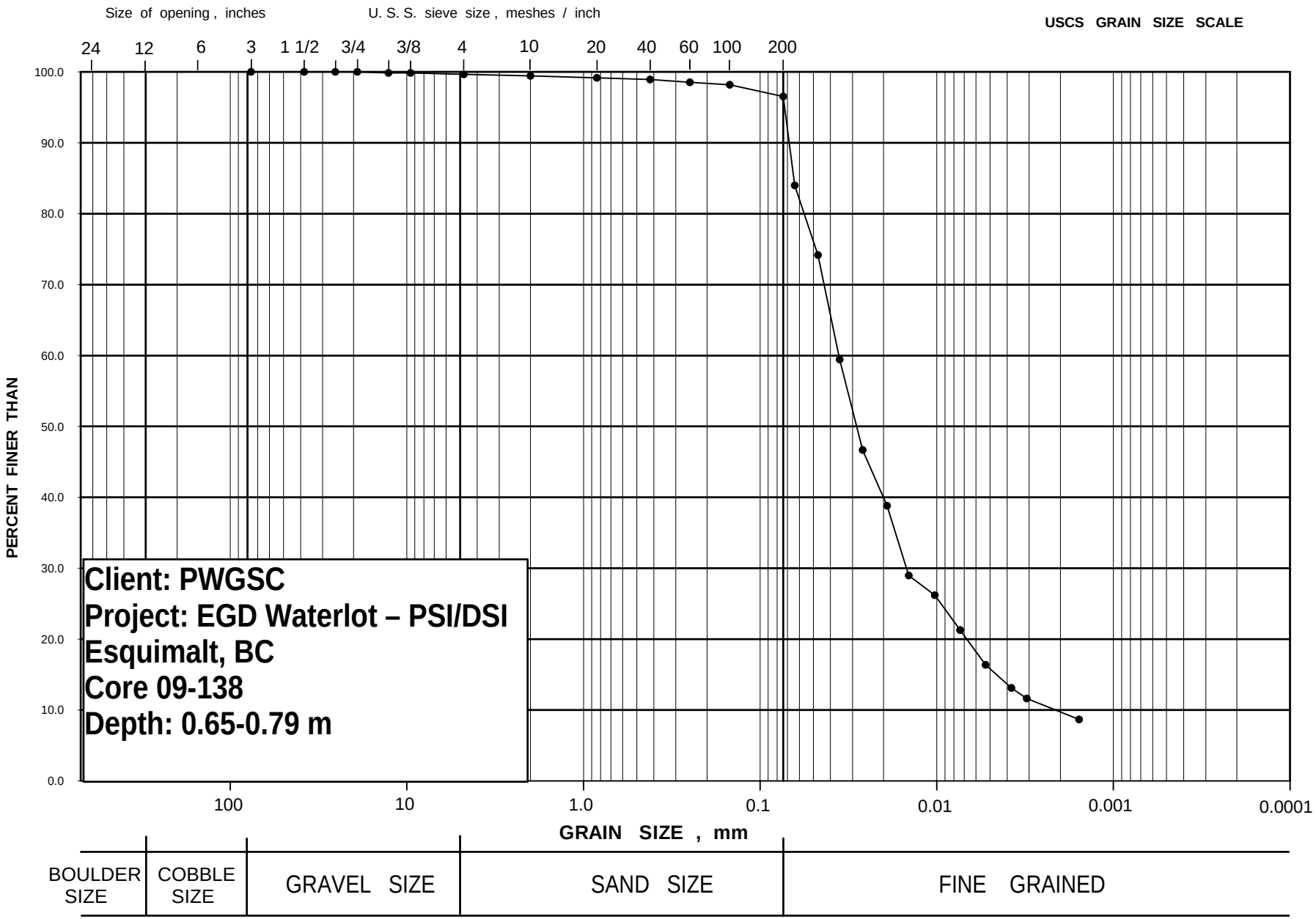

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 27-Jul-09 **SAMPLED BY:** MA-AK

DATE TESTED: 4-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-138	Sample No.			Depth (m) :	0.65-0.79	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.5	
	Total Weight	464.6	Before Wash	50.1	Total -200	48.6	
			After Wash	2.0	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	0.6	0.1			0.1	12.7	99.9
3/8"	0.0	0.0			0.0	9.52	99.9
#4	1.0	0.2			0.2	4.76	99.7
#10	1.0	0.2			0.2	2.00	99.4
#20			0.1	0.3	0.3	0.840	99.2
#40			0.1	0.2	0.2	0.420	98.9
#60			0.2	0.4	0.4	0.250	98.5
#100			0.2	0.3	0.3	0.149	98.2
#200			0.8	1.7	1.7	0.074	96.5
Pan			48.6	97.1	96.5		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	46.0	23.5		-3.25	42.8	0.0637	84.0
1	41.0	23.5		-3.25	37.8	0.0472	74.2
2	33.5	23.5		-3.25	30.3	0.0355	59.4
4	27.0	23.5		-3.25	23.8	0.0263	46.7
8	23.0	23.5		-3.25	19.8	0.0191	38.8
15	18.0	23.5		-3.25	14.8	0.0144	29.0
30	16.5	24.0		-3.17	13.3	0.0103	26.2
60	14.0	24.0		-3.17	10.8	0.0074	21.3
120	11.5	24.0		-3.17	8.3	0.0053	16.4
240	10.0	23.0		-3.33	6.7	0.0038	13.1
360	9.0	24.5		-3.08	5.9	0.0031	11.6
1440	7.5	23.0		-3.08	4.4	0.0016	8.7

Reported by: _____ Reviewed by: _____

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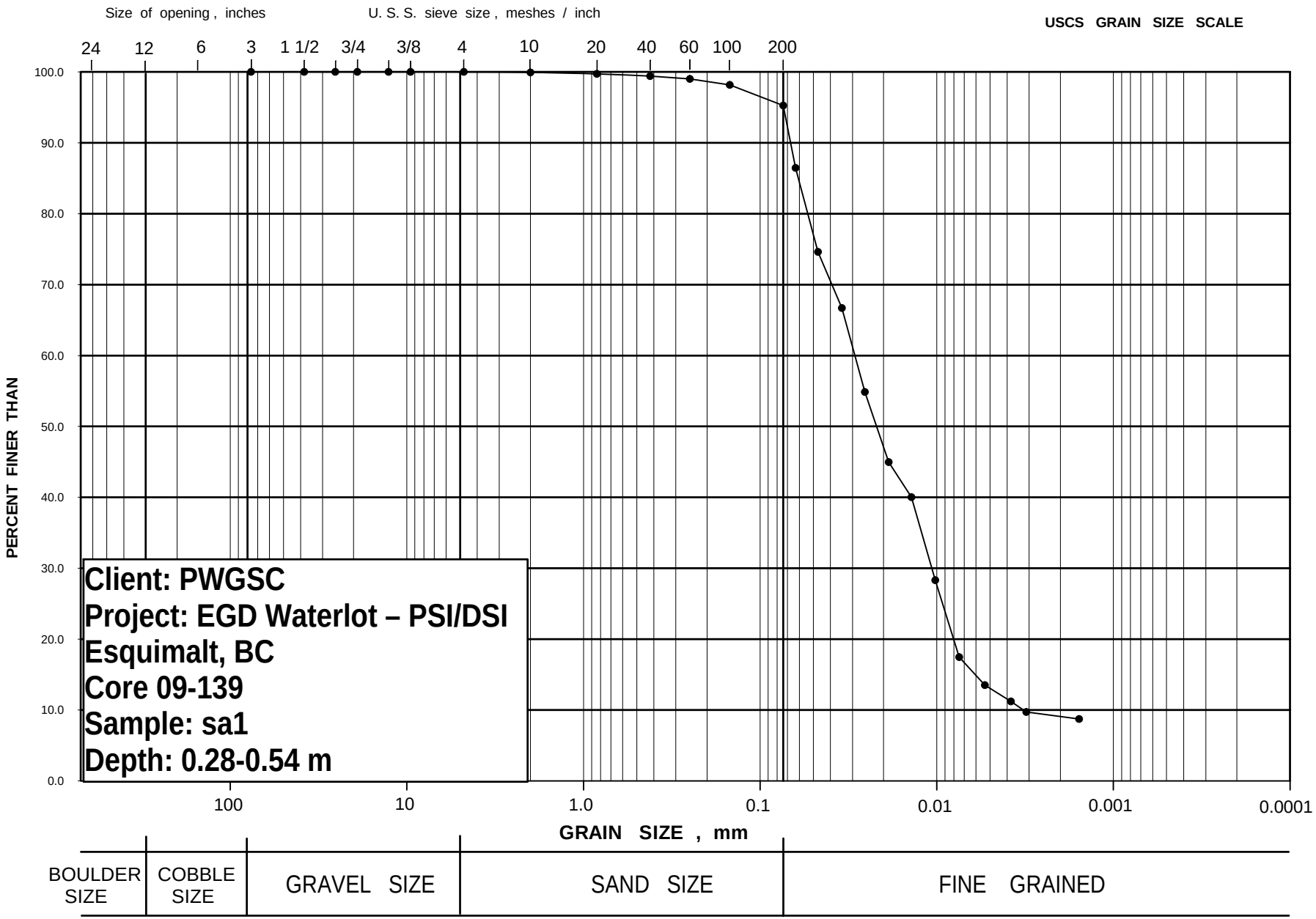

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 27-Jul-09 **SAMPLED BY:** MA-AK

DATE TESTED: 4-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-139	Sample No.	sa1		Depth (m) :	0.28-0.54	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.5	
	Total Weight	131.3	Before Wash	50.0	Total -200	47.7	
			After Wash	2.9	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	0.0	0.0			0.0	12.7	100.0
3/8"	0.0	0.0			0.0	9.52	100.0
#4	0.0	0.0			0.0	4.76	100.0
#10	0.1	0.1			0.1	2.00	99.9
#20			0.1	0.2	0.2	0.840	99.7
#40			0.2	0.3	0.3	0.420	99.4
#60			0.2	0.4	0.4	0.250	99.0
#100			0.4	0.8	0.8	0.149	98.2
#200			1.5	2.9	2.9	0.074	95.2
Pan			47.7	95.3	95.2		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	47.0	23.5		-3.25	43.8	0.0631	86.5
1	41.0	23.5		-3.25	37.8	0.0472	74.6
2	37.0	23.5		-3.25	33.8	0.0345	66.7
4	31.0	23.5		-3.25	27.8	0.0256	54.8
8	26.0	23.5		-3.25	22.8	0.0187	45.0
15	23.5	23.5		-3.25	20.3	0.0139	40.0
30	17.5	24.0		-3.17	14.3	0.0102	28.3
60	12.0	24.0		-3.17	8.8	0.0075	17.5
120	10.0	24.0		-3.17	6.8	0.0053	13.5
240	9.0	23.0		-3.33	5.7	0.0038	11.2
360	8.0	24.5		-3.08	4.9	0.0031	9.7
1440	7.5	23.0		-3.08	4.4	0.0016	8.7

Reported by: _____ Reviewed by: _____

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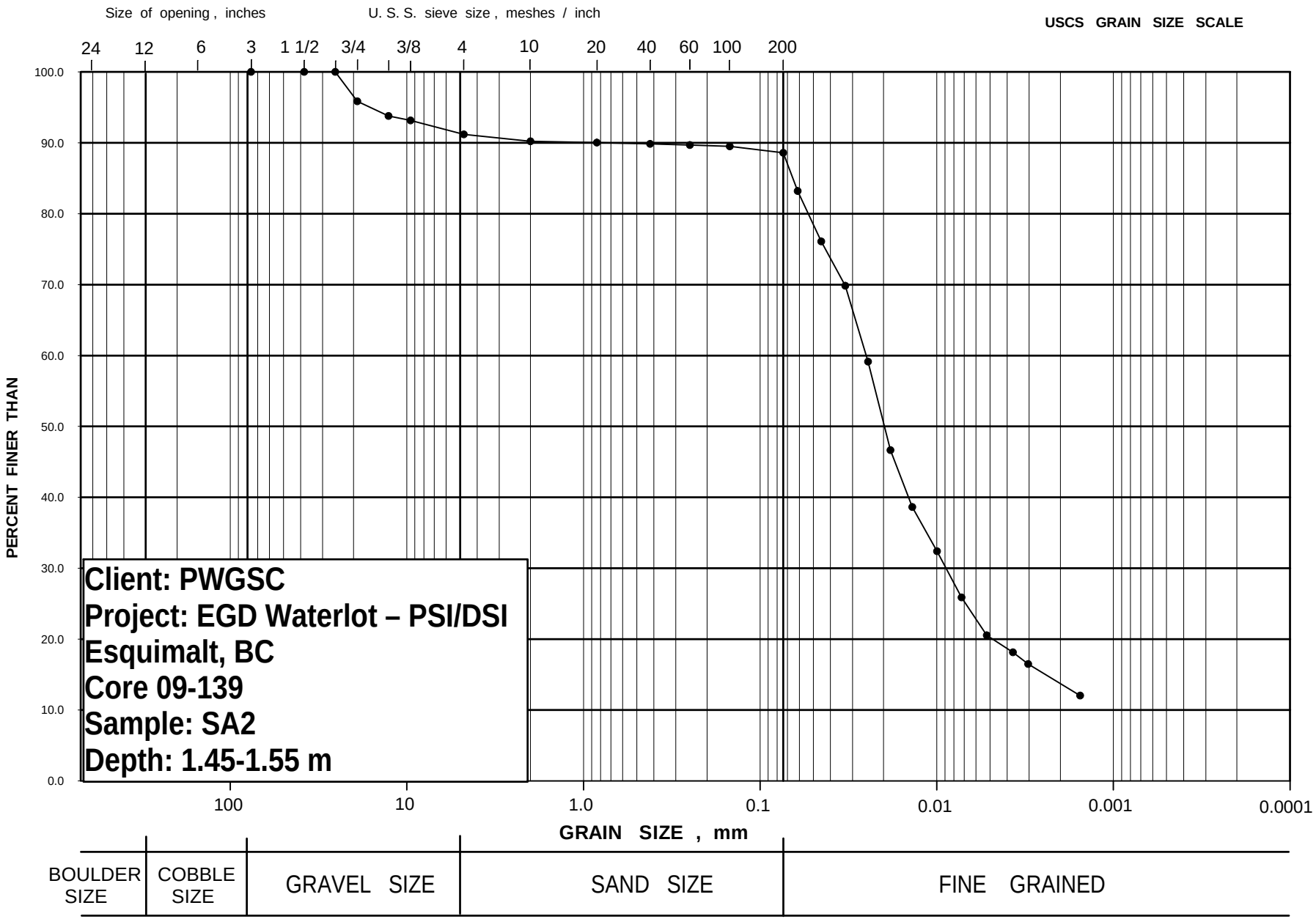

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/RPC

DATE TESTED: 6-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-139	Sample No.	SA2		Depth (m) :	1.45-1.55	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	0.2	
	Total Weight	204.5	Before Wash	50.0	Total -200	49.1	
			After Wash	1.1	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	8.5	4.2			4.2	19.1	95.8
1/2"	4.2	2.1			2.1	12.7	93.8
3/8"	1.3	0.6			0.6	9.52	93.2
#4	4.0	2.0			2.0	4.76	91.2
#10	2.0	1.0			1.0	2.00	90.2
#20			0.1	0.2	0.2	0.840	90.0
#40			0.1	0.2	0.2	0.420	89.9
#60			0.1	0.2	0.2	0.250	89.7
#100			0.1	0.2	0.2	0.149	89.5
#200			0.5	1.0	0.9	0.074	88.6
Pan			49.1	98.2	88.6		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	50.0	23.0		-3.33	46.7	0.0613	83.2
1	46.0	23.0		-3.33	42.7	0.0451	76.1
2	42.5	23.0		-3.33	39.2	0.0329	69.8
4	36.5	23.0		-3.33	33.2	0.0245	59.1
8	29.5	23.0		-3.33	26.2	0.0183	46.7
15	25.0	23.0		-3.33	21.7	0.0138	38.6
30	21.5	23.0		-3.33	18.2	0.0100	32.4
60	18.0	22.0		-3.48	14.5	0.0072	25.9
120	15.0	22.0		-3.48	11.5	0.0052	20.5
240	13.5	23.0		-3.33	10.2	0.0037	18.1
360	12.5	23.5		-3.25	9.3	0.0030	16.5
1440	10.0	23.0		-3.25	6.8	0.0015	12.0

Reported by: _____ Reviewed by: _____

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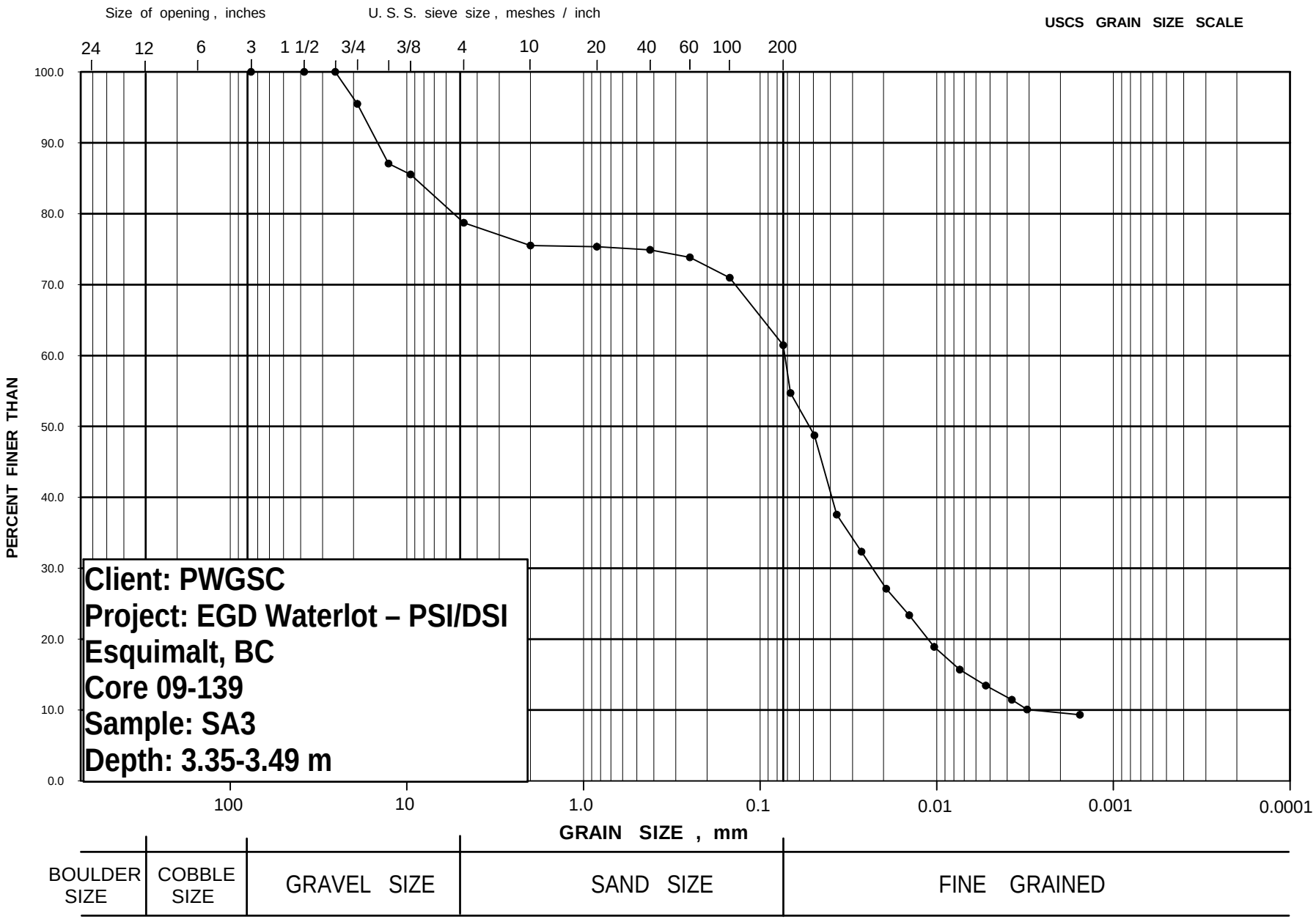

Project No. 09-1475-0026 **Drawn** DGM **Reviewed** **Date** 3 Sept 09	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

PARTICLE SIZE ANALYSIS OF SOILS
ASTM D 4318-93

PROJECT: EGD Waterlot – PSI/DSI

PROJECT NUMBER: 09-1475-0026

DATE SAMPLED: 23-Jul-09 **SAMPLED BY:** MS/RPC

DATE TESTED: 6-Aug-09 **TESTED BY:** DGM

Auger Hole	SC09-139	Sample No.	SA3		Depth (m) :	3.35-3.49	
	1ST SIEVING		Hydrometer: (Minus #10)		Residual #200	1.6	
	Total Weight	204.5	Before Wash	50.0	Total -200	40.7	
			After Wash	10.9	Gs	2.70	(assumed)

Size (USS)	Weight Retained	Retained (%)	Weight Retained	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"		0.0			0.0	152.4	100.0
3"		0.0			0.0	76.2	100.0
1 1/2"		0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	9.2	4.5			4.5	19.1	95.5
1/2"	17.2	8.4			8.4	12.7	87.1
3/8"	3.2	1.6			1.6	9.52	85.5
#4	13.9	6.8			6.8	4.76	78.7
#10	6.6	3.2			3.2	2.00	75.5
#20			0.1	0.2	0.2	0.840	75.4
#40			0.3	0.6	0.5	0.420	74.9
#60			0.7	1.4	1.1	0.250	73.8
#100			1.9	3.8	2.9	0.149	71.0
#200			6.3	12.6	9.5	0.074	61.5
Pan			40.7	81.4	61.5		

HYDROMETER ANALYSIS

Time (min)	Hydrometer Reading	Temperature (oC)		Composite Correction	Hydrometer Corrected	Diameter (mm)	% Passing
0.5	40.0	23.0		-3.33	36.7	0.0674	54.7
1	36.0	23.0		-3.33	32.7	0.0492	48.7
2	28.5	23.0		-3.33	25.2	0.0369	37.6
4	25.0	23.0		-3.33	21.7	0.0267	32.3
8	21.5	23.0		-3.33	18.2	0.0193	27.1
15	19.0	23.0		-3.33	15.7	0.0143	23.4
30	16.0	23.0		-3.33	12.7	0.0103	18.9
60	14.0	22.0		-3.48	10.5	0.0074	15.7
120	12.5	22.0		-3.48	9.0	0.0053	13.5
240	11.0	23.0		-3.33	7.7	0.0038	11.4
360	10.0	23.5		-3.25	6.8	0.0031	10.1
1440	9.5	23.0		-3.25	6.3	0.0015	9.3

Reported by: _____ Reviewed by: _____

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other zones/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

2640 Douglas St. Victoria, BC, V8T 4M1, Tel: 250-881-7372, Fax: 250-881-7470

APPENDIX I

Compilation of Geotechnical Index Test Results (2009 Investigations)

Summary of Geotechnical Index Test Results

Borehole ID	Sample Number	Sample Depth (m)			Measured Bulk Density (kg/m^3)	Total Organic Carbon (%)	Water Content (%)	Atterberg Limits				Grain Size Distribution (in %)			
		From	To	Avg				Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Liquidity Index	Gravel (>4.75 mm)	Sand (4.75 - 0.075 mm)	Fines (<0.075 mm)	Clay-Size Fraction (<0.002 mm)
GBH09-01	G1	4.11	4.27	4.19			107.8	53	134	80	0.7				
GBH09-01	G2	4.42	4.57	4.50			23.2								
GBH09-01	G3	4.72	4.88	4.80			38.6	19	43	24	0.8				
GBH09-01	G4	5.49	5.64	5.56			30.4								
GBH09-01	G6	6.63	6.78	6.71			44.3	30	47	17	0.8				
GBH09-01	G8	8.00	8.15	8.08			23.2								
GBH09-01	G10	8.84	8.99	8.92			27.5	17	38	21	0.5				
GBH09-01	G11	9.60	9.75	9.68			29.3								
GBH09-01	G13	10.82	10.97	10.90			21.3								
GBH09-01	G15	12.04	12.19	12.12			26.9	15	29	14	0.9				
GBH09-01	G17	13.87	14.02	13.94			34.7								
GBH09-01	G18	15.09	15.24	15.16			30.6								
GBH09-01	G20	16.31	16.46	16.38			34.9	18	38	20	0.8				
GBH09-01	G21	17.68	17.83	17.75			32.7								
GBH09-01	G24	19.51	19.66	19.58			31.9								
GBH09-01	G28	24.54	24.69	24.61			34.6								
GBH09-01	G30	27.43	27.58	27.51			33.3								
GBH09-01	G33	30.33	30.48	30.40			27.6								
GBH09-01	G36	33.07	33.22	33.15			32.6								
GBH09-01	G39	35.97	36.12	36.04			29.3								
GBH09-01	G40	36.73	36.88	36.80			9.0					28	52	20	
GBH09-01	G42	37.34	37.49	37.41			27.5					16	45	40	
GBH09-01	G45	38.71	38.86	38.79			4.4					50	25	26	
GBH09-01	G47	41.30	41.45	41.38			7.0					24	36	41	
GBH09-01	G49	44.65	44.81	44.73			7.2					32	42	27	5
GBH09-01	G52	46.94	47.09	47.02			8.8					30	31	39	16
GBH09-02	G3	8.38	8.53	8.46			28.1	17	37	20	0.6				
GBH09-02	G4	8.99	9.14	9.07			27.8								
GBH09-02	G5	9.75	9.91	9.83			32.9	26	42	16	0.4				
GBH09-02	G6	10.97	11.13	11.05			32.0								
GBH09-02	G8	12.80	12.95	12.88			34.9								
GBH09-02	G10	15.09	15.24	15.16			36.0								
GBH09-02	G11	17.53	17.68	17.60			36.7								
GBH09-02	G14	22.10	22.25	22.17			34.2								
GBH09-02	G16	24.69	24.84	24.77			31.9								
GBH09-02	G17	27.13	27.28	27.20			33.4								
GBH09-03	G1	4.57	4.72	4.65			27.3	16	36	20	0.6				
GBH09-03	G2	7.32	7.47	7.39			17.5	17	35	18					
GBH09-04	G1	2.29	2.44	2.36			24.6	15	31	16	0.6				
GBH09-04	G2	3.20	3.35	3.28			31.0	18	36	18	0.8				
GBH09-04	G3	4.42	4.57	4.50			34.1								
GBH09-04	G5	5.49	5.79	5.64			32.6								
GBH09-04	G6	7.16	7.32	7.24			28.6	17	35	18	0.6				
GBH09-04	G8	9.45	9.60	9.53			32.6								
GBH09-04	G10	11.28	11.43	11.35			29.9								
GBH09-04	G12	13.72	13.87	13.79			32.7								
GBH09-04	G14	16.31	16.46	16.38			33.3								
GBH09-04	G16	18.29	18.44	18.36			33.3								
GBH09-04	G17	19.51	19.66	19.58			19.4								
GBH09-04	G18	20.12	20.27	20.19			11.9					62	13	25	10
GBH09-04	G20	21.03	21.18	21.11			31.7								
GBH09-04	G21	22.25	22.40	22.33			28.8								
GBH09-04	G23	23.77	23.93	23.85			1.2					2	45	53	19
GBH09-04	G26	26.21	26.37	26.29			10.1					5	40	55	20
GBH09-10	G1	4.72	4.88	4.80			21.0	16	19	3	1.7	3	48	49	10
GBH09-10	G2	5.33	5.49	5.41			19.1								
GBH09-10	G3	6.55	6.71	6.63			33.4	17	37	20	0.8				
GBH09-10	G5	8.99	9.14	9.07			38.2								
GBH09-13	G2	2.90	3.05	2.97			30.1	26	42	16					
GBH09-14	G2	2.13	2.29	2.21			44.1	30	51	21	0.7				
GBH09-14	G4	3.81	3.96	3.89			33.7	16	30	15	1.2				
GBH09-14	G5	5.33	5.49	5.41			26.5	16	31	15	0.7				
GBH09-14	G6	7.32	7.47	7.39			29.4								
GBH09-15	G1	2.44	2.59	2.51								22	40	39	10
GBH09-16	G1	0.91	1.07	0.99								74	18	8	
GBH09-16	G2	1.98	2.13	2.06								56	17	27	
GBH09-18	G1	0.76	0.91	0.84								13	32	55	17
GBH09-18	G3	3.05	3.20	3.12								77	15	8	
GBH09-19	G1	1.68	1.83	1.75								39	40	21	
GBH09-19	G2	3.05	3.20	3.12			18.1	15	31	16	0.2				
GBH09-19	G3	5.03	5.18	5.11			27.2								
GBH09-19	G4	6.25	6.40	6.32			27.4								
GBH09-20	G1	2.13	2.29	2.21			24.3					7	20	73	10
GBH09-20	G2	3.66	3.81	3.73			27.4	17	38	21	0.5				
GBH09-20	G3	4.88	5.03	4.95			22.3								
GBH09-20	G5	6.25	6.37	6.31			30.4								
GBH09-20	G7	8.75	8.87	8.81			37.2	19	42	23	0.8				

Summary of Geotechnical Index Test Results

Borehole ID	Sample Number	Sample Depth (m)			Measured Bulk Density (kg/m^3)	Total Organic Carbon (%)	Water Content (%)	Atterberg Limits				Grain Size Distribution (in %)			
		From	To	Avg				Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Liquidity Index	Gravel (>4.75 mm)	Sand (4.75 - 0.075 mm)	Fines (<0.075 mm)	Clay-Size Fraction (<0.002 mm)
GBH09-20	G9	11.03	11.13	11.08			30.0								
GBH09-20	G11	13.72	13.87	13.79			37.6								
GBH09-20	G13	16.76	16.92	16.84			36.9								
GBH09-20	G15	20.12	20.27	20.19			37.1								
GBH09-20	G17	25.30	25.45	25.37			29.3								
GBH09-21	G1	2.29	2.44	2.36			31.7	18	36	18	0.8				
GBH09-21	G2	3.66	3.81	3.73			31.5								
GBH09-21	G3	5.18	5.33	5.26			32.4								
GBH09-21	G4	6.71	6.86	6.78			23.5	16	31	15	0.5				
GBH09-21	G5	7.92	8.08	8.00			33.8								
GBH09-21	G7	10.06	10.21	10.13			28.1								
GBH09-21	G9	11.73	11.89	11.81			36.0								
GBH09-21	G11	12.95	13.11	13.03			5.6								
GBH09-22	G1	1.83	2.44	2.13			26.3	17	32	15	0.6				
GBH09-22	G2	2.59	3.20	2.90			29.9								
GBH09-22	G3	3.20	3.81	3.51			18.9	17	34	17					
GBH09-22	G4	4.27	4.88	4.57	2049		29.3	23	34	11	0.6	6	12	82	35
GBH09-22	G5	4.88	5.49	5.18			32.4								
GBH09-22	G7	6.40	7.01	6.71			31.1	20	47	27	0.4				
GBH09-22	G10	8.84	9.45	9.15	1959		34.2								
GBH09-22	G13	12.19	12.80	12.50			33.0								
GBH09-23	G2	1.22	1.83	1.52			65.2								
GBH09-23	G2	1.22	1.83	1.52			54.2	25	48	22	1.3				
GBH09-23	G3	2.13	2.74	2.44	1590		53.2								
GBH09-23	G4	3.05	3.66	3.35	2028		24.1					5	21	74	4
GBH09-23	G5	3.96	4.27	4.11			35.6	20	39	19	0.8				
GBH09-23	G8	5.94	6.55	6.25	2143		20.3								
GBH09-24	G1A	1.12	1.42	1.27			20.7	15	32	17					
GBH09-24	G3	2.97	3.58	3.28			32.2	24	46	22	0.4				
SC09-03		1.36	1.81	1.59			58.7	29	49	19	1.5	1	13	87	14
SC09-03	0775-08	1.81	2.04	1.93		1.3									
SC09-07	0771-10	0.35	0.58	0.47		1.5									
SC09-07		0.58	0.87	0.72			52.9	27	45	18	1.4	1	23	77	11
SC09-08		0.44	0.88	0.66			89.7	30	53	23	2.6	0	11	89	13
SC09-08	0775-02	1.00	1.22	1.11		1.2									
SC09-12		1.48	1.97	1.72			57.6	27	48	21	1.5	0	10	90	14
SC09-12	0778-08	1.97	2.21	2.09		1.0									
SC09-15	0774-03	1.17	1.40	1.29		1.3									
SC09-15		1.52	1.88	1.70			56.9	27	47	20	1.5	0	4	96	14
SC09-17	0770-07	0.22	0.45	0.34		1.0									
SC09-17		0.51	1.12	0.82			96.3	39	84	45	1.3	7	18	75	11
SC09-18		0.59	1.07	0.83			58.9	31	50	19	1.5	0	3	97	13
SC09-18	0769-05	1.07	1.30	1.19		0.9									
SC09-20	0778-01	0.24	0.48	0.36		0.8									
SC09-20		0.48	0.84	0.66			64.2	28	57	29	1.3	0	5	95	12
SC09-23		0.00	0.44	0.22			82.0	32	60	28	1.8	15	8	78	11
SC09-23	0776-06	0.22	0.44	0.33		1.6									
SC09-33	0776-03	0.48	0.69	0.59		<0.1									
SC09-33		0.70	0.95	0.83			16.3					23	57	21	5
SC09-36	0768-07	0.94	1.15	1.05		0.6									
SC09-36		1.15	1.68	1.42			45.4	28	46	17	1.0	0	7	93	13
SC09-41		0.42	0.98	0.70			50.5	27	46	20	1.2	3	14	83	11
SC09-41	0770-12	0.98	1.26	1.12		1.3									
SC09-44		0.06	0.44	0.25			133.5	45	87	42	2.1	0	6	94	13
SC09-44	0769-08	0.22	0.44	0.33		2.7									
SC09-50		0.88	1.25	1.07			116.0	39	83	44	1.8	3	17	80	8
SC09-50	0771-03	1.25	1.50	1.38		2.0									
SC09-101	21553-11	0.52	0.79	0.66		0.9									
SC09-101		0.93	1.13	1.03	1685		58.0								
SC09-101		1.13	1.31	1.22			63.4	29	49	20	1.7				
SC09-102A	21555-10	0.34	0.77	0.56		4.0									
SC09-102B		0.73	0.94	0.83	1658		64.0								
SC09-102B		0.94	1.22	1.08			59.7	34	63	29	0.9	14	46	40	5
SC09-104B	21555-02	0.42	0.78	0.60		1.1									
SC09-104A		0.77	0.92	0.85	1644		61.0								
SC09-105		1.99	2.18	2.09			46.6	30	45	15	1.1	3	9	88	9
SC09-105		2.29	2.49	2.39	1818		44.0								
SC09-105	21559-03	2.49	2.80	2.65		1.2									
SC09-109		1.48	1.72	1.60			65.5	27	44	17	2.3	1	3	96	12
SC09-109	21554-06	2.21	2.58	2.40		0.7									
SC09-111C	21548-08	0.59	0.88	0.74		1.2									
SC09-111B		0.76	0.99	0.88	1619		74.0								
SC09-111B		0.99	1.44	1.21			65.5	24	48	24	1.7	10	8	82	10
SC09-118B	21562-01	0.22	0.54	0.38		3.4									
SC09-118A		0.82	1.01	0.91	2046		31.5								
SC09-121		1.39	1.64	1.52								34	54	12	3

Summary of Geotechnical Index Test Results

Borehole ID	Sample Number	Sample Depth (m)			Measured Bulk Density (kg/m^3)	Total Organic Carbon (%)	Water Content (%)	Atterberg Limits				Grain Size Distribution (in %)			
		From	To	Avg				Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Liquidity Index	Gravel (>4.75 mm)	Sand (4.75 - 0.075 mm)	Fines (<0.075 mm)	Clay-Size Fraction (<0.002 mm)
SC09-121		1.71	1.90	1.80	2446		12.1								
SC09-121	21556-07	1.77	2.33	2.05		0.2									
SC09-125		0.81	0.98	0.89			58.3	30	50	20	1.4	3	3	94	12
SC09-125		1.11	1.27	1.19	1708		62.0								
SC09-125	21559-05	1.49	1.81	1.65		0.9									
SC09-128		0.45	0.61	0.53	1476		120.0								
SC09-128		0.61	0.87	0.74			105.0	35	58	23	3.0	1	9	90	10
SC09-128	21551-10	1.09	1.31	1.20		1.5									
SC09-130	21549-04	2.15	2.40	2.28		0.3									
SC09-130		2.51	2.66	2.59	1893		36.6								
SC09-130		2.66	2.81	2.74			32.4	16	35	19	0.9	1	14	86	43
SC09-132		1.77	1.92	1.84			44.9	14	42	28	1.1	0	5	95	49
SC09-132		2.03	2.20	2.12	1870		44.0								
SC09-132	21552-11	2.34	2.60	2.47		0.4									
SC09-134		0.62	0.79	0.70	1671		50.5								
SC09-134		0.79	1.01	0.90								21	59	20	4
SC09-134	21554-02	1.41	1.69	1.55		0.1									
SC09-135A		0.76	1.14	0.95			51.6	24	39	15	1.9				
SC09-135A		1.33	1.51	1.42	2001		28.0					5	55	40	6
SC09-135B	21556-03	1.47	1.74	1.61		0.5									
SC09-138	21560-09	0.60	0.86	0.73		1.2									
SC09-138		0.86	1.05	0.96			64.4	24	59	35	1.2	0	3	97	10
SC09-138		1.19	1.39	1.29	1694		60.0								
SC09-139	Sa1	0.18	0.28	0.23			152.0	38	80	43	2.7	0	5	95	9
SC09-139	Sa1	0.39	0.55	0.47	1586		60.0								
SC09-139	21562-10	0.91	1.21	1.06		0.8									
SC09-139	Sa2	1.47	1.57	1.52			64.3	30	53	23	1.5	9	3	89	14
SC09-139	Sa2	1.69	1.84	1.76	1626		76.0								
SC09-139	21562-12	3.13	3.44	3.29		0.7									
SC09-139	Sa3	3.39	3.53	3.46			43.3	24	36	12	1.6	21	17	62	10
SC09-139	Sa3	3.56	3.71	3.64	2016		31.6								

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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Asia	+ 852 2562 3658
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Golder Associates

D8

ESQUIMALT GRAVING DOCK

SUPPLEMENTARY SITE ASSESSMENT TIMBER CRIB

GOLDER (2011)

Number of Pages: 48

September 7, 2011

Project No. 11-1436-0061/5100
E/11/331

Andrew Mylly
Public Works and Government Services Canada
641-800 Burrard Street
Vancouver, BC
V6Z 2V8

ESQUIMALT GRAVING DOCK WATERLOT REMEDIATION PROJECT: BOREHOLE INVESTIGATION, TIMBER PORTION OF SOUTH JETTY, FISCAL YEAR 2011-2012

Dear Mr. Mylly,

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Public Works and Government Services Canada (PWGSC) to conduct supplementary site assessment in support of the Esquimalt Graving Dock (EGD) Waterlot Remediation Project. Golder has been working with PWGSC, Anchor QEA L.L.C. (Anchor) and Klohn Crippen Berger Ltd. (KCB) (the project team), to support the development of the remediation design for dredging of contaminated sediments at the EGD Waterlot.

1.1 Background

During Fiscal Year (FY) 2010-2011, the project team (PWGSC, Anchor, KCB and Golder) developed the 60% level remediation design (for the open water dredging of contaminated sediments and the preliminary 95% design for the sheet pile wall construction (under-pier erosion protection) that will be installed around the South Jetty as part of the first phase of remediation construction activities. The purpose of the sheet pile wall is to minimize erosion and re-suspension of contaminated sediments beneath the jetty until this area is remediated at some time in the future, concurrent with proposed demolition and reconstruction of the timber pile supported structure (South Jetty Wharf Redevelopment Project). The sheet pile will be removed following remediation of the under-jetty sediments as part of the redevelopment.

As part of the design process for the under-pier erosion protection (sheet pile wall), Golder undertook modelling during last fiscal year to assess the embedment depth installation requirements for the sheet pile wall. The results of the assessments concluded that on the north side of the South Jetty, in the area adjacent to the timber crib, the required sheet pile embedment depths may be limited by the presence of shallow till and/or bedrock. Stratigraphy beneath the proposed location of the sheet pile wall, was inferred based on available test

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hole data in the immediate vicinity, however Golder recommended drilling an additional borehole as close as possible to the north edge of the jetty, west of the timber crib, to provide site specific information on the depth to till and/or bedrock at this location.

1.2 Objectives and Scope of Work

Golder was requested by PWGSC to submit a proposal for the drilling of one borehole to assess the depth to till and/or bedrock adjacent to the timber crib on the north side of the South Jetty. Task 510 of Golder's final workplan "Site Assessment and Remediation Planning Interim Tasks FY2011-2012" submitted on July 20, 2011, details the scope of work for the drilling, which is summarized below:

- Health and Safety Planning and Field Work Preparation;
  - Health and Safety Plan Preparation, including PWGSC Job Hazard Analysis;
  - Notice of Project to WorkSafe BC as per PWGSC requirements for field investigation work;
  - Co-ordination with Sub-Contractors;
  - Co-ordination with EGD staff regarding field work schedule, arrangements for EGD Site Safety Orientation, site access and field personnel; and,
  - Co-ordination with Fisheries and Oceans Canada regarding the proposed work.
- Identify a suitable location for the borehole based on reference to utility plans for the area, inspection from under-jetty catwalks and co-ordination with EGD staff;
- Cut an access hole in the asphalt-covered timber deck of the South Jetty in advance of the drilling and reinstating the South Jetty deck following drilling; and,
- Advance one borehole through the access hole using a Sonic drill rig to assess the sub-surface stratigraphy and presence of shallow till and/or bedrock. Undertake Standard Penetration Testing and collect sediment samples for chemical and geotechnical laboratory testing (if necessary based on material encountered and field observations);
- Scheduling and co-ordination of laboratory analyses;
- Disposal of soil cuttings and water collected during the drilling; and,
- Preparation of a factual letter report following the work.

2.0 FIELD METHODS

The following sections outline the field related work that was undertaken as part of this task.

Health and Safety

Golder prepared and implemented a Health and Safety Plan (HASP) for Golder employees and subcontractor field personnel working on the project. The HASP addressed potential health and safety issues that were identified for the field work program, with a specific focus on drilling and sediment sampling activities, including handling of contaminated materials. The HASP outlined mitigation measures to be adopted during the course of the works to manage and minimise the identified risks. A PWGSC Job Hazard Analysis (JHA) checklist addressing specific job-related hazards was also reviewed in conjunction with the HASP prior to conducting the field work activities.

This phase of the project involved cutting an access hole through the deck of the South Jetty prior to sonic drilling, which was undertaken by Mud Bay Drilling Co. Ltd. (Mud Bay) under the full time monitoring of Golder. Ruskin Construction Ltd. (Ruskin) previously cut access holes in the South Jetty deck and was again retained to cut and reinstate the access hole in the deck of the jetty structure. Golder maintained full time monitoring during the cutting of the access hole.

Golder also contacted Fisheries and Oceans Canada (F&OC) to advise them of the proposed work and to present project-specific environmental protection measures to be implemented during the field work. F&OC expressed satisfaction that appropriate and sufficient measures were being taken to minimise the potential impacts of the investigation on the environment. Golder included correspondence with F&OC and a copy of the prepared Environmental Management Procedures in the HASP. A copy of the email correspondence with F&OC is provided as Attachment A.

The HASP was submitted to PWGSC and EGD for comment prior to commencement of the work. The Golder field supervisor conducted daily health and safety meetings on site. Field personnel involved with the works were required to review and sign the HASP to confirm their understanding of the potential health and safety hazards, safe work procedures and environmental protection measures.

Daily progress emails were sent at the completion of field work to the project team summarising personnel on site, health and safety information, site conditions and work completed. Copies of the correspondence are included as Attachment B.

2.1 Cutting of Access Hole in South Jetty Deck

On August 4, 2011, Golder personnel were on site to mark the proposed borehole location; the borehole location was selected based on discussions with the project team (specifically Geoff Cooper of KCB) and was proposed to be located approximately 1.8 m south of the north side of the jetty and approximately 1.8 m west of the edge of the timber crib structure. This location was identified by Geoff Cooper at KCB based on visual assessment of the jetty area for structural features and/or utilities that could impede access for the drilling. The proposed location was subsequently assessed by Golder by accessing the under-jetty area from the catwalks. On August 5, 2011, Golder supervised Ruskin during work to cut an access hole in the asphalt covered, timber deck portion of the South Jetty.

Ruskin initially drilled a 6.4 mm (¼") pilot hole in the asphalt and timber surface and then hung a cord through the pilot hole. Ruskin and Golder then accessed the under-jetty catwalk closest to the proposed borehole location, to observe the position of the hole relative to under-jetty utility lines. Golder observed that the proposed location would intersect an under-jetty fire drain utility pipe. The location was therefore moved approximately one metre to the east (nearer to the edge of the timber crib structure) to avoid the utility pipe (see Attachment C, Figure 1 for the actual borehole location).

Ruskin removed a layer of asphalt approximately 8 cm thick and then cut out the 10 cm by 10 cm timbers bridging the supporting timber stringers. The resulting hole in the South Jetty deck was approximately 46 cm by 41 cm, centered on two supporting timber stringers; approximately 8 cm of the stringers was left exposed on either side of the hole to facilitate the reinstatement of the hole. The hole was covered by a steel plate which was fixed in place prior to the drilling and replaced following the drilling.

On August 16, 2011, Ruskin returned to the site to reinstate the hole in the South Jetty. Timbers were set in place between the stringers and asphalt was placed to cover the timbers and match the grade of the adjacent deck surface. The photograph below shows the reinstated surface of the South Jetty.

Photograph 1: Reinstated surface of the South Jetty at borehole BH11-01

2.2 Sonic Drilling

On August 9, 2011, Mud Bay advanced one borehole (BH11-01) through the access hole that had been previously cut in the South Jetty deck, using a small track-mounted sonic rig (DB320 sonic rig). The DB320 drill rig was used to comply with weight restrictions on the South Jetty. The primary purpose of the borehole was to assess the presence of shallow till and/or bedrock; however, sediment samples were also collected for chemical laboratory analysis to provide additional information of sediment contaminant concentrations and for disposal of soil cuttings generated during the drilling.

Borehole advancement was achieved through the process of fracturing, shearing, and displacement depending on the type and consistency of the material encountered. The soil entered the core barrel which resulted in the recovery of 102 mm (4 inch) diameter continuous sample of core. Upon completion of each drill run, a 15 cm (six-inch) diameter steel casing was advanced to the depth of end of the run, the core barrel and drill rods were removed from the hole, and the continuous sonic core sample was extracted out of the core barrel directly into a 15 cm diameter polyethylene liner and placed horizontally for processing. The liners were immediately opened by cutting along the liner vertically with a decontaminated retractable blade, allowing access to the soil/sediment core for logging and sampling.

An initial recovered length from the top of the borehole core to the bottom of the core for each run was recorded in addition to observations regarding the extruded core thickness and consistency. Golder applied a correction factor, calculated by dividing the recovered core length by the run length, to estimate *in situ* sample depths relative to mudline.

A description of the sediment in each stratigraphic layer with respect to colour, density, material type, odour, presence of non-sediment materials (*e.g.,* shell and wood debris) and potential for presence of contamination (*e.g.,* hydrocarbon-like sheen or odour, debris) was recorded on the borehole log (Attachment D).

Samples were collected from the polyethylene liner, into which the soil cores were extruded after each run, at discrete depth intervals, typically every one metre, as well as at changes in observed stratigraphy and/or when debris or odours indicating potential contamination were observed. The outer portion of soil cuttings in contact with the polyethylene liner was removed and samples were recovered from the inner portion of the core so that samples were representative of sediment conditions. Sediment was collected in polyethylene bags for potential geotechnical analysis and in soil jars for chemical analysis. A description of sampling methods employed for chemical analysis will be provided under separate cover.

Standard Penetration Test (SPT) sampling was carried out at selected depths intervals within the borehole to obtain disturbed soil samples and record N-values[1] using a 51 mm diameter split- spoon sampler for assessing the relative density of granular soils or the consistency of stiff to hard fine-grained soils. The SPTs were carried out using an automatic trip hammer that maximizes the driving efficiency of the hammer.

Mud Bay backfilled the borehole to within approximately 1 m of the seabed using an environmentally-friendly mixed grout. The upper 1 m of the borehole was left open and allowed to slough in. Following backfill of the borehole, Mud Bay retracted the steel casing, replaced the steel plate over the hole in the South Jetty and fixed it in place until Ruskin could return to reinstate the South Jetty deck surface.

Soil cuttings and water generated during drilling (including sea water and water used for decontamination) were contained in drums and stored on site until disposal could be arranged.

2.3 Survey of Borehole Location

Survey of the location of borehole BH11-01 was conducted by Golder on September 1, 2011, using a Real Time Kinematic Global Positioning System (RTK GPS).

To determine the mudline elevation at borehole BH11-01, Mud Bay measured the depth from the asphalt surface of the South Jetty to the seabed using a weighted tape measure; the depth was approximately 11.89 m. The surveyed South Jetty deck elevation at borehole BH11-01 was 4.63 m Chart Datum (2.76 m geodetic); therefore, the calculated mudline elevation was approximately -7.26 m Chart Datum (-9.13 m geodetic)[2].

Figure 1 (Attachment C) shows the location of borehole BH11-01 in addition to previous test hole locations.

[1] SPT 'N' = the number of blows of a 63.5 kg (140 lb) hammer dropped from a height of 0.76 m (30") to drive an open split spoon sampler a distance of 0.3 m.

[2] Focus Corporation provided conversion factors between Geodetic and Chart Datum to Klohn Crippen Berger in an email dated November 13, 2009. Klohn Crippen Berger provided the conversion factors to Golder in an email dated July 12, 2010. Conversion: Geodetic = Chart Datum – 1.871 m

3.0 STRATIGRAPHY ENCOUNTERED AND DRILLING CONDITIONS OF NOTE

On August 9, 2011, borehole BH11-01 was advanced to a depth of 10.67 m below mudline (m bml); the terminal elevation was approximately -17.93 m Chart Datum (-19.80 m geodetic).

Table 1, below presents a summary of the observed stratigraphy at borehole BH11-01.

Table 1: Stratigraphy and Approximate Depth Encountered at Borehole BH11-01

Stratigraphy	Approximate Depth Encountered (*in situ*, m bml)	Approximate Elevation (m Chart Datum)
Unconsolidated Sediments Loose silt and shell fragments, wood fragments, hydrocarbon-like odour and sheen	0.0 – 0.99	-7.26 – -8.25
Suspect Fill Materials Compact silty sand and gravel, wood fragments, hydrocarbon-like odour	0.99 – 2.74	-8.25 – -10.00
Wood A continuous segment of wood was recovered having fibres present parallel to the borehole and a diameter equal to the sonic drill casing	2.74 – 5.23	-10.00 – -12.49
Victoria Clay Stiff to firm, grey to grey brown silty clay with minor quantities of sand and gravel, hydrogen sulphide-like odour associated with black (organic) seams of silt	5.23 – 7.42	-12.49 – -14.68
Till-like Dense, grey silty sand and gravel	7.42 – 7.62	-14.68 – -14.88
Inferred Bedrock Strong, fresh to slightly weathered, fine-grained, dark green to blank chloritized AMPHIBOLITE, quartz and calcite veining	7.62 – >10.67 (terminal depth)	-14.88 – -17.93

The observed stratigraphy is consistent with that observed during previous subsurface drilling investigations beneath the timber-deck portion of the South Jetty. The stratigraphic units have previously been described in further detail in Golder's report "*Esquimalt Graving Dock Waterlot – Supplementary Test Hole Investigation for Remedial Action Plan/Risk Management Plan*", dated March 3, 2010.

Sediment core recovery ranged from moderate to full recovery over the length of the borehole. The lowest recovery was in the upper sediments, where 1.93 m of a possible 2.74 m was recovered; however, Mud Bay personnel commented that there was approximately 0.3 m of material left in the casing, and it was suspected that approximately the upper 0.3 m of material was lost due to very wet (saturated) conditions. Therefore, it was inferred that the upper 0.3 m and lower 0.3 m of the core run were lost, with a resulting recovery of 90.5% (1.93 m of 2.13 m).

In the core run from 4.57 – 6.10 m bml a total of approximately 2.13 m of core was recovered (apparent 140% recovery), including a segment of the suspected timber piling and inferred Victoria Clay. The greater than 100% recovery reduces the certainty in the estimated *in situ* depth of the contact between the wood and inferred Victoria Clay.

100% recovery was achieved for the remainder of the borehole. The borehole log for borehole BH11-01 is included as Attachment D and provides additional stratigraphic details.

Golder had proposed that SPTs be conducted at approximately 3 m intervals in sediments overlying till-like materials and at 1.5 m intervals in till-like materials; however, SPTs were not conducted above approximately 6.5 m bgs due to the loose nature of subsurface material encountered in the upper 3 m bgs and due to the presence of wood debris discussed above. SPT results are shown on the borehole log (Attachment D).

4.0 RESULTS

Selected samples were submitted for laboratory analyses of one or more of the following parameters: light and heavy extractable petroleum hydrocarbons (LEPH and HEPH, respectively), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), metals, tributyl tin (TBT), organochlorine pesticides (OCP), dioxins and furans and leachable PAHs using the Toxicity Characteristic Leaching Procedure (TCLP). Table 2, below, presents the samples that were selected for chemical analyses.

Table 2: Scheduled Laboratory Analyses – BH11-01

Sample	Depth (m bgs)	LEPH/HEPH/ PAH	PCB	Metals	TBT	OCP	Dioxins and Furans	TCLP (PAH)
1	0.46 - 0.76	X	X	X	X	X	X	X
2 (duplicate)	0.46 - 0.76	X		X	X			
3	1.07 - 1.14			X				
4	1.14 - 1.3	X	X		X	X	X	X
5	1.83 - 2.03	X		X	X			
6	5.23 - 5.49	X	X	X	X	X	X	X

The laboratory certificate of analyses for the samples identified above is appended as Attachment E; results of laboratory analyses will be discussed under separate cover as part of reporting for additional environmental sampling that will be undertaken at the South Jetty.

5.0 CLOSURE

We trust this draft letter meets with your requirements. Please contact the undersigned if you have any questions.

GOLDER ASSOCIATES LTD.

Michelle Sevenhuysen, B.A.Sc.
Environmental Engineer (EIT)

Rachael Jones, B.Sc. (Hons)
Project Manager

Reviewed by:

Tim Whalen, M.A.Sc., P.Eng.
Project Director, Principal

MS/RJ/smh

CC: Daryl Lawes (PWGSC)
Dan Berlin (Anchor QEA L.L.C.)
Geoff Cooper (Klohn Crippen Berger)

Attachments: Attachment A: Email to F&OC Regarding Proposed Sonic Drilling
Attachment B: Daily Progress Summary Correspondence
Attachment C: Figure 1: Borehole Location Plan
Attachment D: Borehole Log
Attachment E: Laboratory Certificate of Analyses

n:\final\2011\1436\11-1436-0061 egd remediation planning\pwgsc-egd-wl-dft-ltr-south jetty drilling-11-12-golder-20110907.docx

ATTACHMENT A

From: Rouget, Philippe
To: Northrup, Scott
Cc: Jones, Rachael (Burnaby); Sevenhuysen, Michelle; Wernick, Barbara; Chant, Virginia; Mortimor, James; Munday, David
Subject: RE: Proposed sonic drilling at EGD South Jetty - Aug 09-10, 2011
Date: Friday, July 29, 2011 11:57:43 PM
Attachments: image002.png
image003.png
image004.jpg

Scott,

Further to your phone conversation with James Mortimor this afternoon, PWGSC is proposing to drill a single borehole underneath the South Jetty at Esquimalt Graving Dock (EGD) on **August 09 and 10th, 2011**.

The objective of the program is to assess sub-surface conditions underneath the South Jetty in Esquimalt Harbour and to acquire information on the presence of shallow till and/or bedrock in this specific area. The scheduling of this program is sensitive, as the planned exploratory program is needed to delineate aspects of the larger remediation Project for the EGD water lot. The Project site is located in an area of historical industrial use. Sonic drilling with Standard Penetration Tests (SPTs) will take place at a single location underneath the South Jetty, up to 10 m below the seabed {Figure 1 – see Green X only ( )}. If bedrock is not encountered within the upper 10 m of drilling, advancement may continue until bedrock is attained. No temporary or permanent impacts to fish or fish habitat are anticipated. Project-specific environmental protection measures have been prepared for this fieldwork, and are summarized as follows:

- Works will be conducted within the fisheries timing window. For the Victoria area (Area 19), the summer work windows occur between July 1 and October 1 (DFO 2010).
- All works associated with Project construction shall comply with the requirements of the *Fisheries Act*, the *Species at Risk Act*, and all other applicable laws, legislation, and best management practices.
- Contractor shall inspect machinery to confirm it is in good working order and to ensure that fuels and lubricants do not enter the marine environment. A spill kit shall be kept on-site for use in the event of a spill.
- Wash, refuel and service machinery and store fuel and other materials for the machinery, which include hand tools, away from the water to prevent any deleterious substances from entering the water.
- Prior to commencing work activities, visual observations will be made for marine mammals. If a marine mammal is noted within 300 m of Project works, activities shall cease until the marine mammal leaves the area. Operations will resume once marine mammals have cleared the area.
- Noise associated with construction activities will be minimized whenever possible.

We trust that the above mitigation measures are sufficient for the planned exploratory program to proceed on **August 9-10, 2011** in order delineate the larger remediation program within the EGD water lot, as per your confirmation with James Mortimor today.

Regards,

Phil Rouget

Philippe Rouget (M.Sc.) | Marine Biologist | Golder Associates Ltd.
2640 Douglas Street, Victoria, British Columbia, Canada V8T 4M1
T: [+1] (250) 881 7372 | D: [+1] (250) 978 5808 | F: [+1] (250) 881 7470 | C: [+1] 250 888 1100 | E: Philippe_Rouget@golder.com | www.golder.com

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Please consider the environment before printing this email.

ATTACHMENT B

From: Sevenhuysen, Michelle
To: "Kristen Ritchot"; "Daryl Lawes"; "Andrew Mylly"; "Rae-Ann Sharp"
Cc: Whalen, Tim; Jones, Rachael (Burnaby); "Dan Berlin"; "gcooper@klohn.com"
Subject: EGD South Jetty Borehole Investigation Progress Report - August 5, 2011
Date: Friday, August 05, 2011 3:05:00 PM

Hello,

The following is a progress report for work conducted today at the EGD South Jetty.

Please let me know if you have any questions.

Thank you,

Michelle

Date: 5-Aug-2011
Project: EGD Waterlot Site Assessment and Remediation Planning – South Jetty Borehole Investigation

Personnel and Equipment On Site

Client Staff: Kristen Ritchot (site visit)

Consultant Staff: Golder Associates Ltd.
Michelle Sevenhuysen (Field Supervisor)

Contractor: Ruskin Construction Ltd.
Neil Oberg
Equipment: hand tools (e.g. Hilti drill, chainsaw)

Weather: sunny, ~20+C

Description of Field Activities:
Cutting through the deck of the South Jetty to create an access hole in advance of Sonic drilling to be conducted Tuesday, August 9th. Access hole located approximately 1.8 m south of the north timber wharf face and approximately 1 m west of the timber crib face and is approximately 18" x 16" in size. Hole covered with a steel plate which was fixed in place.

Health and Safety:
Golder tailgate H&S meeting, 8:00 AM: Review and sign off of HASP
In attendance: Golder, Ruskin

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From:	Sevenhuysen, Michelle
To:	"Kristen Ritchot"; "Daryl Lawes"; "Andrew Mylly"; "Rae-Ann Sharp"
Cc:	Whalen, Tim; Jones, Rachael (Burnaby); "Dan Berlin"; "gcooper@klohn.com"; Chu, Jennifer; Smith, Dwayne (Victoria)
Subject:	RE: EGD South Jetty Borehole Investigation Progress Report - August 5, 2011
Date:	Tuesday, August 09, 2011 6:18:00 PM

Hello,

The following is a progress report for work conducted today at the EGD South Jetty.

Please let me know if you have any questions.

Thank you,

Michelle

Date: 9-Aug-2011
Project: EGD Waterlot Site Assessment and Remediation Planning – South Jetty Borehole Investigation

Personnel and Equipment On Site (08:00 – 17:15)

Consultant Staff: Golder Associates Ltd.
Michelle Sevenhuysen (Field Supervisor)
Dwayne Smith (Geologist)

Contractor: Mud Bay Drilling
Ian Taylor
Johnny Barone
Ryan Fales
Equipment: Sonic drill rig (DB320) and support vehicles

Weather: sunny, ~20+C

Description of Field Activities:
Drilled borehole BH11-01 adjacent to the timber crib in the timber piled portion of the South Jetty, to confirm the depth to till and/or bedrock in this area. The borehole was advanced using sonic drilling to a depth of approximately 10.7 m (35 ft) below mudline. Standard Penetration Tests (SPTs) were conducted and samples were collected for environmental and geotechnical purposes. Sediment cuttings and water were contained in drums (two) and have been labelled and stored on site near the top of the tug float at the east end of the South Jetty until chemical data has been received and disposal can be arranged. The hole in the South Jetty was re-covered with a steel plate; reinstatement (by Ruskin Construction) will be coordinated to occur as soon as possible.

Health and Safety:
Dwayne Smtih (Golder) and Ryan Fales (Mud Bay) attended EGD site orientation; other personnel had taken the orientation within the previous year.
Golder tailgate H&S meeting, 9:00 AM: Review and sign off of HASP

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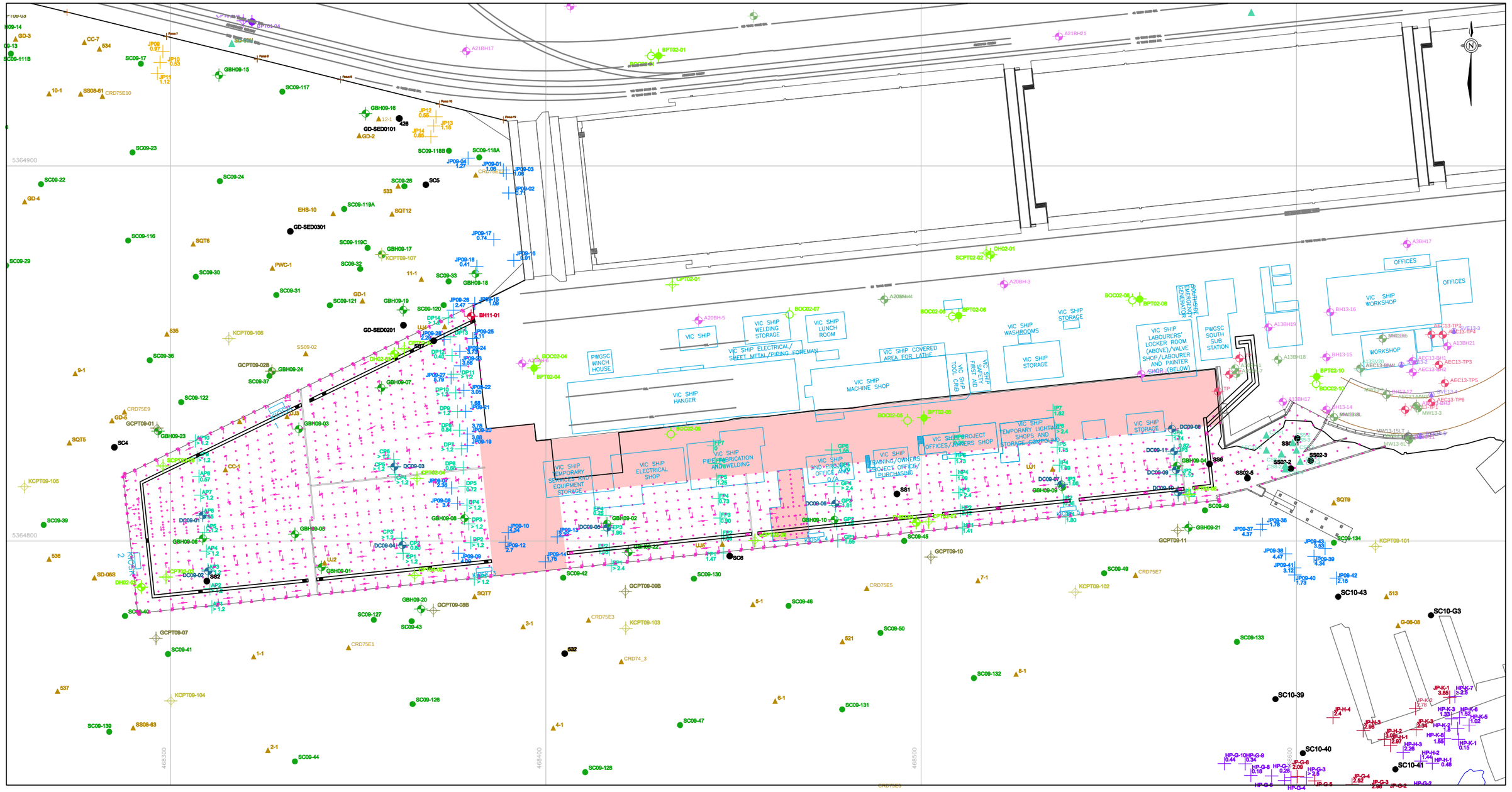
ATTACHMENT C



LEGEND

- Sampling Locations - Golder 2001
- Sampling Locations - Klohn Crippen 2002
- Borehole Locations - Golder 2009
- Borehole Locations - Golder 2010
- Borehole Locations - Golder 2011
- Sediment Core Locations - Golder 2009
- Sediment Core Locations - Golder 2010
- Diver Core Locations - Golder 2009
- Diver Sample Locations - Golder 2010
- Cone Penetration Test Locations - Klohn Crippen 2009
- Cone Penetration Test Locations - Golder 2009
- Jet Probe Locations - Golder 2009
- Jet Probe Locations - Golder 2010
- Jet Probe Locations - Golder 2011
- Hand Probe Locations - Golder 2009
- Hand Probe Locations - Golder 2011
- Probe Locations - Golder 2010
- Sediment Grab Sample Locations - Historical
- Sediment Core Sample Locations - Historical
- Test Pit Locations - SLR 2009
- Monitoring Well Locations - SLR 2009
- Borehole Locations - SLR 2009
- Approximate extent of steel piles under South Jetty
- Timber Piling under South Jetty

NOTES

1. Grid is displayed in UTM NAD 83 Zone 10.

20 0 20
SCALE METRES

DRAFT

PROJECT
PUBLIC WORKS GOVERNMENT SERVICES CANADA
ESQUIMALT GRAVING DOCK WATERLOT REMEDIATION PROJECT
ESQUIMALT, B.C.

TITLE
BOREHOLE LOCATION PLAN

Golder Associates Victoria, BC

PROJECT	11-1436-0061		FILE No.	P11143600615100-01	
DESIGN	MS	24 AUG 11	SCALE	AS SHOWN	REV. 0
CADD	JEF	2 SEP 11			
CHECK					
REVIEW					

FIGURE: 1

B:\Projects\2011\1436\11-1436-0061\CAD\Phase 5100\P11143600615100-01.dwg Sep 02, 2011 - 9:51am

ATTACHMENT D

PROJECT No.: 11-1436-0061

RECORD OF BOREHOLE: BH11-01

SHEET 1 OF 2

LOCATION: Esquimalt Graving Dock
N: 5364859.94 E: 468380.07 NAD83 Zone: 10

DRILLING DATE: August 9, 2011
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Chart Datum

SAMPLER HAMMER, 64kg; DROP, 762mm

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Ground Surface		-7.26							
0		Wet, black, SILT and SHELL FRAGMENTS, trace to some fine to medium subangular to angular gravel, contains wood fragments, slight hydrocarbon-like sheen, hydrocarbon-like odour.		0.00	1/2	CS					
				-8.25							
1		Moist, dark grey to grey, silty SAND and GRAVEL, gravel is rounded to subangular, contains shell fragments and wood fragments, hydrocarbon-like odour. [suspect FILL]		0.99	3	CS					
					4	CS					
2					5	CS					
				-10.00							
		Moist TIMBER, hydrocarbon-like odour		2.74							
3											
4											
5	DB320 Mini-Track Sonic Rig / Sonic			-12.49							
		Stiff, moist, grey brown, SILTY CLAY, trace to some medium subrounded gravel.		5.23	6	CS					
		- Black silt seams with hydrogen-sulphide-like odour from 5.23m to 6.10m depth. - Dark grey mottling from 5.23m to 5.66m depth. - Contains wood fragments at 5.33m, 5.56m, and 6.1m depth. - Trace sand below 6.71m depth.				SS	8				
6											
7					7	CS					
				-14.68							
		Dense to very dense, moist, grey, SILT and SAND, some subrounded to subangular gravel. [TILL-LIKE]		7.42 -14.88	8	CS SS	>50				
		Strong, fresh to slightly weathered, fine-grained, dark green to black chloritized AMPHIBOLITE, quartz and calcite veining (inferred BEDROCK)		7.62	9	CS					
8											
					10	CS					
9											
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MS
CHECKED: DRAFT

File:B:\PROJECTS\2011\1436\11-1436-0061\GINT\BH 11-1436-0061-7000.GPJ Output Form:BC_BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB JFarah 09/06/11

PROJECT No.: 11-1436-0061

RECORD OF BOREHOLE: BH11-01

SHEET 2 OF 2

LOCATION: Esquimalt Graving Dock
N: 5364859.94 E: 468380.07 NAD83 Zone: 10

DRILLING DATE: August 9, 2011
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Chart Datum

SAMPLER HAMMER, 64kg; DROP, 762mm

INCLINATION: -90°

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
10	Sonic	Strong, fresh to slightly weathered, fine-grained, dark green to black chloritized AMPHIBOLITE, quartz and calcite veining (inferred BEDROCK) *(continued)*		-17.93	11	CS					
		End of Borehole.		10.67							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MS
CHECKED: DRAFT

File:B:\PROJECTS\2011\1436\11-1436-0061\GINT\BH 11-1436-0061-7000.GPJ Output Form:BC_BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB JFarah 09/06/11

ATTACHMENT E

GOLDER ASSOCIATES LTD.
ATTN: Rachael Jones
3795 Carey Road
Victoria BC V8Z 6T8

Date Received: 11-AUG-11
Report Date: 22-AUG-11 16:21 (MT)
Version: DRAFT

Client Phone: 250-881-7372

Certificate of Analysis

Lab Work Order #: L1043298

Project P.O. #: NOT SUBMITTED
Job Reference: 11-1436-0061/5100
C of C Numbers: 0251
Legal Site Desc:

DRAFT

Amber Springer
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1043298-1 SED 09-AUG-11 0251-01	L1043298-2 SED 09-AUG-11 0251-02	L1043298-3 SED 09-AUG-11 0251-03	L1043298-4 SED 09-AUG-11 0251-04	L1043298-5 SED 09-AUG-11 0251-05
SOIL						
Physical Tests	Moisture (%)	40.8	36.8	13.1	4.92	
	pH (1:2 soil:water) (pH)	8.16	8.29		9.04	7.27
Metals	Antimony (Sb) (mg/kg)	9.17	4.08		0.11	3.06
	Arsenic (As) (mg/kg)	20.8	16.3		2.42	14.5
	Barium (Ba) (mg/kg)	87.1	108		22.5	65.9
	Beryllium (Be) (mg/kg)	<0.20	0.25		<0.20	<0.20
	Cadmium (Cd) (mg/kg)	1.05	1.57		0.109	0.804
	Chromium (Cr) (mg/kg)	23.4	39.6		26.4	51.9
	Cobalt (Co) (mg/kg)	5.95	7.60		10.2	10.4
	Copper (Cu) (mg/kg)	194	244		37.4	218
	Lead (Pb) (mg/kg)	126	220		4.63	105
	Mercury (Hg) (mg/kg)	9.18 DLA	13.9 DLA		0.123	29.8 DLA
	Molybdenum (Mo) (mg/kg)	5.96	10.8		0.56	5.98
	Nickel (Ni) (mg/kg)	21.8	28.6		20.1	40.9
	Selenium (Se) (mg/kg)	0.55	0.85		<0.20	0.53
	Silver (Ag) (mg/kg)	0.67	1.48		<0.10	0.36
	Thallium (Tl) (mg/kg)	0.108	0.174		0.050	0.120
	Tin (Sn) (mg/kg)	8.1	12.3		<2.0	7.2
	Uranium (U) (mg/kg)	1.75	2.54		0.311	1.47
	Vanadium (V) (mg/kg)	45.4	64.4		62.8	57.1
	Zinc (Zn) (mg/kg)	268	319		40.4	144
TCLP Extractables	Acenaphthene (mg/L)	0.00198		0.00929		
	Acenaphthylene (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Acridine (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Anthracene (mg/L)	0.00050		<0.00050 DLA		
	Benz(a)anthracene (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Benzo(a)pyrene (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Benzo(b)fluoranthene (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Benzo(g,h,i)perylene (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Benzo(k)fluoranthene (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Chrysene (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Dibenz(a,h)anthracene (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Fluoranthene (mg/L)	0.00119		<0.00050 DLA		
	Fluorene (mg/L)	0.00141		0.00170		
	Indeno(1,2,3-c,d)pyrene (mg/L)	<0.00050 DLA		<0.00050 DLA		
	Naphthalene (mg/L)	0.00236		0.00175		
	1st Preliminary PH (pH)	9.23		9.74		

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* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1043298-6				
	Description	SED				
	Sampled Date	09-AUG-11				
	Sampled Time					
	Client ID	0251-06				
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	17.4				
	pH (1:2 soil:water) (pH)	8.60				
Metals	Antimony (Sb) (mg/kg)	0.28				
	Arsenic (As) (mg/kg)	6.68				
	Barium (Ba) (mg/kg)	84.0				
	Beryllium (Be) (mg/kg)	0.37				
	Cadmium (Cd) (mg/kg)	0.051				
	Chromium (Cr) (mg/kg)	43.8				
	Cobalt (Co) (mg/kg)	13.7				
	Copper (Cu) (mg/kg)	42.2				
	Lead (Pb) (mg/kg)	5.28				
	Mercury (Hg) (mg/kg)	0.126				
	Molybdenum (Mo) (mg/kg)	<0.50				
	Nickel (Ni) (mg/kg)	40.5				
	Selenium (Se) (mg/kg)	<0.20				
	Silver (Ag) (mg/kg)	<0.10				
	Thallium (Tl) (mg/kg)	0.064				
	Tin (Sn) (mg/kg)	<2.0				
	Uranium (U) (mg/kg)	0.300				
	Vanadium (V) (mg/kg)	80.0				
	Zinc (Zn) (mg/kg)	70.3				
TCLP Extractables	Acenaphthene (mg/L)	<0.00050 DLA				
	Acenaphthylene (mg/L)	<0.00050 DLA				
	Acridine (mg/L)	<0.00050 DLA				
	Anthracene (mg/L)	<0.00050 DLA				
	Benz(a)anthracene (mg/L)	<0.00050 DLA				
	Benzo(a)pyrene (mg/L)	<0.00050 DLA				
	Benzo(b)fluoranthene (mg/L)	<0.00050 DLA				
	Benzo(g,h,i)perylene (mg/L)	<0.00050 DLA				
	Benzo(k)fluoranthene (mg/L)	<0.00050 DLA				
	Chrysene (mg/L)	<0.00050 DLA				
	Dibenz(a,h)anthracene (mg/L)	<0.00050 DLA				
	Fluoranthene (mg/L)	<0.00050 DLA				
	Fluorene (mg/L)	<0.00050 DLA				
	Indeno(1,2,3-c,d)pyrene (mg/L)	<0.00050 DLA				
	Naphthalene (mg/L)	<0.00050 DLA				
	1st Preliminary PH (pH)	9.91				

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* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1043298-1 SED 09-AUG-11 0251-01	L1043298-2 SED 09-AUG-11 0251-02	L1043298-3 SED 09-AUG-11 0251-03	L1043298-4 SED 09-AUG-11 0251-04	L1043298-5 SED 09-AUG-11 0251-05
SOIL						
TCLP Extractables	2nd Preliminary PH (pH)	1.79		1.57		
	Extraction Solution Initial pH (pH)	4.88		4.88		
	Final pH (pH)	6.71		5.99		
	Phenanthrene (mg/L)	0.00275		0.00206		
	Pyrene (mg/L)	0.00253		0.00063		
Hydrocarbons	EPH10-19 (mg/kg)	250	250	<200	<200	
	EPH19-32 (mg/kg)	1510	1380	<200	<200	
	LEPH (mg/kg)	240	250	<200	<200	
	HEPH (mg/kg)	1390	1300	<200	<200	
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	0.489	0.406	0.452	0.809	
	Acenaphthylene (mg/kg)	1.44	1.78	0.0269	0.0337	
	Anthracene (mg/kg)	3.70	3.03	0.0702	0.377	
	Benz(a)anthracene (mg/kg)	5.19	6.52	0.112	0.347	
	Benzo(a)pyrene (mg/kg)	27.6	9.80	0.110	0.339	
	Benzo(b)fluoranthene (mg/kg)	47.9	14.3	0.153	0.585	
	Benzo(b+j+k)fluoranthene (mg/kg)	51.9	18.0	0.212	0.803	
	Benzo(g,h,i)perylene (mg/kg)	5.55	7.06	0.054	0.136	
	Benzo(k)fluoranthene (mg/kg)	3.94	3.73	0.059	0.218	
	Chrysene (mg/kg)	5.62	7.19	0.122	0.743	
	Dibenz(a,h)anthracene (mg/kg)	1.29	1.57	0.0140	0.0412	
	Fluoranthene (mg/kg)	14.7	16.7	0.300	0.612	
	Fluorene (mg/kg)	0.916	1.18	0.140	0.468	
	Indeno(1,2,3-c,d)pyrene (mg/kg)	5.72	8.04	0.057	0.147	
	2-Methylnaphthalene (mg/kg)	0.206	0.165	0.032	0.127	
	Naphthalene (mg/kg)	0.447	0.449	0.143	0.415	
	Phenanthrene (mg/kg)	7.15	5.45	0.373	1.09	
	Pyrene (mg/kg)	23.1	30.6	0.416	0.897	
	Surrogate: Acenaphthene d10 (%)	82	91	78	83	
	Surrogate: Chrysene d12 (%)	64	81	80	84	
	Surrogate: Naphthalene d8 (%)	72	82	77	81	
	Surrogate: Phenanthrene d10 (%)	85	98	85	89	
	B(a)P Total Potency Equivalent (mg/kg)	35.3	14.8	0.164	0.519	
	IACR (CCME) (mg/kg)	426	173	2.11	7.59	
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.040		<0.040		
	PCB-1221 (mg/kg)	<0.040		<0.040		
	PCB-1232 (mg/kg)	<0.040		<0.040		

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* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1043298-6				
	Description	SED				
	Sampled Date	09-AUG-11				
	Sampled Time					
	Client ID	0251-06				
Grouping	**Analyte**					
SOIL						
TCLP Extractables	2nd Preliminary PH (pH)	1.68				
	Extraction Solution Initial pH (pH)	4.88				
	Final pH (pH)	5.00				
	Phenanthrene (mg/L)	<0.00050 DLA				
	Pyrene (mg/L)	<0.00050 DLA				
Hydrocarbons	EPH10-19 (mg/kg)	<200				
	EPH19-32 (mg/kg)	<200				
	LEPH (mg/kg)	<200				
	HEPH (mg/kg)	<200				
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.0050				
	Acenaphthylene (mg/kg)	<0.0050				
	Anthracene (mg/kg)	<0.0040				
	Benz(a)anthracene (mg/kg)	<0.010				
	Benzo(a)pyrene (mg/kg)	<0.010				
	Benzo(b)fluoranthene (mg/kg)	<0.010				
	Benzo(b+j+k)fluoranthene (mg/kg)	<0.015				
	Benzo(g,h,i)perylene (mg/kg)	<0.010				
	Benzo(k)fluoranthene (mg/kg)	<0.010				
	Chrysene (mg/kg)	<0.010				
	Dibenz(a,h)anthracene (mg/kg)	<0.0050				
	Fluoranthene (mg/kg)	0.011				
	Fluorene (mg/kg)	<0.010				
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.010				
	2-Methylnaphthalene (mg/kg)	<0.010				
	Naphthalene (mg/kg)	0.015				
	Phenanthrene (mg/kg)	0.024				
	Pyrene (mg/kg)	0.012				
	Surrogate: Acenaphthene d10 (%)	85				
	Surrogate: Chrysene d12 (%)	88				
	Surrogate: Naphthalene d8 (%)	84				
	Surrogate: Phenanthrene d10 (%)	89				
	B(a)P Total Potency Equivalent (mg/kg)	<0.020				
	IACR (CCME) (mg/kg)	<0.15				
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.040				
	PCB-1221 (mg/kg)	<0.040				
	PCB-1232 (mg/kg)	<0.040				

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* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1043298-1 SED 09-AUG-11 0251-01	L1043298-2 SED 09-AUG-11 0251-02	L1043298-3 SED 09-AUG-11 0251-03	L1043298-4 SED 09-AUG-11 0251-04	L1043298-5 SED 09-AUG-11 0251-05
Sample ID / Description / Sampled Date / Sampled Time / Client ID						
SOIL						
Polychlorinated Biphenyls	PCB-1242 (mg/kg)	<0.040		<0.040		
	PCB-1248 (mg/kg)	<0.040		<0.040		
	PCB-1254 (mg/kg)	0.490		<0.040		
	PCB-1260 (mg/kg)	<0.040		<0.040		
	PCB-1262 (mg/kg)	<0.040		<0.040		
	PCB-1268 (mg/kg)	<0.040		<0.040		
	Total Polychlorinated Biphenyls (mg/kg)	0.490		<0.040		
Organochlorine Pesticides	Aldrin (mg/kg)	<0.050		<0.050		
	alpha-BHC (mg/kg)	<0.050		<0.050		
	beta-BHC (mg/kg)	<0.050		<0.050		
	Lindane (gamma - BHC) (mg/kg)	<0.050		<0.050		
	delta-BHC (mg/kg)	<0.050		<0.050		
	cis-Chlordane (alpha) (mg/kg)	<0.050		<0.050		
	trans-Chlordane (gamma) (mg/kg)	<0.050		<0.050		
	2,4'-DDD (mg/kg)	<0.050		<0.050		
	4,4'-DDD (mg/kg)	<0.050		<0.050		
	2,4'-DDE (mg/kg)	<0.050		<0.050		
	4,4'-DDE (mg/kg)	<0.050		<0.050		
	2,4'-DDT (mg/kg)	<0.050		<0.050		
	4,4'-DDT (mg/kg)	<0.050		<0.050		
	Dieldrin (mg/kg)	<0.050		<0.050		
	Endosulfan I (mg/kg)	<0.050		<0.050		
	Endosulfan II (mg/kg)	<0.050		<0.050		
	Endosulfan Sulfate (mg/kg)	<0.050		<0.050		
	Endrin (mg/kg)	<0.050		<0.050		
	Heptachlor (mg/kg)	<0.050		<0.050		
	Heptachlor Epoxide (mg/kg)	<0.050		<0.050		
	Methoxychlor (mg/kg)	<0.050		<0.050		
	Mirex (mg/kg)	<0.050		<0.050		
	cis-Nonachlor (mg/kg)	<0.050		<0.050		
	trans-Nonachlor (mg/kg)	<0.050		<0.050		
	Oxychlordane (mg/kg)	<0.050		<0.050		

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* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1043298-6				
	Description	SED				
	Sampled Date	09-AUG-11				
	Sampled Time					
	Client ID	0251-06				
Grouping	**Analyte**					
SOIL						
Polychlorinated Biphenyls	PCB-1242 (mg/kg)	<0.040				
	PCB-1248 (mg/kg)	<0.040				
	PCB-1254 (mg/kg)	<0.040				
	PCB-1260 (mg/kg)	<0.040				
	PCB-1262 (mg/kg)	<0.040				
	PCB-1268 (mg/kg)	<0.040				
	Total Polychlorinated Biphenyls (mg/kg)	<0.040				
Organochlorine Pesticides	Aldrin (mg/kg)	<0.050				
	alpha-BHC (mg/kg)	<0.050				
	beta-BHC (mg/kg)	<0.050				
	Lindane (gamma - BHC) (mg/kg)	<0.050				
	delta-BHC (mg/kg)	<0.050				
	cis-Chlordane (alpha) (mg/kg)	<0.050				
	trans-Chlordane (gamma) (mg/kg)	<0.050				
	2,4'-DDD (mg/kg)	<0.050				
	4,4'-DDD (mg/kg)	<0.050				
	2,4'-DDE (mg/kg)	<0.050				
	4,4'-DDE (mg/kg)	<0.050				
	2,4'-DDT (mg/kg)	<0.050				
	4,4'-DDT (mg/kg)	<0.050				
	Dieldrin (mg/kg)	<0.050				
	Endosulfan I (mg/kg)	<0.050				
	Endosulfan II (mg/kg)	<0.050				
	Endosulfan Sulfate (mg/kg)	<0.050				
	Endrin (mg/kg)	<0.050				
	Heptachlor (mg/kg)	<0.050				
	Heptachlor Epoxide (mg/kg)	<0.050				
	Methoxychlor (mg/kg)	<0.050				
	Mirex (mg/kg)	<0.050				
	cis-Nonachlor (mg/kg)	<0.050				
	trans-Nonachlor (mg/kg)	<0.050				
	Oxychlordane (mg/kg)	<0.050				

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* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
MB-LOR	Method Blank exceeds ALS DQO. LORs adjusted for samples with positive hits below 5 times blank level. Please contact ALS if re-analysis is required.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
EPH-TUMB-FID-VA	Soil	EPH in Solids by Tumbler and GCFID	BCMELP CSR

Extractable Hydrocarbons in Sediment/Soil
This analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Solids by GC/FID, Version 2.1 July 1999". The procedure, based on EPA 3570, uses a rotary extraction technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene or kept in hexane/acetone and analyzed by capillary column gas chromatography with flame ionization detection (GC/FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

Accuracy target values for Reference Materials used in this method are derived from averages of long-term method performance, as certified values do not exist for the reported parameters.

HG-200.2-CVAF-VA Soil Mercury in Soil by CVAFS EPA 200.2/245.7

This analysis is carried out using procedures from CSR Analytical Method: "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve (this sieve step is omitted for international soil samples), and a representative subsample of the dry material is weighed. The sample is then digested at 95 degrees Celsius for 2 hours by block digester using concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 245.7).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

LEPH/HEPH-CALC-VA Soil LEPHs and HEPHs BC MOE LABORATORY MANUAL (2005)

Light and Heavy Extractable Petroleum Hydrocarbons in Solids. These results are determined according to the British Columbia Ministry of Environment, Lands, and Parks Analytical Method for Contaminated Sites "Calculation of Light and Heavy Extractable Petroleum Hydrocarbons in Solids or Water". According to this method, LEPH and HEPH are calculated
by subtracting selected Polycyclic Aromatic Hydrocarbon results from Extractable Petroleum Hydrocarbon results. To calculate LEPH, the individual results for Naphthalene and Phenanthrene are subtracted from EPH(C10-19). To calculate HEPH, the individual results for Benz(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenz(a,h)anthracene, Indeno(1,2,3-c,d)pyrene, and Pyrene
are subtracted from EPH(C19-32). Analysis of Extractable Petroleum Hydrocarbons adheres to all prescribed elements of the BCMELP method "Extractable Petroleum Hydrocarbons in Solids by GC/FID" (Version 2.1, July 20, 1999).

MET-200.2-CCMS-VA Soil Metals in Soil by CRC ICPMS EPA 200.2/6020A

This analysis is carried out using procedures from CSR Analytical Method: "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is dried at 40 C, then ground to < 2 mm particle size using a stainless steel flail grinder. A representative portion is digested with concentrated nitric and hydrochloric acids for 2 hours in an open vessel digestor at 95 degrees. Instrumental analysis of the digested exttract is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

MOISTURE-VA Soil Moisture content ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

OCP1-SOX-ECD-VA Soil OCP-1 in Soil by Soxhlet GCECD EPA METHODS 3540, 3545, 3610, 3630, 3660

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3540, 3545, 3610, 3630, 3660 & 8081, published by the United States Environmental Protection Agency (EPA). The procedure uses an automated system (Accelerated Solvent Extractor - ASE) at high temperature and pressure or a Soxhlet system to extract a subsample of the sediment/soil with dichloromethane. The extract is then solvent exchanged to hexane followed by one or more of the following clean-up procedures (if required): alumina clean-up, silica gel clean-up and/or sulphur clean-up. The final extract is analysed by dual capillary column gas chromatography with electron capture detection (GC/ECD).

PAH-TCLP-SF-MS-VA Soil PAH's IN TCLP LEACHATE EPA 3510/8270 LIQ-LIQ GCMS

The sample is extracted at a 20:1 liquid to solids ratio for 16 to 20 hours using either extraction fluid #1 (acetic acid, water and sodium hydroxide) or extraction fluid #2 (acetic acid and water) depending on the pH of the original sample. The extract is filtered and then extracted with dichloromethane. The extract is solvent exchanged to toluene prior to analysis by capillary column gas chromatography with mass spectrometric detection (GC/MS). Because the two isomers cannot be readily chromatographically separated, benzo(j)fluoranthene is reported as part of the benzo(b)fluoranthene parameter.

PAH-TMB-H/A-MS-VA Soil PAH - Rotary Extraction (Hexane/Acetone) EPA 3570/8270

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Reference Information

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3545 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation. Because the two isomers cannot be readily chromatographically separated, benzo(j)fluoranthene is reported as part of the benzo(b)fluoranthene parameter.

PCB-SE-ECD-VA Soil PCB by Extraction with GCECD EPA 3630/8082 GCECD

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3500, 3620, 3630, 3660, 3665 & 8082, published by the United States Environmental Protection Agency (EPA). The procedure involves a solid-liquid extraction of a subsample of the sediment/soil using a mixture of hexane and acetone. Water is added to the extract and the resulting hexane extract undergoes one or more of the following clean-up procedures (if required): florisil clean-up, silica gel clean-up, sulphur clean-up and/or sulphuric acid clean-up. The final extract is analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

PCB-SUM-CALC-VA Soil Total PCBs in soil CALCULATION

Calculation of Total PCB. Total PCB is the sum of the concentrations of PCB aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268. Results below detection limit (DL) are treated as zero. The Total PCB detection limit is equal to the highest of the aroclor detection limits used in the sum.

PH-1:2-VA Soil pH in Soil (1:2 Soil:Water Extraction) BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA

Chain of Custody Numbers:

0251

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

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Quality Control Report

Workorder: L1043298 Report Date: 22-AUG-11

Client: GOLDER ASSOCIATES LTD.
3795 Carey Road
Victoria BC V8Z 6T8
Contact: Rachael Jones

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
EPH-TUMB-FID-VA	**Soil**							
Batch R2234457								
WG1328898-5 DUP		**L1043298-3**						
EPH10-19		<200	<200	RPD-NA	mg/kg	N/A	40	15-AUG-11
EPH19-32		<200	<200	RPD-NA	mg/kg	N/A	40	15-AUG-11
WG1328898-3 IRM		**ALS PHC1 RM**						
EPH10-19			79		%		70-130	15-AUG-11
EPH19-32			94		%		70-130	15-AUG-11
WG1328898-1 MB								
EPH10-19			<200		mg/kg		200	15-AUG-11
EPH19-32			<200		mg/kg		200	15-AUG-11
HG-200.2-CVAF-VA	**Soil**							
Batch R2234327								
WG1328903-4 CRM		**VA-CANMET-TILL1**						
Mercury (Hg)			90		%		70-130	15-AUG-11
WG1328903-5 CRM		**VA-NRC-PACS2**						
Mercury (Hg)			93		%		70-130	15-AUG-11
WG1328903-1 MB								
Mercury (Hg)			<0.0050		mg/kg		0.005	15-AUG-11
WG1328903-2 MB								
Mercury (Hg)			<0.0050		mg/kg		0.005	15-AUG-11
MET-200.2-CCMS-VA	**Soil**							
Batch R2234353								
WG1328903-4 CRM		**VA-CANMET-TILL1**						
Antimony (Sb)			97		%		70-130	14-AUG-11
Arsenic (As)			104		%		70-130	14-AUG-11
Barium (Ba)			94		%		70-130	14-AUG-11
Chromium (Cr)			102		%		70-130	14-AUG-11
Cobalt (Co)			97		%		70-130	14-AUG-11
Copper (Cu)			95		%		70-130	14-AUG-11
Lead (Pb)			87		%		70-130	14-AUG-11
Nickel (Ni)			99		%		70-130	14-AUG-11
Selenium (Se)			0.32		mg/kg		0.22-0.42	14-AUG-11
Thallium (Tl)			0.118		mg/kg		0.025-0.225	14-AUG-11
Vanadium (V)			104		%		70-130	14-AUG-11
Zinc (Zn)			100		%		70-130	14-AUG-11
WG1328903-5 CRM		**VA-NRC-PACS2**						
Antimony (Sb)			79		%		70-130	14-AUG-11
Arsenic (As)			103		%		70-130	14-AUG-11

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Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-VA	**Soil**							
Batch R2234353								
WG1328903-5 CRM		**VA-NRC-PACS2**						
Barium (Ba)			100		%		70-130	14-AUG-11
Cadmium (Cd)			105		%		70-130	14-AUG-11
Chromium (Cr)			98		%		70-130	14-AUG-11
Cobalt (Co)			92		%		70-130	14-AUG-11
Copper (Cu)			85		%		70-130	14-AUG-11
Lead (Pb)			82		%		70-130	14-AUG-11
Molybdenum (Mo)			100		%		70-130	14-AUG-11
Nickel (Ni)			95		%		70-130	14-AUG-11
Selenium (Se)			94		%		70-130	14-AUG-11
Silver (Ag)			85		%		70-130	14-AUG-11
Thallium (Tl)			90		%		70-130	14-AUG-11
Tin (Sn)			98		%		70-130	14-AUG-11
Vanadium (V)			103		%		70-130	14-AUG-11
Zinc (Zn)			100		%		70-130	14-AUG-11
WG1328903-1 MB								
Antimony (Sb)			<0.10		mg/kg		0.1	14-AUG-11
Arsenic (As)			<0.050		mg/kg		0.05	14-AUG-11
Barium (Ba)			<0.50		mg/kg		0.5	14-AUG-11
Beryllium (Be)			<0.20		mg/kg		0.2	14-AUG-11
Cadmium (Cd)			<0.050		mg/kg		0.1	14-AUG-11
Chromium (Cr)			<0.50		mg/kg		0.5	14-AUG-11
Cobalt (Co)			<0.10		mg/kg		0.1	14-AUG-11
Copper (Cu)			<0.50		mg/kg		0.5	14-AUG-11
Lead (Pb)			<0.50		mg/kg		0.5	14-AUG-11
Molybdenum (Mo)			<0.50		mg/kg		0.5	14-AUG-11
Nickel (Ni)			<0.50		mg/kg		0.5	14-AUG-11
Selenium (Se)			<0.20		mg/kg		0.2	14-AUG-11
Silver (Ag)			<0.10		mg/kg		0.1	14-AUG-11
Thallium (Tl)			<0.050		mg/kg		0.05	14-AUG-11
Tin (Sn)			<2.0		mg/kg		2	14-AUG-11
Uranium (U)			<0.050		mg/kg		0.05	14-AUG-11
Vanadium (V)			<0.20		mg/kg		0.2	14-AUG-11
Zinc (Zn)			<1.0		mg/kg		1	14-AUG-11
WG1328903-2 MB								
Antimony (Sb)			<0.10		mg/kg		0.1	14-AUG-11

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Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-VA	**Soil**							
Batch R2234353								
WG1328903-2 MB								
Arsenic (As)			<0.050		mg/kg		0.05	14-AUG-11
Barium (Ba)			0.62	MB-LOR	mg/kg		0.5	14-AUG-11
Beryllium (Be)			<0.20		mg/kg		0.2	14-AUG-11
Cadmium (Cd)			<0.050		mg/kg		0.1	14-AUG-11
Chromium (Cr)			<0.50		mg/kg		0.5	14-AUG-11
Cobalt (Co)			<0.10		mg/kg		0.1	14-AUG-11
Copper (Cu)			<0.50		mg/kg		0.5	14-AUG-11
Lead (Pb)			<0.50		mg/kg		0.5	14-AUG-11
Molybdenum (Mo)			<0.50		mg/kg		0.5	14-AUG-11
Nickel (Ni)			<0.50		mg/kg		0.5	14-AUG-11
Selenium (Se)			<0.20		mg/kg		0.2	14-AUG-11
Silver (Ag)			<0.10		mg/kg		0.1	14-AUG-11
Thallium (Tl)			<0.050		mg/kg		0.05	14-AUG-11
Tin (Sn)			<2.0		mg/kg		2	14-AUG-11
Uranium (U)			<0.050		mg/kg		0.05	14-AUG-11
Vanadium (V)			<0.20		mg/kg		0.2	14-AUG-11
Zinc (Zn)			<1.0		mg/kg		1	14-AUG-11
MOISTURE-VA	**Soil**							
Batch R2233473								
WG1328901-2 LCS								
Moisture			91		%		90-110	11-AUG-11
WG1328901-1 MB								
Moisture			<0.25		%		0.25	11-AUG-11
OCP1-SOX-ECD-VA	**Soil**							
Batch R2238197								
WG1329789-3 DUP		**L1043298-6**						
alpha-BHC		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Lindane (gamma - BHC)		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
beta-BHC		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
delta-BHC		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Heptachlor		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Aldrin		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Oxychlordane		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
2,4'-DDE		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11

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Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
OCP1-SOX-ECD-VA	**Soil**							
Batch R2238197								
WG1329789-3 DUP		**L1043298-6**						
Heptachlor Epoxide		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
trans-Chlordane (gamma)		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
trans-Nonachlor		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
cis-Chlordane (alpha)		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
4,4'-DDE		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Endosulfan I		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
2,4'-DDD		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Dieldrin		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
2,4'-DDT		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Endrin		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
cis-Nonachlor		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
4,4'-DDD		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Endosulfan II		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
4,4'-DDT		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Methoxychlor		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Mirex		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
Endosulfan Sulfate		<0.050	<0.050	RPD-NA	mg/kg	N/A	50	22-AUG-11
WG1329789-2 LCS								
alpha-BHC			88		%		50-140	22-AUG-11
Lindane (gamma - BHC)			89		%		50-140	22-AUG-11
beta-BHC			96		%		50-140	22-AUG-11
delta-BHC			90		%		50-140	22-AUG-11
Heptachlor			89		%		50-140	22-AUG-11
Aldrin			90		%		50-140	22-AUG-11
Oxychlordane			93		%		50-140	22-AUG-11
2,4'-DDE			112		%		50-140	22-AUG-11
Heptachlor Epoxide			87		%		50-140	22-AUG-11
trans-Chlordane (gamma)			92		%		50-140	22-AUG-11
trans-Nonachlor			91		%		50-140	22-AUG-11
cis-Chlordane (alpha)			94		%		50-140	22-AUG-11
4,4'-DDE			94		%		50-140	22-AUG-11
Endosulfan I			92		%		40-140	22-AUG-11
2,4'-DDD			94		%		50-140	22-AUG-11
Dieldrin			93		%		50-140	22-AUG-11

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Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
OCP1-SOX-ECD-VA	**Soil**							
Batch R2238197								
WG1329789-2 LCS								
2,4'-DDT			94		%		50-140	22-AUG-11
Endrin			98		%		50-140	22-AUG-11
cis-Nonachlor			93		%		50-140	22-AUG-11
4,4'-DDD			94		%		50-140	22-AUG-11
Endosulfan II			91		%		40-140	22-AUG-11
4,4'-DDT			94		%		50-140	22-AUG-11
Methoxychlor			110		%		50-140	22-AUG-11
Mirex			93		%		50-140	22-AUG-11
Endosulfan Sulfate			92		%		40-140	22-AUG-11
WG1329789-1 MB								
alpha-BHC			<0.0010		mg/kg		0.001	22-AUG-11
Lindane (gamma - BHC)			<0.0010		mg/kg		0.001	22-AUG-11
beta-BHC			<0.0010		mg/kg		0.001	22-AUG-11
delta-BHC			<0.0010		mg/kg		0.001	22-AUG-11
Heptachlor			<0.0010		mg/kg		0.001	22-AUG-11
Aldrin			<0.0010		mg/kg		0.001	22-AUG-11
Oxychlordane			<0.0010		mg/kg		0.001	22-AUG-11
2,4'-DDE			<0.0010		mg/kg		0.001	22-AUG-11
Heptachlor Epoxide			<0.0010		mg/kg		0.001	22-AUG-11
trans-Chlordane (gamma)			<0.0010		mg/kg		0.001	22-AUG-11
trans-Nonachlor			<0.0010		mg/kg		0.001	22-AUG-11
cis-Chlordane (alpha)			<0.0010		mg/kg		0.001	22-AUG-11
4,4'-DDE			<0.0010		mg/kg		0.001	22-AUG-11
Endosulfan I			<0.0010		mg/kg		0.001	22-AUG-11
2,4'-DDD			<0.0010		mg/kg		0.001	22-AUG-11
Dieldrin			<0.0010		mg/kg		0.001	22-AUG-11
2,4'-DDT			<0.0010		mg/kg		0.001	22-AUG-11
Endrin			<0.0010		mg/kg		0.001	22-AUG-11
cis-Nonachlor			<0.0010		mg/kg		0.001	22-AUG-11
4,4'-DDD			<0.0010		mg/kg		0.001	22-AUG-11
Endosulfan II			<0.0010		mg/kg		0.001	22-AUG-11
4,4'-DDT			<0.0010		mg/kg		0.001	22-AUG-11
Methoxychlor			<0.0010		mg/kg		0.001	22-AUG-11
Mirex			<0.0010		mg/kg		0.001	22-AUG-11

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Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
OCP1-SOX-ECD-VA	**Soil**							
Batch R2238197								
WG1329789-1 MB								
Endosulfan Sulfate			<0.0010		mg/kg		0.001	22-AUG-11
PAH-TCLP-SF-MS-VA	**Soil**							
Batch R2234607								
WG1329521-2 DUP		**L1043298-3**						
Naphthalene		0.00175	0.00183		mg/L	4.2	50	17-AUG-11
Acenaphthene		0.00929	0.00894		mg/L	3.8	50	17-AUG-11
Acenaphthylene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Acridine		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Anthracene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Benz(a)anthracene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Benzo(a)pyrene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Benzo(b)fluoranthene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Benzo(g,h,i)perylene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Benzo(k)fluoranthene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Chrysene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Dibenz(a,h)anthracene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Fluoranthene		<0.00050	0.00052	RPD-NA	mg/L	N/A	50	17-AUG-11
Fluorene		0.00170	0.00185		mg/L	8.4	50	17-AUG-11
Indeno(1,2,3-c,d)pyrene		<0.00050	<0.00050	RPD-NA	mg/L	N/A	50	17-AUG-11
Phenanthrene		0.00206	0.00215		mg/L	4.1	50	17-AUG-11
Pyrene		0.00063	0.00065		mg/L	3.1	50	17-AUG-11
WG1329521-1 MB								
Naphthalene			<0.00050		mg/L		0.0005	15-AUG-11
Acenaphthene			<0.00050		mg/L		0.0005	15-AUG-11
Acenaphthylene			<0.00050		mg/L		0.0005	15-AUG-11
Acridine			<0.00050		mg/L		0.0005	15-AUG-11
Anthracene			<0.00050		mg/L		0.0005	15-AUG-11
Benz(a)anthracene			<0.00050		mg/L		0.0005	15-AUG-11
Benzo(a)pyrene			<0.00050		mg/L		0.0005	15-AUG-11
Benzo(b)fluoranthene			<0.00050		mg/L		0.0005	15-AUG-11
Benzo(g,h,i)perylene			<0.00050		mg/L		0.0005	15-AUG-11
Benzo(k)fluoranthene			<0.00050		mg/L		0.0005	15-AUG-11
Chrysene			<0.00050		mg/L		0.0005	15-AUG-11
Dibenz(a,h)anthracene			<0.00050		mg/L		0.0005	15-AUG-11

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Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PAH-TCLP-SF-MS-VA	**Soil**							
Batch R2234607								
WG1329521-1 MB								
Fluoranthene			<0.00050		mg/L		0.0005	15-AUG-11
Fluorene			<0.00050		mg/L		0.0005	15-AUG-11
Indeno(1,2,3-c,d)pyrene			<0.00050		mg/L		0.0005	15-AUG-11
Phenanthrene			<0.00050		mg/L		0.0005	15-AUG-11
Pyrene			<0.00050		mg/L		0.0005	15-AUG-11
PAH-TMB-H/A-MS-VA	**Soil**							
Batch R2234421								
WG1328898-5 DUP		**L1043298-3**						
Acenaphthene		0.452	0.575		mg/kg	24	50	17-AUG-11
Acenaphthylene		0.0269	0.0313		mg/kg	15	50	17-AUG-11
Anthracene		0.0702	0.0736		mg/kg	4.7	50	17-AUG-11
Benz(a)anthracene		0.112	0.116		mg/kg	4.1	50	17-AUG-11
Benzo(a)pyrene		0.110	0.123		mg/kg	11	50	17-AUG-11
Benzo(b)fluoranthene		0.153	0.181		mg/kg	17	50	17-AUG-11
Benzo(g,h,i)perylene		0.054	0.062		mg/kg	15	50	17-AUG-11
Benzo(k)fluoranthene		0.059	0.070		mg/kg	17	50	17-AUG-11
Chrysene		0.122	0.128		mg/kg	4.6	50	17-AUG-11
Dibenz(a,h)anthracene		0.0140	0.0161		mg/kg	14	50	17-AUG-11
Fluoranthene		0.300	0.358		mg/kg	18	50	17-AUG-11
Fluorene		0.140	0.192		mg/kg	31	50	17-AUG-11
Indeno(1,2,3-c,d)pyrene		0.057	0.066		mg/kg	16	50	17-AUG-11
2-Methylnaphthalene		0.032	0.039		mg/kg	21	50	17-AUG-11
Naphthalene		0.143	0.192		mg/kg	30	50	17-AUG-11
Phenanthrene		0.373	0.507		mg/kg	30	50	17-AUG-11
Pyrene		0.416	0.474		mg/kg	13	50	17-AUG-11
WG1328898-4 IRM		**ALS PAH1 RM**						
Acenaphthene			85		%		60-130	15-AUG-11
Acenaphthylene			96		%		60-130	15-AUG-11
Anthracene			91		%		60-130	15-AUG-11
Benz(a)anthracene			109		%		60-130	15-AUG-11
Benzo(a)pyrene			96		%		60-130	15-AUG-11
Benzo(b)fluoranthene			98		%		60-130	15-AUG-11
Benzo(g,h,i)perylene			120		%		60-130	15-AUG-11
Benzo(k)fluoranthene			92		%		60-130	15-AUG-11

DRAFT

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PAH-TMB-H/A-MS-VA	**Soil**							
Batch R2234421								
WG1328898-4 IRM		**ALS PAH1 RM**						
Chrysene			105		%		60-130	15-AUG-11
Dibenz(a,h)anthracene			113		%		60-130	15-AUG-11
Fluoranthene			99		%		60-130	15-AUG-11
Fluorene			88		%		60-130	15-AUG-11
Indeno(1,2,3-c,d)pyrene			104		%		60-130	15-AUG-11
2-Methylnaphthalene			83		%		60-130	15-AUG-11
Naphthalene			90		%		50-130	15-AUG-11
Phenanthrene			101		%		60-130	15-AUG-11
Pyrene			100		%		60-130	15-AUG-11
WG1328898-1 MB								
Acenaphthene			<0.0050		mg/kg		0.005	15-AUG-11
Acenaphthylene			<0.0050		mg/kg		0.005	15-AUG-11
Anthracene			<0.0040		mg/kg		0.004	15-AUG-11
Benz(a)anthracene			<0.010		mg/kg		0.01	15-AUG-11
Benzo(a)pyrene			<0.010		mg/kg		0.01	15-AUG-11
Benzo(b)fluoranthene			<0.010		mg/kg		0.01	15-AUG-11
Benzo(g,h,i)perylene			<0.010		mg/kg		0.01	15-AUG-11
Benzo(k)fluoranthene			<0.010		mg/kg		0.01	15-AUG-11
Chrysene			<0.010		mg/kg		0.01	15-AUG-11
Dibenz(a,h)anthracene			<0.0050		mg/kg		0.005	15-AUG-11
Fluoranthene			<0.010		mg/kg		0.01	15-AUG-11
Fluorene			<0.010		mg/kg		0.01	15-AUG-11
Indeno(1,2,3-c,d)pyrene			<0.010		mg/kg		0.01	15-AUG-11
2-Methylnaphthalene			<0.010		mg/kg		0.01	15-AUG-11
Naphthalene			<0.010		mg/kg		0.01	15-AUG-11
Phenanthrene			<0.010		mg/kg		0.01	15-AUG-11
Pyrene			<0.010		mg/kg		0.01	15-AUG-11
Surrogate: Naphthalene d8			91		%		50-150	15-AUG-11
Surrogate: Acenaphthene d10			92		%		50-150	15-AUG-11
Surrogate: Phenanthrene d10			91		%		50-150	15-AUG-11
Surrogate: Chrysene d12			96		%		50-150	15-AUG-11
PCB-SE-ECD-VA	**Soil**							

DRAFT

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PCB-SE-ECD-VA	**Soil**							
Batch R2235991								
WG1330847-2 CRM		**VA-CRM911-050**						
PCB-1254			76		%		65-130	16-AUG-11
WG1330847-1 MB								
PCB-1016			<0.040		mg/kg		0.04	16-AUG-11
PCB-1221			<0.040		mg/kg		0.04	16-AUG-11
PCB-1232			<0.040		mg/kg		0.04	16-AUG-11
PCB-1242			<0.040		mg/kg		0.04	16-AUG-11
PCB-1248			<0.040		mg/kg		0.04	16-AUG-11
PCB-1254			<0.040		mg/kg		0.04	16-AUG-11
PCB-1260			<0.040		mg/kg		0.04	16-AUG-11
PCB-1262			<0.040		mg/kg		0.04	16-AUG-11
PCB-1268			<0.040		mg/kg		0.04	16-AUG-11

DRAFT

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
MB-LOR	Method Blank exceeds ALS DQO. LORs adjusted for samples with positive hits below 5 times blank level. Please contact ALS if re-analysis is required.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

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Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

SAMPLE RECEIPT FORM / CHEMICAL ANALYSIS FORM

FILE #: PR111808

CLIENT: ALS Environmental
8081 Lougheed Hwy, Suite 100
Burnaby, BC
V5A 1W9

Phone: 604-253-4188
Email: amber.springer@alsglobal.com

RECEIVED BY: J. Lawrence **DATE/TIME:** August 12, 2011 (10:45 a.m.)
CONDITION: okay, 10°C

# of Containers	Sample Type	Sample (Client Codes)	Lab Codes	Test Requested
1	sediment	L1043298-1 0251-01	PR111808	TBT
1	sediment	L1043298-2 0251-02	PR111809	TBT
1	sediment	L1043298-3 0251-03	PR111810	TBT
1	sediment	L1043298-4 0251-04	PR111811	TBT
1	sediment	L1043298-6 0251-06	PR111812	TBT

STORAGE: Stored at <-10°C

ANALYTES: HRGC/HRMS analysis for tributyltin (TBT)

SPECIAL INSTRUCTIONS: none

METHODOLOGY

Reference Method: TBT: in house, SOP LAB04

Data summarized in Data Report Attached

Data emailed to: Amber Springer Date: August 18, 2011

Comments: Results relate only to items tested.

_____
Patrick Pond, Chief Technical Officer

DATA REPORT

Client: ALS
Contact: Amber Springer

Date Extracted: 15-Aug-11
Date Analysed: 17-Aug-11

		L1043298-1	L1043298-2	L1043298-3	L1043298-4	L1043298-6	
	Client ID:	**0251-01**	**0251-02**	**0251-03**	**0251-04**	**0251-06**	
	PRL ID:	PR111808	PR111809	PR111810	PR111811	PR111812	
Compound	**DL µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	
Tributyltin Chloride	0.001	0.069	0.471	0.001	0.001	ND	
Dibutyltin dichloride	0.001	0.003	0.010	ND	ND	ND	
Monobutyltin trichloride	0.001	ND	ND	ND	ND	ND	

Compound	**DL µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	
TBT^{+}	0.001	0.062	0.420	0.001	0.001	ND	
DBT^{++}	0.001	0.002	0.007	ND	ND	ND	
MBT^{+++}	0.001	ND	ND	ND	ND	ND	
Surrogate Recoveries (%)							
Tributyltin - d27		83	101	95	81	48	

ND - none detected

Patrick Pond, CTO

Form Name: DOC14 Data Report TBT 11-Dec-09 DGH

QC REPORT

Client: ALS
Contact: Amber Springer

Date Extracted: 15-Aug-11
Date Analysed: 17-Aug-11

	Client ID:	blank			Spike	LOF	Recovery
	PRL ID:	TB110313B			TB110314S		
Compound	**DL µg/g**	**µg/g**			**µg/g**	**µg/g**	
Tributyltin Chloride	0.001	ND			0.045	0.050	89%
Dibutyltin dichloride	0.001	ND			0.035	0.050	70%
Monobutyltin trichloride	0.001	ND			0.009	0.050	18%

Compound	**DL µg/g**	**µg/g**
TBT^{+}	0.001	ND
DBT^{++}	0.001	ND
MBT^{+++}	0.001	ND
Surrogate Recoveries (%)		
Tributyltin - d27		82

ND - none detected

Patrick Pond, CTO

Acronyms used in reporting organotins:

TBT = Tributyltin
DBT = Dibutyltin
MBT = Monobutyltin
TBTCl = Tributyltin chloride
DBTCl = Dibutyltin dichloride
MBTCl = Monobutyltin trichloride

This method analyzes organotin derivatives in water, sediment and biota. The method cannot determine which organotin salt is present in the sample, therefore all data is quantified in terms of organotin chlorides and expressed as cation equivalents (TBT^{+}, DBT^{++}, MBT^{+++}).

In sea water and under normal conditions, TBT exists as three species (hydroxide, chloride, and carbonate), which remain in equilibrium. At pH values less than 7.0, the predominate forms are $Bu_3SnOH_2^{+}$ and Bu_3SnCl, at pH 8, they are Bu_3SnCl, Bu_3SnOH, and $Bu_3SnCO_3^{-}$, and at pH values above 10, Bu_3SnOH and $Bu_3SnCO_3^{-}$ predominate. Source: http://www.inchem.org/documents/ehc/ehc/ehc116.htm#SectionNumber:1.1

TBT data has been reported in many conventions over the years. To convert to other units, use the multipliers below.

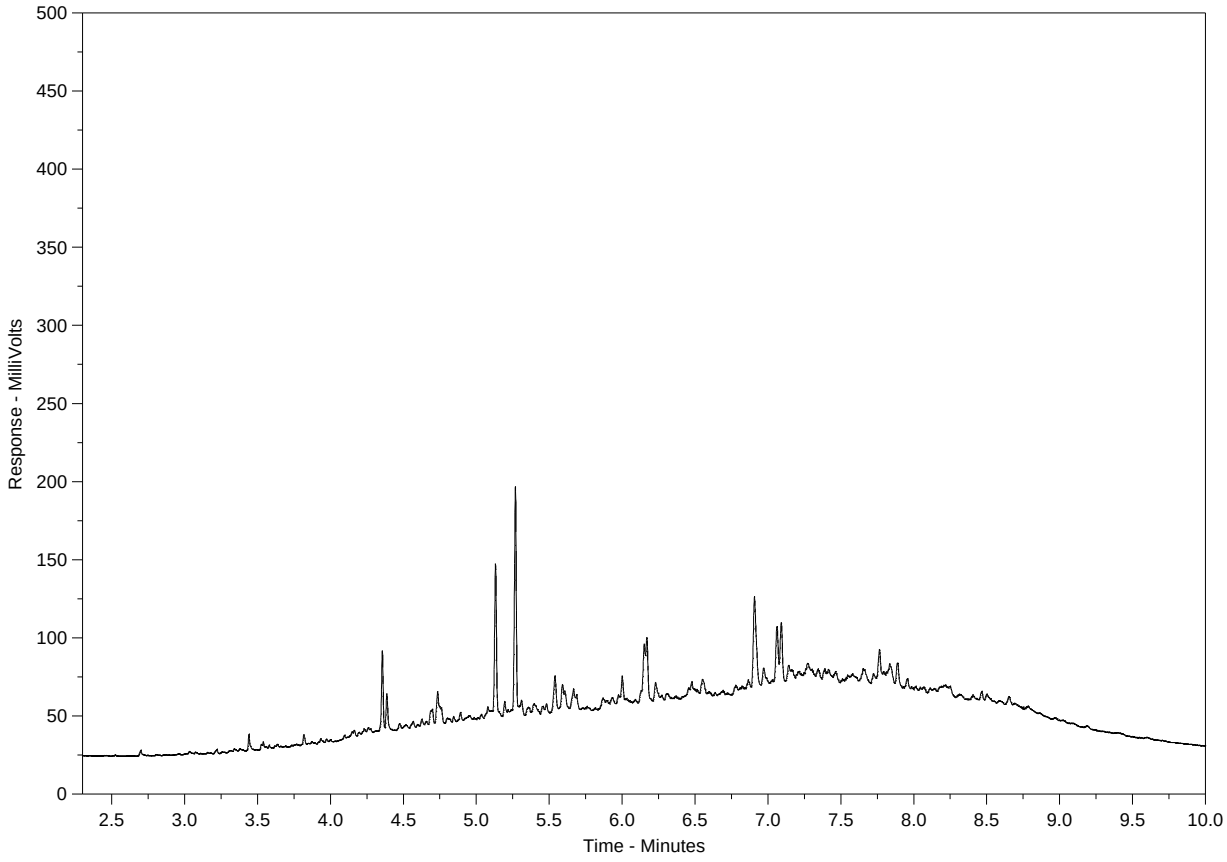
To convert	**To:**	**Multiply by:**
Tributyltin chloride	As Sn	0.3647
Tributyltin chloride	As TBTO	0.9760
Tributyltin chloride	As TBT^{+}	0.8911
Dibutyltin dichloride	As Sn	0.3907
Dibutyltin dichloride	As TBTO	0.9110
Dibutyltin dichloride	As DBT^{++}	0.7666
Dibutyltin dichloride	As TBT^{+}	0.9546
Monobutyltin trichloride	As Sn	0.4207
Monobutyltin trichloride	As TBTO	0.8461
Monobutyltin trichloride	As MBT^{+++}	0.6231
Monobutyltin trichloride	As TBT^{+}	1.0279
As Sn	As TBTO	2.8097

Acceptable recoveries for Tributyltin surrogate standards

Sediment/biota	TBT d_{27}	20-150%
Water	TBT d_{27}	10-130%

Hydrocarbon Distribution Report

ALS Sample ID: L1043298-1
Client Sample ID: 0251-01



nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →	
← Diesel / Jet Fuels →		

The EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample. For further interpretation, a current library of reference products is available on www.alsglobal.com or upon request.

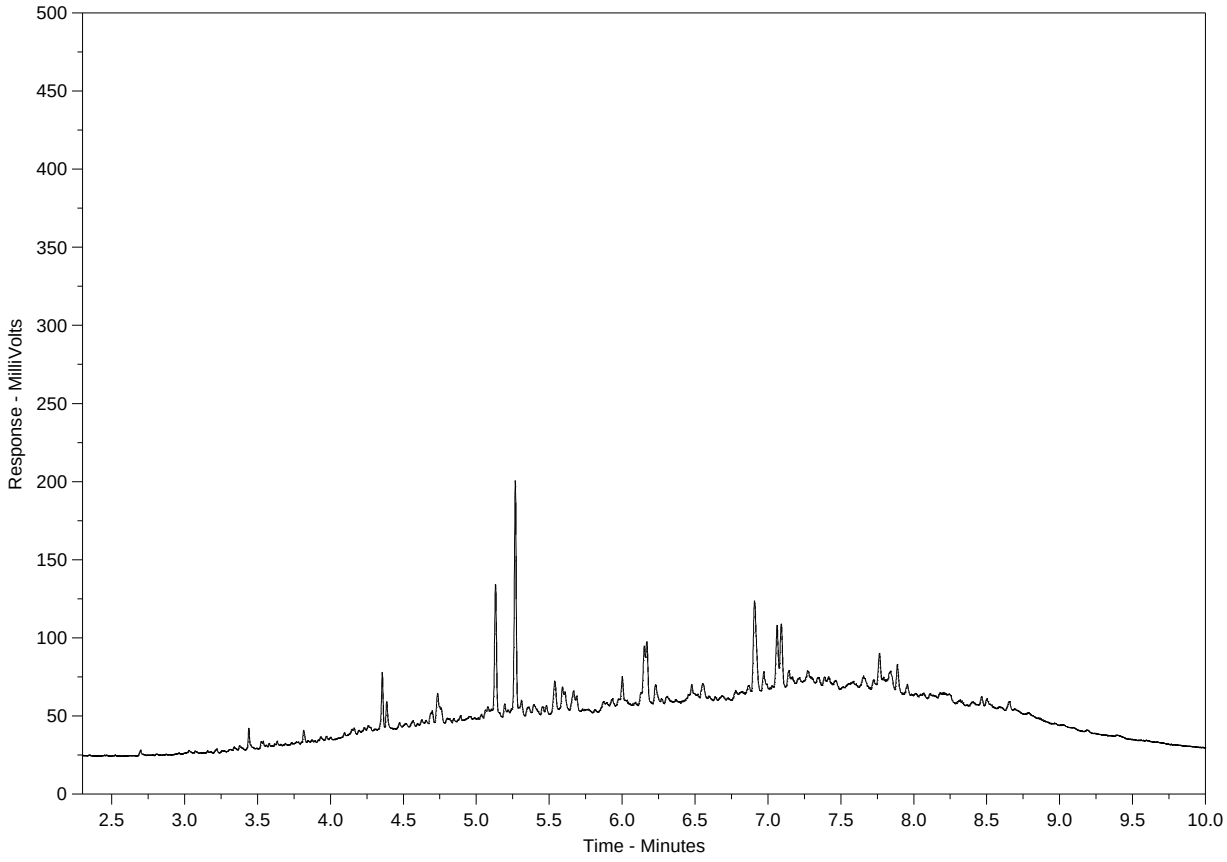
The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples by as much as 0.5 minutes.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the response scale at the left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Hydrocarbon Distribution Report

ALS Sample ID: L1043298-2
Client Sample ID: 0251-02



nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →	
← Diesel / Jet Fuels →		

The EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample. For further interpretation, a current library of reference products is available on www.alsglobal.com or upon request.

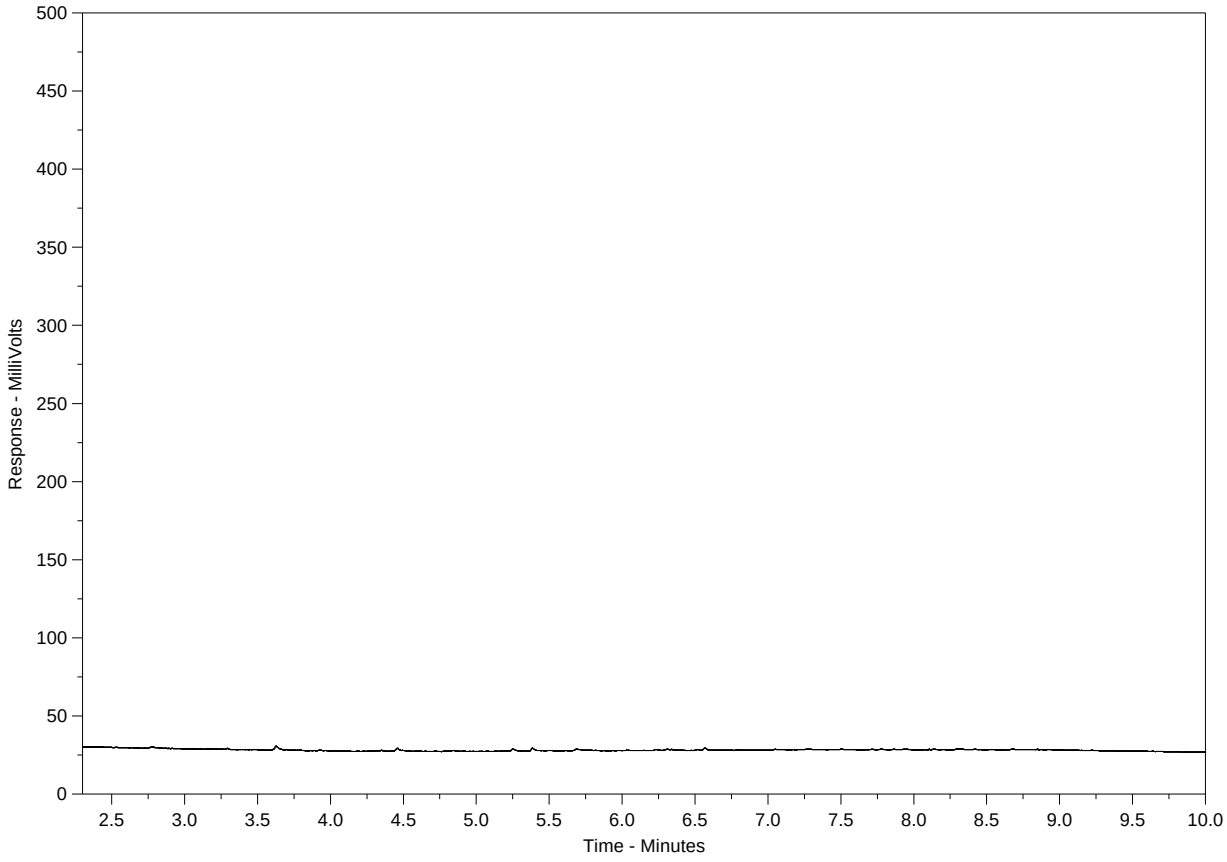
The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples by as much as 0.5 minutes.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the response scale at the left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Hydrocarbon Distribution Report

ALS Sample ID: L1043298-3
Client Sample ID: 0251-03



nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →	
← Diesel / Jet Fuels →		

The EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample. For further interpretation, a current library of reference products is available on www.alsglobal.com or upon request.

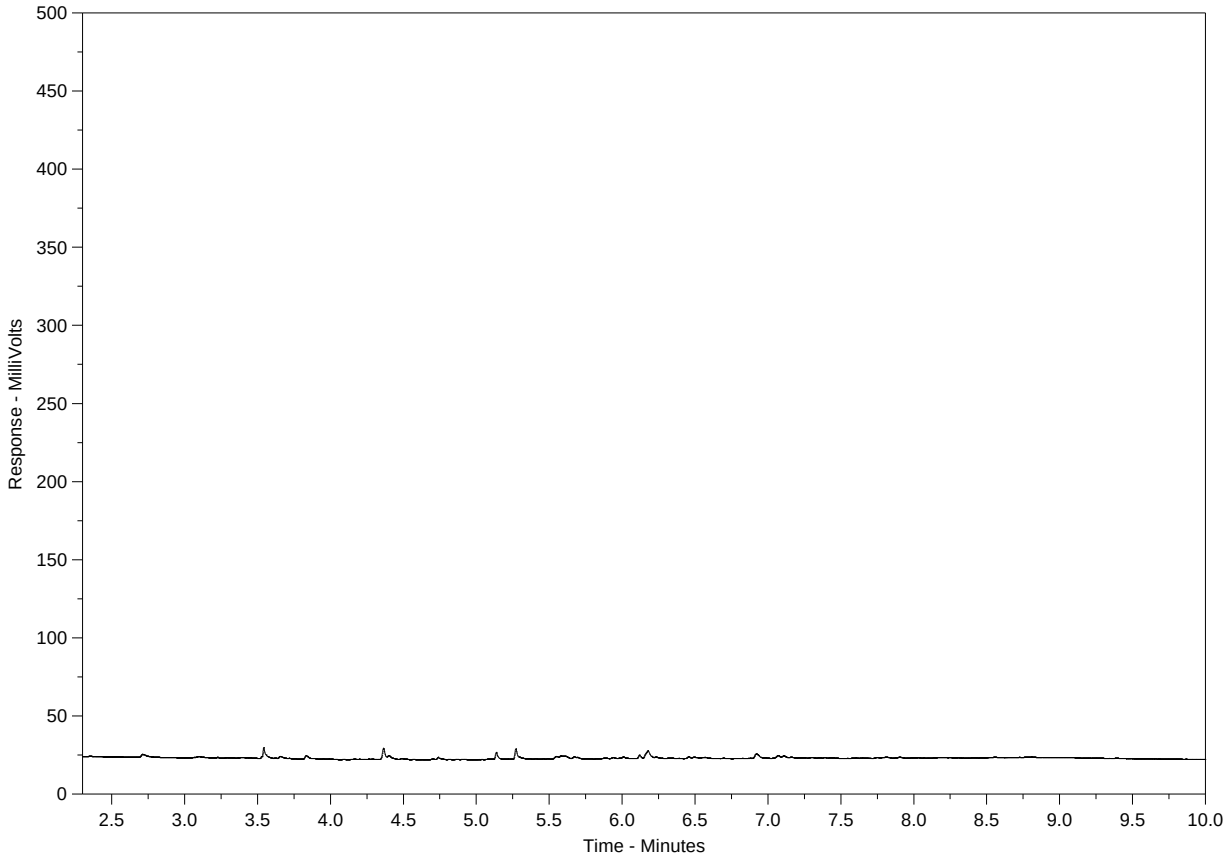
The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples by as much as 0.5 minutes.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the response scale at the left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Hydrocarbon Distribution Report

ALS Sample ID: L1043298-4
Client Sample ID: 0251-04



nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →	
← Diesel / Jet Fuels →		

The EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample. For further interpretation, a current library of reference products is available on www.alsglobal.com or upon request.

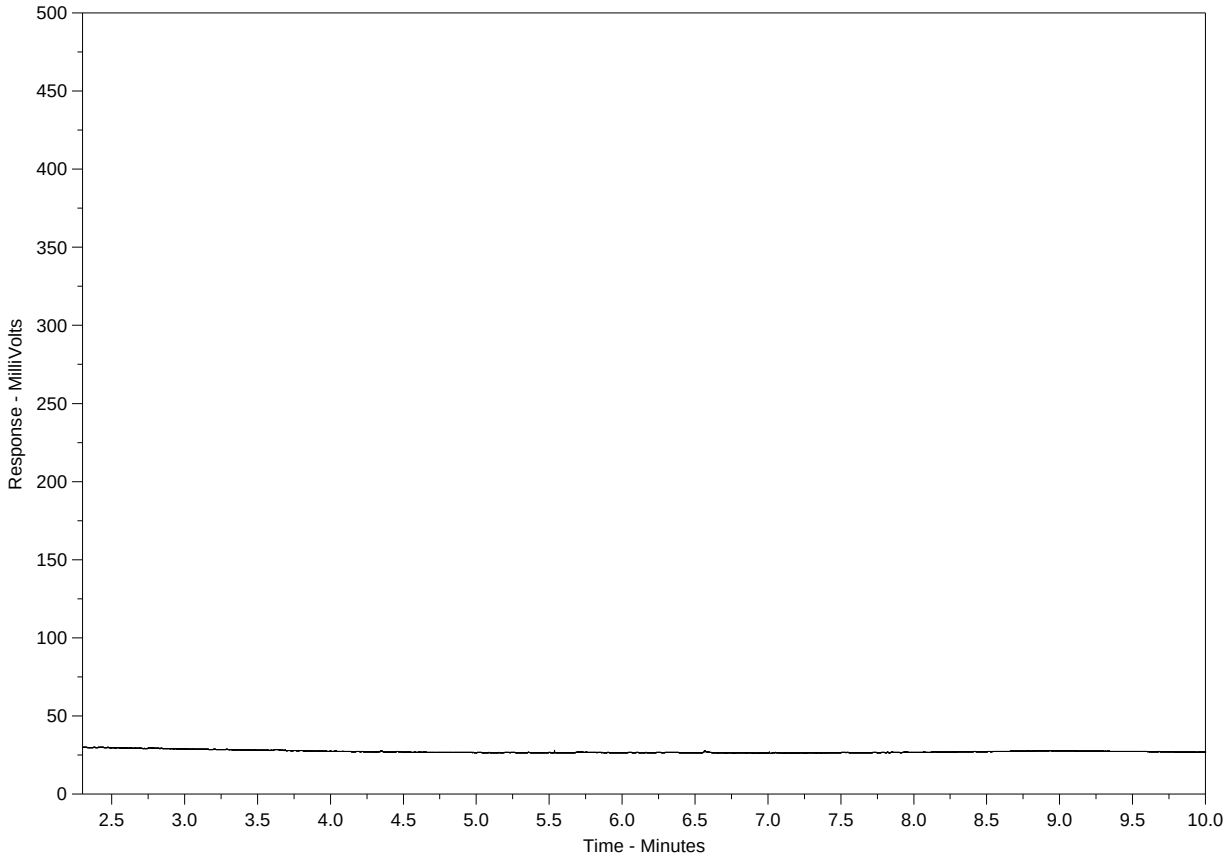
The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples by as much as 0.5 minutes.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the response scale at the left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Hydrocarbon Distribution Report

ALS Sample ID: L1043298-6
Client Sample ID: 0251-06



nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →	
← Diesel / Jet Fuels →		

The EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample. For further interpretation, a current library of reference products is available on www.alsglobal.com or upon request.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples by as much as 0.5 minutes.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the response scale at the left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

L1043298

CHAIN OF CUSTODY RECORD/ANALYSIS REQUEST

№ 0251 page 1 of 1

L1043298-COFC

Project Number:	Laboratory Name:
11-1436-0061/5100	ALS
	Address: 8081 Lougheed Hwy. Bby
Golder Contact: Rachael Jones / Michelle Sevenhuysen	Golder E-mail Address: rachael_jones@golder.com / msevenhuysen@golder.com
	Telephone/Fax: 604-253-4188
	Contact: Amber Springer

Office the final reports should be sent to:

- ☐ 500 – 4260 Still Creek Dr. Burnaby, B.C. V5C 6C6 Tel: 604-298-6623 Fax: 604-298-5253
- ☐ 202 – 2790 Gladwin Road Abbotsford, B.C. V2T 4S8 Tel: 604-850-8786 Fax: 604-850-8756
- ☒ 3795 Carey Road, 2nd floor Victoria, B.C. V8Z 6T8 Tel: 250-881-7372 Fax: 250-881-7470

Analyses Required

Sample Control Number (SCN)	Sample Matrix (over)	Date Sampled (D / M / Y)	Number of Containers	LEPH/HEPH/PAH	Metals	TBT	Total PCB	TCLP/PAH	Dioxins + Furans	OCP			RUSH	Remarks (over)
0251 -01	sed	9/8/11	6	X	X	X	X	X	X	X				
-02			6	X	X	X								
-03			6	X		X	X	X	X	X				
-04			4	X	X	X								
-05			2		X									
-06			6	X	X	X	X	X	X	X				
-07			6											
-08			6											
-09			6											
-10			6											
-11			6											
-12														

Sampler's Signature:	Relinquished by: Signature	Company	Date	Time	Received by: Signature	Company
		Golder	10AUG2011	1600.		
Sample Storage (°C): ONICE	Relinquished by: Signature	Company	Date	Time	Received by: Signature	Company

Comments:	Method of Shipment:	Waybill No.:	Received for Lab by:	Date	Time
Bill PWGSC directly Reg. TAT.	DHL - ground.	D020064333			
	Shipped by:	Shipment Condition: Seal Intact:	Temp (°C): -3	Cooler opened by: JR	Date: Aug 11/11 Time: 8:30

WHITE: Golder Copy YELLOW: Lab Copy PINK: Lab Returns with Final Report

D9

ESQUIMALT GRAVING DOCK

GEOTECHNICAL DATA REPORT

KCB (2010)

Number of Pages: 76

Klohn Crippen Berger

March 23, 2010

Public Works and Government Services Canada
825 Admirals Road
Victoria, British Columbia
V9A 2P1

Mr. Doug Ferrier
Project Manager

Dear Mr. Ferrier:

Esquimalt Graving Dock
South Jetty Wharf Development Project – Geotechnical Data Report

We are pleased to enclose three copies of our Geotechnical Data Report for the Esquimalt Graving Dock South Jetty Wharf Development Project

Please contact us if you have any questions.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Geoff Cooper, P.Eng.
Project Manager

100323R Geotech Data Report_final.doc
File: P09614A01

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Figure 1 Drill Hole Location Plan

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Appendix I 2009 Drill Hole Logs

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Appendix IV Laboratory Test Data

1. INTRODUCTION

This report summarizes the results of the 2009 site investigation program undertaken by Klohn Crippen Berger (KCB) for Public Works and Government Services Canada at Esquimalt Graving Dock (EGD) located in Esquimalt, B.C.

The site investigation program was conducted on the South and West Jetties Wharves between October 7 and 26, 2009 and consisted of cone penetration tests (CPT), mud rotary drill holes and HQ-3 diamond coring of bedrock. The objectives of the site investigation program were:

1) To obtain soil profile, soil density and strength data to supplement existing information;
2) To determine the depth to bedrock at each drill hole location; and
3) To obtain bedrock quality and bedrock strength data for pile design.

All elevations in this report are referenced to chart datum. Chart datum is equal to El. -1.87 m geodetic datum.

Prior to and concurrent with KCB's 2009 site investigation program, Golder Associates conducted a marine-based site investigation program consisting of twenty (20) sonic boreholes, four (4) mud rotary drill holes and eighteen (18) cone penetration tests. The test holes were located along the south and west jetties, north landing wharf and near Munroe Head. The results from Golder Associates' 2009 site investigation program can be found in "Esquimalt Graving Dock Waterlot – Supplementary Test Hole Investigation for Remedial Action Plan/Risk Management Plan; Report Number: 09-1475-5008."

2. SITE INVESTIGATION PROGRAM

The site investigation program consisted of three cone penetration tests and four mud rotary/HQ3 diamond drill holes positioned in the east-west direction along the south edge of the south timber wharf and one mud rotary/HQ3 diamond drill hole located on the north edge of the timber wharf close to the timber crib structure. The drill hole locations are shown in Figure 1. The drilling and the cone penetration testing were carried out by Foundex Explorations Ltd. of Surrey, B.C. using a track mounted HT-700 drill rig. A KCB geotechnical field engineer was on site to supervise the drilling and to log recovered soil/rock samples.

Drill rods were lowered through the existing fire access holes on the south jetty at locations where the fire access holes were in the vicinity of the proposed drill holes. At locations where the usage of fire access holes was not possible, Ruskin Construction was retained to cut holes through the deck prior to drilling and to patch the holes with asphalt upon the completion of drilling.

All drill holes were grouted up to 3 m below the interface between the upper coarse/fine-grained sediments and the native clay using premixed grout mix, GROUT-WELL®DF. The drill cuttings and fluids from the fill and native soil were collected in separate drums and labelled based on content. The drums containing the drill cutting were disposed by Hazco Environmental along with the drill cuttings from Golder Associates' environmental site investigation program.

Table 1 summarizes the 2009 site investigation program at the South Jetty Wharf. The drill hole locations were measured using a tape from the south and west edge of the jetty while the elevation of the top of the deck was estimated from a survey conducted by Focus Survey in November 2009. The depth to mudline was estimated by sounding with

a weighted tape measure. Selected photographs taken during the site investigation are shown in Appendix III.

Table 1: Summary of 2009 Site Investigation Program

Drill Hole ID	Drill/ Test Method	Co-ordinates (m)		Deck Elevation[1] (m)	Max. Test Depth[2] (m)	Depth to Mudline [2] (m)
		Easting	Northing			
CPT09-01 (Q)	CPT	468,350	5,364,800	5.2	21.6	12.3
CPT09-02 (R)	CPT	468,427	5,364,806	5.2	36.5	8.5
CPT09-03 (S)	CPT	468,527	5,364,816	5.2	38.57	9.40
DH09-01 (R)[3]	Mud Rotary	468,423	5,364,805	5.2	14.05	8.84
DH09-02 (S)	Mud Rotary	468,531	5,364,817	5.2	50.29	9.45
DH09-03 (Q)	Mud Rotary	468,343	5,364,799	5.2	64.00	12.80
DH09-04 (P)	Mud Rotary	468,365	5,364,841	4.9	27.70	12.50
DH09-05 (T)	Mud Rotary	468,597	5,364,827	4.8	26.52	4.27

Notes: 1) Deck elevation estimated from survey conducted by Focus Survey in November 2009.
2) Depths measured from the top of the deck surface.
3) The coordinates are in UTM NAD83.

2.1 Mud Rotary Drill Holes

Five mud rotary drill holes (DH) were completed by Foundex Explorations of Surrey, B.C. using a track mounted HT-700 drill rig. SW surface casing (168 mm O.D., 152 mm I.D.) was first lowered through the water and into the subsurface under the weight of the casings and then pounded with a drop hammer into place with the rope and cathead system until refusal was met. The SW casing generally met refusal at about 3 m below the mudline. Because collapsible ground conditions were anticipated in the fill material across the site, a wireline casing advancer system was used to drill the HW- size casing (114 mm O.D., 102 mm I.D.) through the soft fill and the native clay. The casing advancer system consists of an outer sleeve incorporating two drive keys, which engages with retractable latches to drive an inner assembly. The inner assembly accepts a tri-cone bit for drilling, which can be lowered or withdrawn using a typical wireline overshot.

With the tri-cone bit latched into position, the whole assembly rotates and feeds as a single unit to simultaneously drill and case the hole. With the tri-cone bit withdrawn, standard penetration tests (SPT), vane tests, tube sampling and HQ3 rock coring can be conducted through the HW casing.

DH09-01 was terminated at El. -8.82 m when the SW casing shoe was sheared off because it was not properly seated. At all drill holes, advancement was difficult to a depth of 8 m to 9 m below mudline due to the presence of gravel, cobbles and wood pieces.

Standard penetration tests (SPTs) with 51 mm O.D. by 38 mm I.D. split spoon sampler were conducted in DH09-01 to DH09-04 at selected depths using a 63.5 kg (140 lb) with a rope and cathead system with a drop distance of 0.76 m (30”). The number of hammer blows required to drive the sampler each 0.15 m increment was recorded. The field blow counts for the sampler penetration of 0.30 m, after initial seating penetration of 0.15 m, are plotted in the test hole logs in Appendix I.

Intact soil samples were obtained at selected depths in DH09-02 and DH09-03 using 76 mm thin-walled tubes in accordance with ASTM D1587-00 test method.

With the exception of DH09-01, continuous HQ-3 sized bedrock core samples were recovered using a triple tube core barrel system. The detailed logs of bedrock at the site are also presented in Appendix I.

2.1.1 Nilcon Field Vane Tests

Nilcon field vane tests were performed in DH09-02, DH09-03 and DH09-04 at selected (generally at depths where thin-walled tube samples were collected) to determine the undrained shear strength of the silt and clay deposits. The field vane test values are

shown in Table 2 and plotted on the right side of the borehole logs presented in Appendix I.

Table 2: Summary of Nilcon Vane Data

Drill Hole ID	Test Depth (m)	Shear Strength Su (kPa)		
		Peak	Remoulded	Residual
DH09-02 (S)	8.66	70	21	1
	9.27	45	23	15
	11.15	55	38	21
	11.76	50	31	19
	13.05	58	37	18
	13.66	>105	-	n/a
	16.31	51	31	18
	16.92	70	52	18
	20.95	68	43	19
	21.56	65	35	17
	25.55	106	73	12
	26.16	84	46	25
	27.81	>116	-	37
DH09-03 (Q)	5.68	30	27	4
	6.96	52	25	2
	12.14	81	58	23
	12.75	51	31	5
	15.47	53	33	15
	16.08	49	32	16
DH09-03 (P)	6.71	>100	-	n/a
	9.76	48	31	6
	10.37	61	48	15

Notes: 1) "-" in the Remoulded Strength column denotes the tests could not conducted because the Peak Strengths exceeded the upper limit of the size of vane used in the test.
2) Residual Strength tests not conducted at 13.66 m at DH09-02 and at 6.71 m at DH09-03 due to difficulties with the rotating vane apparatus as a result of very stiff soil.

2.2 Cone Penetration Tests

Three cone penetration tests (CPT) were carried out by Foundex of Surrey, B.C. using a track mounted HT-700 drill rig. The CPTs were performed using GEOTECH's CPT Classic Acoustic system. In an acoustic CPT system, the measured data as the cone is pushed into the soil strata is received by the transmitter and then amplified and converted into an acoustic signal that is sent through the drill rods to a surface microphone.

The cone has a tip area of 10 cm^2, friction sleeve area of 150 cm^2 and has a pushing capacity of 10 tons. It was pushed into the soil at a rate of 2 cm/second and following data was collected at 2 cm intervals: cone tip resistance (Qc), sleeve friction (Fs) and dynamic pore pressure (U). The CPT plot is presented in Appendix II.

For CPT09-02 and CPT09-03, HWT casing (114 O.D., 102 I.D.) was first lowered into the subsurface and seated in sand and gravel material within the surficial fill. Collared BQ-sized casing (60 O.D., 36.5 I.D.) was then lowered through the HWT casing to provide lateral support to the CPT rods (36 mm O.D., 16 mm I.D.) and cones through the surficial layers. At CPT09-01, HWT casing could not be lowered due to a pile stringer obstruction below the deck. With only one set of casing (BQ), very little lateral support was provided to the CPT rods and CPT09-01 was terminated at El. -16.4 m as refusal was met due to high deflection angle of the CPT tip.

CPT09-02 and CPT09-03 encountered refusal due to high tip resistance (> 25MPa) at El. -12.2 m and -5.4 m, respectively. The obstructions were drilled out and the CPT tests were carried out to the final depth at each location.

3. GROUND CONDITIONS

Based on the information obtained from the current site investigation, the stratigraphic units at the South Jetty Wharf are summarized in Section 3.1 to 3.5.

3.1 Upper Coarse-Grained Sediments

Granular materials consisting of gravel and sand were encountered as the topmost unit at all drill holes. Well-graded, angular to sub-angular gravel with some sand, various amounts of silt/clay and occasional cobbles and boulders were found in all drill holes aside from DH09-04 based on SPT samples, drill action and drill cuttings. In DH09-04, uniform, loose, fine-grained sand with trace silt was found as the top most unit. The granular material generally had organic and petroleum odour and contained various amounts of white shells, zones of black hydrocarbons and occasional timber pieces. This indicates that some portion of the upper coarse grained sediments may have been placed as fill from various historic dredging activities at EGD.

3.2 Upper Fine-Grained Sediments

Silt and clay were encountered below the surficial sand and gravels. The silt was generally low plastic, soft, with some fine-grained sand and light organic and chemical odour. The clay was generally very soft with medium to high plasticity and usually had chemical/organic odour. At DH09-02 and DH09-03, upper coarse-grained sediments were also found underlying the silt and clay, further indicating that the upper fine-grained sediments may have been placed as fill.

3.3 Victoria Clay

The Victoria clay unit consists of grey, low to medium plastic, soft to increasingly stiff clay with some silt and trace sand and gravel. Although not evident from the mud rotary drill hole samples, CPT09-02, CPT09-03, and previous sonic and CPTs boreholes

conducted in the vicinity show an approximately 2 m thick layer of stiff silty clay 'weathered crust' overlying the unweathered Victoria clay.

3.4 Till-like Deposit

Below the Victoria clay and overlying the bedrock is a discontinuous layer of till-like deposit consisting of dense to very dense, well graded sand and gravel with some silt. The till was encountered in all drill holes except DH09-01, which was terminated at shallow depth.

3.5 Bedrock

The bedrock at the site consists of greenish-grey meta-diorite of the Wark Gneiss complex. The bedrock core samples recovered from DH09-02 and DH09-03 were generally weak, moderate to highly weathered and highly fractured with zones of crushed rock and clay. The rock quality designation (RQD) of the core samples from DH09-02 and DH09-03 were between 0_% and 75 % and the total core recovery (TCR) was between 12% and 100%. The samples recovered from DH09-04 and DH09-05 were generally strong, intact and fresh to slightly weathered. The RQD and TCR of the core samples from these two drill holes were generally between 87 % and 100 %.

Core photographs are shown in Appendix III.

4. LABORATORY TESTING

Soil and rock samples obtained from the drill holes were returned to KCB's Vancouver laboratory for testing. Moisture content, Atterberg limits, consolidation and triaxial compression testing were conducted on selected soil samples. Unconfined compressive strength tests (UCS) were done on two bedrock samples. Two Shelby tube samples were sent to Golder Associates' laboratory in Burnaby for cyclic simple shear testing. The laboratory test results area summarized in Sections 4.1 to 4.5 and detailed results are included in Appendix IV.

4.1 Cyclic Simple Shear Testing

Cyclic simple shear testing was conducted by Golder Associates at their Burnaby laboratory on the following thin-walled tube samples: DH09-02 (S), 'Sy 4', collected at a depth of between 19.51 m and 20.12 m and DH09-03 (Q), 'Sy 1', collected between 23.77 m and 24.38 m. Cyclic testing results are shown in Table 3. The sample collected from DH09-02 consisted of medium plastic, firm, grey clay with trace fine sand from the Victoria Clay unit. The sample from DH09-03 had similar characteristics but had low plasticity.

4.1.1 Initial Consolidation Phase

Samples were initially consolidated to the approximate insitu vertical effective stress σ'_{vc}, in several steps, and allowed to consolidate for about 24 hours prior to shearing.

Test 1, conducted on a portion of DH09-02 (S) 'Sy 4' at about 20.0 m, was consolidated to 110 kPa and experienced about 10.5% axial strain during the consolidation phase. Test 1 was subsequently aborted due to difficulties during the cyclic loading phase. Prior to Test 2, consolidation testing of DH09-02 (S) 'Sy 3', 17.60 m to 18.06 m depth was completed which indicated that the insitu vertical stress was likely less than first

assumed. Test 2 (conducted on 'Sy 4' at about 19.8 m) was therefore consolidated to 80 kPa and experienced about 5.6% axial strain during the consolidation phase.

Test 3 (conducted on 'Sy 1' from DH09-03) was consolidated to 80 kPa and experienced about 7.8% axial strain during the consolidation phase.

4.1.2 Cyclic Loading Phase

Cyclic shear loading was applied at a frequency of 0.5 Hz with a starting cyclic stress ratio (CSR) of 0.15. Cyclic loading was continued at the starting CSR until a maximum shear strain of 3.75% was developed, or until 15 stress cycles, whichever occurred first. If the maximum shear strain was less than 3.75%, the CSR was increased by 0.05 and testing continued.

4.1.3 Post-Cyclic Monotonic Loading

Post cyclic undrained monotonic loading was commenced immediately upon completion of the above cyclic loading phase for Tests 2 and 3. Monotonic loading was carried out at a strain rate of 1.0% per hour, to a maximum of 20% strain. Monotonic loading was carried out in the opposite direction to that of the residual strain at the conclusion of the cyclic loading.

Due to a power failure during Test 2, the monotonic loading data was lost.

Table 3: Summary of 2009 Cyclic Shear Testing

Test No.	Bore Hole ID	W_C	σ'_{vc} (kPa)	Cyclic Loading Phase							Post Cyclic Tests	
				CSR = $\tau_{cyc} / \sigma'_{vc}$	0.15	0.20	0.25	0.30	γ_{max} (%)	$\Delta u_r/\sigma'_{vc}$	S_U (kPa)	γ_{peak} (%)
1	DH09-02 (S)	Aborted										
2	DH09-02 (S)	0.317	80	N	15[(a)]	15[(a)]	15[(a)]	5[(b)]	4.4	0.65[(c)]	-	-
3	DH09-03 (Q)	0.224	115	N	15[(a)]	15[(a)]	4[(b)]	-	4.4	0.71	30	12

Notes:

(a) Cyclic Loading increased to next higher CSR stage since $\gamma_{max} < 3.75\%$

(b) Liquefaction Criterion $\gamma_{max} = 3.75\%$ reached during this cyclic loading stage

(c) Visually estimated from the τ_h vs γ plots (from post-cyclic monotonic loading)

N	Number of cycles required to exceed $\gamma_{max} = 3.75\%$
γ	Horizontal Shear Strain
γ_{peak}	Horizontal Shear Strain corresponding to Su
γ_{max}	Horizontal Shear Strain during cyclic loading
Wc	Water content at end of test
Su	Peak undrained shear strength in post-cyclic loading
σ'_{vc}	Vertical effective consolidation stress
τ_{cyc}	Cyclic shear stress
Δu_r	Residual excess pore pressure at end of cyclic test

4.2 Consolidation Testing

One dimensional consolidation testing (ASTM D2435-96) was done on a thin-walled tube sample collected from DH09-02 at depths of 17.60 to 18.06 m. The sample was collected from the Victoria Clay unit and consisted of medium plastic, firm clay with trace fine sand. Table 4 summarizes the results from the consolidation test.

Table 4: Summary of 2009 Consolidation Testing

Test Pressures (kPa)		Estimated Coefficient of Consolidation, c_v (cm/sec)	Estimated Compression Index for Load Increment, C_c
From	To		
12.5	25	2.9×10^{-4}	0.07
25	50	2.3×10^{-4}	0.19
50	100	2.9×10^{-4}	0.35
100	200	3.5×10^{-4}	0.37
200	400	3.5×10^{-4}	0.34
400	800	6.6×10^{-4}	0.33
800	1600	8.8×10^{-4}	0.32

4.3 Triaxial Testing

Two consolidated undrained (CUP) triaxial tests with pore pressure measurement were conducted on thin-walled tube samples collected from DH09-02 (ASTM D4767-95). Both samples were also collected from the Victoria Clay unit and consisted of medium plastic, firm clay with trace fine sand. The sample collected from 17.60 m to 18.21 m, 'Sy 3', at DH09-02 was tested under confining pressures of 75, 150 and 225 kPa. The sample collected from 24.69 m to 25.30 m, 'Sy 6', at DH09-02 was tested under confining pressures of 150, 225 and 300 kPa. The test results are presented in Appendix IV.

4.4 Unconfined Compressive Strength Testing

Unconfined compressive strength (UCS) testing was conducted on two bedrock samples. The results are summarized in Table 5.

Table 5: Summary of 2009 UCS Testing

Drill Hole	Depth of Sample (m)	Compressive Stress (MPa)
DH09-04	25.9	76.6
DH09-05	25.6	53.7

4.5 Index Testing

Atterberg limit tests (ASTM D4138-00) were performed on two sample collected from DH09-03 and three samples from DH09-02. The results are summarized in Table 6.

Table 6: Summary of 2009 Atterberg Limit Testing

Drill Hole	Depth of Sample (m)	Liquid Limit, LL	Plastic Limit, PL	Plasticity Index, PI
DH09-02 SPT 5	17.0	42	17	26
DH09-02 Sy 3	17.6	46	17	29
DH09-02 Sy 6	24.7	40	16	24
DH09-03 SPT 3	23.2	28	13	15
DH09-03 Sy 1	23.8	25	14	11

5. LIMITATIONS AND USE OF REPORT

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Public Works and Government Services Canada for the specific application of Esquimalt Graving Dock South Jetty Wharf Development Project. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavored to comply with generally accepted geotechnical practice common to the local area. Klohn Crippen Berger makes no other warranty, express or implied.

The geotechnical investigations conducted indicate subsurface conditions only at the specific locations where samples were obtained or where in-situ tests would infer, only at the time they were obtained, and only to the depths penetrated. The samples and tests cannot be relied on to accurately reflect the nature and extent of strata variations that usually exist between sampling or testing locations.

Although Klohn Crippen Berger has explored subsurface conditions as part of this program, Klohn Crippen Berger has not evaluated the site for potential presence of contaminated soil, and has not evaluated groundwater conditions.

KLOHN CRIPPEN BERGER LTD.

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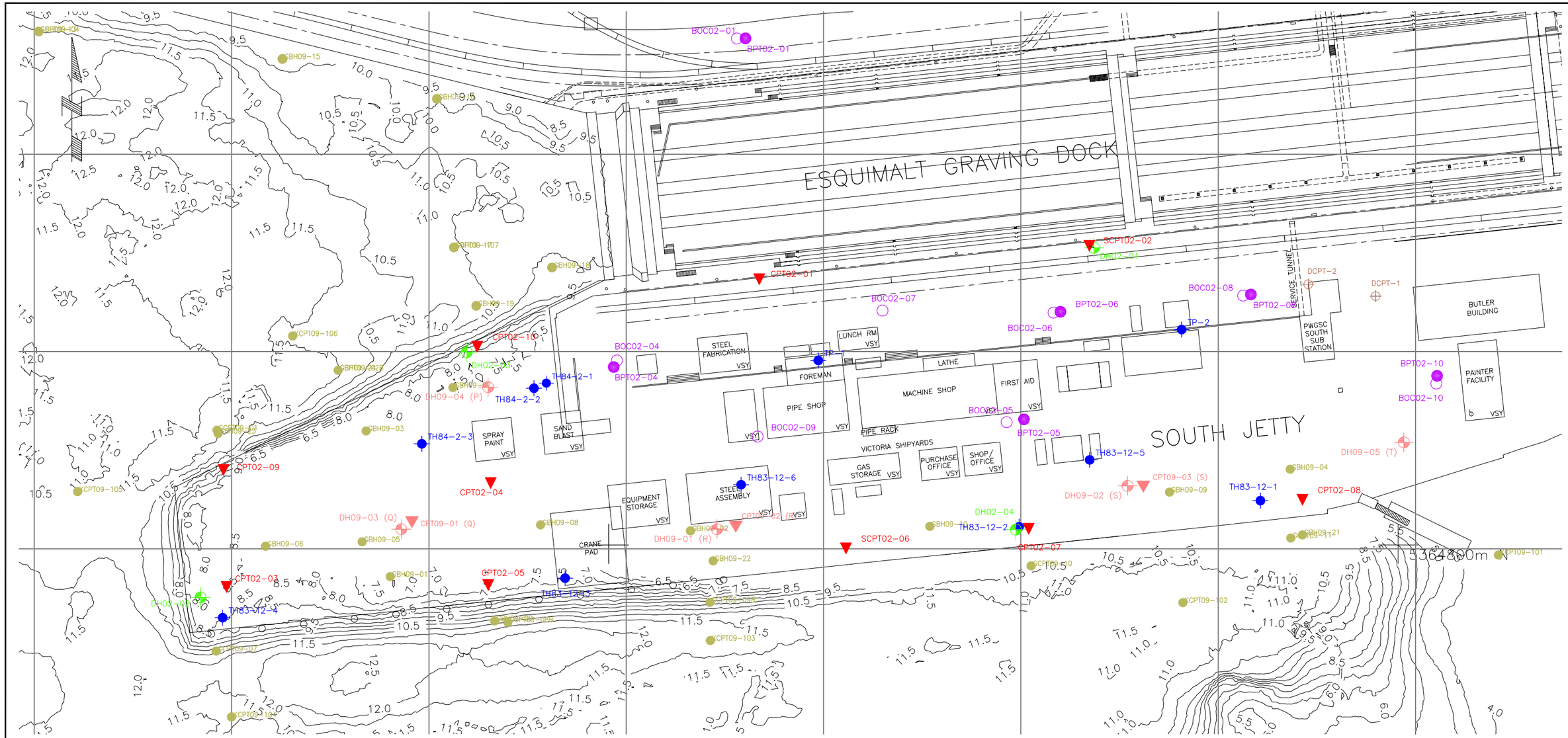


PLAN

LEGEND

- TH83-12-1 — 1983 AND 1984 TEST HOLE BY ASSOCIATED (1978) LTD.
- DCPT-1 — 1997 TEST HOLE BY TERRA ENGINEERING LTD.
- BPT02-01 — 2002 CLOSED-ENDED BECKER DRILL HOLE BY KCB.
- BOC02-01 — 2002 OPEN-ENDED BECKER DRILL HOLE BY KCB.
- DH02-01 — 2002 MUD ROTARY DRILL HOLE BY KCB.
- CPT02-01 — 2002 CONE PENETRATION TEST BY KCB.
- DH09-01 — 2009 MUD ROTARY DRILL HOLE BY KCB.
- CPT09-01 — 2009 CONE PENETRATION TEST BY KCB.
- GBH09-10 — 2009 SITE INVESTIGATION PROGRAM BY GOLDER ASSOCIATES (INCLUDING SONIC BORE HOLES, MUD ROTARY DRILL HOLES AND CONE PENETRATION TESTS)

NOTES:

1. BATHEMETRY CONTOURS (0.5m INTERVALS) PROVIDED BY CRA SURVEYS, FEBRUARY 2007.
2. DRAWING BASE INFORMATION PROVIDED BY PWGSC. LOCATION OF EXISTING FACILITIES ARE APPROXIMATE ONLY.
3. ELEVATIONS REFER TO CHART DATUM.

0 1:500 25

NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

Klohn Crippen Berger

PROJECT
ESQUIMALT GRAVING DOCK
SOUTH JETTY WHARF DEVELOPMENT

TITLE
DRILL HOLE LOCATION PLAN

PROJECT No.	DWG. No.	REV.
P09614A01	FIGURE 1	

CANCEL PRINTS BEARING PREVIOUS

APPENDIX I

2009 Drill Hole Logs

DRILL HOLE LOG DH09-01 (R)

STARTED: 14 Oct 2009 **FINISHED:** 15 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 5.20

COORDINATES (m): N 5364805 E 468423

Su - kPa: 20 60 100 140 180

VANE PEAK ◆ FIELD ■ LAB ▲ UC/2 △ P.PEN/2 REMOLD ◇ □ ★ % FINES

● SPT N BECKER or DPT (Blows / 0.3m)

W_P% W% W_L% : 20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					Space below deck. Tide levels varied during drilling.	
8.84 / -3.64						
9	7 6 5		SPT 1		Gravel (GW), fine, trace fine to medium sand, angular with trace rounded pieces, loose, wet. [Upper Coarse-Grained Sediment]	
13.41 / -8.21						
14	9 7 7		SPT 2		Sand (SW), coarse wtih some fine and medium, trace fine gravel < 1.5 cm, dark grey, compact, wet. [Upper Coarse-Grained Sediment]	
14.02 / -8.82					End of Hole at 14.05 m	

Hole terminated at 14.05 m due to difficulties with the SW casing.

1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.

2. The hole was not backfilled due to the loose nature of the upper coarse-grained sediments.

3. Standard penetration tests (SPT) were conducted using an automatic trip hammer (63.5 kg, 762 mm drop), AWJ rods, and a split spoon sampler (51mm O.D., 38mm I.D.).

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: AW **CHECKED BY:** AP / SRA

SHEET 1 **OF** 1 **HOLE NO.:** **DH09-01 (R)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-02 (S)

STARTED: 15 Oct 2009 **FINISHED:** 20 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 5.20

COORDINATES (m): N 5364817 E 468531

Su - kPa: 20 60 100 140 180

VANE PEAK ◆ FIELD ■ LAB ▲ UC/2 △ P.PEN/2 ★ % FINES

REMOLD ◇ □

● SPT N BECKER or DPT (Blows / 0.3m)

W_P% W% W_L%: 20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					Space below deck. Tide levels varied during drilling.	
9.45 / -4.25					Gravel (GW), fine, angular to subrounded, with wood fragments and black hydrocarbon. [Upper Coarse-Grained Sediments]	
12.19 / -6.99	1 1 0		SPT 1		CLAY (CI-CH) trace silt, medium to high plasticity, very soft, grey, light chemical odour, moist. [Upper Fine-Grained Sediments]	
12.65 / -7.45			Sy 1		SILT (ML) some fine sand, low plastic, soft, black, light chemical odour, moist. [Upper Fine-Grained Sediments]	
13.97 / -8.77	2 3 3		SPT 2		SAND (SP) medium with some fine, uniform graded, loose, grey, wet. [Upper Coarse-Grained Sediments]	
15.55 / -10.35	1 2 1		SPT 3		CLAY (CI) some fine sand, medium plasticity, firm, grey, wet. [Upper Fine-Grained Sediments]	
17.04 / -11.84	1 2 2		SPT 5		CLAY (CI) trace fine sand, medium plasticity, soft, grey, wet, rapid dilatancy. [Victoria Clay]	
			Sy 3		One dimensional consolidation testing and Consolidated Undrained triaxial test (with pore pressure measurement) conducted on Sy 3	
			Sy 4		Cyclic Simple Shear test conducted on Sy 4	

Continued Next Page

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: AW **CHECKED BY:** AP / SRA

SHEET 1 **OF** 3 **HOLE NO.:** **DH09-02 (S)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-02 (S)

STARTED: 15 Oct 2009 **FINISHED:** 20 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 5.20

COORDINATES (m): N 5364817 E 468531

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
21					CLAY (CI) trace fine sand, medium plasticity, firm, grey, wet, rapid dilatancy. [Victoria Clay]	
22			Sy 5			
23						
24						
25			Sy 6		Consolidated undrained triaxial test (with pore pressure measurement) conducted on Sy 6.	
26						
27						
28						
29						
30			Sy 7			
31						
32						
33						
34			Sy 8			
35						
36						
37			Sy 9			
38					37.77 -32.57 SAND (SW) medium with some fine and coarse, trace subangular gravel up to 40mm, well-graded, very dense, grey, wet. [Till-like]	
39	14 30 60		SPT 6			
40					39.90 Continued Next Page	

Su - kPa

20 60 100 140 180

VANE PEAK ◆ FIELD ◆ LAB ■ REMOLD ◇ □ ▲ UC/2 △ P.PEN/2 ★ % FINES

● SPT N BECKER or DPT (Blows / 0.3m)

W_P% W% W_L%

20 40 60 80

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: AW **CHECKED BY:** AP / SRA

 HOLE NO.: **DH09-02 (S)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-02 (S)

STARTED: 15 Oct 2009 **FINISHED:** 20 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 5.20

COORDINATES (m): N 5364817 E 468531

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
41	33 39 28		SPT 7		-34.70 SAND (SW) fine with some medium and trace coarse, some angular to subrounded gravel, trace clay, well-graded, dense, grey, wet.	
42	17 18 9		SPT 8		41.35 -36.15 41.70 -36.50 SAND (SW) coarse grained with trace fine grained, some angular gravel, well-graded, compact to dense, grey, wet.	
43	8 16 22		SPT 9		SAND (SW) fine grained, some silt and clay, trace gravel, gap-graded, loose to compact, light grey, wet. [Till-like]	
44	20 12 10		SPT 10		44.50 -39.30 SAND (SW) medium with some fine and coarse, well-graded, compact, grey, wet.	
45					45.84 -40.64 META-DIORITE, greenish-grey, fine-grained, highly weathered, highly fractured with zones of crushed rock and clay. TCR: 86% - 100%. RQD: 0% - 18%. [Wark Gneiss]	
46						
47						
48						
49						
50					50.29 -45.09 End of Hole at 50.29 m	
51						
52						
53						
54						
55						
56						
57						
58						
59						
60						

Su - kPa

20 60 100 140 180

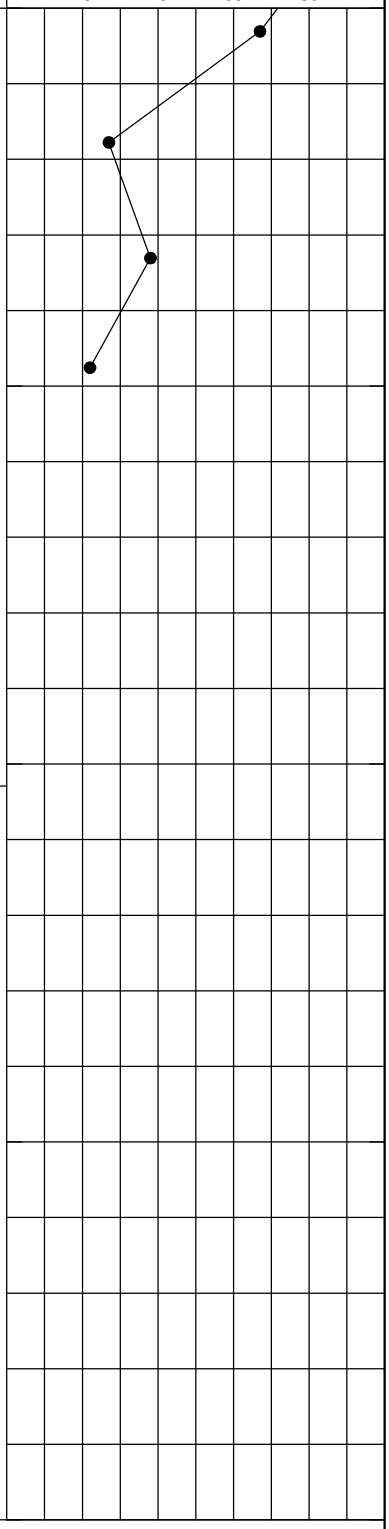
VANE PEAK ◆ FIELD ■ LAB ▲ UC/2 △ P.PEN/2

REMOLD ◇ □ ★ % FINES

● SPT N BECKER or DPT (Blows / 0.3m)

W_P% W% W_L%

20 40 60 80



1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.

2. SW casing (168mm O.D., 152mm I.D.) seated at about 10 m. HW (114mm O.D., 102mm I.D) mud rotary drilling with casing advancer system from 9.45 m to 45.84 m. HQ-3 (96mm O.D., 63.5mm I.D.) diamond coring from 45.84 to 50.29 m.

3. The hole was backfilled with using premixed grout mix, GROUT-WELL®DF to about 3 m below the interface between upper coarse/fine-grained sediments and Victoria Clay.

4. Standard penetration tests (SPT) were conducted using an automatic trip hammer (63.5 kg, 762 mm drop), AWJ rods, and a split spoon sampler (51mm O.D., 38mm I.D.).
* 0 blows indicates that the sampler was advanced from the weight of the hammer.

5. Field vane tests conducted using Nilcon Field Vane.

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: AW **CHECKED BY:** AP / SRA

SHEET 3 **OF** 3 **HOLE NO.:** **DH09-02 (S)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-03 (Q)

STARTED: 20 Oct 2009 **FINISHED:** 23 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 5.20

COORDINATES (m): N 5364805 E 468343

Su - kPa: 20 60 100 140 180

VANE PEAK ◆ FIELD ■ LAB ▲ UC/2 △ P.PEN/2
REMOLD ◇ FIELD □ LAB ★ % FINES

● SPT N BECKER or DPT (Blows / 0.3m)

W_P% W% W_L%

20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					Space below deck. Tide levels varied during drilling.	
12.80 / -7.60					Gravel (GW), some silt, sand and clay, trace cobbles and boulders, angular to subangular, strong organic and petroleum odour, some white shells. (Inferred from drilling action and drill cuttings.) [Upper Coarse-Grained Sediments]	
17.42 / -12.22	0		SPT 1		SILT (ML) some fine sand, low plastic, very soft, dark green, strong petroleum and organic odour, wet, trace white shells. [Upper Fine-Grained Sediments]	
	0		SPT 2			
					Continued Next Page	

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: AW **CHECKED BY:** AP / SRA

SHEET 1 **OF** 4 **HOLE NO.:** **DH09-03 (Q)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-03 (Q)

STARTED: 20 Oct 2009 **FINISHED:** 23 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 5.20

COORDINATES (m): N 5364805 E 468343

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
21					21.33	
22					-16.13 Gravel (GW), similar to 12.8 m with timber pieces and zones of black hydrocarbon (as observed from drilling fluid return). [Upper Coarse-Grained Sediments]	
23					23.16	
24	2 3 4		SPT 3 Sy 1		-17.96 SILT (ML) some clay, trace coarse sand and fine gravel, low plasticity, firm, grey, light petroleum odour, moist. [Victoria Clay] Cyclic Simple Shear test conducted on Sy 1	
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40					Continued Next Page	

Su - kPa

20 60 100 140 180

VANE PEAK ◆ FIELD ■ LAB ▲ UC/2 △ P.PEN/2 ★ % FINES

REMOLD ◇ □

● SPT N BECKER or DPT (Blows / 0.3m)

W_P% W% W_L%

20 40 60 80

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: AW **CHECKED BY:** AP / SRA

SHEET 2 **OF** 4 **HOLE NO.:** **DH09-03 (Q)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-03 (Q)

STARTED: 20 Oct 2009 **FINISHED:** 23 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 5.20

COORDINATES (m): N 5364805 E 468343

Su - kPa: 20 60 100 140 180

VANE PEAK ▲ UC/2 △ P.PEN/2 ★ % FINES

FIELD ◆ ◇ LAB ■ □

● SPT N BECKER or DPT (Blows / 0.3m)

W_P% W% W_L% : 20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					SILT (ML), continued from previous page.	
46	3		SPT 4		46.10 -40.90 SAND (SW) medium with some fine and coarse, trace fine gravel, well graded, dense, grey, wet.	
47	11 26				47.46 -42.26 SAND (SW) fine with trace medium and coarse, trace silt and some gravel, well-graded, very dense, grey, wet. [Till-like]	
48	13 57 62		SPT 5			
49	9		SPT 6			
50	36 91					
51	23 49 53		SPT 7			
52	1		SPT 8			
53	40 130					
54	29		SPT 9			
55	30 44					
56	239		SPT10		55.70 -50.50 META-DIORITE, greenish-grey, fine-grained, very weak, highly weathered, highly fractured with zones of crushed rock and clay. TCR: 12% - 75%. RQD: 0% - 89%. [Wark Gneiss]	
57	8		SPT 11			
58	40 112					
59	180 183/10cm		SPT 12			
60	141		SPT 13		Continued Next Page	

DRILL HOLE LOG DH09-03 (Q)

STARTED: 20 Oct 2009 **FINISHED:** 23 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 5.20

COORDINATES (m): N 5364805 E 468343

Su - kPa: 20 60 100 140 180

VANE PEAK / REMOLD — FIELD ◆ ◇ LAB ■ □ — ▲ UC/2 △ P.PEN/2 ★ % FINES

● SPT N — BECKER or DPT (Blows / 0.3m)

W_P% W% W_L% : 20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
61						
62						
63						
64					64.00 -58.80 End of Hole at 64.00 m	
65						
66						
67						
68						
69						
70						
71						
72						
73						
74						
75						
76						
77						
78						
79						
80						

1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.

2. SW casing (168mm O.D., 152mm I.D.) seated at about 14 m. HW (114mm O.D., 102mm I.D) mud rotary drilling with casing advancer system from 12.80 m to 55.70 m. HQ-3 (96mm O.D., 63.5mm I.D.) diamond coring from 55.70 to 64.00 m.

3. The hole was backfilled with using premixed grout mix, GROUT-WELL®DF to about 3 m below the interface between upper coarse/fine grained sediments and the Victoria Clay.

4. Standard penetration tests (SPT) were conducted using an automatic trip hammer (63.5 kg, 762 mm drop), AWJ rods, and a split spoon sampler (51mm O.D., 38mm I.D.).
* 0 blows indicates that the sampler was advanced from the weight of the hammer.

5. Field vane tests conducted using Nilcon Field Vane.

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: AW **CHECKED BY:** AP / SRA

SHEET 4 **OF** 4 **HOLE NO.:** **DH09-03 (Q)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-04 (P)

STARTED: 24 Oct 2009 **FINISHED:** 25 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 4.90

COORDINATES (m): N 5364841 E 468365

Su - kPa: 20 60 100 140 180

VANE PEAK ◆ FIELD ■ LAB ▲ UC/2 △ P.PEN/2 ★ % FINES

REMOLD ◇ □

● SPT N BECKER or DPT (Blows / 0.3m)

W_P% W% W_L% : 20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					Space below deck. Tide levels varied during drilling.	
12					12.50	
13					-7.60 SAND (SP), fine, trace silt, poorly graded, loose to compact, rounded, grey, some shells [Upper Coarse-Grained Sediment]	
14						
15					Zone of black hydrocarbons inferred from drill fluid return.	
16	3 1 2		SPT 1			
17	6 5 6		SPT 2			
18					17.99 -13.09 CLAY (CI), some silt, trace to some sand, medium plastic, stiff, grey, organic odour. (Inferred from drill action, drilling fluid return and samples collected off of the blades of field vane). [Victoria Clay]	
19						
20					Continued Next Page	

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: JW **CHECKED BY:** AP / SRA

SHEET 1 **OF** 2 **HOLE NO.:** **DH09-04 (P)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-04 (P)

STARTED: 24 Oct 2009 **FINISHED:** 25 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 4.90

COORDINATES (m): N 5364841 E 468365

Su - kPa: 20 60 100 140 180

VANE PEAK ◆ FIELD ■ LAB ▲ UC/2 △ P.PEN/2 ★ % FINES

REMOLD ◇ □

● SPT N

BECKER or DPT (Blows / 0.3m)

W_P% W% W_L%

20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
21						
22						
23					23.17	
	75		SPT 3		-18.27 SAND (SW), silty, some gravel, some cobbles, grey, very dense. [Till-like]	
	100				-18.58	
24					METADIORITE, greenish-grey, fine-medium grained, weak, highly chlorite altered, slightly to moderately weathered. TCR: 81% - 87%. RQD: 84% - 86%. [Wark Gneiss]	
25						
26					Unconfined compressive strength (UCS) testing conducted on bedrock sample collected from 25.9 m	
27					26.89 -21.99 METADIORITE, Greenish-grey, fine to medium-grained, high strength, slight chlorite alteration, fresh to slightly weathered. TCR: 100%. RQD: 97%. [Wark Gneiss]	
28					27.74 -22.84 End of Hole at 27.70 m	
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.

2. HW (114mm O.D., 102mm I.D) mud rotary drilling from 12.50 m to 23.48 m. HQ-3 (96mm O.D., 63.5mm I.D.) diamond coring from 23.48 to 27.70 m.

3. The hole was backfilled with using premixed grout mix, GROUT-WELL®DF to about 3 m below the interface between upper coarse/fine grained sediments and the Victoria Clay.

4. Standard penetration tests (SPT) were conducted using an automatic trip hammer (63.5 kg, 762 mm drop), AWJ rods, and a split spoon sampler (51mm O.D., 38mm I.D.).
* 0 blows indicates that the sampler was advanced from the weight of the hammer.

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: JW **CHECKED BY:** AP / SRA

SHEET 2 **OF** 2 **HOLE NO.:** **DH09-04 (P)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-05 (T)

STARTED: 25 Oct 2009 **FINISHED:** 26 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 4.80

COORDINATES (m): N 5364827 E 468597

Su - kPa: 20 60 100 140 180

VANE PEAK / REMOLD — FIELD ◆ ◇ LAB ■ □ — ▲ UC/2 △ P.PEN/2 ★ % FINES

● SPT N — BECKER or DPT (Blows / 0.3m)

W_P% W% W_L% — 20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					Space below deck. Tide levels varied during drilling.	
4					4.27 (0.53) SAND (SW), gravely, some boulders. (Inferred from drill action and drilling fluid return). [Upper Coarse-Grained Sediments]	
8					8.54 (-3.74) SILT (ML), some clay, trace sand, grey. (Inferred from drill action and drilling fluid return). [Victoria Clay]	
20					Continued Next Page	

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

LOGGED BY: JW **CHECKED BY:** AP / SRA

SHEET 1 **OF** 2 **HOLE NO.:** **DH09-05 (T)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

DRILL HOLE LOG DH09-05 (T)

STARTED: 25 Oct 2009 **FINISHED:** 26 Oct 2009

DRILL METHOD: Mud Rotary

GROUND ELEV. (m): 4.80

COORDINATES (m): N 5364827 E 468597

Su - kPa: 20 60 100 140 180

VANE PEAK / REMOLD — FIELD ◆ ◇ LAB ■ □ — ▲ UC/2 △ P.PEN/2 ★ % FINES

● SPT N — BECKER or DPT (Blows / 0.3m)

W_P% W% W_L% — 20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
21					21.04 / -16.24 SAND (SW), some clay and silt, some gravel, grey, dense. (Inferred from drill action and drilling fluid return). [Till-like]	
22						
23					22.87 / -18.07 METADIORITE, greenish-grey, fine grained, very hard, fresh, slight chlorite alteration with trace pyrite crystals. TCR: 100%. RQD: 87% - 100%. [Wark Gneiss]	
24						
25						
26					Unconfined compressive strength (UCS) testing conducted on bedrock sample collected from 25.6 m.	
27					26.52 / -21.72 End of Hole at 26.52 m	
28					1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.	
29					2. HW (114mm O.D., 102mm I.D) mud rotary drilling from 4.27 m to 22.87 m. HQ-3 (96mm O.D., 63.5mm I.D.) diamond coring from 22.87 to 26.52 m.	
30					3. The hole was backfilled with using premixed grout mix, GROUT-WELL®DF to about 3 m below the interface between upper coarse/fine grained sediments and the Victoria Clay.	
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

Klohn Crippen Berger

PROJECT NO.: P09614A01

PROJECT: EGD South Jetty Wharf Development

LOCATION: Esquimalt Graving Dock, Esquimalt, BC

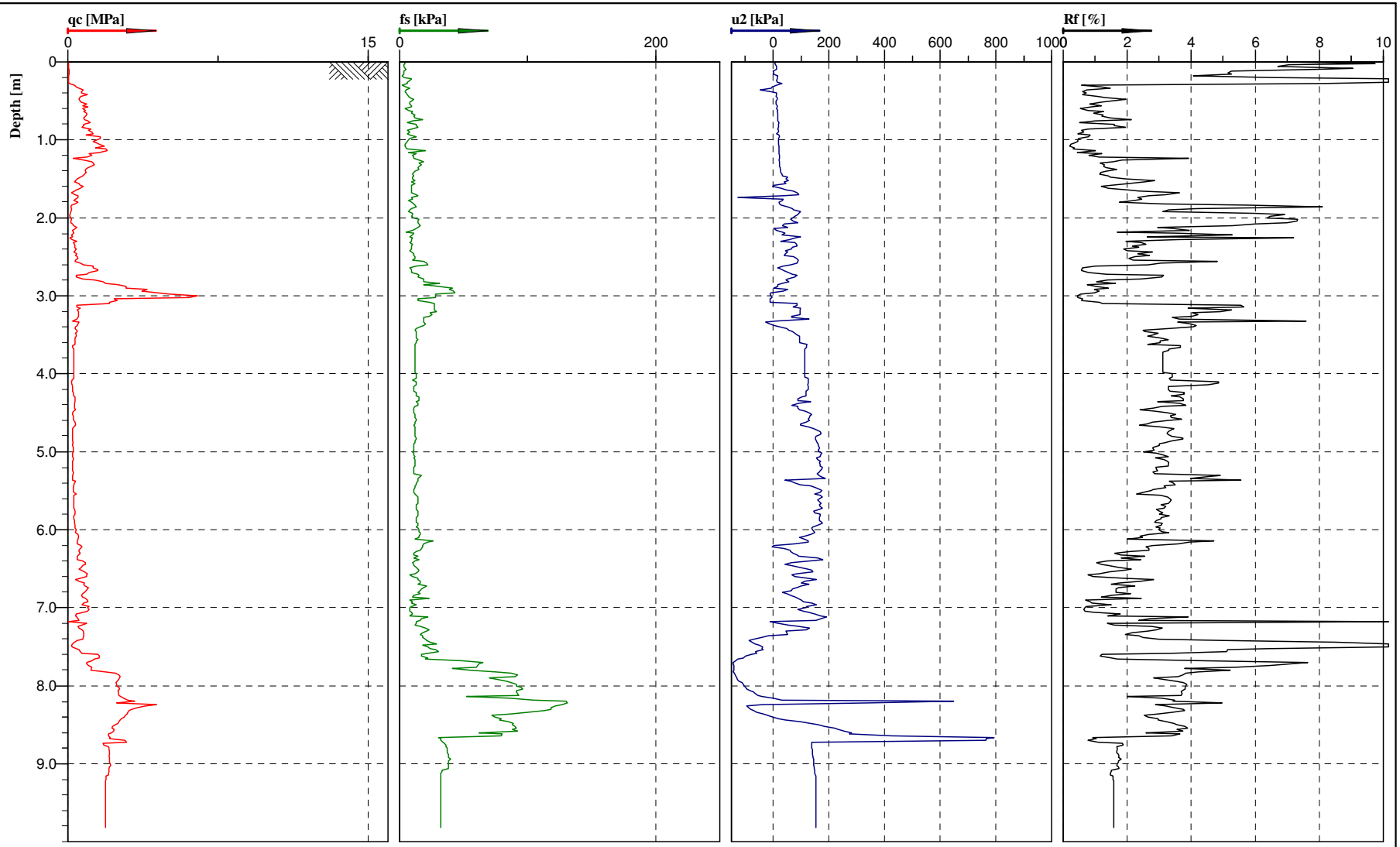
LOGGED BY: JW **CHECKED BY:** AP / SRA

SHEET 2 **OF** 2 **HOLE NO.:** **DH09-05 (T)**

KCBL_DRILL_HOLE-SI EGD FIELD LOGS.GPJ KC_DATA.GDT 3/23/10

APPENDIX II

2009 Cone Penetration Test Logs

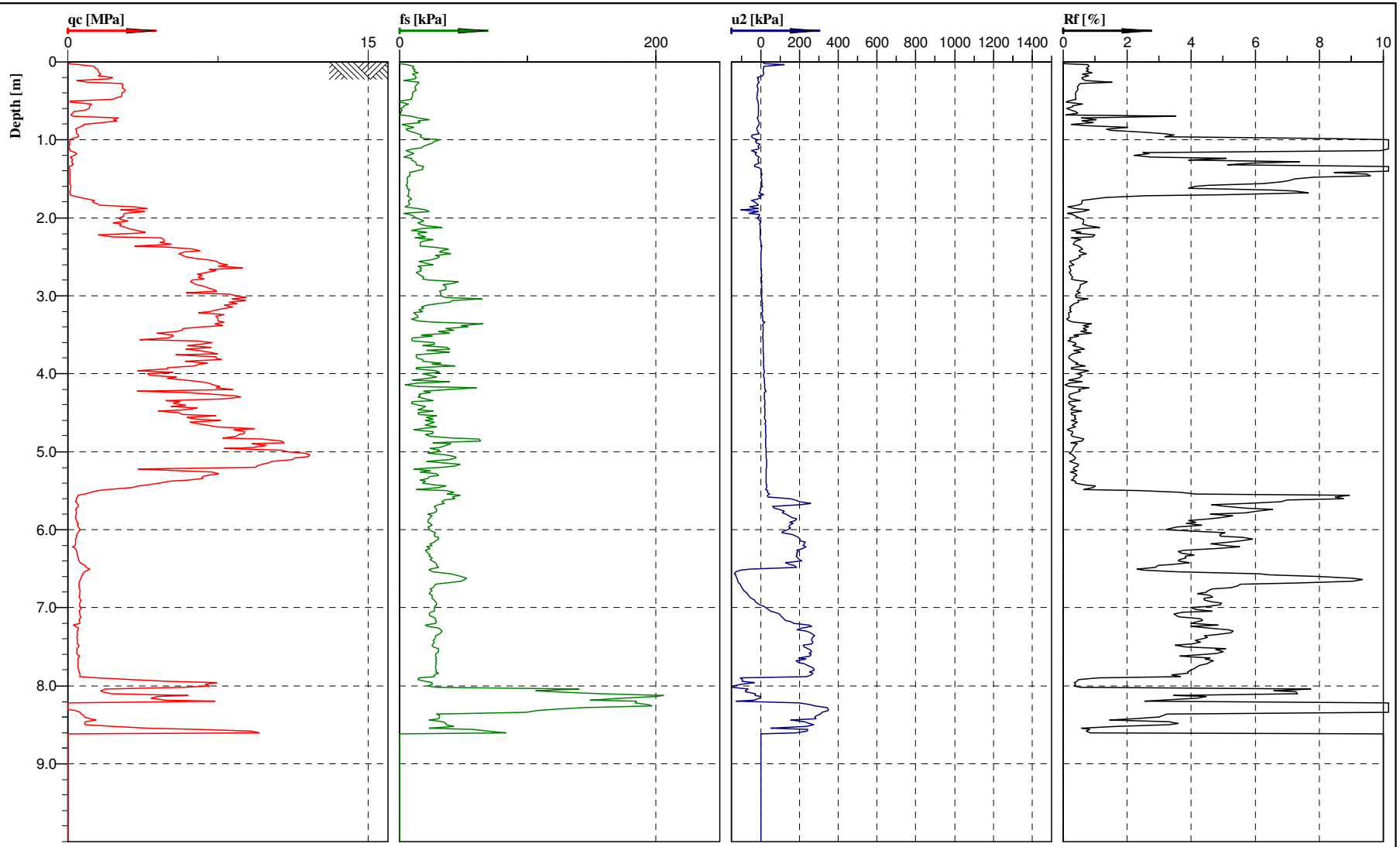


FOUNDEX

U2

Cone No: 3549
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Esquimalt (South jetty)	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: A
Project ID: 2090	Client: KCBL	Date: 10/8/2009	Scale: 1 : 75
Project: Graving Dock investigation		Page: 1/1	Fig:
Push terminated due to casing bowage in unsupported column from mud line to deck		File: CPT09-01 (Q)	

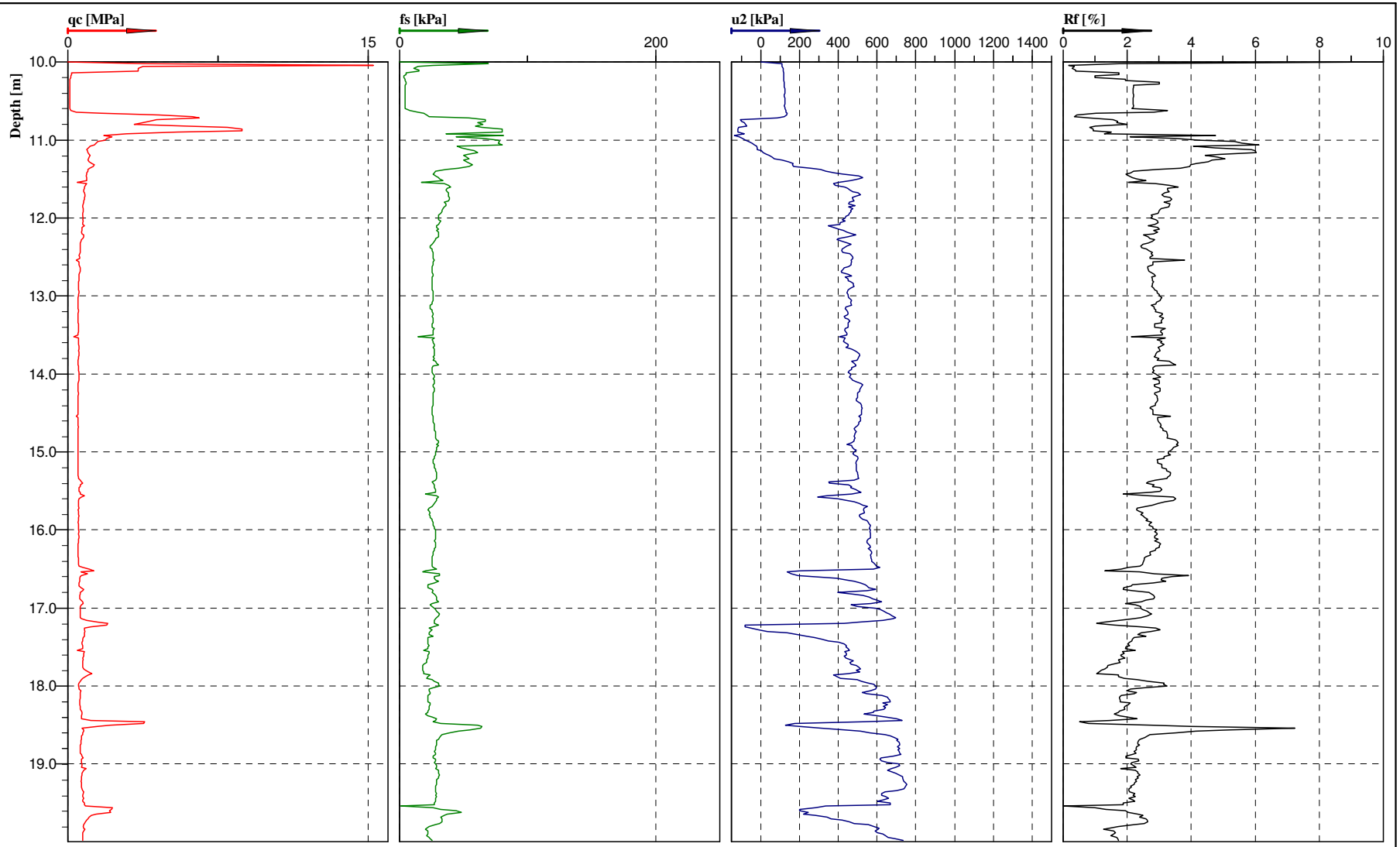


FOUNDEX

U2

Cone No: 3549
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Esquimalt (South jetty)	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: A
Project ID: 2090	Client: KCBL	Date: 10/9/2009	Scale: 1 : 75
Project: Graving Dock investigation		Page: 1/3	Fig:
Pushed to refusal on tilt in fill,Gap in data(8.6M - 10M) is drill out through bolder/blast rock (cored).		File: CPT09-02 (R)	

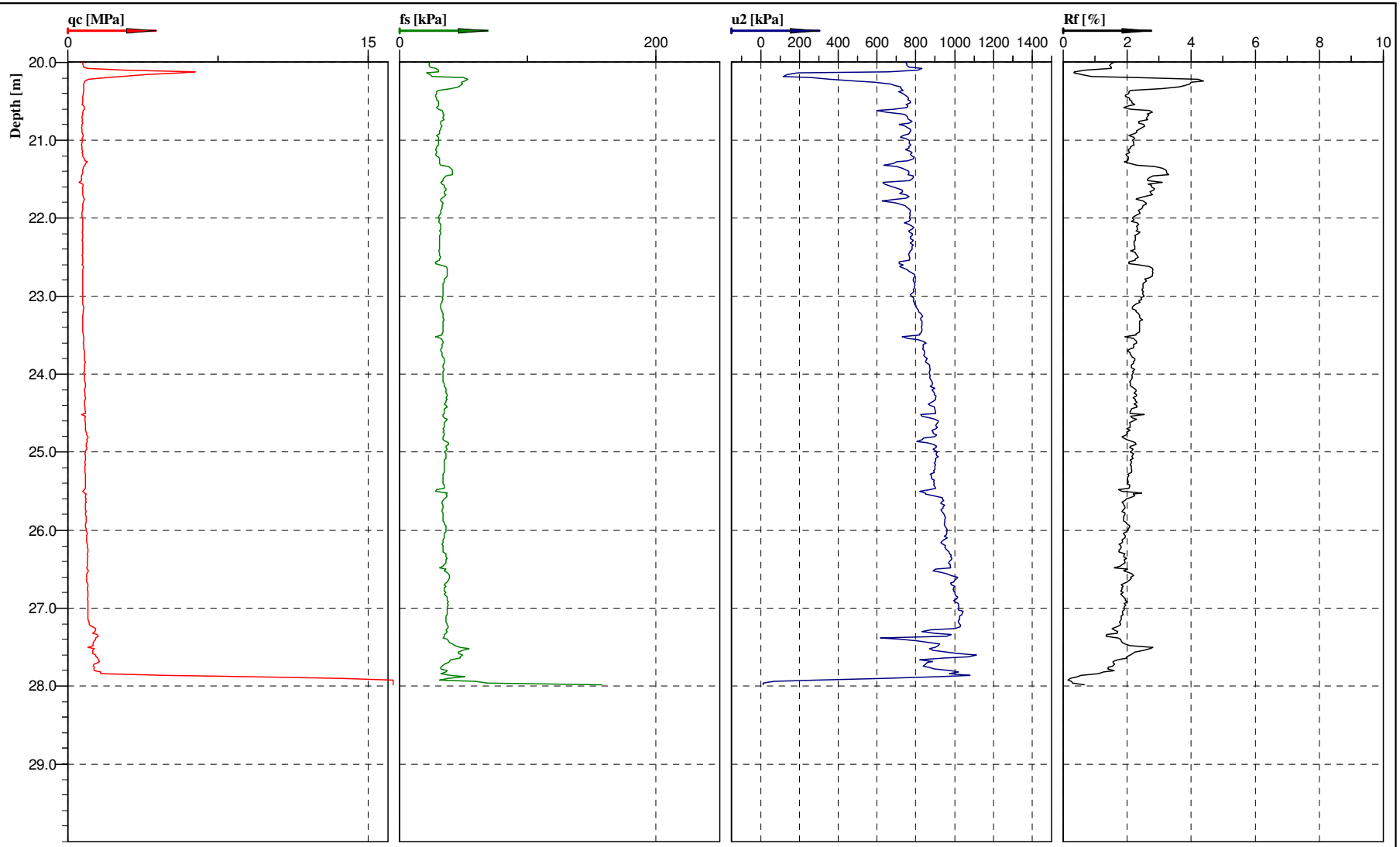


FOUNDEX

U2

Cone No: 3549
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Esquimalt (South jetty)	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: A
Project ID: 2090	Client: KCBL	Date: 10/9/2009	Scale: 1 : 75
Project: Graving Dock investigation		Page: 2/3	Fig:
Pushed to refusal on tilt in fill,Gap in data(8.6M - 10M) is drill out through bolder/blast rock (cored).		File: CPT09-02 (R)	

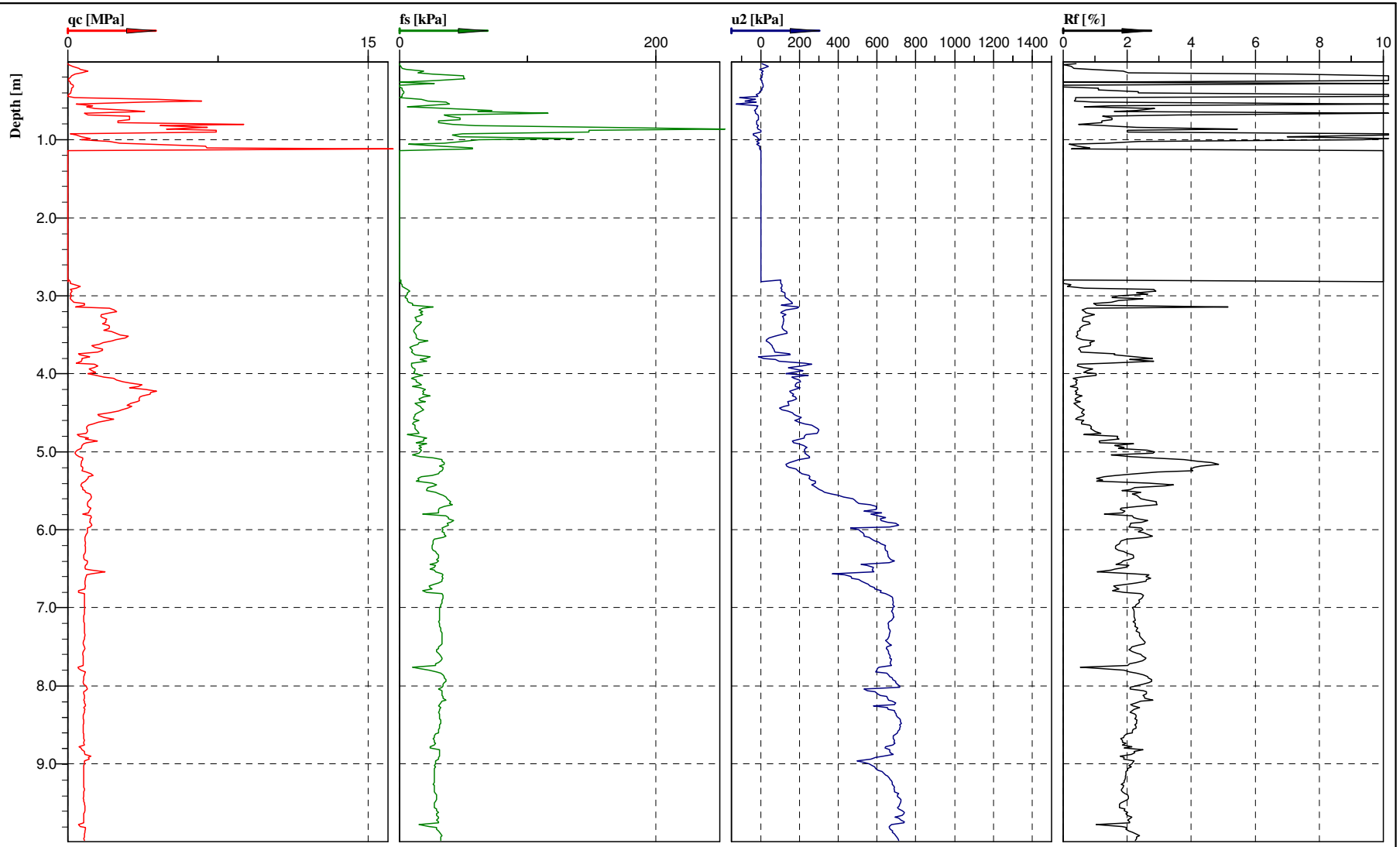


FOUNDEX

U2

Cone No: 3549
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Esquimalt (South jetty)	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: A
Project ID: 2090	Client: KCBL	Date: 10/9/2009	Scale: 1 : 75
Project: Graving Dock investigation		Page: 3/3	Fig:
Pushed to refusal on tilt in fill,Gap in data(8.6M - 10M) is drill out through bolder/blast rock (cored).		File: CPT09-02 (R)	

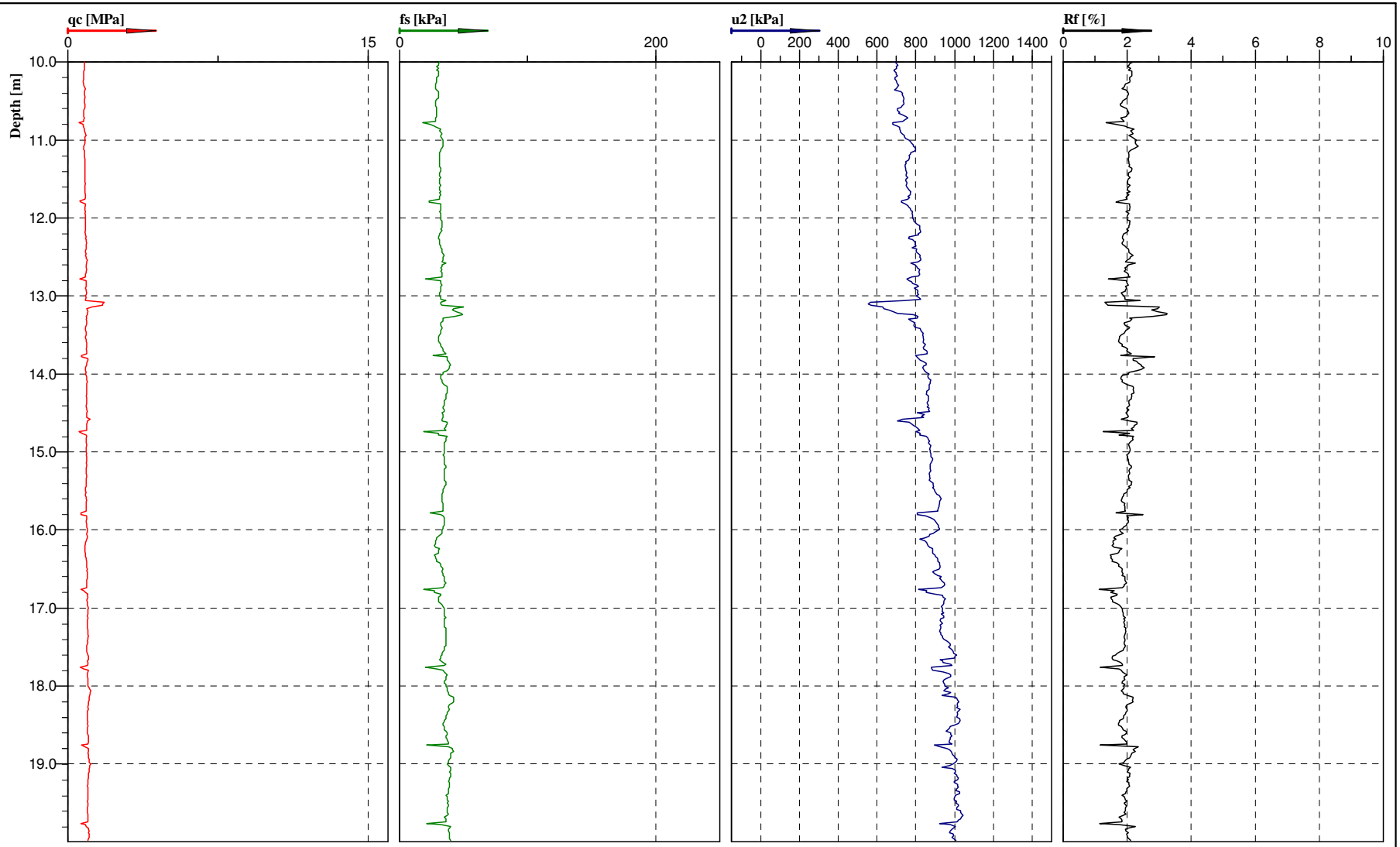


FOUNDEX

U2

Cone No: 3549
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Esquimalt (South jetty)	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: A
Project ID: 2090	Client: KCBL	Date: 10/10/2009	Scale: 1 : 75
Project: Graving Dock investigation		Page: 1/3	Fig:
Gap in data (1.2M - 2.8M)is drill out of rocky fill after refusal		File: CPT09-03 (S)	

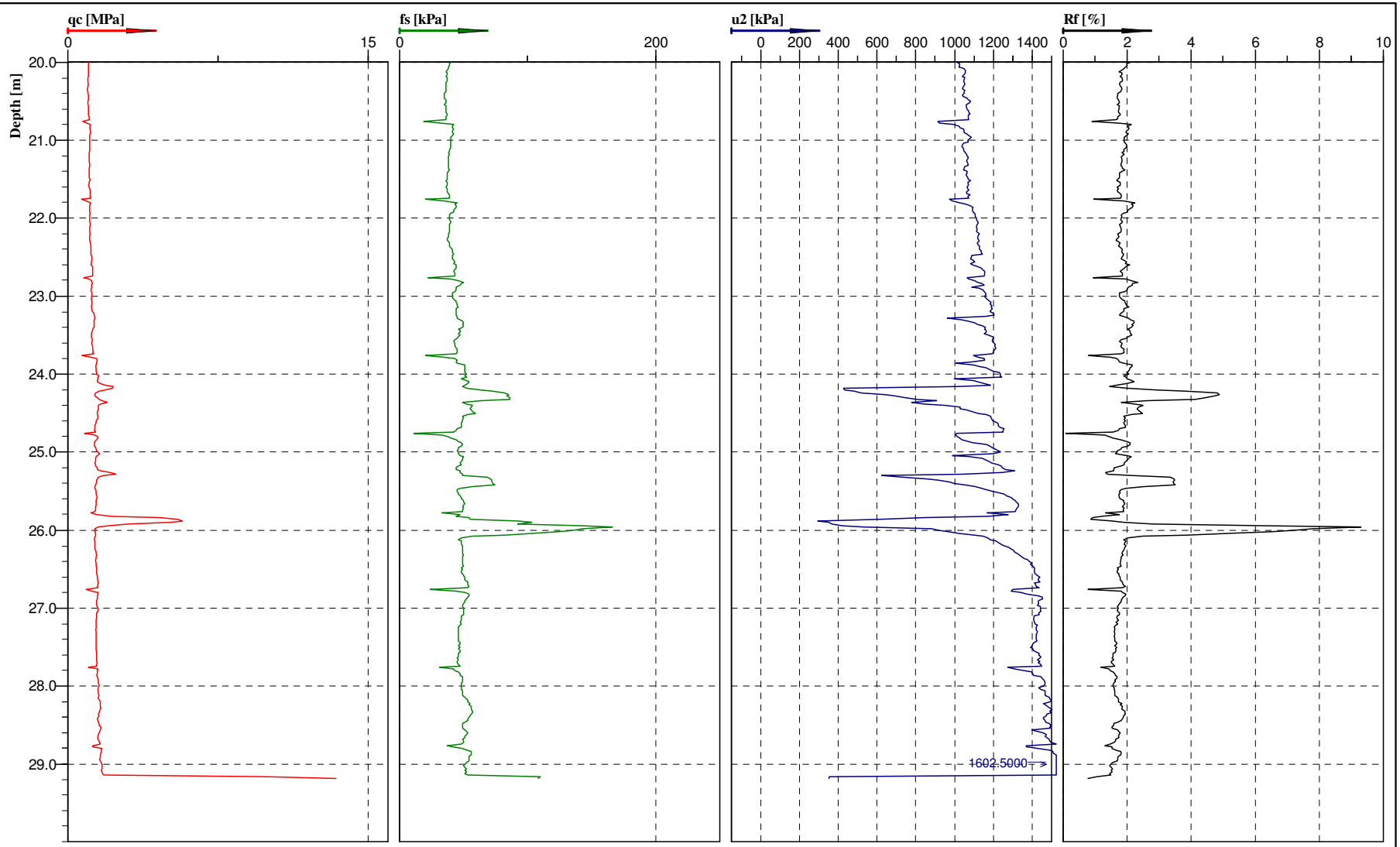


FOUNDEX

U2

Cone No: 3549
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Esquimalt (South jetty)	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: A
Project ID: 2090	Client: KCBL	Date: 10/10/2009	Scale: 1 : 75
Project: Graving Dock investigation		Page: 2/3	Fig:
Gap in data (1.2M - 2.8M)is drill out of rocky fill after refusal		File: CPT09-03 (S)	



FOUNDEX

U2

Cone No: 3549
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Esquimalt (South jetty)	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: A
Project ID: 2090	Client: KCBL	Date: 10/10/2009	Scale: 1 : 75
Project: Graving Dock investigation		Page: 3/3	Fig:
Gap in data (1.2M - 2.8M)is drill out of rocky fill after refusal		File: CPT09-03 (S)	

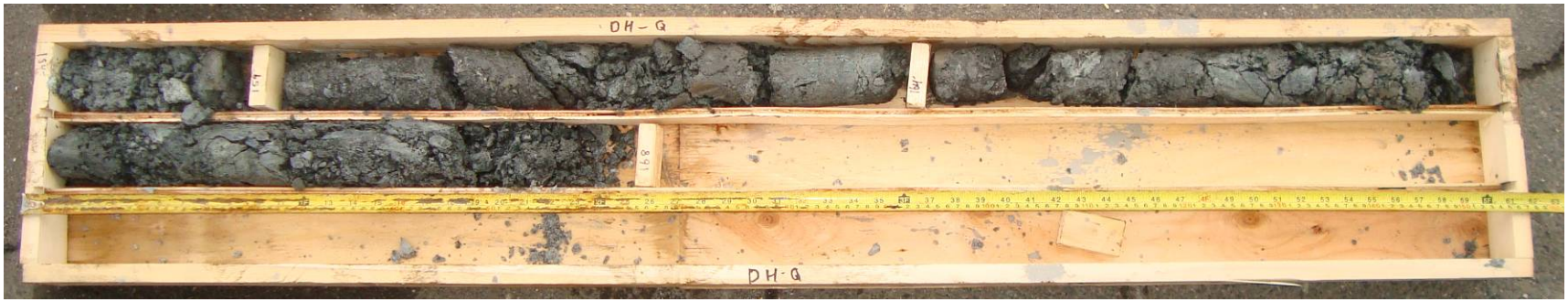
APPENDIX III

Photographs

Core Photographs

DH09-02 (S): From 45.84 m to 50.29 m

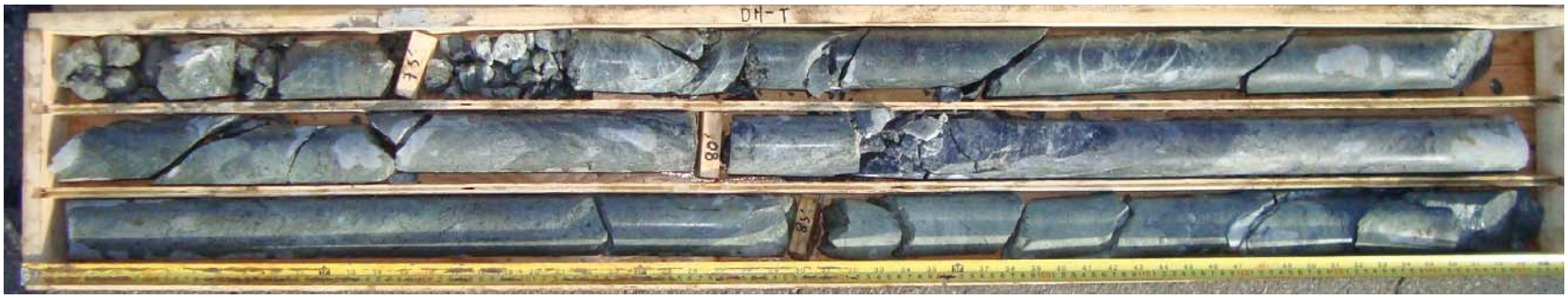
DH09-03 (Q): From 59.73 m to 64.00 m



Core Photographs

DH09-04 (P): From 23.47 m to 27.74 m

DH09-05 (T): From 22.87 m to 26.52 m



Site Photographs

DH09-01 (R)

Site Photographs

DH09-02 (S)

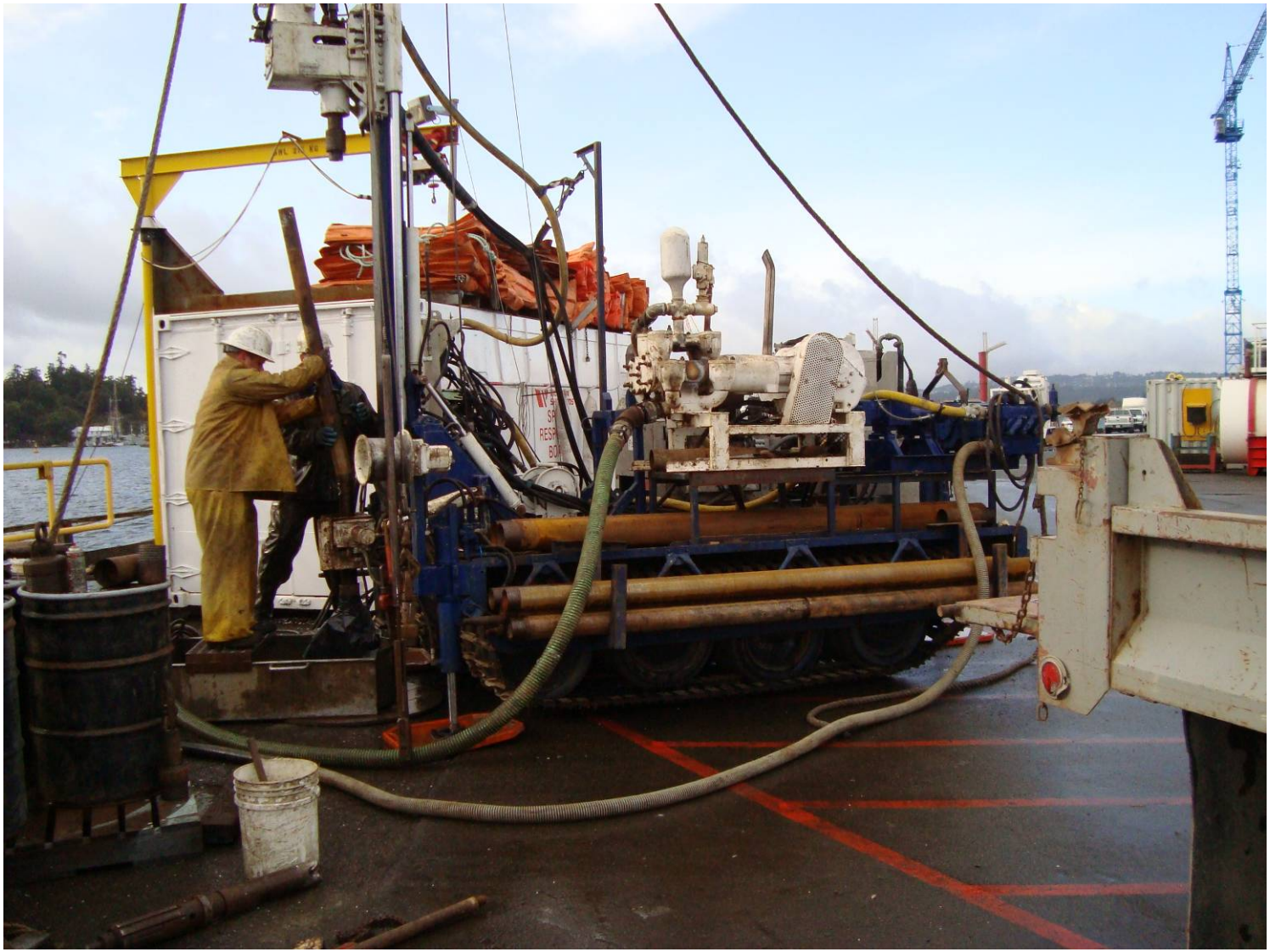
Site Photographs

DH09-03 (Q)

Site Photographs

DH09-04 (P)

Site Photographs



DH09-05 (T)

APPENDIX IV

Laboratory Test Data

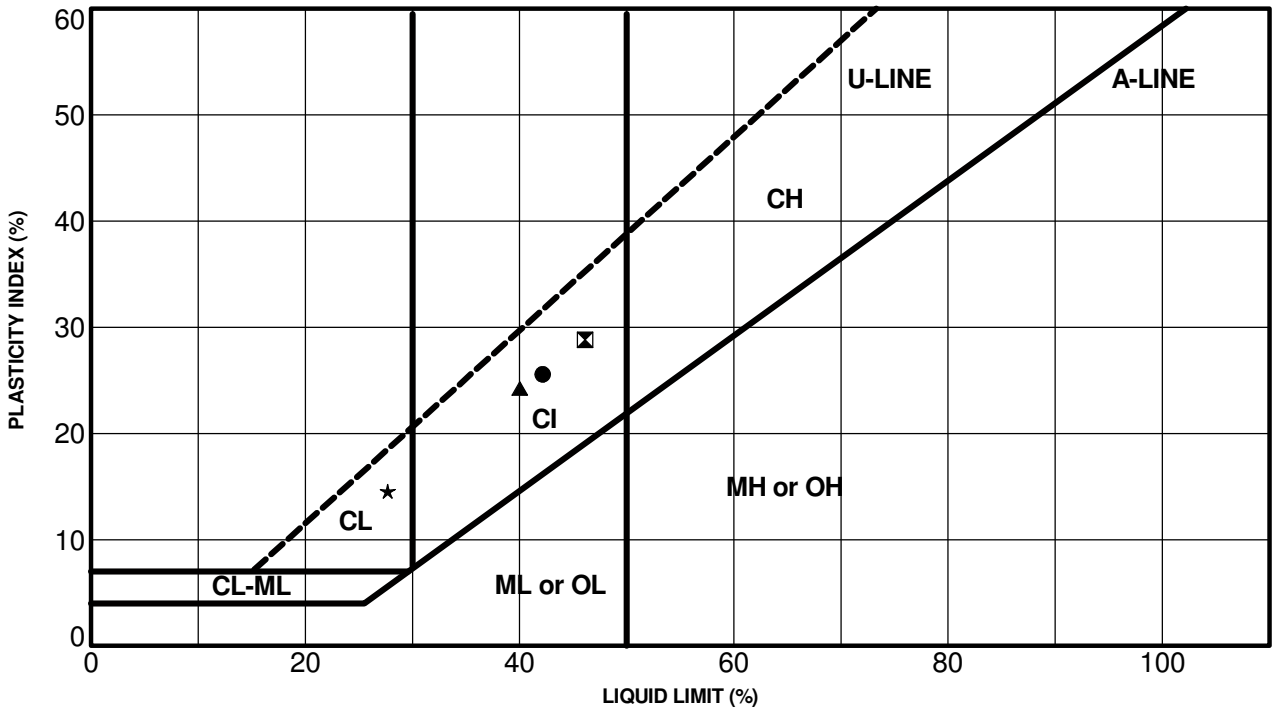
WATER CONTENT OF SOIL
(ASTM D2216)

Hole Number	Sample Number	Depth (m)	ID Number	Wet Weight + Tare (g)	Dry Weight + Tare (g)	Tare (g)	Water Weight (g)	Total Dry Weight (g)	Water Content (%)
DH09-03 (Q)	Sy 1	23.8		56.57	47.02	1.28	9.55	45.74	**20.88**

Klohn Crippen Berger

JOB NO.:	P09614A01		
PROJECT:	EGD South Jetty Wharf Development		
LOCATION:	BC		
DATE:	Feb 5, 2010		
TESTED BY:	BY	CHECKED BY:	JG

PLASTICITY CHART



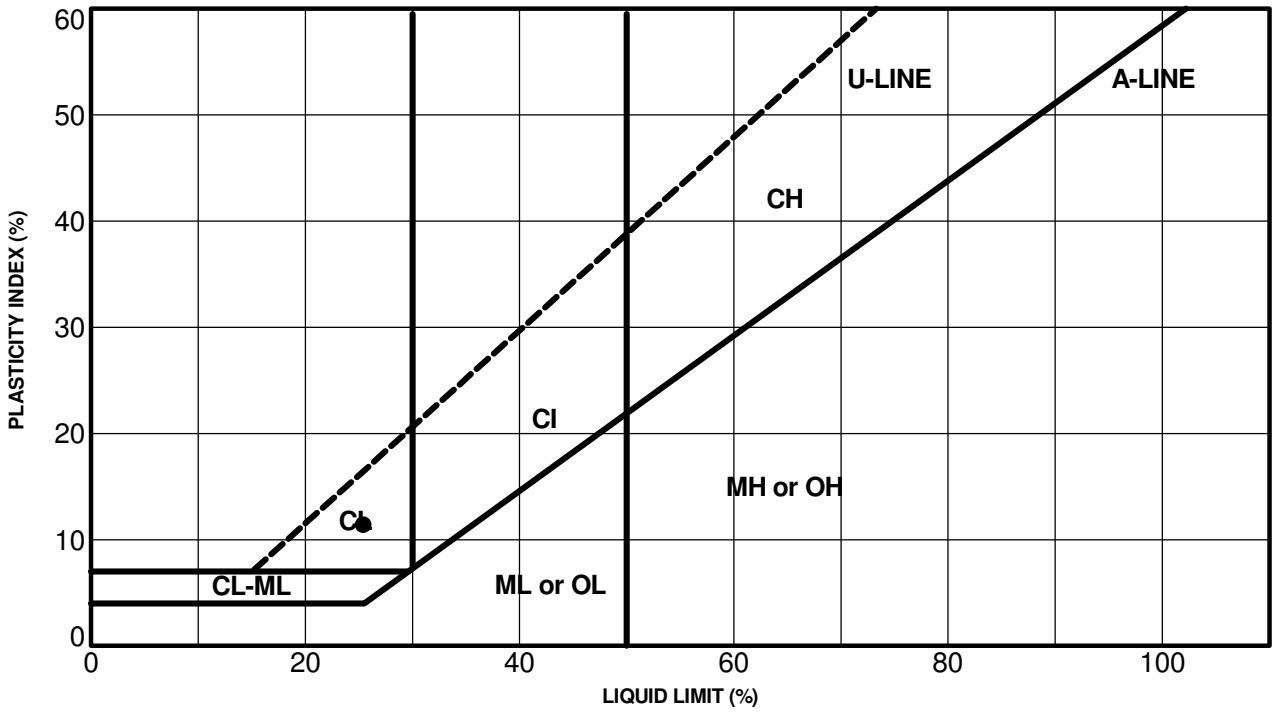
	HOLE	SAMPLE	DEPTH (m)	W_L	W_P	PI	% FINES	REMARKS/SAMPLE DESCRIPTION
●	DH09-02 (S)	SPT#5	17.0	42	17	26		
⊠	DH09-02 (S)	Sy 3	17.6	46	17	29		TX 1, Cons 1
▲	DH09-02 (S)	Sy 6	24.7	40	16	24		TX 2
★	DH09-03 (Q)	SPT#3	23.2	28	13	15		

Klohn Crippen Berger

PROJECT NO.: P09614A01
PROJECT: EGD South Jetty Wharf Development
LOCATION: Esquimalt, Victoria, BC
FIGURE:
DRAWN BY: NG **CHECKED BY:** BY

KCB_ATTERBERG-SI P09614A01 EGD SJWD T0944 NOV 18, 2009.GPJ SIEVE.GDT 3/23/10

PLASTICITY CHART



	HOLE	SAMPLE	DEPTH (m)	W_L	W_P	PI	% FINES	REMARKS/SAMPLE DESCRIPTION
●	DH09-03 (Q)	Sy 1	23.8	25	14	11		Shelby tube sample

Klohn Crippen Berger

PROJECT NO.:	P09614A01
PROJECT:	EGD South Jetty Wharf Development
LOCATION:	Esquimalt, Victoria, BC
FIGURE:	
DRAWN BY: CR	**CHECKED BY:** BY

KCB_ATTERBERG-SI P09614A01 EGD SJWD T1005 FEB 2, 2010.GPJ SIEVE.GDT 3/23/10

CONSOLIDATION

PROJECT NO.: P09614A01
PROJECT: EGD South Jetty Wharf Development
SAMPLE NO.: DH09-02 (S) / Sy 3
DEPTH: 17.60 m - 18.06 m
TEST NO.: Consolidation Test #1
LOADING MACHINE NO.: ID65 New

Initial water content : 44.87 % (based on final dry weight)
Final water content : 26.9 % (based on sample at end of test)

Initial Specimen Height (mm): 25.39
Height of Solid (mm): 11.347 (dry mass =98.82 g, Specimen area =3166.9 mm^2, SG=2.75***)
Initial void ratio: 1.238
Void Ratio Factor 0.0881

* Calibration to be done after test
** Estimated t_{90}
*** Estimated specific gravity

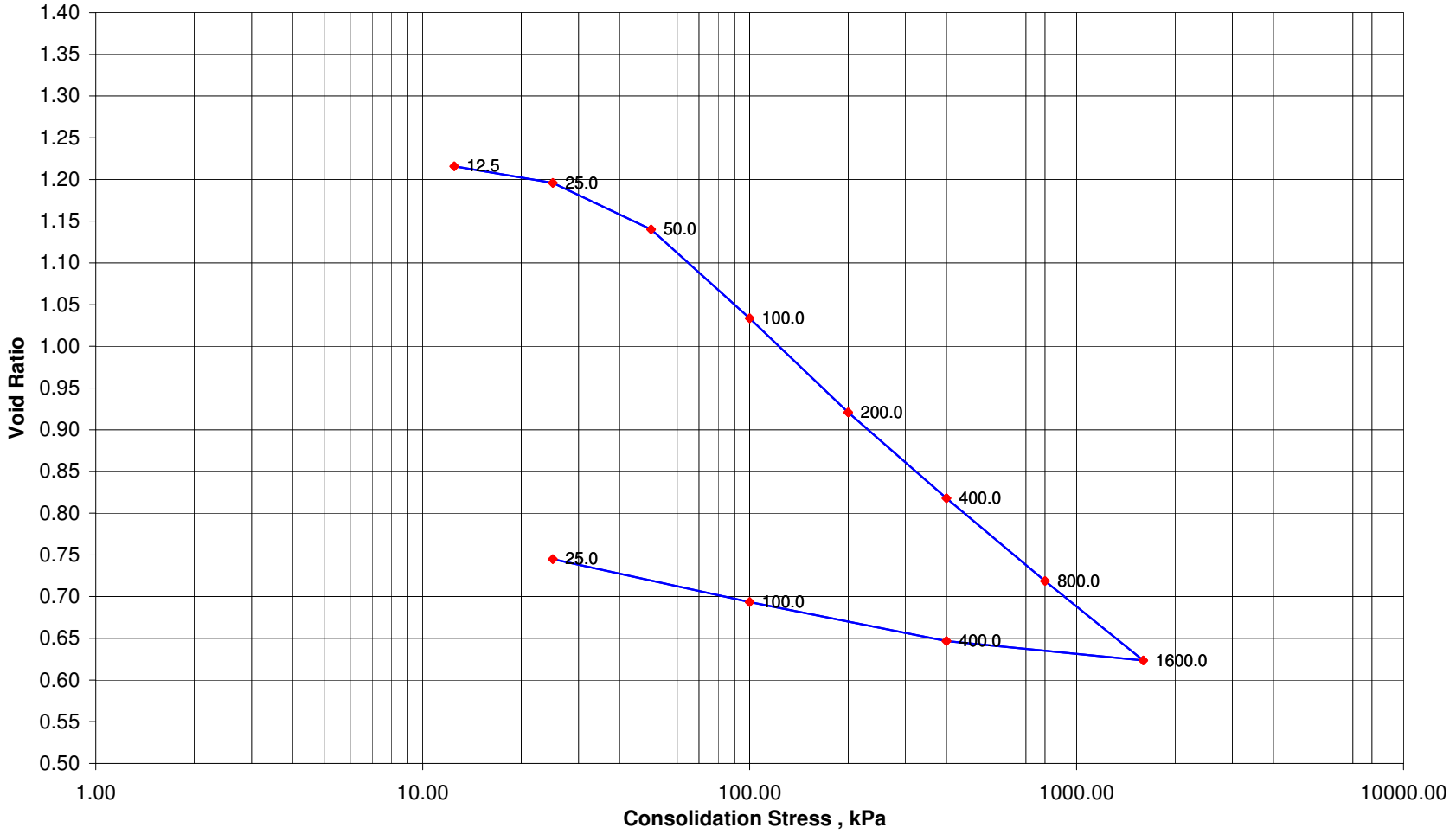
Pressure (kPa)		Change in Height	Final	Change in	Change in	Void	t_{90}**	Cv	Mv	k	Cc
From	To	Corrected (mm)	Height (mm)	Void Ratio	Void Ratio Acc	Ratio	(min)	(cm^2/sec)	(cm^2/N)	(cm/sec)	
0.0	**12.5**	0.246	25.144	0.0217	0.0217	**1.216**					
12.5	**25.0**	0.227	24.917	0.0200	0.0417	**1.196**	75.7	2.9E-04	7.2E-03	2.1E-08	**0.066**
25.0	**50.0**	0.633	24.284	0.0558	0.0975	**1.140**	92.2	2.3E-04	2.0E-02	4.6E-08	**0.185**
50.0	**100.0**	1.208	23.076	0.1065	0.2040	**1.034**	67.2	2.9E-04	2.0E-02	5.8E-08	**0.354**
100.0	**200.0**	1.279	21.796	0.1127	0.3167	**0.921**	50.4	3.5E-04	1.1E-02	3.8E-08	**0.374**
200.0	**400.0**	1.171	20.626	0.1032	0.4199	**0.818**	45.3	3.5E-04	5.4E-03	1.8E-08	**0.343**
400.0	**800.0**	1.122	19.503	0.0989	0.5188	**0.719**	21.6	6.6E-04	2.7E-03	1.8E-08	**0.329**
800.0	**1600.0**	1.084	18.420	0.0955	0.6143	**0.623**	14.4	8.8E-04	1.4E-03	1.2E-08	**0.317**
1600.0	**400.0**	-0.263	18.683	-0.0232	0.5911	**0.647**					
400.0	**100.0**	-0.531	19.214	-0.0468	0.5443	**0.693**					
100.0	**25.0**	-0.587	19.801	-0.0517	0.4926	**0.745**					

Klohn Crippen Berger

PROJECT NO.:	P09614A01		
PROJECT:	EGD South Jetty Wharf Development		
LOCATION:	Esquimalt, Victoria, BC	DATE TESTED:	Nov 10 - Nov 20, 2009
SAMPLE NO.:	DH09-02 (S) / Sy 3	DEPTH:	17.60 m - 18.06 m
TESTED BY:	BY	CHECKED BY:	JG

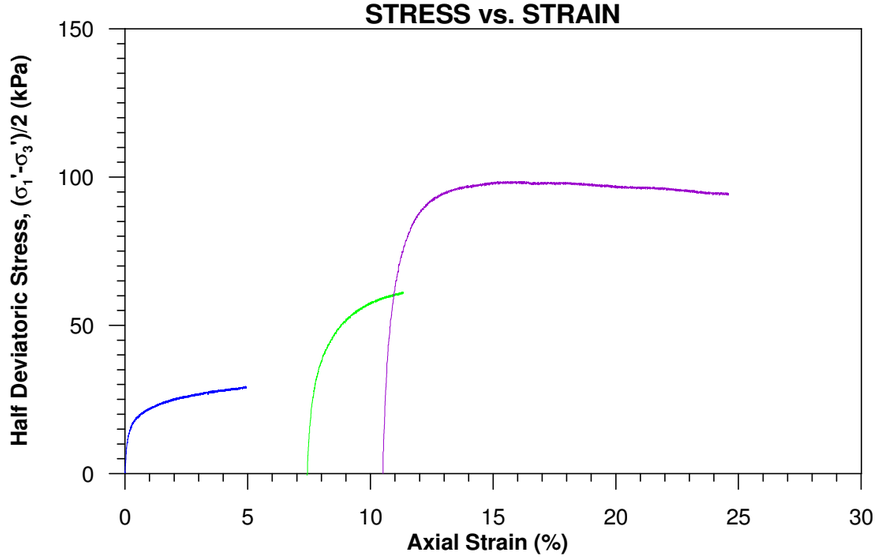
Consolidation Test #1 - DH09-02 (S) / Sy 3

e - log(p)



Klohn Crippen Berger

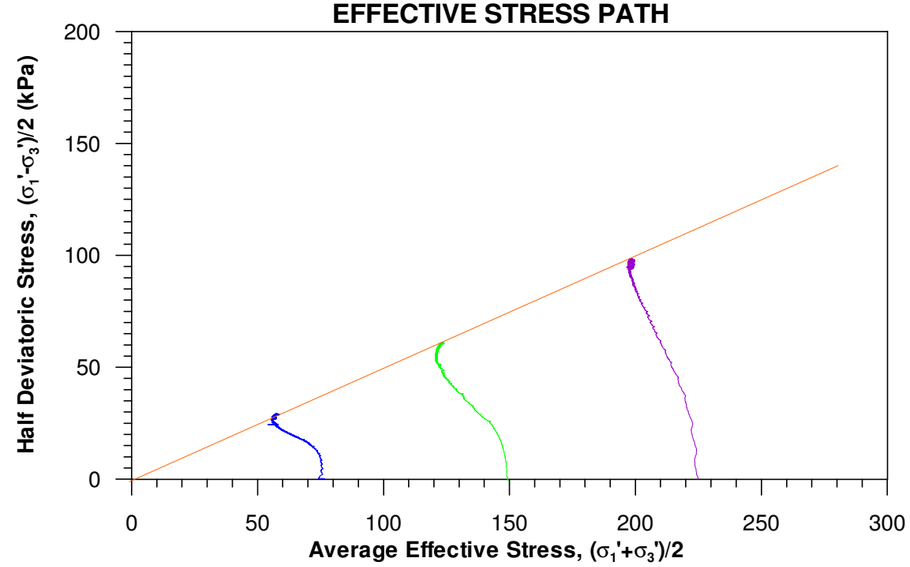
PROJECT NO.:	P09614A01		
PROJECT:	EGD South Jetty Wharf Development		
LOCATION:	Esquimalt, Victoria, BC	DATE TESTED:	Nov 10 - Nov 20, 2009
SAMPLE NO.:	DH09-02 (S) / Sy 3	DEPTH:	17.60 m - 18.06 m
TESTED BY:	BY	CHECKED BY:	JG

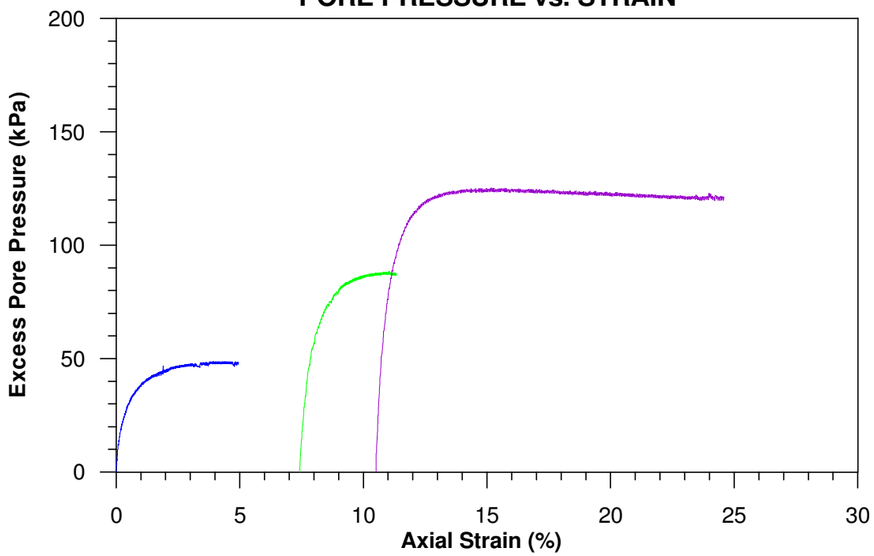


LEGEND
- TX 1-1 @ 75 kPa
- TX 1-2 @ 150 kPa
- TX 1-3 @ 225 kPa

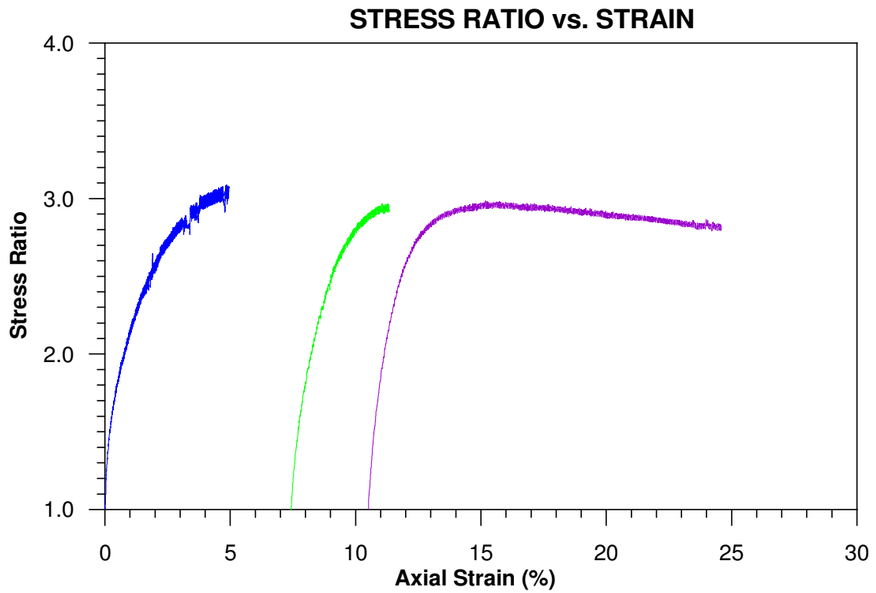
Test Summary

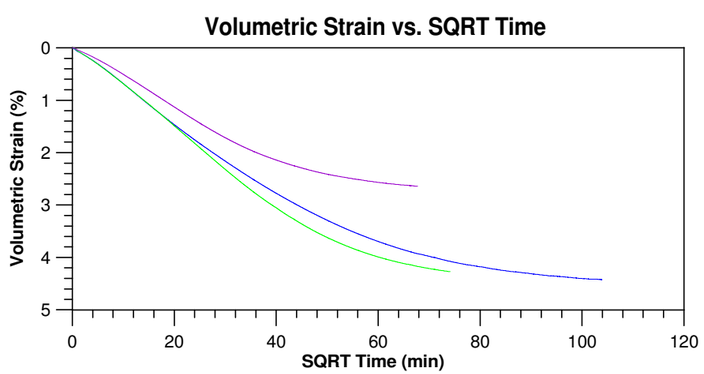
SPECIMEN INFORMATION	UNITS	Stage 1	Stage 2	Stage 3
Date: Dec 18, 2009				
Initial Water Content	%	33.86	30.23	27.47
Initial Dry Density	kg/m^3	1449.16	1546.16	1615.16
Final Water Content	%	30.23	27.47	24.87
Skempton's B Parameter		0.98		
Back Pressure	kPa	780	833	920
Consolidation Stress (σ_3')	kPa	75	150	225
End of Consolidation / Start of shear				
Dry Density	kg/m^3	1545.46	1615.16	1659.05
Specimen Height	mm	144.41	133.69	129.25
Specimen Area	mm^2	3908.87	4040.10	4068.95





After test photograph





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TO BE READ WITH KLOHN-CRIPPEN REPORT DATED _____

KLOHN-CRIPPEN		DATE
DESIGNED		
DRAWN		
CHECKED	Juan G.	DEC 09
RECOMMENDED		
APPROVED		
TESTED	Bin Y.	DEC 09

Klohn Crippen Berger

CLIENT

Public Works and Government Services Canada

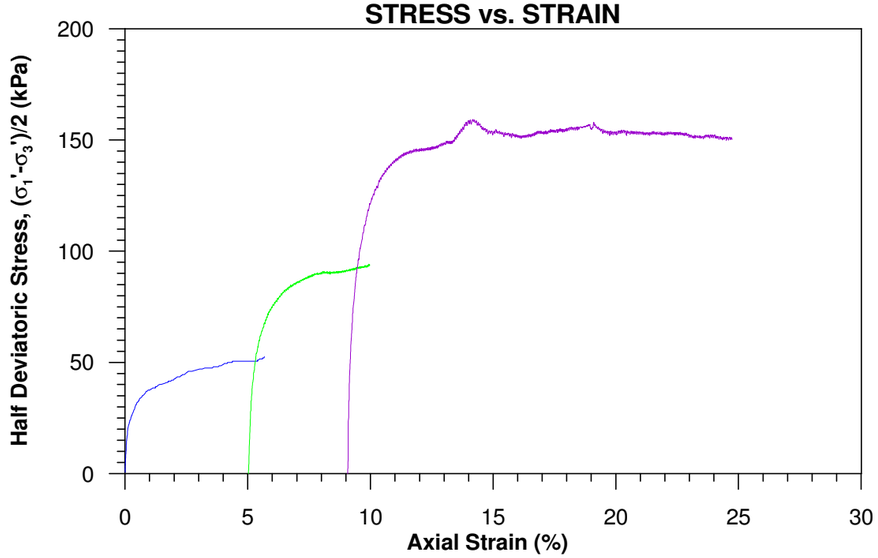
Travaux publics et Services gouvernementaux Canada

PROJECT
EGD SOUTH JETTY WHARF DEVELOPMENT

TITLE
MULTI-STAGE CU TRIAXIAL TEST
TEST No.: TX 1
SAMPLE : DH09-02 (S) / Sy 3 / 17.60 m
Effective Confining Pressure: 75, 150, 225 kPa

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
DEC 2009	P09614A01	FIG.	

STRESS vs. STRAIN

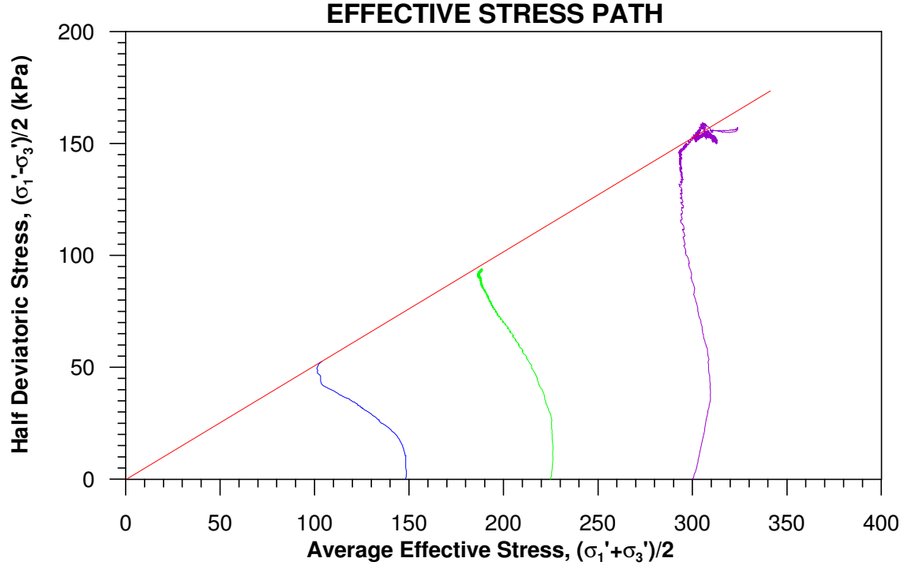


LEGEND
- TX 2-1 @ 150 kPa
- TX 2-2 @ 225 kPa
- TX 2-3 @ 300 kPa

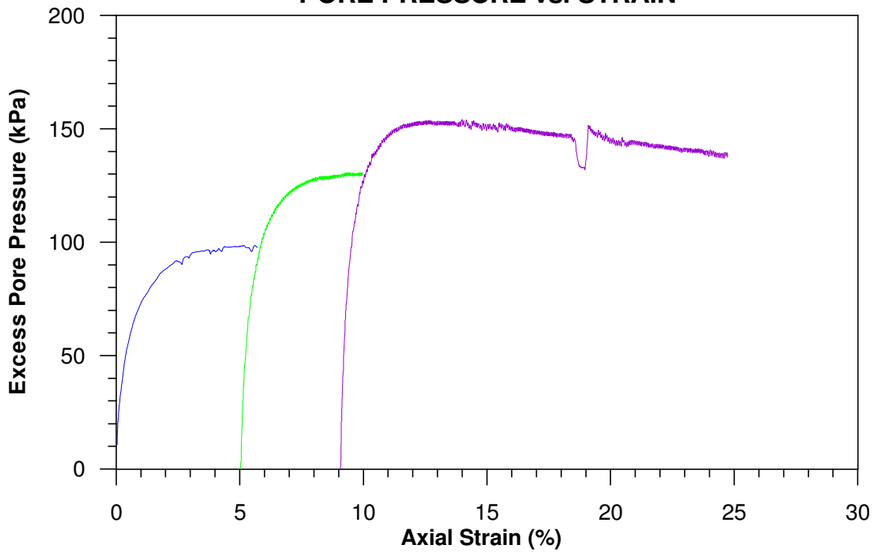
Test Summary

SPECIMEN INFORMATION	UNITS	Stage 1	Stage 2	Stage 3
Date: Dec 21, 2009				
Initial Water Content	%	34.21	27.19	24.93
Initial Dry Density	kg/m^3	1443.34	1606.13	1666.80
Final Water Content	%	27.19	25.08	22.88
Skempton's B Parameter		0.98		
Back Pressure	kPa	775	914	950
Consolidation Stress ($_3$')	kPa	150	225	300
End of Consolidation / Start of shear				
Dry Density	kg/m^3	1606.13	1662.65	1705.47
Specimen Height	mm	140.29	133.23	127.56
Specimen Area	mm^2	3774.74	3839.66	3909.63

EFFECTIVE STRESS PATH

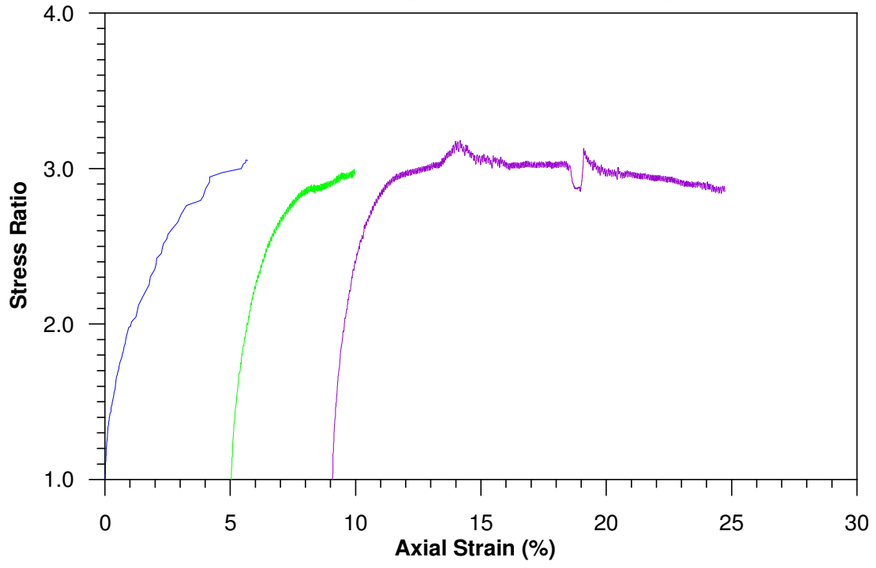


PORE PRESSURE vs. STRAIN

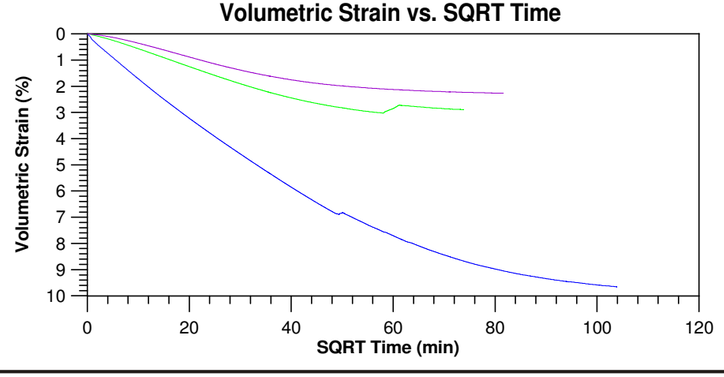


After test photograph

STRESS RATIO vs. STRAIN



Volumetric Strain vs. SQRT Time



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KLOHN-CRIPPEN		DATE
DESIGNED		
DRAWN		
CHECKED	Juan G.	DEC 09
RECOMMENDED		
APPROVED		
TESTED	Bin Y.	DEC 09

Klohn Crippen Berger

CLIENT

Public Works and Government Services Canada

Travaux publics et Services gouvernementaux Canada

PROJECT
EGD SOUTH JETTY WHARF DEVELOPMENT

TITLE
MULTI-STAGE CU TRIAXIAL TEST
TEST No.: TX 2
SAMPLE : DH09-02 (S) / Sy 6 / 24.69 m
Effective Confining Pressure: 150, 225, 300 kPa

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
DEC 2009	P09614A01	FIG.	

Unconfined Compression Test

Hole Number	Sample Number	Depth (m)	Length (L) (mm)	Diameter (D) (mm)	L / D Ratio	Area (mm^2)	Volume (cm^3)	Weight (g)	Bulk Density (g / cm^3)	Max. load at failure (KN)	Compressive Stress (MPa)	Failure Description
DH09-04 (P)	UCS 1	25.9	122.02	60.80	2.01	2903.33	354.26	1076.69	3.039	222.4	**76.61**	Diagonal fracture with cracking through both end,. no well formed cones.
DH09-05 (T)	UCS 2	25.6	123.92	60.74	2.04	2897.61	359.07	1015.72	2.829	155.7	**53.73**	Vertical cracking through both ends, no well formed cones.

Klohn Crippen Berger

JOB NO.:	P09614A01		
PROJECT:	EGD South Jetty Wharf Development		
LOCATION:	Esquimalt, Victoria, BC		
DATE:	Feb 1, 2010		
TESTED BY:	BY	CHECKED BY:	JG

Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference: NORSOK G-001

Project No.:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 1 (CSR 0.15, 0.20, 0.25)
Location:	Not Provided	**Depth (m):**	23.77-24.38
Client:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208

Test Condition:	Constant Volume	**Equipment Description:**		
Visual Description:	-	**Shear LVDT**	Serial No.:	113179
		Vertical LPT:	Serial No.:	89612
		Shear Load Cell	Serial No.:	30465
Remarks:	Tested at received moisture condition			

Initial Sample Dimensions							
Test No.	1						
Sample geometry	Round						
Diameter (mm)	70.45						
Height (mm)	23.90						
Area (cm^2)	38.98						
Volume (cm^3)	93.16						
Weight Volume Relationships							
Sample Type	Undisturbed						
Initial Mass (g)	192.92						
Dry Mass (g)	170.11						
Initial γ_{wet} (kN/m^3)	20.31						
Final γ_{wet} (kN/m^3)	21.54						
Initial γ_{dry} (kN/m^3)	16.60						
Final γ_{dry} (kN/m^3)	18.01						
Initial water content (%)	22.4						
Final water content (%)	19.6						
Specific Gravity (Assumed)	2.72						
Initial Void Ratio, e	0.61						
Final Void Ratio, e	0.48						
Initial Saturation (%)	100.00						
Final Saturation (%)	100.00						
Consolidation Results							
Normal Stress (kPa)	115.17						
Axial Strain at end of Consol. %	7.89						
t_{90} (Taylor Method) (min)	N/A						
Change in height ΔH_c (mm)	1.89						
Test Results							
Frequency (Hz)	0.50						
CSR	Multiple						
Number of Cycles	15 per CSR						
Normal Stress (kPa)	115.00						
Peak Shear Stress (kPa)	17.55						

G. Patton	January 1, 2010	ROB	February 1, 2010
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference
NORSOK G-001

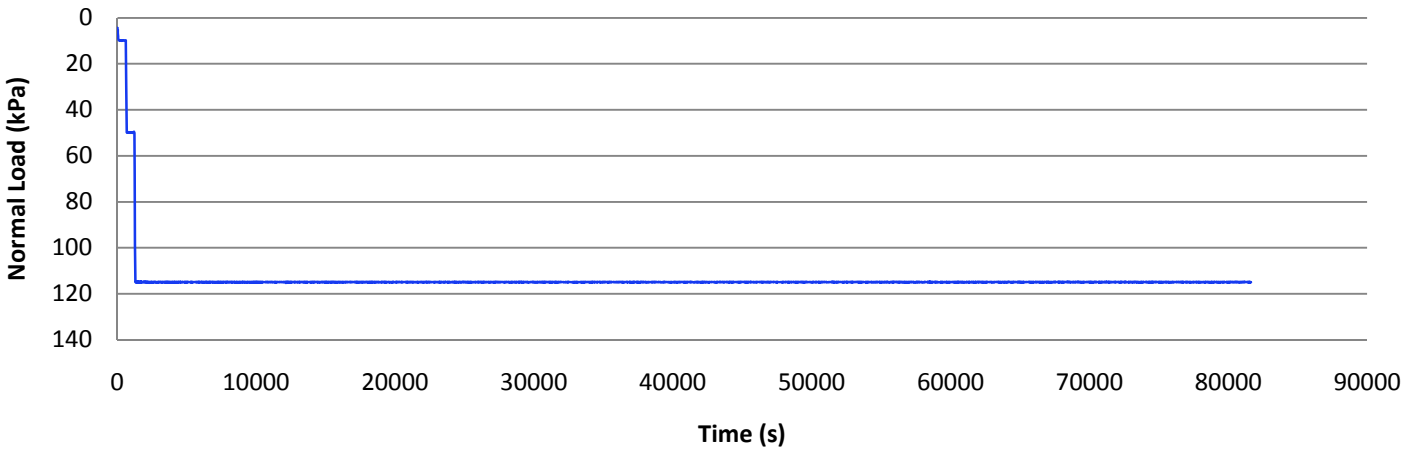
Project No.:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 1 (CSR 0.15, 0.20, 0.25)
Location:	Not Provided	**Depth (m):**	23.77-24.38
Client:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208

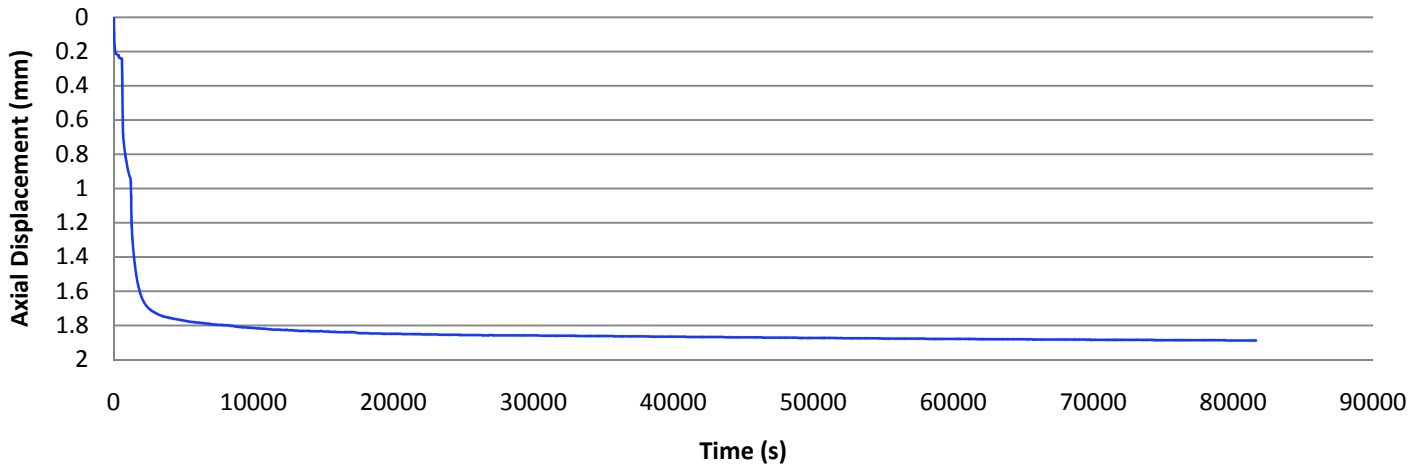
Consolidation Summary

Maxium Consolidation Stress (kPa)	115.17
Maxium Consolidation Axial Strain (%)	7.89
t_{95} of Maximum Conslidation Stress (kPa)	N/A
Change in height ΔH_c (mm)	1.89

Comments

Increment (kPa)	40	80	**115**							
Max Load (kN)	0.0376	0.1893	**0.4363**							
Duration (s)	600	585	**80415**							
Axial Strain (%)	1.0414	3.9852	**7.8426**							





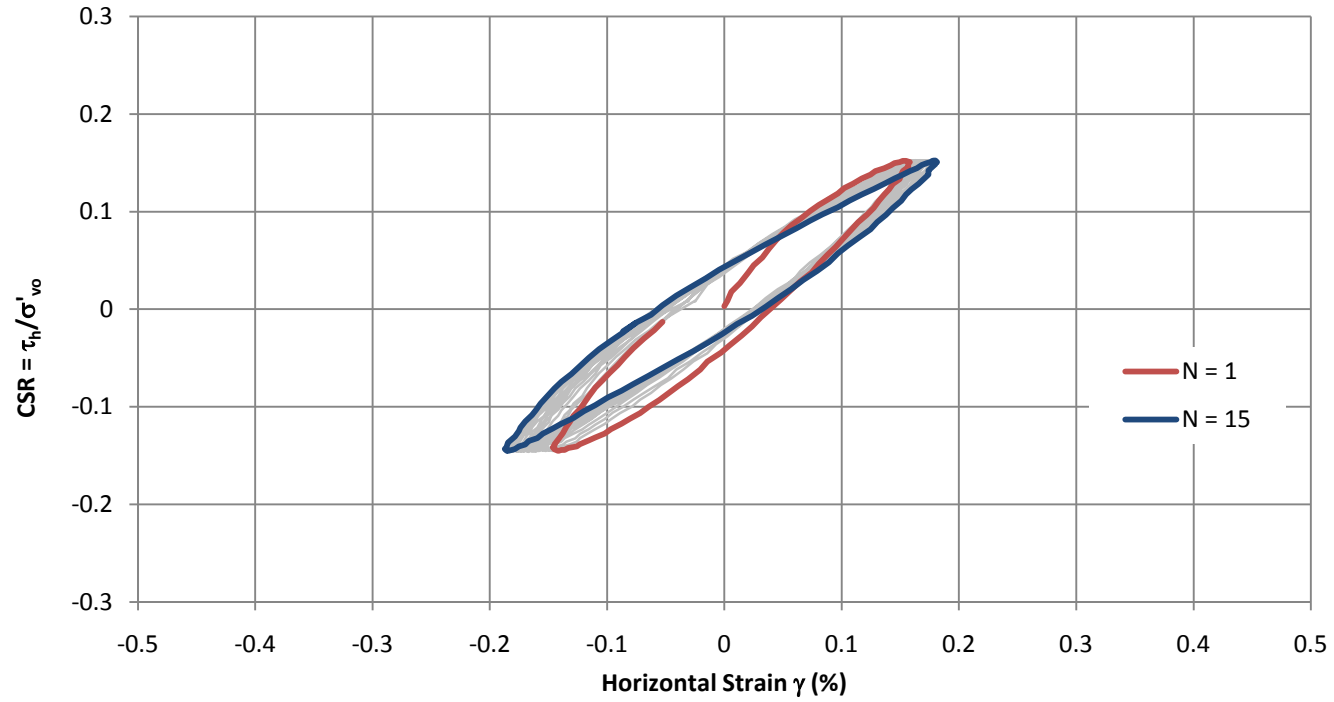
G. Patton	January 1, 2010	ROB	February 1, 2010
TESTED BY	DATE	CHECKED BY	DATE

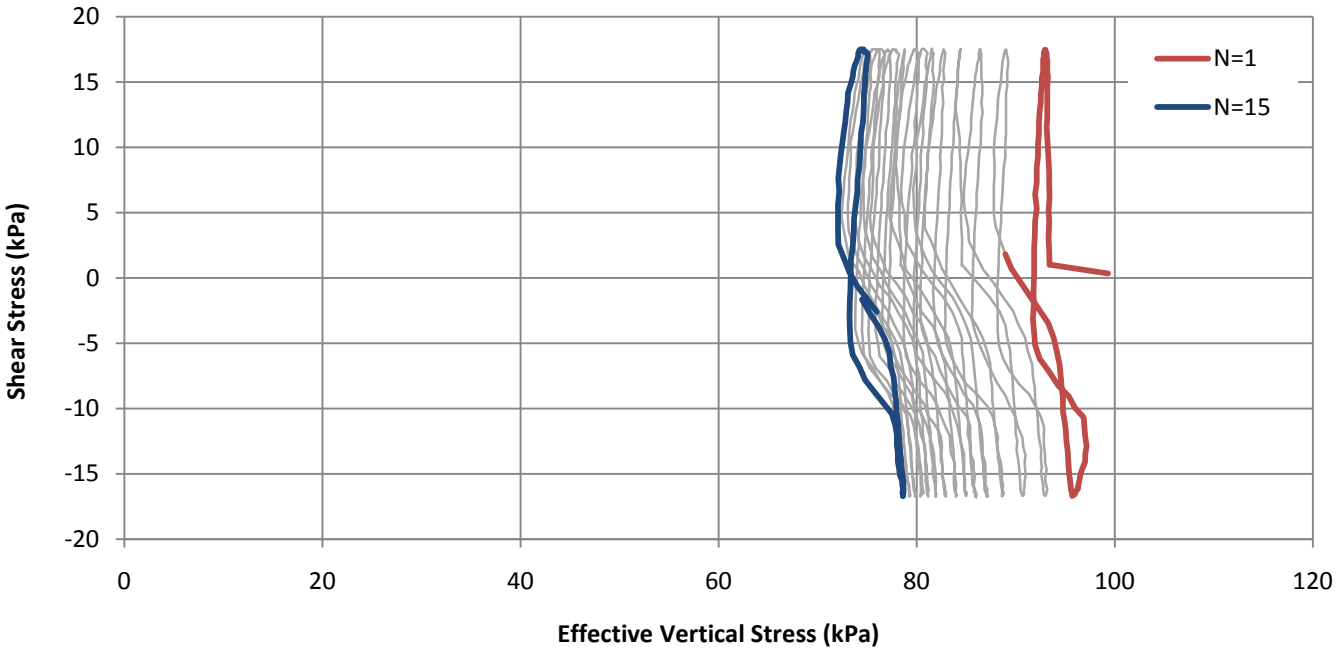
Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference
NORSOK G-001

Client:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 1 CSR 0.15
Location:	Not Provided	**Depth (m):**	23.77-24.38
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





G. Patton	January 1, 2010	ROB	February 1, 2010
TESTED BY	DATE	CHECKED BY	DATE

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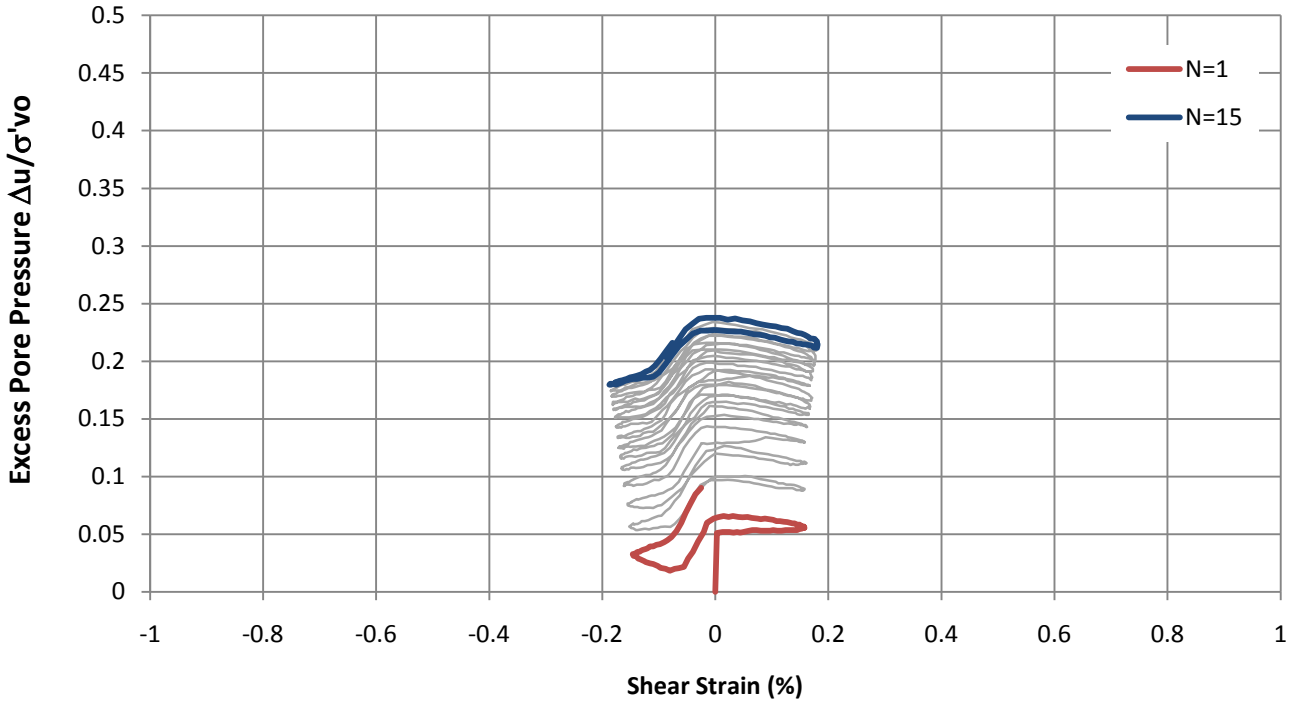
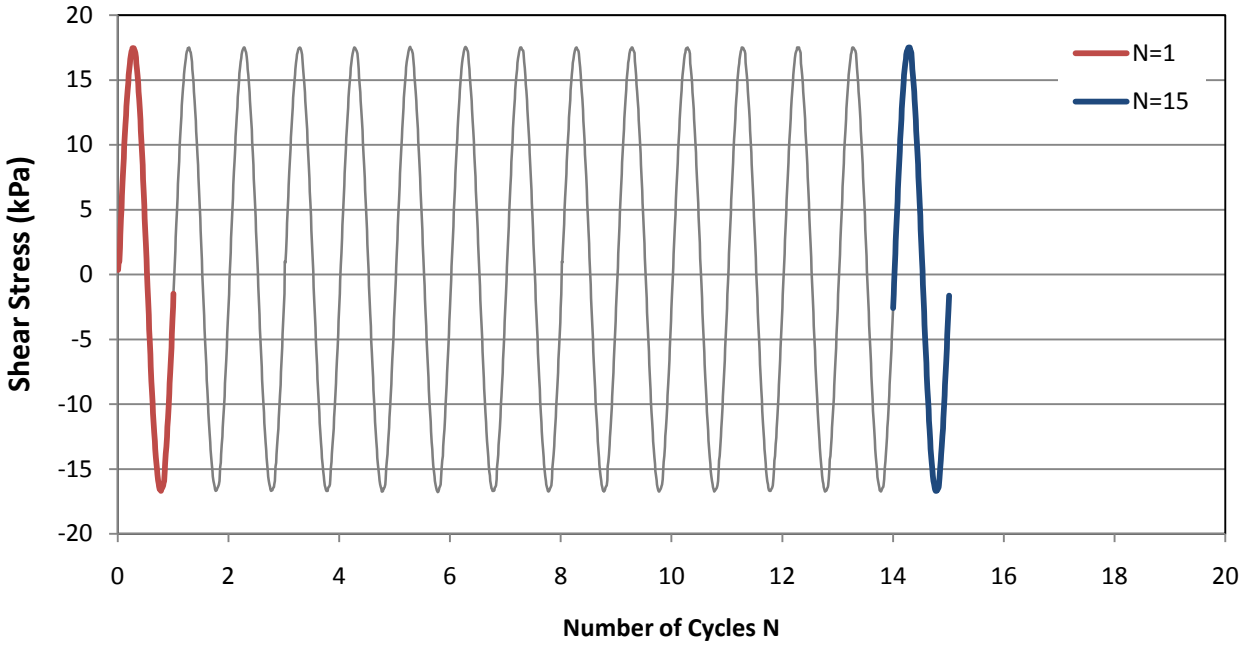
Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference
NORSOK G-001

Client:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 1 CSR 0.15
Location:	Not Provided	**Depth (m):**	23.77-24.38
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





G. Patton	January 1, 2010	ROB	February 1, 2010
TESTED BY	DATE	CHECKED BY	DATE

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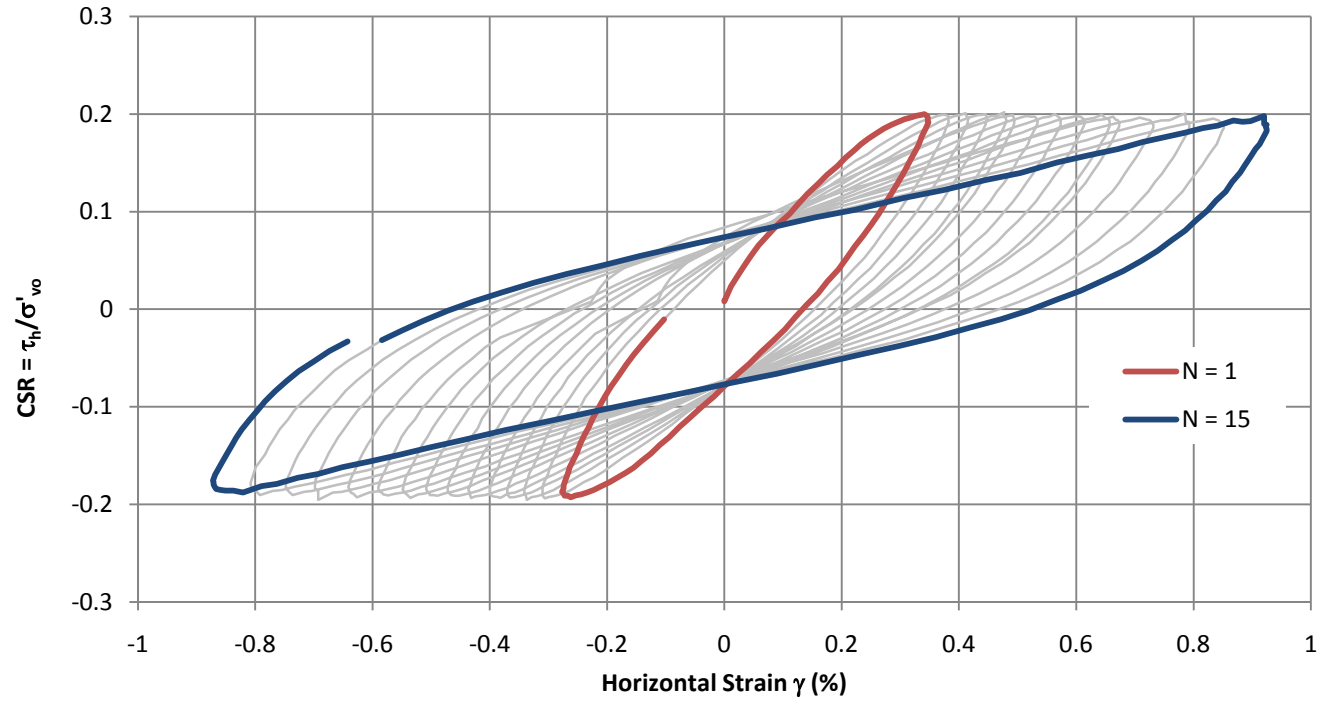
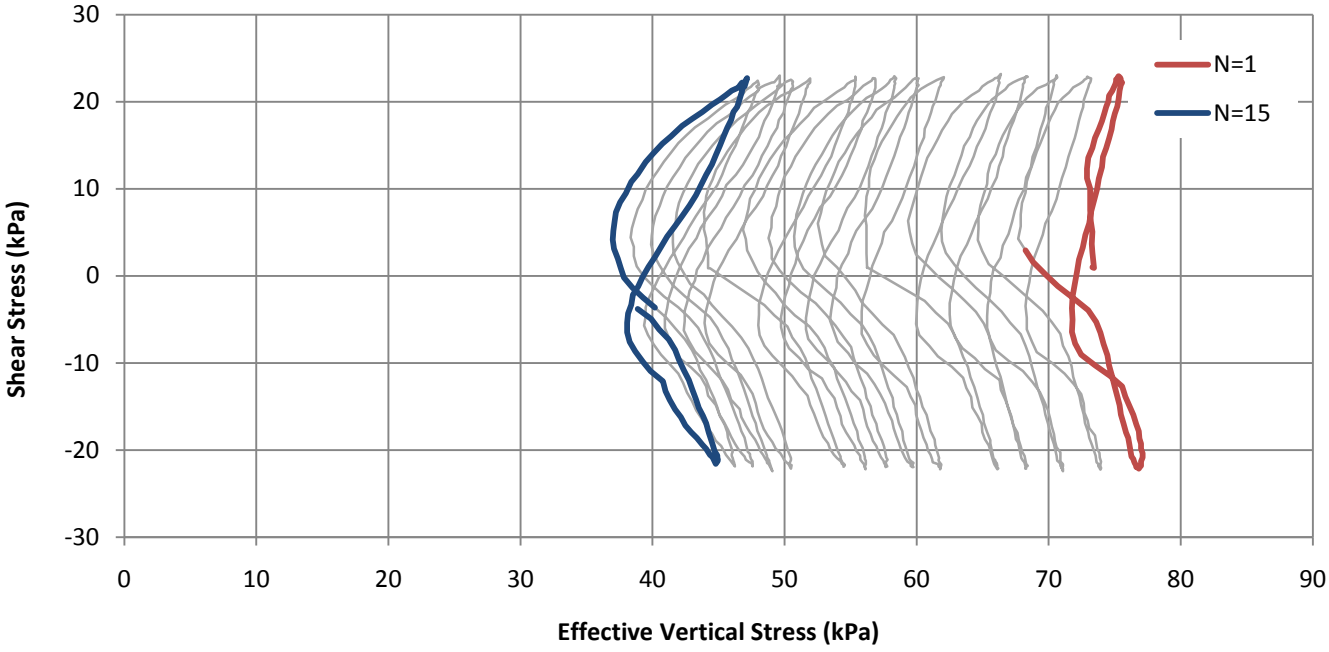
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference
NORSOK G-001

Client:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 1 CSR 0.20
Location:	Not Provided	**Depth (m):**	23.77-24.38
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





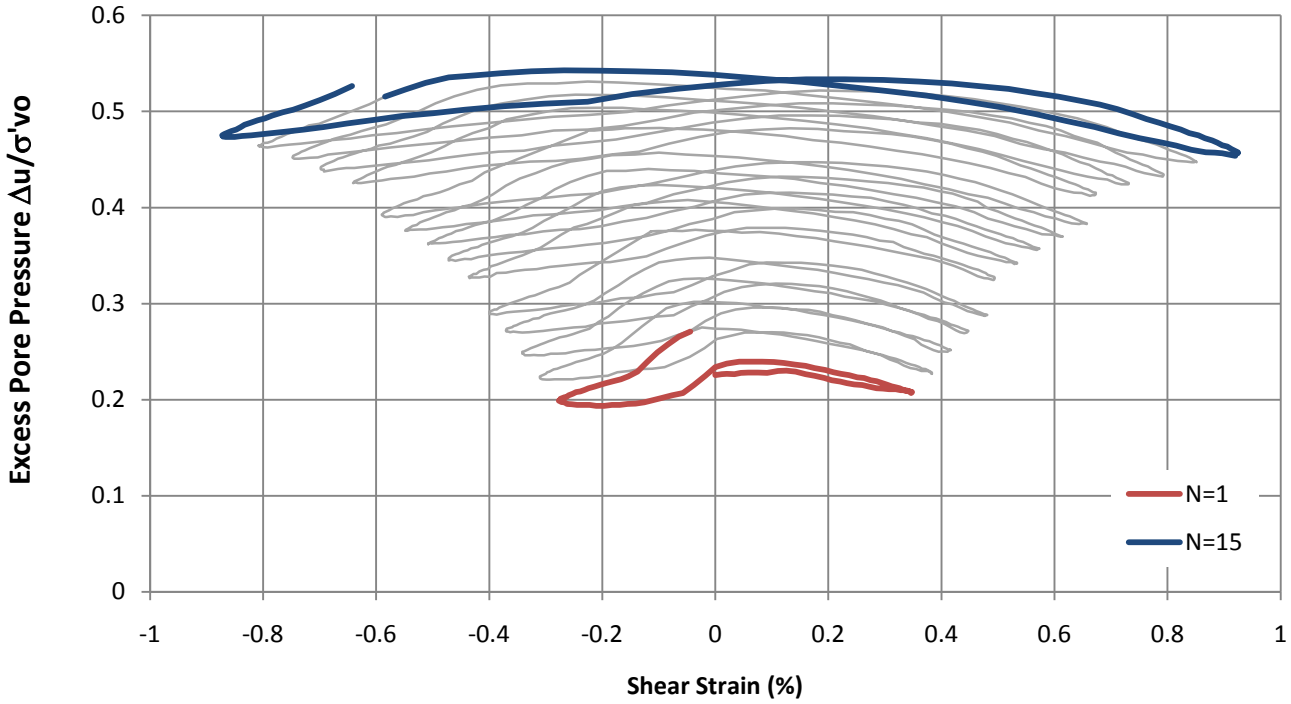
G. Patton	January 1, 2010	ROB	February 1, 2010
TESTED BY	DATE	CHECKED BY	DATE

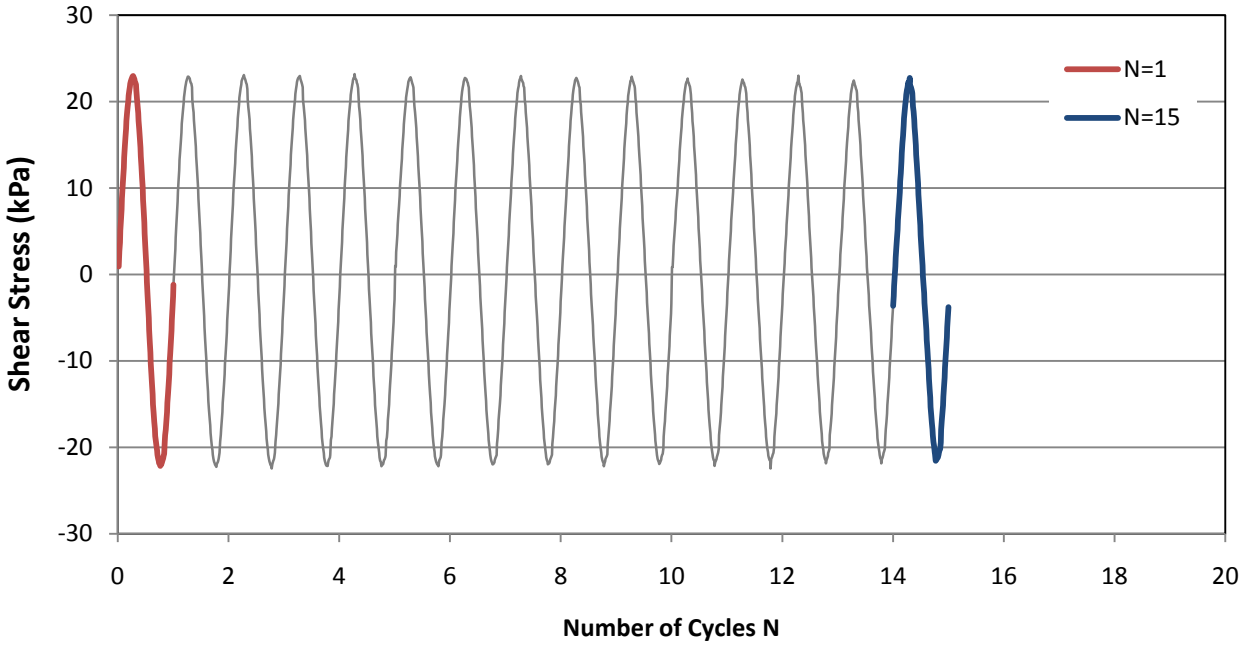
Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference
NORSOK G-001

Client:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 1 CSR 0.20
Location:	Not Provided	**Depth (m):**	23.77-24.38
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





G. Patton	January 1, 2010	ROB	February 1, 2010
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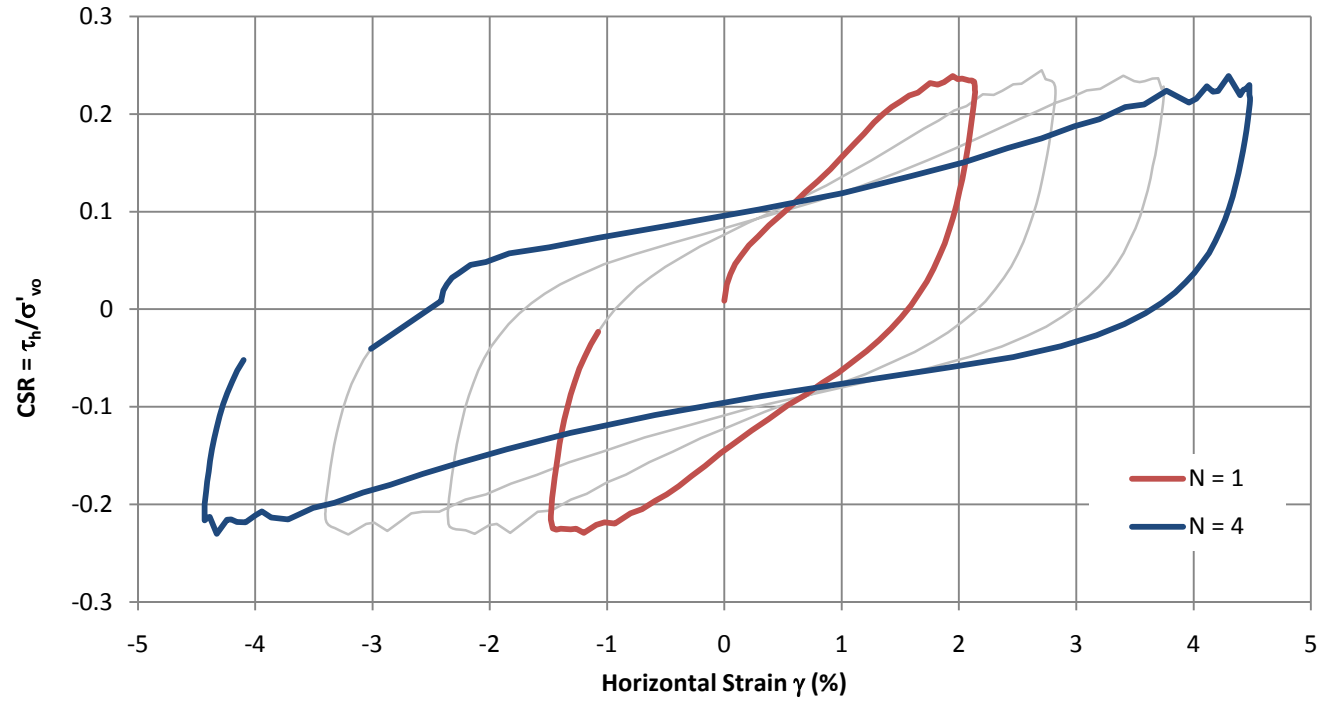
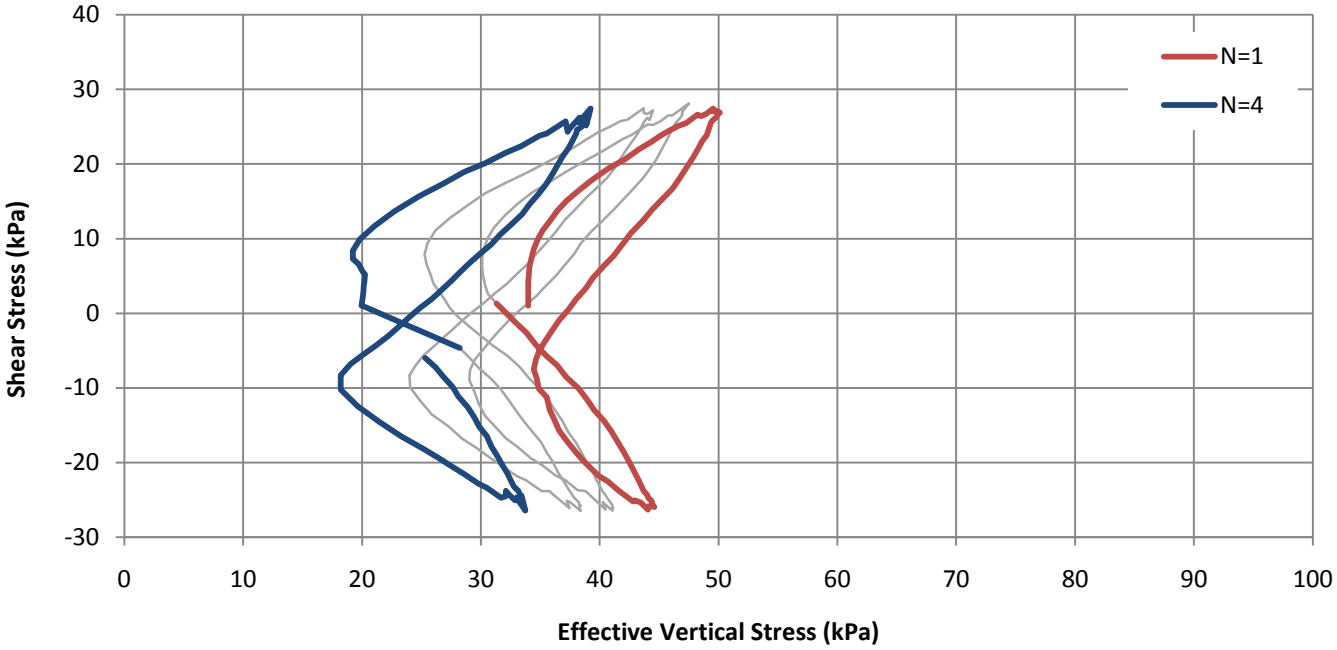
Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference
NORSOK G-001

Client:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 1 CSR 0.25
Location:	Not Provided	**Depth (m):**	23.77-24.38
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





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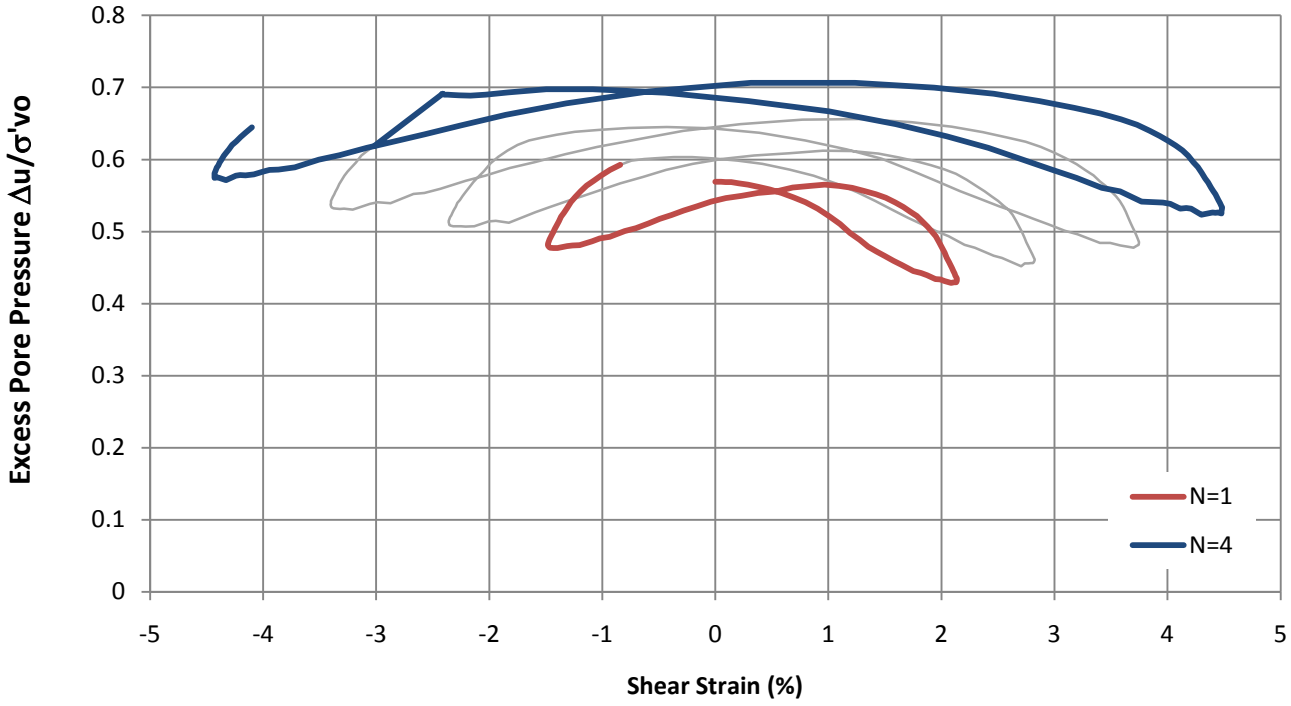
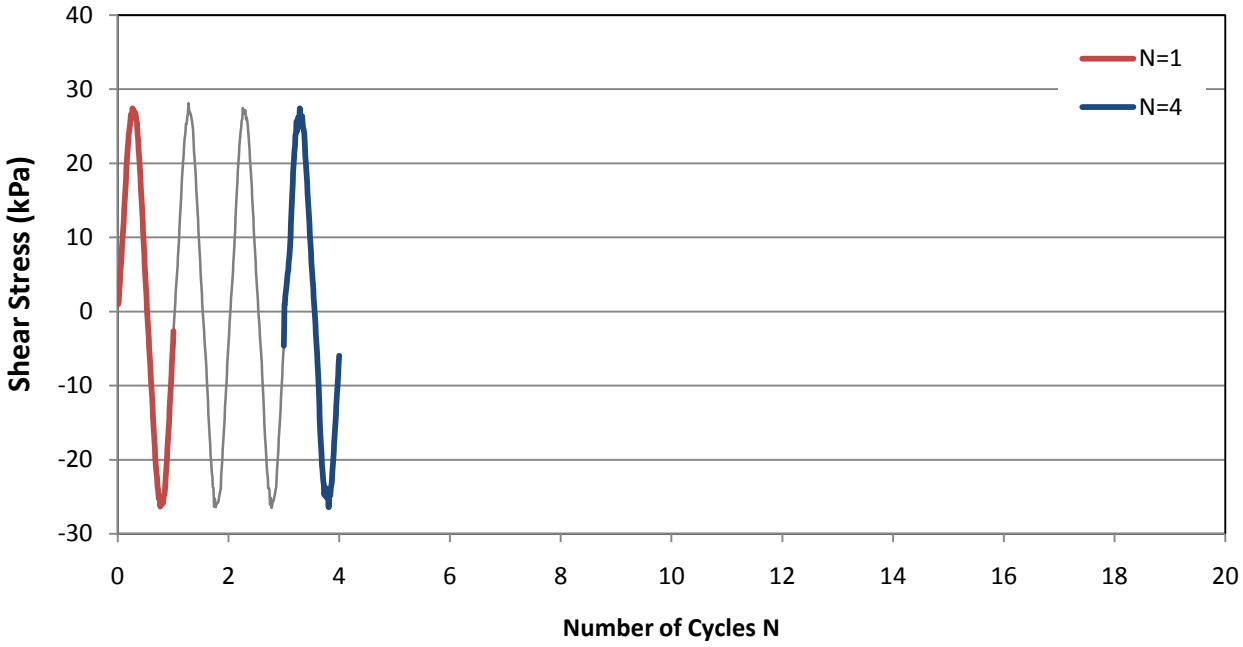
Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference
NORSOK G-001

Client:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 3 CSR 0.25
Location:	Not Provided	**Depth (m):**	23.77-24.38
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





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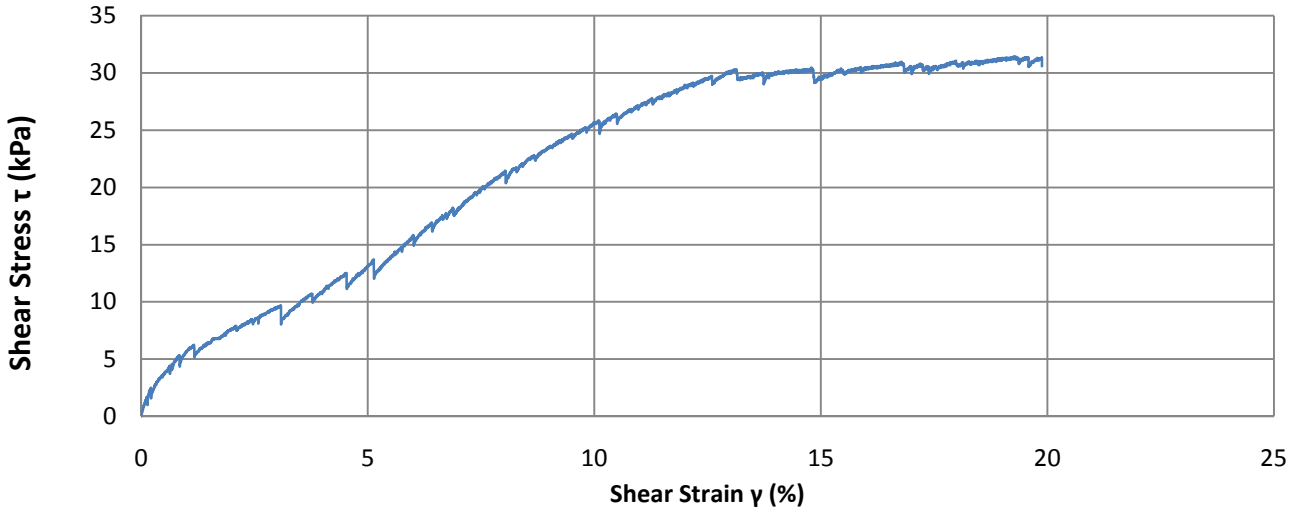
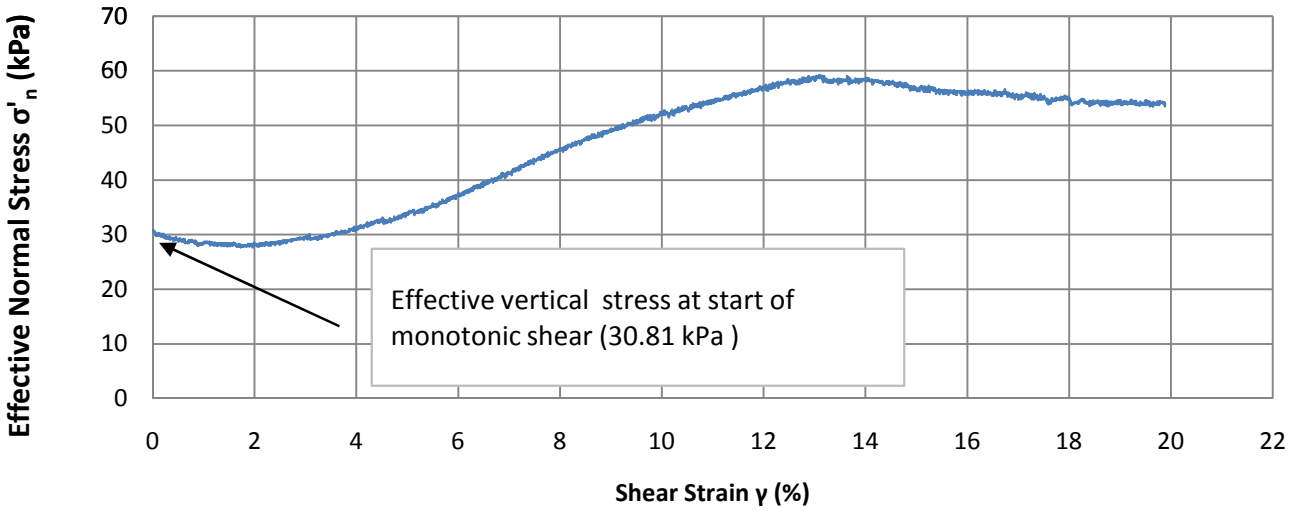
Static Simple Shear Test - Consolidated Constant Volume

Reference
NORSOK G-001

Project No.:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 1 (CSR 0.15, 0.20, 0.25)
Location:	Not Provided	**Depth (m):**	23.77-24.38
Client:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208

Static Shear Summary





Parameters		Comments
Duration of stage (s)	72060	**Post-cyclic test**
Strain rate	1.0%/hr	
Applied vertical load at start of stage (kN)	0.1167	

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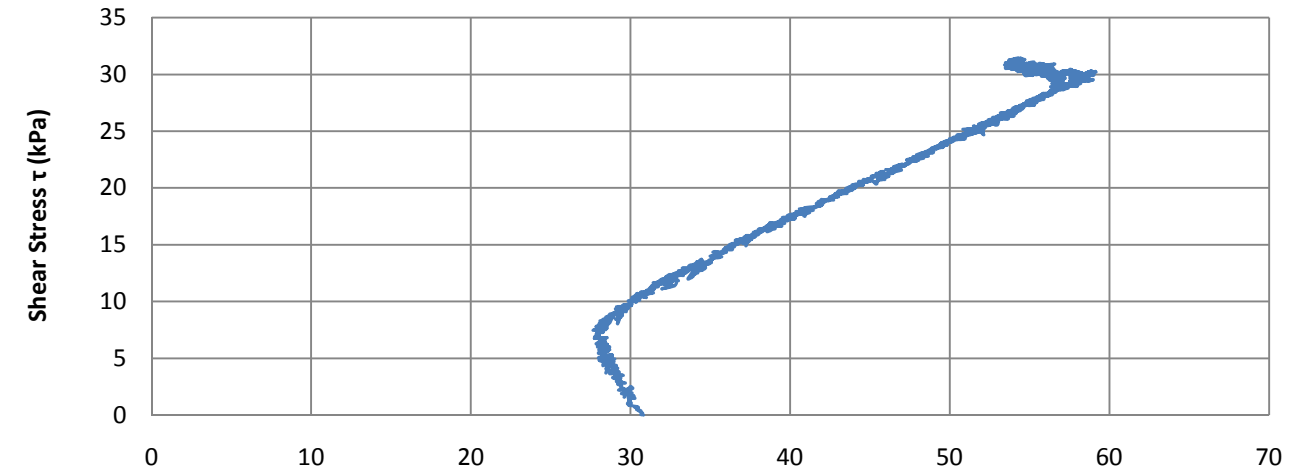
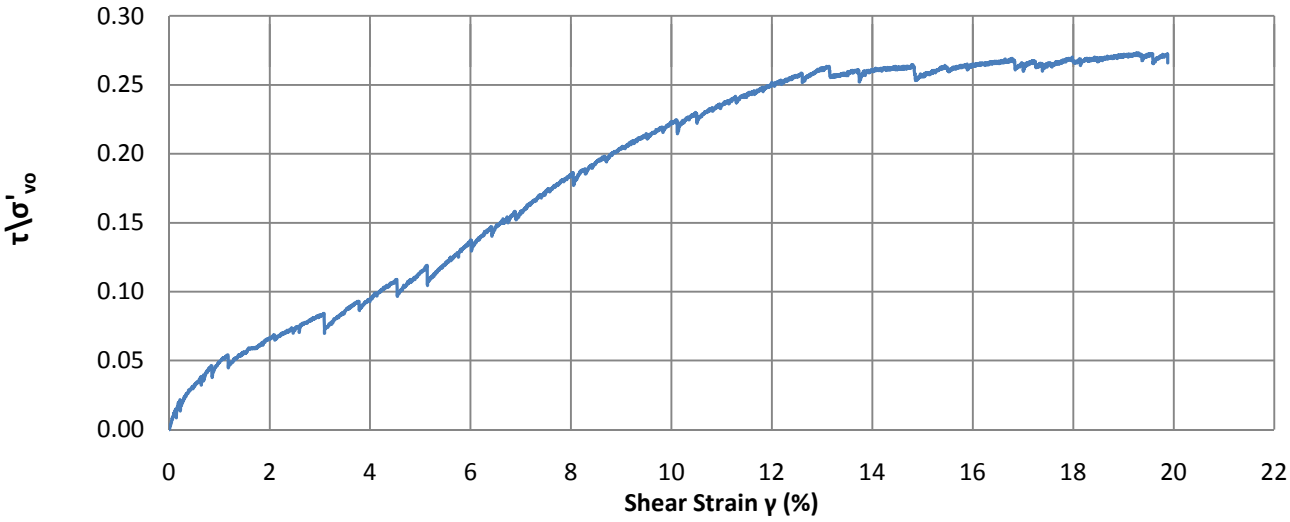
Static Simple Shear Test - Consolidated Constant Volume

Reference
NORSOK G-001

Project No.:	09-1416-5011	**Sample No.:**	DH09-03 (Q) Sy 1
Project:	EGD South Jetty Wharf	**Sample Location:**	Cyclic 1 (CSR 0.15, 0.20, 0.25)
Location:	Not Provided	**Depth (m):**	23.77-24.38
Client:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208

Static Shear Summary





Comments
The graph belows plots the constant volume shear strength normalized by the initial effective confining pressure after consolidation (i.e., σ'_{vo}=115 kPa) versus shear strain.

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Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference
NORSOK G-001

Project No.:	09-1416-5011	**Sample No.:**	DH09-02 (S) Sy 4
Project:	KCB Project P09614A01	**Sample Location:**	Cyclic 1 (CSR 0.1, 0.2, 0.3)
Location:	Unknown	**Depth (m):**	19.51-20.12
Client:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208

Test Condition:	Constant Volume	**Equipment Description:**		
Visual Description:	-	**Shear LVDT**	Serial No.:	113179
		Vertical LPT:	Serial No.:	89612
		Shear Load Cell	Serial No.:	30465

Remarks: Tested at received moisture condition

Initial Sample Dimensions						
Test No.	Round					
Sample geometry	1					
Diameter (mm)	70.20					
Height (mm)	23.72					
Area (cm^2)	38.70					
Volume (cm^3)	91.81					
Weight Volume Relationships						
Sample Type	Undisturbed					
Initial Mass (g)	183.08					
Dry Mass (g)	139.00					
Initial γ_{wet} (kN/m^3)	19.56					
Final γ_{wet} (kN/m^3)	19.64					
Initial γ_{dry} (kN/m^3)	14.85					
Final γ_{dry} (kN/m^3)	15.11					
Initial water content (%)	31.7					
Final water content (%)	24.9					
Specific Gravity (measured)	2.85					
Initial Void Ratio, e	0.88					
Final Void Ratio, e	0.85					
Initial Saturation (%)	100					
Final Saturation (%)	100					
Consolidation Results						
Normal Stress (kPa)	80.12					
Axial Strain at end of Consol. %	3.16					
t_{90} (Taylor Method) (min)	N/A					
Change in height ΔH_c (mm)	0.75					
Test Results						
Frequency (Hz)	0.50					
CSR	Multiple					
Number of Cycles	15 per CSR					
Normal Stress (kPa)	80.00					
Peak Shear Stress (kPa)	12.12					

G. Patton	December 7, 2009	ROB	December 21, 2009
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Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

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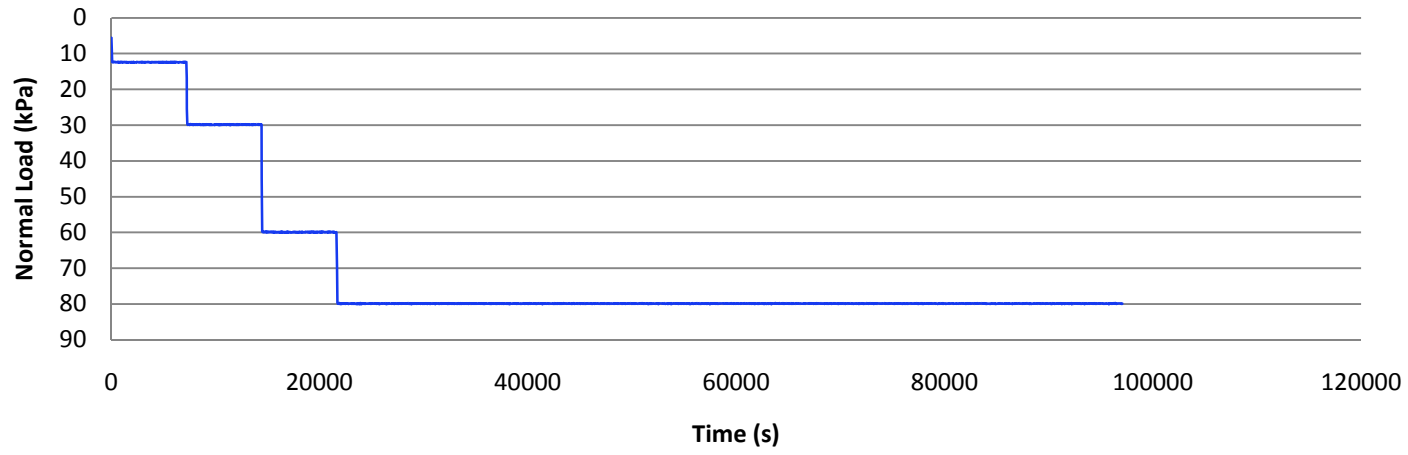
Project:	KCB Project P09614A01	**Sample Location:**	Cyclic 1 (CSR 0.1, 0.2, 0.3)
Location:	Unknown	**Depth (m):**	19.51-20.12
Client:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208

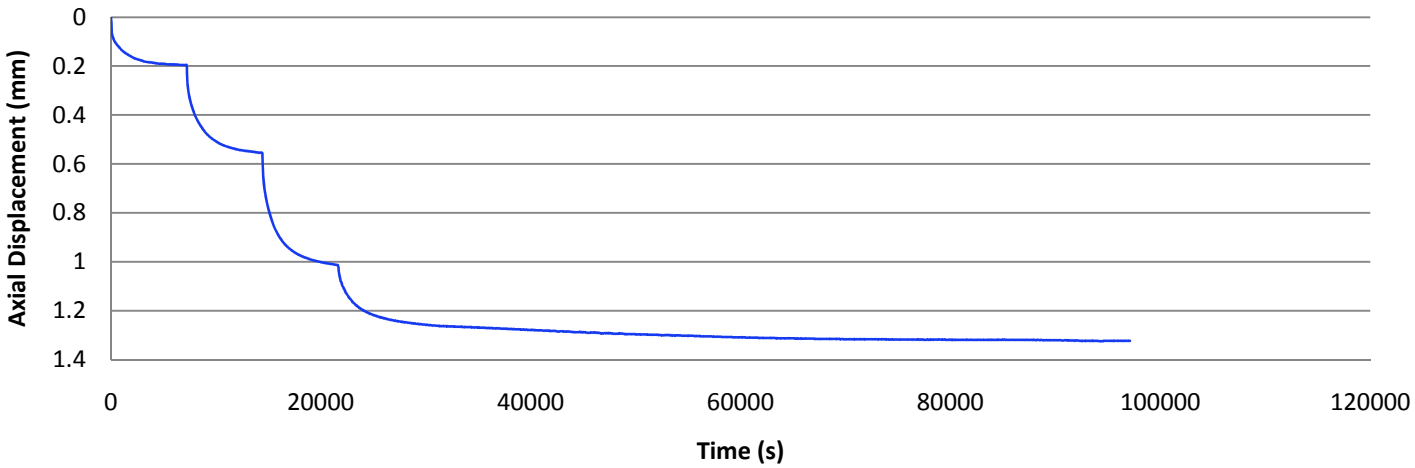
Consolidation Summary

Maximum Consolidation Stress (kPa)	80.12
Maximum Consolidation Axial Strain (%)	5.56
t_{95} of Maximum Consolidation Stress (kPa)	N/A
Change in height ΔH_c (mm)	1.32

Comments

Increment (kPa)	12.5	30	60	80							
Max Load (kN)	0.05	0.12	0.23	0.31							
Duration (s)	7170	7170	7170	75450							
Axial Strain (%)	0.86	2.36	4.24	5.56							





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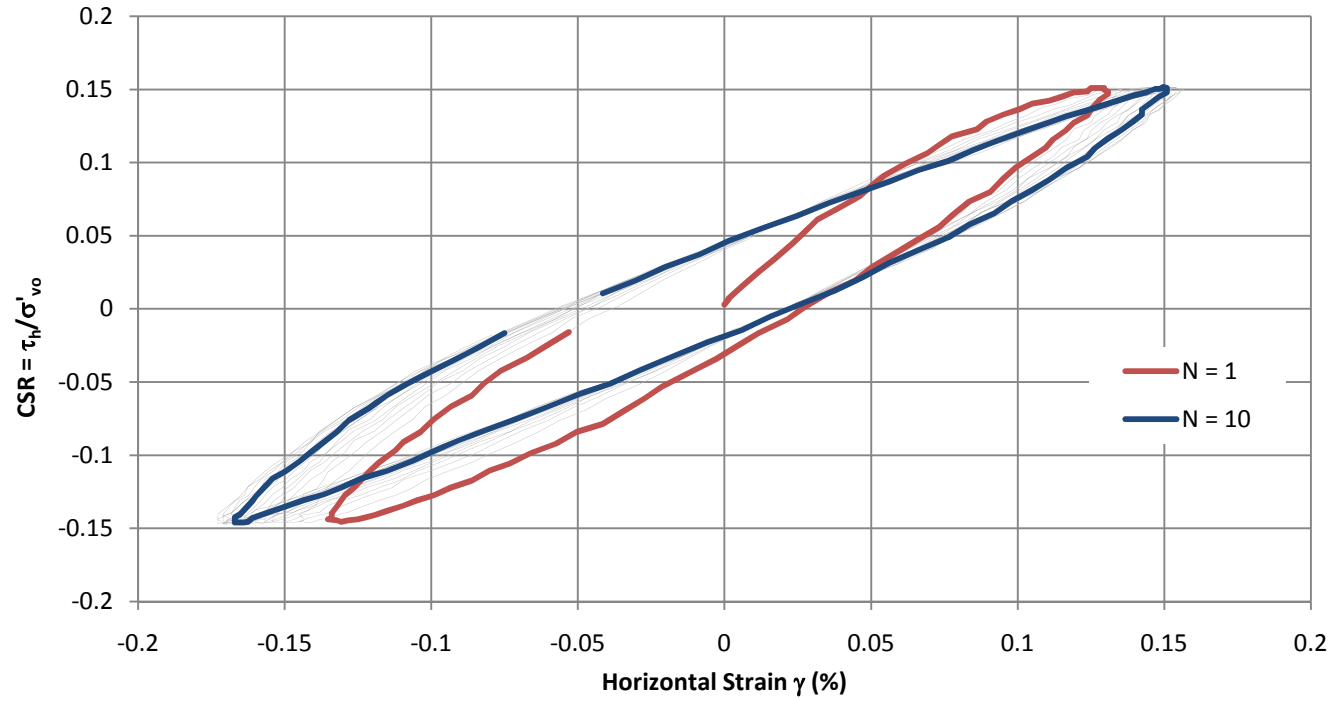
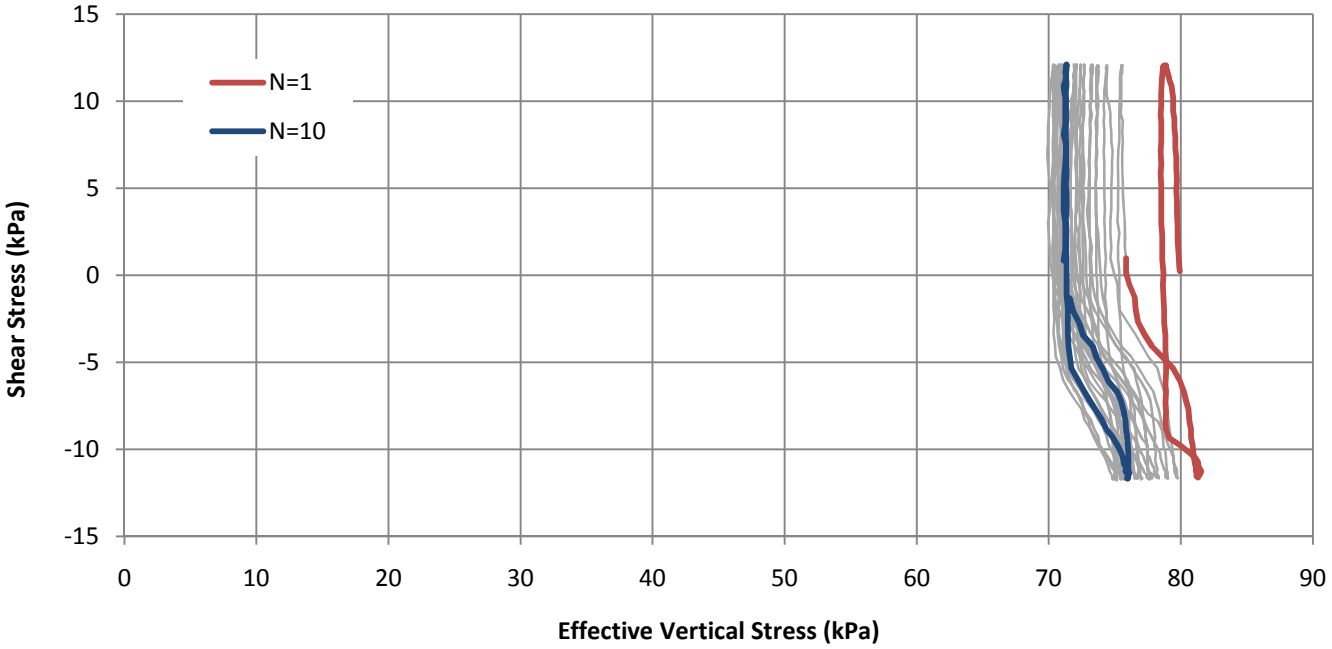
Location:	Unknown	**Depth (m):**	19.51-20.12
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





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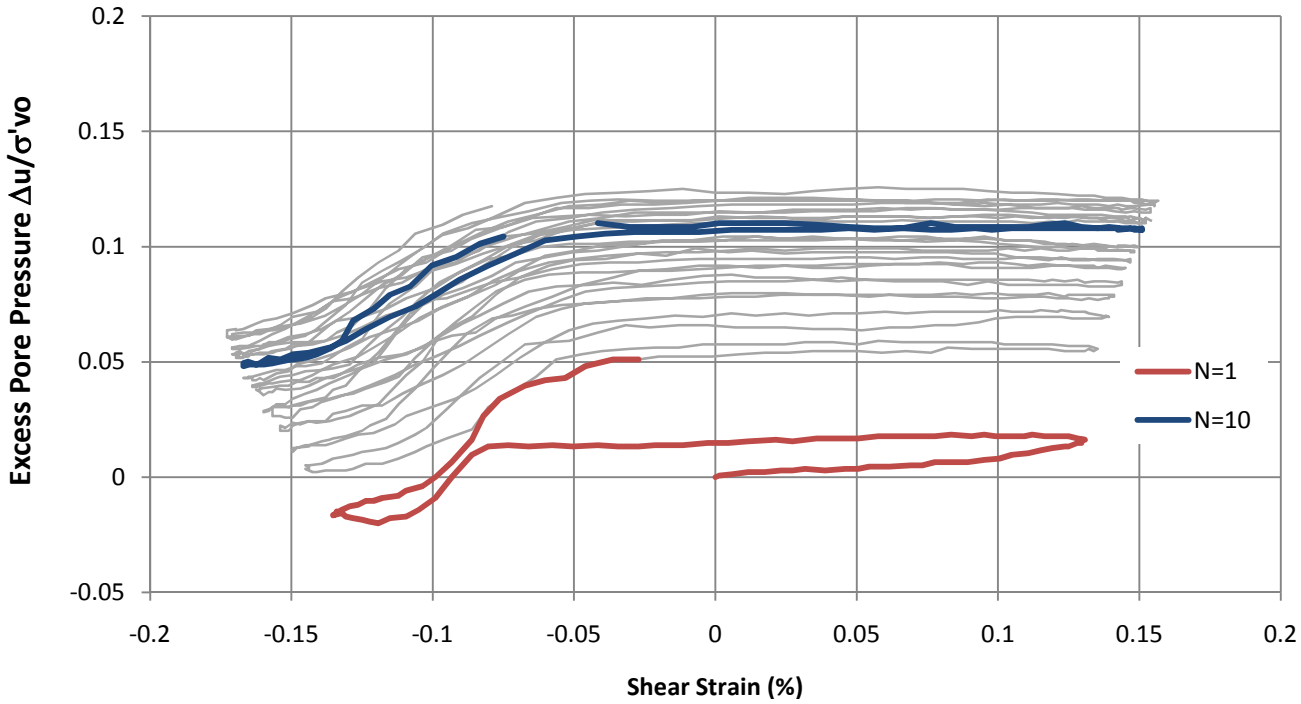

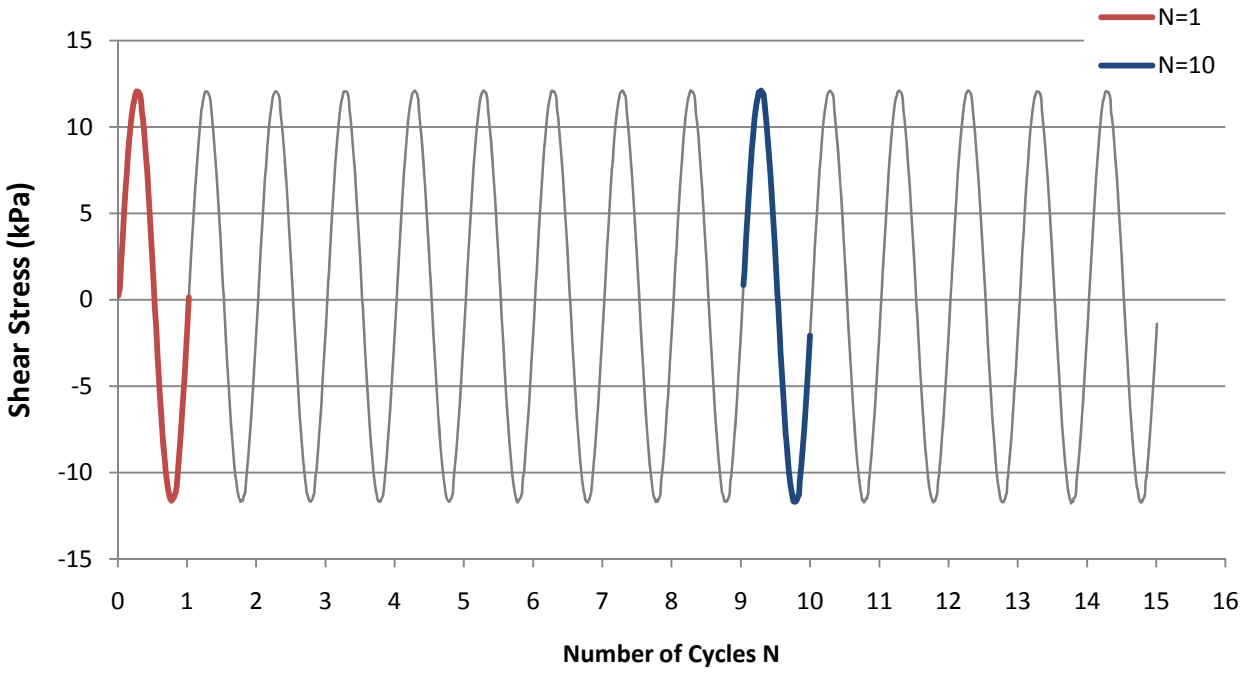

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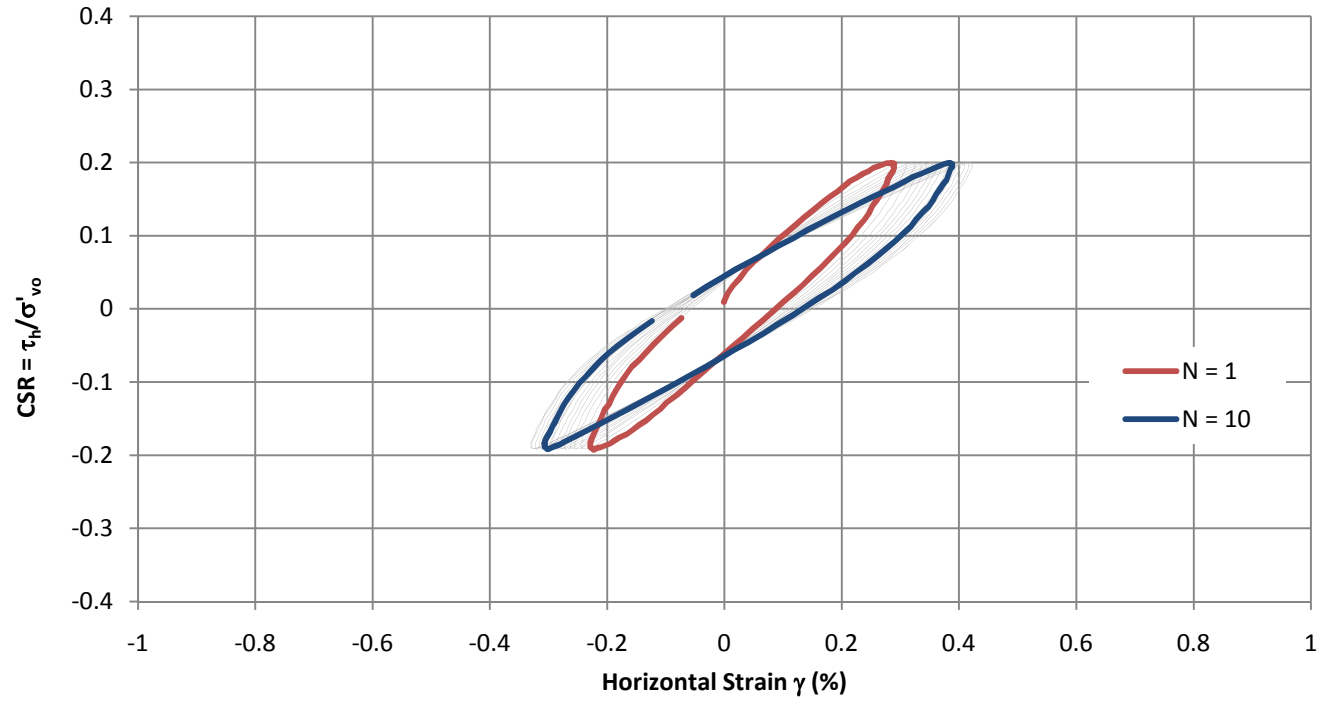
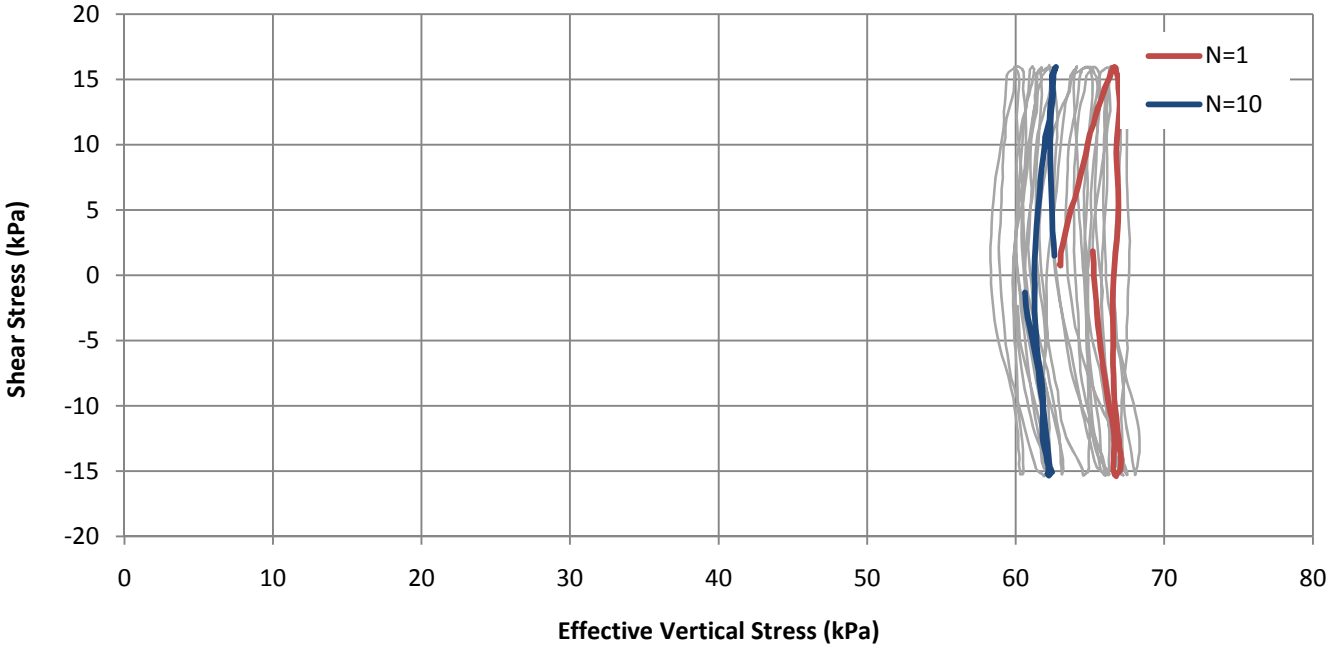
Direct Shear Testing of Soils Under Consolidated Constant-Volume Conditions

Reference
NORSOK G-001

Client:	09-1416-5011	**Sample No.:**	DH09-02 (S) Sy 4
Project:	KCB Project P09614A01	**Sample Location:**	Cyclic 1 CSR 0.20
Location:	Unknown	**Depth (m):**	19.51-20.12
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





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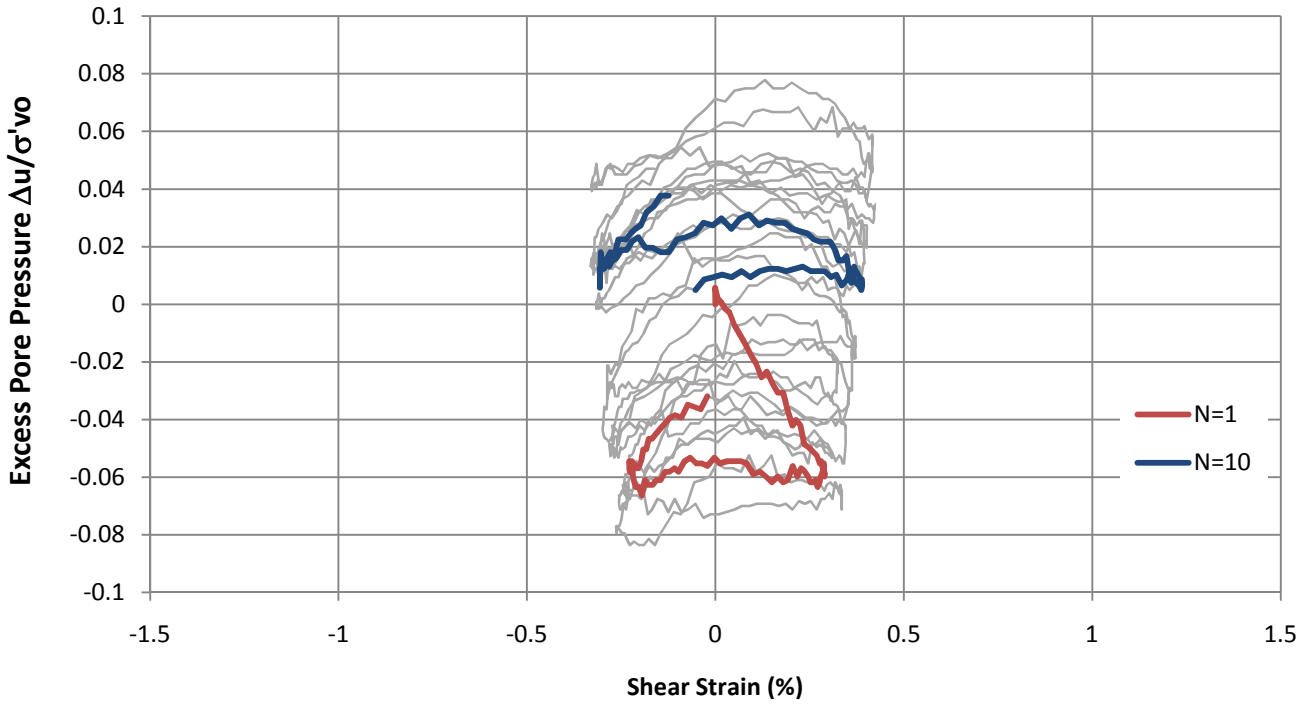
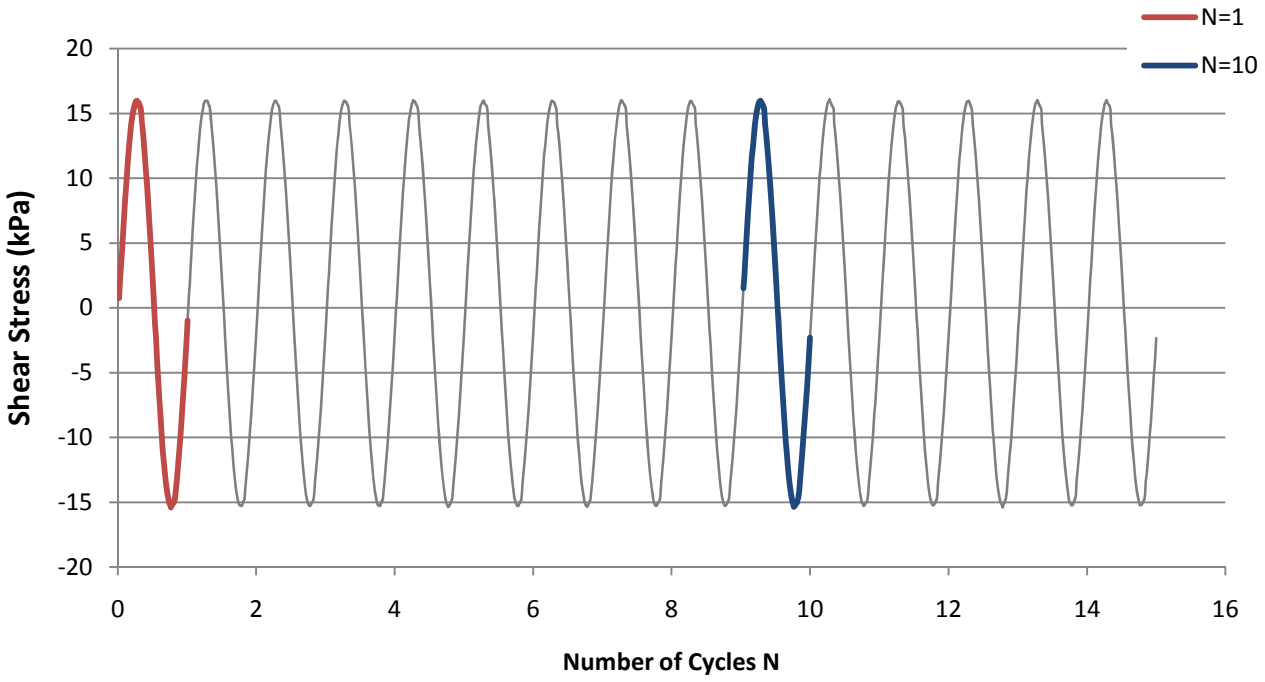
Location:	Unknown	**Depth (m):**	19.51-20.12
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





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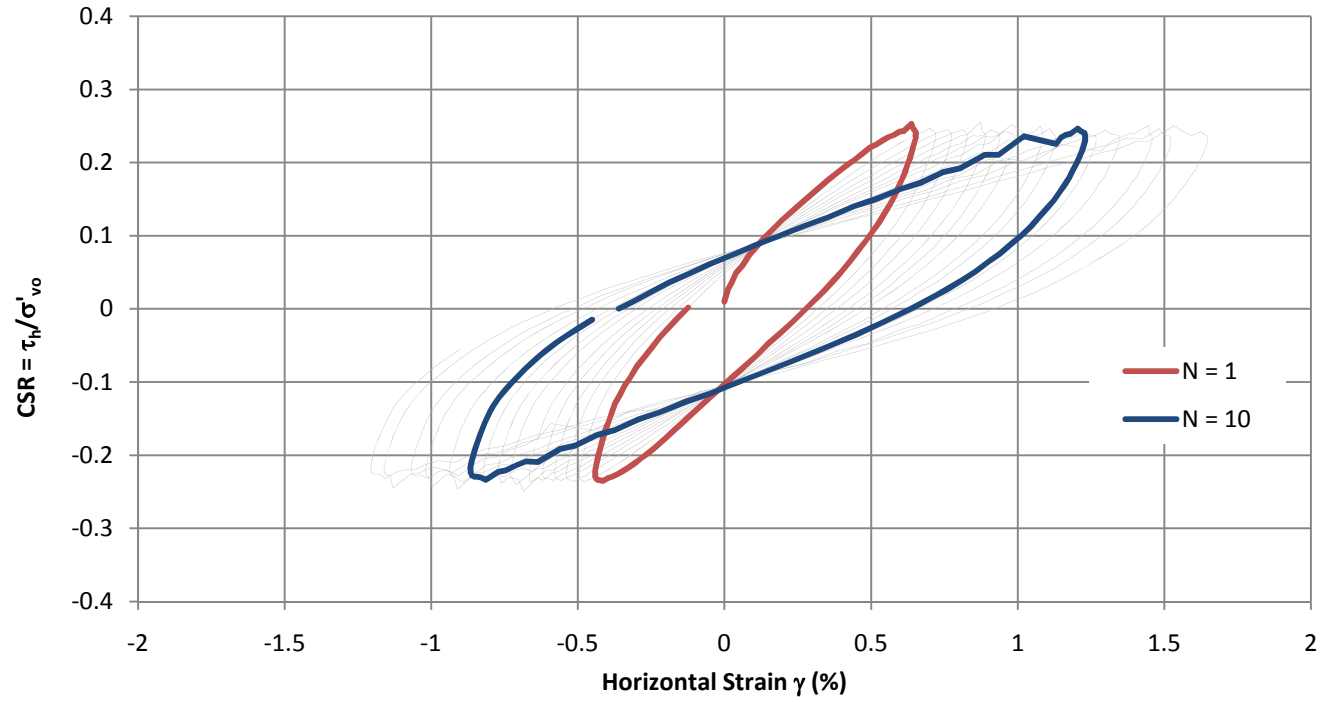
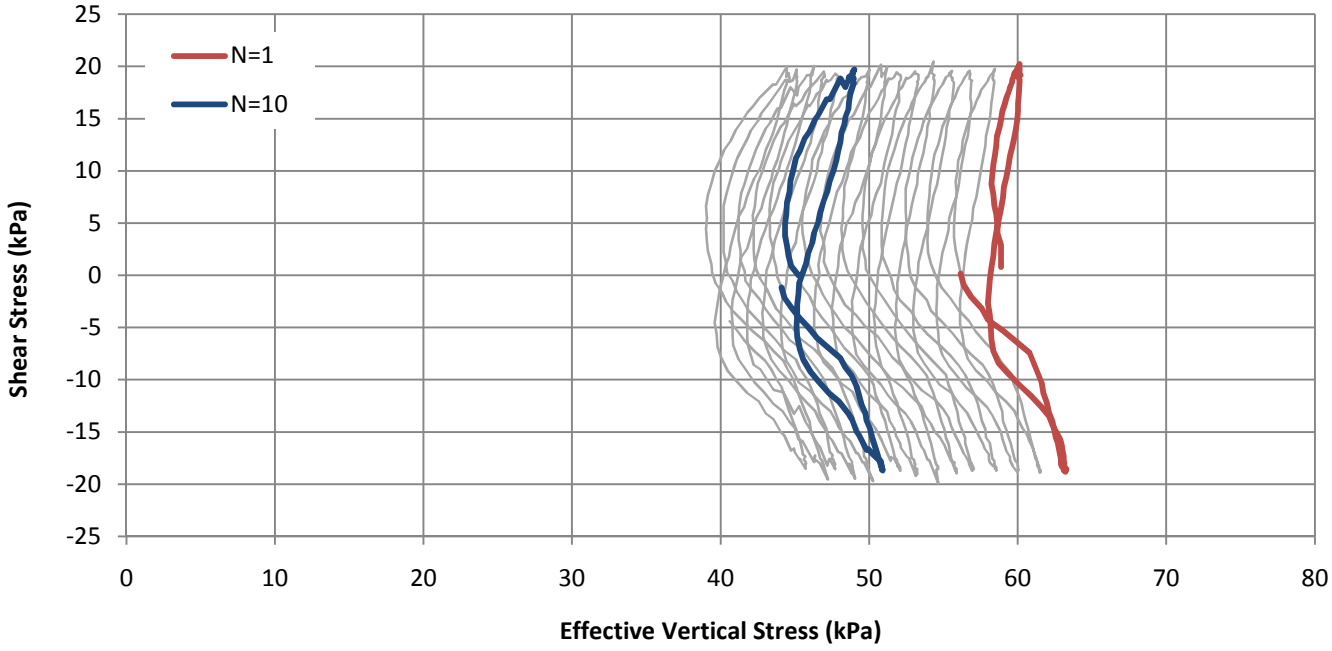
Project:	KCB Project P09614A01	**Sample Location:**	Cyclic 1 CSR 0.25
Location:	Unknown	**Depth (m):**	19.51-20.12
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





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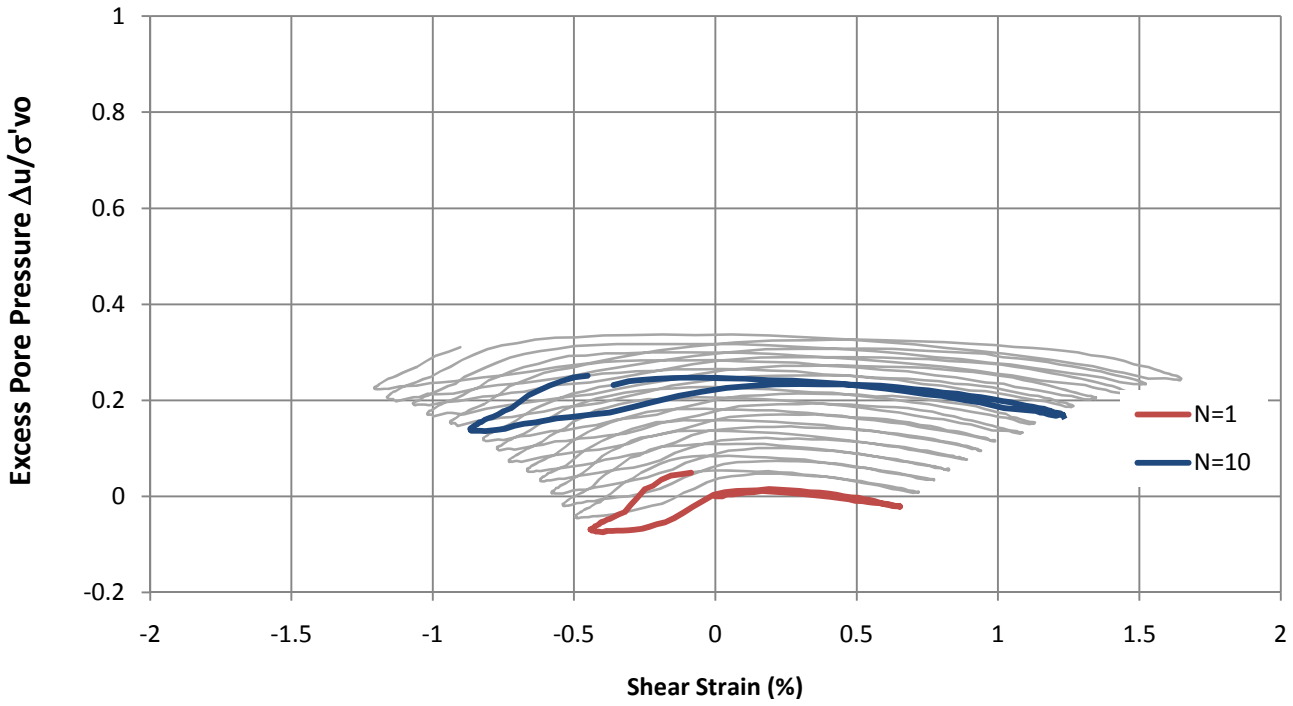
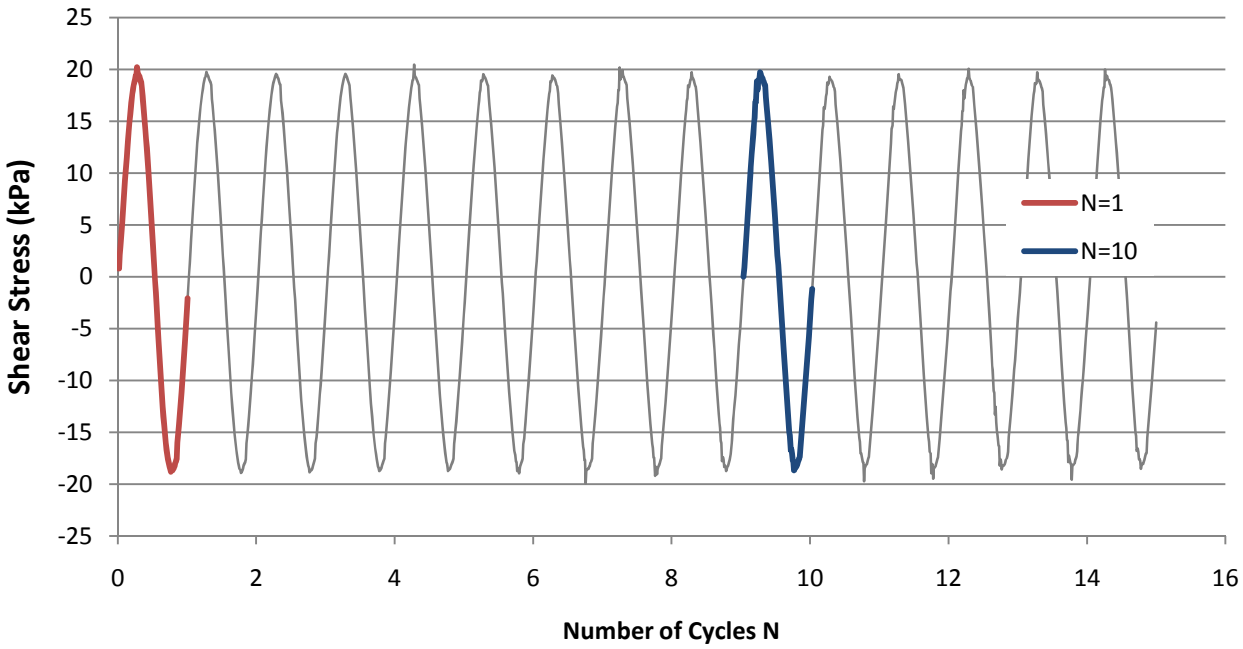
Location:	Unknown	**Depth (m):**	19.51-20.12
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





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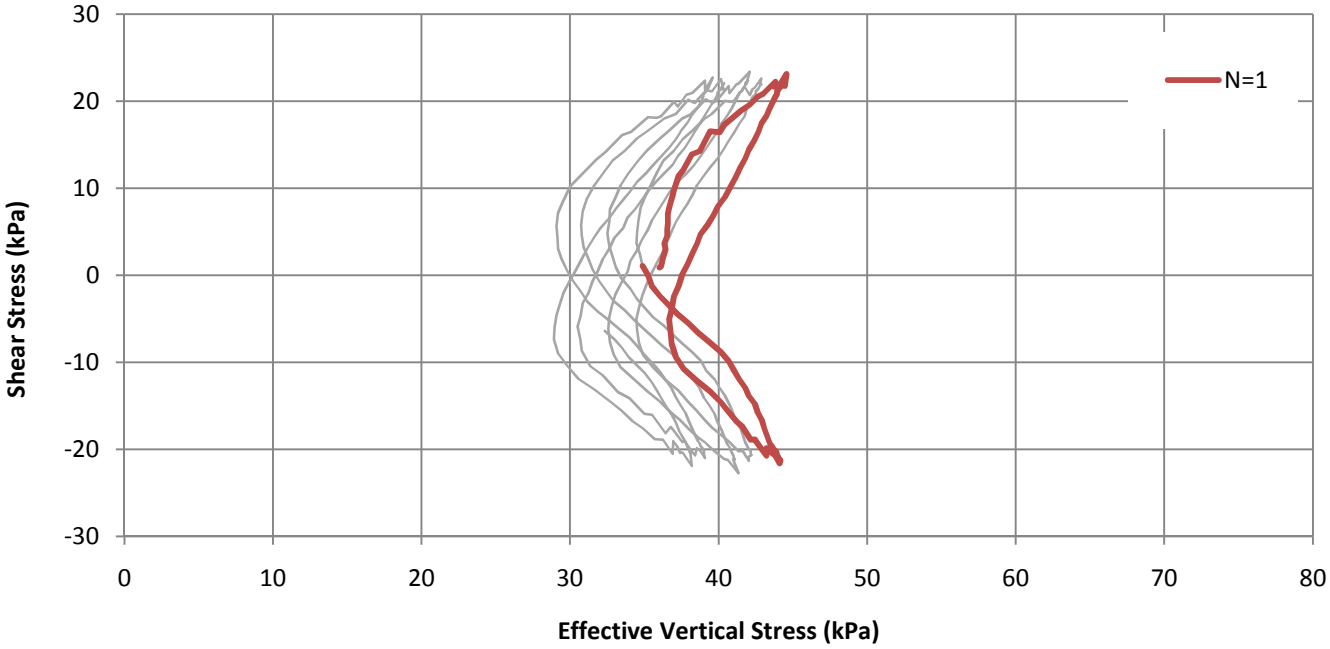
NORSOK G-001

Client:	09-1416-5011	**Sample No.:**	DH09-02 (S) Sy 4
Project:	KCB Project P09614A01	**Sample Location:**	Cyclic 1 CSR 0.30
Location:	Unknown	**Depth (m):**	19.51-20.12
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208



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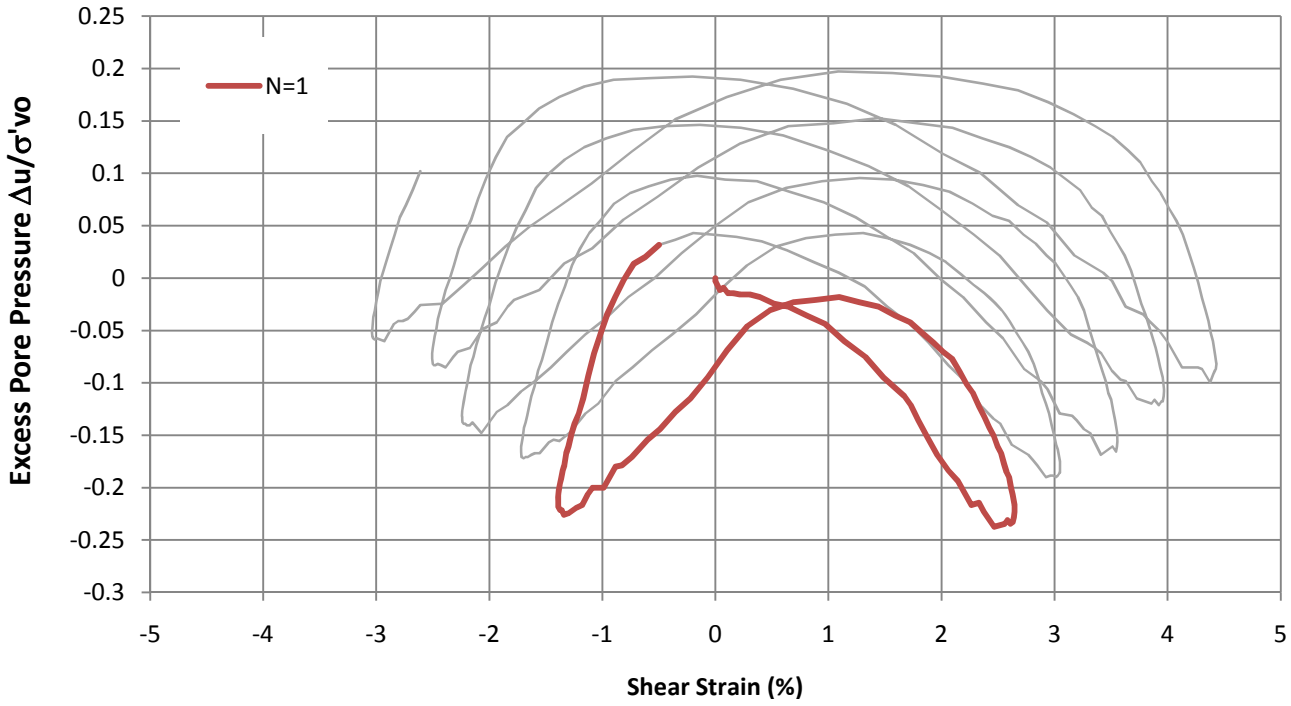
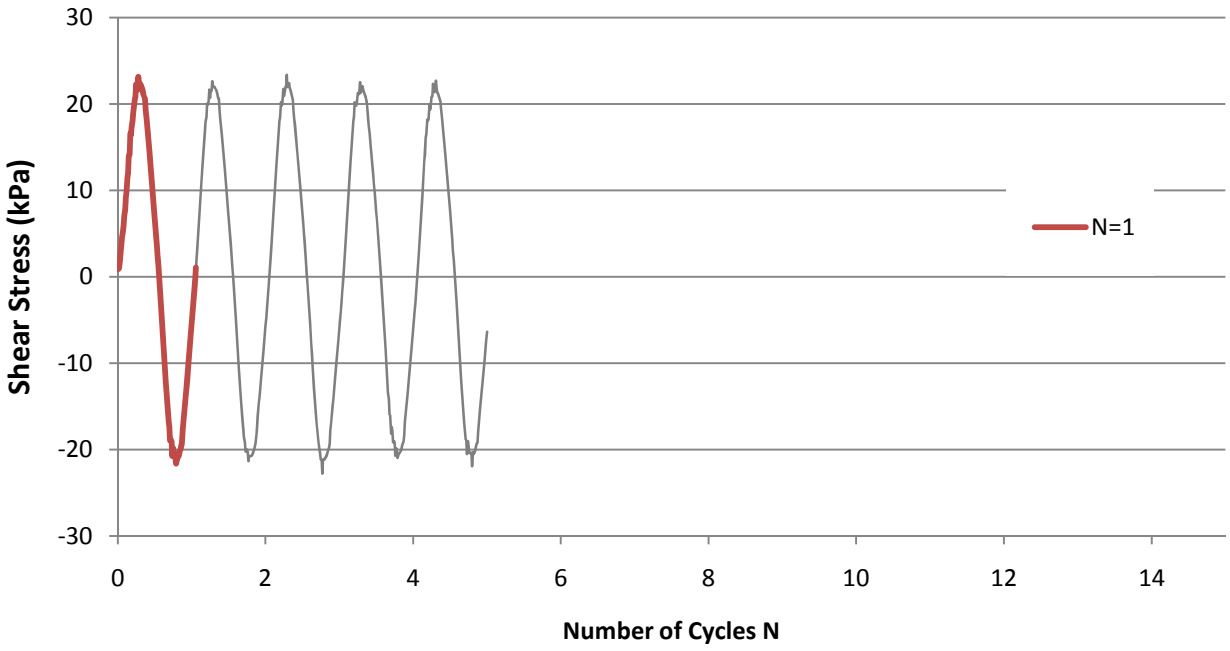
Location:	Unknown	**Depth (m):**	19.51-20.12
Project No.:	Klohn Crippen Berger Ltd.	**Lab ID No:**	208





G. Patton	December 7, 2009	ROB	December 21, 2009
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D10

ESQUIMALT GRAVING DOCK

PILE DESIGN

AMEC (1984)

Number of Pages: 23

VG-03286

January 4, 1984.

Public Works Canada,
Design & Construction,
Pacific Region,
1166 Alberni Street,
VANCOUVER, B.C.
V6E 3W5

ATTENTION: Mr. T.D. Harris, P.Eng.,
Senior Project Manager,
Port & Waterway Engineering.

Dear Sirs:

Re: Esquimalt Dry Dock,
South Landing Wharf
Pile Designs

1.0 INTRODUCTION AND SUMMARY

Public Works Canada propose to upgrade the facilities at their Esquimalt Dry Dock, Esquimalt, B.C. and in particular to upgrade the south landing wharf. The Prime Consultants for this work are Ker Priestman & Associates Ltd.

We understand that currently this project includes provision of several higher capacity areas on the existing south landing wharf from which unloading cranes can operate, and a sheet pile retaining wall along part of the north side of the south landing wharf. Backfill to this retaining wall will provide additional storage area.

In mid-November, 1983, Hardy Associates were instructed by Mr. T.D. Harris, P.Eng. of Public Works Canada to proceed with an investigation of the soils underlying the south landing wharf, this work being part of Project No. 100772, Contract No. 60 3049C.

This report describes the field work carried out and presents the results of laboratory strength and classification tests. The results of the investigation are discussed with respect to the capacity of the existing piles and the provision of higher capacity piles.

The test holes indicate that the area beneath the south landing wharf is underlain from the mud line by soft silts (typical dock bed deposits), a thick bed of soft to firm clay, a sandy till and finally bedrock at depths varying between 34 metres and approximately 60 metres below top of wharf level (+5.2 metres). Unconsolidated, undrained shear strength determinations are shown on Plate 9. The scatter of results is by no means unusual and based on back analysis of pile tests, has been interpreted to indicate a fairly uniform strength with depth having a value of approximately 50 kPa.

On the basis of this strength/depth plot, excellent agreement between the conventional office design of timber piles in clay and the results of in situ load tests is obtained. The existing piles can be shown to have theoretical ultimate pile capacities of approximately 115 kN at the west end to 210 kN at the east end, a 21 metre long pile should have a capacity of approximately 266 kN and a 24.4 metre pile should have a capacity of

approximately 370 kN. As noted, these results are in close agreement with the results of ten pile tests recently carried out and reported separately.

2.0 PROPOSED REDEVELOPMENT OF THE SOUTH LANDING WHARF

Public Works Canada are improving the facilities of Esquimalt Dry Dock and in particular are upgrading the south landing wharf. This upgrading may include a southward extension of the wharf, dredging along the south side of the wharf, the provision of higher load capacity access areas on the existing wharf, increasing the decked area at the west end of the wharf and the construction of a tied-back sheet pile retaining wall.

This particular report is specifically concerned with an understanding of the soil conditions beneath the south landing wharf and the determination of the capacity of piles that may be required during this redevelopment.

3.0 FIELD WORK

The field investigation program, which consisted of six rotary drill holes and two test pits, was carried out between November 29 and December 5, 1983. The six drill holes were put down using wet rotary techniques and the test pits were excavated with a Case 580C 'extender-hoe'. The depth of the six drill holes varied between 35 metres and 59 1/2 metres below the surface of the south landing wharf which we understand to have an elevation of +5.2 metres. The two test pits were excavated to depths of 4 and 4.3 metres from the existing ground surface which we understand to have an elevation of approximately 4.43 metres.

The field work was supervised by a geotechnical engineer who logged the drill cuttings, classified and preserved the samples and directed the methods of investigation. In general, Standard Penetration tests were carried out in non-cohesive soils to provide small, disturbed split spoon samples and a relative indication of density. Undisturbed Shelby tube samples were obtained in cohesive soils. Representative bulk samples were taken from the test pits.

The location of the test holes are shown on Drawing No. 1 and the logs of the test holes are shown on Plates 1 to 8 inclusive, preceded by an 'Explanation of Terms & Symbols' used on the logs.

4.0 SOIL PROFILE

It should be noted that the six drill holes were all drilled from the surface of the south landing wharf which is understood to have an elevation of +5.2 metres. Reference to the test hole logs indicates that the top of the dock bed mud deposits varies from approximately 11 1/2 metres at the east end to 14 metres at the west end along the south face. This wharf partly straddles a sloping fill bank to the north and the ground surface was encountered between 6 metres and 4 1/2 metres below wharf level in test holes 5 and 6 respectively, which were drilled along the north side of the wharf.

Beneath the mud line, the test holes encountered a soft silt deposit which sometimes contained organic materials, sand, shells and gravel. We assume that this material is very recent sediment with some other debris. Underlying the recent sedimentary silt, there is a relatively thick bed of clay which is firm to stiff and in some zones contains shell fragments, pebbles and sand laminations. The thickness of this clay encountered in test holes 1 to 4 varied between 16 and 32 metres in test holes 1 and 4 respectively. In test holes 5 and 6, the thickness of this clay was 20 metres and 12 metres respectively. The clay was generally underlain by a sand till which was generally dense. Bedrock was either proven or inferred below the sand till. In general, the elevation of the top of bedrock trends downwards from east to west and north to south.

5.0 LABORATORY TESTS

The unconsolidated, undrained shear strength of all the samples obtained within a depth of 30 metres from the wharf deck level was determined. Several samples were unsuitable for testing because of the sandy nature of the particular samples. One sample was too soft to prepare for testing and its undrained shear strength was determined using the laboratory vane apparatus. The shear strengths are shown on Plate 9. An indication of the shear strength of the samples was also obtained during drilling operations using a pocket penetrometer and the inferred shear strengths are also shown on Plate 9.

As an aid to classification and relative comparison of soils, classification tests consisting of moisture contents, densities and Atterberg limits were also measured. The results of these tests are shown on the test hole logs, Plate 1 to 8 inclusive.

6.0 DISCUSSION

The design of friction piles in clay is most commonly based on the unconsolidated, undrained shear strength of the clay. The formula for ultimate pile capacity is simple. Total pile capacity is assumed to equal the sum of friction on the pile shaft embedded in the soil and the bearing capacity at the tip of the pile. For relatively long, straight shafted (or slightly tapered) piles, pile tip bearing capacity is not a major component of the total capacity. More significantly, during working conditions, the settlement required to mobilize the maximum tip resistance far exceeds that settlement required to fully mobilize (fail in shear) the shaft resistance. An estimate of shaft resistance then, is the most important aspect of the design of straight shafted piles in clay.

Ultimate pile shaft resistance has been shown to be equal to the area of the shaft multiplied by average soil adhesion. The relationship between soil shear strength and pile/soil adhesion is contentious though it is general practice to use one of several accepted published relationships between strength and adhesion.

The representative design shear strength between 12 and 29 metres below wharf deck level is shown on Plate 9. It should be noted that a fairly optimistic representative line has been adopted following a trial and error process based on the measured ultimate capacities from 10 pile tests at the wharf. The ratio of adhesion and shear strength was assumed to be 0.85 and the taper on timber piles was assumed to enhance the capacity by 10%.

Calculations for the ultimate capacity of four piles, two 18.3 metres long (one at the east end and one at the west end of the wharf), a 21.3 metre long pile and a 24.4 metre long pile, these latter two being at average locations, are shown in Appendix C.

It can be seen that these calculations indicate that an existing pile at the west end of the wharf probably has an ultimate capacity of 115 kN, while an existing pile at the east end of the wharf has a capacity of the order of 210 kN. An average 21.3 metre long pile (70 feet) should have an ultimate capacity of 265 kN and a 24.4 metre long pile (80 feet) should have an ultimate capacity of the order 370 kN. We would normally suggest factors of safety should be applied to these ultimate capacities of between 2.5 and 3.0, however, because of the pile testing program, we feel that it is acceptable to reduce the factor of safety to approximately 2. Therefore, suggested working capacities are as shown in the following table.

CALCUATED WORKING CAPACITY OF PILES

PILE LENGTH	CAPACITY
Existing	
18.3 m long (west end)	57 kN
18.3 m long (east end)	105 kN
New	
21.3 m long (average)	132 kN
24.4 m long (average)	185 kN

We understand that the existing wharf piles have an approximate penetration below the mud line of 6 metres and we infer that the original piles were approximately 60 feet (18.3 metres) long. Since the elevation of the mud line falls steadily from east to west, the actual penetration into the underlying soils achieved at the west end of the wharf would be significantly smaller than at the east end. During a separate phase of this project, Hardy Associates carried out pile loading tests on nine of the existing wharf piles and although we are not aware of the precise location of the test piles, there were indications that piles with higher number designations had significantly less capacity than lower numbered piles. We understand that piles were numbered from east to west. These pile test results are presented in our report VG-03403 dated December 14, 1983.

It is our understanding that a new pile was driven recently on the instructions of Ker Priestman & Associates and that this pile has a penetration below the mud line of 11.3 metres and has an overall length of 24.4 metres (80 feet). This pile was also load tested as part of the pile testing program described above.

In summary, the pile test program indicated that existing piles at the east end of the wharf have ultimate capacities of approximately 260 kN, piles in the center of the wharf have capacities of approximately 198 kN, but piles at the west end of the wharf have capacities of approximately 102 kN. It can be seen that the capacities predicted by design are in good agreement with those actually measured. It is admitted that this is not wholly fortuitous since the choice of a representative strength/depth profile was guided by a back analysis of the pile test results.

Nevertheless, the agreement provides additional confidence in pile behaviour and back analysis is a valid and essential technique in geotechnical design.

7.0 CONCLUSIONS & RECOMMENDATIONS

This investigation has indicated that the existing south landing wharf at Esquimalt Dry Dock is underlain by soft dock bed deposits, a relatively thick bed of soft to firm clay, dense sandy till and bedrock. The elevation of the dock bed deposits is significantly lower at the west end of the wharf than at the east end and assuming the existing wharf piles are all approximately 18.3 metres (60 feet) long, then pile penetration into the clay at the west end of the dock is considerably smaller than at the east end. Consequently, the capacity of the existing piles at the west end is significantly less than those at the east end.

The theoretical capacity of friction piles of various lengths has been calculated and compared with the results of pile tests carried out under a separate phase of this work. Although back analysis of the piles was used to some extent to determine the operating strength of the clay, good agreement was obtained between the results of the pile tests and the calculated theoretical pile capacities.

We recommend that the working capacities of piles in the immediate vicinity of this wharf be based on the capacities given in the table in Section 6 above.

We are pleased to continue our assistance on this project and we trust the above report contains the information you require at this stage. However, please do not hesitate to contact us if you should require any additional details.

Yours truly,

HARDY ASSOCIATES (1978) LTD.

Per: E.H Harrington

E.J. Harrington, P.Eng.,
Geotechnical Project Engineer.

EJH:cm,nmd

Enclosures

EXPLANATION OF TERMS AND SYMBOLS

The terms and symbols used on the borehole logs to summarize the results of field investigation and subsequent laboratory testing are described in the following pages.

It should be noted that materials, boundaries, and conditions have been established only at the borehole locations, and are not necessarily representative of subsurface conditions elsewhere across the site.

TEST DATA

Data obtained from laboratory and field testing are shown on the grid at the appropriate depth interval.

The natural moisture (water) content of the soil at the time of drilling is plotted against depth, together with the plastic and liquid limits where determined.

Abbreviations, graphic symbols, and relevant test method designations are as follows:

⊙	w	natural moisture content (ASTM D 2216)
⊡	w_P	plastic limit (ASTM D 424)
△	w_L	liquid limit (ASTM D 423)
	NP	non plastic soil
——→		seepage
▼		observed water level

Other abbreviations and symbols are as shown on the borehole log sheet.

DEPTH

The depth of borehole below existing ground surface is shown. Corresponding elevations sometimes are shown with respect to the datum given.

SOIL CLASSIFICATION AND DESCRIPTION

Soils are classified and described according to their engineering properties and behaviour.

The soil of each stratum is described using the Unified Soil Classification System[1] modified slightly so that an inorganic clay of "medium plasticity" is recognized.

The use of modifying adjectives may be employed to define the actual or estimated percentage range by weight of minor components. This is similar to a system developed by D.M. Burmister.[2]

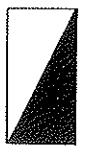
The soil classification system is shown in greater detail on page 3.

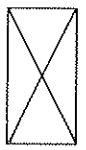
1. "Unified Soil Classification System", Technical Memorandum 3-357 prepared for Office, Chief of Engineering, by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S Army Vol 1, March 1953.

2. American Society for Testing and Materials Procedures for Testing Soils, "Suggested Methods of Testing for Identification of Soils", 4th Ed. pp 221-233, Dec 1964.

SOIL SAMPLES

CONDITION — This column graphically indicates the depth and condition of the sample:


undisturbed


disturbed

not recovered

TYPE — The type of sample is indicated in this column as follows:

A auger sample
B block sample
C rock core, or frozen soil core
D drive sample
P Pitcher tube sample
U tube sample (usually thin-walled)
W wash or air return sample
O other (see report text)

PENETRATION RESISTANCE — Unless otherwise noted this column refers to the number of blows (N) of a 140 pound (63.5 kg) hammer freely dropping 30 inches (0.76 m) required to drive a 2 inch (50.8 mm) O.D. open-end sampler 0.5 feet (0.15 m) to 1.5 feet (0.45 m) into the soil, or until 100 blows have been applied, in which case, the penetration is stated. This is the standard penetration test referred to in ASTM D 1586.

OTHER TESTS

In this column are tabulated results of other laboratory tests as indicated by the following symbols:

*C	Consolidation test
Fines	Percentage by weight smaller than #200 sieve
D_R	Relative density (formerly specific gravity)
k	Permeability coefficient
*MA	Mechanical grain size analysis and hydrometer test (if appropriate)
pp	Pocket penetrometer strength
*q	Triaxial compression test
q_u	Unconfined compressive strength
*SB	Shearbox test
SO_4	Concentration of water-soluble sulphate
*ST	Swelling test
TV	Torvane shear strength
VS	Vane shear strength (undisturbed-remolded)
ε_f	Unit strain at failure
γ	Unit weight of soil or rock
γ_d	Dry unit weight of soil or rock
ρ	Density of soil or rock
ρ_d	Dry density of soil or rock

* The results of these tests usually are reported separately.

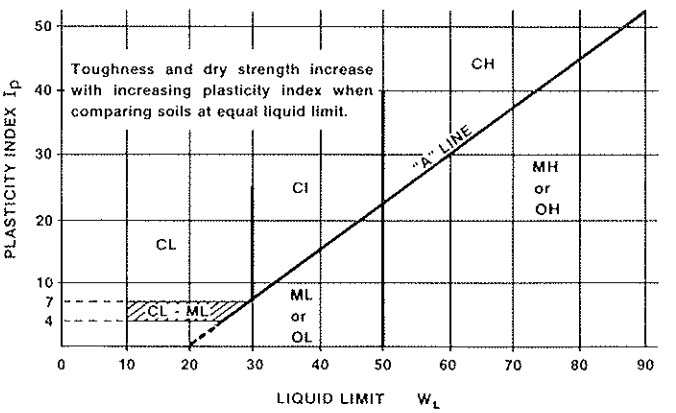
SOIL CLASSIFICATION SYSTEM (MODIFIED U.S.C.)

MAJOR DIVISION			GROUP SYMBOL	GRAPHIC SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE SIZE)	GRAVELS MORE THAN HALF COARSE FRACTION LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS	GW		RED	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, < 5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			GP		RED	POORLY-GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, < 5% FINES	NOT MEETING ALL ABOVE REQUIREMENTS	
		DIRTY GRAVELS	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES > 12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR $I_p < 4$	
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES > 12% FINES	ATTERBERG LIMITS ABOVE "A" LINE, $I_p > 7$	
	SANDS MORE THAN HALF COARSE FRACTION SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS	SW		RED	WELL-GRADED SANDS, GRAVELLY SANDS, < 5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			SP		RED	POORLY-GRADED SANDS, OR GRAVELLY SANDS, < 5% FINES	NOT MEETING ALL ABOVE REQUIREMENTS	
		DIRTY SANDS	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES > 12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR $I_p < 4$	
			SC		YELLOW	CLAYEY SANDS, SAND-CLAY MIXTURES > 12% FINES	ATTERBERG LIMITS ABOVE "A" LINE OR $I_p > 7$	
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO. 200 SIEVE SIZE)	SILTS BELOW "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	$W_L < 50$	SEE CHART BELOW
			MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	$W_L > 50$	
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	$W_L < 30$	
			CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY SILTY CLAYS	$W_L > 30$, < 50	
			CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	$W_L > 50$	
	ORGANIC SILTS & ORGANIC CLAYS BELOW "A" LINE ON PLASTICITY CHART		OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	$W_L < 50$	
			OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY	$W_L > 50$	

1. All sieve sizes mentioned on this chart are U.S. Standard, ASTM E11.
2. Boundary classifications possessing characteristics of two groups are given combined group symbols eg GW-GC is a well-graded gravel-sand mixture with clay binder between 5% and 12%.
3. Soil fractions and limiting textural boundaries are in accordance with the Unified Soil Classification System, except that an inorganic clay of medium plasticity (CI) is recognized.
4. The following adjectives may be employed to define percentage ranges by weight of minor components:

and	50 - 36%
some	35 - 21%
little	20 - 11%
trace	10 - 1%

PLASTICITY CHART



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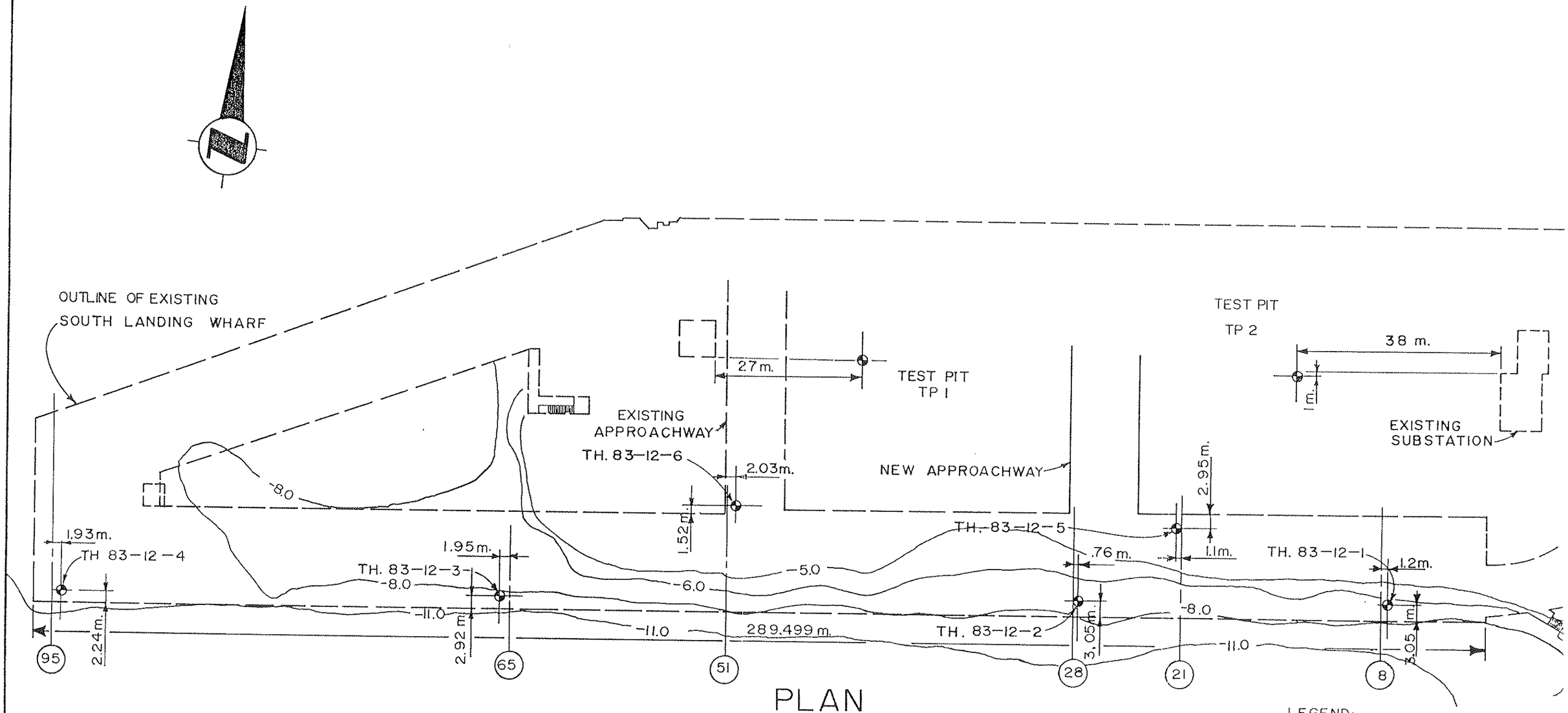

PLAN

LEGEND:

TEST HOLE -- YEAR-MONTH-NO.

PRODUCED FROM A DRAWING SUPPLIED BY KER PRIESTMAN & ASSOC. LTD.

REVISIONS	REFERENCES	SCALE DO NOT I DATE 83-12-21 MADE D.D.M. CHKD. E.H. APPD. E.H.	HARDY ASSOCIATES (1978) LTD. CONSULTING ENGINEERING & PROFESSIONAL SERVICES	PUBLIC WORKS CANADA ESQUIMALT DRY DOCK SOUTH LANDING WHARF TEST HOLE LOCATIONS No. VG-03286-1

RT14 - 79/0

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

PROJECT: PUBLIC WORKS CANADA
ESQUIMALT DRY DOCK, SOUTH LANDING WHARF
ESQUIMALT, B.C.

LOGGED/DWN). fic/DDH | CKD. EJH | DATE OF INVEST. 83-11-29 | JOB NO. VG-83286 | HOLE NO. TH 1

DRILL TYPE: Wet-Rotary

WATER CONTENT
W_P - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DATUM: South Landing Wharf
SURFACE ELEVATION: +5.20 m (17.0 ft.)

DEPTH ft./m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS
0 0		Wharf, 2" asphalt, 4" timber				PP,tsf (kPa)
10 5						
20						
30 10						
40		SILT, highly organic, very soft, non-low plasticity, black.				
50 15		SILT - trace fine sand, shell fragments, soft, non-low plast., grey. Trace angular coarse sand.		U		PP,1.2(14.9
				U		PP,0.7(67.0
						γ=1958 kg/m3
60		CLAY - little-some silt, trace fine sand in clay matrix, med.-stiff to stiff, medium to high plast., grey, moist.		U		PP,0.8(76.6
20						γ= 2024 kg/m3
70				U		
				U		PP,0.7(67.0
						γ= 2012 kg/m3
80 25		Higher plasticity noted at 37 ft. homogeneous clay.				
		- Isolated gravel sizes.		U		PP,1.1(105.6
90						γ= 1927 kg/m3
30 100						
		SAND & GRAVEL, clean, and clay layers.				
110		SAND - fine to coarse, little fine gravel, clean, sub-angular, grey, medium dense.				
35				W		
115		BEDROCK, whitish-grey.				
		End of hole @ 115 ft.				

Figure 1

HT08 - 79/05

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BOREHOLE LOG

PROJECT PUBLIC WORKS CANADA
ESQUIMALT DRY DOCK, SOUTH LANDING WHARF
ESQUIMALT, B.C.

LOGGED/DWN. D.Mc/DDM	CKD. EJH	DATE OF INVEST. 83-11-29	JOB NO. VG-03286	HOLE NO. TH 2

WATER CONTENT — W_p - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH ft./m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM South Landing Wharf

SURFACE ELEVATION +5.20 m (17.0 ft.)

DRILL TYPE: Wet-Rotary

0 0 — Wharf: 2" asphalt, 4" deck timbers.

10 5 — 20

30 10 — 40

50 15 — SILT - trace of fine sand, trace organics, soft, structureless, low plast., grey-black, shells, strong smell of decaying organics, moist, sensitive. — U

U

U — PP,0.3(28.7) γ= 2006 kg/m^3

60 — SAND & Silt, trace fine gravel, fine sand, loose non-plast., grey, shells, sensitive, moist.

20 70 — CLAY - little fine sand, trace silt, very soft, stratified, high plast., grey, moist,
- increasing stiffness at 65 ft. (19.8 m)
- trace pebbles
- isolated cobble

80 25 — U — γ= 1951 kg/m^3

90

30 100

110

35 120

130 40

140 — Bedrock - End of hole @ 141.1 ft.

U

Figure 6

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BOREHOLE LOG

PROJECT: PUBLIC WORKS CANADA
ESQUIMALT DRY DOCK, SOUTH LANDING WHARF
ESQUIMALT, B.C.

LOGGED/DWN. D.Mc/DDM	CKD. EJH	DATE OF INVEST. 83-11-30	JOB NO. VG-03286	HOLE NO. TH 3

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH ft./m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM South Landing Wharf

SURFACE ELEVATION +5.20 (17.0 ft.)

DRILL TYPE: Wet-Rotary

Depth ft.	Depth m	Soil Description	Type	Penetration Resistance	Other Tests
0	0	Wharf, 2" asphalt, 4" deck timbers			PP,tsf (kPa)
10	3				
20	5				
30	10				
40					
50	15	SILT			
		GRAVEL - little sand, clean, sub-rounded, poorly graded, shell fragments, loose, grey-green.	U		
			D		γ = 1738 kg/m^3
60		SILT - some clay, trace fine sand, stiff, low plast., moist, shells, decaying organic smell, grey-green.	U		PP,1.1(105.3)
			U		
70	20		U		PP,1.5(143.6)
		CLAY - some silt, trace sand, stiff, med.-plast., shells, occasional pebble, moist, grey.			γ = 2337 kg/m^3
80	25				
90		CLAY - trace silt, firm, high plasticity, occasional pebble, grey, moist.	U		PP,0.8(76.6)
100	30				
110					
	35		U		PP,0.8(76.6)
120					
130	40	SAND till, some gravel, little silt, dense, grey-green.	D	74/6"	
140		Note: Hole drilled to 134' but filled with slough to 131'-4". After punching sampler through slough, blow counts were recorded from 134'-4" to 136'-10")			
	45	BEDROCK, grey and white			
		End of hole @ 138'-6"			

Plate 3

HARDY ASSOCIATES (1978) LTD.
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BO :HOLE LOG

PROJECT PUBLIC WORKS CANADA
ESQUIMALT DRY DOCK, SOUTH LANDING WHARF
ESQUIMALT, B.C.

LOGGED/DWN. D.Hc/DDM	CKD. EJH	DATE OF INVEST. 83-12-01	JOB NO. VG-03286	HOLE NO. TH 4

WATER CONTENT — Wp - □ w - ○ w_L - △ — PERCENT % — 10 20 30 40 50 60

DRILL TYPE: Wet-Rotary

DATUM South Landing Wharf

SURFACE ELEVATION +5.20 m (17.0 ft.)

DEPTH ft/m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	SOIL SAMPLE PENETRATION RESISTANCE	OTHER TESTS
0 0		Wharf, 2" asphalt, 4" deck timbers.				PP,tsf(kPa)
10 5						
20						
30 10						
40						
50 15		SILT - numerous shells, occas. decaying wood fragments, very soft, black (organic)				
60		SILT - frequent shells, trace sand, occasional sub-rounded pebbles, structureless, very soft, moist, non-plastic, grey-green.	☒	D	0	
70 20				D	12	
80		CLAY - some silt, trace sand, stiff, medium plastic, grey.				γ=2045 kg/m^3
25						
90		CLAY - little silt, stiff - very stiff, structureless, med.-high plast.,moist,grey.				
100 30		CLAY - trace silt, stiff, structureless, high plasticity grey, moist.				
120						
130 40						
140		End of hole @ 177 ft.				
180 55		Probed with cone (@175 ft.) - pushed to 196 ft. - SPT hammer				
190					25/0.25"	
60 200		BEDROCK (detected by refusal of probe cone)				

Plate 4

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

PROJECT: PUBLIC WORKS CANADA
ESQUIMALT DRY DROCK, SOUTH LANDING WHARF
ESQUIMALT, B.C.

LOGGED/DWN. D.Mc/DDM | CKD. EJH | DATE OF INVEST. 82-12-03 | JOB NO. VG-03286 | HOLE NO. TH 6

DRILL TYPE: Wet-Rotary

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DATUM South Landing Wharf
SURFACE ELEVATION +5.20 m (17.0 ft.)

DEPTH ft./m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	SOIL SAMPLE PENETRATION RESISTANCE	OTHER TESTS
0 0		Wharf, 2" asphalt, 4" deck timbers				PP,tsf (kPa)
10 5		SAND (fill) - fine to coarse grained, trace gravel, little-some silt, loose, black.				
20 10		CLAY (fill) - trace-little silt, little fine to coarse sand, very soft, structureless, high plast., grey, moist, wet, shell fragments.		D	< 1	
30 40 50 15		GRAVEL (fill) - cobbles, sand, angular-subangular particles.				
60 20		SILT - trace clay, trace little fine sand, soft, non-low plast., green-black, organic smell, moist, wet, med.-stiff @ 59'		D	10	
70 80 25		CLAY - trace silt, stiff, high plasticity, grey, occasional shell fragments & pebble, moist. - gravel layer 4" thick @ 78'		U		
90 100 30				U		PP,1.3(124.5)
110		SAND (till) some gravel, little silt, dense-very dense, grey, occasional cobble, - increasing denseness with depth. End of hole @ 110 ft.				

Plate 6

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BOREHOLE LOG

PROJECT PUBLIC WORKS CANADA
ESQUIMALT DRY DOCK, SOUTH LANDING WHARF
ESQUIMALT, B.C.

LOGGED/DWN. D.MC/DDM | CKD. EJR | DATE OF INVEST. 83-12-02 | JOB NO. VG-03286 | HOLE NO. TH 5

DRILL TYPE: Wet-Rotary

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DATUM South Landing Wharf
SURFACE ELEVATION +5.20 m (17.0 ft.)

DEPTH ft./m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	SOIL SAMPLE PENETRATION RESISTANCE	OTHER TESTS
0 0		Wharf, 2" asphalt, 4" deck timbers.				PP,tsf (kPa)
10 5						
20		SILT (fill) - trace little sand, little gravel, non-plastic, soft, black, frequent cobbles.				
30 10		CLAY (fill) - trace-little silt, trace sand lenses, very soft, structureless, high plasticity, grey, moist-wet.	⊠	D	<2	
40			◥			PP,0.3(28.7) γ=2012 kg/m³
50 15		SILT - trace fine sand, very soft, non-plastic, black, frequent shells.	⊠	D	2	
		CLAY - trace silt, med. stiff, high plast., grey, occasional oxide stain, occasional shell fragments, moist.	◥	D	10	
60 20				U		PP,0.9(86.2) γ=1909 kg/m³
70		- trace fine-medium sand.				
80 25		- laminations of silt and fine sands.		U		PP,0.8(76.6) γ=1934 kg/m³
90						
100 30			◥	U		
110		- fine-medium grain sand lenses	⊠	D	7	
35						
120		SAND (till) - fine-coarse grained, little gravel to 75 mm trace fines, loose to med.dense multi-coloured, but predominantly grey-green.				
130 40		Progressively denser and harder drilling.				
140		End of hole @ 139'				

Plate 5

HARDY ASSOCIATES (1978) LTD.
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BOREHOLE LOG

PROJECT: PUBLIC WORKS CANADA
ESQUIMALT DRY DOCK, SOUTH LANDING WHARF
ESQUIMALT, B.C.

LOGGED/DWN. D.Mc./DDM | CKD. EGH | DATE OF INVEST. 83-12-05 | JOB NO. VG-03286 | HOLE NO. TP 1

DRILL TYPE: Backhoe

WATER CONTENT
W_P - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | OTHER TESTS

DATUM: Ground Surface
SURFACE ELEVATION: 14.55 ft.(4.43 m)

0.25 / 0.50 / 0.75 / 1.0 — SAND (fill) - little-some gravel, trace - little silt, loose, structureless, borwn, occ. - frequent angular cobbles (to 500 mm dia.), red oxide or pullutant stain.
TYPE: 0 / 0 / 0

2.0 — CLAY (fill) - trace-little silt, little sand, little angular gravel, soft, structureless, grey, occasional angular cobble (to 300 mm dia.)moist-wet.

Water level @ 2.4 m

3.0 / 4.0 — COBBLES & GRAVEL - fine to coarse, angular, little angular sand, little clay, numerous cobble (to 600 mm dia.)

Test pit discontinued @ 4.3 m

Plate 1

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BOREHOLE LOG

PROJECT: PUBLIC WORKS CANADA
ESQUIMALT DRY DROCK, SOUTH LANDING WHARF
ESQUIMALT, B.C.

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
D.Mc/DDM	EJH	83-12-05	VG-03286	TP 2

DRILL TYPE: Backhoe

OTHER TESTS:

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DATUM: Ground Surface
SURFACE ELEVATION:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
0.25		SAND (Fill) - fine-coarse, little silt, little gravel, dense, rust brown, damp, moist.			
0.50					
1.0		GRAVEL (Fill) - some sand, little clay pockets, loose, structureless, oist, frequent angular cobbles.			
2.0		CLAY (Fill) - little silt, little sand, little gravel, soft - med. dense, grey, occ. ang. cobble, moist-wet.			
		Water level at 1.8 m.			
3.0		COBBLES - angular, occasional boulders to 500 mm dia., some gravel, trace sand, little clay pockets, moist.			
4.0		Test pit discontinued @ 4.0 m.			

Plate 8

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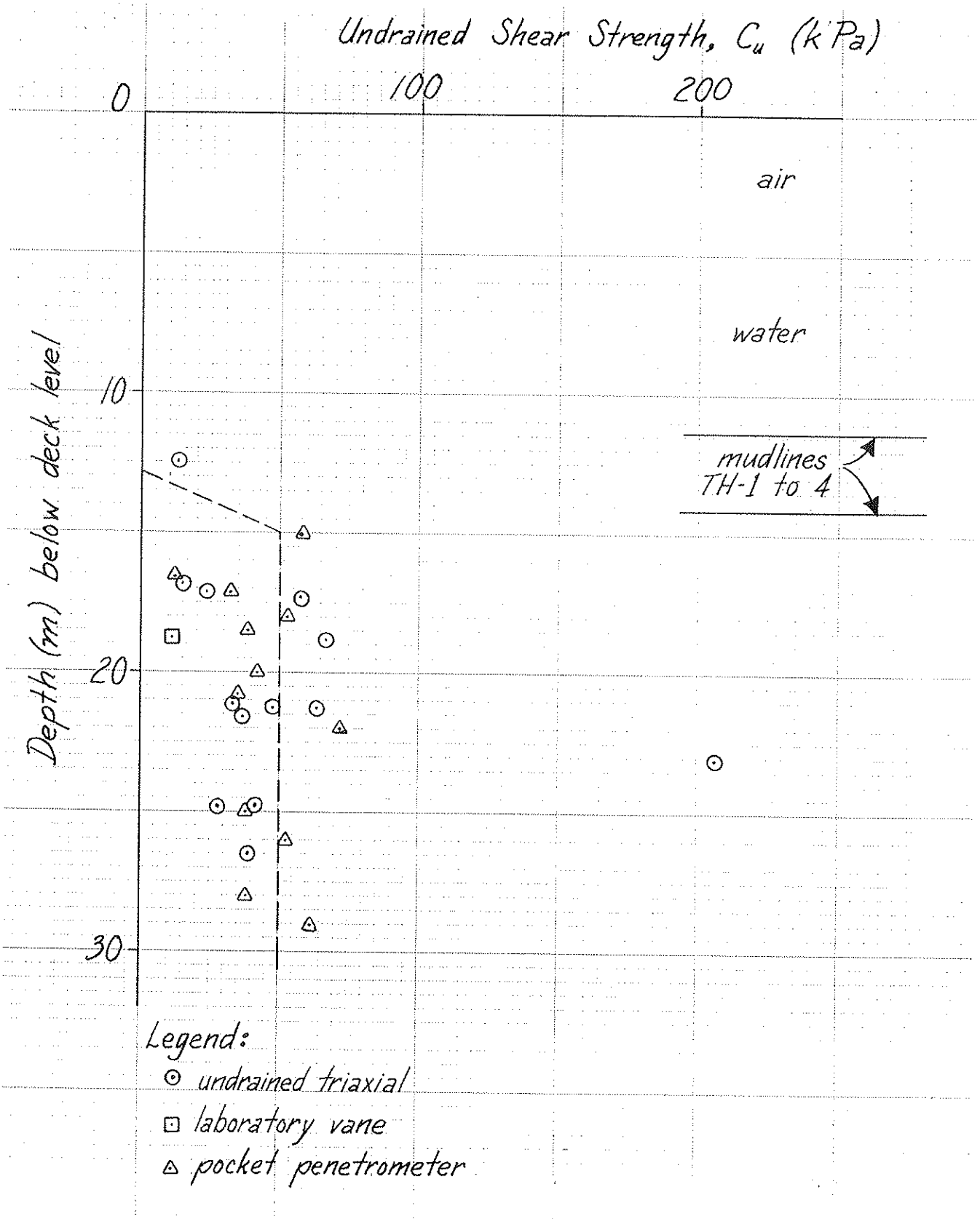

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SCALE	DATE	MADE	CHKD.	JOB:	PLATE
–	DEC 1983	DM	EH	V6D5236	9

HT12 - 79/05

D11

ESQUIMALT GRAVING DOCK

GEOTECHNICAL DESIGN VALIDATION

KCB (2016)

Number of Pages: 83

MEMORANDUM

TO:	Andrew Mylly (PWGSC)	**DATE:**	April 18th, 2016
CC:	Dan Berlin (Anchor QEA) Sarah Morse (Golder Associates)		
FROM:	Geoff Cooper, P.Eng. Manager, Port & Harbours Klohn Crippen Berger, Vancouver, BC	**FILE NO:**	P09614A02
SUBJECT:	EGD South Jetty Phase 2 Environmental Remediation Geotechnical Design Validation (final)		

This memorandum summarizes the findings of Klohn Crippen Berger's (KCB's) geotechnical design validation for the Esquimalt Graving Dock (EGD) Waterlot Phase 2 Environmental Remediation project. The validation comprised a complete technical review and, where required, independent geotechnical evaluations of Golder Associates Ltd.'s (Golder's) design work for the project, as outlined in the Anchor QEA, LLC (Anchor) "*Workplan for Phase 2 Underpier Remediation Revised 99% Design Esquimalt Graving Dock Waterlot Remediation Project R.018400.002*" dated February 20, 2014.

1 INTRODUCTION AND PROJECT BACKGROUND

The EGD Waterlot is located in Skinner Cove, Esquimalt Harbour, BC. Public Works and Government Services Canada (PWGSC) is implementing a remedial dredging program to remove sediments within the Waterlot that have been contaminated as a result of historical activities at the EGD facility. Phase 2 of the remediation project comprises:

- Removal of contaminated sediment beneath the South Jetty in coordination with the staged demolition and reconstruction of the timber South Jetty structures;
- Placement of engineered capping materials; and
- The re-drive and subsequent removal of the temporary erosion protection sheet pile wall around the perimeter of the jetty.

2 SCOPE AND LIMITATIONS OF REPORT

KCB's scope for the geotechnical design validation includes a complete technical review of the geotechnical evaluations performed by Golder for the EGD Waterlot Phase 2 Environmental Remediation 99% design, in sufficient detail to comfortably take over the role of geotechnical Engineer of Record for the work. The work includes:

- Review of Golder's design input for the Phase 2 re-drive of the cantilever sheet pile wall (around the South Jetty perimeter) designed for prop wash and differential soil elevations;
- Review of Golder's stability analysis for dredging in front of the east end retaining wall (that will form part of the South Jetty Wharf Development); and
- Review of Golder's recommendations for the lateral offset / slope of dredging at the timber crib, the pile-supported concrete deck and crane pad, the anchored sheet pile wall bulkhead, the concrete L-wall, and the east approach shoreline.

The source documentation for the geotechnical validation work comprises the following Golder reports and memoranda:

- Esquimalt Graving Dock Waterlot Remediation Project: Borehole Investigation, Timber Portion of South Jetty, Fiscal Year 2011-2012 (September 7, 2011);
- Esquimalt Graving Dock Waterlot Remediation Project: Updated Draft Sheet Pile Design Inputs for the Under – Jetty Erosion Protection (September 9, 2011);
- Esquimalt Graving Dock Waterlot Remediation Project: Stability Assessment of the Existing South Jetty Sheet Pile Wall - Interim Geotechnical Input for Phase 2 80% Design (December 10, 2013);
- Draft Esquimalt Graving Dock Waterlot Remediation Project: South Jetty Phase 2 99 % Under-Pier Remediation Geotechnical Design Input Report (December 12, 2013); and
- Esquimalt Graving Dock Waterlot Remediation Project: Stability Assessment of New East End Retaining Wall (mistakenly dated February 20, 2013, received by KCB from Golder on February 21, 2014).

In addition to the geotechnical design validation, KCB's scope includes completion of any additional geotechnical design evaluations needed in support of the Phase 2 Environmental Remediation revised 99% design. At the time of writing, this entails providing recommendations for long-term fill slopes for placement of engineered capping and armouring materials under the West Jetty and South Jetty structures.

The general arrangement of the project site and the location of sections examined for analyses are presented in Figure 1. The sections analyzed by KCB, as reported in draft versions of this memorandum, were generally the same as the sections analyzed by Golder for assessing slope geometries during dredging. KCB also analyzed sections based on Anchor QEA's 99% Phase 2 design drawings, which show dredge grades that differ from the dredge grades assumed for Golder's original analysis.

3 GEOTECHNICAL VALIDATION FOR RE-DRIVE OF SHEET PILE CONTAINMENT WALL

This section describes the assumptions, methodology, and results of the analyses for the re-driven cantilevered sheet pile containment wall installed around the perimeter of the South Jetty. KCB reviewed and validated analyses carried out by Golder as reported in their technical memorandum to

PWGSC dated September 9, 2011, reissued as a final document on March 31, 2014. The Phase 1 jetty-supported (propped) sheet pile wall design, described in the first part of Golder's technical memorandum, was not included in PWGSC's scope for this geotechnical design validation (and therefore has not been examined by KCB) as this portion of the project has already been constructed.

Discrepancies between the results of the analyses by Golder and KCB were reported in the first issue of this memorandum on March 28, 2014 and were discussed between representatives of Golder, KCB, and Anchor QEA on April 14, 2014 by conference call, by email between April 22 and April 29, 2014, and in person at a meeting on July 3, 2014. Clarifications and recommendations for moving forward based on the discussions with PWGSC and Golder, and further internal review by KCB, were incorporated in this memorandum. A record of the meeting held on July 3, 2014 is provided in Appendix I.

3.1 Assumptions

3.1.1 Soil Properties

Soil properties assumed for this sheet pile wall analysis are generally based on the geotechnical data utilized by KCB for the South Jetty Wharf Development project as presented in Table 3.1. KCB previously characterized the marine sediments as having an undrained shear strength / effective stress ratio (s_u/σ_{vo}') of 0.22 with a minimum undrained shear strength of 25 kPa; for this analysis, an effective stress friction angle of 27° was assumed for the marine sediments.

Following discussions with Golder, KCB also analyzed the sheet pile containment wall at Section A considering a higher strength desiccated crust layer at the top of the Victoria Clay. The undrained shear strength (s_u) of the Victoria Clay Crust was inferred from Cone Penetration Test (CPT) data obtained near Section A by Golder in 2009 and Klohn Crippen Consultants in 2002. A site-specific bearing factor, N_{kt}, of 14 was used to correlate CPT tip resistance to undrained strength. Golder presents similar undrained shear strength interpretations in their report titled "Esquimalt Graving Dock Waterlot - Supplementary Test Hole Investigation for Remedial Action Plan/Risk Management Plan" submitted to PWGSC, dated March 3, 2010.

Table 3.1 Summary of Soil Properties

Soil Description	Unit Weight (kN/m^3)	Shear Strength
Marine Sediments	17.5	ϕ = 27°, c = 0 kPa
Victoria Clay Crust (Section A only)	19.0	s_u = 80 kPa
Victoria Clay General	19.0	s_u = 50 kPa
Till	20.0	s_u = 100 kPa

KCB checked the effect of the different assumed soil properties between Golder and KCB and concluded that the difference was insignificant.

3.1.2 Soil Stratigraphy

KCB validated the assumed soil stratigraphy for the analyzed section by reviewing drill hole logs from the area. The available data generally agrees with the section interpreted by Golder, presented in Figure 1B of the Golder Technical Memorandum and Figure 2 of this report. The analysis using the Victoria Clay Crust as described in Section 3.1.1 considered the desiccated crust in the upper 4.5 m of the Victoria Clay layer, based on the profile of interpreted undrained strength with depth for CPTs completed in the vicinity of Section A.

3.1.3 Slope Geometry

Slope geometries originally analyzed by KCB were based on Figures 2a, 2c, 2d, and 2e in Golder's Technical Memorandum and Golder's descriptions of dredging. KCB analyses as presented in this final memorandum are based on geometries of Anchor QEA's 99% Phase 2 design. Irregular geometries near the sheet pile wall were conservatively approximated as uniform slopes.

3.1.4 Groundwater Conditions

Golder's technical memorandum does not specify the tidal and groundwater conditions assumed for the analysis. The KCB validation was carried out for mean water level at El. 1.9 m, as assumed for the validation of other Phase 2 designs. The high water level case was not analyzed, as the sheet pile wall (re-driven down to El. 0.0 m) will not be subjected to the full propeller wash force at high water level.

The analysis did not consider differential water levels due to tidal lag, because the top of the re-driven pile (El. 0.0 m) will be below the water surface at all normal tidal levels (LWL is at El. 0.0 m); therefore, the water level is assumed to be equal on both sides of the re-driven sheet pile wall at all times.

3.2 Methodology

The following section is subdivided for clarity, to describe different aspects of the analysis methodology and the discrepancies between KCB and Golder's methodologies.

3.2.1 Application and Factoring of Loads

The meeting between Golder and KCB on July 3, 2014 revealed that the factoring of prop wash load was the main cause of differing results (which were described in draft versions of this memo).

For KCB's analysis, the lateral force at El. 0.0 m on the sheet pile (V_d) required to mobilize the design bending moment provided by KCB structural engineers was determined. The lateral force (V_d) was then increased by a factor of 1.30 to obtain the ultimate lateral force ($V_{ultimate}$), and the required sheet pile wall embedment depth was determined to satisfy force and moment equilibrium. This approach was used to account for uncertainties in the driving propeller wash load; no other forces or pressures acting on the wall (e.g. hydrostatic or lateral earth pressures) were factored. Therefore, the factor of safety is defined as:

$$Factor\ of\ Safety = \frac{V_{ultimate}}{V_d} = \frac{1.30 \times V_d}{V_d} = 1.30$$

Golder's analysis was carried out without applying the aforementioned factor of safety, due to a misunderstanding regarding the bending moment provided by KCB to Golder in January 2011 (KCB's Jan 28th 2011 email to Golder is attached to the meeting minutes in Appendix I). Whereas on January 28th, 2011 KCB provided **allowable bending moments** for the various sheet pile types for input to Golder's analysis, Golder understood the input to be **ultimate bending moments**, as identified in Table 2 of Golder's September 9, 2011 memorandum. As a consequence, Golder's analysis was carried out for a design prop wash shear force (applied at the top of the sheet pile wall) about 28% less than KCB intended.

3.2.2 Local Stability Using Free Earth Support Method

Local stability was calculated using the Free Earth Support method for cantilevered walls as described in the Canadian Foundation Engineering Manual (Ed. 2006) Section 26.8 and as described in general in Golder's technical memorandum. KCB used a design factor of safety (FOS) of 1.3 for rotational stability to determine the required pile embedment depth, while Golder did not, as described in Section 3.2.1.

3.2.3 Earth Pressures due to Sloping Ground

At Sections D-D and E-E where slope geometries near the sheet piles were regular, Golder used closed form solutions to derive the active and passive earth pressures. For KCB's analysis, irregular slope geometries at Sections A-A and C-C were simplified as regular geometries using conservative assumptions. Golder's Technical Memorandum states that the Culmann analytical method was used for determining representative active and passive earth pressure coefficients.

3.2.4 Factoring of Passive Earth Pressures

In Golder's analysis, a resistance factor of 0.5 (FOS of 2.0) was apparently applied to passive earth pressures in the marine sediments (silt), as commonly applied to limit displacements in a sheet pile wall during loading. However, Golder confirmed that no resistance factor was applied to passive earth pressures in the Victoria Clay.

Due to the higher than normal tolerance for displacement at this sheet pile wall during Phase 2, KCB believes that the use of a 0.5 resistance factor (FOS of 2.0) may not be necessary. However, since the expected displacement of the sheet pile wall in the marine sediments during design loading conditions may be less than the displacement required to mobilize full passive resistance, the passive resistance in the marine sediments was reduced using a factor of 0.67.

3.2.5 Effective Stresses in Victoria Clay

Golder and KCB have discussed the appropriateness of using effective stresses to calculate earth pressures acting on the sheet pile wall in the Victoria Clay, whereas the 2006 Canadian Foundation Engineering Manual recommends the use of total stresses in such calculations. Upon detailed review

of the subject, KCB found that the use of effective stress or total stress results in the same net pressure diagram. The use of the effective stress method is valid for this wall analysis only with the following conditions:

1. Water levels on both sides of the sheet pile are always equal (which is true since tide is always at or above top of wall level);
2. Pore water pressures are correctly accounted for throughout the calculation; and,
3. Apparent negative pressures are included where appropriate.

3.3 Results

The findings of KCB's analyses are summarized in Tables 3.2 and 3.4 (note that Table 3.3 was deleted in a draft version of this memo).

Table 3.2 reports the design working bending moment and the applied shear to achieve this design bending moment, and also the applied shear to obtain the pile embedment for a rotational factor of safety of 1.3.

In draft versions of this memorandum, Table 3.3 reported the required embedment depths to achieve rotational (moment) factor of safety of 1.3, comparing results from KCB and Golder's analyses. Table 3.3 is not presented in this final memorandum as the dredge line elevations used by Golder and KCB are now different, and embedment depths are not comparable.

Table 3.4 compares the required embedment, as calculated by KCB, to the actual "available" embedment from re-driving the existing Phase 1A sheet pile wall generally installed to El. 4.8 m, or El. 5.1 m for Type E sheets at the west end wall, down to El. 0.0 m (top of pile) in Phase 2. Refer to Phase 2 revised 99% integrated design Drawings CSM3, CSM4 and CSM5 for pile elevations (issued March 31st 2014). This "available" embedment is deeper than the minimum required embedment calculated by Golder, because the installed length of sheet piles was based on the governing design basis of the Phase 1 condition.

Calculated earth pressure distributions are provided in Figures 3 to 6.

Table 3.2 Bending Moments and Applied Shear (for a FS of 1.30)

Section	Design Working Bending Moment (kN-m)	Unfactored Applied Shear (kN)	Factored Applied Shear for embedment calculation (kN)
A-A' Case 1	1105	70.84	92.09
A-A' Case 2	1105	79.91	103.88
C-C'	1105	69.06	89.78
D-D'	816	58.40	75.92
E-E'	541	49.63	64.52

Note that the unfactored shear values shown in Table 3.2 are all lower than the corresponding values in Golder's Table 5 (per September 9, 2011 technical memo). This is primarily due to Golder's interpretation that the design working bending moment (supplied by KCB) was the ultimate bending moment.

For Section A, results are presented for two cases based on Anchor QEA's 99% Phase 2 design; Case 1 considers a dredge elevation (on the landward side) of El. -11.30 m, while Case 2 considers a dredge elevation of El. -10.30 m.

Table 3.4 Comparison of KCB Required Embedment with Actual Embedment (for a FS of 1.30)

Section	Wall Tip Elevation		
	Required per KCB Analyses (m)	Achieved After Re-Drive per Drawings CSM3, CSM4 and CSM5 (m)	Difference (m)
A-A' Case 1	-20.32	-20.80	+0.48 (satisfactory)
A-A' Case 2	-20.11	-20.10	-0.01 (satisfactory)
C-C'	-20.81	-20.80	-0.01 (satisfactory)
D-D'	-18.30	-18.30	+0.00 (satisfactory)
E-E'	-14.84	-16.80	+1.96 (satisfactory)

The results in Table 3.4 indicate that the actual embedment achieved after re-driving the Phase 1 sheet piles down to El. 0.0 m in Phase 2 is sufficient at Sections C-C', D-D', and E-E'. The actual sheet pile embedment at Section A-A' is also sufficient when a 4.5 m thick desiccated crust is considered at the top of the Victoria Clay stratum, as per the analysis carried out in a draft version of this memorandum.

We have also estimated the lateral displacement of the pile head (top of re-driven pile) for the minimum sheet pile embedments that KCB finds acceptable for wall stability (a theoretical analysis at this time). Top of wall displacements are in the order of 0.50 m to 0.75 m under working load conditions (unfactored applied shear, FS = 1.0), which although significant, are not large enough to invalidate the design assumptions. The magnitude of lateral displacement under prop wash loading should be taken into account in the final design of this wall and the temporary re-suspension barrier (TRB).

With regards to lateral support conditions at this sheet pile wall, Golder's email response on April 22, 2014 to the original issue of this memorandum states that:

> "*[I]t is further understood that the Phase 2 dredging works will also include a pile supported silt curtain placed along the landside of the sheet piling, thereby providing redundancy for the secondary purpose of the sheet pile wall.*"

As discussed at the July 3, 2014 meeting between KCB, Golder, and PWGSC, the support piles for the silt curtain (Temporary Re-suspension Barrier, TRB), which are in fact shown on the outside (seaward), not the inside (landside) of the sheet pile containment wall (per KCB Drawing CSM-6), will not be used to provide redundancy to help support the sheet pile containment wall.

3.3.1 Pile Capacity near Dry Dock

Golder's site investigation found shallow bedrock near the dry dock entrance that would prevent pile penetration to mobilize the required pile capacity. As a result, Golder recommended that:

> "*Consideration should be given to structurally distributing the existing concrete faced crib structure and the adjacent section of sheet pile wall that is able to achieve sufficient embedment to support the applied/distributed loads, or reducing the imposed moment capacity to a maximum of 526kNm locally the vicinity around BH11-01, based on the pile tip located at the interface between the Victoria Clay and the glacial deposits.*"

The analysis by KCB for this validation confirmed the need for distributing loads from areas where the sheet pile wall is unable to support the applied loads due to inadequate embedment. The Phase 2 design for the re-driven containment wall in this area includes a structural load distribution system (steel walers attached to re-driven wall) which satisfies this requirement.

4 GEOTECHNICAL VALIDATION FOR STABILITY OF EAST END RETAINING WALL

This section describes the assumptions, methodology and results for the stability analysis of the proposed East End Retaining Wall that will be incorporated into the east approach of the South Jetty as part of the new South Jetty design. KCB has reviewed and validated the analysis carried out by Golder, as reported in their technical memorandum to PWGSC (mistakenly dated February 20, 2013) received by KCB on February 21, 2014.

4.1 Assumptions

4.1.1 Material Properties

The material properties assumed for this stability analysis are based on the geotechnical data utilized by KCB for the South Jetty Wharf Development project, and are as presented in Table 4.1. The assumed shear strengths are slightly more conservative than those reported by Golder for their analysis.

Table 4.1 Summary of Material Properties

Material Description	Unit Weight (kN/m^3)	Shear Strength
Sand and Gravel Fill	20.0	ϕ = 33°, c = 0 kPa
Unconsolidated Marine Sediments	17.3	ϕ = 27°, c = 0 kPa
Victoria Clay	19.0	s_u = 50 kPa
Till	20.0	s_u = 100 kPa

4.1.2 Groundwater Conditions

The groundwater conditions assumed for this stability analysis are per the original analysis conducted by Golder. The high water level was taken at El. 3.4 m Chart Datum (CD); mean water level at El. 1.9 m CD; and low tide at El. 0.0 m CD, Lower Low Water Large Tide.

4.1.3 Groundwater Conditions

KCB validated the assumed soil stratigraphy for the analyzed section by reviewing drill hole logs from the area. The available data agrees with the section interpreted by Golder.

4.2 Methodology

KCB analyzed the global slope stability of the East End Retaining Wall based on the proposed retaining wall, dredge, and capping geometries shown in the South Jetty Wharf Development preliminary 99% design drawings (dated December 18, 2013). The analysis was performed using the computer software program Slope/W 2012 with the Morgenstern-Price limit equilibrium method. The same three construction and dredging scenarios were considered as assumed by Golder:

1. Backfill behind proposed retaining wall, no capping material in place;
2. No backfill behind proposed retaining wall, no capping material in place; and
3. Backfill behind proposed concrete retaining wall, capping material in place.

The analysis considered static global stability only; seismic stability was not evaluated by Golder and is not part of the scope of this validation. The analysis considered uniform surcharge loads of 6 kPa or 30 kPa applied behind the retaining wall to represent typical live loads during construction, with and without a load restriction.

4.3 Results

Analysis results are summarized in Table 4.2 for the static global slope stability of the retaining wall. The required factor of safety (FOS) is 1.5 for permanent conditions. A minimum FOS of 1.3 is considered acceptable for temporary conditions, including the first two load cases during construction/dredging. Based on the results of the analysis, the static slope stability of the retaining wall has an adequate FOS for the load cases with a 6 kPa uniform surcharge load. Figures 7 to 9 present slope stability analysis sections, with results shown for the tide levels giving the lowest FOS. Golder's analysis required installation of the engineered capping material / slope armour before

backfilling behind the wall. KCB's results indicate that the uniform surcharge load must be restricted to 6 kPa to satisfy the design criterion (minimum factor of safety of 1.3), and this would also allow the construction sequencing constraint that was proposed by Golder to be eliminated. This requirement should be reviewed with PWGSC (and EGD operations) because it would limit the allowable vehicle loading on a portion of the South Jetty Access Road during wall construction, which may not be acceptable from a practical viewpoint.

Table 4.2 Slope Stability Factors of Safety

Load Case (with 6 kPa uniform surcharge)	Calculated Factor of Safety		
	Low Tide	Mean Tide	High Tide
Backfill Behind Wall, No Capping Material	1.4	1.3	1.3
No Backfill Behind Wall, No Capping Material	1.6	1.5	1.5
Backfill Behind Wall, Capping Material Placed	2.0	1.8	1.9

5 GEOTECHNICAL VALIDATION FOR DREDGING RECOMMENDATIONS

This section describes the assumptions, methodology, and results of the validation of Golder's dredging recommendations adjacent to the following existing South Jetty structures:

- Timber crib;
- Pile-supported concrete deck and crane pad;
- Anchored sheet pile bulkhead wall;
- Concrete L-wall; and
- East end rock slope.

KCB has reviewed and validated the analyses carried out by Golder as reported in their Geotechnical Design Input Report to PWGSC dated December 12, 2013.

5.1 Assumptions

5.1.1 Material Properties

The material properties assumed for this design validation are based on the geotechnical data utilized by KCB for the South Jetty Wharf Development project and are presented in Table 5.1. KCB previously characterized the marine sediments as having an undrained shear strength / effective vertical stress (s_u/σ_{vo}') ratio of 0.22 and a minimum undrained shear strength of 25 kPa. For this analysis, KCB has assumed an effective stress friction angle of 27° for those marine sediments. A brief description of the various materials is also provided in Table 5.1 based on information from existing drill hole logs by KCB, Golder and AMEC. The shear strengths used for the analyses are slightly more conservative than the values reported by Golder.

Table 5.1 Summary of Material Properties

Material	Description	Unit Weight (kN/m^3)	Shear Strength
Sand and Gravel Fill	Coarse-grained sediments ranging from medium with some fine sand to angular gravel. Wood fragments and other organics present	20.0	$\phi = 33°$, c = 0 kPa
Unconsolidated Marine Sediments	Primarily soft to firm silt with some clay and fine sand. Petroleum and organic odours, shells present	17.3	$\phi = 27°$, c = 0 kPa
Victoria Clay	Clay with some silt and trace sand. Medium plasticity, firm, grey, wet and organic odour	19.0	s_u = 50 kPa
Till	Sand, silt and gravel mixture. Very dense, grey, thin layer normally overlying bedrock	20.0	s_u = 100 kPa
Bedrock	Metadiorite. Greenish-grey, fine to medium grained, low to high strength and slight to moderate weathering	23.0	High Strength

5.1.2 Tidal and Groundwater Conditions

The groundwater conditions assumed for the analyses are per the original analyses conducted by Golder. The high water level was taken at El. 3.4 m Chart Datum (CD); mean water level at El. 1.9 m CD; and low tide at El. 0.0 m CD, Lower Low Water Large Tide.

Golder also considered tidal lag in their analyses; their report describes their assumptions as follows:

> "*Where tidal water was directly against the sheet pile, a maximum lag height between the tidal level and adjacent groundwater level behind the piling was assumed to be 0.1 m at both high and low tides, with a maximum lag of 0.5 m occurring at the mean water level at El. 1.9 m. Where tidal levels intersected the existing or temporary slopes, a maximum lag of about 0.5 m was assumed between the shoreline and the end of the model geometry.*"

No measurable difference in waterside and groundwater levels were reported in KCB's 2002 geotechnical report, and the analyses performed at that time assumed the tidal lag to be zero. For this validation, analyses were initially performed using Golder's assumptions and then assuming zero tidal lag, with no significant variance in results. Tidal lag is not expected to significantly affect slope stability; however, in order to be consistent with Golder, tidal lag was considered in KCB's analyses per Golder's assumptions.

5.1.3 Soil Stratigraphy

KCB validated the soil stratigraphy for the various sections provided by Golder in their report by reviewing drill hole logs from the area. The available drill hole data generally confirms the interpreted sections included in Golder's report. Golder's report did not provide sections through every structure

analyzed; in those cases, KCB instead inferred the soil stratigraphy directly from available data. Figures 10 to 13 show the sections of the interpreted soil stratigraphy for KCB's review.

5.1.4 Additional Assumptions for Existing Sheet Pile Wall

KCB agrees with the following assumptions made by Golder for their stability analysis of the existing sheet pile bulkhead wall. KCB has applied these same assumptions in our analysis of the sheet pile wall:

- Unconsolidated Sediments over the upper slope areas in front of the wall are mixed with riprap.
- The combination of dredge cut, over-dredge depth, and scour will not exceed the dredge depth or dredge slope recommendations specified within Golder's report and shown on the Preliminary 99% Integrated Design drawing.
- The yield strength of the existing sheet pile bulkhead wall tie-rods was considered as the limiting condition in the global stability analysis of the wall. A factored load of 80% of the yield strength of the tie rods was used for the external sheet pile wall stability analysis.
- The existing steel pipe piles beneath the South Jetty pile supported concrete deck structure will likely provide some resistance to global slope instability, and to lateral and rotational instability of the existing sheet pile bulkhead wall. However, this resistance was not considered to be consistent over the length of the sheet pile wall and has therefore been excluded from the analysis (a conservative assumption).
- Forces due to water suction on the surface of the sheet pile wall were not considered.
- Seismic loading conditions have not been considered in these stability analyses due to the temporary nature of the remediation operation.
- Corrosion loss has not compromised the strength of the tie-rods.

5.2 Methodology and Results

5.2.1 Dredging Adjacent to Timber Crib

In their report, Golder considered the local slope failure of the dredge cuts in front of the timber crib, but did not consider the global stability of the structure. Golder appears to have conducted their analysis based on KCB's 2002 Geotechnical Report, which described the timber crib to be in sound condition and not at risk of slope failure. For our validation, KCB checked the local stability of the dredge cuts in front of the timber crib to examine the risk of local sloughing of the proposed slope. In addition, KCB checked the global stability of the timber crib before and after dredging to determine if the timber crib's stability will be undermined by the dredging activities.

Live loading was not considered in Golder's report; however, in KCB's 2002 report a surcharge load of 48 kPa was added on top and behind the crib structure. This same surcharge load was used for KCB's validation to reflect the maximum expected operational conditions at the wharf.

KCB assumed the fill behind the timber crib has a unit weight of 17 kN/m^3. The weight of the fill produces an additional load on the slope. This load does not appear to have been considered by Golder. Table 5.2 summarizes the results of KCB's stability analysis of the timber crib. Figures 14 to 16 present slope stability analysis sections with results shown for tide levels giving the lowest FOS.

Table 5.2 Slope Stability Factors of Safety – Timber Crib

Stability Case	Low Tide Level	Mean Tide Level	High Tide Level
Current Conditions – Global Stability	2.5	2.6	2.7
Dredged Slope – Global Stability	1.7	1.8	1.8
Dredged Slope – Local Stability	1.3	1.3	1.3

The global factor of safety for the timber crib is acceptable (>1.5) for both the current and dredged conditions. The factor of safety decreases following dredging, but not to a level that would pose a significant risk to the structure. Local stability analysis of the dredged slopes indicates that the critical trial failure mode would only be surficial (sloughing), not crib foundation failure. Golder's recommended 2H:1V slope is considered stable.

5.2.2 Dredging Adjacent to Pile-Supported Concrete Deck and Crane Pad

KCB analyzed the local slope stability beneath the concrete deck and crane pad. The model created by KCB was based on the existing soil stratigraphy beneath the steel-piled jetty structure. Table 5.3 summarizes the results of the stability analysis for dredging adjacent to the pile-supported concrete deck and crane pad. Figure 17 presents the slope stability analysis section.

Table 5.3 Slope Stability Factors of Safety – Concrete Deck and Crane Pad

Stability Case	Low Tide Level	Mean Tide Level	High Tide Level
Dredged Slope – Local Stability	1.0	1.0	1.0

Factors of safety for the local slope stability were found to be about 1.0. Some surficial sloughing is therefore expected to occur on the temporary 2H:1V dredged slope. Golder appears to have recognized the possibility of sloughing in their design report, as indicated by their statement:

> *"As the current slope in this area is 2H:1V, we recommend a maximum dredge slope of 2H:1V down to the target dredge elevation provided some surficial sloughing on the dredge slope is acceptable*".

Therefore, the Phase 2 design documents (drawings and specifications) should take the possibility of surficial sloughing into account, and PWGSC needs to be made aware of any potential consequences.

5.2.3 Dredging Adjacent to Anchored Sheet Pile Bulkhead

The dredging plan for the sheet pile bulkhead has been described in detail in Appendix B of Golder's report. KCB confirmed that the soil stratigraphy used by Golder is consistent with the logs of nearby

drill holes. For our analysis, KCB used the same stratigraphy and loading conditions as Golder for consistency.

KCB's slope stability analyses for the anchored sheet pile bulkhead includes allowance for the specified 0.3m payable overdredge depth (per AnchorQEA dredging specifications). Dredging in front of the anchored bulkhead is not permitted below the 0.3m payable overdredge allowance, and therefore each required dredge elevation along the face of the anchored bulkhead is identified on the contract Drawings as "Required Dredge Elevation" (a term defined in the construction Specifications).

KCB analyzed the global and local slope stability of the anchored sheet pile bulkhead wall at the same three locations as Golder, taken at sections D-D', E-E' and K-K' (Figures 2 to 4 in Appendix B of Golder's Geotechnical Design Input Report). KCB also analyzed local slope stability at Section E-E' with a modified slope geometry in order to achieve the target factor of safety without requiring any special dredging methodologies. For the external bulkhead stability, the rotational stability of the sheet pile bulkhead and tensile load on the anchors was determined. The structural capacity of the sheet pile bulkhead is not expected to govern the stability, and factors of safety have therefore not been provided for the moment in the sheet pile bulkhead.

Lateral and rotational stability was determined using the Free Earth Support method for anchored flexible walls recommended in the Canadian Foundation Engineering Manual (Ed. 2006), as was done by Golder. Only dredged conditions were considered for the Free Earth Support calculations.

Tables 5.4 to 5.6 summarize the results of KCB's slope stability analysis for the sheet pile bulkhead wall at the three different locations; Table 5.7 summarizes external bulkhead stability results.

The slope stability results for sections D-D', E-E' and K-K' are presented in Figures 18 to 23, with results shown for tide levels giving the lowest FOS.

Table 5.4 Slope Stability Factors of Safety – Sheet Pile Bulkhead Wall Section D-D'

Stability Case	Low Tide Level	Mean Tide Level	High Tide Level
Dredged Slope– Global Stability	1.3	1.3	1.3
Dredged Slope – Local Stability	1.2	1.2	1.3

Table 5.5 Slope Stability Factors of Safety – Sheet Pile Bulkhead Wall Section E-E'

Stability Case	Low Tide Level	Mean Tide Level	High Tide Level
Dredged Slope– Global Stability	1.4	1.4	1.5
Dredged Slope – Local Stability	1.5	1.5	1.5

Table 5.6 Slope Stability Factors of Safety – Sheet Pile Bulkhead Wall Section K-K'

Stability Case	Low Tide Level	Mean Tide Level	High Tide Level
Dredged Slope – Global Stability	1.4	1.4	1.5
Dredged Slope – Local Stability	1.5	1.5	1.5

Table 5.7 External Bulkhead Stability Results

Section	Low Tide Level	Mean Tide Level	High Tide Level
Rotational Stability Factor of Safety			
D-D'	3.6	3.1	3.0
E-E' Original	1.4	1.0	1.2
E-E' Modified	1.9	1.3	1.7
K-K'	2.4	2.3	2.7
Anchor Tensile Load (kN/m)			
D-D'	9.0	9.0	10.1
E-E'	27.9	22.8	25.4
K-K'	34.4	36.5	29.2

KCB found somewhat lower factors of safety than reported by Golder for the global stability of the existing case (pre-dredge conditions), based on different assumed properties of the Victoria Clay that governs the stability of deep-seated slip surfaces that dominate in the existing case; however, KCB did not further examine existing stability as it is not part of the Phase 2 dredging project.

KCB found that the target temporary factor of safety of 1.3 is achieved for the global stability of the wall at all three locations analyzed for the proposed dredged slopes at all tidal levels.

The anchor tensile loads presented in our results are reached once moment equilibrium is achieved (i.e. at a rotational factor of safety of 1.0). These values are higher than the loads that the anchor will likely be subjected to, since the sheet piles have been driven to an embedment depth deeper than required. The maximum tensile load that is exerted on the anchor was determined to be 36.5 kN/m, which is well below the tensile yield strength of 54 kN/m.

The factor of safety for rotational stability of the sheet pile wall exceeds the 1.3 target factor of safety for temporary conditions at all locations except at Section E-E' based on the original design dredge elevations. As also found by Golder's analysis, the factor of safety for rotational stability at Section E-E' is around 1.0.

Golder recommended that dredging of the sediments and backfilling (capping) be carried out concurrently in front of the 12.8 m long section of sheet pile bulkhead wall modeled as Section E-E', effectively using slot cuts. However, slot cuts would be difficult to construct (as this location is difficult to access with mechanical excavation equipment and has constrained headroom) and may result in recontamination of capping materials. Therefore, in consultation with AnchorQEA, KCB proposes dredging to a slightly higher elevation, which leaves behind some of the contaminated soils but facilitates more precise placement of the engineered cap materials and avoids the complexity of slot cuts, resulting in a more practical and achievable remediation. KCB analyzed a modified Section E-E' to determine the lowest possible dredge elevation that does not require slot cuts. KCB recommends a minimum dredge elevation of 1.5 m for the 12.8 m long section of sheet pile bulkhead wall modeled as Section E-E'.

The local stability of the dredged slopes in front of the wall at Sections E-E' and K-K' is sufficiently high that local sloughing should not be an issue. Local stability analyses of the dredged slope at Section D-D' (FS = 1.2) indicates some surficial sloughing may occur; however, the extent of anticipated sloughing is not a concern for the stability of upslope structures. KCB agrees with Golder's recommended dredge slopes at this location.

5.2.4 Dredging Adjacent to Existing Concrete L-Wall

KCB could not locate a cross section showing the mudline elevation and L-wall configuration within Golder's report. A cross section was therefore produced by KCB using information from topographic site plans, drill hole data and existing reports. Dredge cuts adjacent to the L-wall were assumed to be as specified in Golder's report and shown on the Preliminary 99% Integrated Design drawings.

Live loads were not considered by Golder in their analysis. Drawings show that the wall is located adjacent to a vehicle access route and vehicle traffic is expected. KCB included a surcharge load of 30 kPa behind the L-wall to account for anticipated live loads. Table 5.8 summarizes the results of KCB's stability analysis for the concrete L-wall. Figures 24 to 26 present slope stability analysis sections with results for tide levels giving the lowest FOS.

Table 5.8 Slope Stability Factors of Safety – Concrete L-Wall

Stability Case	Low Tide Level	Mean Tide Level	High Tide Level
Current Conditions – Global Stability	1.5	1.4	1.4
Dredged Slope – Global Stability	1.5	1.4	1.4
Dredged Slope – Local Stability	1.4	1.3	1.4

The global stability factor of safety for the current and dredged conditions is acceptable, with dredging expected to have only a small effect on the global stability of the L-wall.

Internal KCB review of local stability analysis found that surficial sloughing of the proposed slopes is not an issue (contrary to what was indicated in the first issue of this memorandum). Therefore, the Phase 2 design documents need not consider the possibility of surficial sloughing at this location.

5.2.5 Dredging Adjacent to East Rock Slope

KCB performed local stability analyses for the east approach shoreline rock slope after the recommended dredging. Golder's dredging recommendations at this location were provided in their December 2013 design report. The global slope stability of the new East End Retaining Wall at the same location was also checked by Golder, and results were reported in a separate memorandum (incorrectly dated February 20, 2013). KCB performed a separate validation of that analysis, as summarized in Section 4 of this memorandum.

KCB created a slope stability model using data taken from nearby drill holes. The soil stratigraphy was adjusted slightly compared to the stratigraphy used for analysis of the East Concrete Retaining Wall as the contact between unconsolidated marine sediments and sand and gravel fill will be further away from the retaining wall. Table 5.9 summarizes the results of the stability analysis for the

dredged east approach shoreline rock slope. Figure 27 presents the slope stability analysis section with results for low tide level.

Table 5.9 Slope Stability Factors of Safety – Adjacent to Rock Slope

Stability Case	Low Tide Level	Mean Tide Level	High Tide Level
Dredged Slope –Local Stability	1.6	1.7	1.7

The 3H:1V dredge slope should be stable and sloughing is not expected.

6 OTHER GEOTECHNICAL DESIGN EVALUATIONS

KCB has provided to AnchorQEA (in separate correspondence) our recommendations for size and type of fill materials to satisfy geotechnical slope stability requirements for engineered capping and armouring materials under the EGD jetty structures. Shore protection considerations (i.e. stability against wave attack) are included in AnchorQEA's design scope.

7 RECOMMENDATIONS AND CONCLUSION

Our review and validation has confirmed the technical basis and validity of Golder's recommendations for lateral offsets and slopes of dredging adjacent to existing South Jetty structures, which may be implemented for the South Jetty Integrated Wharf Development/Remediation project, with the exception of dredging at the east end of the existing anchored sheet pile bulkhead where we recommend dredging without slot cuts to an elevation of 1.5 m with a 0.3 m payable overdredge allowance.

Our review of Golder's evaluation for the proposed east end retaining wall stability found that the recommended construction sequence of placing capping material in front of the retaining wall prior to placement of the backfill behind the retaining wall is not necessary, provided that temporary surcharge loads are limited to 6 kPa. This requirement should be reviewed with PWGSC (and EGD operations) because it would limit the allowable vehicle loading on a portion of the South Jetty Access Road during wall construction, which may not be acceptable from a practical viewpoint. The other recommendations regarding the east end retaining wall may be implemented as described in Golder's Technical Memorandum.

Our review of Golder's evaluations for the re-driven sheet pile containment wall found that the recommended embedment depth and pile tip elevations provided in Golder's September 9, 2011 technical memorandum would be insufficient to resist the Phase 2 design loads. However, as stated earlier in this report, the actual pile lengths installed in Phase 1 are longer (and hence the pile tip elevations as re-driven in Phase 2 are deeper) than the minimum values required by Golder's analysis. Our analyses indicate that the actual embedment depths that will be achieved when the sheet pile wall is re-driven in Phase 2 is sufficient at Sections C-C', D-D', and E-E'. Our additional analysis carried out for this memorandum considered a 4.5 m thick desiccated crust at the top of the Victoria Clay stratum based on CPTs completed in this area of the site. This supplemental analysis indicated that the actual embedment depth of the Phase 2 re-driven sheet pile wall is also sufficient at Section A.

After meeting to discuss the cause of the discrepancy in analysis results, Golder and KCB, with input from AnchorQEA and PWGSC, discussed potential solutions for resolving the issue of insufficient embedment, described in the meeting record in Appendix I. The following four steps were recommended:

Step 1: Re-evaluation of design soil parameters (Victoria Clay) specifically for Section A-A' at applicable depths.

Step 2: Evaluate methods to reduce prop wash force.

Step 3: Wall retrofit (if Steps 1 and/or 2 are not effective).

Step 4: Slot cuts for dredging inside the wall (if Step 3 is financially punitive).

Step 1 was carried out and demonstrated that the Phase 2 re-driven sheet pile wall will achieve adequate embedment without the need for considering Steps 2 to 4. The steps are presented in this memorandum for the record, and for future reference if the capacity of the sheet pile wall requires further re-evaluation.

In finalizing this memorandum, KCB notes that an updated (final) version of Golder's "Draft Esquimalt Graving Dock Waterlot Remediation Project: South Jetty Phase 2 99% Under-Pier Remediation Geotechnical Design Input Report" (Dec 12, 2013) has not been provided. We also recommend that the date of Golder's "Esquimalt Graving Dock Waterlot Remediation Project: Stability Assessment of New East End Retaining Wall" (February 20, 2013) be changed to reflect the date that it was finalized, in 2014.

8 EXCLUSIVE USE OF REPORT

This memorandum is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Public Works and Government Services Canada and AnchorQEA LLC for the specific application to the South Jetty Integrated Development/Remediation project. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

9 CLOSING

We trust this memorandum meets your requirements.

KLOHN CRIPPEN BERGER LTD.

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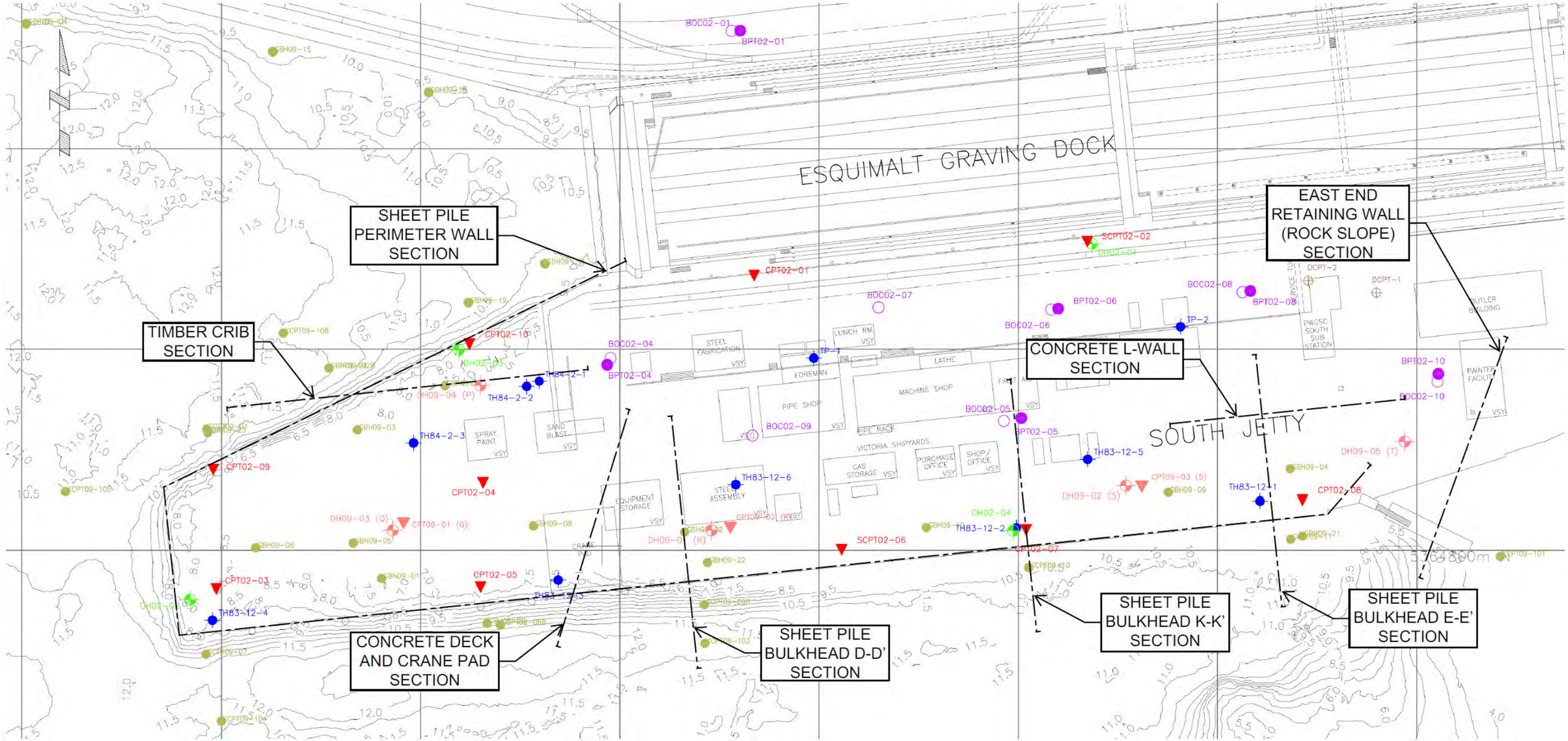
FIGURES



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PROJECT

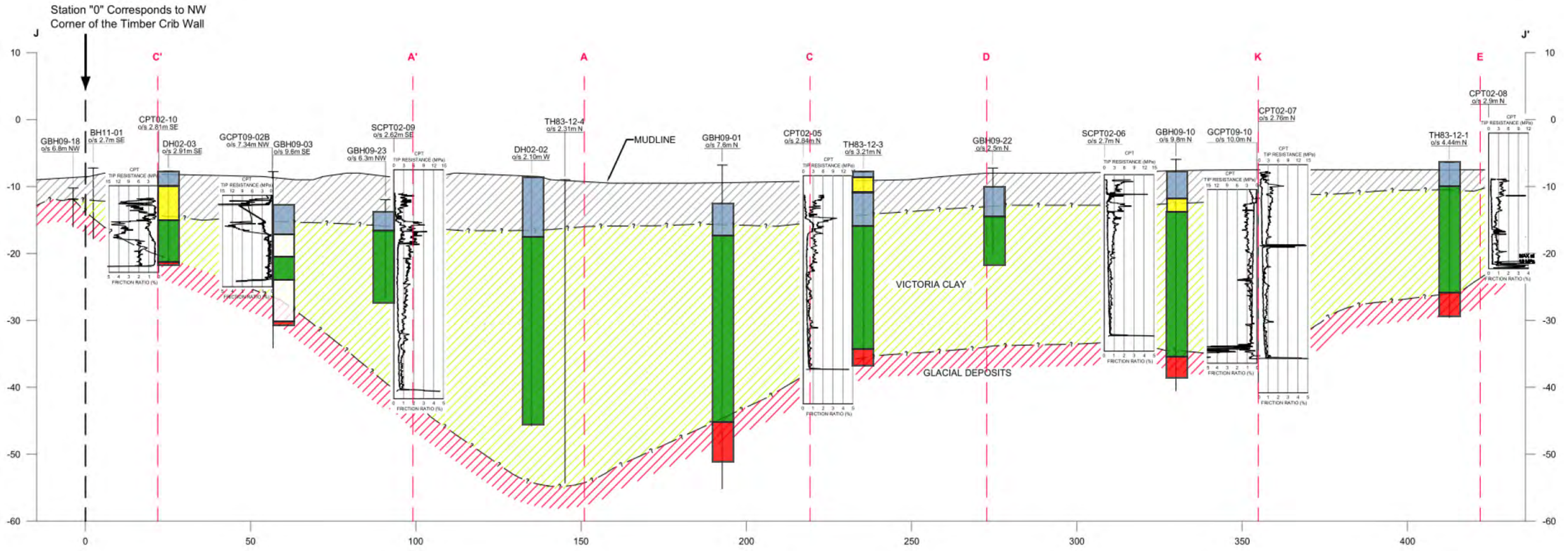
EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE

SITE PLAN

PROJECT NO. P09614 A02

FIGURE NO. 1



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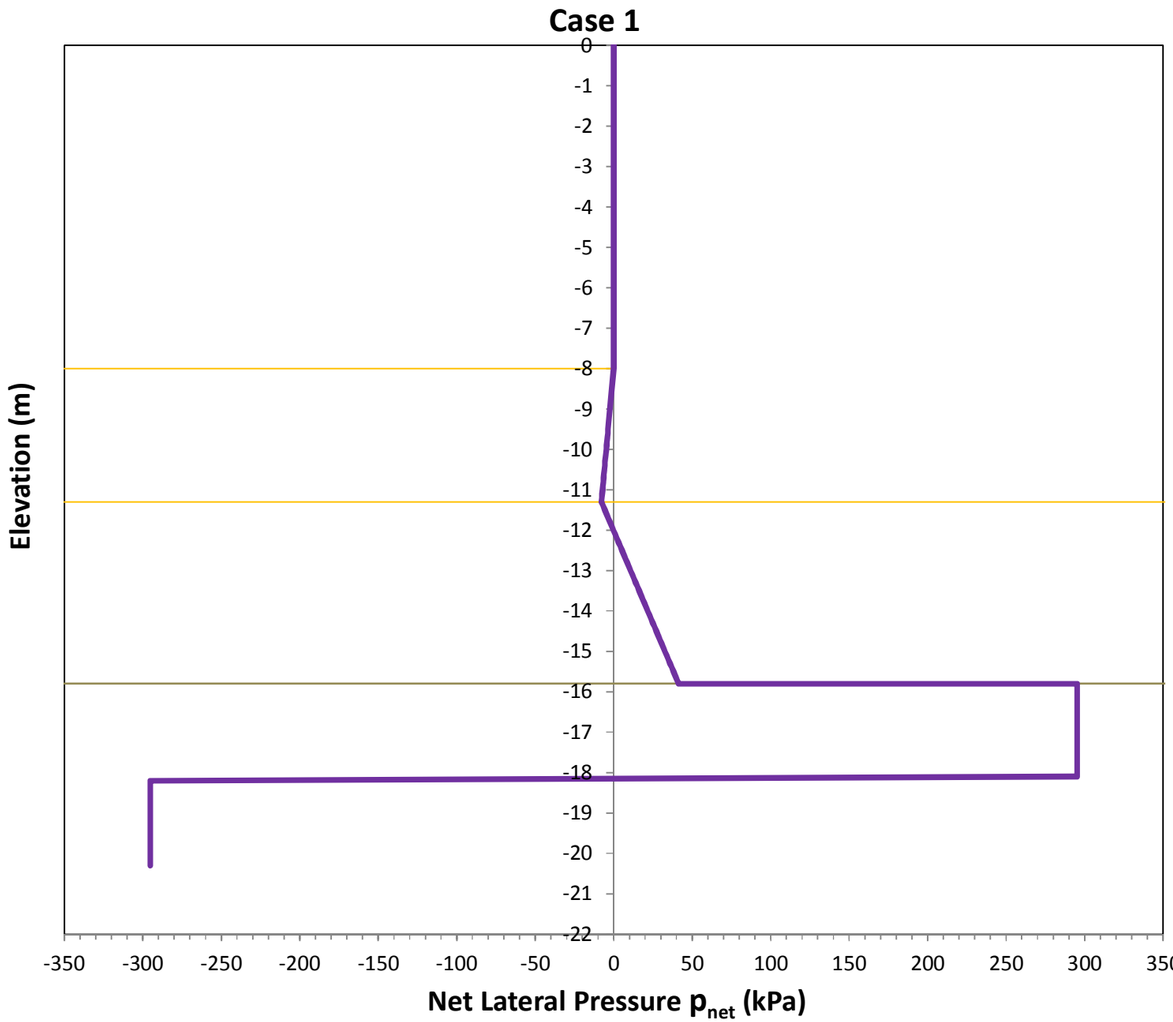
EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

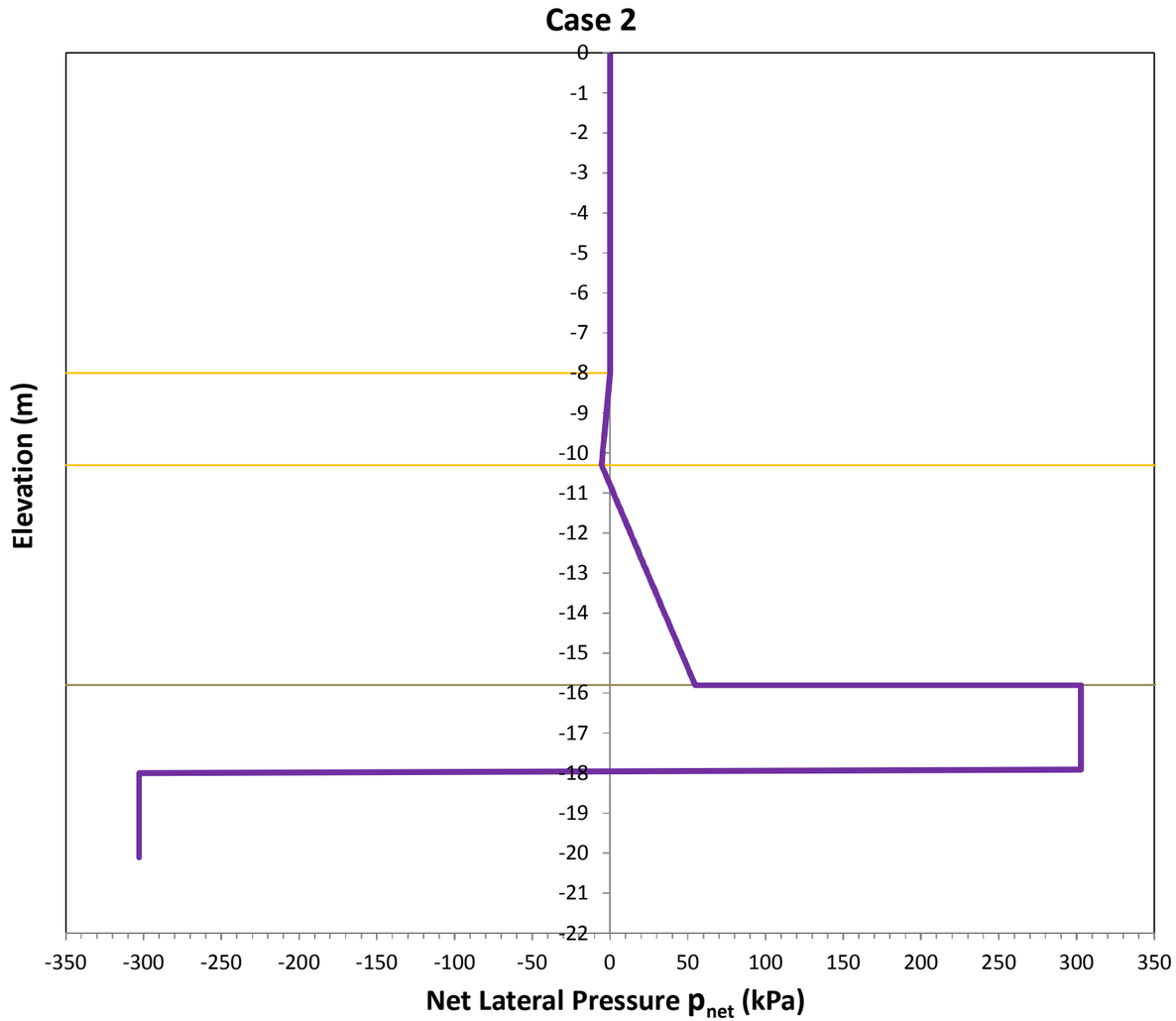
TITLE

SHEET PILE PERIMETER WALL SECTION J-J'

PROJECT NO. P09614 A02

FIGURE NO. 2





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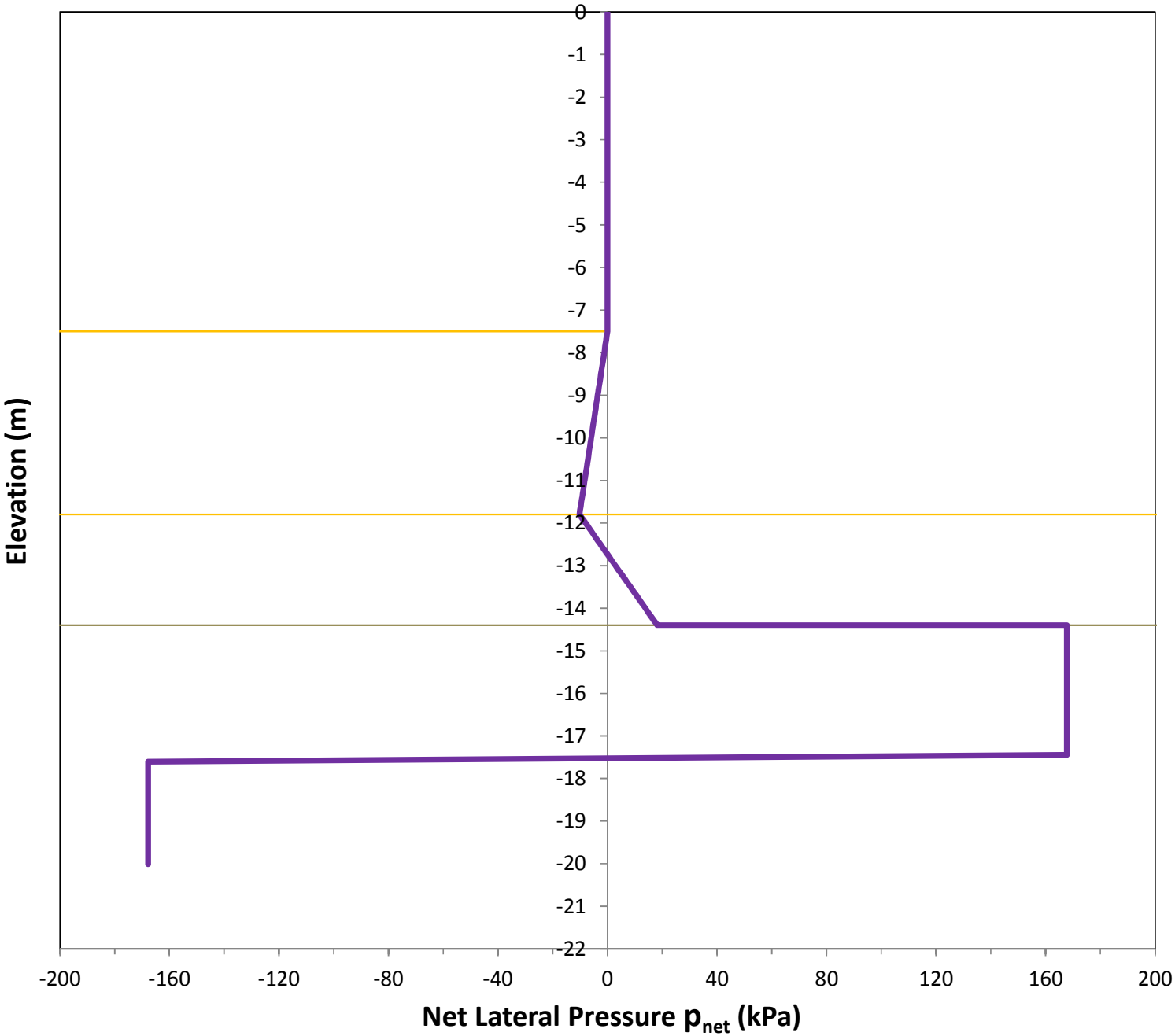
PROJECT

EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE

SHEET PILE CONTAINMENT WALL
LATERAL EARTH PRESSURE DISTRIBUTION SECTION A-A

PROJECT NO.	FIGURE NO.
P09614 A02	3



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TITLE: SHEET PILE CONTAINMENT WALL
LATERAL EARTH PRESSURE DISTRIBUTION SECTION C-C

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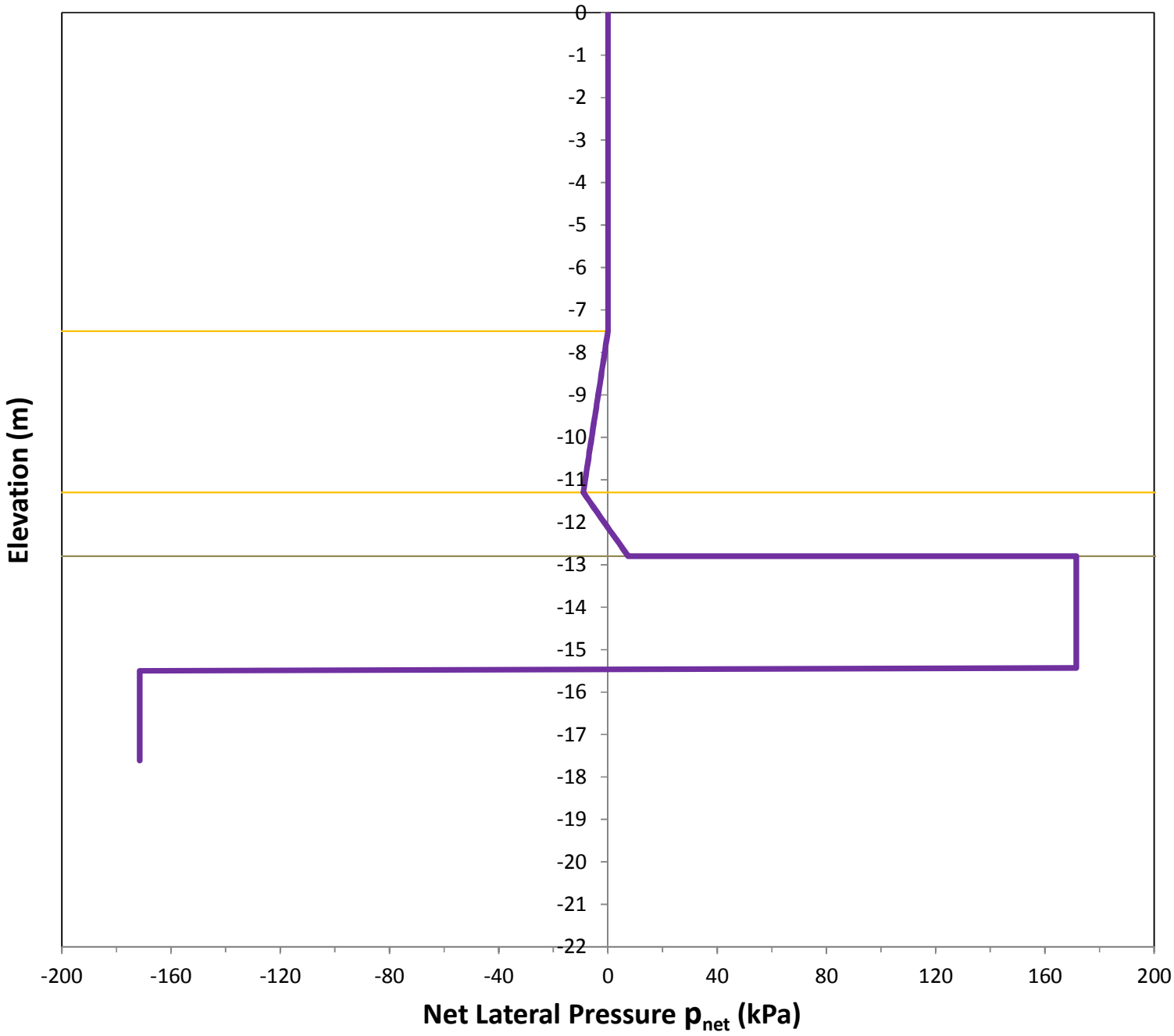
APPROVAL	P09614 A02	4	



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TITLE: SHEET PILE CONTAINMENT WALL
LATERAL EARTH PRESSURE DISTRIBUTION SECTION D-D

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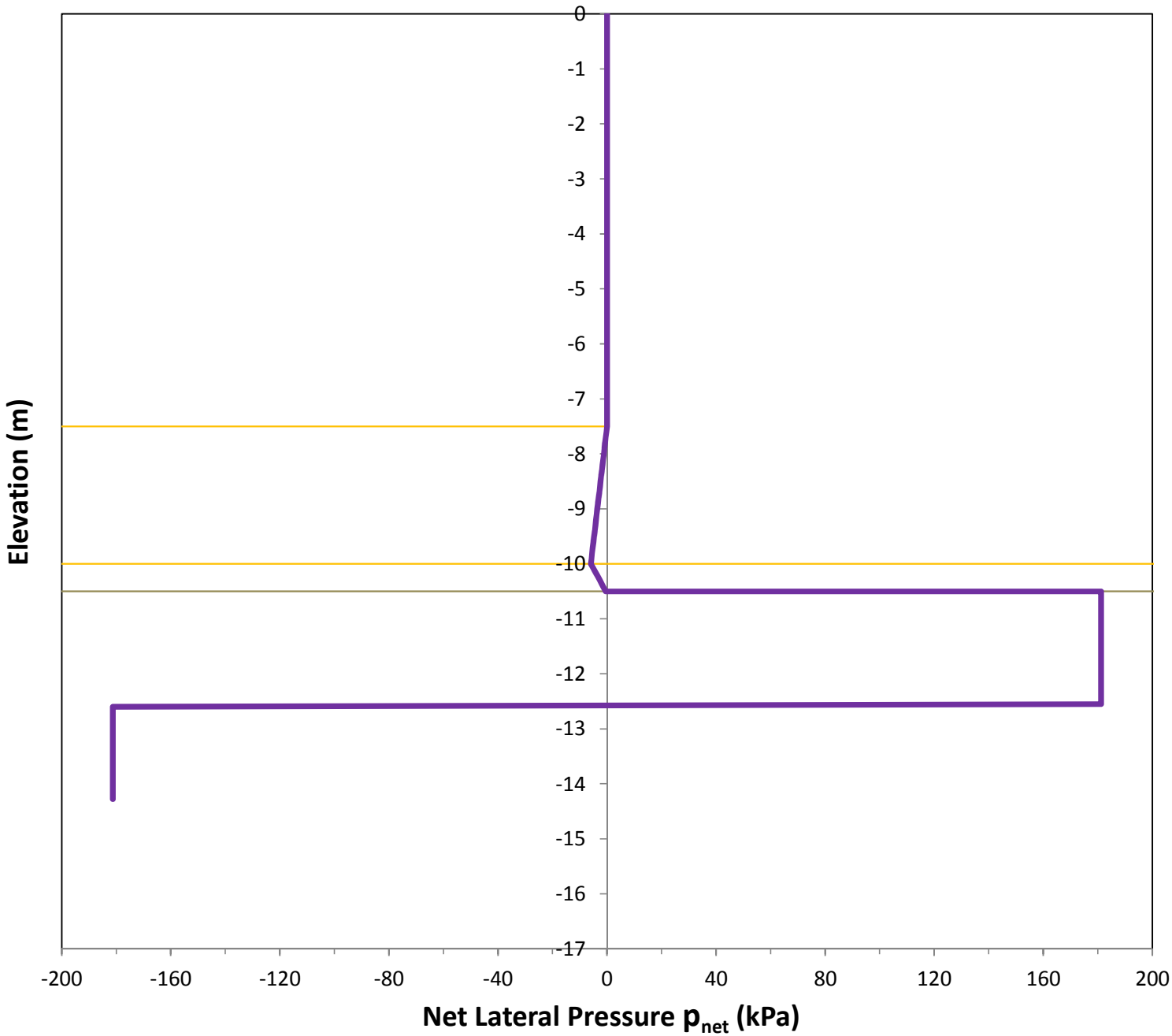
APPROVAL	P09614 A02	5	



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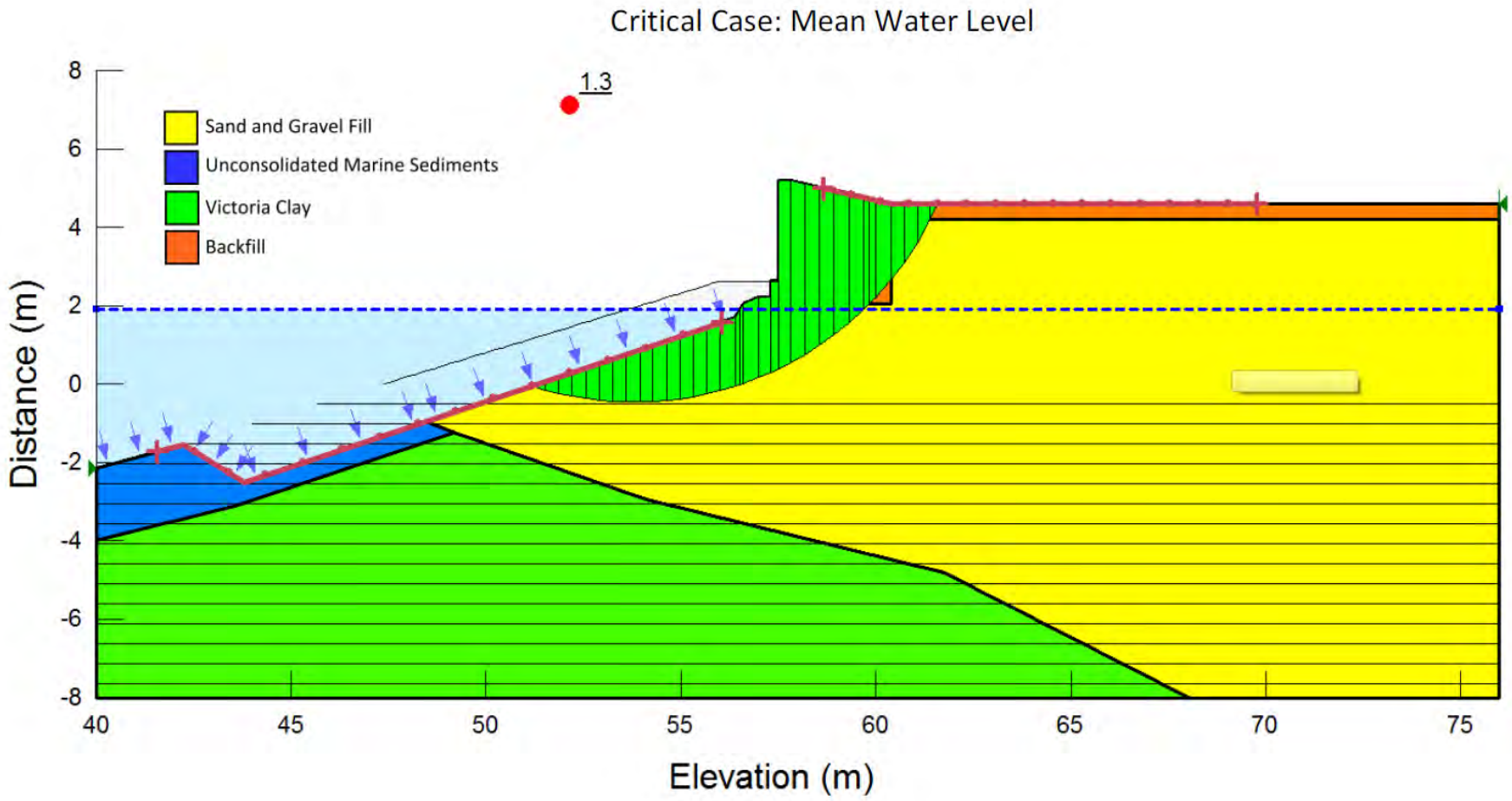
LATERAL EARTH PRESSURE DISTRIBUTION SECTION E-E

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	6	



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PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: EAST END RETAINING WALL BACKFILLED NO CAPPING MATERIAL

DATE OF ISSUE:

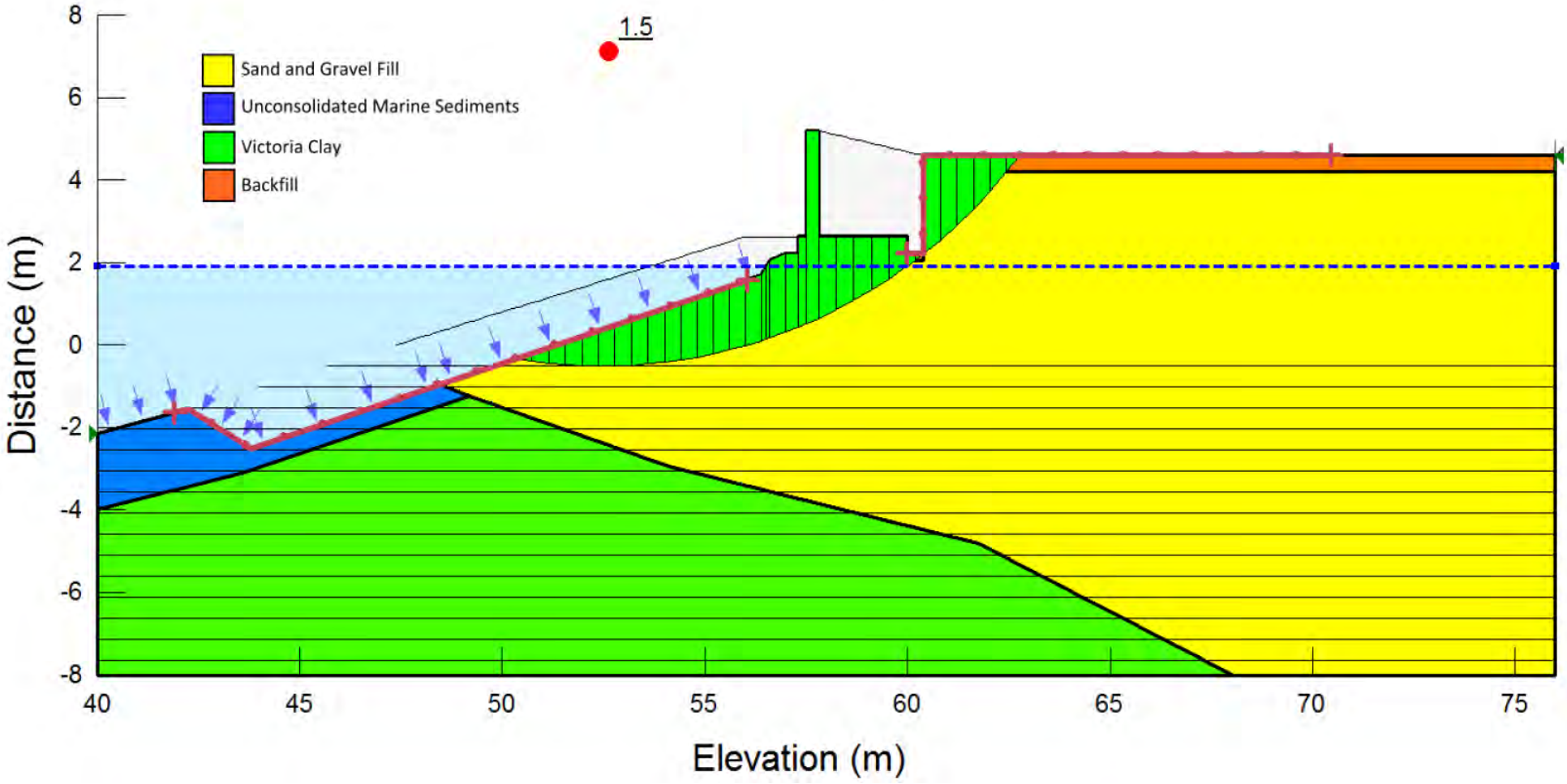
APPROVAL:

PROJECT No.: P09614 A02

FIGURE. No.: 7

REV.:

Critical Case: Mean Water Level



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Klohn Crippen Berger

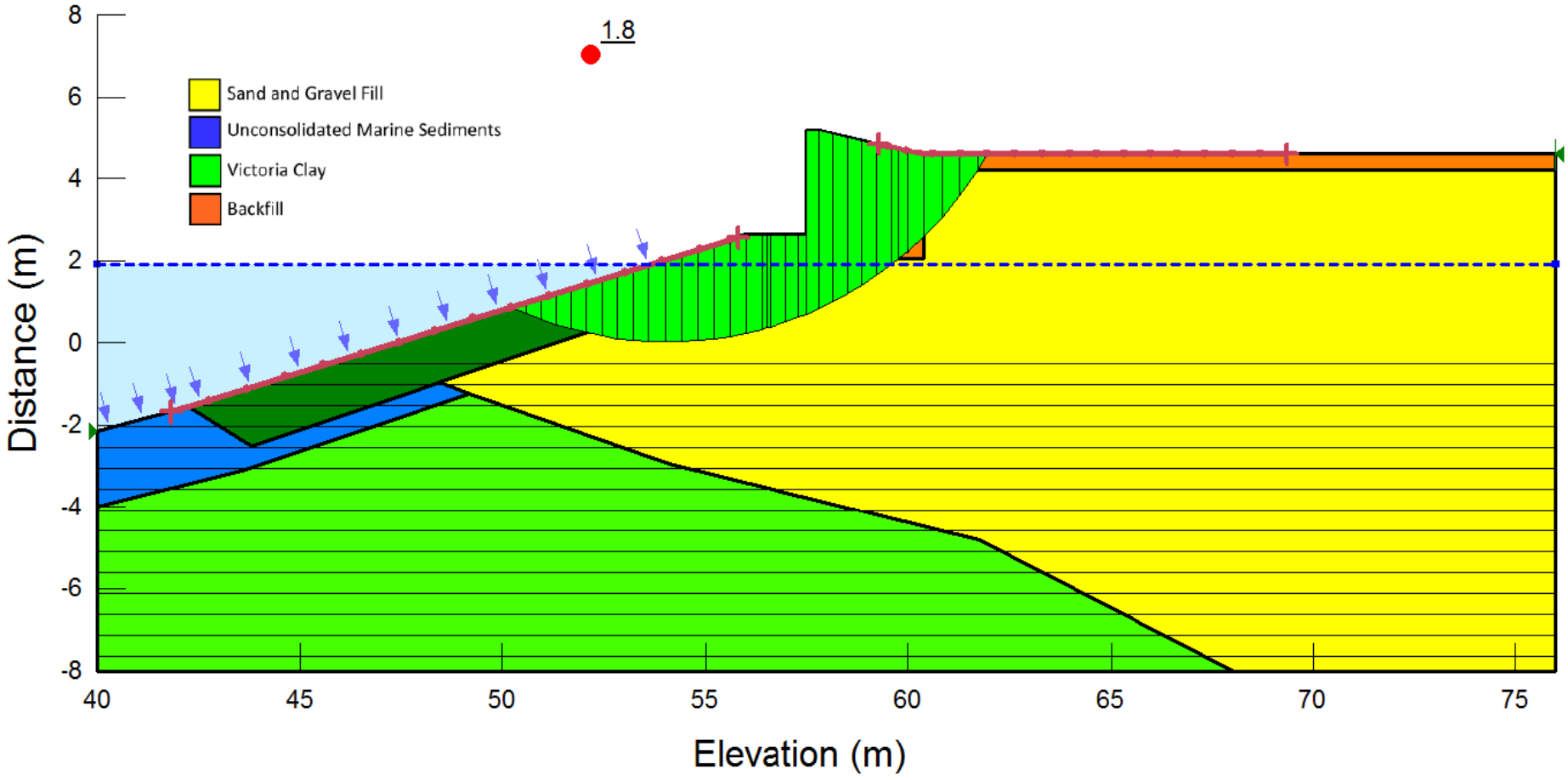
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: EAST END RETAINING WALL
NO BACKFILL NO CAPPING MATERIAL

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	8	

Critical Case: Mean Water Level



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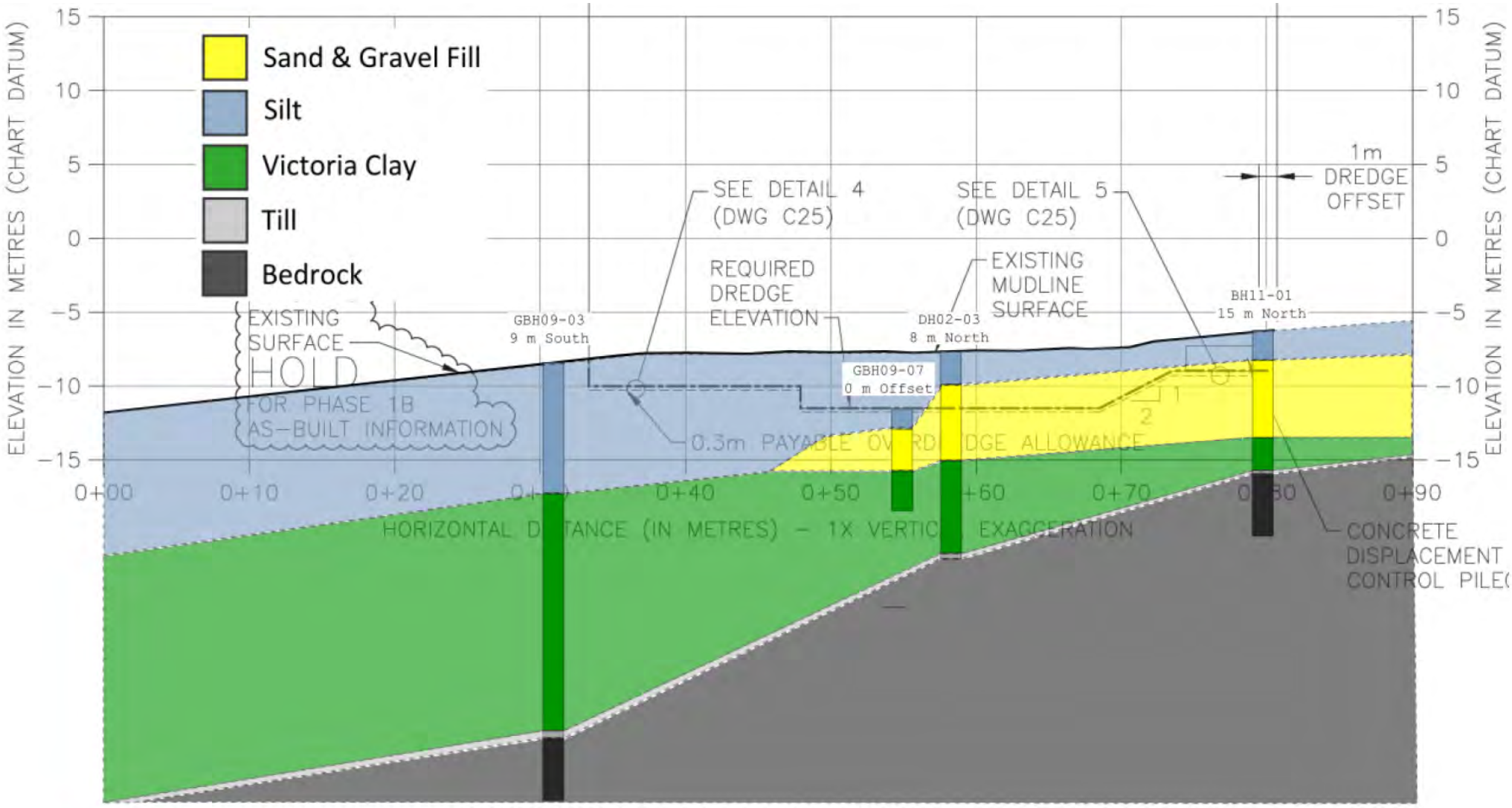
Klohn Crippen Berger

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: EAST END RETAINING WALL BACKFILLED WITH CAPPING MATERIAL

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	9	



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Klohn Crippen Berger

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: TIMBER CRIB CROSS SECTION

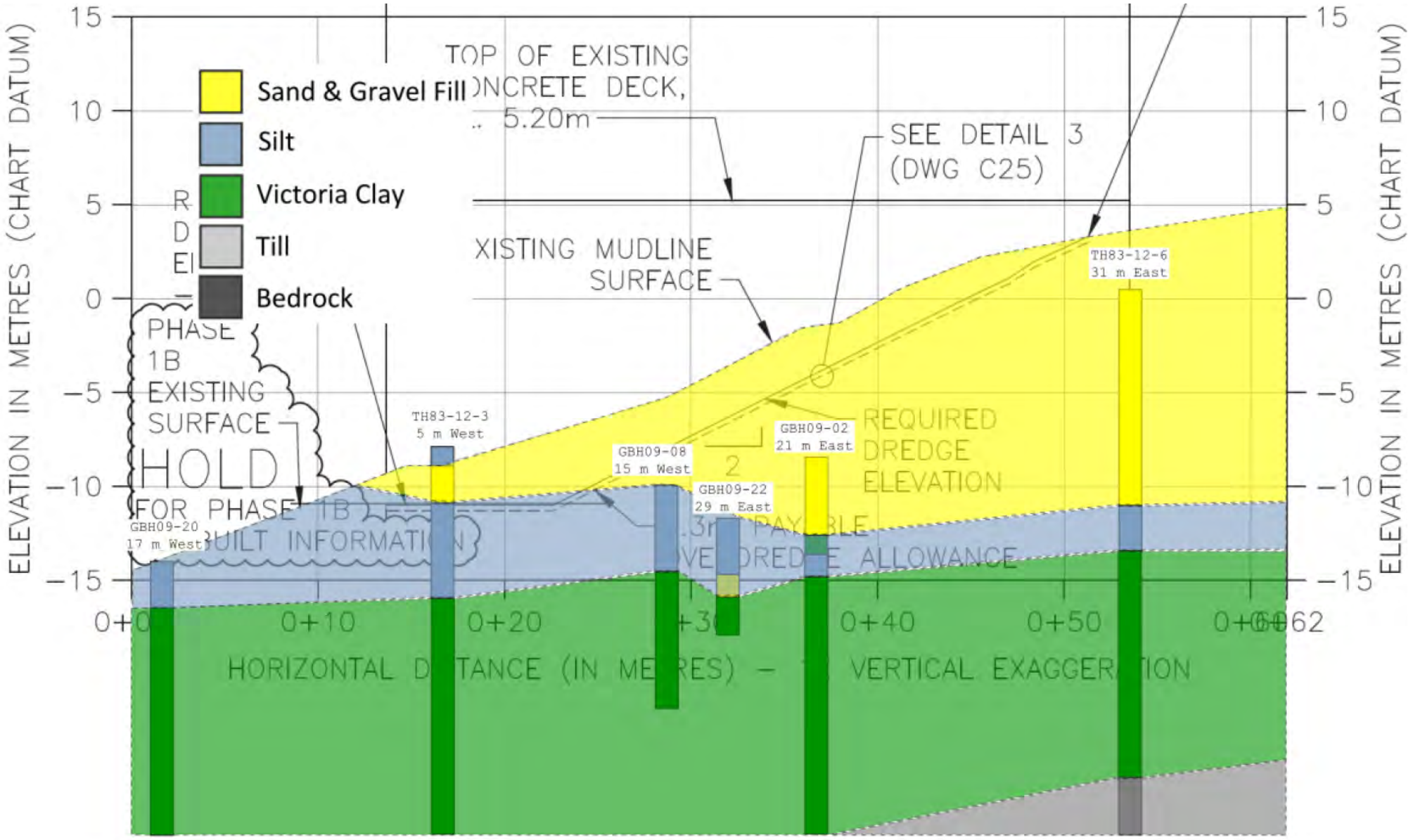
DATE OF ISSUE:

APPROVAL:

PROJECT No.: P09614 A02

FIGURE. No.: 10

REV.



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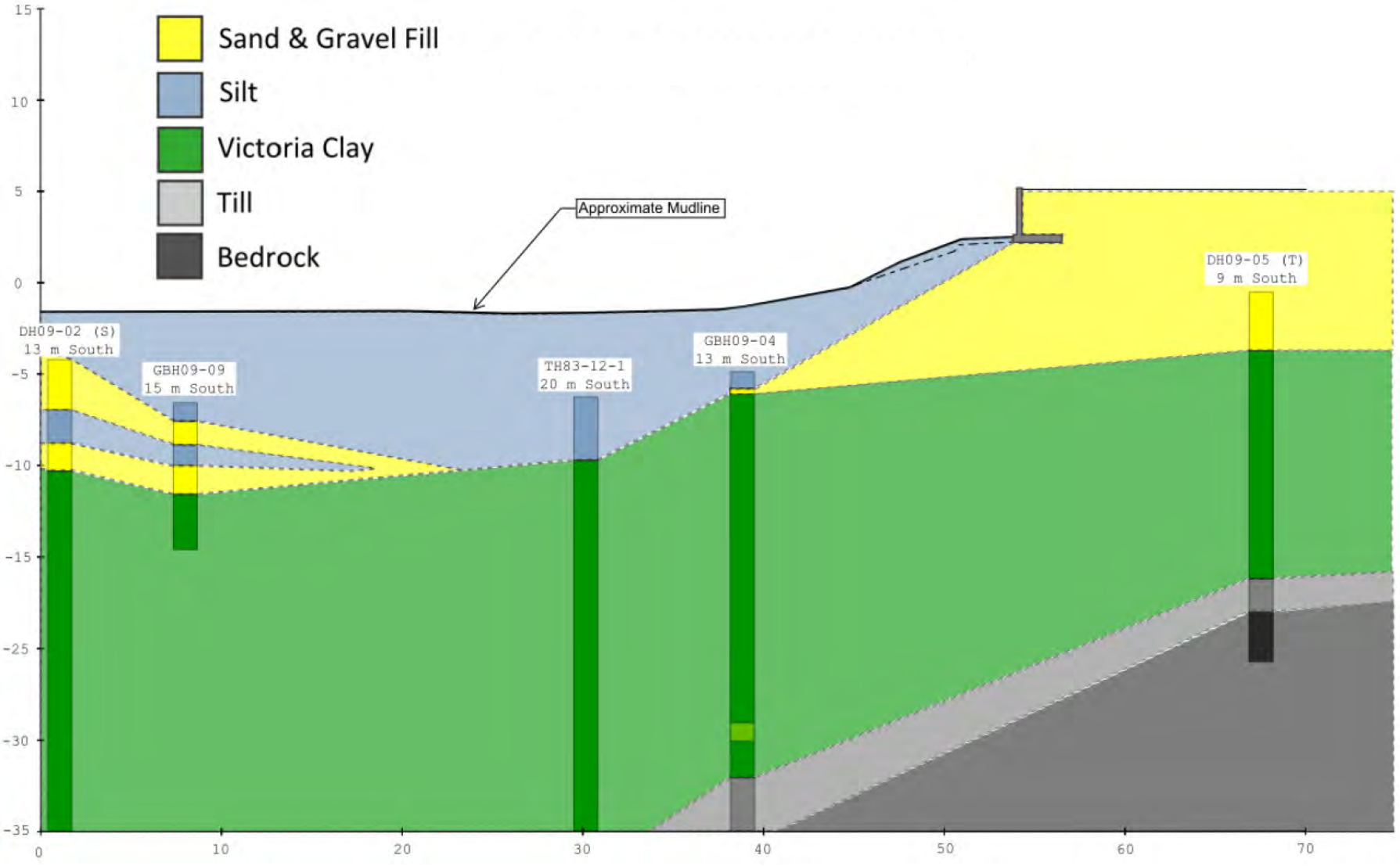
Klohn Crippen Berger

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: CONCRETE DECK AND CRANE PAD CROSS SECTION

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	11	



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Klohn Crippen Berger

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: CONCRETE L-WALL CROSS SECTION

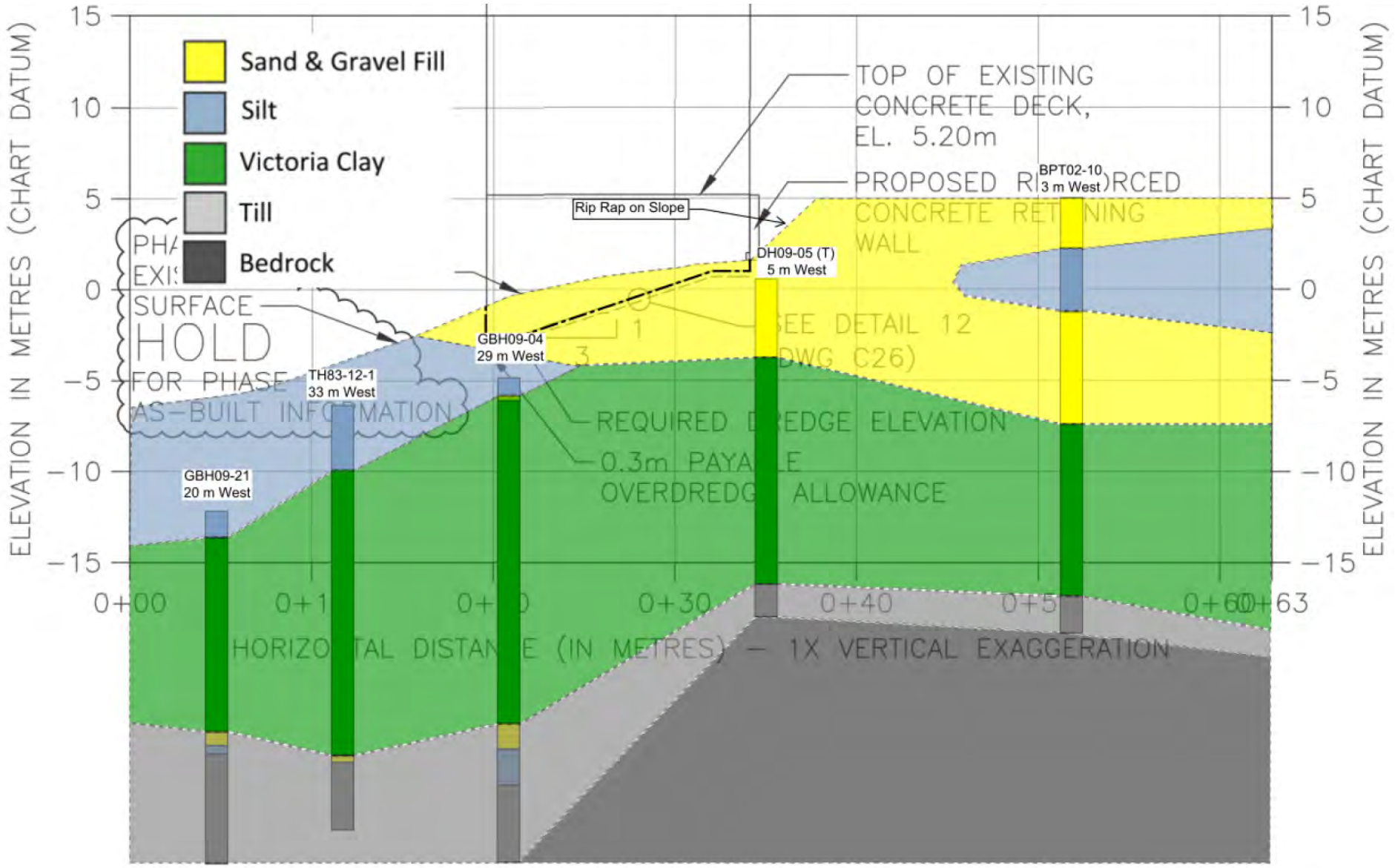
DATE OF ISSUE:

APPROVAL:

PROJECT No.: P09614 A02

FIGURE. No.: 12

REV.:



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Klohn Crippen Berger

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: ROCK SLOPE CROSS SECTION

DATE OF ISSUE:

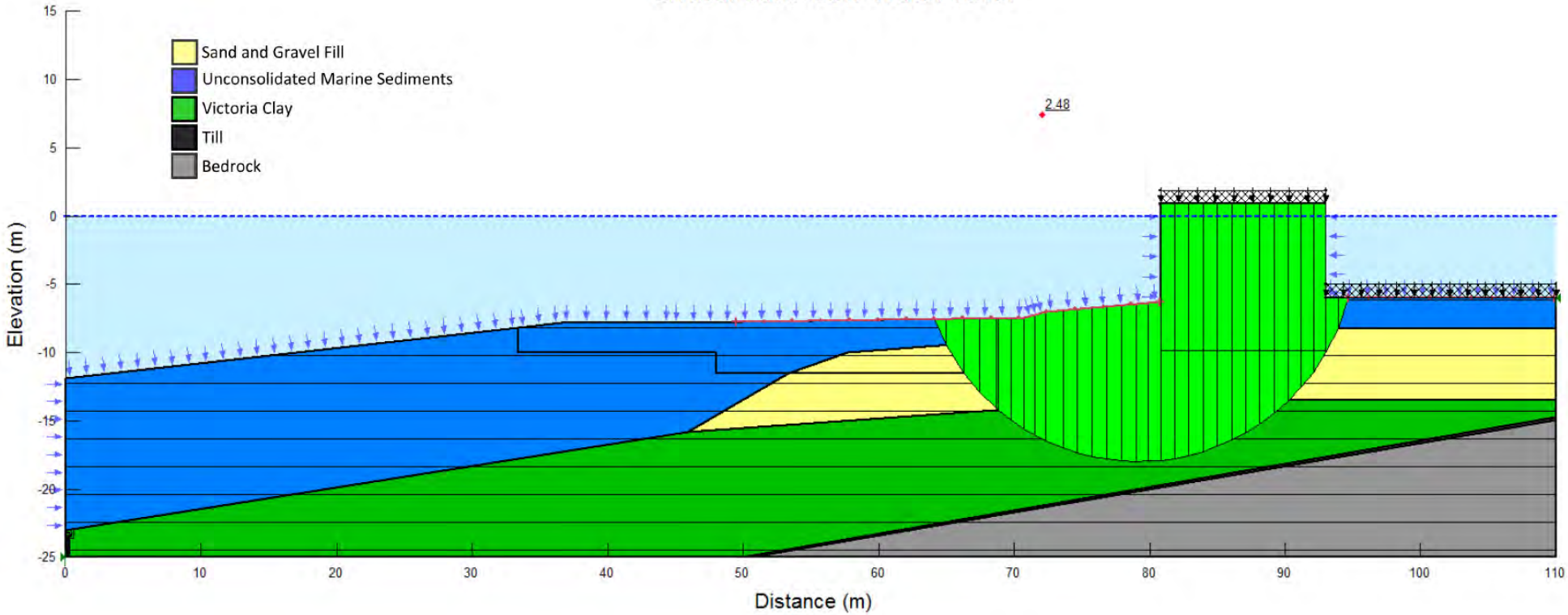
APPROVAL:

PROJECT No.: P09614 A02

FIGURE. No.: 13

REV.:

Critical Case: Low Water Level



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Klohn Crippen Berger

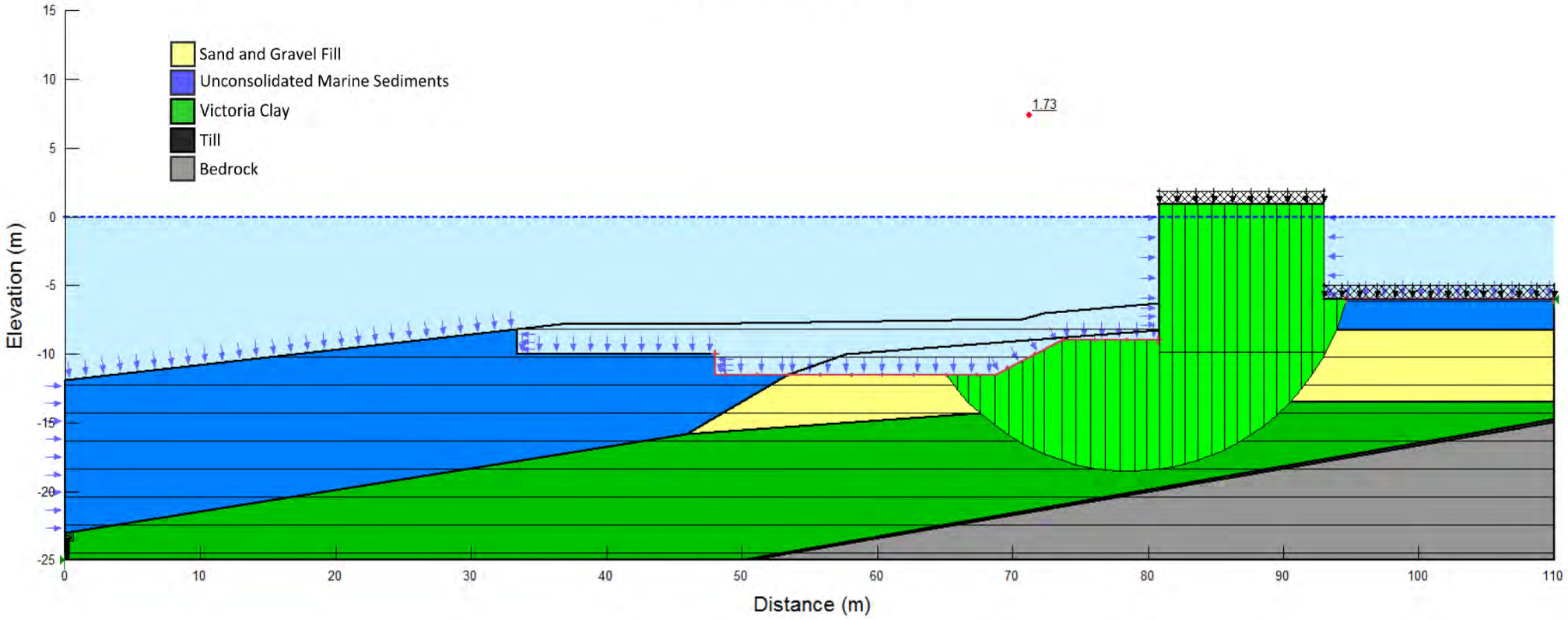
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: TIMBER CRIB CURRENT CONDITIONS GLOBAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	14	

Critical Case: Low Water Level



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Klohn Crippen Berger

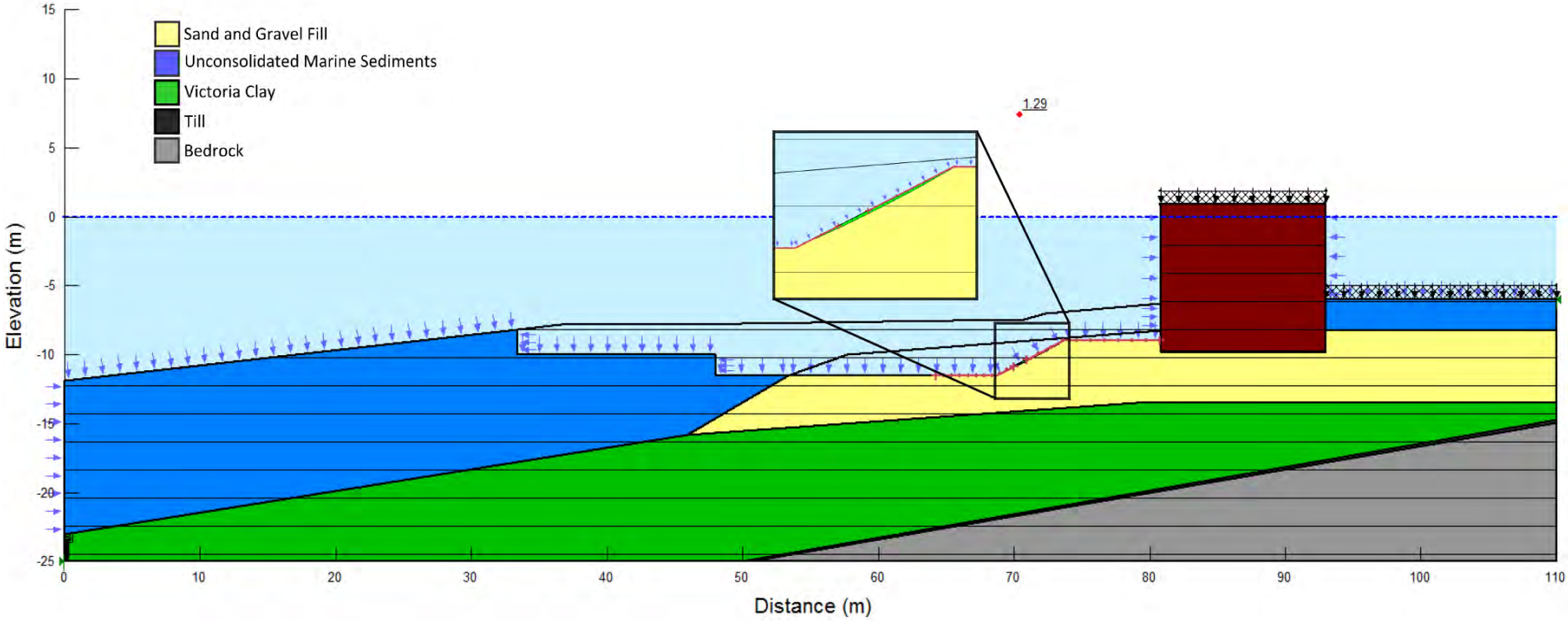
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: TIMBER CRIB DREDGED CONDITIONS GLOBAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	15	

Critical Case: Low Water Level



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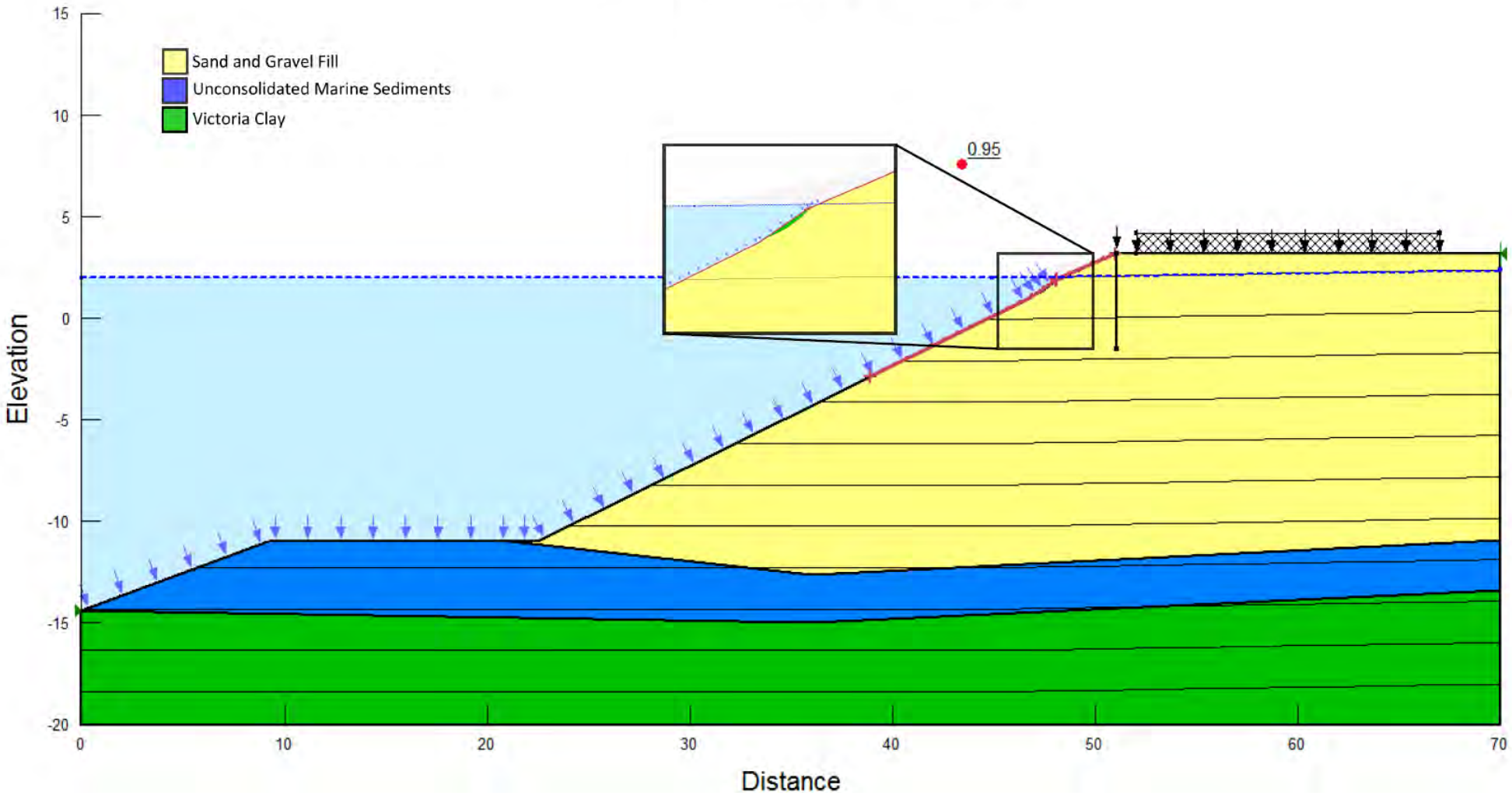
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: TIMBER CRIB DREDGED CONDITIONS LOCAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	16	

Critical Case: Mean Water Level



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Klohn Crippen Berger

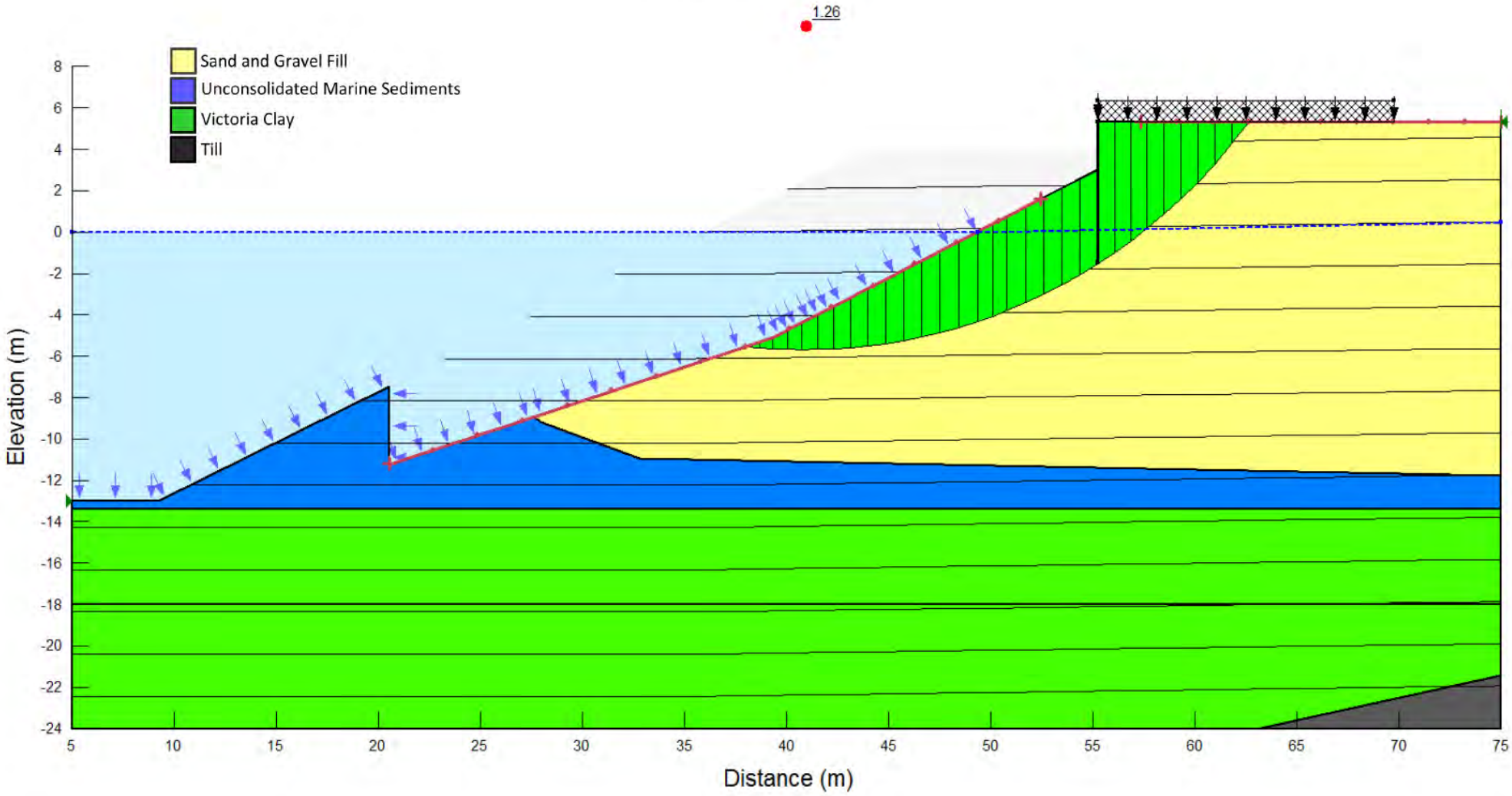
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: CONCRETE DECK AND CRANE PAD
DREDGED CONDITIONS - LOCAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	17	

Critical Case: Low Water Level



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Klohn Crippen Berger

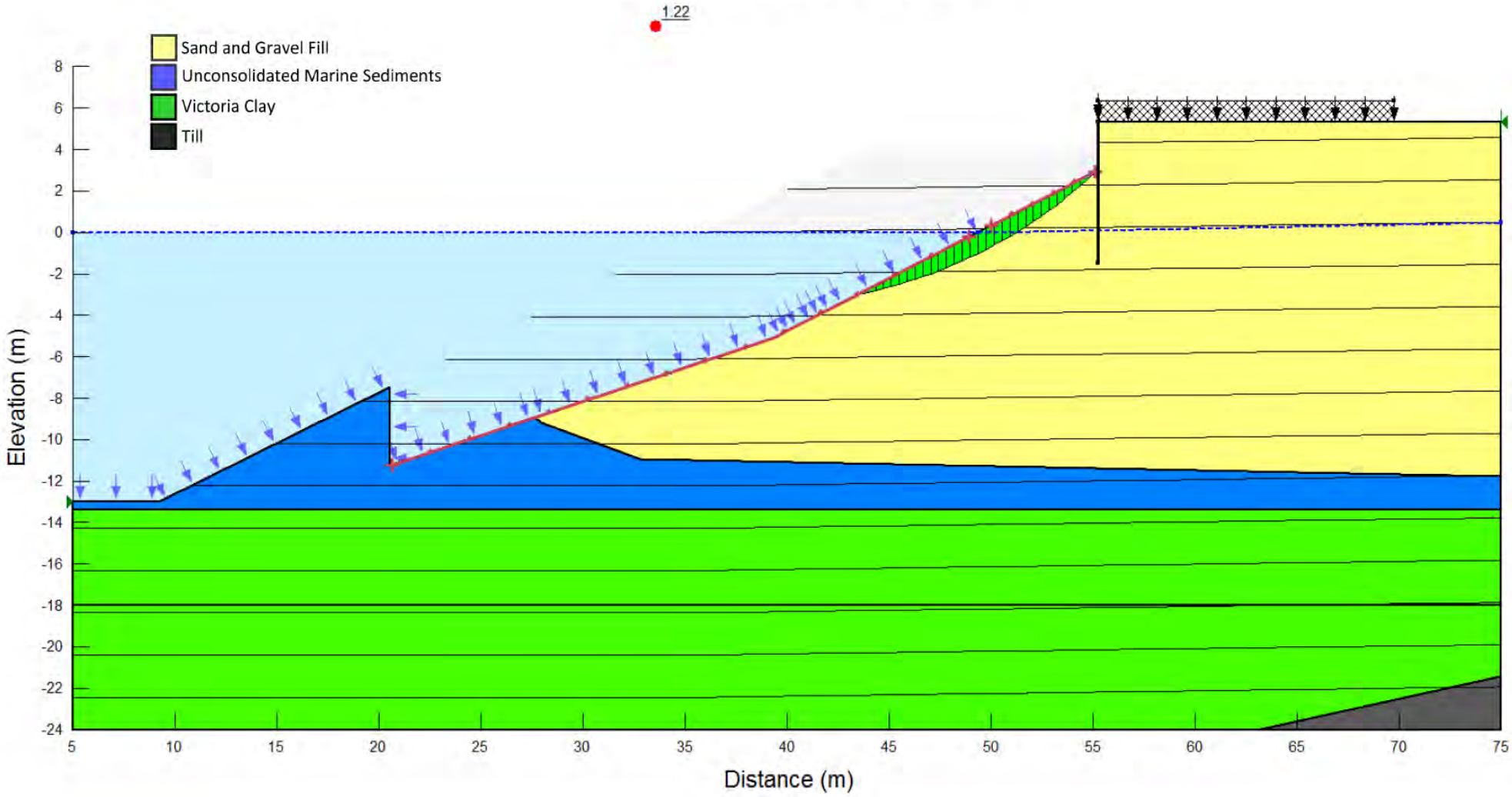
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: SHEET PILE BULKHEAD SECTION D-D'
DREDGED CONDITIONS - GLOBAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	18	

Critical Case: Low Water Level



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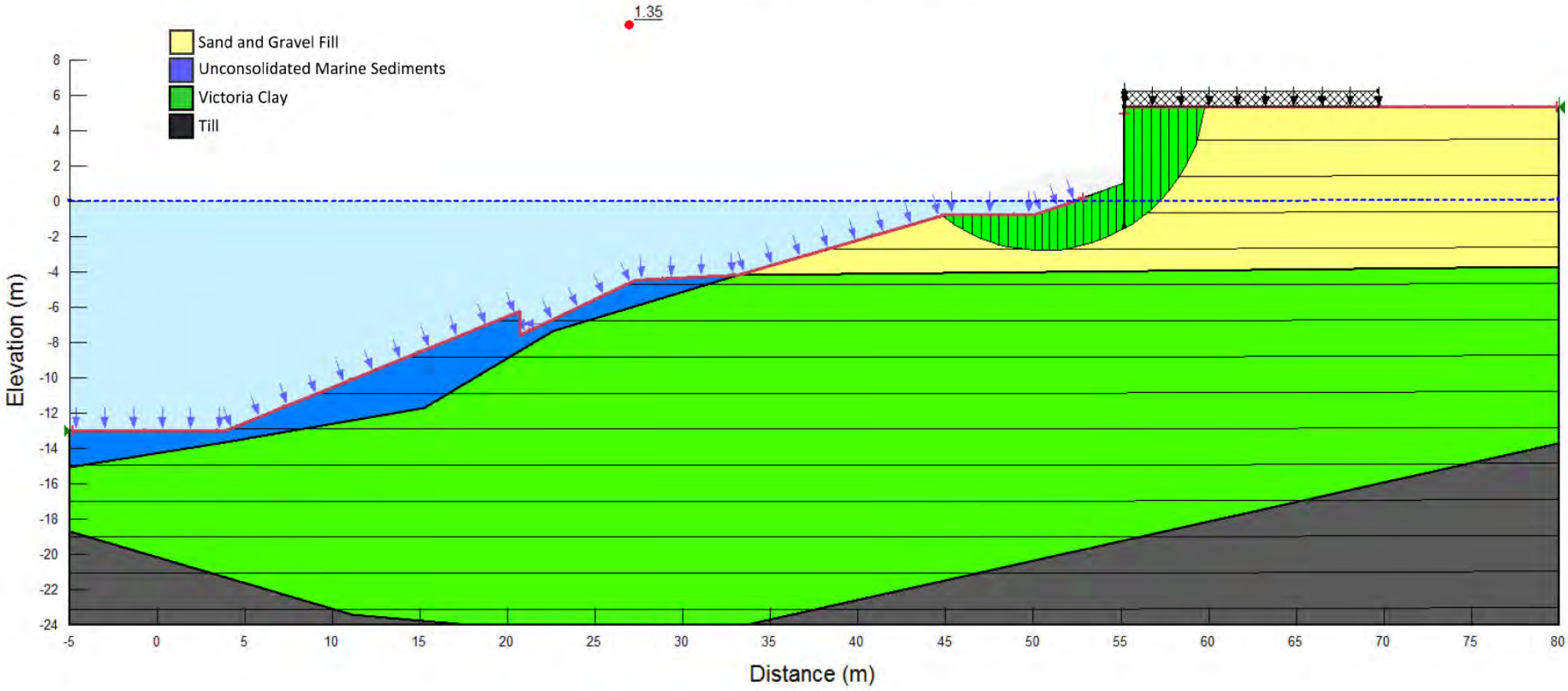
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: SHEET PILE BULKHEAD SECTION D-D' DREDGED CONDITIONS - LOCAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	19	

Critical Case: Low Water Level



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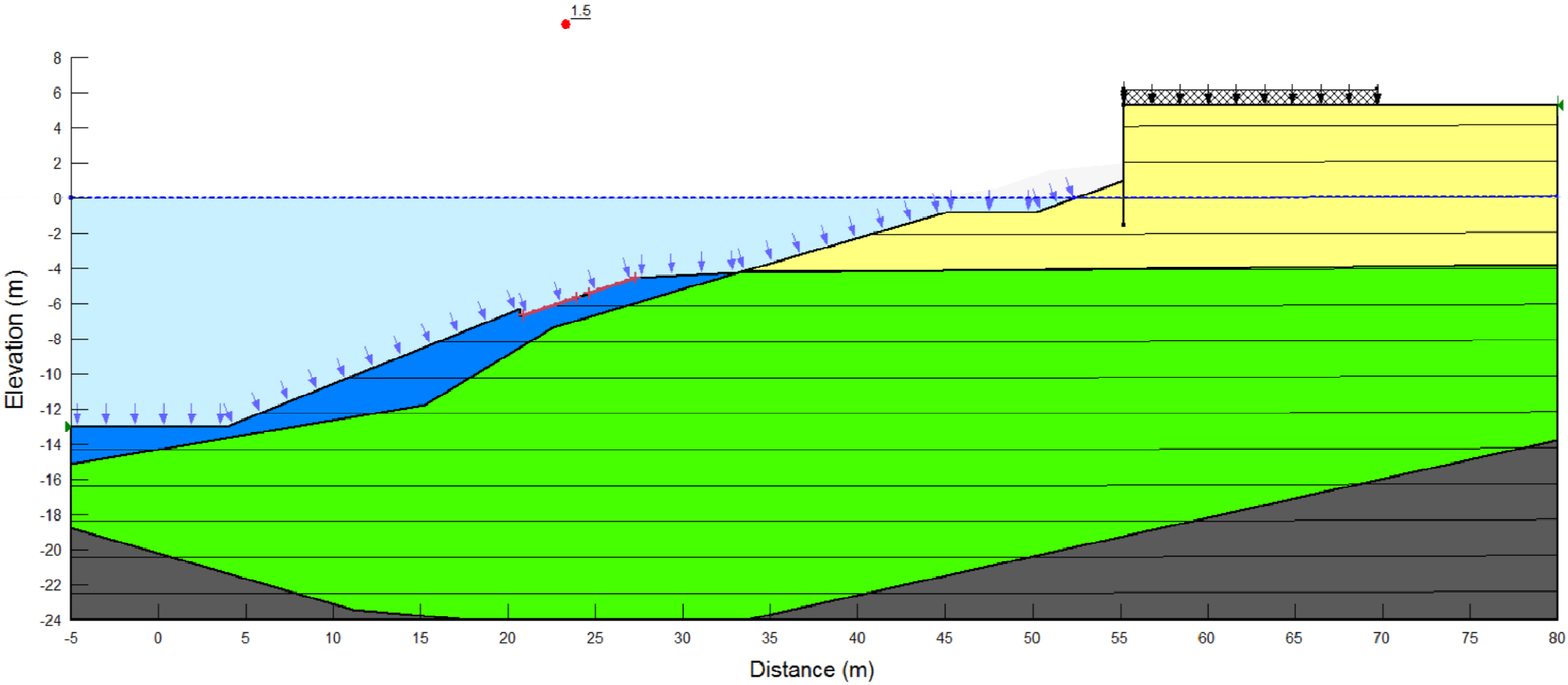
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: SHEET PILE BULKHEAD SECTION E-E'
DREDGED CONDITIONS - GLOBAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	20	



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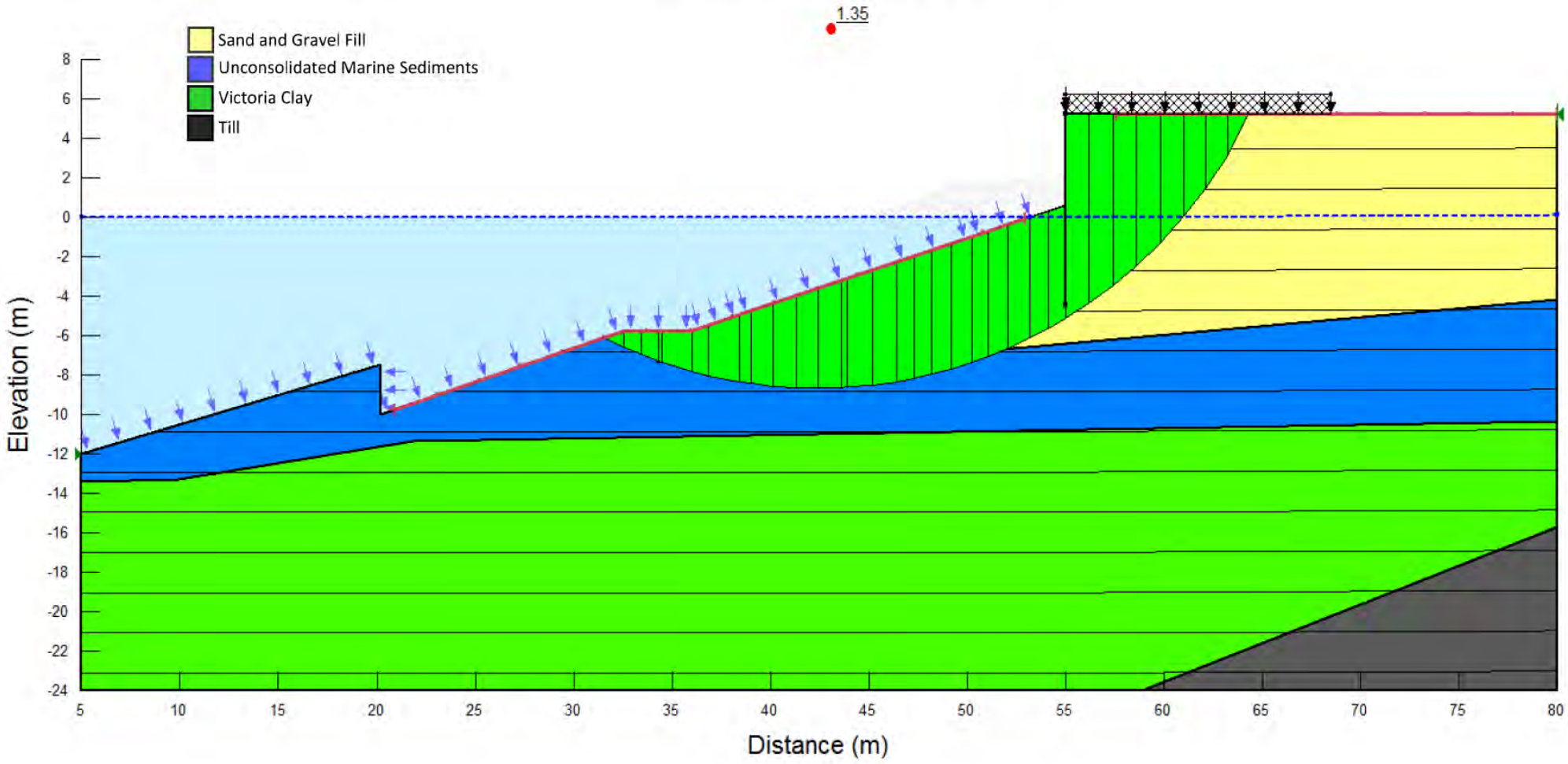
PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: SHEET PILE BULKHEAD SECTION E-E'
DREDGED CONDITIONS - LOCAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	21	

Critical Case: Low Water Level



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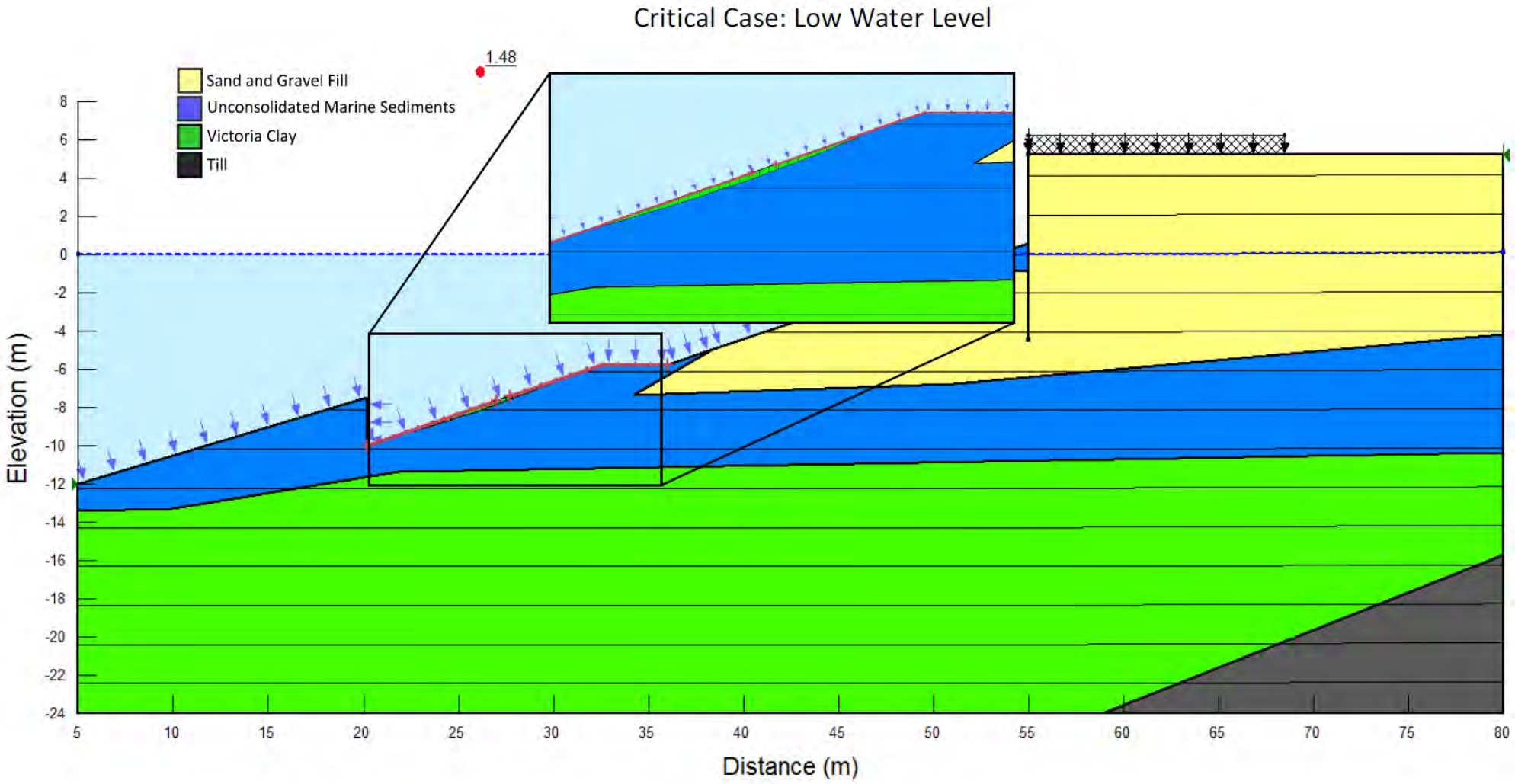
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: SHEET PILE BULKHEAD SECTION K-K'
DREDGED CONDITIONS - GLOBAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	22	



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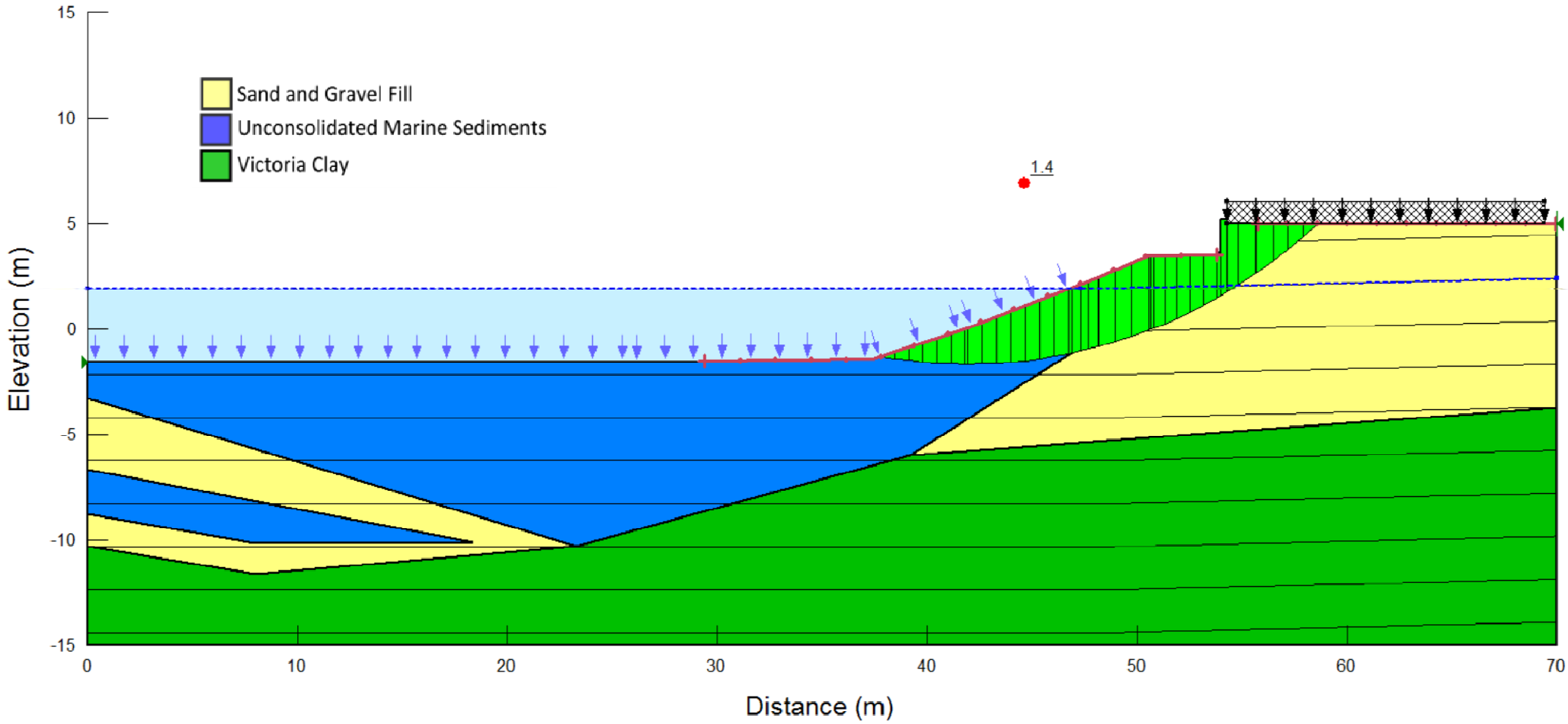
PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: SHEET PILE BULKHEAD SECTION K-K'
DREDGED CONDITIONS - LOCAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	23	



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Klohn Crippen Berger

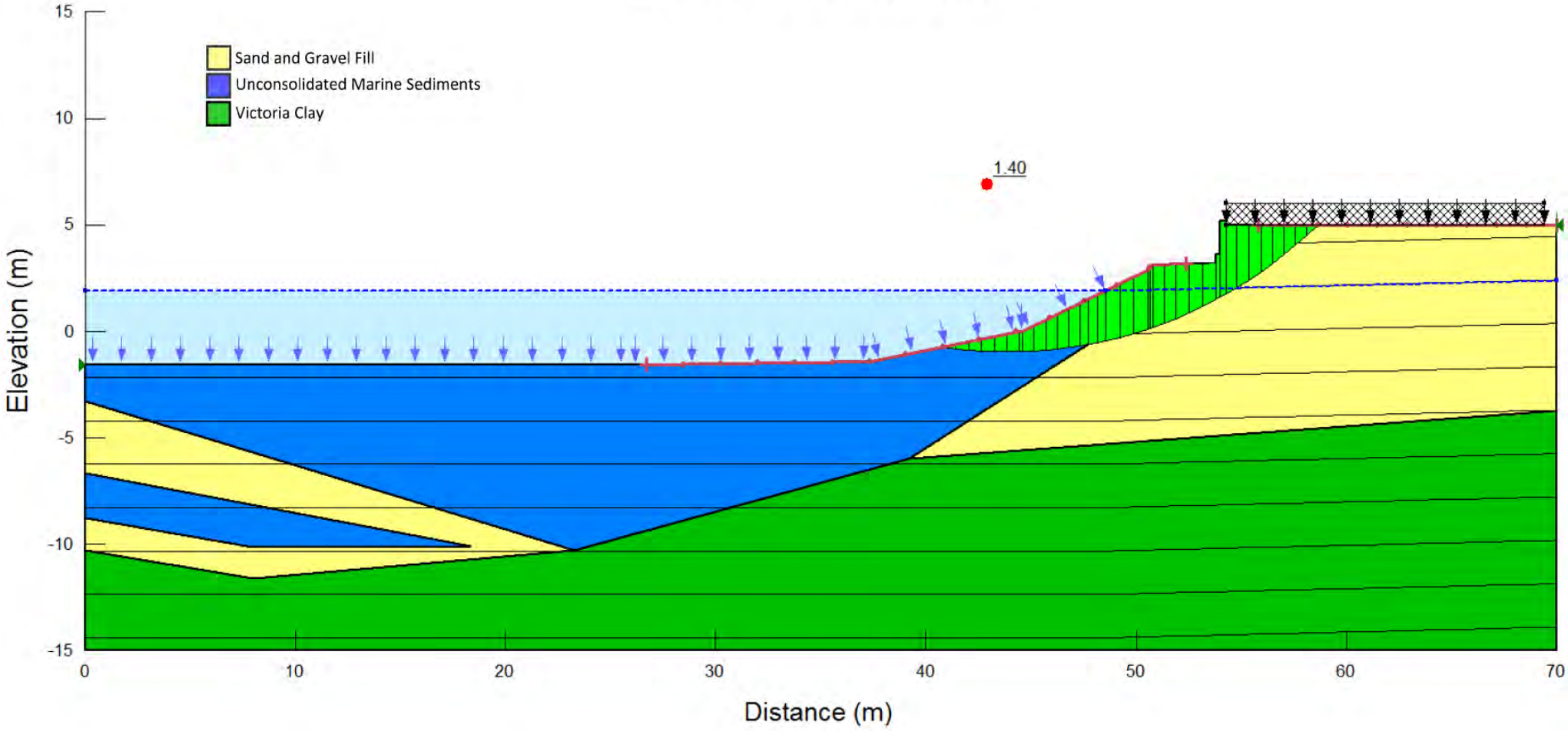
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: CONCRETE L-WALL CURRENT CONDITIONS GLOBAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	24	

Critical Case: Mean Water Level



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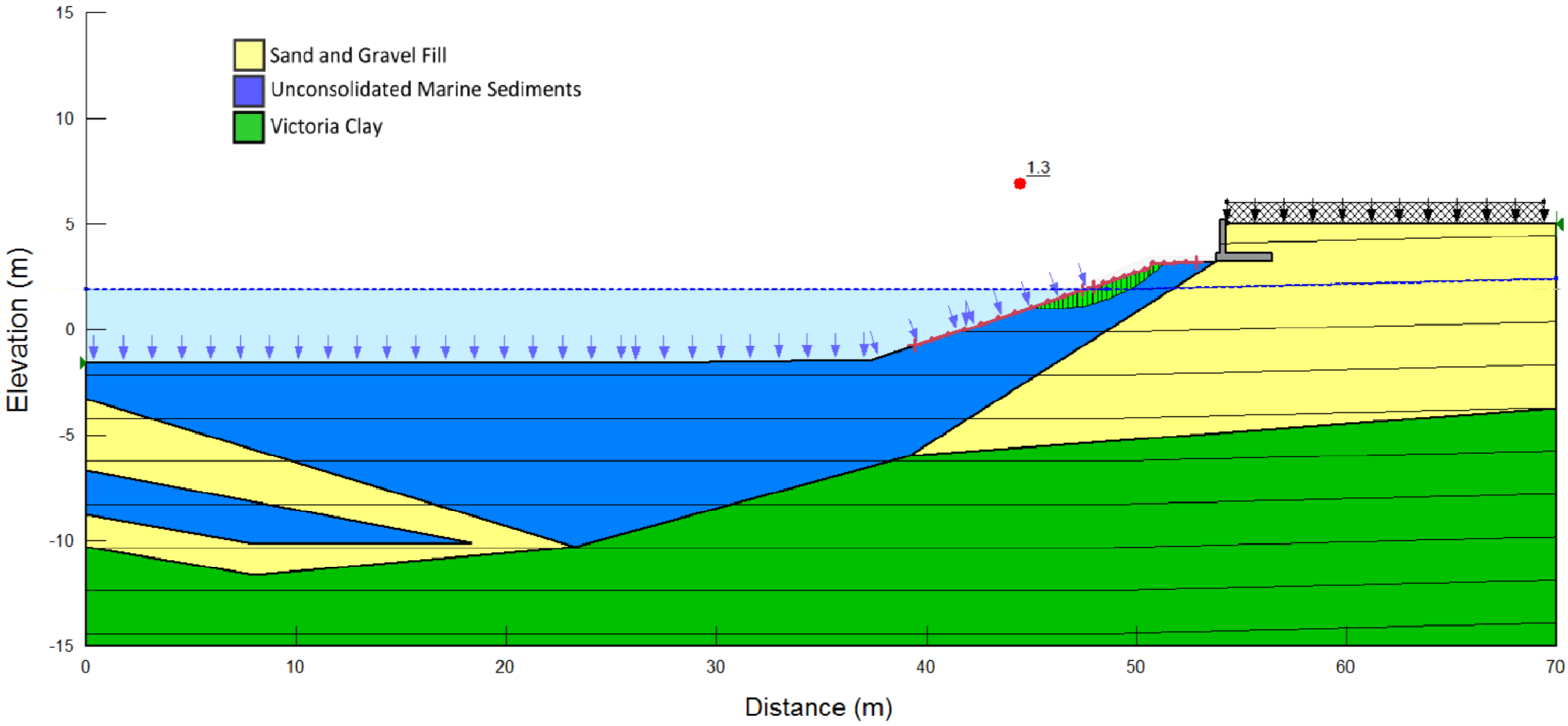
PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: CONCRETE L-WALL DREDGED CONDITIONS GLOBAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	25	



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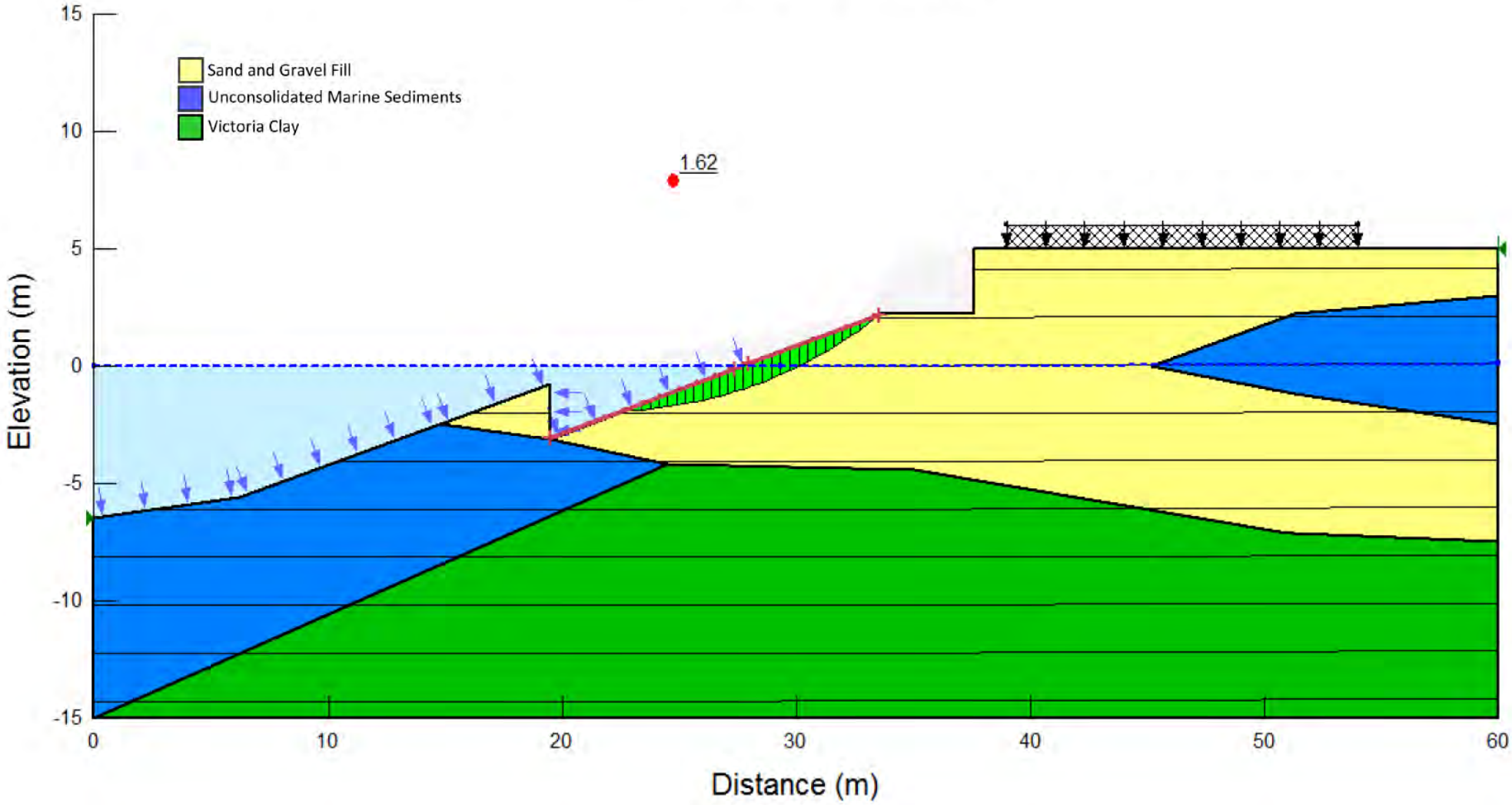
PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: CONCRETE L-WALL DREDGED CONDITIONS LOCAL STABILITY

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
APPROVAL	P09614 A02	26	

Critical Case: Low Water Level



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Klohn Crippen Berger

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

PROJECT: EGD SOUTH JETTY PHASE 2 ENVIRONMENTAL REMEDIATION

TITLE: ROCK SLOPE DREDGED CONDITIONS LOCAL STABILITY

DATE OF ISSUE:

APPROVAL:

PROJECT No.: P09614 A02

FIGURE. No.: 27

REV.:

APPENDIX I

July 3, 2014 Meeting Record

MEETING RECORD

Project:	EGD South Jetty Phase 2 Environmental Remediation
Purpose of Meeting:	Geotechnical Validation
Meeting Date:	July 3, 2014
Location:	KCB Office, 500-2955 Virtual Way, Vancouver
Prepared by:	Monta Maeda (KCB)
Issued Date:	Issued as Final, July 8, 2014
Attachments:	KCB presentation slides (including final slide listing potential solutions and recommendations), and KCB's sheet pile bending moment email of January 28, 2011

Attendees:	**Company:**
Jon Siska	PWGSC
Dan Berlin (conference call)	AnchorQEA
Matt Woltman (conference call)	AnchorQEA
Dick Butler	Golder Associates
Sarah Morse	Golder Associates
Geoff Cooper	Klohn Crippen Berger
Steve Ahlfield	Klohn Crippen Berger
Juan-Carlos Carvajal	Klohn Crippen Berger
Monta Maeda	Klohn Crippen Berger

This meeting was held to discuss differences between the geotechnical analysis by Golder Associates Ltd. (Golder) and the geotechnical validation by Klohn Crippen Berger Ltd. (KCB), affecting the embedment depth design at the west end portion of the sheet pile wall (re-driven in Phase 2). Representatives of Anchor QEA, LLC (Anchor) and Public Works and Government Services Canada (PWGSC) also participated in the meeting.

Golder and KCB presented details of their respective analyses; KCB's slideshow is attached for reference. Based on the presentations and subsequent discussions, Golder and KCB agreed that the main cause of differing results was a misunderstanding regarding the bending moment provided by KCB to Golder in January 2011 (KCB's Jan 28th 2011 email to Golder is attached for reference). Whereas on January 28th, 2011 KCB provided **allowable bending moments** for the various sheet pile types for input to Golder's analysis, Golder understood the input to be **ultimate bending moments**, as identified in Table 2 of Golder's September 9, 2011 memorandum. As a consequence, Golder's analysis was carried out for a design shear force (applied at the top of the sheet pile wall) about 28% less than KCB intended, which led to the discrepancies found during KCB's validation.

Both KCB and Golder agreed that incorrect bending moment properties were used in the original analysis, which requires further action (discussed below) to mitigate the potentially insufficient embedment of the currently installed sheet pile wall (when re-driven to El.0.0 m chart datum) for the loading conditions considered. KCB and Golder agreed that other differences in assumptions and methodology (e.g. differences in soil properties used in the respective analyses) do not have any significant effect on the wall embedment calculation results.

As presented in KCB's slides, the area of potentially insufficient embedment is limited to the west end portion of the sheet pile wall (west end face plus short sections of the west ends of the north and south walls).

The embedment of the existing sheet pile wall after re-driving in Phase 2 will be sufficient for the other portions of the containment wall despite the misunderstanding regarding design bending moment. It was agreed that this is likely because the design of the existing sheet pile wall in those areas was governed by the Phase 1 propped cantilever support condition, which was less sensitive to the value of bending moment used in the design.

After reaching consensus on the main cause of the discrepancy between Golder / KCB analyses and the need to resolve the issue, the parties in attendance discussed potential solutions listed below:

1. **Recommended Step 1:** Re-evaluation of design soil parameters (Victoria Clay) specifically for Section A-A' at applicable depths.

   Both the Golder design and KCB validation used lower-bound averaged soil parameters for the whole south jetty site. Closer examination / interpretation of soil data for this specific west end wall location may confirm if a "crust" of higher strength clay exists at upper zone of the clay layer, or if less conservative soil strength can be used in the design. If so, this may allow a reduction in required wall embedment. Even if only partly successful, this Step 1 could be useful in re-evaluating prop wash effects.

2. **Recommended Step 2:** Evaluate methods to reduce prop wash force.

   Original assumptions by AQ for Phase 2 prop wash loading: smaller tug boat, 10-25% power at 5 m from wall; larger tugboat, 10% power at 15 m from wall. It was noted the resulting velocity of 3-4 m/s is a large load for the temporary re-suspension barrier (TRB) to withstand.

   In order to avoid making any change to the current (re-driven) wall embedment design, the prop wash pressure would need to be reduced by 30-40%. The minimum distance of tug boat to wall could be increased, or a lower % of tugboat horsepower could be specified, or a restriction on direction of prop wash could be imposed. Consider disallowing access to west end wall (15 m wide contractor water zone) for Seaspan Hawk tugboat.

3. **Recommended Step 3:** Wall retrofit. This is only to be considered if Step 1 and/or Step 2 are not effective.

   Potential Retrofit Options:

   a) Add 1.2 m structure on top of wall (most viable of retrofit options, but would incur additional cost and may be somewhat challenging to install);

   b) Insert additional support piles behind wall (ineffective unless driven much deeper than wall, and must be stiffer than wall, costly);

   c) Add horizontal waler behind wall (likely ineffective due to longitudinal distribution

extent of prop wash pressures);

d) Add corner bracing to support wall (impractical, costly). Lateral bracing back to existing deck structure, i.e. initial demolition of 10 m wide strip of deck (impractical, costly); and

e) Inclined pile bracing down to seabed inside wall (interferes with dredging, costly). Inclined tension bracing down to seabed on outside of wall (interferes with navigation, likely to be impacted and damaged during remediation works, costly).

4. **Recommended Step 4:** Slot cuts for dredging inside the wall. This is only to be considered if Step 3 is financially punitive.

   This would need a longitudinal steel waler to spread wall loads, which is likely to be ineffective from a geotechnical perspective. This option is likely challenging to avoid recontamination, and slot-cut dredging would be slow due to the water depth.

5. Other options that were discussed, but rejected are outlined below:

   a) Reduction of safety factor – would have to be reduced from 1.3 to about 1.0. Consider duration of loading (about 10 to 20 seconds, which should be enough to generate soil pressures), and safety considerations. (Although applied in some cases of short term transient loading such as earthquakes, this is not a normal engineering practice where the structure is expected to remain in serviceable condition, so not recommended.)

   b) Raise dredge depth inside wall. (Would achieve only minimal benefit since marine sediments near seabed surface are weak, does not achieve FCSAP remediation objectives).

The agreed plan moving forward is for KCB to carry out analyses for **Recommended Step 1** with inputs from Golder. KCB will prepare an engineering budget in next few days (for review by PWGSC by July 10), with approval to proceed anticipated by July 17. Step 1 would then be completed by July 31 (2 weeks after approval to proceed).

If Step 1 alone does not resolve the issue, Anchor will carry out analyses for **Recommended Step 2** starting August 1, with completion in approximately two weeks (to be confirmed by Anchor).

The parties in attendance believe that the results of **Recommended Steps 1 and 2** should allow the existing sheet pile wall to be re-driven without modification in Phase 2. In the event that the sheet pile wall embedment is still insufficient, Steps 3 and/or 4 will be considered.

Cooper, Geoff

From: Cooper, Geoff
Sent: Friday, January 28, 2011 11:02 AM
To: 'Williams, Randy'
Cc: 'Jones, Rachael (Burnaby)'; 'Dan Berlin'; Tom Wang (AnchorQEA); Tong, Janet
Subject: Corrected Max Moment Capacities for SPWall Sections for EGD Underpier Erosion (temporary cantilever case)

Randy;
In support of your analysis of the cantilevered sheetpile wall that will exist temporarily during timber jetty deconstruction, Janet sent you a list of maximum pile moments on Jan 20th. Those values neglected to allow for 0.9 material resistance factor on steel yield strength. See **corrected** values below. To clarify Janet's results and avoid any confusion, we also have added some explanations for the calculated bending moments (edits to her email below).

Per yesterday's team conference call, the results of your analysis are required ASAP, to allow the team to assess the best course of action and give the client a cost/viability comparison for three options: (a) do nothing if the cantilevered wall is already strong enough to take the temporary soil/propwash/wave loading, or (b) re-drive the sheetpiles deeper at time of jetty deconstruction to reduce the effective height of the cantilever, or (c) install the sheetpiles deeper during initial wall construction to achieve the same objective.

Please call if any questions.
Geoff Cooper, P.Eng.
Manager, Ports & Harbours
Klohn Crippen Berger
500-2955 Virtual Way, Vancouver, BC, V5M 4X6
Phone: (604) 251-8439 Fax: (604) 251-8420

From: Tong, Janet
Sent: Thursday, January 20, 2011 9:24 AM
To: Williams, Randy; 'Jones, Rachael (Burnaby)'; 'Dan Berlin'
Cc: Cooper, Geoff; Tom Wang; 'Tim_Whalen@golder.com'
Subject: Maximum moment capacities for Sheet pile wall Sections for EGD Underpier erosion

Hi Randy
We are using 3 AZ pile sheet types for the underpier erosion : AZ 25, AZ 37-700 and AZ 50.

The maximum (allowable bending) moment for these sections are:

AZ 25 = ~~601 kN/m~~ (calculated from elastic section modulus of 2,455cm3/m width, times 0.9Fy of 0.9*350MPa, divided by 1.30 safety factor, and divided by 1.10 allowance for maximum moment in the soil = **541 kN/m width**). Please note the following:
1) The 1.30 safety factor is simply an inversion of the wave load factor of 1.30 per Canadian Highway Bridge Design Code S6-06.
2) The maximum moment will occur at point of fixity within the soil, not at the mudline; the 1.10 factor is simply an additional allowance that we have included at preliminary design to account for this difference. This allowance needs to be validated by the final design bending moment profile down through the soil.

AZ 37-700 = ~~907 kN/m~~ (**816 kN/m width**)

AZ 50 = ~~1227 kN/m~~ (**1105 kN/m width**)

These moments account for 10% increase for maximum moment in soil and a SF = 1.3 (for standard tug load case) (see my comments above).

If you have any questions, please do not hesitate to call.
Regards
Janet C. Tong, P.Eng., PE

Structural Engineer
Klohn Crippen Berger 500 - 2955 Virtual Way, Vancouver, BC V5M 4X6, CANADA
D 604.251.8494 | T 604.669.3800 | F 604.669.8420 | jtong@klohn.com | www.klohn.com <http://www.klohn.com/>

If you have received this email in error, please delete the original message.

EGD South Jetty

Phase 2 Environmental Remediation

Geotechnical Design Validation by KCB

Re-Driven Sheet Pile Containment Wall

Klohn Crippen Berger

Design Objectives

Objectives of the analysis:

1). Determine the working shear force (F_D) applied at the top of the re-driven sheet pile wall to mobilize the working bending moment for design ($\mathbf{M_{Design}}$):

a. 1,105 kN·m (section A-A' and C-C'),

b. 816 kN·m (section D-D'), and

c. 541 kN·m (section D-D').

(Based on email from Geoff Cooper (KCB) to Randy Williams (Golder) on January 28, 2011.)

Klohn Crippen Berger

Design Objectives

Objectives of the analysis:

2). Determine the embedment of the re-driven sheet pile wall for a factored shear force (F_{Max}) equal to 1.3 times the working shear force (F_D):

$$F_{Max} = 1.3\ F_D$$

where 1.3 is the factor of safety (FS) for design.

Klohn Crippen Berger

Design Objectives

Objectives of the analysis:

3). Verify that the maximum bending moment mobilized by the factored shear force (F_{Max}) is less than the yield bending moment (M_y) of the sheet pile wall.

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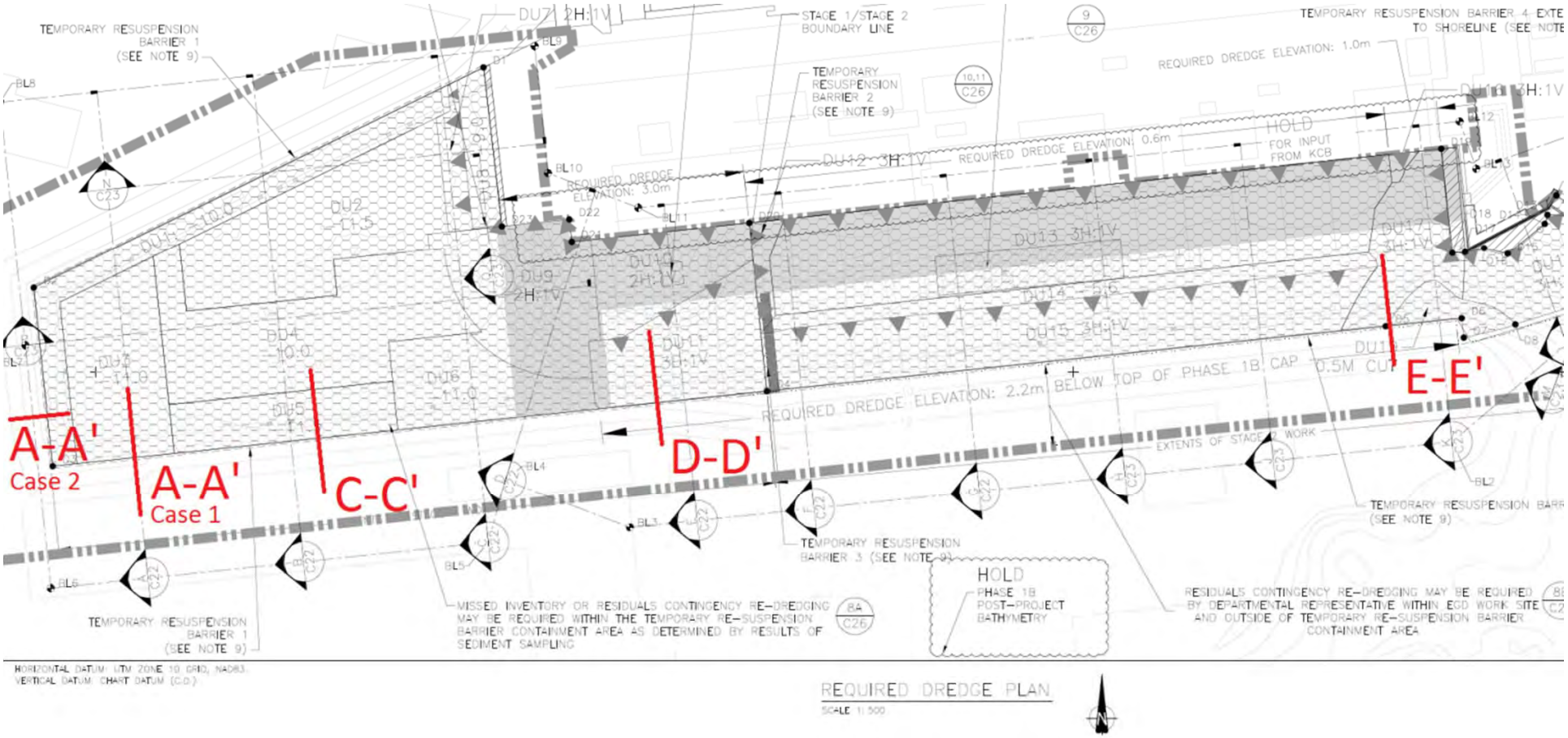
Site Plan and KCB Section Locations



Reference: Anchor QEA 99% Integrated Design (2014-03-31)
Drawing C21 – Required Dredge Plan

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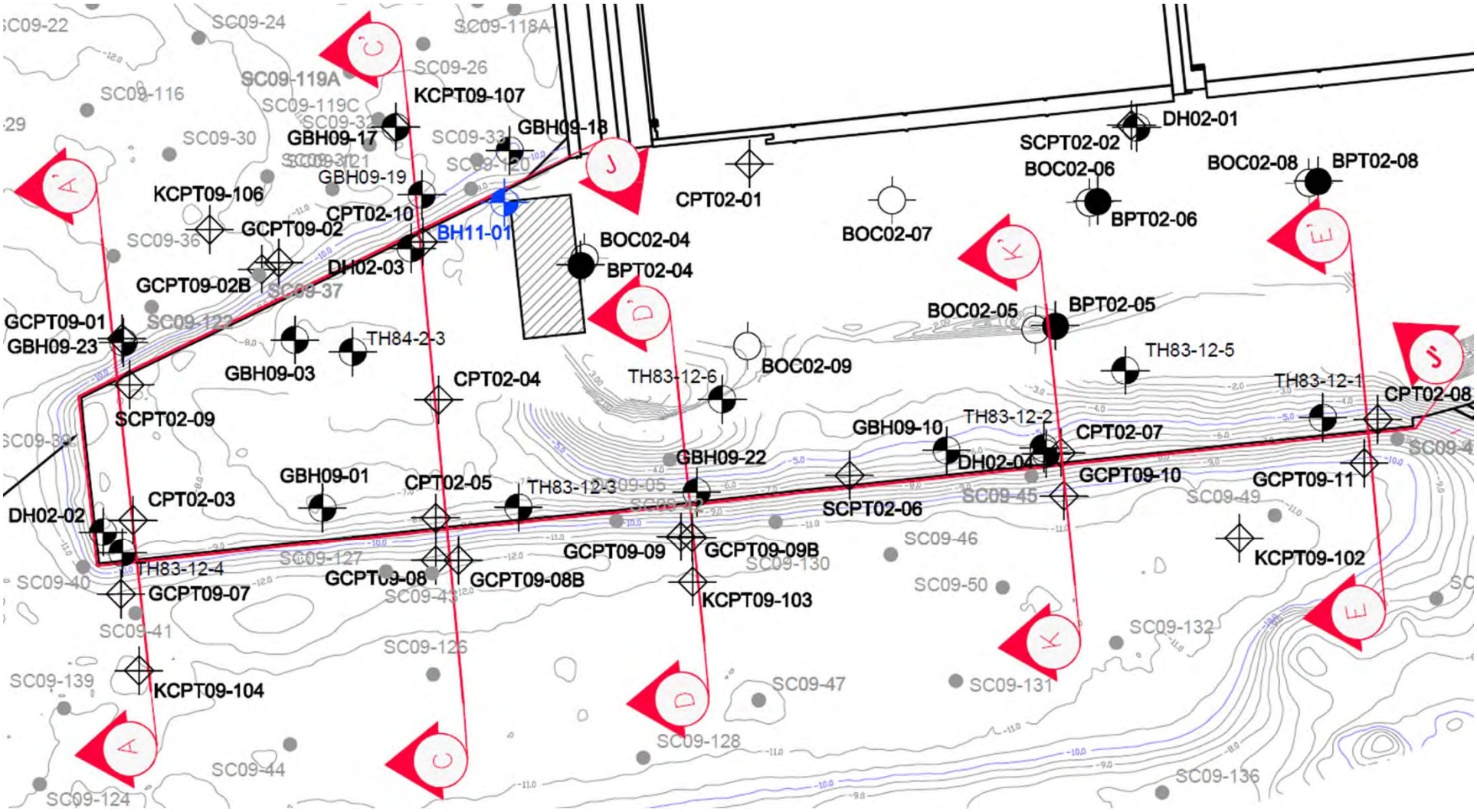
Site Plan and Golder Section Locations



Reference: Golder Technical Memorandum (2011-09-09)

Figure 1A – South Jetty Plan

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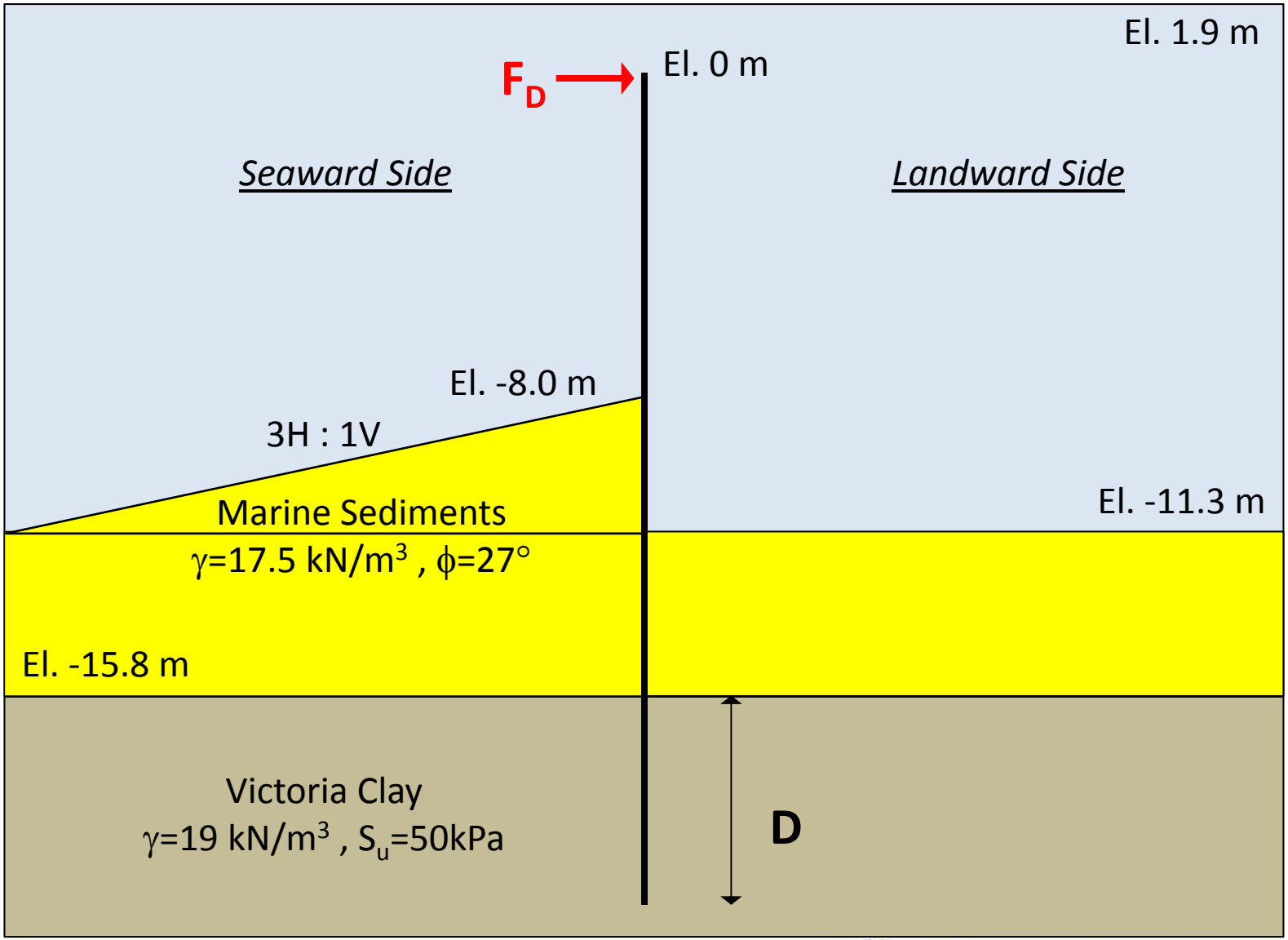
Section A-A' Case 1



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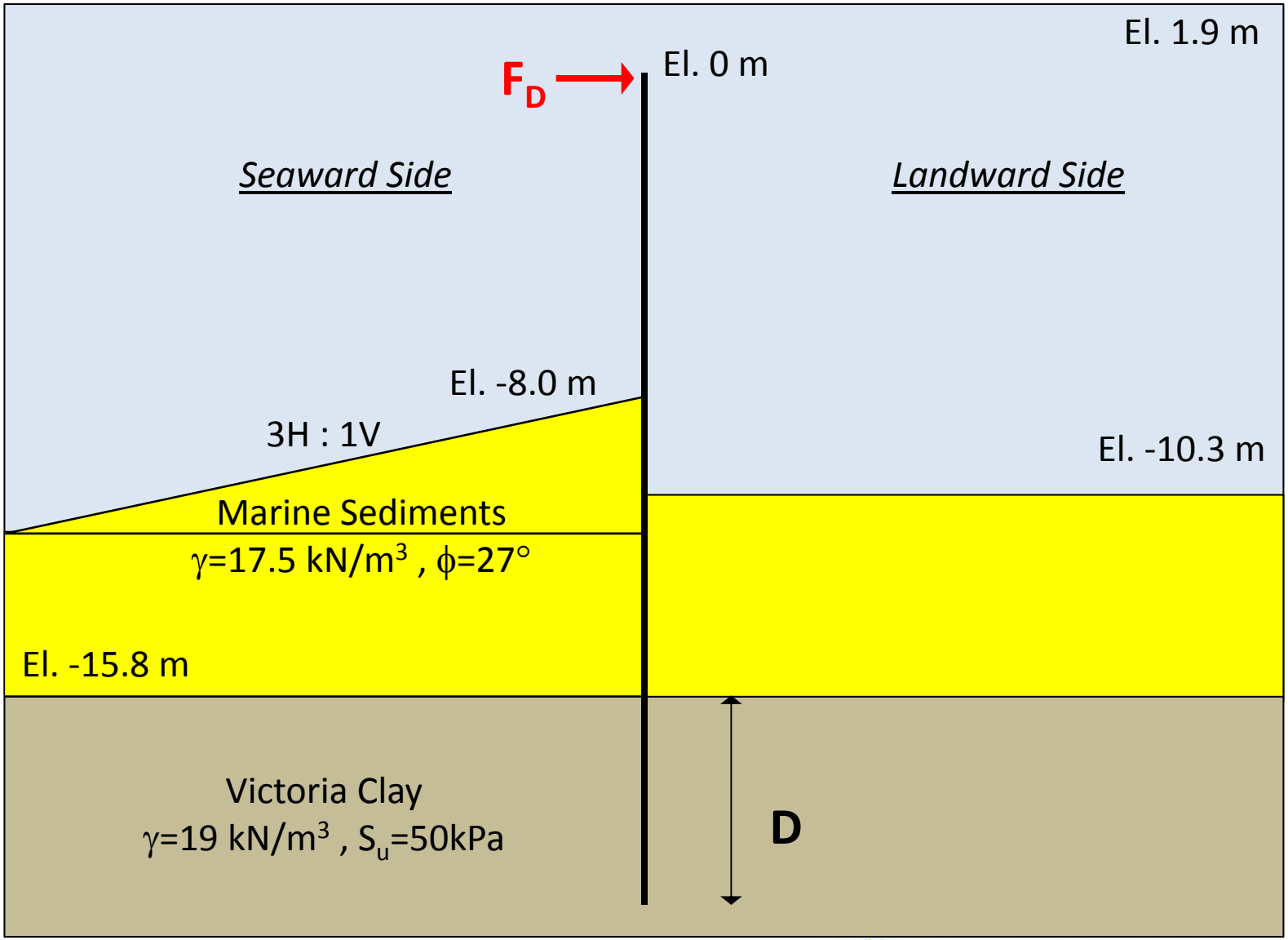
Section A-A' Case 2



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Summary of Soil Elevations

Section	Soil Elevations (m)		
	Mudline Seaward	Mudline Landward	Top of V. Clay
A-A' Case 1	-8.0	-11.3	-15.8
A-A' Case 2	-8.0	-10.3	-15.8
C-C'	-7.5	-11.8	-14.4
D-D'	-7.5	-11.3	-12.8
E-E'	-7.5	-10.0	-10.5

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Comparison of Assumed Soil Properties

Material Description	Unit Weight (kN/m³)		Shear Strength	
	KCB	Golder	KCB	Golder
Marine Sediments	17.5	17.5	$\phi' = 27°$ $c' = 0$ kPa	$\phi' = 33°$ $c' = 0$ kPa
Victoria Clay	19	18	$s_u = 50$ kPa	$s_u = 50$ kPa

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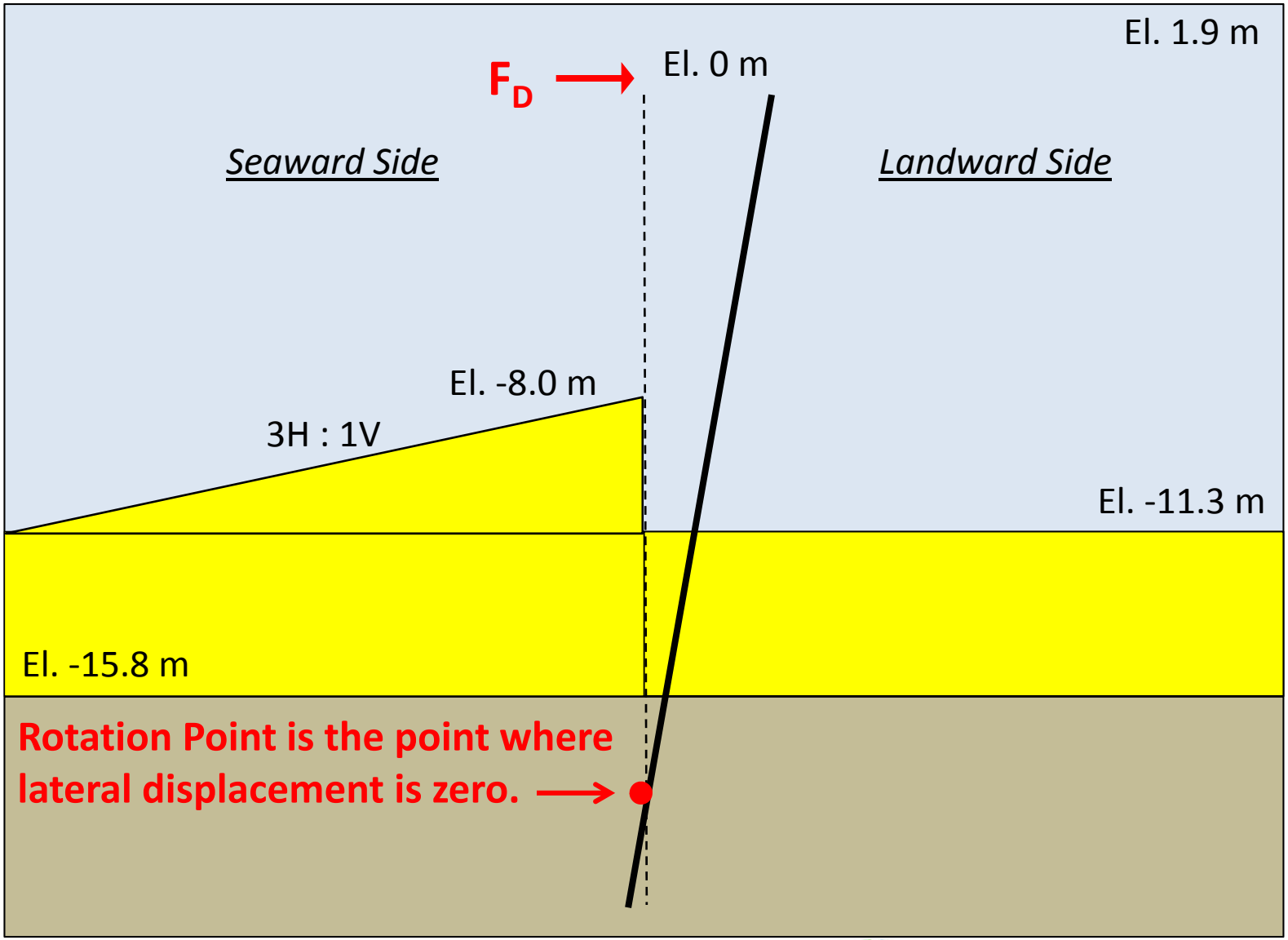
Wall Rotation at Section A-A' Case 1



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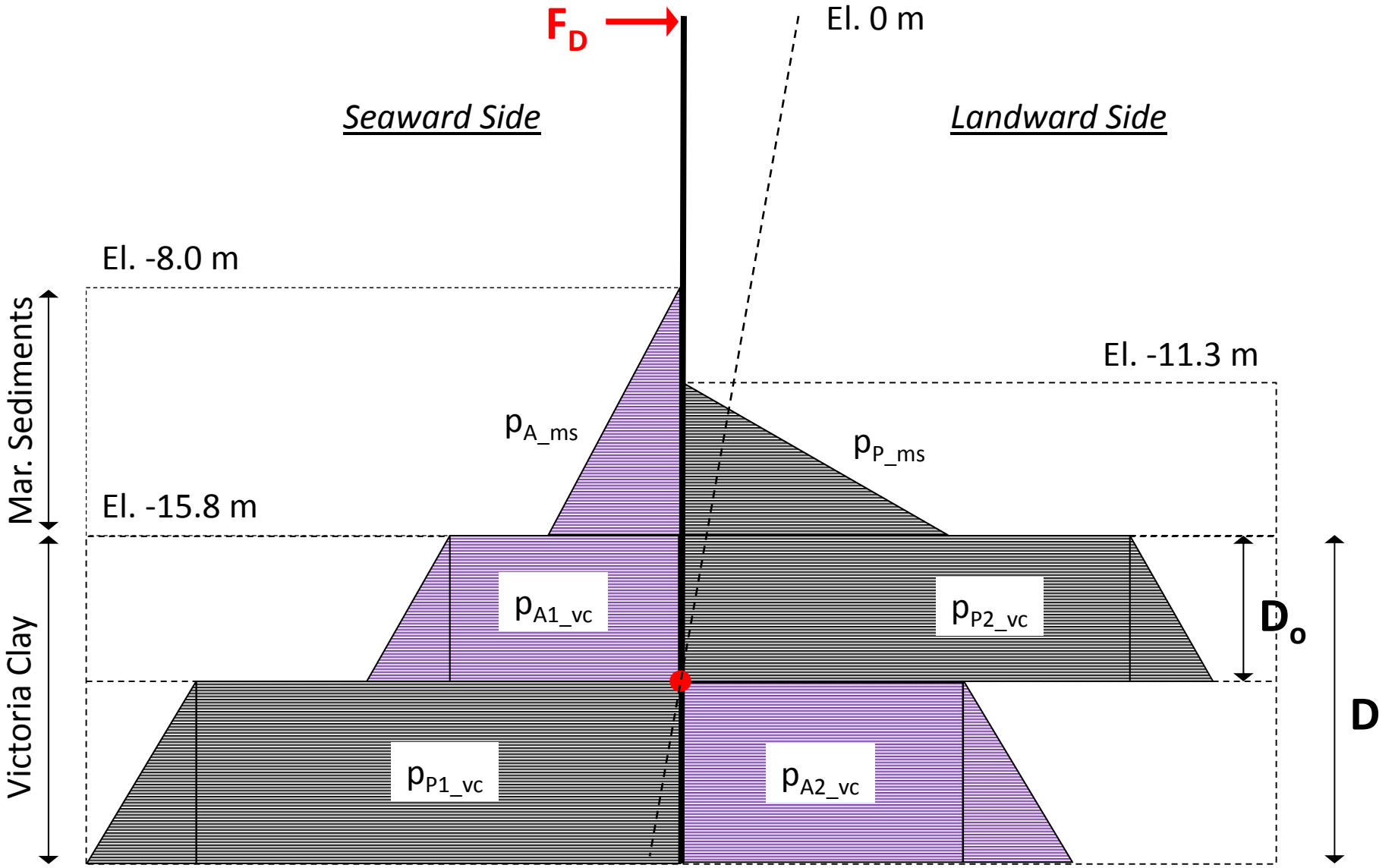
Lateral Force and Earth Pressures



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Net Pressure Approach

$$p_{net} = p_P - p_A$$

in the Victoria Clay:

$$\mathbf{p_A = p_{vo1} - 2S_u \geq 0} \quad = \quad p_A = (p'_{vo1} + u_1) - 2S_u \geq 0$$

$$\mathbf{p_P = p_{vo2} + 2S_u} \quad = \quad p_P = (p'_{vo2} + u_2) + 2S_u$$

$$\mathbf{p_A > 0 \ \& \ u_1 = u_2 = u_o \rightarrow p_{net} = p_P - p_A}$$

$$p_{net} = (p_{vo2} + 2S_u) - (p_{vo1} - 2S_u) \quad = \quad p_{net} = (p'_{vo2} + u_o + 2S_u) - (p'_{vo1} + u_o - 2S_u)$$

$$p_{net} = 4S_u + (p_{vo2} - p_{vo1}) \rightarrow p_{net} = 4S_u + (p'_{vo2} - p'_{vo1})$$

For this specific case, p_{net} is the same in total or effective stress analysis

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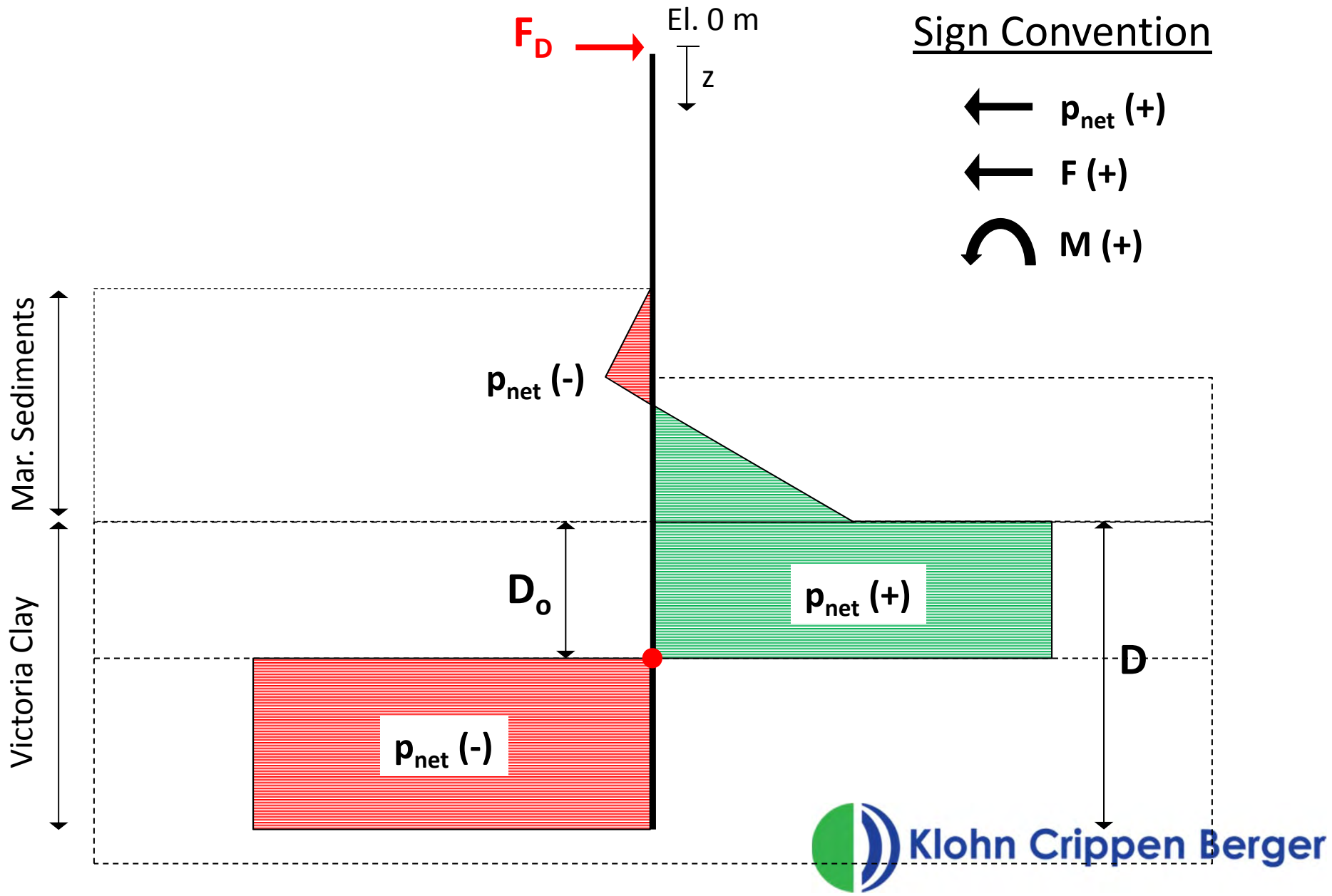
Net Pressure Distribution



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Determination of Embedment Depth

PROBLEM:

Three Unknowns:

(1). F_D?

(2). D?

(3). D_o?

Three Equations:

(1). $M_{max} = M_{Design}$

(2). $\Sigma F = 0$

(3). $\Sigma M = 0$

Is there a unique solution?: **Yes**

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Shear Force and Bending Moment

Calculation of Shear Force:

$$\mathbf{V(z) = Vo + \int p_{net}(z)\, \delta z}$$

Calculation of Bending Moment:

$$\mathbf{M(z) = Mo + \int V(z)\, \delta z}$$

$$\mathbf{M(z) = Mo + \int V_o \delta z + \iint p_{net}(z)\, \delta z \delta z}$$

Eq.1: $\mathbf{M(z)_{max} = M_{Design}}$

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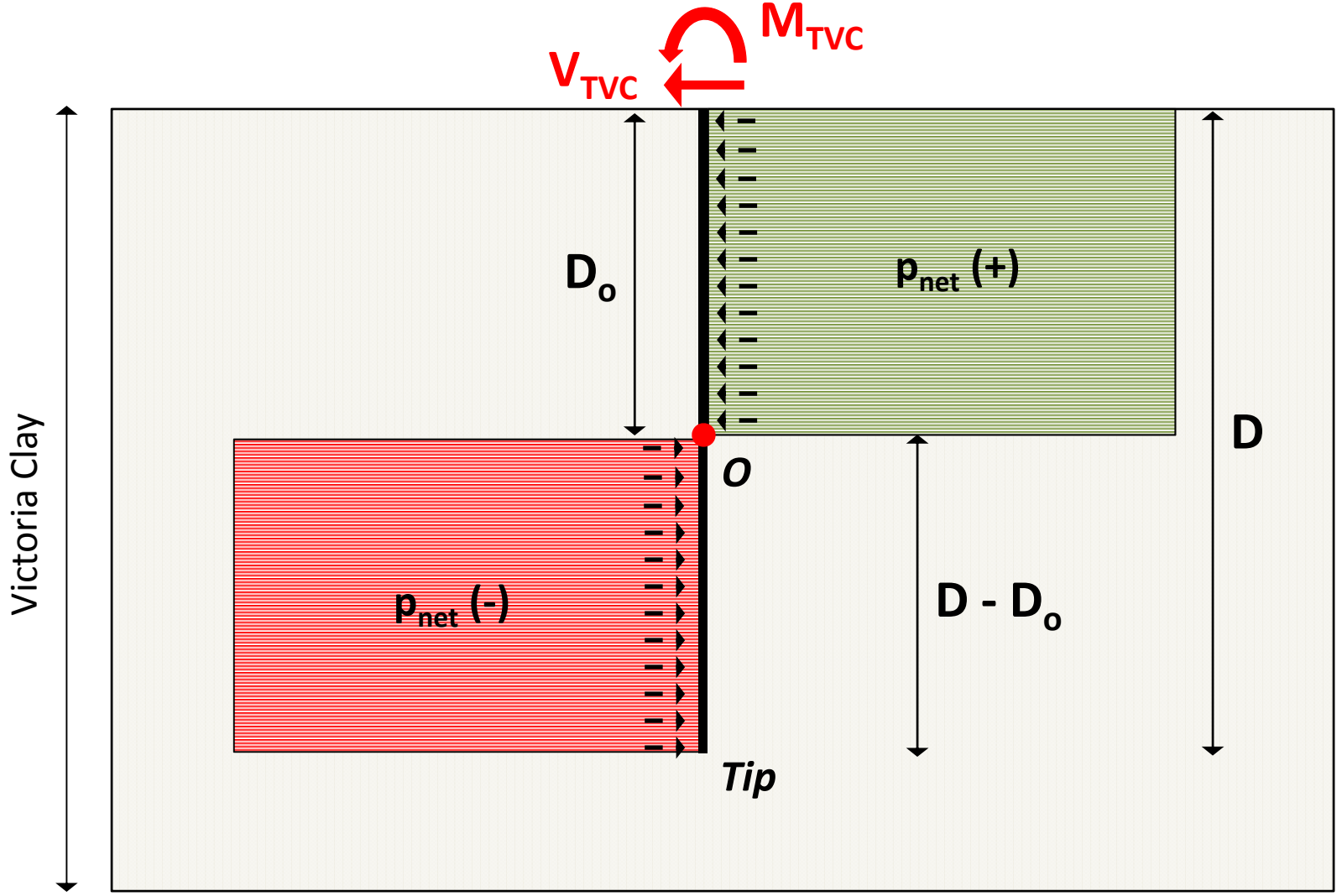
Equilibrium of the Sheet Pile Wall



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Shear Force and Bending Moment

Eq.2: $\Sigma F=0$

$$V_{TVC} + p_{net} (D_o) - p_{net} (D-D_o) = 0$$

$$D_o = \tfrac{1}{2} (D - V_{TVC}/p_{net})$$

Eq.3: $\Sigma M_{Tip}=0$

$$M_{TVC} + V_{TVC} (D) + p_{net} (D_o)(D-D_o/2) - p_{net} (D-D_o)^2/2 = 0$$

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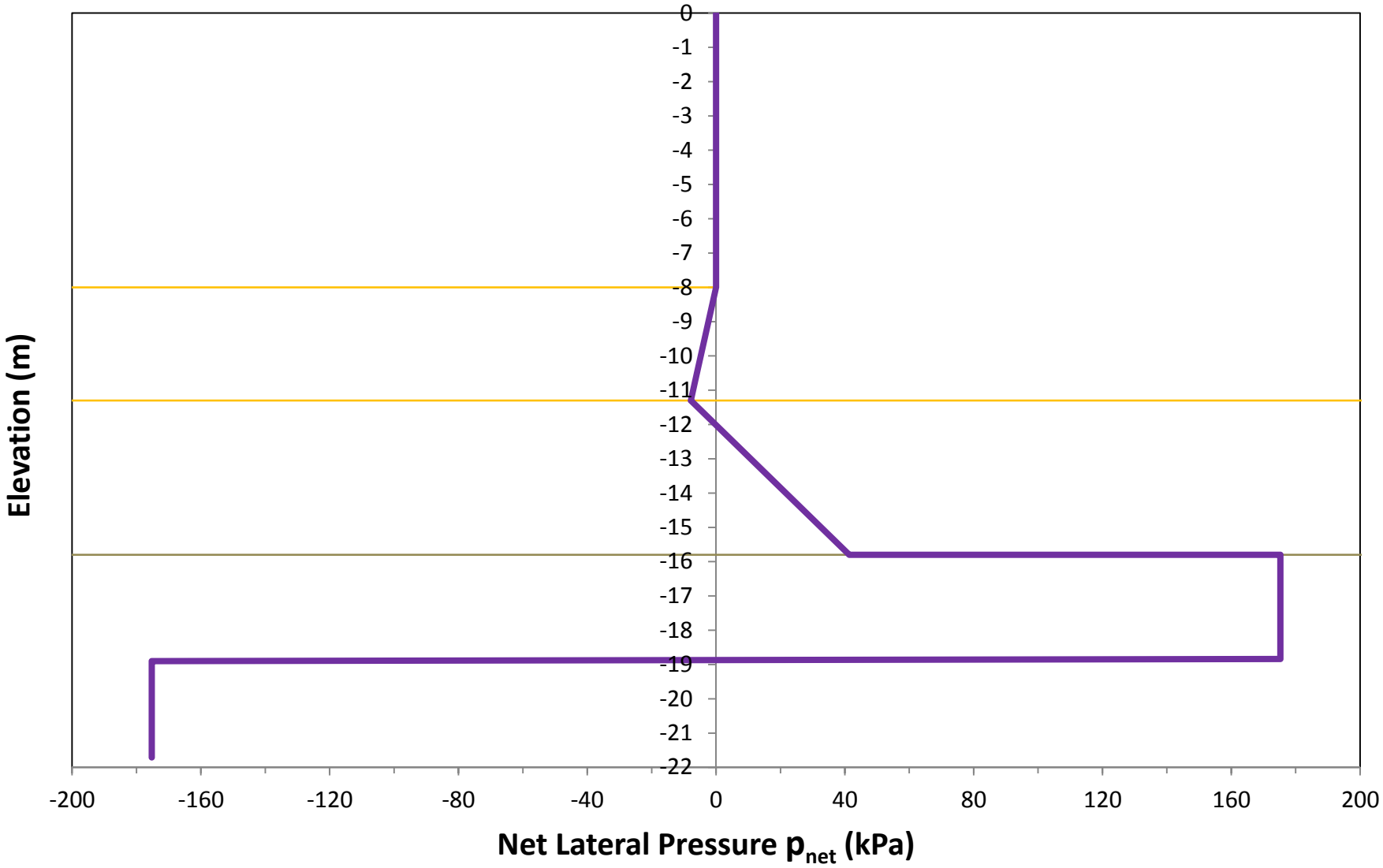
Net Pressure Diagram (Section A-A' Case 1)



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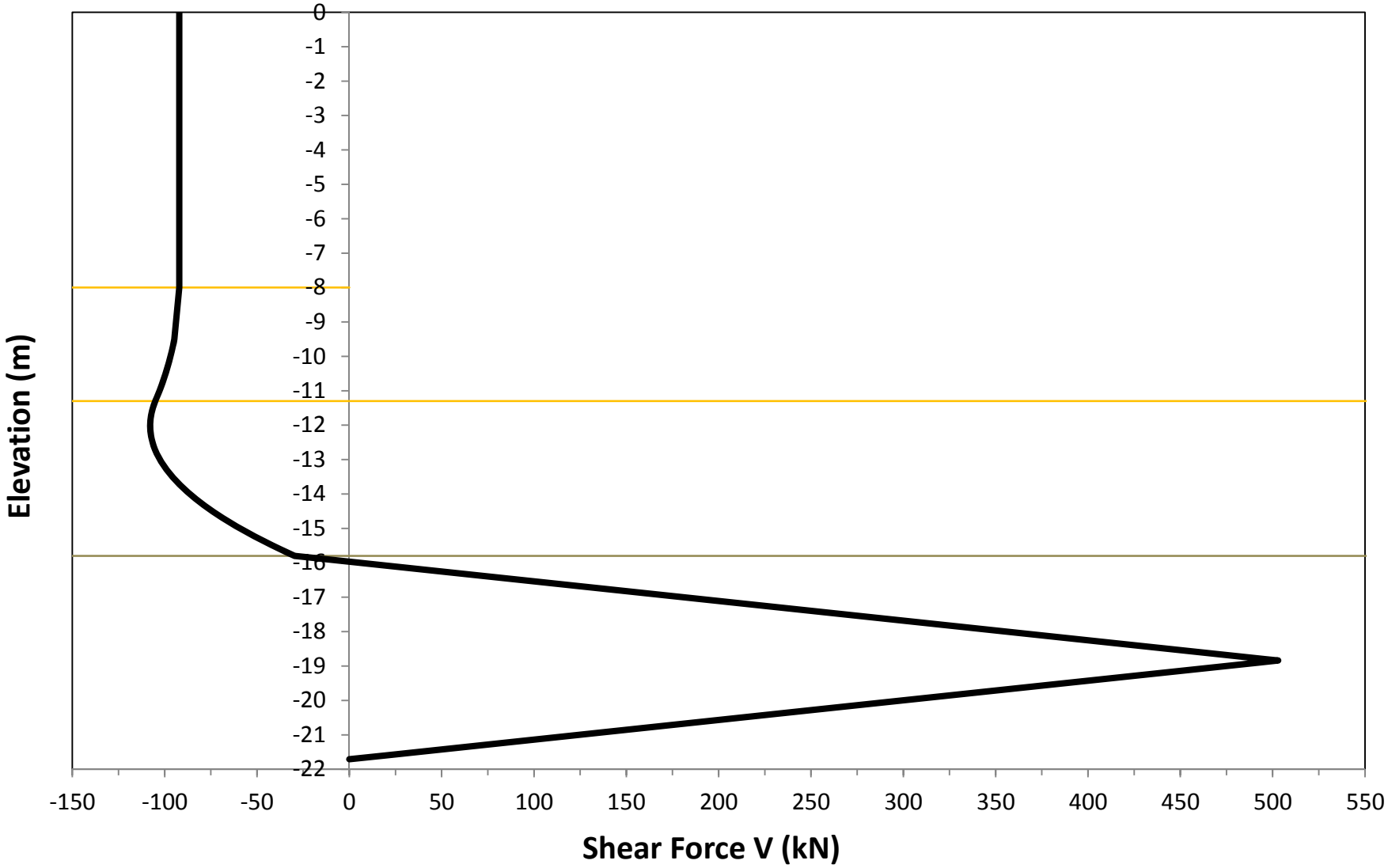
Shear Force Diagram (Section A-A’ Case 1)



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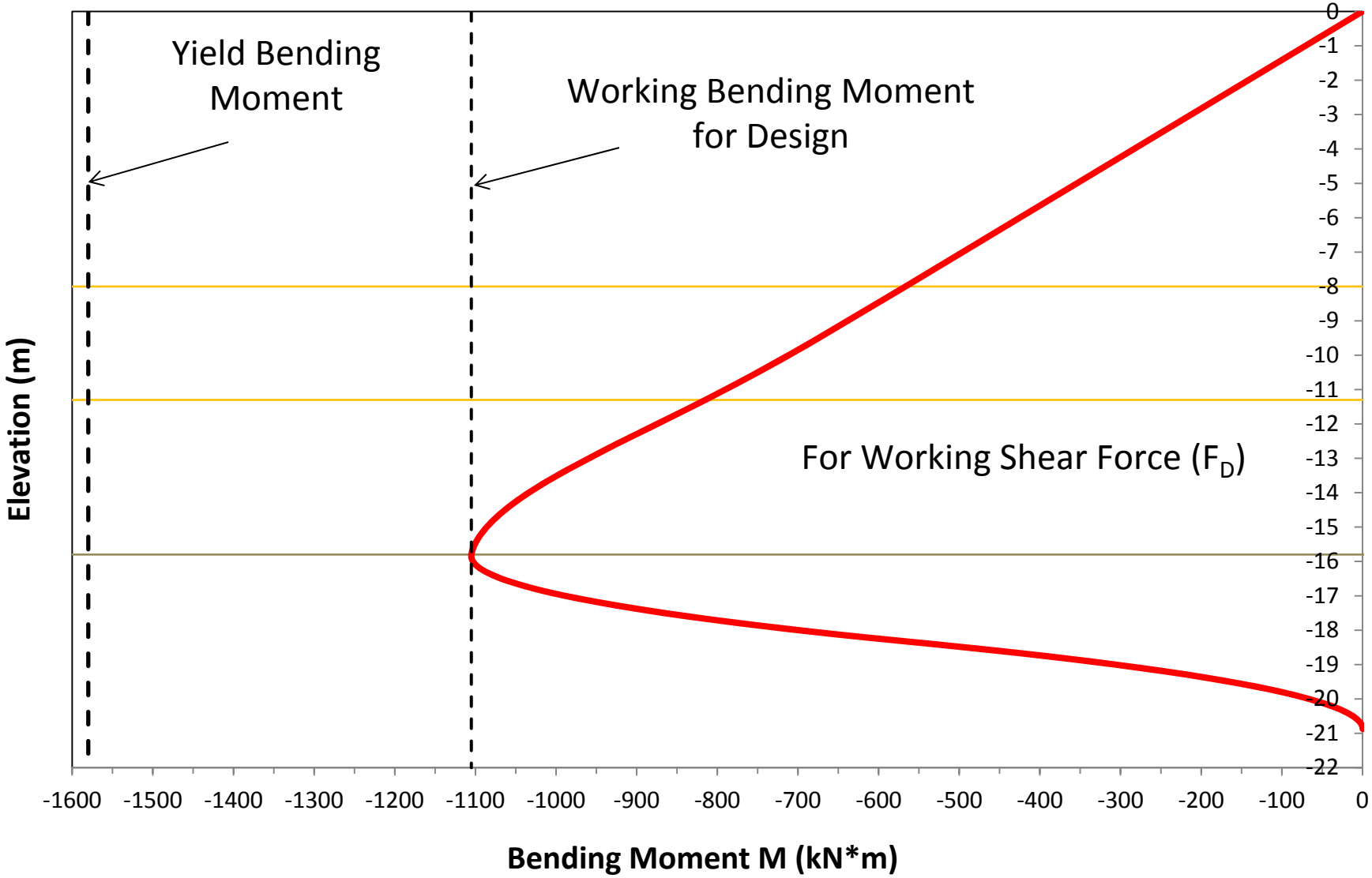
Bending Moment Diagram (Section A-A' Case 1)



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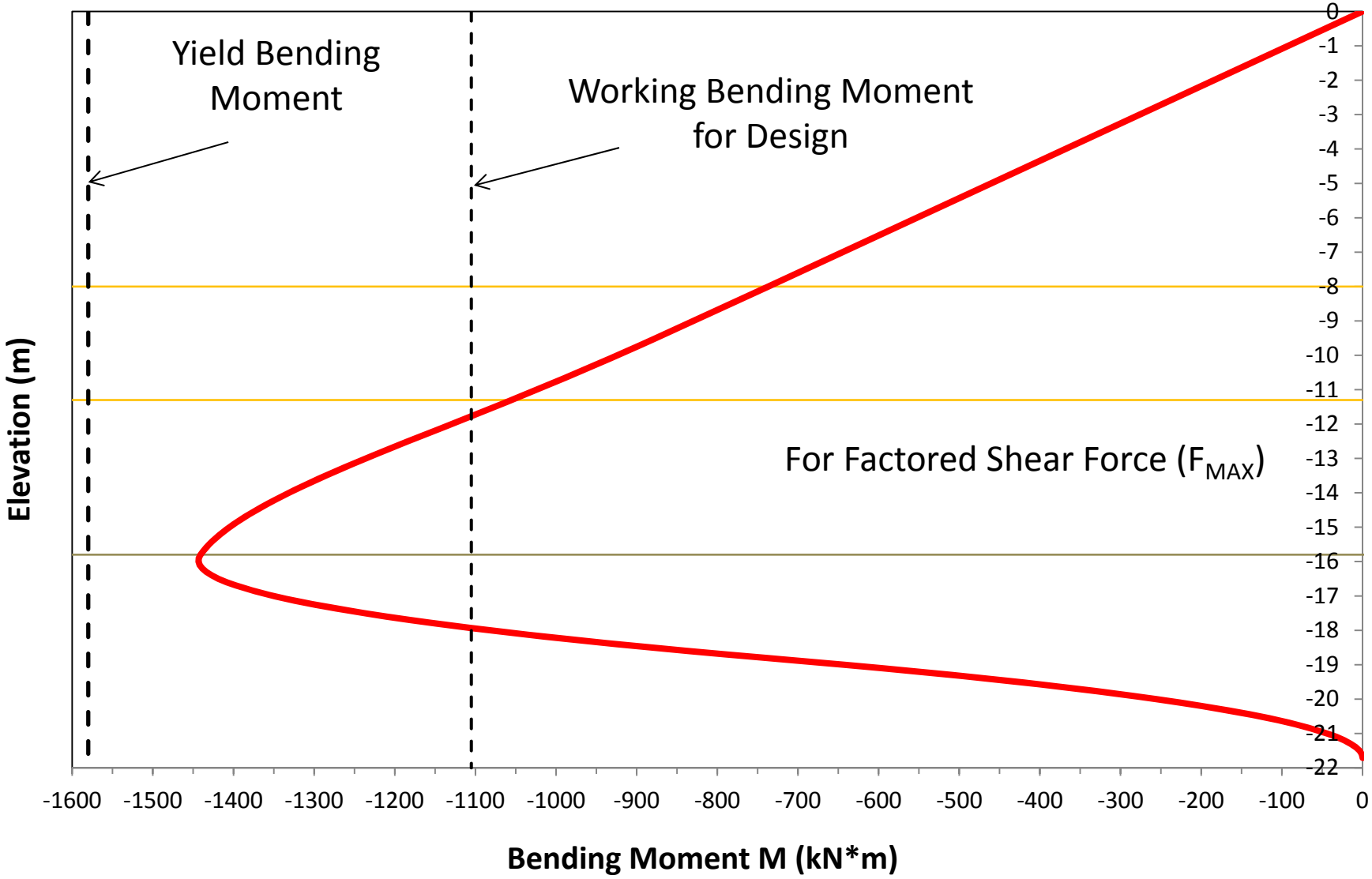
Bending Moment Diagram (Section A-A' Case 1)



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Bending Moments and Applied Shear

Section	Design Working Bending Moment M_{Design} (kN-m)	Applied Working Shear Force F_D (unfactored) (kN)	Applied Factored Shear Force F_{max} (includes 1.3 factor for embedment calculation) (kN)
A-A' Case 1	1,105	70.84	92.09
A-A' Case 2	1,105	79.91	103.88
C-C'	1,105	69.06	89.78
D-D'	816	58.4	75.92
E-E'	541	49.63	64.52

The applied shear force (F_D) to mobilize the working bending moment (M_{Design}) was factored by 1.3.

The factored shear force (F_{max} = 1.3 F_D) was then used to calculate the required embedment.

The required embedment therefore has a Factor of Safety FS = 1.3.

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Summary of Results

Section	Wall Tip Elevation (m)			Required Wall Embedment Depth (m)	
	Required per KCB Calculation	Achieved after Re-Drive per AQ Drawings	Difference	Below landw. Mudline	Below Victoria Clay
A-A' Case 1	-21.71	-20.80	-0.91 (inadequate)	10.41	5.91
A-A' Case 2	-21.32	-20.10	-1.22 (inadequate)	11.02	5.52
C-C'	-20.81	-20.80	-0.01 (satisfactory)	9.01	6.41
D-D'	-18.30	-18.30	0.00 (satisfactory)	7.00	5.50
E-E'	-14.84	-16.80	+1.96 (satisfactory)	4.84	4.34

Section	Elevation of Wall Rotation (m)	Depth to Wall Rotation (m)	
		Below landw. mudline	Below Victoria Clay
A-A' Case 1	-18.84	7.54	3.04
A-A' Case 2	-18.49	8.19	2.69
C-C'	-17.91	6.11	3.51
D-D'	-15.82	4.52	3.02
E-E'	-12.87	2.87	2.37

Section	Achieved Working Moment of Existing Wall Re-Driven (kN·m)	Percent of Design Capacity Achieved
A-A' Case 1	827	75%
A-A' Case 2	753	68%

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Potential Solutions (as developed during the July 3rd 2014 meeting)

Potential solutions

1. Reduction of prop wash force
   Assumptions by AQ: smaller tug boat, 10-25% power at 5 m from wall; larger tugboat, 10% power at 15 m from wall. 3-4 m/s velocity (large load for TRB).
   Would need to be reduced by 30-40%; minimum distance of tug boat to wall to be increased, or lower power specified, or restrict direction of prop wash. Consider disallowing access to west end wall 15 m wide zone for Seaspan Hawk tugboat. **(Recommended Step 2)**
2. Reduction of safety factor – reduce from 1.3 to 1.0. Consider duration of loading (about 10 seconds), safety considerations. (Not a normal engineering practice, not recommended.)
3. Re-evaluation of design soil parameters (Victoria Clay) specifically for Section A-A' at applicable depths. **(Recommended Step 1)**
4. Raise dredge depth inside wall. (Would achieve only minimal benefit, does not achieve FCSAP remediation objectives.)
5. Slot cuts for dredging inside the wall, would need steel waler to spread wall loads (likely to be geotechnically ineffective, likely challenging to avoid recontamination, slow). **(Recommended Step 4, only if Step 3 is financially punitive)**
6. Wall retrofit **(Recommended Step 3, only if Step 1 and/or 2 are not adopted)**
   a) Add 1.2 m structure on top of wall (most viable of retrofit options)
   b) Insert additional support piles behind wall (ineffective unless driven much deeper than wall, and must be stiffer than wall, costly)
   c) Add horizontal waler behind wall (likely ineffective due to longitudinal extent of prop wash pressures)
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Additional Slides:

Dredge Cross-Sections (Anchor QEA)

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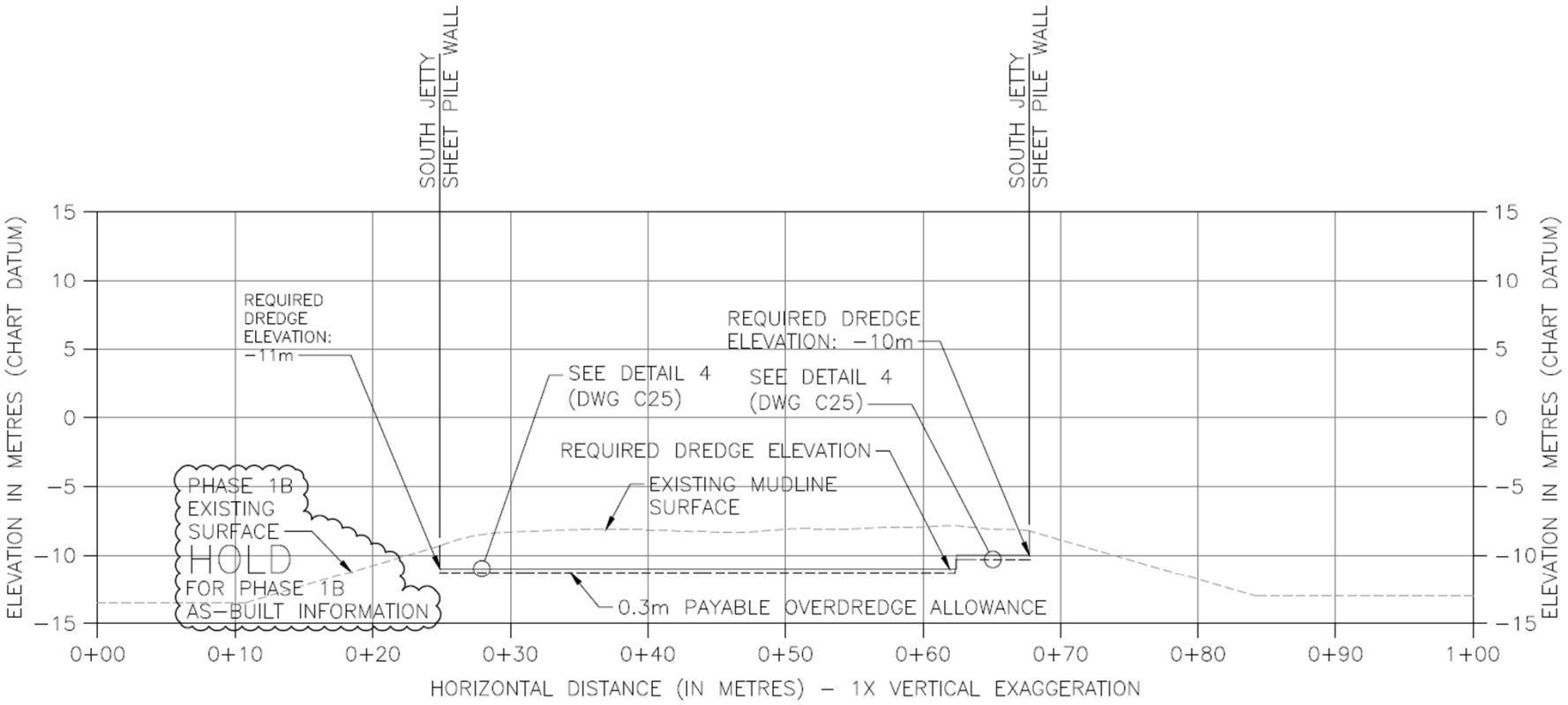
Section A (Anchor QEA)



SECTION A
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C21

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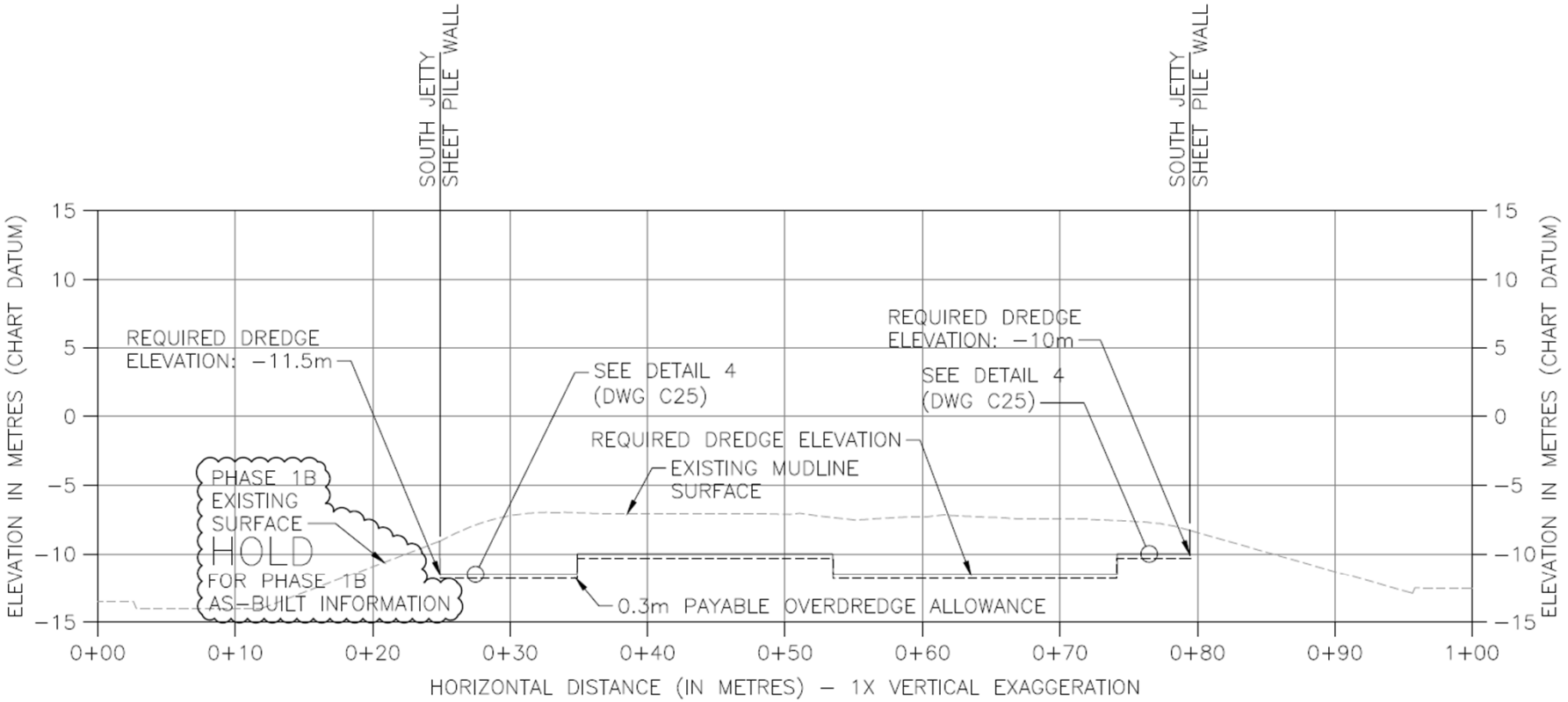
Section B (Anchor QEA)



SECTION B
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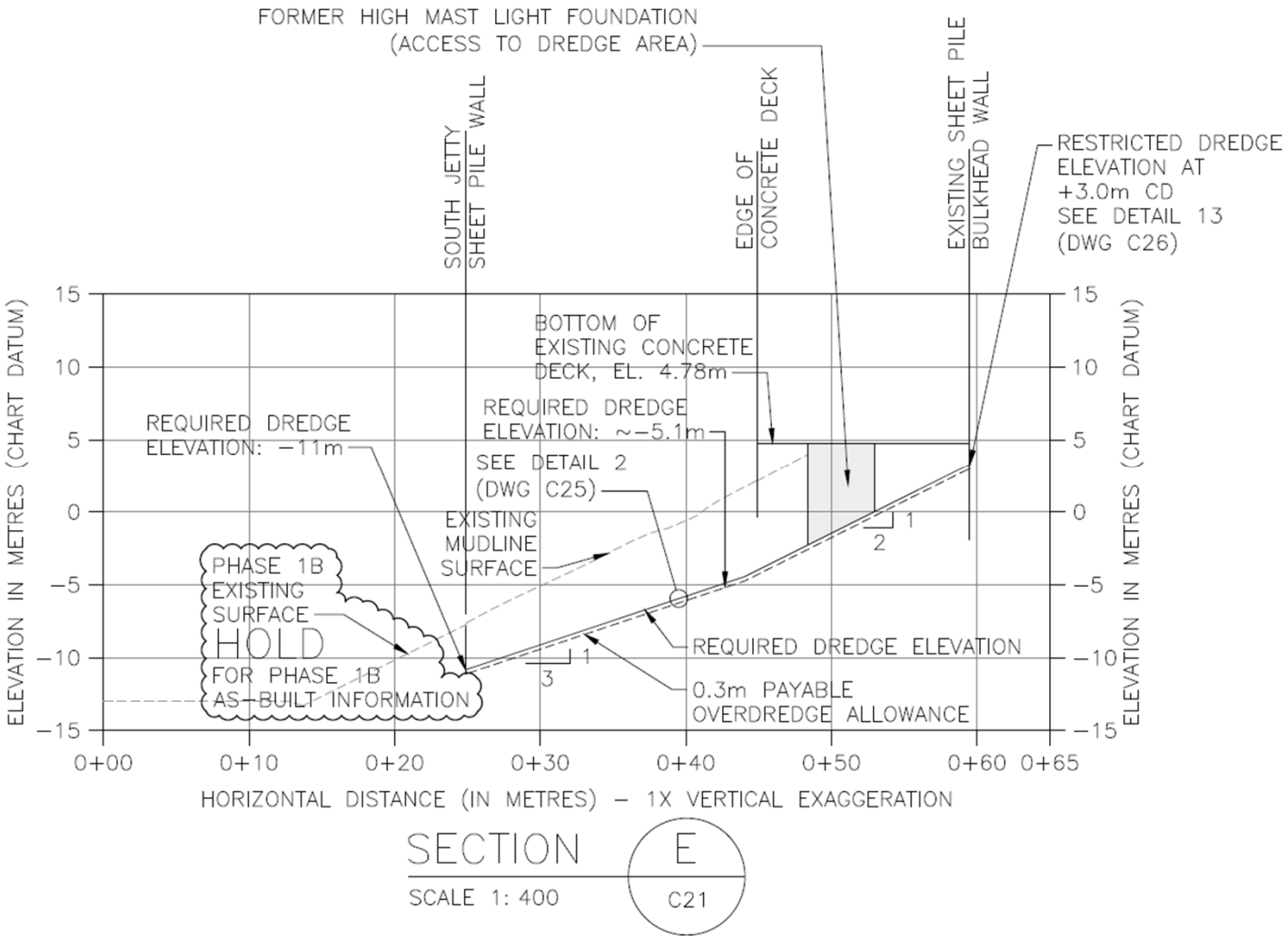
Section E (Anchor QEA)



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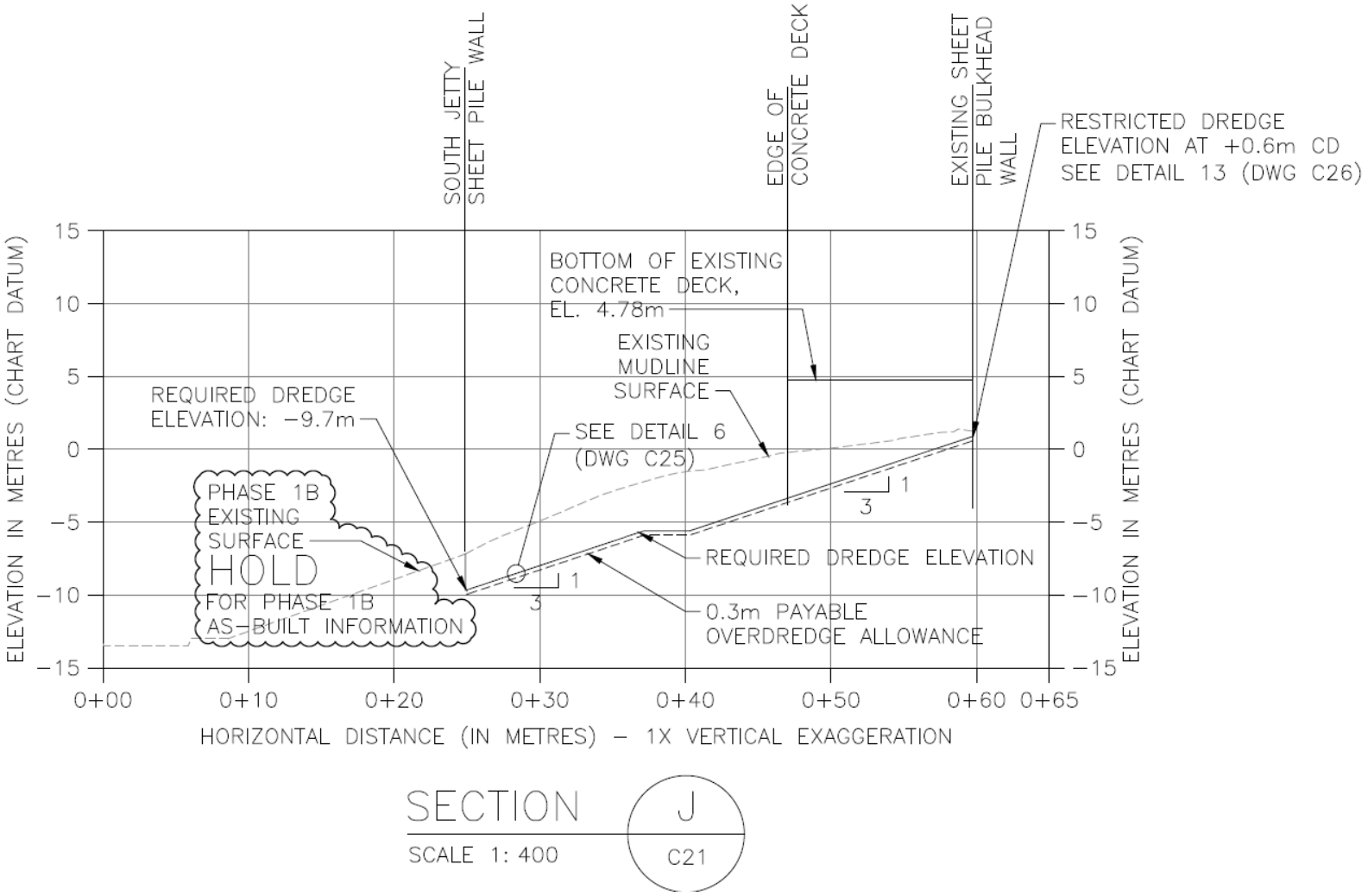
Section J (Anchor QEA)



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D12

ESQUIMALT GRAVING DOCK

SOUTH JETTY DESIGN CRITERIA

KCB (2010)

Number of Pages: 23

DESIGN CRITERIA

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1. GENERAL

1.1 Project Scope and Limitations

The South Jetty Wharf Development project at Esquimalt Graving Dock (EGD) for Public Works and Government Services Canada (PWGSC), referred to herein as the "Project", includes design engineering for:

- Demolition of existing timber jetties (west jetty, west infill deck, south jetty, and east approach structure);
- Marine dredging of contaminated seabed soils within the footprint of the existing timber jetties that are to be demolished. In each affected area, the dredging will be performed after removal of the existing timber jetty structures/piles, and before driving new jetty piles. Depth, exact extent and method of dredging to be as specified by PWGSC (see Section 1.2);
- Scour protection is generally not required at the new piled jetty structures. In cases where final cut/fill slopes would be exposed to wave action, then scour/slope protection will be included in the design;
- Piled jetty foundations and deck structures;
- Marine fenders, mooring bollards/cleats and miscellaneous wharf hardware (e.g. safety ladders);
- Civil works including asphalt paving and storm water drainage;
- Utilities including electrical, telecommunications, ships' sanitary sewage, compressed air, and fire water system (general firefighting). In general, utilities are to match existing provision.

The existing wharf face alignments around the perimeter of the South Jetty are to be maintained for the new jetty development.

Seismic retrofit of the existing steel-piled concrete deck (1985), existing sheet-piled retaining wall (1985), existing timber crib (1921), and seismic stability of under-pier soil slopes, are all excluded from scope as directed by PWGSC.

At the east end approach, the existing tug boat facilities (floats and piles) are to be temporarily removed during wharf reconstruction, and then reinstated (re-use existing float) with new mooring piles, matching the existing in terms of footprint and general utility. The existing gangway will be re-used if feasible.

The existing tower crane, sited on the steel-piled concrete deck (at the L-corner originally called "Crane Pad" on the 1985 deck construction drawings) together with its cruciform foundation, is to be retained "as is".

1.2 Marine Dredging at South Jetty

Environmental compensation/mitigation works are generally excluded from the scope of this project at this time. However, PWGSC is planning to dredge out the seabed at the South Jetty, to a depth of about 2.0m below current mud-line, to remove contaminated

sediments and miscellaneous debris that has accumulated over many years. Per PWGSC direction (email correspondence Jan 26th 2010), the new South Jetty foundation and structures will be designed assuming sediments are removed to 2.0m below existing mud-line. The scope and details for this dredging work (and associated scour/slope protection) will be included in the South Jetty drawings and specifications at 100% submission.

Input on scope and construction sequencing for the dredging will be provided by PWGSC and their environmental consultants.

1.3 Codes and Standards

The design of the Project shall conform to the latest edition or revision of the following codes, standards and guidelines, except where a specific edition is quoted:

a) Environmental Loads: National Building Code of Canada (NBCC 2005);
b) Seismic Loads: Marine Oil Terminal Engineering and Maintenance Standards, California State Lands Commission (MOTEMS, Rev.8, June 2003);
c) Guidelines for the Design of Fender Systems (PIANC, 2002);
d) British Standard for Maritime Structures BS6349 Part 1 (2000) and Part 4 (1994);
e) Load Factors and Material Design: CAN/CSA-S6-06, Canadian Highway Bridge Design Code (reference may also be made to CAN/CSA-A23.1-04 and CAN/CSA S16.1-05 where appropriate);
f) Safety Standard for Electrical Installations: Canadian Electrical Code CAN/CSA C22.1 (latest edition);
g) National Fire Code of Canada (2005);
h) WorkSafeBC Regulations;
i) Canadian Standards Association (CSA); and,
j) American Society of Testing of Materials (ASTM).

1.4 Standards for Drawings and Technical Specifications

Project drawings shall be in AutoCad 2007 and shall conform to PWGSC's Pacific Region 2007 drafting standards. Drawing sheets shall have standard PWGSC project title boxes. Drawing scales shall be appropriate for the subject. All dimensions shall be in millimetres, or metres where noted.

Technical specifications shall utilize National Master Specification (NMS) format.

1.5 Units of Measurement

The metric system (SI) shall be used for all dimensions on project drawings, shop drawings, specifications, material data sheets and in all documents for the Project.

1.6 Project Datum and Grid

Local Hydrographic Tide and Chart Datum is the project datum. All elevations shall be given in metres relative to project datum.

UTM NAD 83 (Universal Transverse Mercator, North American Datum) ground level coordinates shall be used for the project layout.

1.7 Navigation Water Depth

PWGSC has determined that the navigation water depth at the northwest / west / south berth faces shall be = 9.15 m (30 ft) below Chart Datum, to match existing general seabed grade around the South Jetty, and to match the depth of dry dock entrance Sill #2.

1.8 Elevation of Deck and Apron Areas

Elevation of deck and apron areas (nominal) = EL +5.20 m, sloped as required for drainage and tie-in to adjacent apron areas/structures. The original design elevation at the existing steel-piled deck (which is to remain in place) was EL +5.20 m, sloping seaward to EL +5.06 m. The new deck/apron will slope downwards towards the existing dry dock apron grade at the south entrance wall and crane rails.

1.9 Design Service Life and Durability

Major structural components including steel pipe piles and concrete deck shall have a minimum design service life of 75 years, based on the assumption of conventional maintenance procedures, without replacement of main structural components. This will require that an ongoing inspection and maintenance program is implemented to ensure that deterioration and damage, normal to infrastructure exposed to the marine environment, is repaired.

In the case of concrete deck structures, the design service life shall be achieved primarily by the provision of a durable concrete mix, adherence to specified values of concrete cover, and employment of construction procedures that produce well consolidated concrete.

Some components may need significant repair or total replacement during their service life. Unless otherwise noted, the service life of such components shall be consistent with typical service life given in Table C2.1 of S6.1-06, Commentary on CAN/CSA-S6-06, Canadian Highway Bridge Design Code.

Design Service Life for Specific Items:

- The corrosion protection system for steel pipe piles shall be sufficient to assure a 75-year design life with minimal maintenance over the life of the structure. Minimal maintenance includes occasional monitoring and repair of damage (e.g. resulting from accidental impacts). Corrosion protection will be achieved by incorporating a one-time application paint system on the piles with a 15-year design life (before onset of major deterioration), in combination with a sacrificial steel allowance. The coating system will extend from the pile cap soffit elevation to 2 metres below the mud-line and will be pre-applied to the pile with sufficient time allowed for curing prior to pile handling and installation. The Contractor will be required to incorporate a tolerance to ensure pile lengths are sufficiently coated such that the installed piles meet the above criteria in relation to the mud-line elevation. The sacrificial steel allowance will be 10 mm for the 60-year period commencing from the end of the 15-year coating system life to the end of the 75-year pile design life, with the intent of never having to replace the coating.
- Marine fender systems shall have a minimum design service life of 20 years.

- Utilities (electrical, telecommunications, compressed air, sewage, fire water, and kiosks) shall have a minimum design service life of 20 years, except where re-use of existing cables has been sanctioned by PWGSC (i.e. remaining life likely less than 20 years).
- Asphalt pavements (if used) shall have a minimum design service life of 20 years.

2. ENVIRONMENTAL PARAMETERS

Unless otherwise noted, environmental loads shall be in accordance with data published for Victoria, British Columbia, in the supplement to NBCC 2005. Relevant data, together with other site-specific information is included here. The Project shall be designed to withstand environmental loads generated by a 50-year return period event for wind, waves, rain, snow and ice, unless noted otherwise.

2.1 Tidal Data

Normal tides in Esquimalt Harbour range from 0.0 m at LWL to approximately +3.0 m at HWL (Chart Datum). Tidal elevations for design, measured from Chart Datum, are given in **Table 1**:

TABLE 1 – Tidal Data for Esquimalt Harbour

Tidal State	Tidal Elevation
Extreme High Water (EHWL)	3.8 m
Higher High Water (HHWL)	3.4 m
Mean Water Level (MWL)	1.9 m
Lower Low Water (LLWL)	0.1 m
Extreme Low Water (ELWL)	-0.5 m

2.2 Wind

The hourly wind pressures stipulated for Victoria (Gonzales Heights) in Appendix C of the National Building Code of Canada, and inferred wind speeds, are given in **Table 2**:

TABLE 2 – NBCC 2005 Wind Pressures for Victoria (and Wind Speeds)

Return Period (Years)	Hourly Wind Pressure	Inferred Hourly Wind Speed
10	NBCC 2005 = 0.49 kPa	99.0 kph (27.5 m/s)
50	NBCC 2005 = 0.63 kPa	112.2 kph (31.2 m/s)

Note: $q = (50*10^{-6}) * V^2$, where q is in kilopascals (kPa) and V is in km per hour (kph).

The design wind pressures to be used for the South Jetty mooring analyses will be determined (as outlined in MOTEMS and BS6349) from the above-mentioned information, based on a 30-second gust for wind with a return period of 25 years.

2.3 Waves

Due to the relatively sheltered harbour environment at the Esquimalt Graving Dock, wave conditions are not severe. The design wave (significant wave height, H_S) for a return period of 50 years is taken conservatively as 1.0 m.

2.4 Current

Due to the relatively sheltered harbour environment at the Esquimalt Graving Dock, and location of the South Jetty structures, current flows need not be considered in the design.

2.5 Rainfall and Snowfall

The rainfall and snow loading stipulated for Victoria (Gonzales Heights) in Appendix C of National Building Code of Canada (NBCC 2005) are given in **Table 3**:

TABLE 3 – NBCC 2005 Rainfall and Snow Loading for Victoria

Rain Condition	Rainfall Intensity
15 Minutes	9 mm
One Day	91 mm
Annual Total Precipitation	600 mm
Snow Condition	**Ground Loading**
Snow Load, S_s	1.5 kPa
Rain Load, S_r	0.3 kPa

The rainfall "Intensity-Duration-Frequency" (IDF) curves for Victoria International Airport, as supplied Atmospheric Environment Service (AES) Canada, are the most appropriate available data set for the Esquimalt Graving Dock location, and will be used for storm water drainage design at the South Jetty. See Appendix A for details.

A 10-year return period will be used for the design of the storm water drainage system. Peak flows will be determined by the Rational Method based on the estimated time of concentration for each drain run. Minimum time of concentration used will be 5 minutes.

2.6 Temperature

January (2.5%) = -5 degrees Celsius; July (2.5% Dry) = +23 degrees Celsius

3. MARINE DESIGN PARAMETERS

The South Jetty Wharf Development is designed to provide safe berthing and moorage for specific large vessels in the BC Ferries fleet, and for specific DND vessels resident at

CFB Esquimalt. In the event that small/intermediate size ferries are berthed at the South Jetty, then PWGSC will require the ship repair contractor to provide any necessary additional fenders to protect the jetty structure and ensure safe berthing conditions.

The fender design for the northwest and west berthing faces must be suitable for berthing the steel Caisson Gates that are used at the dry dock (see photo below). The South Jetty facility is not designed to accept cruise ships, submarines or floating dry docks.

Fenders will be provided to absorb the design berthing energy over a range of 10 – 100 compression cycles (some fenders degrade with long-term use).

Design vessel parameters are as given in **Table 4 (BCF) and Table 5 (DND)** overleaf.

Caisson Gates Berthed at South Jetty

TABLE 4 – BC Ferries Vessel Parameters for South Jetty

Parameter	Coastal Class	Spirit "S" Class	Cowichan "C" Class
Deadweight, DWT (tonne)	1,770	2,645	1,632
Gross Tonnage, GT (tonne)	21,980	18,747	6,551
Displacement, Δ (tonne)	10,034	11,681	6,965
Length (overall), L (m)	160.0	167.5	139.29
Length (between perpendiculars), L_P	154.0	156.0	127.2
Beam (over fenders), B (m)	28.2	27.5	27.127
Beam (moulded), B_M (m)	27.8	26.6	27.075
Max. Draft, D_{MAX} (m)	5.765	5.03	5.827
Lightship Draft, D_{LT} (m)	4.728	4.09	4.993
Windage Area, A_W (m^2)	3,267	3,242	2,229
Height / Width of Rubbing Strip (m)	0.5 x 0.3	0.35 x 0.26	0.25 x 0.23
Max. Hull Pressure (tonne/m^2)	25.0	25.0	25.0
Approach Velocity, V_N (m/sec)	0.15	0.15	0.15
Approach Angle (degrees)	10	10	10
1st Berthing Contact	¼ point	¼ point	¼ point

Note: Ferry ship data was provided by Bob Kearney, AScT, Naval Architect, Fleet Technical Engineering, BC Ferries, Tel: (250) 978-1137, bob.kearney@bcferries.com.

Note: Approach velocity is based on recommendations in BS6349 Part 4 for tug-assisted berthing (or use of bow thrusters) in sheltered conditions.

TABLE 5 – DND Vessel Parameters for South Jetty

Parameter	Halifax Class Patrol Frigate (FELEX program) (e.g. HMCS Vancouver, Regina, Calgary, Winnipeg and Ottawa)	Protecteur Class Supply Ship (AOR) (e.g. HMCS Protecteur)	Iroquois Class Destroyer (DDH) (e.g. HMCS Algonquin)
Deadweight, DWT (tonne)	835	9,462	1,396
Gross Tonnage, GT (tonne)	5,235	26,115	5,396
Displacement, Δ (tonne)	5,235 (max draft)	26,115 (10,552 light)	5,396 (5,165 light)
Length (overall), L (m)	135.5	172.52	129.78
Length (between perpendiculars), L_P	124.5	158.18	121.30
Beam (overall), B (m)	16.4	23.20	15.24
Max. Draft, D_{MAX} (m)	6.15 (but 8.45 to sonar dome)	* 10.3 (no sonar dome)	4.96 (but 7.40 to sonar dome)
Lightship Draft, D_{LT} (m)	4.836	7.30	5.032
Windage Area, A_W (m^2)	approx 1,600 (approx 1,700 light)	2,220 (3,000 light)	1,436 (1,510 light)
Max. Hull Pressure (tonne/m^2)	approx 20.0	approx 20.0	approx 20.0
Approach Velocity, V_N (m/sec)	0.15	0.15	0.15
Approach Angle (degrees)	10	10	10
1st Berthing Contact	¼ point	¼ point	¼ point

Note: DND vessel data was provided by David Latoski, PWGSC at Esquimalt Graving Dock, Tel: (250) 363-8056, David.Latoski@pwgsc-tpsgc.gc.ca , supplemented by data from DND websites and other project sources.

* At maximum draft the HMCS Protecteur cannot berth at the South Jetty, so lightship condition will be assumed for this ship in the fendering/mooring design.

4. LIVE LOADS AND LOAD COMBINATIONS

4.1 Jetty Deck Live Loading

Uniformly Distributed Live/Storage Loads (UDL):

- Apron UDL shall be 28.7 kPa (600 psf) (note: this matches the design UDL for the adjacent steel-piled concrete deck built in 1985).
- Apron UDL need not be considered coincident with vehicle wheel loads.
- Apron UDL for Long Term Settlement = 10 kPa.

Highway Truck Loading:

- CL625 truck load per CAN/CSA-S6-06 (but no lane loading).

Mobile Crane Loading (Grove RT530E):

- Gross Vehicle Weight = 257 kN (26,173 kg) max, with 45 ft telescopic boom.
- Wheel base = 3.378 m along truck, 2.590 m laterally to outside of tires.
- Maximum Outrigger Load = 220 kN (22,498 kg) per outrigger.
- Outrigger Pad Locations: 5.969 m (235 in) spacing along truck, and 6.096 m (240 in) lateral spread (fully extended). Outrigger pads = 420 mm square (16.5 in).

Esquimalt Fire Truck (Type 1), 1993 Thibault Engine:

- Total GVW = 17,481 kg (38,450 lbs).
- 4.83 m (190 in) between front/rear axles.
- Front axle = 7,502 kg (16,540 lbs) (2 wheels on this axle).
- Rear axle = 9,979 kg (22,000 lbs) (4 wheels on this axle).

Esquimalt Fire Truck (Type 2), 1999 E One Ladder Truck:

- Total GVW = 29,348 kg (64,701 lbs).
- 5.18 m (204 in) between 1st and 2nd axle, and 1.37 m (54 in) between two rear axles.
- Front Axle Weight = 8,482 kg (18,700 lbs) (2 wheels on this axle).
- Rear Axle Weight (total on two tandem axles) = 20,866 kg (46,000 lbs) (4 wheels on each of these two axles).

Esquimalt Fire Truck (Type 3), 2008 Fort Garry Rescue Truck:

- Total GVW = 15,876 kg (35,000 lbs).
- 5.92 m (233 in) between front/rear axles.
- Front Axle Weight = 5,443 kg (12,000 lbs) (2 wheels on this axle).
- Rear Axle Weight = 10,432 kg (22,046 lbs) (4 wheels on this axle).

Dynamic Load Allowance (DLA) should be added to all axle/wheel loads.

4.2 Live Loading within Deck Utilidors

Uniformly Distributed Live Load (UDL) = 3.6 kPa, per NBCC2005 for equipment areas.

4.3 Load Combinations

The South Jetty deck structures shall be designed for the following load combinations, which are generally based on Table 3-12 in MOTEMS. Modifications were made to the prescribed MOTEMS load combinations to include companion loads as described in the National Building Code of Canada 2005. Partial snow loading was added to load combinations LC1, LC2 and LC3. Partial live and snow loads were added to load combination LC5. In load combinations LC4, LC7 and LC9 where vertical load is acting to resisting overturning, uplift or sliding, a reduced dead load (without live and snow loads) is considered. The load combinations listed have been chosen to produce the most critical effects in the structural components of the South Jetty deck structure.

Load Combinations:

1.4D + 1.7L + 0.5S + 1.6H	(LC1, max dead and live loads)
1.2D + 1.7L + 0.5S + 1.6H + 1.3M	(LC2, mooring load case)
1.2D + 0.5S + 1.6H + 1.7B	(LC3, berthing load case)
0.9D + 1.6H	(LC4, min dead load)
1.2D + 0.5L + 0.25S + 1.0E	(LC5, seismic and live loads)
1.2D + 1.0E + 1.6H	(LC6, seismic and max dead load)
0.8D + 1.0E + 1.6H	(LC7, seismic and min dead load)
1.2D + 0.25E + 1.0HD	(LC8, seismic and max dead load)
0.8D + 0.25E + 1.0HD	(LC9, seismic and min dead load)

Symbols:

D = Dead Load
L = Live Load
M = Mooring Load
B = Berthing Load
H = Lateral Earth Pressure (non-seismic)
H_D Foundation Deformation Load (e.g. soil flow force during seismic event)
S = Snow Load
E = Earthquake Inertial Loads

The load factor for live load (L) is reduced to 1.3 for the maximum outrigger float load from the Grove RT530E mobile crane.

The East Approach retaining wall shall be designed for the load combinations and load factors set forth in the CAN/CSA-S6-06, Canadian Highway Bridge Design Code.

For all structures, uniform and concentrated live loads should be applied in a logical manner. Designated uniform live loadings and concentrated live loading from pneumatic-tired equipment will not be applied simultaneously in the same area.

4.4 Pile Loss Scenario

The South Jetty structures shall be designed not to collapse in the event that a single front row pile (on a berthing face) is damaged and cannot carry load. In this scenario, the deck will likely crack under live loading, thus possibly revealing the location of the damaged pile. In the highly unlikely event that two adjacent piles in the same bent are damaged and cannot carry load, then the structure would be at risk of collapse in that specific location.

5. SEISMIC DESIGN PARAMETERS

5.1 Seismic Performance Criteria

The seismic design philosophy is that the seismic displacement demands on the new/retrofitted South Jetty structures shall be accommodated by the displacement capacity of those structures, with life safety (no collapse) as the over-riding criterion. Seismic gaps and joint details will be developed to prevent loss of deck support and to prevent impact by adjacent structures.

The design earthquake is defined as the seismic event that produces ground motions associated with a 475-year return period (A475), or the Cascadia subduction event (CSE), collectively referred to as the A475 design event for convenience.

The wharf elements shall be designed to resist the A475 design event earthquake ground motion without collapse. Wharf elements may undergo controlled inelastic structural behavior leading to significant damage. Any damage that may occur shall be readily detectable and accessible for inspection and repair. Design shall be such that it will be possible to repair or rebuild the jetty structures without major demolition. After the A475 design event, there may be temporary loss of operations, which should be restored within a few months.

5.2 Seismic Criteria

The liquefaction potential of foundation soils, the effect of liquefaction induced forces on structures, seismic soil-structure interaction, seismic slope stability and seismic deformations shall be addressed by the design.

The target design spectra for the A475 earthquake event is taken from the Seismic Hazard Analysis by Pacific Geodynamics Inc. (November 1999). Together with the A475 event, the Cascadia subduction event (CSE) shall also be considered. The design spectra for the CSE event shall be developed based on the GSC's seismic hazard model. Site specific amplification and de-amplification effects due to local soil conditions shall be addressed with a site response analysis (SHAKE).

The seismic acceleration for the A475 design event, and post-quake functionality at the prescribed seismic performance level, are listed in **Table 6**:

TABLE 6 – Seismic Criteria

Earthquake Characteristics	A475 event *
Probability of Exceedance per Annum	0.0021
Probability of Exceedance in 50 Years	10 %
Structure Damping	5 %
Peak Horizontal Firm Ground Acceleration	A = 0.35 g

* Note: In addition to the A475 event, the Cascadia subduction event (CSE) shall also be considered.

6. GEOTECHNICAL DESIGN

6.1 Geotechnical Guidelines

The following documents shall be used as guidelines for geotechnical design:

a) Canadian Foundation Engineering Manual, 4th Edition, 2006;
b) CAN/CSA-S6-06, Canadian Highway Bridge Design Code., 2006;
c) MCEER Workshop on Evaluation of Liquefaction Resistance of Soils, Technical Report MCEER-97-0022;
d) American Petroleum Institute Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Load and Resistance Factor Design, 2003;
e) Post-Tensioning Institute, Recommendation for Prestressed Rock and Soil Anchors, 2004;
f) Idriss, I.M., and Boulanger, R.W., "Soil Liquefaction During Earthquakes", Earthquake Engineering and Research Institute, 2008;
g) Kulhawy, F., Phoon, K. "Drilled Shaft Side Resistance in Clay to Rock", Geotechnical Special Publication No.38, Design and Performance of Deep Foundations; and,
h) Wylie, D.C., "Foundations on Rock" (1992).

6.2 Foundation Materials

For foundation soil and bedrock material properties refer to the Geotechnical site investigation reports.

6.3 Foundation Design

Design foundations in accordance with 2005 Edition of the National Building Code of Canada supplemented by the Canadian Bridge Code CAN/CSA-S6-06, and American Petroleum Institute Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Load and Resistance Factor Design, 2003.

Open-end Pipe Piles:

Ultimate geotechnical compression resistance of open-end steel pipe piles shall be calculated in accordance with API methodology. The calculated outside skin friction and annulus resistance shall be reduced to 80% to account for remoulding during driving. The calculated inside skin friction shall be reduced to 30% to account for remoulding and inside pile shoe effects. The pile shall be assumed to be unplugged. Annulus resistance shall be based on the cross sectional area of the cutting shoe and skin friction shall be based on the pipe pile wall dimensions. A geotechnical resistance factor of 0.5 shall be applied to the ultimate geotechnical compression resistance to obtain the factored geotechnical compression resistance.

The required pile embedment at each pile location shall be based on the factored pile load and estimated stratigraphy. If the required embedment length places the pile toe below the estimated rock elevation, the design toe elevation shall be the estimated rock elevation.

Indicator Piles with PDA and CAPWAP wave equation analysis shall be driven at the beginning of the project to confirm the factored pile resistance and termination criteria.

Rock-Socketed Displacement Control Piles:

Ultimate geotechnical resistance of rock-socketed piles (used as displacement control piles in front of the timber crib) shall be calculated in accordance with Duncan (1992) and Kulhawy (1993).

For compression piles, a geotechnical resistance factor of 0.5 shall be applied to the ultimate friction resistance of the rock socket to obtain the factored geotechnical compression resistance. Tip resistance of the socket shall not be included.

For tension piles, a geotechnical resistance factor of 1.0 shall be applied to the weight of a 90 degree rock cone originating at the bottom of the rock socket. A geotechnical resistance factor of 0.4 shall be applied to the ultimate friction resistance of the socket to obtain the factored geotechnical tension resistance.

Laterally Loaded Piles:

Soil force on individual, laterally loaded piles, for input into the structural model, shall be determined using the computer program LPile Plus (Ensoft, 2005). The pile shall be modeled as a linear elastic material and the soil-pile interaction modeled using a set of soil-pile springs (p-y curves) attached to the pile along its length. API-recommended p-y curves shall be used for the non-liquefiable soils. For liquefiable soils, API-recommended p-y curves for soft clay shall be used, using the post-liquefaction residual strength of the liquefied soils as ultimate strength.

Pile head conditions shall be taken as fixed, unless the fixed pile head moment exceeds the plastic moment. If the fixed pile head moment exceeds the plastic moment, pile conditions shall be taken as pinned, with an applied moment equal to the plastic moment.

Soil displacement shall be estimated based on limit equilibrium, Newmark-type analyses, supplemented by FLAC results from Klohn Crippen's seismic analyses performed for this site in 2002 (under a previous project).

7. MARINE AND STRUCTURAL DESIGN

7.1 Concrete Cover

Minimum concrete covers and tolerances to steel reinforcement shall comply generally with CAN/CSA-S6-06. The minimum clear cover from the face of concrete to any reinforcing steel shall be as shown in **Tables 7 and 8**. For other situations not covered in Table 7, see CAN/CSA S6-06 Table 8.5.

TABLE 7 – Concrete Cover for Reinforcement (Cast-in-Place)

Location	Cover (mm)
Top Surfaces of Jetty Structures	70 *
Seaward Faces of Jetty Structures	100
Structures Cast Against Soil	100
Structures Cast Against Precast Concrete	40
All Other Concrete Faces, U.N.O	70

* Note: CAN/CSA S6-06 strictly only requires 60 mm cover for jetty top surfaces, but this design will adopt 70 mm for uniformity with other similar concrete faces.

TABLE 8 – Concrete Cover for Reinforcement (Precast)

Location	Cover (mm)
Seaward Face of Fender Panels	100
Exterior Walls of Precast Box Girders, U.N.O.	60
Seaward Permanently Exposed Wall of Precast Box Girders	85
Exterior Soffits of Precast Box Girders	70
Interior Surfaces of Precast Box Girders	40
Permanently Exposed Faces of Utilidor	70
Interior Surfaces of Utlidor	40
Faces of Precast Elements Against Cast-in-Place Concrete	40
Pre-tensioning Strands (Seaward Permanently Exposed Surfaces)	100
Pre-tensioning Strands on Permanently Exposed Exterior Walls of Box Girders	70
Pre-tensioning Strands on Permanently Exposed Exterior Soffits of Box Girders	80
Pre-tensioning Strands (Interior Surfaces)	45
All Other Concrete Faces, U.N.O	70

7.2 Fender System

Fenders shall be designed to PIANC guidelines, MOTEMS guidelines and BS6349 recommendations. Maximum and minimum vessel dimensions, berthing energy, point of 1st contact, and allowable hull pressure are all factors to be considered in sizing the fenders – see **Table 4 and Table 5** for vessel design parameters. Due to lack of firm

data, some of the tabulated parameters are estimates based on marine background knowledge.

The fenders shall be designed to accommodate the various design vessels, and special characteristics such as rubbing strips on ferries. Per MOTEMS, fender shear forces may be computed using a friction coefficient, $\mu = 20$ % at the fender face / ship hull interface for UHMW-Plastic faced fenders, or $\mu = 65$ % at the fender face / ship hull interface for plain rubber fenders. The use of fender pads, support chains and shear chains, or fender piles are to be considered in the design.

It has been agreed with PWGSC that there is no need to include retrofitted fenders at the existing 1985 steel-piled concrete deck (south side crane pad) due to the relatively short gap between fender units on the new jetties either side of the 1985 structure.

7.3 Mooring Bollards

Mooring bollards and cleats shall be designed to resist the severest load combination of wind, wave and current. The 950 ft (289.56 m) long south berthing face shall be furnished with bow/stern bollards and intermediate spring-line bollards located to suit typical mooring line arrangements for the major design vessels. The bollard/cleat spacing along the northwest and west berthing faces shall be similar to existing.

At all bollards/cleats, the mooring line loads are to be applied at angles between horizontal and a maximum of 30° above horizontal in a vertical plane outboard of the wharf face. These load directions represent possible bow and stern breasting line loads. In applying these loads to the jetty structure, consideration should be given to bow and stern breasting line separations as well as distances to possible adjacent vessel breasting lines. Mooring bollards/cleats will be located so as to not cause line interference with the fenders. The bollard/cleat layout is to be planned to accommodate the various stipulated ship sizes, with the general intent of matching the existing bollard/cleat layout.

Although the existing steel-piled concrete deck (built 1985), and the timber-piled crane pads (built 2003) are equipped with 100 tonne bollards set-back about 20 m behind the wharf face (due to the presence of the relative weak timber jetty structures in front), the South Jetty Wharf Development will only include mooring bollards/cleats along the berth faces.

8. CIVIL AND UTILITIES DESIGN

8.1 Deck Drainage and Pavements

The jetty decks and apron area shall include provisions for drainage and direction of storm water and snow melt runoff from the apron surfaces, and accidental spillages. The runoff collected from the apron area is to be collected within a drainage system using catch basins and piping (or deep-channel retention system within deck structure), and directed into the storm water collection and treatment system. Jetty decks and apron shall have maximum slopes of 2 % (unless otherwise approved by PWGSC), and shall be sloped inwards so that runoff is not released directly to ocean.

For environmental reasons, all storm water is to be treated before discharge into the sea. Therefore, all storm water outfall routes will be equipped with oil/water separators,

sedimentation tanks and isolation valves (shut-off gates). Each oil/water separator and sedimentation tank generally comes as one unit; valves are separate supply. The isolation valves will be located just downstream of each separator, to facilitate initial installation and operational maintenance.

8.2 Utilities

The utilities required at the South Jetty Wharf Development are as follows:

- Electrical (480-277V and 208-120V ac, all 3-phase)
- Telecommunications (SCADA water meters and utility kiosk telephone);
- Fire Detection (pull stations, horns and locator lights on jetty deck);
- Ships' sanitary sewage (similar to existing system);
- Compressed air (similar to existing system);
- Fire water system for general firefighting (similar to existing system);
- Utilidor lighting and receptacles; and,
- Utilidor drainage system (floor swale, sumps and sump pumps).

Although provision is made for general firefighting (service in the utilidor), specific fire protection for the new steel/concrete jetty structures is not required.

The recently installed utility kiosks are to be re-used wherever possible. Kiosks will be kept in the same general locations as existing. However, in the event that some electrical cables are found suitable for re-use, kiosks shall be relocated slightly to account for shortened line lengths after cable terminations/splicing. No vehicle protection bollards are required at the kiosk locations.

Utilities are to be designed with flexible connections across expansion joints and seismic movement joints in the wharf structures.

Lockable hatches are required at all access points into the utilidor.

(Note: PWGSC plans to install a new potable water system at the existing South Jetty. Details are not yet available, so the impact of this system is not included in the design.)

8.3 Civil Items and Utilities Not in Scope

The following civil/electrical items are excluded from the South Jetty Wharf Development project scope:

- No modifications to existing buildings/workshops. PWGSC will arrange for any buildings/workshops affected by the South Jetty works to be relocated prior to jetty construction;
- No provision for 600V electrical supply at the South Jetty kiosks;
- Existing high mast lighting will be left unchanged; and,
- Cold ironing facilities will not be provided.

9. MISCELLANEOUS DESIGN PARAMETERS

9.1 Safety Ladders

Per the WorkSafeBC regulations (clause 24.2), the maximum spacing of safety ladders shall be 30 m (100 ft) along all new berthing faces. Each ladder shall extend from dock surface down to at least 1.0 m below LLWL. The location of each ladder shall be identified by high visibility paint on the bull rail.

9.2 Bull Rail

On the waterside edges of the wharf apron, a concrete bull rail 300 mm (12 in) high by 400 mm (16 in) wide will be provided, with chamfered outer edge to minimize wear on mooring lines. The bull rail will be continuous around the whole wharf perimeter, to prevent accidental spillages entering the marine environment. Mooring bollards/cleats and safety ladders will be affixed on top of the continuous bull rail. No removable sections of bull rail are required.

9.3 Utilidor Tunnel

The utilidor tunnel will house electrical and communications systems, firewater mains, compressed air line and sanitary sewer piping along the perimeter of the South/West Jetties. The utilidor will be interrupted only where it intercepts the existing steel-piled concrete crane pad structure at midway along the south jetty; utilities will be supported by hangers across this gap.

The utilidor will be provided with drainage collection sumps at regular intervals, with a limited number of installed sump pumps. The floor of the utilidor will have a cross-slope to promote drainage to a small longitudinal swale, thence to the collection sumps. This drainage/pump system is adopted as a precaution only; no significant amount of water is expected in the utilidor under normal operating circumstances.

Air vents (about 150 mm dia) will be provided at approx 3.0 m intervals along the utilidor tunnel. The vents will be cast into the tunnel wall (inside face, above HWL, away from wave action) just under the precast deck girders. The vents will serve two purposes: they will allow natural airflow which will minimize any condensation in the utilidor; and the vents should allow PWGSC to consider the utilidor as “restricted access” rather than “confined space”, in similar manner to the existing pipe tunnel around the dry dock.

There is no prescribed spacing criterion for access manholes providing entry into, or egress from a “restricted access” utilidor. For service areas, the BC Building Code requires a maximum travel distance of 25 m to means of egress. Note that the existing graving dock service tunnel has manholes at 100 ft (30.48 m) spacings. Access/egress manholes for the south jetty utilidor will be spaced at maximum 30 m intervals (mostly around 25 m), with maximum distance from a tunnel end of around 15 m, which easily satisfies the BC Building Code requirement.

The utilidor will also be provided with service openings (with lift-up hatches) to facilitate installation and maintenance/repair of pipework and electrical services.

9.4 Access Opening in South Jetty Deck

A single personnel access opening (with ladder and lockable hatch) is to be retrofitted into the existing steel-piled concrete deck structure. The access point will be located at the northeast corner of the existing concrete deck, set close to the sheet pile wall. The purpose is to facilitate access down to the foreshore area at low tide for future inspections of jetty structures and cathodic protection systems. The retrofitted access opening will be designed to carry the original 1985 deck design live loading (i.e. not the live loading listed elsewhere in this document for the new jetty decks).

9.5 Existing Steel-Piled Deck Structure

Seismic retrofit of the existing steel-piled concrete deck structure (built in 1985-1986) is excluded from the scope of the South Jetty Wharf Development design. However, the following background information is presented here for completeness:

The as-built Drawings and Specifications do not give explicit steel strength for the pipe piles at the steel-piled concrete deck structure. Addendum 4 of the Specifications for the 1985 construction contract gave bidders several steel supply options, of varying grade, but the actual steel grade supplied was not stated. Accordingly, coupon sampling at three selected pile locations (9B, 20B and 21B) was undertaken for Klohn Crippen's October 2002 seismic study. The following tensile yield values were recorded from the coupon samples; Pile 20B = 339 MPa; Pile 21B = 360 MPa; Pile 9B = 434 MPa.

The steel piles are a combination of vertical and battered piles, generally set at 6.1 m centres; all piles are 559 mm diameter with 9.5 mm wall thickness. The batter piles are aligned in both the transverse and longitudinal directions of the deck; the batters are mostly 3V:1H. According to the as-built Ker Priestman drawings all piles are "driven to refusal on rock", with only a couple of exceptions. Pilings are approximately 30 to 40 m long. The exposed (unrestrained) length above the ground surface is approximately 5 m at the centre and east structures, but up to 12 m at the 1985 crane pad structure. All piles extend into their pile caps by 300 mm. Batter piles are connected to the cap with 6 – 20M hook bars welded to the pile. However, there are no connection bars attached to the vertical piles, so this connection has no useful tension capacity.

An impressed current cathodic protection system was installed soon after original construction and appears to be still operational. Foreshore Technology's pile survey in December 2000 indicated minimal corrosion loss over the 17 years life up to that date.

The as-built Drawings and Specifications do not give any indication of concrete strength for the precast units or for the cast-in-place deck topping at the steel-piled deck structure. Accordingly, cores were extracted in 2002 at three selected locations along the deck structure (the same access locations used by the drillers for the 2002 geotechnical field investigations). The cores, therefore, were drilled right through the cast-in-place topping and the precast unit below that, yielding properties of both materials.

The concrete deck is a 200 mm (nominal) thick cast-in-place topping, placed on 200 mm thick precast panels; drainage runoff is accommodated by slab thickness variations. The

precast units and the deck topping are both of reinforced concrete and act compositely. Testing was performed during Klohn Crippen's 2002 seismic study to determine the compressive strength of the concrete, which is not given by the "as-built" drawings or contract specifications. Three samples of the cast-in-place slab tested between 34 and 40 MPa. One sample of the precast slab was tested at 73 MPa.

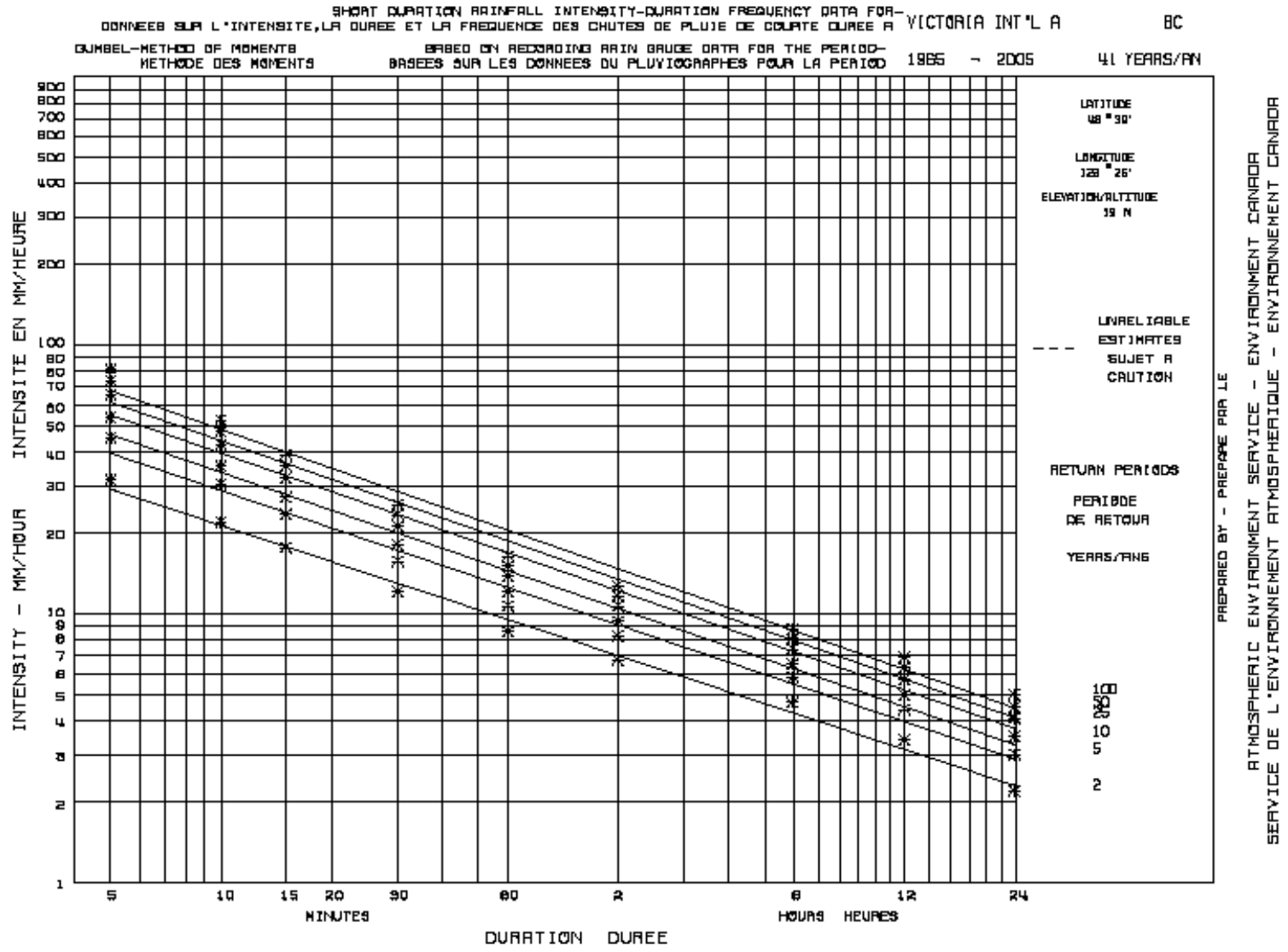
The above-mentioned concrete/steel test results can be used to determine design strengths for the existing steel-piled concrete deck structure, using the methodology outlined in Section 14 of CAN/CSA S6-06.

APPENDIX A

RAINFALL AMOUNTS AND INTENSITY CURVES FOR STORM WATER DRAINAGE DESIGN

Duration	Return Period Rainfall Amounts (mm)						
	2 year	5 year	10 year	25 year	50 year	100 year	No. of Years
5 min	2.6	3.8	4.5	5.5	6.2	6.8	41
10 min	3.7	5.0	6.0	7.1	8.0	8.8	41
15 min	4.4	5.9	6.8	8.0	8.9	9.8	41
30 min	6.0	7.9	9.1	10.6	11.7	12.8	41
1 hr	8.6	10.7	12.1	13.8	15.1	16.4	41
2 hr	13.5	16.7	18.8	21.5	23.5	25.4	41
6 hr	27.9	34.6	39.0	44.6	48.8	52.9	39
12 hr	41.2	52.2	59.5	68.7	75.6	82.4	39
24 hr	53.2	71.1	83.0	98.0	109.1	120.2	41

Duration	Return Period Rainfall Rates (mm/hour, 95% Confidence Limits)					
	2 year	5 year	10 year	25 year	50 year	100 year
5 min	31.8 +/- 4.3	45.3 +/- 7.2	54.2 +/- 9.8	65.5 +/- 13.2	73.9 +/- 15.7	82.2 +/- 18.4
10 min	22.0 +/- 2.6	30.3 +/- 4.4	35.7 +/-6.0	42.6 +/- 8.0	47.7 +/- 9.6	52.8 +/- 11.2
15 min	17.7 +/- 1.8	23.5 +/- 3.1	27.3 +/- 4.2	32.1 +/- 5.6	35.7 +/- 6.7	39.2 +/- 7.8
30 min	12.1 +/- 1.2	15.7 +/- 1.9	18.1 +/- 2.6	21.2 +/- 3.5	23.4 +/- 4.2	25.6 +/- 4.9
1 hr	8.6 +/- 0.7	10.7 +/- 1.1	12.1 +/-1.5	13.8 +/- 2.0	15.1 +/- 2.4	16.4 +/- 2.8
2 hr	6.7 +/- 0.5	8.3 +/- 0.9	9.4 +/- 1.2	10.7 +/- 1.6	11.7 +/- 1.9	12.7 +/- 2.2
6 hr	4.7 +/- 0. 4	5.8 +/- 0.6	6.5 +/- 0.8	7.4 +/- 1.1	8.1 +/- 1.3	8.8 +/- 1.6
12 hr	3.4 +/- 0.3	4.4 +/- 0.5	5.0 +/- 0.7	5.7 +/- 0.9	6.3 +/- 1.1	6.9 +/- 1.3
24 hr	2.2 +/- 0.2	3.0 +/- 0.4	3.5 +/- 0.5	4.1 +/- 0.7	4.5 +/- 0.9	5.0 +/- 1.0



Source: Rainfall IDF Data for Victoria International Airport.

D13

ESQUIMALT GRAVING DOCK

UNDER PIER REMEDIATION GEOTECHNICAL DESIGN INPUT

GOLDER (2014)

Number of Pages: 60

March 27, 2014

ESQUIMALT GRAVING DOCK WATERLOT REMEDIATION PROJECT

South Jetty Phase 2 99 % Under-Pier Remediation Geotechnical Design Input Report

Submitted to:
Public Works and Government Services Canada
641-800 Burrard Street
Vancouver, BC
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PWGSC Project # R.018400.001
Golder Submission No. 1001/001

REPORT

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Golder Associates

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1.0 INTRODUCTION

As requested by Public Works and Government Services Canada (PWGSC), Golder Associates Ltd. (Golder) provided geotechnical design input and remediation design support during the Phase 2 - 99% South Jetty Under-Pier remediation design undertaken by Anchor QEA L.L.C. (Anchor). This work was undertaken and performed in accordance with Golder's workplan, "Esquimalt Graving Dock Waterlot Remediation Project: Revised Workplan for South Jetty Phase 2 99% Under-Pier Remediation Design Support FY2013-2014," dated December 2, 2013. This work was performed under the Task Authorization agreement TA No. 700276837 (Sediment Remediation Consultants Standing Offer Agreement E0276-131364/002/VAN). The purpose of this report is to document the recommendations provided to the consultant design team (Anchor and Klohn Crippen Berger [KCB]) during the 99% design process.

2.0 BACKGROUND

The Esquimalt Graving Dock (EGD) facility is located on the north shore of Constance Cove, in Esquimalt Harbour on the southern tip of Vancouver Island, within an area formerly known as Skinner Cove (see Figures 1 and 2). PWGSC is implementing a remedial dredging program, to remove sediments within the Waterlot that have been contaminated as a result of historical activities at the EGD facility.

Phase 2 of the remediation plan comprises the removal of sediments beneath the existing South Jetty. Our current understanding of the dredge plan for remediation of sediments beneath the South Jetty is based on the 95% Detailed Design plans prepared by Anchor (dated August 22, 2013) together with discussions with Anchor during weekly project conference calls and at consultant design team co-ordination meetings. The dredging of contaminated sediments beneath the South Jetty is proposed to take place concurrent with the South Jetty Wharf Redevelopment Project, which involves decommissioning of the existing timber jetty and subsequent replacement with a steel pipe pile supported concrete jetty. Removal of contaminated sediments is proposed to be undertaken inside the temporary sheet pile wall that was placed around the perimeter of the South Jetty in Phase 1A of the EGD Waterlot Remediation Project. The purpose of the temporary sheet pile wall was to provide support to the sediments beneath the timber supported jetty during Phase 1A remediation within the adjacent water lots, as well as provide containment of the sediments in the under-jetty area until the Phase 2 remediation activities are complete. The proposed remediation will be undertaken by a combination of mechanical and hydraulic dredging methods.

Golder has been requested to provide comments and recommendations regarding constraints for dredging adjacent to existing structures that are to remain in place (namely the existing timber crib, existing sheet pile wall that retains the filled area of the South Jetty, and existing steel pipe piles).

3.0 OVERVIEW OF SUB-SURFACE STRATIGRAPHY

A plan of the existing South Jetty area is shown in Figure 3. The geotechnical assessments and recommendations were prepared based on the stratigraphic conditions in the Phase 2 remediation area inferred from data collected during field investigations carried out by Golder and others. A detailed discussion of the geotechnical properties of each of the stratigraphic units can be found in Golder's factual report (Golder, March 2010), and Golder's Detailed Site Investigation report (Golder, December 20, 2012).

The soil stratigraphy within the Phase 2 remediation area consists of Unconsolidated Sediments and Upper Marine Sediments overlying Victoria Clay. Glacial deposits and bedrock are located beneath the Victoria Clay. The upper slopes of some areas comprise rock fill/slope armour material. Interpreted sub-surface stratigraphic sections through the South Jetty area are provided in Figures 4a, 4c, 4d, 4e, 4j, and 4k.

4.0 OVERVIEW OF EXISTING STRUCTURES

4.1 General

Our understanding of the existing South Jetty structures is primarily based on the following:

- Klohn Crippen report "Esquimalt Graving Dock, Seismic Evaluation of South Jetty & North Entrance Wall," dated October 25, 2002;
- Design drawings for the 1985 "Improvements to Graving Dock, Contract No. 3" prepared by Ker, Priestman & Associates Ltd., dated May 1984; and
- Visual observations during field investigation programs.

The existing South Jetty Structures that will remain in place and require consideration during dredging include:

- A timber crib bulkhead located in the northeast area of the existing South Jetty;
- An existing steel pipe piled deck and crane pad;
- A sheet piled retaining wall;
- A concrete retaining wall; and
- The east end rock slope.

Each of these structures is described in the sections below. The locations of these structures are indicated on Figure 5.

4.2 Timber Crib

We understand that a timber crib bulkhead was installed in 1923 at the southwest end of the South Jetty (just south of the dry dock entrance) as part of the original graving dock construction. The crib structure is approximately 10.7 m high by 12.2 m wide and 30.5 m long. The timber crib bulkhead, was likely floated to the location, sunk and filled with sand, gravel, and rockfill. We understand that a 3.5 m high concrete parapet wall was subsequently constructed above and along the west and south sides of the crib. According to the 2002 Klohn report, original EGD construction drawings indicate that this crib served as a short approach wharf at the west end of a 15 m wide roadway located adjacent to the south side of the dry dock. According to available information from the 2002 Klohn report, the toe of the timber crib is buried approximately 3 m below mudline (approximate chart elevation -9.8 m). The Klohn report also indicates that the timbers in this crib can be presumed to be in generally sound condition. Photographs 1 and 2 show the portion of the existing timber crib visible above the water surface.

Klohn's assessment indicates that the construction of the timber crib is consistent with the construction of the timber cribs along the North Landing Wharf, which have no toe fill above the base level. Based on the evaluation provided in the 2002 Klohn report, the fill in front of the timber crib was likely placed to reduce the exposed length of piles in this area, and not related to the stability of the timber crib.

Available information on the timber crib structure indicates that it is founded on rock fill. A review of the available borehole data for the area to the west of the timber crib indicates that the upper 4 to 5 m of material generally comprises a mixture of unconsolidated sediments, fill, and fine grained marine sediments, over coarse grained marine sediments. Detailed descriptions and results of laboratory testing on these materials can be found in Golder's factual report (Golder, March 2010), and Golder's Detailed Site Investigation report (Golder, December 20, 2012).

4.3 Existing Steel Pipe Pile Supported Deck and Crane Pad

We understand that steel pipe piles support the concrete deck structure which was constructed as an upgrade to the existing South Jetty in 1985. The concrete deck structure is approximately 200 m in length, 15 m in width and supports a square concrete crane pad located at the west end of the structure. Available information indicates that the steel pipe piles comprise a combination of vertical and battered piles, set at 6.1 m centres and generally driven to effective refusal. Based on our understanding of the existing soil conditions, it is assumed that this refusal was either on till or bedrock. The total piling lengths are reported to range from approximately 30 m to 40 m. The exposed length of the piles above ground surface is approximately 5 metres along most of the steel piled area. However, in the area of the crane pad, the exposed length above ground surface is reported to be approximately 12 m. The existing slope in the vicinity of the deck pilings ranges from approximately 6H:1V to 2H:1V (Horizontal:Vertical).

A high mast light post supported on a concrete foundation is located within the steel pile supported deck area of the south jetty at the location indicated on Figure 5. Based on the available information, we understand that the concrete foundation is supported by 9 treated timber piles which are approximately 9 m in length. The existing slope south of this area is currently 2H:1V (see Figure 4D). Photograph 3 shows the unformed concrete mass surrounding the piled foundation for the high mast light post.

4.4 Existing Sheet Pile Retaining Wall

An existing sheet pile retaining wall, installed in 1985, is approximately 189 m in length and located immediately north of the pipe-pile-supporting concrete deck. Based on a review of Klohn Crippen Berger (Klohn) Reports and Ker Priestman Drawings, we understand that the sheet piles vary in length and range from 6.1 m to 9.1 m in length. The exposed height of the sheet pile wall varies from 0 m to approximately 4 m along the length of the wall. The sheet pile wall is reported to be tied back with anchor rods spaced at 4.88 m intervals. The tie-back anchors are shown at Chart Datum El 4.0 m and connect to a shallow retaining wall "deadman" foundation located approximately 15.4 m north of the sheet pile facing. The sheet pile wall is capped along its length with a reinforced concrete beam measuring 750 mm wide by 850 mm deep. We further understand that a 350 mm deep reinforced concrete "floating" grade slab approximately 6 m in length is founded on the retained backfill. Thinner slabs form the dock surface area further toward the north. Golder reviewed sheet pile retaining wall information from: "Improvements to Esquimalt Graving Dock Contractor No. 3" By Ker Priestman & Associates Ltd. Consulting Engineers; November 6, 1985. The existing sheet pile wall consists of three segments:

- West Wall Segment: The west wall segment is approximately 44 m in length incudes a 4.9 m section of west-facing bulkhead wall. This wall section comprises sheet piles 6.1 m in length with tip elevations at -1.5 m (chart). The grade elevation behind the sheet pile wall is at Chart Datum 5.2 m and the mudline elevation varies from approximately 2 m to 4 m (chart).
- Middle Wall Segment: The middle wall segment is approximately 132 m in length and comprises sheet piles 9.1 m in length with tip elevations at -4.5m (chart). The grade elevation behind the sheet pile wall is at Chart Datum 5.2 m and the mudline elevation varies from approximately 1 m to 2 m (chart).
- East Wall Segment: The east wall segment is 12.8 m in length and comprises sheet piles 6.1 m in length with tip elevations at -1.5m. The grade elevation behind the sheet pile wall is at Chart Datum 5.2 m and the mudline elevation varies from approximately 2 m to 3 m (chart).

Ancillary structures are currently located at the top of the wall. A recommended live load estimate for these structures of 6.0 kPa was provided by Klohn Crippen Berger in a memorandum dated March 13, 2013 (File No. P09614A02) for temporary conditions during under-pier dredging/capping.

4.5 Concrete Retaining Wall and East End Rock Slope

A concrete retaining wall is located at the east end of the existing South Jetty as indicated on Figure 5. Based on the available information, the concrete retaining wall is a reinforced L-shaped structure approximately 1.4 m to 2.5 m in height and 16 m in length with the foundation extending 0.75 m to 2.1 m into the infill area (east of the South Jetty). Based on the available bathymetry information, the burial depth of the toe is minimal.

There is a rubble slope located adjacent to the concrete retaining wall on the east side (east of the south jetty) as indicated on Figure 5. The existing slope descends away from the wall at approximately 3H:1V. Photograph 4 shows the slope as viewed from the existing South Jetty.

5.0 RECOMMENDATIONS FOR DREDGING ADJACENT TO EXISTING STRUCTURES

5.1 Timber Crib

Based on our review of the available information, it is recommended a nominal offset (minimum approximately 1 m) from the face of the crib structure to reduce the risk of damage. We understand that the South Jetty re-construction will require the installation of displacement control piles adjacent to the face of the timber crib. Based on the requirements for the construction of these piles, we understand that the target dredge elevation adjacent to the timber crib is -9.0 m (chart). We further understand that for construction purposes, the -9.0 m dredge elevation will extend a distance of 6.0 m from the face of the timber crib, forming a level bench parallel to the face of the timber crib.

Based on our understanding of the existing structure, the proposed dredging should not negatively impact the overall stability of the timber crib. We recommend a maximum 2H:1V dredge slope beyond the 6 m wide bench at -9 m elevation, extending down to the target dredge elevation (approximately -11.5 m), provided some surficial sloughing of the dredge slope is acceptable. The unconsolidated sediments, and upper fine grained marine sediments will likely be marginally stable at a slope of 2H:1V, and may be subject to surficial sloughing between the time of dredging and the placement of cap materials. These recommendations are based on the assumption that as per the 2002 Klohn report that the timbers in the timber crib can be presumed to be in generally sound condition.

5.2 Existing Pile Supported Concrete Deck and Crane Pad

The existing soil and rock slope in this area varies up to 2H:1V. We understand that the current dredge plan requires the removal of the existing high mast light tower located within the existing pile supported concrete deck area, and removal of material (up to 5 m in thickness) from under the pipe pile supported structure. The proposed dredging activities will require a vertical cut adjacent to the existing sheet pile retaining wall (see Section 5.3). We understand that KCB is providing input regarding the potential impacts of removing the sediments surrounding the existing steel piles and the impact of placing capping material around the existing piles. As the current slope in this area is 2H:1V, we recommend a maximum dredge slope of 2H:1V down to the target dredge elevation provided some surficial sloughing of the dredge slope is acceptable. The unconsolidated sediments and upper fine grained marine sediments will likely be marginally stable at a slope of 2H:1V, and may be subject to surficial sloughing between the time of dredging and the placement of cap materials.

5.3 Existing Sheet Pile Retaining Wall

Based on our review of the sheet pile wall design drawings and the inferred subgrade conditions, we anticipate that excavation adjacent (downslope) to the sheet pile wall will likely increase the loads developed within the tie back anchors which could lead to displacement of the wall and/or overstressing of the anchorages. Golder conducted an analysis of the existing sheet pile wall under existing conditions, and potential dredging configurations to assess the proposed dredge profiles. The live loading under existing conditions was limited to the 6.0 kPa surcharge assumed for temporary conditions during under-pier dredging and capping for this analysis. Our analysis and detailed recommendations regarding dredging adjacent to the existing sheet pile wall are provided in Appendix B, with the proposed dredge slopes and recommendations summarized below.

- Western Wall Segment: Proposed post-dredge conditions consider removal of materials adjacent to the sheet piling to minimum Chart Datum El. +3.0 m followed by a dredged slope not steeper than 2 H:1V extending to an inflection point near elevation -5.1 m, after which the slope flattens to 3H:1V until the dredge slope encounters the temporary containment wall near the toe of the slope.
- Centre Wall Segment: Proposed post-dredge conditions consider removal of materials adjacent to the sheet piling to minimum Chart Datum El. +0.6 m followed by a dredge slope dipping at 3H:1V, as well as two near-horizontal intermediate benches 5 and 7 m wide near chart elevations -1.5 m and -4.5 m, after which the dredged slope parallels the original slope until meeting the temporary containment wall.
- East Wall Segment: Proposed post-dredge conditions consider removal of materials adjacent to the sheet piling to minimum Chart Datum El. +1.3 m, including over-dredge allowance, dipping at 3H:1V with two gently sloping intermediate benches about 6 to 7 m wide near chart elevations 0.5 and 4.0 m.

The maximum depth of excavation adjacent to the temporary sheet pile wall is 2.5 m, as described in the technical memorandum “Updated Sheet Pile Design Inputs for the Under-Jetty Erosion Protection” dated September 9, 2011.

Stability analyses of the dredged slopes as currently proposed and based on the design parameters presented herein, indicated that dredging as proposed can be carried out while meeting the minimum factors of safety except for the length of wall modelled as Section E-E. For this area, it is recommended that the dredged slope is backfilled immediately after dredging so that the dredged slope length (measured from undredged slope to the leading edge of the backfill) does not exceed 3 m. This treatment must be completed for dredging operations within 20 m horizontal distance of the sheet pile wall. Alternatively, shallower dredging depths and flatter dredge slopes may be considered for this limited section of wall.

Our analyses were conducted assuming a maximum surcharge loading of 6.0 kPa behind the existing sheet pile wall, based on the assumed restricted loading conditions during dredging. We recommend that surcharge loading be limited to a maximum of 6.0 kPa for a distance of 15 m behind the existing sheet pile wall during the under-pier remediation activities.

It is recommended that placement of cap material take place as soon as practical following dredging for all wall segments, to return the wall to suitable long-term factors of safety for global stability. It is also recommended that suitable slope and wall (temporary sheet pile) monitoring be implemented during dredging work as the above analyses is based on interpretation between broadly spaced test hole information within the South Jetty area. The methodology, frequency and areal extent of the monitoring program should be considered and reviewed for adequacy prior to initiating the dredging works.

5.4 Concrete L-Wall

Excavation immediately adjacent to the wall could de-stabilize the wall and lead to displacement or failure. Based on the limited height of the wall (1.4 m measured from the crest to the toe of the footing), we recommend a 3 m setback (undisturbed zone) from face of L-Wall, followed by a maximum 2H:1V cut slope down to the target dredge depth. We understand that the maximum anticipated dredge depth in this area is approximately 3 m.

5.5 Rock Slope

Vertical excavation immediately adjacent to the toe of the slope could cause movement of the rock slope. We recommend an interim cut slope of 3H:1V adjacent to the toe of the rock slope, extending down to the target dredge depth in this area.

6.0 NEW EAST END RETAINING WALL

A new retaining wall has been incorporated into the east approach of the South Jetty as part of the new South Jetty design. It is assumed that this retaining wall would be constructed after dredging, but prior to placement of the capping material associated with the Phase 2 Esquimalt Graving Dock Remediation dredging. Golder conducted a global stability assessment of the proposed retaining wall during remediation activities. A summary of the assessment and results are provided in Appendix C.

Golder analyzed the global slope stability of the proposed retaining wall based on the available geotechnical information, the proposed retaining wall configuration provided by Klohn Crippen Berger, and the proposed dredge and capping profiles provided by Anchor QEA. The models were adapted to reflect high, mean and low tide water levels, as well as the following construction/dredging conditions:

- Backfill Behind Proposed Retaining Wall, No Capping Material in Place: This condition represents the case where the dredging is conducted down to the target (plus allowable overdredge) dredge depth, the proposed retaining wall is constructed, and fully backfilled prior to placement of capping material in front of the wall.
- No Backfill Behind New Concrete Retaining Wall, No Capping Material In Place: This condition represents the case where the dredging is conducted down to the target (plus allowable overdredge) dredge depth and the proposed retaining wall is constructed. .
- Backfill Behind New Concrete Retaining Wall, Capping Material In Place: This condition represents the assumed final wall configuration, and was analyzed to confirm the long term ***static*** global stability of the wall following construction.

Based on the results of the stability analyses conducted, it is recommended that the capping material be placed in front of the retaining wall prior to placement of backfill behind the retaining wall.

It is recommended that suitable slope and wall monitoring be implemented both during and after dredging work as the above analyses is based on interpretation between broadly spaced test hole information within the South Jetty area. The methodology, frequency and areal extent of the monitoring program should be considered and reviewed for adequacy prior to initiating the dredging works

7.0 SUMMARY OF RECOMMENDATIONS

The recommendations regarding Phase 2 dredging adjacent to the identified existing structures are summarized in the table below:

Table 1: Summary of Recommendations

Structure	Setback and Slope Recommendations
Timber Crib	1 m setback from structure, bench at -9 m chart elevation having a minimum 6 m width, followed by 2H:1V slope down to target dredge depth.
Steel Pile Supported Deck and Crane Pad	No setback, maximum 2H:1V dredge slopes.
Existing Sheet Pile Wall	No setback. **Western Wall Segment:** removal of materials adjacent to the sheet piling to minimum Chart Datum El. +3.0 m followed by a dredged slope not steeper than 2 horizontal to 1 vertical extending to an inflection point near chart elevation -5.1 m, after which the slope flattens to 3H:1V until the dredge slope encounters the containment wall near the toe of the slope. **Centre Wall Segment:** removal of materials adjacent to the sheet piling to minimum Chart Datum El. +0.6 m followed by a dredge slope dipping at 3H:1V, as well as two near-horizontal intermediate benches 5 and 7 m wide near chart elevations -1. 5 m and -4.5 m, after which the dredged slope parallels the original slope until meeting the containment wall. **East Wall Segment:** removal of materials adjacent to the sheet piling to minimum Chart Datum El. +1.3 m, including over-dredge allowance, dipping at 3H:1V to the containment wall near the toe of the slope with intermediate benches. For this area, it is recommended that the dredged slope is backfilled immediately after dredging so that the dredged slope length (measured from un-dredged slope to the leading edge of the backfill) does not exceed 3 m. This treatment must be completed for dredging operations within 20 m horizontal distance of the sheet pile wall.
Concrete L-Wall	3 m setback from structure followed by 2H:1V slope down to target dredge depth, no vertical cut.
Rock Slope	No setback, maximum 3H:1V slope down to target dredge depth, no vertical cut.

8.0 CLOSURE

We trust that the information contained in this report is suitable for your current requirements. Please contact the undersigned if you require any further information.

GOLDER ASSOCIATES LTD.

Sarah Morse, P.Eng., PMP
Geotechnical Engineer

Reviewed by:

Randy Williams, P.Eng.
Principal, Senior Geotechnical Engineer

SEM/RW/rv/lmk/ran

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REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE

KEY PLAN

REFERENCE

TOPOGRAPHIC MAP 92B/06 © 2000 HER MAJESTY THE QUEEN IN RIGHT OF CANADA.
DEPARTMENT OF NATURAL RESOURCES. ALL RIGHTS RESERVED.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD83 COORDINATE SYSTEM: UTM ZONE 10.

Golder Associates

PROJECT No.	13-1447-0478.1000.1001		FILE No.	1314470478-1001-01
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN
CADD	AMW	2013-12-09	FIGURE	1
CHECK	SEM	2014-03-24		
REVIEW	RW	2014-03-24		

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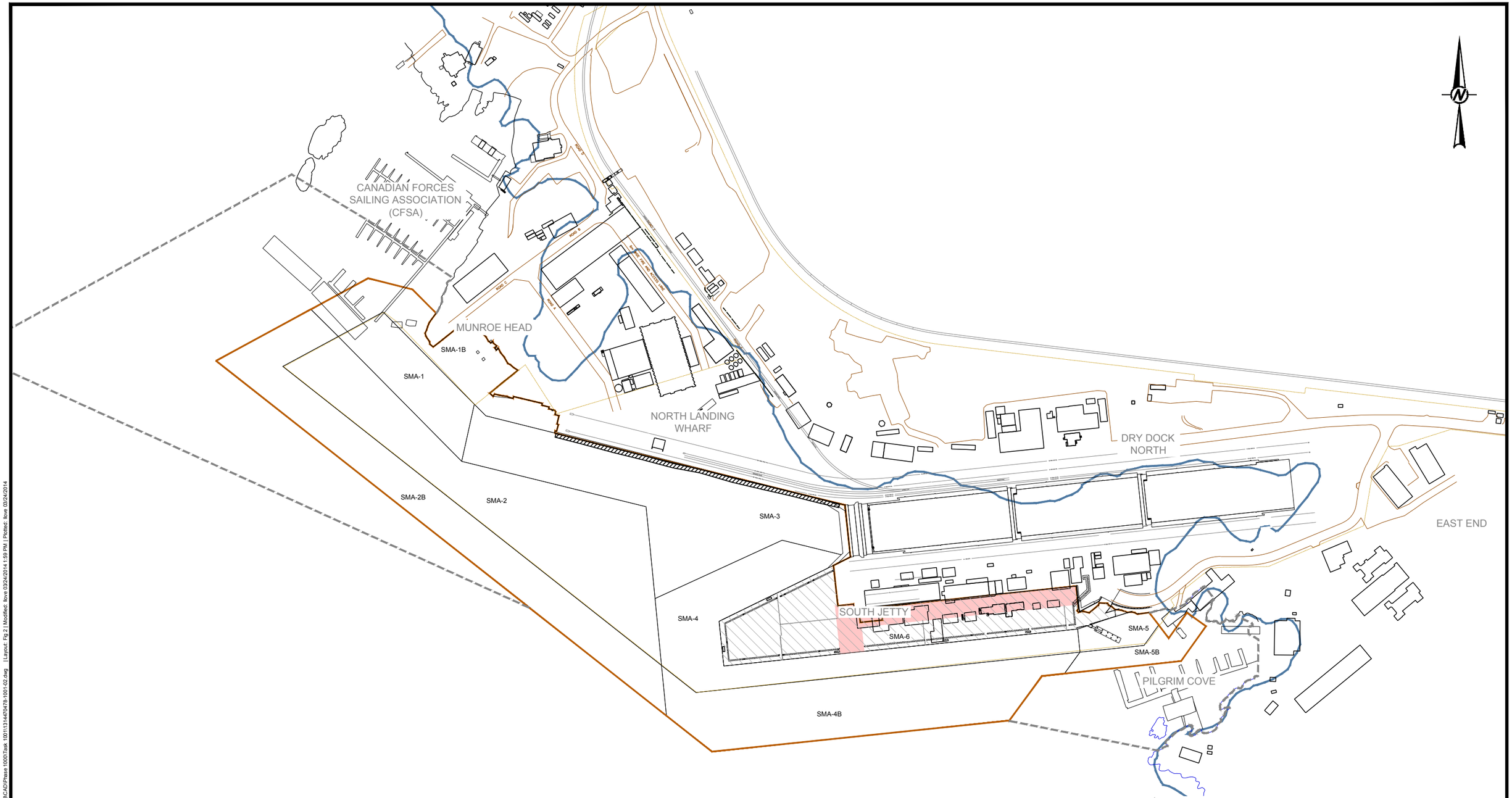

LEGEND

- PROJECT AREA
- EGD FACILITY (COMPRISING WATERLOT AND EGD UPLANDS)
- SUPPLEMENTAL INVESTIGATION AREAS
- SEDIMENT MANAGEMENT AREA (SMA)
- HISTORICAL SHORELINE (1925)
- LOCATION OF TIMBER / STEEL PIPE PILED JETTY
- GABION MAT

REFERENCE

BASE OBTAINED FROM CLIENT.

0 60 120 180

SCALE METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE

SITE PLAN

Golder Associates

PROJECT No.	13-1447-0478 .1000.1001		FILE No.	1314470478-1001-02
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN
CADD	AMW	2013-12-09	FIGURE	2
CHECK	SEM	2014-03-24		
REVIEW	RW	2014-03-24		

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LEGEND

- SECTION LINE
- GBH09 — BOREHOLE LOCATIONS - GOLDER 2009
- SC09 — SEDIMENT CORE LOCATIONS - GOLDER 2009
- BH11 — BOREHOLE LOCATIONS - GOLDER 2011
- KCPT — CONE PENETRATION TEST LOCATIONS - KLOHN CRIPPEN 2009
- GCPT — CONE PENETRATION TEST LOCATIONS - GOLDER 2009

BPT02 DH02 BOC02 CPT02 SCPT02 — SAMPLING LOCATIONS - KLOHN CRIPPEN 2002

BATHYMETRY CHART DATUM CONTOUR - MAJOR (5m INTERVALS) CRA CANADA SURVEYS INC. (2009 AND 2010)

BATHYMETRY CHART DATUM CONTOUR - MINOR (0.5m intervals) CRA CANADA SURVEYS INC. (2009 AND 2010)

EXISTING TIMBER CRIB

EXISTING TIMBER PILE SUPPORTED JETTY

EXISTING STEEL PILE SUPPORTED JETTY

NOTE

FOR DETAILS OF SECTIONS A-A', C-C', D-D', E-E', J-J' AND K-K' REFER TO FIGURES 4a, 4c, 4d, 4e, 4j, and 4k.

REFERENCES

BASE OBTAINED FROM CLIENT.

CRIB LOCATION PROVIDED BY KLOHN CRIPPEN BERGER, CAD FILE: *Existing EGD Timber Jetty Base.dwg*, E-MAILED: AUGUST 9, 2010

0 30 60 90
SCALE METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE

SOUTH JETTY
SECTION LOCATION PLAN

Golder Associates

PROJECT No.	13-1447-0478.1000.1001		FILE No.	1314470478-1001-03	
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN	
CADD	AMW	2013-12-09	FIGURE		
CHECK	SEM	2014-03-24		3	
REVIEW	RW	2014-03-24			

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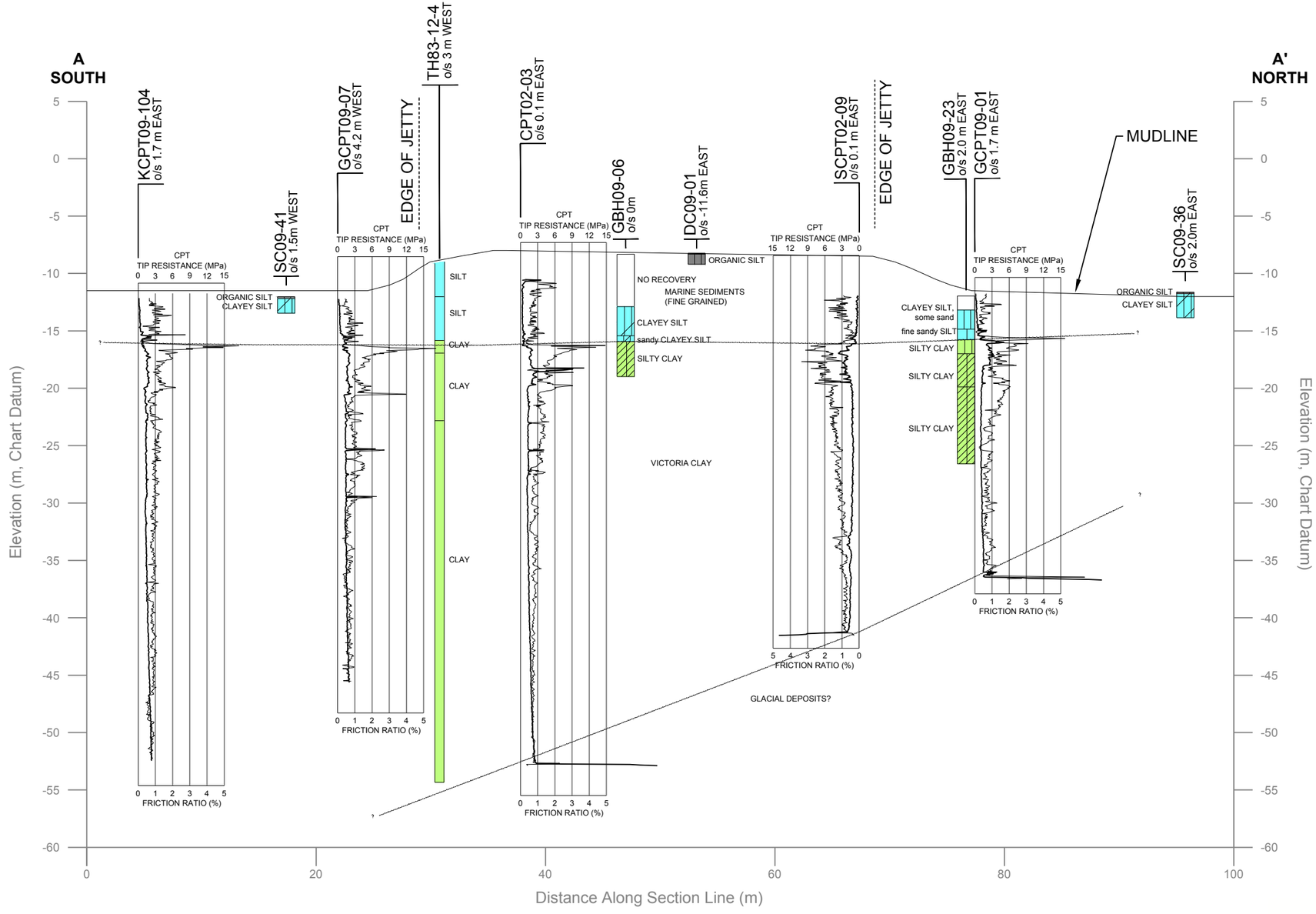

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LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

BHxx-xx — TEST HOLE IDENTIFICATION
o/s 1m NW — OFFSET FROM SECTION LINE
MUDLINE ELEVATION
FINAL DEPTH OF BOREHOLE

NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN. FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY AT EACH BOREHOLE LOCATION, REFER TO THE RECORD OF BOREHOLE SHEETS.

REFERENCE

MUDLINE PROFILE WAS DERIVED FROM BATHYMETRIC CONTOURS (INTERVAL = 0.5 m) PROVIDED BY CRA CANADA SURVEYS INC. (2009 AND 2010).

0 8 16 24
SCALE METRES

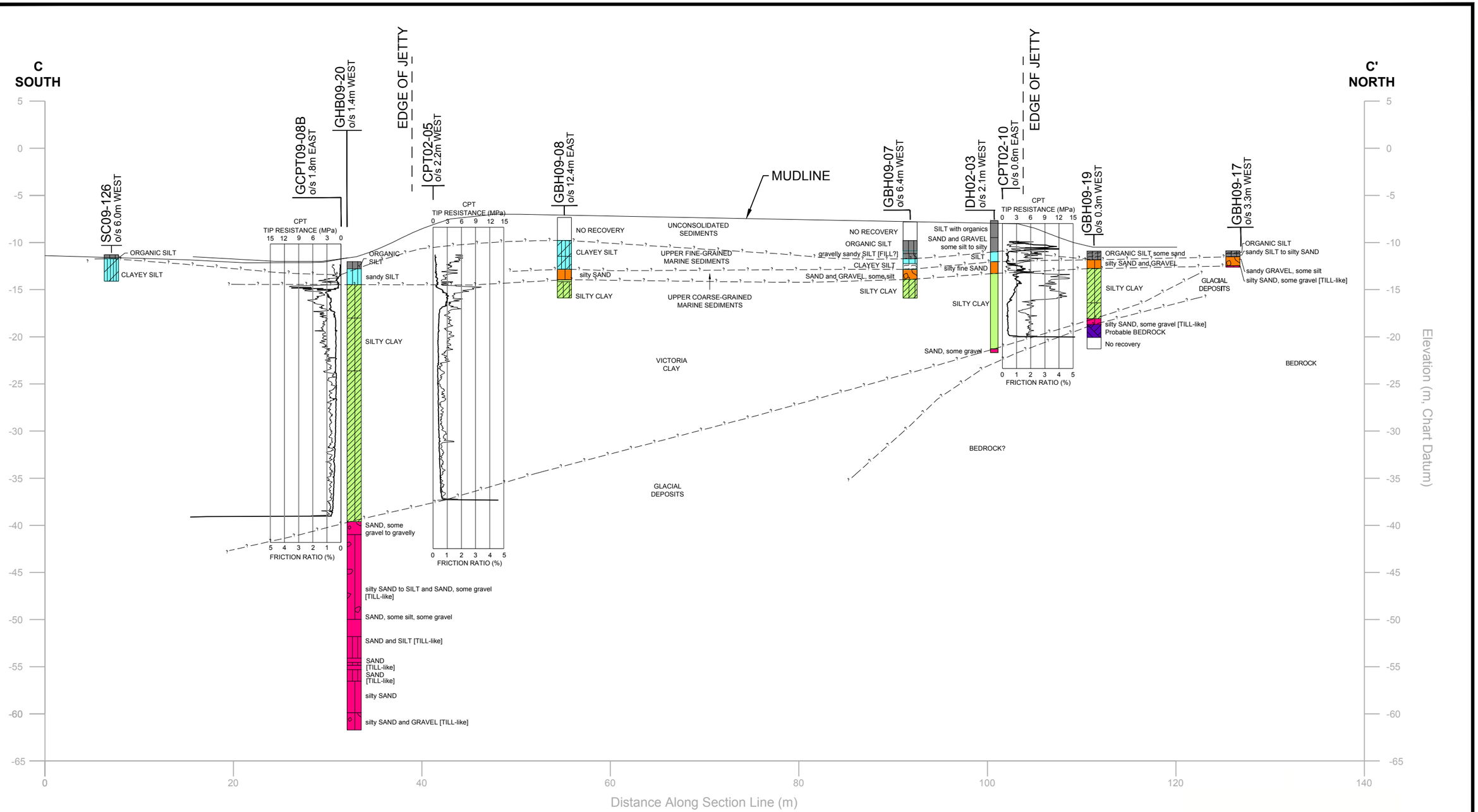
REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
2	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE
STRATIGRAPHIC CROSS-SECTION A - A'

Golder Associates

PROJECT No.	13-1447-0478 .1000.1001		FILE No.	1314470478-1001-04a	
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN	
CADD	AMW	2013-12-09	FIGURE		
CHECK	SEM	2014-03-24		4A	
REVIEW	RW	2014-03-24			



LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- UPPER MARINE SEDIMENTS (COARSE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f
- BHxx-xx / o/s 1m NW — TEST HOLE IDENTIFICATION / OFFSET FROM SECTION LINE
- MUDLINE ELEVATION
- FINAL DEPTH OF BOREHOLE

NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN. FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY AT EACH BOREHOLE LOCATION, REFER TO THE RECORD OF BOREHOLE SHEETS.

REFERENCE

MUDLINE PROFILE WAS DERIVED FROM BATHYMETRIC CONTOURS (INTERVAL = 0.5 m) PROVIDED BY CRA CANADA SURVEYS INC. (2009 AND 2010).

SCALE 0 8 16 24 METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
A	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE

STRATIGRAPHIC CROSS-SECTION C - C'

Golder Associates

PROJECT No.	13-1447-0478.1000.1001		FILE No.	1314470478-1001-04c	
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN	
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REVIEW	RW	2014-03-24			

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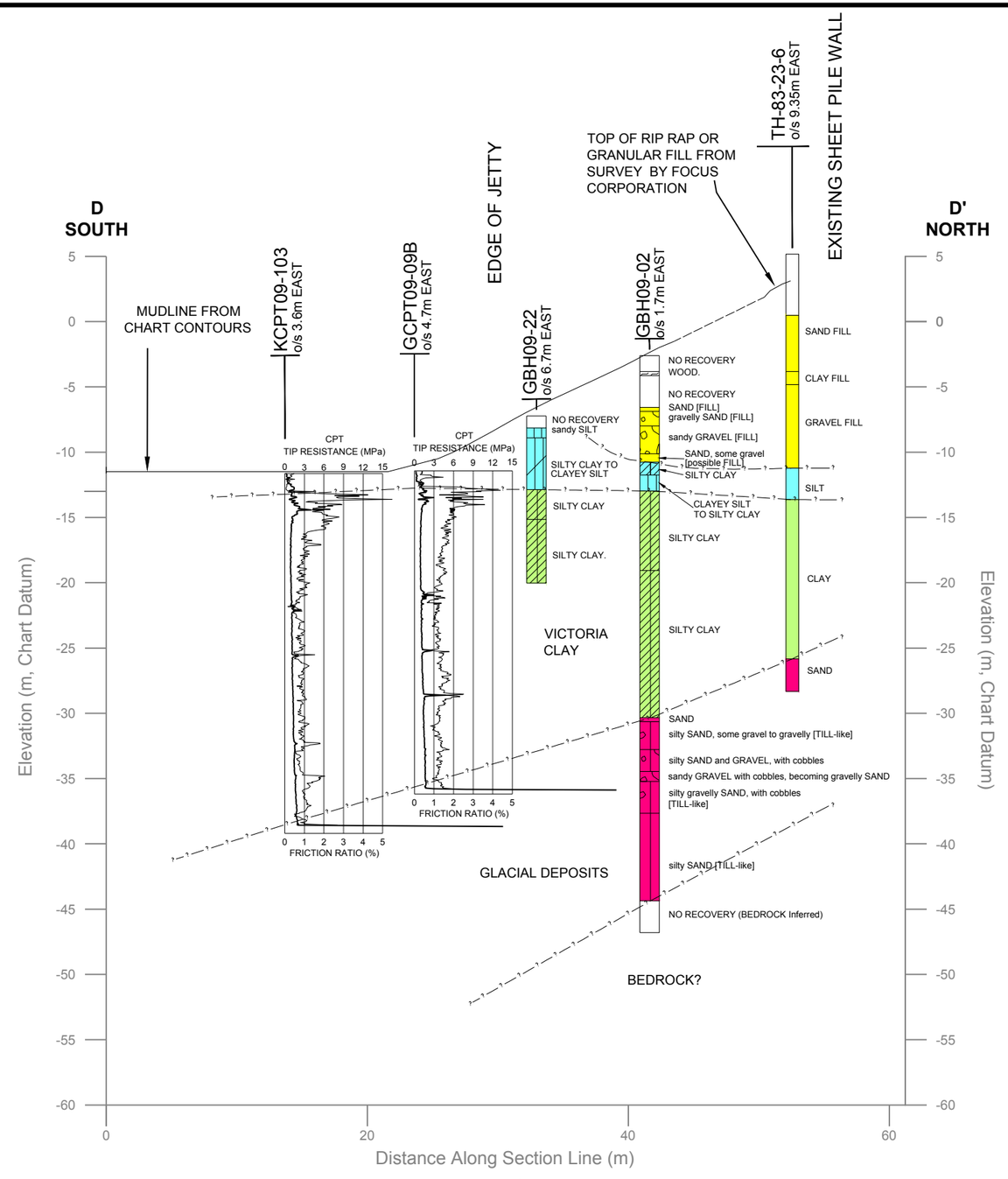

LEGEND

- UNCONSOLIDATED SEDIMENTS
- GRANULAR AND/OR ROCK FILL
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f
- BHxx-xx / o/s 1m NW — TEST HOLE IDENTIFICATION / OFFSET FROM SECTION LINE
- MUDLINE ELEVATION
- FINAL DEPTH OF BOREHOLE

NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN. FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY AT EACH BOREHOLE LOCATION, REFER TO THE RECORD OF BOREHOLE SHEETS.

REFERENCES

MUDLINE PROFILE WAS DERIVED FROM BATHYMETRIC CONTOURS (INTERVAL = 0.5 m) PROVIDED BY CRA CANADA SURVEYS INC. (2009 AND 2010).

RIP RAP ELEVATIONS FROM FOCUS CORPORTATION: *03020056-104TS2.dwg*, DATED JANUARY 15, 2010.

0 8 16 24
SCALE METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
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ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE
STRATIGRAPHIC CROSS-SECTION D - D'

Golder Associates

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REVIEW	RW	2014-03-24			

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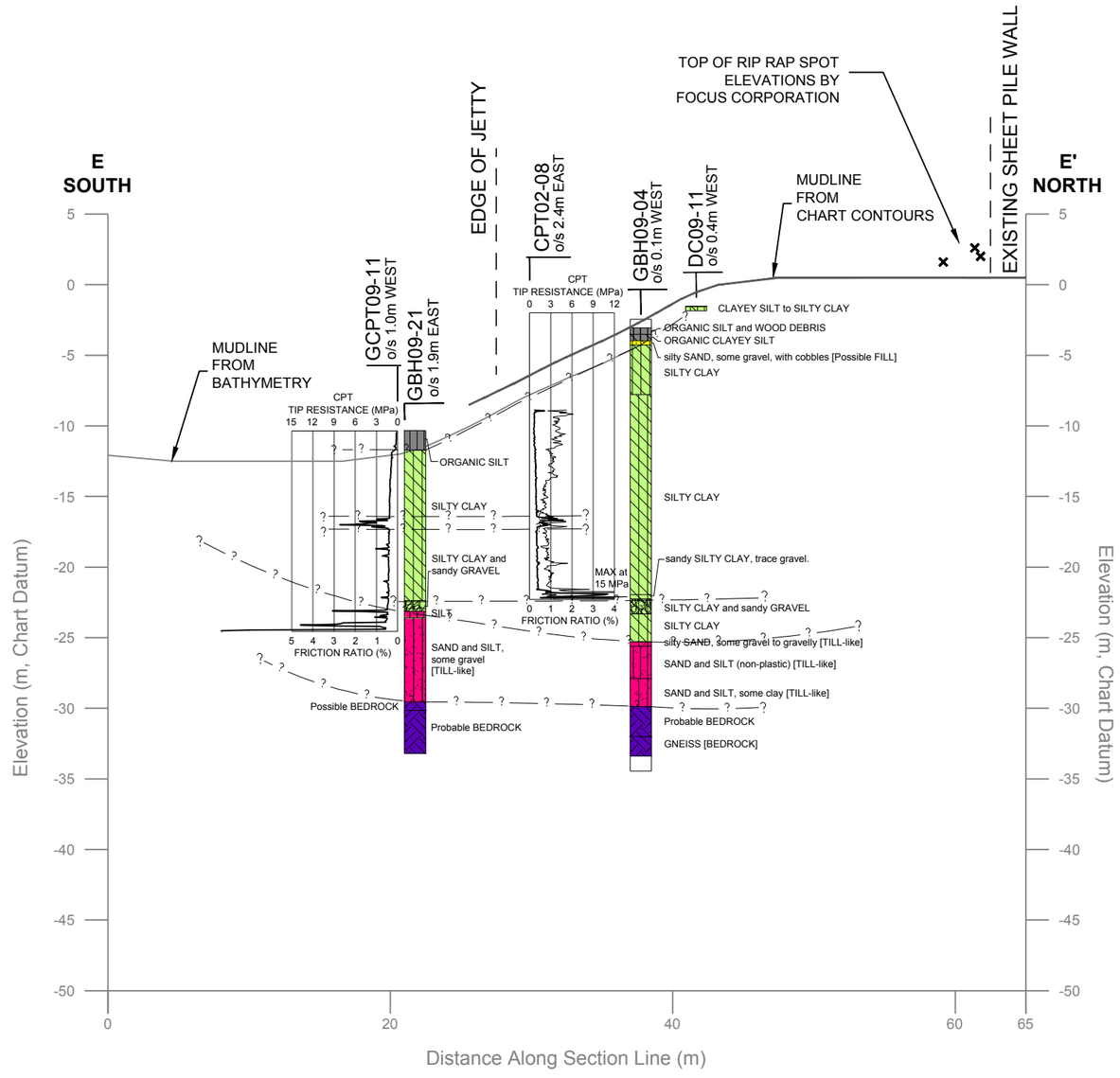

LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- GRANULAR AND/OR ROCK FILL
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f
- BHxx-xx / o/s 1m NW — TEST HOLE IDENTIFICATION / OFFSET FROM SECTION LINE
- MUDLINE ELEVATION
- FINAL DEPTH OF BOREHOLE

NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN. FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY AT EACH BOREHOLE LOCATION, REFER TO THE RECORD OF BOREHOLE SHEETS.

REFERENCES

MUDLINE PROFILE WAS DERIVED FROM BATHYMETRIC CONTOURS (INTERVAL = 0.5 m) PROVIDED BY CRA CANADA SURVEYS INC. (2009 AND 2010).

RIP RAP ELEVATIONS FROM FOCUS CORPORTATION: *03020056-104TS2.dwg*, DATED JANUARY 15, 2010.

SCALE 0 8 16 24 METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
2	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE

STRATIGRAPHIC CROSS-SECTION E - E'

Golder Associates

PROJECT No.	13-1447-0478..1000.1001		FILE No.	1314470478-1001-04e	
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN	
CADD	AMW	2013-12-09	FIGURE		
CHECK	SEM	2014-03-24		4E	
REVIEW	RW	2014-03-24			

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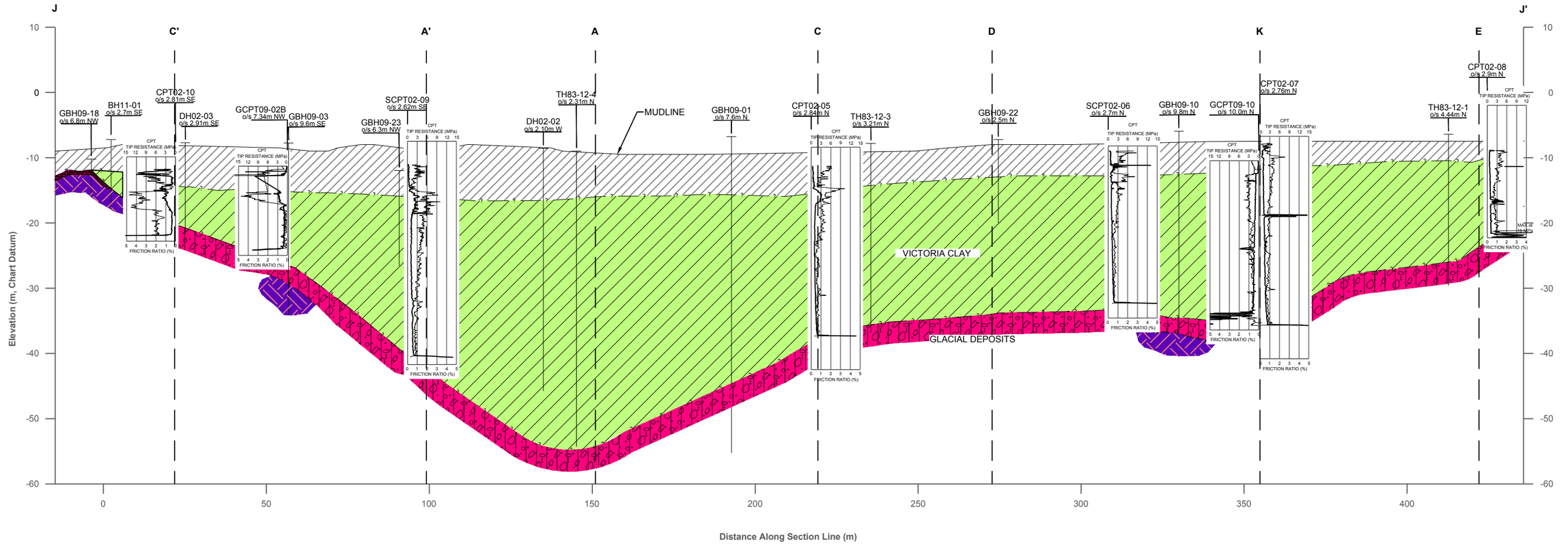

LEGEND

- UNCONSOLIDATED SEDIMENTS / UPPER MARINE SEDIMENTS
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

BHxx-xx — TEST HOLE IDENTIFICATION
o/s 1m NW — OFFSET FROM SECTION LINE
MUDLINE ELEVATION
FINAL DEPTH OF BOREHOLE

NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN. FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY AT EACH BOREHOLE LOCATION, REFER TO THE RECORD OF BOREHOLE SHEETS.

FOR DETAILS OF SECTIONS A-A', C-C', D-D', E-E', AND K-K' REFER TO FIGURES 4a, 4c, 4d, 4e, AND 4k.

REFERENCE

MUDLINE PROFILE WAS DERIVED FROM BATHYMETRIC CONTOURS (INTERVAL = 0.5 m) PROVIDED BY CRA CANADA SURVEYS INC. (2009 AND 2010).

0 25 50 75
SCALE (2x VERTICAL EXAGGERATION) METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE
PROFILE J - J'

Golder Associates

PROJECT No.	13-1447-0478 .1000.1001		FILE No.	1314470478-1001-04j
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN
CADD	AMW	2013-12-09	FIGURE	
CHECK	SEM	2014-03-24		4J
REVIEW	RW	2014-03-24		

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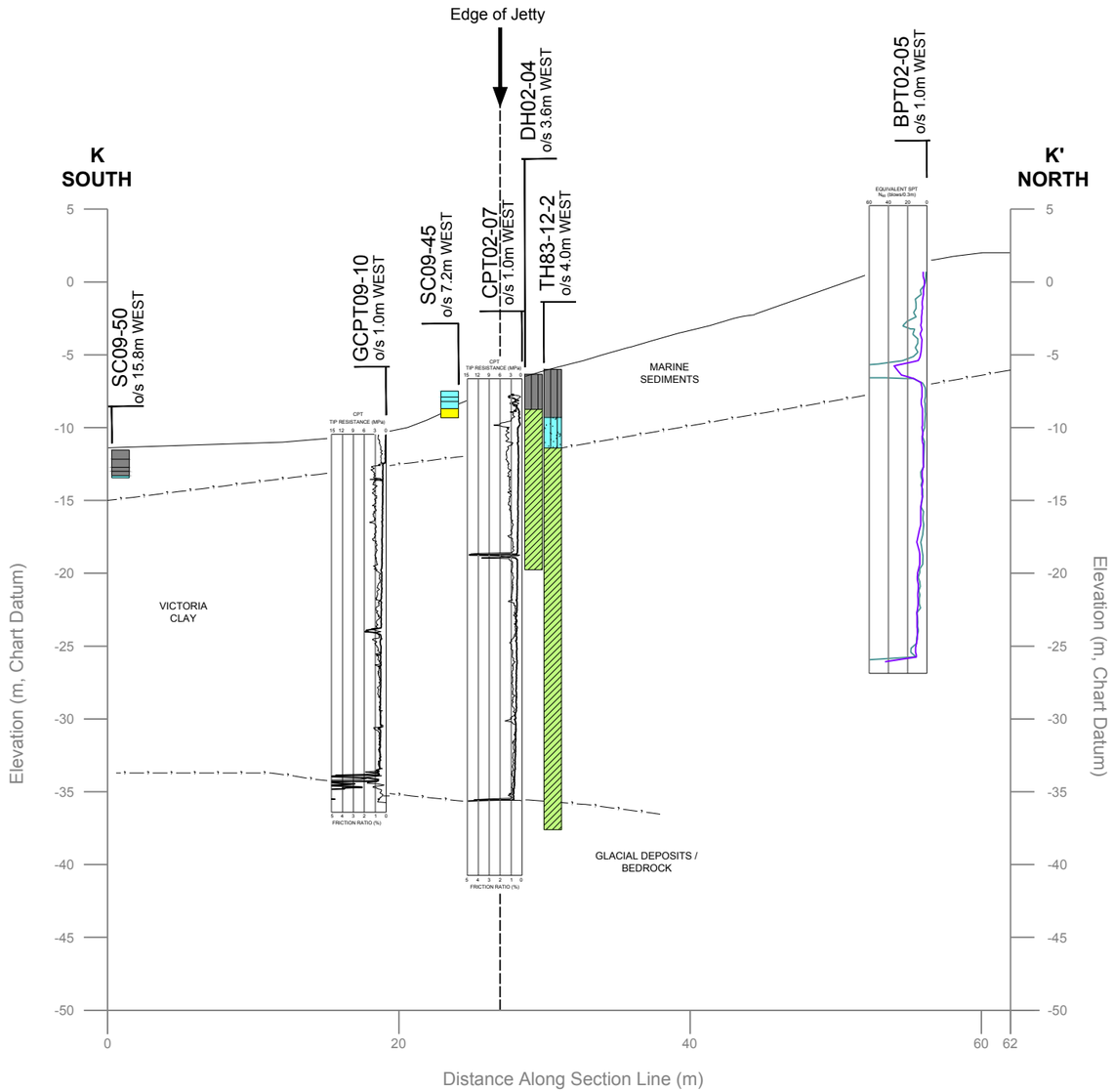


LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- GRANULAR AND/OR ROCK FILL
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f
- BPT - HARDER METHOD
- BPT - SY METHOD
- BHxx-xx / o/s 1m NW — TEST HOLE IDENTIFICATION / OFFSET FROM SECTION LINE
- MUDLINE ELEVATION
- FINAL DEPTH OF BOREHOLE

NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN. FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY AT EACH BOREHOLE LOCATION, REFER TO THE RECORD OF BOREHOLE SHEETS.

REFERENCES

MUDLINE PROFILE WAS DERIVED FROM BATHYMETRIC CONTOURS (INTERVAL = 0.5 m) PROVIDED BY CRA CANADA SURVEYS INC. (2009 AND 2010).

RIP RAP ELEVATIONS FROM FOCUS CORPORTATION: *03020056-104TS2.dwg*, DATED JANUARY 15, 2010.

BPT DATA DIGITIZED FROM KLOHN CRIPPEN REPORT: *Esquimalt Graving Dock and South Landing Wharf - Site Investigation and Liquefaction Assessment.* DATED JUNE 25, 2002

0 8 16 24

SCALE METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
2	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

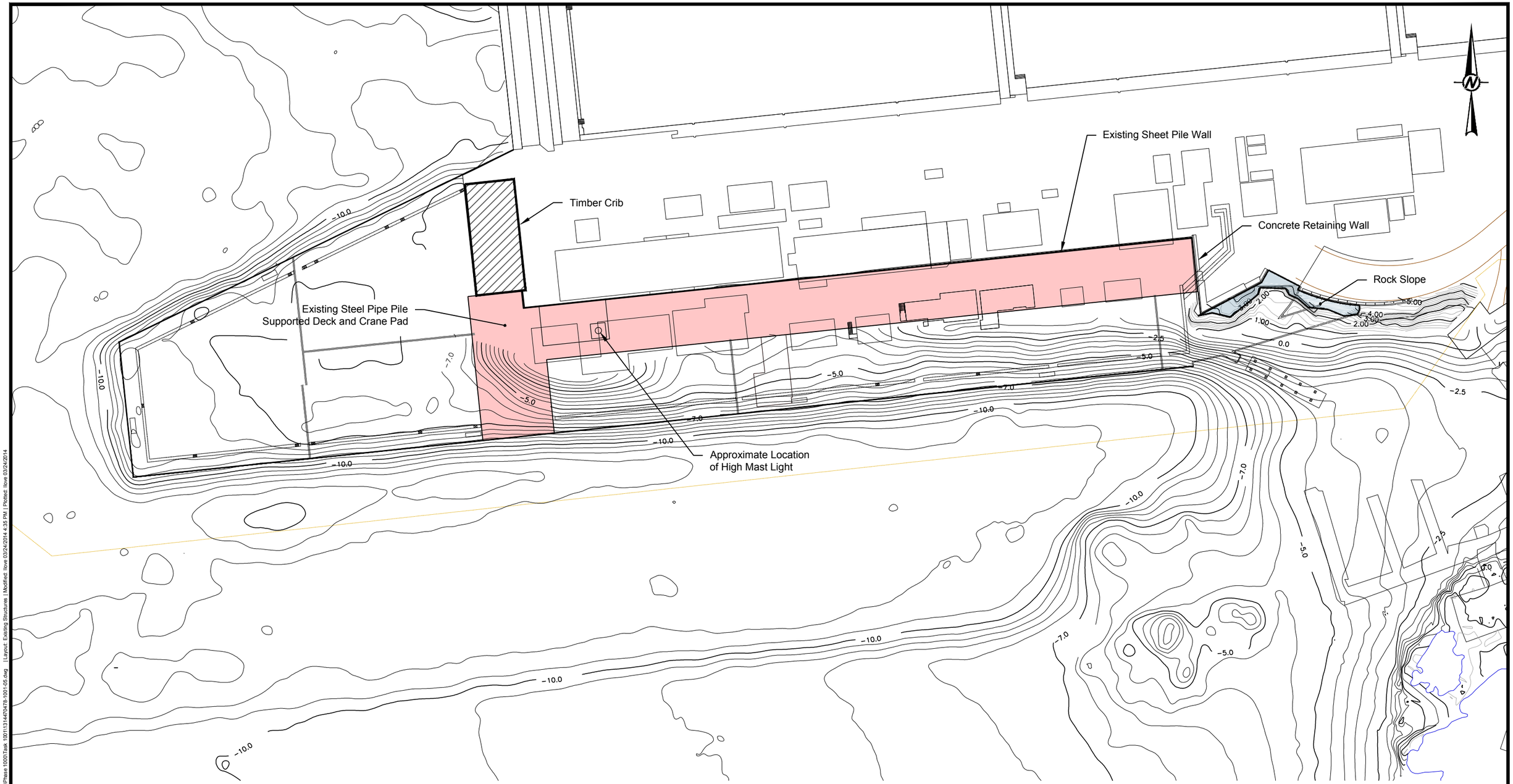
TITLE

STRATIGRAPHIC CROSS-SECTION K - K'

Golder Associates

PROJECT No.	13-1447-0478.1000.1001		FILE No.	1314470478-1001-04k
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN
CADD	AMW	2013-12-09	FIGURE	
CHECK	SEM	2014-03-24		4K
REVIEW	RW	2014-03-24		

\\golder.gds\gal\Burnaby\CAD-GIS\Bur-Graphics\Projects\2013\13-1447-0478\CAD\Phase 1000\Task 1001\1314470478-1001-04k.dwg | Layout: Section K | Modified: ilove 03/24/2014 4:16 PM | Plotted: ilove 03/24/2014



LEGEND

- BATHYMETRY CHART DATUM CONTOUR - MAJOR (5m INTERVALS) CRA CANADA SURVEYS INC. (2009 AND 2010)
- BATHYMETRY CHART DATUM CONTOUR - MINOR (0.5m intervals) CRA CANADA SURVEYS INC. (2009 AND 2010)
- EXISTING TIMBER CRIB
- EXISTING STEEL PILE SUPPORTED JETTY

0 20 40 60
SCALE METRES

REFERENCES

BASE OBTAINED FROM CLIENT.

CRIB LOCATION PROVIDED BY KLOHN CRIPPEN BERGER, CAD FILE: *Existing EGD Timber Jetty Base.dwg*, E-MAILED: AUGUST 9, 2010

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE

SOUTH JETTY
EXISTING STRUCTURES PLAN

Golder Associates

PROJECT No.	13-1447-0478 .1000.1001		FILE No.	1314470478-1001-05	
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN	
CADD	AMW	2013-12-09	FIGURE		
CHECK	SEM	2014-03-24		5	
REVIEW	RW	2014-03-24			

\\golder.gds\gal\Burnaby\CAD-GIS\Bur-Graphics\Projects\2013\1447\13-1447-0478\CAD\Phase 1000\Task 1001\13144704478-1001-05.dwg | Layout: Existing Structures | Modified: ilove 03/24/2014 4:35 PM | Plotted: ilove 03/24/2014

APPENDIX A

Selected Site Photographs

Photograph 1: South Jetty Timber Crib.

Photograph 2: South Jetty Timber Crib.

Photograph 3: Concrete mass surrounding high mast light foundation.

Photograph 4: Rock Slope at east end of South Jetty.

APPENDIX B

Technical Memorandum, Assessment of Existing South Jetty Sheet Pile Wall

TECHNICAL MEMORANDUM

DATE March 27, 2014 **PROJECT No.** 12-1436-0061-25001-001
PWGSC Project # R.018400.001

TO Mr. Andrew Mylly
Public Works and Government Services Canada

CC Dan Berlin (Anchor QEA); Geoff Cooper (Klohn Crippen Berger)

FROM Andrew Van Dyk, Sarah Morse **EMAIL** Andrew_VanDyk@golder.com, Sarah_Morse@golder.com

ESQUIMALT GRAVING DOCK WATERLOT REMEDIATION PROJECT:
STABILITY ASSESSMENT OF THE EXISTING SOUTH JETTY SHEET PILE WALL
INTERIM GEOTECHNICAL INPUT FOR PHASE 2 80% DESIGN

This technical memorandum summarizes Golder Associates Ltd.'s (Golder's) assessment of an existing sheet pile wall to provide geotechnical input for the 80% Phase 2 (South Jetty) remediation design of the Esquimalt Graving Dock (EGD). The geotechnical analyses and preparation of comments and recommendations as input to the overall remediation design have been carried out in accordance with the scope of work submitted to Public Works and Government Services Canada (PWGSC) and as outlined in Golder's work plan titled "*Esquimalt Graving Dock Waterlot Remediation Project: Workplan for Phase 2 80% Remediation Design Support FY2012-2013*", dated February 19, 2013 (Golder Project Reference 11-1436-0061/25000).

1.0 PROJECT BACKGROUND AND SITE DESCRIPTION

The EGD Esquimalt Graving Dock (EGD) Waterlot is located in Skinner Cove, Esquimalt Harbour, BC. Structures associated with the EGD include the Dry Dock, the North Wall and the South Jetty. The South Jetty includes the following structures, also shown on Figure 1:

- sheet pile bulkhead;
- concrete deck supported by pipe piles (south of sheet pile bulkhead);
- concrete deck supported by engineered fill (north of sheet pile bulkhead); and
- temporary sheet pile wall recently installed along the perimeter of the timber pile supported jetty.

PWGSC is implementing a remedial dredging program, to remove sediments within the Waterlot that have been contaminated as a result of historical activities at the EGD facility. Phase 2 of the remediation plan comprises sediment removal at areas west, south and east of the South Jetty. The dredged sediments are planned to be replaced with granular materials and rip-rap armour although the final finished grades and distribution of the replacement materials has not been confirmed at the time of preparation of this memorandum.

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2.0 SCOPE OF WORK

A review of proposed dredging plan adjacent to the bulkhead indicated that, due to the limited embedment of the sheet piles and the adjacent foreshore slope, removal of contaminated submarine sediments could result in potential stability issues during dredging operations. Significant deformations in the bulkhead and associated slope would likely have a detrimental effect on the structures and operating facilities upslope of the bulkhead. As such, Golder was requested to assess the potential effect of dredging operations on the existing sheet pile bulkhead stability and to provide geotechnical engineering recommendations for dredging activities adjacent to the bulkhead.

The geotechnical analyses and preparation of input have been carried out in accordance with the scope of work submitted to Public Works and Government Services Canada (PWGSC) and as outlined in Golder's work plan titled "*Esquimalt Graving Dock Waterlot Remediation Project: Workplan for Phase 2 80% Remediation Design Support FY2012-2013*", dated February 19, 2013 (Golder Project Reference 11-1436-0061/25000).

As part of our scope of work, Golder has conducted the following:

- review of available information regarding subsurface conditions, existing structures, and documents related to the current state of EGD remediation;
- assessment of the existing sheet pile retaining wall stability at selected locations under current conditions including the local and global stability;
- re-assessment of the above sections to develop maximum allowable dredging depths; and
- provision of geotechnical recommendations for dredging procedures.

This technical memorandum provides a summary of the methodology and the results of our assessment followed by geotechnical recommendations for dredging adjacent to the existing sheet pile wall.

In preparation of this technical memorandum, the following documents were reviewed by Golder:

- Golder Associates Ltd. October 4, 2012. (Golder 2012). *Geotechnical Design Input, Report for Open Water Remedial Dredging*.
- Golder Associates Ltd. September 9, 2011. (Golder 2011). *Technical Memorandum, Esquimalt Graving Dock Waterlot Remediation Project: Updated Sheet Pile*.
- Golder Associates Ltd. March 3, 2010. (Golder 2010). *Esquimalt Graving Dock Waterlot Supplementary Test Hole Investigation for Remedial Action Plan and Risk Management Plan*.
- Ker Priestman & Associates Ltd. July 26, 1985. (Ker Priestman 1985). *Esquimalt Graving Dock Improvements, Contract No. 3, Project No. PR100772, Drawing 19 of 75 (as-built)*.
- Klohn Crippen Berger. October 2002. (KCB 2002a). *EGD and SLW Site Investigation*,
- Klohn Crippen Berger. October 2002. (KCB 2002b). *Esquimalt Graving Dock Seismic Evaluation of South Jetty & North Entrance Wall, Final Report*.
- Klohn Crippen Berger. March 13, 2013 (KCB 2013). *Temporary Live Loading on Anchored Sheet Pile Bulkhead Wall Adjacent to South Jetty Structures*.

3.0 BACKGROUND INFORMATION

4.0 OVERVIEW OF SUBSURFACE STRATIGRAPHY

Subsurface soil and groundwater conditions inferred from our review of previous geotechnical reports are summarized below. For geotechnical analysis and discussion purposes, three cross-sections were developed across the South Jetty at the locations shown on Figure 1. The generalized stratigraphy at each cross-section location is represented on Figures 2, 3 and 4. Subsurface conditions at each cross-section have been grouped into the following stratigraphic units (in the order of increasing depth below ground surface) based on physical soil properties and inferred geologic origin:

- **Riprap, Mixed Fills and Marine Sediments**: The existence of riprap was confirmed by review of site photographs and is present in front of the sheet pile retaining wall. The coarse riprap rockfill is mixed with, and underlain by other materials such as unconsolidated marine sediments and mixed fill generally comprising sand and gravel. Riprap rock with mixed fill and sediment was inferred to be 0.9 to 2.1 m thick from available borehole information. Although clear delineation and thickness of the unit is not available, increased riprap thickness is anticipated immediately adjacent to the existing sheet pile bulkhead wall.
- **Mixed Fill**: The imported fill materials are generally composed of sand and gravel mixtures and are present on both sides of the sheet pile bulkhead retaining wall and underlie the concrete slab. The inferred relative density of the material is compact. The mixed fill material thickness varies with location behind the sheet pile wall as shown in the cross sections and discussed in the following sections.
- **Upper Marine Sediments**: The upper portion of this layer consists of soft to firm mixtures of silt, clay and fine sand typically ranging from silty clay to clayey silt to sandy silt. The deposits also contain varying quantities of shells and minor organic content. The upper portion of the marine sediments has been interpreted to be Holocene deposits of “Marine mud”. The lower portion of the marine deposits consist of loose to compact granular marine sediments ranging in composition from silty sand to silty sand which also contains varying quantities of shells. These have been inferred to be beach deposits derived from erosion of exposed glacial deposits.
- **Glaciomarine Sediments (Victoria Clay)**: Glaciomarine sediments known locally as *Victoria Clay* are composed of firm to stiff silty clay with minor sand and gravel. A stiff crust of brown to mottled grey and brown silty clay was observed in some, but not all of the test holes.
- **Glacial Soils (Till)**: Glacial till in this area consists of dense to very dense silt and sand with slightly plastic fines. These deposits are discontinuous and generally less than a few meters thick. The till deposits are typically underlain by bedrock. They are inferred to represent part of the Vashon Drift formation.

Limited available data suggests that groundwater behind the sheet pile wall is closely related to fluctuating tide levels.

5.0 EXISTING SHEET PILE BULKHEAD WALL

Golder reviewed the sheet pile bulkhead wall drawings prepared by Ker Priestman. The drawings indicate that the 189 m long bulkhead is separated into three sections of varying depths. Tie-backs are shown below the top of the sheet piles and connect the bulkhead to a deadman anchor, typically located approximately 15.4 m behind (north of) the sheet pile facing. The elevation of the tie-back anchors is approximately 4.0 m chart datum. Overlying the mixed fills and natural soils, a reinforced concrete slab 350 mm thick is founded on the backfill supported by the bulkhead.

The Ker Priestman drawings indicate that the bulkhead was constructed using CASTEEL K141Z sections, which has a section modulus of approximately 2100 cm^3/m. The steel grade was not provided in the Ker Priestman drawings; however, it is understood that the grade of sheet piles fabricated for general use in United States is A 328 (a yield grade of about 270 MPa), such that the estimated elastic bending moment capacity of the sheet pile is approximately 567 kN-m/m. Based on Allowable Stress Design methodology, the maximum working capacity of the sheet piling is approximately 340 kN-m/m. Correspondence with KCB has indicated that the tie-back anchor rods have a yield capacity of 54 kN per bar. At 80% of yield strength, the tie-backs are assumed to have a capacity of about 43 kN per metre length of wall. We have also assumed that corrosion loss has not compromised the strength of the tie rods below the strengths given herein. KCB (2013) recommended that stability analysis of the sheet pile bulkhead should consider a uniformly distributed 6 kN/m^2 surcharge to allow for the impact of existing structures.

The three existing wall segments are described below as represented by the cross-sections shown on Figures 2, 3 and 4.

5.1 West Wall Segment

The west wall segment, represented as Section D-D' on Figure 2, is approximately 44 m in length, including a 4.9 m section of west-facing bulkhead wall. This wall section consists of sheet piles 6.1 m in length with tip elevation at -1.5 m. Available data indicates that the soil stratigraphy in front of the bulkhead comprises riprap and upper marine sediments overlying sand and gravel fill. The sand and gravel fill is inferred to extend some 10 m beneath the sheet pile at this location, followed by about 1.7 m of marine sediments overlying Victoria Clay. Ground surface in front of the wall has a maximum estimated elevation of +3.9 m. The slope dips away from the sheet piling at approximately 5 degrees (all slope angles reference a horizontal datum) for a horizontal distance of about 12 m after which the slope increases to about 26 degrees, until flattening near elevation -13 m. The material retained by the sheet pile is inferred to consist predominantly of sand and gravel fills overlying the Victoria Clay.

5.2 Middle Wall Segment

The middle wall segment, represented as Section K-K' on Figure 3, is approximately 132 m in length, consisting of piles 9.1 m in length with tip elevations at -4.5 m. Available data indicates that the soil stratigraphy in front of the sheet piles comprises riprap and upper marine sediments overlying Victoria Clay. Fill is inferred to extend some 2 m beneath the sheet pile at this location, followed by about 4.5 m of marine sediments above Victoria Clay. Ground surface in front of the wall has a maximum estimated elevation of about +2.1 m. The slope dips away from the sheet piling at approximately 2 degrees for about 6 horizontal metres after which the slope

increases to about 18 degrees until flattening near elevation -13 m. The 18-degree slope has two intermediate benches about 2 m wide near elevations +0.5 and -1.5 m. The material retained by the sheet pile wall is inferred to consist of sand and gravel fill.

5.3 East Wall Segment

The east wall segment, represented as Section E-E' on Figure 4, is approximately 12.8 m in length, consisting of piles 6.1 m in length with tip elevations of -1.5 m. However, dredging restrictions adjacent to structures located at the east end of the east wall segment limit the lateral extent of dredging to approximately 9.8 m for this segment. Available data indicates that the soil stratigraphy in front of the sheet piles comprises riprap and overlying sand and gravel fill. The fill is inferred to extend approximately 3 m beneath the sheet pile at this location followed by Victoria Clay. The ground surface in front of the wall has a maximum estimated elevation of about +2.0 m. The slope dips away from the sheet piling at an average 5 degrees for about 22 horizontal metres after which the slope increases to about 22 degrees until flattening near elevation -13 m. The material retained by the sheet pile wall is inferred to consist of sand and gravel fill.

6.0 GEOTECHNICAL ASSESSMENT

6.1 Methodology

Golder analyzed the external bulkhead stability and global slope stability based on the three cross-sections shown on Figures 2, 3 and 4 and inferred soil parameters discussed below. The models were adapted to reflect high, mean and low tide water levels as well as and the target dredging slope profiles suggested by Anchor QEA.

External bulkhead stability analysis included evaluation of lateral and rotational stability using the *Free Earth Support* design method for anchored flexible wall systems. This approach assumes that the upper portion of the pile is essentially restrained from horizontal movement by an anchor while the toe of the wall is free to rotate about the anchor location. Moment equilibrium is resolved by summing the moments about the anchor location. Likewise, horizontal forces are summed over the wall height. The anchor load is determined by the net horizontal force where moment equilibrium is achieved. Bending moments acting over the full sheet pile length were also calculated and compared to the yield capacity of the pile. The minimum factor of safety adopted for overturning and force equilibrium is 1.3 for temporary (dredging) conditions. This is consistent with the temporary safety factors adopted for design of the South Jetty sheet pile containment wall which was accepted by PWCGS and the consulting team for feasibility purposes. The interface friction angle between the granular materials and steel sheet pile was selected as 60% of the peak friction angle.

Global stability analysis was carried out using the computer software program Slope/W 2007. The Morgenstern-Price limit equilibrium method was selected to calculate the global stability analyses for each slope section. A factor of safety greater than 1.5 was considered suitable for long-term conditions whereas 1.3 was assumed to be acceptable for short-term conditions during dredging. Slope profiles represented by cross-sections shown on Figures 2, 3 and 4 were considered typical of the site conditions although actual ground surface topography varies along the bulkhead. Pile tip elevations were assumed to be constant within each wall segment.

The following assumptions were used in our analyses:

- Unconsolidated Sediments over the upper slope areas are mixed with riprap.
- The combination of dredge cut, over-dredge depth, and scour will not exceed the recommended removal thickness or slope profiles as shown in the sections.
- The yield strength of the tie-rod was considered as the limiting condition in the global stability analysis. A factored capacity of 80% yield strength was considered as the limiting strength for the external sheet pile stability analyses.
- Existing steel pipe piles located within the steel pipe pile supported concrete deck area shown on Figure 1 will likely provide some additional resistance to global slope instability, and to lateral and rotational instability of the sheet piles. However, this resistance was not considered to be consistent over the length of the sheet pile wall and has therefore been excluded from our analysis (a conservative assumption).
- Forces due to water suction on the surface of sheet pile wall were not considered.
- Seismic loading conditions have not been considered in these stability analyses due to the temporary natural of the remediation operation.

6.2 Material Strength Parameters

A summary of the inferred soil properties used in the assessment is provided in Table 1. Material strength parameters were selected based on our interpretation of field and lab tests conducted by Golder, KCB and others at the EGD site.

Table 1: Inferred Soil Strength and Unit Weight and Model Parameters

Material Description	Unit Weight (kN/m³)	Model Parameters
Riprap, Mixed Fill and Marine Sediments	17.3	Drained: ϕ'=33°, c'=0 kPa;
Mixed Fill (sand and gravel)	18.0	Drained: ϕ'=35°, c'=0 kPa;
Upper Marine Sediments	17.3	Drained: ϕ'=33°, c'=0 kPa;
Victoria Clay	18.7	Undrained: varies, see below
Glacial Till	22.0	Drained: ϕ'=35°, c'=35 kPa;
Capping Materials: Filter and Armour rock	22.0	Drained: ϕ'=40°
Concrete slab	24.0	Drained: ϕ'=35°

Undrained strength for Victoria clay was estimated using undrained shear strength plots derived from CPT interpretations. We assumed a N_{kt} factor of 13 in our CPT-derived undrained shear strength interpretations based on our experience on this project and others in the vicinity. Undrained strength profiles of the Victoria clay were different at each cross-section location prompting development of a different model of the strength profile in the stability analyses for the individual cross-sections:

- Section D-D' used a minimum undrained shear strength of 55 kPa, increasing with depth at a rate of 1.5 kPa/m. Section D-D' was the only cross-section where the Victoria clay was capped by a stiff crust. This stiff crust was modelled as a layer with uniform strength not exceeding 55 kPa for a thickness of about 4.5 m.

- Section K-K' used a minimum undrained shear strength of 55 kPa, increasing with depth at a rate of 2.0 kPa/m.
- Section E-E' used a minimum undrained shear strength of 55 kPa, increasing with depth at a rate of 2.0 kPa/m.

6.3 Tidal and Groundwater Conditions

Limited available data suggests that the groundwater behind the sheet pile wall is closely related to fluctuating tide levels. For the assessment presented below, the high water level was taken at El. 3.4 m (Chart Datum), Higher High Water Large Tide, with the low tide taken at El. 0.0 m (Chart Datum), Lower Low Water Large Tide. Where tidal water was directly against the sheet pile, a maximum lag height between the tidal level and adjacent groundwater level behind the piling was assumed to be 0.1 m at both high and low tides, with a maximum lag of 0.5 m occurring at the mean water level at El. 1.9 m. Where tidal levels intersected the existing or temporary slopes, a maximum lag of about 0.5 m was assumed between the shoreline and the end of the model geometry.

7.0 GEOTECHNICAL ANALYSIS RESULTS

Global stability analysis results are provided on Figures 2, 3 and 4. Results for each wall segment are summarized below.

7.1 Western Wall Segment (Section D-D')

The external bulkhead and global slope stability analysis results for Section D-D' are summarized in Table 2. Proposed post-dredge conditions consider removal of materials adjacent to the sheet piling to minimum Chart Datum El. +3.0 m followed by a dredged slope not steeper than 2 horizontal to 1 vertical extending to an inflection point near elevation -5.1 m, after which the slope flattens to 3 horizontal to 1 vertical until the dredge slope encounters the containment wall near the toe of the slope. Table 2 presents a comparison of the results of the dredged profile analyses to those calculated for the existing slope configuration.

Table 2: Summary of Local and Global Analysis Safety Factors for Section 'D-D'

	Ground Profile	High Tide	Low Tide	Mean Tide
Calculated Minimum Factor of Safety for Global Stability	Existing	1.88	1.57	1.73
Calculated Rotational Factor of Safety for External sheet pile stability	Existing	>5	>5	>5
Calculated Shear Factor of Safety for External sheet pile stability	Existing	>5	>5	>5
Pile bending moment (kN-m/m)	Existing	<340	<340	<340
Anchor Tensile Load (kN/m)	Existing	<43	<43	<43
Calculated Minimum Factor of Safety for Global Stability	Temporary	1.53	1.39	1.45
Calculated Rotational Factor of Safety for External sheet pile stability	Temporary	1.53	3.23	1.96

	Ground Profile	High Tide	Low Tide	Mean Tide
Calculated Shear Factor of Safety for External sheet pile stability	Temporary	1.42	2.82	1.83
Pile bending moment (kN-m/m)	Temporary	4.73	2.53	2.54
Anchor Tensile Load (kN/m)	Temporary	15.05	12.83	12.85

Calculated factors of safety for external and global slope stability for both the existing and temporary dredging conditions satisfy the targeted factors of safety. The calculated maximum pile bending moment was less than the estimated working moment capacity and the calculated anchor tensile load was less than the interpreted working capacity of the steel tie rods.

7.2 Centre Wall Segment (Cross Section K-K')

The local and global stability analysis results for Section K-K' are summarized in Table 3. Proposed post-dredge conditions consider removal of materials adjacent to the sheet piling to minimum Chart Datum El. +0.6 m followed by a dredge slope dipping at 3 horizontal to 1 vertical, as well as two near-horizontal intermediate benches 5 and 7 m wide near elevations -1. 5 m and -4.5 m, after which the dredged slope parallels the original slope until meeting the containment wall. The results of the dredged profile analyses are compared with the calculated results for the existing slope configuration.

Table 3: Summary of Local and Global Analysis Results for Section K-K'

	Ground Profile	High Tide	Low Tide	Mean Tide
Calculated Minimum Factor of Safety for Global Stability	Existing	2.34	2.07	2.19
Calculated Rotational Factor of Safety for External sheet pile stability	Existing	2.60	4.75	2.82
Calculated Shear Factor of Safety for External sheet pile stability	Existing	2.41	4.6	2.66
Pile bending moment (kN-m/m)	Existing	8.59	7.43	8.58
Anchor Tensile Load (kN/m)	Existing	18.09	17.17	18.03
Calculated Minimum Factor of Safety for Global Stability	Temporary	1.75	1.56	1.61
Calculated Rotational Factor of Safety for External sheet pile stability	Temporary	1.59	2.03	1.57
Calculated Shear Factor of Safety for External sheet pile stability	Temporary	1.45	1.81	1.43
Pile bending moment (kN-m/m)	Temporary	40.71	43.51	61.15
Anchor Tensile Load (kN/m)	Temporary	34.57	35.98	43.1

Calculated factors of safety for external and global slope stability for both the existing and temporary dredge conditions satisfy the targeted factors of safety. The calculated maximum pile bending moment is less than the estimated working moment capacity and the calculated anchor tensile load was at or less than the interpreted working capacity of the steel tie rods.

7.3 East Wall Segment (Cross Section E-E')

The external bulkhead and global stability analysis results for Section E-E' are summarized in Table 4. Proposed post-dredge conditions consider removal of materials adjacent to the sheet piling to minimum Chart Datum El. +1.3 m, including over-dredge allowance, dipping at 3 horizontal to 1 vertical with two gently sloping intermediate benches about 6 to 7 m wide near elevations -0.5 and 4.0 m. The results of the dredged profile stability analyses are compared with the calculated results for the existing slope configuration.

Table 4: Summary of Local and Global Analysis Results for Section E-E'

	Ground Profile	High Tide	Low Tide	Mean Tide
Calculated Minimum Factor of Safety for Global Stability	Existing	2.70	2.29	2.52
Calculated Rotational Factor of Safety for External sheet pile stability	Existing	2.13	5.07	2.30
Calculated Shear Factor of Safety for External sheet pile stability	Existing	1.87	4.10	2.01
Pile bending moment (kN-m/m)	Existing	10.48	9.10	12.16
Anchor Tensile Load (kN/m)	Existing	19.54	18.52	20.63
Calculated Minimum Factor of Safety for Global Stability	Temporary	1.68	1.53	1.52
Calculated Rotational Factor of Safety for External sheet pile stability	Temporary	1.27	2.17	1.71
Calculated Shear Factor of Safety for External sheet pile stability	Temporary	1.19	1.82	1.12
Pile bending moment (kN-m/m)	Temporary	21.6	19.8	33.4
Anchor Tensile Load (kN/m)	Temporary	25.5	24.7	31.3

The stability of this wall segment is controlled by the external bulkhead stability force and moment factors of safety which indicate marginally stable conditions at low tide and high tide. Calculated factors of safety for global slope stability at the existing and temporary dredge conditions satisfied the recommended minimum factor of safety.

8.0 RECOMMENDATIONS

8.1 Suitability of the proposed dredged slope profiles

Proposed dredge slopes have been presented on Figures 2, 3, and 4 and are summarized in the opening paragraphs of Sections 7.1, 7.2 and 7.3 above. Stability analyses of the dredged slopes as currently proposed and based on the design parameters presented herein, indicated that dredging as proposed can be carried out while meeting the minimum factors of safety except for the length of wall modelled as Section E-E. For this area, it is recommended that the dredged slope is backfilled immediately after dredging so that the dredged slope length (measured from undredged slope to the leading edge of the backfill) does not exceed 3 m. This treatment must be completed for dredging operations within 20 m horizontal distance of the sheet pile wall. Alternatively, shallower dredging depths and flatter dredge slopes may be considered for this limited section of wall.

The suitability of these slope profiles and the recommendations provided herein are based on the design assumptions contained in this memorandum, such as structural capacity of steel components, surcharge loads behind the bulkhead and subsurface soil conditions and profiles as well as maximum dredge depths as described above. Performance of the dredged slope and the bulkhead will depend on confirmation that actual conditions are in agreement with these assumptions. Where such conditions cannot be met, Golder should be permitted to reassess and revise the recommendations contained herein.

8.2 Dredge slope cuts

Dredging depths, including over-dredge and scour, should not extend deeper than as shown on the proposed dredge profiles shown on Figures 2, 3 and 4. Dredging beyond these limits could lead to excessive local displacement of the sheet pile wall and/or global slope instability. Dredging should be carried out in a manner to minimize scour where possible, particularly within 20 m of the sheet pile bulkhead.

Where incremental excavation is recommended above (i.e., short dredge lengths followed by backfilling to limit dredged length to less than 3 m), or where dredging (plus scour) is expected to extend below the suggested dredged slope profiles, consideration could be given to conducting the dredging works using slot-cuts. Slot cuts could occur as 3 m to maximum 5 m wide (base width) slots or trenches perpendicular to the sheet pile wall with backfilling to occur immediately following dredging. Careful consideration will be required when developing a methodology for slot-cut implementation to limit re-contamination of a completed slot when dredging in the adjacent slot as well as deformation and/or displacement of the adjacent facilities. More than one slot on the slope can be excavated simultaneously provided they are no closer than three slot widths apart.

Weak unconsolidated marine sediments may exist at some locations under the riprap, near the sheet pile, or in the lower portion of the slopes. Golder should be informed when extensive unconsolidated marine sediments are encountered to re-assess the recommendations provided in this technical memorandum.

8.3 Capping

We understand that Anchor is designing a cap for the dredged slope surface which will comprise armour stone and filter material. As it relates to the long-term stability of the existing sheet pile wall, the final capped slope can be graded to a slope that is consistent with the pre-dredged slope using the above-described materials to achieve the recommended long-term stability criterion. Stability of the wall under seismic loading was not assessed.

Capping materials should be placed on the dredged slope as soon after dredging as possible, without causing cross-contamination with in situ sediments to reduce potential for excessive scour.

8.4 Slope Monitoring

Slopes should be surveyed before dredging to confirm the slope configurations used in this assessment. We recommend that Golder be retained to review the survey data and, where deviations are noted, to re-assess the stability of the slope and bulkhead.

It is recommended that suitable slope and wall monitoring be implemented both during and after dredging work as the above analyses is based on interpretation between broadly spaced test hole information within the South Jetty area. The analysis presented herein has indicated that both the global and local stability models are sensitive to variation in the soil properties, slope geometry and cyclic tidal/groundwater levels. The methodology, frequency and areal extent of the monitoring program should be considered and reviewed for adequacy prior to initiating the dredging works. Ideally, a tolerance level for lateral/vertical movements of the sheet pile bulkhead should be established prior to the commencement of the remediation works, and utilized as control criteria during regular review and assessment of recorded wall movements during the course of the remediation works. In the event that the selected displacement tolerances are being approached due to the dredging works, updated procedures for dredging and/or modification of the dredge profile should be undertaken to limit further displacements to within the designated tolerances.

If slope movements are observed, such as localized sloughing, dredging work should be immediately halted and the slope stabilized until Golder has had opportunity to review the slope condition and provide recommendations for further stabilization and mitigation measures, if and where required.

The final slope bathymetry should be surveyed upon completion of both dredging and the subsequent slope capping. This information can be used as a baseline for subsequent surveys to confirm that final slope dressing is performing as expected.

9.0 CLOSURE

We trust that the information contained in this technical memorandum is suitable for your current needs. Please do not hesitate to contact us if you require further information.

GOLDER ASSOCIATES LTD.

Andrew Van Dyk, P.Eng.
Geotechnical Engineer

Sarah Morse, P.Eng., P.M.P.
Geotechnical Engineer

Reviewed by:

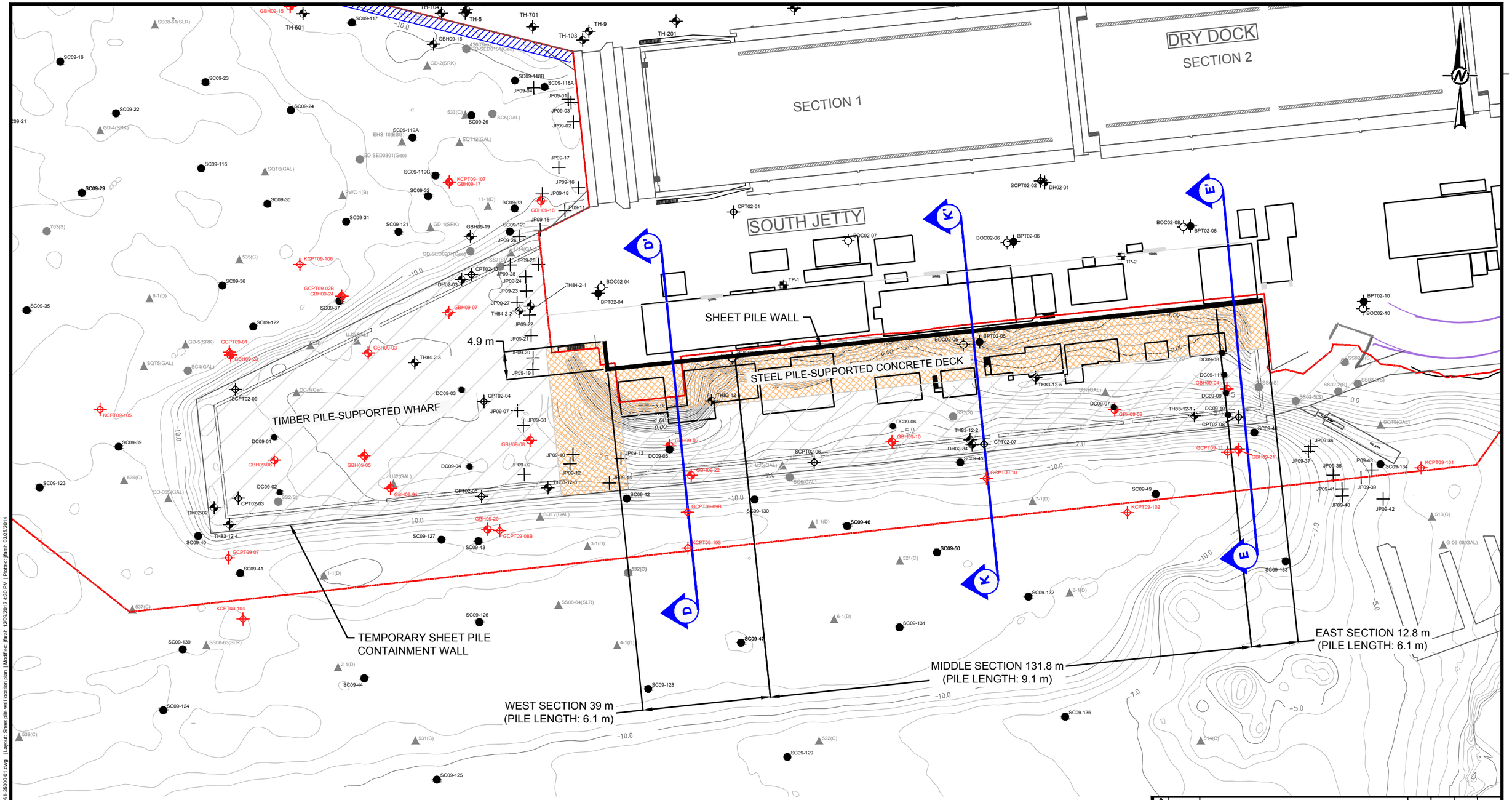
Randy Williams, P.Eng.
Principal, Senior Geotechnical Engineer

R.C. Butler, P.Eng.
Principal, Senior Geotechnical Engineer

AVD/SEM/RW/RCB/asd

Attachments: Figure 1 – Sheet Pile Wall Location Plan and Dredge Thickness Recommendations
Figure 2 – Global Slope Stability Section D-D'
Figure 3 – Global Slope Stability Section K-K'
Figure 4 – Global Slope Stability Section E-E'

o:\final\2011\1436\11-1436-0061\phase 25000\pwgsc-egd-wl-ph2 80 percent geotech 13-14 golder 20140327\pwgsc-egd-wl-ph2 80 percent geotech 13-14 golder 20140327.doc



LEGEND

- GBH09-xx — SONIC OR MUD ROTARY BOREHOLE (BY GOLDER 2009)
- GCPT09-xx / KCPT09-xx — CONE PENETRATION TEST (BY GOLDER 2009)
- SC09-xx / DC09-xx — SEDIMENT CORE AND DIVER CORE (BY GOLDER 2009)
- JP09-xx — JET PROBE (BY GOLDER 2009)
- TH-xx — TESTHOLES (BY HARDY ASSOCIATES)
- BPT01-xx — BECKER PENETRATION TEST (BY GOLDER 2001)
- BPT02-xx — BECKER PENETRATION TEST (BY KLOHN CRIPPEN 2002)
- BOC01-xx — BECKER OPEN HOLE (BY GOLDER 2001)
- BOC02-xx — BECKER OPEN HOLE (BY KLOHN CRIPPEN 2002)
- AH02-01 — HOLLOW-STEM AUGER HOLE (BY GOLDER 2001)
- DH02-01 — MUD ROTARY BOREHOLE (BY KLOHN CRIPPEN 2002)
- SCPT02-xx / CPT02-xx — CONE PENETRATION TEST (BY KLOHN CRIPPEN 2002)
- APPROXIMATE AREA OF TIMBER PILING UNDER JETTY
- APPROXIMATE AREA OF STEEL PILE-SUPPORTED CONCRETE DECK
- CROSS SECTION LOCATIONS
- WATERLOT BOUNDARY

NOTES

1. BATHYMETRY CONTOURS (0.5M INTERVALS) PROVIDED BY CRA SURVEYS, 2011. ELEVATIONS (IN METRES) REFERENCED TO CHART DATUM.
2. TOPOGRAPHIC CONTOURS (0.25M INTERVALS) PROVIDED BY FOCUS CORPORATION, 2011. ELEVATIONS (IN METRES) REFERENCED TO CHART DATUM.
3. DRAWING BASE INFORMATION PROVIDED BY PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

0 20 40 60
SCALE METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-25	REVISED SECTION E LOCATION	AVD	JEF	AVD	RW

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
GEOTECHNICAL INVESTIGATION
ESQUIMALT GRAVING DOCK, ESQUIMALT, B.C.

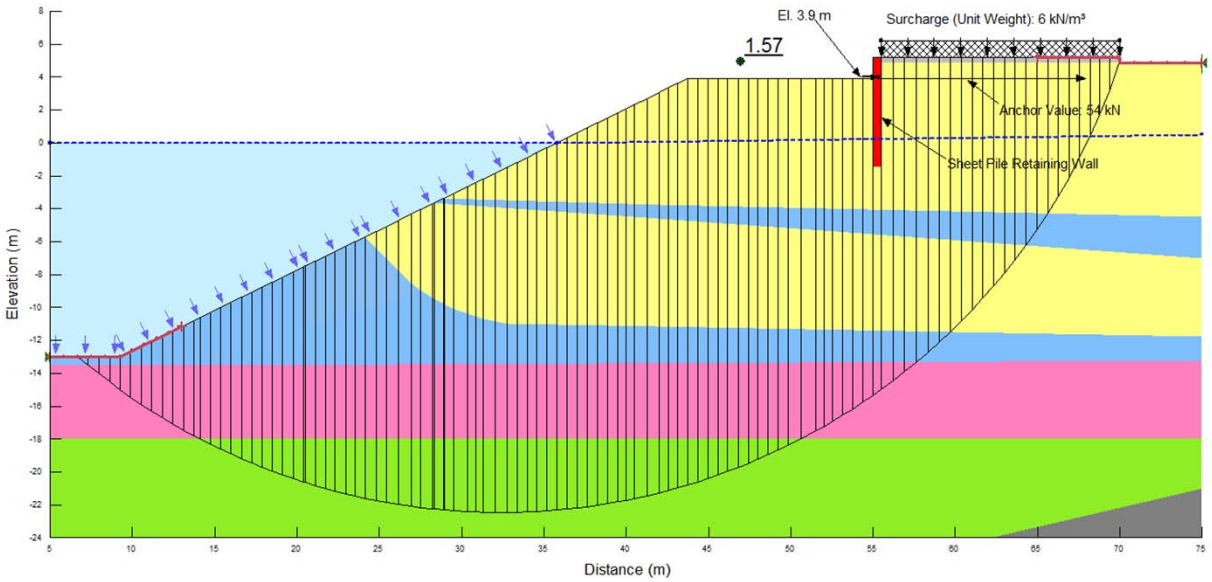
TITLE
SHEET PILE WALL LOCATION PLAN AND DREDGE THICKNESS RECOMMENDATIONS

Golder Associates

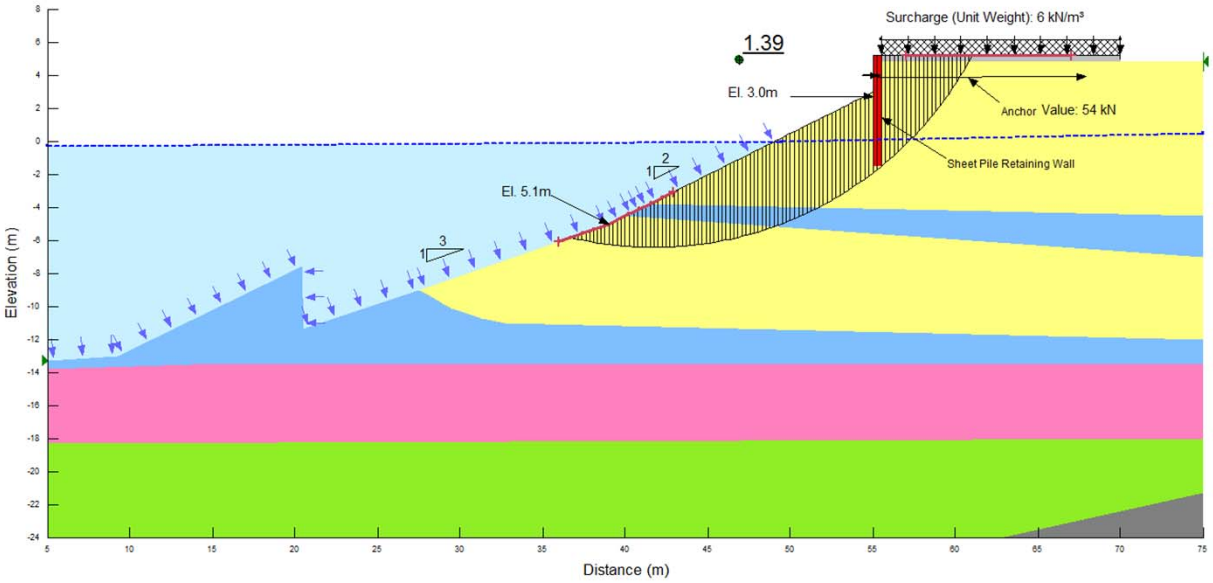
PROJECT No.	11-1436-0061.25000		FILE No.	1114360061-25000-01
DESIGN	MR	2013-04-12	SCALE	AS SHOWN
CADD	JEF	2013-04-15	FIGURE	1
CHECK	AVD	2013-12-09		
REVIEW	RWW	2013-12-09		

B:\Bur-Graphics\Projects\2011\1436\11-1436-0061\CAD\Phase 25000\1114360061-25000-01.dwg | Layout: Sheet pile wall location plan | Modified: jfarah 12/09/2013 4:30 PM | Plotted: jfarah 03/25/2014

Current Condition (critical at low tide)



Proposed Dredged Condition (critical at low tide)



Elevations are relative to chart datum.

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
ASSESSMENT OF EXISTING SOUTH JETTY SHEET PILE WALL
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

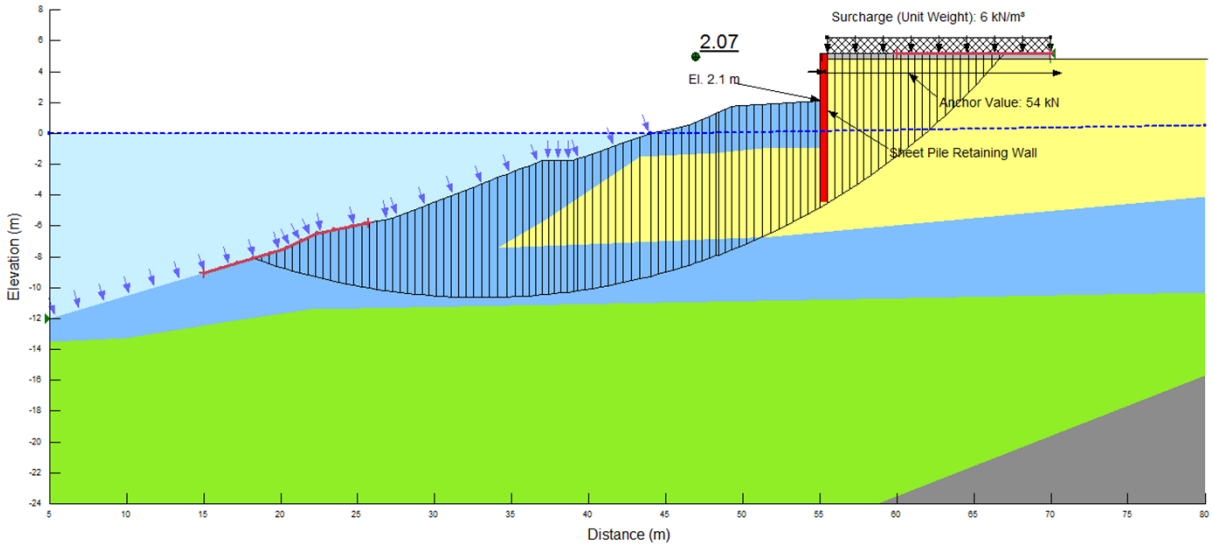
TITLE
Global Slope Stability
Section D-D'

Golder Associates

PROJECT No. 11-1436-0061/25000			FILE No.	-----
DESIGN	4DEC2013	AVD	SCALE	NTS
CADD	4DEC2013	AVD	FIGURE	2
CHECK	4DEC2013	AVD		
REVIEW	4DEC2013	RRW		

FILE: O:\Final\2011\1436\11-1436-0061\Phase 25000\PWGSC-EGD-WL-Ph2 80 Percent Geotech 13-14 Golder 20140327

Current Condition (critical at low tide)



Unconsolidated Marine Sediments

Sand and Gravel Fill

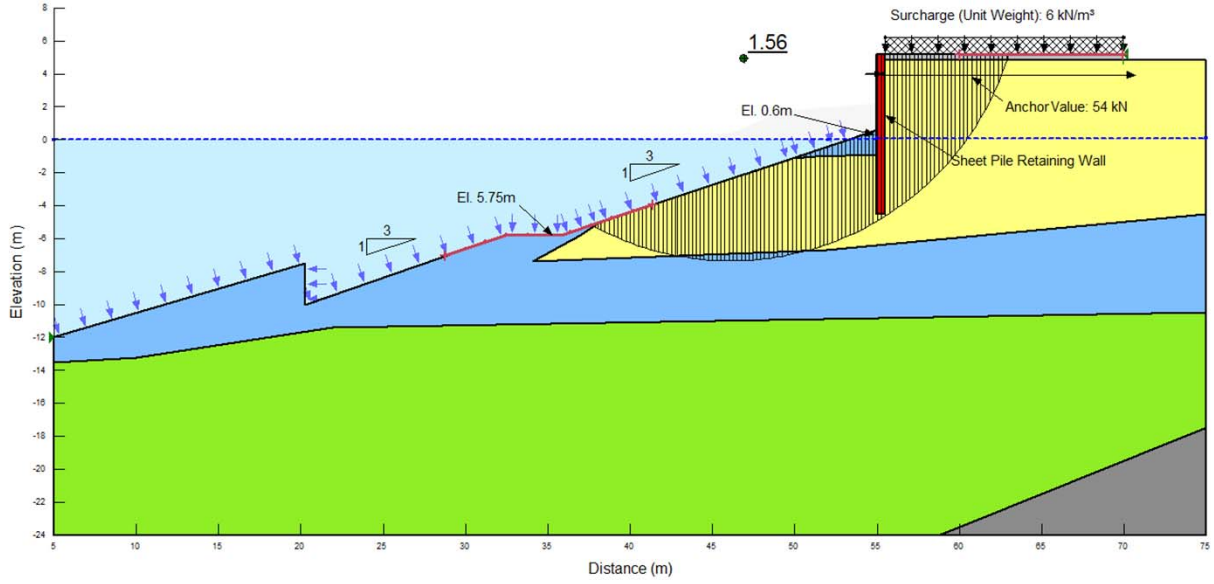
Victoria Clay (desiccated crust)

Victoria Clay (undrained)

Victoria Clay (drained)

Glacial Till

Proposed Dredged Condition (critical at low tide)



Elevations are relative to chart datum.

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
ASSESSMENT OF EXISTING SOUTH JETTY SHEET PILE WALL
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

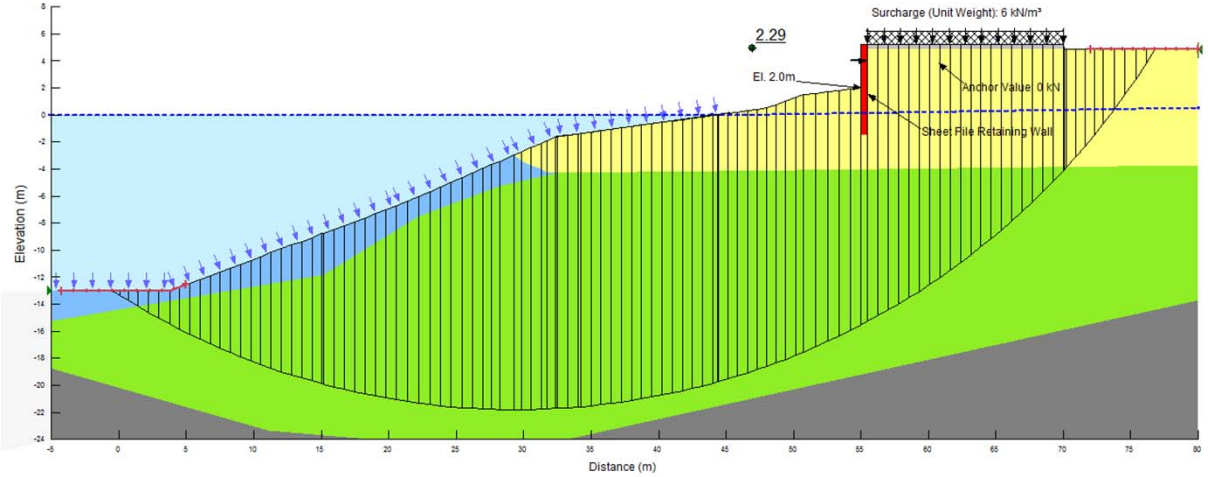
TITLE

Global Slope Stability
Section K-K'

Golder Associates

PROJECT No.	11-1436-0061/25000		FILE No.	-----
DESIGN	4DEC2013	AVD	SCALE	NTS
CADD	4DEC2013	AVD	FIGURE	3
CHECK	4DEC2013	AVD		
REVIEW	4DEC2013	RRW		

Current Condition (critical at low tide)



Unconsolidated Marine Sediments

Sand and Gravel Fill

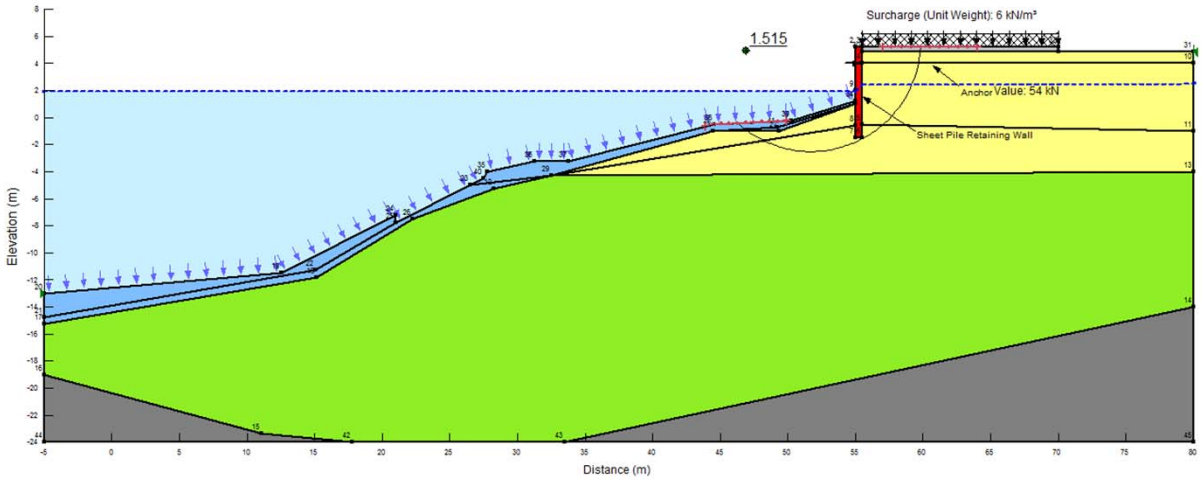
Victoria Clay (desiccated crust)

Victoria Clay (undrained)

Victoria Clay (drained)

Glacial Till

Proposed Dredged Condition (critical at mean tide)



Elevations are relative to chart datum.

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
ASSESSMENT OF EXISTING SOUTH JETTY SHEET PILE WALL
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

Global Slope Stability
Section E-E'

Golder Associates

PROJECT No.	11-1436-0061/25000		FILE No.	-----
DESIGN	4DEC2013	AVD	SCALE	NTS
CADD	4DEC2013	AVD	FIGURE	4
CHECK	4DEC2013	AVD		
REVIEW	4DEC2013	RRW		

APPENDIX C

East Retaining Wall Report

TECHNICAL MEMORANDUM

DATE March 25, 2014 **PROJECT No.** 13-1447-0478-1002-001
PWGSC Project # R.018400.001

TO Mr. Andrew Mylly
Public Works and Government Services Canada

CC Dan Berlin (Anchor QEA); Geoff Cooper (Klohn Crippen Berger)

FROM Sarah Morse, P.Eng., P.M.P. **EMAIL** smorse@golder.com

ESQUIMALT GRAVING DOCK WATERLOT REMEDIATION PROJECT:
STABILITY ASSESSMENT OF NEW EAST END RETAINING WALL

This technical memorandum summarizes Golder Associates Ltd.'s (Golder's) assessment of a proposed retaining wall at the east end of the South Jetty as part of the 99% South Jetty Integration. The geotechnical analyses and preparation of comments and recommendations as input to the overall remediation design have been carried out in accordance with the scope of work submitted to Public Works and Government Services Canada (PWGSC) and as outlined in Golder's work plan titled "*Esquimalt Graving Dock Waterlot Remediation Project: Revised Workplan for Phase 2 99% Under-Pier Remediation Support FY2013-2014*", dated December 2, 2013 (Golder Project Reference P3-1447-0478).

1.0 PROJECT BACKGROUND AND SITE DESCRIPTION

The EGD Esquimalt Graving Dock (EGD) Waterlot is located in Skinner Cove, Esquimalt Harbour, BC. PWGSC is implementing a remedial dredging program to remove sediments within the Waterlot that have been contaminated as a result of historical activities at the EGD facility. Phase 2 of the remediation plan comprises sediment removal areas along the west, south and east perimeters of the South Jetty. The dredged sediments are planned to be replaced with granular materials and rip-rap armour although the final finished grades and distribution of the replacement materials has not been confirmed at the time of this writing.

2.0 SCOPE OF WORK

A new retaining wall has been incorporated into the east approach of the South Jetty as part of the new South Jetty design. It is assumed that this retaining wall would be constructed after dredging, but prior to placement of the capping material associated with the Phase 2 Esquimalt Graving Dock Remediation dredging. As such, Golder was requested to assess the global stability of the retaining wall during remediation activities.

This technical memorandum provides a summary of the methodology and the results of our assessment followed by geotechnical recommendations for dredging adjacent to the proposed retaining wall.

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3.0 OVERVIEW OF SUBSURFACE STRATIGRAPHY

Subsurface soil and groundwater conditions inferred from our review of previous geotechnical reports are summarized below. For geotechnical analysis and discussion purposes, subsurface conditions have been grouped into the following stratigraphic units (in the order of increasing depth below ground surface) based on physical soil properties and inferred geologic origin:

- **Mixed Fill**: The imported fill materials are generally composed of sand and gravel mixtures and are present on both sides of the proposed retaining wall. The inferred relative density of the material is compact.
- **Upper Marine Sediments**: The upper portion of this layer consists of soft to firm mixtures of silt, clay and fine sand typically ranging from silty clay to clayey silt to sandy silt. The deposits also contain varying quantities of shells and minor organic content. The upper portion of the marine sediments has been interpreted to be Holocene deposits of “Marine mud”. The lower portion of the marine deposits consist of loose to compact granular marine sediments ranging in composition from silty sand to silty sand which also contains varying quantities of shells. These have been inferred to be beach deposits derived from erosion of exposed glacial deposits.
- **Glaciomarine Sediments (Victoria Clay)**: Glaciomarine sediments known locally as *Victoria Clay* are composed of firm to stiff silty clay with minor sand and gravel. A stiff crust of brown to mottled grey and brown silty clay was observed in some, but not all of the test holes.
- **Glacial Soils (Till)**: Glacial till in this area consists of dense to very dense silt and sand with slightly plastic fines. These deposits are discontinuous and generally less than a few metres thick. The till deposits are typically underlain by bedrock. They are inferred to represent part of the Vashon Drift formation.

4.0 PROPOSED RETAINING WALL

A new retaining wall is proposed to be incorporated into the east approach of the South Jetty as part of the South Jetty Wharf Redevelopment design being prepared by Klohn Crippen Berger (KCB). The proposed configuration of the new retaining wall is shown on KCB Drawing S141, provided in Attachment 1. Proposed dredging and capping profiles are also shown on drawing S141. Our stability assessment is based on the retaining wall, dredge and capping geometries indicated on drawing S141, and those provided in the Anchor QEA Preliminary 99% South Jetty Wharf Development drawings C21, C23, C26, and C30 which are provided in Attachment 2.

5.0 GEOTECHNICAL ASSESSMENT

5.1 Methodology

Golder has carried out a global stability analysis of the proposed retaining wall based on the available geotechnical information, the retaining wall configuration provided by Klohn Crippen Berger, and the proposed dredge and capping profiles provided by Anchor QEA. The models were adapted to reflect high, mean and low tide water levels, as well as the following construction/dredging conditions:

- Backfill Behind Proposed Retaining Wall, No Capping Material in Place: This condition represents the case where the dredging is conducted down to the target (plus allowable overdredge) dredge depth, the proposed retaining wall is constructed, and fully backfilled prior to placement of capping material in front of the wall.
- No Backfill Behind New Concrete Retaining Wall, No Capping Material In Place: This condition represents the case where the dredging is conducted down to the target (plus allowable overdredge) dredge depth, and the proposed retaining wall is constructed.
- Backfill Behind New Concrete Retaining Wall, Capping Material In Place: This condition represents the assumed final wall configuration, and was analyzed to confirm the long term ***static*** global stability of the wall following construction.

Global stability analyses were carried out using the computer software program Slope/W 2007. The Morgenstern-Price limit equilibrium method was selected to calculate the global stability factor of safety for a typical section along the proposed retaining wall. A factor of safety greater than 1.3 was assumed to be acceptable for short-term conditions during dredging.

The following assumptions were used in our analyses:

- unconsolidated sediments over the upper slope areas are mixed with riprap; and
- seismic loading conditions have not been considered in these stability analyses due to the temporary natural of the remediation operation.

5.2 Material Strength Parameters

A summary of the inferred soil properties used in the assessment is provided in Table 1. Material strength parameters were selected based on our interpretation of field and lab tests conducted by Golder, KCB and others at the EGD site.

Table 1: Inferred Soil Strength and Unit Weight and Model Parameters

Material Description	Unit Weight (kN/m³)	Model Parameters
Riprap, Mixed Fill and Marine Sediments	17.3	Drained: ϕ'=33°, c'=0;
Mixed Fill (sand and gravel)	18.0	Drained: ϕ'=35°, c'=0;
Upper Marine Sediments	17.3	Drained: ϕ'=33°, c'=0;
Victoria Clay	18.7	Undrained: varies, see below
Glacial Till	22.0	Drained: ϕ'=35°, c'=35;
Capping Materials: Filter and Armour rock	22.0	Drained: ϕ'=40°
Concrete slab	24.0	Drained: ϕ'=35°

Undrained strength for Victoria clay was estimated using undrained shear strength plots derived from CPT interpretations. We assumed an N_{kt} factor of 13 in our CPT-derived undrained shear strength interpretations based on our experience on this project and others in the vicinity. A minimum undrained shear strength of 55 kPa, increasing with depth at a rate of 2.0 kPa/m was applied.

5.3 Tidal and Groundwater Conditions

For the assessment presented below, the high water level was taken at El. 3.4 m (Chart Datum), mean water level at El. 1.9 m, and low tide at El. 0.0 m (Chart Datum), Lower Low Water Large Tide.

6.0 GEOTECHNICAL ANALYSIS RESULTS

Global stability analysis results are provided on Figures 1, 2 and 3, and summarized in Table 2 below.

Table 2: Summary of Global Analysis Safety Factors

Analysis Considerations	Calculated Factor of Safety		
	Low Tide	Mean Tide	High Tide
Backfill Behind New Concrete Retaining Wall, No Capping Material In Place	1.3	1.2	1.3
No Backfill Behind New Concrete Retaining Wall, No Capping Material In Place	1.5	1.4	1.5
Backfill Behind New Concrete Retaining Wall, Capping Material In Place	1.8	1.6	1.8

The stability of the temporary soil support shown on the attached KCB drawing, and seismic global stability of the final arrangement were not considered during this assessment. We have assumed that these cases are being considered as part of the retaining wall design by KCB.

7.0 RECOMMENDATIONS

Based on the results of the stability analyses conducted, it is recommended that the capping material be placed in front of the retaining wall prior to placement of backfill behind the retaining wall.

It is recommended that suitable slope and wall monitoring be implemented both during and after dredging work as the above analyses is based on interpretation between broadly spaced test hole information within the South Jetty area. The methodology, frequency and areal extent of the monitoring program should be considered and reviewed for adequacy prior to initiating the dredging works. Ideally, a tolerance level for lateral/vertical movements of the concrete retaining wall should be established prior to the commencement of the remediation works, and utilized as control criteria during regular review and assessment of recorded wall movements during the course of the remediation works. In the event that the selected displacement tolerances are being approached due to the dredging works, updated procedures for dredging and/or modification of the dredge profile should be undertaken to limit further displacements to within the designated tolerances.

If slope movements are observed, such as localized sloughing, dredging work should be immediately halted and the slope stabilized until the slope conditions have been reviewed, and recommendations have been provided for further stabilization and mitigation measures, if and where required.

The final slope bathymetry should be surveyed upon completion of both dredging and the subsequent slope capping. This information can be used as a baseline for subsequent surveys to confirm that final slope dressing is performing as expected.

8.0 CLOSURE

We trust that the information contained in this technical memorandum is suitable for your current needs. Please do not hesitate to contact us if you require further information.

Yours very truly,

GOLDER ASSOCIATES LTD.

Reviewed by:

Sarah Morse, P.Eng., PMP
Geotechnical Engineer

Randy Williams, P.Eng.
Principal, Geotechnical Engineer

SEM/RW/ran

Attachments: Attachment 1 – Klohn Crippen Berger – South Jetty Wharf Development Preliminary 99% Design Drawing S141 – East Approach Retaining Wall Concrete

Attachment 2 – Anchor QEA – South Jetty Wharf Development Preliminary 99% Design Drawings C21, C23, C26, and C30.

Attachment 3 – Figures

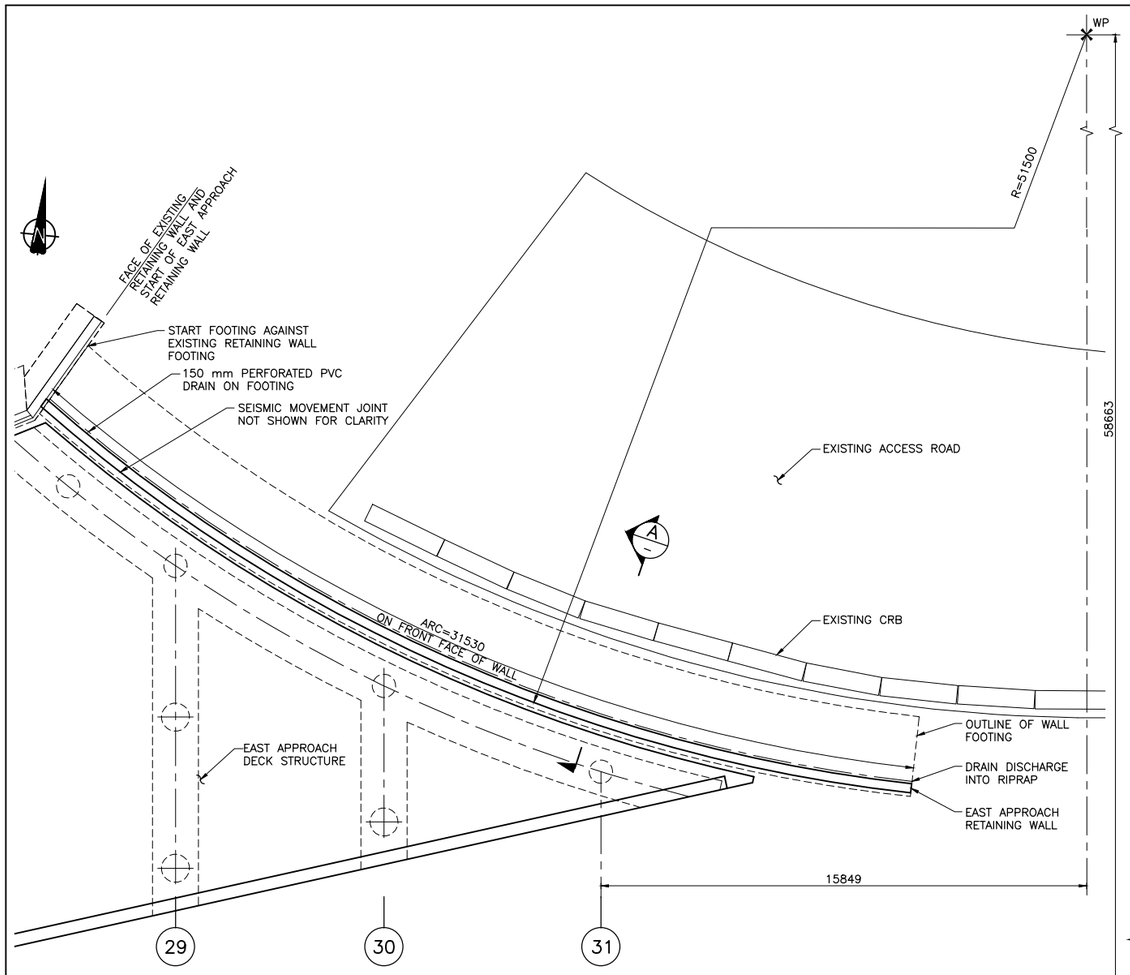
n:\final\2013\1447\p3-1447-0478 pwgsc - egd phase 2 99% sppt\pwgsc-egd-wl-east retaining wall finaltech memo 13-14 25mar_14\pwgsc-egd-wl-east retaining walltech memo 13-14 golder 20140325.docx

ATTACHMENT 1

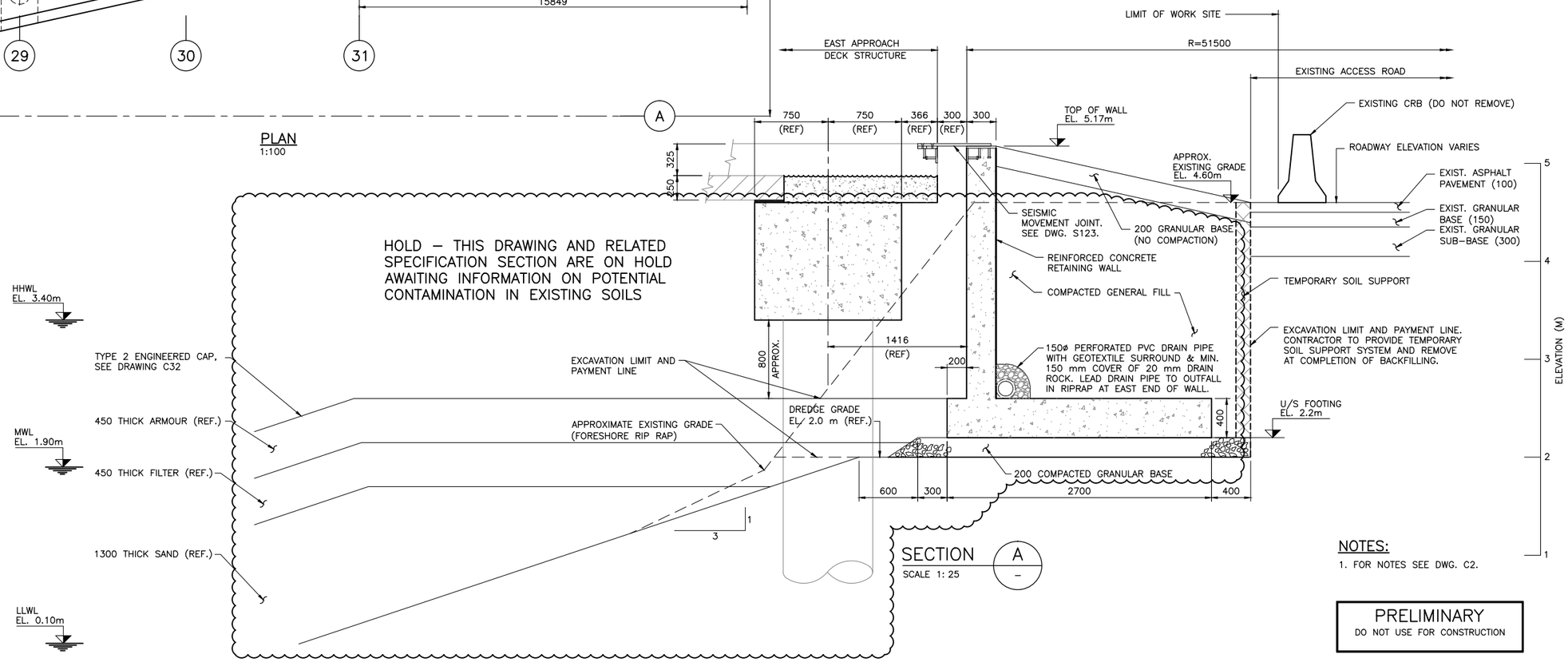
Klohn Crippen Berger

South Jetty Wharf Development Preliminary 99% Design Drawing S141

East Approach Retaining Wall Concrete



PLAN
1:100



SECTION A
SCALE 1: 25

NOTES:
1. FOR NOTES SEE DWG. C2.

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

PWGSC – A1 – 841X594

0 10 20 30 40 50 60 70 80 90 100mm

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

Klohn Crippen Berger

Revision/ Revision	Description/Description	Date/Date
E	PRELIM 99% INTEGRATED DESIGN	2013/12/18
D	95% INTEGRATED DESIGN	2013/08/23
C	80% INTEGRATED DESIGN	2013/03/15
B	99% DETAILED DESIGN	2010/11/12
A	95% DETAILED DESIGN	2010/07/09

Client/client
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

SOUTH JETTY WHARF DEVELOPMENT

Consultant Signature Only

Designed by/Concept par
BILL CHRISTENSEN

Drawn by/Dessine par
ARNIE RIST

PWGSC Project Manager/Administrateur de Projets TPSGC
JAMIE LeBLANC

Regional Manager, Architectural and Engineering Services
Regional Manager, Environmental Services

Drawing title/Titre du dessin
EAST APPROACH RETAINING WALL CONCRETE

Project No./No. du projet	Sheet/	Revision no./
R.026729.002 R.018400.002	S141 OF XX	E

DM5

ATTACHMENT 2

Anchor QEA

South Jetty Wharf Development Preliminary 99% Design Drawings C21, C23, C26, and C30

DREDGE AREA BOUNDARY POINT TABLE		
	NORTHING (m)	EASTING (m)
D1	5364862.3	468379.4
D2	5364817.2	468287.3
D3	5364780.8	468291.2
D4*	5364796.1	468437.3
D5	5364809.3	468564.0
D6	5364811.0	468579.5
D7	5364807.0	468579.9
D8	5364809.7	468590.5
D9	5364820.2	468624.6
D10	5364827.1	468623.4
D11	5364830.0	468610.5
D12	5364836.1	468598.9

*CONFIRM IN FIELD TO SUIT STAGE 1/STAGE 2 BOUNDARY AT EXISTING JETTY STRUCTURE

DREDGE AREA BOUNDARY POINT TABLE		
	NORTHING (m)	EASTING (m)
D13	5364832.2	468597.1
D14	5364830.4	468596.5
D15	5364824.2	468588.9
D16	5364825.3	468584.1
D17	5364824.5	468580.2
D18	5364824.3	468577.6
D19	5364845.7	468575.3
D20*	5364830.5	468433.7
D21	5364826.7	468397.4
D22	5364831.3	468396.9
D23	5364829.8	468383.1

PROJECT BASELINE POINT TABLE		
	NORTHING (m)	EASTING (m)
BL1	5364805.7	468601.0
BL2	5364785.0	468570.8
BL3	5364768.1	468409.3
BL4	5364777.9	468383.9
BL5	5364765.1	468380.4
BL6	5364755.7	468290.8
BL7	5364805.4	468285.6
BL8	5364855.2	468280.4
BL9	5364866.6	468389.8
BL10	5364840.7	468392.6
BL11	5364833.6	468411.0
BL12	5364851.2	468579.1
BL13	5364841.6	468582.5
BL14	5364854.7	468619.6

PROJECT BASELINE DEFINES STATION 0+00 OF CROSS-SECTIONS. SEE DWGS C22/C23.

E:468300.0
N:5364900.0
E:468400.0
E:468500.0
E:468600.0
N:5364800.0

DU1 -10.0
DU2 -11.5
DU3 -11.5
DU4 -10.0
DU5 -11.5
DU6 -11.0
DU7 2H:1V
DU8 2H:1V
DU9 2H:1V
DU10 2H:1V
DU11 3H:1V
DU12 3H:1V
DU13 3H:1V
DU14 -5.6
DU15 3H:1V
DU16 3H:1V
DU17 3H:1V
DU18 3H:1V
DU19 0.5M CUT

TEMPORARY RESUSPENSION BARRIER 1 (SEE NOTE 9)
TEMPORARY RESUSPENSION BARRIER 2 (SEE NOTE 9)
TEMPORARY RESUSPENSION BARRIER 3 (SEE NOTE 9)
TEMPORARY RESUSPENSION BARRIER 4 EXTENDS TO SHORELINE (SEE NOTE 9)
TEMPORARY SOIL SUPPORT SYSTEM AT STEP IN DREDGE CUT (SEE DWG CSM8)
HIGH MAST LIGHT FOUNDATION
STAGE 1/STAGE 2 BOUNDARY LINE 10,11/C26
HAZARDOUS WASTE MATERIAL SUBAREA 2A 9/C26
REQUIRED DREDGE ELEVATION: 1.0m
REQUIRED DREDGE ELEVATION: 0.6m
REQUIRED DREDGE ELEVATION: 3.0m
REQUIRED DREDGE ELEVATION: 2.2m BELOW TOP OF PHASE 1B CAP
HOLD FOR INPUT FROM GOLDER
EXTENTS OF STAGE 1 WORK
EXTENTS OF STAGE 2 WORK
MISSED INVENTORY CONTINGENCY RE-DREDGING MAY BE REQUIRED BY DEPARTMENTAL REPRESENTATIVE INSIDE OF THE PROJECT BOUNDARY 8A/C26
RESIDUALS CONTINGENCY RE-DREDGING MAY BE REQUIRED BY DEPARTMENTAL REPRESENTATIVE WITHIN EGD WORK SITE AND OUTSIDE OF PROJECT BOUNDARY 8B/C26
HOLD PHASE 1B POST-PROJECT BATHYMETRY

HORIZONTAL DATUM: UTM ZONE 10 GRID, NAD83.
VERTICAL DATUM: CHART DATUM (C.D.)

NOTES:
1. UNDERPIER AREA LOWER INTERTIDAL AND SUBTIDAL BATHYMETRY WITHIN THE PROJECT BOUNDARY IS FROM FEBRUARY 2009, JUNE 2010 AND JANUARY 2011 CRA CANADA SURVEYS LTD. MULTI BEAM SURVEY. UPPER INTERTIDAL ELEVATIONS FROM SEPTEMBER 2009 AND JULY 2011 SURVEY BY FOCUS CORPORATION. OPEN WATER AREAS OUTSIDE OF THE PROJECT BOUNDARY WERE DREDGED AS PART OF THE PHASE 1B OPEN-WATER REMEDIATION PROJECT. OPEN WATER BATHYMETRY SURVEY WAS CONDUCTED BY X ON XX/XX/201X FOLLOWING COMPLETION OF PHASE 1B WORK. CONTRACTOR SHALL ALSO COMPLETE PRE-CONSTRUCTION SURVEY TO MEET BATHYMETRY DATA COLLECTION REQUIREMENTS AS DESCRIBED IN SECTION 02 21 13 - SURVEYING AND POSITIONAL CONTROL. HOLD
2. BASE MAP FROM GOLDER, JANUARY 2012.
3. DEBRIS AND STRUCTURE DETAILS FROM KLOHN CRIPPEN BERGER DECEMBER 2010 CONDITION INSPECTION REPORT FOR SOUTH JETTY PERIMETER, NADEN FLOATS, AND CFSA FLOATS.
4. REFERENCE DWG C1 FOR DATUM INFORMATION.
5. EGD WORK SITE ALSO INCLUDES UPLAND AREAS OF THE EGD FACILITY AS SHOWN ON THE DRAWINGS AND DESCRIBED IN THE SPECIFICATIONS.
6. CONTRACTOR SHALL COMPLETE DREDGING ACTIVITIES ACCORDING TO SEQUENCING REQUIREMENTS SHOWN ON DRAWINGS AND DESCRIBED IN THE SPECIFICATIONS.
7. SEE APPENDIX D REFERENCE DRAWINGS FOR A COMPLETE LIST OF CONTROL POINTS USED TO DEFINE EXTENTS OF DREDGING FOR DREDGE UNITS. CONTRACTOR SHALL TRANSITION DREDGE CUTS FROM THESE EXTENTS TO THE EGD WORK SITE BOUNDARY AS SHOWN ON THE DRAWINGS.
8. DREDGE SURFACE 0.5m WITHIN HAZARDOUS WASTE SUBAREA (DU15, 16, 18, 19, AND 20) AND DISPOSE OF MATERIAL AS HAZARDOUS WASTE. PWGSC TO SAMPLE TO DETERMINE WHETHER UNDERLYING MATERIAL IS HAZARDOUS WASTE. COMPLETE DREDGING TO REQUIRED ELEVATIONS AND GRADES. UNIT PRICE TABLE ASSUMES OTHER MATERIAL REMOVED TO ACHIEVE THE REQUIRED ELEVATIONS WILL BE DISPOSED AS IL+ MATERIAL.
9. TRB LOCATIONS SHOWN AS EXAMPLE ONLY. CONTRACTOR SHALL DESIGN, INSTALL AND MAINTAIN TRBS IN ACCORDANCE WITH THE SPECIFICATIONS. CONTRACTOR TO PROVIDE TRB LAYOUT AND DESIGN DETAILS IN THE ENVIRONMENTAL PROTECTION PLAN.
10. OPEN PILE LOCATIONS BENEATH SOUTH JETY DECK POSE HEALTH AND SAFETY RISK. CONTRACTOR TO IDENTIFY IN HEALTH AND SAFETY PLAN APPROPRIATE RISK MITIGATION MEASURES THAT WILL BE IMPLEMENTED AT THESE LOCATIONS.
11. CONTINGENCY RE-DREDGING MAY BE REQUIRED FOR MISSED INVENTORY MATERIAL REMOVAL WITHIN THE SHEETPILE WALL AREAS OF WORK AND FOR POTENTIAL RESIDUALS REMOVAL OUTSIDE OF THE SHEETPILE WALL AREA (WITHIN THE EGD WORK SITE BOUNDARY) IF RESULTS OF CONFIRMATIONAL SAMPLING INDICATE DREDGE RESIDUALS ARE PRESENT AT THE SEABED SURFACE OUTSIDE OF THE SHEETPILE WALL.
12. STAGE 1/STAGE 2 TEMPORARY RE-SUSPENSION BARRIER CONFIGURATIONS ARE FOR ILLUSTRATIVE PURPOSES ONLY. CONTRACTOR (AND 3RD PARTY VENDOR) SHALL DETERMINE FINAL LAYOUT FOR TEMPORARY RE-SUSPENSION BARRIER SYSTEM(S).

REQUIRED DREDGE PLAN

SCALE 1: 500

SCALE : 1:500
0m 10 20 30 40 50m

LEGEND:
- —14.0— BATHYMETRY IN METRES
- STAGE 1/STAGE 2 BOUNDARY LINE
- EGD WORK SITE BOUNDARY
- PROJECT BOUNDARY
- DU4 -11.0 DREDGE UNIT BOUNDARY AND REQUIRED DREDGE ELEVATION
- DU10 2H:1V SLOPE DREDGING DREDGE UNIT (DU) BOUNDARY AND REQUIRED GRADE
- SLOPE DESIGNATION
- STAGE 1 TEMPORARY RESUSPENSION BARRIER
- STAGE 2 TEMPORARY RESUSPENSION BARRIER
- DREDGE AREA
- DREDGE AREA UNDER STEEL-PILE SUPPORTED DECK
- HAZARDOUS WASTE MATERIAL SUBAREA 2A
- STAGE 1/STAGE 2 TRANSITION AREA
- NO DREDGE AREA
- BASE LINE CONTROL POINT
- DREDGE AREA CONTROL POINT

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

0 10 20 30 40 50 60 70 80 90 100mm

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Pacific Region
SERVICES IMMOBILIERS

ANCHOR QEA
Golder Associates
Klohn Crippen Berger

Revision/Revision	Description/Description	Date/Date
E	PRELIM 99% INTEGRATED DESIGN	2013/12/18
D	95% INTEGRATED DESIGN	2013/08/23
C	80% INTEGRATED DESIGN	2013/03/15
B	99% DETAILED DESIGN	2010/11/12
A	95% DETAILED DESIGN	2010/07/09

Client/client
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

SOUTH JETTY WHARF DEVELOPMENT

Consultant Signature Only

Designed by/Concept par
MATT WOLTMAN

Drawn by/Dessine par
CHRIS HEWETT

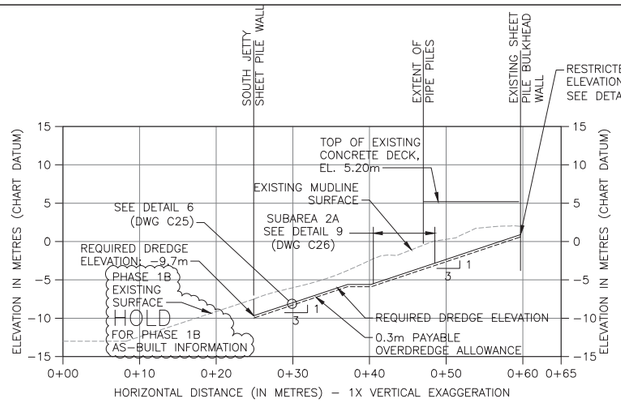
PWGSC Project Manager/Administrateur de Projets TPSGC
JAMIE LeBLANC

Regional Manager, Architectural and Engineering Services
Regional Manager, Environmental Services

Drawing title/Titre du dessin
REQUIRED DREDGE PLAN

Project No./No. du projet	Sheet/	Revision no./
R.026729.002 R.018400.002	C21 OF XX	E

DMS



SECTION H
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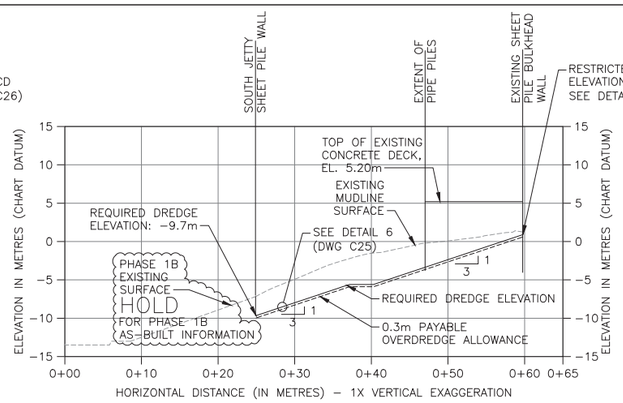
C21



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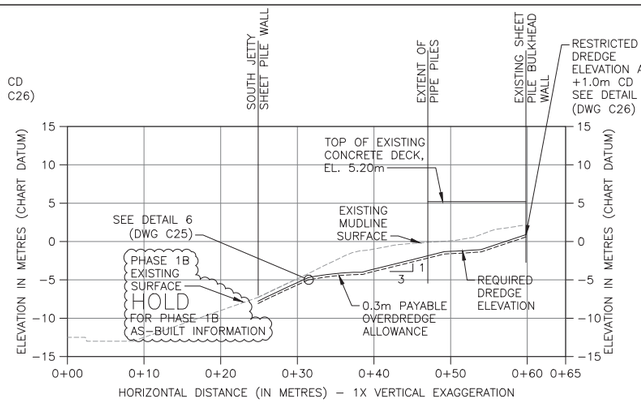

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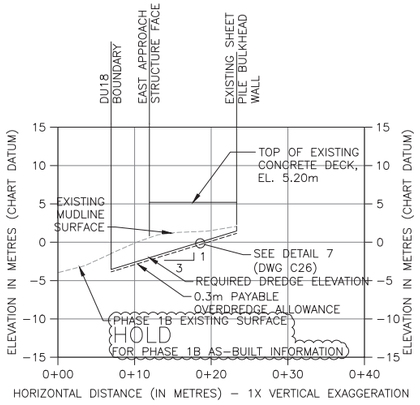

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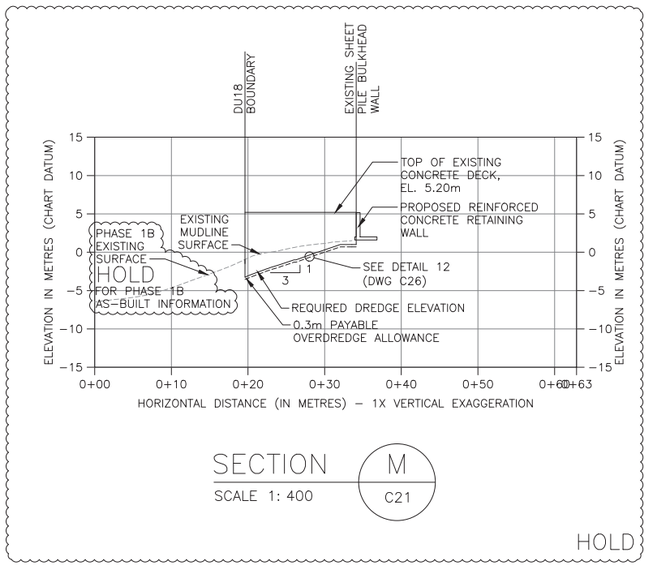

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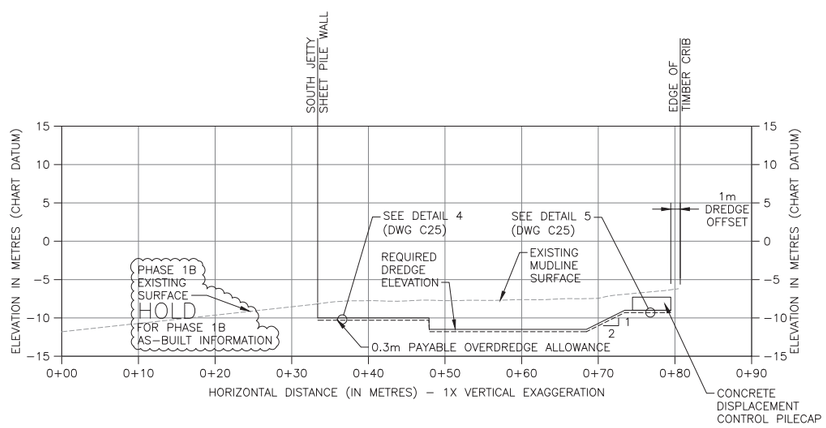
HOLD



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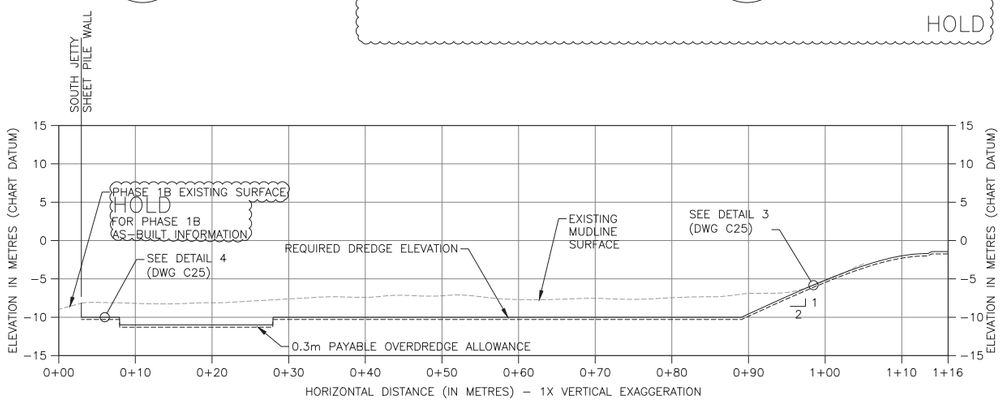

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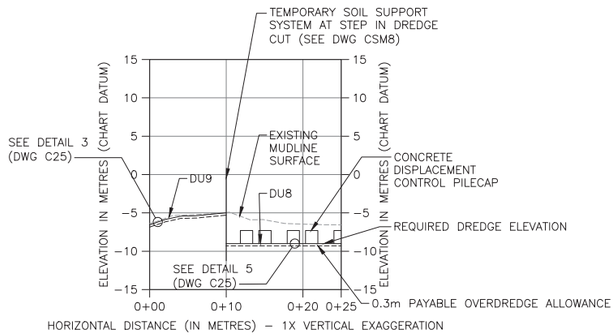

SECTION Q
SCALE 1: 400
C21

CROSS SECTIONS

SCALE 1: 400

HORIZONTAL DATUM: UTM ZONE 10 GRID, NAD83.
VERTICAL DATUM: CHART DATUM (C.D.)

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2. REFERENCE DWG C1 FOR DATUM INFORMATION.

HOLD

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

0 10 20 30 40 50 60 70 80 90 100mm

PWGSC – A1 – 841X594

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Pacific Region
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Consultant Signature Only

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Drawn by/Dessine par
CHRIS HEWETT

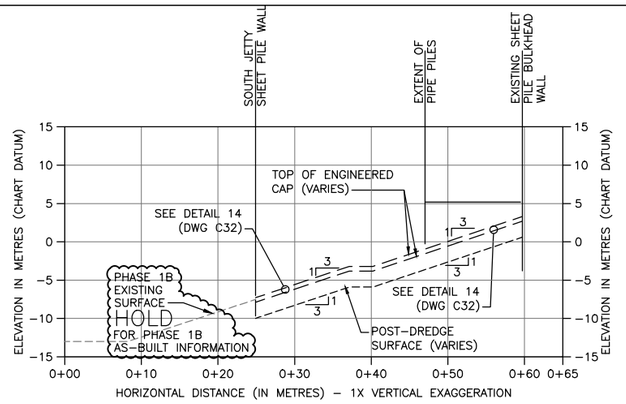
PWGSC Project Manager/Administrateur de Projets TPSGC
JAMIE LeBLANC

Regional Manager, Architectural and Engineering Services
Regional Manager, Environmental Services

Drawing title/Titre du dessin
DREDGE CROSS-SECTIONS - SHEET 2

Project No./No. du projet	Sheet/	Revision no./
R.026729.002 R.018400.002	C23 OF XX	E

DM5XXXXXX



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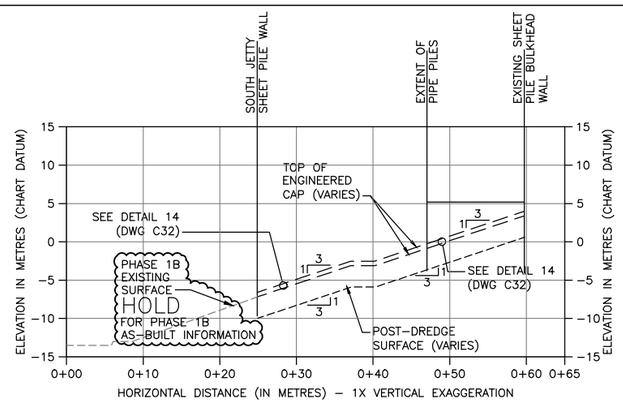

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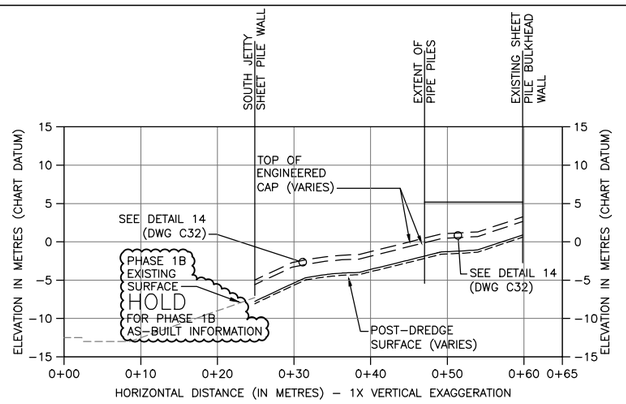

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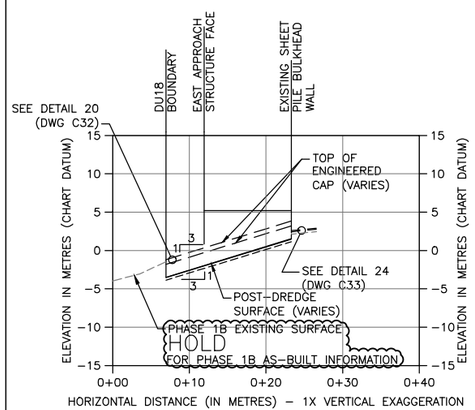

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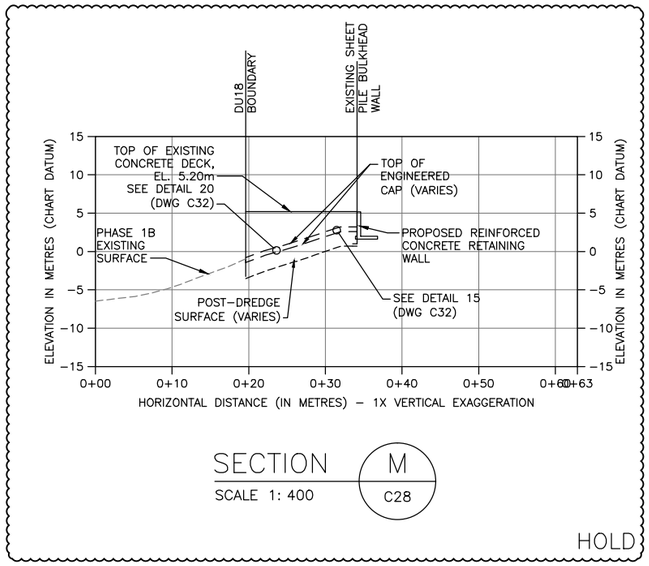

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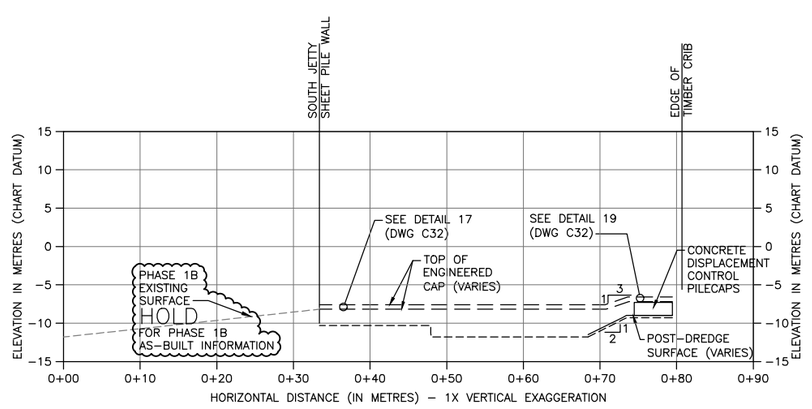

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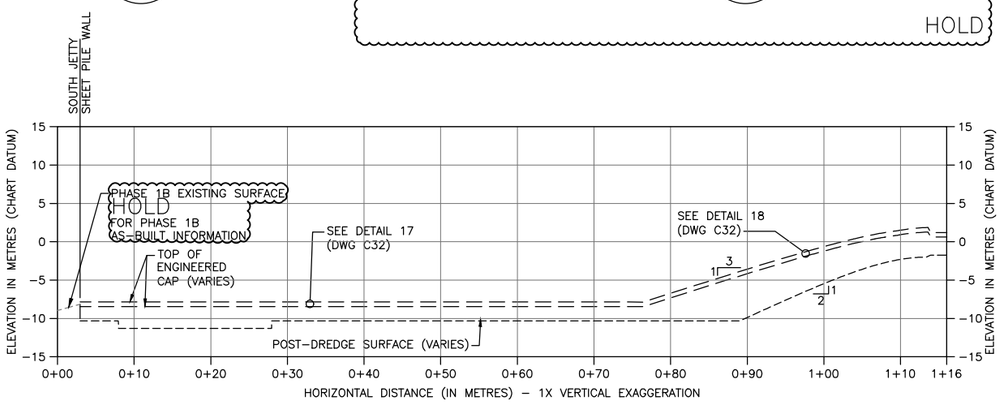

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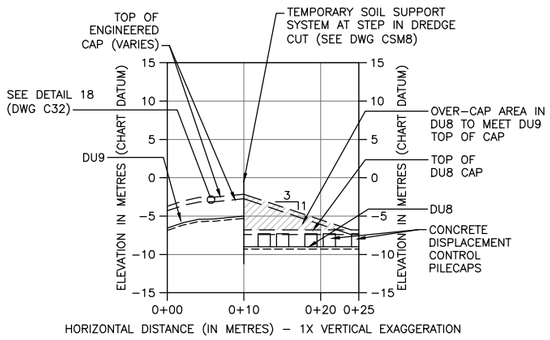

SECTION Q
SCALE 1: 400
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HORIZONTAL DATUM: UTM ZONE 10 GRID, NAD83.
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2. REFERENCE DWG C1 FOR DATUM INFORMATION.
3. TOP OF ENGINEERED CAP SURFACES REPRESENT MINIMUM PLACEMENT THICKNESS AND MAXIMUM OVERPLACEMENT ALLOWANCES.
4. TOP OF ENGINEERED CAP SHOWN ON CROSS SECTIONS IN NON-SLOPE AREAS OF THE STAGE 1 AREA OF WORK ARE BASED ON NEED TO RESTORE POST-CAP ELEVATIONS WITHIN (+/-X METRES OF PRE-CONSTRUCTION SEABED ELEVATIONS. HOLD
5. TOP OF ENGINEERED CAP SHOWN ON CROSS SECTIONS IN 2H:1V DREDGE SLOPE AREAS OF THE STAGE 1 AND STAGE 2 AREAS OF WORK NEAR EXISTING SHEET PILE BULKHEAD WALL HAVE VARIABLE THICKNESS REQUIREMENTS THAT ARE NEEDED TO CONSTRUCT THE TYPE 1 SEDIMENT CAP TO A STABLE 3H:1V GRADE.

CROSS SECTIONS
SCALE 1: 400

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

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0 10 20 30 40 50 60 70 80 90 100mm

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Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

ANCHOR QEA

Golder Associates

Klohn Crippen Berger

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PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

SOUTH JETTY WHARF DEVELOPMENT

Consultant Signature Only

Designed by/Concept par
MATT WOLTMAN

Drawn by/Dessine par
CHRIS HEWETT

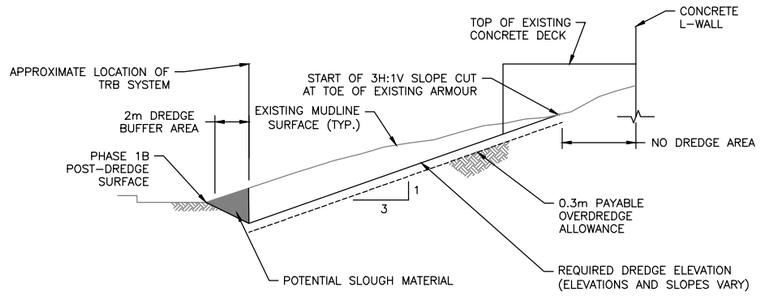
PWGSC Project Manager/Administrateur de Projets TPSGC
JAMIE LeBLANC

Regional Manager, Architectural and Engineering Services
Regional Manager, Environmental Services

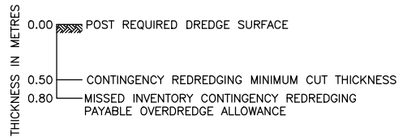
Drawing title/Titre du dessin
ENGINEERED CAPPING
CROSS-SECTIONS - SHEET 2

Project No./No. du projet	Sheet/	Revision no./
R.026729.002 R.018400.002	C30 OF XX	E

DMS

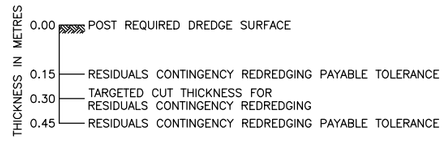


DETAIL 7 / NOT TO SCALE / C23



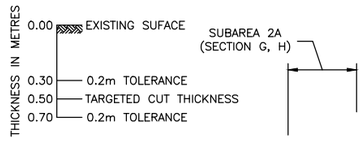
CONTINGENCY REDREDGE – MISSED INVENTORY

DETAIL 8A / NOT TO SCALE / C21



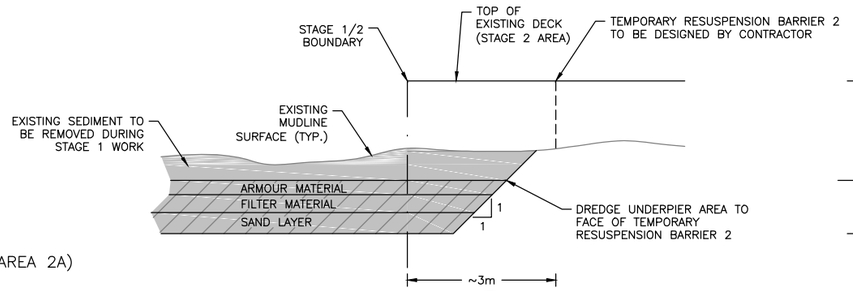
CONTINGENCY REDREDGE – RESIDUALS

DETAIL 8B / NOT TO SCALE / C21



TARGETED CUT THICKNESS FOR HAZARDOUS WASTE AREA (SUBAREA 2A)

DETAIL 9 / NOT TO SCALE / C21



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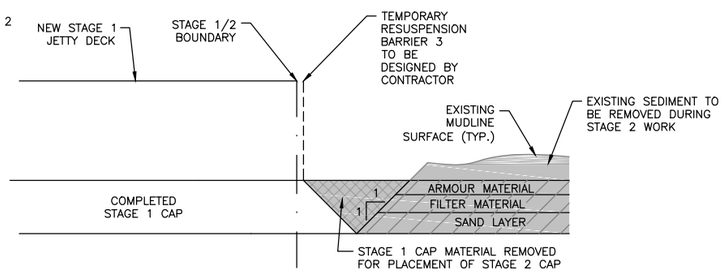

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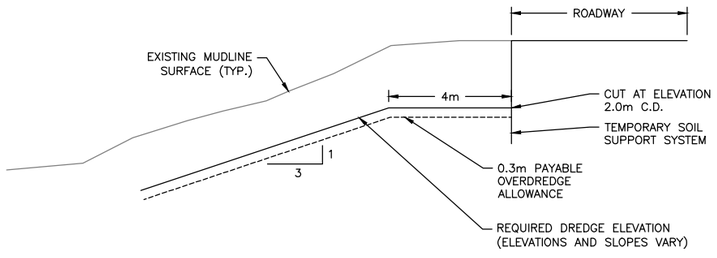

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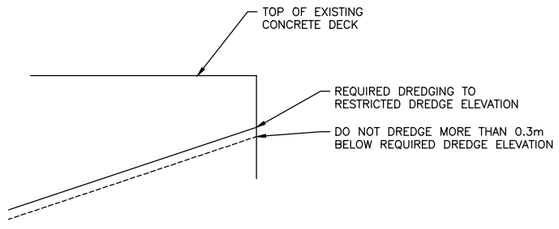

DETAIL 13 / NOT TO SCALE / C22

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada
REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

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Regional Manager, Environmental Services

Drawing title/Titre du dessin
DREDGE DETAILS - SHEET 2

Project No./No. du projet	Sheet/	Revision no./
R.026729.002 R.018400.002	C26 OF XX	B

PWGSC – A1 – 841X594

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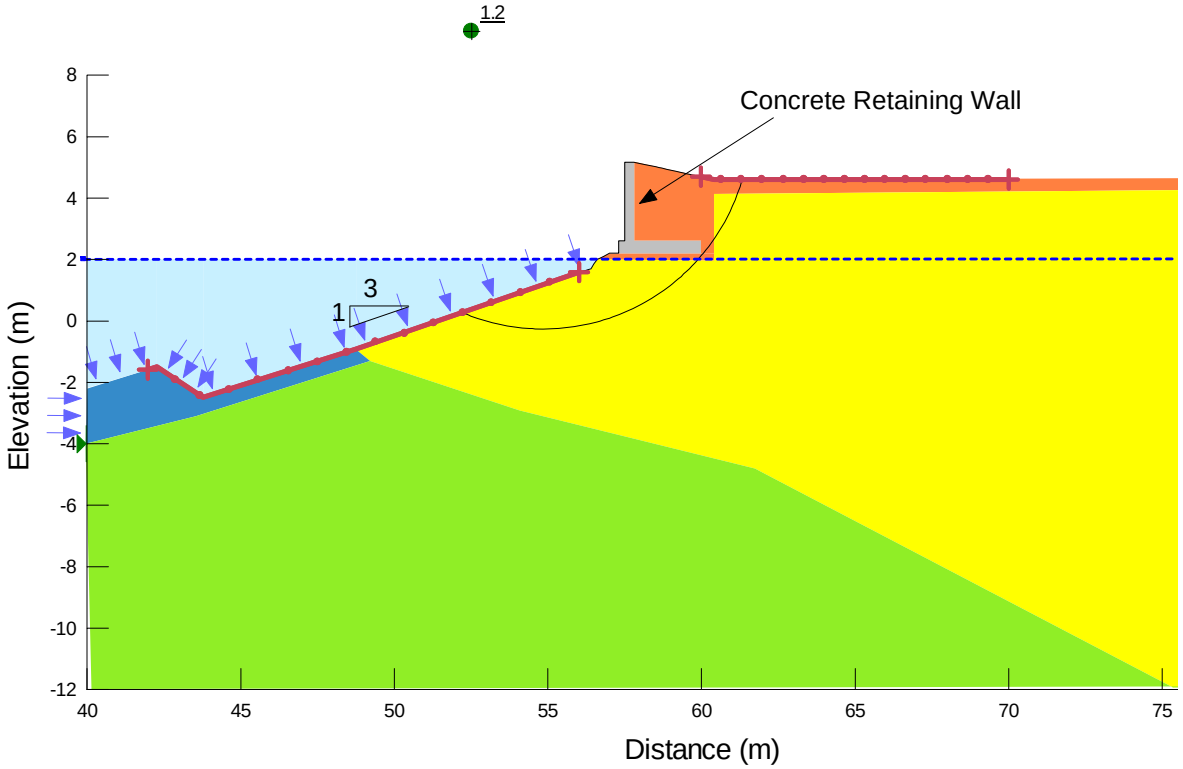
DM5

ATTACHMENT 3

Figures

FILE:

Critical Case: Mean Water Level



Unconsolidated Marine Sediments

Sand and Gravel Fill

Victoria Clay (undrained)

Compacted Backfill

Elevations are relative to chart datum.

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
ASSESSMENT OF EAST END CONCRETE RETAINING WALL
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

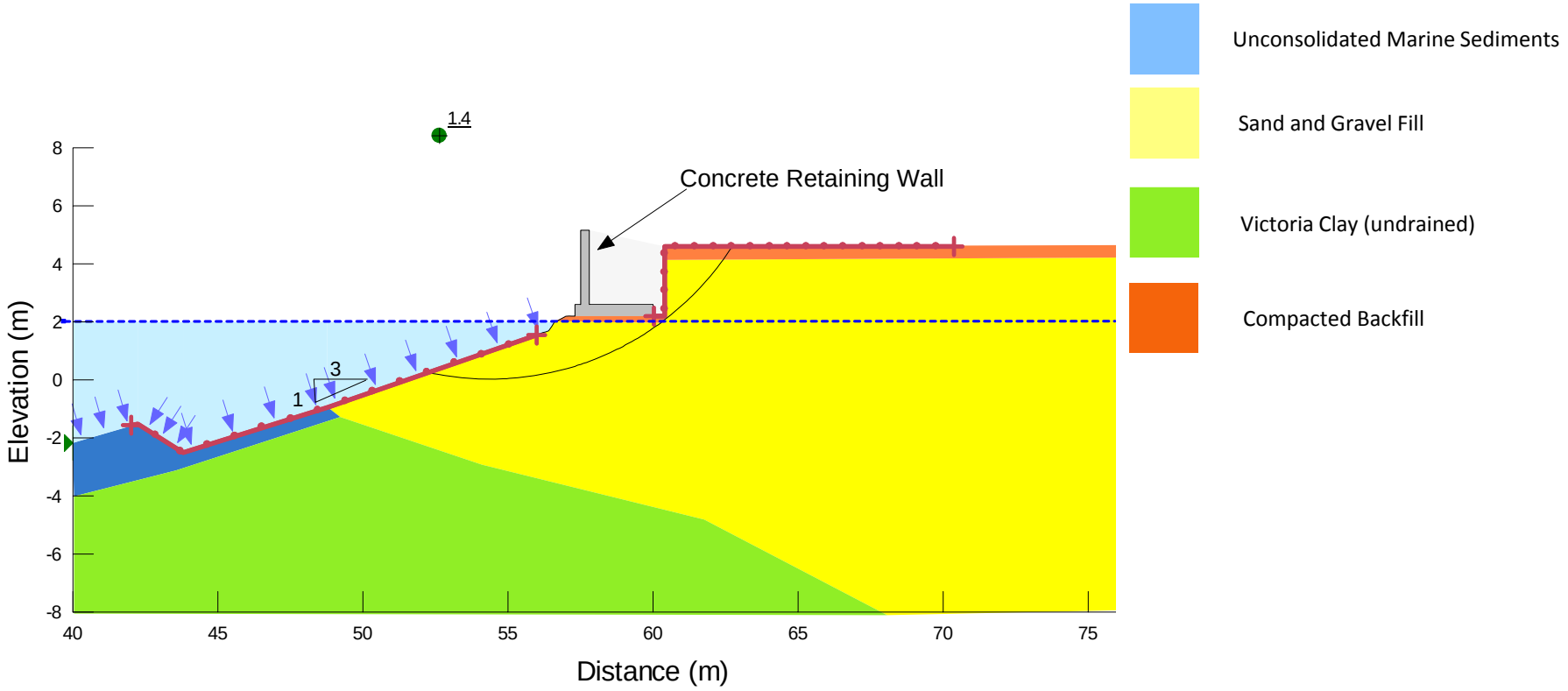
TITLE
Global Slope Stability
Backfill Behind New Concrete Retaining Wall
No Capping Material in Place

Golder Associates

PROJECT No. 13-1447-0478			FILE No.	-----
DESIGN	12FEB14	SEM	SCALE	NTS
CADD	12FEB14	SEM	FIGURE	1
CHECK	20FEB14	SEM		
REVIEW	20FEB14	RRW		

FILE:

Critical Case: Mean Water Level



Elevations are relative to chart datum.

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
ASSESSMENT OF EAST END CONCRETE RETAINING WALL
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

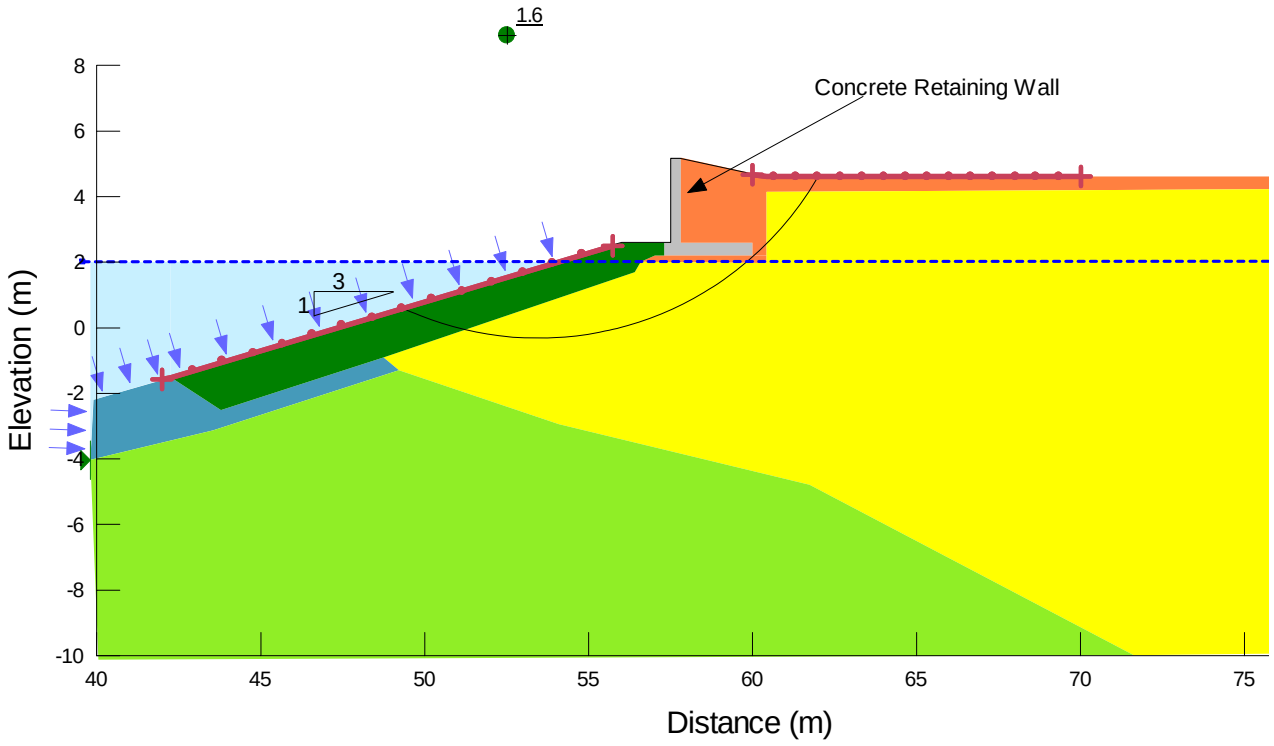
TITLE
Global Slope Stability
No Backfill Behind New Concrete Retaining Wall
No Capping Material in Place

Golder Associates

PROJECT No. 13-1447-0478			FILE No.	-----	
DESIGN	12FEB14	SEM	SCALE	NTS	
CADD	12FEB14	SEM	FIGURE		
CHECK	20FEB14	SEM	**2**		
REVIEW	20FEB14	RRW			

FILE:

Critical Case: Mean Water Level



Unconsolidated Marine Sediments

Sand and Gravel Fill

Victoria Clay (undrained)

Compacted Backfill

Capping Material

Elevations are relative to chart datum.

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
ASSESSMENT OF EAST END CONCRETE RETAINING WALL
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
Global Slope Stability
Backfill Behind New Concrete Retaining Wall
With Capping Material in Place

Golder Associates

PROJECT No. 13-1447-0478			FILE No.	-----	
DESIGN	12FEB14	SEM	SCALE	NTS	
CADD	12FEB14	SEM	FIGURE		
CHECK	20FEB14	SEM		3	
REVIEW	20FEB14	RRW			

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Golder Associates

D14

ESQUIMALT GRAVING DOCK

PRE-CONSTRUCTION CONDITION SURVEY

WSP (2015)

Number of Pages: 44

PACIFIC REGION – Professional and Technical Services (PTS)	Request for Information Form	Business Unit: ES	Page: 1 of 1
Title: Contractor Request for Information – EZ899-151108/001/PWY – PH2 - EGD Waterlot Remediation Project South Jetty Under-Pier Sediment Remediation			

RFI #: PH2 - 151

Project No.: R.018400.002 Project Name: EGD Waterlot Remediation Project - PH2 South Jetty Under-Pier Sediment Remediation

To: Canada - PWGSC Date: 2 February 2016

Attention: Rae-Ann Sharp, PWGSC Departmental Representative

Please find the attached Pre-construction Condition Survey with revisions to address ADV 109.

References – Specification item: Drawings:

Response required by:

Anticipated Change to – Contract Amount: ☐ Yes ☒ No Contract time: ☐ Yes ☒ No

From: Stephen Pinto @ MNQM Contracting Ltd.

(Name) (MNQM Contracting Ltd.)

REPORT N^{O} 151-10283-00

ESQUIMALT GRAVING DOCK PRE-CONSTRUCTION CONDITION SURVEY

DRAFT

SEPTEMBER 2015
UPDATED: JAN 20. 2016

WSP

ESQUIMALT GRAVING DOCK PRE-CONSTRUCTION CONDITION SURVEY

Quantum Murray LP

Report Final

Project no: 151-10283-00
Date: February 01, 2016

WSP Canada Inc.
Suite 400 - 401 Garbally Rd
Victoria, B.C. V8T 5M3
Phone: 250 384-5510
Fax: 250 3862844
www.wspgroup.com

February 01, 2016

Mr. Stephen Pinto, P.Ag. EP B.Sc.
Quantum Murray LP
110-2940 Jutland Road
Victoria, BC V8T 5K6

Subject : **Esquimalt Graving Dock Pre-Construction Condition Survey**

Dear Sir,

We are pleased to provide the attached Pre-condition Survey of the area that you are going to be working in at the PWGSC Esquimalt Graving Dock.

The survey was carried out in September 2015 with the exception of the Bulkhead wall that was inspected in January 2016.

II have incorporated your comments and those of PWGSC Advisory 109 dated January 28, 2016.

Please contact the writer if you have any questions.

.Yours truly,

Ian W. Martin, P.Eng.
Senior Project Manager

WSP Canada Inc.
Suite 400 - 401 Garbally Rd
Victoria, B.C. V8T 5M3
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EXECUTIVE SUMMARY

Public Works and Government Services Canada (PWGSC) requires the remediation of contaminated marine sediments within the South Jetty under-pier area as Phase 2 of the Esquimalt Graving Dock (EGD) Water Lot Remediation Project in Constance Cove of Esquimalt Harbour on Vancouver Island, British Columbia. PWGSC also requires the demolition of the timber pile supported sections of the South Jetty at the EGD Facility, to provide access to the under-pier area for remediation.

WSP was tasked by Quantum Murray LP to conduct a Pre-construction Condition Survey in accordance with the specification for the remediation work. The purpose is to provide a baseline of the existing condition of works that are going to be remaining in place after the completion of the work. In particular the report was to identify existing damage to the existing structure and buildings.

A visual survey of both the under jetty and above deck conditions were visually examined where accessible.

Due to the lack of access and the lack of light the Bulkhead Wall was not examined completely during the original survey in September. The Bulkhead wall was visually examined from a boat on January 14th, 2016.

Of the elements that were examined they were general found to be in good repair. In some areas pile corrosion is more than found in the overall pile population.

The only place there is consistent damage in on the skins of the various buildings adjacent to the Concrete Jetty. Most of the damage is from objects being pushed or falling against the buildings.

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APPENDIX D REFERENCE DRAWING E11

1 BACKGROUND & CONTEXT

1.1 PROJECT SCOPE

Public Works and Government Services Canada (PWGSC) requires the remediation of contaminated marine sediments within the South Jetty under-pier area as Phase 2 of the Esquimalt Graving Dock (EGD) Water Lot Remediation Project in Constance Cove of Esquimalt Harbour on Vancouver Island, British Columbia. PWGSC also requires the demolition of the timber pile supported sections of the South Jetty at the EGD Facility, to provide access to the under-pier area for remediation.

1.2 REPORT SCOPE

WSP Canada Inc. (WSP) was tasked by Quantum Murray LP (the Contractor) to conduct a pre-construction survey covering the existing structures adjacent to the areas that are to be remediated. The prime objective of this report is to identify areas and element of the existing structure that show obvious damage prior to the commencement of the work by the contractor. The under Jetty examination includes:

- Steel Piled Deck Structure Including Piles
- Anchored Sheet Pile Bulkhead Wall
- Concrete Faced Timber Crib
- The Small L Wall
- Steel Sheet Pile Perimeter Wall and Attachment to Timber Jetty

The above deck survey includes

- Concrete Jetty Deck Surface
- Adjacent Buildings

1.3 ACCESS

Access to the underside of the jetty was provided by PWGSC Staff following their confined space protocols on September 16, 2015.

The first area examined was the west end of the anchored bulkhead wall and the South face of the timber crib wall and the piles around the existing high mast lighting.

The second manhole provided access to the small “L” wall and the east end of the anchored bulkhead wall.

In the afternoon the entire outside of the sheet pile enclosure wall was examined visually from a PWGSC operated boat. This was followed by accessing the underside of the crane pad for pile and deck condition. Access was not practical for the majority of the sheet pile wall, piles and Jetty deck due to a combination of cross bracing and tides. I addition lack of light would limit the detail of damage to de found.

On September 17th inspection of the underside of the jetty was attempted from the catwalk using the confined space protocol. Due to the lack of light and the distance from the wall the sheet pile wall inspection was not realistic. It was a good vantage point however to inspect portions of the perimeter sheet pile wall.

In the later morning a visual inspection of the perimeter sheet pile wall and its attachments was conducted.

A visual inspection of the jetty mounts, concrete deck and the adjacent buildings was conducted approaching noon

The follow up inspection of the bulkhead wall took place on January 14, 2016 from a small boat provided by Quantum Murray / Vancouver Pile. The inspection took place during the low day time tide of 2m. As a result the top of the riprap slope was only exposed in some areas.

1.4 LAYOUT GRID

For the purposes of this report the pile layout grid that is shown on Drawing E11 of the contract package is used to reference the individual piles that show evidence of damage during the survey. This is the most appropriate grid as it clearly identifies the pile locations after the removal of the timber pile structures. A Copy of this Drawing is attached in Appendix “D” for reference.

The photographs under the jetty in Appendices A & C have been referenced to the grid show on Drawing E11 according to the following Key: (East West Grid, North South Grid, Direction of Image).

1.5 GENERAL REPORT REMARKS

In general a number of photos exist and will be kept on file. Exceptional conditions are imbedded in the report where discussed.

Representative sample photographs have been provided in the Appendices to the report however there are more photographs on file at the WSP office if detail of existing damage is required in the future. This is particularly aimed at the adjacent buildings.

2 UNDER JETTY DECK CONDITION OBSEVATIONS

2.1 STEEL PILED DECK STRUCTURE INCLUDING PILES

2.1.1 CONCRETE DECK STRUCTURE

The Concrete Deck was in very good shape with no signs of cracking and or voids as a result of poor construction practices. It was noted that there was no visible efflorescence deposits on the underside of the concrete. There were no visible signs of damage in any of the concrete deck examined from the underside.

This finding was confirmed during the follow up visit on January 14, 2016.

The Two Access hatches through the concrete deck are in good repair. The galvanized support structure an hatch framing appear to be free from signs of breakdown. The ladders are also in good shape. The hatch covers are showing the expected signs of traffic wear & tear.

2.1.2 STEEL PILES

The steel piles were apparently coated when installed the majority of the piles appear to have deteriorated coating and as a result surface rusting is evident. It was observed that the coating is

generally intact in areas where it has been protected by overburden. The author has no knowledge of whether these piles are filled their entire length with concrete, a top plug or connected to the concrete deck in some other fashion.

One pile near the high mast lighting had a 1/8 inch thick layer of scale on it just above the mud line.

This seemed to be the exception rather than the rule. Due to access not all piles were examined during the inspection.

During the inspection on January 14th it was noted that other piles in the field were showing signs of corrosion and had scaling and spalling. The deterioration was mainly in the upper splash zone. These were random and not concentrated in any one area. The effectiveness of the corrosion protection system should be reviewed for these piles.

Consistently the coating on the piles has lost its integrity in the high tide to upper splash zone.

The pile all appear to be free from physical damage that might be caused by impact or scraping by an outside source such as a boat or large piece of machinery.

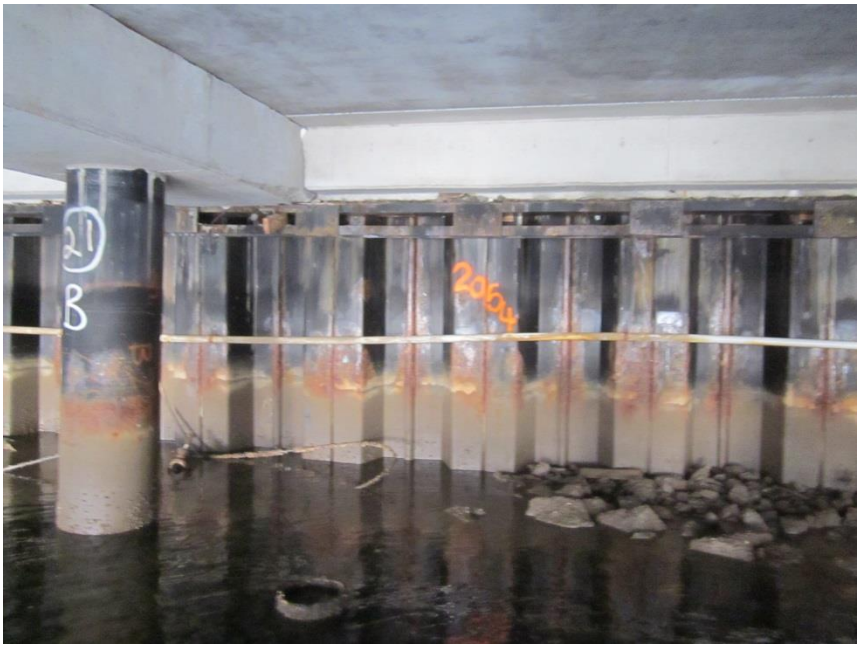
2.2 ANCHORED SHEET PILE BULKHEAD WALL

The east and west ends of the Sheet Pile Bulkhead Wall were examined via the manhole entrances to the underside of the jetty during the original inspection. In general the coated sheet pile wall was in good repair with the surface corrosion appearing at the interlocking joints. There was some rust staining in other areas on the sheet pile but the source appears to be from the cuts and welds in the whaler at the top of the wall as shown in photo below

The Inspection of January 14th showed no physical damage to the integrity of the Bulkhead Wall. There were however consistent signs of corrosion at the joints of the sheet pile and deterioration of the coating on the sheet pile. The top whaler was in relatively good shape. The worst case appears in the photo above taken during the September inspection.

The above photo shows the typical whaler condition and the general good condition of the concrete deck and support structure. There is some surface rusting of the tie back attachment.

The photo below shows the typical sheet pile condition with rusting at the joints



2.3 CONCRETE FACED TIMBER CRIB

The examination of the Concrete Timber Crib wall was successful and was generally in good repair considering its age. There is a pit in the south face if the wall which should be examined for possible repair once the timber pile structure is removed. This is illustrated in Photo A12 of Appendix A. From the observations there is no signs of spalling or cracking in the concrete facing if the timber crib.

2.4 THE SMALL L WALL

This retaining wall at the east end of the south jetty was examined through the access hatch at the east end of the jetty. This wall was in good condition and is showing no signs of distress. See Photos A14 & A15 of Appendix A

2.5 STEEL SHEET PILE PERIMITER WALL

2.5.1 SHEET PILE EXTERIOR

The perimeter Sheet pile wall installed in the previous phase of the cleanup is in very good condition and has no visible damage from impact or other misadventures. The top of the piling is restrained by a timber assembly which in turn also holds relatively new fender piles in pairs. A visual inspection was carried out from the water and a limited inside inspection was carried out from the catwalk under the jetty. The steel whaler securing the top of the sheet pile is in good condition

2.5.2 TIMBER WHALERS

The timber whaler assembly attaching the perimeter sheet pile to the fender piles is in near new condition. The fastenings are in very good shape. There may be some salvage value in this material if removed carefully

2.5.3 FENDER PILES

The recently installed fender piles are also in very good shape they are set in pairs every 10 ft. there is definitely some salvage value in these piles.

3 ABOVE JETTY DECK CONDITION OBSEVATIONS

3.1 CONCRETE JETTY DECK SURFACE

The existing concrete deck was examined visually for signs of damage that are presently evident.

Overall the deck is in good shape with no evident large cracks. Over the years a number of "temporary" buildings have been attached or placed on the deck mostly near the southern face of the concrete deck. These buildings were in the process of being removed or were already gone at the time of examination. There was some evidence of wood bull rails which had rotted behind or under the buildings but no evidence that the concrete deck had been compromised.

Where the temporary buildings have been removed there is staining or discoloration of the concrete and some painting spills.

There are occasional places where services have been fished through the deck to meet the needs of the building.

3.2 JETTY MOUNTS

All of the jetty mounts were given a examination to look for damage to the enclosure. All mounts appeared to be in good repair. There was no attempt to confirm whether the services at each mount were working as it is understood that the contractor is to remove and store the units.

3.3 ADJACENT BUILDINGS

The existing buildings are in general good repair and keep the weather out as intended. They are of industrial construction most with metal cladding of some sort. The skins show signs of normal wear and tear that could be expected where machinery and parts are being constantly moved adjacent to them. The best example is the Sheet Metal shop where steel plate and other steel goods have been stored and have fallen or been pushed against the siding.

4 SUMMARY

After reviewing the jetty components highlighted in the PWGSC specification it is the writers opinion that there is no significant signs of damage to the below deck components of the jetty The deterioration of the steel piles and the bulkhead wall components is as one would expect given the age of the structure.

It is recommended that the corrosion protection system be reviewed for integrity with respect to the piles that are showing signs of scaling

The above deck buildings are showing cosmetic damage as detailed in the report but no structural issues at the time of the inspection.

Respectfully Submitted

Ian W. Martin, P.Eng.

Senior Project Manager

Appendix A

UNDER JETTY PHOTOS

STEEL PILED DECK STRUCTURE INCLUDING PILES

Photo A1 - Typical Deck, Wall & Piles (GL 33-34, B, West)

Photo A2 - Typical U/S of Deck

Photo A3 Typical Pile with Surface Corrosion (GL 2, A, East)

Photo A4 – Typical Pile Corrosion in Spalsh Zone (GL 2, E, East)

Photo A5 Typical piles near existing boat access (GL 2-3, I+, North)

Photo A6 – Corrosion at Mud Line (GL 7, D, North)

ANCHORED SHEET PILE BUKKHEAD WALL

Photo A7 – Bulkhead Wall near East End (GL 33-34, B-, West)

Photo A8 - Typical Corrosion at Joints. Note Rust Staining From Weld on Whaler Above (GL 33-34, B-, North)

Photo A9 – Whaler Weld & Cutting Corrosion (GL 33-34, B-, North)

Photo A10 Typical Tie Back and Whaler Assembly (GL, B-, North)

CONCRETE FACED TIMBER CRIB

Photo A11 - West Wall of Timber Crib (GL 1, a-, North)

Photo A12 - South Wall (Note Pit in Wall Face) (GL 1-2, A-, North)

Photo A13 - SW Corner of Concrete Faced Timber Crib (GL 1-2, A-, North)

Photo A14 – South Face of L Wall (GL 35+, F+, East)

THE SMALL L WALL

Photo A15 – West Face of Small L Wall (GL 35+, F+, North East)

STEEL SEET PILE PERIMETER WALL

Photo A16 - Typical Section of Perimeter Sheet Pile Wall

Photo A17 - Sheet Pile Wall (Note Typical Surface Corrosion)

Photo A18 – Typical Perimeter Sheet Pile Top Assembly

Appendix B

ABOVE DECK PHOTOS

CONCRETE DECK

Photo B1 – East End of Concrete Deck with Asphalt Approach

Photo B2 – Typical Deck Area

Photo B3 – Central Deck Area

Photo B4 – South Edge of Central Deck

Photo B5 – Central Deck Showing Staining & Penetrations

Photo B6 – Near High Mast Lighting – Mastic Staining

Photo B7 – Crane Pad Deck

Photo B8 – West End of Deck

JETTY MOUNTS

Photo B9 – Jetty Mount #3

Photo B10 – Jetty Mount #1 Water Side

Photo B11- Typical Skin Damage to Buildings

Photo B12 – Paint Shop

Photo B13 – Overview of Plate Shop

Photo B14 Damage at Plate Shop Doors

Photo B15 – Plate Shop Wall Damage

Photo B16 More Damage at Plate Shop Wall

Appendix C

BULKHEAD WALL PHOTOS

BULKHEAD WALL

Photo C1 – East End Bulkhead Wall (GL 33-34, B-, North)

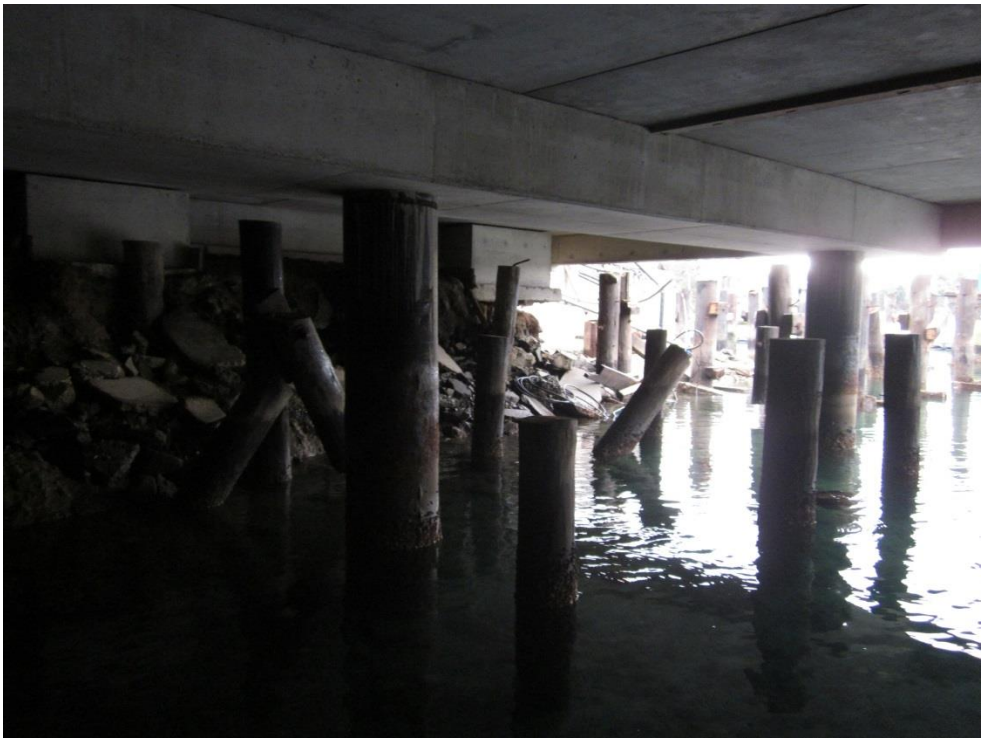


Photo C2 – Typical Underside of Deck (East End) (GL 33-34, C-, East)

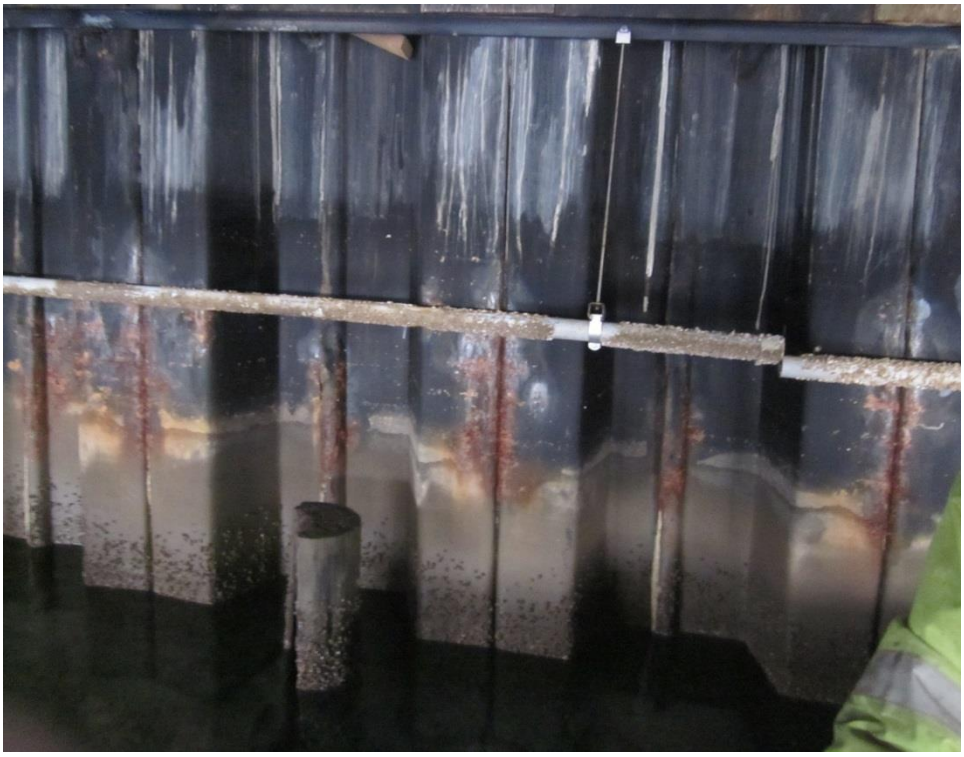


Photo C3 – Typical Bulkhead Wall (Corrosion at Joints) (GL B-, North)

Photo C4 – Typical Tie Back (GL B-, North)

Photo C5 – Typical Configuration (GL 21-22, B-, North)

Photo C6 – Typical Wailer Installation (GL B-, North)

Photo C7 – East of high Mast Lighting Foundation (GL 8-9, B-, North)

Photo C8 – West End Abandon Sheet Pile Wall (GL 11-12, B-, North)

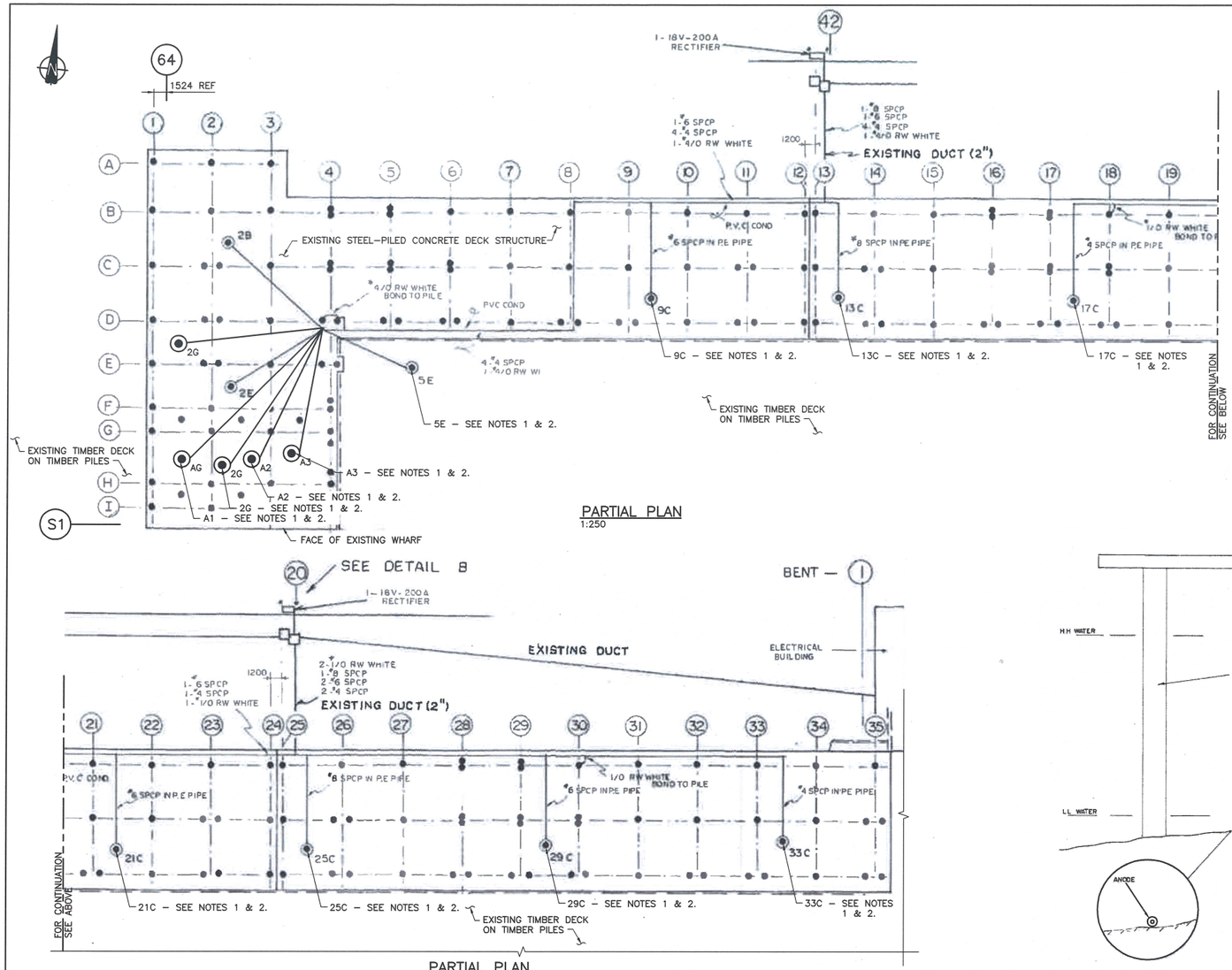
Photo C9 – Debris in Fill around High Mast lighting (GL 7, E, North)

Photo C10 – Fill East of High Mast lighting (GL 8-10, B-,West)

Photo c11- Overview of West End of Deck (GL 4, G, North East)

Appendix D

REFERENCE DRAWING E11



PARTIAL PLAN
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PARTIAL PLAN
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TYPICAL SECTION
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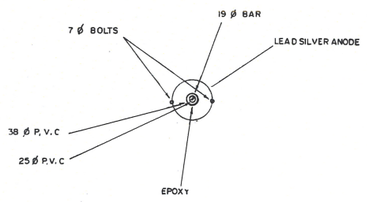
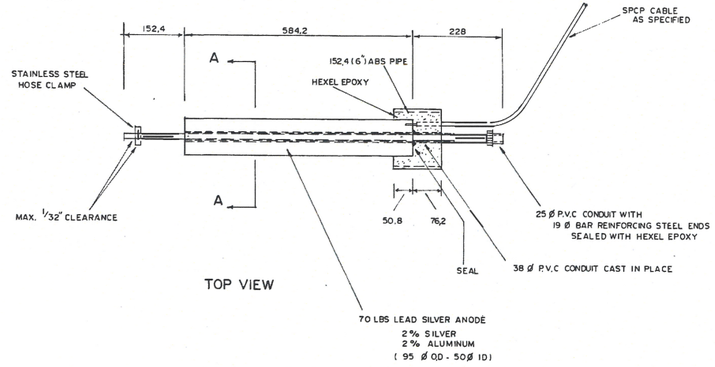


SECTION A-A



TOP VIEW

TYPICAL ANODE ASSEMBLY DETAILS
N.T.S.

LEGEND:

- LEAD SILVER ANODE
- EXISTING STEEL PIPE PILE

NOTES:

1. TEMPORARILY REMOVE, STORE AND REINSTATE ANODES TO ORIGINAL LOCATION AFTER DREDGING AND ENGINEERED CAPPING WORK ARE COMPLETED.
2. DO NOT DAMAGE THE INSULATION ON THE ANODE CABLE DURING REMOVAL AND REINSTATING.
3. DETAILS TAKEN FROM ESQUIMALT GRAVING DOCK IMPROVEMENTS, PROJECT NUMBER PR.100772 DRAWINGS 15 AND 16 OF 75, SUPPLEMENTED BY FIELD INFORMATION FROM EGD SEDIMENT REMEDIATION SOUTH JETTY UNDER-PIER EROSION PROTECTION RECORD DRAWINGS S15 (REFERENCE DRAWINGS).
4. REFER TO SPECIFICATION SECTION 02 41 13 FOR ICCP SYSTEM REQUIREMENTS.

CORROSION TESTING REQUIREMENTS:

1. INSPECT AND TEST THE ICCP SYSTEM BEFORE DISCONNECTING AND AFTER REINSTATEMENT TO CONFIRM THAT THE REINSTATED ICCP SYSTEM PROVIDES THE SAME OPERATIONAL PERFORMANCE LEVEL AS PREVIOUSLY EXISTED.

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

Klohn Crippen Berger

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
L. DUONG
39514
2014-12-18

Revision/ Revisions	Description/Description	Date/Date
0	ISSUED FOR TENDER	2014/12/19

Client/client

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

ESQUIMALT GRAVING DOCK WATERLOT PHASE 2 SOUTH JETTY UNDER-PIER SEDIMENT REMEDIATION

Consultant Signature Only

Designed by/Concept par
GEOFF COOPER

Drawn by/Dessins par
ARNIE RIST

PWGSC Project Manager/Administrateur de Projets TPSGC
ANDREW MYLLY

Regional Manager, Environmental Services
COLLIN KINGMAN

Drawing title/Titre du dessin
SOUTH JETTY MODIFICATIONS TO CATHODIC PROTECTION SYSTEM

Project No./No. du projet	Sheet/	Revision no./
R.018400.002	E11	0

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D15

ESQUIMALT GRAVING DOCK

LIQUIFACTION ASSESSMENT

KCB (2002)

Number of Pages: 242

Public Works and Government Services Canada

ESQUIMALT GRAVING DOCK AND SOUTH LANDING WHARF

SITE INVESTIGATION AND LIQUEFACTION ASSESSMENT

Final Report

KLOHN CRIPPEN

PG 9060 01

KLOHN CRIPPEN

June 25, 2002

Public Works and Government Services Canada
Pacific Region
641-800 Burrard Street
Vancouver, British Columbia
V6Z 2V8

Mr. Chris Henoch, P.Eng.
Project Manager

Dear Mr. Henoch:

Esquimalt Graving Dock and South Landing Wharf
Site Investigation and Liquefaction Assessment

Enclosed please find eight copies of our final report on the geotechnical site investigation and liquefaction assessment at the Esquimalt Graving Dock and South Landing Wharf in Esquimalt, British Columbia. We will also be forwarding two CDs with electronic files of the report separately.

We trust this meets your requirements. Please call if you have any questions.

Yours truly,

KLOHN CRIPPEN CONSULTANTS LTD.

Alex Sy, Ph.D., P.Eng.
Project Manager

AS:gs

cc: Geoff Cooper (KC)

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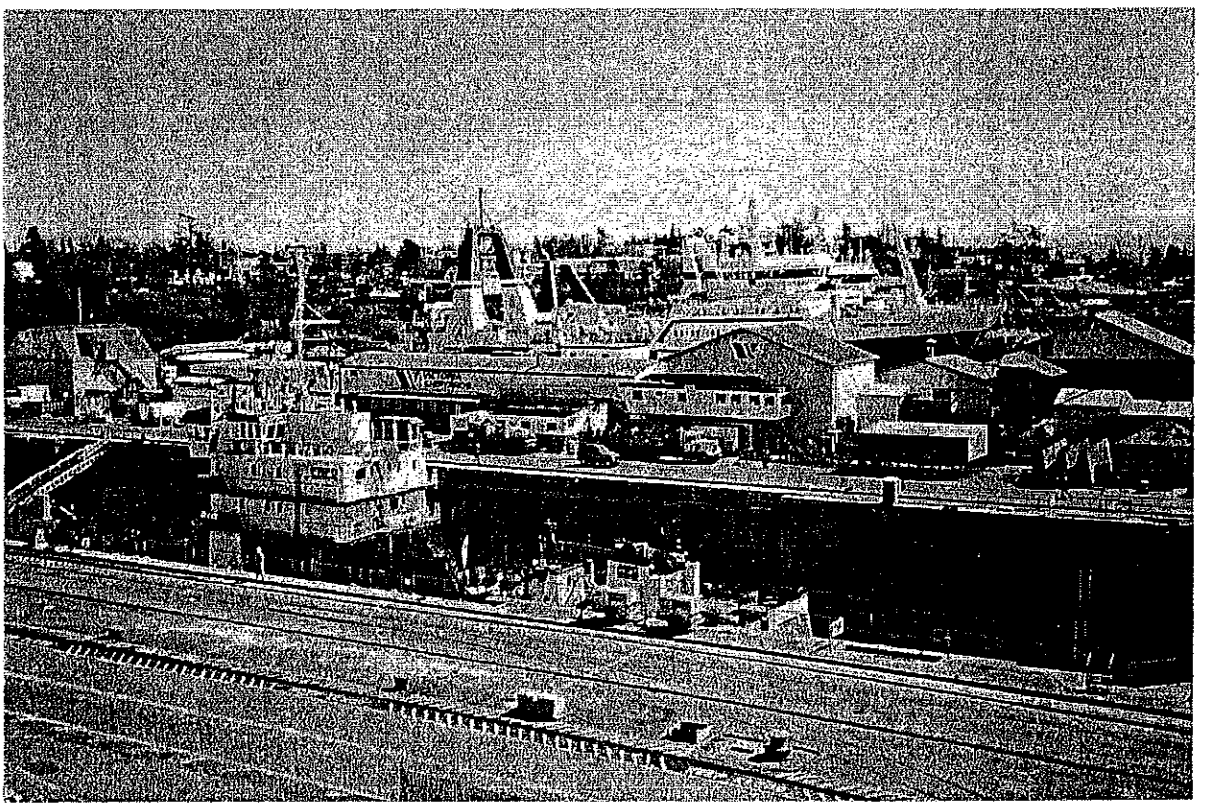
020625R

Public Works and Government Services Canada

ESQUIMALT GRAVING DOCK AND SOUTH LANDING WHARF

SITE INVESTIGATION AND LIQUEFACTION ASSESSMENT

Final Report



PG 9060 01

June 2002

KLOHN CRIPPEN

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1. INTRODUCTION

As part of the seismic evaluation program at the Esquimalt Graving Dock (EGD), Public Works and Government Services Canada (PWGSC) retained Klohn Crippen to conduct a site investigation and prepare a geotechnical report for the dry dock and adjoining South Landing Wharf (SLW). This report presents the results of our site investigation and seismic liquefaction assessment for the EGD and SLW in Esquimalt, British Columbia.

The work consisted of:

- a site investigation program at EGD and SLW;
- laboratory soil testing;.
- ground response and liquefaction assessments;
- seismic stability and ground deformation analyses;
- seismic failure mode and effect analysis; and
- preparation of a geotechnical report.

The work was carried out in general accordance with our proposal dated March 7, 2002. Authorization to proceed was given by Mr. Chris Henoch, and confirmed by Public Works and Government Services Canada's Commitment for Services dated March 19, 2002, pursuant to Agreement No. E0276-012130/001 dated January 25, 2002.

Unless otherwise stated, all coordinates in this report are referenced to UTM, and all elevations refer to Chart datum. Metric units are used throughout this report; Imperial units are included for selected values or measurements.

2. SITE DEVELOPMENT HISTORY

The existing EGD and SLW were constructed in several phases beginning in the early 1920s. Based on the available information provided by PWGSC for this study, including historical photographs of the original construction, our understanding of the previous site development and foundations of the dry dock and adjacent wharf structures is outlined below. Selected historical photographs and drawings of the original construction are enclosed in Appendix VII.

2.1 Graving Dock (1921-26)

The existing graving dock is approximately 361 m long, 45 m wide and 15 m deep, with two floating caisson gates which can be positioned at any of four alternative locations to partition the dry dock into two separate compartments or dock sections. The top of the dry dock floor slab is El. -10.5 m (-34.5 ft), and the coping (top of dock retaining walls) is at El. 4.4 m (14.5 ft). High water on spring tide (HWOST) is El. 3.0 m (10.0 ft) and low water on spring tide (LWOST) is El. 0.0 m.

The graving dock was originally constructed during 1921 to 1926, within a cofferdam enclosing the south and west sides of the site. Historical photographs (1922) suggested that a double cofferdam system, comprising a dyke and a timber pile wall outside of the dyke, was constructed west and south of the site to permit foundation excavation and construction of the graving dock in the dry. The base (floor slab) of the dock was founded directly on bedrock underlying the site. The north and east retaining walls of the dry dock, and the eastern 110 m of the south retaining wall were cast on and against rock for a large part of their height. The western 250 m of the south wall was also founded on rock, with a 2 m wide puddle clay seal placed between the wall and the "rubble fill" to the south. A 1925 photograph (see Appendix VII) appeared to suggest that part of the puddle

clay and "rubble fill" between the south wall of the dry dock and the cofferdam was placed in the wet.

As part of the original graving dock construction, a timber crib was installed at the southwest end of the site, just south of the dry dock entrance (see Appendix VII). The timber crib structure is approximately 10.7 m (35 feet) high by 12.2 m (40 feet) wide and 30.5 m (100 feet) long. The timber crib, similar to those used in the North Landing Wharf construction during the same period, was likely towed in place, sunk and filled with sand, gravel, and rockfill. The base of the timber crib appears to have been placed at approximately El. –9.8 m (El. –32 ft), likely on a 2 m layer of "mattress" fill overlying native fine grained soils. A 3.5 m high concrete parapet wall was constructed above and along the west and south sides of the timber crib. The west wall of the crib, including the west parapet wall above it, appears to have been connected to the west extension of the south retaining wall of the dry dock. Original EGD construction Drawing No. 7 indicates that this crib served as a wharf at the west end of a 15 m wide roadway located adjacent to the south side of the dry dock.

2.2 South Landing Wharf (1940-41) and Extension (1943)

The timber pile supported South Landing Wharf (also known as the South Jetty) was originally constructed in 1940 to 1941 south of the graving dock beyond the filled area. The original SLW consisted of a 20 m wide by 290 m long south facing timber wharf, with a 20 m wide by 104 m long northwest approach section, a 24 m long centre approach (since demolished), and a 35 m long east approach. The original SLW and approach sections were supported on creosote-treated timber piles, which were not driven to bedrock. The piled approach sections connected the south jetty to the filled area south of the dry dock. The top surface of the south jetty was at El. 5.06 m.

An extension was built north of the south jetty in 1943. The 1943 extension consisted of a series of buildings and warehouses constructed between the south jetty and dry dock; these buildings have since been demolished and the area now occupied by a concrete wharf. Old site photos taken in the 1970s appeared to suggest that these buildings were placed on a steel crate or grillage type foundation. We speculate that this former grillage foundation was partly supported on fill and partly on timber piles.

2.3 South Landing Wharf Upgrade (1984-85)

The South Landing Wharf was upgraded in 1984 to 1985. The main upgrade consisted of a 13 m wide by 195 m long concrete wharf structure, located parallel to and adjoining the north side of the south timber jetty (1940-41). The concrete deck, including a new crane pad on its west end, was supported on steel pipe piles driven to practical refusal. A new sheet pile wall, tied back to a shallow retaining wall foundation about 15 m away, was also installed along the north side of the new concrete wharf. The new sheet pile wall was constructed using 6.1 m and 9.1 m long sheet piles. As part of the SLW upgrade, an "infill" timber pile supported timber wharf was also constructed at the west end of the SLW area.

3. PREVIOUS GEOTECHNICAL INFORMATION

3.1 Relevant Reports and Drawings

The following relevant existing reports and drawings provided by PWGSC were reviewed for this project.

- "Phase II Draft Report, Esquimalt Graving Dock, Esquimalt, B.C." by Pacific Geodynamics Inc., draft report provided by PWGSC in October 2001;
- "Report on Condition of South Landing Wharf, Esquimalt Graving Dock, Esquimalt, British Columbia" by Hay & Company Consultants Inc. dated June 2001;
- "Inspection Results of the South Jetty Wharf, Esquimalt Graving Dock, Victoria, British Columbia" by Foreshore Technologies Inc. dated January 19, 2001;
- "Report on Compilation of Existing Geotechnical Information, Esquimalt Graving Dock, Esquimalt, B.C., PWGSC Project #846348" by Golder Associates Ltd. dated January 5, 2000;
- "Seismic hazard analysis, Esquimalt Graving Dock, Esquimalt, B.C., Phase I" by Pacific Geodynamics Inc. dated November 30, 1999;
- "Geotechnical Exploration, Southside Substation Building, Esquimalt Graving Dock, Victoria, B.C." by Terra Engineering Ltd. dated March 20, 1997;
- Drawing No. 55 of 75, Esquimalt Graving Dock Improvements, Esquimalt, B.C., Contract No. 3, Improvements to South Landing Wharf – Test Hole Investigations sheet 1 of 2 by Ker Priestman & Associates Ltd. dated April 1984;
- Drawing No. 56 of 75, Esquimalt Graving Dock Improvements, Esquimalt, B.C., Contract No. 3, Improvements to South Landing Wharf – Test Hole Investigations sheet 2 of 2 by Ker Priestman & Associates Ltd. dated April 1984;

- Drawing No. 19 of 75, Improvement to South Landing Wharf – East Infill Area General Arrangement by Ker Priestman & Associates Ltd. dated March 1984;
- Drawing No. 4 of 4, Esquimalt Graving Dock Improvements, Esquimalt, B.C., Contract No. 2 – Dredging Test Hole Investigations by Ker Priestman & Associates Ltd. dated December 1983;
- "Esquimalt Dry Dock, South Landing Wharf, Supplementary Boreholes" by Hardy Associates (1978) Ltd. dated February 17, 1984;
- "Esquimalt Dry Dock, South Landing Wharf, Pile Designs" by Hardy Associates (1978) Ltd. dated January 4, 1984;
- "Report on Stability of Timber Cribs, Proposed 150 Tonne Travelling Crane, Esquimalt Graving Dock, Esquimalt, B.C." by Hardy Associates (1978) Ltd. dated January 31, 1979;
- "Factual Report on Graving Dock Section, Foundation Investigation for Proposed 150 Tonne Travelling Crane, Esquimalt, B.C. for Choukalos, Woodburn, McKenzie, Maranda Ltd." by Hardy Associates (1978) Ltd. dated January 30, 1979;
- "Assessment of Foundation Conditions, Proposed 200 Ton Travelling Crane, Esquimalt Graving Dock, Esquimalt, B.C." by Hardy Associates (1978) Ltd. dated May 25, 1978; and
- Original EGD construction drawings (incomplete).

3.2 Existing Test Holes

Most of the existing test holes are located north of the graving dock (see Drawing GA 992-1221-1, Golder Associates Ltd. report dated January 5, 2000). These test holes were the 10 (e.g., TH-12), 100, 200, 400 and 500 series test holes carried out by Hardy Associates in 1978 to 1979 to provide information on foundation conditions beneath a proposed 150 tonne crane. At the South Landing Wharf area, limited test holes exist, and these are listed in Table 1.

Table 1 Previous Site Investigations by Others at the South Landing Wharf

Drill Hole	Drill/Test Method	Max. Test Depth (m)	Ground Elevation (m)
1997 Test Holes by Terra Engineering Ltd. – Southside Substation Building			
DCPT-1	Dynamic cone penetration test	7.0	Not available
TH-2	Auger/dynamic cone penetration test	7.6/7.9	Not available
1984 Test Holes by Hardy Associates Ltd. – South Landing Wharf			
TH84-2-1	Mud rotary drilling	14.9	4.7 (Est.)
TH84-2-2	Mud rotary drilling	27.9	4.7 (Est.)
Th84-2-3	Mud rotary drilling	32.0	5.2
1983 Test Pits and Test Holes by Hardy Associates Ltd. – South Landing Wharf			
TP1	Test pit	4.3	4.4
TP2	Test pit	4.0	Not available
TH83-12-1	Mud rotary drilling	35.1	5.2
TH83-12-2	Mud rotary drilling	43.0	5.2
TH83-12-3	Mud rotary drilling	42.2	5.2
TH83-12-4	Mud rotary drilling	59.7	5.2
TH83-12-5	Mud rotary drilling	42.4	5.2
TH83-12-6	Mud rotary drilling	33.5	5.2

The existing test holes in the SLW area indicate that the site is underlain by random fill overlying soft native silt and clay, which overlie a thin layer of dense till above the bedrock. The fill thickness appears to decrease and the clay thickness increase to the south. The bedrock surface generally dips to the south and west.

4. FIELD AND LABORATORY PROGRAM

4.1 Site Investigation Program

A site investigation program, consisting primarily of Becker test holes (BK), cone penetration tests (CPT), and mud rotary drill holes (DH), was conducted between March 14 and April 2, 2002 at the EGD and SLW. The test hole locations were positioned approximately in five lines in the east-west direction from north to south, namely:

- Adjacent to north wall of dry dock;
- Adjacent to south wall of dry dock;
- Middle of the filled area between dry dock and sheet pile wall;
- Along the concrete wharf; and
- Along the south edge of the south timber wharf.

The purpose of the site investigation program was to determine detailed subsoil stratigraphy to supplement existing test hole information, to obtain soil density and strength data for seismic liquefaction and deformation analyses, to obtain shear wave velocities of the subsoils for site response analyses, and to determine the nature of the puddle clay fill adjacent to the south wall of the dry dock.

Table 2 summarizes the 2002 site investigation program at the EGD and SLW. The drill hole locations and elevations were surveyed by Terra Remote Sensing Inc. of Sidney, British Columbia. The depth to mudline was estimated by sounding with a tape. The test hole locations are shown on Drawing B-1001. Selected photographs taken during the site investigation are enclosed in Appendix VIII.

Table 2 2002 Site Investigation Program

Drill Hole	Drill/Test Method	Max. Test Depth (m)	COORDINATES (m)		Reference Elevation* (m)	Depth to Mudline (m)
			Easting	Northing		
BPT02-01	Closed end Becker	3.68	468430.20	5364929.40	4.39	-
BOC02-01	Open end Becker	3.05	468428.03	5364929.35	4.39	-
BPT02-02	Closed-end Becker	3.66	468654.28	5364949.60	4.41	-
BOC02-02	Open-end Becker	3.20	468652.32	5364949.41	4.40	-
BPT02-03	Closed-end Becker	1.83	468662.16	5364891.30	4.42	-
BOC02-03	Open-end Becker	2.44	468660.37	5364891.03	4.41	-
BPT02-04	Closed-end Becker	20.22	468396.82	5364846.10	4.54	-
BOC02-04	Open-end Becker	18.69	468397.63	5364847.76	4.44	-
BPT02-05	Closed-end Becker	31.55	468500.75	5364832.84	5.17	4.4
BOC02-05	Open-end Becker	32.61	468496.36	5364832.12	5.16	4.4
BPT02-06	Closed-end Becker	21.18	468510.00	5364860.11	4.41	-
BOC02-06	Open-end Becker	21.64	468508.25	5364859.88	4.41	-
BOC02-07	Open-end Becker	16.76	468464.92	5364860.41	4.33	-
BPT02-08	Closed-end Becker	19.81	468558.24	5364864.49	4.40	-
BOC02-08	Open-end Becker	19.20	468556.28	5364864.20	4.38	-
BOC02-09	Open-end Becker	29.26	468433.28	5364828.48	5.18	2.7
BPT02-10	Closed-end Becker	23.62	468605.42	5364843.87	4.54	-
BOC02-10	Open-end Becker	23.62	468605.23	5364841.93	4.54	-
CPT02-01	CPT	3.65	468433.69	5364868.34	4.38	-
SCPT02-02	SCPT	13.15	468517.33	5364876.81	4.39	-
CPT02-03	CPT	57.95	468298.72	5364790.38	5.07	13.6
CPT02-04	CPT	0.00	468365.66	5364816.71	5.12	13.1
CPT02-05	CPT	42.65	468365.03	5364790.86	5.17	13.7
SCPT02-06	SCPT	37.60	468455.66	5364800.16	5.15	12.0
CPT02-07	CPT	40.95	468501.95	5364805.11	5.14	11.9
CPT02-08	CPT	27.50	468571.32	5364812.46	5.13	11.6
SCPT02-09	SCPT	46.60	468297.95	5364820.01	5.11	13.5
CPT02-10	CPT	25.05	468362.25	5364851.27	4.90	13.0
DH02-01	Mud rotary	12.19	468518.49	5364876.33	4.44	-
DH02-02	Mud rotary	50.75	468292.16	5364787.71	4.91	13.6
DH02-03	Mud rotary	26.82	468359.61	5364849.87	4.97	12.8
DH02-04	Mud rotary	24.99	468498.69	5364804.92	5.13	11.6

* Reference elevation refers to ground surface for on-land test holes, and to top of deck for under-deck test holes.

4.2 Becker Test Holes

The Becker test holes were conducted by Foundex Explorations Ltd. of Surrey, British Columbia using a truck-mounted model HAV180 Becker hammer drill rig. The test holes comprised both close-ended casing penetration tests (BPT) and open-ended casing sampling holes (BOC). The BPT consisted of driving a closed-ended double-walled 170 mm diameter casing into the ground with an ICE 180 double-acting diesel pile hammer having a manufacturer's rated hammer energy of 11 kJ per blow. The following data were recorded during the BPT:

- The number of blows for every 0.3 m of casing penetration. The penetration resistance profiles are presented in the test hole logs in Appendix I;
- Hammer bounce chamber pressures using a computerized data acquisition system. The bounce chamber pressure data are required in the procedure proposed by Harder (1988) to convert BPT blow counts to equivalent standard penetration test (SPT) N-values;
- Dynamic measurements using a pile driving analyzer (PDA) were performed by Robert Miner Dynamic Testing, Inc. of Manchester, Washington on two of the BPTs (BPT02-05 and BPT02-06). The dynamic monitoring data (enclosed in Appendix IV) are required in the BPT-SPT N-values interpretation procedure proposed by Sy (1993); and
- Casing friction measurements from pull-up tests. During each casing add-on at 2.4 m intervals, the casing was pulled up and the pull-up tension force was measured with a load cell connected to the top of the casing. The pull-up force is a measure of the skin friction developed on the outside of the Becker casing during the penetration test. The casing friction data are required in the Sy (1993) approach to estimate equivalent SPT N-values.

The open-ended Becker sampling holes were carried out adjacent to the close-ended Becker penetration test holes. In these sampling holes, the casing was driven open-ended

with compressed air forced down the annulus of the casing to flush the cuttings up the centre of the inner pipe to the ground surface. Continuous cuttings (soil particles) were collected at the ground surface via a cyclone. Disturbed soil samples were obtained and the subsoil stratigraphy was logged by a Klohn Crippen field engineer. At selected depths, the drilling was stopped and Shelby tube sampling or standard penetration test (SPT) was conducted. The Shelby tube sampling was carried out using 76 mm Shelby tubes in accordance with ASTM D1587-00 test method. The SPT consisted of driving a split spoon sampler (51 mm O.D. by 38 mm I.D.) 0.45 m into the subsoil using an automatic trip hammer. The SPT was carried out in accordance with ASTM D1586-99 test method. The field blow counts for the sampler penetration of 0.30 m, after an initial seating penetration of 0.15 m, were recorded and are plotted in the test hole logs in Appendix I.

For this project, eight Becker penetration tests (BPT02-01 to BPT02-06, BPT02-08 and BPT02-10) and ten Becker sampling holes (BOC02-01 to BOC02-10) were carried out. BPT/BOC02-01 to 02-03 were carried out adjacent to the graving dock. The other BPT/BOC holes were carried out in the South Landing Wharf area. The Becker test hole logs are presented in Appendix I.

In BOC02-09 and BOC02-10, Nilcon field vane tests were also performed to obtain the undrained shear strengths of cohesive soil deposits. A standpipe piezometer was installed in BPT02-08 at 7.3 m depth to monitor the groundwater level in the rockfill and tidal influence on the groundwater level. In addition, a 76 mm diameter PVC pipe was installed in BPT02-04 to approximately 20 m depth, and grouted in place using a mixture of bentonite and cement. Downhole shear wave velocity measurements were subsequently carried out by ConeTec Investigations Ltd. in accordance with ASTM D 4428/D 4428M-91 test method. Seismic wave signals were generated by striking a solid

stem auger with a sledge hammer. The test results are presented in ConeTec report enclosed in Appendix II. All the Becker test holes, including the standpipe piezometer and the PVC pipe, were subsequently grouted up for abandonment. The soil cuttings and drill fluids were collected in drums and moved to the Peninsula Waste Water Services Ltd. office located at the North Landing Wharf for disposal as per request of PWGSC.

4.3 Cone Penetration Tests and Mud Rotary Drill Holes

Ten cone penetration tests (CPT) and four mud rotary drill holes (DH) were carried out by ConeTec Investigations Ltd. of Vancouver, B.C. and Mud Bay Drilling Co. Ltd. of Surrey, B.C. using a truck mounted Mobile B-80 drill rig. The CPTs were performed in accordance with ASTM test method D3441 using a 10-ton and a 20-ton electric friction-cone penetrometers equipped with a pore pressure transducer. The 10-ton cone has a tip area of 10 cm^2 and a friction sleeve area of 150 cm^2. The 20-ton cone has a tip area of 15 cm^2 and a friction sleeve area of 225 cm^2. The pore pressure filter, comprising a 5 mm thick porous plastic, was located immediately behind the cone tip. The cone was advanced into the soil at a rate of 2 cm/sec and the following data were collected at 5 cm intervals during penetration: cone tip resistance (Qc), sleeve friction (Fs) and dynamic pore pressure (U). At selected depths, pore pressure dissipation tests were also carried out. In addition to the above measurements, seismic shear wave velocities were measured at 1 m intervals in seismic cone penetration tests SCPT02-02, SCPT02-06 and SCPT02-09. At SCPT02-02, subsurface waves were generated using two methods: (1) a 6.8 kg sledge hammer striking a solid stem auger vertically; and (2) a "buffalo gun" discharging blank cartridges into the ground. At SCPT02-06 and SCPT02-09, an underwater blasting plate loaded with seismic blasting caps was used to generate S-wave pulses. The drill hole logs are included in Appendix I. The CPT and SCPT data are presented in the ConeTec report enclosed in Appendix II.

Standard penetration tests (SPT) with 51 mm O.D. by 38 mm I.D. split spoon sampler were conducted in DH02-01 and DH02-03 at selected depths using a 63.5 kg (140 lb) safety hammer with a drop distance of 0.76 m. The field blow counts for the sampler penetration of 0.30 m, after an initial seating penetration of 0.15 m, were recorded. Undisturbed Shelby tube samples were also obtained at selected depths in DH02-01, DH02-02 and DH02-03. In addition, Nilcon field vane tests were performed in DH02-01, DH02-02 and DH02-04 to determine the undrained shear strengths of the silt and clay deposits. Test results are summarized in ConeTec report enclosed in Appendix II. The drill holes were subsequently grouted up for abandonment. The soil cuttings and drill fluids were collected in drums and moved to the Peninsula Waste Water Services Ltd. office located at the North Landing Wharf for disposal as per request of PWGSC.

4.4 Laboratory Testing

Soil samples obtained from the drill holes were returned to our Richmond laboratory for visual classification and moisture content determination. Sieve analyses, hydrometer and Atterberg limits tests were conducted on selected samples. The laboratory test results are included in Appendix III.

5. SITE AND SUBSOIL CONDITIONS

5.1 Adjacent to Graving Dock Walls

The areas north and south of the graving dock are generally paved with asphalt and concrete about 0.2 to 0.3 m thick. As described in Section 2.1, the north, east, and southeast sides of the dry dock were excavated into rock, and the retaining walls were subsequently cast against rock for most of their height. As a result, relatively shallow backfills were expected at the north, east and southeast portions of the dry dock retaining walls. BOC02-01 and BOC02-02 at the north side of the graving dock encountered 3.0 m to 3.2 m thick granular fill and/or rockfill overlying bedrock. The fill or rockfill comprises fine to coarse, subangular to subrounded sand and gravel, with trace silt and occasional cobbles and boulders. BOC02-03 at the southeast side of the dry dock encountered 2.4 m of similar granular fill or rockfill overlying bedrock.

Hardy Associates (1978) Ltd. report dated January 30, 1979, Drawing No. 2 – cross section B-B indicated that the bedrock level is undulating along an east-west section, approximately 14 m north of the north dry dock wall, and may range in depth from about 0.3 m to 9.0 m, with a "gully" to about 17.5 m depth in the area adjacent to the tunnels leading to the Pump House.

West of BOC02-03, a 2 m wide puddle clay fill was placed against the graving dock south wall as a hydraulic seal to bedrock (described in Section 2.1). Test holes DH02-01, SCPT02-02 and CPT02-01 confirmed the existence of the puddle clay immediately south of the Graving Dock south retaining wall (see cross-section C in Drawing No. B-1002). The puddle clay comprises firm to stiff clay of intermediate plasticity (CI) with interlayers of silt, sand and gravel. Limited Nilcon field vane tests carried out in DH02-01 indicated that the peak undrained shear strength of the clay varies between 49 kPa to 96 kPa. The

original EGD construction drawings indicate that "rubble fill" or rockfill was placed against the puddle clay on the south side. The rockfill was likely underlain by soft native clay.

5.2 South Landing Wharf

The South Landing Wharf can be conveniently divided into five different zones as shown on Drawing Nos. B-1001 and B-1003, namely, the south timber jetty (1941), the west timber infill section (1985), the concrete deck (1985), the area north of the steel-sheet pile wall (1985), and the east approach section (note that the figures in brackets indicate the approximate year that the structures were constructed). Geologic sections A through D in the SLW area are shown on Drawing No. B-1002.

The South Landing Wharf is generally underlain by granular fill and rockfill consisting of mainly sand and gravel with layers of silt and clay. The sand and gravel are fine to coarse, angular to subrounded, and loose to compact (as inferred from the equivalent $(N_1)_{60}$ values from BPT test data), with trace to some silt and occasional cobbles and boulders. Below the timber jetty, the fill is mainly organic silt and sand. The thickness of the fill and rockfill ranges from about 9 m to 18 m.

The fill and rockfill layer overlies a layer of silt, which in turn is underlain by native clay. The silt layer is discontinuous at some locations, as can be seen on the geologic sections in Drawing No. B-1002. The silt layer comprises low plasticity silt (ML) with trace to some sand and gravel, and trace seashells. The silt is generally soft to firm. The underlying native clay layer increases in thickness from north to south, as indicated by test hole data shown on geologic sections C and D. The clay is of intermediate plasticity (CI), generally soft to stiff, and contains trace to some sand and gravel, with occasional

cobbles and seashells. A thin layer of sand and gravel underlies the clay and overlies the bedrock.

The Nilcon field vane test results are plotted against elevation as shown on Figure 5.1. The peak undrained shear strength of the native silt and clay, as measured from Nilcon field vane tests in DH02-02, DH02-04, BOC02-09 and BOC02-10, ranges from 13.5 kPa to 118 kPa, with an average value of about 50 kPa. The horizontal coefficient of permeability values (k_h) of the silt and clay layers were estimated based on CPT pore pressure dissipation data; these values range from $1.5x10^{-7}$ cm/s to $4x10^{-6}$ cm/s, with an average value of about $1.2x10^{-6}$ cm/s. Note that Baligh and Levadoux (1980) suggested that the ratio of horizontal to vertical coefficient of permeability (k_h/k_v) is typically about 1.2±0.2 for clay with no layering, to 2 to 5 for clay with slight layering.

5.3 Groundwater Level

A piezometer was installed in the rockfill at BPT02-08, and monitored on March 29 and 30, 2002. In addition, tide levels were also monitored by Klohn Crippen at SCPT02-06 location relative to the deck level during the field program. The measured tide and piezometric levels are compared with the forecasted tide levels from tide chart for the Esquimalt Harbour on Figure 5.2, for the period of March 27 to 31, 2002. As shown, the groundwater level in the rockfill at BPT02-08 varies with the tidal fluctuations.

6. BPT DATA INTERPRETATION

The BPT blow counts are commonly converted to equivalent SPT N_{60} values for evaluation of soil density and liquefaction resistance in gravelly soils. For this study, equivalent SPT N_{60} values were estimated from BPT blow counts following two procedures: Harder (1988) method, and Sy (1993) method. The Harder method uses peak bounce chamber pressure data from the BPT, with empirical BPT-SPT correlation curve, to obtain equivalent SPT N_{60} values. In the more fundamental Sy method, the transferred energy data from the PDA and soil friction acting on the Becker casing are used to determine equivalent SPT N_{60} values. The Sy BPT-SPT correlation curves explicitly account for casing friction. For this project, casing friction data were obtained from casing pull-up tests, and confirmed by CAPWAP analyses of the PDA recorded wave traces (Appendix IV). More details of the Harder and the Sy BPT-SPT interpretation methods are given in Appendix V.

The Harder and Sy methods were applied to the eight BPTs conducted in the EGD and SLW areas, and the results are presented in Appendix V. Comparison of the equivalent SPT N_{60} values from the two methods (see Figures V-3 to V-10 in Appendix V) indicates that the Sy approach generally gives higher equivalent N_{60} values than those from the Harder approach, except in deep soft clay where the Sy approach gives similar or lower N_{60} values. The differences in interpreted N_{60} values, as high as 2 to 3 times in gravelly soils, are mainly attributed to the effects of casing friction, which are not explicitly accounted for in the Harder method.

SPT measurements from Becker drill holes BOC02-05, BOC02-08 and BOC02-10, conducted adjacent to the corresponding BPTs, are also plotted in Figures V-7, V-9 and V-10 in Appendix V, for comparison with equivalent N_{60} values estimated from the

BPTs. As shown, the limited SPT measurements are more consistent with the equivalent N_{60} values interpreted from the Sy method than those from the Harder method.

The Harder BPT-SPT empirical correlation, based on test data from three sand and silty sand test sites, has embedded casing friction representative of sand and silty sand sites, and therefore can not fundamentally be applied to gravelly soil sites where the casing friction is significantly different (Sy, 1997). The Sy BPT-SPT correlation method explicitly considers site-specific casing friction, and thus is considered to give more representative equivalent SPT N_{60} values of the gravelly soils at the EGD and SLW site.

7. SITE RESPONSE ANALYSES

One dimensional total stress site response analyses, using the SHAKE computer program (SHAKE91 version by Idriss and Sun, 1992), were carried out for five locations in the SLW area; namely, BPT02-04, BPT02-05, BPT02-06, BPT02-08 and BPT02-10. The objective of the site response analyses was to determine the variations of peak horizontal ground accelerations and cyclic shear stresses with depth for liquefaction assessment. The locations selected for analyses are representative of ground conditions in the SLW area. Soil stratigraphic data from the adjacent open-ended Becker test holes were used to provide subsoil information at all five BPT locations.

The design earthquake events specified by PWGSC for this liquefaction study are summarized in Table 3. Figure 7.1 shows the target spectra for the three design earthquake events.

Table 3 Seismic Design Events

Earthquake Return Period	Earthquake Moment Magnitude	Peak Horizontal Ground Acceleration
1 in 475 year	Up to 7.6	0.35 g
1 in 1000 year	Up to 7.6	0.45 g
Cascadia Subduction	8.2	0.24 g

Three synthetic earthquake records and eight scaled natural earthquake records were provided by PWGSC for this study. These records were produced by Pacific Geodynamics Inc. (1999), and covered the three levels of design earthquakes as shown in Table 3. The input acceleration time histories, soil models, and the results of the ground response analyses are presented in Appendix VI.

Table 4 summarizes the computed surface peak ground accelerations (PGA) at the five soil columns analyzed under the three design earthquake events. The PGAs are significantly amplified at BPT02-04, but generally deamplified at the other locations. Note that the granular fill zone at BPT02-04 is the thickest among the sites analyzed, and the underlying clay is the thinnest. The SHAKE results indicate that deamplification generally occurs in the thick soft native silt and clay deposit overlying bedrock, and amplification generally occurs in the loose granular fill overlying the silt and clay.

Table 4 Surface Peak Ground Accelerations From SHAKE Analyses

Soil Column	Surface Peak Ground Acceleration (g)				
	475 Year Return Period EQ		1000 Year Return Period EQ	Cascadia Subduction EQ	
	Synthetic Record (A_{max}=0.35 g)	Average of Seven Natural Records	Synthetic Record (A_{max}=0.45 g)	Synthetic Record (A_{max}=0.24 g)	Natural Record (A_{max}=0.24 g)
BPT02-04	0.47	0.54	0.56	0.38	0.51
BPT02-05	0.28	0.35	0.29	0.25	0.26
BPT02-06	0.25	0.37	0.27	0.24	0.28
BPT02-08	0.37	0.40	0.36	0.27	0.35
BPT02-10	0.23	0.31	0.24	0.22	0.22

The fundamental periods of the five soil columns obtained from the SHAKE analyses, as well as the periods associated with the small-strain condition, are summarized in Table 5. The fundamental periods of the soil columns during earthquake shaking range from about 0.5 to 1.3 seconds. These are significantly higher than the predominant periods of the three design earthquakes (0.1 to 0.3 seconds as shown on Figure 7.1); hence, resonance of the fundamental mode is not expected to occur.

Table 5 Fundamental Periods of Soil Columns from SHAKE analyses

Soil Column	Fundamental Period (seconds)					
	Small Strain	Large Strain				
		475-yr EQ		1000-yr EQ	Subduction EQ	
		Synthetic	Average of 7 Natural Records	Synthetic	Synthetic	Natural Record
BPT02-04	0.34	0.50	0.54	0.52	0.49	0.49
BPT02-05	0.71	1.10	1.30	1.18	1.14	1.09
BPT02-06	0.52	0.83	1.04	0.92	0.83	0.83
BPT02-08	0.44	0.69	0.82	0.74	0.69	0.69
BPT02-10	0.56	0.84	0.98	0.88	0.83	0.81

8. LIQUEFACTION ASSESSMENT

Seismic liquefaction assessment of the saturated granular soils was carried out in general accordance with the Seed approach as recommended in Youd et al. (2001). The liquefaction assessment is appropriate for "free field" condition and neglects soil-structure interaction effects of the wharf. In the Seed liquefaction approach, the cyclic shear stress ratios induced by the design earthquakes are compared to the cyclic resistance ratios derived from field observations of soils with known standard penetration test (SPT) N values, at sites which have or have not liquefied during earthquakes. For this study, the induced cyclic shear stresses were computed directly from SHAKE. The cyclic shear resistances of the granular soils at the SLW were estimated from the BPTs, following the method proposed by Sy (1993) for converting BPT blow counts to equivalent SPT N_{60} values.

The liquefaction analyses are described in Appendix VI. The results of the liquefaction analyses at BPT02-04, BPT02-05, BPT02-06, BPT02-08 and BPT02-10 are summarized in Figures 8.1 to 8.5, respectively. The figures show, for the three design seismic events, the equivalent SPT N_{60} values from the BPT plotted against the required N_{60} values for a factor of safety against liquefaction of 1.0. The required N_{60} values derived from the Seed liquefaction chart (Youd et al. 2001) are for clean sand (i.e. fines content of 5%). Liquefaction is expected to occur during the design earthquakes where the equivalent N_{60} values estimated from the BPTs are less than the N_{60} values required to prevent liquefaction. The zones of predicted liquefaction, corresponding to the worst-case scenario earthquakes, are shown as hatched zones in Figures 8.1 to 8.5. As shown, significant liquefaction of the saturated loose granular fills will occur for the three design seismic events at all BPT locations, except BPT02-08. The total 12.8 m thick fill in BPT02-08 comprises mostly cohesive silt, with only a 3 m thick dense sand and gravel layer (rockfill) which is not predicted to liquefy. The soil conditions at BPT02-08 are

likely localized, and may not be representative of the general ground conditions in the SLW area.

Liquefaction potential was also assessed at CPT02-10, adjacent to the timber crib at the west end of the SLW. Results of the liquefaction assessment for the three design earthquake events are shown in Figure 8.6, which shows the measured cone tip resistance (Qt) and the tip resistance required to prevent liquefaction (for fines content of 35%) plotted against depth. The results indicate that the 6 m thick surficial silty sand layer at CPT02-10 will likely liquefy.

There were no significant differences in the liquefaction threshold N values for the three design earthquake events at each soil column analyzed. This was mainly because the motions were significantly deamplified in the deep clay layer underlying the upper sand and gravel fill, with larger deamplification for larger input ground motion.

The liquefaction susceptibility of the fine-grained native soils was assessed, as described in Appendix VI, based on the Chinese criteria (Seed and Idriss, 1982) and the Andrews and Martin (2000) criteria. Because of the high clay content (defined as particles <0.005 mm) of the samples tested, i.e. >40%, the silt and clay are considered not susceptible to liquefaction. However, the fine-grained soils could still soften during earthquake shaking. Therefore, further laboratory testing was conducted as discussed below.

Cyclic/static simple shear tests were performed at the University of British Columbia on three silt and clay Shelby tube samples obtained in DH02-01, BOC02-05 and BOC02-08. The samples were tested under constant volume cyclic stress-controlled loading, followed by post-cyclic monotonic loading. The results of the laboratory simple shear tests (report

prepared by Dr. D. Wijewikreme. P.Eng., of U.B.C.) are enclosed in Appendix IX. The results indicate that the silt and clay will not liquefy but could strain and soften significantly during design earthquake loading.

The granular backfills adjacent to the north, east and southeast sections of the dry dock retaining walls, because of their limited depths and lack of water, are not considered susceptible to liquefaction.

In summary, the saturated loose granular fill and rockfill at the SLW will liquefy under all three levels of design earthquakes. The underlying native silt and clay, including the puddle clay adjacent to the south wall of the dry dock, will not likely liquefy, but are expected to soften and strain significantly during earthquake shaking. The limited granular backfills adjacent to the north and east walls of the dry dock, and the eastern 110 m of the south wall, will not likely liquefy during the design earthquakes, but could settle due to earthquake shaking.

9. SEISMIC STABILITY AND LIQUEFACTION INDUCED GROUND DISPLACEMENTS

Liquefaction of the saturated loose fill and rockfill at the SLW area will induce permanent lateral displacements and ground settlements, which could adversely affect the stability and performance of the existing supporting structures, including the timber crib, the steel and timber pile foundations, the steel sheet pile wall, and the concrete retaining wall at the east approach. The liquefaction-induced ground deformations and foundation failures may cause significant damage to the supported structures and facilities, such as the concrete wharf, the timber jetty, and the concrete slabs south of the graving dock. Drawing No. B-1003 shows a plan of the SLW with the pile layout, and Drawing No. B-1004 shows typical cross-sections illustrating the soil profile and foundations of the main SLW structures.

Liquefaction of the saturated loose granular fill and rockfill underlying the SLW will result in the following ground failures or deformations:

- Flow slides, i.e., lateral ground movements in the range of several metres, are expected to occur in the relatively steep ground slopes underlying the south timber jetty and concrete wharf (see Sections F and G on Drawing No. B-1004). The flow slide movements are not dependent on the direction of earthquake impulses;
- In the filled ground north of the sheet pile wall and east of the timber crib, and in the east approach area, liquefaction will result in lateral spreading of the order of 0.5 m to 2.0 m, and liquefaction-induced settlements of 0.2 m to 0.5 m. These estimates of ground deformations were partly based on the empirical equations by Youd et al. (2002) and Tokimatsu and Seed (1987).

Liquefaction-induced ground deformations of waterfront structures have been observed and documented following strong earthquakes. For example, Ishihara et al. (1996) has

published data on ground movements behind caisson-type quay walls due to liquefaction in the saturated backfill during the 1995 Kobe earthquake in Japan. Figure 9.1 shows a typical cross-section of the quay wall and the distribution of observed lateral displacements behind the quay walls, while Figure 9.2 shows the observed settlements behind the quay walls. The wall at P-6 in Kobe moved outward some 3 m and settled about 2 m. As shown in Figures 9.1 and 9.2, the magnitudes of lateral displacements and settlements decreased with distances from the quay walls or the waterfront.

10. POTENTIAL SEISMIC FAILURE MODES AND EFFECTS

Liquefaction-induced ground deformations will affect the performance of the existing structures and facilities in the SLW. The potential ground failure modes and effects on the various components of the SLW are summarized in Table 6.

Table 6 Potential Seismic Failure Modes and Effects

Component	Foundation	Ground Failure Modes	Consequences
South timber jetty (1941)	Short timber friction piles (only 5 – 6m embedment)	Flow slide of liquefiable fill layer, lateral deformation of lower clay layer	Large movement of pile toes, leading to pile failure and possible deck collapse
Concrete infill wharf (1985)	End bearing steel pipe piles, including vertical and battered piles	Flow slide of liquefiable layer, deformation of lower clay layer	Large pile deformations, possible pile failure, and damage to deck and supported facilities
Tied-back sheet pile wall (1985)	Sheet piles (6 – 9m long) embedded in liquefiable fill, with tie-backs anchored to shallow concrete retaining wall	Lateral spreading and settlement	Large lateral movement of sheet pile wall to the south, probable toe failure
Concrete slabs on grade south of dry dock	Slabs founded on liquefiable fill	Lateral spreading and settlement	Significant cracking of slabs and damage to supported facilities, roadway and crane rail
Puddle clay adjacent to dry dock south wall (1927)	Gravelly clay "core" – non-liquefiable	Increased lateral soil pressure and loss of soil support due to liquefaction of adjacent fill	Likely minor cracking and lateral deformation of puddle clay "core"
Graving dock south retaining wall (1927)	Wall founded on bedrock	Increased lateral soil pressure and loss of soil support due to liquefaction of adjacent fill	Bending and/or shearing of wall or dock floor slab – failure possible depending on wall/floor strength. Leakage possible at vertical joints

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Table 6 Potential Seismic Failure Modes and Effects (continued)

Component	Foundation	Ground Failure Modes	Consequences
Timber crib (1923)	Crib embedded in and founded on liquefiable fill	Increased lateral pressures and loss of foundation support	Sliding and foundation failure of crib structure leading to major displacement/rotation and possible collapse
West timber jetty (1941 & 1985)	Timber friction piles (about 6m embedment for 1941 structure and about 15m for 1985 structure)	Lateral spreading on generally mild slope. Possible flow of liquefied soils from fills/foundation at timber crib	Lateral pile movement and likely damage to 1941 deck, possibly less damage to 1985 infill deck. NE corner of this deck affected by timber crib failure
East end of wharf, including service tunnel, concrete retaining wall and timber approach deck	Pavement and retaining wall founded on liquefiable fill; deck on short timber piles	Flow slide and settlement	Significant cracking of pavement, damage to service tunnel, failure of retaining wall and piled deck, and damage to supported structures

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11. SOIL PARAMETERS FOR FURTHER SOIL-STRUCTURE INTERACTION ANALYSES

Soil-structure interaction analyses will be required to evaluate the seismic performance of the existing structures and to determine possible remedial measures. Estimated soil parameters for further soil-structure interaction analyses are summarized in Tables 7a and 7b. These parameters are provided at selected test hole locations to cover the variable ground conditions at the SLW. The estimated parameters shown include total unit weight (γ), shear wave velocities (V_s), equivalent SPT $(N_1)_{60}$, cone tip resistance (Q_t), and peak undrained shear strength (S_u).

Other pre- and post-liquefaction soil properties, as required, can be estimated from the parameters in Tables 7a and 7b, as described below:

- $G_{max} = \rho \cdot V_s^2$, where ρ is the soil density ($\rho = \gamma/g$), and V_s is the shear wave velocity;
- G/G_{max} for the different soils can be obtained from the modulus reduction curves shown on Figure VI-6 (Appendix VI);
- Friction angles, ϕ, of the sand and gravel fill or rockfill can be estimated from correlations based on $(N_1)_{60}$ or Q_t values, e.g., Schmertmann (1975), and Robertson and Campanella (1983); and
- Post-liquefaction residual undrained shear strength values, S_{ur}, can be estimated from $(N_1)_{60}$ values using Seed and Harder (1990).

Table 7a Estimated Soil Parameters for Soil-Structure Analyses at BPT Locations

Soil Type	Ground/ Mudline El. (m)	Depth Range[1] (m)		Unit Weight, γ (kN/m^3)	Shear Wave Velocity, V_s (m/s)	$(N_1)_{60}$	S_u[2] (kPa)
		Top	Bottom				
BPT02-04							
Sand and Gravel (FILL)	4.54	0.0	2.8	20	115	>30	-
Sand and Gravel (FILL)		2.8	5.5	20	150	13	-
Sand and Gravel (FILL)		5.5	7.9	20	180	6	-
Clay (FILL)		7.9	9.1	19	160	-	25-50
Sand and Gravel (FILL)		9.1	11.0	20	215	2	-
Clay (FILL)		11.0	11.9	19	160	-	25-50
Sand and Gravel (FILL)		11.9	13.1	20	245	2	-
Sand and Gravel (FILL)		13.1	15.2	20	265	9	-
Sand and Gravel (FILL)		15.2	16.4	20	285	>30	-
Sand and Gravel (FILL)		16.4	17.7	20	300	4	-
CLAY		17.7	20.4	20	160	-	50
Bedrock		20.4		23	1500		
BPT02-05							
Clay (FILL)	5.17	0.0	2.8	19	160	-	25
Gravel (FILL)		2.8	4.6	20	145	20	-
Gravel (FILL)		4.6	7.5	20	170	13	-
Clay		7.5	27.6	19	160	-	25-50
Sand and Gravel		27.6	28.2	20	425	>30	-
Bedrock		28.2		23	1500		
BPT02-06							
Sand and Gravel (FILL)	4.41	0.0	1.4	20	110	>30	-
Sand and Gravel (FILL)		1.4	3.4	20	130	12	-
Sand and Gravel (FILL)		3.4	8.5	20	170	2	-
Silt and Clay		8.5	14.6	19	160	-	25
Clay		14.6	20.4	19	160	-	50
Sand and Gravel		20.4	21.5	20	345	>30	-
Bedrock		21.5		23	1500		
BPT02-08							
Sand and Gravel (FILL)	4.40	0.0	1.2	20	105	15	-
Silt (FILL)		1.2	5.8	19	160	-	12-25
Sand and Gravel (FILL)		5.8	8.8	20	185	>30	-
Silt (FILL)		8.8	12.8	19	160	-	25-50
Clay		12.8	18.3	19	160	-	50
Sand and Gravel		18.3	19.8	20	320	>30	-

Table 7a Estimated Soil Parameters for Soil-Structure Analyses at BPT Locations (continued)

Soil Type	Ground/ Mudline El. (m)	Depth Range[1] (m)		Unit Weight, γ (kN/m^3)	Shear Wave Velocity, V_s (m/s)	$(N_1)_{60}$	S_u[2] (kPa)
Bedrock		19.8		23	1500		
BPT02-10							
Sand and Gravel (FILL)	4.54	0.0	2.6	20	115	15	-
Silt and Clay (FILL)		2.6	6.1	19	160	-	25-50
Sand and Gravel (FILL)		6.1	7.3	20	180	6	-
Sand and Gravel (FILL)		7.3	9.0	20	195	13	-
Sand and Gravel (FILL)		9.0	12.2	20	225	2	-
Clay		12.2	21.6	19	160	-	50
Sand and Gravel		21.6	23.6	20	365	20	-
Bedrock		23.6		23	1500		

Notes:
1. Depths indicated are below mudline or ground surface.

Table 7b Estimated Soil Parameters for Soil-Structure Analyses at CPT Locations

Soil Type	Ground / Mudline El. (m)	Depth Range[1] (m)		Unit Weight, γ (kN/m^3)	Shear Wave Velocity, V_s (m/s)	Q_t (Bar)	S_u[2] (kPa)
		Top	Bottom				
SCPT02-02							
Sand and Gravel	4.39	0.0	1.5	20	110	-	-
Clay		1.5	12.2	19	180	8	40
Silty Sand		12.2	13.2	20	250	-	-
Bedrock		13.2		23	1500		-
CPT02-03							
Organic Silt	-8.53	0.0	7.8	19	80	4	20
Clayey Silt/Silt		7.8	11.9	19	125	17	50
Silt and Clay		11.9	24.0	19	160	12	50
Clay		24.0	39.0	19	175	14	50
Clay		39.0	44.4	19	190	25	100
Bedrock		44.4		23	1500		
SCPT02-06							
Clayey Silt/Silt	-6.35	0.0	10.8	19	160	10	50
Clay		10.8	25.6	19	175	13	60
Bedrock		25.6		23	1500		
CPT02-08							
Clayey Silt	-6.47	0.0	8.4	19	160	7	40
Clay		8.4	15.9	19	180	16	60
Bedrock		15.9		23	1500		
SCPT02-09							
Organic Silt	-8.43	0.0	8.0	19	80	5	25
Silt		8.0	11.3	19	125	22	60
Clayey Silt		11.3	17.9	19	150	11	50
Clay		17.9	33.1	19	175	14	60
Bedrock		33.1		23	1500		
CPT02-10							
Silty Sand (FILL)	-8.05	0.0	4.8	19	104	77	-
Silty Sand (FILL)		4.8	6.5	19	132	14	-
Silty Sand (FILL)		6.5	7.4	19	144	42	-
Silty Sand (FILL)		7.4	8.1	19	152	28	-
Clay		8.1	14.1	19	160	-	60
Bedrock		14.1		23	1500		

Notes:

1. Depths indicated are below mudline or ground surface.
2. S_u values were estimated based on CPT data using correlation proposed by Lunne et al (1985); calibration was carried out based on Su values from Nilcon field vanes from DH02-02 and DH02-04

12. SUMMARY AND CONCLUSIONS

A site investigation program was carried out in March 2002 at the EGD and SLW to determine the detailed subsoil stratigraphy, to obtain soil information for ground response analysis, and to characterize subsoil density for liquefaction assessment. The site investigation consisted of Becker penetration tests and sampling holes, cone penetration tests, seismic cone penetration tests, and mud rotary drill holes with sampling and downhole insitu vane shear tests. The results of the site investigation indicate the following:

- Substantial loose granular fill and rockfill, up to about 18 m thick, exist beneath the SLW area and overlie native silt and clay.
- The test holes confirm the existence of the puddle clay fill adjacent to the south wall of the dry dock. The puddle clay fill comprises firm to stiff clay of intermediate plasticity with interlayers of silt, sand and gravel.
- Test holes behind the north wall of the dry dock, and the eastern portion of the south wall, indicate limited depths of dry granular backfill overlying bedrock.

The results of the site response and liquefaction analyses indicate:

- Significant liquefaction of the saturated loose granular fill and rockfill will occur under all three levels of design earthquake shaking;
- The native silt and clay are not likely liquefiable, but will soften and strain significantly during earthquake shaking;
- The puddle clay is not considered susceptible to liquefaction; and
- The granular backfills adjacent to the dry dock retaining walls on the north, east and southeast section are not considered susceptible to liquefaction.

Liquefaction of the saturated loose granular fill and rockfill underlying the SLW will result in permanent lateral and vertical ground deformations, including flow slides on steep slopes, that will affect the stability and performance of the wharf structures and facilities in the SLW. A seismic failure mode and effect analysis was performed to identify the structural components in the SLW that will be at risk due to ground liquefaction and deformations. Further soil-structure interaction analyses are needed to more accurately evaluate the potential structural failure mechanisms and to assess potential remediations.

13. LIMITATIONS AND USE OF REPORT

This geotechnical report is an instrument of service of Klohn Crippen Consultants Ltd. The report has been prepared for the exclusive use of Public Works Government Services Canada for the specific application to the seismic evaluation of the Esquimalt Graving Dock and South Landing Wharf at Esquimalt, British Columbia. The report's contents may not be relied upon by any other party without the expressed written permission of Klohn Crippen. In this report, Klohn Crippen has endeavoured to comply with generally accepted geotechnical practice common to the local area. Klohn Crippen makes no other warranty, expressed or implied.

The analyses, conclusions and recommendations contained in this report are based on data derived from a limited number of test holes obtained from widely spaced subsurface explorations. The testing methods used indicate subsurface conditions only at the specific locations where samples were obtained or where insitu tests would infer, only at the time they were obtained, and only to the depths penetrated. The samples and tests cannot be relied on to accurately reflect the nature and extent of strata variations that usually exist between sampling or testing locations.

Although Klohn Crippen has explored subsurface conditions as part of this program, Klohn Crippen has not conducted analytical laboratory testing of samples obtained, and has not evaluated the site for potential presence of contaminated soil.

The data and drawings furnished in this report by Klohn Crippen are prepared on the assumption that any and all information supplied to Klohn Crippen by PWGSC, or by others on behalf of or on the instructions of the PWGSC, are correct and accurate, and Klohn Crippen shall not be liable for any loss, cost, expense or damage arising from or as a result of the incorrectness or inaccuracy of such information. PWGSC shall, upon such

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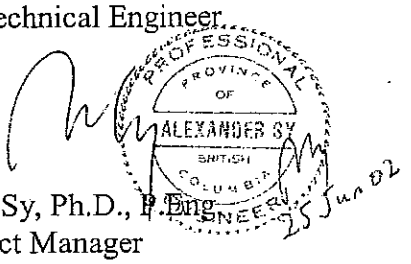

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FIGURES

Figure 5.1 Undrained Shear Strengths from Field Vane Tests

Figure 5.2 Groundwater and Tide Monitoring Data

Figure 7.1 Target Spectra for Design Earthquake Events

Figure 8.1 Liquefaction Results at BPT02-04

Figure 8.2 Liquefaction Results at BPT02-05

Figure 8.3 Liquefaction Results at BPT02-06

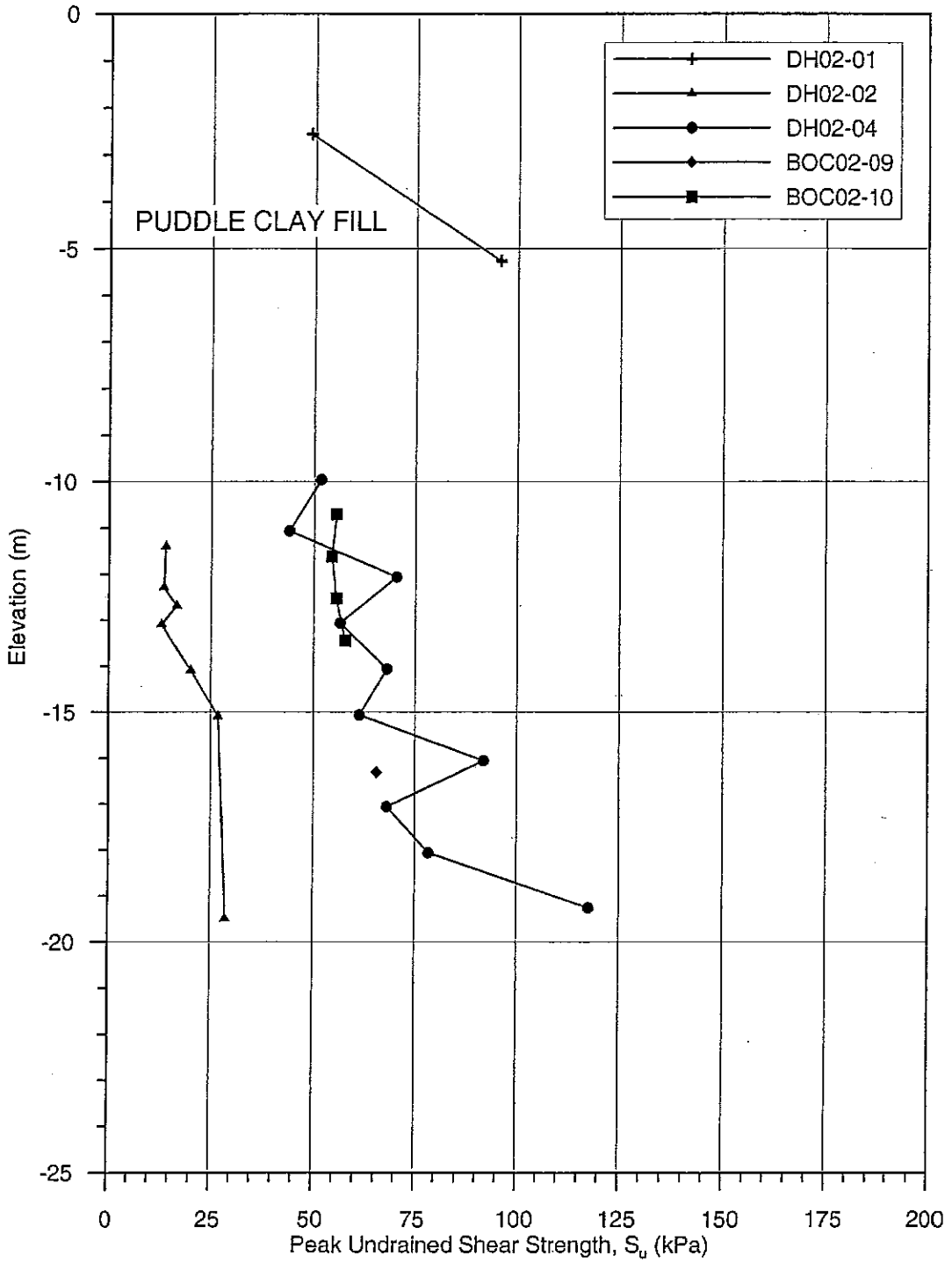
Figure 8.4 Liquefaction Results at BPT02-08

Figure 8.5 Liquefaction Results at BPT02-10

Figure 8.6 Liquefaction Results at CPT02-10

Figure 9.1 Liquefaction-induced Lateral Displacement Behind Quay Walls (Ishihara, 1996)

Figure 9.2 Liquefaction-induced Settlements Behind Quay Walls (Ishihara, 1996)



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TO BE READ WITH KLOHN-CRIPPEN REPORT DATED June 25, 2002

SCALE

CLIENT: **PWGSC**

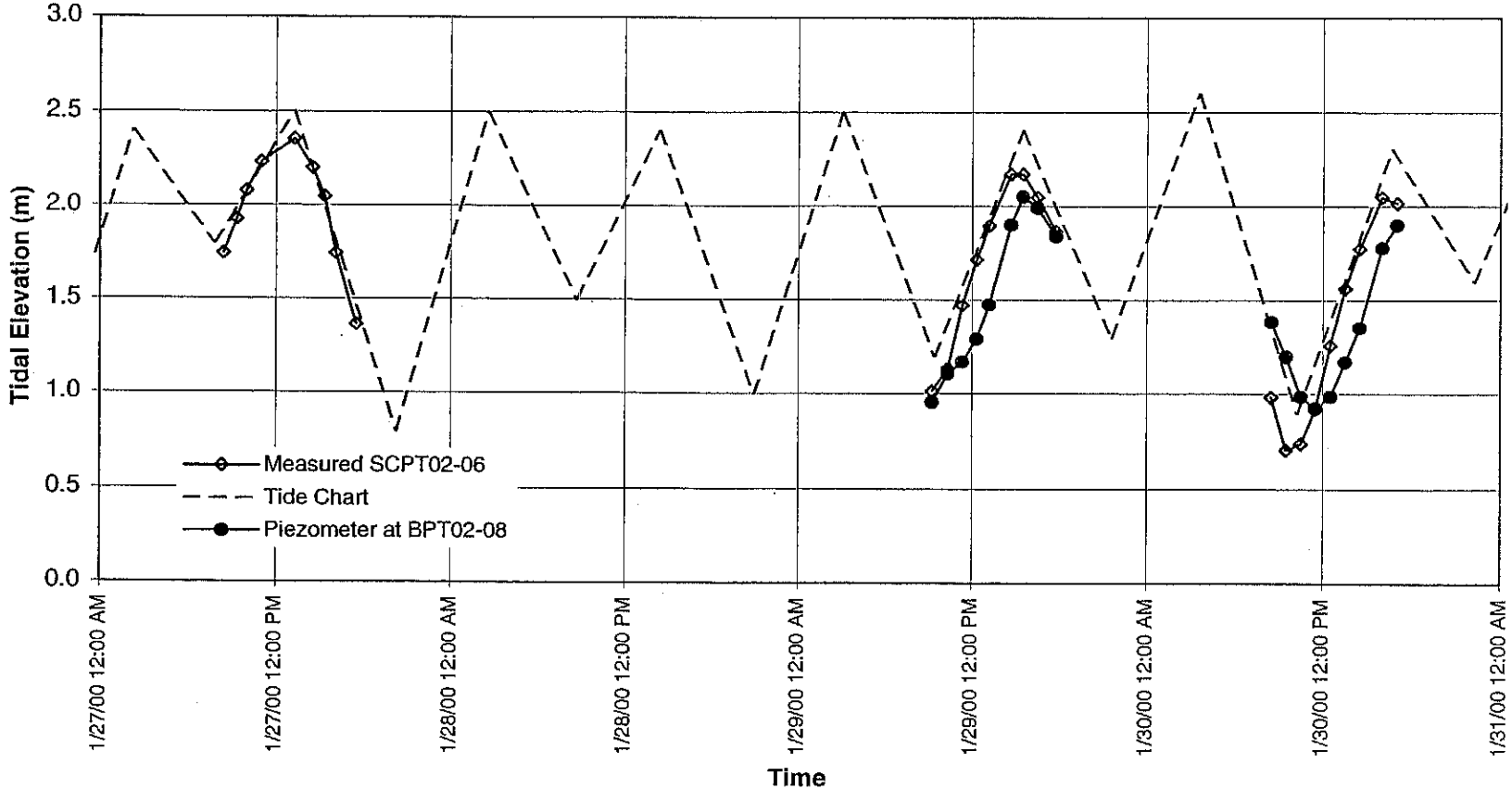
PROJECT: EGD and SLW Site Investigation

TITLE: Undrained Shear Strengths from Field Vane Tests

KLOHN CRIPPEN

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
June 25, 2002	PG 9060 01	FIGURE 5.1	
APPROVAL DT			

Tide Monitoring at SCPT02-06
March, 2002



June 25, 2002

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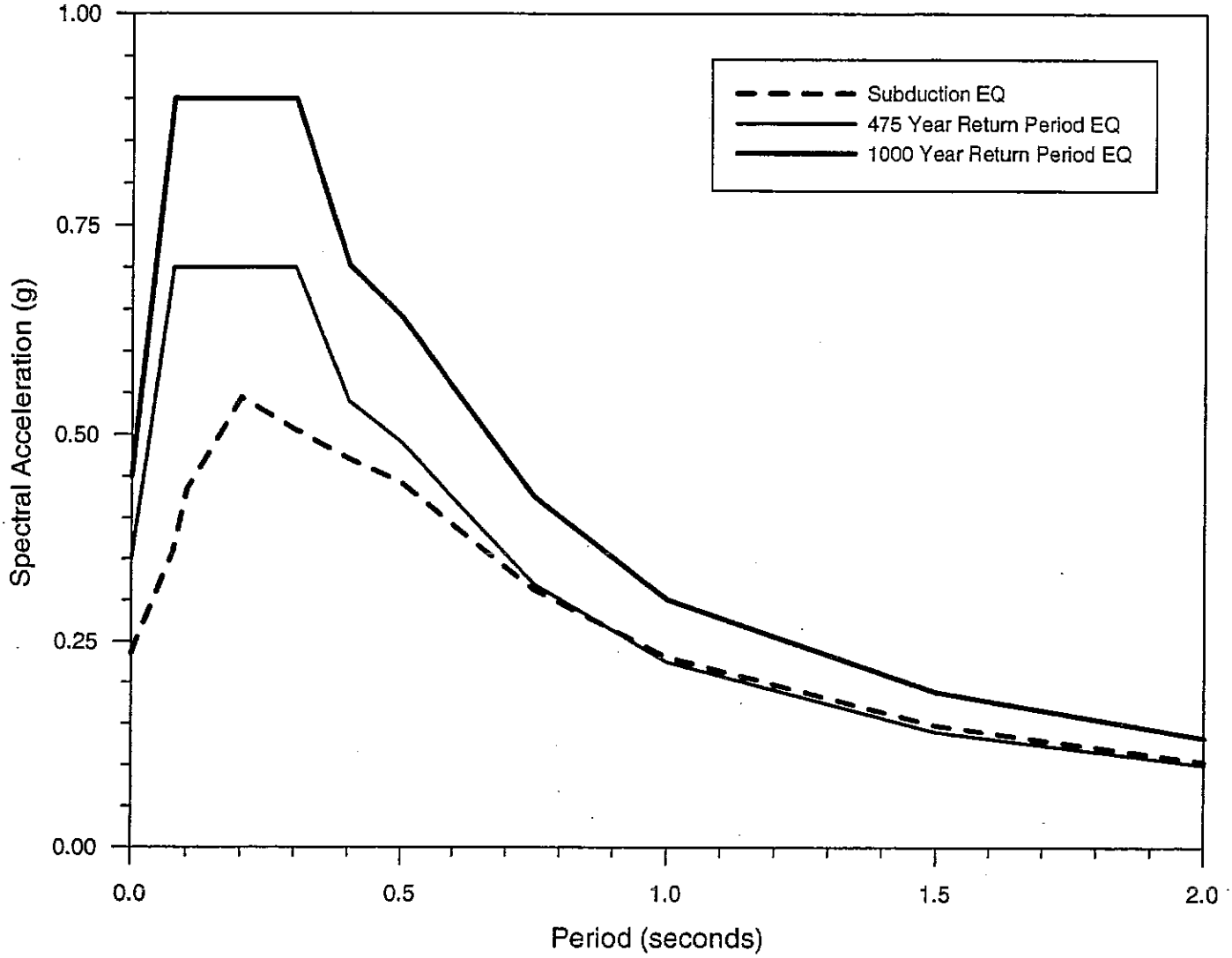
CLIENT	PWGSC
	KLOHN CRIPPEN
PROJECT	EGD and SLW Site Investigation
TITLE	Groundwater and Tide Monitoring Data
DATE OF ISSUE	June 25, 2002
APPROVAL	DT
PROJECT No.	PG9060 01
DWG. No.	FIGURE 5.2
REV.	



Note:

Target spectra obtained from Phase I, Seismic Hazard Analysis of Esquimalt Graving Dock by Pacific Geodynamics Inc. Report dated November 30, 1999.

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TO BE READ WITH KLOHN-CRIPPEN REPORT DATED June 25, 2002

SCALE

KLOHN CRIPPEN

PROJECT: EGD and SLW Site Investigation

TITLE: Target Spectra for Design Earthquake Events

CLIENT: PWGSC

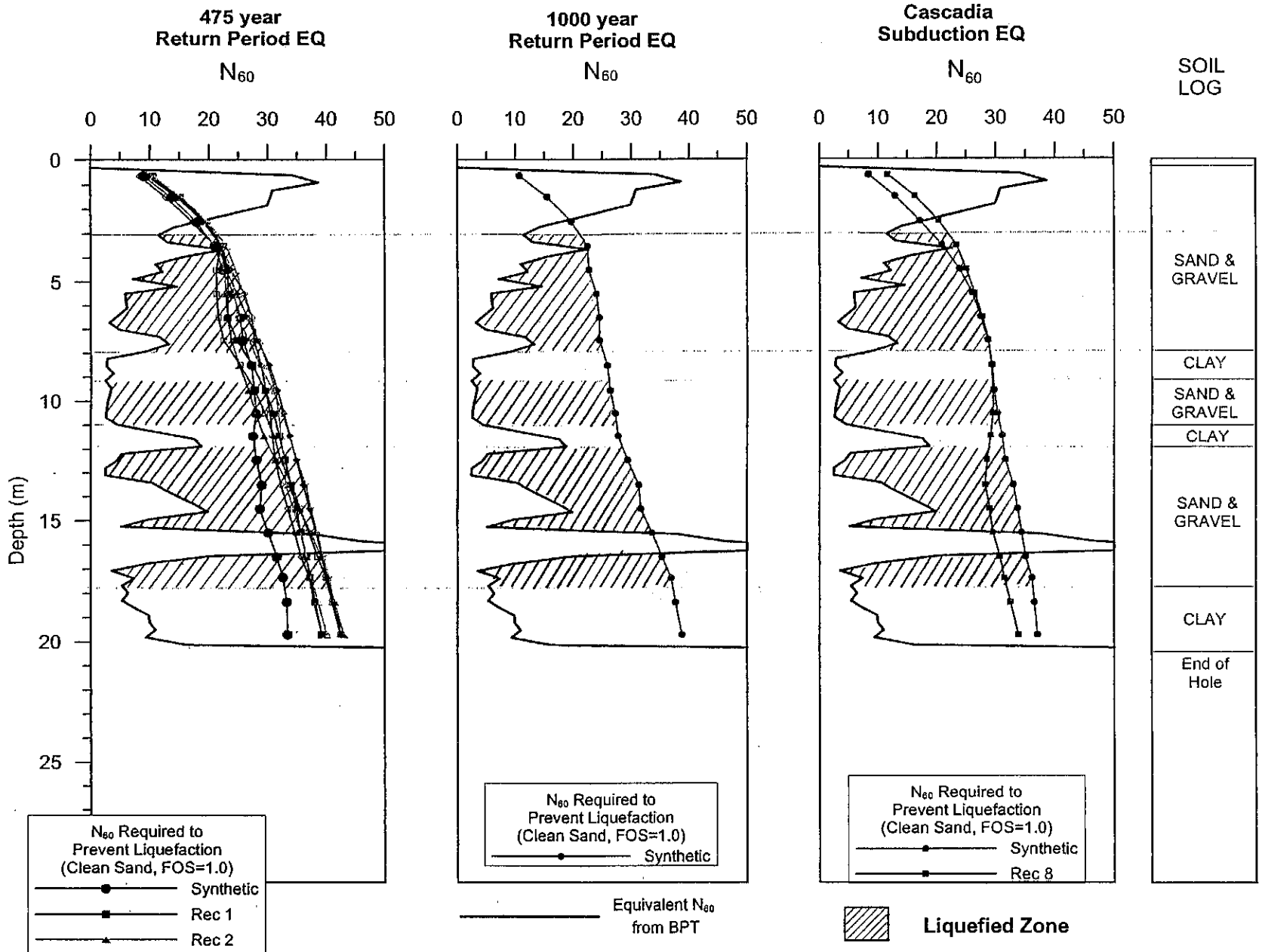
DATE OF ISSUE: June 25, 2002

APPROVAL: DT

PROJECT No.: PG 9060 01

DWG. No.: FIGURE 7.1

REV.



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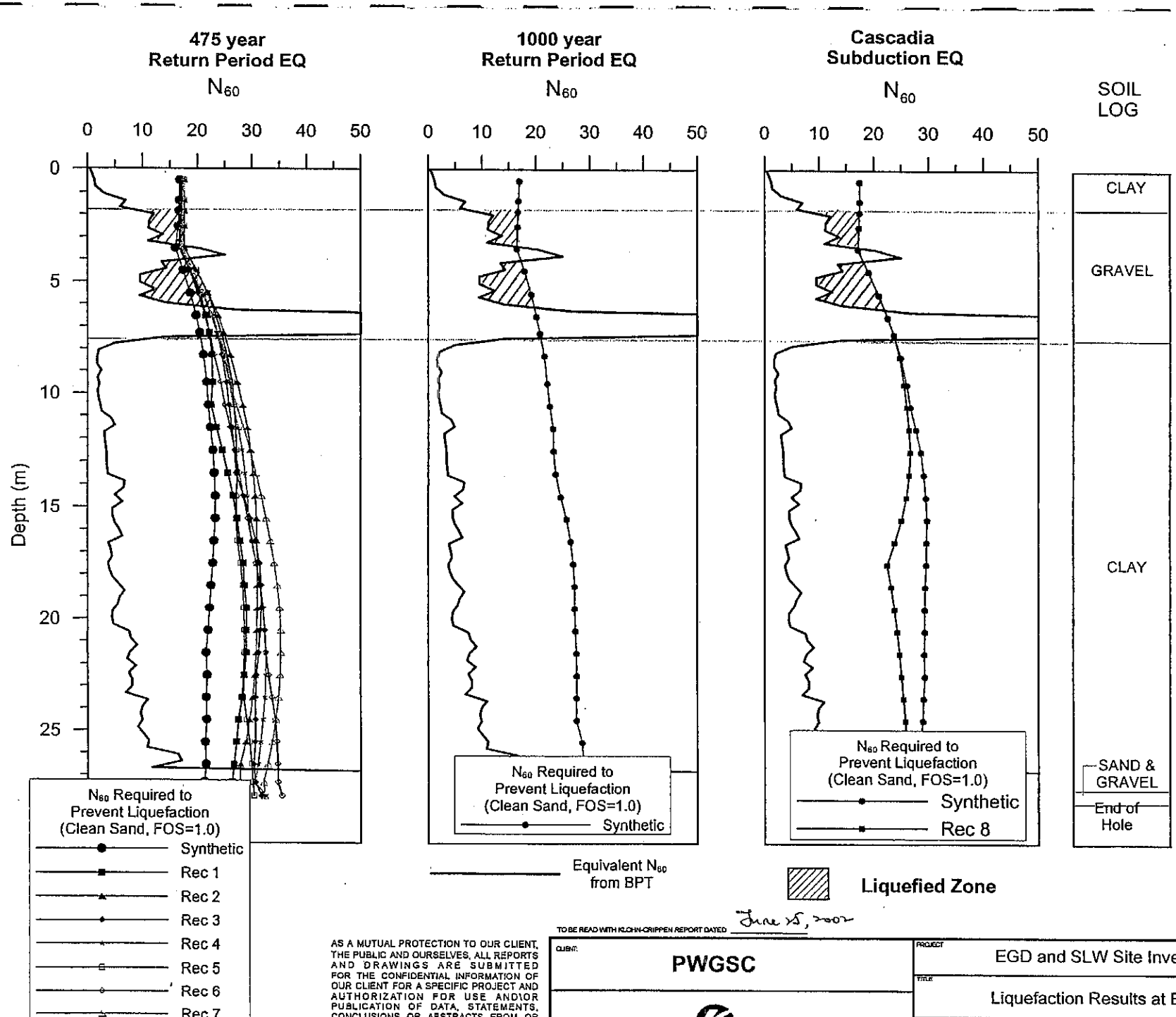
CLIENT	PWGSC
	KLOHN CRIPPEN
PROJECT	EGD and SLW Site Investigation
TITLE	Liquefaction Results at BPT02-04
DATE OF ISSUE	June 25, 2002
APPROVAL	DT
PROJECT No.	PG9060 01
DWG No.	FIGURE 8.1
REV	



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CLIENT: PWGSC

KLOHN CRIPPEN

PROJECT: EGD and SLW Site Investigation

TITLE: Liquefaction Results at BPT02-05

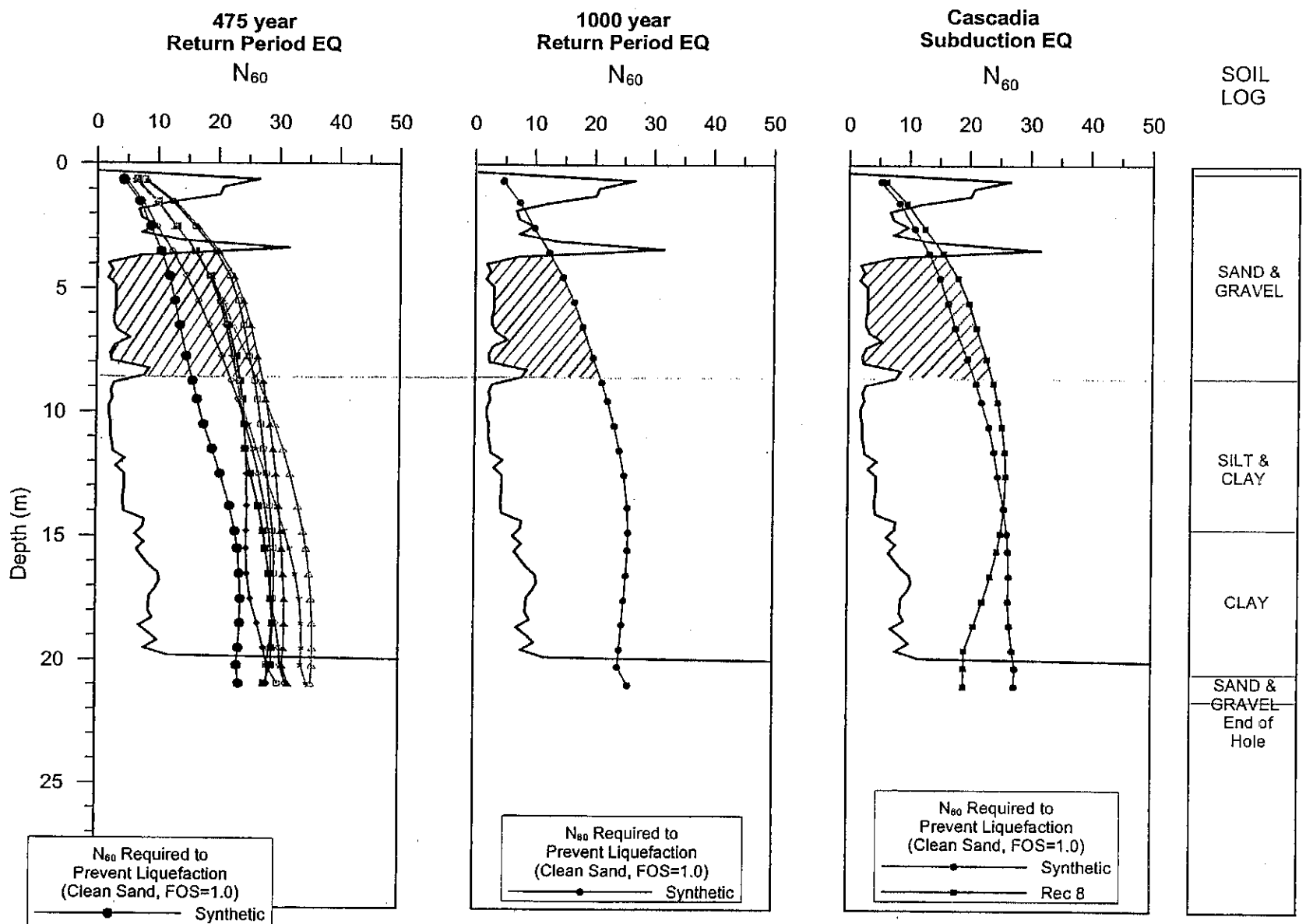
DATE OF ISSUE: June 25, 2002

APPROVAL: DT

PROJECT No: PG9060 01

DWG No: FIGURE 8.2

REV:



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CLIENT: **PWGSC**

KLOHN CRIPPEN

PROJECT: EGD and SLW Site Investigation

TITLE: Liquefaction Results at BPT02-06

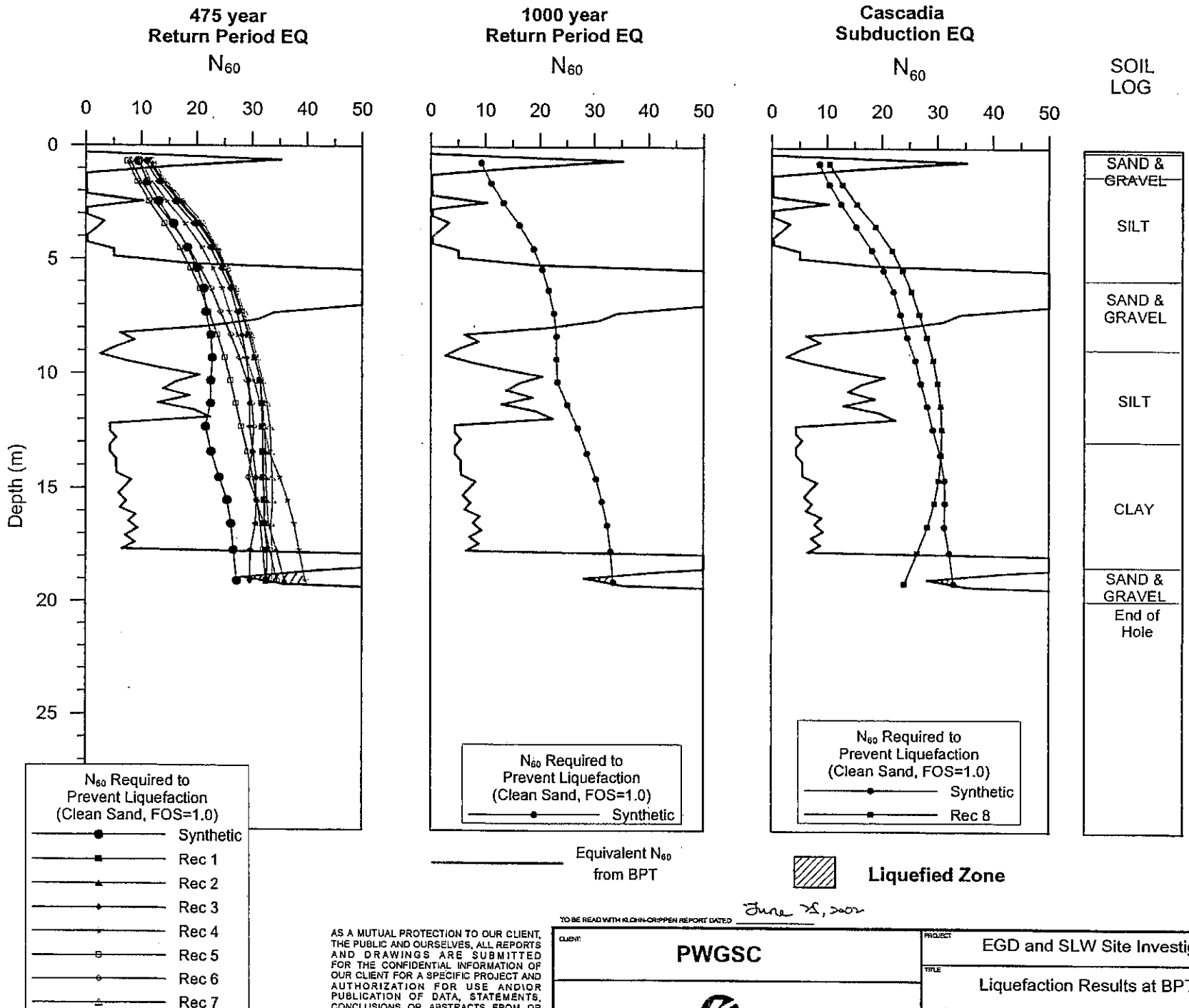
DATE OF ISSUE: June 25, 2002

APPROVAL: DT

PROJECT No.: PG9060 01

DWG No.: FIGURE 8.3

REV:



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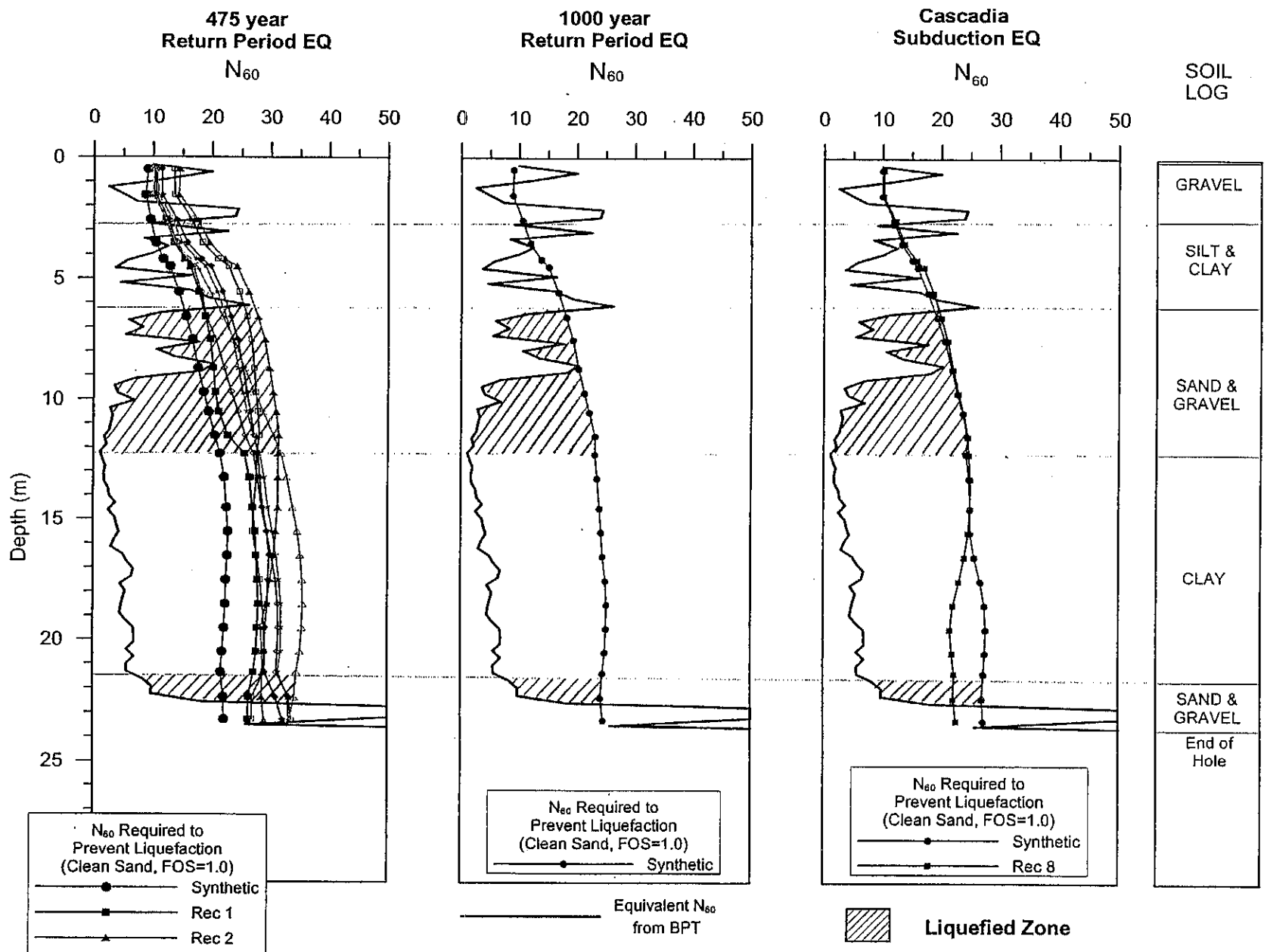
CLIENT	PWGSC
	KLOHN CRIPPEN
PROJECT	EGD and SLW Site Investigation
TITLE	Liquefaction Results at BPT02-08
DATE OF ISSUE	June 25, 2002
APPROVAL	DT
PROJECT No.	PG9060 01
DWG. No.	FIGURE 8.4
REV.	



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CLIENT: **PWGSC**

KLOHN CRIPPEN

PROJECT: EGD and SLW Site Investigation

TITLE: Liquefaction Results at BPT02-10

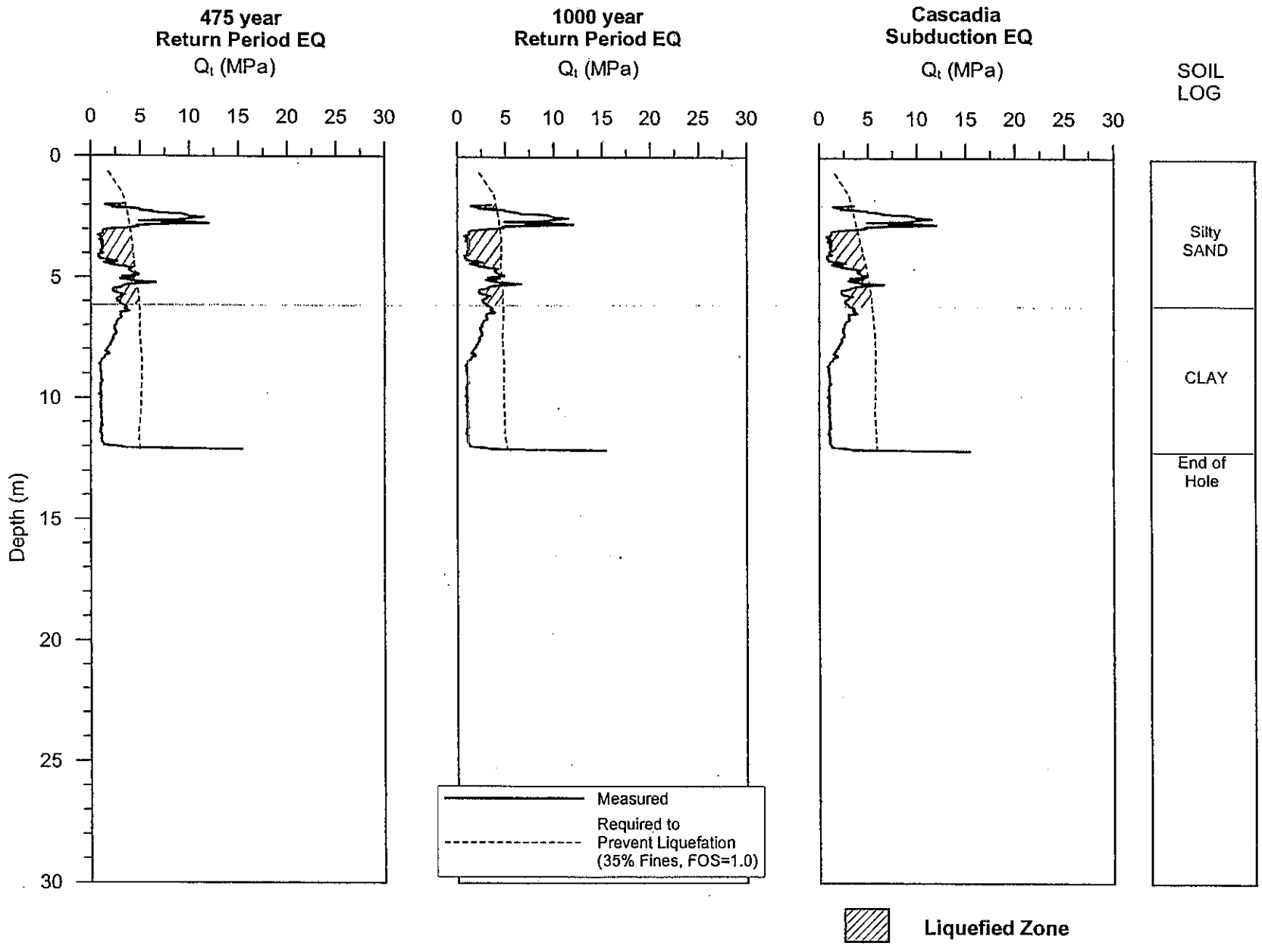
DATE OF ISSUE: June 15, 2001

APPROVAL: DT

PROJECT No.: PG9060 01

DWG No.: FIGURE 8.5

REV:



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CLIENT: PWGSC

KLOHN CRIPPEN

PROJECT: EGD and SLW Site Investigation

TITLE: Liquefaction Results at CPT02-10

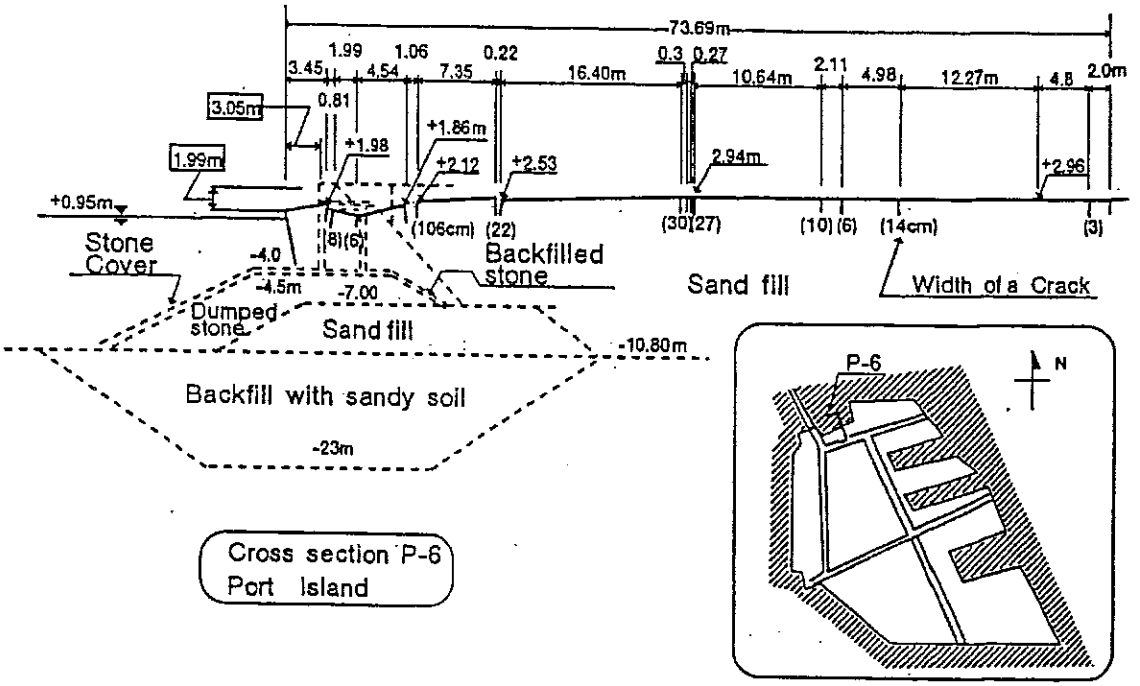
DATE OF ISSUE: June 25, 2002

APPROVAL: DT

PROJECT No.: PG9060 01

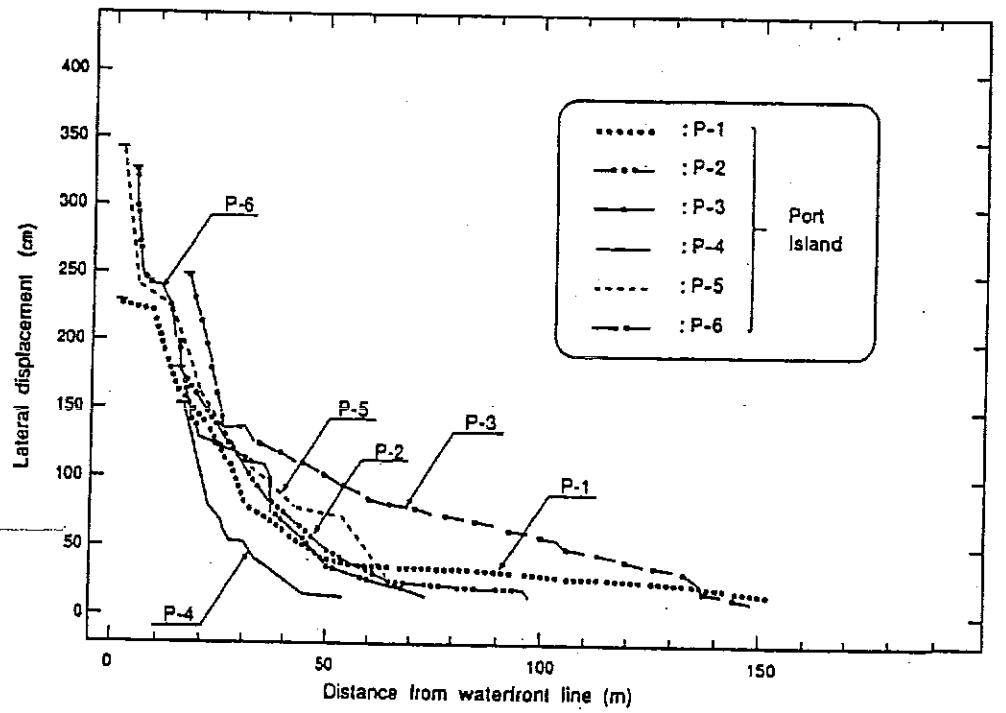
DWG. No.: FIGURE 8.6

REV.



Cross section P-6
Port Island

Ground deformation behind a quaywall in Port Island



Distribution of lateral displacement behind the quaywall

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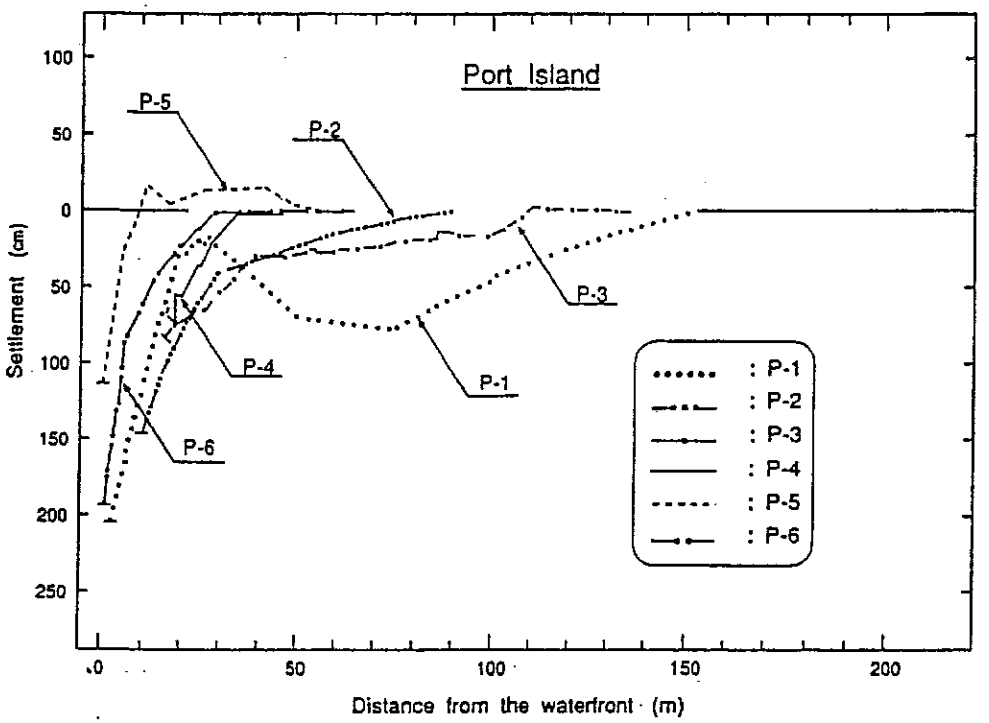
TO BE READ WITH KLOHN-CRIPPEN REPORT DATED June 15, 2001

SCALE

CLIENT: **PWGSC**	PROJECT: EGD and SLW Site Investigation
KLOHN CRIPPEN	TITLE: Liquefaction-induced Lateral Displacements Behind Quay Walls (Ishihara, 1996)
DATE OF ISSUE: June 15, 2001	PROJECT No.: PG9060 01
APPROVAL: DT	DWG. No.: FIGURE 9.1
	REV.



Settlement of the ground surface behind the quaywall

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TO BE READ WITH KLOHN-CRIPPEN REPORT DATED June 15, 2001

SCALE

CLIENT: **PWGSC**

PROJECT: EGD and SLW Site Investigation

TITLE: Liquefaction-induced Settlements Behind Quay Walls (Ishihara, 1996)

KLOHN CRIPPEN

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
June 15, 2001	PG9060 01	FIGURE 9.2	
APPROVAL DT			

APPENDIX I

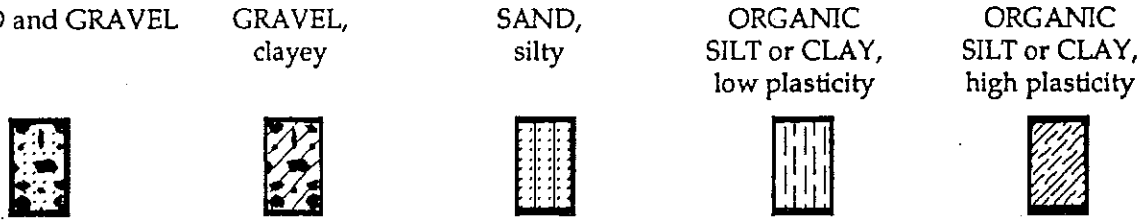
Test Hole Logs

KLOHN-CRIPPEN

SYMBOLS AND TERMS
FOR SOIL DESCRIPTION AND TEST HOLE LOGS

BASIC SYMBOLS

SYMBOL VARIATIONS - EXAMPLES[1]



CLASSIFICATION BY PARTICLE SIZE

Name		Size Range (mm)[3]	U.S. Standard Sieve Size Retained	U.S. Standard Sieve Size Passing
Boulders		> 200	8 inch	-
Cobbles		75 - 200	3 inch	8 inch
Gravel:	coarse	19 - 75	0.75 inch	3 inch
	fine	5 - 19	No. 4	0.75 inch
Sand:	coarse	2 - 5	No. 10	No. 4
	medium	0.4 - 2	No. 40	No. 10
	fine	0.075 - 0.4	No. 200	No. 40
Fines (Silt or Clay)[4]		< 0.075	-	No. 200

PROPORTION OF MINOR COMPONENTS BY WEIGHT[2]

and	35 - 50%
y/ey	20 - 35%
some	10 - 20%
trace	0 - 10%

PARTICLE SHAPE

Flat	width/thickness > 3
Elongated	length/width > 3

DENSITY OF GRANULAR SOILS

Description	SPT N[5]	SPT $(N_1)_{60}$[6]
Very Loose	0 - 4	0 - 3
Loose	4 - 10	3 - 8
Compact	10 - 30	8 - 25
Dense	30 - 50	25 - 42
Very Dense	> 50	> 42

CONSISTENCY OF COHESIVE SOILS

Description	S_u[7] (kPa)[3]	S_u[7] (ksf)[8]	SPT N[9]
Very Soft	< 12	< 0.25	< 2
Soft	12 - 25	0.25 - 0.5	2 - 4
Firm	25 - 50	0.5 - 1	4 - 8
Stiff	50 - 100	1 - 2	8 - 15
Very Stiff	100 - 200	2 - 4	15 - 30
Hard	> 200	> 4	> 30

(1) Only selected examples of the possible variations or combinations of the basic symbols are illustrated.
(2) Example: SAND, silty, trace of gravel = sand with 20% to 35% silt and up to 10% gravel, by weight.
(3) Approximate metric conversion.
(4) Fines are classified as silt or clay on the basis of Atterberg limits (refer to Plasticity Chart).
(5) Standard Penetration Test (SPT) blow count (uncorrected), after Terzaghi and Peck, 1948.
(6) Standard Penetration Test blow count, based on above N value corrected to 60% hammer efficiency and 96 kPa (1.0 ton/ft²) effective overburden pressure, after Skempton, 1986.
(7) Undrained shear strength can be estimated by vane (gives S_u), pocket penetrometer (gives unconfined compressive strength, i.e., 2 S_u), or unconfined compression test (gives 2 S_u).
(8) ksf = 1000 pounds per square foot = 0.5 tsf (ton/ft²) = approximately 0.5 kg/cm².
(9) Very approximate correlation with Standard Penetration Test blow counts, after Terzaghi and Peck, 1948.

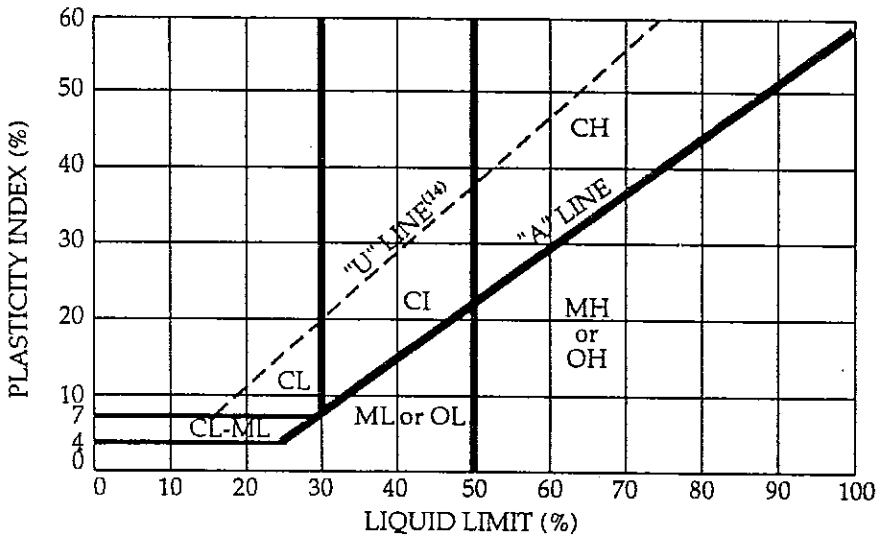
KLOHN-CRIPPEN

SYMBOLS AND TERMS
FOR SOIL DESCRIPTION AND TEST HOLE LOGS

PLASTICITY OF COHESIVE SOILS[10]		
Description	Silt	Clay
High	W_L[11] > 50	W_L > 50
Medium	–	30 < W_L < 50
Low	W_L < 50	W_L < 30
Non-Plastic	NP[12]	–

SENSITIVITY OF COHESIVE SOILS	
Description	Undisturbed Strength[13] / Remoulded Strength
High	> 8
Medium	4 to 8
Low	< 4

PLASTICITY CHART FOR SOILS PASSING NO. 40 SIEVE[10]



CLASSIFICATION OF GROUND ICE[15]			
GROUP		SUBGROUP	
Symbol	Description	Symbol	Description
N	Ice not visible by unaided eye	Nf	Poorly bonded or friable
		Nbn	Well bonded, no excess ice
		Nbe	Well bonded, excess ice
V	Visible ice less than 25 mm thick	Vx	Individual ice crystals or inclusions
		Vc	Ice coatings on soil particles
		Vr	Random or irregularly oriented ice
		Vs	Stratified or distinctly oriented ice
ICE	Visible ice greater than 25 mm thick	ICE + (soil type)	Ice with soil inclusions
		ICE	Ice without soil inclusions

(10) This plasticity classification conforms to the Unified Soil Classification System (USCS) and the ASTM D-2487 plasticity chart, except for the addition of an intermediate category for clay, where the liquid limit is between 30% and 50% (CI). Under ASTM and USCS, all clays with a liquid limit less than 50% are classified as low plasticity (CL).
(11) W_L = Liquid Limit (%).
(12) NP = Non Plastic (silts only).
(13) Dimensionless ratio.
(14) "U" Line marks typical upper limit. "A" Line divides clays from silts and organic soils.
(15) For soil descriptions, estimate percentage of ground ice based on volume, after National Research Council of Canada, 1963.

BECKER TEST HOLE LOG

STARTED: Mar 15, 2002 FINISHED: Mar 16, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.4
COORDINATES (m): N 468428 E 5364929.4

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.3 ASPHALT (5 cm) and CONCRETE (20 cm).	
1					4.1 SAND and GRAVEL (SW, GW), fine to coarse, trace silt, occasional cobble and boulder, compact, subangular to subrounded, grey to black, dry (FILL/ROCKFILL).	
2		Grab	1			
		Grab	2			
3					3.0 1.4 BEDROCK.	
4					End of Becker Drill Hole at 3.0 m	
5					Notes:	
6					1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.	
7					2. BPT02-01 was carried out approximately 2 m east of the open ended Becker hole, BOC02-01.	
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

BECKER PENETRATION TEST

Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)

W_P% W% W_L%
20 40 60 80

322

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT CHECKED BY:
SHEET 1 OF 1 HOLE NO.: BK02-01

...ER-SI Esquimalt KC_Data.gpj 6/12/02

BECKER TEST HOLE LOG

STARTED: Mar 16, 2002 FINISHED: Mar 16, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.4
COORDINATES (m): N 468652.3 E 5364949.4

BECKER PENETRATION TEST
Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)
W_P% W% W_L% (20 40 60 80)

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.3 ASPHALT (5 cm) and CONCRETE (20 cm).	
1		Grab	1		4.1 SAND and GRAVEL (SW, GW), fine to coarse, trace silt, occasional cobble, compact, angular to subrounded, grey to black, dry (FILL/ROCKFILL).	
2		Grab	2			
3		Grab	3		- Some silt at 2.43 m depth.	
					3.2 1.2 BEDROCK.	
4					End of Becker Drill Hole at 3.2 m	
5					Notes:	
6					1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.	
7					2. BPT02-02 was carried out approximately 2 m east of the open ended Becker hole, BOC02-02.	
8						
9						
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KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT CHECKED BY:
SHEET 1 OF 1 HOLE NO.: BK02-02

BECKER TEST HOLE LOG

STARTED: Mar 17, 2002 FINISHED: Mar 17, 2002

DRILL RIG MODEL: BECKER HAV180

GROUND ELEV. (m): 4.4

COORDINATES (m): N 468660.4 E 5364891

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.2 ASPHALT (5 cm) and CONCRETE (15 cm).	
1		Grab	1		4.2 SAND and GRAVEL (SW, GW), fine to coarse, trace silt, very loose, subangular to subrounded, grey to black, moist (FILL/ROCKFILL).	
		Grab	2		1.1 3.3 SAND (SW), fine to coarse, silty, gravelly, very loose, grey, moist, trace seashells (FILL).	
2		Grab	3		1.8 2.6 SAND and GRAVEL (SW, GW), fine to coarse, trace silt, very loose, subangular to subrounded, grey to black, moist (FILL/ROCKFILL).	
					2.4 2.0 BEDROCK.	
					End of Becker Drill Hole at 2.4 m	

Notes:

1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.
2. BPT02-03 was carried out approximately 2 m east of the open ended Becker hole, BOC02-03.

BECKER PENETRATION TEST

Casing O.D.: 170 mm

Hammer Energy: 11 kJ max. rated

● SPT N

CLOSE ENDED (blows/0.3m)

OPEN ENDED (blows/0.3m)

BOUNCE PRESS (kPa)

W_P% W% W_L%

20 40 60 80

225

KLOHN CRIPPEN

PROJECT NO.: PG9060 01

PROJECT: PWGSC EGD and SLW Site Investigation

LOCATION: Esquimalt, BC

LOGGED BY: TT CHECKED BY:

SHEET 1 OF 1 HOLE NO.: BK02-03

KC_BECKER-SI_EGD.GPJ KC_DATA.GDT 5/12/02

BECKER TEST HOLE LOG

STARTED: Mar 18, 2002 **FINISHED:** Mar 24, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.4
COORDINATES (m): N 468397.6 E 5364847.8

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.3 ASPHALT (8 cm) and CONCRETE (23 cm).	
					4.1 SAND and GRAVEL (SW, GW), fine to coarse, trace silt, occasional cobble, loose to compact, angular to subrounded, grey to black, moist to wet (FILL/ROCKFILL).	
1		Grab	1			
2						
3		Grab	2			
4						
5					- Water returned from cyclone at 4.57 m depth.	
6		Grab	3			
7						
					7.9	
8		Grab	4		-3.5 CLAY (CI), medium plasticity, some fine to coarse gravel, firm, grey, wet, trace seashells (FILL).	
		Grab	5			
9					9.1	
		Grab	6		-4.7 SAND and GRAVEL (SW, GW), fine to coarse, trace to some clay, loose, subangular to rounded, grey to black, wet (FILL).	
10		Grab	7		- Some seashells at 10.06 m depth.	
					11.0	
11		Grab	8		-6.6 CLAY (CI), medium plasticity, silty, some sand and gravel, firm to stiff, grey, wet, trace seashells (FILL).	
					11.9	
12		Grab	9		-7.5 SAND and GRAVEL (SW, GW), fine to coarse, silty in the top 1 m, loose to compact, angular to subrounded, grey to black, wet, trace seashells (FILL/ROCKFILL).	
13		Grab	10			
14						
15						
		Grab	11			
16						
17						
					17.7	
18		Grab	12		-13.3 CLAY (CI), medium plasticity, silty, firm to stiff, grey, wet.	
					18.7	
19					-14.3 BEDROCK.	
					End of Becker Drill Hole at 18.7 m	
20					Continued Next Page	

BECKER PENETRATION TEST

Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)

W_P% W% W_L%
20 40 60 80

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT&DT **CHECKED BY:**
SHEET 1 OF 2 **HOLE NO.:** BK02-04

KC_BECKER-SI EGD.GPJ KC_DATA.GDT 5/12/02

BECKER TEST HOLE LOG

STARTED: Mar 18, 2002 FINISHED: Mar 24, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.4
COORDINATES (m): N 468397.6 E 5364847.8

DEPTH (m) | SPT BLOWS PER 0.15m | SAMPLE TYPE | SAMPLE No. | SYMBOL | DESCRIPTION OF MATERIALS | INSTRUMENT DETAILS

Notes:

1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.
2. BPT02-04 was carried out approximately 2 m south west of the open ended Becker hole, BOC02-04.
3. A 76 mm diameter, Schedule 40 PVC pipe was installed in BPT02-04 to approximately 20 m depth for downhole shear wave velocity measurements. The PVC pipe was subsequently abandoned and backfilled on April 2, 2002.

BECKER PENETRATION TEST

Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)

W_P% W% W_L%
20 40 60 80
250

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT&DT CHECKED BY:
SHEET 2 OF 2 HOLE NO.: BK02-04

BECKER TEST HOLE LOG

STARTED: Mar 19, 2002 FINISHED: Mar 23, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 5.2
COORDINATES (m): N 468496.4 E 5364832.1

BECKER PENETRATION TEST
Casing O.D.: 170 mm
Hammer Energy: 11 kJ max. rated
● SPT N
CLOSE ENDED (blows/0.3m)
OPEN ENDED (blows/0.3m)
BOUNCE PRESS (kPa)
W_P% W% W_L%
20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.4 CONCRETE DECK (38 cm).	
					4.8 Space below deck.	
					4.4	
					0.8 CLAY (Cl), medium plasticity, some fine to coarse sand and gravel, soft to firm, grey, wet.	
6	2,9,2	SPT	1		6.1	
					-0.9 GRAVEL (GW), fine to coarse, sandy, fine to coarse sand, trace to some silt, trace cobble, loose to compact, angular to subangular, grey, wet, trace seashells (FILL/ROCKFILL).	
7		Grab	2			
8	8,7,7	SPT	3			
9		Grab	4			
10		Grab	5			
11	15,7,8	SPT	6			
		Grab	7		11.9	
12		Grab	8		-6.7 CLAY (Cl), medium plasticity, some fine to coarse sand and gravel, trace cobble, soft to firm, grey, wet, trace seashells.	
13	0,0,0	SPT	9			
14		Grab	10		- Lots of seashells at 14.02 m depth.	
15		Grab	11			
16					- Sand and gravel content decreases to trace amount at 15.54 m depth.	
17		Grab	12			
18		Shelby	12b		- Wood at about 18 m depth.	
19						
20		Grab	13			

Continued Next Page

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT&DT CHECKED BY:
SHEET 1 OF 2 HOLE NO.: BK02-05

K:\Projects\PG9060 01 PWGSC EGD and SLW Site Investigation\KC_DATA\GINT\BECKER-SI EGD.GPJ KC_DATA.GDT 5/12/02

BECKER TEST HOLE LOG

STARTED: Mar 19, 2002 **FINISHED:** Mar 23, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 5.2
COORDINATES (m): N 468496.4 E 5364832.1

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
21		Shelby	14			
		Grab	15			
22						
23						
24						
		Grab	16			
25						
26						
		Grab	17			
27						
		Shelby	18			
28		Grab	19			
29						
30						
31		Grab	20			
32		Grab	21		32.0 -26.8 SAND and GRAVEL (SW, GW), fine to coarse, trace to some silt, subrounded, grey to black, wet. 32.6 -27.4 BEDROCK.	
33						
34						
35						
36						
37						
38						
39						
40						

End of Becker Drill Hole at 32.6 m

Notes:

1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.
2. BPT02-05 was carried out approximately 2 m east of the open ended Becker hole, BOC02-05.
3. Standard penetration tests (SPT) were conducted using an automatic trip hammer (63.5 kg), AWJ rods and a split-spoon sampler (51 mm O.D., 38 mm I.D.).

BECKER PENETRATION TEST

Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)

W_P% W% W_L%
20 40 60 80

130

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT&DT **CHECKED BY:**
SHEET 2 **OF** 2 **HOLE NO.:** BK02-05

KC_BECKER-SI EGD.GPJ KC_DATA.GDT 5/12/02

BECKER TEST HOLE LOG

STARTED: Mar 20, 2002 **FINISHED:** Mar 21, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.4
COORDINATES (m): N 468508.3 E 5364859.9

BECKER PENETRATION TEST
Casing O.D.: 170 mm
Hammer Energy: 11 kJ max. rated
● SPT N
CLOSE ENDED (blows/0.3m)
OPEN ENDED (blows/0.3m)
BOUNCE PRESS (kPa)
W_P% W% W_L%
20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.3 ASPHALT (5 cm) and CONCRETE (20 cm).	
1		Grab	1		4.1 SAND and GRAVEL (SW, GW), fine to coarse, some silt to silty, loose to compact, angular to subrounded, grey to black, moist to wet, trace seashells (FILL/ROCKFILL).	
2						
3					- Water returned from cyclone at 3.35 m depth.	
4		Grab	2			
5						
6		Grab	3			
7		Grab	4			
8					8.5	
9		Grab	5		-4.1 SILT and CLAY (ML, CI), trace gravel, occasional cobble, soft, grey, wet.	
10						
11					- Trace seashells at 11.28 m depth.	
12		Grab Shelby	6 7			
13		Grab	8		- Lots of seashells (>90%) and trace silt, gravel and wood pieces from 12.8 m to 14.0 m depth.	
14		Grab	9		- Clayey silt with seashells at 13.71 depth.	
15		Grab	10		14.6 -10.2 CLAY (CI), medium plasticity, firm, grey, moist to wet, trace seashells.	
16		Grab	11			
17		Shelby	12			
18		Grab	13			
19						
20						

Continued Next Page

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT **CHECKED BY:**
SHEET 1 OF 2 **HOLE NO.:** BK02-06

KC_BECKER-SI_EGD.GPJ KC_DATA.GDT 5/12/02

BECKER TEST HOLE LOG

STARTED: Mar 20, 2002 **FINISHED:** Mar 21, 2002

DRILL RIG MODEL: BECKER HAV180

GROUND ELEV. (m): 4.4

COORDINATES (m): N 468508.3 E 5364859.9

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
		Grab	14		20.4 / -16.0 GRAVEL (GW), fine to coarse, sandy, fine to coarse sand, some silt to silty, subangular to subrounded, brown to grey, wet.	
					21.5 / -17.1 BEDROCK.	

End of Becker Drill Hole at 21.5 m

Notes:

1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.
2. BPT02-06 was carried out approximately 2 m east of the open ended Becker hole, BOC02-06.

BECKER PENETRATION TEST

Casing O.D.: 170 mm

Hammer Energy: 11 kJ max. rated

● SPT N

CLOSE ENDED (blows/0.3m)

OPEN ENDED (blows/0.3m)

BOUNCE PRESS (kPa)

W_P% W% W_L%

20 40 60 80

150

125

KLOHN CRIPPEN

PROJECT NO.: PG9060 01

PROJECT: PWGSC EGD and SLW Site Investigation

LOCATION: Esquimalt, BC

LOGGED BY: TT **CHECKED BY:**

SHEET 2 **OF** 2 **HOLE NO.:** BK02-06

KC_BECKER-SI EGD.GPJ KC_DATA.GDT 5/12/02

BECKER TEST HOLE LOG

STARTED: Mar 25, 2002 **FINISHED:** Mar 25, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.3
COORDINATES (m): N 468464.9 E 5364860.4

BECKER PENETRATION TEST
Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)
W_P% W% W_L% (20 40 60 80)

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.2 ASPHALT (5 cm) and CONCRETE (15 cm).	
					4.1 SAND and GRAVEL (SW, GW), fine to coarse, trace silt to silty, loose to compact, angular to subrounded, brown to grey, dry, trace wood pieces and seashells (FILL/ROCKFILL).	
1		Grab	1			
2		Grab	2			
	16,19,19	SPT	3		- Soil became wet at 2.4 m depth.	
3		Grab	4			
4		Grab	5			
	8,4,4	SPT	6			
5		Grab	7			
6		Grab	8		- Occasional boulder at 6.09 m depth.	
7	20,12,21 /12 cm	SPT	9		- SPT sampler likely hit some gravel.	
8		Grab	10			
9		Grab	11			
	8,11,10	SPT	12			
10					10.4	
					-6.1 SILT (ML), low plasticity, trace to some fine to coarse sand and gravel, soft to firm, grey, wet, trace to some seashells.	
11						
12	6,4,3	SPT	13			
13		Grab	14		- Lots of seashells (>90%) from 13.4 to 14.3 m depth.	
14	1,2,3	SPT	15		- Silt and fine sand with trace organics at 14.32 m depth.	
15					15.2	
					-10.9 CLAY (CI), medium plasticity, trace fine gravel, trace silt, firm, grey, moist to wet.	
16		Grab	16			
					16.7	
17					-12.4 BEDROCK.	
					End of Becker Drill Hole at 16.7 m	
18					Notes:	
19					1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.	
20					Continued Next Page	

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT **CHECKED BY:**
 HOLE NO.: BOC02-07

KC_BECKER_ST_EGD.GPJ KC_DATA.GDT 5/1/2002

BECKER TEST HOLE LOG

STARTED: Mar 25, 2002 FINISHED: Mar 25, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.3
COORDINATES (m): N 468464.9 E 5364860.4

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
21					2. Standard penetration tests (SPT) were conducted using an automatic trip hammer (63.5 kg), AWJ rods and a split-spoon sampler (51 mm O.D., 38 mm I.D.).	
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

BECKER PENETRATION TEST

Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)

W_P% × — o — × W_L%
20 40 60 80

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT CHECKED BY:
SHEET 2 OF 2 HOLE NO.: BOC02-07

KC_BECKER_SLEGD.GPJ KC_DATA.GDT 5/4/2002

BECKER TEST HOLE LOG

STARTED: Mar 26, 2002 **FINISHED:** Mar 27, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.4
COORDINATES (m): N 468556.3 E 5364864.2

BECKER PENETRATION TEST
Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)
W_P% W% W_L% (20 40 60 80)

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	DESCRIPTION OF MATERIALS
				0.2 / 4.2 ASPHALT (5 cm) and CONCRETE (10 cm).
1		Grab	1	SAND and GRAVEL (SW, GW), fine to coarse, silty, angular to subrounded, grey to black, moist, trace seashells (FILL).
				1.2 / 3.2 SILT (ML), low plasticity, clayey, sandy, trace to some gravel, soft to firm, grey, wet, trace seashells (FILL).
2		Grab	2	
3	2,0,0	SPT	2b	
4		Grab	3	
5				5.8
6	5,8,24	SPT	4	-1.4 SAND and GRAVEL (SW, GW), fine to coarse, trace to some silt, trace cobble, angular to subangular, grey to black, wet, trace seashells (ROCKFILL).
		Grab	5	
7				
8		Grab	6	
				8.8
9	2,2,4	SPT	7	-4.4 SILT (ML), low plasticity, trace to some fine to coarse sand and gravel, soft, grey, wet, trace wood pieces and seashells (FILL).
10		Grab	8	
11		Grab	9	
12		Grab	10	
				12.8
13		Grab	11	-8.4 CLAY (CI), medium plasticity, trace sand, firm to stiff, grey, wet.
14				
		Shelby	12	
15				
		Grab	13	
16				
17		Grab	14	
18				
				18.3
		Grab	15	-13.9 SAND and GRAVEL (SW, GW), fine to coarse, silty, trace to some clay, occasional cobble, subangular to subrounded, grey, wet.
19				19.2
				-14.8 End of Becker Drill Hole at 19.2 m
20				

Continued Next Page

INSTRUMENT DETAILS

KLOHN CRIPPEN

PROJECT NO.: PG9060 01	
PROJECT: PWGSC EGD and SLW Site Investigation	
LOCATION: Esquimalt, BC	
LOGGED BY: TT	**CHECKED BY:**
SHEET 1 OF 2	**HOLE NO.:** BK02-08

K:\BECKER-SL\Esq\SPJ\KCP.APJ 5/1/02

BECKER TEST HOLE LOG

STARTED: Mar 26, 2002 **FINISHED:** Mar 27, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.4
COORDINATES (m): N 468556.3 E 5364864.2

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS

Notes:

1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.

2. BPT02-08 was carried out approximately 2 m east of the open ended Becker hole, BOC02-08.

3. Piezometer construction details:
   0.00 m - 0.15 m Concrete mixture;
   0.15 m - 4.72 m Cement-bentonite grout;
   4.72 m - 5.18 m 1/4" Coated bentonite tablets;
   5.18 m - 7.92 m Silica filter sand;
   7.92 m - 8.53 m 1/4" Coated bentonite tablets;
   8.53 m - 18.59 m Pea gravel;
   18.59 m - 19.81 m Medium bentonite chips;

   Surface to 5.79 m 25 mm O.D. PVC pipe;
   5.79 m - 7.32 m No. 10 slot, 25 mm O.D. PVC pipe.

4. The piezometer was subsequently abandoned and backfilled on April 2, 2002.

5. Standard penetration tests (SPT) were conducted using an automatic trip hammer (63.5 kg), AWJ rods and a split-spoon sampler (51 mm O.D., 38 mm I.D.).

BECKER PENETRATION TEST

Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)

W_P% W% W_L%
20 40 60 80

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT **CHECKED BY:**
SHEET 2 OF 2 **HOLE NO.:** BK02-08

BECKER TEST HOLE LOG

STARTED: Mar 27, 2002 FINISHED: Mar 28, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 5.2
COORDINATES (m): N 468433.3 E 5364828.5

BECKER PENETRATION TEST
Casing O.D.: 170 mm
Hammer Energy: 11 kJ max. rated
SPT N
CLOSE ENDED (blows/0.3m)
OPEN ENDED (blows/0.3m)
BOUNCE PRESS (kPa)
W_P% W% W_L%
20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.4 CONCRETE DECK (40 cm).	
					4.8 Space below deck.	
					2.7	
3					2.5 SAND and GRAVEL (SW-GW), fine to coarse, some silt to silty, loose to compact, subangular to rounded, black, moist to wet, trace organics and seashells (FILL).	
4		Grab	1		- Silt content decreases with depth.	
		Grab	2		- Water returned from cyclone at 4.27 m depth.	
5		Grab	3			
		Grab	4			
6	4,4,4	SPT	5			
7		Grab	6			
8					8.2	
	8,7,3	SPT	7		-3.0 SAND and GRAVEL (SW-GW), fine to coarse, trace silt, loose to compact, angular to subangular, grey to black, wet, trace wood pieces and seashells (ROCKFILL).	
10		Grab	8			
11	3,3,2	SPT	8b			
		Grab	9			
12		Grab	10		- Occasional cobble at 12.19 m depth.	
13						
14		Grab	11			
15		Grab	12			
16					16.5	
		Grab	13		-11.3 SILT (ML), low plasticity, sandy, fine sand, trace fine gravel, trace clay, soft to firm, grey, wet, trace seashells (FILL?).	
18	18,7,5	SPT	14		18.3	
		Grab	15		-13.1 GRAVEL (GP), medium to coarse, trace silt, occasional cobble, subrounded, grey, wet, trace seashells (FILL?).	
19					19.2	
		Grab	16		-14.0 CLAY (CI), medium plasticity, trace sand and gravel, occasional cobble, soft to firm, grey, wet.	
20						

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT&DT CHECKED BY:
SHEET 1 OF 2 HOLE NO.: BOC02-09

...ER-SI ... KC_DA... a/12/02

BECKER TEST HOLE LOG

STARTED: Mar 27, 2002 FINISHED: Mar 28, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 5.2
COORDINATES (m): N 468433.3 E 5364828.5

BECKER PENETRATION TEST
Casing O.D.: 170 mm — CLOSE ENDED (blows/0.3m)
Hammer Energy: 11 kJ max. rated — OPEN ENDED (blows/0.3m)
● SPT N — BOUNCE PRESS (kPa)
W_P% W% W_L% (20 40 60 80)

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
21		Shelby	17			
		Grab	18			
22	3,2,3	SPT	19			
		Grab	20			
23	5,4,4	SPT	21			
24		Grab	22			
		Grab	23			
25	8,3,4	SPT	24			
26		Grab	25			
27		Grab	26			
28		Grab	27			
		Grab	28		28.6 -23.4 SAND and GRAVEL (SW, GW), fine to coarse, some silt to silty, angular to rounded, grey to black, wet. 29.3 -24.1 BEDROCK.	

End of Becker Drill Hole at 29.3 m

Notes:

1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.
2. Standard penetration tests (SPT) were conducted using an automatic trip hammer (63.5 kg), AWJ rods and a split-spoon sampler (51 mm O.D., 38 mm I.D.).

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: TT&DT CHECKED BY:
SHEET 2 OF 2 HOLE NO.: BOC02-09

...ER-SI Boreh...KC_DAT...gpj 3/12/02

BECKER TEST HOLE LOG

STARTED: Mar 29, 2002 FINISHED: Mar 30, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.5
COORDINATES (m): N 468605.2 E 5364841.9

BECKER PENETRATION TEST
Casing O.D.: 170 mm
Hammer Energy: 11 kJ max. rated
SPT N
CLOSE ENDED (blows/0.3m)
OPEN ENDED (blows/0.3m)
BOUNCE PRESS (kPa)
W_P% W% W_L%
20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.1 4.4 ASPHALT (6 cm). GRAVEL (GW), fine to coarse, sandy, fine to coarse sand, some silt, angular to subangular, brown, moist, trace seashells (ROCKFILL).	
1		Grab	1			
2	6,1,1	SPT	2		2.6	
					1.9 SILT and CLAY (ML-CI), some fine to coarse sand and gravel, occasional cobble, soft to firm, brown, wet, trace organics and seashells (FILL).	
3		Grab	3			
4		Grab	4			
5	5,3,5	SPT	5		- Water returned from cyclone at 4.57 m depth.	
6		Grab	6		6.1	
		Grab	7		-1.6 SAND and GRAVEL (SW, GW), fine to coarse, some silt to silty, occasional cobble, angular to subrounded, brown to grey, wet (FILL/ROCKFILL).	
7	32,11,6	SPT	8			
8		Grab	9			
9						
10	36,13,17	SPT	10		9.9	
		Grab	11		-5.4 SAND (SP), fine, silty, gravelly, brown to grey, wet, trace seashells (FILL). - Lots of seashells at 10.36 m depth.	
11		Grab	12			
12	0,0,2	SPT	13		12.2	
					-7.7 CLAY (CI), medium plasticity, trace to some sand and gravel, soft to stiff, grey, wet, trace organics and seashells. - Sand and gravel content decreases with depth.	
13		Grab	14			
14		Grab	15			
15						
16		Grab	16			
17						
18		Grab	17		- Some medium to coarse sand between 18.1 m and 18.6 m depth.	
19						
20		Shelby	18			

Continued Next Page

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 1 OF 2 HOLE NO.: BK02-10

w:\becker-si esquimalt KC_Drawings\ 5/12/02

BECKER TEST HOLE LOG

STARTED: Mar 29, 2002 FINISHED: Mar 30, 2002
DRILL RIG MODEL: BECKER HAV180
GROUND ELEV. (m): 4.5
COORDINATES (m): N 468605.2 E 5364841.9

BECKER PENETRATION TEST
Casing O.D.: 170 mm
Hammer Energy: 11 kJ max. rated
SPT N
CLOSE ENDED (blows/0.3m)
OPEN ENDED (blows/0.3m)
BOUNCE PRESS (kPa)
W_P% W% W_L%
20 40 60 80

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
21		Grab	19			
		Grab	20		21.6 - Trace to some sand and gravel at 21.34 m depth.	
22		Grab	21		-17.2 SAND (SP), fine, silty, grey, wet. 22.2	
		Grab	22		-17.8 SAND and GRAVEL (SW, GW), fine to coarse, some silt to silty, occasional cobble, angular to subrounded, grey to black, wet.	
23		Grab	23		23.6	
24					-19.1 BEDROCK.	
25					End of Becker Drill Hole at 23.6 m	
26					Notes:	
27					1. Drilling was carried out by Foundex Explorations Ltd. of Surrey, B.C.	
28					2. BPT02-10 was carried out approximately 2 m north of the open ended Becker hole, BOC02-10.	
29					3. Standard penetration tests (SPT) were conducted using an automatic trip hammer (63.5 kg), AWJ rods and a split-spoon sampler (51 mm O.D., 38 mm I.D.).	
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 2 OF 2 HOLE NO.: BK02-10

KL_BECKER-SI Boulder KC_DAT 9/12/02

TEST HOLE LOG

STARTED: Mar 15, 2002 FINISHED: Mar 15, 2002
DRILL METHOD: Mud Rotary
GROUND ELEV. (m): 4.4
COORDINATES (m): N 468518.5 E 5364876.3

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	DESCRIPTION OF MATERIALS
				0.2 ASPHALT (5 cm) and CONCRETE (14 cm).
				4.2 SAND, GRAVEL and ROCKFILL (SW, GW), fine to coarse, trace clay, grey to brown, dry to moist (FILL).
1		Grab	1	
				1.5 - Clay content increases from trace to clayey at 1.37 m depth.
2				2.9 CLAY (CI), medium plasticity, with layers of silt and fine to coarse sand and gravel, firm to stiff, grey, moist to wet, trace seashells (CLAY PUDDLE).
3	2,3,4	SPT	2	
4	3,1,2	SPT	3	
5	2,2,4	SPT	4	- Gravel and wood pieces at 5.18 m depth.
6	1,1,1	SPT	5	
7				
8	1,2,1	SPT	6	
9		Shelby	7	
10				
11				
12		Shelby	8	12.2 -7.8 BEDROCK?
13				End of Hole at 12.2 m
14				
15				
16				
17				
18				
19				
20				

INSTRUMENT DETAILS

Su - kPa
20 60 100 140 180
VANE PEAK ◆ ■ ▲ UC/2
REMOLD ◇ □ △ P.PEN/2
★ % FINES ● SPT N
W_P% W% W_L%
20 40 60 80

Notes:

1. Drilling was carried out by Mud Bay Drilling Co. Ltd. of Surrey, B.C. using a mobile drill B80 truck.

2. SCPT02-02 was carried out approximately 1.2 m west and 0.5 m north of the mud rotary drill hole DH02-01.

3. Standard penetration tests (SPT) were conducted using a safety hammer (63.5 kg), AWJ rods and split-spoon sampler (51 mm O.D., 38 mm I.D.).

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 1 OF 1 HOLE NO.: DH02-01

K:_ ... HOLES ... .PJ KC_ ...JT 5/12_

TEST HOLE LOG

STARTED: Mar 25, 2002 FINISHED: Mar 26, 2002
DRILL METHOD: Mud Rotary
GROUND ELEV. (m): 4.9
COORDINATES (m): N 468292.2 E 5364787.7

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.2 / 4.7 ASPHALT (10 cm) and WOOD (10 cm) DECK. Space below deck.	
					13.6 / -8.7 SILT (ML), low plasticity, trace to some fine to coarse sand and gravel, soft, grey to black, wet, lots of organics, trace to some seashells.	
		Shelby	1			

Su - kPa
20 60 100 140 180
VANE PEAK ◆ FIELD ■ LAB
REMOLD ◇ □
▲ UC/2
△ P.PEN/2
★ % FINES ● SPT N
W_P% W% W_L%
× – – – – o – – – – ×
20 40 60 80

Continued Next Page

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 1 OF 3 HOLE NO.: DH02-02

TEST HOLE LOG

STARTED: Mar 25, 2002 FINISHED: Mar 26, 2002
DRILL METHOD: Mud Rotary
GROUND ELEV. (m): 4.9
COORDINATES (m): N 468292.2 E 5364787.7

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					22.6 -17.7 CLAY (CI), medium plasticity, trace fine to medium gravel, firm to stiff, grey, wet, trace organics.	
		Grab	2			
		Shelby	3			

Continued Next Page

Su - kPa
20 60 100 140 180
VANE PEAK ◆ FIELD ■ LAB ▲ UC/2
REMOLD ◇ □ △ P.PEN/2
★ % FINES ● SPT N
W_P% W% W_L%
× – – – – o – – – – ×
20 40 60 80

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 2 OF 3 HOLE NO.: DH02-02

TEST HOLE LOG

STARTED: Mar 25, 2002 FINISHED: Mar 26, 2002
DRILL METHOD: Mud Rotary
GROUND ELEV. (m): 4.9
COORDINATES (m): N 468292.2 E 5364787.7

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
41		Shelby	4			
42						
43						
44						
45						
46						
47						
48						
49						
50		Shelby	5			
51					50.8 / -45.8 End of Hole at 50.8 m	
52						
53						
54						
55						
56						
57						
58						
59						
60						

Su - kPa
20 60 100 140 180
VANE PEAK ◆ FIELD ■ LAB ▲ UC/2
REMOLD ◇ □ △ P.PEN/2
★ % FINES ● SPT N
W_P% W% W_L%
20 40 60 80

Notes:

1. Drilling was carried out by Mud Bay Drilling Co. Ltd. of Surrey, B.C. using a mobile drill B80 truck.

2. CPT02-03 was carried out approximately 6.5 m east and 2.5 m north of the mud rotary drill hole, DH02-02.

3. Undrained shear strength values are from Nilcon field vane tests.

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 3 OF 3 HOLE NO.: DH02-02

KC_TEST_HOLE-SI ESQUIMALT KC_Template 5/12/04

TEST HOLE LOG

STARTED: Apr 01, 2002 FINISHED: Apr 01, 2002
DRILL METHOD: Mud Rotary
GROUND ELEV. (m): 5.0
COORDINATES (m): N 468359.6 E 5364849.9

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
0					0.2 / 4.8 ASPHALT (10 cm) and WOOD (10 cm) DECK. Space below deck.	
13					12.8 / -7.8 SILT (ML), low plasticity, trace to some fine to coarse sand and gravel, soft, grey to black, wet, excessive organics, trace to some seashells.	
15	20,18,16	SPT	1		14.9 / -9.9 - Hard drilling at 14.63 m depth; casings were driven using a 113 kg weight. SAND and GRAVEL (SW, GW), fine to coarse, some silt to silty, grey, wet, trace organics and seashells.	
16		Grab	2			
17					- Silt with trace fine sand at 16.76 m depth. - Lots of seashells at 17.07 m depth.	
18	6,7,6	SPT	3		- Silty fine sand with trace fine to coarse gravel at 17.98 m depth. - Some clay at 18.6 m depth.	
20						

Continued Next Page

Su - kPa
20 60 100 140 180
VANE PEAK ◆ ■ ▲UC/2
REMOLD ◇ □ △P.PEN/2
★ % FINES ● SPT N
W_P% W% W_L%
× — — — o — — — ×
20 40 60 80

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 1 OF 2 HOLE NO.: DH02-03

5/12/20 J KC_C HOLE-SI KC

TEST HOLE LOG

STARTED: Apr 01, 2002 FINISHED: Apr 01, 2002
DRILL METHOD: Mud Rotary
GROUND ELEV. (m): 5.0
COORDINATES (m): N 468359.6 E 5364849.9

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					20.1 -15.1 CLAY (Cl), medium plasticity, firm, grey, wet.	
21						
22		Shelby	4		- Clayey silt, firm to stiff, at 21.95 m depth.	
23						
24						
25						
26					26.4 -21.4 SAND (SW), fine to coarse, some fine gravel, grey to	
27					26.8 -21.8 black, wet. BEDROCK?	
28					End of Hole at 26.8 m	
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

Su - kPa
20 60 100 140 180
VANE PEAK ◆ FIELD ■ LAB ▲ UC/2
REMOLD ◇ □ △ P.PEN/2
★ % FINES ● SPT N
W_P% W% W_L%
× ——— ○ ——— ×
20 40 60 80

Notes:

1. Drilling was carried out by Mud Bay Drilling Co. Ltd. of Surrey, B.C. using a mobile drill B80 truck.

2. CPT02-12 was carried out approximately 2.6 m east and 1.4 m north of the mud rotary drill hole, DH02-03.

3. Standard penetration tests (SPT) were conducted using a safety hammer (63.5 kg), AWJ rods and split-spoon sampler (51 mm O.D., 38 mm I.D.).

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 2 OF 2 HOLE NO.: DH02-03

K:\Jobs\PG9060 01 Esquimalt SLW\Drawings\Logs\PG9060-01_HOLES.dwg Layout: 5/12/04

TEST HOLE LOG

STARTED: Apr 01, 2002 FINISHED: Apr 02, 2002
DRILL METHOD: Mud Rotary
GROUND ELEV. (m): 5.1
COORDINATES (m): N 468498.7 E 5364804.9

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.2 / 5.0 ASPHALT (5 cm) and WOOD (10 cm) DECK. Space below deck.	
					11.6 / -6.5 SILT (ML), low plasticity, trace to some fine to coarse sand and gravel, soft, grey to black, wet, excessive organics, trace to some seashells.	
					14.0 / -8.9 CLAY (CI), medium plasticity, trace to some silt, stiff, grey, wet.	
					Continued Next Page	

Su - kPa
20 60 100 140 180
VANE PEAK ◆ FIELD ■ LAB ▲ UC/2
REMOLD ◇ □ △ P.PEN/2
★ % FINES ● SPT N
W_P% W% W_L%
× ——— o ——— ×
20 40 60 80

KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 1 OF 2 HOLE NO.: DH02-04

JT 5/12 PJ KC _HOLES_ K_

TEST HOLE LOG

STARTED: Apr 01, 2002 FINISHED: Apr 02, 2002
DRILL METHOD: Mud Rotary
GROUND ELEV. (m): 5.1
COORDINATES (m): N 468498.7 E 5364804.9

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
21						
22						
23						
24						
25					25.0 -19.9 End of Hole at 25.0 m	
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

Su - kPa
20 60 100 140 180
VANE PEAK ◆ FIELD ■ LAB ▲ UC/2
REMOLD ◇ □ △ P.PEN/2
★ % FINES ● SPT N
W_P% W% W_L%
20 40 60 80

Notes:

1. Drilling was carried out by Mud Bay Drilling Co. Ltd. of Surrey, B.C. using a mobile drill B80 truck.

2. CPT02-07 was carried out approximately 3.3 m east of the mud rotary drill hole, DH02-04.

3. Undrained shear strength values are from Nilcon field vane tests.

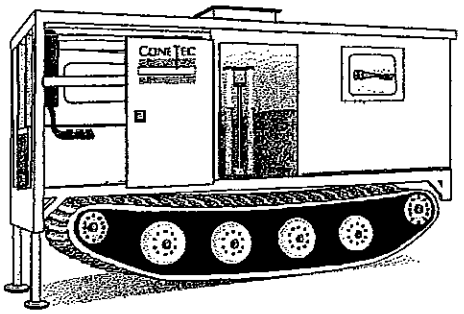
KLOHN CRIPPEN

PROJECT NO.: PG9060 01
PROJECT: PWGSC EGD and SLW Site Investigation
LOCATION: Esquimalt, BC
LOGGED BY: DT CHECKED BY:
SHEET 2 OF 2 HOLE NO.: DH02-04

KC_TEST_HOLE-SI EGD.GPJ KC_DATA.GDT 5/12/02

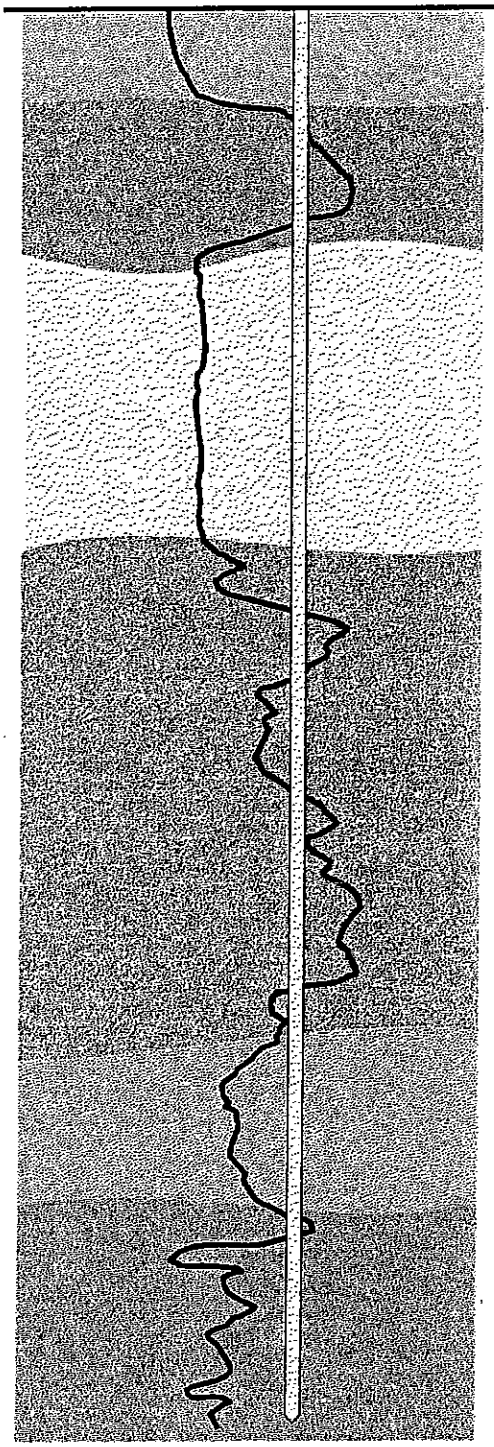
APPENDIX II

ConeTec Investigations Ltd. Report



CONETEC

Geotechnical and Environmental In Situ Testing Contractors



ConeTec Field Report

Prepared for:

Klohn-Crippen Consultants Ltd.
Richmond, BC

Cone Penetration Testing
and Seismic Cone Penetration Testing
Esquimalt Graving Dock
Esquimalt, BC

- March 14 - April 2, 2002 -

Vancouver • Edmonton • Salt Lake City • New Jersey • Los Angeles • San Francisco • Houston
Tel: (604) 327-4311 • Fax: (604) 327-4066 • Email: insitu@conetec.com

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Appendix A STANDARD CPT PLOTS

Appendix B SELECTED PORE PRESSURE DISSIPATION PLOTS

Appendix C SEISMIC CPT AND DOWNHOLE SEISMIC PLOTS

Appendix D FIELD VANE TEST RESULTS

Appendix E DATA DISKETTE CONTENTS

Appendix F CPTSUMM INTERPRETATION TABLES

1.0 INTRODUCTION

The enclosed report presents the results of a Cone Penetration Testing (CPT) and Seismic Cone Penetration Testing (SCPT) program carried out at the Esquimalt Graving Dock. The program consisted of 6 CPT's and 3 SCPT's performed from March 14, 2002 to April 2, 2002, as shown below in Table 1.

Table 1: CPT Summary

CPT Sounding	Date	Type of Cone	Final Depth (m)
CPT02-01 (EGD10)	03/14/02	10 ton 005	3.65
SCPT02-02 (EGD9)	03/14/02	10 ton 005	13.15
CPT02-03 (SLW1)	03/18/02	20 ton 094	57.95
CPT02-05 (SLW2)	03/20/02	20 ton 094	42.65
SCPT02-06 (SLW3)	03/21/02	20 ton 094	37.60
CPT02-07 (SLW4)	03/22/02	20 ton 094	40.95
CPT02-08 (SLW5)	03/22/02	20 ton 094	27.50
SCPT02-09 (SLW11)	03/27/02	20 ton 094	46.60
CPT02-10 (SLW12)	03/28/02	20 ton 094	25.05

2.0 EQUIPMENT AND PROCEDURES

2.1 CPT Procedures

The cone penetration tests were conducted by ***ConeTec Investigations Ltd.*** using an integrated electronic cone and data acquisition system. Both a 10-ton and a 20-ton compression type cone were used during the testing program. The cone was deployed through the dock surface using Mud Bay Drilling's B80 truck mounted drill rig.

The 10-ton cone has a tip area of 10 cm^2 and a friction sleeve area of 150 cm^2. The 20-ton cone has a tip area of 15 cm^2 and a friction sleeve area of 225 cm^2. A porous element, 5mm thick was used for collecting dynamic and static water pressure data. All testing was conducted with the pore pressure element located directly behind the cone tip at the "u_2" position. The elements were saturated in glycerine under vacuum pressure prior to testing.

ConeTec compression cones are designed with an equal end area friction sleeve and a tip end area ratio of 0.85. The cone system used during the program recorded the following parameters at 5 cm depth increments:

- Tip Resistance (q_c) in bars
- Sleeve Friction (f_s) in bars
- Dynamic Pore Pressure (u_2) in metres of water

The above parameters were stored on digital media for future analysis and reference.

A complete set of baseline readings was taken before and after each sounding to determine if a zero load offset had occurred due to a temperature change of the probe. Establishing the presence of temperature shifts and load offsets enables the operator to make corrections to the cone data if necessary. These corrections can be important, especially where the load conditions are relatively low, and generally represent the single largest source of error with respect to the accuracy of cone data. Since the probes are temperature compensated, load shifts due to changes in probe temperature are only a problem when extreme temperature changes occur during the test. For the testing done on this project, the cone remained within a normal operating temperature range and hence temperature shifts were negligible.

2.2 Seismic CPT Procedures

The equipment and procedures used for determining shear wave velocities were generally the same as those reported by Robertson et al. (1983). The procedure was incorporated with the CPT testing and conducted when the penetration was stopped at the end of a 1-metre stroke. Secondary waves (shear waves or *s-waves*) were generated at 1-metre intervals until refusal. Before taking wave measurements, the rods were decoupled from the rig, serving to minimize the background noise that can occur during the testing.

At SCPT location EGD-9 subsurface waves were generated using two methods: (1) a 15 lb sledge hammer striking a solid stem auger vertically; (2) a "buffalo gun" discharging blank cartridges into the ground; (3) at SCPT locations SLW-3 and SLW-11 an underwater blasting plate loaded with seismic blasting caps was used to generate an s-wave pulse. The depth from

ground surface or mudline (in the case of the over water seismic holes) to the tip of the cone and the horizontal offset of the seismic source to the cone were recorded and applied in subsequent calculations.

At SCPT location EGD-9 at least 2 wave traces were recorded per one meter depth advancement of the cone penetrometer. This serves two purposes: first, the operator can check the consistency of the waveforms; and secondly, stacking of the waveforms improves the signal to noise ratio of the data. An electrical contact trigger between the both the hammer/auger and the buffalo gun/shot cartridge produced accurate triggering times and allowed for precision timing of the s-wave markers. At SCPT locations SLW-3 and SLW-11 at least one seismic cap was detonated at each test depth. The seismic caps were detonated using an electric seismic detonator assembly to allow for accurate triggering times.

The subsurface wave receiver used was a horizontally active geophone located in the body of the piezocone. The geophone is located 0.2 metres behind the cone tip. This offset is accounted for in all calculations. Data was sampled at frequencies of 20kHz (ie. 20,000 and samples per second) with a total of 5000 to 8000 points being recorded per wave trace, depending on the depth of the test. The s-wave signal experienced some attenuation in the soils; and therefore input sensitivity (gain) of the receiver was increased with depth to maintain optimal signal amplitude.

2.3 Downhole Seismic Procedures

The downhole seismic testing equipment comprises a downhole triaxial geophone receiver with a pneumatic line, a field computer equipped with an A/D card, a seismic source at a shallow depth (solid stem auger hit with a sledgehammer), an interface control unit that links the field laptop and the receiver. The testing procedure for acquiring shear wave data followed **ASTM D 4428/D 4428M-91,** The Standard Test Methods for Downhole Seismic Testing. For the downhole test, the seismic source was placed a measured distance from the cased borehole. The receiver package was lowered to the bottom of the borehole and coupling between the receiver and the borehole was achieved with a pneumatic packer. As the seismic receiver was raised in one metre intervals, the solid stem auger was struck with the sledgehammer and the resulting seismic wave was recorded. This procedure was repeated to the top of the cased borehole.

2.4 Field Vane Test Procedures

The field vane tests were performed using a Roctest M-1000 Vane Borer (Nilcon Vane). In-situ shear tests were conducted on cohesive soils and the tests were recorded graphically on a paper disk. The instrument was mounted at the top of the mud rotary drillhole H-casing using an adaptor.

3.0 CONE PENETRATION TEST DATA AND FIELD TEST RESULTS

3.1 CPT Data

The cone penetration test data is presented in graphical form in Appendix A. ConeTec's standard CPT plots consist of Corrected Tip Resistance (q_t) in bar, Sleeve Friction (f_s) in bar, Pore Pressure (u_2) in metres of water, and Friction Ratio (R_f) plotted versus depth. Stratigraphic interpretations included in the plot series are based on charts developed by Robertson et al. (1990). The charts relate cone tip resistance and friction ratio to determine the respective soil behaviour type.

The cone tip (q_t) reading is the total force acting on the cone tip divided by the projected area of the tip. It indicates the relative density, or stiffness, of the soil. The sleeve friction (f_s) is the frictional force the soil is imposing on the friction sleeve divided by the surface area of the friction sleeve. The friction ratio (R_f), expressed as a percentage, is a ratio of the sleeve friction readings divided by the cone tip readings. The friction ratio gives an indication of the grain size characteristics of the material. Fine grained soils typically have a higher friction ratio than coarse grained soils. The dynamic pore pressure readings record the pore pressures generated behind the cone tip during cone penetration. To record equilibrium or static water pressures, the penetration must be stopped to allow the dynamic pore pressures to come into equilibrium. The data acquisition system automatically records and displays the pore pressure dissipation traces in real time allowing the operator to assess when equilibrium conditions have been reached.

Due to the complex stress conditions around the cone, pore pressures will be different at various locations on the cone. For this project all of our pore pressures were recorded behind the tip in the u_2 position.

Due to the inner geometry of a cone penetrometer, the ambient pore water pressure will act on the shoulder area behind the cone and on the ends of the friction sleeve. This results in an imbalance of stresses and is known as the "unequal area effect". This effect influences the total stress determined from the cone and friction sleeve. For the cone resistance, the unequal area is represented by the cone area ratio 'a', which is approximately equal to the ratio of the cross-sectional area of the load cell or shaft divided by the projected area of the cone. The corrected total cone resistance, q_t, is given by the equation:

$$q_t = q_c + u_2 (1-a)$$

For ConeTec cones, the area ratio is 0.85. All of our calculations and plots are in terms of q_t, however, our data files contain the recorded data q_c.

A similar effect occurs for friction sleeves that have different cross-sectional areas at each end. This condition will result in an imbalance of forces on the friction sleeve leading to incorrect friction values. ConeTec cones are designed with equal end area friction sleeves to eliminate this problem.

Appendix F contains the results of the ConeTec interpretation program CPTSUMM. A number of interpreted soil parameters are presented in these tables. For the analysis soil densities are based on standard values assigned to each zone depending on soil behaviour type.

Due to the tidal actions at the Esquimalt Graving Dock, the water level below the dock fluctuated, resulting in varying water tables during the testing period. For analysis purposes the water level at the time of the CPT was used in order for proper calculation of effective stresses. A summary of the methods used to calculate the tabulated geotechnical parameters has been included in Appendix F.

The CPT data and the interpretation files are stored in ASCII text files on the accompanying data disks. The contents of the diskettes are detailed in Appendix E. Penetration data is referenced to the existing dock surface.

3.2 Seismic CPT and Downhole Seismic Results

Plots of shear wave velocity versus depth for all the tests are presented in Appendix C. The velocity profiles are plotted as a step plot with the shear wave velocity depicted as a point at the mid layer depth.

3.3 Pore Pressure Dissipation Results

Pore pressure dissipations were recorded during select pauses in penetration for most of the CPT tests. The pore pressure data was recorded at 5 second intervals for each test and is included on the data disk in files having the extension *PPD*.

A summary of the dissipation data has been enclosed with the plots in Appendix B.

Pore pressure dissipations were carried out as indicated in Table 2 below. The soils at this site were generally fine grained with low permeability characteristics resulting in lengthy dissipation times.

Table 2: Pore Pressure Dissipation Summary

CPT Sounding	Test Depth (m)	Test Duration (s)	Estimated Equilibrium (m)	Assumed Water Table (m) (Below Deck)
SCPT02-02 (EGD9)	5.70	280	3.3	2.0*
	12.70	365	10.9	
CPT02-03 (SLW1)	21.75	1520	18.2	3.6
	31.75	1960	28.2	
CPT02-05 (SLW2)	21.60	515	17.6	4.0
SCPT02-06 (SLW3)	15.90	2245	12.4	3.5
	25.90	1485	22.4	
CPT02-07 (SLW4)	22.80	1815	19.4	3.4
CPT02-08 (SLW5)	18.85	2500	15.0	3.9
	27.50	430	23.6	
SCPT02-09 (SLW11)	18.80	665	15.2	3.6
	33.80	900	30.2	
CPT02-10 (SLW12)	16.80	2100	13.2	3.7
	25.05	870	21.4	

*Estimated based on equilibrium values from pore pressure dissipations

3.4 Field Vane Test Results

A summary of the field vane tests is presented below in Table 3. See Appendix D for the detailed results indicating peak, residual and remolded shear stress for each vane.

Table 3: Field Vane Test Summary

CPT Sounding	Test Depth (m)	Peak Su (kPa)	Comments
DH 02-01	7.0	48.8	
	9.7	95.6	
DH 02-02	16.3	13.9	
	17.2	13.4	
	17.6	16.7	
	18.0	12.9	Rods slipped 40 cm during remold
	19.0	20.1	Rods slipped 30 cm during remold
	20.0	26.8	Rods slipped 40 cm during remold
	24.4	28.7	
	24.9	>96.6	
	25.1	>96.6	
DH 02-04	15.1	51.6	Rods slipped 4 cm during remold
	16.2	44.0	Rods slipped 5 cm during remold
	17.2	70.3	
	18.2	56.4	
	19.2	67.9	
	20.2	61.2	
	21.2	91.8	
	22.2	67.9	
	23.2	78.4	
	24.2	117.6	

4.0 DATA DISKETTES

The data diskettes provided in Appendix E of this report contains the CPT data files, pore pressure dissipation files and the CPT interpretation output. The main directory of disk 1 contains the CPT data in files having the extension COR and the pore pressure dissipation data in files having the extension PPD.

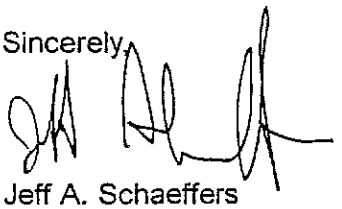
The standard interpretation output is located on disks 2 and 3, in files having the extensions IFI and IFP. The IFI files contain tabular output without any page formatting. These files can be imported into spreadsheets. The IFP files have been formatted with page breaks and span

across several pages (at 70 lines per page). These files can be output to printers that print using a compressed type face.

5.0 CLOSING

We trust that the information presented in this report is sufficient for your purposes. If you have any questions regarding the contents of this report, please do not hesitate to contact the author.

Sincerely,



Jeff A. Schaeffers
Ref/02-128.rpt

Appendix A

Standard CPT Plots

CONETEC

Job No: 02-128
Client: Klohn Crippen
Project: Esquimalt Graving Dock
Date: March 14, 2002 - April 2, 2002

CPT SUMMARY

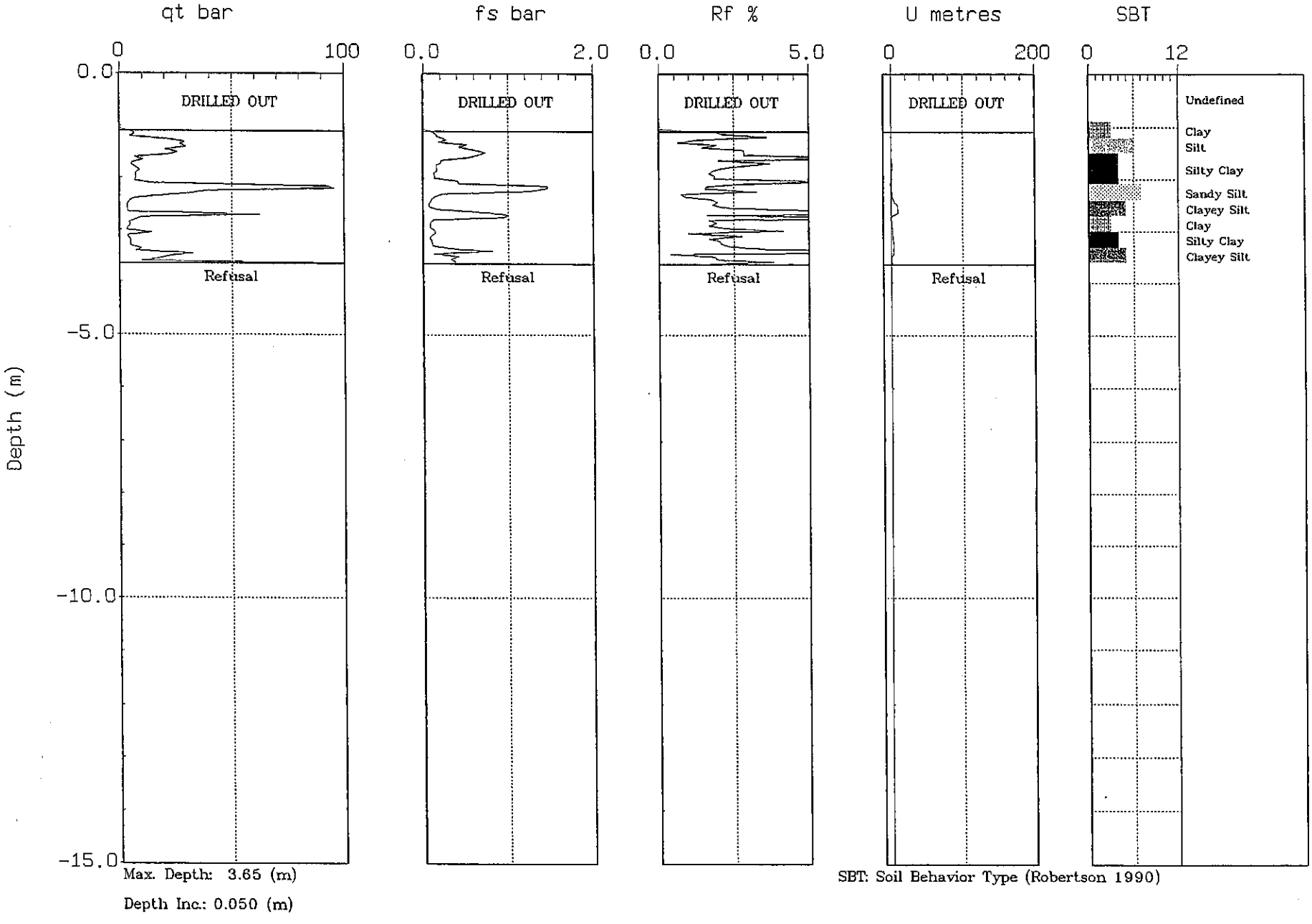
CPT Sounding	Date	Type Of Cone	Final Depth (m)
CPT02-01 (EGD10)	03/14/02	10 ton 005	3.65
SCPT02-02 (EGD9)	03/14/02	10 ton 005	13.15
CPT02-03 (SLW1)	03/18/02	20 ton 094	57.95
CPT02-05 (SLW2)	03/20/02	20 ton 094	42.65
SCPT02-06 (SLW3)	03/21/02	20 ton 094	37.60
CPT02-07 (SLW4)	03/22/02	20 ton 094	40.95
CPT02-08 (SLW5)	03/22/02	20 ton 094	27.50
SCPT02-09 (SLW11)	03/27/02	20 ton 094	46.60
CPT02-10 (SLW12)	03/28/02	20 ton 094	25.05

CONETEC

Klohn Crippen

Site: CPT02-01(EGD10)
Location: ESQUIMALT

Cone: 10 TON A 005
Date: 03:14:02 13:15



Max. Depth: 3.65 (m)

Depth Inc.: 0.050 (m)

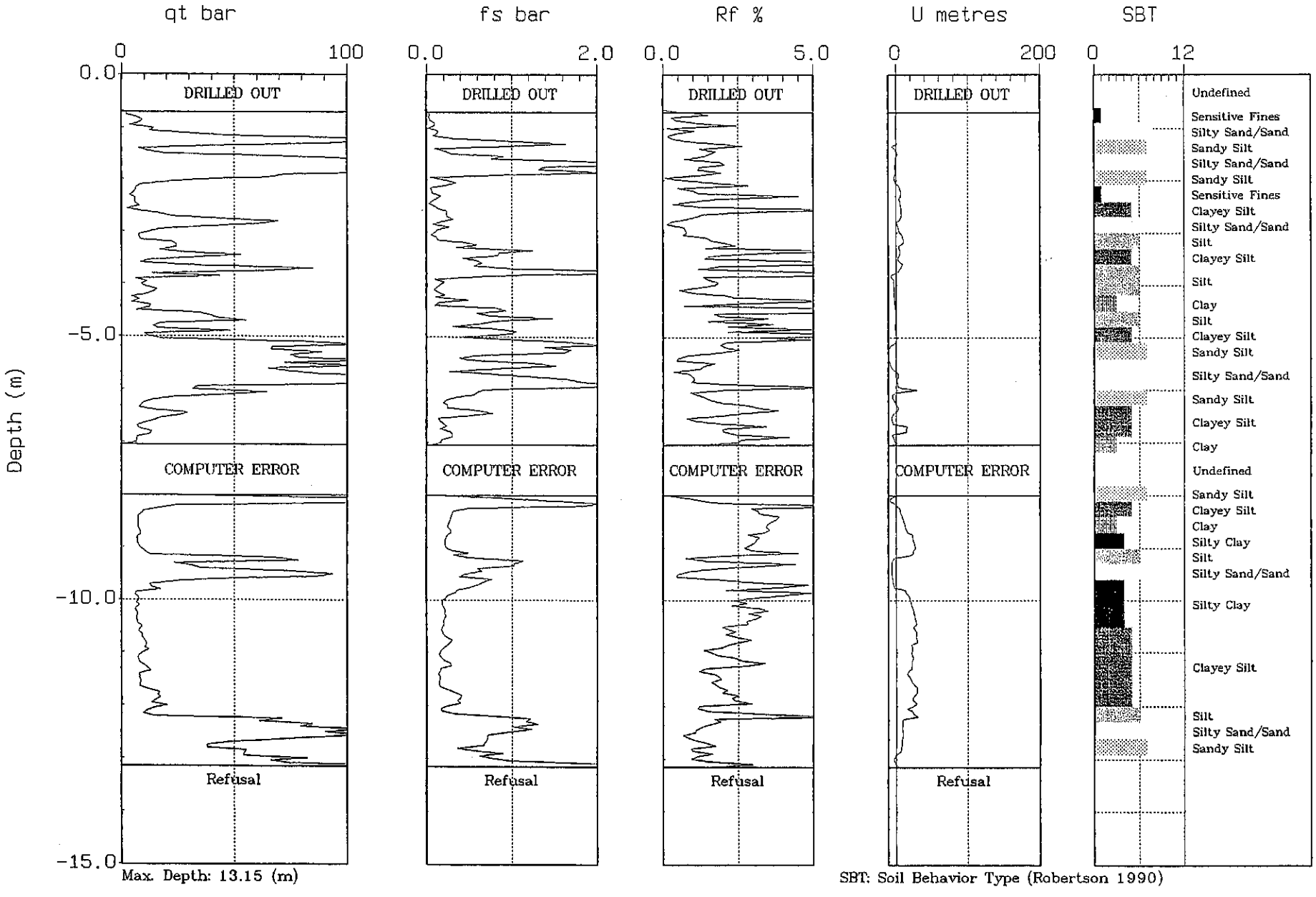
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Klohn Crippen

Site: SCPT02-02(EGD9)
Location: ESQUIMALT

Cone: 10 TON A 005
Date: 03:14:02 16:15



Max. Depth: 13.15 (m)

Depth Inc.: 0.050 (m)

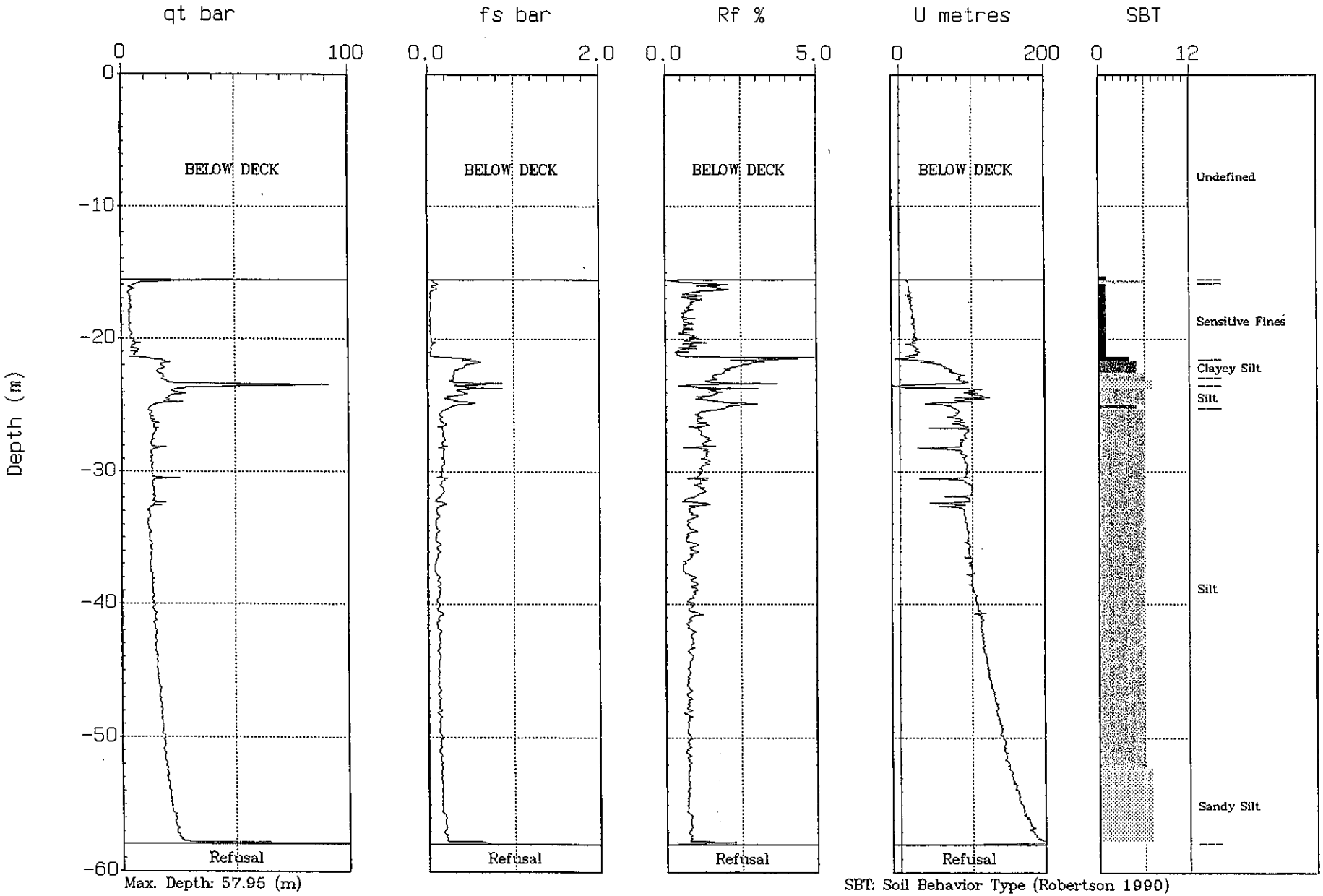
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Klohn Crippen

Site: CPT02-03(SLW1)
Location: ESQUIMALT

Cone: 20 TON A 094
Date: 03:18:02 16:00



Max. Depth: 57.95 (m)

Depth Inc.: 0.050 (m)

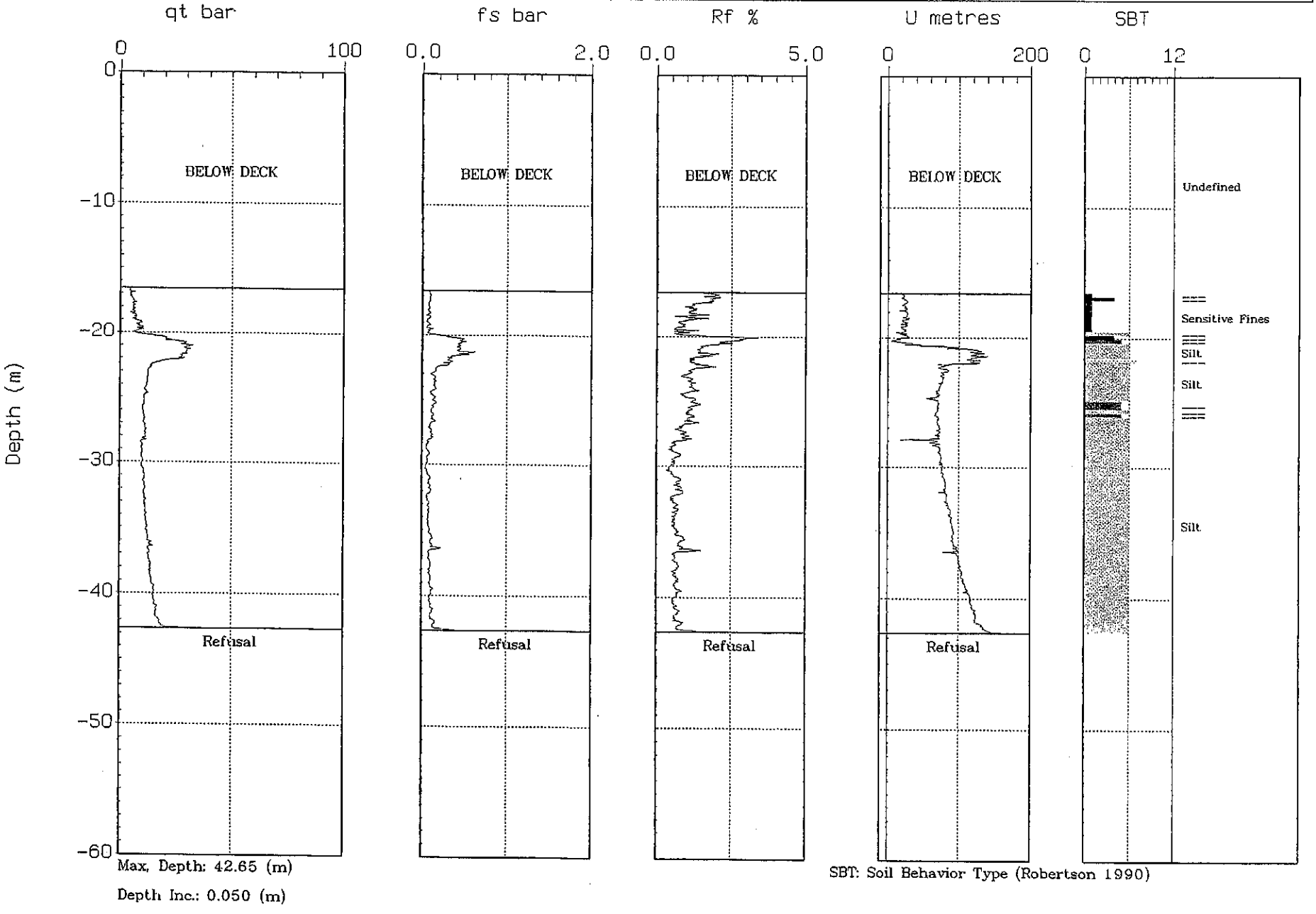
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Klohn Crippen

Site: CPT02-05(SLW2)
Location: ESQUIMALT

Cone: 20 TON A 094
Date: 03:20:02 12:45



Max. Depth: 42.65 (m)

Depth Inc.: 0.050 (m)

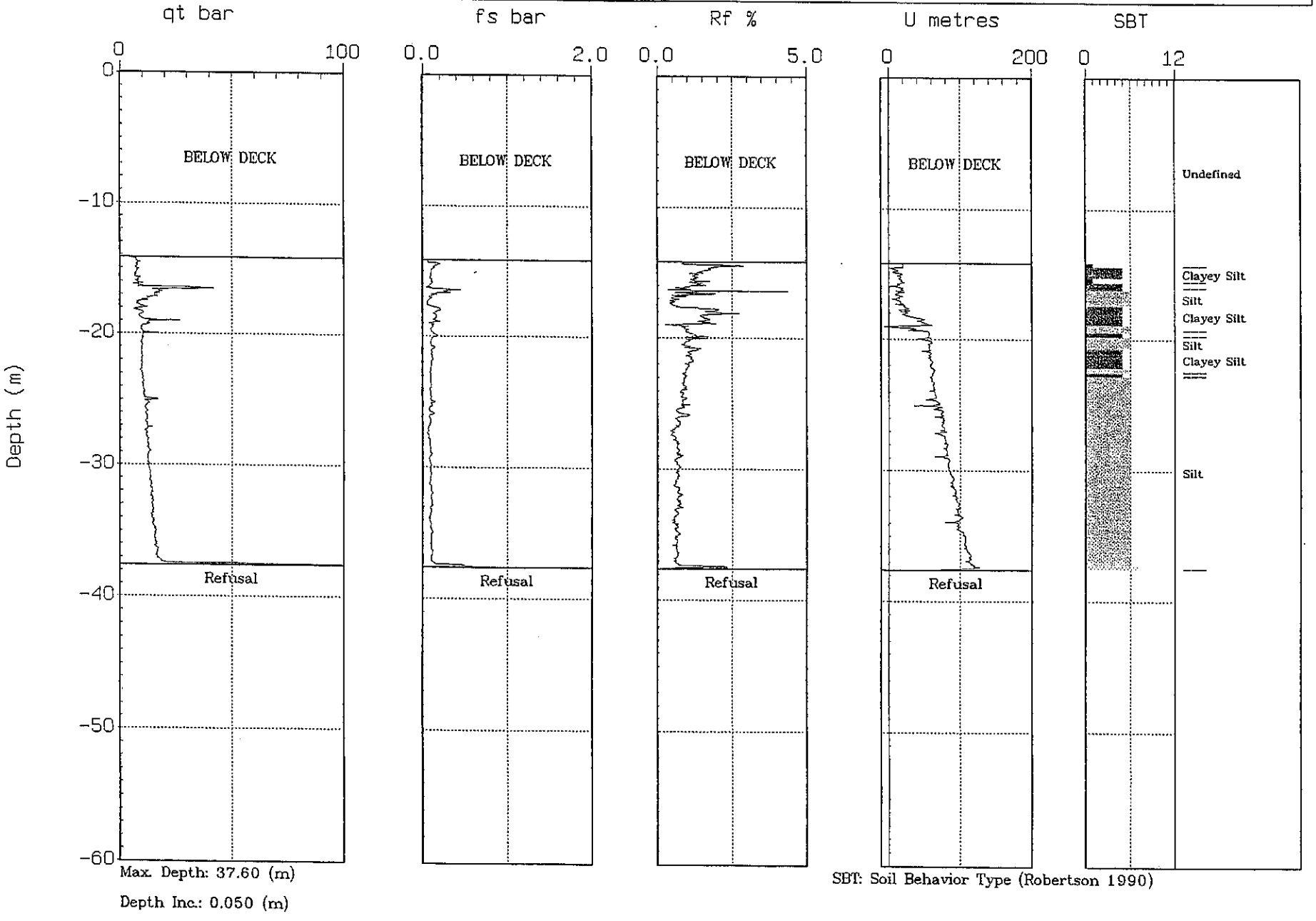
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Klohn Crippen

Site: SCPT02-06(SLW3)
Location: ESQUIMALT

Cone: 20 TON A 094
Date: 03:21:02 10:50



Max. Depth: 37.60 (m)

Depth Inc.: 0.050 (m)

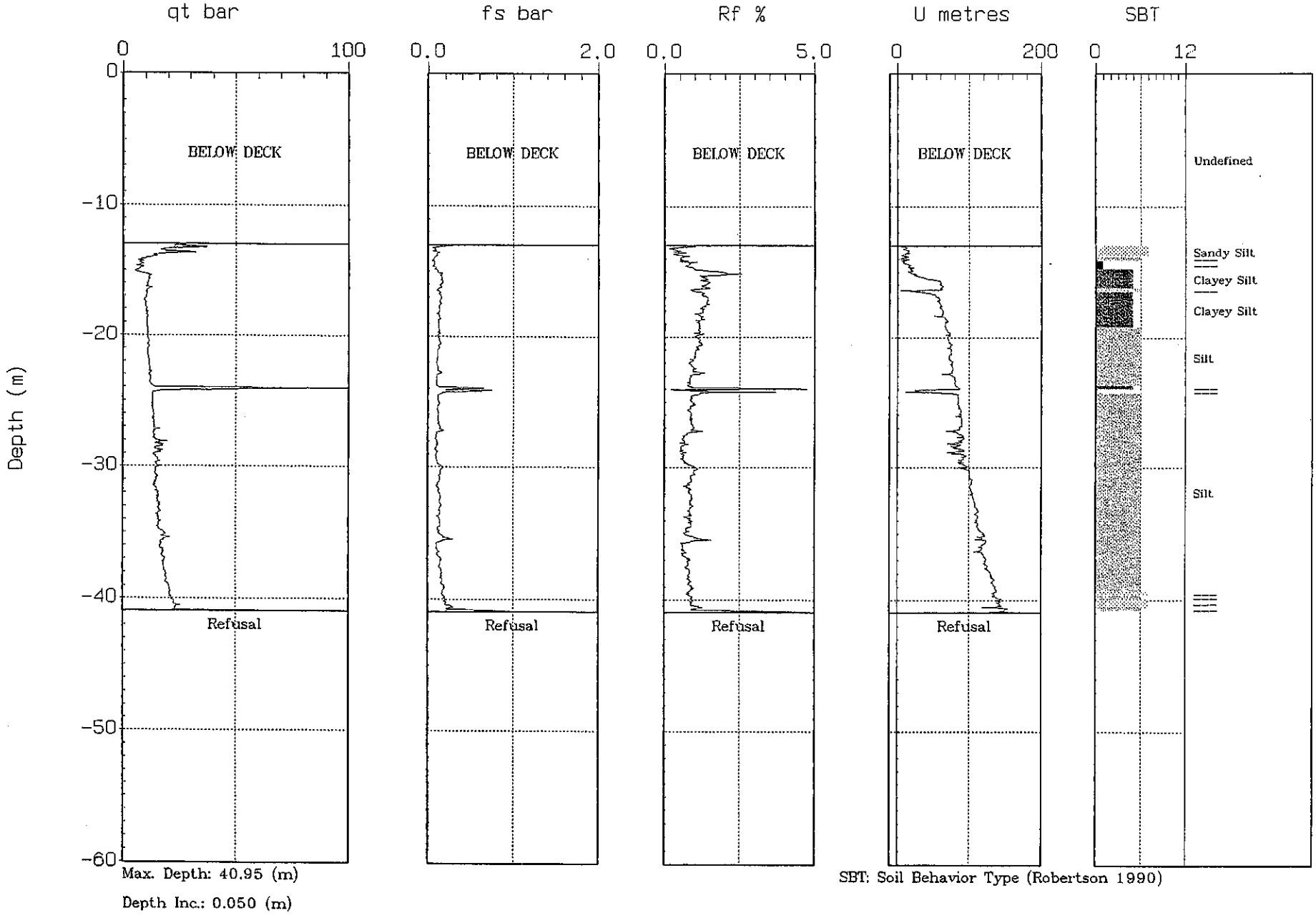
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Klohn Crippen

Site: CPT02-07(SLW4)
Location: ESQUIMALT

Cone: 20 TON A 084
Date: 03:22:02 09:30



Max. Depth: 40.95 (m)

Depth Inc.: 0.050 (m)

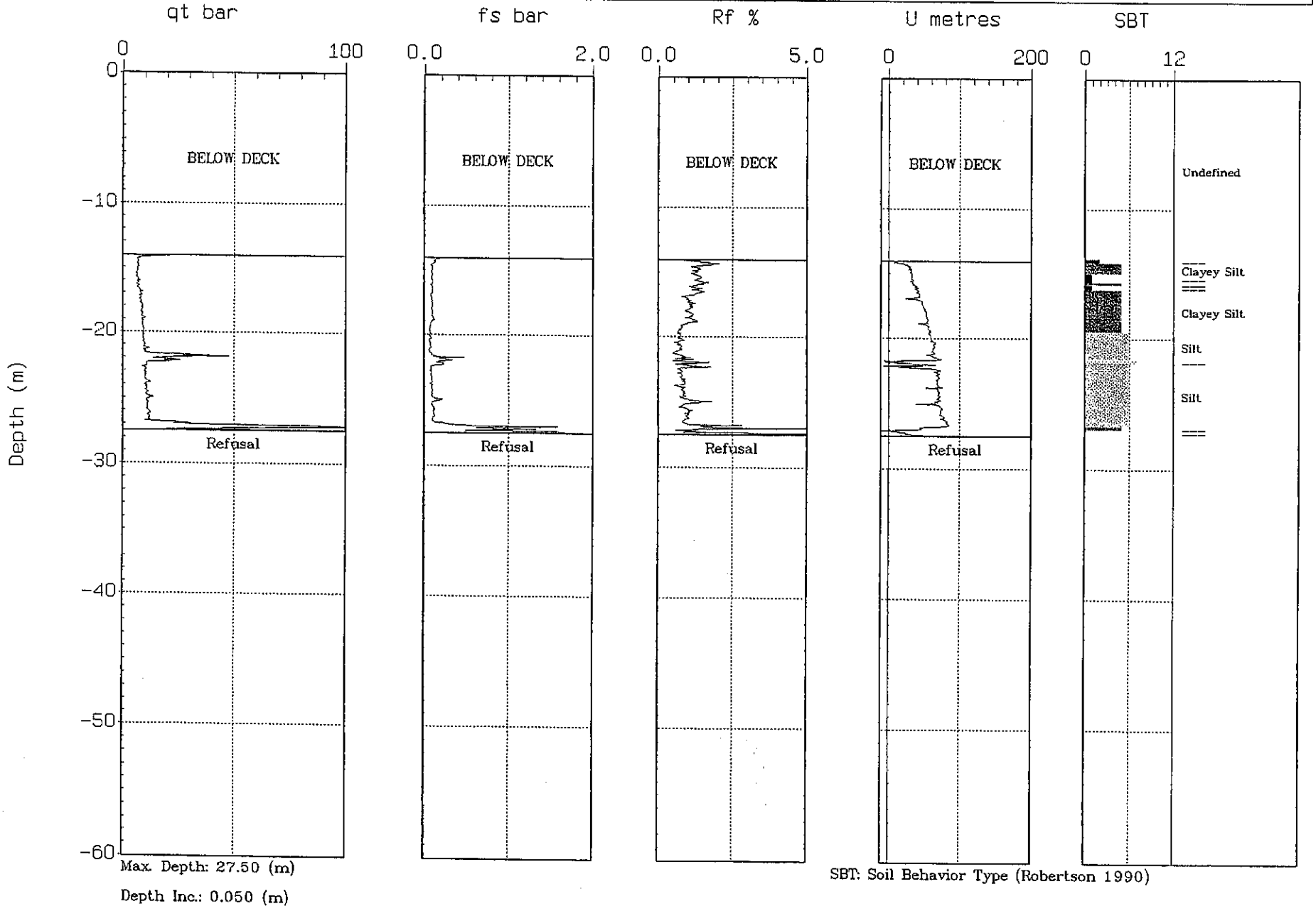
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Klohn Crippen

Site: CPT02-08(SLW5)
Location: ESQUIMALT

Cone: 20 TON A 094
Date: 03:22:02 13:30



Max. Depth: 27.50 (m)

Depth Inc.: 0.050 (m)

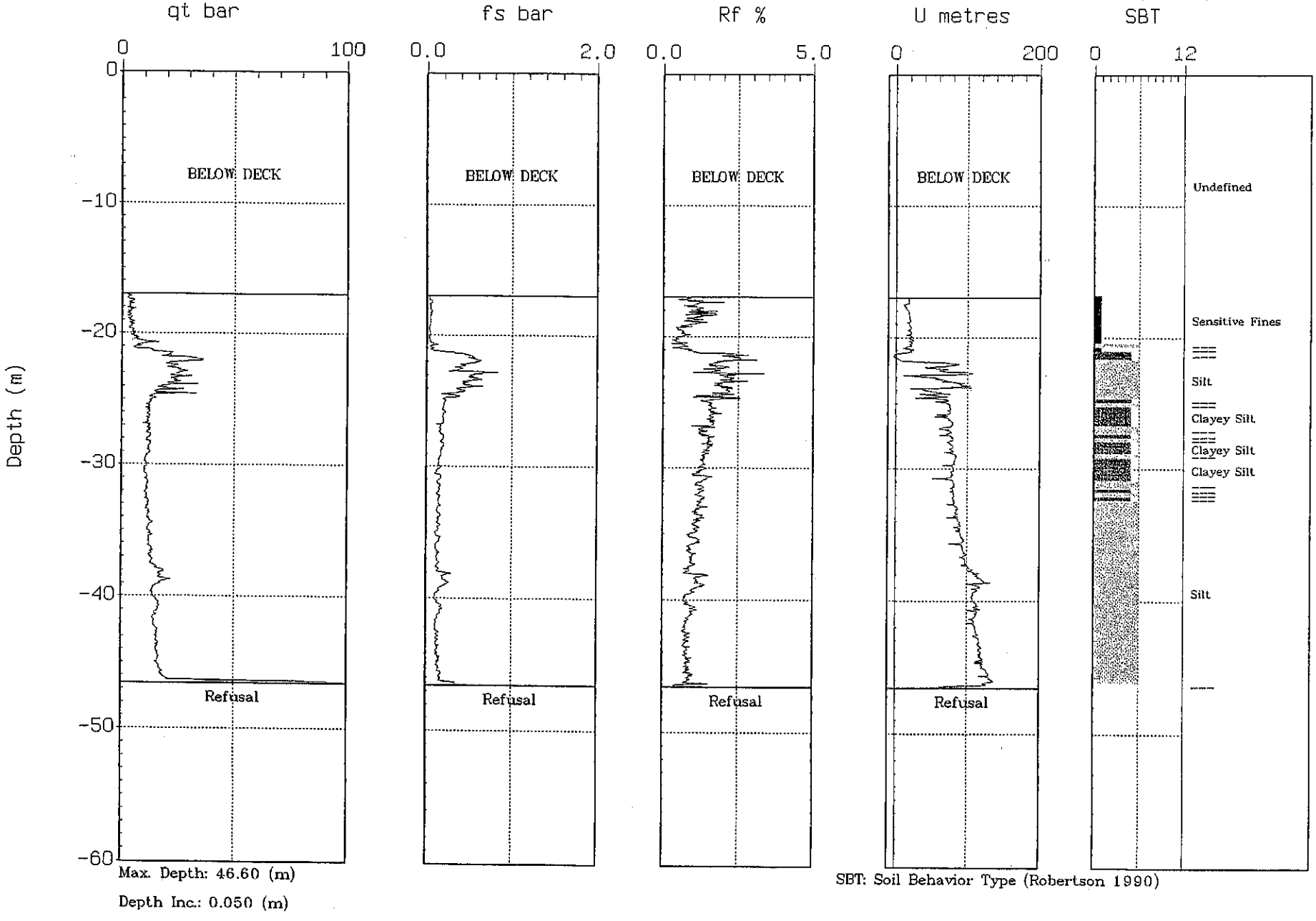
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Klohn Crippen

Site: SCPT02-09(SLW11)
Location: ESQUIMALT

Cone: 20 TON A 094
Date: 03:27:02 10:15



Max. Depth: 46.60 (m)

Depth Inc.: 0.050 (m)

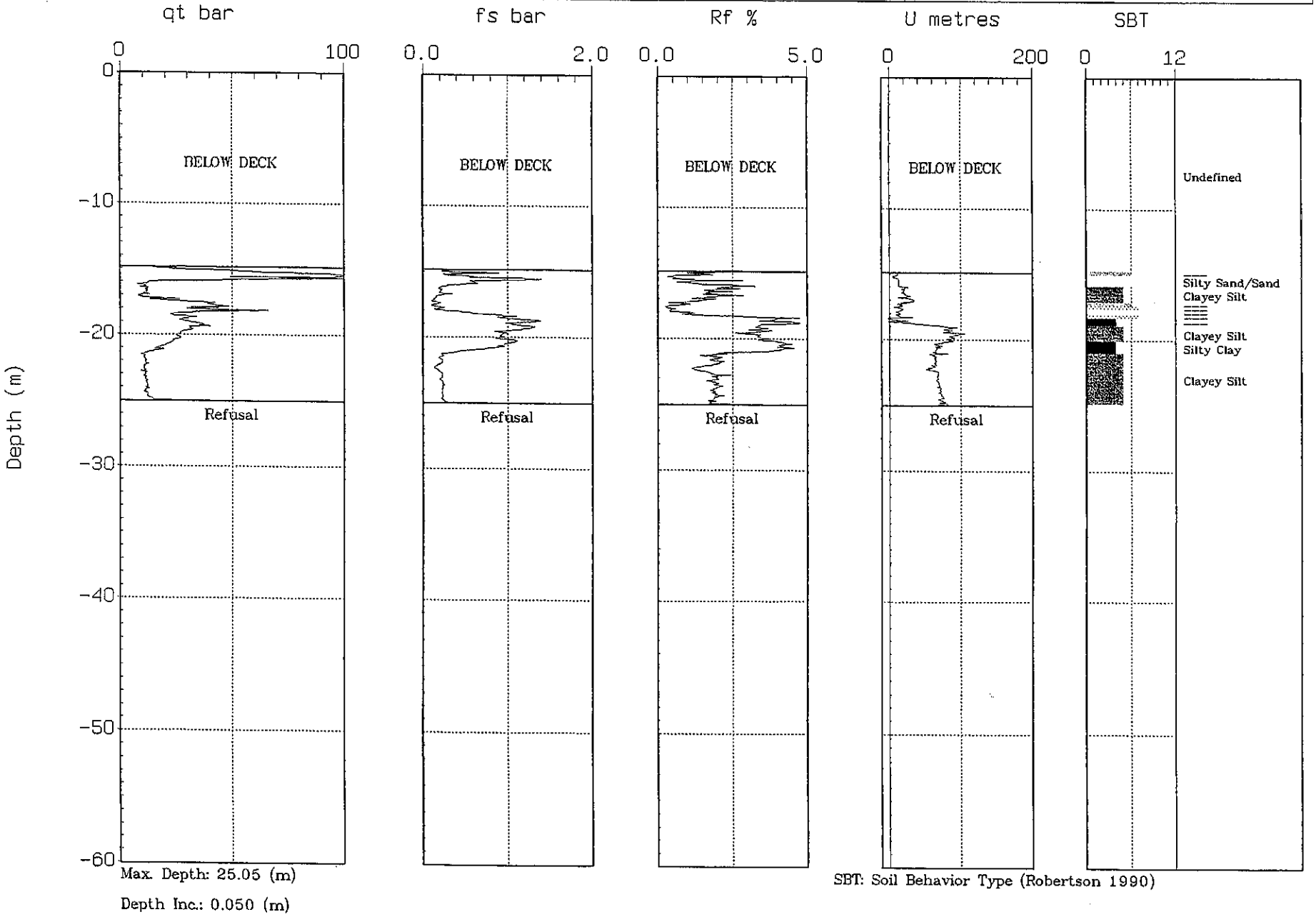
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

Klohn Crippen

Site: CPT02-10(SLW12)
Location: ESQUIMALT

Cone: 20 TON A 094
Date: 03:28:02 10:15



Max. Depth: 25.05 (m)

Depth Inc.: 0.050 (m)

SBT: Soil Behavior Type (Robertson 1990)

Appendix B

Selected Pore Pressure Dissipation Plots

CONETEC

Job No: 02-128
Client: Klohn Crippen
Location: Esquimalt Graving Dock
Dates: March 14, 2002 - April 2, 2002

Pore Pressure Dissipation Summary

Sounding ID	Dissipation Filename	Test Depth (m)	Estimated Equilibrium (m)	Assumed Water Table (m)	T_{50} (s)	Comments
SCPT02-02 (EGD9)	128CP02.ppd	5.70	3.3	2.4**		Achieved Equilibrium
		12.70	10.9	1.8**		Achieved Equilibrium
CPT02-03 (SLW1)	128CP03.ppd	21.75	18.2*		160	U_{50}% = 43.95m
		31.75	28.2*	3.6		Estimate: U_{50}% = 62.43m
CPT02-05 (SLW2)	279CP05.ppd	21.60	17.6*	4.0	475	U_{50}% = 79.73m
SCPT02-06 (SLW3)	128CP06.ppd	15.90	12.4*		193	U_{50}% = 20.52m
		25.90	22.4*	3.5		Estimate: U_{50}% = 50.99m
CPT02-07 (SLW4)	128CP07.ppd	22.80	19.4*	3.4		Estimate: U_{50}% = 48.39m
CPT02-08 (SLW5)	128CP08.ppd	18.85	15.0*			Estimate: U_{50}% = 35.84m
		27.50	23.6*	3.9		Achieved Equilibrium
SCPT02-09 (SLW11)	128CP09.ppd	18.80	15.2*		418	U_{50}% = 19.16m
		33.80	30.2*	3.6		Estimate: U_{50}% = 59.50m
CPT02-10 (SLW12)	128CP10.ppd	16.80	13.2*		248	U_{50}% = 23.21m
		25.05	21.4*	3.7	695	U_{50}% = 34.24m

* Equilibrium values based on water level below the dock at the time of the CPT

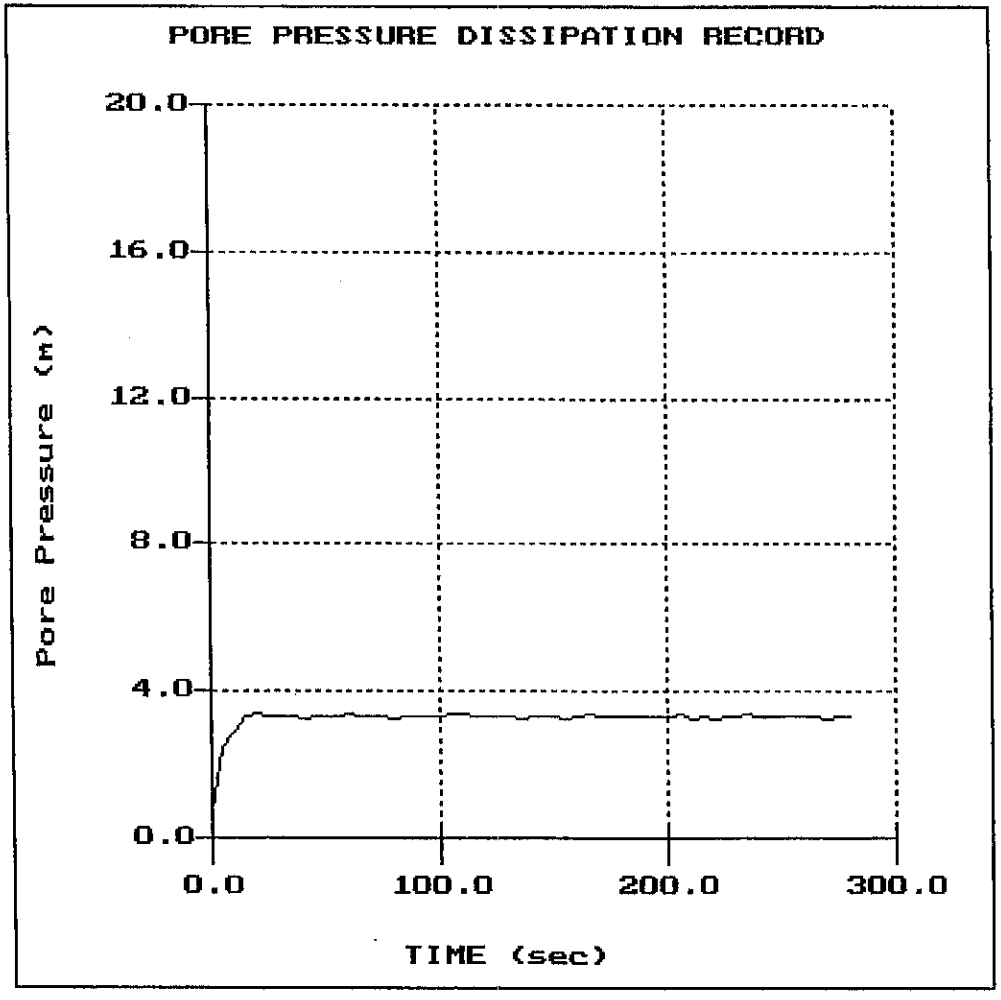
**Water table based on estimated equilibrium value from dissipation plot

Klohn Crippen

Hole:SCPT02-02(EGD9)
Location:ESQUIMALT

Cone:10 TON A 005
Date:03:14:02 16:15

File: 128CP02.PPD
Depth (m): 5.70
(ft): 18.70
Duration : 280.0s

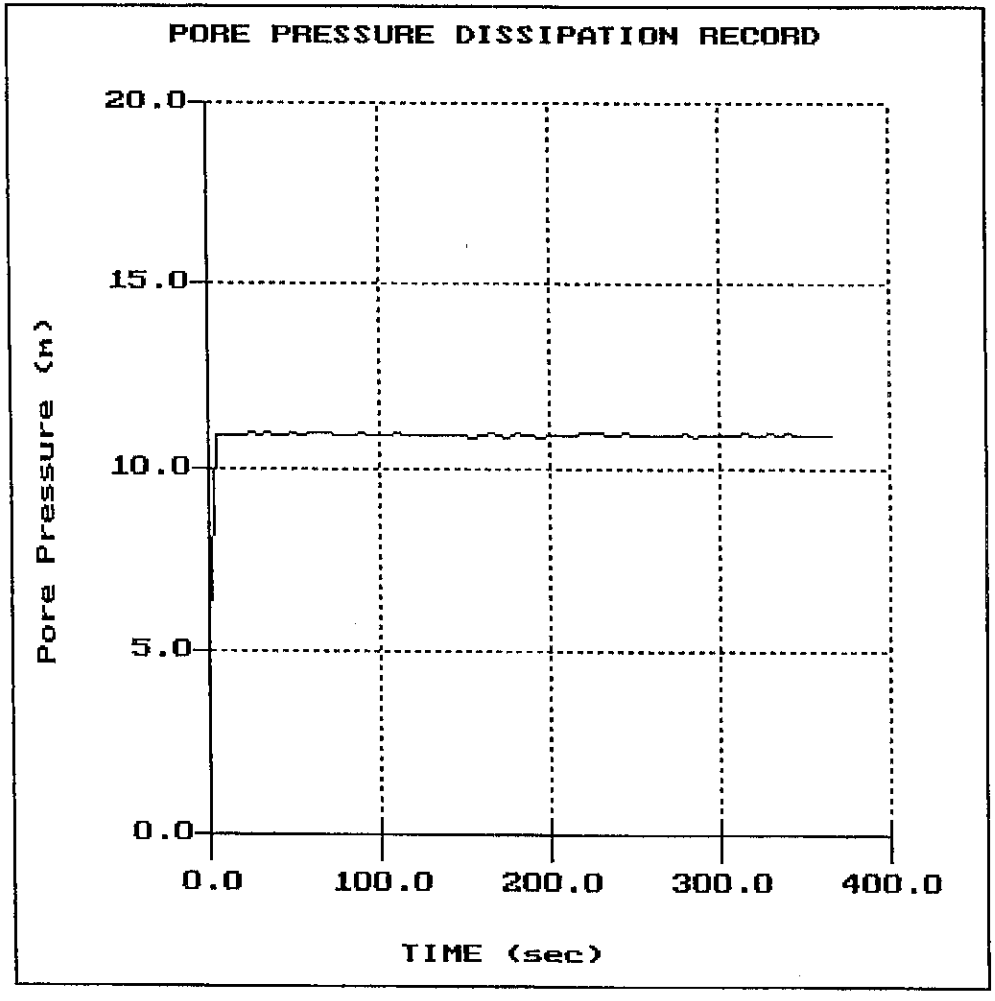


Klohn Crippen

Hole:SCPT02-02(EGD9)
Location:ESQUIMALT

Cone:10 TON A 005
Date:03:14:02 16:15

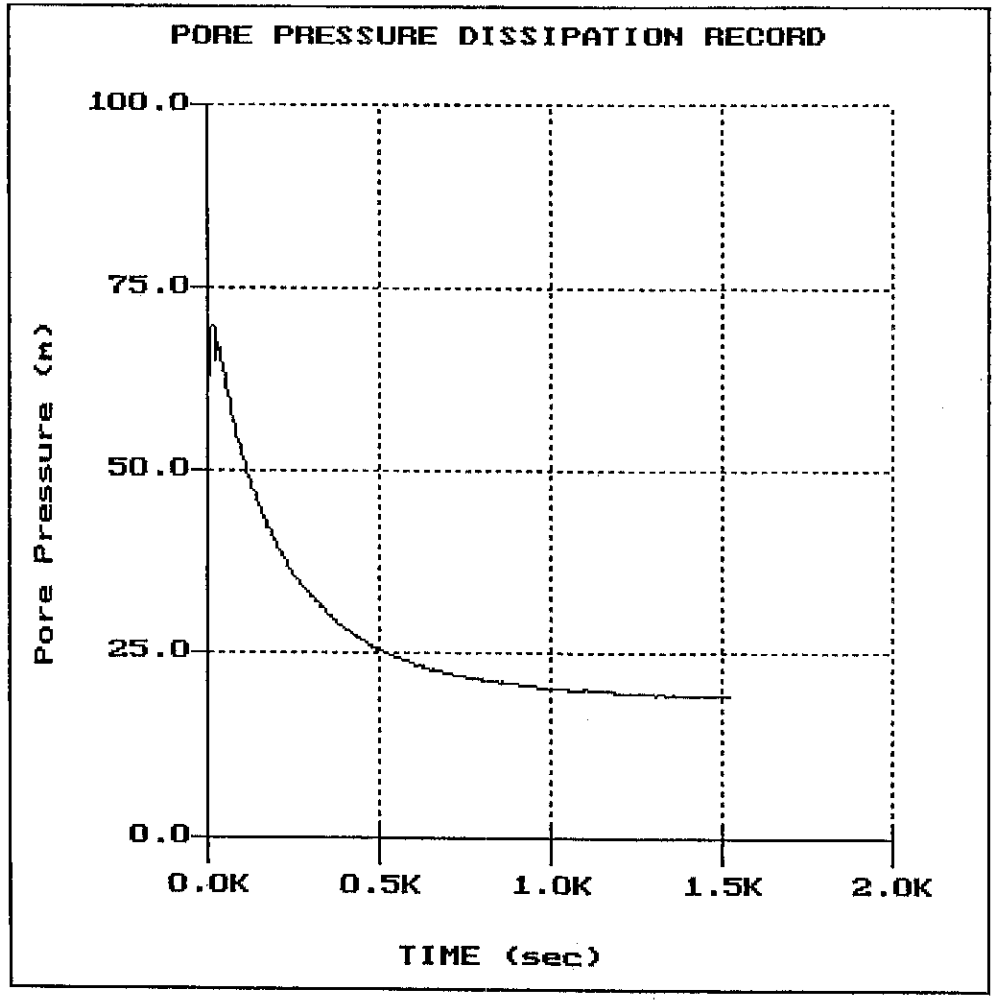
File: 128CP02.PPD
Depth (m): 12.70
(ft): 41.67
Duration : 365.0s



Klohn Crippen

Hole:CPT02-03(SLW1)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:18:02 16:00



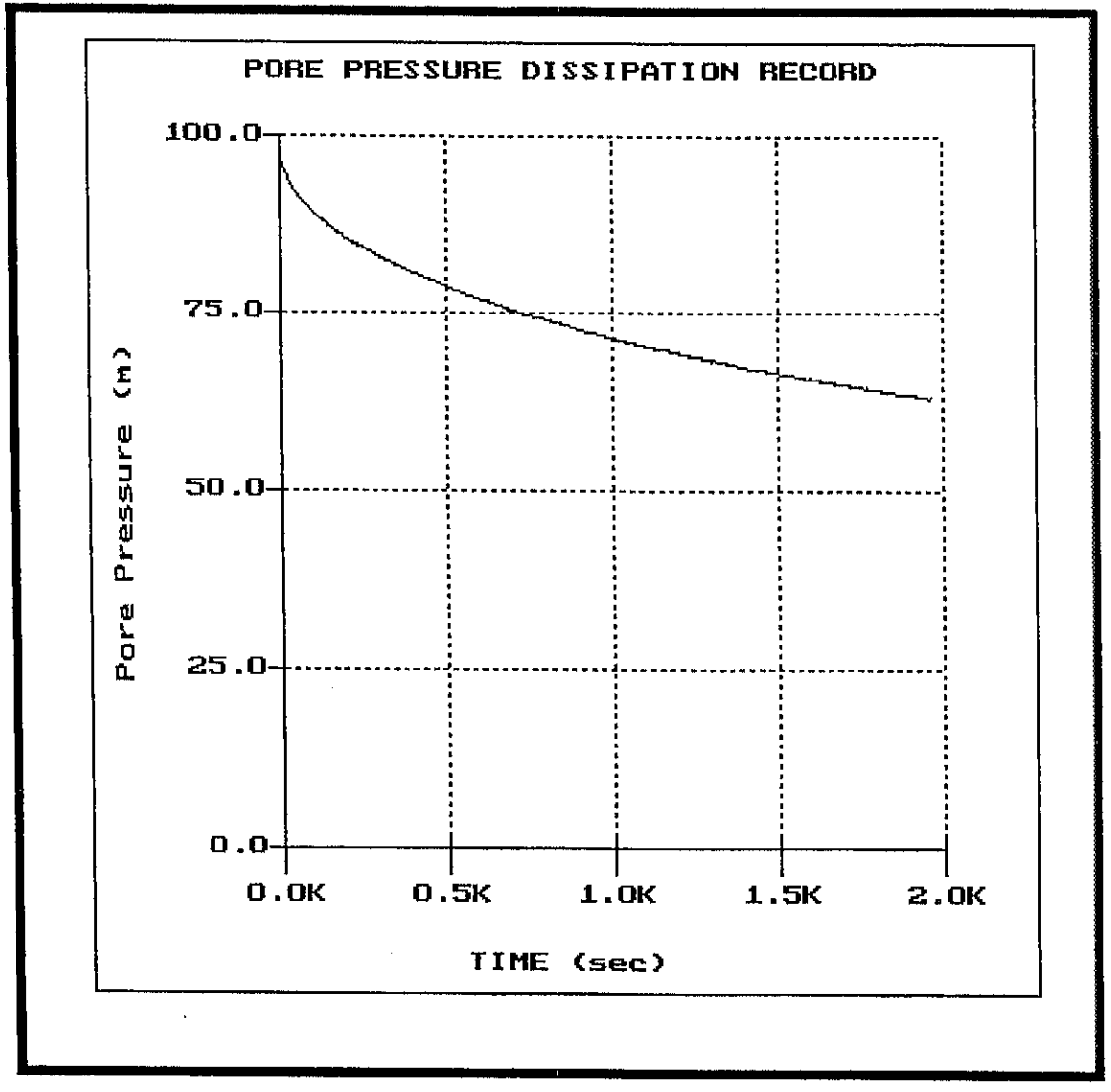
File: 128CP03.PPD
Depth (m): 21.75
(ft): 71.36
Duration : 1520.0s
U-min: 18.95 1495.0s
U-max: 69.70 15.0s
U-eq.: 18.20
U-50 : 43.95 160.2s
ch : 4.471 cm^2/min
%Ut: 0.99

Plot u-min: 0.00
u-max:100.00
t-min: 0.00
t-max:2000.0
# of TicksX: 4
# of TicksY: 4
Rigidity Ir:100.0
Water table: 3.55 m
11.65 ft

Klohn Crippen

Hole:CPT02-03(SLW1)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:18:02 16:00

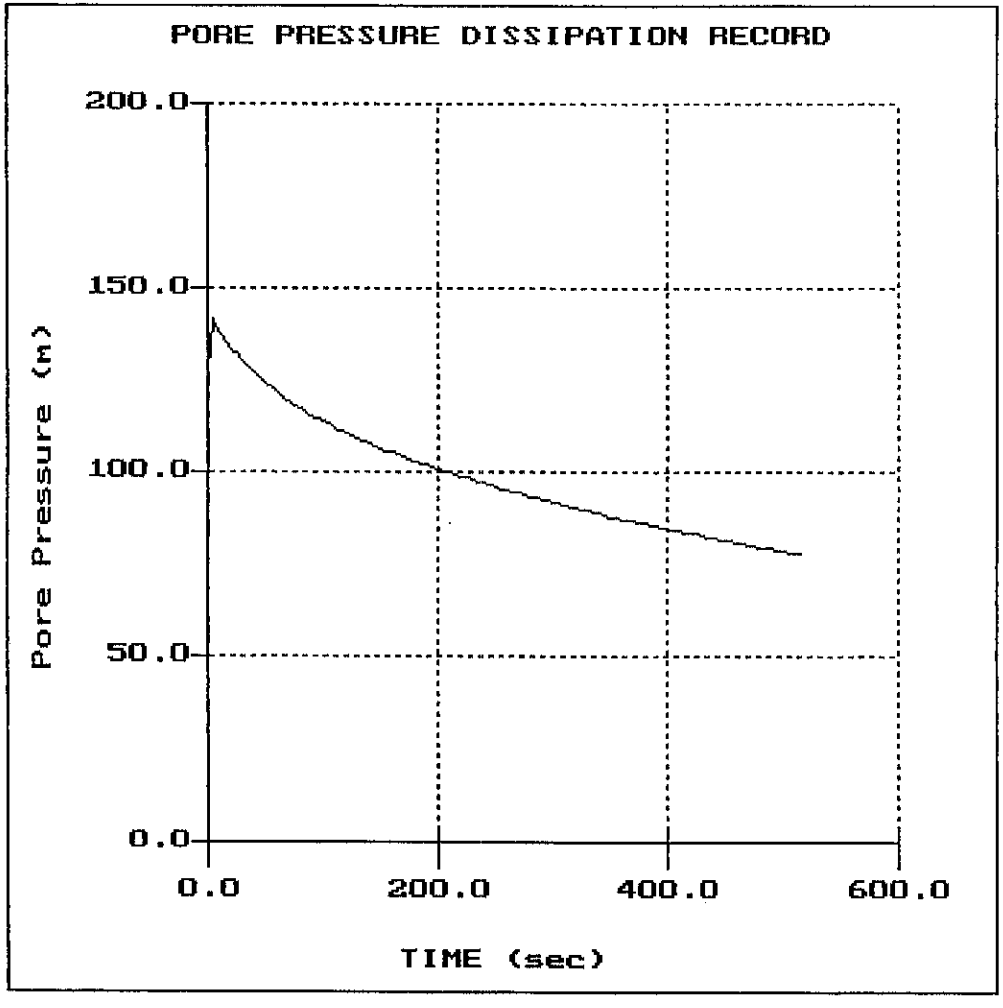


File: 128CP03.PPD
Depth (M): 31.75
(ft): 104.17
Duration : 1960.0s

Klohn Crippen

Hole:CPT02-05(SLW2)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:20:02 12:45



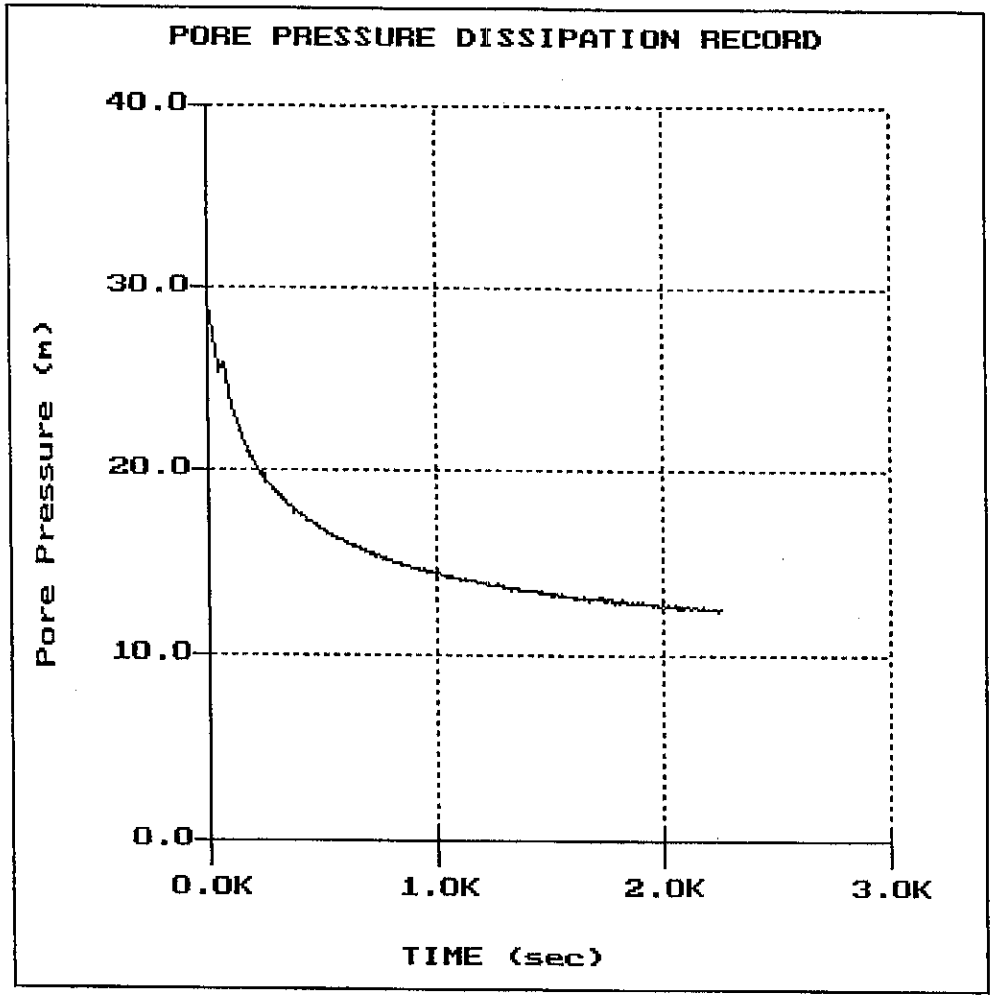
File: 128CP05.PPD
Depth (m): 21.60
(ft): 70.87
Duration : 515.0s
U-min: 77.48 515.0s
U-max: 141.85 5.0s
U-eq.: 17.60
U-50 : 79.73 475.3s
ch : 1.507 cm^2/min
%Ut: 0.52

Plot u-min: 0.00
u-max:200.00
t-min: 0.00
t-max:600.0
# of TicksX: 3
# of TicksY: 4
Rigidity Ir:100.0
Water table: 4.00 m
13.12 ft

Klohn Crippen

Hole:SCPT02-06(SLW3)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:21:02 10:50



File: 128CP06.PPD
Depth (m): 15.90
(ft): 52.17
Duration : 2245.0s
U-min: 12.43 2240.0s
U-max: 28.64 10.0s
U-eq.: 12.40
U-50 : 20.52 193.0s
ch : 3.711 cm^2/min
%Ut: 1.00

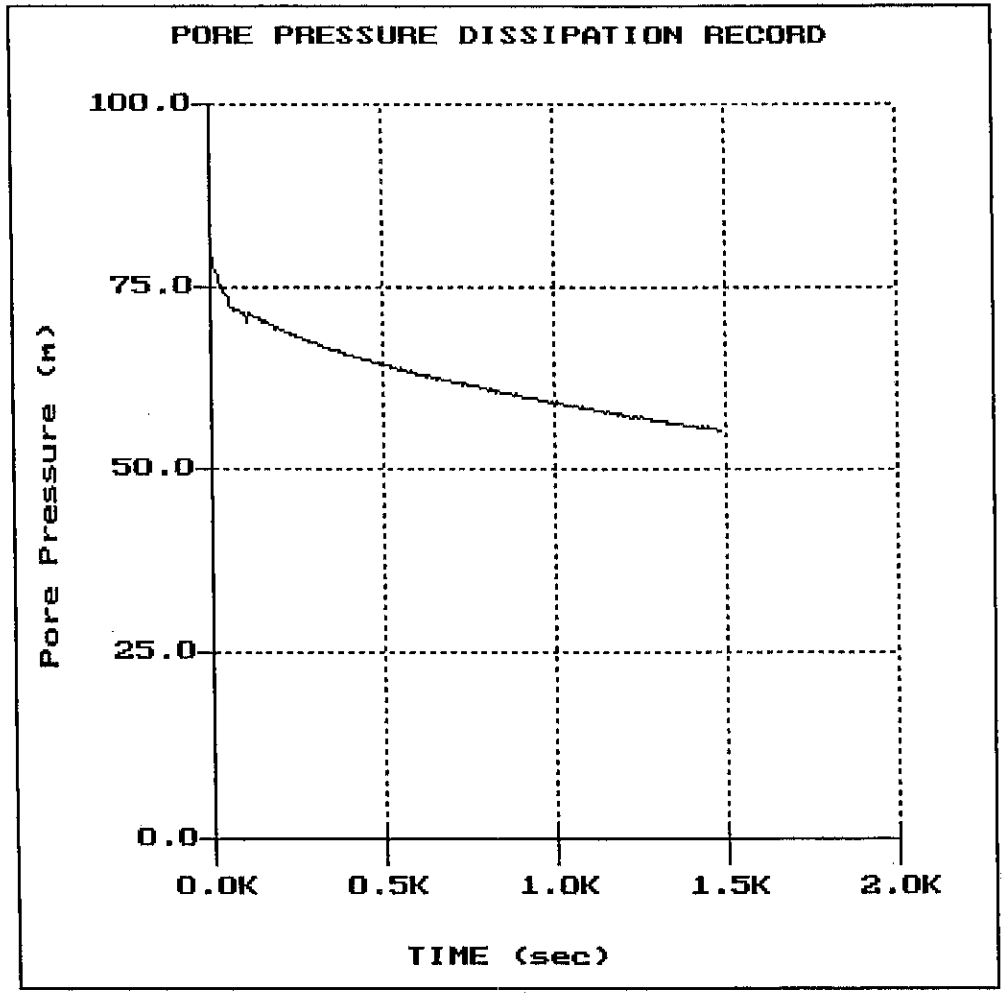
Plot u-min: 0.00
u-max:40.00
t-min: 0.00
t-max:3000.0
# of TicksX: 3
# of TicksY: 4
Rigidity Ir:100.0
Water table: 3.50 m
11.48 ft

Klohn Crippen

Hole:SCPT02-06(SLW3)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:21:02 10:50

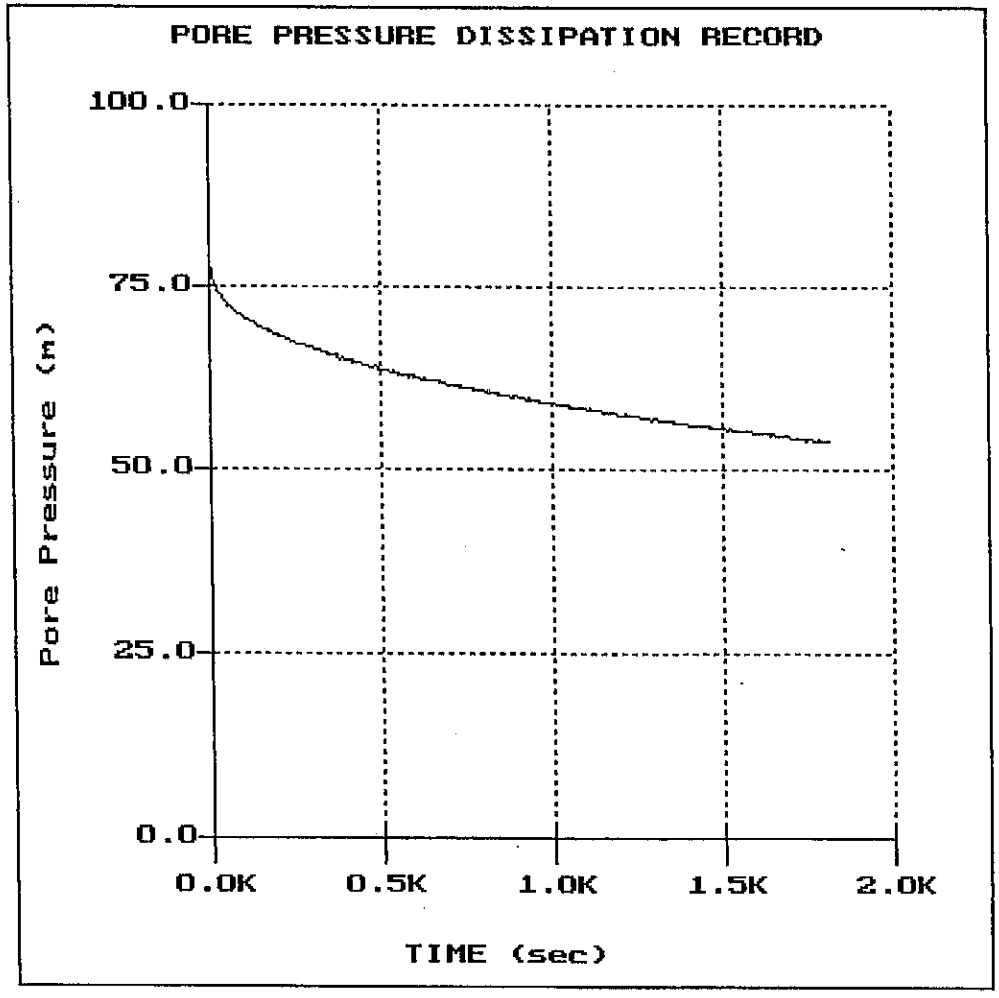
File: 128CP06.PPD
Depth (m): 25.90
(ft): 84.97
Duration : 1485.0s



Klohn Crippen

Hole:CPT02-07(SLW4)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:22:02 09:30



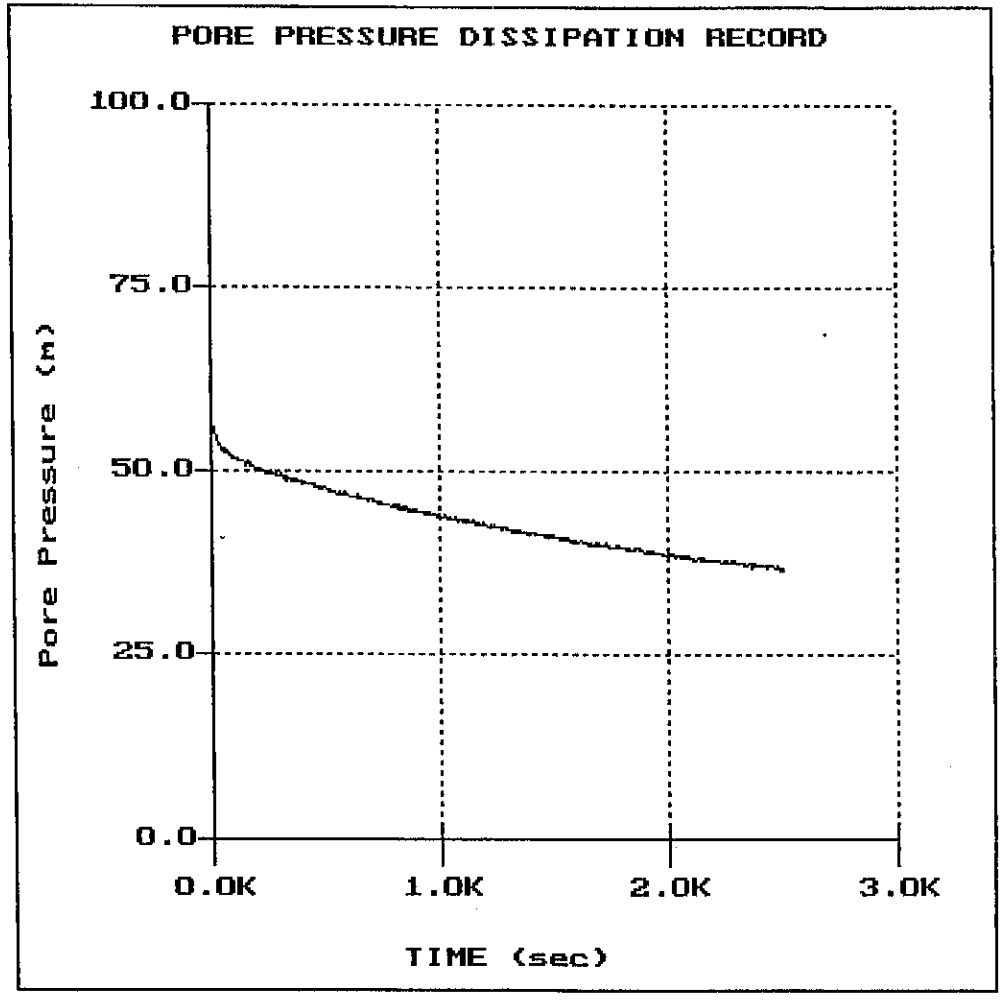
File: 128CP07.PPD
Depth (m): 22.80
(ft): 74.80
Duration : 1815.0s

Klohn Crippen

Hole:CPT02-08(SLW5)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:22:02 13:30

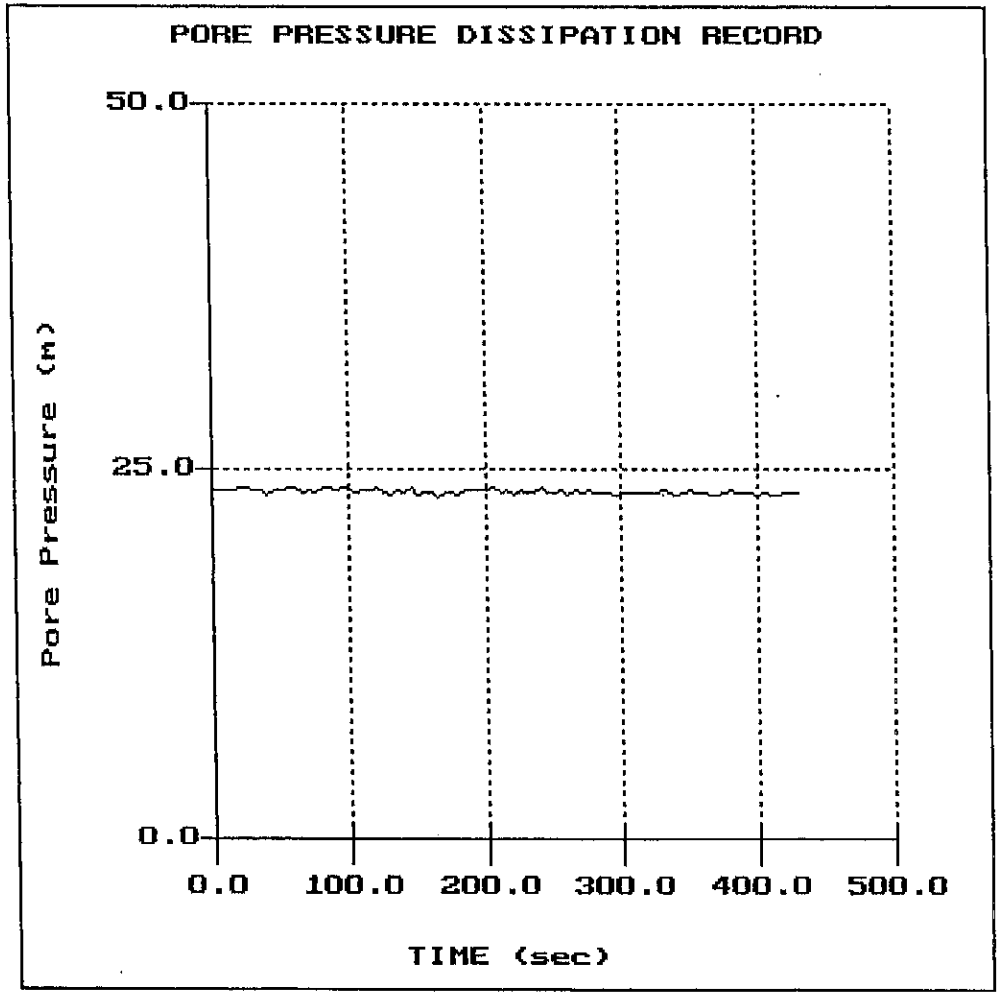
File: 128CP08.PPD
Depth (m): 18.85
(ft): 61.84
Duration : 2500.0s



Klohn Crippen

Hole:CPT02-08(SLW5)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:22:02 13:30

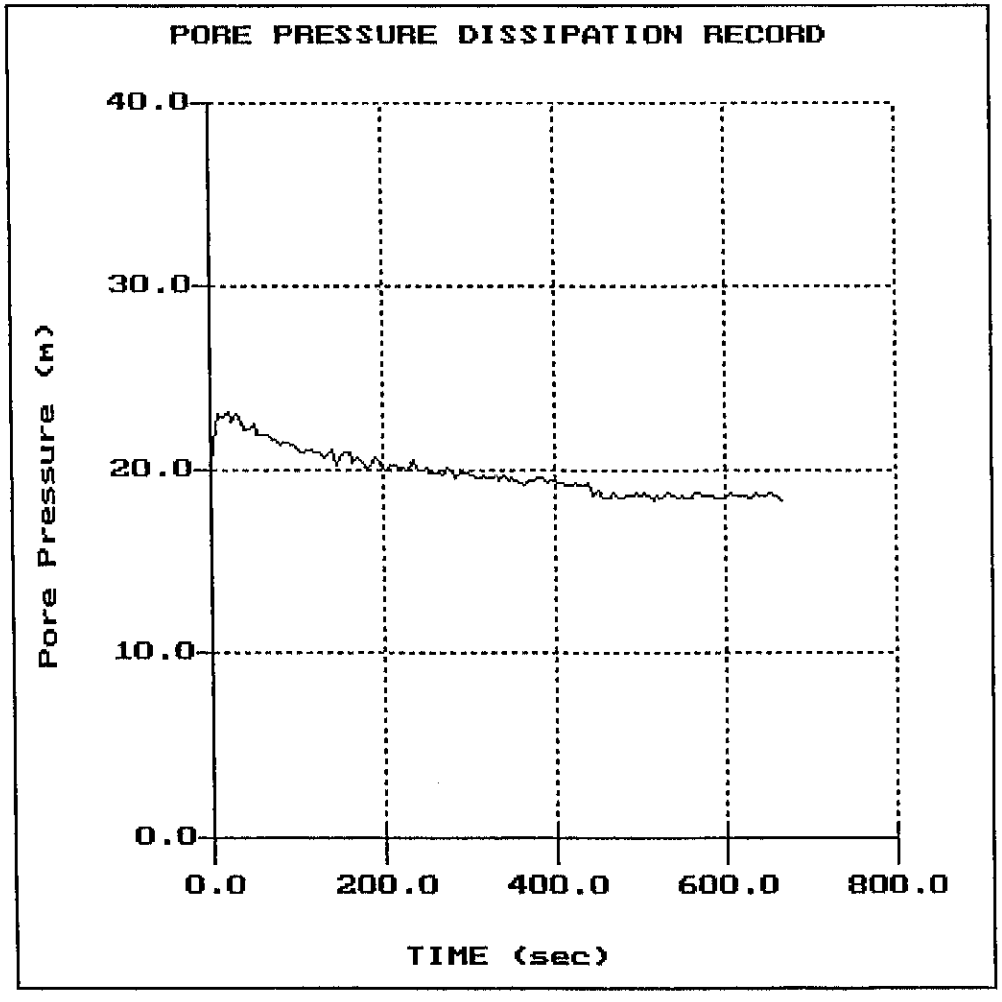


File: 128CP08.PPD
Depth (m): 27.50
(ft): 90.22
Duration : 430.0s

Klohn Crippen

Hole:SCPT02-09(SLW11)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:27:02 10:15



File: 128CP09.PPD
Depth (m): 18.80
(ft): 61.68
Duration : 665.0s
U-min: 18.37 665.0s
U-max: 23.13 20.0s
U-eq.: 15.20
U-50 : 19.16 417.5s
ch : 1.715 cm^2/min
%Ut: 0.60

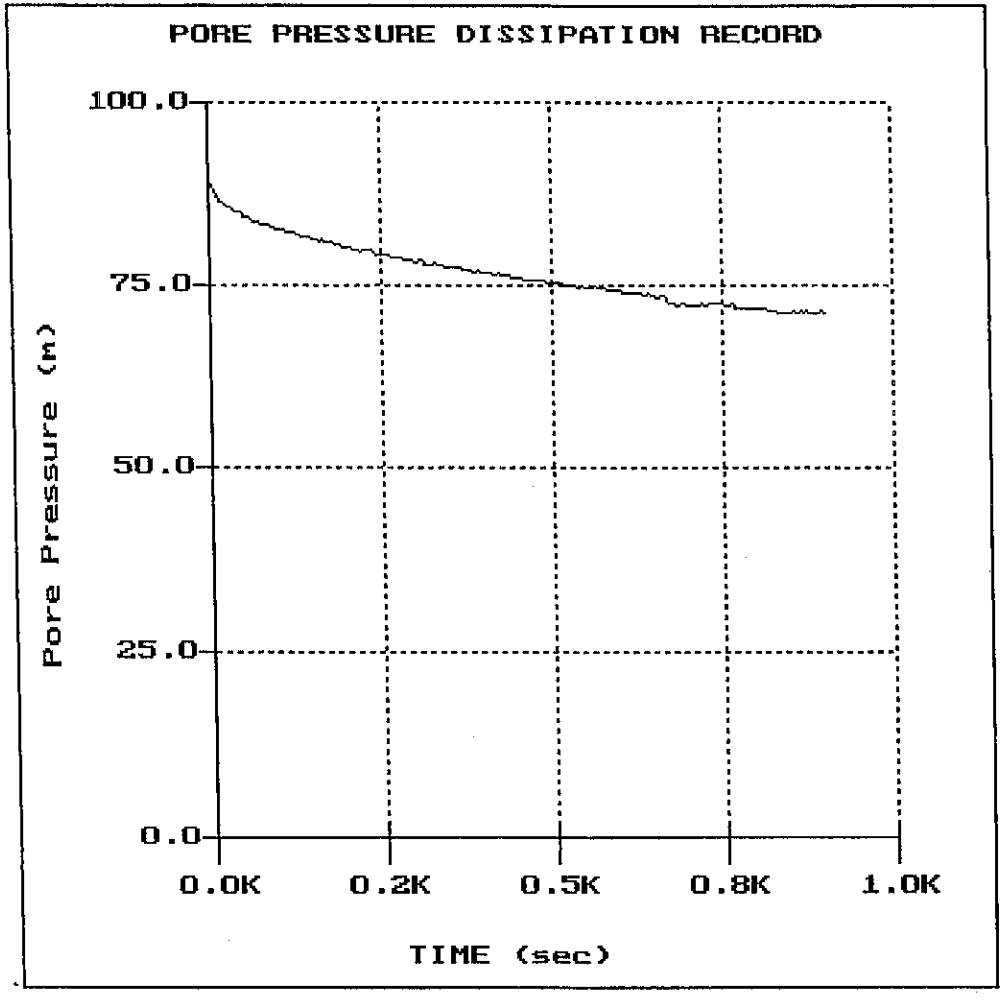
Plot u-min: 0.00
u-max:40.00
t-min: 0.00
t-max:800.0
# of TicksX: 4
# of TicksY: 4
Rigidity Ir:100.0
Water table: 3.60 m
11.81 ft

Klohn Crippen

Hole:SCPT02-09(SLW11)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:27:02 10:15

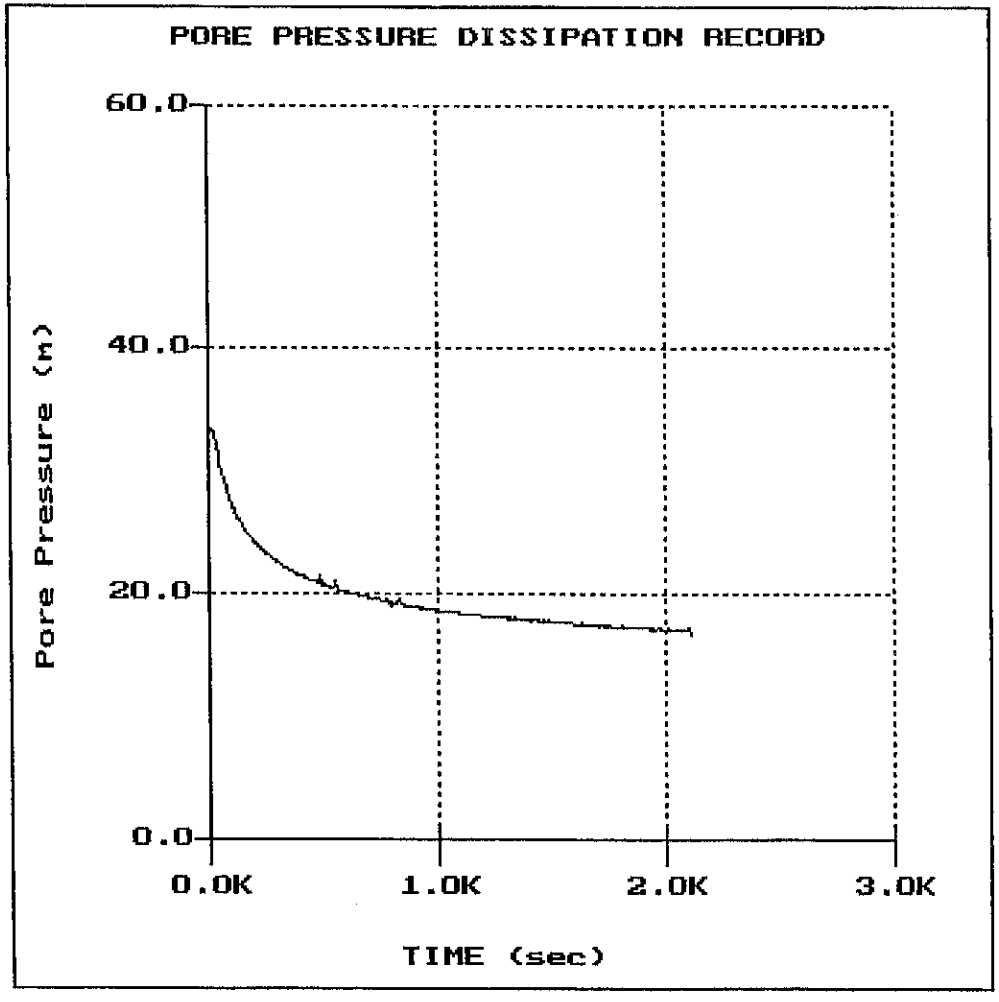
File: 128CP09.PPD
Depth (m): 33.80
(ft): 110.89
Duration : 900.0s



Klohn Crippen

Hole:CPT02-10(SLW12)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:28:02 10:15



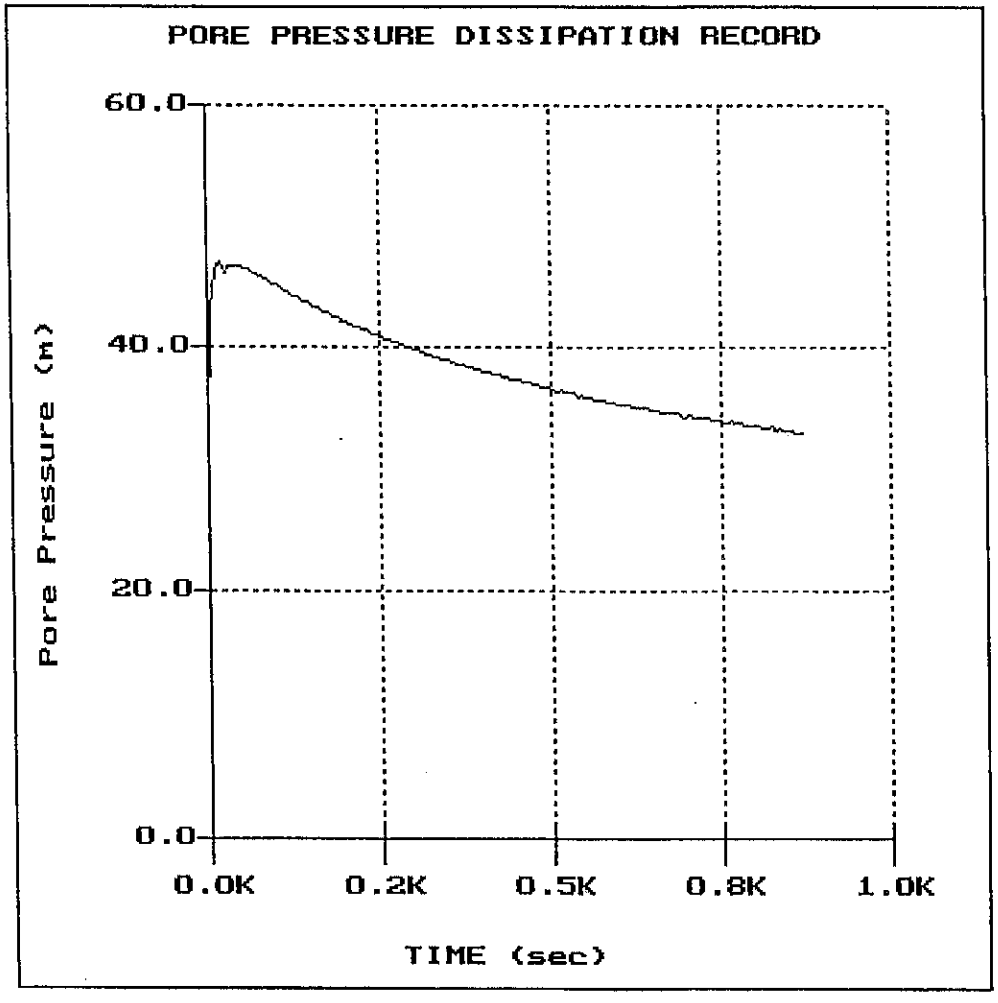
File: 128CP10.PPD
Depth (m): 16.80
(ft): 55.12
Duration : 2100.0s
U-min: 16.76 2100.0s
U-max: 33.27 15.0s
U-eq.: 13.15
U-50 : 23.21 247.8s
ch : 2.890 cm^2/min
%Ut: 0.82

Plot u-min: 0.00
u-max:60.00
t-min: 0.00
t-max:3000.0
# of TicksX: 3
# of TicksY: 3
Rigidity Ir:100.0
Water table: 3.65 m
11.98 ft

Klohn Crippen

Hole:CPT02-10(SLW12)
Location:ESQUIMALT

Cone:20 TON A 094
Date:03:28:02 10:15



File: 128CP10.PPD
Depth (m): 25.05
(ft): 82.19
Duration : 870.0s
U-min: 31.50 0.0s
U-max: 47.09 20.0s
U-eq.: 21.40
U-50 : 34.24 694.8s
ch : 1.031 cm^2/min
%Ut: 0.55

Plot u-min: 0.00
u-max:60.00
t-min: 0.00
t-max:1000.0
# of TicksX: 4
# of TicksY: 3
Rigidity Ir:100.0
Water table: 3.65 m
11.98 ft

Appendix C

Seismic CPT and Downhole Seismic Results

CONETEC

Job No.: 02-128
Client: Klohn Crippen
Project: Esquimalt Graving Dock
Sounding: SCPT02-02 (EGD9)
Date: March 14, 2002

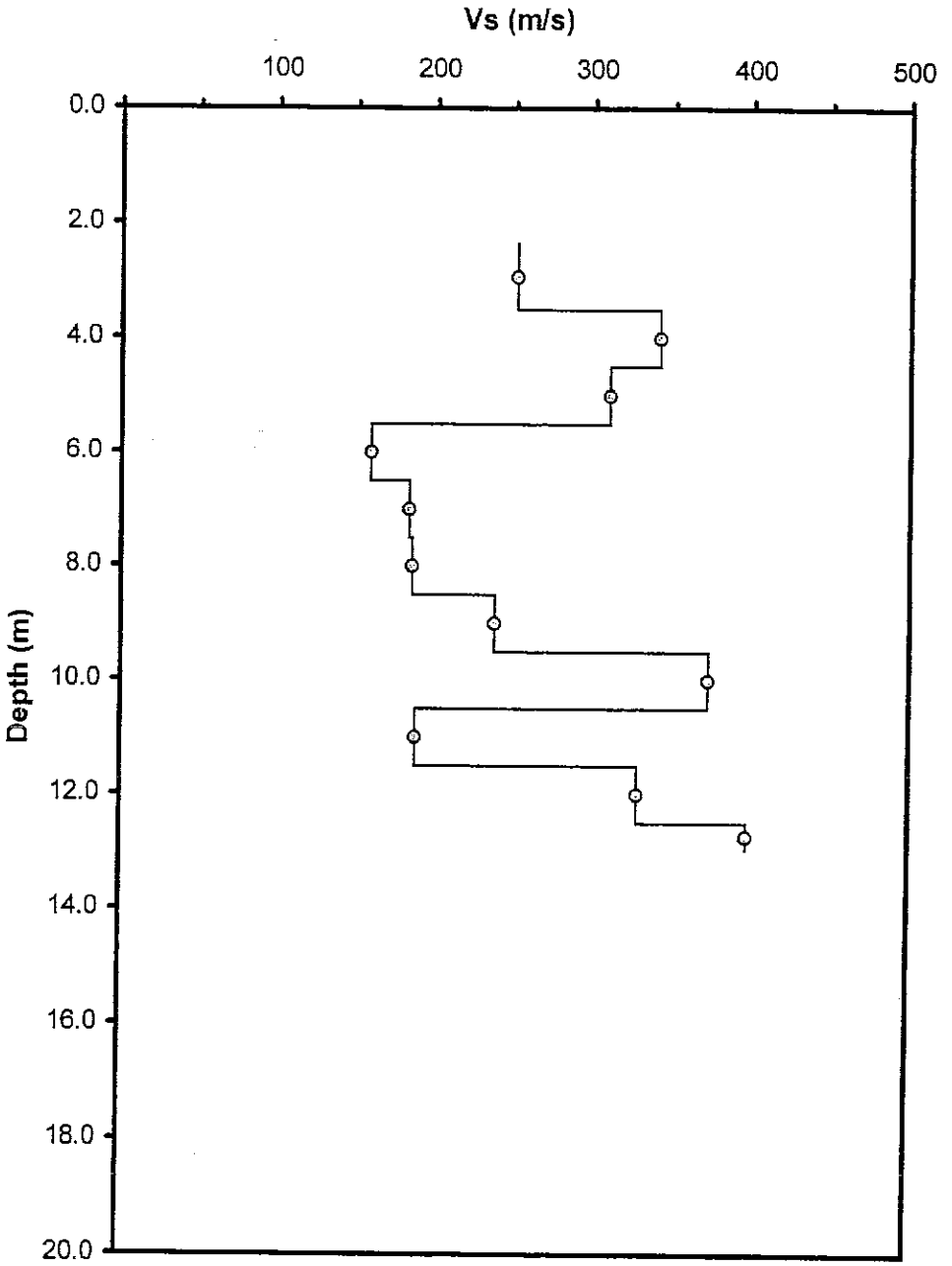
Seismic Source: Auger/Buffalo Gun
Source Offset (m): 1.80
Source Depth (m): 0.30
Geophone Offset (m): 0.20

Seismic

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Depth Interval (m)	Time Interval (ms)	Vs (m/s)	Mid Layer Depth (m)
2.55	2.35	2.73				
3.70	3.50	3.67	0.94	3.76	251	2.93
4.70	4.50	4.57	0.90	2.63	341	4.00
5.70	5.50	5.50	0.93	3.01	310	5.00
6.70	6.50	6.46	0.95	6.00	159	6.00
7.70	7.50	7.42	0.97	5.28	183	7.00
8.70	8.50	8.40	0.97	5.26	185	8.00
9.70	9.50	9.37	0.98	4.13	237	9.00
10.70	10.50	10.36	0.98	2.64	372	10.00
11.70	11.50	11.34	0.99	5.26	187	11.00
12.70	12.50	12.33	0.99	3.01	328	12.00
13.15	12.95	12.78	0.45	1.12	398	12.73

CONETEC

Job No: 02-128
Client: Klohn Crippen
Location: Esquimalt Graving Dock
Sounding: SCPT02-02 (EGD9)
Sounding Date: March 14, 2002



CONETEC

Job No.: 02-128
Client: Klohn Crippen
Project: Esquimalt Graving Dock
Sounding: SCPT02-06 (SLW3)
Date: March 21, 2002

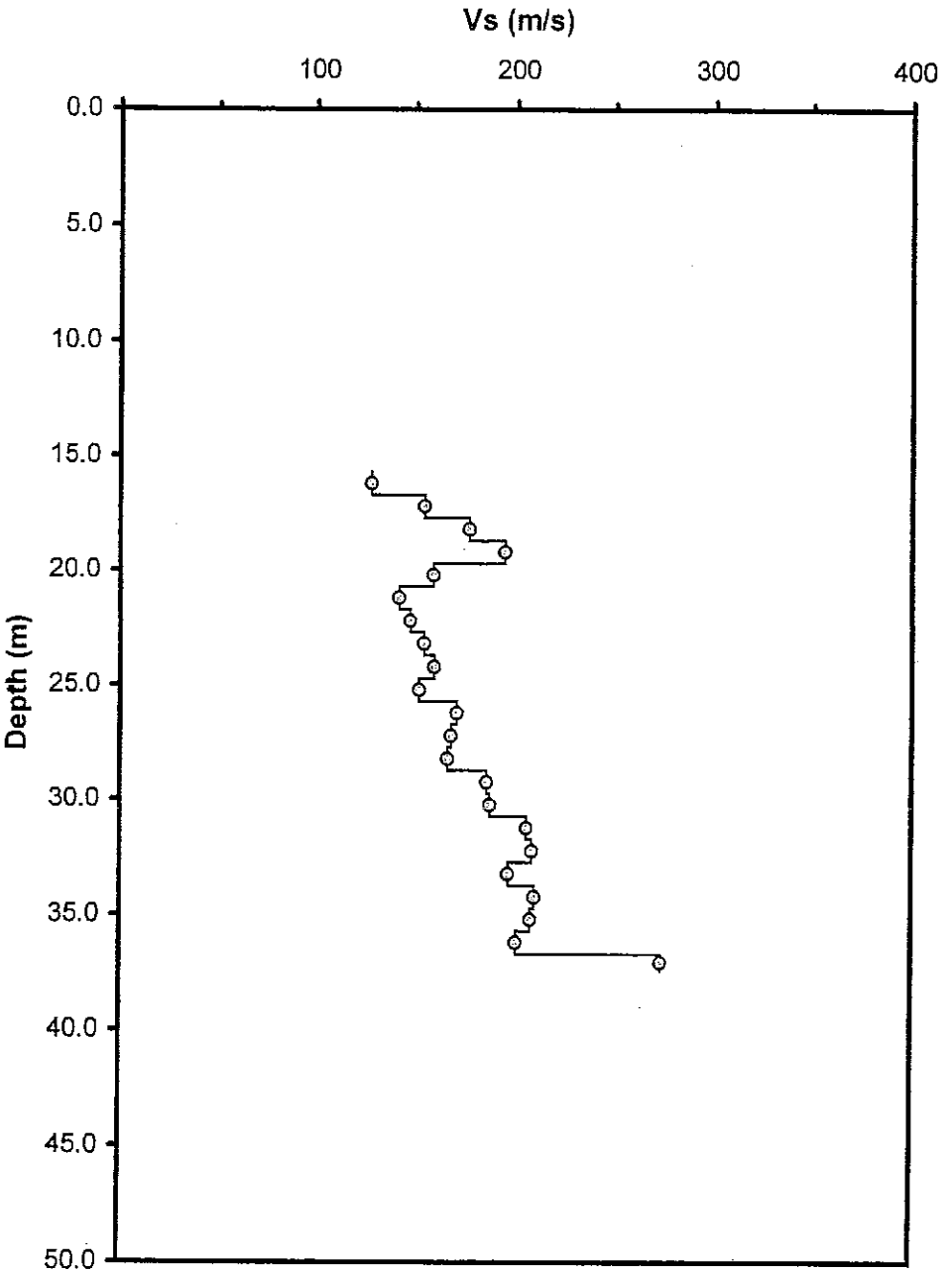
Seismic Source: Seismic Plate Underwater
Source Offset (m): 6.00
Source Depth (m): 12.00
Geophone Offset (m): 0.20

Seismic

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Depth Interval (m)	Time Interval (ms)	Vs (m/s)	Mid Layer Depth (m)
15.90	15.70	7.05				
16.90	16.70	7.62	0.57	4.50	127	16.20
17.90	17.70	8.28	0.65	4.23	155	17.20
18.90	18.70	8.99	0.72	4.06	177	18.20
19.90	19.70	9.76	0.77	3.95	194	19.20
20.90	20.70	10.57	0.81	5.07	159	20.20
21.90	21.70	11.41	0.84	5.92	141	21.20
22.90	22.70	12.27	0.86	5.85	147	22.20
23.90	23.70	13.15	0.88	5.72	154	23.20
24.90	24.70	14.05	0.90	5.63	159	24.20
25.90	25.70	14.96	0.91	5.99	152	25.20
26.90	26.70	15.88	0.92	5.39	171	26.20
27.90	27.70	16.81	0.93	5.54	168	27.20
28.90	28.70	17.75	0.94	5.64	166	28.20
29.90	29.70	18.69	0.94	5.08	186	29.20
30.90	30.70	19.64	0.95	5.07	187	30.20
31.90	31.70	20.59	0.95	4.64	206	31.20
32.90	32.70	21.55	0.96	4.60	208	32.20
33.90	33.70	22.51	0.96	4.90	196	33.20
34.90	34.70	23.48	0.97	4.60	210	34.20
35.90	35.70	24.45	0.97	4.66	208	35.20
36.90	36.70	25.42	0.97	4.84	201	36.20
37.60	37.40	26.10	0.68	2.49	273	37.05

CONETEC

Job No: 02-128
Client: Klohn Crippen
Location: Esquimalt Graving Dock
Sounding: SCPT02-06 (SLW3)
Sounding Date: March 21, 2002



CONETEC

Job No.:	02-128
Client:	Klohn Crippen
Project:	Esquimalt Graving Docks
Sounding:	SCPT 02-09 (SLW11)
Date:	March 27, 2002

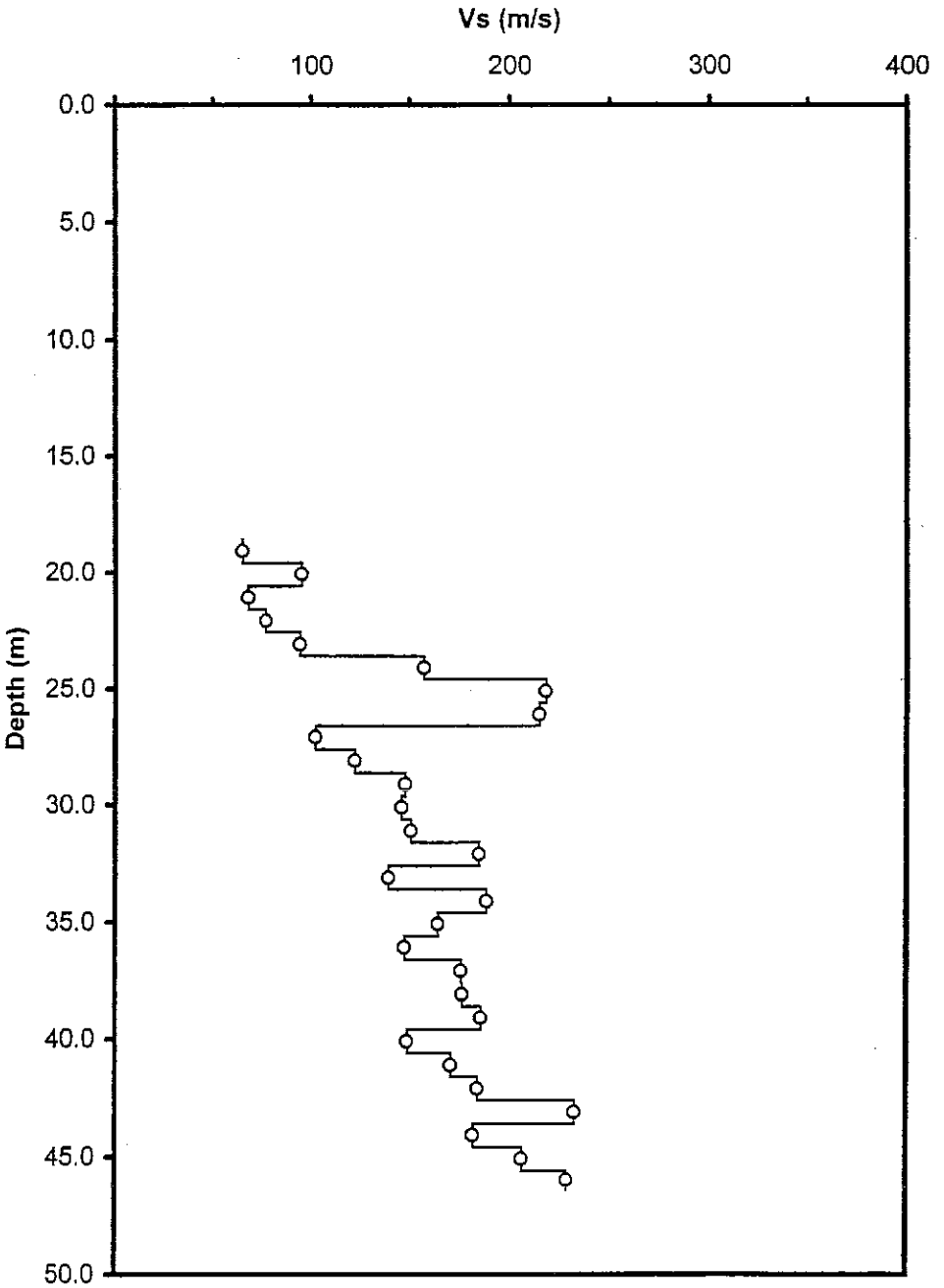
Seismic Source:	Seismic Plate Underwater
Source Offset (m):	5.00
Source Depth (m):	13.50
Geophone Offset (m):	0.20

Seismic

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Depth Interval (m)	Time Interval (ms)	Vs (m/s)	Mid Layer Depth (m)
18.80	18.60	7.14				
19.80	19.60	7.89	0.75	11.44	65	19.10
20.80	20.60	8.68	0.80	8.35	95	20.10
21.80	21.60	9.52	0.84	12.24	68	21.10
22.80	22.60	10.38	0.86	11.21	77	22.10
23.80	23.60	11.27	0.89	9.39	94	23.10
24.80	24.60	12.17	0.90	5.75	157	24.10
25.80	25.60	13.09	0.92	4.21	218	25.10
26.80	26.60	14.02	0.93	4.33	215	26.10
27.80	27.60	14.96	0.94	9.18	102	27.10
28.80	28.60	15.91	0.95	7.74	122	28.10
29.80	29.60	16.86	0.95	6.44	148	29.10
30.80	30.60	17.82	0.96	6.55	146	30.10
31.80	31.60	18.78	0.96	6.38	151	31.10
32.80	32.60	19.74	0.97	5.23	185	32.10
33.80	33.60	20.71	0.97	6.95	139	33.10
34.80	34.60	21.68	0.97	5.15	189	34.10
35.80	35.60	22.66	0.97	5.93	164	35.10
36.80	36.60	23.63	0.98	6.61	148	36.10
37.80	37.60	24.61	0.98	5.56	176	37.10
38.80	38.60	25.59	0.98	5.56	176	38.10
39.80	39.60	26.57	0.98	5.29	186	39.10
40.80	40.60	27.56	0.98	6.60	149	40.10
41.80	41.60	28.54	0.98	5.77	171	41.10
42.80	42.60	29.53	0.99	5.35	184	42.10
43.80	43.60	30.51	0.99	4.23	233	43.10
44.80	44.60	31.50	0.99	5.42	182	44.10
45.80	45.60	32.49	0.99	4.79	206	45.10
46.60	46.40	33.28	0.79	3.45	229	46.00

CONETEC

Job No: 02-128
Client: Klohn Crippen
Location: Esquimalt Graving Docks
Sounding: SCPT 02-09 (SLW11)
Sounding Date: March 27, 2002



CONETEC

Job No.:	02-128
Client:	Klohn Crippen
Project:	Esquimalt Graving Dock
Sounding:	Downhole Seismic
Date:	March 28, 2002

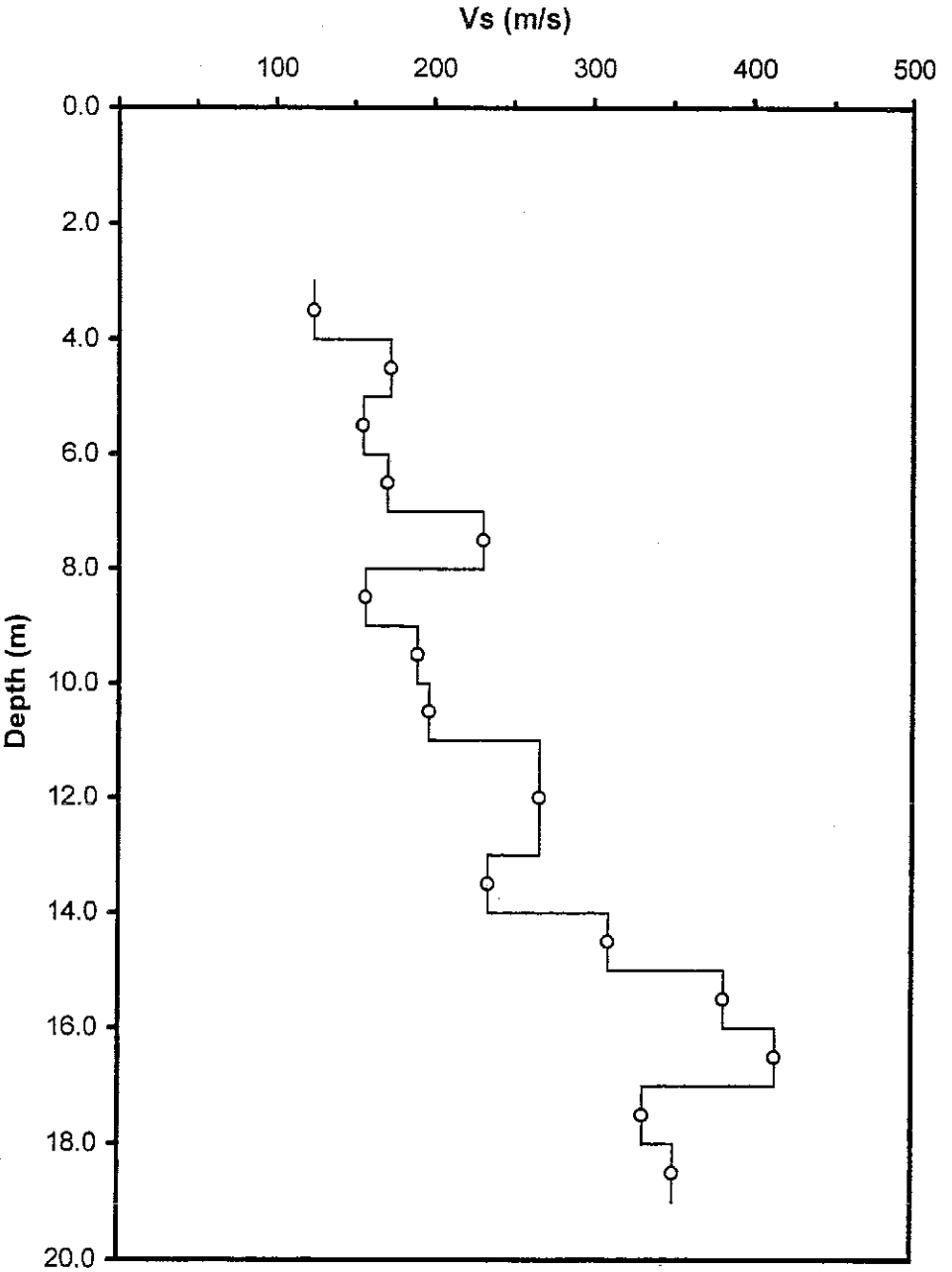
Seismic Source:	Auger
Source Offset (m):	1.80
Source Depth (m):	0.90
Geophone Offset (m):	0.00

Downhole Seismic

Geophone Depth (m)	Ray Path (m)	Depth Interval (m)	Time Interval (ms)	Vs (m/s)	Mid Layer Depth (m)
3.00	2.77				
4.00	3.58	0.82	6.59	124	3.50
5.00	4.48	0.89	5.17	173	4.50
6.00	5.41	0.93	6.00	155	5.50
7.00	6.36	0.95	5.57	171	6.50
8.00	7.32	0.96	4.18	231	7.50
9.00	8.30	0.97	6.20	157	8.50
10.00	9.28	0.98	5.16	190	9.50
11.00	10.26	0.98	5.00	197	10.50
13.00	12.23	1.97	7.40	267	12.00
14.00	13.22	0.99	4.23	234	13.50
15.00	14.21	0.99	3.20	310	14.50
16.00	15.21	0.99	2.60	382	15.50
17.00	16.20	0.99	2.40	414	16.50
18.00	17.19	0.99	3.00	331	17.50
19.00	18.19	0.99	2.84	350	18.50

CONETEC

Job No: 02-128
Client: Klohn Crippen
Location: Esquimalt Graving Dock
Sounding: Downhole Seismic
Sounding Date: March 28, 2002



Appendix D

Field Vane Test Results

CONETEC

ConeTec Investigations Ltd.

Project No: 02-128
Client: Klohn Crippen
Site: Esquimalt Graving Dock
Date: March 14, 2002 - April 2, 2002

Field Vane Test Results

Vane Constants - C		Tourque Head Spring Constant - K:	0.975
Small Vane	0.20		
Medium Vane	0.10		
Large Vane	0.05		

Su (kPa) = 98.1 * K*c*a

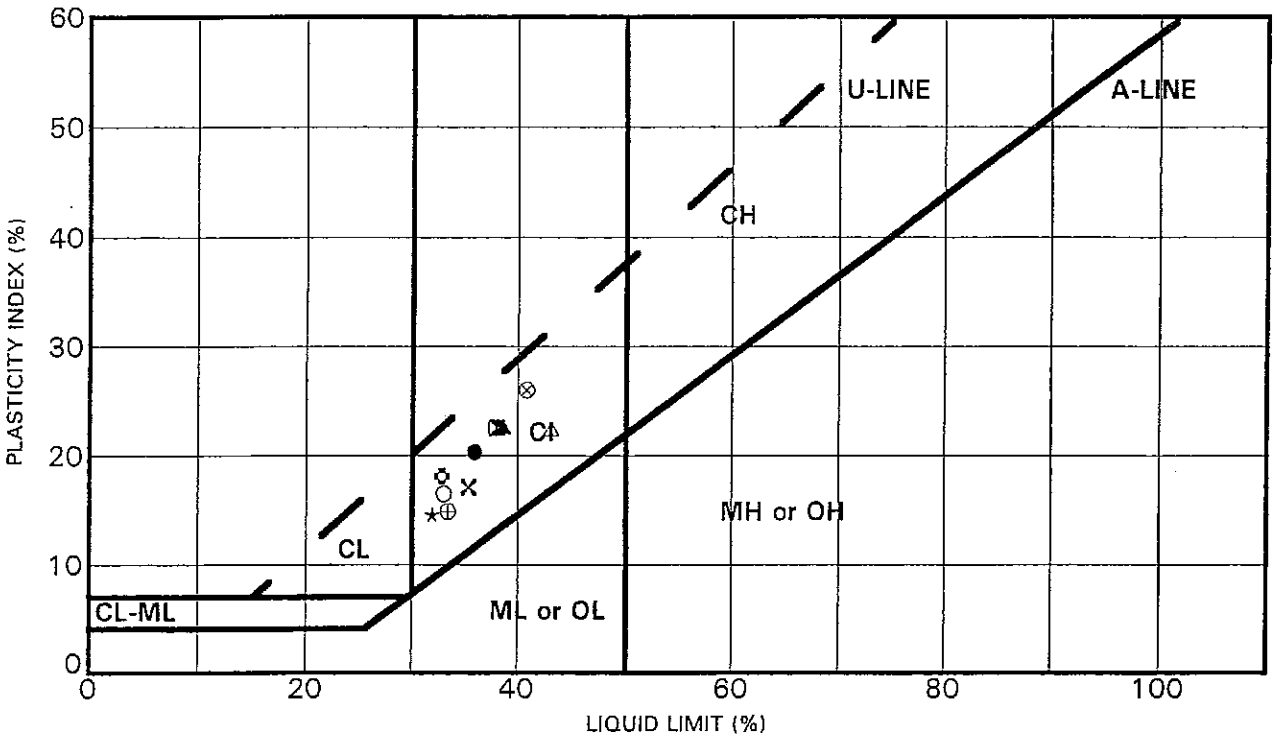
Where: K is Torque Head Spring Constant
C is Vane Constant
A is distance (cm) on vane disk between peak and friction readings

Adjacent Sounding	Test Depth (m)	Test Date	Vane Used	Vane Constant	Peak a (cm)	Residual a (cm)	Remolded a (cm)	Su (kPa) Peak	Su (kPa) Residual	Su (kPa) Remolded
DH 02-01	7.0	15-Mar-02	Medium	0.10	5.10	2.30	1.25	48.8	22.0	12.0
	9.7	15-Mar-02	Medium	0.10	10.00	2.40	0.80	95.6	23.0	7.7
DH 02-02	16.3	25-Mar-02	Medium	0.10	1.45	0.70	0.40	13.9	6.7	3.8
	17.2	25-Mar-02	Medium	0.10	1.40	0.70	0.45	13.4	6.7	4.3
	17.6	25-Mar-02	Medium	0.10	1.75	0.95	0.50	16.7	9.1	4.8
	18.0	25-Mar-02	Medium	0.10	1.35	0.60	0.45	12.9	5.7	4.3
	19.0	25-Mar-02	Medium	0.10	2.10	0.70	0.40	20.1	6.7	3.8
	20.0	25-Mar-02	Medium	0.10	2.80	1.00	0.60	26.8	9.6	5.7
	24.4	25-Mar-02	Medium	0.10	3.00	2.35	1.70	28.7	22.5	16.3
	24.9	25-Mar-02	Medium	0.10	>10.10	-	-	>96.6	-	-
	25.1	25-Mar-02	Medium	0.10	>10.10	-	-	>96.6	-	-
DH 02-04	15.1	1-Apr-02	Medium	0.10	5.40	1.50	0.95	51.6	14.3	9.1
	16.2	1-Apr-02	Medium	0.10	4.60	1.60	0.90	44.0	15.3	8.6
	17.2	1-Apr-02	Medium	0.10	7.35	4.20	2.45	70.3	40.2	23.4
	18.2	2-Apr-02	Small	0.20	2.95	2.00	1.85	56.4	38.3	35.4
	19.2	2-Apr-02	Small	0.20	3.55	2.30	1.90	67.9	44.0	36.3
	20.2	2-Apr-02	Small	0.20	3.20	2.15	1.95	61.2	41.1	37.3
	21.2	2-Apr-02	Small	0.20	4.80	3.10	2.95	91.8	59.3	56.4
	22.2	2-Apr-02	Small	0.20	3.55	2.80	2.60	67.9	53.6	49.7
	23.2	2-Apr-02	Small	0.20	4.10	2.95	2.75	78.4	56.4	52.6
	24.2	2-Apr-02	Small	0.20	6.15	3.30	3.20	117.6	63.1	61.2

APPENDIX III

Laboratory Test Results

PLASTICITY CHART

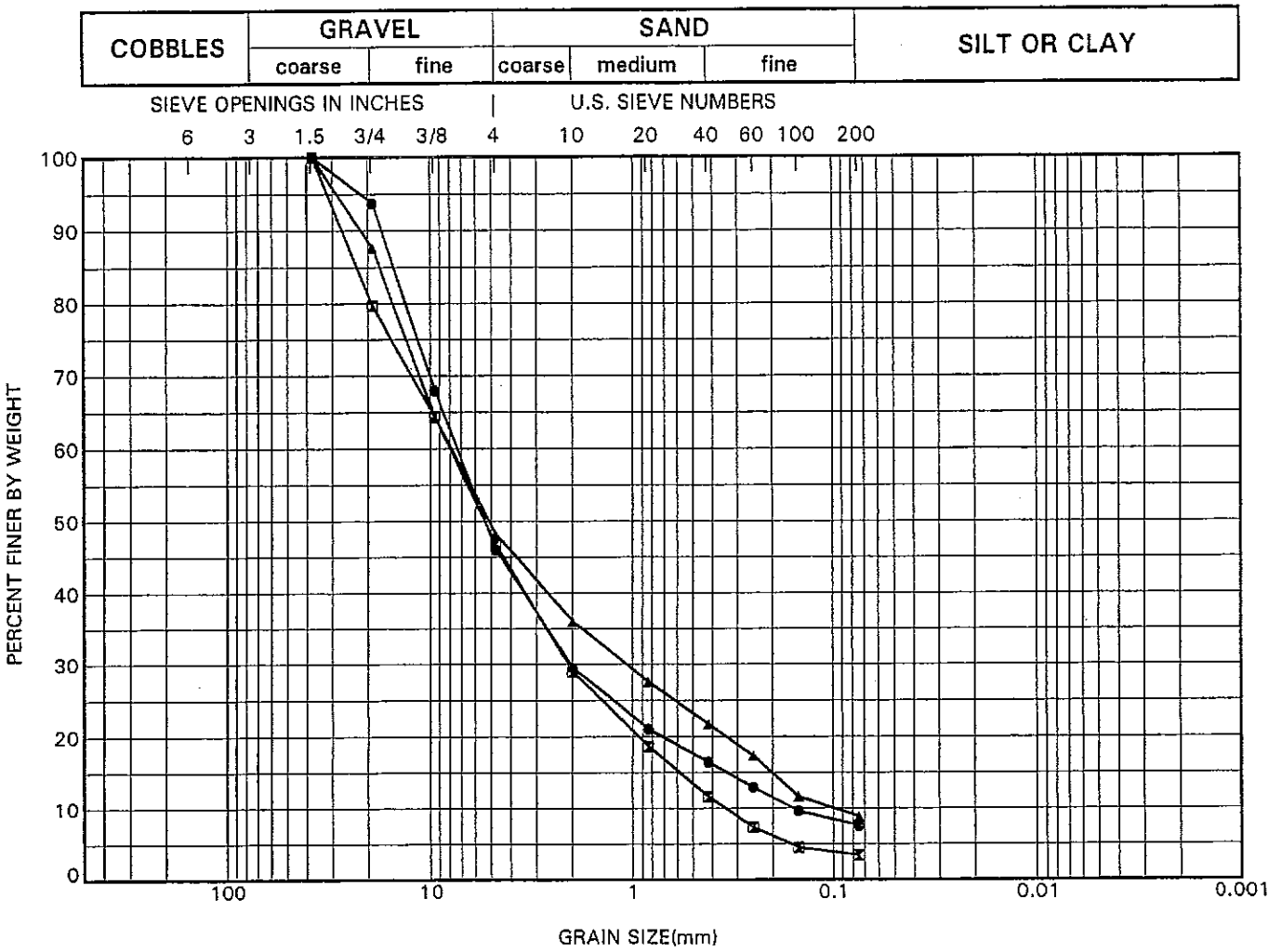


	HOLE	SAMPLE	DEPTH(m)	%W	W_L	W_P	PI	% FINES	REMARKS
●	BOC02-05		16.75	30.9	36	16	20	87.1	Grab 12
⊠	BOC02-05		21.80	38.8	38	16	23	95.4	Grab 15
▲	BOC02-05		31.10	32.2	39	16	23	97.9	Grab 20
★	BOC02-06		9.00	22.4	32	17	15	76.9	Grab 5
✕	BOC02-06		16.00	31.0	35	18	17	85.2	Grab 11
✿	BOC02-08		4.10	29.4	33	15	18	83.3	Grab 3
○	BOC02-08		12.05	18.1	33	17	17	4.9	Grab 10
△	BOC02-08		15.70	36.1	43	21	22	99.0	Grab 13
⊗	BOC02-09		25.50	32.0	41	15	26	95.3	SPT 24
⊕	DH02-01		8.85	18.5	33	19	15	82.2	Shelby 7 (Puddle clay)

KLOHN CRIPPEN

PROJECT NO.:	PG 9060 01
PROJECT:	PWGSC Esquimalt EGD and SLW
LOCATION:	Esquimalt, BC
FIGURE:	
DRAWN BY:	Juan CHECKED BY: PT

GRAIN SIZE DISTRIBUTION



	HOLE/SAMPLE	Depth(m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	BOC02-01	2.45	15.100	7.414	5.402	0.341	0.159	46.7	54.0	38.5	7.5
⊠	BOC02-04	6.25	22.830	8.037	5.421	0.588	0.346	23.2	53.3	43.3	3.4
▲	BOC02-04	13.25	17.670	7.911	5.144	0.203	0.101	78.6	51.8	39.4	8.8

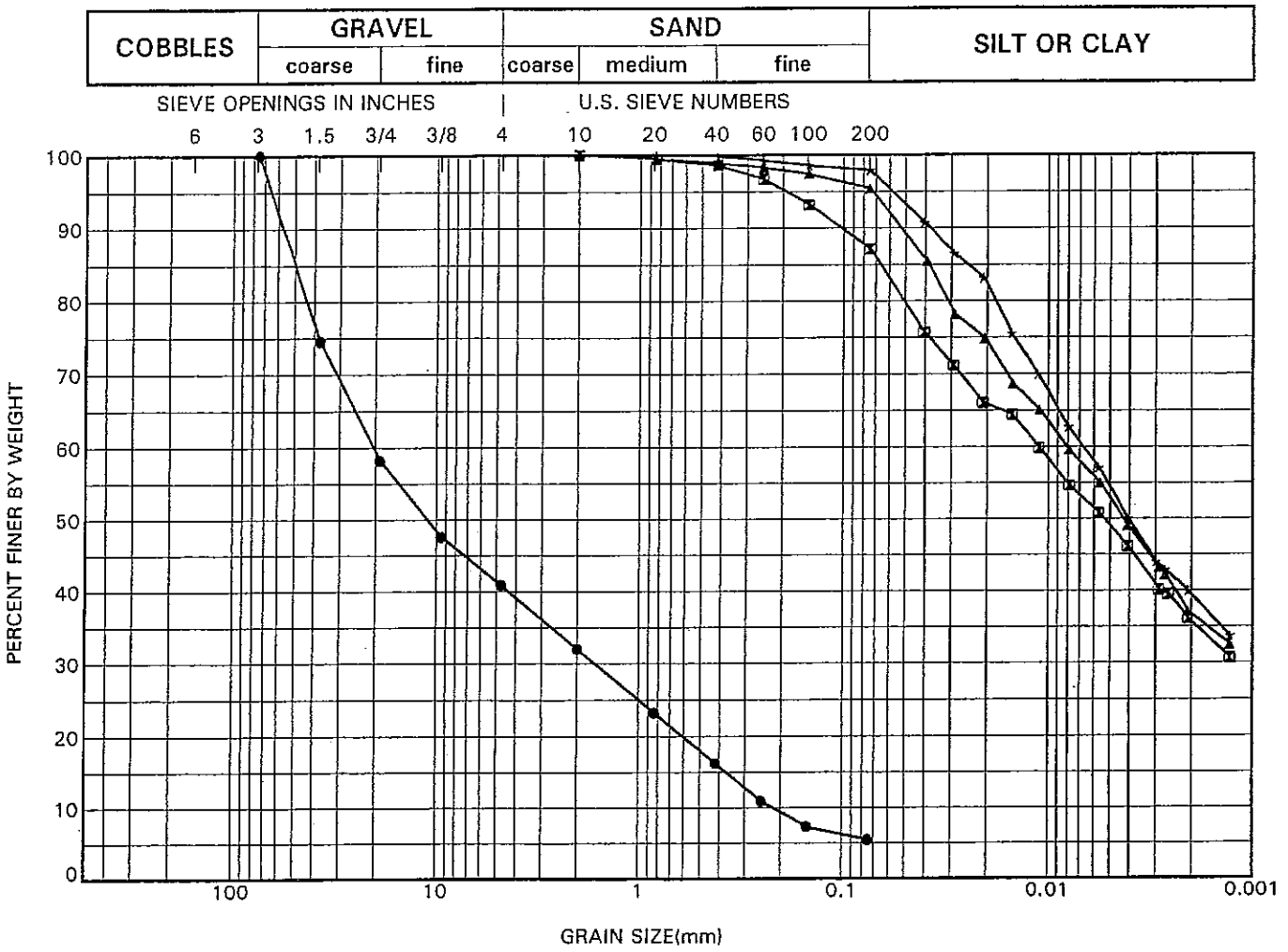
	HOLE/SAMPLE	Depth(m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	BOC02-01	2.45	3.4				Grab 2
⊠	BOC02-04	6.25	10.4				Grab 3
▲	BOC02-04	13.25	9.8				Grab 10

CU = Coefficient of Uniformity = D60/D10 Particle Sizes, e.g. D85, in mm Mechanical sieving(ASTM D422) after wash & dry(D1140) or hydrometer(D422)

KLOHN CRIPPEN

PROJECT NO.:	PG 9060 01
PROJECT:	PWGSC Esquimalt EGD and SLW
LOCATION:	Esquimalt, BC
FIGURE:	
DRAWN BY:	Juan CHECKED BY: DT

GRAIN SIZE DISTRIBUTION



	HOLE/SAMPLE	Depth(m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	BOC02-05	7.00	49.890	20.580	11.150	0.374	0.220	93.7	59.1	35.5	5.4
⊠	BOC02-05	16.75	0.067	0.011	0.005				0.0	12.9	87.1
▲	BOC02-05	21.80	0.039	0.008	0.004				0.0	4.6	95.4
★	BOC02-05	31.10	0.025	0.007	0.004				0.0	2.1	97.9

	HOLE/SAMPLE	Depth(m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	BOC02-05	7.00	6.8				Grab 2
⊠	BOC02-05	16.75	30.9	36	16	20	Grab 12
▲	BOC02-05	21.80	38.8	38	16	23	Grab 15
★	BOC02-05	31.10	32.2	39	16	23	Grab 20

CU = Coefficient of Uniformity = D60/D10 Particle Sizes, e.g. D85, in mm Mechanical sieving(ASTM D422) after wash & dry(D1140) or hydrometer(D422)

KLOHN CRIPPEN

PROJECT NO.: PG 9060 01

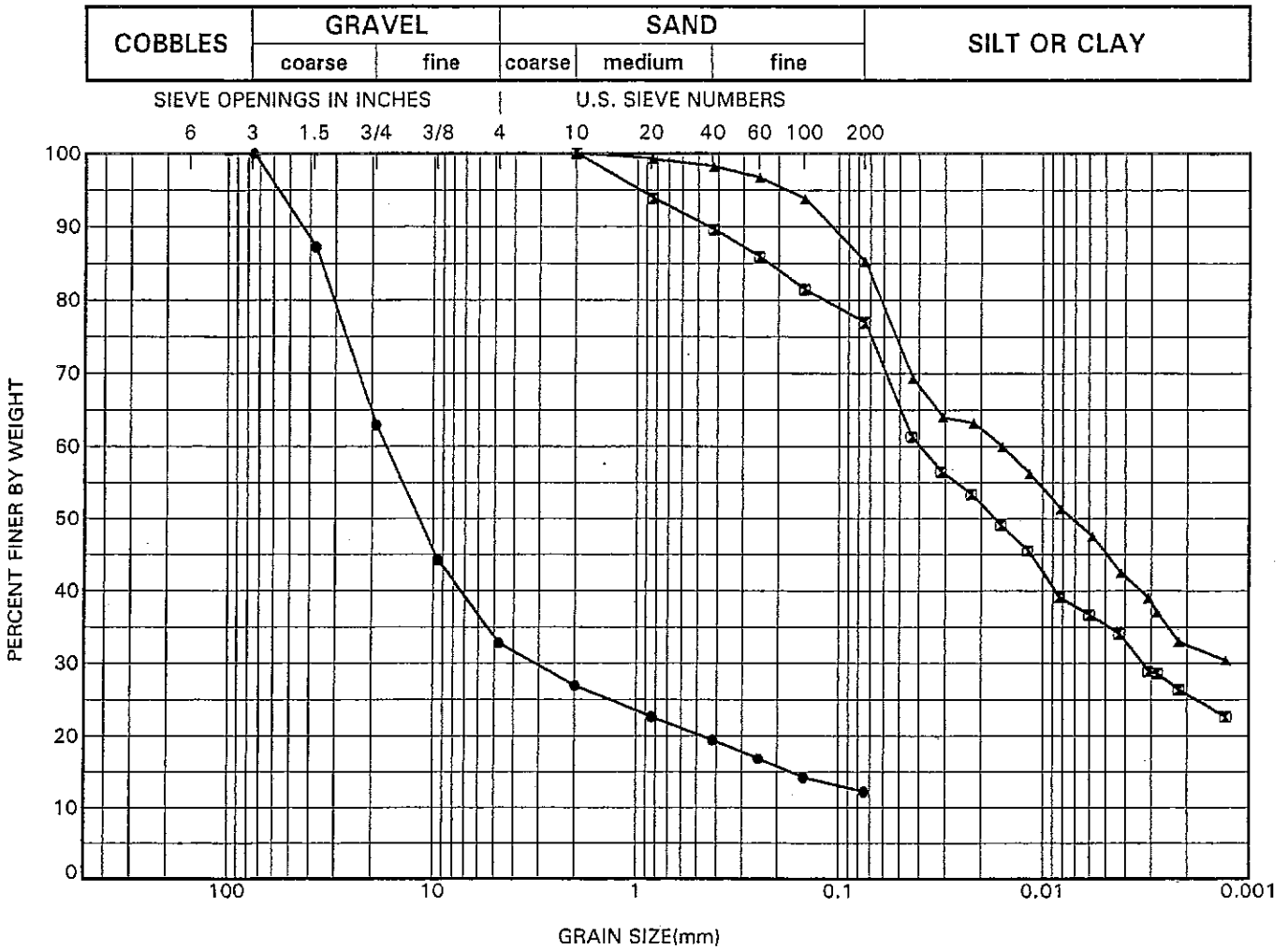
PROJECT: PWGSC Esquimalt EGD and SLW

LOCATION: Esquimalt, BC

FIGURE:

DRAWN BY: Juan CHECKED BY: DT

GRAIN SIZE DISTRIBUTION



	HOLE/SAMPLE	Depth(m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	BOC02-06	5.95	35.280	17.150	11.810	0.175		244.9	67.2	20.6	12.2
⊠	BOC02-06	9.00	0.225	0.040	0.017				0.0	23.1	76.9
▲	BOC02-06	16.00	0.075	0.016	0.007				0.0	14.8	85.2

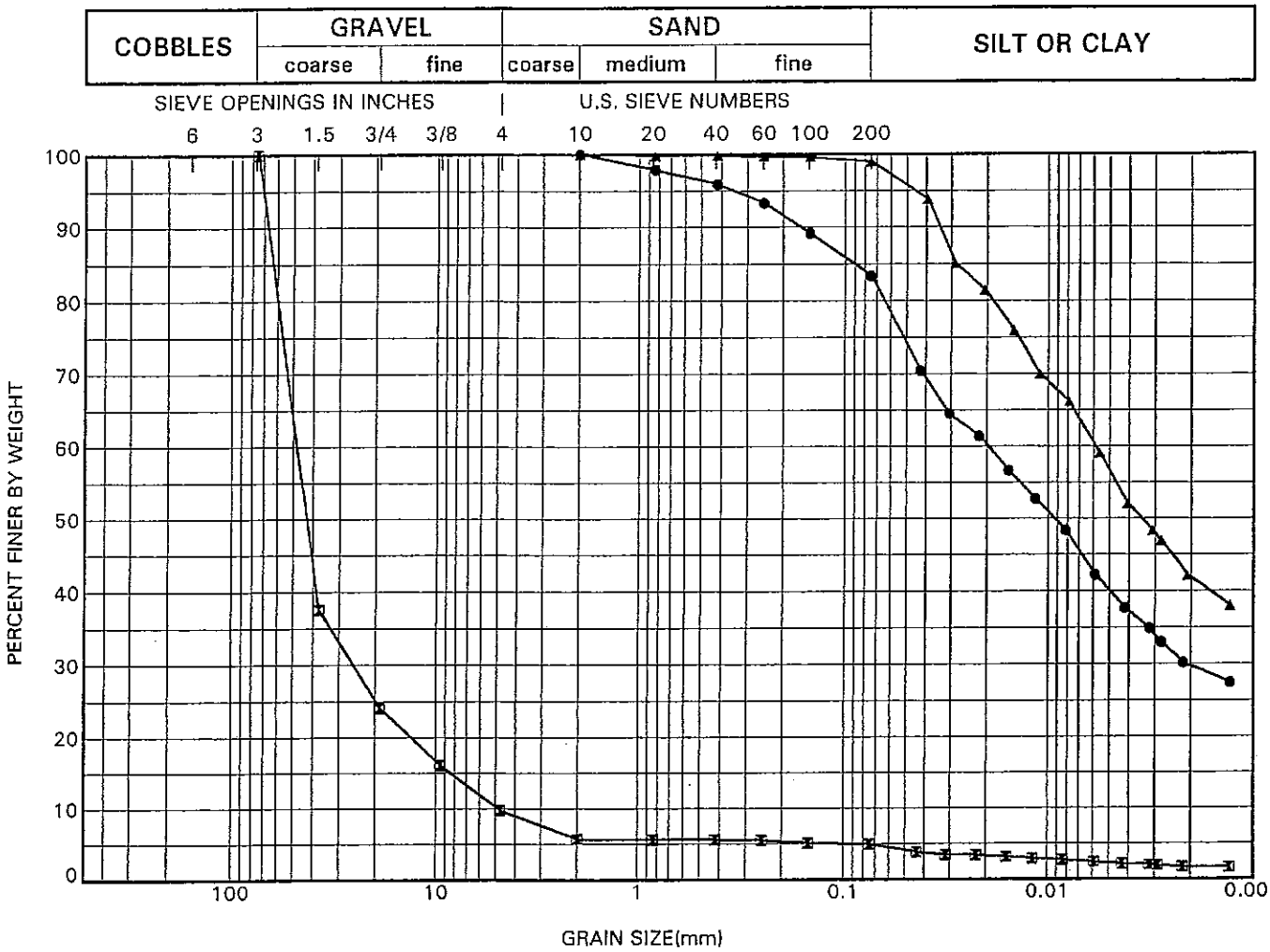
	HOLE/SAMPLE	Depth(m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	BOC02-06	5.95	8.8				Grab 3
⊠	BOC02-06	9.00	22.4	32	17	15	Grab 5
▲	BOC02-06	16.00	31.0	35	18	17	Grab 11

CU = Coefficient of Uniformity = D60/D10 Particle Sizes, e.g. D85, in mm Mechanical sieving(ASTM D422) after wash & dry(D1140) or hydrometer(D422)

KLOHN CRIPPEN

PROJECT NO.: PG 9060 01
PROJECT: PWGSC Esquimalt EGD and SLW
LOCATION: Esquimalt, BC
FIGURE:
DRAWN BY: Juan CHECKED BY: DT

GRAIN SIZE DISTRIBUTION



	HOLE/SAMPLE	Depth(m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	BOC02-08	4.10	0.092	0.020	0.009				0.0	16.7	83.3
⊠	BOC02-08	12.05	63.490	48.090	43.040	8.451	4.917	9.8	90.3	4.8	4.9
▲	BOC02-08	15.70	0.029	0.006	0.004				0.0	1.0	99.0

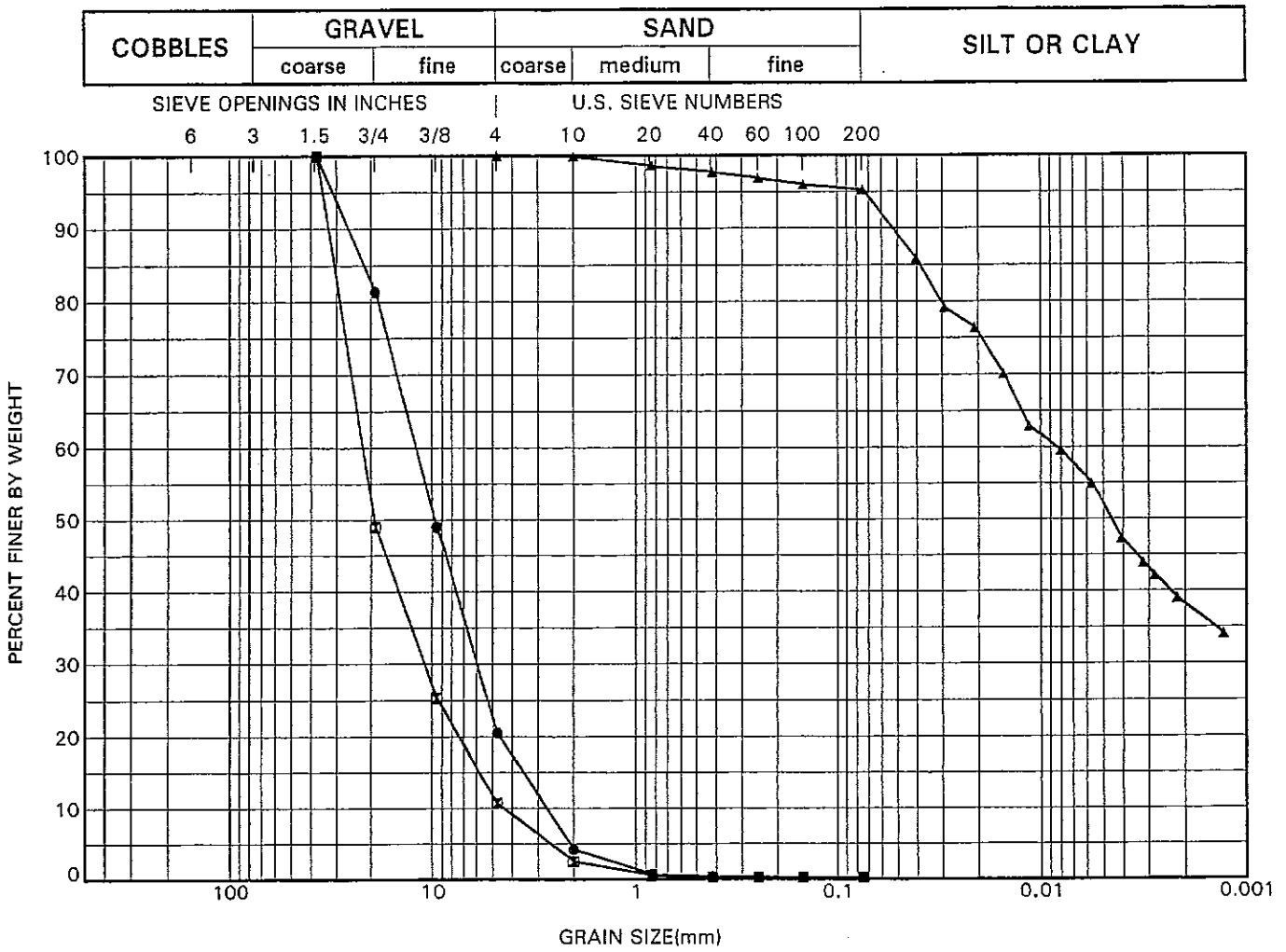
	HOLE/SAMPLE	Depth(m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	BOC02-08	4.10	29.4	33	15	18	Grab 3
⊠	BOC02-08	12.05	18.1	33	17	17	Grab 10
▲	BOC02-08	15.70	36.1	43	21	22	Grab 13

CU = Coefficient of Uniformity = D60/D10 Particle Sizes, e.g. D85, in mm Mechanical sieving(ASTM D422) after wash & dry(D1140) or hydrometer(D422)

KLOHN CRIPPEN

PROJECT NO.:	PG 9060 01
PROJECT:	PWGSC Esquimalt EGD and SLW
LOCATION:	Esquimalt, BC
FIGURE:	
DRAWN BY:	Juan CHECKED BY:

GRAIN SIZE DISTRIBUTION



	HOLE/SAMPLE	Depth(m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	BOC02-09	6.00	21.830	12.070	9.727	3.553	2.723	4.4	79.5	20.3	0.2
⊠	BOC02-09	13.85	30.750	22.090	19.350	5.838	4.420	5.0	89.3	10.5	0.2
▲	BOC02-09	25.50	0.039	0.008	0.005				0.0	4.7	95.3

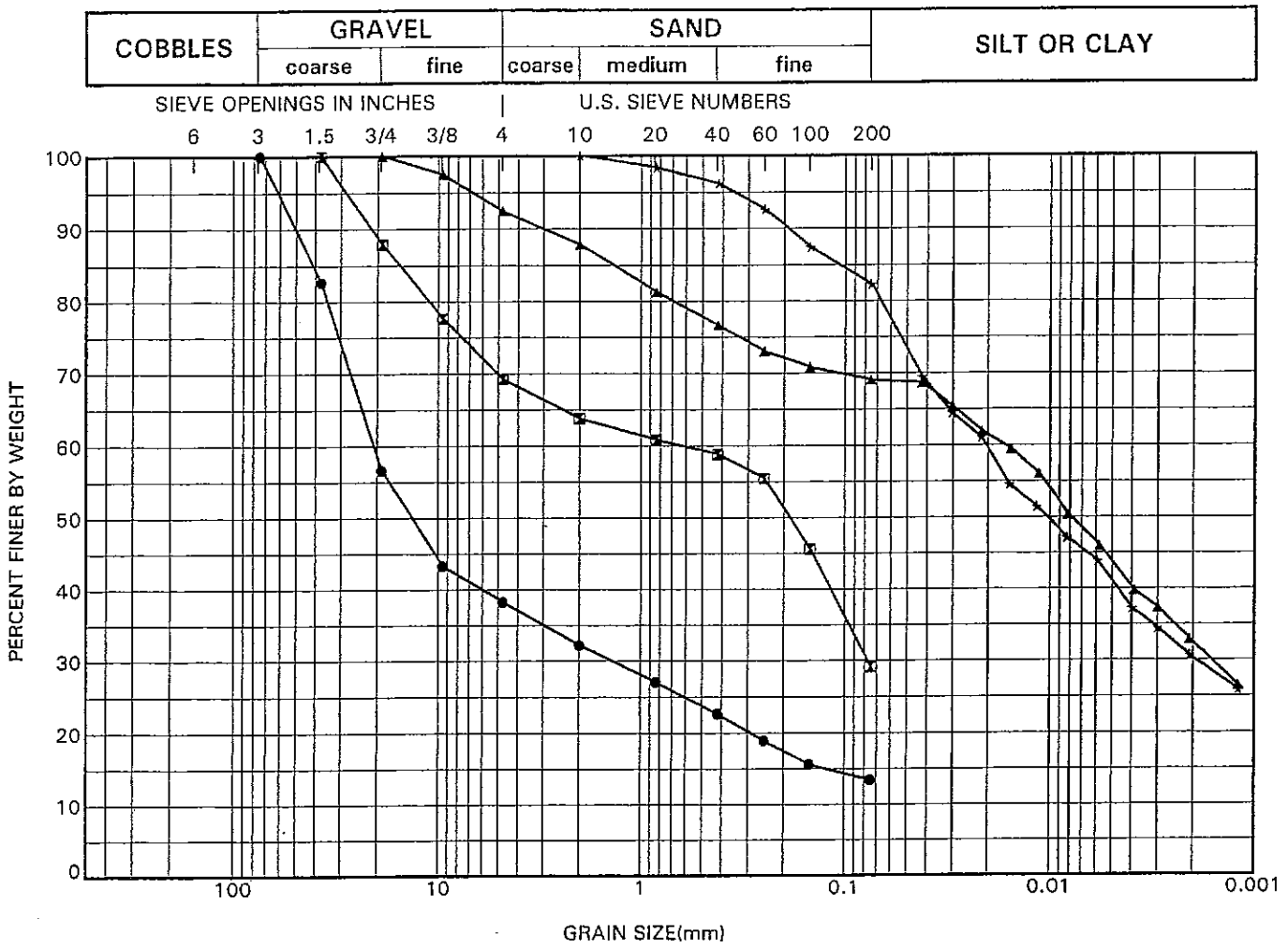
	HOLE/SAMPLE	Depth(m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	BOC02-09	6.00	4.8				SPT 5
⊠	BOC02-09	13.85	3.7				Grab 11
▲	BOC02-09	25.50	32.0	41	15	26	SPT 24

CU = Coefficient of Uniformity = D60/D10 Particle Sizes, e.g. D85, in mm Mechanical sieving(ASTM D422) after wash & dry(D1140) or hydrometer(D422)

KLOHN CRIPPEN

PROJECT NO.:	PG 9060 01
PROJECT:	PWGSC Esquimalt EGD and SLW
LOCATION:	Esquimalt, BC
FIGURE:	
DRAWN BY:	Juan CHECKED BY: DT

GRAIN SIZE DISTRIBUTION



	HOLE/SAMPLE	Depth(m)	D85	D60	D50	D15	D10	CU	%GRAVEL	%SAND	%FINES
●	BOC02-10	6.55	41.260	20.860	13.520	0.124			61.7	24.9	13.4
⊠	BOC02-10	11.00	15.700	0.637	0.188				30.8	40.1	29.1
▲	BOC02-10	18.40	1.384	0.017	0.008				7.6	23.4	69.0
★	DH02-01	8.85	0.109	0.021	0.010				0.0	17.8	82.2

	HOLE/SAMPLE	Depth(m)	W%	W_L	W_P	PI	REMARKS / SAMPLE DESCRIPTION
●	BOC02-10	6.55	9.4				Grab 7
⊠	BOC02-10	11.00	21.0				Grab 12
▲	BOC02-10	18.40	31.7				Grab 17
★	DH02-01	8.85	18.5	33	19	15	Shelby 7 (Puddle clay)

CU = Coefficient of Uniformity = D60/D10 Particle Sizes, e.g. D85, in mm Mechanical sieving(ASTM D422) after wash & dry(D1140) or hydrometer(D422)

KLOHN CRIPPEN

PROJECT NO.:	PG 9060 01
PROJECT:	PWGSC Esquimalt EGD and SLW
LOCATION:	Esquimalt, BC
FIGURE:	
DRAWN BY:	Juan CHECKED BY: DT

APPENDIX IV

BPT PDA Measurements

Robert Miner Dynamic Testing, Inc.

Consulting, Dynamic Measurements and Analyses for Deep Foundations

May 10, 2002

Mr. Alex Sy, P. Eng.
Klohn Crippen
10200 Shellbridge Way
Richmond, B.C. Canada V6X 2W7

Re: Dynamic Measurements of Becker Hammer Drilling
BK02-05, BK02-06, March 19-20, 2002
Esquimalt Graving Dock, Victoria, B.C.

RMDT Job No. 02F16

Dear Mr. Sy;

This final report presents results from dynamic measurements made during operation of a Becker hammer drill for two test holes at the project referenced above. The dynamic measurements were made by Robert Miner Dynamic Testing, Inc. (RMDT) at the request of Klohn Crippen Consultants, Ltd. Field results were provided to Klohn Crippen shortly after the testing. Preliminary results of six CAPWAP analyses were provided to Klohn Crippen on March April 12, 2002.

Results from RMDT's monitoring and analysis include data on energy transfer from the hammer to the drill casing and soil resistance acting on the casing. These results are based on Case Method and CAPWAP analyses. Appendix A provides descriptions of our test equipment, the Case Method and CAPWAP analysis. Appendix B contains a summary of the field Case Method results. Appendix C contains measured force and velocity records for representative hammer blows from various penetrations in each monitored Becker test hole.

Attached figures provide a graphical summaries of the energy transfer data for each test hole. These figures, and the numerical summaries in Appendix B indicate that energy transfer to the drill casing varied significantly over the test holes and depths monitored, especially for the shallower depths. Becker hammer drills use an ICE 180 double acting diesel hammer with a maximum energy rating of 8.1 kip-ft and a 1.73 kip ram. For BK02-05 the transfer efficiency was typically between 25 and 35 percent. For BK02-06 the transfer efficiency was typically 22 and 38 percent.

Following the testing, RMDT completed CAPWAP analyses of individual hammer blows at depths selected by Klohn Crippen Consultants, Ltd. Results from these analyses are summarized below and Appendix D contains detailed CAPWAP output. The CAPWAP results include computed soil resistance along the casing shaft and at the toe.

Mailing Address: P.O. Box 340, Manchester, WA, 98353, USA **Phone:** 360-871-5480
Location: 2288 Colchester Dr. E., Ste A, Manchester, WA, 98353 **Fax:** 360-871-5483

Test	Blow No.	Depth	Blow Count	CAPWAP Soil Resistance, kips		
		ft	Blow/ft	Total	Shaft	Toe
BK02-05	19	27 to 27	6	4	2	2
BK02-05	49	34 to 35	14	20	8	12
BK02-05	159	42 to 43	5	8	4	4
BK02-06	48	14 to 15	3	5	2	3
BK02-06	23	22 to 23	4	11	7	4
BK02-06	33	30 to 31	3	12	10	2

It was a pleasure to assist you on this project. Please do not hesitate to contact us if you have any questions regarding this report or our participation on the project.

Sincerely Yours,

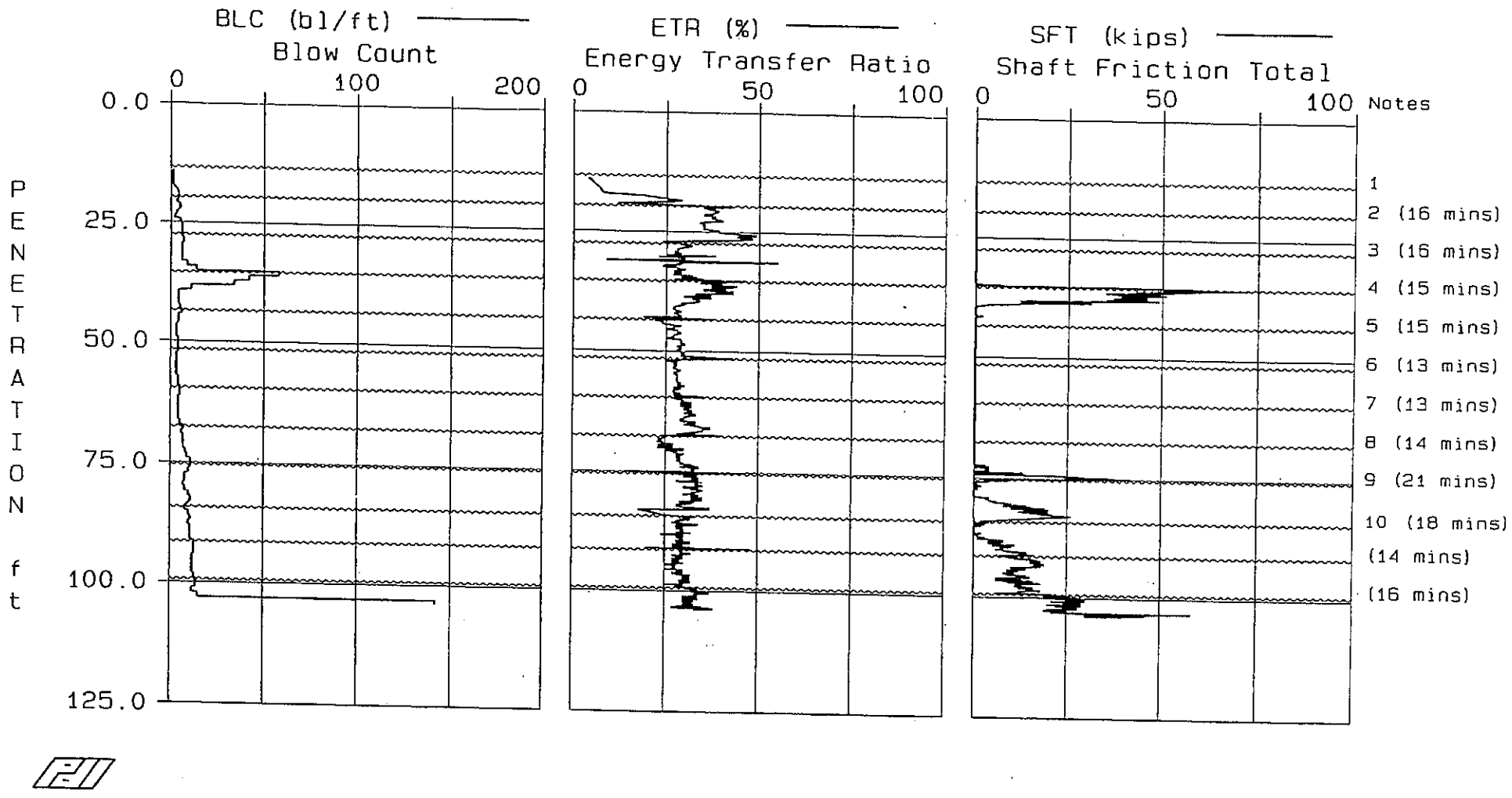
Robert Miner Dynamic Testing, Inc.

Robert F. Miner

R Miner Dynamic Test

2002-Mar-19

ESQUIMALT GRAVING DOCK, BK0205, HAV 180, 6-5/8" CLOSED



Notes

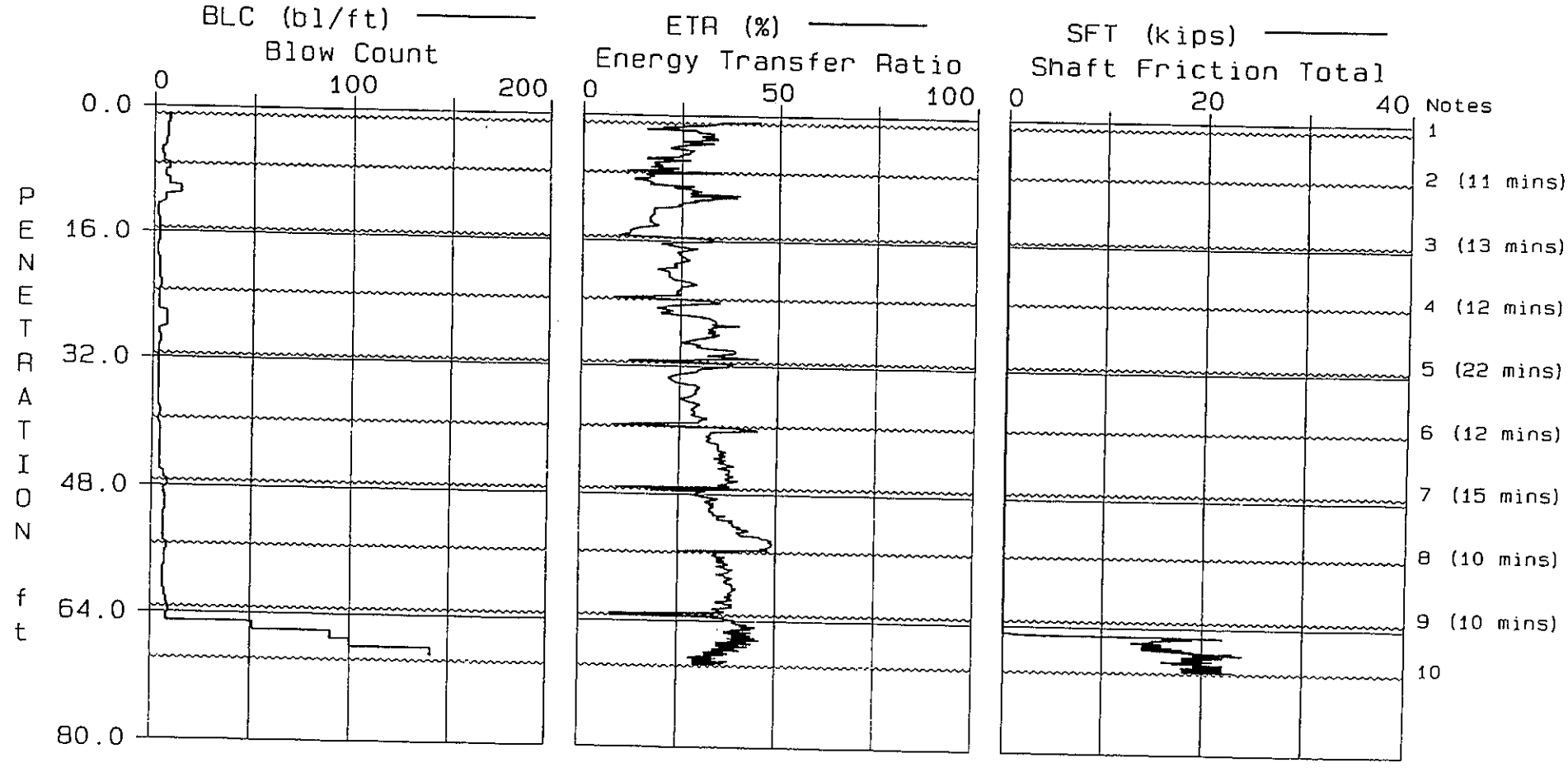
1. BEGIN BK0205 19-MAR-02 13:55 WITH REFERENCE PENETRATION OF 51 FT.
2. STOP NEAR 19.3 FT, PULL-TEST, ADD 8 FT ROD, CONTINUE.
3. STOP NEAR 27 FT, PULL-TEST, ADD 8 FT, CONTINUE.
4. STOP AT 35 FT, PULL-TEST, ADD 8 FT, CONTINUE.
5. STOP NEAR 43 FT, PULL-TEST, ADD 8 FT CONTINUE.
6. STOP NEAR 51 FT, PULL-TEST, ADD 8 FT, CONTINUE
7. STOP NEAR 59FT, PULL-TEST, ADD8 FT, CONTINUE. INCREASING
8. STOP, MOVE RIG TO REALIGN, PULL-TEST, ADD 8 FT, CONTINUE
9. STOP NEAR 75 FT, PULL-TEST, ADD 8 FT ROD, CONTINUE.
10. STOP NEAR 83 FT, PULL-TEST, ADD 8 FT ROD, CONTINUE.

Robert Miner Dynamic Testing, Inc.

R Miner Dynamic Test

2002-Mar-20

ESQUIMALT GRAVING DOCK, BK0206, HAV 180, 6-5/8" CLOSED



Notes
1. BEGIN BK0206 AT 0.8 FT, 20-MARCH-2002, 15:18.
2. STOP NEAR 7 FT, PULL-TEST, ADD 8 FT, CONTINUE.
3. STOP NEAR 15 FT, PULL-TEST, ADD 8 FT, CONTINUE.
4. STOP NEAR 23 FT, PULL-TEST, ADD 8 FT, CONTINUE.
5. STOP NEAR 31 FT, PULL-TEST, ADD 8 FT, CONTINUE.

Notes
6. STOP NEAR 39 FT, PULL-TEST, ADD 8 FT, CONTINUE.
7. STOP NEAR 47 FT, PULL-TEST, ADD 8 FT, CONTINUE.
8. STOP NEAR 55 FT, PULL-TEST, ADD 8 FT, CONTINUE.
9. STOP NEAR 63 FT, PULL-TEST, ADD 8 FT, CONTINUE.
10. HALT BK0206 NEAR 69.5 FT, 20-MARCH-2002, 17:17.

Robert Miner Dynamic Testing, Inc.

APPENDIX V

BPT Data Interpretation

APPENDIX V

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APPENDIX V
BPT DATA INTERPRETATION

V-1. INTRODUCTION

The field observations of the performance of sites during earthquakes have formed the basis for the widely used Seed's simplified method of liquefaction potential assessment for level ground (Youd et al. 2001). The Seed procedure uses Standard penetration test (SPT) N_{60}-value as the soil density index and is applicable to sand and silty sand sites for which the performance database was compiled. For assessing soil liquefaction at gravelly sites, the current practice is to use the Becker penetration test (BPT) to determine the equivalent SPT N_{60}-values for the gravelly soils, and then evaluate the liquefaction potential using the Seed SPT-based procedure for sand and silty sand sites. Two procedures were used to convert the Becker blowcounts to equivalent SPT N_{60}-values; namely, the empirical approach proposed by Harder (1988) and the wave equation based approach proposed by Sy (1993).

V-2. HARDER APPROACH

Harder (1988) proposed an empirical BPT-SPT correlation procedure based on standardizing the BPT blowcounts to a constant combustion condition by measuring peak pressures in the bounce chamber of the double-acting diesel hammer used in the BPT. The Harder procedure involves two basic steps. First, the field measured BPT blowcount (N_b) is corrected to a reference full combustion condition using the correction chart as shown on Figure V-1a, and secondly, the bounce chamber corrected BPT blowcount (N_{bc}) is used to estimate equivalent SPT N_{60}-value using the correlation curve shown on Figure V-1b. In practice, the Harder procedure has several limitations:

- The Harder reference combustion line A-A, although developed for a turbo-charged AP-1000 drill rig, is specific for the particular drill rig-hammer system used and for the ground conditions encountered in the

Harder (1988) correlation study, and is, therefore, not unique. Sy and Campanella (1993) and Sy (1997) illustrated that different reference combustion lines could be derived from the same drill rig at different sites or using different casing sizes at the same site, or from using different drilling rigs.

- The BPT-SPT correlation shown on Figure V-1b was based on test data from three sand and silty sand sites to 15 m depth. Since the Harder approach does not explicitly consider casing friction, it may not be applicable directly to depths greater than 15 m or to gravelly soil sites.

Despite the above limitations, Harder (1988) demonstrated that the empirical method could "predict" liquefaction at the Whiskey Springs site and Pence Ranch site, which experienced liquefaction in gravelly soils during the 1983 Borah Peak earthquake in Idaho. Within limitations, the Harder procedure has been adopted by National Centre for Earthquake Engineering Research (Youd et al, 2001) in the United States as an acceptable simple procedure for liquefaction assessment in gravelly soils.

V-3. SY APPROACH

An alternative and more fundamental approach to BPT-SPT correlation, based on experimental and numerical studies of the SPT and BPT, was proposed by Sy (1993). In this approach, a Pile Driving Analyzer (PDA) is used during the BPT to determine the energy transferred into the top of the casing, similar to dynamic monitoring of pile driving (ASTM D4945-89). The PDA records force and velocity time histories for each hammer blow and calculates the transferred energy for each blow in real time. The transferred energy is then used to correct the measured field blowcount to a reference energy of 30% of the manufacturer's rated energy for the ICE 180 hammer used in the Becker system:

$$N_{b30} = N_b \frac{ENTHRU}{30}$$

where N_{b30} is the BPT blowcount normalized to the 30% reference energy level, N_b is the measured Becker blowcount, and ENTHRU is the measured transferred energy expressed as percent of the rated hammer energy of 11.0 kJ for the ICE 180 hammer.

The Sy approach further considers soil friction acting on the Becker casing during driving. The soil friction and its distribution along the casing can be measured during the BPT by casing pull-up tests, or estimated from the PDA stress wave measurement using a signal-matching wave equation analysis program, CAPWAP. The energy-corrected N_{b30}, together with the measured casing friction or shaft resistance value, R_s, is then used to estimate the equivalent SPT N_{60} value from the theoretical BPT-SPT correlation shown on Figure V-2.

The pull-up test consists of pulling the top of the Becker casing during each rod change or casing add-on, and measuring the pull-up force with a tension load cell connected to the top of the casing. Sy (1997) found that this pull-up tension force, although fundamentally different from the compressive soil friction acting on the casing during driving, is comparable to the CAPWAP-estimated casing friction.

V-4. BPT-SPT INTERPRETATION RESULTS

The Harder and Sy methods were applied to the eight BPTs at the Esquimalt Graving Dock (BPT02-01, BPT02-02 and BPT02-03) and South Landing Wharf (BPT02-04. BPT02-05, BPT02-06, BPT02-08, BPT02-10) sites. For the Harder method, the measured peak bounce chamber pressures (BCP) were used in the BPT data interpretation. For the Sy method, the measured transferred energies from the PDA, together with the load cell measured casing friction from pull-up tests, were used in the BPT data interpretation. Since PDA measurements were performed only in BPT02-05 and BPT02-06, the transferred energy required to interpret the other BPTs following the Sy procedure was assumed based on the measured energy data. The measured transferred

energies in BPT02-05 and BPT02-06 varied between about 20% and 40%; thus an average transferred energy of 30% was selected for interpretation of the other six BPTs.

The BPT-SPT interpretation results are presented in Figures V-3 to V-10 for the eight BPTs. The figures show the recorded BPT blow counts (N_b); the measured bounce chamber pressures (BCP); the measured transferred energies (ENTHRU); the bounce chamber pressure corrected blow counts (N_{bc}); the transferred energy corrected blow counts (N_{b30}); the casing friction values from pull-up tests, and the equivalent SPT N_{60}-values from both Sy and Harder methods. Also shown in the figures, where applicable, are the shaft resistances computed from CAPWAP analyses of six selected hammer blows, and measured N-values from limited SPTs (automatic trip hammer was used) conducted in the adjacent Becker sampling test holes. The generalized subsoil stratigraphy from the adjacent open-ended Becker sampling hole is also included in the figures.

REFERENCES

Harder, L.F. Jr. 1988. Use of penetration tests to determine the liquefaction potential of soils during earthquake shaking. Ph.D. dissertation, University of California, Berkeley.

Sy, A. 1993. Energy measurements and correlations of the Standard penetration tests (SPT) and the Becker penetration tests (BPT). Ph.D. thesis, Department of Civil Engineering, University of British Columbia, Vancouver, B.C.

Sy, A. 1997. Twentieth Canadian Geotechnical Colloquium: Recent developments in Becker penetration test: 1986 to 1996. Canadian Geotechnical Journal, 34(6):952-973.

Sy, A. and Campanella, R.G. 1993. Dynamic performance of the Becker hammer drill and penetration test. Canadian Geotechnical Journal, 30(4): 607-619.

Youd, T.L., Idriss, I.M., Andrus, R. D., Arango, I., Castro, G., Christian, J. T., Dobry, R., Finn, W. D. L., Harder, L. F., Hynes, M. E., Ishihara, K., Koester, J. P., Liao, S. S. C., Marcuson III, W. F., Martin, G. R., Mitchell, J. K., Moriwaki, Y., Power, M. S., Robertson, P. K., Seed, R. B., Stoke II, K. H. (2002). Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils. ASCE Journal of Geotechnical and Geoenvironmental Engineering, Vol. 27, No. 10, pp817-833.

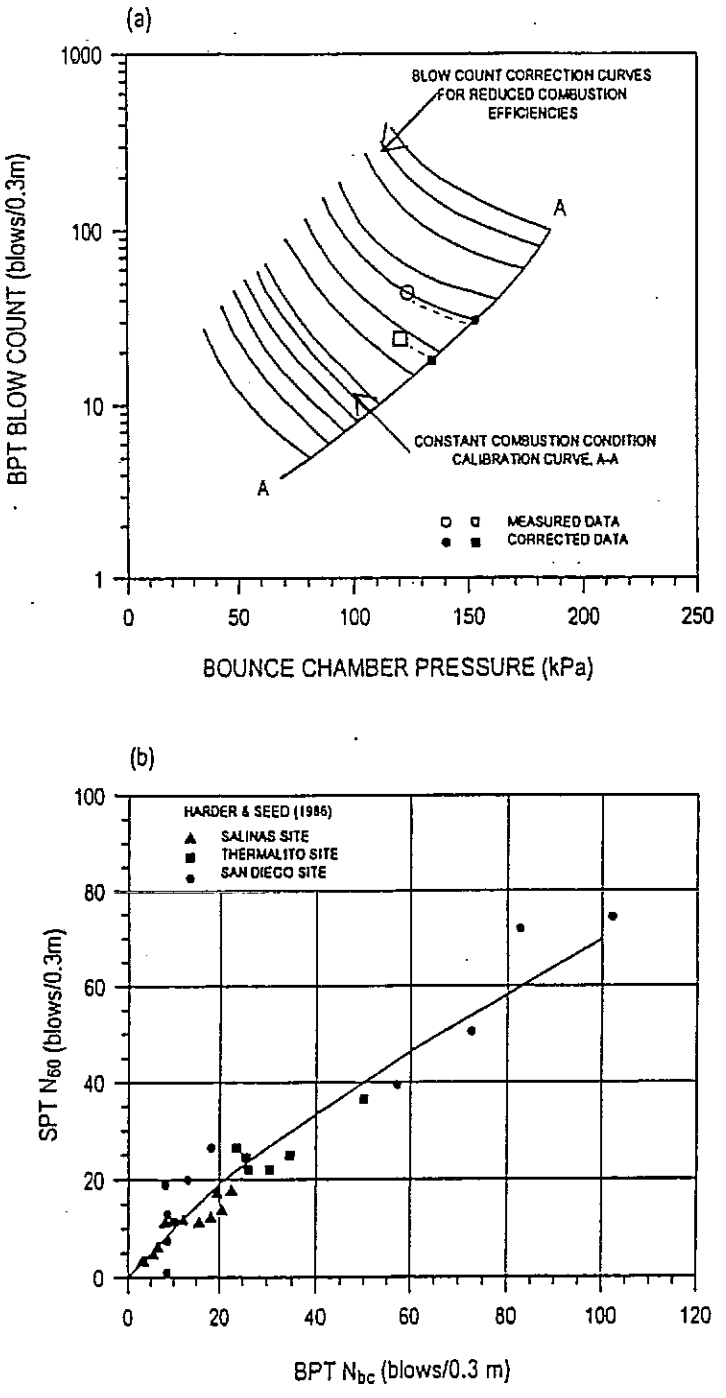


FIGURE V-1 HARDER BPT INTERPRETATION PROCEDURES

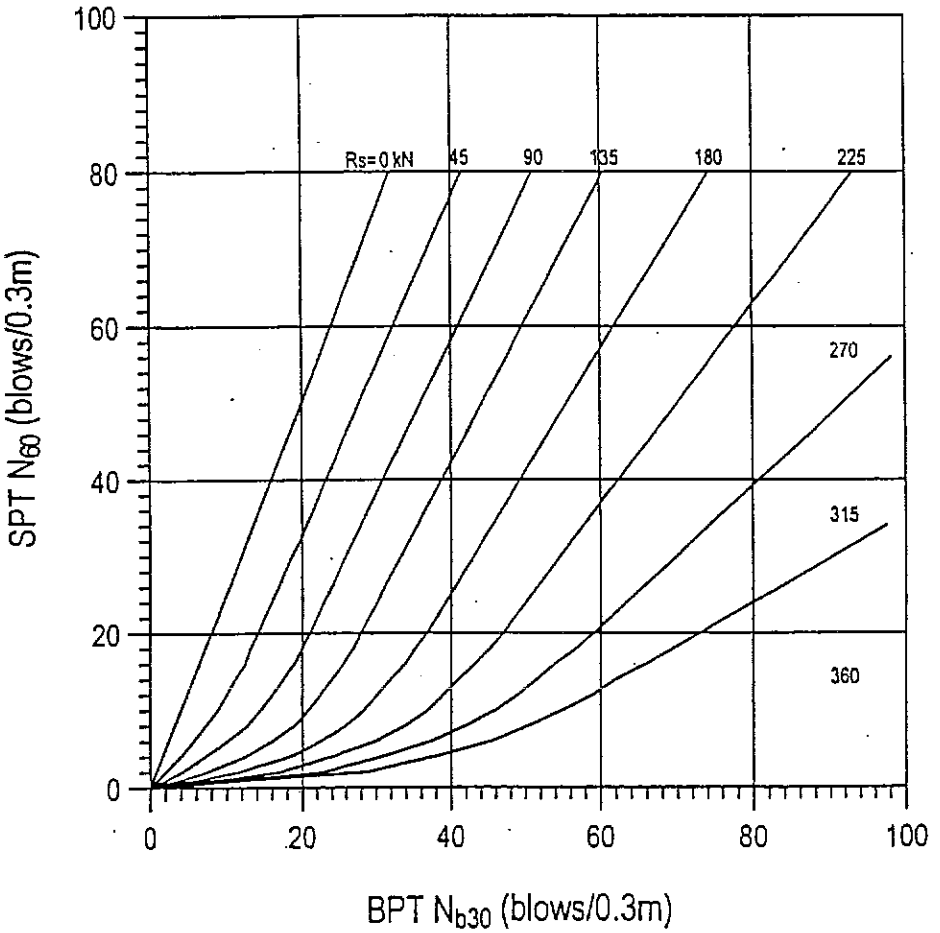
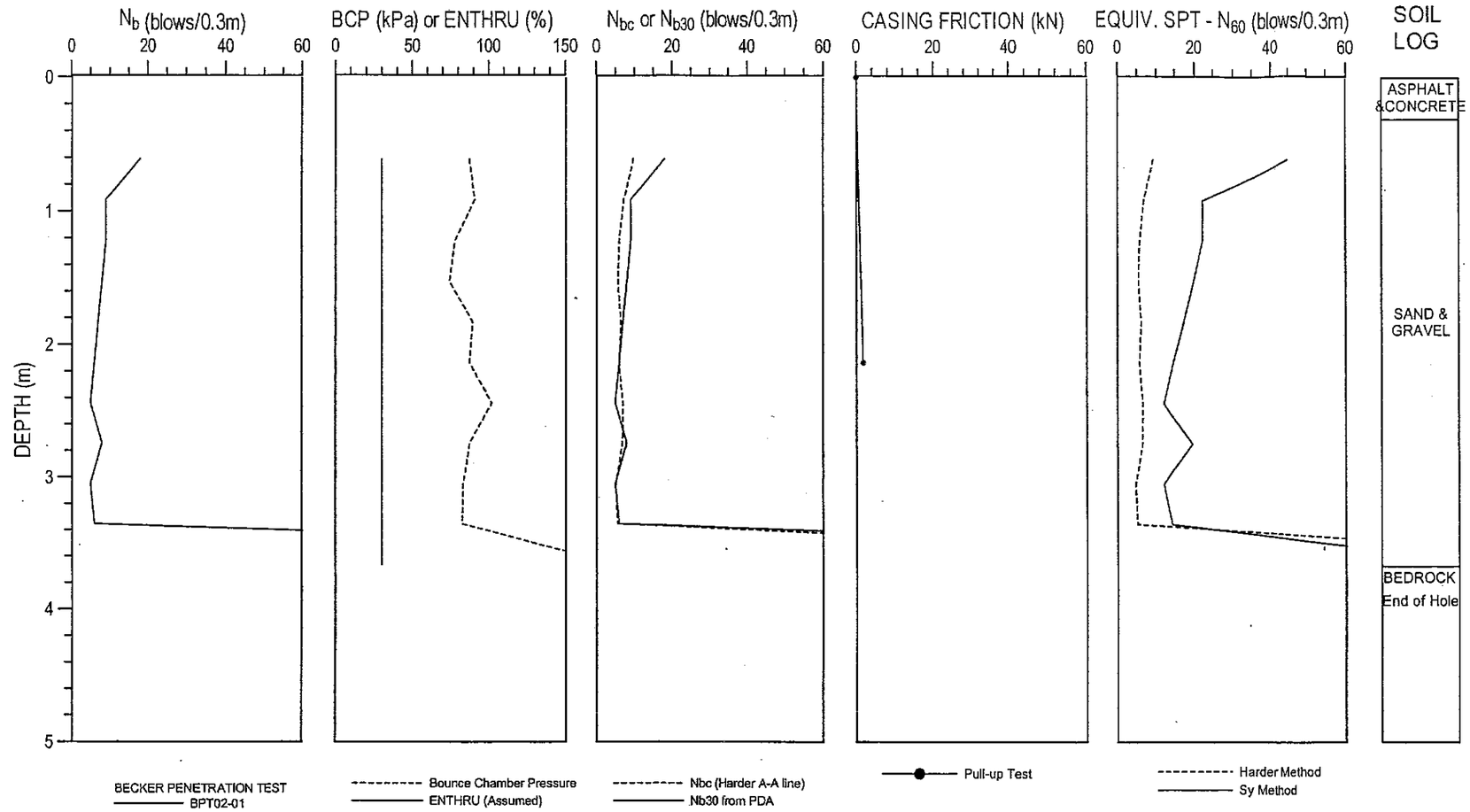


FIGURE V-2 SY BPT-SPT CORRELATIONS



LEGEND

N_b	Measured BPT blow counts per 0.3 m
ENTHRU	Measured transferred energy as % of hammer rated energy
BCP	Measured bounce chamber pressure
Nbc	Corrected BPT blow counts to a constant combustion condition using Harder rating curve (1986)
Nb30	Corrected BPT blow counts to 30% reference energy of the rated energy for the ICE 180 hammer
HARDER method	Seed and Harder (1986) method for standardizing measured BPT blow counts to a constant combustion condition using measured bounce chamber pressures and correlation of the corrected blow count, Nbc, to the equivalent SPT N_{60}
SY Method	SY (1993) method for correcting measured BPT blow counts to the 30% reference energy level and estimation of the equivalent SPT N_{60} using the corrected blow count, Nb30, and measured or computed shaft resistance to account for soil friction effect

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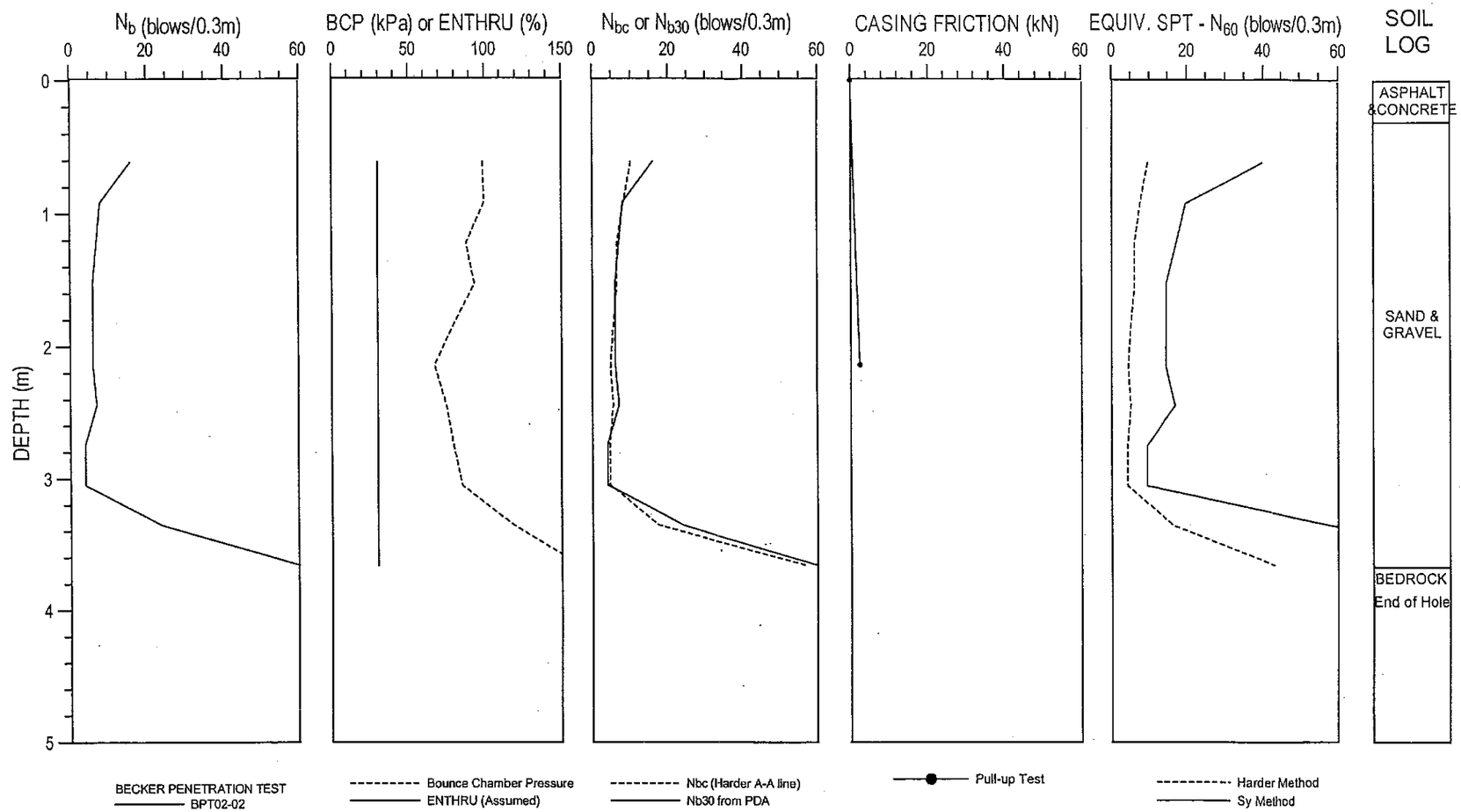
PROJECT: EGD & SLW SITE INVESTIGATION

TITLE: BPT DATA INTERPRETATION -- BPT02-01

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
June 25, 2002	PG9060 01	FIGURE V-3	



LEGEND

N_b	Measured BPT blow counts per 0.3 m
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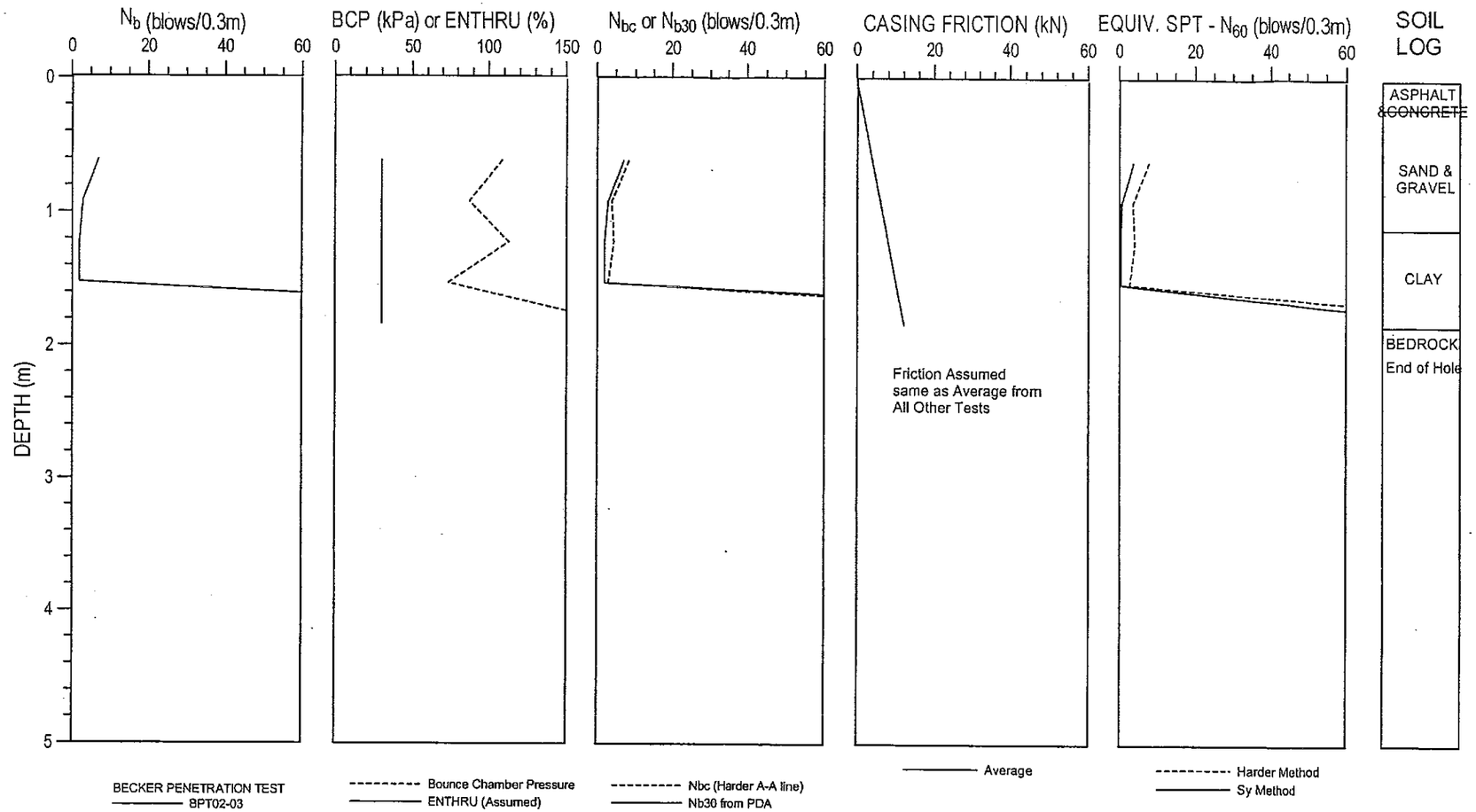
TITLE: BPT DATA INTERPRETATION -- BPT02-02

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
June 25, 2002	PG9060 01	FIGURE V-4	



LEGEND

N_b	Measured BPT blow counts per 0.3 m
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TO BE READ WITH KLOHN-CRIPPEN REPORT DATED June 25, 2002

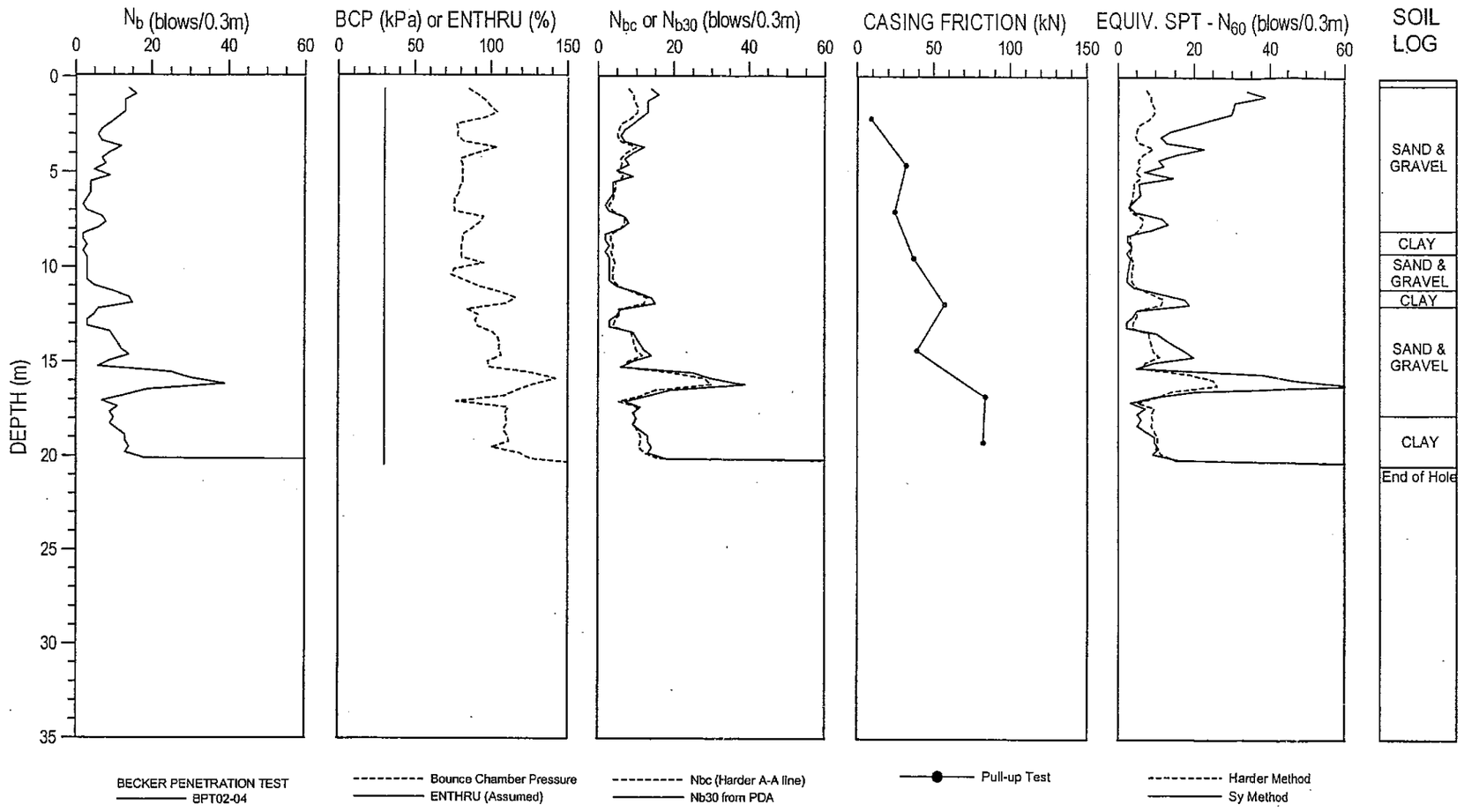
CLIENT: PWGSC

KLOHN CRIPPEN

PROJECT: EGD & SLW SITE INVESTIGATION

TITLE: BPT DATA INTERPRETATION -- BPT02-03

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
June 25, 2002	PG9060 01	FIGURE V-5	



LEGEND

N_b	Measured BPT blow counts per 0.3 m
ENTHRU	Measured transferred energy as % of hammer rated energy
BCP	Measured bounce chamber pressure
Nbc	Corrected BPT blow counts to a constant combustion condition using Harder rating curve (1986)
Nb30	Corrected BPT blow counts to 30% reference energy of the rated energy for the ICE 180 hammer
HARDER method	Seed and Harder (1986) method for standardizing measured BPT blow counts to a constant combustion condition using measured bounce chamber pressures and correlation of the corrected blow count, Nbc, to the equivalent SPT N_{60}
SY Method	SY (1993) method for correcting measured BPT blow counts to the 30% reference energy level and estimation of the equivalent SPT N_{60} using the corrected blow count, Nb30, and measured or computed shaft resistance to account for soil friction effect

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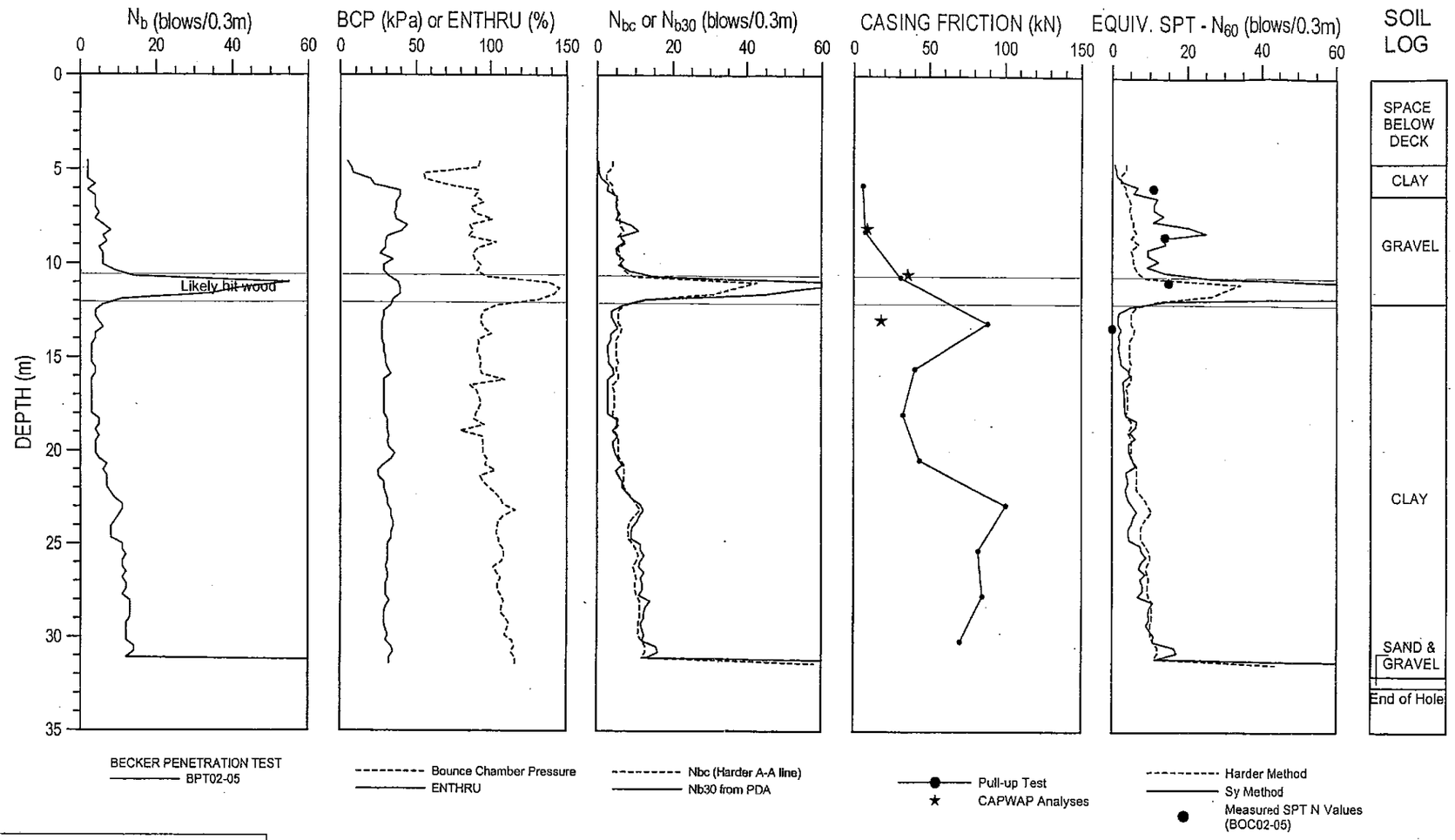
PROJECT: EGD & SLW SITE INVESTIGATION

TITLE: BPT DATA INTERPRETATION -- BPT02-04

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
June 25, 2002	PG9060 01	FIGURE V-6	



LEGEND

N_b	Measured BPT blow counts per 0.3 m
ENTHRU	Measured transferred energy as % of hammer rated energy
BCP	Measured bounce chamber pressure
Nbc	Corrected BPT blow counts to a constant combustion condition using Harder rating curve (1986)
Nb30	Corrected BPT blow counts to 30% reference energy of the rated energy for the ICE 180 hammer
HARDER method	Seed and Harder (1986) method for standardizing measured BPT blow counts to a constant combustion condition using measured bounce chamber pressures and correlation of the corrected blow count, Nbc, to the equivalent SPT N_{60}
SY Method	SY (1993) method for correcting measured BPT blow counts to the 30% reference energy level and estimation of the equivalent SPT N_{60} using the corrected blow count, Nb30, and measured or computed shaft resistance to account for soil friction effect

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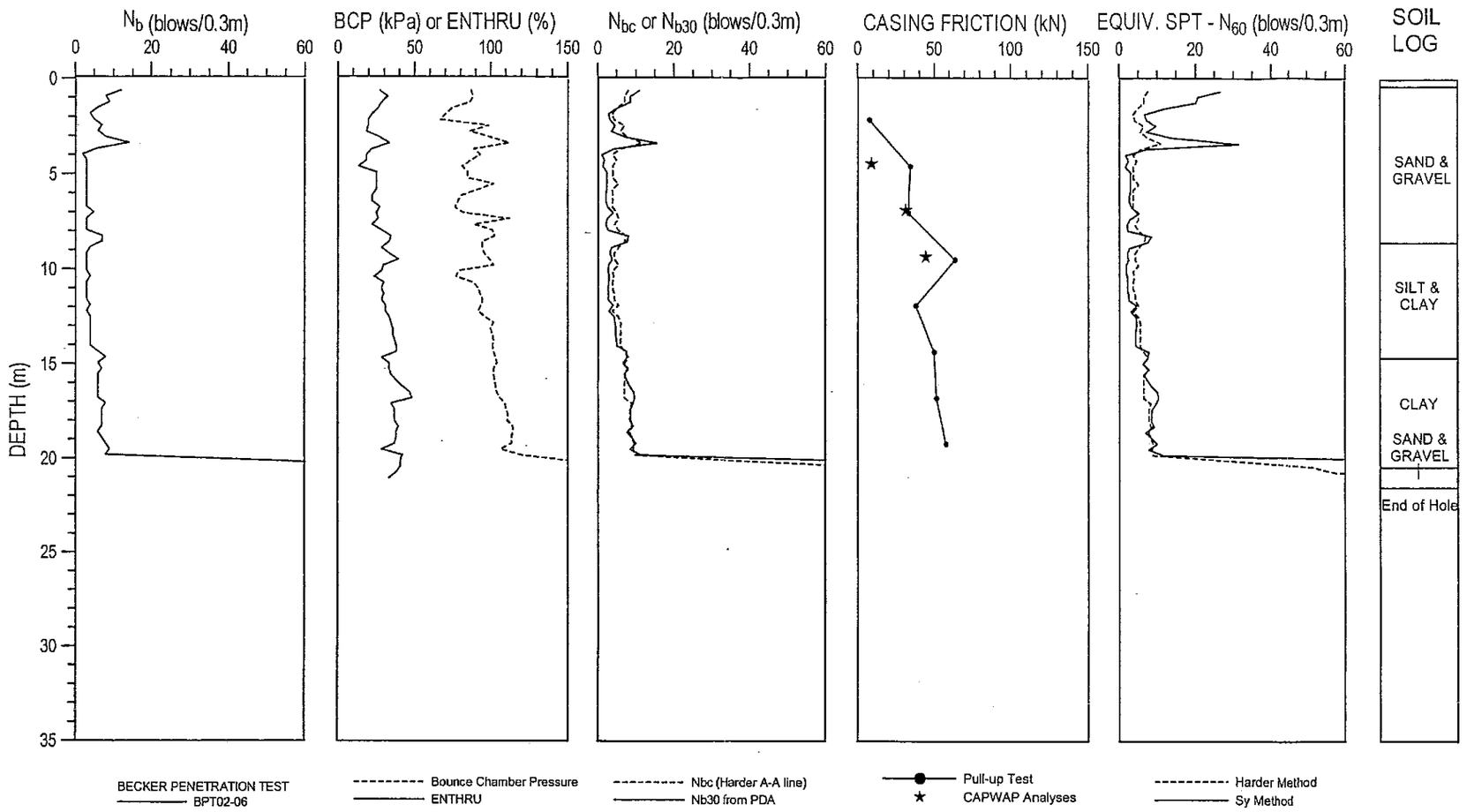
PROJECT: EGD & SLW SITE INVESTIGATION

TITLE: BPT DATA INTERPRETATION -- BPT02-05

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
June 25, 2002	PG9060 01	FIGURE V-7	



LEGEND

N_b	Measured BPT blow counts per 0.3 m
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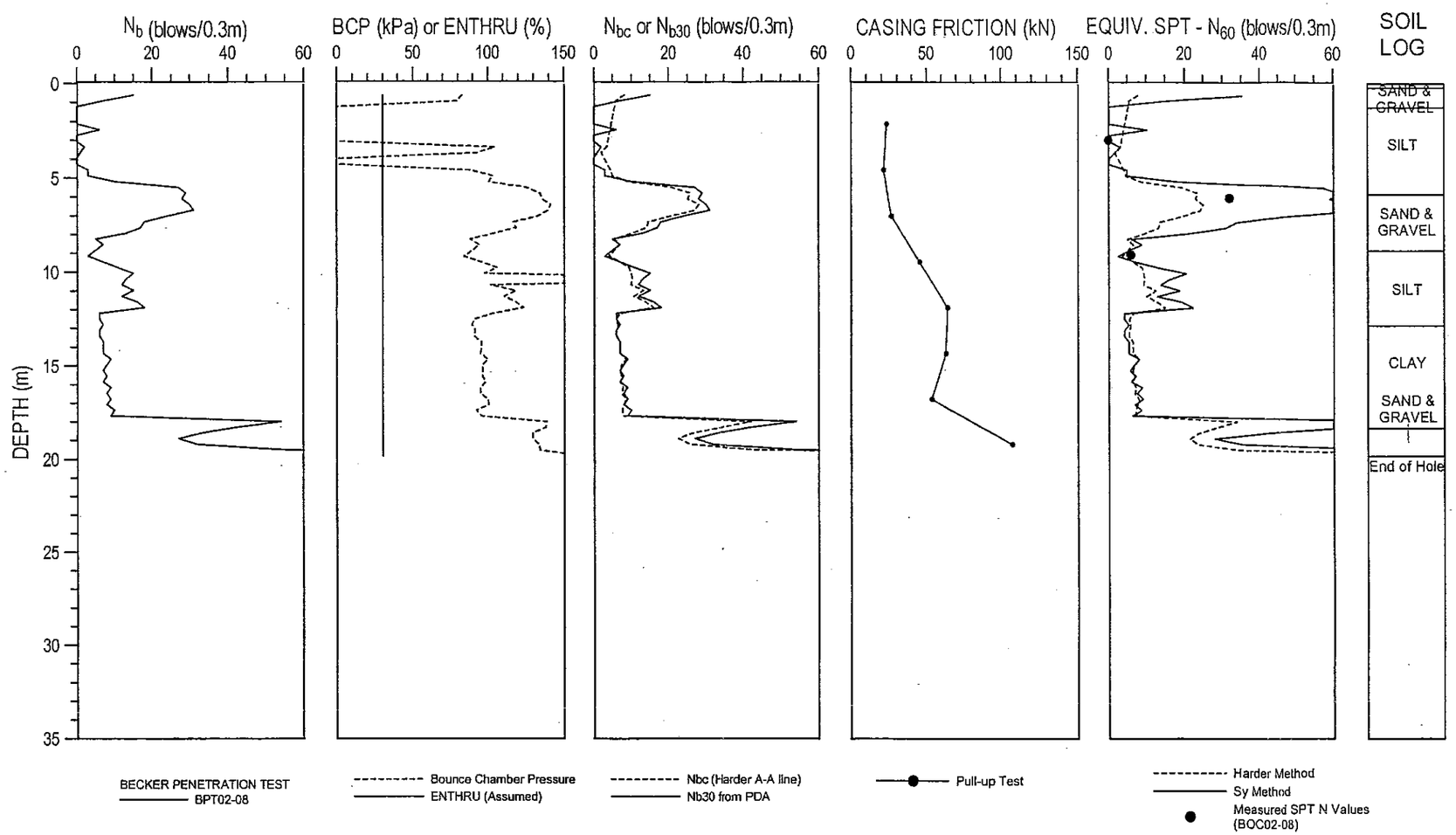
PROJECT: EGD & SLW SITE INVESTIGATION

TITLE: BPT DATA INTERPRETATION -- BPT02-06

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
June 25, 2002	PG9060 01	FIGURE V-8	



LEGEND

N_b	Measured BPT blow counts per 0.3 m
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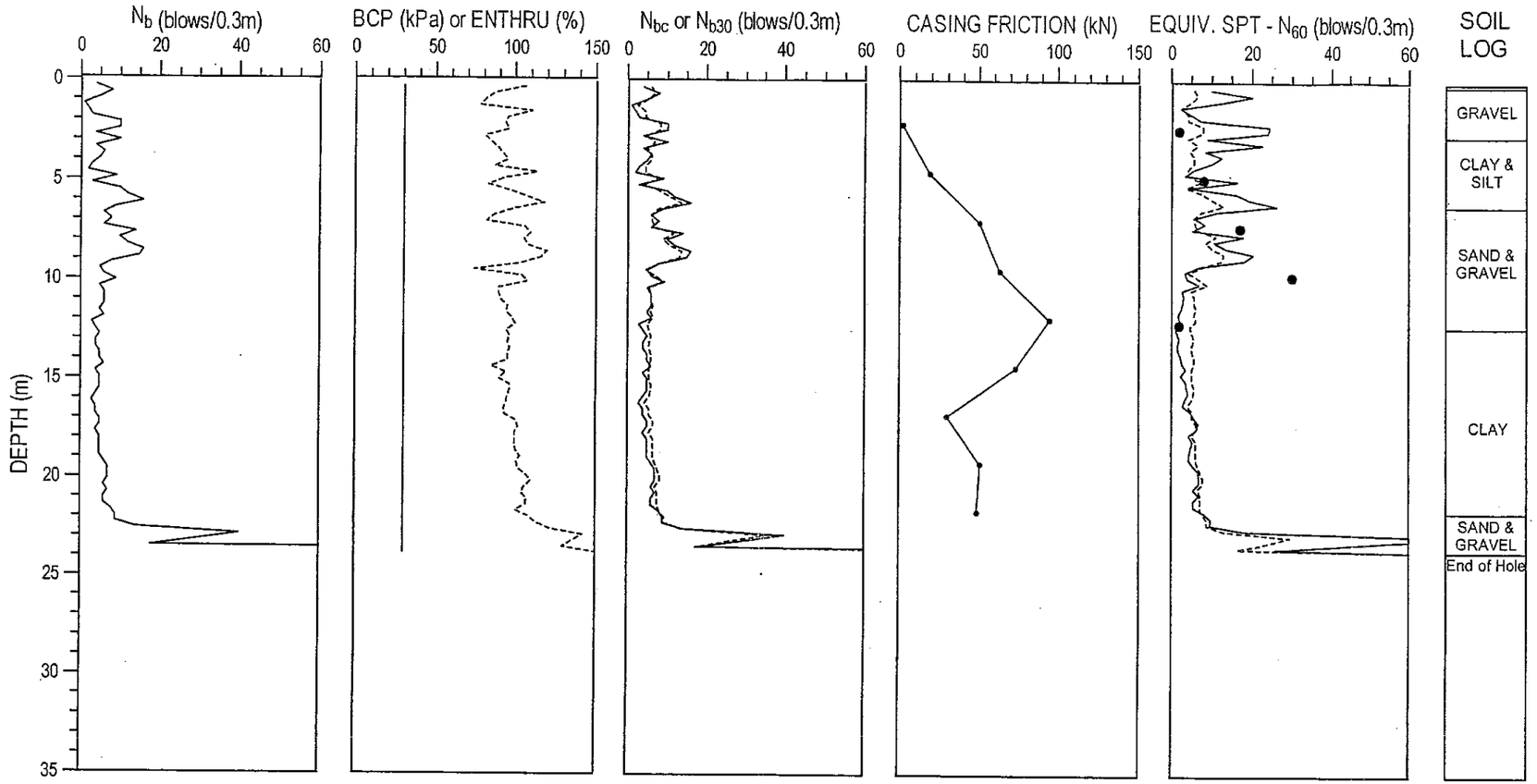
PROJECT: EGD & SLW SITE INVESTIGATION

TITLE: BPT DATA INTERPRETATION -- BPT02-08

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
June 25, 2002	PG9060 01	FIGURE V-9	



LEGEND

N_b	Measured BPT blow counts per 0.3 m
ENTHRU	Measured transferred energy as % of hammer rated energy
BCP	Measured bounce chamber pressure
Nbc	Corrected BPT blow counts to a constant combustion condition using Harder rating curve (1986)
Nb30	Corrected BPT blow counts to 30% reference energy of the rated energy for the ICE 180 hammer
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PROJECT: EGD & SLW SITE INVESTIGATION

TITLE: BPT DATA INTERPRETATION -- BPT02-10

DATE OF ISSUE	PROJECT No.	DWG. No	REV.
June 25, 2002	PG9060 01	FIGURE V-10	

APPENDIX VI

Site Response and Liquefaction Analyses

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APPENDIX VI

SITE RESPONSE AND LIQUEFACTION ANALYSES

VI-1. INTRODUCTION

One dimensional total-stress site response analyses were carried out at five representative locations in South Landing Wharf (SLW) area. The objective of the site response analyses was to determine the variations of peak horizontal accelerations and cyclic shear stresses with depth for liquefaction assessment of the SLW area.

The computer program SHAKE (SHAKE91 version by Idriss and Sun, 1992) was used to analyse the response of the soil columns under imposed acceleration time histories at the base. SHAKE computes the response of a horizontally layered soil deposit overlying a uniform half-space subjected to vertically propagating shear waves. The analysis is done in the frequency domain. An equivalent linear method is used to account for the non-linearity of the soil using an iterative procedure to obtain values for modulus and damping that are compatible with the shear strain induced in each soil layer.

VI-2. DESIGN GROUND MOTIONS

Three synthetic earthquake records and eight scaled natural earthquake records were provided by PWGSC for the study. These records were produced by Pacific Geodynamics Inc. as described in their Phase I: Seismic Hazard Analysis of Esquimalt Graving Dock report dated November 30, 1999. The three synthetic earthquake records are characteristic of the three seismic design events as listed in Table VI-1. The 475 year and 1000 year return period synthetic records were produced by matching the uniform hazard spectrum. Table VI.2 lists the characteristics of the 8 natural acceleration records. Record Nos. 1 to 7 correspond to the 475 year return period event and were produced by scaling the natural records to match the target peak ground velocity (PGV) of 0.35 m/s.

Record No. 8 corresponds to the Cascadia subduction event and was scaled to a PGA of 0.24 g. The acceleration time histories of the synthetic records are shown in Figure VI.1, and the scaled natural acceleration records shown in Figures IV-2 and IV-3.

Table VI-1 Synthetic Earthquake Records

Record No.	Earthquake Design Event	Magnitude	Peak Ground Acceleration (g)
S1	1 in 475 year Return Period EQ	7.6	0.35
S2	1 in 1000 year Return Period EQ	7.6	0.45
S2	Cascadia Subduction EQ	8.2	0.24

Table VI-2 Natural Earthquake Records

Record No.[1]	Earthquake and Station	Magnitude	Original		Scaled	
			PGA (g)	PGV (m/s)	PGA (g)	PGV (m/s)
1	1971 San Fernando EQ, Griffith Park Observatory	M_L6.6	0.180	0.205	0.282	0.350
2	1971 San Fernando EQ, Millikan Laboratory, CIT Seismic Laboratory	M_L6.6	0.185	0.163	0.360	0.350
3	1971 San Fernando EQ, 3838 L.A. Lankershim Blvd., L.A.	M_L6.6	0.150	0.149	0.320	0.350
4	1989 Loma Prieta EQ, Stanford, SLAC Lab	M_S7.1	0.288	0.284	0.361	0.350
5	1989 Loma Prieta EQ, Palo Alto Hospital Basement	M_S7.1	0.386	0.405	0.334	0.350
6	1979 Yugoslavia Monte Negro EQ, M_L=7.0, Ulcinj Albatros Hotel	M_L7.0	0.171	0.194	0.288	0.350
7	1994 Northridge EQ, Pacoima-Kagel Canyon	M_L6.7	0.300	0.310	0.339	0.350
8	1985 Mexican Michocan EQ, La Villita, Guerrero Array	M_S8.1	0.123	0.105	0.240	-

[1] Records No. 1-7 are for the 475 year return period event and record No. 8 is for the Cascadia subduction event.

VI-3. GROUND RESPONSE ANALYSES

VI-3.1 Soil Models

The soil layers in the five soil columns analyzed are summarized in Table VI-3. The soil layers were determined from the open-ended Becker test holes. The bedrock was treated as a half space and the input acceleration time histories were applied at bedrock as "outcropping" input motions. The total unit weight of the sand and gravel was taken as 20 kN/m^3 and that of the silt and clay was taken as 19 kN/m^3.

Table VI-3 Shake Soil Columns Analysed

Location of Soil Column	Total Depth of Soil Column (m)	Soil Layers (0 m refers to existing ground surface or mudline level)	
BPT02-04	20.4	0 – 0.3 m	Asphalt/Concrete
		0.3 – 7.9 m	Sand & Gravel Fill
		7.9 – 9.1 m	Clay Fill
		9.1 – 11.0 m	Sand & Gravel Fill
		11.0 – 11.9 m	Clay Fill
		11.9 – 17.7 m	Sand & Gravel Fill
		17.7 – 20.4 m	Clay
BPT02-05	27.9 (below of mudline)	0 – 1.7 m	Clay
		1.7 – 7.5 m	Gravel Fill
		7.5 – 27.6 m	Clay
		27.6 – 28.2 m	Sand & Gravel
BPT02-06	21.5	0 – 0.3 m	Asphalt/Concrete
		0.3 – 8.5 m	Sand & Gravel Fill
		8.5 – 14.6 m	Silt & Clay
		14.6 – 20.4 m	Clay
		20.4 – 21.5 m	Sand & Gravel
BPT02-08	19.8	0 – 0.2 m	Asphalt/Concrete
		0.2 – 1.2 m	Sand & Gravel Fill
		1.2 – 5.8 m	Silt Fill
		5.8 – 8.8 m	Sand & Gravel Fill
		8.8 – 12.8 m	Silt
		12.8 – 18.3 m	Clay
		18.3 – 19.8 m	Sand & Gravel
BPT02-10	23.5	0 – 0.1 m	Asphalt
		0.1 – 2.6 m	Sand & Gravel Fill
		2.6 – 6.1 m	Silt & Clay
		6.1 – 12.2 m	Sand & Gravel Fill
		12.2 – 21.6 m	Clay
		21.6 – 23.6 m	Sand & Gravel

VI-3.2 Shear Wave Velocities

Downhole shear wave velocity measurements were conducted at BPT02-04 to 19 m depth. Figure VI-4 shows the measured shear wave velocity profile with depth at BPT02-04. Shear wave velocity values were also estimated using equivalent N_{60} values from BPT02-04, with the empirical correlations proposed by Rollins et al. (1998) for Holocene gravel and by Seed et al. (1986) for loose and dense gravels. The empirical shear wave velocities are also shown in Figure VI-4 for comparison with the measured data. Figure VI-4 indicates that the measured shear wave velocity values in the granular fill are in general agreement with values predicted from empirical correlations.

The measured shear wave velocity profile was used in the SHAKE analysis of the soil column at BPT02-04. A linearly increasing shear wave velocity profile, as shown in Figure VI-4, was assumed for the granular fill in the other four soil columns analyzed in SHAKE.

Figure VI-5 shows the measured shear wave velocity profiles within the fine-grained soils (silt and clay) at SCPT02-06 and SCPT02-09. An average uniform shear wave velocity value of 160 m/s was assumed for the fine-grained soils (silt and clay) for all five soil columns analysed in SHAKE.

The shear wave velocity of the hard bedrock was taken as 1500 m/s. Monahan and Levson (1997) quoted a range of shear wave velocity values of 760 m/s to 1500 m/s for bedrock underlying Victoria. The low-strain shear modulus values required for input into SHAKE were calculated from the above measured and assumed shear wave velocities.

VI-3.3 Modulus Reduction and Damping Curves

The modulus reduction and damping curves as a function of shear strain are required as part of the input to SHAKE for the equivalent linear analysis. Modulus reduction and damping curves, generally considered characteristics of soil type, were obtained from (i) curves suggested by Rollins, et al. (1998) for gravel; (ii) curves suggested by Seed and Idriss (1970) and Idriss (1990) for sand, and (iii) curves suggested by Vucetic and Dobry (1991) for silt and clay with different plasticity indices. The modulus reduction and dampling curves for gravel, sand, silt and clay used in our SHAKE analyses are shown in Figure VI-6.

VI-3.4 SHAKE Analyses

The results of the SHAKE analyses for the three synthetic and eight natural input ground motions are shown in Figures VI.7 to VI.16 for the five soil columns. For each soil column, the results of the synthetic records are shown on one figure, and the results of the natural records are shown on another figure. Each figure shows the computed peak accelerations and the cyclic shear stress ratios (CSR) versus depth. The CSR is the earthquake induced shear stress divided by the initial effective overburden stress.

VI-4. LIQUEFACTION EVALUATION OF GRANULAR SOILS

VI-4.1 Methodology for Liquefaction Evaluation Using BPT

The seismic free field liquefaction assessment of granular soils in the five soil columns was carried out in general accordance with the Seed simplified approach as described in Youd et al. (2001), which summarises the final recommendations from the 1996 NCEER and 1998 NCEER/NSF workshops on evaluation of liquefaction resistance of soils. In this approach, the cyclic shear stress ratios (CSR) induced by the design earthquake are compared with the cyclic resistance ratios (CRR) derived from field observations of soils with known standard penetration test (SPT) resistances, at sites that have or have not

liquefied during earthquakes. For this project, the induced CSRs were computed from the SHAKE ground response analyses. The CRRs were evaluated based on the equivalent $(N_1)_{60}$ values derived from the Becker penetration test (BPT) blow counts using the Sy (1997) method (Appendix V).

The procedure used for assessment of the liquefaction potential is described as follows:

- The cyclic shear stress ratios (CSR) induced by the design earthquake are computed directly using results from the SHAKE analyses, where CSR is 0.65 times the maximum earthquake-induced cyclic shear stress divided by the initial effective overburden pressure at the depth of interest. The mean tide elevation of El. 1.5 m was assumed in the calculation of initial effective stress.

- With the above computed CSR and a factor of safety (FOS) of 1.0, the required cyclic resistance ratio (CRR) is computed as:

$$CRR = FOS \; x \; CSR$$

- Since the Seed's liquefaction chart is for a M7.5 earthquake at an overburden stress of 100 kPa (1 tsf), the above CRR is corrected as follows:

$$CRR_{M7.5} = \frac{CRR}{K_m K_\sigma}$$

where K_m is the correction factor for design earthquake magnitude other than M7.5, and K_σ is the correction factor for initial static confining stress greater than 100 kPa (1 tsf). M7.6 was used for the 475 year and 1000 year earthquakes and M8.2 for the Cascadia subduction earthquake.

- The required SPT $(N_1)_{60}$ value corresponding to the above corrected $CRR_{M7.5}$ is determined from the liquefaction resistance chart originally developed by Seed et al. (1985), and recently modified by Youd et al. (2001). The liquefaction curve for fines content of 5% was used.

- The required $(N_1)_{60}$ values for a factor of safety of 1.0 are then compared with the equivalent $(N_1)_{60}$ values estimated from BPTs to identify the liquefiable zones. If the required $(N_1)_{60}$ values (demand) are greater than

the equivalent $(N_1)_{60}$ values (resistance), the factor of safety against liquefaction is less than one, and liquefaction is expected during the design earthquake at the depths where this condition occurs.

VI-4.2 Methodology for Liquefaction Evaluation Using CPT

The liquefaction potential of the silty sand encountered up to about 6 m depth at CPT02-10 was evaluated using the procedure described below.

- The required $(N_1)_{60}$ values for FOS=1.0 and for fines content of 35% were derived from the SHAKE analysis at BPT02-04, which is located approximately 35 m south east of CPT02-10, and were used to evaluate the liquefaction potential at CPT02-10. The required $(N_1)_{60}$ values were converted to N_{60} using the C_n overburden stress correction factor proposed by Liao and Whitman (1986). The N_{60} values were subsequently converted to equivalent cone bearing values, Q_c, based on an assumed Q_c/N_{60} ratio of 3.5 for the silty sand.
- The required Q_c values for a factor of safety of 1.0 are then compared with the measured CPT data to identify the liquefiable zones at CPT02-10.

VI-5. RESULTS OF LIQUEFACTION ANALYSES

The required $(N_1)_{60}$ values for a factor of safety against liquefaction of 1.0 are plotted in Figures VI.7 to VI.16 to assess the liquefaction potential at BPT02-04, 02-05, 02-06, 02-08 and 02-10. Also included in the figures are the equivalent $(N_1)_{60}$ profiles determined from the BPTs following the Sy (1997) method. Liquefaction is deemed to occur under a design earthquake, if the equivalent $(N_1)_{60}$ values estimated from BPT are less than the required $(N_1)_{60}$.

The results of the liquefaction evaluation are summarised as follows:

- Liquefaction will occur through most of the 13 m thick submerged granular fills at BPT02-04 for both synthetic and natural records.

- Liquefaction will be triggered in most of the 5 m thick submerged granular fill at BPT02-05 for both synthetic and natural records. (Figures VI.9 and VI.10). Note that the high measured BPT blow counts between 6.2 m and 7.5 m do not reflect the in-situ soil conditions, as a wooden pile was encountered at this depth.

- Liquefaction will occur through most of the 5.6 m thick submerged granular fill at BPT02-06 for both synthetic and natural records (Figures VI.11 and VI.12).

- Only a 3 m thick granular fill with very high BPT blow counts was encountered at BPT02-08. Liquefaction is not predicted in this granular fill due to the high blow counts (Figures VI.13 and VI.14).

- Liquefaction will occur through most of the 6 m thick submerged granular fill at BPT02-10 for both synthetic and natural records. (Figures VI.15 and VI.16).

- Figure VI.17 shows the liquefaction assessment at CPT02-10 for the three synthetic records. Liquefaction will occur in most of the 6 m thick submerged silty sand for all three synthetic earthquakes.

VI-6. SENSITIVITY ANALYSES

Additional SHAKE analyses were carried out at BPT02-05 to assess the sensitivity of the results to the input shear wave velocities (V_s) in clay and bedrock. These analyses were performed using the synthetic input acceleration record corresponding to the 475 year earthquake (A_{max}=0.35 g).

VI-6.1 Shear Wave Velocity in Clay

In the "base case" analysis in Section VI-4, an average constant V_s of 160 m/s was used. Sensitivity analyses were conducted at BPT02-05 for the following changes to the "base case" model:

a) A constant V_s of 200 m/s.

b) A linearly increasing V_s with 105 m/s at the surface to 171 m/s at 20 m.

These two assumed V_s profiles are shown with the base case V_s profile (i.e. Vs = 160 m/s) in Figure VI-18, as well as with the measured V_s profile from SCPT02-06. The results of the sensitivity analysis with V_s of 200 m/s in clay are compared to the base case results in Figure VI-19. As shown, the higher shear wave velocity results in higher peak accelerations and CSRs. However, there is no significant change in the extent of the liquefaction in the granular soils. The results of the sensitivity analysis with linearly increasing shear wave velocity profile in clay are compared with the base case in Figure VI-20. As shown, the linearly increasing V_s profile also results in increased peak ground accelerations and CSRs. Again, the extent of the liquefaction in the granular fill is not noticeably changed.

VI-6.2 Shear Wave Velocity in Bedrock

Monahan and Levson (1997) suggested a range of values from 760 to 1500 m/s for shear wave velocities in "rock" underlying Victoria. In the base case, the shear wave velocity of bedrock was taken as 1500 m/s. A sensitivity analysis was carried out using the SHAKE soil column at BPT02-05 by reducing the shear wave velocity in bedrock to 760 m/s, while keeping all the other properties unchanged. Figure VI-21 shows the results of this sensitivity analysis in comparison with the base case. As shown, the effect of changing the shear wave velocity values in the bedrock from 1500 m/s to 760 m/s is negligible.

VI-7. LIQUEFACTION EVALUATION OF FINE GRAINED SOILS

The liquefaction susceptibility of the fine-grained soils (silts and silty clays) is typically assessed using the Chinese liquefaction criteria (Seed and Idriss, 1982) and Andrews and Martin criteria (2000) as screening tools. The Chinese criteria is outlined below:

- Clay content (percent finer than 0.005 mm) <15%;

- Liquid limit (LL) <35%; and
- Water content (W) >0.9 x LL.

All three criteria must be satisfied for the soil to be considered potentially liquefiable and recommended for further laboratory testing. The criteria proposed by Andrews and Martin (2000) for fine grained soils are as follows:

- Clay content (percent finer than 0.002 mm) < 10%
- Liquid limit < 32 %.

Both criteria need to be satisfied for the soil to be considered potentially liquefiable. If only one of the two criteria is satisfied, further testing is recommended by Andrews and Martin (2000).

Samples from the fine grained soil layers (silt and clay) collected from either the open-ended Becker test holes (disturbed grab samples) and mud rotary drill holes (shelby tube samples) were tested. The results of the Atterberg limit and hydrometer tests were used to assess the liquefaction potential of the silt/clay based on the Chinese criteria and Andrews and Martin criteria. Figure VI-22 summarises the results from liquefaction assessment of ten samples taken from BOC02-05, BOC02-06, BOC02-08, BOC02-09 and DH02-01 using the Chinese criteria. None of the samples satisfied the Chinese criteria, and the clay content (<0.005 mm) in all the samples is very high (>40%), suggesting that the tested fine grained soils will likely not be susceptible to liquefaction.

The liquefaction assessment of the same samples using Andrews and Martin criteria is shown on Figure VI-23. Again, all the silt and clay samples are shown to be not likely susceptible to liquefaction.

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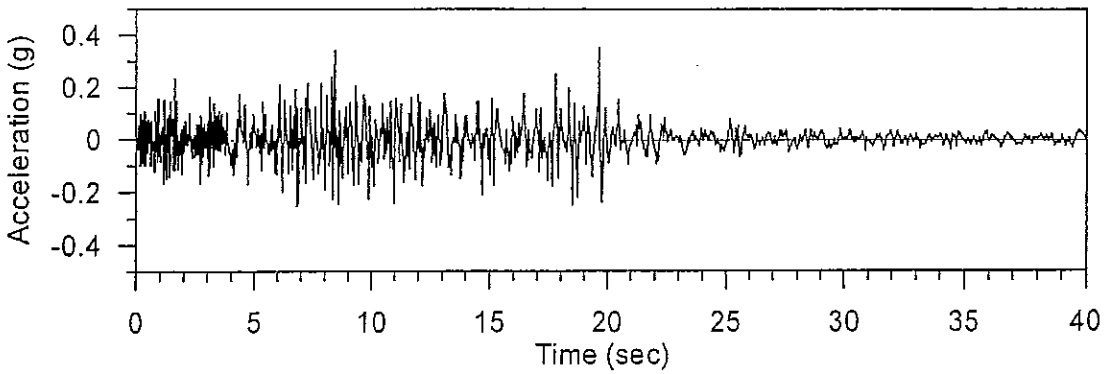
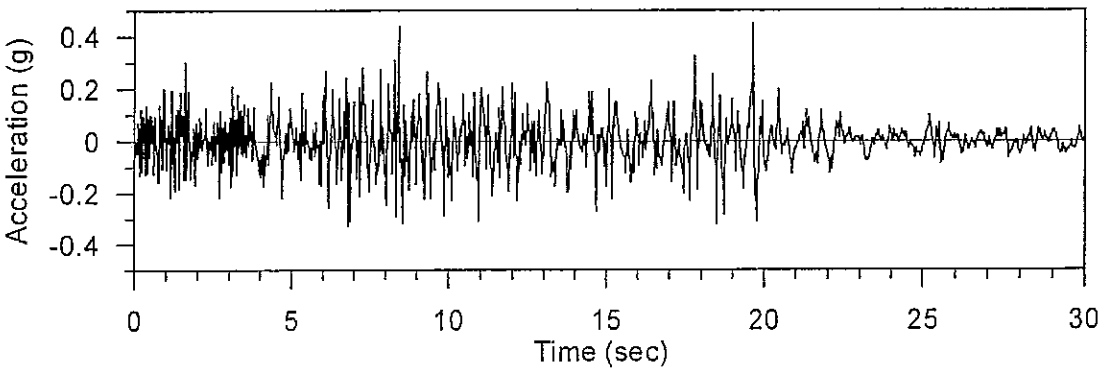


A_{max}=0.35g, 475 Year Synthetic EQ Record, M=7.6



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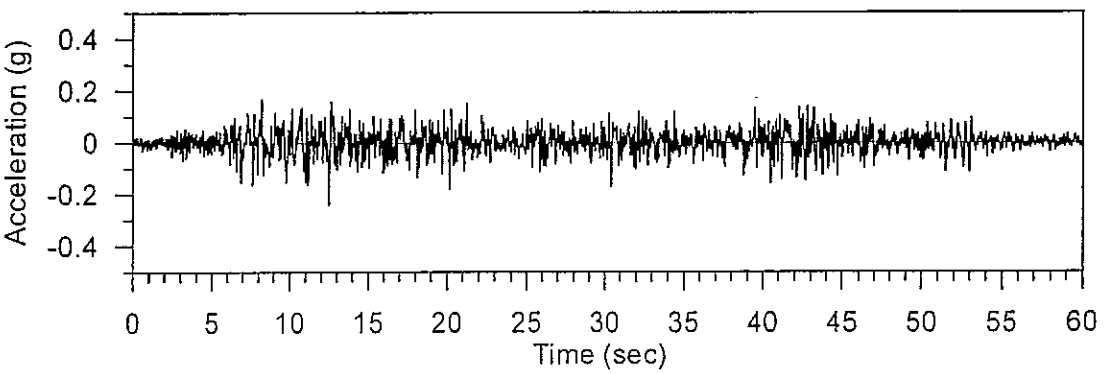


A_{max}=0.24g, Cascadia Subduction EQ, M=8.2

Figure VI-1 Synthetic Acceleration Time Histories

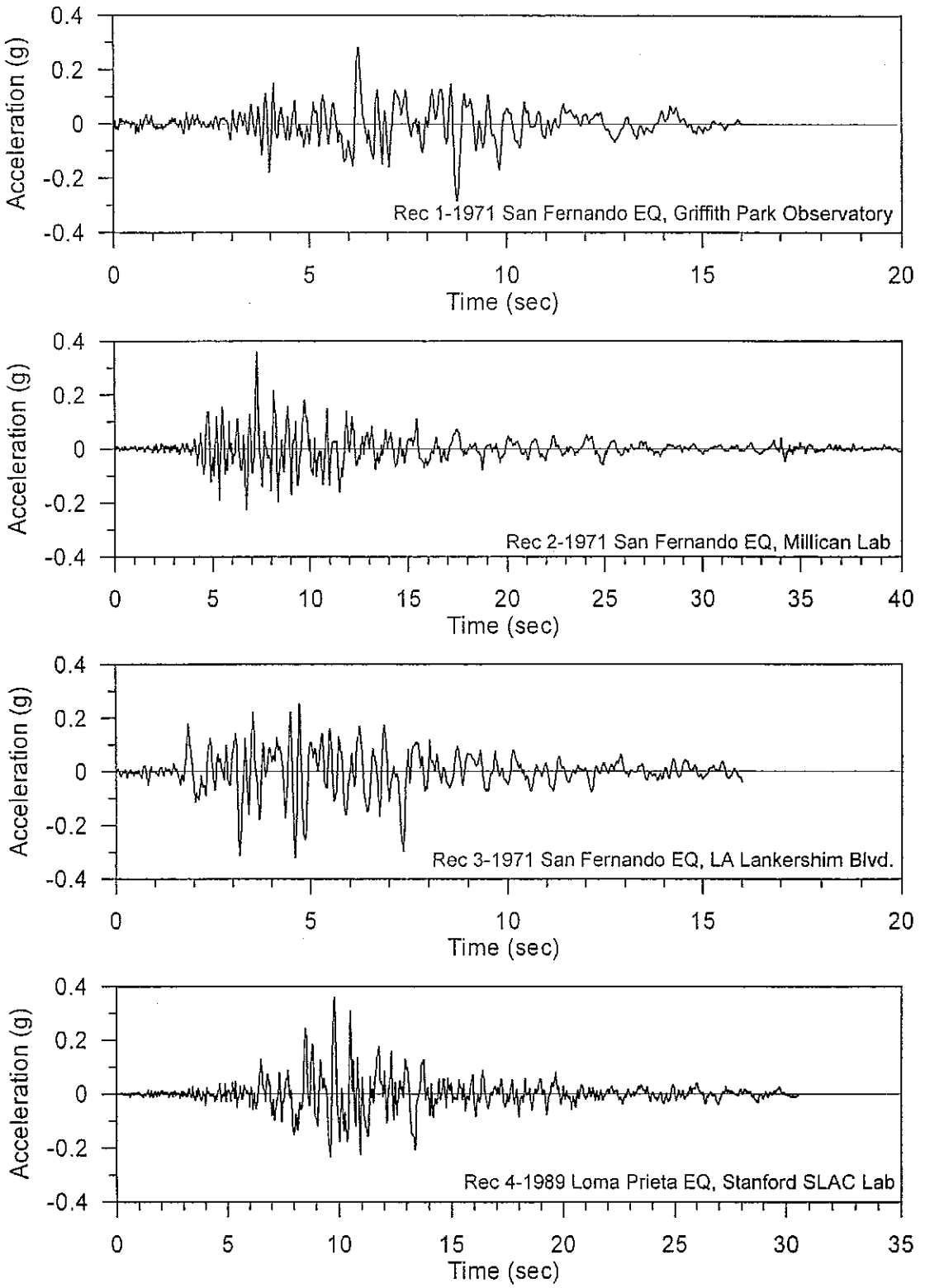


Figure VI-2 Scaled Natural Acceleration Time Histories (Rec 1-4)

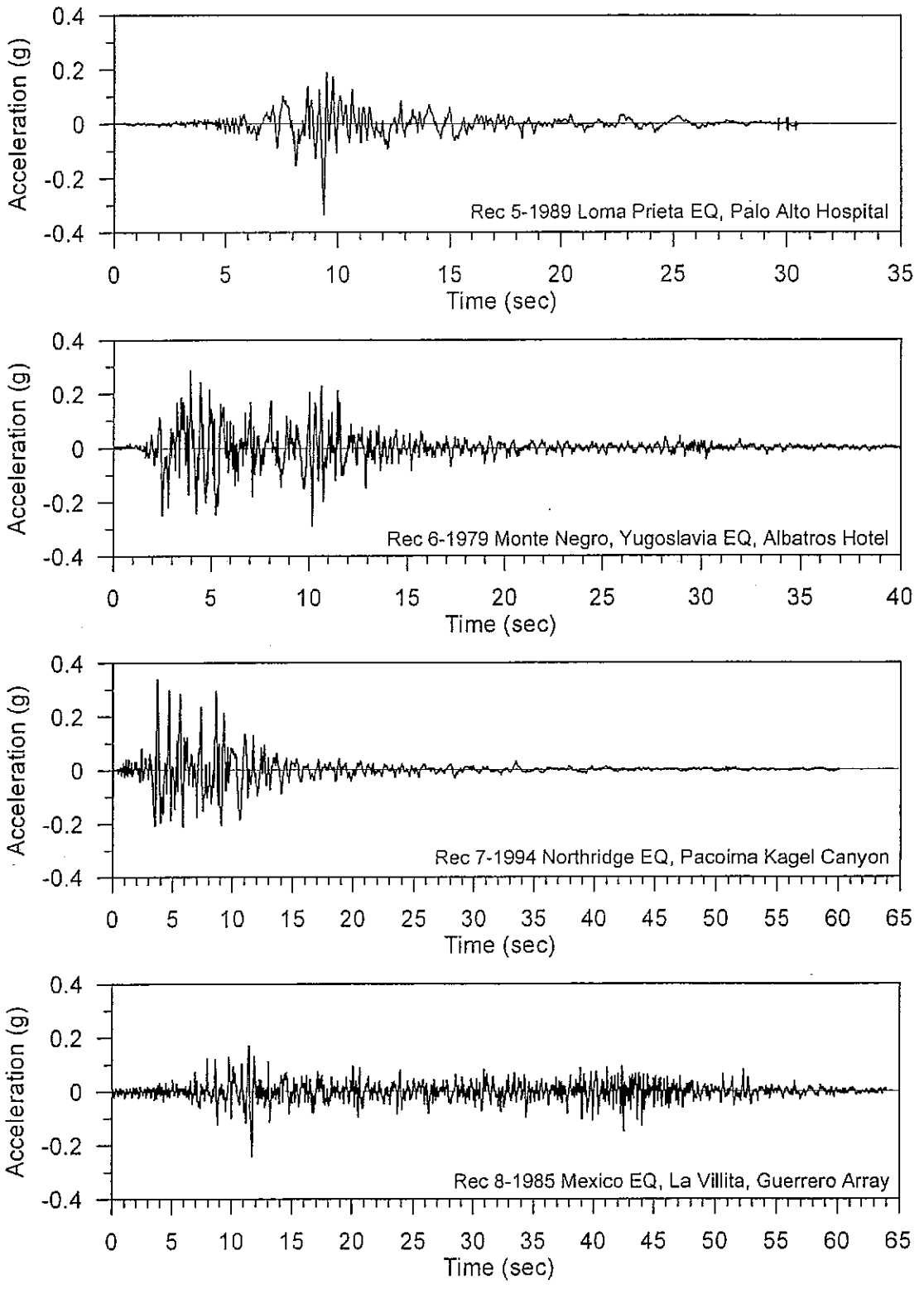


Figure VI-3 Scaled Natural Acceleration Time Histories (Rec 5-8)

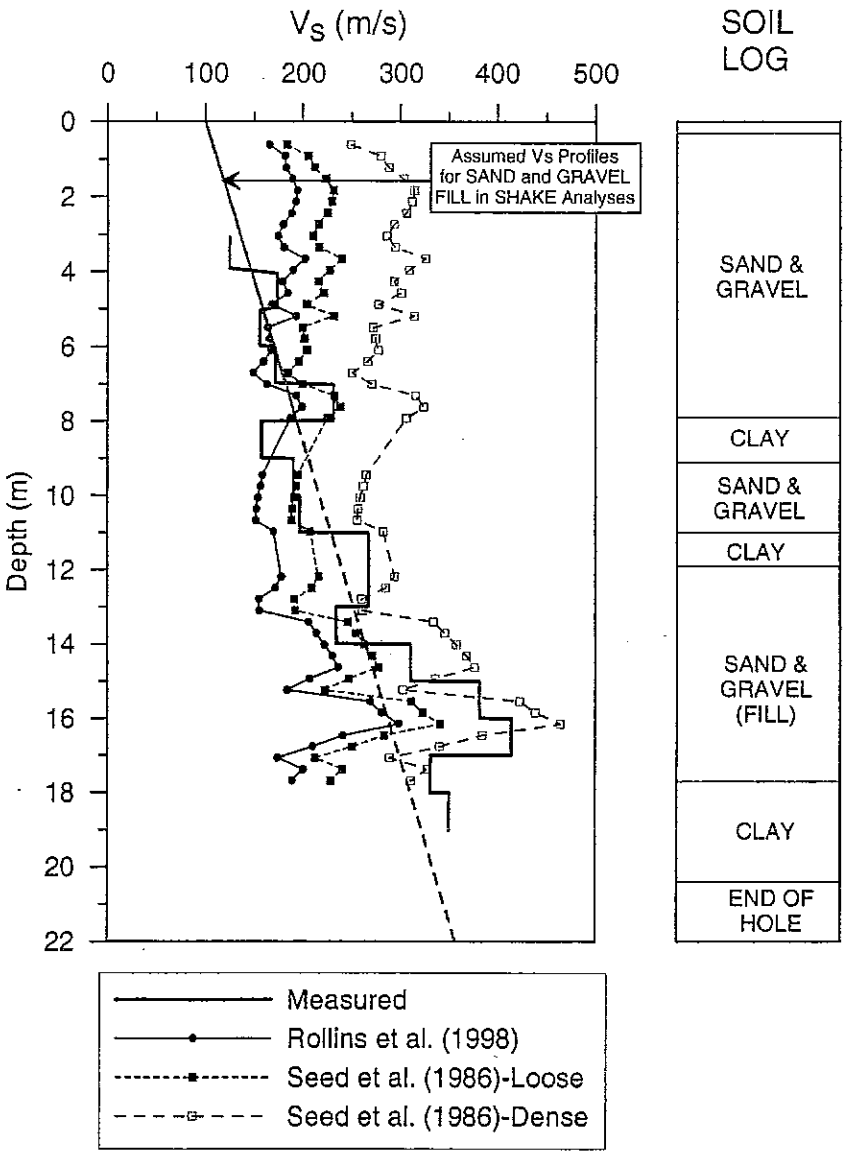


Figure VI-4 Comparison of Shear Wave Velocity Profiles at BPT02-04

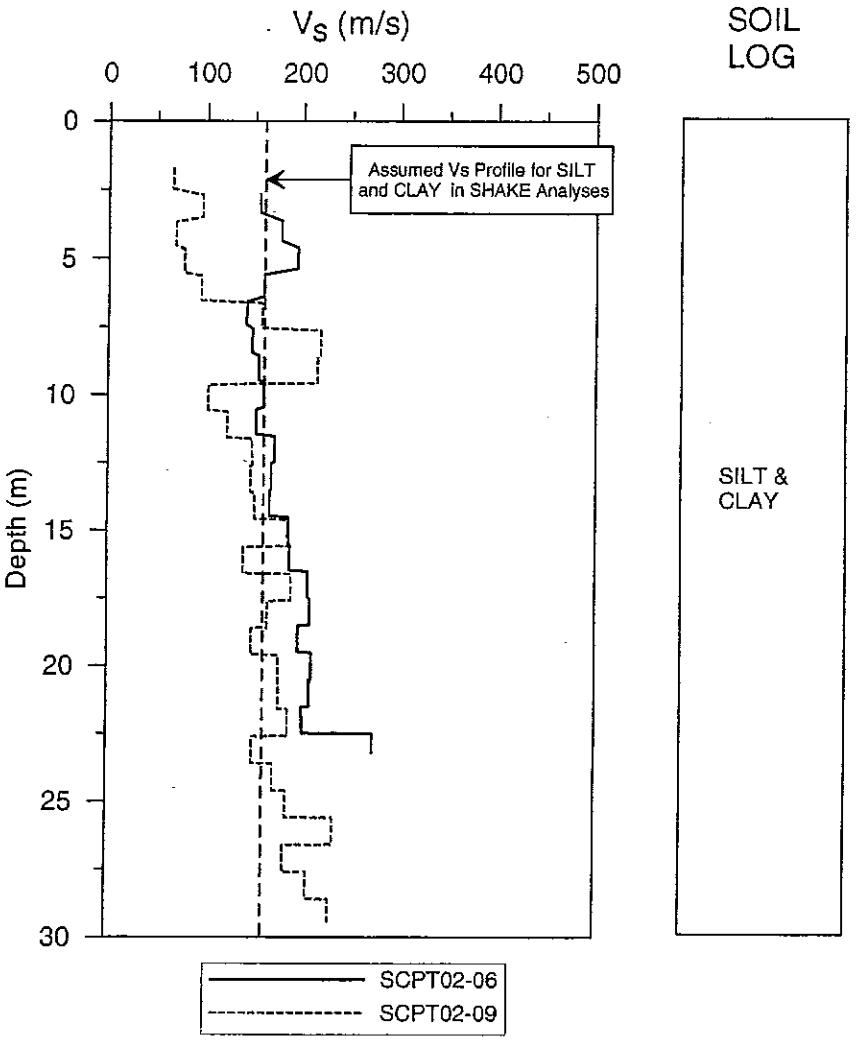


Figure VI-5 Measured Shear Wave Velocity Profiles at SCPT02-06 and SCPT02-09

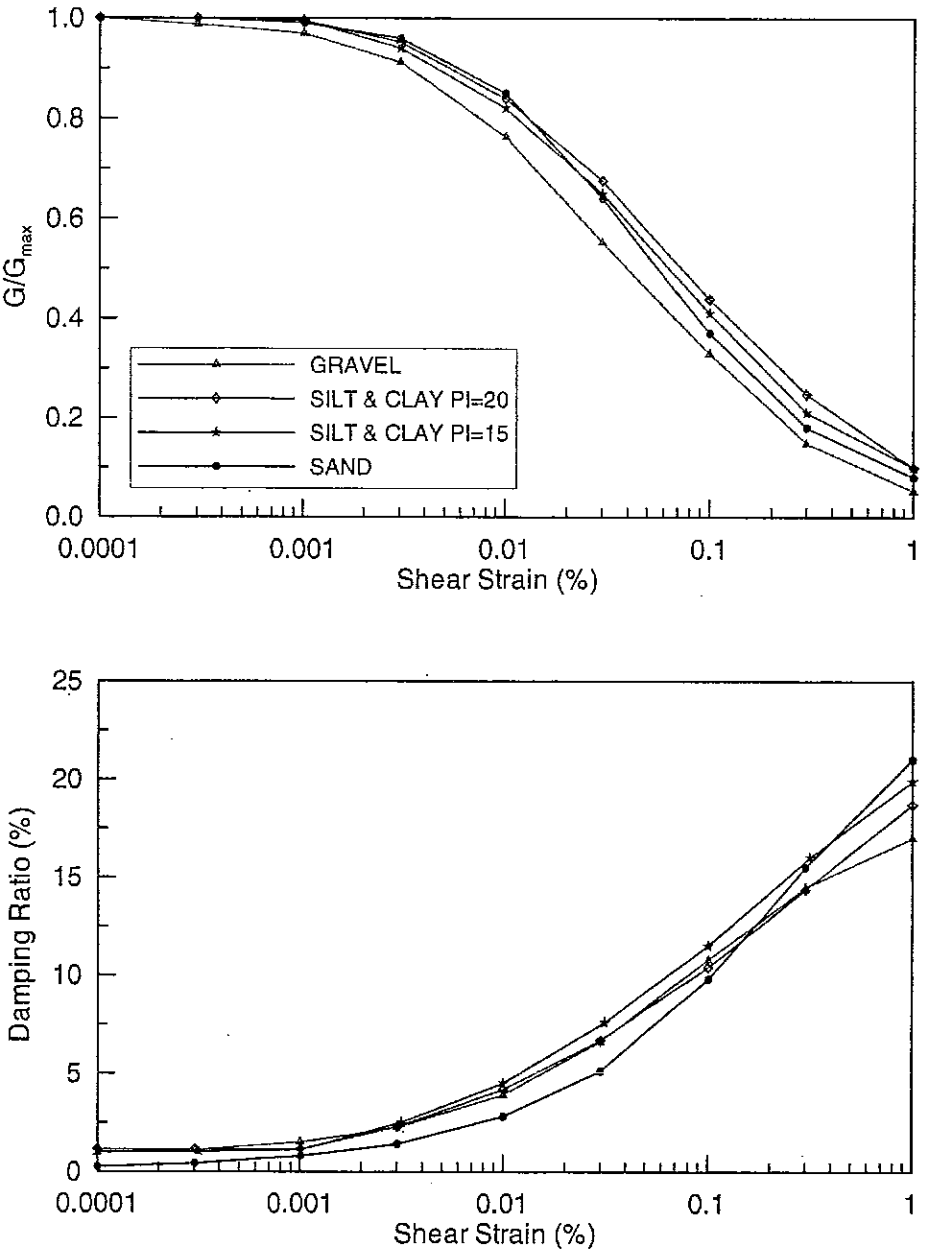


Figure VI-6 Modulus Reduction and Damping Curves Used in SHAKE Analyses

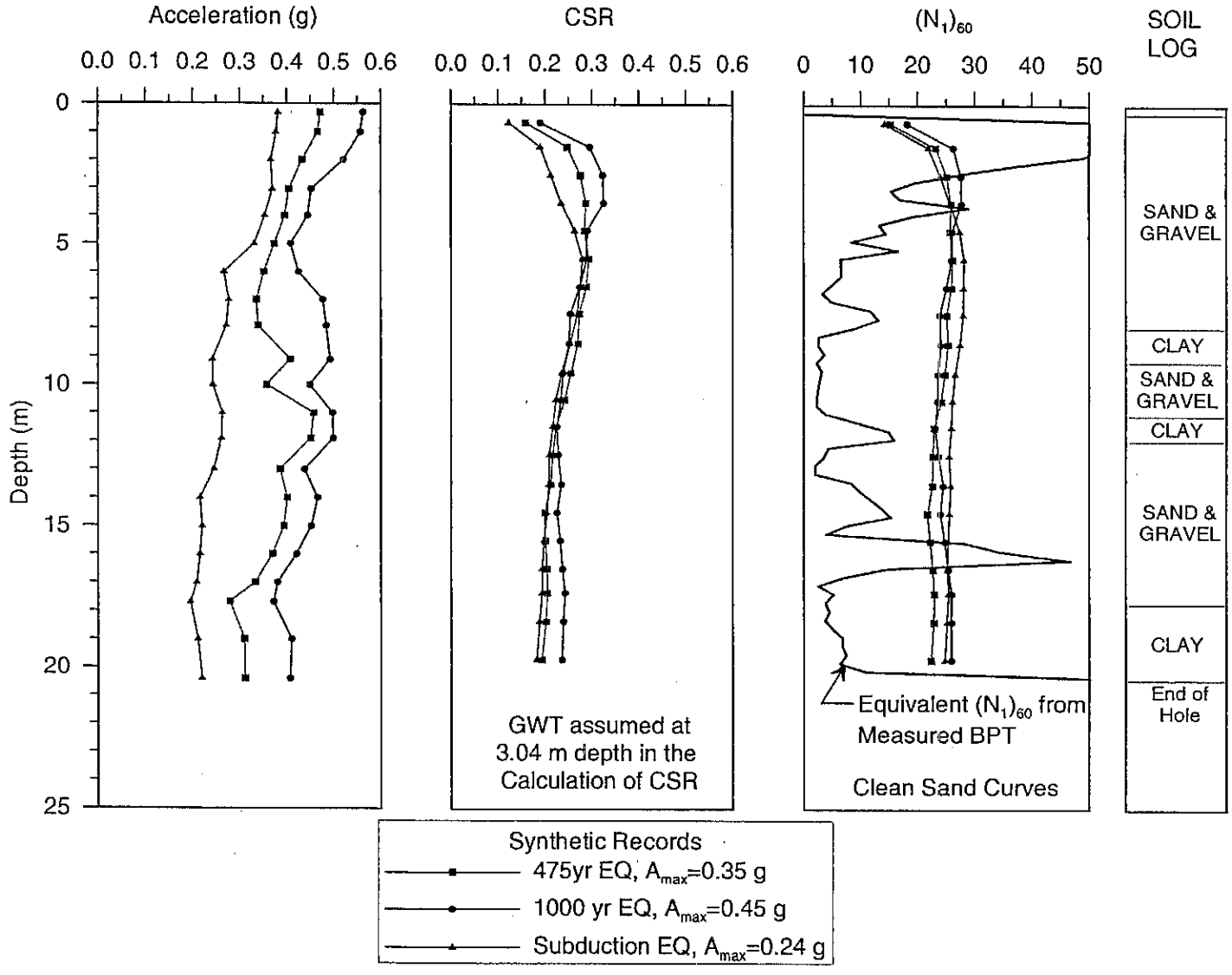


Figure VI-7 Liquefaction Assessment Using Synthetic Records at BPT02-04

KLOHN CRIPPEN

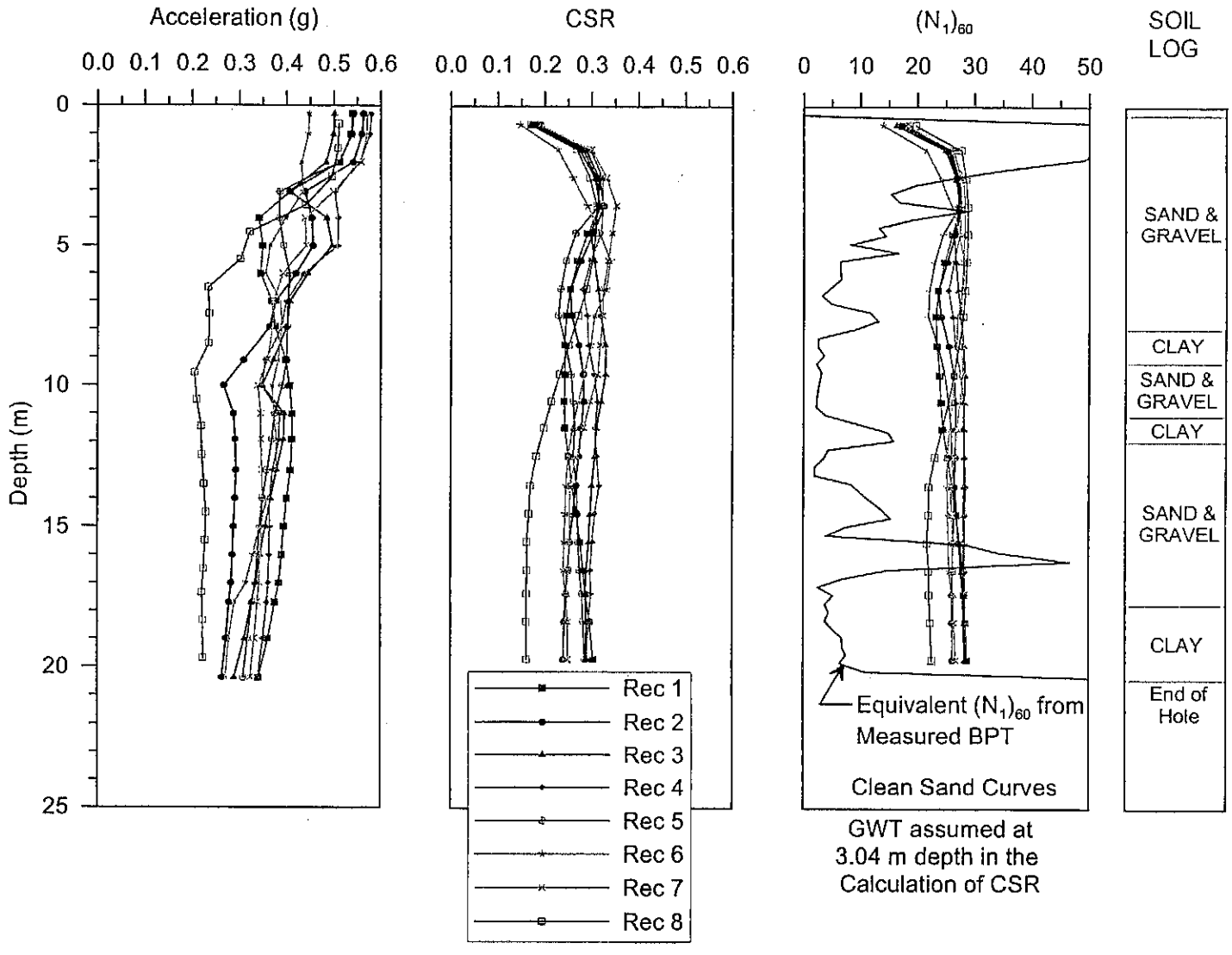


Figure VI-8 Liquefaction Assessment Using Scaled Natural Records at BPT02-04

KLOHN CRIPPEN

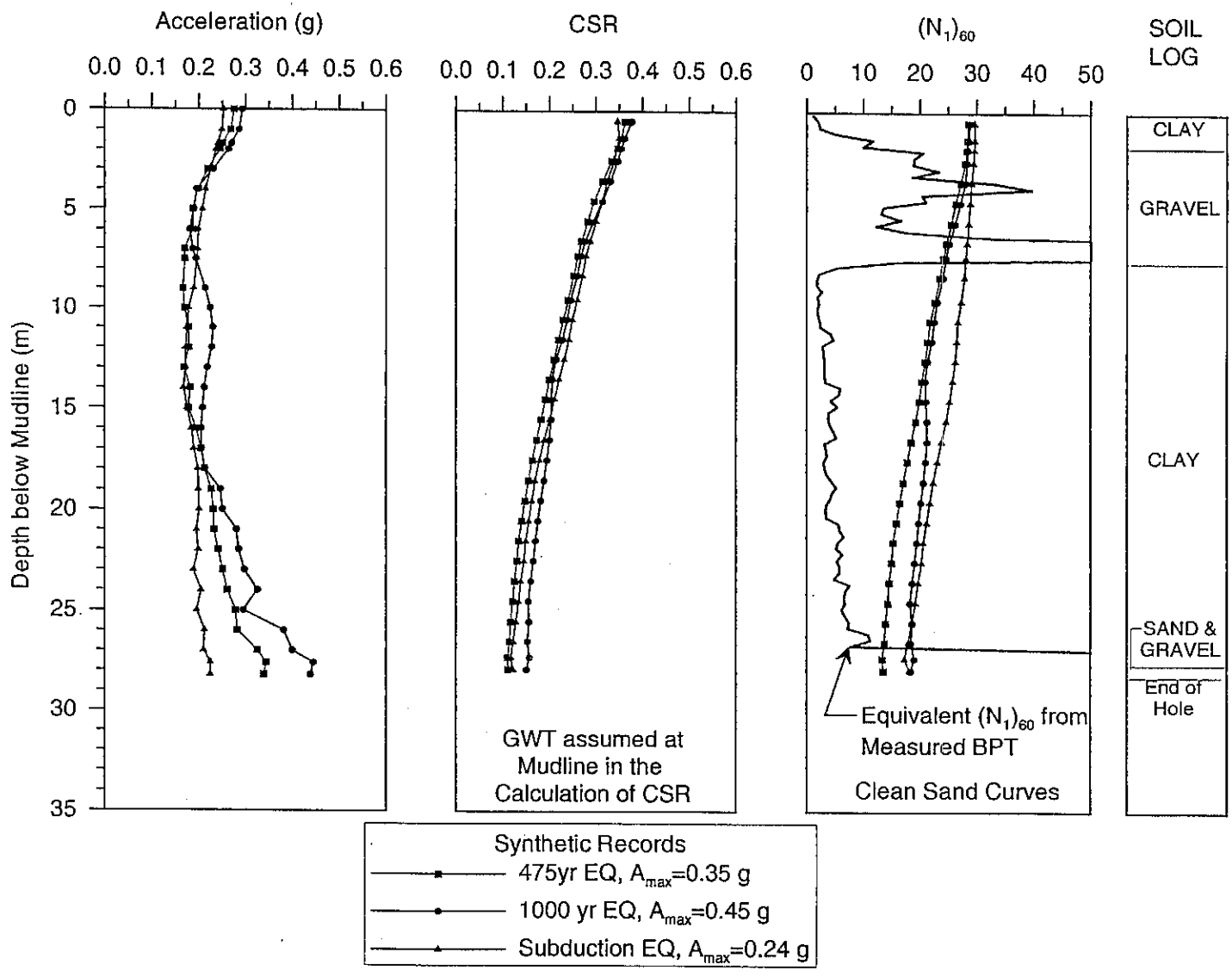


Figure VI-9 Liquefaction Assessment Using Synthetic Records at BPT02-05

KLOHN CRIPPEN

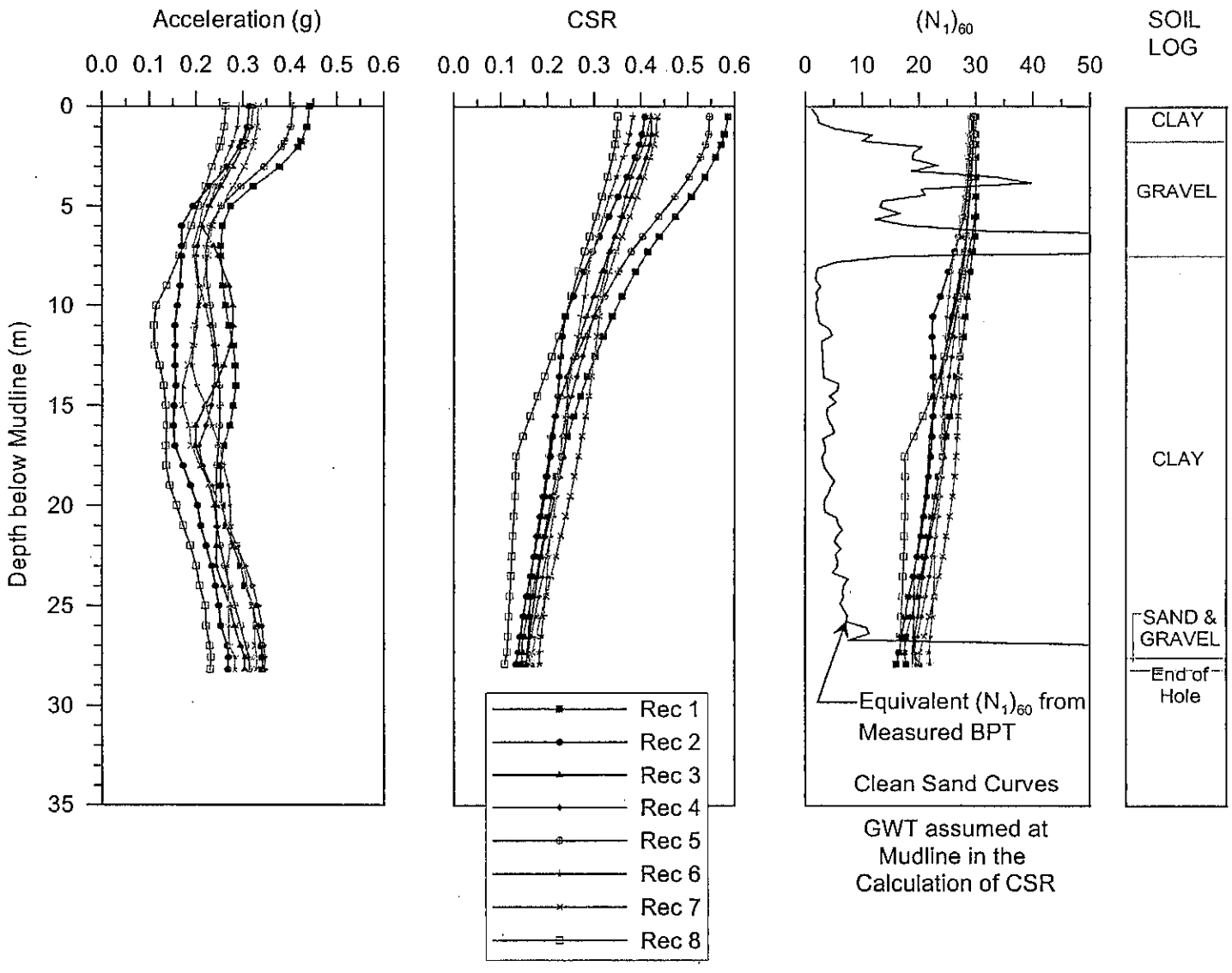


Figure VI-10 Liquefaction Assessment Using Scaled Natural Records at BPT02-05

KLOHN CRIPPEN

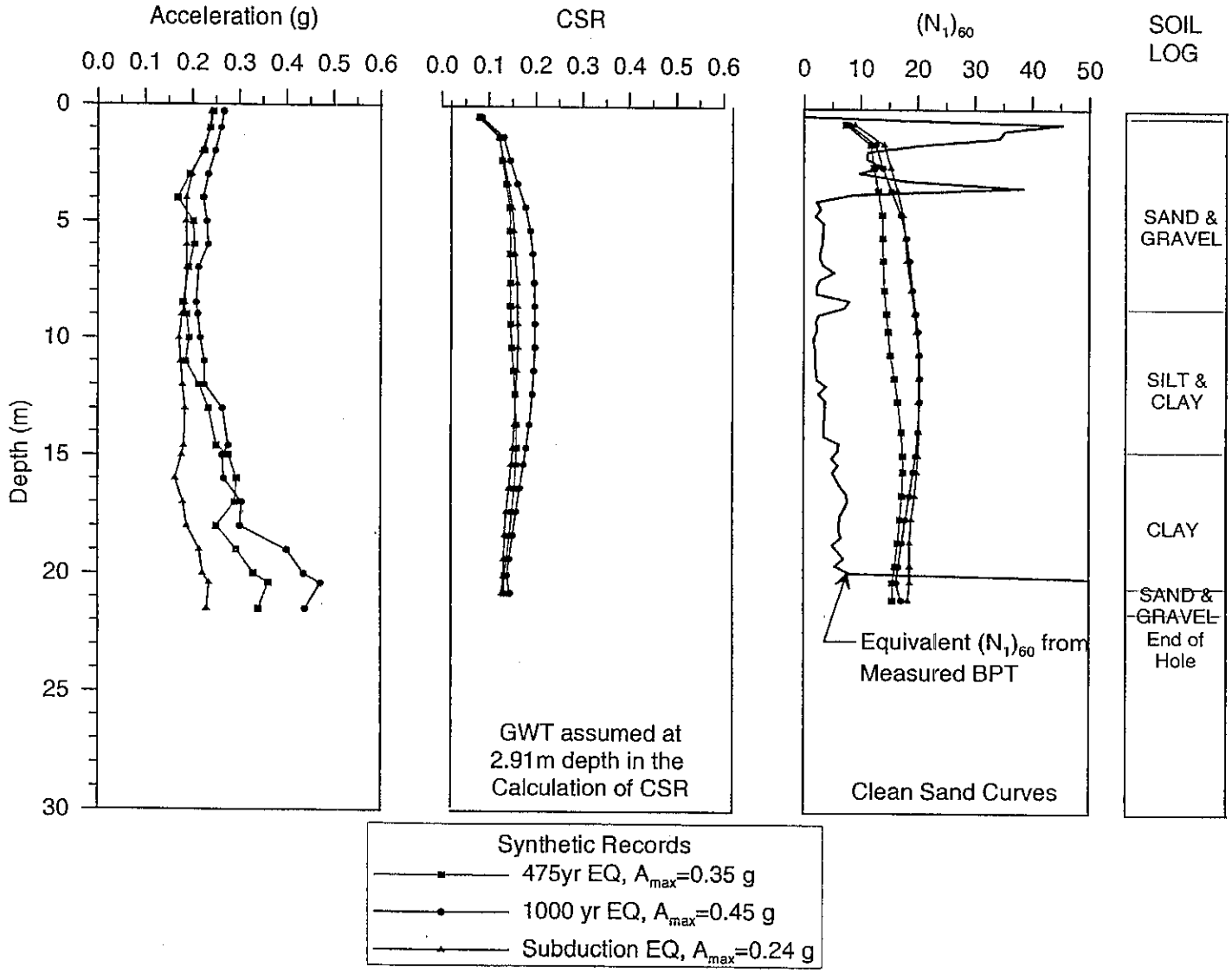


Figure VI-11 Liquefaction Assessment Using Synthetic Records at BPT02-06

KLOHN CRIPPEN

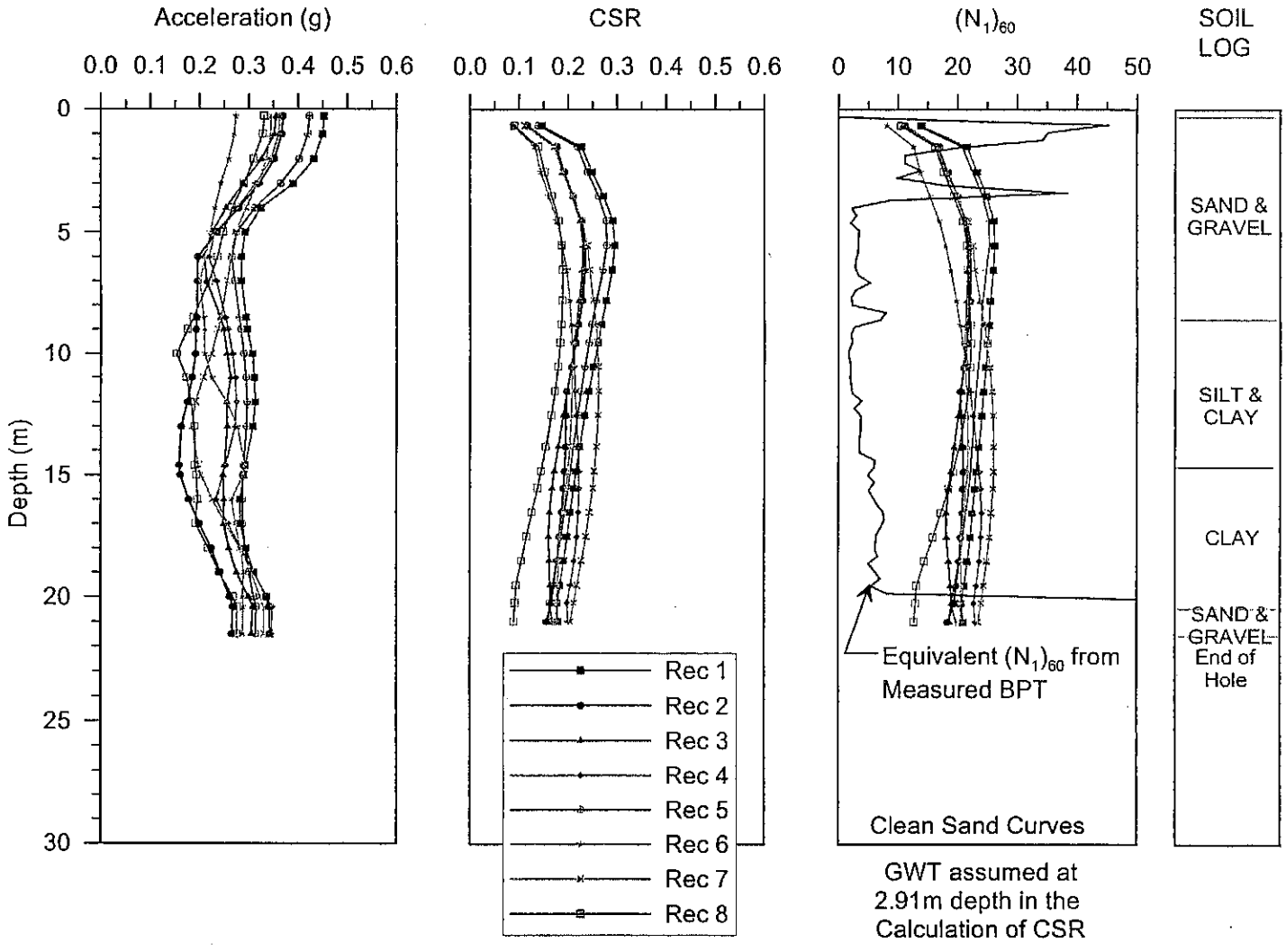


Figure VI-12 Liquefaction Assessment Using Scaled Natural Records at BPT02-06

KLOHN CRIPPEN

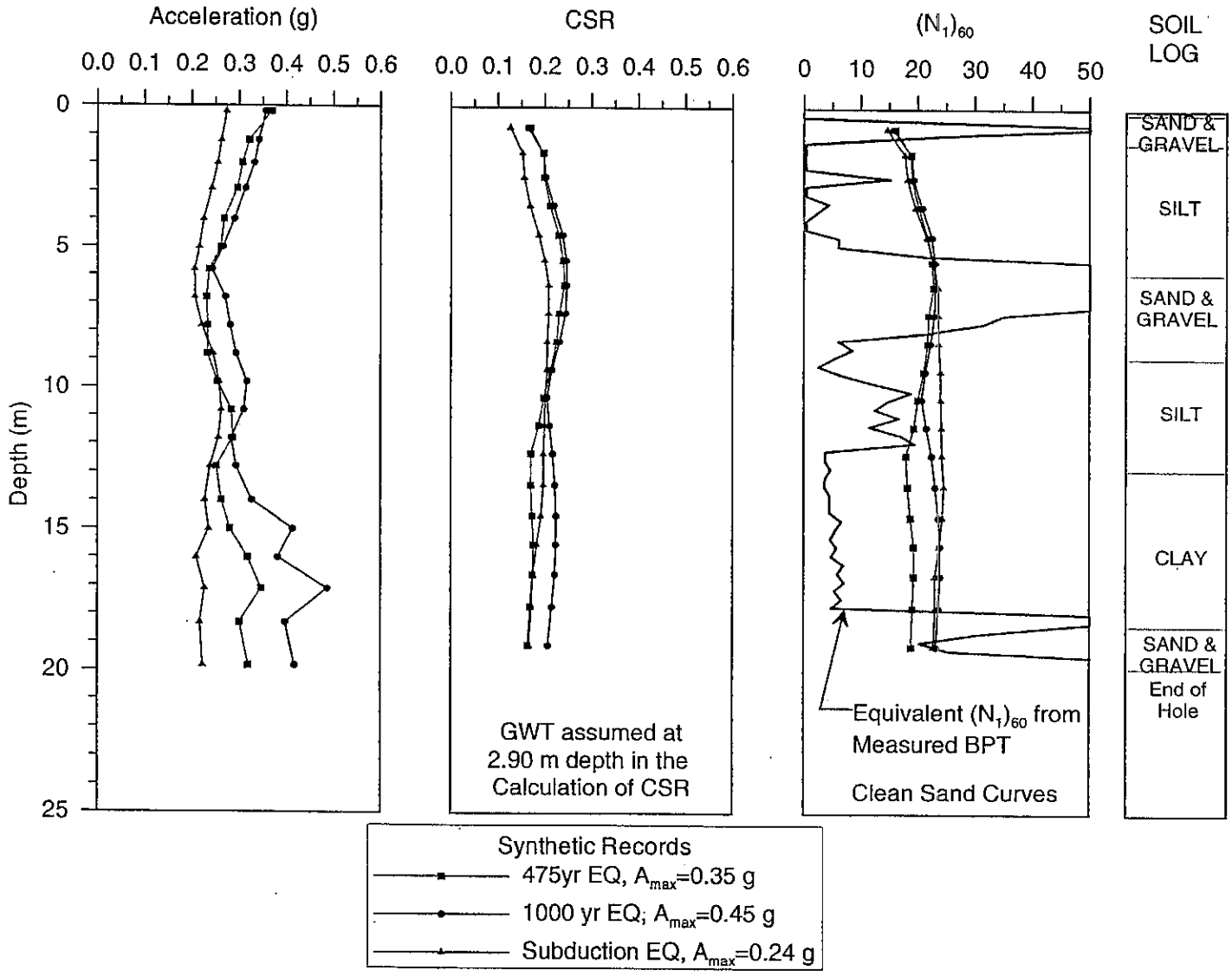


Figure VI-13 Liquefaction Assessment Using Synthetic Records at BPT02-08

KLOHN CRIPPEN

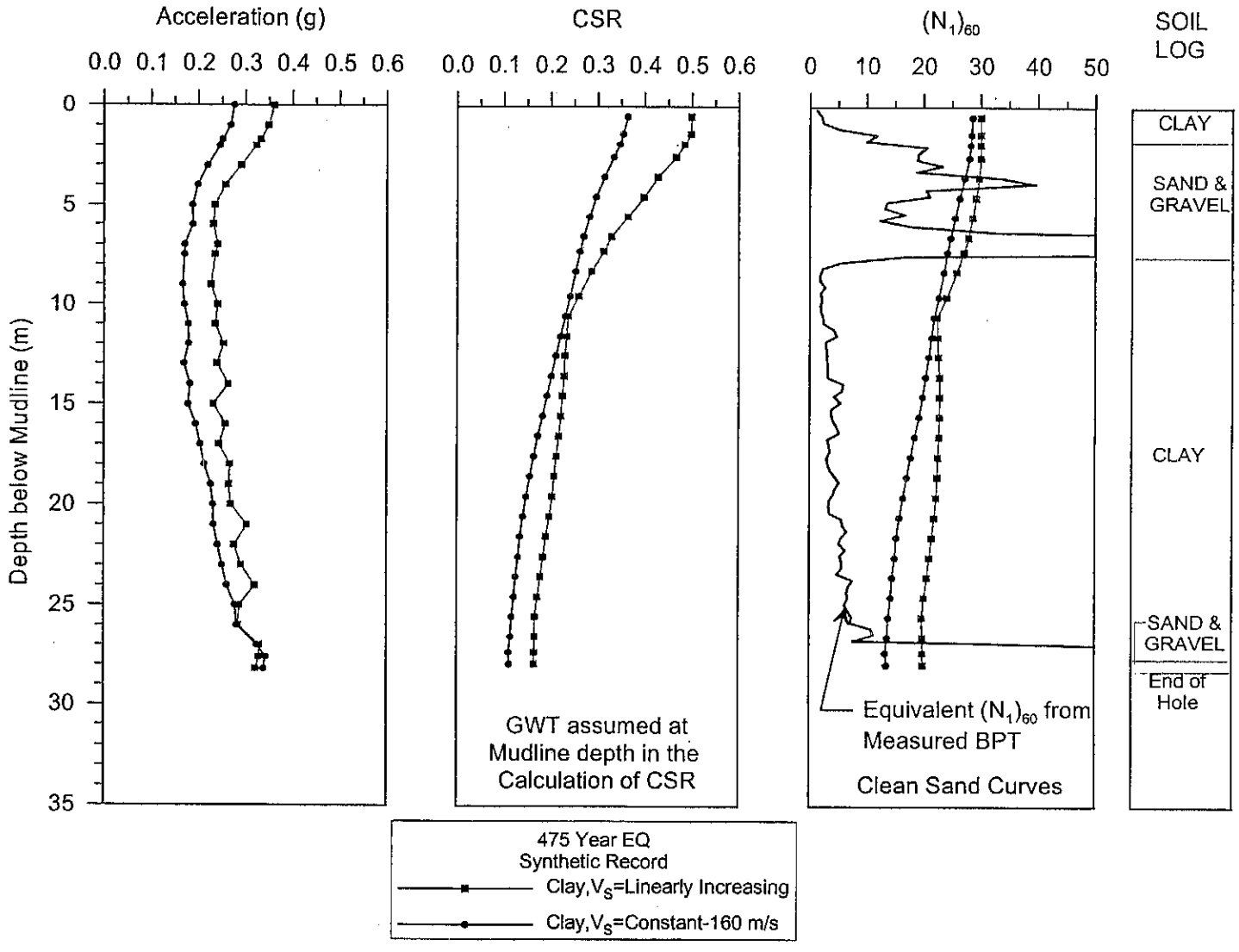


Figure VI-20 Sensitivity of Vs of Clay on the Liquefaction Potential at BPT02-05

KLOHN CRIPPEN

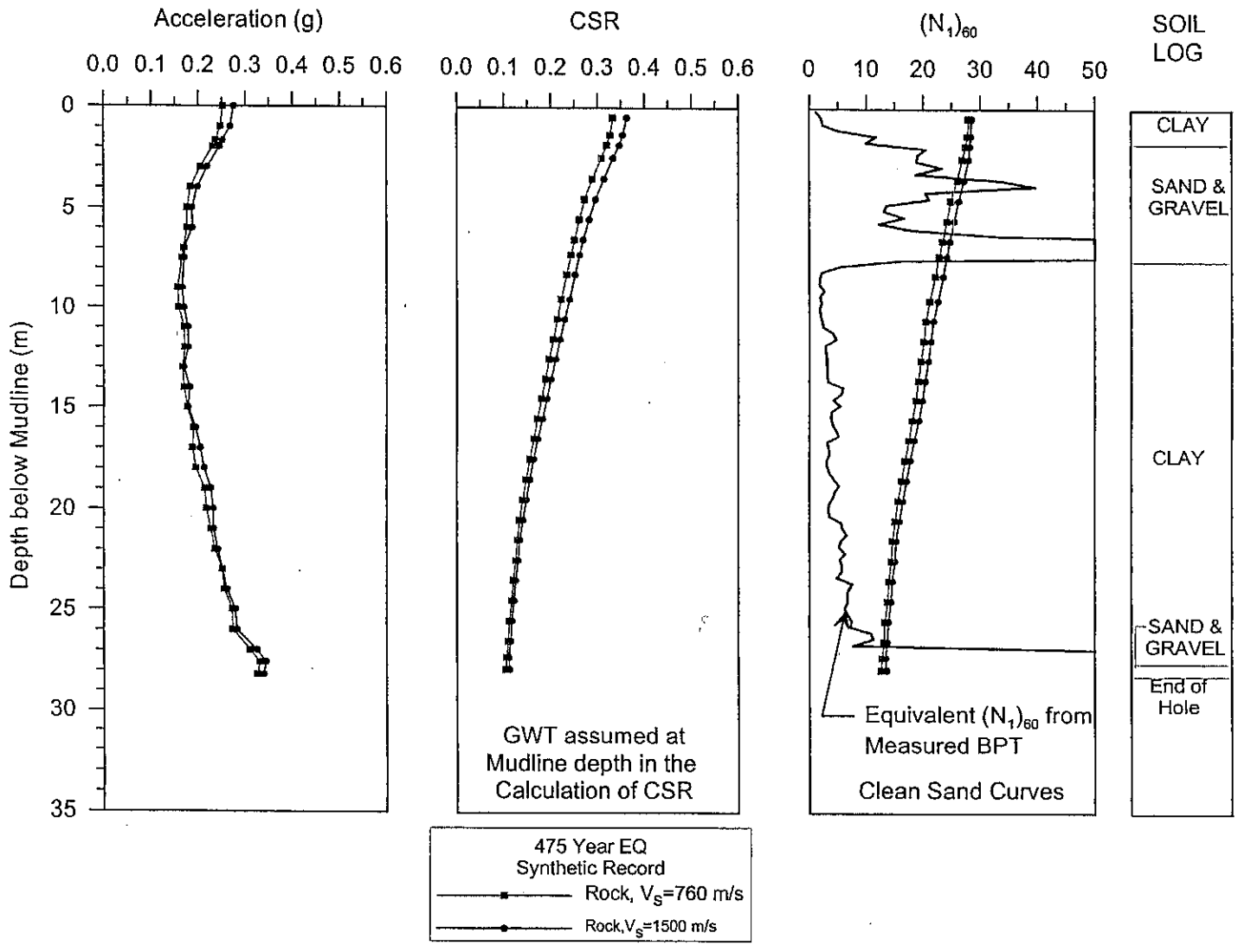
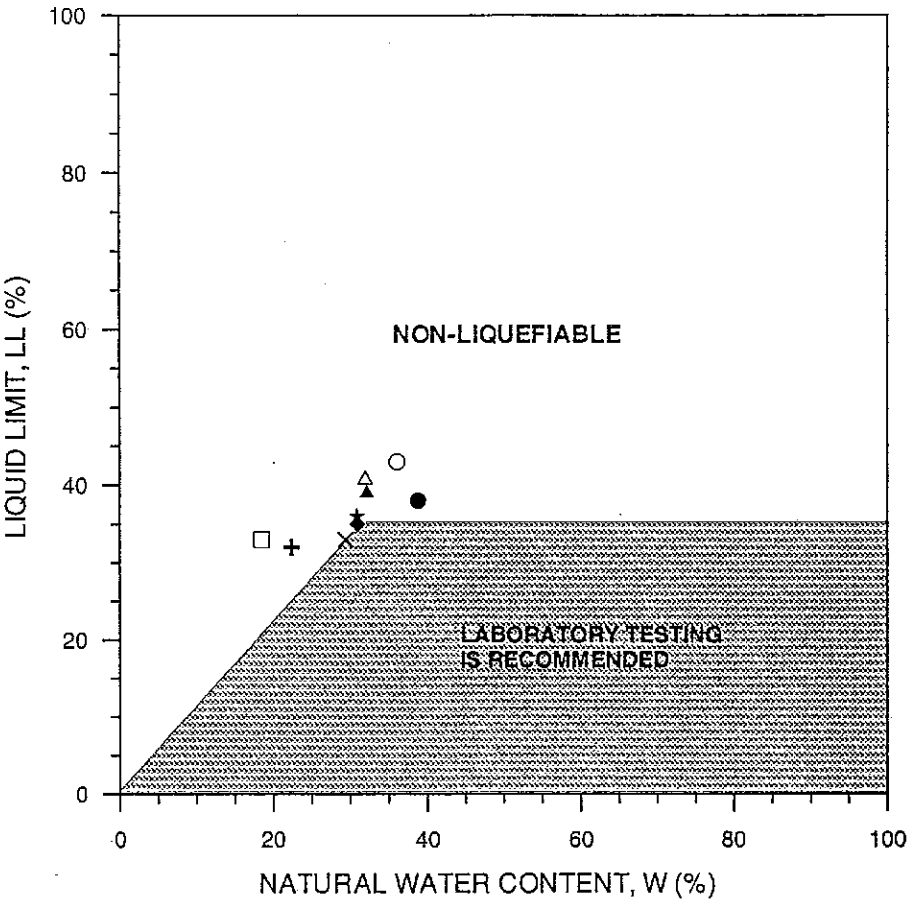


Figure VI-21 Sensitivity of Vs of Bedrock on the Liquefaction Potential at BPT02-05

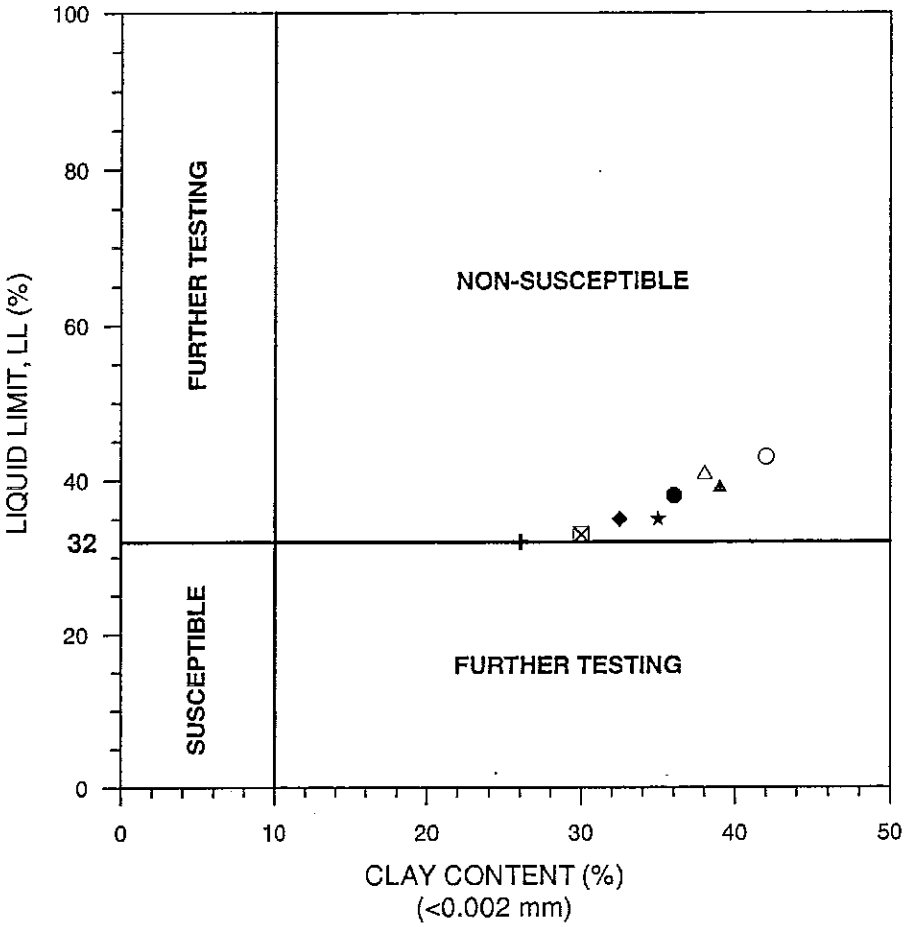
KLOHN CRIPPEN



Test Hole	Sample No.	Depth (m)	Moisture Content (%)	Liquid Limit (%)	Clay Content (<0.005 mm) (%)
BOC02-05	Grab 12	16.8	30.9	36	48
BOC02-05	Grab 15	21.8	38.8	38	53
BOC02-05	Grab 20	31.1	32.2	39	55
BOC02-06	Grab 5	9.0	22.4	32	35
BOC02-06	Grab 11	16.0	31.0	35	45
BOC02-08	Grab 3	4.1	29.4	33	40
BOC02-08	Grab 13	15.7	36.1	43	56
BOC02-09	SPT 24	25.5	32.0	41	52
DH02-01	Shelby 7	8.8	18.5	33	41

★ BOC02-05 (16.8 m)
● BOC02-05 (21.8 m)
▲ BOC02-05 (31.1 m)
✚ BOC02-06 (9.0 m)
◆ BOC02-06 (16.0 m)
× BOC02-08 (4.1 m)
○ BOC02-08 (15.7 m)
△ BOC02-09 (25.5 m)
□ DH02-01 (8.8 m)

Figure VI-22 Liquefaction Assessment of Fine Grained Soils Based on Chinese Criteria



Test Hole	Sample No.	Depth (m)	Liquid Limit (%)	Clay Content (<0.002 mm) (%)
BOC02-05	Grab 12	16.8	36	35
BOC02-05	Grab 15	21.8	38	36
BOC02-05	Grab 20	31.1	39	39
BOC02-06	Grab 5	9.0	32	26
BOC02-06	Grab 11	16.0	35	32.5
BOC02-08	Grab 3	4.1	33	30
BOC02-08	Grab 13	15.7	43	42
BOC02-09	SPT 24	25.5	41	38
DH02-01	Shelby 7	8.8	33	30

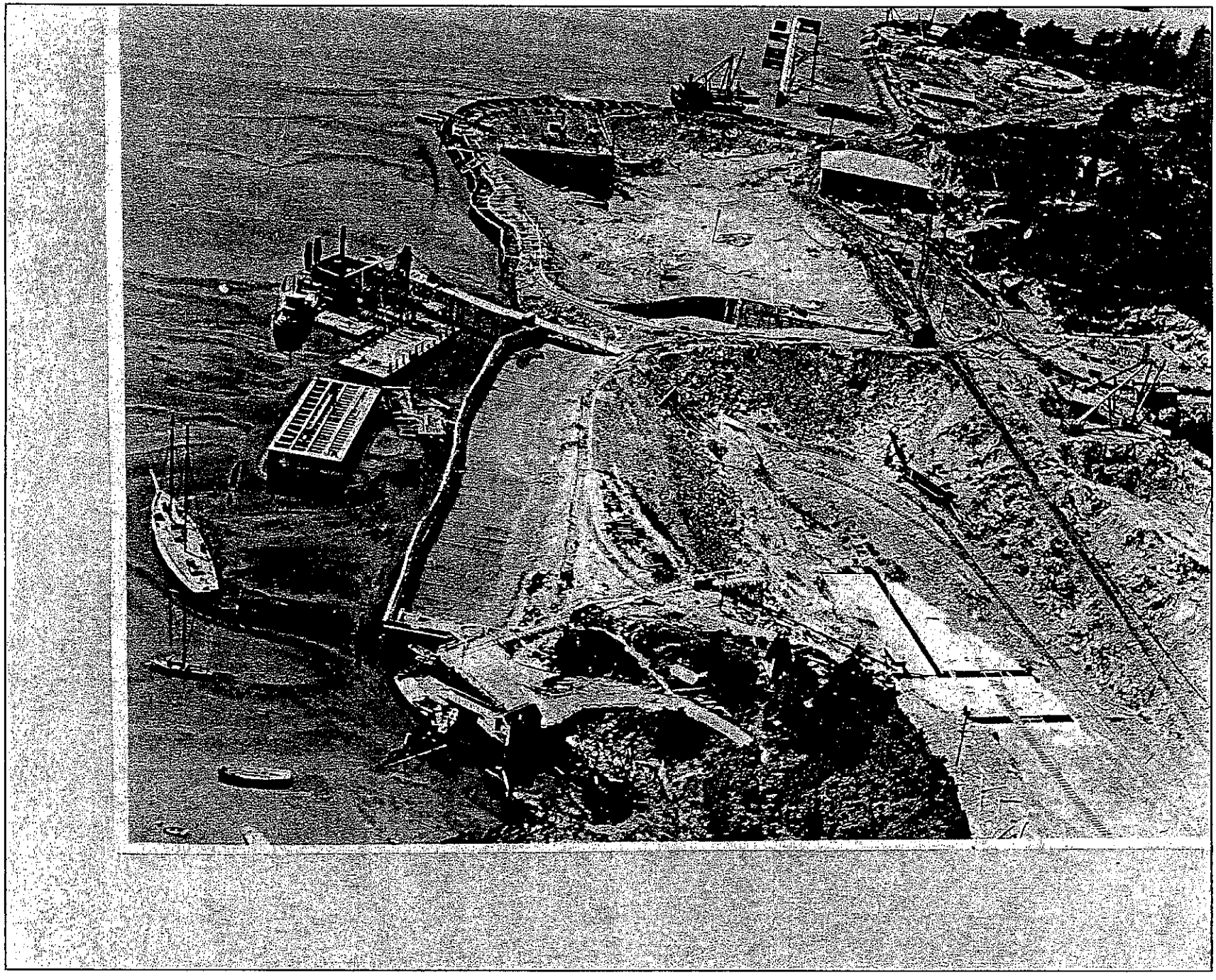
★ BOC02-05 (16.8 m)
● BOC02-05 (21.8 m)
▲ BOC02-05 (31.1 m)
+ BOC02-06 (9.0 m)
◆ BOC02-06 (16.0 m)
× BOC02-08 (4.1 m)
○ BOC02-08 (15.7 m)
△ BOC02-09 (25.5 m)
□ DH02-01 (8.8 m)

Figure VI-23 Liquefaction Assessment of Fine Grained Soils Based on Andrews and Martin (2000) Criteria

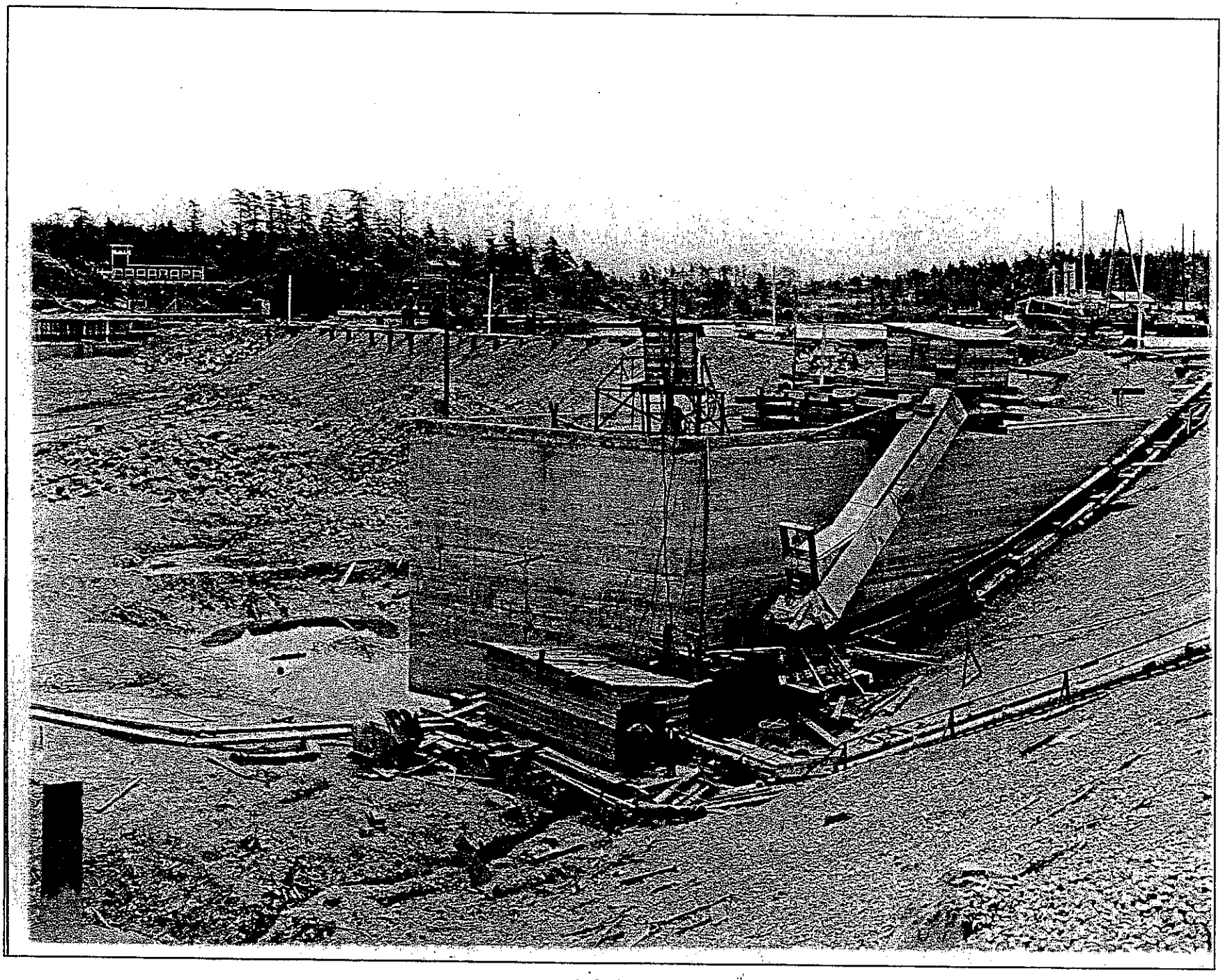
APPENDIX VII

Selected Original Construction Photographs and Drawings

1922



1923



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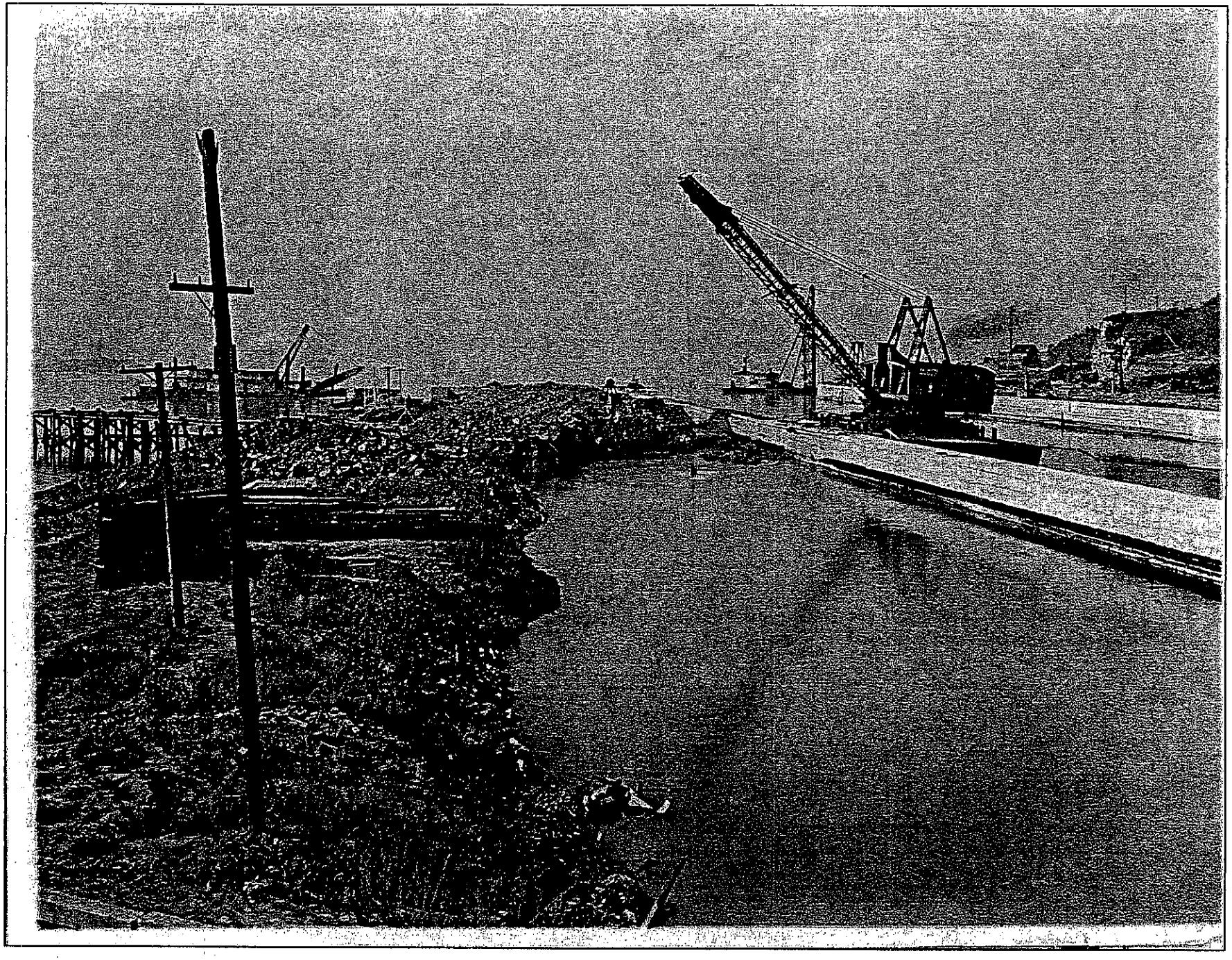
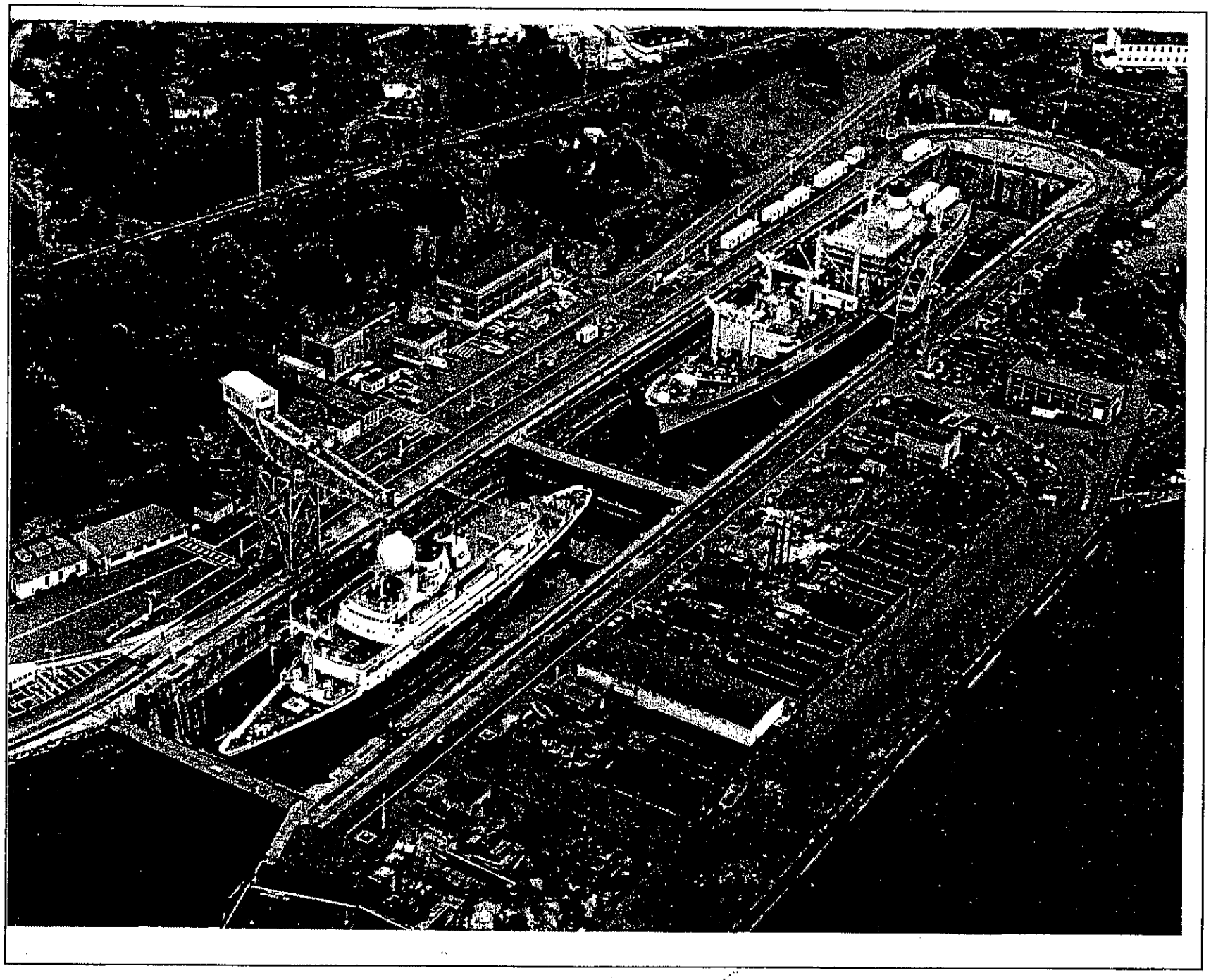


1925

1969



1977

NOTE:
FOR SECTIONS AT STATIONS 0+00 TO 13+00
SEE SHEET No 3

SCALE OF FEET

ADMIRALS ROAD

PUMP HOUSE No 2

BOUNDARY OF TOWNSITE OF ESQUIMALT

BOUNDARY OF ROYAL NAVAL RESERVE

GRAVING DOCK

COFFERDAM

ABERDEEN ST.

LIVERPOOL ST.

PUMP HOUSE No 1

SOUTH LANDING WHARF

EXTENSION (BUILT 1940)

BUILT 1941-42

LANDING WHARF

FENDER WHARF (BUILT 1943)

DOLPHIN

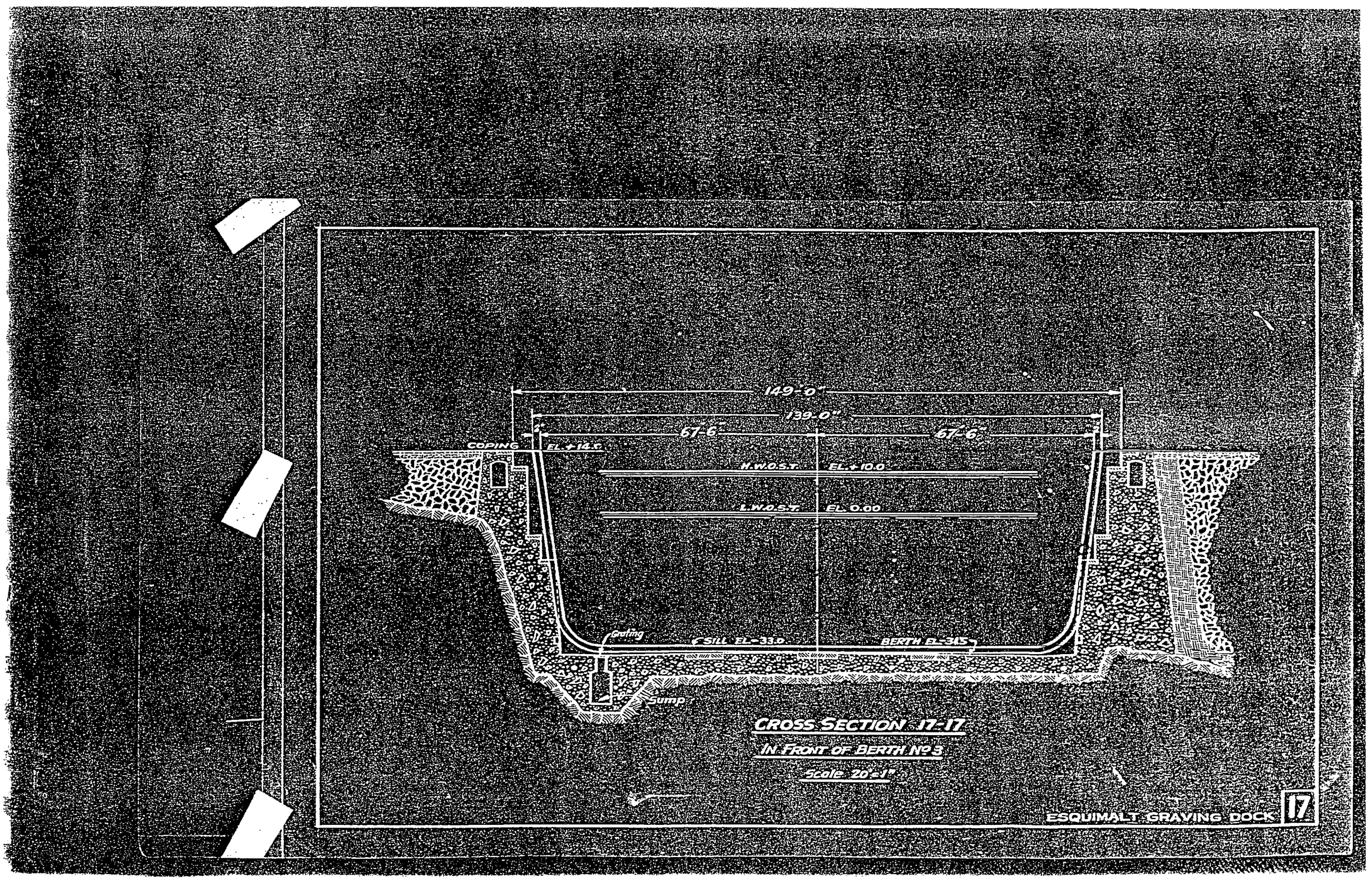
SEE SHEETS 33A, 37 & CONTRACT PLANS 937, 996 & 1006

PLAN SHOWING
CONTOURS AND LOCATION OF DOCK AND WHARVES

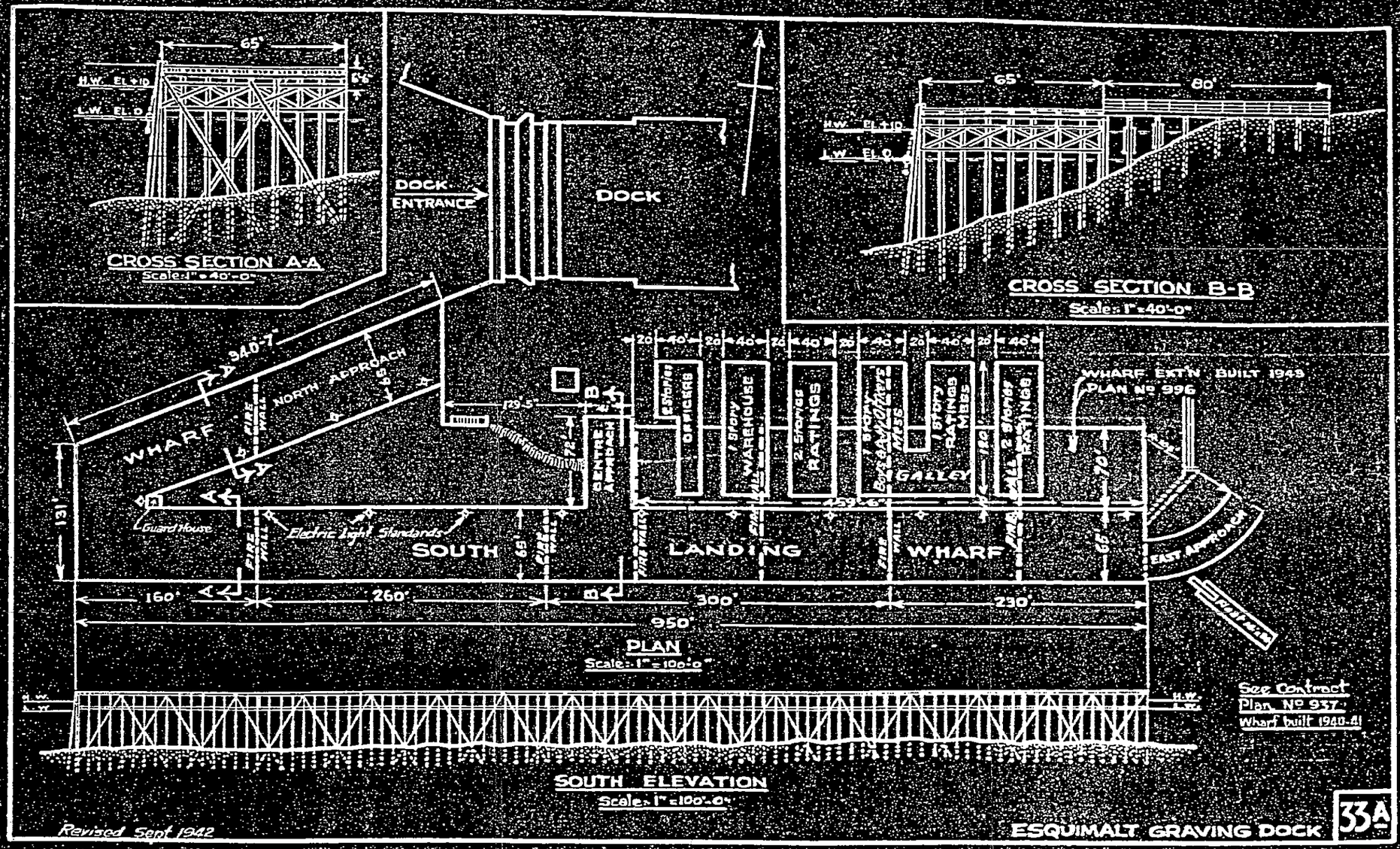
Revised Dec. 1942 - Revised Feb. 1943

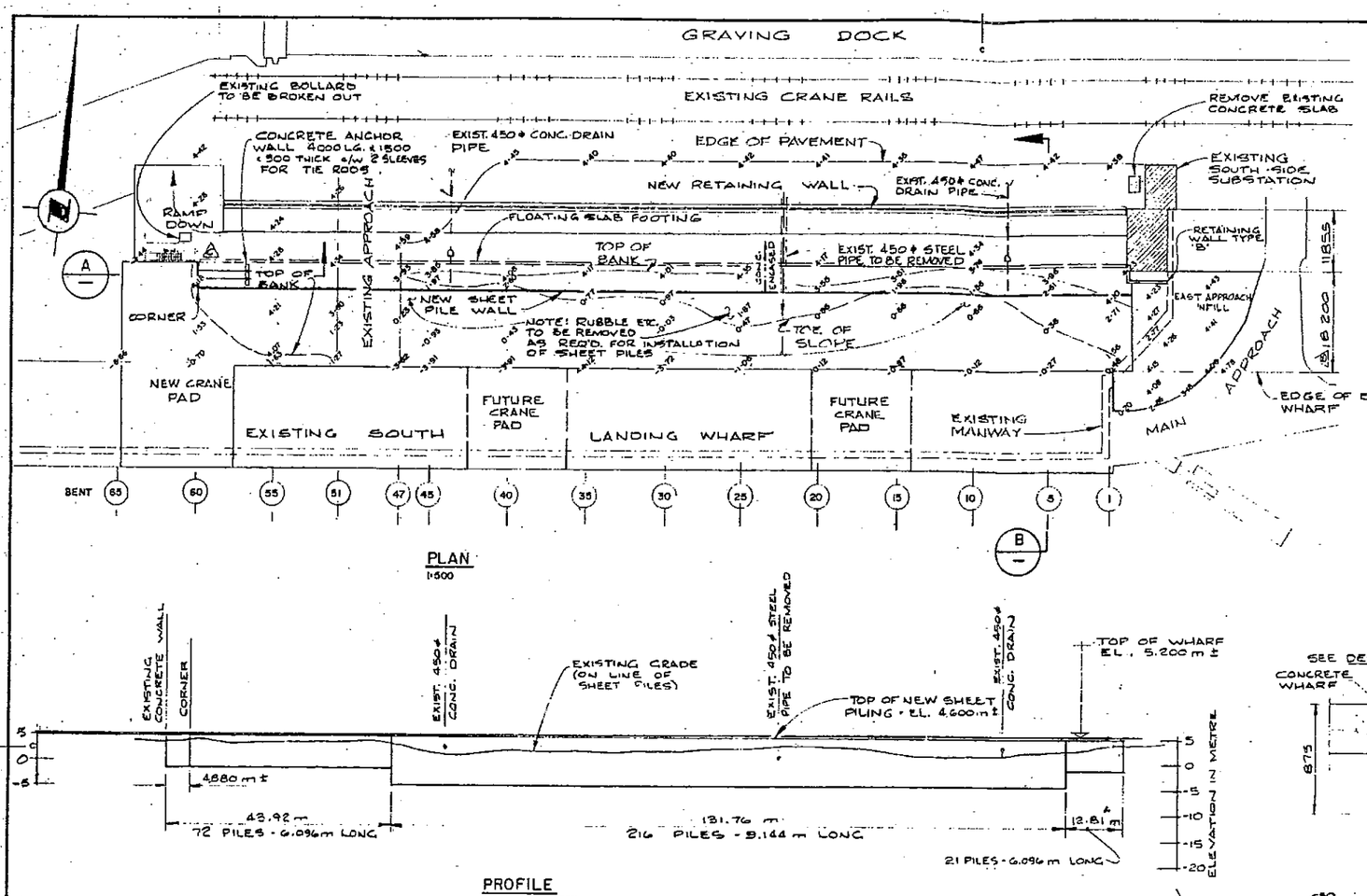
Revised May 1943 - Revised Dec. 1941

ESQUIMALT GRAVING DOCK 2

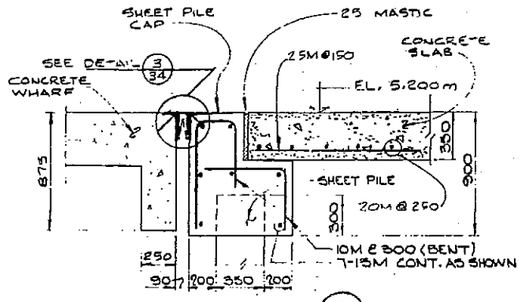


CROSS SECTION 17-17
IN FRONT OF BERTH No 3
Scale 20'=1"

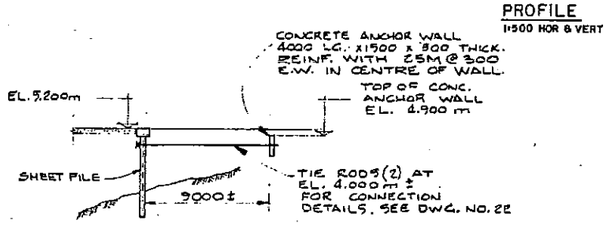

65'
H.W. EL +10
L.W. EL 0
CROSS SECTION A-A
Scale: 1" = 40'-0"
DOCK ENTRANCE
DOCK
65'
80'
H.W. EL +10
L.W. EL 0
CROSS SECTION B-B
Scale: 1" = 40'-0"
340'-7"
WHARF
NORTH APPROACH
FIRE WALL
CENTRE APPROACH
83'-5"
20
40'
20
40'
20
40'
20
40'
20
40'
20
40'
2 Storey OFFICERS
1 Story WAREHOUSE
2 Storey RATINGS
1 Story BOAT & PAINT HOUSE
1 Story RATINGS MESS
GALLEY
2 Storey RATINGS
WHARF EXT'N BUILT 1943 PLAN No 996
131'
Guard House
Electric Light Standards
SOUTH
LANDING
WHARF
65'
EAST APPROACH
160'
260'
300'
230'
950'
PLAN
Scale: 1" = 100'-0"
See Contract Plan No 937. Wharf built 1940-41
SOUTH ELEVATION
Scale: 1" = 100'-0"
Revised Sept 1942
ESQUIMALT GRAVING DOCK
33A



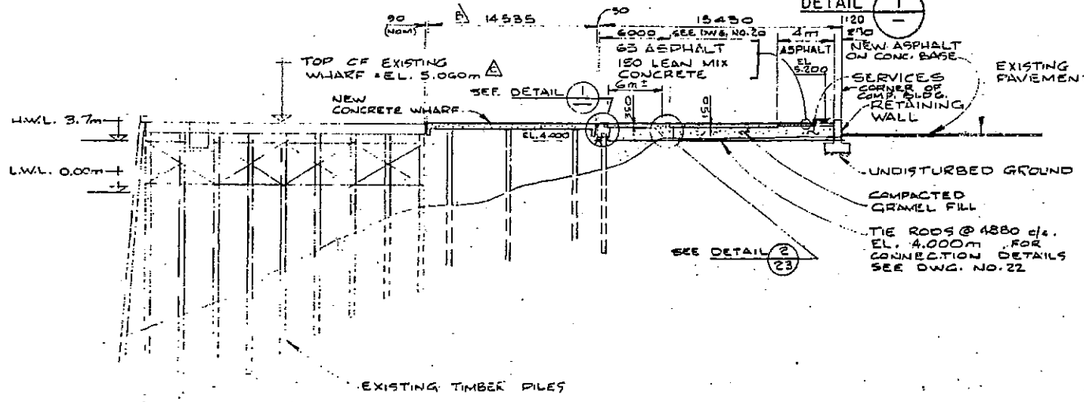
PLAN
1:500



PROFILE
1:500 HOR & VERT



SECTION A
1:200



SECTION B
1:200

BENT 5

SHEET PILE SCHEDULE	
PILES SUPPLIED BY OWNER : (CAPPCO K141Z)	121 @ 18.288 m 29 @ 6.096 m 2 @ 12.192 m 1 CORNER @ 12.192 m
PILES REQUIRED	OBTAIN FROM
72 @ 6.096 m *	29 @ 6.096 m 2 @ 12.192 m 13 @ 18.288 m
21 @ 6.096 m	CONTRACTOR TO PURCHASE
1 CORNER @ 6.096 m	1 CORNER @ 12.192 m
216 @ 9.144 m	108 @ 18.288 m

NOTES
1) FOR GENERAL NOTES & LEGEND, SEE DWG NO 1
2) EXISTING GRADE SPOT ELEVATION IN METRES SHOWN THUS 0.0
3) EXISTING TIMBER PILES AND EXISTING APPROACHWAY TO BE REMOVED FROM INFILL AREA.

NOV 6 1985

The Contractor shall confirm the actual location of all Services shown and any of Services and Utilities not shown that are affected by the Works shown on these Drawings are either existing or proposed.

Public Works Canada / Travaux publics Canada

KER PRIESTMAN & ASSOCIATES LTD
consulting engineers
VICTORIA VANCOUVER PRINCE RUPERT
FILE NO. 25125

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA

revisions		date
C	AS BUILT	JULY 26/85
B	CRANE PADS 263 DELETED. DIMENSIONS ADDED	SEPT. 11/84

A detail no. no. du détail
B location drawing no. sur dessin no.
C drawing no. dessin no.

project / projet
ESQUIMALT GRAVING DOCK IMPROVEMENTS
ESQUIMALT, BC

CONTRACT NO 3

drawing / dessin
IMPROVEMENTS TO SOUTH LANDING WHARF

EAST INFILL AREA
GENERAL ARRANGEMENT

8CD41451

designed PM / concu
date MARCH 1984
drawn GHP / dessiné
date MARCH 1984
reviewed / examiné
date
approved / approuvé
date
Tender / Soumission
PWC Project Manager / Administrateur de projets TPC
project number / no. du projet
PR 100772
drawing no / no. du dessin
19 OF 75

PWC A1

For Details of Pendant Wharf see Sheet No 31

Superintendent's Residence

Foundation for 100 Ton Derrick

250'

North Landing Wharf

Railway Track

Lumber Shed

Carpenter Shop

Contractor's Locomotive Road

Pipe

Road

171'

36 Bollards and 8 Capstans supplied with Dock.

CHANNEL BED ELEV.-35.00

371'-0" Clearance

407'-4" Clearance

Original Wharf South of Dock Entrance

Filling

For details of South Landing Wharf and Buildings see Sheet 33A

NOTE

For Enlarged Plan of Entrance See Sheet No 25

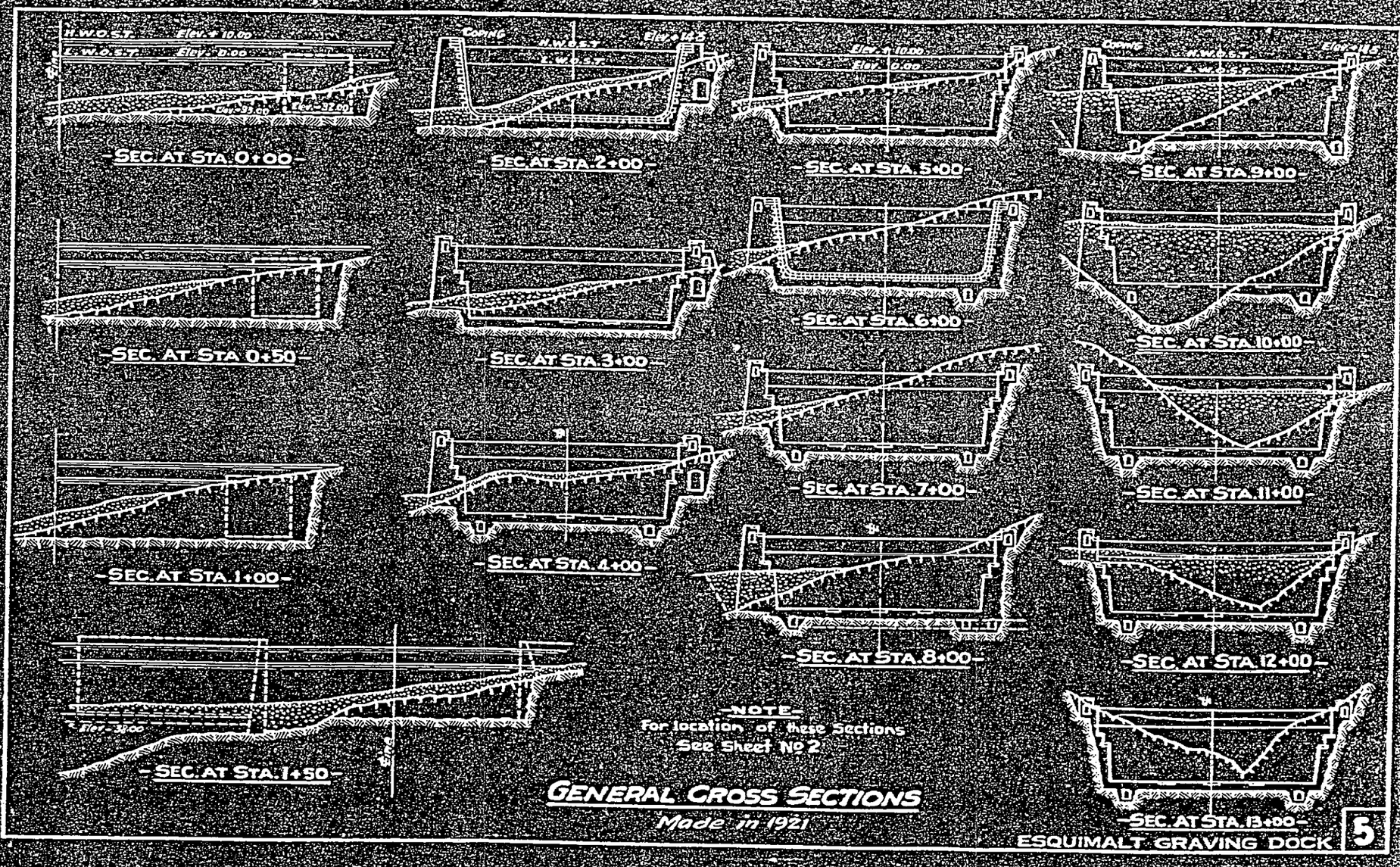
For Enlarged Plans of Intermediate Sills See Sheets Nos 26 & 27

For Enlarged Plan of Inner End See Sheet No 28

For Enlarged Sectional Plan of Power House See Sheet No 30

For Drawings of Sections See Sheets of same number as Sections shown

PART OF DRAWING 17



- NOTE -
For location of these Sections
See Sheet No 2

GENERAL CROSS SECTIONS

Made in 1921

ESQUIMALT GRAVING DOCK

5

KEY PLAN

SCALE 80' = 1"

Superintendent's Residence

Senior Operators Residence

Carpenter Shop

Contractors Time Room

Office

Lower Battery

POWER HOUSE

Penstocks

Air

Fire Engine House

ROADWAY

Capstan

Lamp Standard

Bollard

ENTRANCE ROAD

371'-4" Clearance between Caisson Fenders

401'-4" Clearance between Caisson Fenders

321'-4" Clearance between Caisson Fenders

731'-9"

350'

721'-4" Clearance between Caisson Fenders

751'-4" Clearance between Caisson Fenders

381'-9" Clearance between Caisson Fender and End Wall

Clearance between Caisson Fender and End Wall

400'

1137'-9" Clearance between Caisson Fender and End Wall

1173'-9" Clearance between Caisson Fender and End Wall

Rope

Filling

Revised Dec. 1912

Revised

ESQUIMALT GRAVING DOCK 7

APPENDIX VIII

Site Investigation Photographs

PHOTO VIII-1 CORING AT BPT02-01 BY B.C. CONCRETE CUTTING LTD. (Mar. 15, 2002)

PHOTO VIII-2 CORING AT CPT02-03 BY B.C. CONCRETE CUTTING LTD. (Mar. 18, 2002)

PHOTO VIII-3 SEISMIC CONE PENETRATION TEST AT SCPT02-02 BY CONETEC INVESTIGATIONS LTD. (Mar. 14, 2002)

PHOTO VIII-4 SEISMIC CONE PENETRATION TEST AT SCPT02-02 BY CONETEC INVESTIGATIONS LTD. (Mar. 14, 2002); NOTE TEST HOLE AT 7° OFF VERTICAL

PHOTO VIII-5 MUD ROTARY DRILLING AT DH02-02 BY MUD BAY DRILLING CO. LTD. (Mar. 26, 2002)

PHOTO VIII-6 NILCON FIELD VANE TESTING AT DH02-02 BY CONETEC INVESTIGATIONS LTD. (Mar. 26, 2002)

PHOTO VIII-7 SEISMIC CONE PENETRATION TEST AT SCPT02-06 BY CONETEC INVESTIGATIONS LTD. (Mar. 21, 2002)

PHOTO VIII-8 SEISMIC CONE PENETRATION TEST AT SCPT02-09 BY CONETEC INVESTIGATIONS LTD. (Mar. 27, 2002)

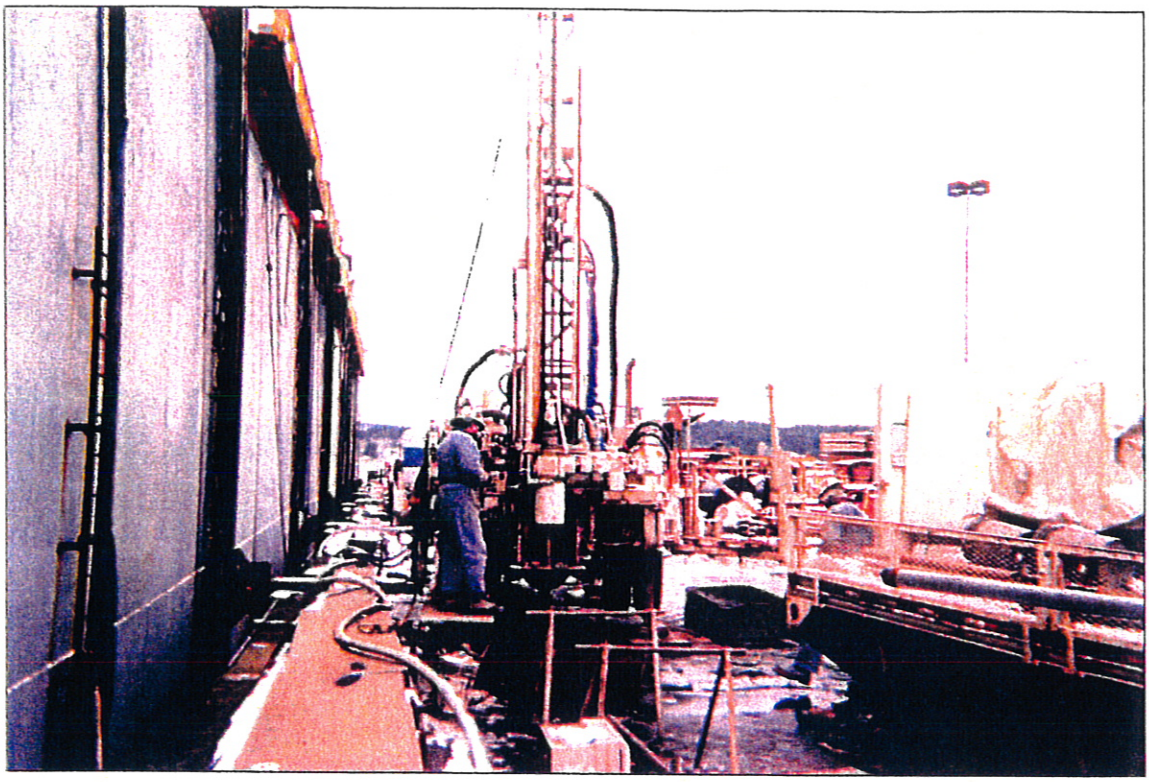


PHOTO VIII-9 CONE PENETRATION TESTING AT CPT02-05 BY CONETEC INVESTIGATIONS LTD. (Mar. 20, 2002)

PHOTO VIII-10 CONE PENETRATION TESTING AT CPT02-07 BY CONETEC INVESTIGATIONS LTD. (Mar. 22, 2002)

PHOTO VIII-11 OPEN ENDED BECKER TESTING AT BOC02-04 BY FOUNDEX EXPLORATIONS LTD. (Mar. 18, 2002)

PHOTO VIII-12 CLOSED ENDED BECKER PENETRATION TESTING AT BPT02-04 BY FOUNDEX EXPLORATIONS LTD. (Mar. 24, 2002)

PHOTO VIII-13 OPEN ENDED BECKER TESTING AT BOC02-09 BY FOUNDEX EXPLORATIONS LTD. (Mar. 29, 2002)

PHOTO VIII-14 OPEN ENDED BECKER TESTING AT BOC02-10 BY FOUNDEX EXPLORATIONS LTD. (Mar. 31, 2002)

PHOTO VIII-15 PULL-UP TEST DURING BECKER PENETRATION TESTING AT BPT02-05 BY FOUNDEX EXPLORATIONS LTD. (Mar. 19, 2002)

PHOTO VIII-16 DOWNHOLE SHEAR WAVE VELOCITY MEASUREMENTS AT BPT02-04 BY CONETEC INVESTIGATIONS LTD. (Mar. 28, 2002)

APPENDIX IX

U.B.C. Laboratory Test Results

Dr. Dharma Wijewickreme, P.Eng.

7972 Meadowood Drive
Burnaby, B.C., V5A 4J2

Phone: (604)-822-5112
Fax: (604)-822-6901

Our Project No: 02-KCC-002

June 21, 2002

Klohn Crippen Consultants Ltd.
10200 Shellbridge Way
Richmond, B.C.
V6X 2W7

Attn: Dr. Alex Sy, P.Eng.
Vice President, Geoenvironment

RE: LABORATORY DIRECT SIMPLE SHEAR TESTING AT UBC GEOTECHNICAL RESEARCH LABORATORY PWGSC ESQUIMALT DRY DOCK AND SOUTH JETTY

Dear Dr. Sy:

Further to our recent discussions and the information provided by Mr. Dennis Teo of your office on June 6, 2002, a series of laboratory constant volume (undrained) direct simple shear (DSS) tests were conducted on a number of Shelby tube soil samples related to the above project. The tests were performed to determine the development of cyclic strains and excess pore pressures under cyclic shear loading as well as the post-cyclic undrained behaviour of the subject soils. This report is intended to present the results of these tests along with a summary of the sample preparation and test procedure(s).

1.0 SAMPLE PREPARTION AND TEST PROCEDURE – GENERAL INFORMATION

All the tests were carried out in the UBC Geotechnical Research Laboratory by engineering personnel experienced in the area of advanced geotechnical laboratory testing under the supervision of Dr. D. Wijewickreme, P.Eng.

Three undisturbed samples were provided in the form of 76 mm (3.0 in) nominal diameter Shelby tubes (Shelby tubes No. BOC02-08#12, BOC02-05#14, and DH02-01#8). The Shelby tubes No. BOC02-08#12 and BOC02-05#14 was extruded at the UBC laboratories at the time of testing; the former of the above two Shelby tubes was extruded in the presence of Klohn Crippen engineering personnel. The Shelby tube No. DH02-01#8 had been already extruded, secured in plastic wrap, and placed inside a split PVC pipe at the time of delivery to the UBC laboratory. Except at the time of testing and extrusion, all the samples were carefully enclosed in plastic wrap (as appropriate) and kept in a "moist room" which is maintained at high humidity by automatic spraying of water.

The test variables including initial consolidation stresses and cyclic shear stress levels (τ_{cy}/σ'_{vc} = CSR) for the laboratory program were provided by Klohn Crippen.

The DSS test specimens, 71 mm in diameter and approximately 20 to 25 mm in height, were set up in the UBC simple shear apparatus using a reinforced rubber membrane and in accordance with procedures described in the Geonor brochure on NGI simple shear testing, together with some modifications. Details of the NGI simple shear apparatus are described by Bjerrum and Landva in Geotechnique, Vol. 16, No. 1, 1966, pp. 1-20.

1.1 Initial Consolidation Phase

The test specimens were initially consolidated to the specified vertical effective stress σ'_{vc} in one increment. All the samples were allowed to consolidate for more than 10 hours prior to shearing, thus allowing time for the full completion of the primary consolidation phase. The vertical consolidation effective stress σ'_{vc} applied, and the DSS test number assigned for each specimen are summarized below.

Summary of Test Variables for Direct Simple Shear Testing

Test Hole	Shelby Sample No.	DSS TEST No.	Sample Depth (In situ)			Vertical Consolidation Effective Stress
			(m)		(m)	σ'_{vc} (kPa)
BOC02-08	#12	DSS-KC01	14.33	-	15.09	166
BOC02-05	#14	DSS-KC02	20.42	-	21.03	197
DH02-01	#8	DSS-KC03	11.58	-	12.19	132

1.2 Cyclic Shear Loading Phase

Cyclic shear loading was applied at a frequency of 0.1 Hz. This consisted of a symmetrical sinusoidal loading pulse applied at a constant cyclic stress ratio τ_{cy}/σ'_{vc} amplitude. A continuous record of test data was obtained by a computer interfaced data acquisition system. The monitored test variables consisted of full time-histories of horizontal shear stress (τ_h), decrease in vertical stress (= induced excess pore water pressure, Δu), and horizontal shear strain (γ%).

Upon consolidation to the specified vertical effective stress level, all the samples were tested in cyclic simple shear at constant cyclic stress ratio (CSR) amplitude with a starting CSR of 0.1. Cyclic loading was continued with this starting CSR value until a maximum shear strain (γ) amplitude $\geq$ 3.75% (considered as the liquefaction criterion) was developed or until 15 stress cycles, whichever occurred first. If the liquefaction criterion was reached first, then the cyclic loading phase was terminated, and monotonic loading was commenced as described in Section 1.3. If the liquefaction criterion was not reached, the constant-CSR cyclic loading phase was repeated after increasing the CSR value by 0.05. This sequence of staged cyclic shear loading (by increasing the CSR value in 0.05 increments) was repeated until the liquefaction criteria was reached.

1.3 Post-cyclic Monotonic Loading Phase

The post-cyclic undrained monotonic loading phase for the three specimens was commenced immediately upon completion of the above cyclic loading phase. Monotonic loading was carried

out at a horizontal shear strain rate of about 10% per hour. It is also noted that the post-cyclic loading was performed in the direction opposite to that of residual strain at the conclusion of cyclic loading.

2.0 TEST RESULTS

The locations of the specimens selected for the three cyclic simple shear tests (Test Nos. DSS-KC01 through DSS-KC03) in relation to the length of each Shelby tube sample are illustrated in Figures 1 through 3. Any significant observations made during the extrusion/trimming, description of soil type and consistency, or other relevant comments, in relation to a given sample are also presented on the same figures, as required. A tabulated summary of the loading conditions and key test results derived from the tests are presented in the attached Table 1. The water contents based on the dry and wet mass of sample trimmings, as well as of each specimen at the conclusion of testing, are presented in Table 2.

The results of the tests are presented in Figures 4 through 12. Contents of each figure in relation to a given test are outlined below:

Test No.	DSS-KC01	DSS-KC02	DSS-KC03
Consolidation Phase: Volumetric strain (ε_v) vs. time	Fig. 4	Fig. 7	Fig. 10
Cyclic Loading Phase: τ_{cy}/σ'_{vc}, $\Delta u/\sigma'_{vc}$, and γ% vs. Number of cycles;	Fig. 5	Fig. 8	Fig. 11
Post-cyclic Monotonic Loading Phase: τ_h and $\Delta u/\sigma'_{vc}$ vs. γ%, and stress path in τ_h-σ'_v space.	Fig. 6	Fig. 9	Fig. 12

3.0 CLOSURE

I trust that this report provides an adequate summary of the testing program and presentation of results meeting with your testing requirements. If you have any questions, or require additional information, please do not hesitate to contact me.

Yours truly,

Dharma Wijewickreme, Ph.D., P.Eng.

TABLE 1. TEST INFORMATION AND SUMMARY RESULTS

LABORATORY DIRECT SIMPLE SHEAR TESTING
AT UBC GEOTECHNICAL RESEARCH LABORATORY
PWGSC Esquimalt Dry Dock and South Jetty

Test No	Bore Hole ID	W_c	σ'_{vc} (kPa)	Cyclic Loading Phase								Post Cyclic Tests	
				CSR = τ_{cyc}/σ'_{vc}	0.1	0.15 [d]	0.20	0.25	0.30	γ_{max}(%)	$\Delta u_r/\sigma'_{vc}$	S_u (kPa)	γ_{peak} (%)
DSS-KC01	BOC02-08 Shelby 12 (14.33-15.09 m)	0.291	166	N	15 [a]	15 [a]	15 [a]	15 [a]	1 [b]	4.4	0.646	48 [c]	7
DSS-KC02	BOC02-05 Shelby 14 (20.42-21.03 m)	0.248	197	N	15 [a]	15 [a]	15 [a]	2 [b]	-	4.4	0.690	52 [c]	9
DSS-KC03	DH02-01 Shelby 8 (11.58-12.19 m)	0.251	132	N	15 [a]	15 [a]	15 [a]	12 [b]	-	4.2	0.725	40 [c]	12

NOTES: (a) Cyclic loading increased to next higher CSR stage since $\gamma_{max} < 3.75\%$; (b) Liquefaction criterion $\gamma_{max} = 3.75\%$ reached during this cyclic loading stage; (c) Visually estimated form the τ_h vs γ plots (from post-cyclic monotonic loading); (d) The applied CSR (τ_{cyc}/σ'_{vc}) value = 0.18 for the 2nd cyclic loading stage of Test No. DSS-KC01 (i.e. not CSR = 0.15 as used for the 2nd cyclic loading stage for other tests).

Notation:

- N Number of cycles required to exceed $\gamma_{max} = 3.75\%$
- γ Horizontal shear strain
- γ_{peak} Shear strain corresponding to S_u
- γ_{max} Maximum shear strain during cyclic loading
- W_c Water content at end of test
- S_u Peak undrained shear strength in post-cyclic loading
- σ'_{vc} Vertical effective consolidation stress
- τ_{cyc} Cyclic shear stress
- τ_h Horizontal shear stress
- Δu Excess pore pressure
- Δu_r Residual excess pore pressure at the end of cyclic test

TABLE 2 SUMMARY OF MOISTURE CONTENTS

LABORATORY DIRECT SIMPLE SHEAR TESTING
AT UBC GEOTECHNICAL RESEARCH LABORATORY
PWGSC Esquimalt Dry Dock and South Jetty

TEST ID	Moisture contents			
	Side Trimmings	Bottom Trimmings	Top Trimmings	End of Test
DSS-KC01	0.279	0.294	0.298	0.291
DSS-KC02	0.271	0.285	0.302	0.248
DSS-KC03	0.241	0.222	0.261	0.251

Our File No: 02-KCC-002

Shelby Tube Sample Extrusion Log
Graduate Soil Mechanics Laboratory
University of British Columbia

Project : PWGSC Esquimalt Dry Dock and South Jetty

Bore Hole ID : BOC02-08

Specimen ID/ Test No : DSS-KC01

Shelby Tube ID : BOC02-08 (#12)

Date of Extrusion : June 13, 2002

Shelby sample depth : 14.33 – 15.09 m

Tube length : 76.5 cm

Depth to Packers Top : 6.5 cm
Bottom : 3.0 cm

Sample length : 67.0 cm

Extruded length of sample :.12.7 cm

Remaining length of soil :.54.3 cm

Sample description : Firm to stiff, grey, CLAY

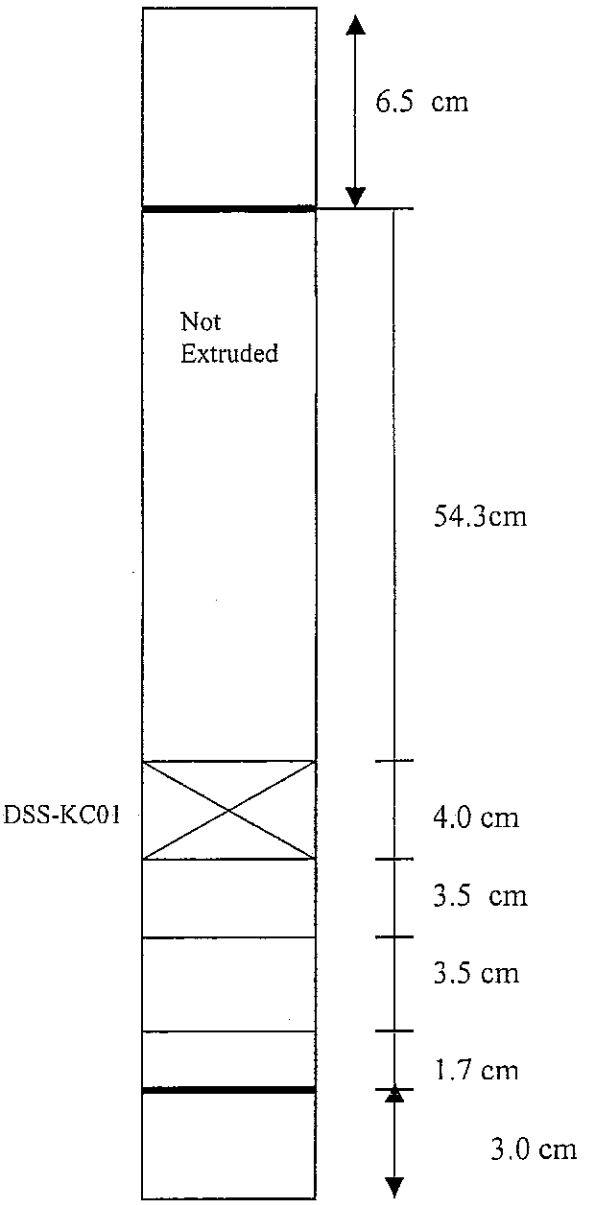


Fig.1

Our File No: 02-KCC-002

Shelby Tube Sample Extrusion Log
Graduate Soil Mechanics Laboratory
University of British Columbia

Project : PWGSC Esquimalt Dry Dock and South Jetty

Bore Hole ID : BOC02-05

Specimen ID/Test No : DSS-KC02

Shelby Tube ID : BOC02-05 (#14)

Date of Extrusion : June 15, 2002

Shelby sample depth : 20.42 – 21.03 m

Tube length : 76.5 cm

Depth to Packers Top : 15.5 cm
Bottom : 3.5 cm

Sample length : 57.5 cm

Extruded length of sample : 10.5 cm

Remaining length of soil : 47.0 cm

Sample description: Soft to firm, grey, CLAY.

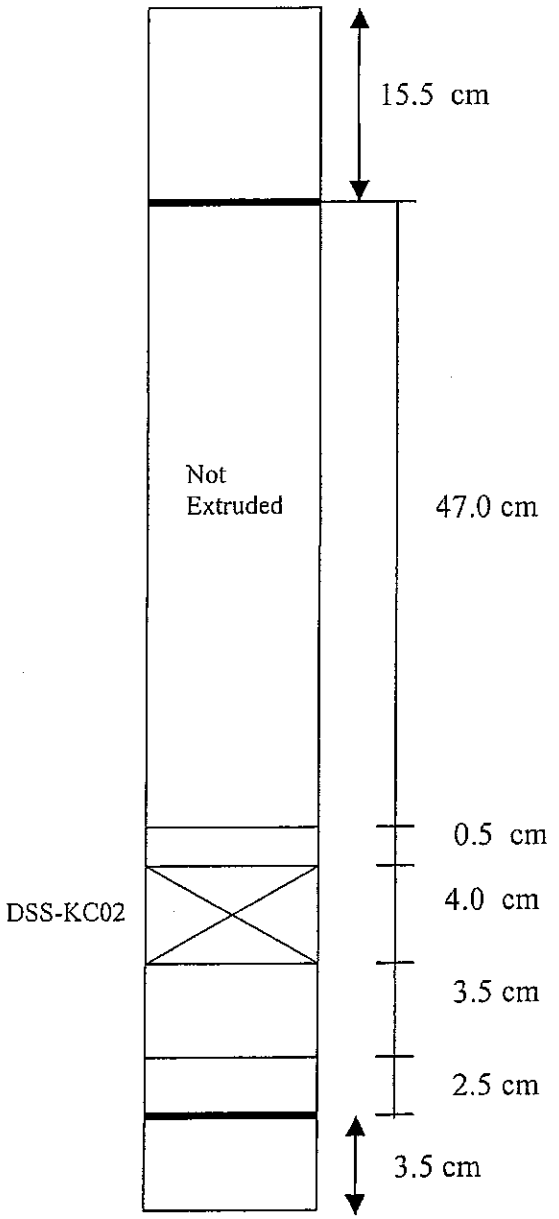


Fig.2

Our File No: 02-KCC-002

Shelby Tube Sample Extrusion Log
Graduate Soil Mechanics Laboratory
University of British Columbia

Project : PWGSC Esquimalt Dry Dock and South Jetty

Bore Hole ID : DH02-01 Specimen ID/Test No : DSS-KC03

Specimen ID : DH02-01(#8) Date of Extrusion : Extruded by Klohn Crippen

Shelby sample depth : 11.58 – 12.19 m

Sample lengths

Segment 1 = 7.0 cm

Segment 2 = 21.0 cm

Segment 3 = 8.0 cm

Sample description : Firm to stiff, grey, CLAY
Fine to coarse sand, sea shells,
Occasional small stones of
2 –3 mm size.

Note:
DSS specimen obtained from
Segment 2 as shown.

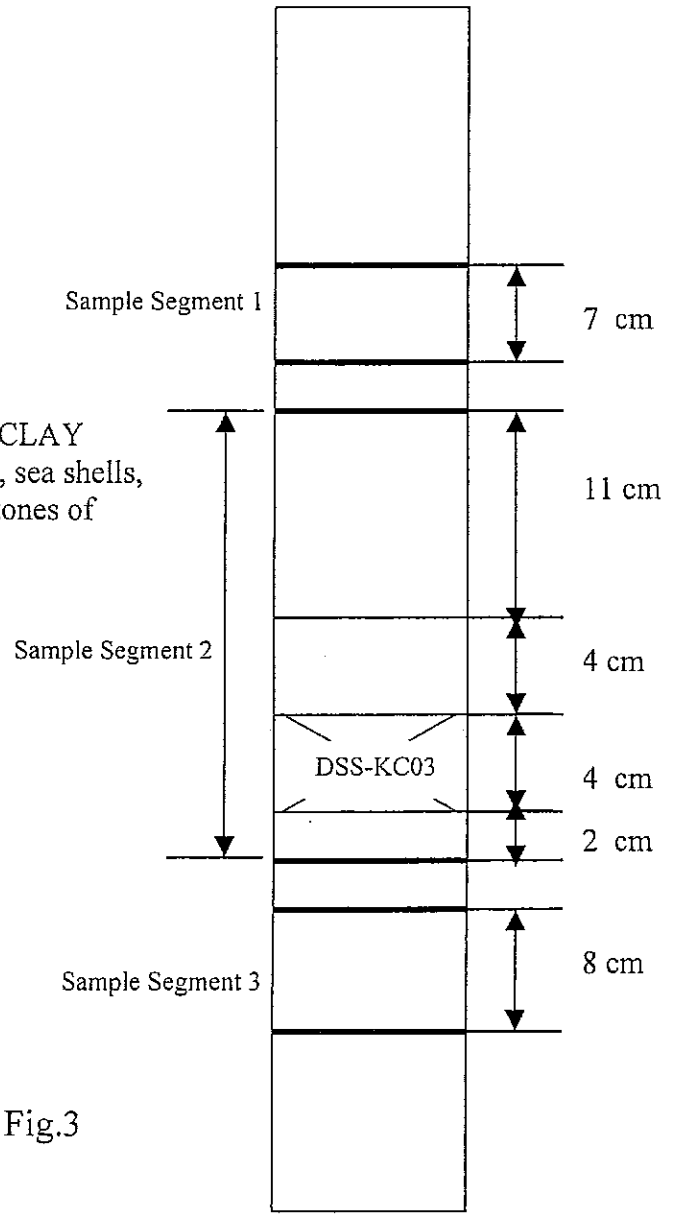


Fig.3

Our File No: 02-KCC-002

Constant Volume Simple Shear Test **Consolidation Phase**

Bore Hole ID: BOC02-08 Shelby 12 (Depth 14.33 - 15.09 m) Test No: DSS-KC01
σ'_{vc} = 166 kPa

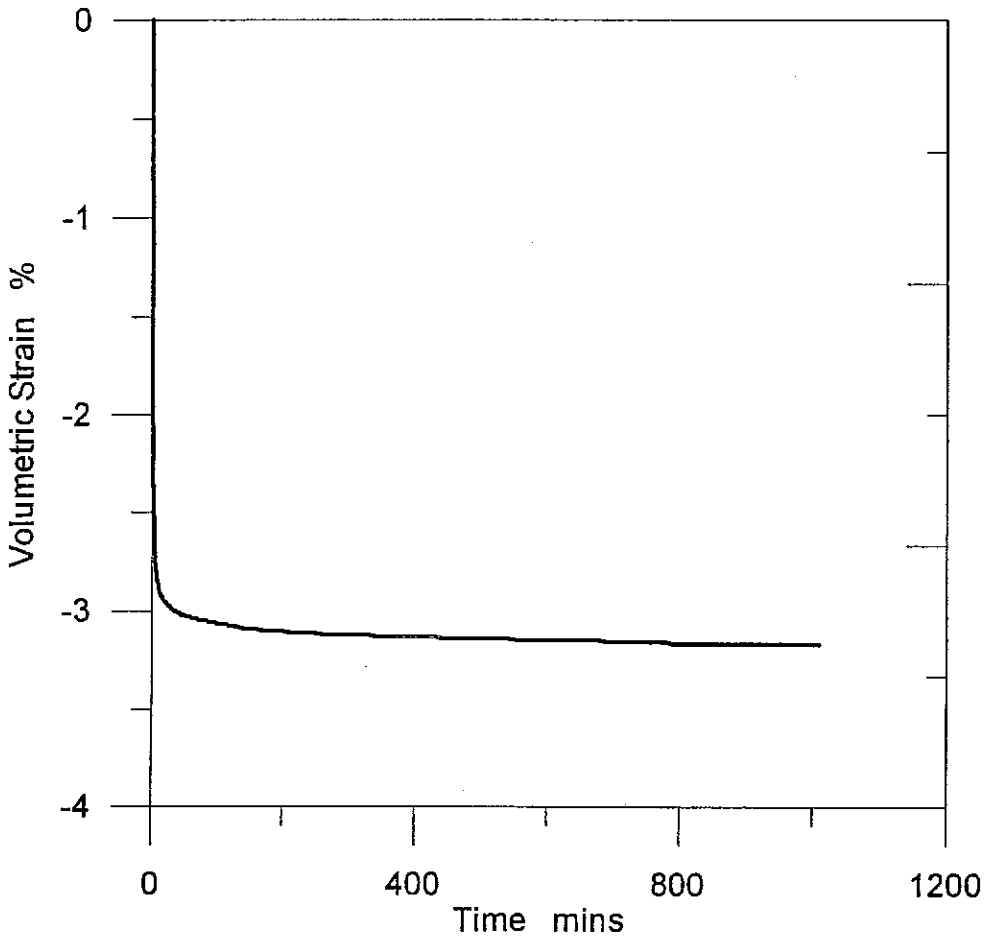


Fig.4

Our File No: 02-KCC-002

Constant Volume Simple Shear Test **Cyclic Loading Phase**

Bore Hole ID: BOC02-08 Shelby 12 (Depth 14.33 - 15.09 m) Test No: DSS-KC01
σ'_{vc} = 166 kPa

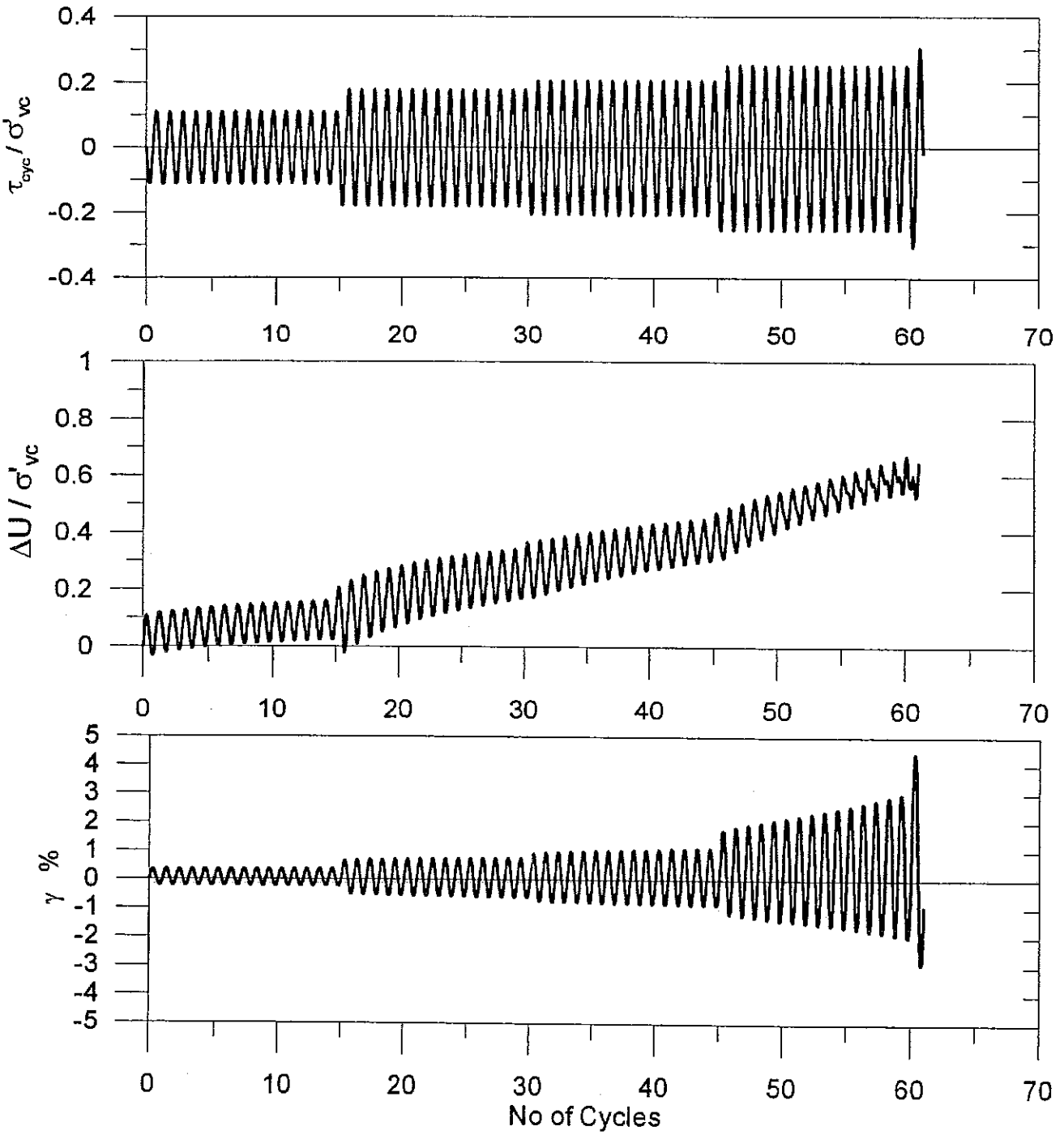


Fig.5

Our File No: 02-KCC-002

Constant Volume Simple Shear Test **Post_Cyclic Loading Phase**

Bore Hole ID: BOC02-08 Shelby 12 (Depth 14.33 - 15.09 m) Test No: DSS-KC01

σ'_{vc} = 166 kPa

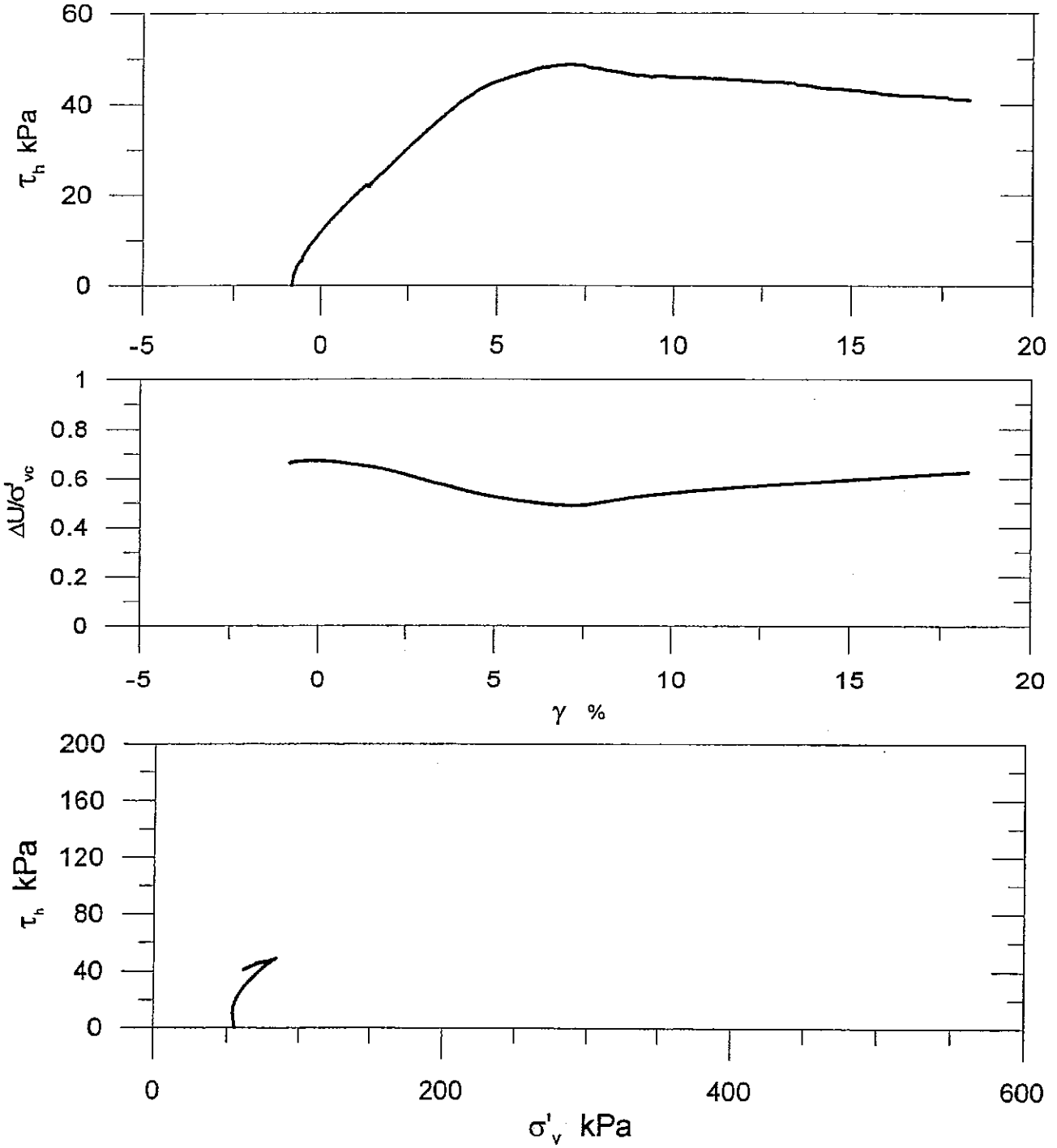


Fig.6

Our File No: 02-KCC-002

Constant Volume Simple Shear Test **Consolidation Phase**

Bore Hole ID: BOC02-05 Shelby 14 (Depth 20.42 - 21.03 m) Test No: DSS-KC02
σ'_{vc} = 197 kPa

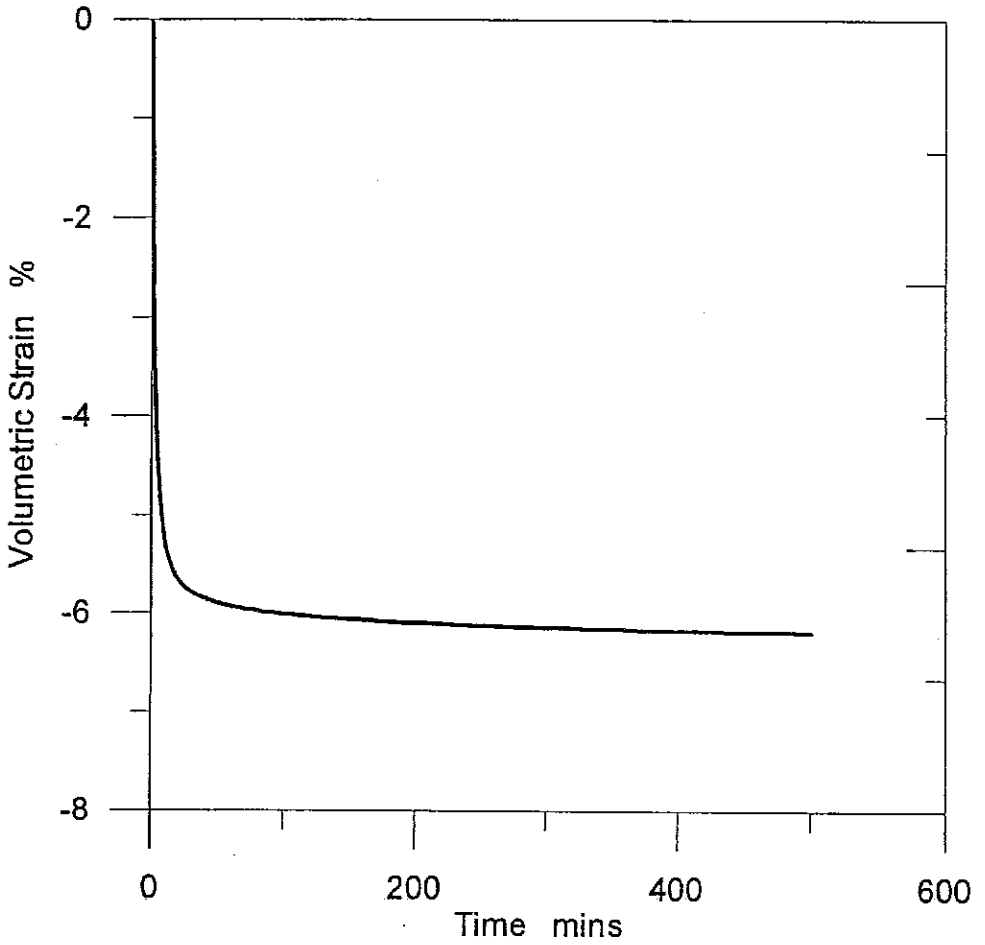


Fig.7

Our File No: 02-KCC-002

Constant Volume Simple Shear Test **Cyclic Loading Phase**

Bore Hole ID: BOC02-05 Shelby 14 (Depth 20.42 - 21.03 m) Test No: DSS-KC02
σ'_{vc} = 197 kPa

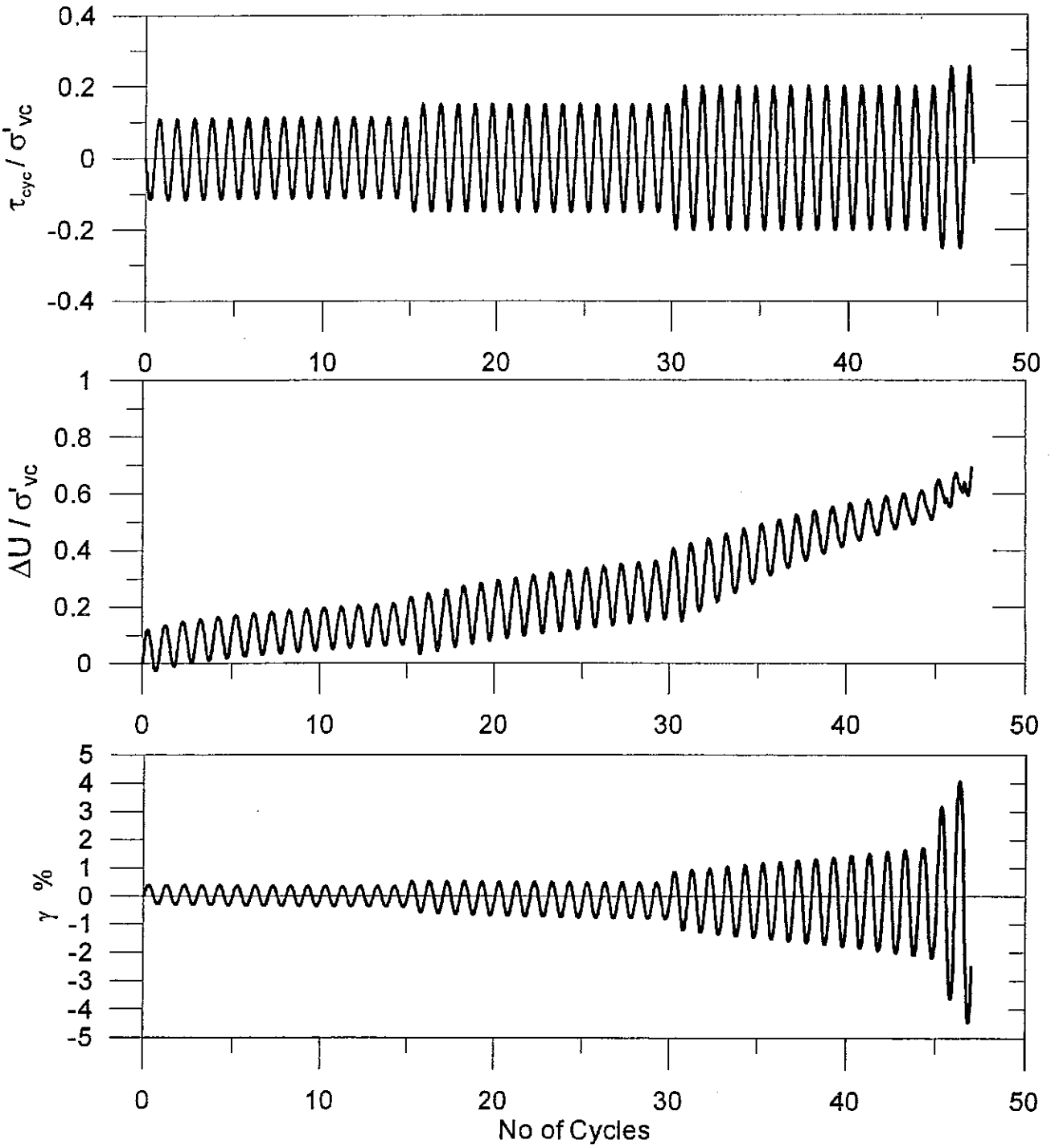


Fig.8

Our File No: 02-KCC-002

Constant Volume Simple Shear Test Post_Cyclic Loading Phase

Bore Hole ID: BOC02-05 Shelby 14 (Depth 20.42 - 21.03 m) Test No: DSS-KC02

σ'_{vc} = 197 kPa

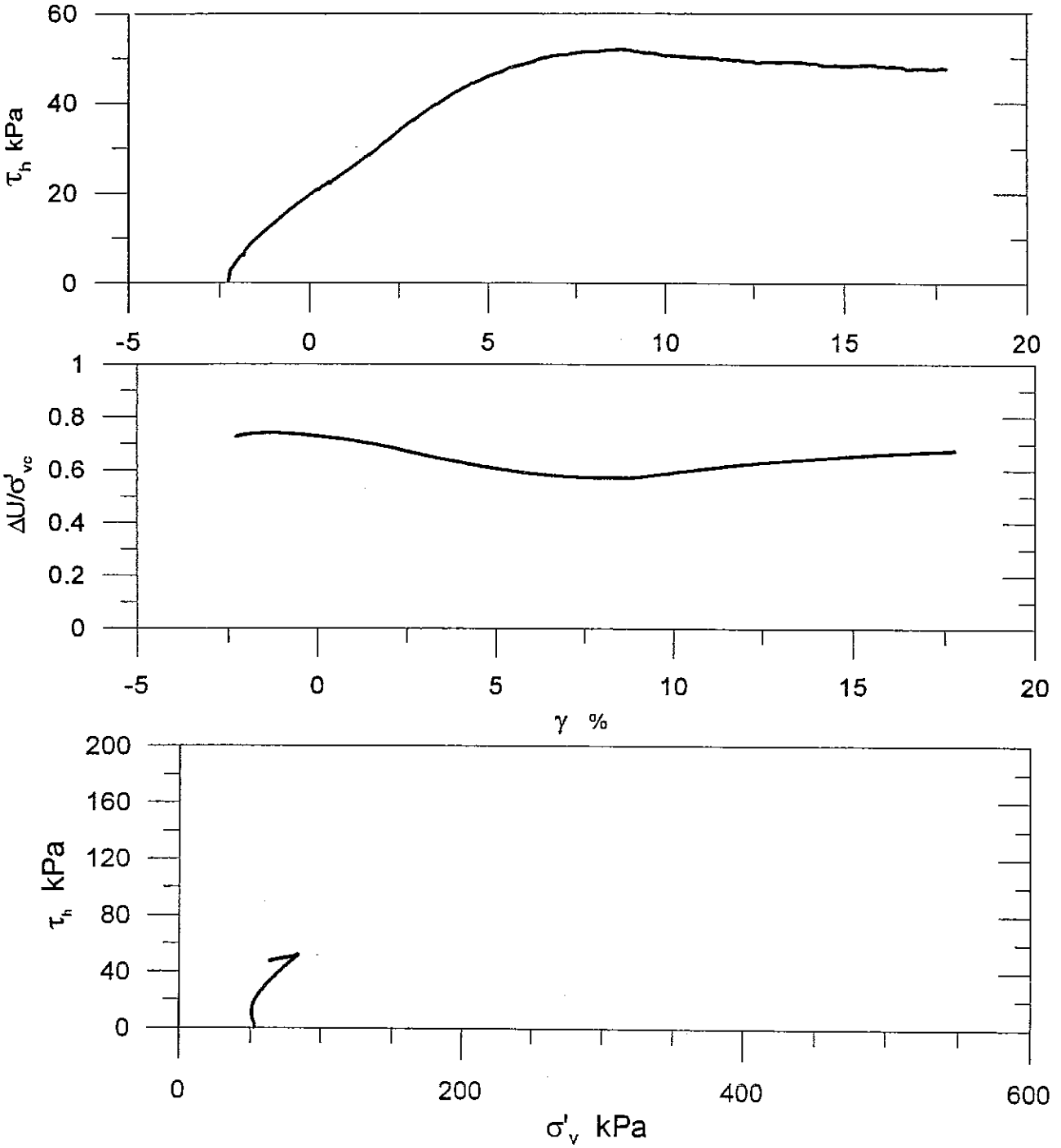


Fig.9

Our File No: 02-KCC-002

Constant Volume Simple Shear Test **Consolidation Phase**

Bore Hole ID: DH02-01 Shelby 8 (Depth 11.58 - 12.19 m) Test No: DSS-KC03
σ'_{vc} = 132 kPa

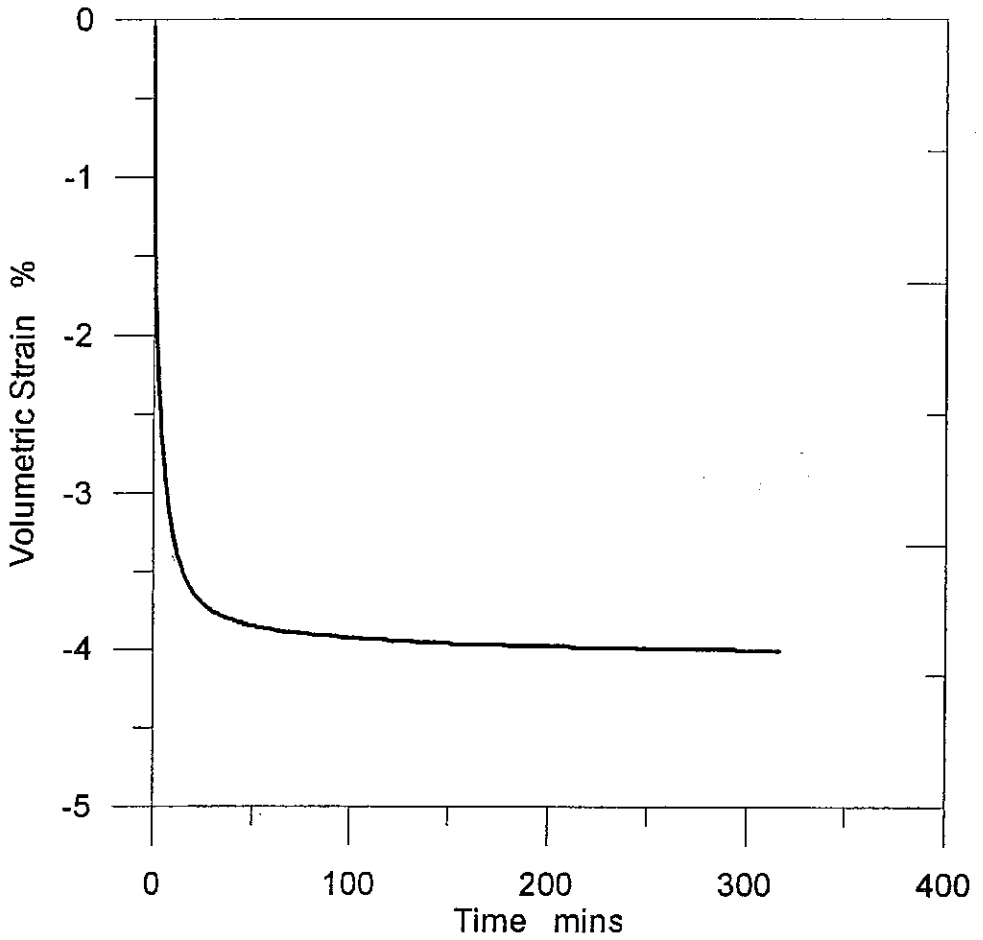


Fig.10

Our File No: 02-KCC-002

Constant Volume Simple Shear Test **Cyclic Loading Phase**

Bore Hole ID: DH02-01 Shelby 8 (Depth 11.58 - 12.19 m) Test No: DSS-KC03

σ'_{vc} = 132 kPa

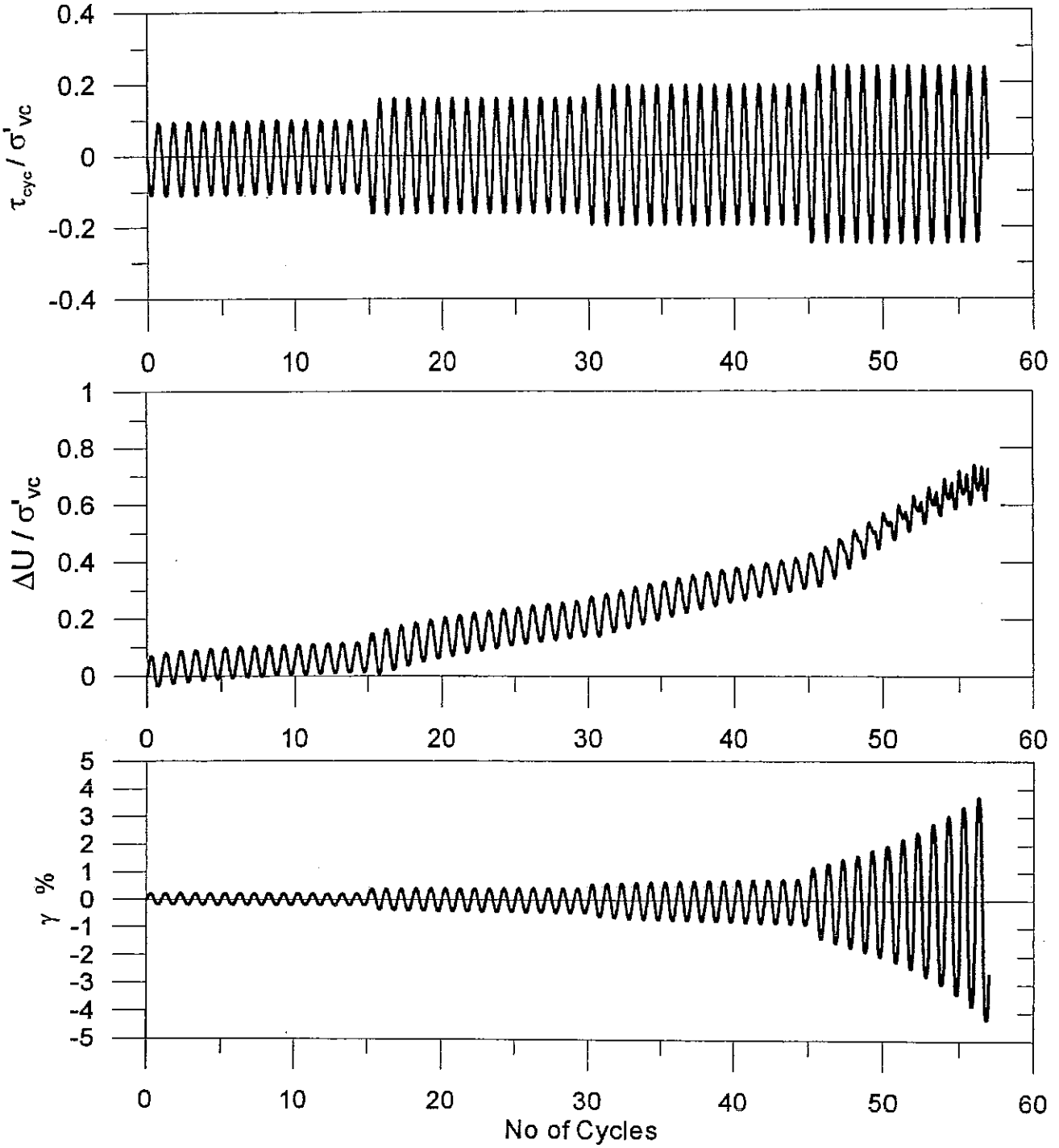


Fig.11

Our File No: 02-KCC-002

Constant Volume Simple Shear Test **Post_Cyclic Loading Phase**

Bore Hole ID: DH02-01 Shelby 8 (Depth 11.58 - 12.19 m) Test No: DSS-KC03
σ'_{vc} = 132 kPa

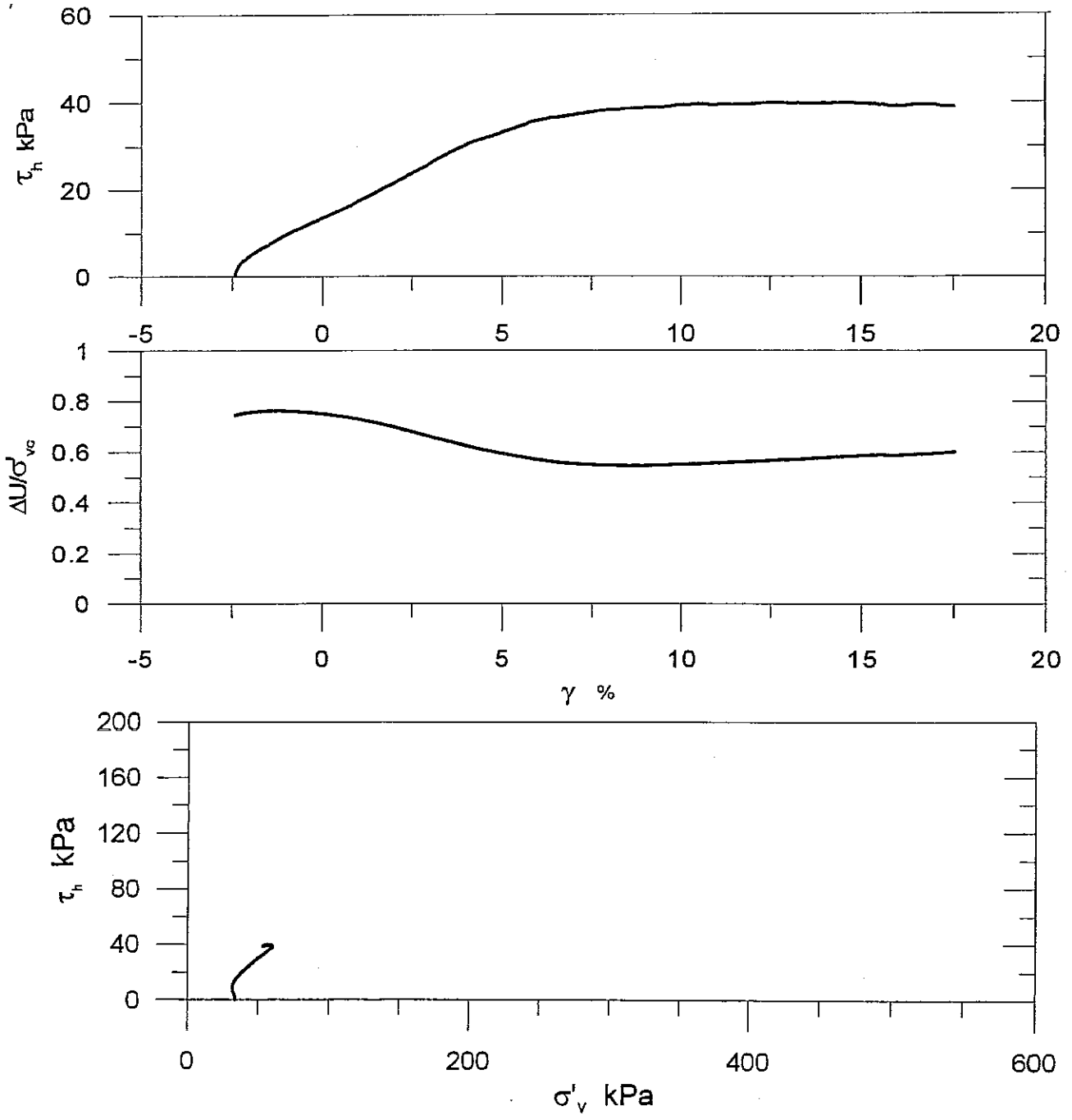


Fig.12

Our File No: 02-KCC-002

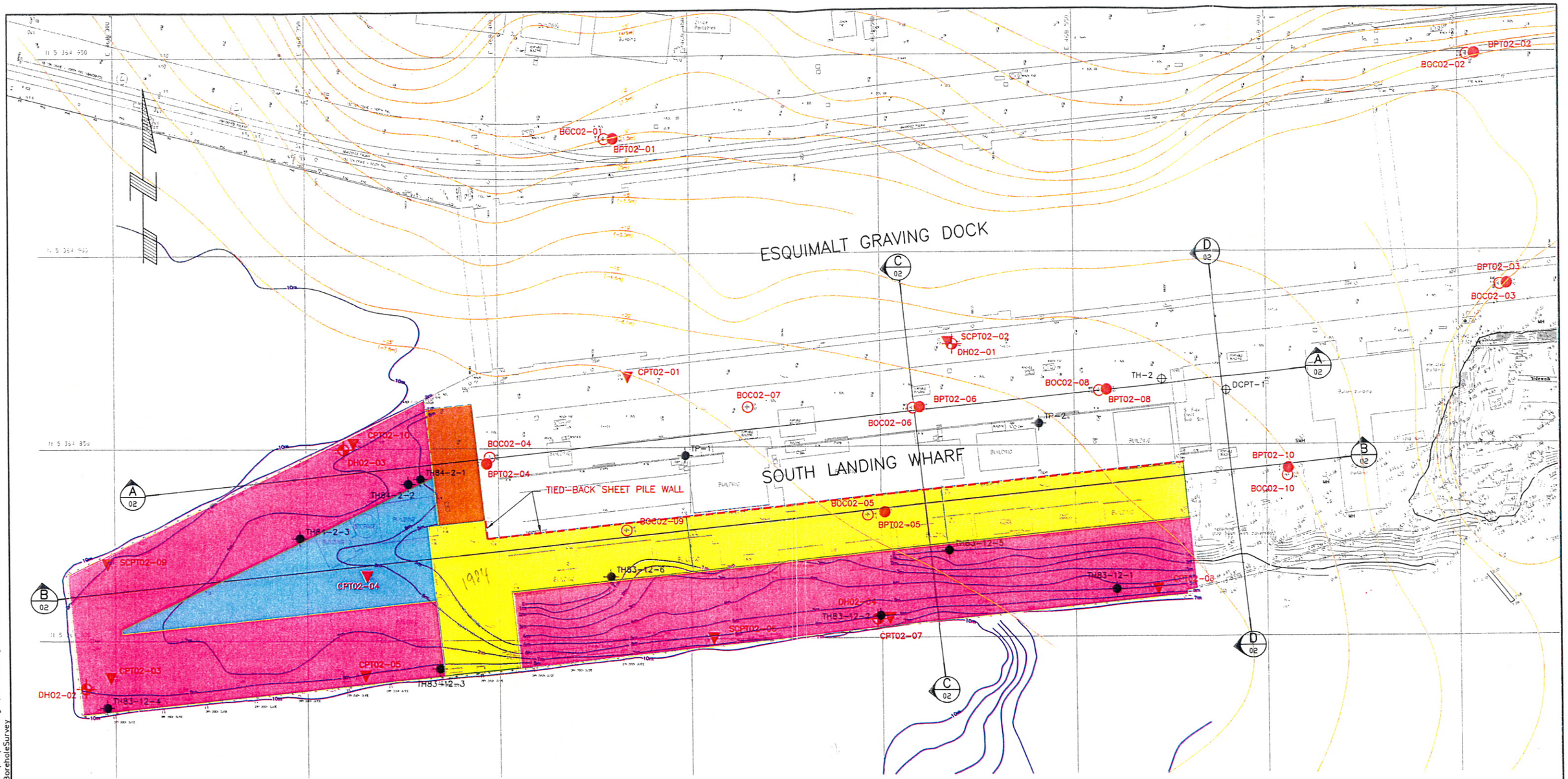
DRAWINGS

Drawing B-1001 Test Hole Location Plan

Drawing B-1002 Geologic Sections A, B, C and D

Drawing B-1003 Pile Layout and Bedrock Contours

Drawing B-1004 Cross Sections E, F and G



LEGEND

- BPT02-01 — CLOSED-ENDED BECKER DRILL HOLE
- BOC02-01 — OPEN-ENDED BECKER DRILL HOLE
- DH02-01 — MUD ROTARY DRILL HOLE
- CPT02-01 — CONE PENETRATION TEST
- TH83-12-1 — 1983 AND 1984 TEST HOLES BY HARDY ASSOCIATES (1978) LTD.
- DCPT-1 — 1997 TEST HOLES BY TERRA ENGINEERING LTD.
- BELOW DECK SOUNDING CONTOURS (2001)
- PRE-DEVELOPMENT CONTOURS (1920s)
- TIMBER JETTY
- TIMBER INFILL STRUCTURE
- TIMBER CRIB
- CONCRETE WHARF

NOTES:

1. SITE PLAN PROVIDED BY PWGSC. LOCATIONS OF FACILITIES ARE APPROXIMATE ONLY.
2. BELOW DECK SOUNDING CONTOURS WERE TAKEN FROM FORESHORE TECHNOLOGIES REPORT DATED JANUARY 19, 2001.
3. PRE-DEVELOPMENT CONTOURS WERE BASED ON PWGSC'S DRAWING No. 2 ORIGINAL CONSTRUCTION. NOTE INCONSISTENCIES WITH DIFFERENT CONTOURS AT THE EAST END OF THE SOUTH JETTY.
4. ELEVATIONS REFER TO CHART DATUM.

PT June 25, 2002

DRAWING NO.	REFERENCE DRAWING	NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

KLOHN CRIPPEN

PROJECT: EGD AND SLW SITE INVESTIGATION

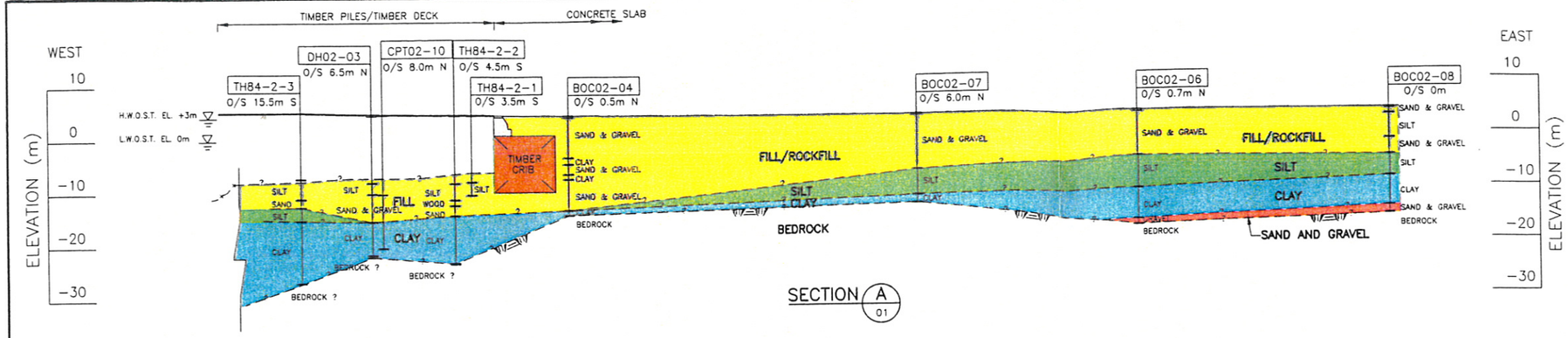
TITLE: TEST HOLE LOCATION PLAN

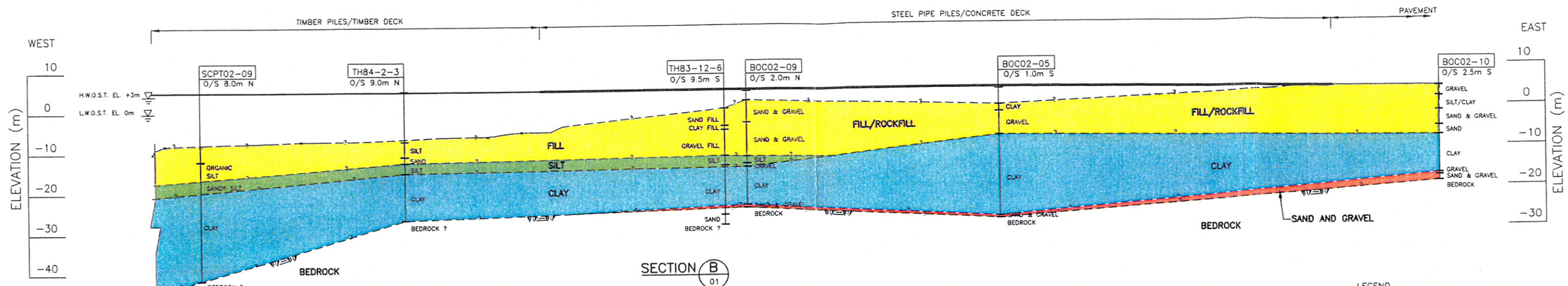
SCALE	PROJECT No.	DWG. No.	REV.
1:1000	PG9060 01	B-1001	–

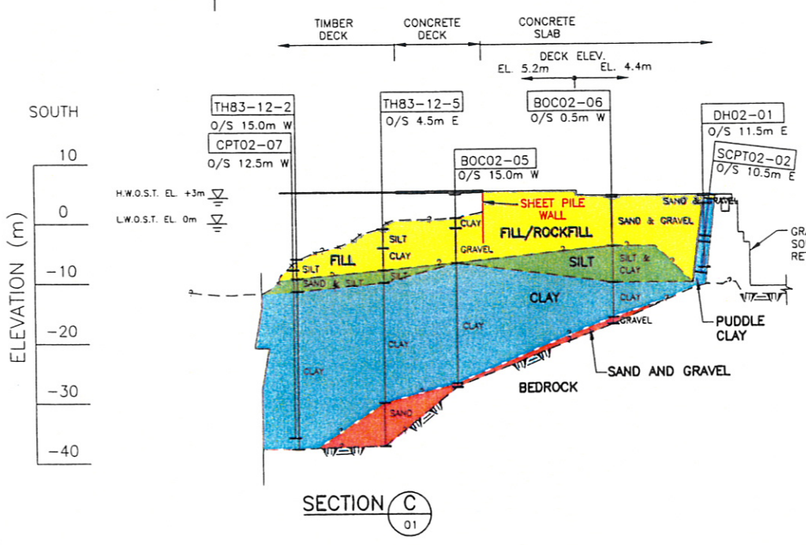
CANCEL PRINTS BEARING PREVIOUS REVISION

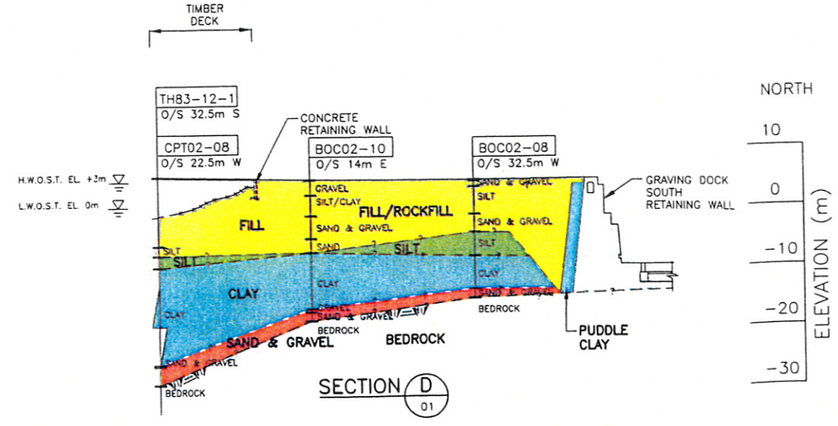
KCC-BM

Drawing File: G:\G9060 PWGSC Esquimalt Graving Dock\01\400 Design\410 Drawings\b-1001R2.dwg (WONGC)
Xrefs: 1920topsteel, golder, soundingutm, April2002BoreholeSurvey









LEGEND

H.W.O.S.T.	HIGH WATER ON SPRING TIDE
L.W.O.S.T.	LOW WATER ON SPRING TIDE
	FILL/ROCKFILL
	SILT
	CLAY
	SAND AND GRAVEL ABOVE BEDROCK

NOTES:

1. ELEVATIONS REFER TO CHART DATUM.
2. LOCATIONS OF STRUCTURES ARE APPROXIMATE ONLY. REFER TO ORIGINAL CONSTRUCTION DRAWINGS FOR DETAILS.

0 50m

DT June 5, 2002

DRAWING NO.	REFERENCE DRAWING	NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D

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CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

KLOHN CRIPPEN

PROJECT: EGD AND SLW SITE INVESTIGATION

TITLE: GEOLOGIC SECTIONS A, B, C AND D

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KCC-BM

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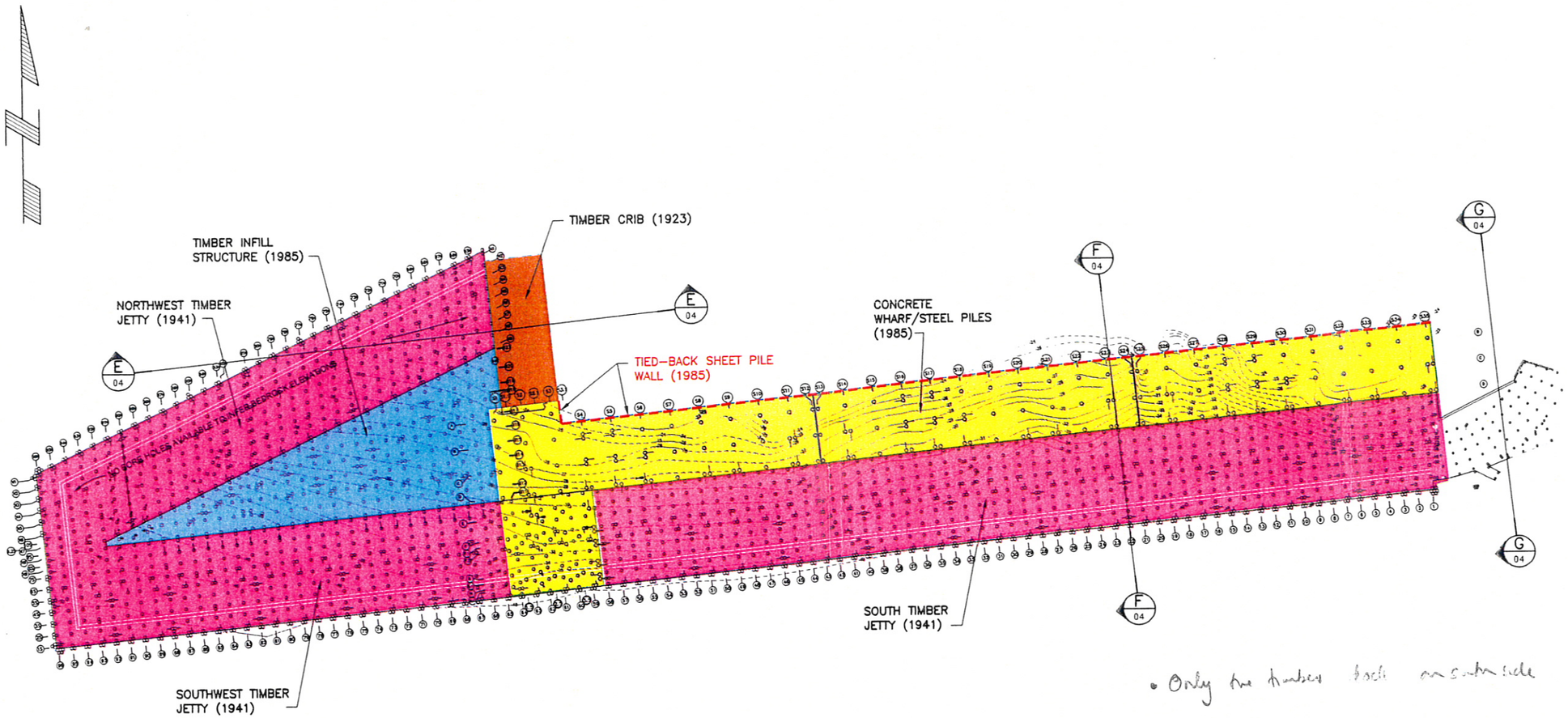

NOTES:

1. DRAWING TAKEN FROM HAY & COMPANY CONSULTANTS INC. REPORT DATED JUNE 2001, DRAWING No. RJC003-B03.
2. ELEVATIONS SHOWN REFER TO CHART DATUM.

0 50m

DT June 8, 2001

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CLIENT
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PROJECT
EGD AND SLW SITE INVESTIGATION

TITLE
PILE LAYOUT AND BEDROCK CONTOURS

SCALE	PROJECT No.	DWG. No.	REV.
1:1000	PG9060 01	B-1003	–

CANCEL PRINTS BEARING PREVIOUS REVISION

KCC-IM

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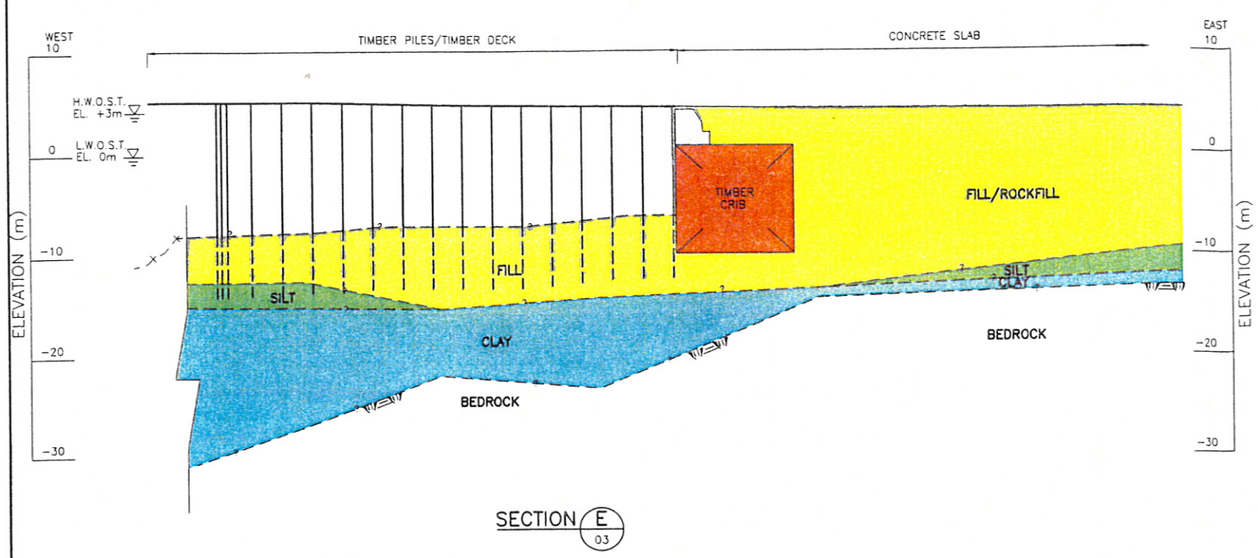
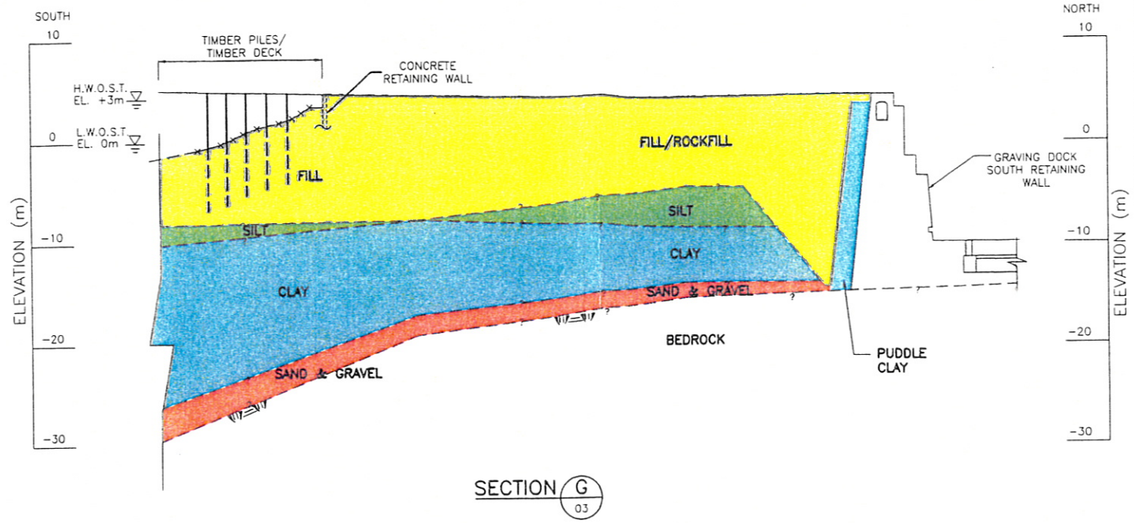
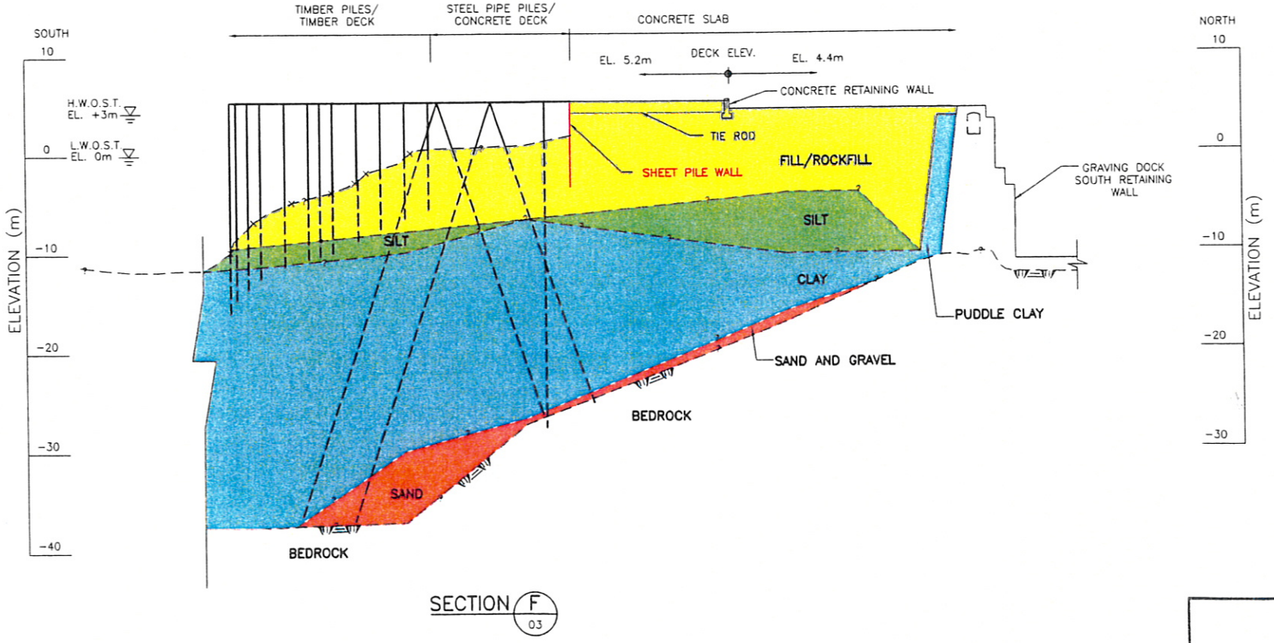
Xrefs: BOUNDARY, FIG03 BEDROCK



SECTION E 03



SECTION G 03



SECTION F 03

NOTES:

1. ELEVATIONS REFER TO CHART DATUM.
2. PILE LOCATIONS ARE APPROXIMATE ONLY. SEE ORIGINAL CONSTRUCTION DRAWINGS FOR DETAILS.
3. LOCATIONS OF STRUCTURES ARE APPROXIMATE ONLY. REFER TO ORIGINAL CONSTRUCTION DRAWINGS FOR DETAILS.

0 30m

DT June 25, 2002

DRAWING NO.	REFERENCE DRAWING	NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D

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PROJECT
EGD AND SLW SITE INVESTIGATION

TITLE
CROSS SECTIONS E, F AND G

SCALE	PROJECT No.	DWG. No.	REV
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KCC-BIM

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Xrefs: HATT002

D16

ESQUIMALT GRAVING DOCK

PILE DRIVING THROUGH A CAP ASSOCIATED IMPACTS AND CONCERNS

ANCHOR QEA (2002)

Number of Pages: 16

PILE DRIVING THROUGH A CAP: ASSOCIATED IMPACTS AND CONCERNS

Christine Boudreau [1], Bruce McDonald [2], Paul Brown [3], and Tom Wang [2]

ABSTRACT

Although a cap can be placed and has been proven to be an effective control and isolation mechanism for contaminated sediments, concerns have been raised by regulating authorities as well as project proponents as to the effects any construction or maintenance activities will have on a cap. Various remedial projects near or under existing or proposed pier structures have had to address and manage environmental and structural issues pertaining to pile removal, pile installation, and construction. The predominant environmental concern with pile driving is that contaminated sediments will either be exposed or contaminants themselves will be mobilized through pore water advection/migration to the biologically active zone or overlying water column.

This paper will review the technical issues associated with driving piles through an environmental remedial cap. A summary of the technical concerns and precedence that has been set for driving piling into a cap will be provided. This will include a discussion of any measurable impacts, standard ways of mitigating potential impacts, regulatory precedence and project examples.

Keywords: capping design; pore water pressure; sediment displacement

INTRODUCTION

Subaqeous capping is defined as the controlled, accurate placement of a clean isolating layer (i.e., silt, sand or gravel) on top of contaminated sediments to isolate contaminants from the marine environment. Significant experience on capping has been gained from numerous modeling studies, pilot and field studies, and monitoring experience during earlier programs and projects. Results from numerous capping projects over the past 20 years have provided a general understanding of the physical and chemical behavior of underlying fine-grained sediments and the overlying sand or mud layer used as capping material (Palermo, et al. 1998, Thibodeaux, et al. 1994, Thoma, et al. 1993, and O'Connor 1983). With proper operational control, capping material can be placed in a controlled, well-defined layer to provide effective isolation of contaminants.

Although capping has proven to be an effective control and isolation mechanism for contaminated sediments, concerns have been raised by regulating authorities as well as project proponents as to the effects any construction or maintenance activities will have on the integrity of a cap. Various remedial projects near or under existing or proposed pier structures have had to address and manage environmental and structural issues pertaining to pile removal, pile installation, and construction. The predominant environmental concern with pile driving is that contaminated sediments will either be exposed or contaminants themselves will be mobilized through pore water advection/migration to the biologically active zone or overlying water column.

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For the past 30 years, similar concerns regarding core sampling through caps have been raised during monitoring studies of capping projects (Palermo 2002). Concerns revolved around the core holes remaining open and/or penetration compromising the effectiveness of the cap. Based on numerous monitoring studies, cap effectiveness should not be degraded because the core holes have been shown to close back up and penetration effects do not significantly alter contaminant migration. Programs such as DAMOS (Disposal Area Monitoring System) administered by the U.S. Army Corps of Engineers (USACE), New England Division, Dredged Material Research Program (DMRP), and other research projects sponsored by the Waterways Experiment Station administered through the USACE have documented the sustainability of cap effectiveness through monitoring results. Federal and state regulatory agencies have repeatedly approved the use of coring equipment to monitor capping projects in multiple year monitoring programs. The successful results from the majority of cap monitoring programs supports the conclusion that using coring equipment does not adversely impact the structural or chemical effectiveness of a cap.

POTENTIAL IMPACTS FROM PILE DRIVING

When looking at the process of driving a pile through a cap, the concerns relate to structural integrity of the cap and potential environmental impacts that may occur during the pile driving operation. Driving piles generally causes movement of the surrounding sediments. In the event that a pile is driven through a cap into underlying contaminated sediments, particular concerns arise with exposure of contaminants to the water column or failure of the cap. Some parameters that may be of influence and cause concern are listed below.

- Slope stability and sediment displacement
- Pore water pressure
- Contaminant migration through potential newly created preferential pathways
- Resuspension of sediments from pile driving

Primarily, the movement of sediment due to pile driving results from sediment being displaced by the penetrating pile and from a reduction in sediment resistance due to the buildup in pore water pressure created as the sediment is compressed and sheared during pile installation. Although the vibration caused by driving piles is another potential source of sediment movement, this generally is not a primary concern. Ground vibration induced by pile driving activities normally last for only short periods (tenths of a second) of time. It appears that the shearing strains associated with vibration attenuate so rapidly that their direct effect on sediment movement is very limited (Anderson 1992, Hwang 2001).

Although cap placement and pile driving within the construction area will result in the temporary disturbance and loss of some benthic assemblages, the small area of impact and short duration time in a typical industrialized harbor where pier or harbor development is conducted is not likely to have any appreciable effect on productivity, species richness, or sustainability of the aquatic community. For this paper, we will focus on physical and chemical related impacts.

Numerous investigations have been conducted studying the effects of pile driving on slope stability and sediment mobility (D'Appolonia 1971, Anderson 1992 and Hwang, et al. 2001). Effects from pile driving are related to slope failure and movement or liquefaction of sediment and not to intense mixing events or extreme exposure of underlying sediments to the surface. The following sections will review potential physical and chemical impacts associated with pile driving.

Sediment Displacement

The most apparent result of pile driving is ground heave. This is typically evidenced by a settlement or depression within the surface sediments close to or adjacent to the penetrating pile and corresponding displacement of sediments extending beyond the depression. For example, the settlement observed from driving a 24-inch diameter pile can potentially range from 12 inches immediately adjacent to the pile to several inches of radial displacement at a distance of 10 to 15 feet extending from the pile (Anderson 1992). To simplify the discussion of displacement, both horizontal and vertical movement within the sediment will be reviewed.

Horizontal displacement due to a single pile or multiple piles being driven is typically greater towards the center point of the pile and decreases outward from the pile center. Hwang's (2001) investigation provided a graphical depiction of the radial displacement and affected depth during pile driving in relation to sediment type (Figure 1). Varying types of sediment (e.g. clays to sands) were recorded at different depths that in turn exhibited different radial displacements. Radial displacement varies in relation to the physical properties of each sediment type and the depth of an individual layer. The results recorded at three inclinometers placed at increasing distances from the center of a pile in Hwang's (2001) investigation showed that the maximum movement occurred closest to the pile (Figure 1).

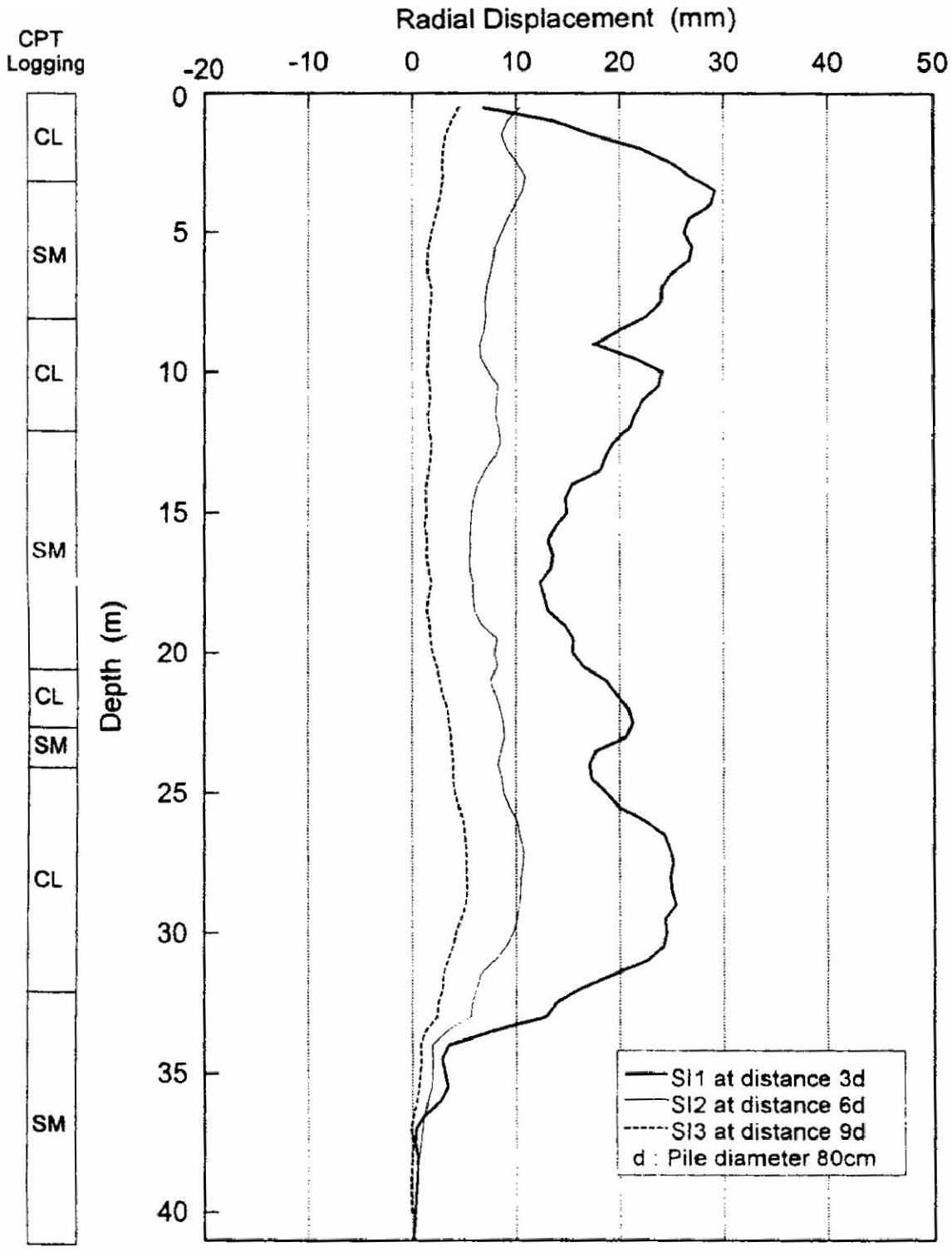
A maximum radial displacement of 29 mm (1.14 inches) from the center of the pile at 3.5 meters (11.5 ft) below the surface was exhibited (Hwang, et al. 2001). Radial displacement is also shown to decrease as the horizontal distance from the pile increases. After completion of the pile driving, the mean horizontal displacement at various vertical layers of sediment types was 2 cm (0.8 inches).

Vertical displacement also decreases as the horizontal distance from the pile increases. Typically, as the pile reaches an intermediary depth the greatest amount of heave will occur. For example, Hwang reported a vertical displacement reaching a maximum of 3.6 cm when the pile (diameter 2.5 feet) reached a depth of 9 meters. Inclinometers closer to the pile recorded a gradual decrease in vertical displacement with increasing pile penetration depth. This can be interpreted as being due to the downward drag effect from the pile.

Additional piles driven close to a previously driven pile can increase the displacement or settlement witnessed at the previously driven pile. The exact magnitude of displacement is difficult to predict and is dependent on numerous parameters such as the size of the piles, sediment stratigraphy, and depth the pile will be driven.

To estimate settlement for cap design and slope stability in general, various models and methods have been developed and can be applied. However, due to the multitude of variables inherent in pile installation, the models are difficult to apply and are normally utilized under idealized conditions. The usual recourse to conducting complex slope stability analyses with various methods and models is to specify the pile driving sequence. In addition, other techniques can be implemented to minimize displacement such as using nondisplacement piles and installing the piles from the top of the slope toward the bottom of the slope.

Figure 1



Source: Journal of Geotechnical and Geoenvironmental Engineering / November 2001

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Figure 1
Radial Displacement of SI1, SI2, and SI3, and DP1 Driving

Pore Water Pressure

Pile driving can increase the pore water pressure in the surrounding sediments. This increase in pressure can potentially affect the stability and shear strength of the sediment. Buildup of pore water pressure is closely related to the penetration depth of the pile and sediment type. The zone of influence exerted from a pile being driven is concentrated around the pile tip (e.g. a sphere of increased pore water pressure surrounding the pile tip) as the radial distance from the pile tip increases, pore water pressure decreases. The pore water pressure is greatest below the pile tip during a driving sequence and lower above the tip. Depending on the depth and the sediment layers the pile is being driven through will dictate the amount of time for pore water pressure to dissipate to ambient conditions.

The time required to develop the full bearing capacity of a driven pile is dependent on sediment type. The presence of a clay or a low permeability silt layer does not allow a rapid decrease in the pore water pressure in surrounding sediments. Whereas, sediments predominantly composed of sand exhibit rapid dissipation of pore water pressure during and after pile driving. Hwang reported after pile driving, an 18-hour lag in a clay layer and a 4-minute lag in a sand layer for the pore water pressure to return to ambient conditions. In comparison to other studies (D'Appolonia and Lambe 1971, and Airhart, et al. 1969, and Bjerrum and Johannessen 1961), Hwang's recorded pore water pressures near the driven pile within a clay layer were significantly higher. When assessing pore water pressure in multiple sediment layers, average increases within a clay layer can range around 3 to 4 times ambient conditions extending radially from 10 to 20 feet from the pile center (assuming a 2.5 to 5 foot pile diameter). Within a sand layer pore water pressure can range between 1 to 2 times ambient conditions extending 10 to 30 feet from the pile center Depending on the sediment type, the effects of pore water pressure become negligible beyond 40 to 75 feet from the pile diameter (Eigenbrod and Issigonis 1996 and Hwang 2001). These distances and pressures would decrease if using a smaller diameter pile. Additionally, it should be noted that circular or spherical contours of pore water pressure change will radiate from the pile tip. As the distance from the pile tip increases the pore water pressure contours will exhibit a decreasing trend in strength approaching the surface.

Although there is a notable increase in pore water pressure from pile driving, the dissipation rate even in a clay layer is such that there is not a significant change in water content and reduction in the strength of the slope stability (Anderson 1992). Consequently, the cumulative effects on slope stability generally are not significant (Anderson 1992). However, pore water pressure changes should still be considered when assessing slope stability and capping designs. To address the issue where multiple layers of varying grain size occur, models such as the standard one-dimensional consolidation theory can be used to predict the dissipation rate. However, they have been shown to grossly overestimate in-situ conditions. The preferred approach has been to install pore water pressure transducers and monitor the buildup during pile driving. As long as the water content does not change appreciably, the effects on a cohesive soil will likely be minimal. A contingency program of altering driving sequence or schedule can also be implemented to ensure acceptable levels of pore pressure during installation.

Contaminant Migration

Contaminant migration could potentially occur through the preferential flow of water alongside the driven pile if the site has a general upward flow gradient or through pore water. Available chemicals within the pore water may migrate through sediments by advection. The degree of sediment consolidation and pore water pressure will determine the amount of advection that occurs upward or laterally from underlying contaminated sediments to overlying clean sediments. Numerous cap studies have been conducted to determine the distance that pore water advection will advance into overlying sediments from underlying contaminated sediments (Murray et al 1994; Palermo et al 1998 a, b; Thoma et al 1993; Thibodeaux et al 1994; Bokuniewicz and Gordon 1979) and conclusions of these studies have varied. For example, Palermo et al. (1998b) calculated that pore water would only advance 18 cm into an overlying cap of 45 cm thickness. In contrast, Thoma, et al (1993) cited within their investigation of chemical penetration of PCBs in pore water into a typical cap during consolidation, when chemical advection is upward, that only about 1 mm of penetration occurred within a few months of the cap formation. These calculations and measurements varied due to sediment type and site-specific parameters and constraints.

To address contaminant migration concerns a general review of the chemicals of concern should be conducted specific to a site. An appropriate cap thickness specific to the design criteria for each site should address fundamental concerns

with contaminant migration. Based on the potential chemical availability and mobility within pore water and other transport mechanisms, short-term effects could be anticipated and control measures could be incorporated into the general cap and pile driving installation design. Allowance for general cap consolidation as well as settlement after pile driving would also be part of any construction design. Depending on the type of material used for a cap, standard monitoring surveys after pile driving would identify any voids if present, and in turn these voids could be filled to address exposure issues.

Potential for Resuspension of Sediment

The impact of a pile being driven in the sediment has the potential to discharge surface sediments causing a transient increase in turbidity in the water column. However, pile driving is unlikely to resuspend the contaminated sediment underlying a clean cap unless the cap thickness is minimal. The process of pile driving would typically push (or pull) overlying sediment along the pile circumference lower in the sediment profile.

In the reverse case of pile driving (i.e., pile removal) there is also the risk of temporarily increasing water column concentrations of chemical constituents present in the underlying contaminated sediments. The duration and severity of the transient changes depends on the method of discharge, the physical nature of the material, the chemical concentrations in the material, and the availability of the chemical constituents.

If there is a concern that underlying contaminated sediment could become resuspended during pile driving, or if piles are being removed, leachate tests can be conducted. Analytical results from leachate tests (e.g., WET, TCLT, MET, and DRET) could be compared to applicable water quality criteria. In addition, leachate results could be utilized in a suitable mixing model to determine if adverse water quality impacts would occur. These strategies can be formulated to meet regulatory guidelines regarding potential transient toxic effects due to resuspension of contaminated sediments. However, as detailed in the Case Studies section of this paper, an alternative is to place a thin layer of sand before any pile driving or removal is conducted to prevent any potential resuspension. The purpose of a thin layer of sand is to contain or inhibit underlying contaminated sediments from being suspended into the water column due to construction activities. It should be noted that resuspension of sediments is significantly less from pile driving than from pile removal. In pile driving the pile effectively pulls a small portion of sediment surrounding it as it is driven. As stated in the Potential Impacts Section vibrations from pile driving last for tenths of a second and dissipate rapidly having minimal effects on sediment movement (Anderson 1992, Hwang 2001). Whereas, in pile removal, the sediment profile of underlying sediments surrounding the pile is disturbed and pulled up with the pile. This action causes a greater potential for resuspension.

Figure 2

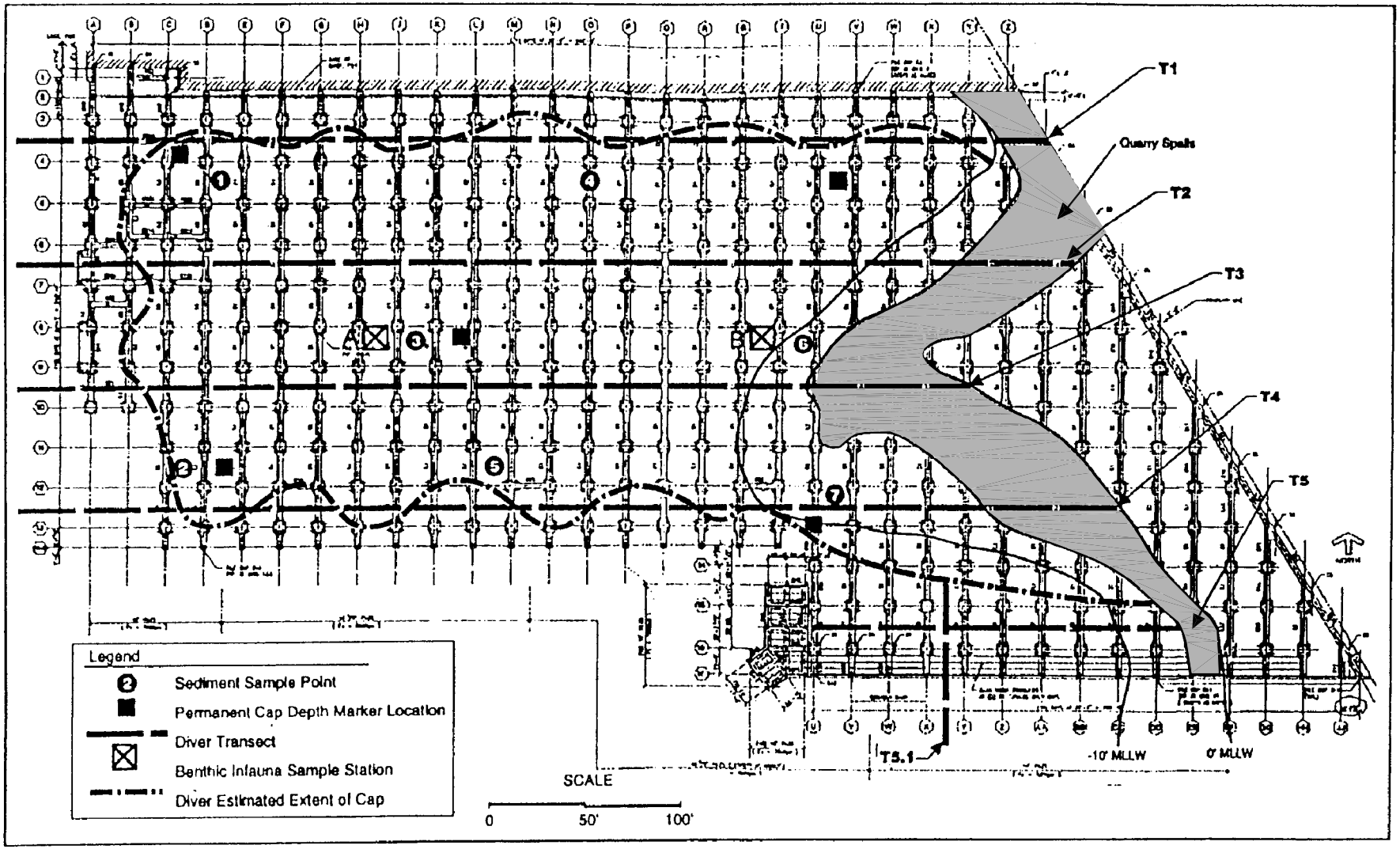

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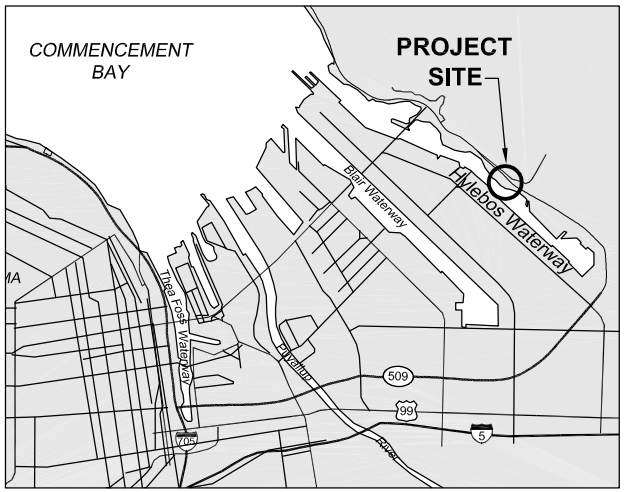
Figure 2
Pier 51 Capping Area

Figure 3



Vicinity Map
Not to Scale

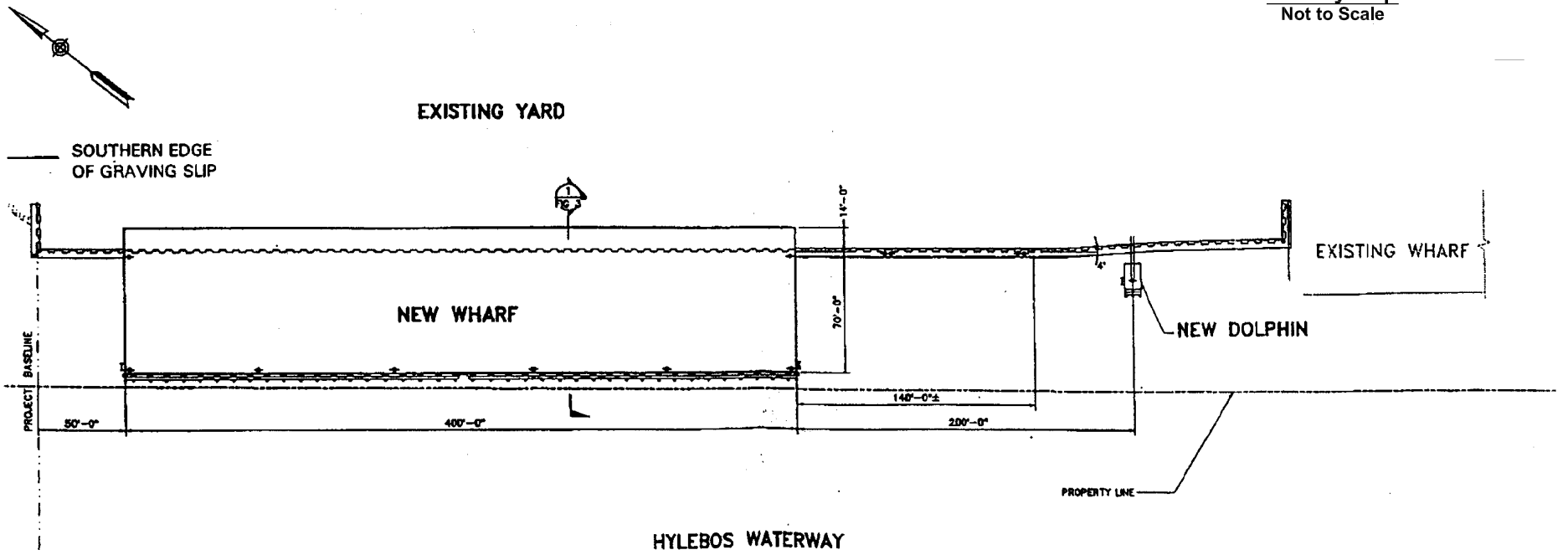


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Figure 3
Project Site Plan

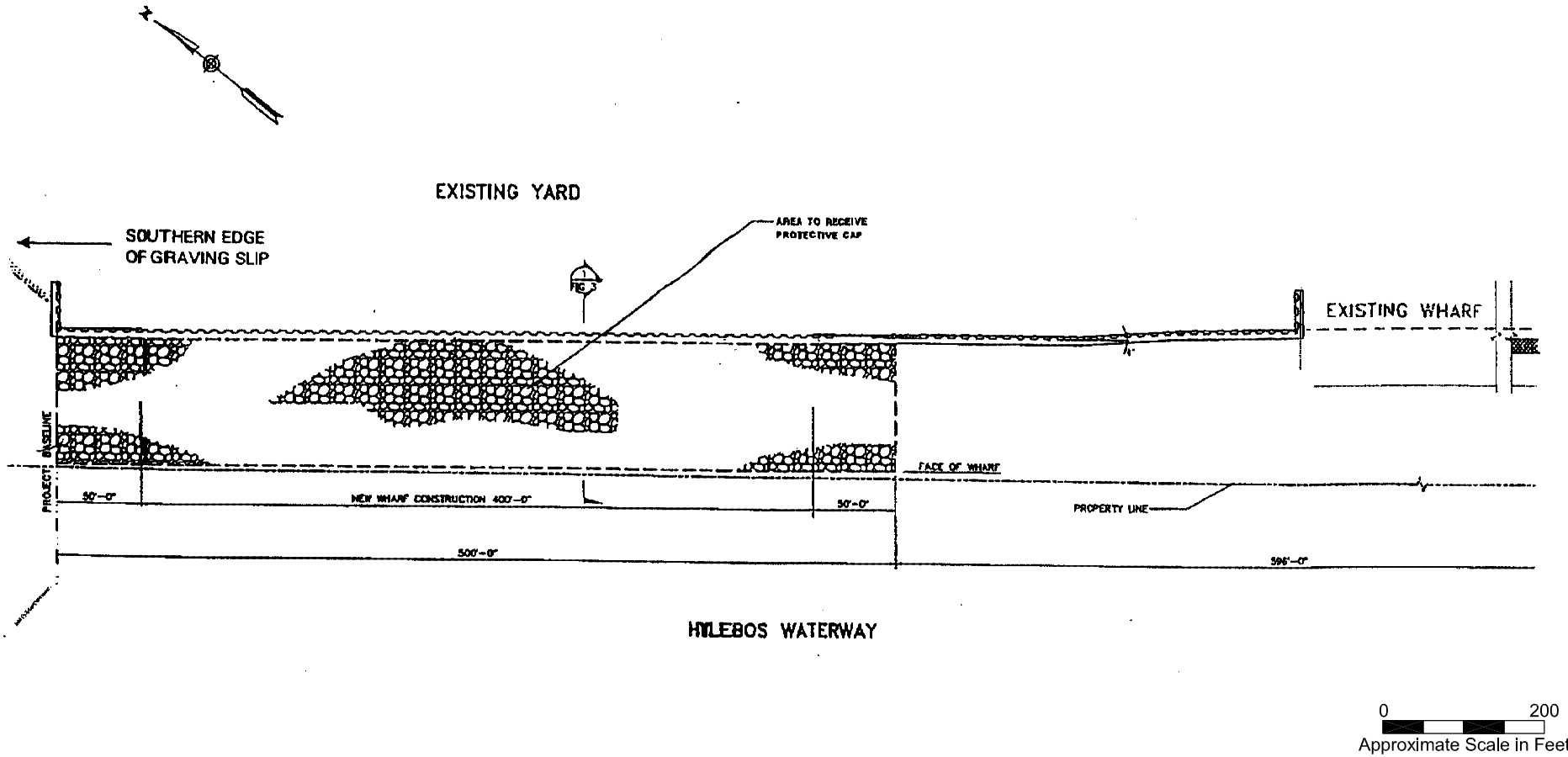

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Figure 4
Cap Location

CASE STUDIES

Pier 51 Coleman North Trestle Replacement

The Washington State Department of Transportation (WSDOT) was required to address contaminated sediment in the construction area of the Coleman Ferry Terminal (Pier 51) on the Seattle waterfront. This project included the renovation and expansion of the Pier. Based on the sediment characterization results and the likelihood of future cleanup being required, WSDOT decided to address contaminants of concern (e.g., metals and PAHs) by isolating the underpier contaminated sediments with a cap. A cap of clean sand approximately 0.5 m (1.5 ft) in thickness was placed prior to driving piling for the rehabilitation and expansion of Pier 51 (Figure 2). The layer of sand was also intended to reduce resuspension of contaminated sediments during the installation of numerous piles (CH2M Hill 1999).

WSDOT performed a diver survey the week after placing the cap. The cap placement was found to be satisfactory with thickness ranging between 1.5 and 2 ft consistently over the area of coverage. Marine invertebrates and several species of bottom-dwelling fish were also observed on the cap during the diver survey (Sumeri 1994). Following placement of the cap, WSDOT constructed a reinforced concrete piling-supported asphalt apron used for vehicle holding/loading and ferry slips, otherwise known as the trestle.

In August 1994, WSDOT conducted a second monitoring event of the sand cap at Pier 51. A diver probing with a steel rod measured the cap thickness and reported that it ranged from 1.5 to 2 ft. Sediment samples were collected from three depths (surface, cap material, and sub-cap material) at seven locations. Of the reported samples, only one of the seven surface sediment samples did not meet the Washington State Sediment Quality Standards (SQS) (Sumeri 1994). Samples of cap material represented by sediments collected below the biologically active zone, did not exhibit any exceedances of the SQS for metals. Organic concentrations were difficult to interpret due to method detection limits for some of the individual PAH compounds exceeding the SQS and Maximum Cleanup Level criteria. However, only two stations exhibiting detected concentrations of PAHs were below the SQS criteria.

In an effort to interpret these monitoring results, it was speculated that recontamination of the surface sediment of the cap could have been from one or more of the following potential sources: adjacent construction activities, effluent from combined sewage outfall's in the area, or from resuspension of contaminated sediments within the adjacent channel. Monitoring conducted in an adjacent uncapped area south of the site at nine locations exhibited eight of these surface sediment samples exceeding the SQS criteria for mercury. PAH concentrations within sediments at six of the nine stations exceeded SQS criteria for multiple individual PAH compounds.

Schnitzer Steel of Tacoma

The Schnitzer Steel of Tacoma (SST) site, formerly know as General Metals of Tacoma is located along the Hylebos Waterway (Figure 3). SST conducted a removal action involving the installation of a cap over contaminated sediments approximately 30,000 square feet (0.8 acres) along the shoreline and to depth in the bulkhead area. Remedial work performed at the site was in accordance with the requirements of the SST's Administrative Order on Consent (AOC) No. 10-98-0133 dated October 13, 1998. The remedial effort resulted in the design of a cap that entailed the layering of a geotextile barrier, a sand/gravel layer, and then finally rip rap and fishrock layers (Bridgewater Group 2000). Piles were driven into the cap after construction and any depressions or deviations from the design specifications were filled in with additional rip rap after a diver survey.

The design thickness was 2.5 feet in most areas and 3 feet for the fish rock regions. Settlement was estimated to be 6 inches during construction. Measurements from the post construction survey showed that on average, even with the isolated low spots near the piles, there was adequate material placed to meet the design requirements for the entire cap area. The overall function of the cap was not compromised by the presence of the isolated low spots since they were the result of settlement not reduction in cap thickness (Berger ABAM 1999).

After the project was completed, a barge struck the new pier and damaged several piles. EPA was notified that a dock repair project was necessary to remove and replace seven damaged pier fender piles and associated hardware

(Bridgewater Group 2001). A post-repair visual inspection of the cap was conducted after the piles were driven. The diver survey found that the cap around the newly installed fender piles was intact and it did not appear that any material movement in between the newly installed piles occurred. However, the divers noted that there was a 2 foot long depression behind each new fender pile that was approximately 2.5 feet wide exposing the gravel layer. There was also a shallow depression approximately 1 foot in diameter around each new fender pile. On the down hill slope of the piles the riprap was still intact with no gravel exposed. All the riprap between the piles was still intact and showed no signs of movement. These depressions were also noted around the originally installed piles and were associated with the forces exerted during pile driving.

Follow up actions included placing 1.5 to 2 feet of riprap rock behind each newly installed fender pile. Approximately 50 to 70 cubic feet of new material was placed behind the 7 fender piles. The survey following this placement action reported that the pile driving did not alter the in-place cap thickness.

Monitoring in 2001 confirmed that the cap was performing as planned and within design specifications (Bridgewater Group Inc 1998). Lead line and diver survey measurements showed that there was only localized settlement from the weight of the riprap and no general slope movement.

ADDRESSING REGULATORY CONCERNS AND MONITORING REQUESTS

The process for gaining approval to drive piles through an environmental cap will be dependent on the regulatory agencies' concerns, site-specific constraints, chemicals of concern, and the time frame of the project. Depending on the region and district, permits will vary. The fundamental permits are those for construction, remediation, and addressing impacts to pertinent biological species or habitat. Agencies that normally have governing authority in some capacity include the USACE, USEPA, Department of Fish and Wildlife, and applicable City and State Departments that regulate construction, development, and environmental concerns such as water quality and biological resources.

As stated previously, the standard concerns with pile driving through an environmental cap are the potential for contaminated sediments to be transported or forced through the cap or exposed to the surface or water column. As discussed in previous sections, pile driving does not cause subsurface sediments to erupt through an overlying layer such as a cap. The results are subtler; impacts typically have been shown to induce depressions or divots upslope of the pile and depressions immediately surrounding the pile after driving is complete. In general, sediment displacement and changes in pore water pressure do not significantly impact surficial sediments to prohibit thick capping as an alternative. However, concerns may be warranted when utilizing a thin cap where small pore water pressure changes may influence contaminant migration. Solutions to these events are to incorporate potential displacement and pore water pressure changes into the design of the cap whether it is thick (i.e., > than 3 ft) or thin (i.e., approximately 6 inches). Follow up procedures to the design to ensure cap effectiveness might include placing additional cover material in areas of depression surrounding the pile or divots upslope after pile driving has been completed.

When a cap design anticipates the impacts associated with the installation of piles it is reasonable to assume that the affected portion of the cap may have a reduced efficiency for a short time. It is anticipated that the overall potential for reduced effectiveness is negligible for most sites when comparing the potentially affected area versus the overall surface area of a typical cap. To address short-term impacts monitoring and follow up measures can be implemented.

After the cap construction, a survey should be conducted to confirm that the cap is within design specifications. This can be performed using either a diver or lead-line survey or both. Once the design parameters for cap thickness and coverage have been confirmed pile installation can commence. Monitoring will be a crucial part of this phase of construction to address both structural and environmental concerns. Typically, the cap will have long-term monitoring requirements (e.g., 1, 2, 5, and 10 years) from the time of completion. Equipment that could be used for monitoring the physical parameters of ground heave and pore water pressure can include the following: instrumentation clusters to monitor the consolidation of material, slope inclinometers, Sondex settlement sensors, pneumatic pore pressure transducers and surface settlement plates. Leachate tests or pore water chemistry for chemicals of concern could be conducted to address the potential for contaminant migration or resuspension.

The ease in which future projects are accepted and approved will be dependent on the region in which the project is proposed. In those areas where knowledge and continued success of previous projects such as the Pier 51 and Schnitzer Steel sites are well known the precedence has been set. In other regions, education and presentation of the physical and chemical dynamics will be necessary to alleviate concerns regarding the effectiveness and sustainability of the cap design.

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E1

ESQUIMALT GRAVING DOCK

INDEMNIFICATION FORM (2002)

Number of Pages: 1

INDEMNIFICATION CLAUSE

I (We), the undersigned, hereby indemnify Canada for the vessel described below, located at _____ within the Esquimalt Graving Dock and Munroe Head, for the purpose and time stated, for the period of _____, 20___.

Name of Vessel: _____

Vessel Owner's Name: _____

The Agent assumes and agrees to hold harmless, indemnify, protect and defend Her Majesty the Queen in right of Canada ("Her Majesty"), Her agents and employees, against any and all liability for injuries and damages to Her Majesty, the Vessel, crew, employees, agents, sub-contractors, guests, third parties or otherwise, incident to or resulting from the Vessel using the facilities of Esquimalt Graving Dock and Munroe Head, except in instances of an act or acts of negligence by Her Majesty or agents, servant of the Corporation of the Township of Esquimalt and all mutual aid partners. Damages will be deemed to include liability which is attributable to environmental impairment, or clean up expenses, including fire fighting.

Should the Agent and the Vessel owner not be one and the same, the authorized signatory verifies that the following clause has also been included in the contract between the Agent and the Vessel owner:

> The Vessel owner assumes and agrees to hold harmless, indemnify, protect and defend Her Majesty the Queen in right of Canada ("Her Majesty"), Her agents and employees, against any and all injuries and damages to Her Majesty, the Vessel, crew, employees, agents, sub-contractors, guests, third parties on a contractual, tort, statutory or any other legal or equitable basis including not limited to public safety service providers, fire protection officials, police, and rescue workers, related to the Vessel using the facilities of Esquimalt Graving Dock and Munroe Head, and resulting from an act or acts of negligence by the Vessel Owner, its agents and employees. Damages are deemed to include but not be limited to the liability which is attributable to environment impairment or clean up expenses, including fire fighting.

_____ _____

Authorized Signature of Agent Company Name

_____

Signature of Witness

_____

Date

Revised: 18/June/2002

E2

ESQUIMALT GRAVING DOCK

SCHEDULE 1 – APPLICATION FOR USE OF ESQUIMALT GRAVING DOCK FORM (2012)

Number of Pages: 2

SCHEDULE 1

APPLICATION FOR THE USE OF ESQUIMALT GRAVING DOCK, PUBLIC WORKS AND GOVERNMENT SERVICES CANADA, VICTORIA, BRITISH COLUMBIA

I (We), the undersigned, hereby make application for use of the facilities within the Esquimalt Graving Dock as indicated below:

Dates of Dry-dock: _____	Name of Vessel_____
Purpose of Dry-dock:_____	Owner's Name_____
Dates of Berthage(NLW)_____	Port of Registry_____
Purpose of Berthage:_____	Owner's Address_____
Master's Name_____	Master's Address_____
Agent's Name_____	Agent's Address_____
Dockmaster's Name_____	Gross Tonnage_____
Length, Overall_____	Length between Perpendiculars_____
Breadth, Extreme_____	Draft, Forward_____
Draft, Aft_____	Type of Vessel (*screw, sailing, not self-propelled, etc.*)_____
Engines:Steam/Gasoline/Oil_____	Fuel Type: _____
Keel:Bar/Flat (*If bar, state depth*)_____	Rise of Floor Amidships_____
If there any explosive matter on board describe: _____	

Is this vessel carrying or did carry any flammable material or dangerous cargo? If so, describe materials below and attach a copy of the gas free certificate supplied from a marine chemist.

_____

Is there any oil escaping from the vessel? (*If so, to what extent?*) _____

Special features of ship, such as the length of "cut up" forward and aft, camber of keel, if any, and underwater form (*State if "usual"; if "unusual", give particulars*) _____

_____

Do you require additional length on the North Landing Wharf other than for the vessel described above? If so, give details below:

_____

Revised: 30 July, 2012
SOR/95-462, s. 8.

SCHEDULE 1

International Ship Security Certificate Number (MANDATORY): _____

International Maritime Organization Number (MANDATORY): _____

Specify any cargo, equipment etc. that relates to the vessel described above, that requires storage within the Esquimalt Graving Dock facility. This should include the description as to how much space will be required, weight and period (dates) of storage:

Date(s) of Storage:_____
Space Required:_____**Weight**: _____
Description as to how space will be used: _____
_____

VESSELS VISITING THIS FACILITY FOR MORE THAN EIGHT (8) HOURS ARE TO ATTACH THE FOLLOWING DOCUMENTATION WITH THIS APPLICATION: Post Docking Survey, Vessel Fire Control Plans, Vessel Drawings, and the Vessel Crew List. These documents are to be given to Risk Management at the Esquimalt Graving Dock. The documents will be kept in the Incident Command Post, located in the Main Office Building of Esquimalt Graving Dock.

I (We), the undersigned, hereby agree to comply with the *Esquimalt Graving Dock Regulations, 1989*, and all other applicable Acts and regulations, including, but not limited to, the applicable provisions under the *Safe Working Practices Regulations* and the *Tackle Regulations* under the *Canada Shipping Act*, the *Industrial Health and Safety Regulations* of the *Workers' Compensation Act* of British Columbia, the *Fisheries Act* and the *Canadian Environmental Protection Act*.

(1) _____ Date_____, 20____
(*Signature of Agent*)

(2) _____ Date_____, 20____
(*Signature of Witness*)

SPECIAL BILLING INSTRUCTIONS:

Company Name:_____

GST/HST Number:_____

Mailing Address:_____

Contact Name & Telephone Number: _____

Revised: 30 July, 2012
SOR/95-462, s. 8.

F1

ESQUIMALT GRAVING DOCK

SOUTH JETTY EXISTING PILE CONDITION ASSESSMENT

Number of Pages: 4

HEROLD ENGINEERING

July 27, 2016 3191-008

Via email: Patrick.Truong@pwgsc-tpsgc.gc.ca

Public Works and Government Services Canada (PWGSC)
219 - 800 Burrard Street
Vancouver, B.C.
V6Z 0B9

Attn: Patrick V Truong, P.Eng

Re: Esquimalt Graving Dock South Jetty
Existing Pile Condition Assessment

Dear Patrick:

As requested by PWGSC, Herold Engineering Limited (HEL) conducted a condition assessment of the steel piles beneath the South Jetty at the Esquimalt Graving Dock (EGD). The structure subject to the inspection is the central concrete portion of the South Jetty that was rebuilt in 1985 and will be referred to herein as the 'existing structure'. The purpose of this assessment is to estimate the remaining service life of the existing piles and to provide recommendations for preventative maintenance.

Due to its age and condition, the South Jetty is undergoing remediation and reconstruction work. In order to meet the performance requirements of increasingly large vessels and to address the health, safety, and seismic risks of the aging structure, a new concrete structure supported on steel piles will be constructed in the same location as the recently demolished timber portion. The original timber jetty, built in 1940, has been demolished and the sea floor in the EGD Waterlot is being dredged of contaminated soil.

The existing structure will remain intact and be incorporated into the reconstruction of the new South Jetty. The steel piles of the existing structure were inspected to determine if immediate repairs should be implemented in conjunction with new the Jetty construction.

Existing Structure

The existing structure consists of an L-shaped concrete slab on concrete beams which overlay concrete pile caps supported by steel piles. The deck has a surface area of approximately 3325 m^2. The existing pile layout is approximately 182 steel piles and includes both straight-driven and battered piles. See Appendix A for a plan drawing.

The piles are 0.6m in diameter with an assumed original wall thickness of 12.7mm. A protective coating was applied to the piles at the time of construction to limit corrosion.

Several piles currently have corrugated steel jackets to protect them from adjacent dredging work.

In preparation for HEL's assessment the following consultants' reports were reviewed:

- Foreshore Technologies Inc: Condition Assessment Report (2001)
- Hay & Company Consultants Inc and Read Jones Christofferson Ltd: Condition of South Landing Wharf Esquimalt Graving Dock Esquimalt, BC (2001)
- Focus: Survey of Pilings Under South Jetty of Esquimalt Graving Dock (2010)
- Golder Associates: Sub-Surface Probing and Dive Surveys Interpretive Report Esquimalt Graving Dock Esquimalt, BC (2012)
- WSP: Esquimalt Graving Dock Pre-Construction Condition Survey (2016)

Observations

Herold Engineering Limited conducted a site investigation of the existing piles. The assessment team included Tyler Wilson, P.Eng and Brendan O'Grady, AScT. Access was provided via a small work boat by the Contractor currently on site completing demolition and remediation work in the adjacent area of the South Jetty. This provided under-pier access in order to be in direct contact with the piles. Field measurements and photographs were taken to record their general condition. The assessment took place on June 7, 2016.

The assessment conducted was visual and included regular thickness testing. Specifically, a visual scan of all exposed surfaces determined the general severity of scaling and bubbling of the coating. Furthermore, localized thickness testing using a handheld ultrasonic thickness tester quantitatively determined the approximate extent of corrosion to the base metal in select locations.

The majority of piles showed a similar degree of corrosion in a consistent pattern. Visible bubbling and flaking of the coating was observed and, generally, the upper portion of the pile experienced less severe corrosion than the lower portion (directly above the water surface).

As pictured in Figure 1, the upper portion of the pile is relatively clear of damage and the degree of corrosion and the prevalence of barnacles increases along the pile toward the water surface. The degree of typical coating corrosion involves some flaking and bubbling as seen in Figure 2. A detailed summary of measurements taken is included below as Appendix B.

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Figure 1 - Typical Pile Condition

Figure 2 - Typical Coating Condition

A previous report completed in 2001 by Foreshore Technologies Incorporated indicates that at the time of assessment the coating was in a condition similar to as it is now found and that pile thickness measurements ranged from 8.3mm to 11.5mm. The current assessment found steel thickness from 6.5mm to 12.2mm.

Conclusions and Recommendations

Based on our review, we believe that the remaining service life of the piles is dependent on maintenance undertaken in the short term (within 3 years). If left alone without maintenance, the reliable service life could be expected to be in the range of 10 to 20 years. If maintenance is completed as recommended below, and minor ongoing maintenance is continued, the reliable service life could be expected to exceed 50 years.

The severity of the corrosion is minor to moderate, with the majority of degradation to date affecting the pile coatings. This can reasonably be mitigated by remedial measures and ongoing preventative maintenance. A time-sensitive remediation plan will prevent further damage and corrosion; this will allow the piles to continue to meet the performance requirements of the South Jetty.

Herold Engineering Limited recommends that the existing piles be cleaned of loose/damaged coating and marine growth and that they be re-coated with a pile-wrap system. Typically this would consist of an asphalt-impregnated fabric wrap, shielded with an HDPE outer layer to protect against mechanical damage.

The scope of this assessment was limited to the above-water portions of the piles only, and not every pile was assessed in detail. As such, the extent of damage towards the bottom of the piles is unknown, as is the number of corrosion points requiring steel patching. It is

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recommended that the maintenance work be completed on a unit rate basis with an allowance for localized repairs, as required, based on the conditions encountered by the dive team installing the pile-wrap system.

Our opinion on the probable cost for the supply and installation of such a protective system is in the order of $400,000 to $500,000. This estimate is based on the following:

- 182 Piles to be protected for top 5m of length,
- Installation by 4-person Dive team (2 divers active in-water), completing 4 piles per day, at a rate of $3500 per day - $160,000
- Material including primer coating, bitumen wrap, and outer shell at $1300 per pile - $240,000
- Contingency of $100,000 to account for unconfirmed extent of protection needed below low tide elevation.

It is recommended that if budget allows, this remediation should be implemented during the upcoming South Jetty Reconstruction. Otherwise it should be planned as a stand-alone project in the near future.

Further to these short-term remedial efforts, we also recommend a preventative maintenance plan involving an annual visual inspection by an EGD representative, followed up with a detailed assessment by an engineering professional every 5 years.

We trust that this information meets your requirements at this time, and invite you to contact the undersigned with any questions or concerns.

Yours truly,

HEROLD ENGINEERING LIMITED

Prepared By:

Tyler Wilson, P.Eng.
Structural Engineer

Reviewed By:

Kate Ulmer, P.Eng.
Structural Engineer

Enclosure

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F2

ESQUIMALT GRAVING DOCK

SHEET PILE DRIVING RECORDS

VPD (2016)

Number of Pages: 22

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: Tuesday, November 10, 2015
Weather: Cloud
Equipment: APE 50 Vibratory Hammer
Derrick: No.4 Derrick
Total # Driven: 35.50

Type A	Pile Pair ID	Section Type	Location on Structure	Initial Cut-Off Elevation	Initial Tip Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments	
Type A	0.5	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	1	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	2	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	3	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	4	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	5	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	6	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	7	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	8	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	9	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	10	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	11	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	12	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	13	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	14	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	15	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	16	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	17	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	18	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	19	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	20	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	21	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	22	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	23	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	24	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	25	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	26	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	27	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	28	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	29	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	30	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	31	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	32	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	33	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	34	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	35	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: Wednesday, November 11, 2015
Weather: Cloud
Equipment: APE 50 Vibratory Hammer
Derrick: No.4 Derrick
Total # Driven: 35.00

Type A	Pile Pair ID	Section Type	Location on Structure	Initial Cut-Off Elevation	Initial Tip Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments	
Type A	36	AZ 26-693	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	37	AZ 26-694	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	38	AZ 26-695	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	39	AZ 26-696	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	40	AZ 26-697	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	41	AZ 26-698	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	42	AZ 26-699	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	43	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	44	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	45	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	46	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	47	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	48	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	49	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	50	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	51	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	52	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	53	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	54	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	55	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	56	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	57	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	58	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	59	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	60	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	61	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	62	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	63	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	64	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	65	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	66	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	67	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	68	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	69	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		
Type A	70	AZ 26-700	South Face	4.80	-12.00	2.00	-14.80	None.	Not Recorded		

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: Thursday, November 12, 2015
Weather: Cloud
Equipment: APE 50 Vibratory Hammer
Derrick: No.4 Derrick
Total # Driven: 35.00

Type A	Pile Pair ID	Section Type	Location on Structure	Initial Cut-Off Elevation	Initial Tip Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	71	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type A	72	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type A	73	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	1	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	2	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	3	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	4	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	5	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	6	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	7	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	8	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	9	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	10	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	11	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	12	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	13	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	14	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	15	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	16	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	17	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	18	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	19	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	20	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	21	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	22	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	23	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	24	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	25	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	26	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	27	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	28	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	29	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	30	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	31	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	
Type B	32	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded	

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: Monday, November 16, 2015
Weather: Cloud
Equipment: APE 50 Vibratory Hammer
Derrick: No.4 Derrick
Total # Driven: 19.00

Type A	Pile Pair ID	Section Type	Location on Structure	Initial Cut-Off Elevation	Initial Tip Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments	
Type B	32	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	33	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	34	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	35	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	36	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	37	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	38	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	39	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	40	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	41	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	42	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	43	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	44	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	45	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	46	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	47	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	48	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	49	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		
Type B	50	AZ 38-700N	South Face	4.80	-13.50	2.00	-16.30	None.	Not Recorded		

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: Tuesday, November 24, 2015
Weather: Sun/Cold
Equipment: APE 300 Vibratory Hammer
Derrick: No.6 Derrick
Total # Driven: 24.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	1	AZ 26-700	South Face	12:00	4.80	-13.50	2.83	0.02	-18.28	None.	Not Recorded	
Type A	2	AZ 26-700	South Face	10:06	4.80	-13.50	2.87	0.02	-18.28	None.	Not Recorded	
Type A	3	AZ 26-700	South Face	9:57	4.80	-13.50	2.83	1.01	-17.29	None.	Not Recorded	
Type A	4	AZ 26-700	South Face	9:15	4.80	-13.50	2.88	1.01	-17.29	None.	Not Recorded	
Type A	5	AZ 26-700	South Face	12:07	4.80	-13.50	2.85	0.02	-18.28	None.	Not Recorded	
Type A	6	AZ 26-700	South Face	12:17	4.80	-13.50	2.82	0.02	-18.28	None.	Not Recorded	
Type A	7	AZ 26-700	South Face	12:24	4.80	-13.50	2.78	0.01	-18.29	None.	Not Recorded	
Type A	8	AZ 26-700	South Face	12:32	4.80	-13.50	2.79	0.03	-18.27	None.	Not Recorded	
Type A	9	AZ 26-700	South Face	12:41	4.80	-13.50	2.85	0.03	-18.27	None.	Not Recorded	
Type A	10	AZ 26-700	South Face	12:50	4.80	-13.50	2.83	0.02	-18.28	None.	Not Recorded	
Type A	11	AZ 26-700	South Face	13:01	4.80	-13.50	2.82	0.01	-18.29	None.	Not Recorded	
Type A	12	AZ 26-700	South Face	13:09	4.80	-13.50	2.84	0.03	-18.27	None.	Not Recorded	
Type A	13	AZ 26-700	South Face	13:19	4.80	-13.50	2.95	0.02	-18.28	None.	Not Recorded	
Type A	14	AZ 26-700	South Face	13:30	4.80	-13.50	2.99	0.03	-18.27	None.	Not Recorded	
Type A	15	AZ 26-700	South Face	14:09	4.80	-13.50	2.94	0.02	-18.28	None.	Not Recorded	
Type A	16	AZ 26-700	South Face	14:25	4.80	-13.50	2.93	0.10	-18.20	None.	Not Recorded	
Type A	17	AZ 26-700	South Face	15:58	4.80	-13.50	2.88	0.08	-18.22	None.	Not Recorded	
Type A	18	AZ 26-700	South Face	16:05	4.80	-13.50	2.91	0.08	-18.22	None.	Not Recorded	
Type A	19	AZ 26-700	South Face	16:11	4.80	-13.50	2.90	0.09	-18.21	None.	Not Recorded	
Type A	20	AZ 26-700	South Face	16:20	4.80	-13.50	2.89	0.10	-18.20	None.	Not Recorded	
Type A	21	AZ 26-700	South Face	16:28	4.80	-13.50	2.99	0.09	-18.21	None.	Not Recorded	
Type A	22	AZ 26-700	South Face	16:35	4.80	-13.50	3.00	0.09	-18.21	None.	Not Recorded	
Type A	23	AZ 26-700	South Face	16:46	4.80	-13.50	3.05	0.09	-18.21	None.	Not Recorded	
Type A	24	AZ 26-700	South Face	16:54	4.80	-13.50	3.00	0.10	-18.20	None.	Not Recorded	

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: Wednesday, November 25, 2015
Weather: Sun/Cold
Equipment: APE 300 Vibratory Hammer
Derrick: No.6 Derrick
Total # Driven: 18.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	25	AZ 26-700	South Face	8:25	4.80	-13.50	2.99	0.02	-18.28	None.	2.00	
Type A	26	AZ 26-700	South Face	8:31	4.80	-13.50	2.96	0.08	-18.22	None.	2.04	
Type A	27	AZ 26-700	South Face	8:38	4.80	-13.50	2.90	0.08	-18.22	None.	2.07	
Type A	28	AZ 26-700	South Face	8:44	4.80	-13.50	2.92	0.08	-18.22	None.	2.11	
Type A	29	AZ 26-700	South Face	8:50	4.80	-13.50	2.95	0.09	-18.21	None.	2.14	
Type A	30	AZ 26-700	South Face	8:57	4.80	-13.50	2.95	0.10	-18.20	None.	2.18	coffee break
Type A	31	AZ 26-700	South Face	9:25	4.80	-13.50	2.98	0.10	-18.20	None.	2.21	
Type A	32	AZ 26-700	South Face	9:50	4.80	-13.50	2.96	0.07	-18.23	None.	2.25	
Type A	33	AZ 26-700	South Face	9:57	4.80	-13.50	3.02	0.08	-18.22	None.	2.28	
Type A	34	AZ 26-700	South Face	10:03	4.80	-13.50	3.01	0.06	-18.24	None.	2.32	
Type A	35	AZ 26-700	South Face	10:07	4.80	-13.50	3.05	0.10	-18.20	None.	2.35	
Type A	36	AZ 26-700	South Face	10:12	4.80	-13.50	3.01	0.06	-18.24	None.	2.39	
Type A	37	AZ 26-700	South Face	10:20	4.80	-13.50	3.06	0.11	-18.19	None.	2.42	
Type A	38	AZ 26-700	South Face	10:26	4.80	-13.50	3.03	0.09	-18.21	None.	2.46	western single sheet slid down to cut off elevation of -0.77 during Pair #39 driving
Type A	39	AZ 26-700	South Face	10:33	4.80	-13.50	3.00	1.06	-17.24	None.	2.49	stopped at cut off elevation 1.06 due to #39 movement
Type A	40	AZ 26-700	South Face	10:56	4.80	-13.50	2.98	0.10	-18.20	None.	2.53	
Type A	41	AZ 26-700	South Face	11:03	4.80	-13.50	2.90	0.07	-18.23	None.	2.56	
Type A	42	AZ 26-700	South Face	11:09	4.80	-13.50	2.84	0.08	-18.22	None.	2.60	#6 Derrick encountered mechanincal breakdown after lunch break. Shut dowr

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: Thursday, November 26, 2015
Weather: Sun/Cold
Equipment: APE 300 Vibratory Hammer
Derrick: No.6 Derrick
Total # Driven: 17.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	43	AZ 26-700	South Face	12:45	4.80	-13.50	2.83	0.06	-18.24	None.	2.90	start late due to maintenance/mechanical
Type A	44	AZ 26-700	South Face	12:51	4.80	-13.50	2.88	0.08	-18.22	None.	2.90	
Type A	45	AZ 26-700	South Face	12:57	4.80	-13.50	2.95	0.06	-18.24	None.	2.90	
Type A	46	AZ 26-700	South Face	13:04	4.80	-13.50	2.97	0.10	-18.20	None.	2.90	
Type A	47	AZ 26-700	South Face	13:12	4.80	-13.50	2.94	0.10	-18.20	None.	2.90	
Type A	48	AZ 26-700	South Face	13:19	4.80	-13.50	2.95	0.10	-18.20	None.	2.90	
Type A	49	AZ 26-700	South Face	13:29	4.80	-13.50	2.99	0.08	-18.22	None.	2.90	
Type A	50	AZ 26-700	South Face	13:36	4.80	-13.50	3.02	0.08	-18.22	None.	2.90	shut down for mechanical issues
Type A	51	AZ 26-700	South Face	16:18	4.80	-13.50	2.84	0.09	-18.21	None.	2.20	
Type A	52	AZ 26-700	South Face	16:22	4.80	-13.50	2.96	0.10	-18.20	None.	2.15	
Type A	53	AZ 26-700	South Face	16:26	4.80	-13.50	2.90	0.08	-18.22	None.	2.10	
Type A	54	AZ 26-700	South Face	16:33	4.80	-13.50	2.62	0.07	-18.23	None.	2.05	
Type A	55	AZ 26-700	South Face	16:37	4.80	-13.50	2.75	0.10	-18.20	None.	2.02	
Type A	56	AZ 26-700	South Face	16:42	4.80	-13.50	2.95	0.02	-18.28	None.	2.00	
Type A	57	AZ 26-700	South Face	16:47	4.80	-13.50	2.98	0.09	-18.21	None.	1.97	
Type A	58	AZ 26-700	South Face	16:51	4.80	-13.50	2.97	0.08	-18.22	None.	1.94	
Type A	59	AZ 26-700	South Face	16:56	4.80	-13.50	3.06	0.05	-18.25	None.	1.90	shut down for night

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: Tuesday, December 01, 2015
Weather: overcast/rain
Equipment: ICE 44B Vibratory Hammer (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 10.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	60	AZ 26-700	South Face	15:36	4.80	-13.50	3.07	0.09	-18.21	None.	2.55	start
Type A	61	AZ 26-700	South Face	15:45	4.80	-13.50	3.05	0.10	-18.20	None.	2.50	coffee
Type A	62	AZ 26-700	South Face	16:14	4.80	-13.50	3.10	0.10	-18.20	None.	2.50	
Type A	63	AZ 26-700	South Face	16:21	4.80	-13.50	3.06	0.08	-18.22	None.	2.50	
Type A	64	AZ 26-700	South Face	16:26	4.80	-13.50	3.08	0.10	-18.20	None.	2.50	soft / easy driving
Type A	65	AZ 26-700	South Face	16:30	4.80	-13.50	3.08	0.10	-18.20	None.	2.50	
Type A	66	AZ 26-700	South Face	16:34	4.80	-13.50	3.08	0.10	-18.20	None.	2.50	
Type A	67	AZ 26-700	South Face	16:44	4.80	-13.50	3.10	0.10	-18.20	None.	2.50	had to cut bolt from sheet
Type A	68	AZ 26-700	South Face	16:49	4.80	-13.50	3.10	0.11	-18.19	None.	2.50	
Type A	69	AZ 26-700	South Face	16:52	4.80	-13.50	3.09	2.38	-15.92	None.	2.48	Bolts sheared off from hammer head. Stop driving at Cut Off elevation 2.48m

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: Wednesday, December 02, 2015
Weather: overcast
Equipment: ICE 44B Vibratory Hammer (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 55.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	69	AZ 26-700	South Face	9:07	2	4.80	-13.50	2.38	0.11	-18.19	None.	2.80	start
Type A	70	AZ 26-700	South Face	9:13	2	4.80	-13.50	2.99	0.07	-18.23	None.	2.80	
Type A	71	AZ 26-700	South Face	9:39	2	4.80	-13.50	3.16	0.06	-18.24	None.	2.90	
Type A	72	AZ 26-700	South Face	9:43	2	4.80	-13.50	3.17	0.05	-18.25	None.	2.90	
Type A	73	AZ 26-700	South Face	9:46	2	4.80	-13.50	3.19	0.08	-18.22	None.	2.90	
Type A	74	AZ 26-700	South Face	9:50	3	4.80	-13.50	3.26	0.11	-18.19	None.	2.90	
Type A	75	AZ 26-700	South Face	9:57	2	4.80	-13.50	3.25	0.10	-18.20	None.	2.90	
Type A	76	AZ 26-700	South Face	10:02	3	4.80	-13.50	3.15	0.09	-18.21	None.	2.90	move rig
Type A	77	AZ 26-700	South Face	10:45	2	4.80	-13.50	3.18	0.08	-18.22	None.	2.90	
Type A	78	AZ 26-700	South Face	10:49	3	4.80	-13.50	3.03	0.10	-18.20	None.	2.90	
Type A	79	AZ 26-700	South Face	10:53	2	4.80	-13.50	3.18	0.10	-18.20	None.	2.90	
Type A	80	AZ 26-700	South Face	10:56	3	4.80	-13.50	3.19	0.08	-18.22	None.	2.90	
Type A	81	AZ 26-700	South Face	11:00	1	4.80	-13.50	3.15	0.12	-18.18	None.	2.90	
Type A	82	AZ 26-700	South Face	11:05	2	4.80	-13.50	3.13	0.09	-18.21	None.	2.90	lunch
Type A	83	AZ 26-700	South Face	11:53	2	4.80	-13.50	3.14	0.14	-18.16	None.	2.80	
Type A	84	AZ 26-700	South Face	11:57	3	4.80	-13.50	3.12	0.08	-18.22	None.	2.80	
Type A	85	AZ 26-700	South Face	12:03	1	4.80	-13.50	3.05	0.11	-18.19	None.	2.80	
Type A	86	AZ 26-700	South Face	12:05	1	4.80	-13.50	3.13	0.05	-18.25	None.	2.80	
Type A	87	AZ 26-700	South Face	12:08	1	4.80	-13.50	3.14	0.05	-18.25	None.	2.80	
Type A	88	AZ 26-700	South Face	12:11	2	4.80	-13.50	3.14	0.07	-18.23	None.	2.80	
Type A	89	AZ 26-700	South Face	12:14	2	4.80	-13.50	3.14	0.08	-18.22	None.	2.75	
Type A	90	AZ 26-700	South Face	12:19	1	4.80	-13.50	3.15	0.09	-18.21	None.	2.72	
Type A	91	AZ 26-700	South Face	12:23	1	4.80	-13.50	3.19	0.10	-18.20	None.	2.71	
Type A	92	AZ 26-700	South Face	12:26	1	4.80	-13.50	3.18	0.11	-18.19	None.	2.70	move rig
Type A	93	AZ 26-700	South Face	13:07	2	4.80	-13.50	3.20	0.08	-18.22	None.	2.60	
Type A	94	AZ 26-700	South Face	13:12	1	4.80	-13.50	3.23	0.10	-18.20	None.	2.56	
Type A	95	AZ 26-700	South Face	13:15	2	4.80	-13.50	3.23	0.12	-18.18	None.	2.53	
Type A	96	AZ 26-700	South Face	13:19	2	4.80	-13.50	3.23	0.10	-18.20	None.	2.50	
Type A	97	AZ 26-700	South Face	13:22	2	4.80	-13.50	3.25	0.09	-18.21	None.	2.47	
Type A	98	AZ 26-700	South Face	13:26	1	4.80	-13.50	3.27	0.10	-18.20	None.	2.47	
Type A	99	AZ 26-700	South Face	13:29	1	4.80	-13.50	3.27	0.10	-18.20	None.	2.47	
Type A	100	AZ 26-700	South Face	13:33	1	4.80	-13.50	3.28	0.10	-18.20	None.	2.47	coffee
Type A	101	AZ 26-700	South Face	14:03	2	4.80	-13.50	3.29	0.05	-18.25	None.	2.45	
Type A	102	AZ 26-700	South Face	14:06	3	4.80	-13.50	3.31	0.10	-18.20	None.	2.45	
Type A	103	AZ 26-700	South Face	14:10	2	4.80	-13.50	3.33	0.07	-18.23	None.	2.45	
Type B	104	AZ 38-700N	South Face	14:15	2	4.80	-13.50	3.30	0.10	-18.20	None.	2.45	start new sheet type at overlap
Type B	105	AZ 38-700N	South Face	14:19	2	4.80	-13.50	3.30	0.03	-18.27	None.	2.44	
Type B	106	AZ 38-700N	South Face	14:22	2	4.80	-13.50	3.37	0.04	-18.26	None.	2.44	western sheet of pair 105 dragged from 0.10 to 0.03 during driving
Type B	107	AZ 38-700N	South Face	14:26	3	4.80	-13.50	3.37	0.08	-18.22	None.	2.42	
Type B	108	AZ 38-700N	South Face	14:30	2	4.80	-13.50	3.37	0.07	-18.23	None.	2.40	
Type B	109	AZ 38-700N	South Face	14:35	2	4.80	-13.50	3.35	0.10	-18.20	None.	2.40	
Type B	110	AZ 38-700N	South Face	14:39	3	4.80	-13.50	3.33	0.10	-18.20	None.	2.40	move rig
Type B	111	AZ 38-700N	South Face	15:48	3	4.80	-13.50	3.32	0.10	-18.20	None.	2.35	
Type B	112	AZ 38-700N	South Face	15:52	2	4.80	-13.50	3.40	0.06	-18.24	None.	2.35	
Type B	113	AZ 38-700N	South Face	15:55	2	4.80	-13.50	3.12	0.03	-18.27	None.	2.35	
Type B	114	AZ 38-700N	South Face	15:58	2	4.80	-13.50	3.15	0.00	-18.30	None.	2.35	
Type B	115	AZ 38-700N	South Face	16:02	3	4.80	-13.50	4.70	0.10	-18.20	None.	2.35	sheets at full height
Type B	116	AZ 38-700N	South Face	16:06	2	4.80	-13.50	4.90	0.10	-18.20	None.	2.34	easy driving
Type B	117	AZ 38-700N	South Face	16:11	2	4.80	-13.50	4.90	0.05	-18.25	None.	2.34	
Type B	118	AZ 38-700N	South Face	16:14	2	4.80	-13.50	4.89	0.10	-18.20	None.	2.34	
Type B	119	AZ 38-700N	South Face	16:18	3	4.80	-13.50	4.90	0.05	-18.25	None.	2.34	
Type B	120	AZ 38-700N	South Face	16:23	2	4.80	-13.50	4.91	0.10	-18.20	None.	2.33	
Type B	121	AZ 38-700N	South Face	16:27	1.5	4.80	-13.50	4.88	0.09	-18.21	None.	2.32	
Type B	122	AZ 38-700N	South Face	16:30	2	4.80	-13.50	4.88	0.14	-18.16	None.	2.31	
Type B	123	AZ 38-700N	South Face	16:35	1	4.80	-13.50	4.90	0.07	-18.23	None.		

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: January-11-16
Weather: overcast/rain
Equipment: ICE 44B Vibratory Hammer (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 5.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	39 east	AZ 26-700	South Face	12:00	2	4.80	-13.50	-0.68	0.11	-18.19	None.	2.95	diver assisted. Pull single sheet up to grade
Type A	39 west	AZ 26-700	South Face	12:22	10	4.80	-13.50	1.32	0.14	-18.16	None.	2.95	diver assisted. Drive single sheet down to grade while holding 39 east with crane line
Type A	0.5	AZ 26-700	South Face	13:33	7	4.80	-13.50	3.72	0.09	-18.21	None.	2.93	drive first single sheet down to grade. Diver assisted.
Type A	3	AZ 26-700	South Face	13:45	3	4.80	-13.50	1.00	0.09	-18.21	None.	2.92	diver assisted. Drive pair to grade
Type A	4	AZ 26-700	South Face	13:53	2	4.80	-13.50	0.99	0.09	-18.21	None.	2.90	diver assisted. Drive pair to grade

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: January-13-16
Weather: overcast
Equipment: ICE 44B Vibratory Hammer (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 3.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	122	AZ 26-700	South Face	16:25	1	4.80	-13.50	0.14	0.08	-18.22	None.	2.95	diver assisted.
Type A	95	AZ 26-700	South Face	16:52	1	4.80	-13.50	0.12	0.07	-18.23	None.	2.95	diver assisted.
Type A	92	AZ 26-700	South Face	16:57	1	4.80	-13.50	0.11	0.08	-18.22	None.	2.93	Diver assisted.

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: January-14-16
Weather: overcast
Equipment: ICE 44B Vibratory Hammer (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 39.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	37	AZ 26-700	South Face	8:39	2	4.80	-13.50	0.11	0.02	-18.28	None.	2.80	start
Type A	38	AZ 26-700	South Face	8:51	2	4.80	-13.50	0.13	0.02	-18.28	None.	2.79	
Type A	39	AZ 26-700	South Face	8:54	2	4.80	-13.50	0.14	0.00	-18.30	None.	2.77	
Type A	46	AZ 26-700	South Face	9:47	6	4.80	-13.50	0.10	-1.01	-19.31	None.	2.76	start gate piiles
Type A	47	AZ 26-700	South Face	9:54	2	4.80	-13.50	0.10	-1.01	-19.31	None.	2.74	
Type A	48	AZ 26-700	South Face	9:58	2	4.80	-13.50	0.10	-1.01	-19.31	None.	2.73	
Type A	49	AZ 26-700	South Face	10:10	2	4.80	-13.50	0.09	-1.02	-19.32	None.	2.71	
Type A	50	AZ 26-700	South Face	10:15	2	4.80	-13.50	0.08	-1.04	-19.34	None.	2.70	
Type A	51	AZ 26-700	South Face	10:20	2	4.80	-13.50	0.09	-1.05	-19.35	None.	2.68	
Type A	52	AZ 26-700	South Face	10:24	1	4.80	-13.50	0.10	-1.04	-19.34	None.	2.67	
Type A	53	AZ 26-700	South Face	10:35	1	4.80	-13.50	0.08	-1.05	-19.35	None.	2.65	move rig
Type A	54	AZ 26-700	South Face	10:52	1	4.80	-13.50	0.07	-1.04	-19.34	None.	2.64	
Type A	55	AZ 26-700	South Face	10:55	1	4.80	-13.50	0.09	-1.06	-19.36	None.	2.62	
Type A	56	AZ 26-700	South Face	10:58	1	4.80	-13.50	0.02	-1.07	-19.37	None.	2.61	
Type A	57	AZ 26-700	South Face	11:03	1	4.80	-13.50	0.05	-1.06	-19.36	None.	2.59	
Type A	58	AZ 26-700	South Face	11:06	2	4.80	-13.50	0.08	-1.06	-19.36	None.	2.58	
Type A	59	AZ 26-700	South Face	11:09	1	4.80	-13.50	0.04	-1.06	-19.36	None.	2.56	lunch
Type A	60	AZ 26-700	South Face	12:16	12	4.80	-13.50	0.09	-1.09	-19.39	None.	2.55	bearing pile in way. Needs trimming
Type A	61	AZ 26-700	South Face	12:31	1	4.80	-13.50	0.09	-1.08	-19.38	None.	2.53	
Type A	62	AZ 26-700	South Face	12:35	1	4.80	-13.50	0.10	-1.09	-19.39	None.	2.52	
Type A	63	AZ 26-700	South Face	12:38	2	4.80	-13.50	0.07	-1.07	-19.37	None.	2.50	
Type A	64	AZ 26-700	South Face	12:41	1	4.80	-13.50	0.10	-1.08	-19.38	None.	2.49	
Type A	65	AZ 26-700	South Face	12:45	1	4.80	-13.50	0.09	-1.10	-19.40	None.	2.47	
Type A	66	AZ 26-700	South Face	12:47	1	4.80	-13.50	0.11	-1.08	-19.38	None.	2.46	
Type A	67	AZ 26-700	South Face	12:50	1	4.80	-13.50	0.08	-1.10	-19.40	None.	2.44	
Type A	68	AZ 26-700	South Face	12:53	1	4.80	-13.50	0.11	-1.08	-19.38	None.	2.43	
Type A	69	AZ 26-700	South Face	12:56	1	4.80	-13.50	0.11	-1.09	-19.39	None.	2.41	
Type A	70	AZ 26-700	South Face	12:59	1	4.80	-13.50	0.07	-1.11	-19.41	None.	2.40	move rig
Type A	71	AZ 26-700	South Face	13:16	2	4.80	-13.50	0.06	-1.09	-19.39	None.	2.40	
Type A	72	AZ 26-700	South Face	13:20	2	4.80	-13.50	0.04	-1.08	-19.38	None.	2.40	
Type A	73	AZ 26-700	South Face	13:24	1	4.80	-13.50	0.06	-1.10	-19.40	None.	2.40	
Type A	74	AZ 26-700	South Face	13:28	1	4.80	-13.50	0.10	-1.10	-19.40	None.	2.40	
Type A	75	AZ 26-700	South Face	13:31	3	4.80	-13.50	0.08	-1.11	-19.41	None.	2.40	
Type A	76	AZ 26-700	South Face	13:38	1	4.80	-13.50	0.10	-1.10	-19.40	None.	2.40	break. Move rig
Type A	77	AZ 26-700	South Face	14:20	1	4.80	-13.50	0.08	-1.11	-19.41	None.	2.40	
Type B	78	AZ 26-700	South Face	14:26	1	4.80	-13.50	0.12	-1.12	-19.42	None.	2.40	End gate piles
Type B	81	AZ 26-700	South Face	14:32	1	4.80	-13.50	0.12	0.07	-18.23	None.	2.40	
Type B	83	AZ 26-700	South Face	14:36	1	4.80	-13.50	0.14	0.07	-18.23	None.	2.40	
Type B	85	AZ 26-700	South Face	14:40	1	4.80	-13.50	0.11	0.06	-18.24	None.	2.40	

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: January-19-16
Weather: overcast
Equipment: Ape 300 (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 2.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type A	45	AZ 26-700	South Face	14:20	8	4.80	-13.50	0.06	-1.03	-19.33	None.	1.60	need to lower pair to accommodate gate opening based on as-built location of TRB
Type A	78	AZ 26-700	South Face	14:51	6	4.80	-13.50	-1.12	0.09	-18.21	None.	1.60	need to raise pair to accommodate gate opening by keeping 33 pairs lowered (to keep 45m)

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: February-03-16
Weather: overcast - wind
Equipment: APE 200 Vibratory Hammer (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 29.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type C	145	AZ 50	South Face	16:50	8	4.80	-13.50	4.81	-0.02	-18.32	None.	1.25	DRIVEN ON FEB 2 2016
Type C	142	AZ 50	South Face	7:28	11	4.80	-13.50	3.98	0.01	-18.29	None.	2.73	encountered breakdown
Type C	143	AZ 50	South Face	11:49	19	4.80	-13.50	4.58	0.00	-18.30	None.	2.50	hard driving
Type C	144	AZ 50	South Face	12:11	8	4.80	-13.50	4.88	0.01	-18.29	None.	2.49	
Type C	146	AZ 50	South Face	12:21	6	4.80	-13.50	4.88	-0.01	-18.31	None.	2.47	
Type C	147	AZ 50	South Face	12:29	7	4.80	-13.50	4.15	-0.01	-18.31	None.	2.46	
Type C	148	AZ 50	South Face	12:37	9	4.80	-13.50	4.88	-0.01	-18.31	None.	2.44	
Type C	149	AZ 50	South Face	12:48	4	4.80	-13.50	4.88	0.00	-18.30	None.	2.43	
Type C	150	AZ 50	South Face	12:54	4	4.80	-13.50	4.88	-0.02	-18.32	None.	2.41	
Type C	151	AZ 50	South Face	12:59	5	4.80	-13.50	4.88	-0.02	-18.32	None.	2.40	
Type C	152	AZ 50	South Face	13:07	11	4.80	-13.50	4.85	-0.02	-18.32	None.	2.38	
Type C	153	AZ 50	South Face	13:19	13	4.80	-13.50	4.77	0.01	-18.29	None.	2.37	coffee break
Type C	154	AZ 50	South Face	13:57	6	4.80	-13.50	4.88	-0.01	-18.31	None.	2.20	
Type C	155	AZ 50	South Face	14:04	5	4.80	-13.50	3.12	-0.01	-18.31	None.	2.10	
Type C	156	AZ 50	South Face	14:10	9	4.80	-13.50	4.43	0.00	-18.30	None.	2.00	
Type C	157	AZ 50	South Face	14:23	5	4.80	-13.50	4.87	0.00	-18.30	None.	1.90	move barge
Type C	158	AZ 50	South Face	14:44	6	4.80	-13.50	3.99	-0.06	-18.36	None.	1.80	
Type C	159	AZ 50	South Face	14:52	5	4.80	-13.50	4.88	-0.01	-18.31	None.	1.75	
Type C	160	AZ 50	South Face	14:58	5	4.80	-13.50	4.87	-0.01	-18.31	None.	1.74	
Type C	161	AZ 50	South Face	15:06	5	4.80	-13.50	4.86	0.00	-18.30	None.	1.72	
Type C	162	AZ 50	South Face	15:13	3	4.80	-13.50	4.86	0.00	-18.30	None.	1.71	
Type C	163	AZ 50	South Face	15:18	4	4.80	-13.50	4.89	-0.01	-18.31	None.	1.69	
Type C	164	AZ 50	South Face	15:23	3	4.80	-13.50	4.87	-0.03	-18.33	None.	1.66	
Type C	165	AZ 50	South Face	15:28	3	4.80	-13.50	4.88	-0.02	-18.32	None.	1.62	coffee break
Type C	166	AZ 50	South Face	15:59	6	4.80	-13.50	4.87	0.01	-18.29	None.	1.46	
Type C	167	AZ 50	South Face	16:07	5	4.80	-13.50	4.86	-0.01	-18.31	None.	1.45	
Type C	168	AZ 50	South Face	16:13	3	4.80	-13.50	4.87	0.00	-18.30	None.	1.43	
Type C	169	AZ 50	South Face	16:17	3	4.80	-13.50	4.87	-0.01	-18.31	None.	1.40	
Type C	170	AZ 50	South Face	16:24	3	4.80	-13.50	4.87	0.01	-18.29	None.	1.36	shut down due to wind blowing 60km/hr

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: February-04-16
Weather: overcast drizzle
Equipment: APE 200 Vibratory Hammer (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 43.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type C	171	AZ 50	South Face	7:47	3	4.80	-13.50	4.87	-0.01	-18.31	None.	2.65	
Type C	172	AZ 50	South Face	7:51	3	4.80	-13.50	4.88	0.00	-18.30	None.	2.66	
Type C	173	AZ 50	South Face	7:56	3	4.80	-13.50	4.89	-0.01	-18.31	None.	2.66	
Type C	174	AZ 50	South Face	7:59	5	4.80	-13.50	4.88	0.00	-18.30	None.	2.67	
Type C	175	AZ 50	South Face	8:06	4	4.80	-13.50	4.87	0.00	-18.30	None.	2.67	
Type C	176	AZ 50	South Face	8:12	3	4.80	-13.50	4.87	-0.01	-18.31	None.	2.68	
Type C	177	AZ 50	South Face	8:17	4	4.80	-13.50	4.88	-1.02	-19.32	None.	2.69	Start gate piles
Type C	178	AZ 50	South Face	8:22	4	4.80	-13.50	4.88	-1.02	-19.32	None.	2.70	
Type C	179	AZ 50	South Face	8:27	3	4.80	-13.50	4.87	-1.01	-19.31	None.	2.70	
Type C	180	AZ 50	South Face	8:31	3	4.80	-13.50	4.86	-1.02	-19.32	None.	2.70	
Type C	181	AZ 50	South Face	8:37	4	4.80	-13.50	4.88	-0.98	-19.28	None.	2.70	hammer broke down
Type C	182	AZ 50	South Face	10:36	4	4.80	-13.50	4.87	-1.04	-19.34	None.	2.66	restart with fixed hammer jaw
Type C	183	AZ 50	South Face	10:41	4	4.80	-13.50	4.87	-1.01	-19.31	None.	2.65	
Type C	184	AZ 50	South Face	10:47	3	4.80	-13.50	4.86	-1.00	-19.30	None.	2.64	
Type C	185	AZ 50	South Face	10:51	2	4.80	-13.50	3.73	-1.00	-19.30	None.	2.63	
Type C	186	AZ 50	South Face	10:54	3	4.80	-13.50	3.70	-0.99	-19.29	None.	2.62	
Type C	187	AZ 50	South Face	10:58	4	4.80	-13.50	4.86	-1.00	-19.30	None.	2.61	lunch & crane repair
Type C	188	AZ 50	South Face	12:04	3	4.80	-13.50	4.87	-1.02	-19.32	None.	2.55	
Type C	189	AZ 50	South Face	12:08	3	4.80	-13.50	4.88	-0.98	-19.28	None.	2.53	
Type C	190	AZ 50	South Face	12:13	3	4.80	-13.50	4.88	-1.00	-19.30	None.	2.52	
Type C	191	AZ 50	South Face	12:17	2	4.80	-13.50	4.87	-0.99	-19.29	None.	2.50	
Type C	192	AZ 50	South Face	12:20	3	4.80	-13.50	4.88	-1.00	-19.30	None.	2.48	
Type C	193	AZ 50	South Face	12:24	3	4.80	-13.50	4.87	-1.01	-19.31	None.	2.47	
Type C	194	AZ 50	South Face	12:28	2	4.80	-13.50	4.88	-1.00	-19.30	None.	2.46	
Type C	195	AZ 50	South Face	12:31	3	4.80	-13.50	4.87	-1.02	-19.32	None.	2.45	
Type C	196	AZ 50	South Face	12:35	2	4.80	-13.50	4.87	-1.01	-19.31	None.	2.44	
Type C	197	AZ 50	South Face	12:38	3	4.80	-13.50	4.86	-1.02	-19.32	None.	2.43	
Type C	198	AZ 50	South Face	12:42	2	4.80	-13.50	4.87	-1.00	-19.30	None.	2.42	
Type C	199	AZ 50	South Face	12:46	3	4.80	-13.50	4.85	-0.99	-19.29	None.	2.41	
Type C	200	AZ 50	South Face	12:50	3	4.80	-13.50	4.87	-1.01	-19.31	None.	2.38	
Type C	201	AZ 50	South Face	12:55	2	4.80	-13.50	4.87	-1.00	-19.30	None.	2.35	
Type C	202	AZ 50	South Face	12:59	3	4.80	-13.50	4.88	-0.99	-19.29	None.	2.30	stop driving to clean wood debris
Type C	203	AZ 50	South Face	14:40	2	4.80	-13.50	4.87	-1.00	-19.30	None.	1.85	
Type C	204	AZ 50	South Face	14:43	3	4.80	-13.50	4.87	-1.04	-19.34	None.	1.80	
Type C	205	AZ 50	South Face	14:47	3	4.80	-13.50	4.89	-0.99	-19.29	None.	1.77	
Type C	206	AZ 50	South Face	14:51	3	4.80	-13.50	4.88	-1.00	-19.30	None.	1.74	
Type C	207	AZ 50	South Face	14:54	3	4.80	-13.50	4.87	-1.00	-19.30	None.	1.71	
Type C	208	AZ 50	South Face	14:59	2	4.80	-13.50	4.88	-1.00	-19.30	None.	1.68	
Type C	209	AZ 50	South Face	15:02	2	4.80	-13.50	4.87	-1.00	-19.30	None.	1.67	
Type C	210	AZ 50	South Face	15:05	8	4.80	-13.50	4.87	-1.00	-19.30	None.	1.66	
Type C	211	AZ 50	South Face	15:14	3	4.80	-13.50	4.86	-1.00	-19.30	None.	1.65	
Type C	212	AZ 50	South Face	15:19	3	4.80	-13.50	4.85	-1.00	-19.30	None.	1.63	
Type C	213	AZ 50	South Face	15:24	4	4.80	-13.50	4.88	-1.00	-19.30	None.	1.60	End gate piles. Stop driving. Clean wood debris

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: February-05-16
Weather: overcast
Equipment: APE 200 Vibratory Hammer (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 6.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type C	214	AZ 50	South Face	7:31	3	4.80	-13.50	4.85	-0.01	-18.31	None.	2.70	start driving
Type C	215	AZ 50	South Face	7:36	3	4.80	-13.50	4.87	-0.02	-18.32	None.	2.70	
Type C	216	AZ 50	South Face	7:41	2	4.80	-13.50	4.86	0.00	-18.30	None.	2.70	
Type C	217	AZ 50	South Face	7:44	2	4.80	-13.50	4.43	0.00	-18.30	None.	2.70	
Type C	218	AZ 50	South Face	7:48	3	4.80	-13.50	4.88	-0.02	-18.32	None.	2.70	
Type C	219	AZ 50	South Face	7:52	3	4.80	-13.50	4.87	0.04	-18.26	None.	2.70	stop driving. Leaving 4 pairs undriven to corner of west jetty.

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: February-26-16
Weather: overcast
Equipment: APE 200 Vibratory Hammer (with APE extension)
Derrick: No.6 Derrick
Total # Driven: 17.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type C	124	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	0.00	-18.30	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	125	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	-0.03	-18.33	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	126	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	-0.01	-18.31	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	127	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	-0.02	-18.32	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	128	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	-0.03	-18.33	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	129	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	-0.09	-18.39	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	130	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	-0.05	-18.35	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	131	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	0.02	-18.28	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	132	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	0.00	-18.30	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	133	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	0.02	-18.28	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	134	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	0.04	-18.26	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	135	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	-0.01	-18.31	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	136	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	-0.02	-18.32	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	137	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	-0.03	-18.33	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	138	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	0.00	-18.30	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	139	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	0.00	-18.30	None.	unknown	final elevations were surveyed in after the pile driving was completed
Type C	140	AZ 50	South Face	unknown	unknown	4.80	-13.50	4.80	0.01	-18.29	None.	unknown	final elevations were surveyed in after the pile driving was completed

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: March-08-16
Weather: cloud/sun
Equipment: APE 200 Vibratory Hammer (with APE extension)
Derrick: W.M. Saunders (1411)
Total # Driven: 29.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type C	220	AZ 50	South Face	12:32	4	4.85	-13.50	4.85	-0.02	-18.37	None.	2.82	
Type C	221	AZ 50	South Face	12:39	5	4.86	-13.50	4.86	0.00	-18.36	None.	2.82	
Type C	222	AZ 50	South Face	12:46	4	4.86	-13.50	4.86	0.00	-18.36	None.	2.82	
Type C	223	AZ 50	South Face	12:52	7	4.87	-13.50	4.87	-0.01	-18.38	None.	2.82	
Type E	224	AZ 38-700N	West Face	13:04	2	4.88	-13.50	4.88	-0.01	-18.39	None.	2.82	
Type E	225	AZ 38-700N	West Face	13:10	1	5.10	-13.50	5.10	-0.01	-18.61	None.	2.82	
Type E	226	AZ 38-700N	West Face	13:13	2	5.01	-13.50	5.10	-0.03	-18.54	None.	2.82	
Type E	227	AZ 38-700N	West Face	13:18	2	5.10	-13.50	5.10	-0.06	-18.66	None.	2.82	
Type E	228	AZ 38-700N	West Face	13:21	3	5.15	-13.50	5.15	-0.05	-18.70	None.	2.82	Location of overlap joint
Type E	229	AZ 38-700N	West Face	13:26	1	5.10	-13.50	5.10	0.04	-18.56	None.	2.82	
Type E	230	AZ 38-700N	West Face	13:29	2	5.20	-13.50	5.20	-0.01	-18.71	None.	2.82	
Type E	231	AZ 38-700N	West Face	13:33	1	5.20	-13.50	5.20	-0.01	-18.71	None.	2.82	coffee break
Type E	232	AZ 38-700N	West Face	13:58	1	5.19	-13.50	5.19	0.00	-18.69	None.	2.81	
Type E	233	AZ 38-700N	West Face	14:02	2	5.20	-13.50	5.20	-0.01	-18.71	None.	2.81	
Type E	234	AZ 38-700N	West Face	14:05	1	5.12	-13.50	5.12	-0.03	-18.65	None.	2.81	
Type E	235	AZ 38-700N	West Face	14:07	2	5.17	-13.50	5.17	-0.02	-18.69	None.	2.81	stop to unload CSP
Type E	236	AZ 38-700N	West Face	14:33	1	5.20	-13.50	5.20	-0.02	-18.72	None.	2.80	
Type E	237	AZ 38-700N	West Face	14:36	1	5.20	-13.50	5.20	-0.02	-18.72	None.	2.79	
Type E	238	AZ 38-700N	West Face	14:39	1	5.16	-13.50	5.16	-0.02	-18.68	None.	2.77	
Type E	239	AZ 38-700N	West Face	14:42	1	5.15	-13.50	5.15	-0.02	-18.67	None.	2.76	
Type E	240	AZ 38-700N	West Face	14:45	1	5.16	-13.50	5.16	-0.01	-18.67	None.	2.74	
Type E	241	AZ 38-700N	West Face	14:48	4	5.17	-13.50	5.17	0.00	-18.67	None.	2.73	
Type E	242	AZ 38-700N	West Face	14:54	1	5.17	-13.50	5.17	0.04	-18.63	None.	2.71	
Type E	243	AZ 38-700N	West Face	14:58	1	5.16	-13.50	5.16	0.00	-18.66	None.	2.70	
Type E	244	AZ 38-700N	West Face	15:01	2	5.18	-13.50	5.18	-0.03	-18.71	None.	2.69	
Type E	245	AZ 38-700N	West Face	15:05	3	5.17	-13.50	5.17	0.01	-18.66	None.	2.67	
Type E	246	AZ 38-700N	West Face	15:09	3	5.20	-13.50	5.20	0.00	-18.70	None.	2.65	
Type E	247	AZ 38-700N	West Face	15:17	2	5.20	-13.50	5.20	-0.02	-18.72	None.	2.62	
Type E	248	AZ 38-700N	West Face	15:21	2	5.19	-13.50	5.19	-0.02	-18.71	None.	2.60	End driving

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: March-10-16
Weather: clear/windy
Equipment: APE 200 Vibratory Hammer (with APE extension)
Derrick: W.M. Saunders (1411)
Total # Driven: 46.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type C	176	AZ 50	South Face	9:57	2	-0.01	-16.00	-0.01	-1.01	-17.00	N/A	2.50	Redrive to accommodate TRB gate
Type E	249	AZ38-700N	West Face	11:57	2	5.18	-15.00	5.18	-0.01	-20.19	N/A	2.45	Last pair on west face
Type C	250	AZ 50	North Face	12:03	3	4.88	-16.00	4.88	-0.02	-20.90	N/A	2.47	
Type C	250.5	AZ 50	North Face	19:20	6	4.88	-16.00	4.88	0.30	-20.58	N/A	1.76	
Type C	251	AZ 50	North Face	19:35	5	4.34	-16.00	4.34	0.05	-20.29	N/A	1.76	
Type C	252	AZ 50	North Face	12:28	3	4.87	-16.00	4.87	0.00	-20.87	N/A	2.50	
Type C	253	AZ 50	North Face	12:33	3	4.87	-16.00	4.87	0.01	-20.86	N/A	2.52	
Type C	254	AZ 50	North Face	12:37	4	4.87	-16.00	4.87	0.00	-20.87	N/A	2.56	
Type C	255	AZ 50	North Face	12:43	4	4.87	-16.00	4.87	0.00	-20.87	N/A	2.60	
Type C	256	AZ 50	North Face	12:49	3	4.85	-16.00	4.85	0.01	-20.84	N/A	2.60	Stop to load TRB
Type C	257	AZ 50	North Face	17:38	3	4.83	-16.00	4.83	0.04	-20.79	N/A	2.49	Start driving again
Type C	258	AZ 50	North Face	17:45	4	4.84	-16.00	4.84	-0.13	-20.97	N/A	2.38	
Type C	259	AZ 50	North Face	17:53	5	4.85	-16.00	4.85	0.04	-20.81	N/A	2.27	
Type C	260	AZ 50	North Face	18:09	5	4.87	-16.00	4.87	0.02	-20.85	N/A	2.16	
Type C	261	AZ 50	North Face	18:18	6	4.34	-16.00	4.34	0.01	-20.33	N/A	2.04	
Type C	262	AZ 50	North Face	18:27	5	4.86	-16.00	4.86	0.02	-20.84	N/A	1.93	
Type C	263	AZ 50	North Face	19:44	5	4.86	-16.00	4.86	0.01	-20.85	N/A	1.82	
Type C	264	AZ 50	North Face	19:56	7	4.86	-16.00	4.86	0.03	-20.83	N/A	1.71	
Type E	265	AZ38-700N	North Face	20:07	6	4.70	-15.00	4.70	0.01	-19.69	N/A	1.60	
Type E	266	AZ38-700N	North Face	20:16	6	4.86	-15.00	4.86	0.02	-19.84	N/A	1.54	
Type E	267	AZ38-700N	North Face	20:27	6	4.85	-15.00	4.85	0.03	-19.82	N/A	1.49	
Type E	268	AZ38-700N	North Face	20:35	6	4.84	-15.00	4.84	0.02	-19.82	N/A	1.43	
Type E	269	AZ38-700N	North Face	20:42	5	4.85	-15.00	4.85	0.01	-19.84	N/A	1.38	
Type E	270	AZ38-700N	North Face	20:54	8	4.84	-15.00	4.84	0.01	-19.83	N/A	1.32	
Type E	271	AZ38-700N	North Face	21:41	4	4.82	-15.00	4.82	0.02	-19.80	N/A	1.27	
Type E	272	AZ38-700N	North Face	21:47	4	4.83	-15.00	4.83	-0.01	-19.84	N/A	1.21	
Type E	273	AZ38-700N	North Face	21:53	4	4.81	-15.00	4.81	0.01	-19.80	N/A	1.22	
Type E	274	AZ38-700N	North Face	22:28	3	4.81	-15.00	4.81	0.04	-19.77	N/A	1.22	
Type C	275	AZ 50	North Face	22:34	4	4.85	-16.00	4.85	-0.01	-20.86	N/A	1.23	
Type C	276	AZ 50	North Face	22:40	3	4.80	-16.00	4.80	-0.02	-20.82	N/A	1.23	
Type C	277	AZ 50	North Face	22:45	5	4.88	-16.00	4.88	0.04	-20.84	N/A	1.24	
Type C	278	AZ 50	North Face	22:54	3	4.87	-16.00	4.87	0.02	-20.85	N/A	1.27	
Type C	279	AZ 50	North Face	22:59	4	4.85	-16.00	4.85	0.02	-20.83	N/A	1.30	
Type C	280	AZ 50	North Face	23:04	4	4.85	-16.00	4.85	-0.01	-20.86	N/A	1.32	
Type C	281	AZ 50	North Face	23:10	5	4.87	-16.00	4.87	0.01	-20.86	N/A	1.35	
Type C	282	AZ 50	North Face	23:18	5	4.88	-16.00	4.88	0.02	-20.86	N/A	1.38	
Type C	283	AZ 50	North Face	23:25	3	4.88	-16.00	4.88	0.00	-20.88	N/A	1.41	
Type C	284	AZ 50	North Face	0:02	6	4.87	-16.00	4.87	0.06	-20.81	N/A	1.55	
Type C	285	AZ 50	North Face	0:14	4	4.87	-16.00	4.87	-0.01	-20.88	N/A	1.60	
Type C	286	AZ 50	North Face	0:20	5	4.87	-16.00	4.87	0.00	-20.87	N/A	1.66	
Type C	287	AZ 50	North Face	0:28	12	4.88	-16.00	4.88	-0.08	-20.96	N/A	1.71	
Type C	288	AZ 50	North Face	0:45	5	4.88	-16.00	4.88	-0.06	-20.94	N/A	1.76	
Type C	289	AZ 50	North Face	0:52	5	4.87	-16.00	4.87	0.01	-20.86	N/A	1.81	
Type C	290	AZ 50	North Face	0:59	5	4.86	-16.00	4.86	0.06	-20.80	N/A	1.85	
Type C	291	AZ 50	North Face	1:06	6	4.87	-16.00	4.87	0.01	-20.86	N/A	1.90	
Type C	292	AZ 50	North Face	1:14	7	4.87	-16.00	4.87	0.02	-20.85	N/A	1.94	
Type C	293	AZ 50	North Face	1:23	9	4.87	-16.00	4.87	-0.01	-20.88	N/A	1.99	
Type C	294	AZ 50	North Face	1:50	11	4.87	-16.00	4.87	0.02	-20.85	N/A	2.03	

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: March-11-16
Weather: clear/windy
Equipment: APE 200 Vibratory Hammer (with APE extension)
Derrick: W.M. Saunders (1411)
Total # Driven: 23.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type C	295	AZ 50	North Face	17:54	6	4.88	-16.00	4.88	0.02	-20.86	N/A	2.22	
Type E	296	AZ38-700N	North Face	18:04	8	4.88	-15.00	4.88	0.04	-19.84	N/A	2.20	
Type E	297	AZ38-700N	North Face	18:17	8	4.89	-15.00	4.89	0.03	-19.86	N/A	2.17	
Type E	298	AZ38-700N	North Face	18:30	8	4.89	-15.00	4.89	0.03	-19.86	N/A	2.15	
Type E	299	AZ38-700N	North Face	18:40	7	4.89	-15.00	4.89	0.01	-19.88	N/A	2.12	
Type E	300	AZ38-700N	North Face	18:53	11	4.89	-15.00	4.89	0.00	-19.89	N/A	2.08	
Type E	301	AZ38-700N	North Face	19:24	10	4.89	-15.00	4.89	0.02	-19.87	N/A	2.04	
Type E	302	AZ38-700N	North Face	19:36	11	4.87	-15.00	4.87	0.02	-19.85	N/A	2.00	
Type E	303	AZ38-700N	North Face	19:49	10	4.86	-15.00	4.86	0.01	-19.85	N/A	1.96	
Type E	304	AZ38-700N	North Face	20:02	9	4.86	-15.00	4.86	0.03	-19.83	N/A	1.92	Drove 5' and came back @ 21:55
Type E	305	AZ38-700N	North Face	20:13	14	4.85	-15.00	4.85	0.01	-19.84	N/A	1.85	Drove 5' and came back @ 22:02
Type E	306	AZ38-700N	North Face	20:25	14	4.84	-15.00	4.84	0.04	-19.80	N/A	1.79	Drove 5' and came back @ 22:10
Type E	307	AZ38-700N	North Face	20:35	17	4.83	-15.00	4.83	0.03	-19.80	N/A	1.72	Drove 5' and came back @ 22:18
Type E	308	AZ38-700N	North Face	20:45	15	4.82	-15.00	4.82	0.03	-19.79	N/A	1.65	Drove 5' and came back @ 22:29
Type E	309	AZ38-700N	North Face	20:58	15	4.81	-15.00	4.81	0.02	-19.79	N/A	1.58	Drove 5' and came back @ 22:40
Type E	310	AZ38-700N	North Face	21:35	14	4.80	-15.00	4.80	-0.04	-19.84	N/A	1.52	Lunch
Type D	311	AZ 50	North Face	22:48	12	4.80	-14.40	4.80	0.05	-19.15	N/A	1.45	
Type D	312	AZ 50	North Face	23:04	6	4.79	-14.40	4.79	0.00	-19.19	N/A	1.49	
Type D	313	AZ 50	North Face	23:13	8	4.77	-14.40	4.77	-0.01	-19.18	N/A	1.53	
Type D	314	AZ 50	North Face	13:23	10	4.72	-14.40	4.72	0.02	-19.10	N/A	1.57	
Type D	315	AZ 50	North Face	23:55	15	4.68	-14.40	4.68	0.02	-19.06	N/A	1.61	
Type D	316	AZ 50	North Face	0:12	8	4.63	-13.70	4.63	0.16	-18.17	-18.17	1.67	Hit bedrock
Type D	317	AZ 50	North Face	0:31	9	4.67	-13.70	4.67	4.33	-14.04	N/A	1.73	Hammer overheated - did not complete driving

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: March-15-16
Weather: clear/windy
Equipment: APE 200 Vibratory Hammer (with APE extension)
Derrick: W.M. Saunders (1411)
Total # Driven: 3.00

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Elevation of Water	Comments
Type D	318	AZ 50	North Face				-13.70							
Type D	319	AZ 50	North Face				-13.70							
Type D	320	AZ 50	North Face	Not Available	Not Available	4.53	-13.70	4.53	3.24	-14.99	N/A			Stopped to weld vent hole.
Type D	321	AZ 50	North Face				13.70							
Type D	322	AZ 50	North Face				-12.90							
Type D	323	AZ 50	North Face				-12.90							
Type D	324	AZ 50	North Face	15:50	1	4.49	-12.90	4.49	4.47	-12.92	-12.92	9.22	0.77	Hit assumed bedrock.
Type D	325	AZ 50	North Face				-12.90							
Type D	326	AZ 50	North Face				-12.90							
Type D	327	AZ 50	North Face				-12.90							
Type D	328	AZ 50	North Face	16:00	<1	4.45	-12.10	4.45	4.43	-12.12	-12.12	13.22	0.78	Hit assumed bedrock.
Type D	329	AZ 50	North Face				-12.10							
Type D	330	AZ 50	North Face				-12.10							
Type D	331	AZ 50	North Face				-12.10							
Type D	332	AZ 50	North Face				-12.10							
Type D	333	AZ 50	North Face				-12.10							
Type D	334	AZ 50	North Face				-13.70							

VANCOUVER PILE DRIVING
MARINE GENERAL CONTRACTORS

Pile Driving Records

Project: EGD Remediation Project PH2 South Jetty
Date: March-19-16
Weather: clear/light breeze
Equipment: APE 200 Vibratory Hammer (with APE extension)
Derrick: W.M. Saunders (1411)
Total # Driven: 13.0

Type A	Pile Pair ID	Section Type	Location on Structure	Time Driven	Duration (mins)	Initial Cut-Off Elevation	Initial Tip Elevation	Start Elevation	Final Cut-Off Elevation	Final Tip Elevation	Elevation of Bedrock	Elevation of Water	Comments
Type D	315	AZ 50	North Face	14:56	3	0.02	-19.06	0.02	-0.06	-19.14	N/A		
Type D	316	AZ 50	North Face	15:05	2	0.16	-18.17	0.16	0.00	-18.33	N/A		
Type D	317	AZ 50	North Face	16:07	2	4.33	-14.04	4.33	4.25	-14.12	-14.12		
Type D	318	AZ 50	North Face	16:13	1	4.61		4.61	4.59				
Type D	319	AZ 50	North Face	N/A			-13.70		4.28				
Type D	320	AZ 50	North Face	N/A		3.24	-14.99	3.24	3.06	-15.17	-15.17		
Type D	321	AZ 50	North Face	N/A			-13.70		4.55				
Type D	322	AZ 50	North Face	16:51	10	4.46	-12.90	4.46	0.31	-17.05	-17.05	1.21	Hit assumed bedrock
Type D	323	AZ 50	North Face	17:04	20	4.46	-12.90	4.46	0.66	-16.70	-16.70	1.14	Stopped to weld vent hole; finished driving @ 21:53
Type D	324	AZ 50	North Face	17:53	29	4.46	-12.90	4.46	1.07	-16.29	-16.29	0.90	Stopped to weld vent hole; finished driving @ 22:03
Type D	325	AZ 50	North Face	18:16	12	4.42	-12.90	4.42	0.91	-16.41	-16.41	0.87	Stopped to weld vent hole; finished driving @ 22:12
Type D	326	AZ 50	North Face	18:23	13	4.43	-12.90	4.43	1.64	-15.69	-15.69	0.85	Stopped to weld vent hole; finished driving @ 22:22
Type D	327	AZ 50	North Face	18:33	11	4.4	-12.90	4.40	1.42	-15.88	-15.88	0.84	Stopped to weld vent hole; finished driving @ 22:30
Type D	328	AZ 50	North Face	18:41	7	4.37	-12.10	4.37	3.02	-13.45	-13.45	0.83	Hit assumed bedrock.
Type D	329	AZ 50	North Face	18:50	4	4.35	-12.10	4.35	3.24	-13.21	-13.21	0.83	Hit assumed bedrock.
Type D	330	AZ 50	North Face	18:55	8	4.34	-12.10	4.34	3.38	-13.06	-13.06	0.82	Hit assumed bedrock.
Type D	331	AZ 50	North Face	19:20	12	3.94	-12.10	3.94	2.62	-13.42	-13.42	0.83	Stopped to weld vent hole; finished driving @ 23:09
Type D	332	AZ 50	North Face	19:29	3	4.21	-12.10	4.21	3.20	-13.11	-13.11	0.85	Hit assumed bedrock.
Type D	333	AZ 50	North Face	19:34	5	4.16	-12.10	4.16	3.52	-12.74	-12.74	0.85	Hit assumed bedrock.
Type D	334	AZ 50	North Face	19:40	6	4.14	-13.70	4.14	1.86	-15.98	-15.979	0.87	Stopped to weld vent hole; finished driving @ 23:16

F3

ESQUIMALT GRAVING DOCK

TEMPORARY CAPPING EASTERN PORTION

Number of Pages: 4

EGD WATERLOT REMEDIATION PROJECT PH2 SOUTH JETTY UNDER-PIER SEDIMENT REMEDIATION (EZ899-151108/001/PWY)
ADVISORY 372

Advisory number: 372 **Date:** Sept 2, 2016

To: MNQM Contracting Ltd.

Attention: Stephen Pinto (QMLP) – MNQM Project Manager

From: Rae-Ann Sharp, Departmental Representative, Public Works and Government Services Canada

cc:

MNQM
Nick Doucette, MNQM Quality Control Manager
Vancouver Pile Driving Ltd.
Wes Yewell – Superintendent

PWGSC
Chris Major – Senior Technical Support Officer
Andrew Mylly – Senior PM – Technical

Subject: **East End Engineered Cap Design**

Dear Mr. Pinto,

Canada provides this Advisory to address placement of engineered capping materials in the eastern portion of Zone 2 (east of approximate Station 0+50). The attached plan map and cross sections show layout for placement of the temporary capping materials (0.15m Armour Material and Filter Material) prior to completion of the project work and removal of the TRB. The intent of placing these materials is to provide temporary stability and erosion protection to the slope areas in advance of construction of the new jetty structure (to be completed under a separate contract).

The intent of this approach is to provide approximate locations for placement of the 0.15m Armour Material and Filter Material such that the temporary cover can be transitioned to the permanent engineered sediment cap west of approximate Station 0+050 and the temporary access road adjacent to the concrete L-Wall structure. The approximate locations, material types and thicknesses of material for placement are described on the attached plan map and cross sections.

Canada intends this approach to be a guide for placement of the materials and MNQM shall describe in Record Drawings for the EGD P2 project the boundaries of permanent cap placement, temporary access road construction, and transitions to the temporary capping area. Material placement activities shall be completed in a manner that protects the integrity of the TRB. Additionally, Canada expects some boundaries will require coordination in the field to make final decision prior to and during placement of the temporary capping materials.

CAD files that include this information will also be uploaded to Oproma for use in placing the temporary capping materials.

Rae-Ann Sharp
Departmental Representative and Senior Project Manager-Operational
Ph: 250-889-4948
Rae-Ann.Sharp@pwgsc-tpsgc.gc.ca
Public Works and Government Services Canada
825 Admirals Road, Victoria, BC V9A 2P1
Travaux publics et Services gouvernementaux Canada
825 chemin Admirals, Victoria, C-B V9A 2P1

Government of Canada / Government du Canada

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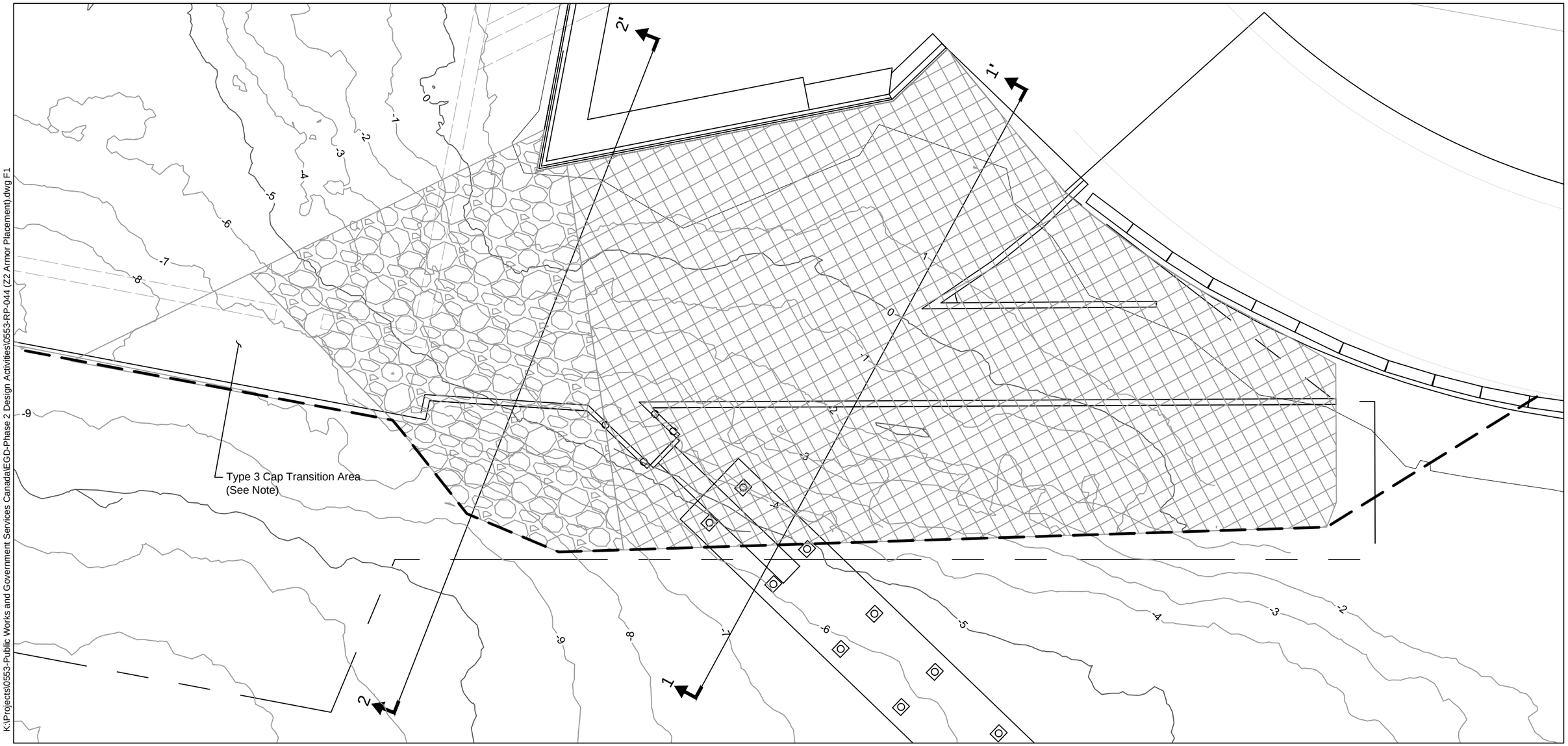


K:\Projects\0553-Public Works and Government Services Canada\EGD-Phase 2 Design Activities\0553-RP-044 (Z2 Armor Placement).dwg F1

Sep 01, 2016 11:04am chewett

SOURCE: Basemap from Golder Associates, dated 2012. Phase 1B Post-construction bathymetry from McCoi Marine, dated March 2014. Progress Survey by McCoi Marine, dated July 18, 2016.
HORIZONTAL DATUM: UTM Zone 10, NAD83.
VERTICAL DATUM: Chart Datum (CD).
NOTE: MNQM shall coordinate with PWGSC to define boundary of Type 3 Cap material placement adjacent to the re-driven sheet pile wall and transition to the temporary cap material to be placed in eastern portion of Zone 2 and temporary road access around the concrete L-Wall.

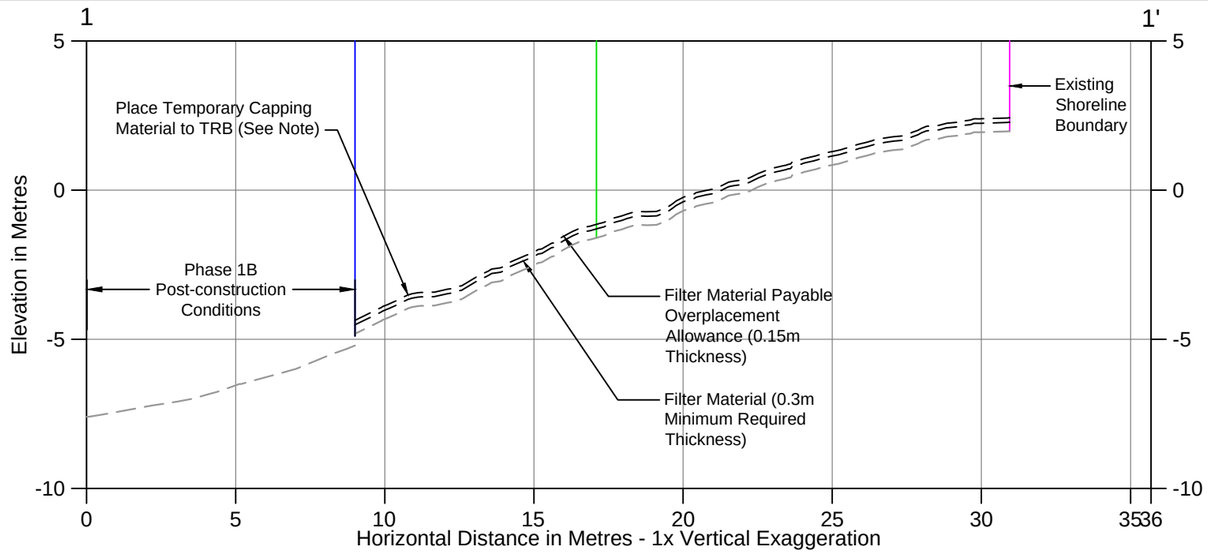
LEGEND:

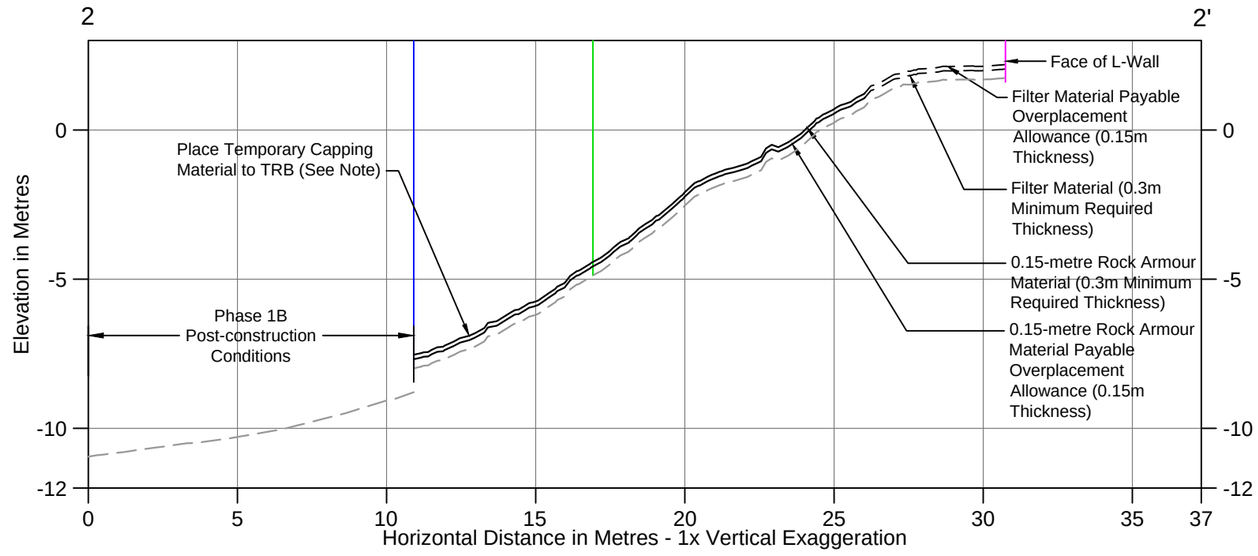
- July 17, 2016 Bathymetry (1m and 5m Contours)
- TRB As-built Location
- 0.15-metre Rock Armour Material Placement Area
- Filter Material Placement Area

0 2 4
Scale in Metres

ANCHOR QEA

Figure 1
Cross Section Locations
Esquimalt Graving Dock Waterlot Project
Phase 2 South Jetty Under-pier Sediment Remediation Project





SOURCE: Zone 2 progress survey from McCoi Marine, dated July 18, 2016.
HORIZONTAL DATUM: UTM Zone 10, NAD83.
VERTICAL DATUM: Chart Datum (CD).
NOTE: MNQM to place temporary capping materials adjacent to the TRB so that the TRB is not damaged by the placement activities. An offset of up to 2 metres for placement of material adjacent to the TRB is acceptable in order to protect the integrity of the TRB.

LEGEND:

- July 18, 2016 Zone 2 Survey/Phase 1B Post-construction Conditions
- Face of L-Wall/Existing Shoreline Boundary
- Approximate TRB Location
- Former Extent of East Approach Structures
- Filter Material Placement and Payable Overplacement Allowance
- Armour Material Placement and Payable Overplacement Allowance

0 2 4
Scale in Metres

K:\Projects\0553-Public Works and Government Services Canada\EGD-Phase 2 Design Activities\0553-RP-044 (Z2 Armor Placement).dwg F2
Sep 01, 2016 11:04am chewett

ANCHOR QEA

Figure 2
Cross Sections
Esquimalt Graving Dock Waterlot Project
Phase 2 South Jetty Under-pier Sediment Remediation Project

F4

ESQUIMALT GRAVING DOCK

NAVIGATION MARKER MONOPILE DESIGN

ALLSPAN (2016)

Number of Pages: 12

PACIFIC REGION – Professional and Technical Services (PTS)	Request for Information Form	Business Unit: ES	Page: 1 of 1
Title: Contractor Request for Information – EZ899-151108/001/PWY – PH2 - EGD Waterlot Remediation Project South Jetty Under-Pier Sediment Remediation			

RFI #: PH2 - 649

Project No.: R.018400.002 Project Name: EGD Waterlot Remediation Project - PH2 South Jetty Under-Pier Sediment Remediation

To: Canada - PWGSC Date: 21-Oct-2016

Attention: Rae-Ann Sharp, PWGSC Departmental Representative

Navigational Marker Dolphin design

Please find attached All-Spans stamped design for the Navigation Marker Dolphin's.

- *Shop drawings for the ladders are currently being drafted. Note that the shop drawing will show galvanized rebar ladder rungs. Please confirm if this is an acceptable alternative to twisted square bar rungs. All-Span has been notified of the change and they agree to this alternative.*
- *The piles are used material and have been spliced in Vanpile's North Vancouver yard. Vanpile has arranged for a third-party testing agency to perform a pile condition assessment on October 25th. The report will be submitted to PWGSC.*
- *Corrosion Services will be advising Vanpile on the suitable size and quantity of passive anodes required for the piles. Vanpile will submit the recommendations when finalized.*
- *A sign layout is currently being drafted and will be submitted to PWGSC for review prior to fabrication.*

References – Specification item: Drawings:

Response required by:

Anticipated Change to – Contract Amount: ☐ Yes ☒ No Contract time: ☐ Yes ☒ No

From: Nicholas Doucette @ MNQM Contracting Ltd.

(Name) (MNQM Contracting Ltd.)

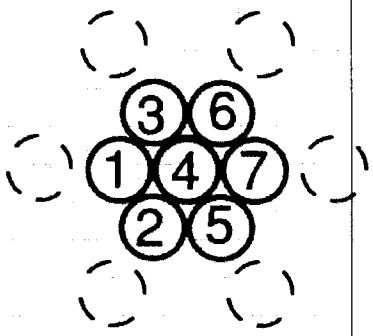
ALL-SPAN
ENGINEERING & CONSTRUCTION LTD.
(604) 940-2212 Fax (604) 940-1516

PROJECT ESQ. MONOPILE DOLPHIN FILE # 16-089
DESIGN MB CHECK
ITEM EQUIV. ENERGY & LOAD SUMMARY REVISION A
DATE 21 OCT 2016 PAGE # 1 OF 1

7-PILE DOLPHIN GROUP PIN-CONNECTED AT TOP, ANALYSED ELASTICALLY FOR LAT'L DEFL'N FROM POINT LOADING:
POINT LOAD, P, APPLIED AT TOP OF PILE.
ASSUMED THAT 1st PILE YIELDS WHEN IT REACHES ITS PULL-OUT VALUE.
LATERAL LOAD AND DEFL'N IS ASSESSED FOR 1st PILE PULL-OUT, AND THEN FOR EA. SUBSEQUENT PILE YIELD LOAD.

BASED ON PILE PULL-OUT RESISTANCE FROM AVAILABLE SOIL ADHESION OF 12 kPa
TIMBER PILE Tr = 12 kPa(3.14)(DIA)(Lembed)
DIA = 0.355 m
EMBED = 6.0 m

Tr = 80 kN PER PILE



MOMENT RESISTANCE, Mr = 90 kN-m PER PILE

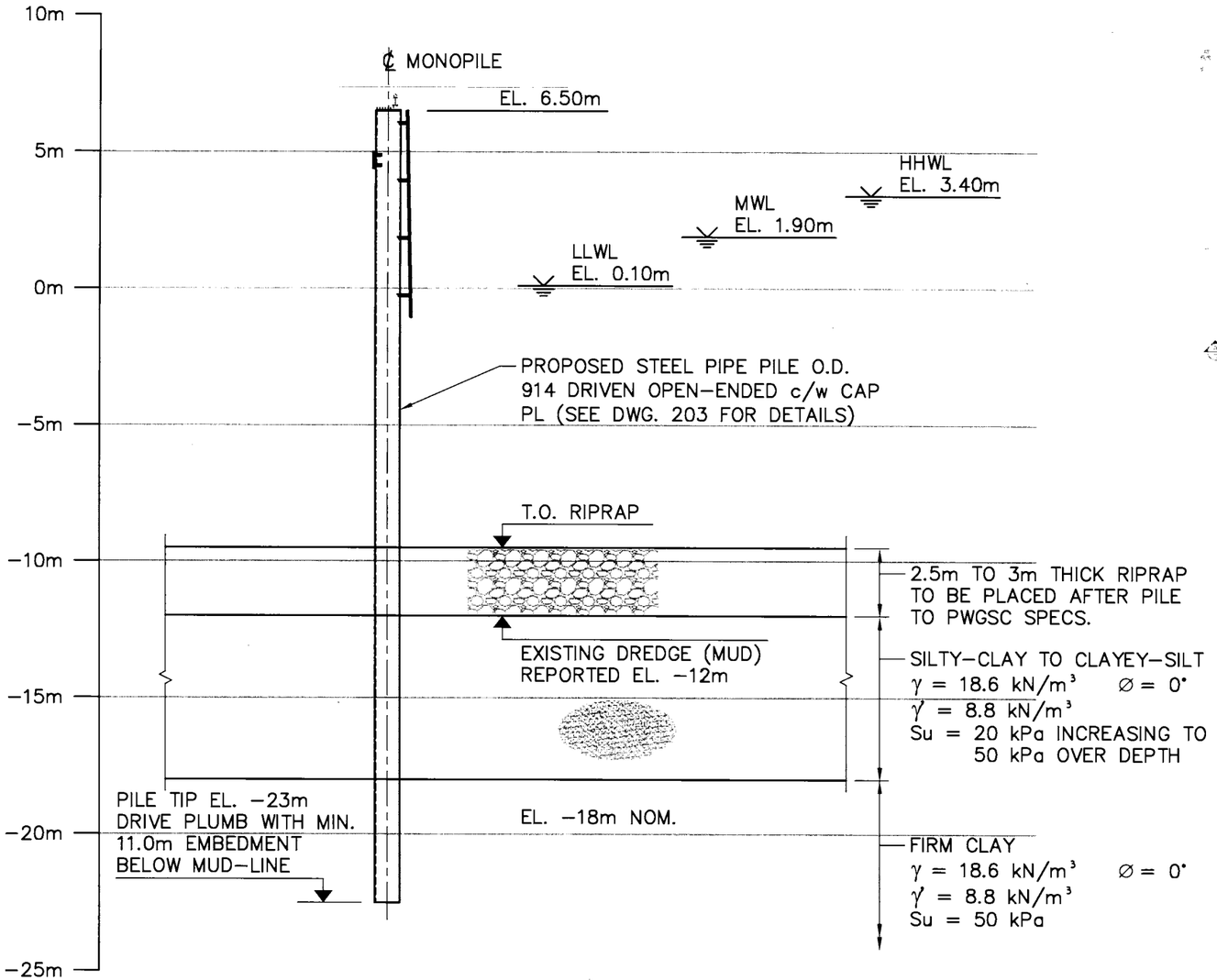
PILE LENGTH ABOVE MUD-LINE = 6.5 m -(-12 m) = 18.5 m
TIMBER PILE LENGTH = 18.5 m ABOVE + 6 m EMBED = 24.5 m
EFFECTIVE TIMBER PILE LENGTH FOR BENDING = 18.5 + 3 = 21.5 m

SUMMARY OF FORCE DEFLECTION ENERGY CALCULATION FOR 7-PILE TIMBER DOLPHIN:

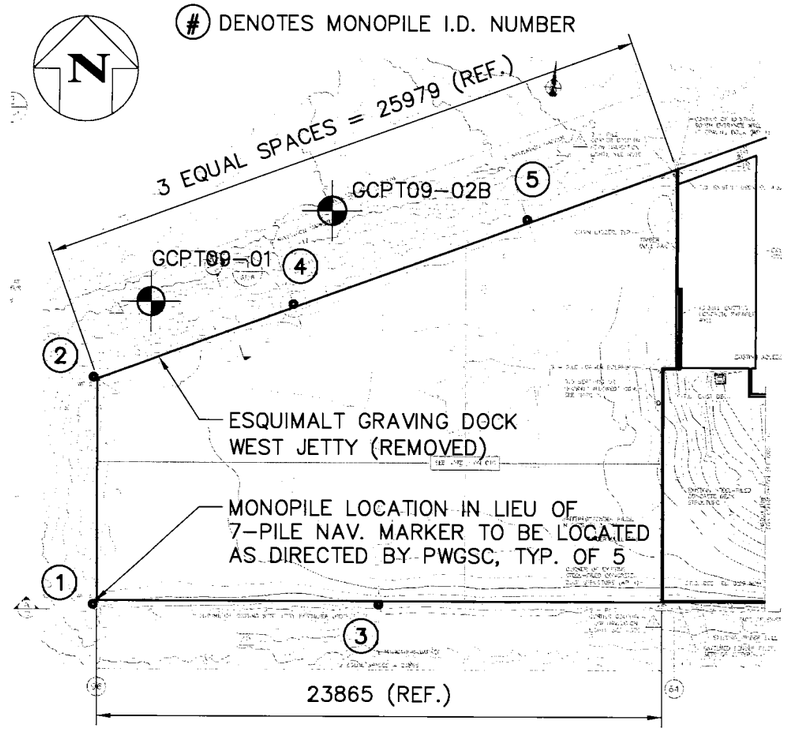
STAGE	CONFIGURATION	PILE GROUP FLEXIBILITY	LATERAL FORCE P, (kN)	GROUP DEFL'N d, (mm)	U = 1/2*P*d (kN-m)
1	7-PILES LOADED TO PULL-OUT OF 1st PILE	0.85 mm / kN	20	17	0.17
2	6-PILES LOADED TO PULL-OUT OF 2nd & 3RD PILE	1.368 mm / kN	9.5	13	0.06
3	4-PILES LOADED TO PULL-OUT OF 4TH, CENTRE, PILE	4.667 mm / kN	6	28	0.08
4	3-PILES LOADED TO PULL-OUT OF 5th & 6TH PILE (POSSIBILITY OF COMPRESSION FAILURE OF 7th PILE IGNORED)	14.285 mm / kN	7	100	0.35
5	SINGLE, 7th, PILE FAILURE BY BENDING M = P*(Leff) = P*(21.5 m):		4.2 kN	U = P^2*Leff^3/6EI	3.74 kN-m
				FORCE DEFLECTION ENERGY SUM =	4.41 kN-m
			SUM P's =	46.7 kN	

BASED ON COHESIVE SOIL ASSUMPTION OF Su VARYING FROM 20 kPa TO A MAX OF 50 kPa @ 6m DEPTH, AND
CORRESPONDING SOIL SPRING STIFFNESSES INCREASINGLY VARYING FROM ZERO TO A MAX @ 6 m DEPTH, AND
STEEL PIPE MONOPILE 914 DIA x 19:

EI = 1,070,400 kN-m^2
Myield = 3267 kN-m
EMBED = 11.0 m BELOW MUDLINE
PILE FLEXIBILITY = 5.1 mm/kN
P = 47 kN
DEFL'N = 238 mm, (ELASTIC PILE TOP DEFL'N)
U = 5.56 kN-m



TYPICAL MONOPILE PROFILE
1:200



KEY PLAN
N.T.S.

NOTES:

1. REF. PWGSC DOCUMENT ADV−403−2016−09−30−RS−EGD−WL... "NAVIGATION MARKER DOLPHIN ALTERNATE", AND RELATED CONTRACT DRAWINGS.
2. REFERENCE DWGS. DATED , 2015/03/31 PWGSC/ANCHOR QEA/KLOHN CRIPPEN BERGER: R.018400.002−C5−REV. 1, R.018400.002−C7−REV. 1, R.018400.002−S128−REV. 1, & R.018400.002−S131−REV. 0
3. DESIGN SOIL PARAMETERS PER SOIL LOG REFERENCES FROM BOREHOLES GCPT09−01 & GCPT09−02B (FIGURES F−1 AND F−2, REV. 2) IN GOLDER ASSOCIATES GEOTECH REPORT #09−1475−5008, DATED MARCH 3, 2010.
4. MONOPILE EMBEDMENT AND CROSS SECTION BASED ON COMPARABLE IMPACT RESISTANCE TO SPECIFIED 7−PILE, 14ø, TIMBER NAV. MARKER EMBEDDED 6m, PER REF. DWGS.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA
M. L. BUCKLEY
21 OCT 2016

REV.	DESCRIPTION	DATE
A	ISS'D FOR PILE CONSTRUCTION	21/10/16

DATE	18/10/16
SCALE	AS SHOWN
DRAWN BY	J.P.
DESIGN BY	M.B.
CHECKED BY	DM
APPROVED	
PROJECT No.	16089
DRAWING No.	201
REV.	A

CLIENT
VANCOUVER PILE DRIVING LTD.

PROJECT
ESQUIMALT MONOPILE DOLPHIN

DRAWING TITLE
LOCATION PLAN AND TYP. MONOPILE PROFILE

ALL-SPAN
ENGINEERING & CONSTRUCTION LTD.
#201 − 7198 VANTAGE WAY
DELTA, B.C. V4G 1K7
E−mail: all−span@telus.net
PH: (604) 940−2212 FAX: (604) 940−1516

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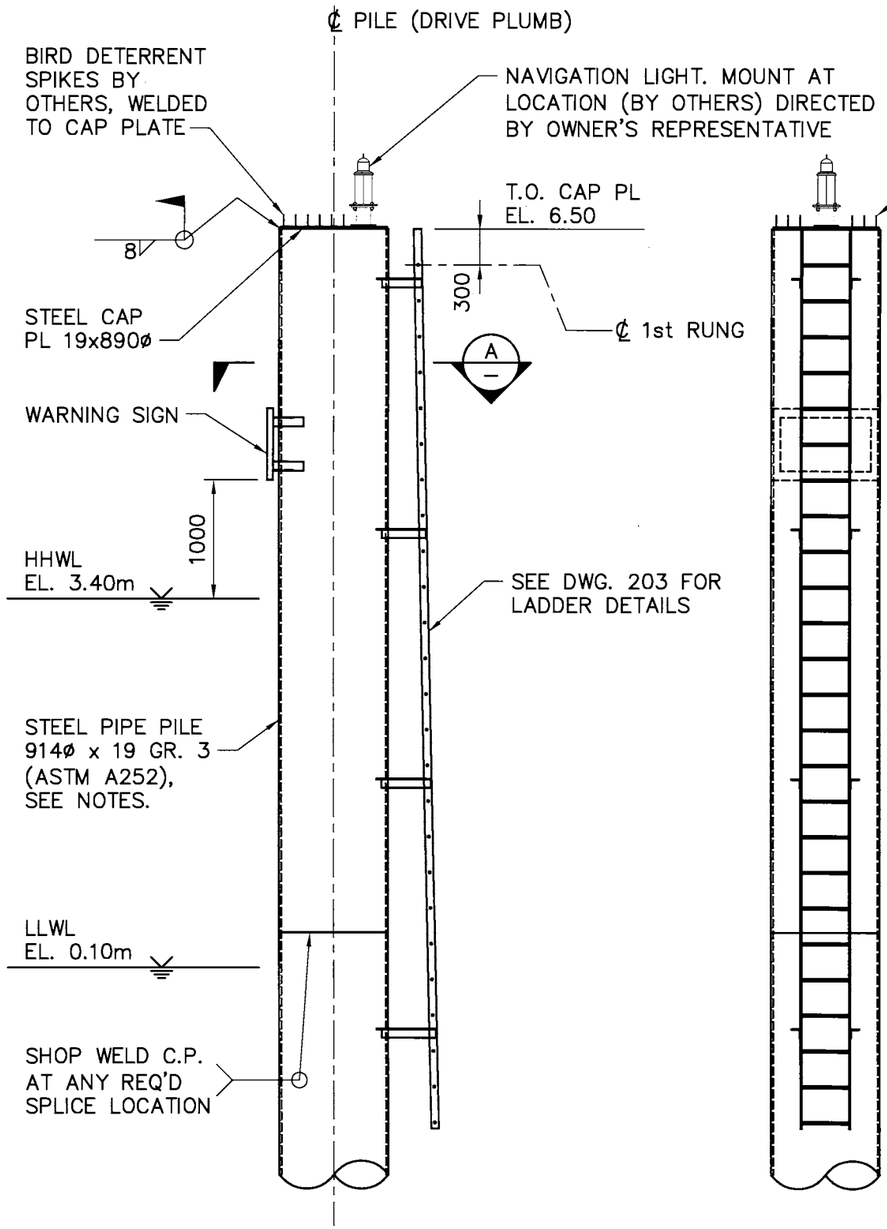
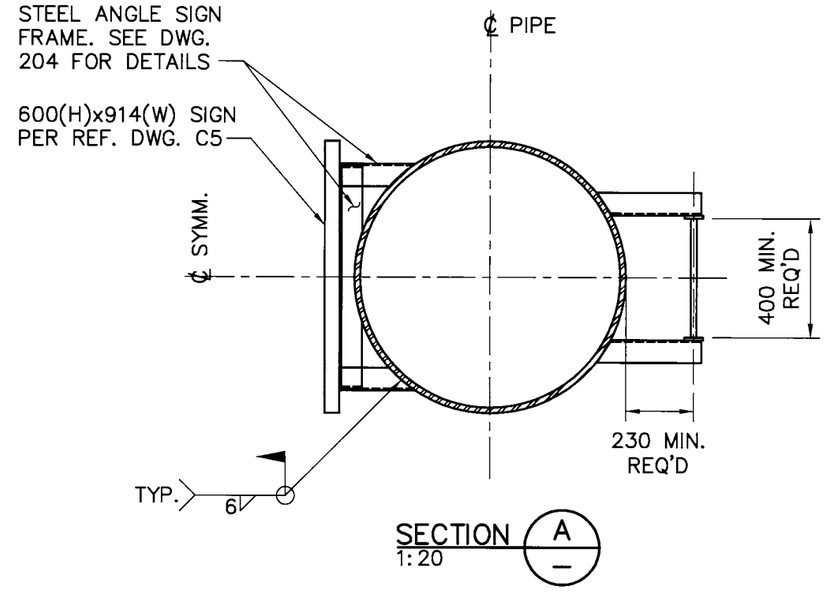
CADFILE: 16089−201.DWG



DETAILS AT UPPER END OF MONOPILE
1:50

SIDE VIEW
1:50



SECTION A
1:20

NOTES:

1. DESIGN LIFE 10 YEARS.
2. VANCOUVER PILE DRIVING LTD. TO PROVIDE DETAILS FOR PASSIVE ANODES FOR CORROSION PROTECTION SYSTEM.
3. SIGN BRACKET DESIGN: 1:50 WIND
4. PIPE PILES WILL BE ASSEMBLED FROM MISC. LENGTHS OF USED PILES, ALL OF SAME CROSS-SECTION AND TO MIN. REQ'D AND COMPATIBLE GRADES. CONDITION ASSESSMENT OF ASSEMBLIES TO BE SUBMITTED FOR REVIEW.

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — M. L. BUCKLEY — 21/10/2016

	DATE	18/10/16
	SCALE	AS SHOWN
	DRAWN BY	J.P.
	DESIGN BY	M.B.
	CHECKED BY	DM
	APPROVED	
	PROJECT No.	16089 REV. A
	DRAWING No.	202

REV.	DESCRIPTION	DATE
A	ISS'D FOR PILE CONSTRUCTION	21/10/16

CLIENT: VANCOUVER PILE DRIVING LTD.

PROJECT: ESQUIMALT MONOPILE DOLPHIN

DRAWING TITLE: TYP. MONOPILE UPPER END DETAILS

ALL-SPAN ENGINEERING & CONSTRUCTION LTD.
#201 – 7198 VANTAGE WAY
DELTA, B.C. V4G 1K7
E-mail: all-span@telus.net
PH: (604) 940-2212 FAX: (604) 940-1516

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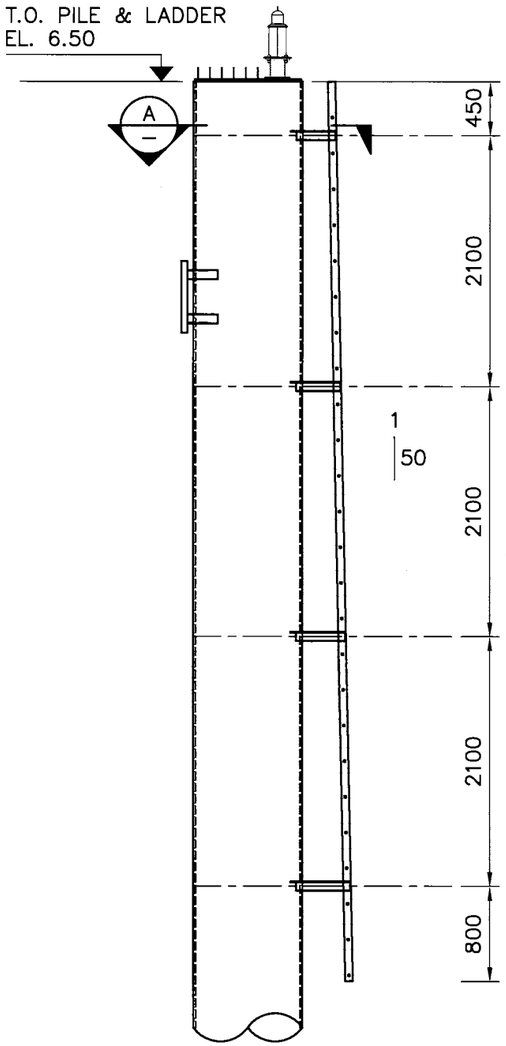
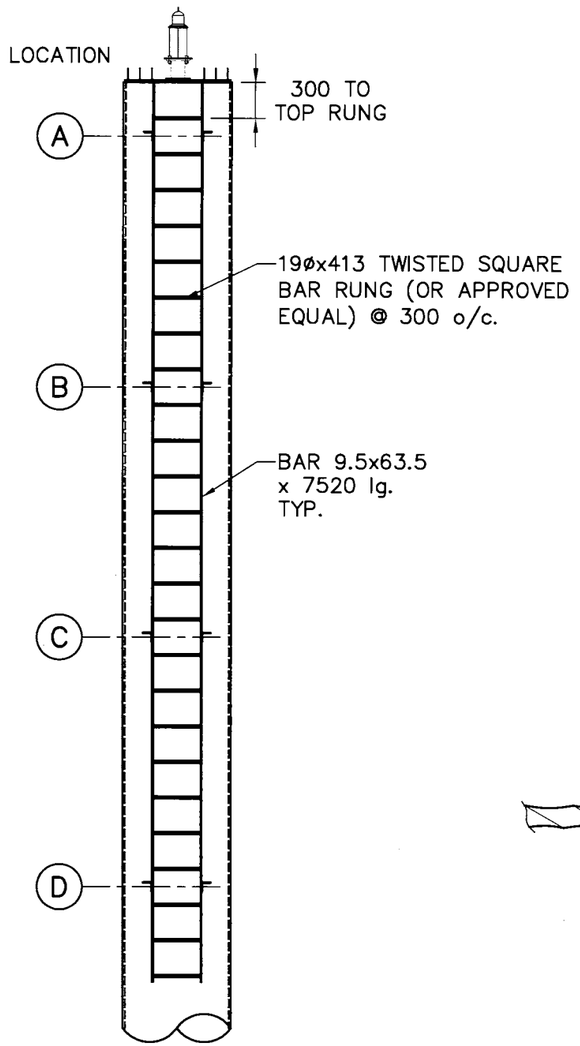
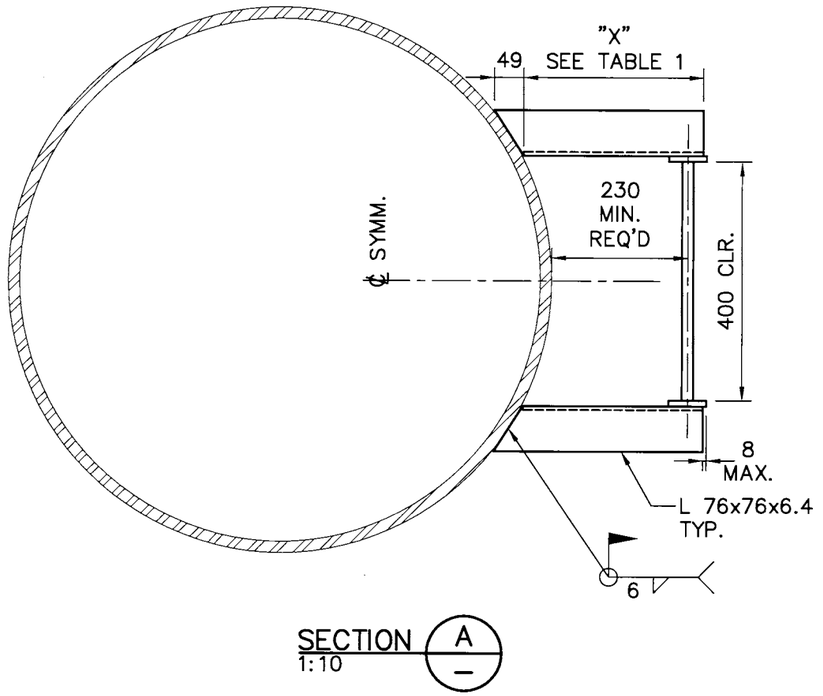
CADFILE: 16089-201.DWG



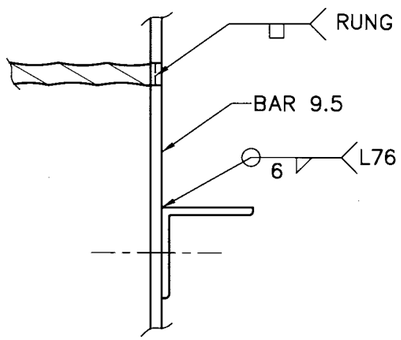
LADDER SIDE VIEW
1:50



LADDER FRONT VIEW
1:50



SECTION A
1:10



TYP. WELD DETAILS
1:5

TABLE 1	
LOCATION	"X" (mm)
A	304
B	346
C	388
D	430

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
M. L. BUCKLEY
21 OCT 2016

NOTES:

1. ALL STEEL SUPPLY AND FABRICATION TO CSA G40.20/G40.21–13, AND S16–14; ALL MAT'L GRADE 300W.
2. ALL WELDING IN ACCORDANCE WITH CSA W59–13. ALL WELDERS SHALL BE APPROPRIATELY CERTIFIED, AND ALL WELDING SHALL BE PERFORMED IN A SHOP CERTIFIED TO W47.1–09 (R2014).
3. GRIND SMOOTH ANY BURRS ON HANDHOLDS PRIOR TO GALVANIZING.
4. ASSEMBLY TO BE HOT DIPPED GALVANIZED IN CONFORMANCE WITH CSA–G164 AND TOUCHED–UP AROUND SITE WELDS AS DIRECTED BY OWNER'S REPRESENTATIVE.
5. DESIGN LIFE: 10 YEARS.
6. WORKSAFEBC CONFORMANCE PER PWGSC ADV–432 DATED 18 OCT. 2016.

REV.	DESCRIPTION	DATE
A	ISS'D FOR PILE CONSTRUCTION	21/10/16

DATE	18/10/16
SCALE	AS SHOWN
DRAWN BY	R.C.
DESIGN BY	M.B.
CHECKED BY	
APPROVED	
PROJECT No.	16089
DRAWING No.	203
REV.	A

CLIENT
VANCOUVER PILE DRIVING LTD.

PROJECT
ESQUIMALT MONOPILE DOLPHIN

DRAWING TITLE
LADDER DETAILS

ALL-SPAN
ENGINEERING & CONSTRUCTION LTD.
#201 – 7198 VANTAGE WAY
DELTA, B.C. V4G 1K7
E–mail: all–span@telus.net
PH: (604) 940–2212 FAX: (604) 940–1516

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CADFILE: 16089–201.DWG

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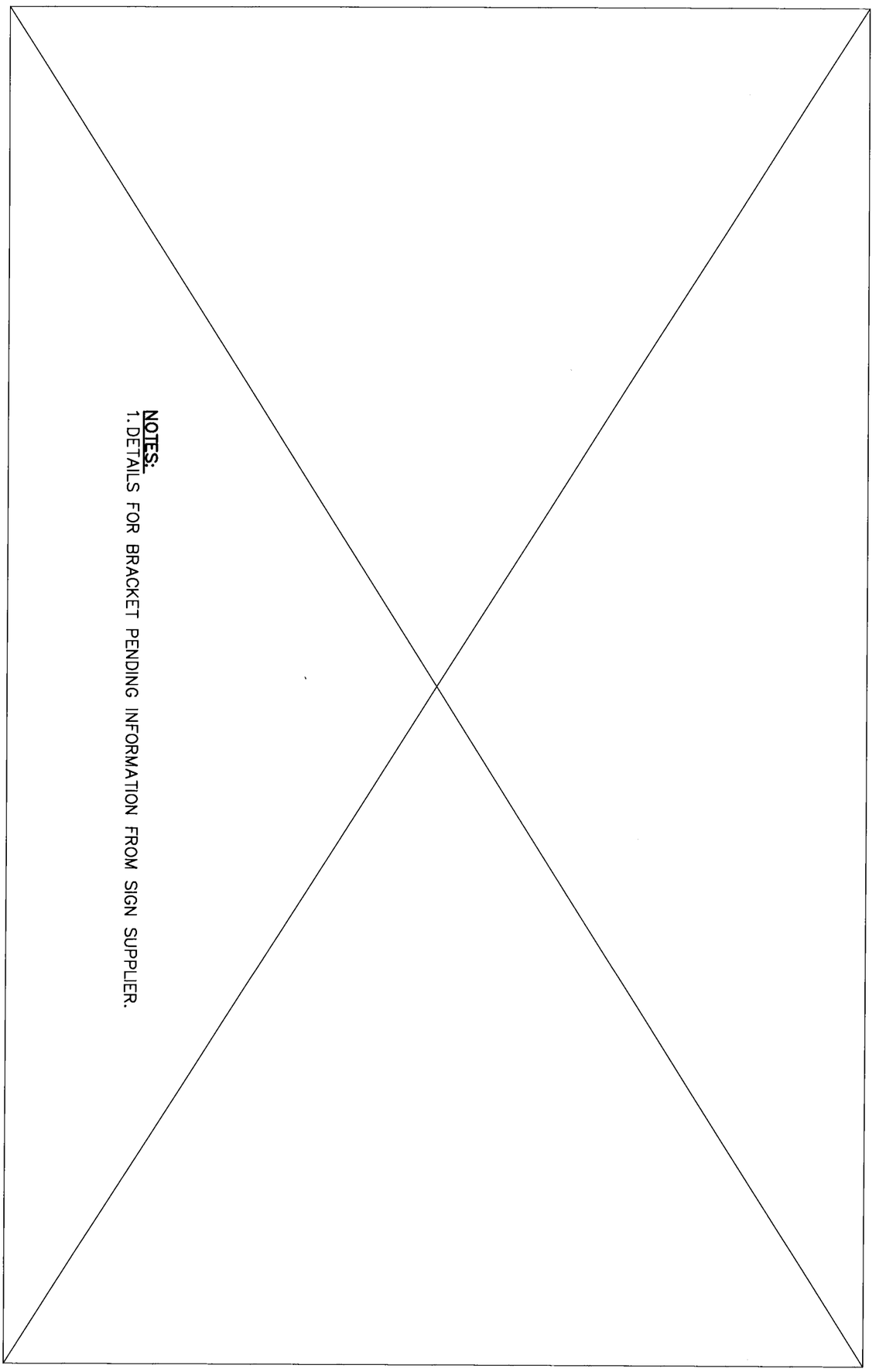


NOTES:
1. DETAILS FOR BRACKET PENDING INFORMATION FROM SIGN SUPPLIER.

ALL-SPAN
ENGINEERING & CONSTRUCTION LTD.
#201 – 7198 VANTAGE WAY
DELTA, B.C. V4G 1K7
E-mail: all-span@telus.net
PH: (604) 940-2212 FAX: (604) 940-1516

CLIENT
VANCOUVER PILE DRIVING LTD.

PROJECT
ESQUIMALT MONOPILE DOLPHIN

DRAWING TITLE
WARNING SIGN MOUNTING BRACKET DETAILS

REV.	DESCRIPTION	DATE
H		
G		
F		
E		
D		
C		
B		
A	ISS'D FOR PILE CONSTRUCTION	21/10/16

DATE	18/10/16
SCALE	AS SHOWN
DRAWN BY	R.C.
DESIGN BY	M.B.
CHECKED BY	
APPROVED	
PROJECT No.	16089 REV.
DRAWING No.	204 A

CADFILE:16089-201.DWG

MUNROE HEAD

NORTH LANDING WHARF

WATERLOT

DRY DOCK

SECTION 1

SECTION 2

SECTION 3

SOUTH JETTY

STEEL PILE-SUPPORTED CONCRETE DECK

TIMBER PILE-SUPPORTED WHARF

Crib #6

Crib #5

Crib #4

Crib #3

Crib #2

Crib #1

Gabion Mats

(1) = DOLPHIN I.D. #

LEGEND

- GBH09-xx — Sonic or Mud Rotary Borehole (by Golder 2009)
- CP.PT09-xx / I-CPT09-xx — Cone Penetration Test (by Golder 2009)
- SC09-xx / DC09-xx — Sediment Core and Diver Core (by Golder 2009)
- JP09-xx — Jet Probe (by Golder 2009)
- TH-xx — Testholes (by Hardy Associates)
- BPT01-xx — Becker Penetration Test (by Golder 2001)
- BPT02-xx — Becker Penetration Test (by Klohn Crippen 2002)
- BOC01-xx — Becker Open Hole (by Golder 2001)
- BOC02-xx — Becker Open Hole (by Klohn Crippen 2002)
- AH02-01 — Hollow-stem Auger hole (by Golder 2001)
- DH02-01 — Mud Rotary Borehole (by Klohn Crippen 2002)
- SCPT02-xx / CPT02-xx — Cone Penetration Test (by Klohn Crippen 2002)
- Approximate Area of Timber Piling Under Jetty
- Approximate Area of Steel Pile-supported Concrete Deck
- (x) — Cross Section Locations
- Waterlot Boundary

NOTES

1. Bathymetry contours (0.5m intervals) provided by CRA Surveys, February 2009. Elevations (in metres) referenced to Geodetic Datum.
2. Drawing base information provided by Public Works and Government Services Canada

20 0 20
SCALE METRES

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

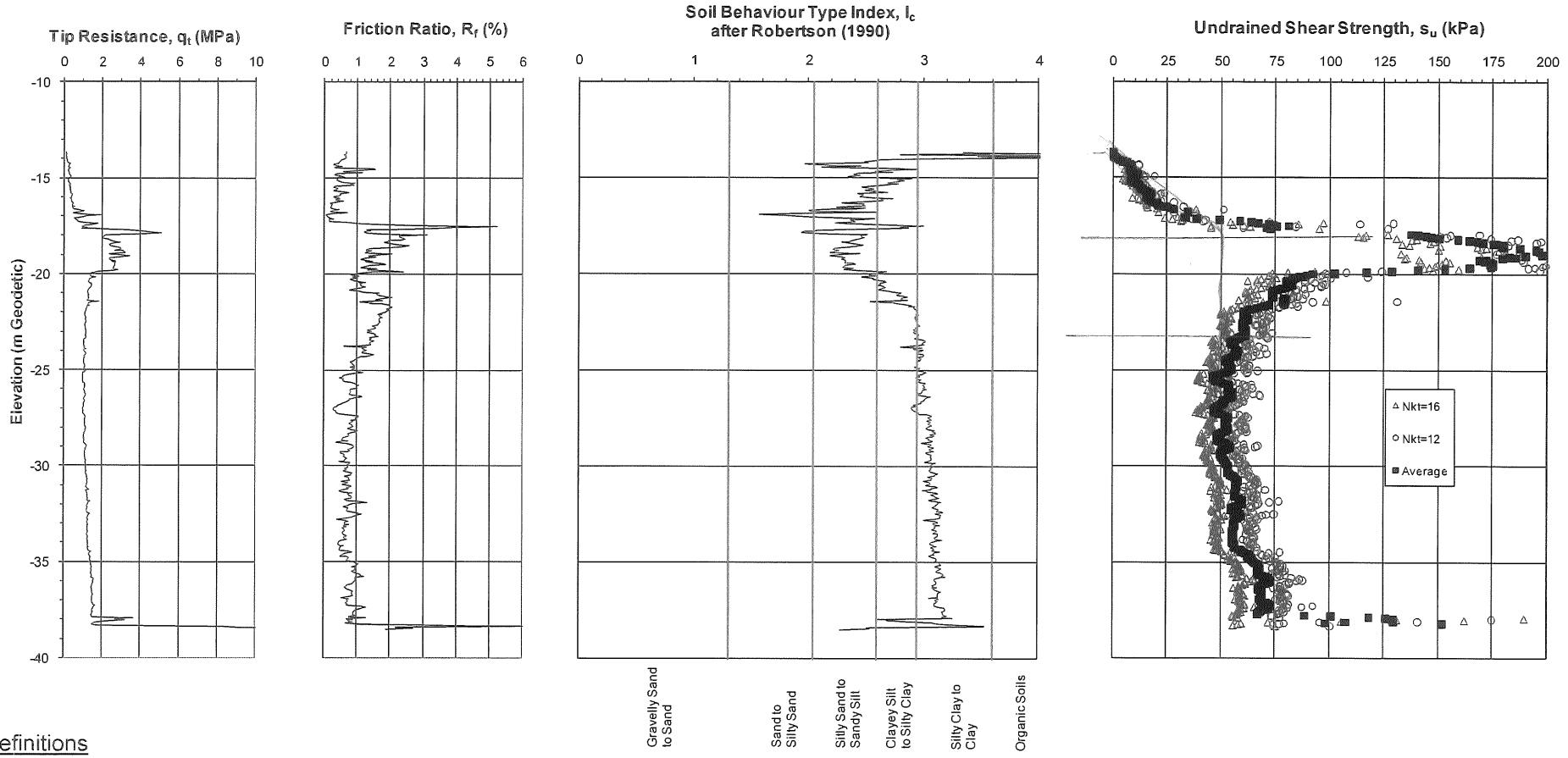
TITLE

TEST HOLE LOCATION PLAN

Golder Associates
Victoria, BC

PROJECT No. 09-1475-5008			FILE No.P0914755008 1000-01		
DESIGN	CNW	3 NOV 09	SCALE	AS SHOWN	REV. 0
CADD	CLF	11 JAN 09			
CHECK	CNW	2 MAR 10	FIGURE 1		
REVIEW	JF	2 MAR 10			

N:\Active\2009\1475\09-1475-5008 (PWGSC Testhole Bh ESQ)\Civil Drafting\proSIS 1000\ Drawing file: Fig 1- P0914755008 1000-01.dwg Ver. 10, 2010 - 1:35pm



Definitions

$R_f = \frac{f_s}{q_t}$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1 - B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

where: $Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$, $B_q = \frac{u - u_o}{q_t - \sigma_{vo}}$ *and* $F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

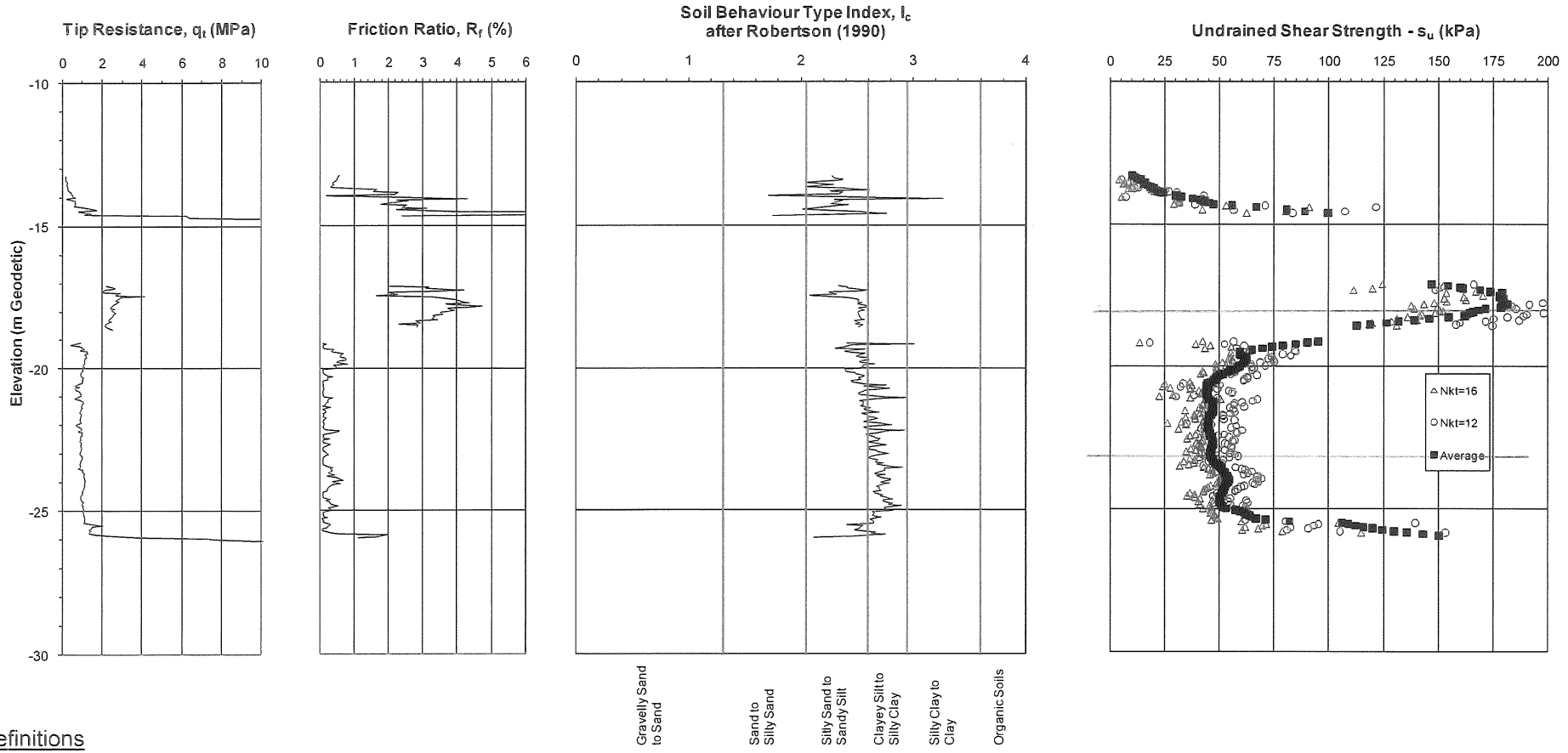
PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE: GCPT09-01 INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No.	09-1475-5008		FILE No.	—	
Analysis	CNW	11/01/10	SCALE	None	REV. 2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-1



Definitions

$R_f = \frac{f_s}{q_t}$ *where* f_s = *sleeve friction*

$$I_c = \sqrt{\{3 - \log[Q(1-B_q)]\}^2 + (1.5 + 1.3[\log F])^2}$$

where: $Q = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$, $B_q = \frac{u - u_o}{q_t - \sigma_{vo}}$ *and* $F = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$

$$s_u = \frac{q_t - \sigma_{vo}}{N_{kt}}$$

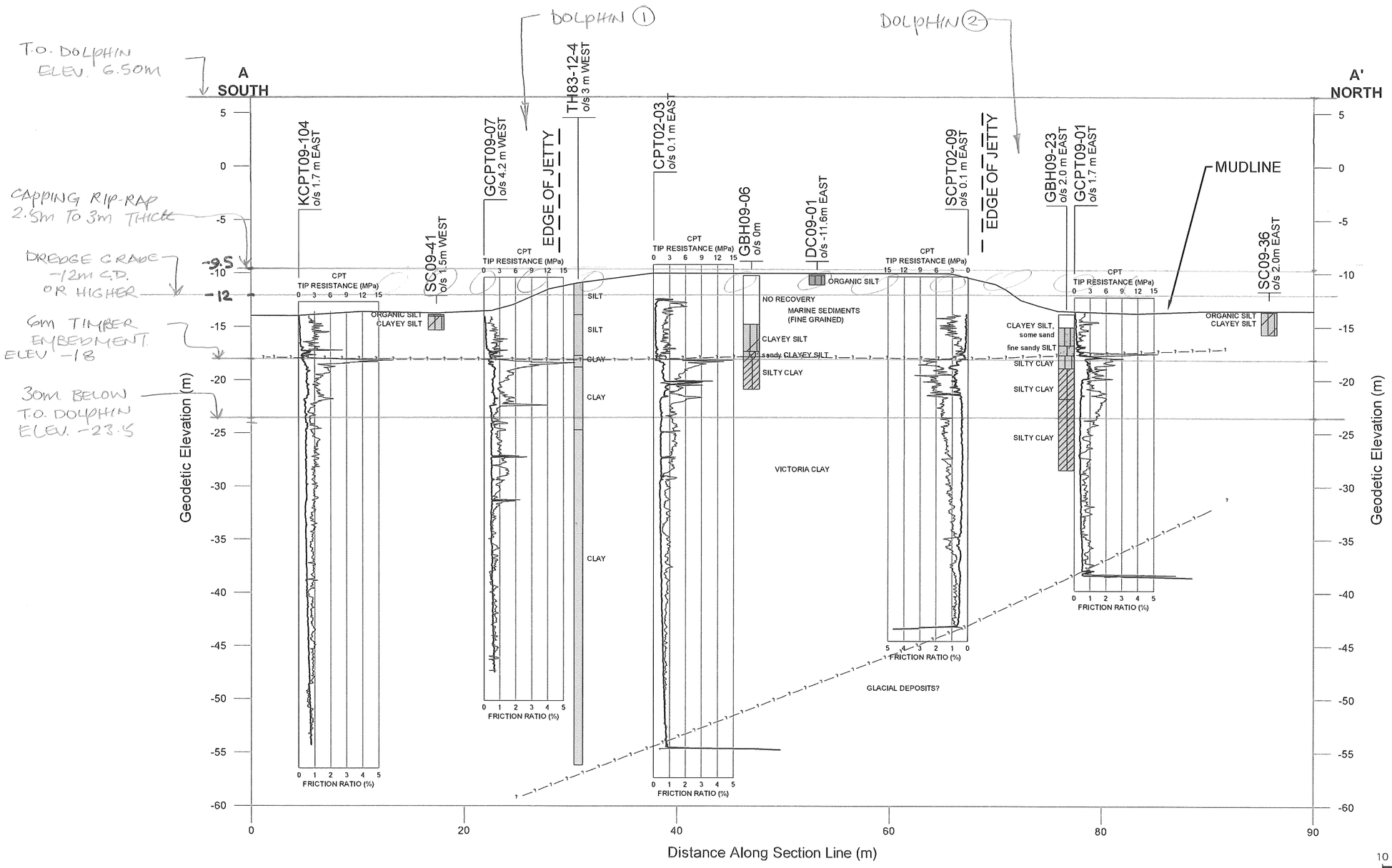
PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE: GCPT09-02b INTERPRETATION:
SOIL BEHAVIOUR TYPE AND UNDRAINED SHEAR STRENGTH

Golder Associates

PROJECT No. 09-1475-5008			FILE No. ---		
Analysis	CNW	11/01/10	SCALE None	REV.	2
Graphics	NG	11/01/10			
Check	CNW	18/02/10			
Review	JF	02/03/10			

FIGURE F-2



LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C

TITLE
STRATIGRAPHIC CROSS-SECTION A-A'

Golder Associates Victoria, BC

PROJECT	09-1475-5008		FILE No.	S09147550081000-03
DESIGN	CNW	21 SEP 09	SCALE	AS SHOWN REV. 0
CADD	TRE	30 DEC 09		
CHECK	CNW	2 MAR 10		
REVIEW	JF	2 MAR 10		

FIGURE 2a

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2a S09147550081000-03 A-A.dwg Mar 03, 2010 - 1:38pm

DOLPHIN (5)

C
SOUTH

C'
NORTH

SC09-126 o/s 6.0m WEST

GCPT09-08B o/s 1.8m EAST

GHB09-20 o/s 1.4m WEST

EDGE OF JETTY

CPT02-05 o/s 2.2m WEST

GBH09-08 o/s 12.4m EAST

MUDLINE

GBH09-07 o/s 6.4m WEST

DH02-03 o/s 2.1m WEST

CPT02-10 o/s 0.6m EAST

EDGE OF JETTY

GBH09-19 o/s 0.3m WEST

GBH09-17 o/s 3.3m WEST

CPT TIP RESISTANCE (MPa)

FRICTION RATIO (%)

ORGANIC SILT
CLAYEY SILT
ORGANIC SILT
sandy SILT
SILTY CLAY
SAND, some gravel to gravelly
NO RECOVERY
CLAYEY SILT
silty SAND
SILTY CLAY
UNCONSOLIDATED SEDIMENTS
UPPER FINE-GRAINED MARINE SEDIMENTS
UPPER COARSE-GRAINED MARINE SEDIMENTS
NO RECOVERY
ORGANIC SILT
gravelly sandy SILT [FILL?]
CLAYEY SILT
SAND and GRAVEL, some silt
SILTY CLAY
SILT with organics
SAND and GRAVEL
some silt to silty
SILT
silty fine SAND
SILTY CLAY
SAND, some gravel
VICTORIA CLAY
GLACIAL DEPOSITS
BEDROCK?
ORGANIC SILT some sand
silty SAND and GRAVEL
SILTY CLAY
silty SAND, some gravel [TILL-like]
Probable BEDROCK
No recovery
GLACIAL DEPOSITS
ORGANIC SILT
sandy SILT to silty SAND
sandy GRAVEL, some silt
silty SAND, some gravel [TILL-like]
BEDROCK
silty SAND to SILT and SAND, some gravel [TILL-like]
SAND, some silt, some gravel
SAND and SILT [TILL-like]
SAND [TILL-like]
SAND [TILL-like]
silty SAND
silty SAND and GRAVEL [TILL-like]

Geodetic Elevation (m)

Distance Along Section Line (m)

SCALE 1:400 METRES

LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- UPPER MARINE SEDIMENTS (COARSE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

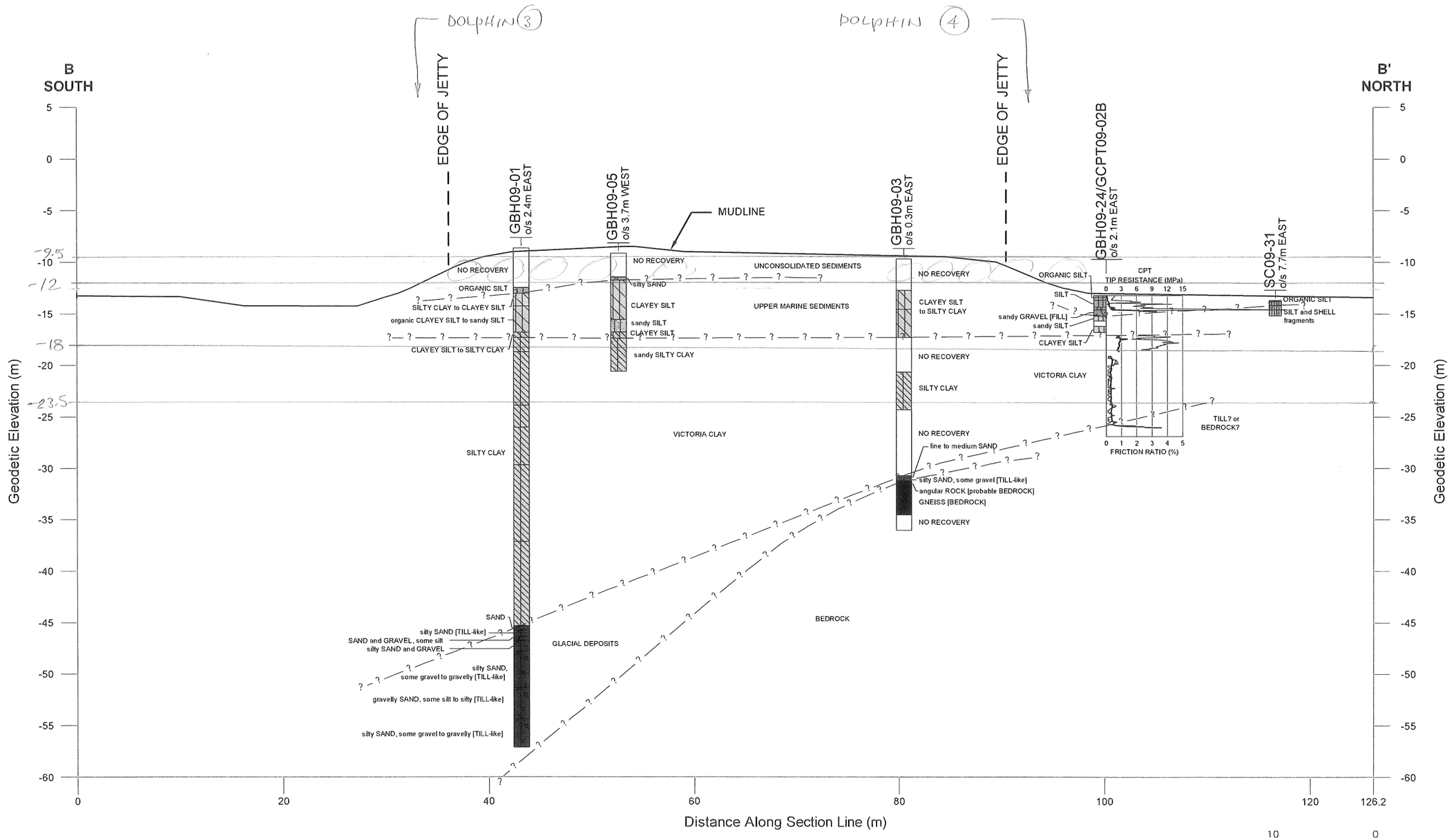
TITLE
STRATIGRAPHIC CROSS-SECTION C-C'

Golder Associates
Victoria, BC

PROJECT No. 09-1475-5008			FILE No S09147550081000-02		
DESIGN	CNW	21 SEP 09	SCALE	AS SHOWN	REV. 0
CADD	TRE	29 DEC 09			
CHECK	CNW	2 MAR 10			
REVIEW	JF	2 MAR 10			

FIGURE 2c

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2c S09147550081000-02 C-C.dwg Mar 03, 2010 - 1:05pm



10 0 10
SCALE 1:400 METRES

LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
STRATIGRAPHIC CROSS-SECTION B-B'

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No. S09147550081000-01		
DESIGN	CNW	21 SEP 09	SCALE	AS SHOWN	REV. 0
CADD	TRE	29 DEC 09	FIGURE 2b		
CHECK	CNW	2 MAR 10			
REVIEW	JF	2 MAR 10			

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2b S09147550081000-01 B-B.dwg Mar 03, 2010 - 1:39pm

F5

ESQUIMALT GRAVING DOCK

NAVIGATION DOLPHIN LAYOUT

VPD (2016)

Number of Pages: 2

PACIFIC REGION – Professional and Technical Services (PTS)	Request for Information Form	Business Unit: ES	Page: 1 of 1
Title: Contractor Request for Information – EZ899-151108/001/PWY – PH2 - EGD Waterlot Remediation Project South Jetty Under-Pier Sediment Remediation			

RFI #: PH2 - 687

Project No.: R.018400.002 Project Name: EGD Waterlot Remediation Project - PH2 South Jetty Under-Pier Sediment Remediation

To: Canada - PWGSC Date: November 02, 2016

Attention: Rae-Ann Sharp, PWGSC Departmental Representative

Navigation Dolphin Layout Drawing

Further to email discussions, please find attached a Navigation Dolphin Layout Drawing showing the locations of the five Navigation Dolphins at the following coordinates:

N 5364785.174	E 468338.675	
N 5364780.059	E 468290.655	
N 5364818.003	E 468286.666	
N 5364833.219	E 468317.980	Coordinates to achieve “3 Equal Spacing” Per ADV 461
N 5364848.435	E 468349.295	Coordinates to achieve “3 Equal Spacing” Per ADV 461

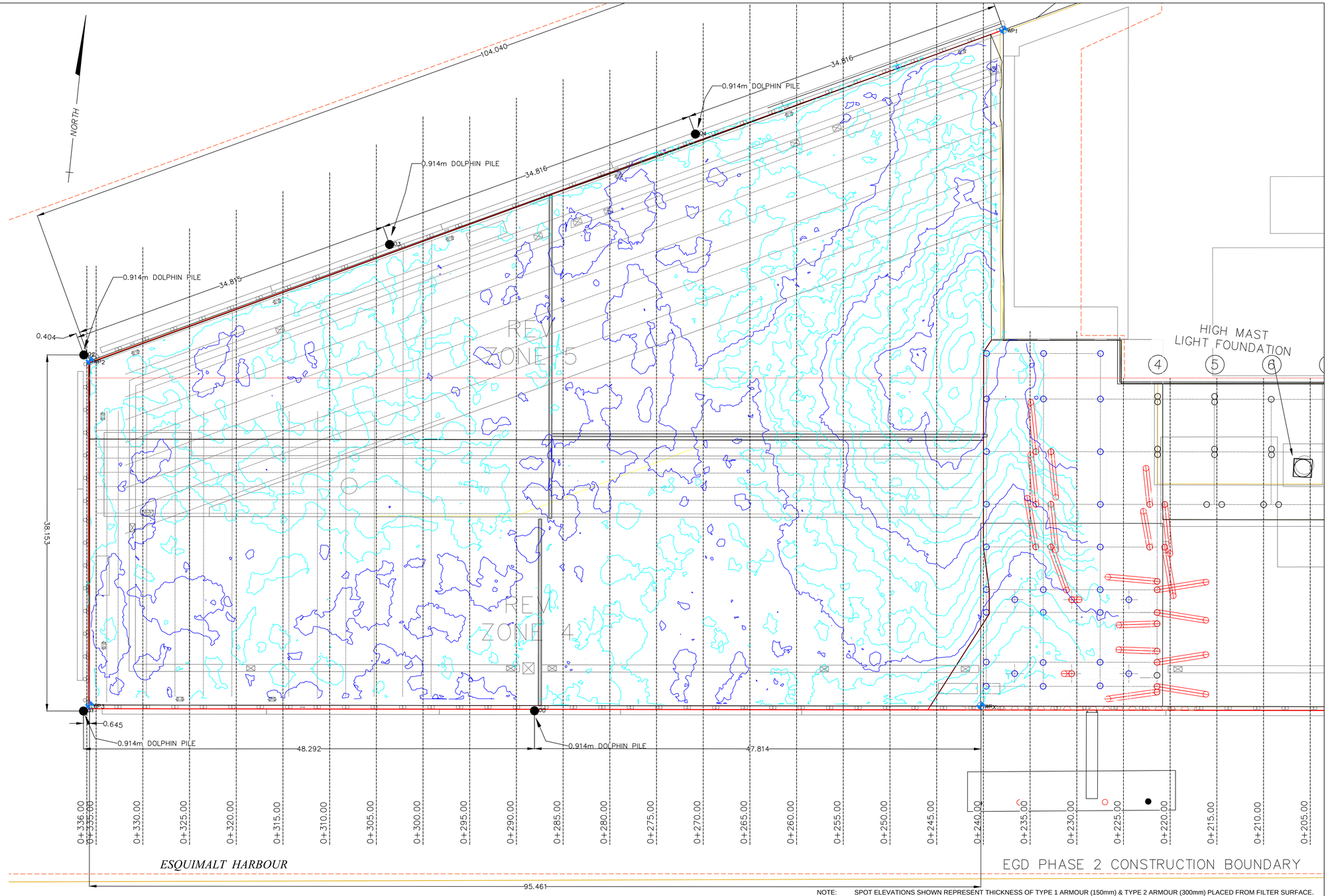
References – Specification item: Drawings:

Response required by:

Anticipated Change to – Contract Amount: ☐ Yes ☒ No Contract time: ☐ Yes ☒ No

From: Nicholas Doucette @ MNQM Contracting Ltd.

(Name) (MNQM Contracting Ltd.)



NOTE: SPOT ELEVATIONS SHOWN REPRESENT THICKNESS OF TYPE 1 ARMOUR (150mm) & TYPE 2 ARMOUR (300mm) PLACED FROM FILTER SURFACE.

GENERAL NOTES:

1. LATEST SURVEY PERFORMED ON OCTOBER 20, 2016 @ 1600HRS BY VPDL SURVEY DEPARTMENT.
2. DATA COLLECTION PARAMETERS:
   SURVEY VESSEL: ***STELLAR***
   POSITION/ATTITUDE/HEADING DATA: APPLANIX POS MV WAVEMASTER WITH RTK CORRECTIONS FROM THE CAN-NET ESQUIMALT (BCES) BASE STATION.
   SOUNDING DATA: NORBIT iWBMS WIDEBAND MULTIBEAM SONAR SYSTEM.
3. SOUNDINGS ARE IN METRES AND REDUCED TO CHART DATUM (LLWLT=0m).
4. SOUNDINGS ARE REFERENCED TO PWGSC CONTROL POINT CM1 (ELEVATION = 19.782m)
5. HORIZONTAL POSITIONS ARE REFERENCED TO NAD83 CSRS DATUM.
6. CONTOUR SHOWN AT A 0.5m INTERVAL WITH INDEX CONTOURS AT 2.5m.
7. EXISTING STRUCTURES SHOWN ARE FOR REFERENCE ONLY.
8. THE INFORMATION SHOWN ON THIS PLAN REPRESENTS CONDITIONS AT TIME OF THE SURVEY.

4 0 4 8 12
Scale – 1:200 (metres)

MCCOI MARINE LTD.
Hydrographic Surveying & Marine Contracting
PO BOX 2091
SECHELT, B.C.
V0N 3A0
(604) 740-6616
www.mccoi-marine.com

No.	DATE	REVISION	BY	CH	AP
1	11/02/2016	REVISED PILE COORDINATES	MF		

CLIENT: VANCOUVER PILE DRIVING MARINE GENERAL CONTRACTORS

PROJECT: EGD WATERLOT REMEDIATION PHASE 2 - SOUTH JETTY

DRAWING TITLE: PLAN OF PROPOSED 0.914m Ø DOLPHIN PILINGS

SURVEYED BY:	MF/WY	DATE:	10/20/2016	MCCOI PROJECT No.	2015-32-M
DRAFTED BY:	MF	DATE:	11/01/2016	DRAWING No.	2015-32-M_651

SCALE: 1:200 | VPDL PROJECT No. 316-215 | REV 1

F6

ESQUIMALT GRAVING DOCK

SOUTH JETTY SEDIMENT REMEDIATION

Number of Pages: 4

PACIFIC REGION – Professional and Technical Services (PTS)	Request for Information Form	Business Unit: ES	Page: 1 of 1
Title: Contractor Request for Information – EZ899-151108/001/PWY – PH2 - EGD Waterlot Remediation Project South Jetty Under-Pier Sediment Remediation			

RFI #: PH2 - 780

Project No.: R.018400.002 Project Name: EGD Waterlot Remediation Project - PH2 South Jetty Under-Pier Sediment Remediation

To: Canada – PWGSC Date: December 27, 2016

Attention: Rae-Ann Sharp, PWGSC Departmental Representative

Zone 3 Armour – Final Post Construction Survey

Please find attached the Final Post Construction Bathymetric Survey for the EGD Phase 2 Project Site.

Files included in submission package are outlined below:

- Final Post Construction Survey PDF
- Calibration Block Survey PDF
- Final Post Construction Survey .dwg
- Post Con survey 0.3x0.3 Chart CAN ADJ .xyz
- Calibration Block Survey .dwg
- Calibration Block Survey Chart .xyz
- Calibration Block Survey Full Res Chart .xyz

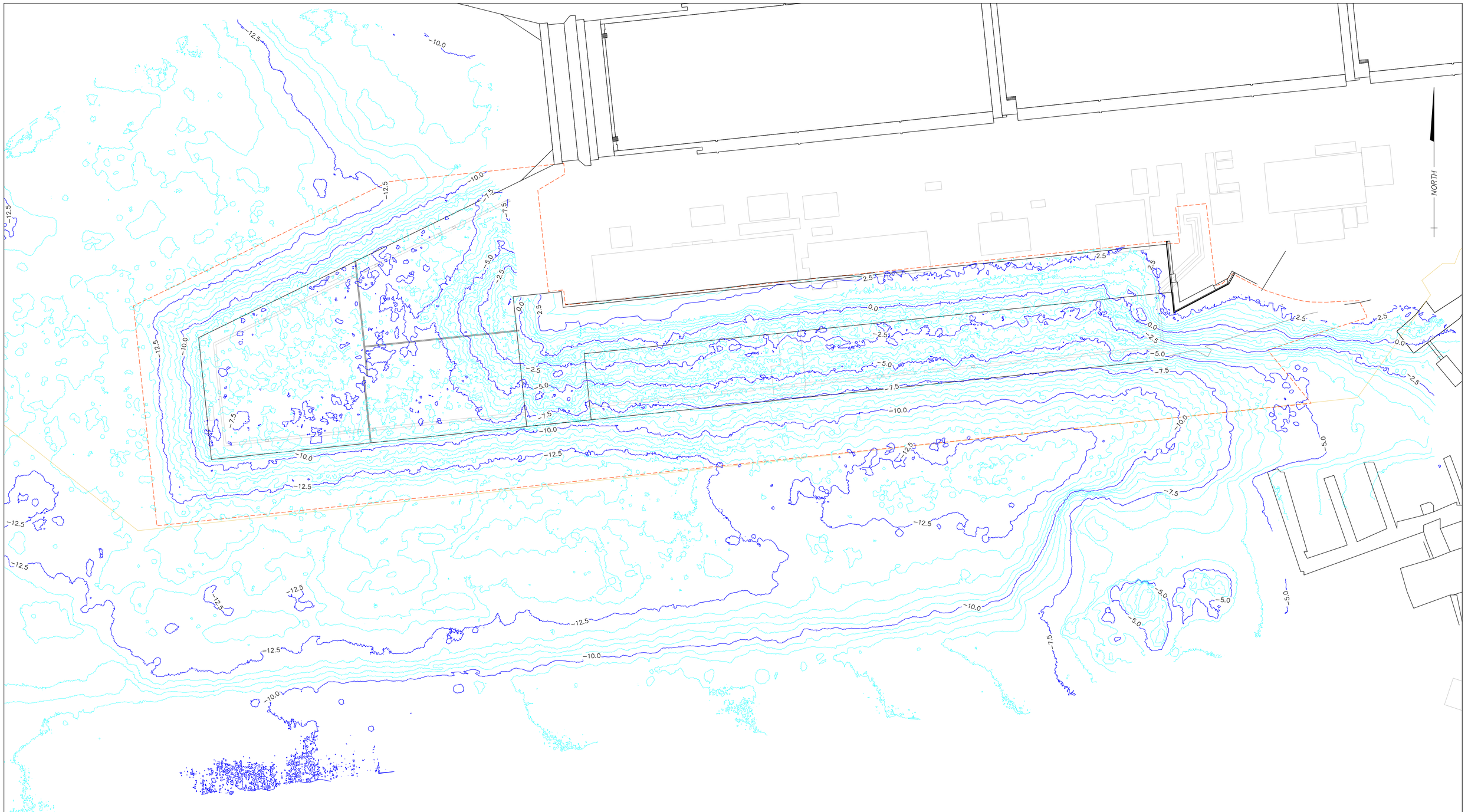
References – Specification item: Drawings:

Response required by:

Anticipated Change to – Contract Amount: ☐ Yes ☒ No Contract time: ☐ Yes ☒ No

From: Nicholas Doucette @ MNQM Contracting Ltd.

(Name) (MNQM Contracting Ltd.)



GENERAL NOTES:

1. LATEST SURVEY PERFORMED ON DECEMBER 14, 2016 BY MCCOI MARINE LTD. ADDITIONAL TOPOGRAPHIC DATA FROM DECEMBER 12, 2016 USED FOR SOME UNDER PIER AREAS.
2. DATA COLLECTION PARAMETERS:
   SURVEY VESSEL: ***STELLAR***
   POSITION/ATTITUDE/HEADING DATA: APPLANIX POS MV WAVEMASTER WITH RTK CORRECTIONS FROM THE CAN-NET ESQUIMALT (BCES) BASE STATION.
   SOUNDING DATA: NORBIT iWBMS WIDEBAND MULTIBEAM SONAR SYSTEM.
3. SOUNDINGS ARE IN METRES AND REDUCED TO CHART DATUM (LLWLT=0m).
4. SOUNDINGS ARE REFERENCED TO PWGSC CONTROL POINT CM1 (ELEVATION = 19.782m)
5. HORIZONTAL POSITIONS ARE REFERENCED TO NAD83 CSRS DATUM.
6. CONTOUR SHOWN AT A 0.5m INTERVAL WITH INDEX CONTOURS AT 2.5m.
7. EXISTING STRUCTURES SHOWN ARE FOR REFERENCE ONLY.
8. THE INFORMATION SHOWN ON THIS PLAN REPRESENTS CONDITIONS AT TIME OF THE SURVEY.

10 0 10 20 30
Scale – 1:500 (metres)

MCCOI MARINE LTD.
Hydrographic Surveying & Marine Contracting
PO BOX 2091
SECHELT, B.C.
V0N 3A0
(604) 740-6616
www.mccoi-marine.com

No.	DATE	REVISION	BY	CH	AP

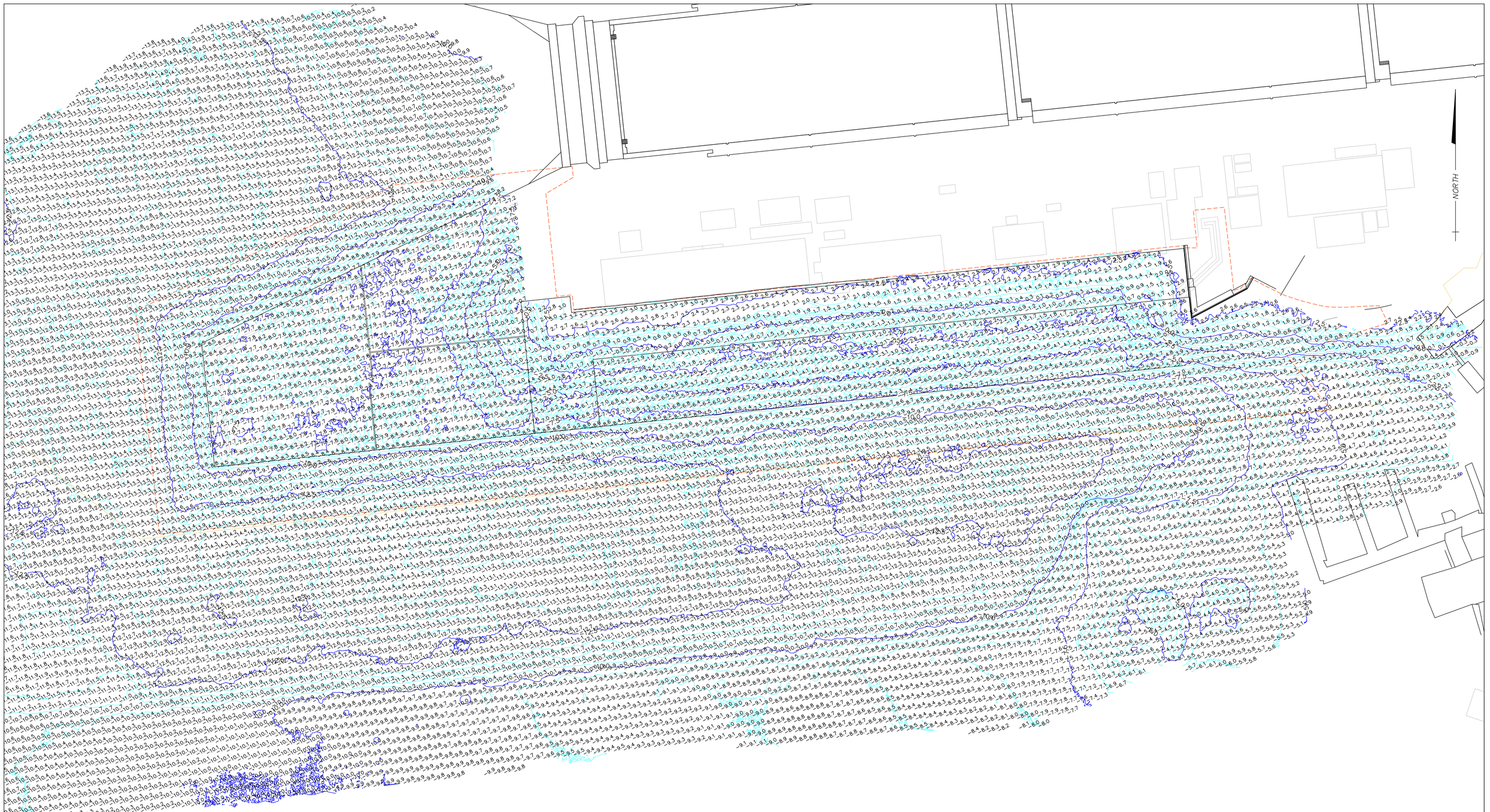
CLIENT: VANCOUVER PILE DRIVING — MARINE GENERAL CONTRACTORS

PROJECT: EGD WATERLOT REMEDIATION PHASE 2 - SOUTH JETTY

DRAWING TITLE: ESQUIMALT GRAVING DOCK WATERLOT PHASE 2 SOUTH JETTY UNDER PIER SEDIMENT REMEDIATION POST CONSTRUCTION SURVEY BATHYMETRIC CONTOUR PLAN

SCALE: 1:500

SURVEYED BY:	MF	DATE:	12/14/2016	MCCOI PROJECT No.	2015-32-M	VPDL PROJECT No.	316-215
DRAFTED BY:	MF	DATE:	12/23/2016	DRAWING No.	2015-32-M_823	REV	-



GENERAL NOTES:

1. LATEST SURVEY PERFORMED ON DECEMBER 14, 2016 BY MCCOI MARINE LTD. ADDITIONAL TOPOGRAPHIC DATA FROM DECEMBER 12, 2016 USED FOR SOME UNDER PIER AREAS.
2. DATA COLLECTION PARAMETERS:
   SURVEY VESSEL: ***STELLAR***
   POSITION/ATTITUDE/HEADING DATA: APPLANIX POS MV WAVEMASTER WITH RTK CORRECTIONS FROM THE CAN-NET ESQUIMALT (BCES) BASE STATION.
   SOUNDING DATA: NORBIT iWBMS WIDEBAND MULTIBEAM SONAR SYSTEM.
3. SOUNDINGS ARE IN METRES AND REDUCED TO CHART DATUM (LLWLT=0m).
4. SOUNDINGS ARE REFERENCED TO PWGSC CONTROL POINT CM1 (ELEVATION = 19.782m)
5. HORIZONTAL POSITIONS ARE REFERENCED TO NAD83 CSRS DATUM.
6. CONTOUR SHOWN AT A 0.5m INTERVAL WITH INDEX CONTOURS AT 2.5m.
7. EXISTING STRUCTURES SHOWN ARE FOR REFERENCE ONLY.
8. THE INFORMATION SHOWN ON THIS PLAN REPRESENTS CONDITIONS AT TIME OF THE SURVEY.

10 0 10 20 30

Scale – 1:500 (metres)

MCCOI MARINE LTD.
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SECHELT, B.C.
V0N 3A0
(604) 740-6616
www.mccoi-marine.com

No.	DATE	REVISION	BY	CH	AP

CLIENT: VANCOUVER PILE DRIVING — MARINE GENERAL CONTRACTORS

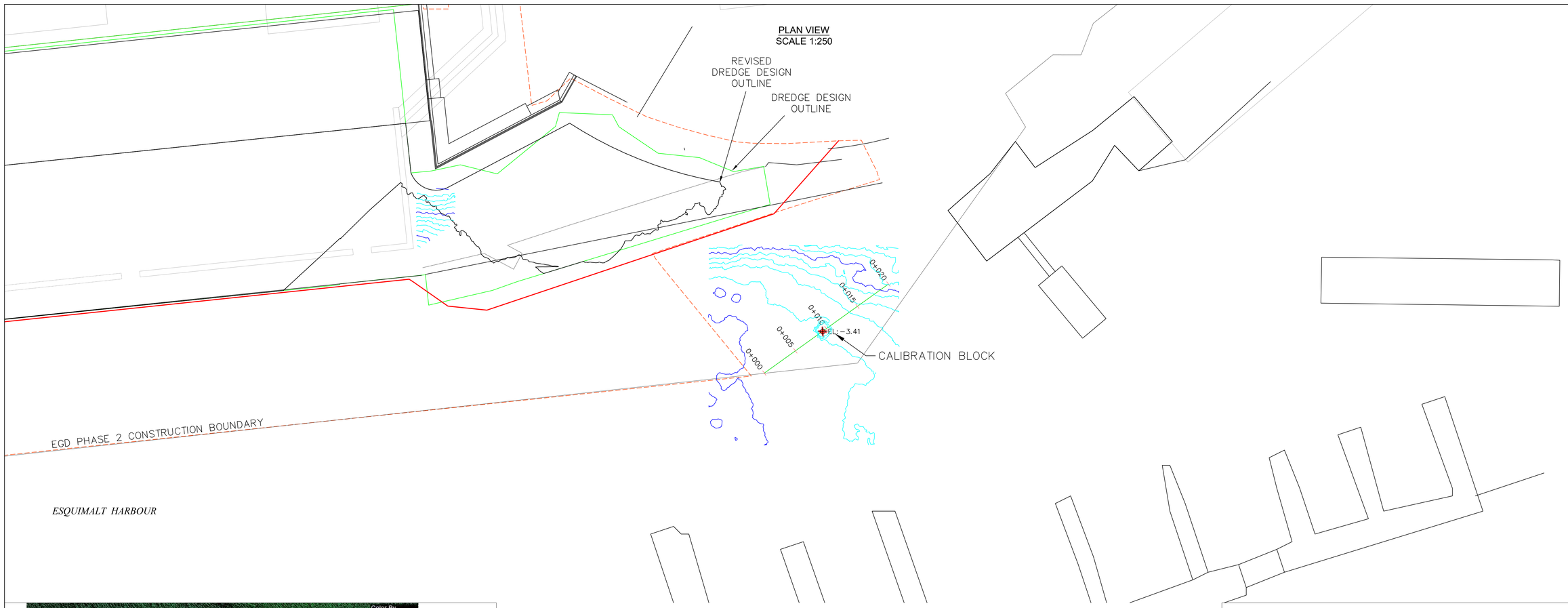
PROJECT: EGD WATERLOT REMEDIATION PHASE 2 - SOUTH JETTY

DRAWING TITLE: ESQUIMALT GRAVING DOCK WATERLOT PHASE 2 SOUTH JETTY UNDER PIER SEDIMENT REMEDIATION POST CONSTRUCTION SURVEY BATHYMETRIC SPOT ELEVATION PLAN

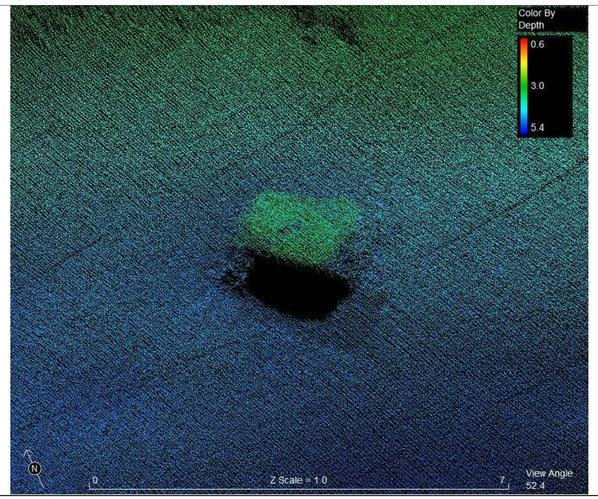
SCALE: 1:500

SURVEYED BY:	MF	DATE:	12/14/2016	MCCOI PROJECT No.	2015-32-M	VPDL PROJECT No.	316-215
DRAFTED BY:	MF	DATE:	12/23/2016	DRAWING No.	2015-32-M_824	REV	-

PLAN VIEW
SCALE 1:250



ESQUIMALT HARBOUR



ETRAC 2016–02–23 AVERAGE RTK POLE SHOTS (4)
N: 5364803.53
E: 468631.53
EL: –3.44m

MCCOI MARINE LTD. 2016–02–24 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.44m

MCCOI MARINE LTD. 2016–04–01 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.45m

MCCOI MARINE LTD. 2016–05–02 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.45m

MCCOI MARINE LTD. 2016–07–18 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.42m

MCCOI MARINE LTD. 2016–08–03 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.44m

MCCOI MARINE LTD. 2016–08–18 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.42m

MCCOI MARINE LTD. 2016–08–30 MULTIBEAM DATA
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E: 468631.53
EL: –3.43m

MCCOI MARINE LTD. 2016–09–12 MULTIBEAM DATA
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E: 468631.53
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MCCOI MARINE LTD. 2016–09–21 MULTIBEAM DATA
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EL: –3.43m

MCCOI MARINE LTD. 2016–09–23 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.44m

MCCOI MARINE LTD. 2016–09–29 MULTIBEAM DATA
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MCCOI MARINE LTD. 2016–10–05 MULTIBEAM DATA
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E: 468631.53
EL: –3.42m

MCCOI MARINE LTD. 2016–10–11 MULTIBEAM DATA
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EL: –3.40m

MCCOI MARINE LTD. 2016–10–19 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.42m

MCCOI MARINE LTD. 2016–11–02 MULTIBEAM DATA
N: 5364803.53
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MCCOI MARINE LTD. 2016–11–21 MULTIBEAM DATA
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E: 468631.53
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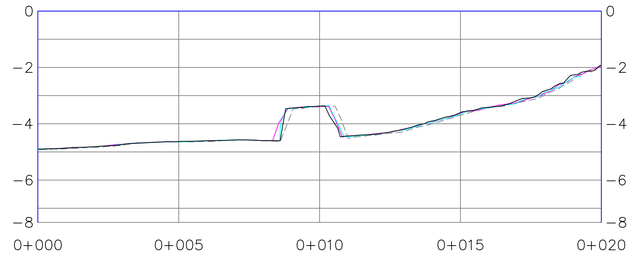
MCCOI MARINE LTD. 2016–12–01 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.43m

MCCOI MARINE LTD. 2016–12–13 MULTIBEAM DATA
N: 5364803.53
E: 468631.53
EL: –3.41m

CALIBRATION BLOCK CL PROFILE



PROFILE VIEW
SCALE 1:100

GENERAL NOTES:

1. LATEST SURVEY PERFORMED ON DECEMBER 13, 2016 BY VPDL SURVEY DEPARTMENT.
2. DATA COLLECTION PARAMETERS:
   SURVEY VESSEL: ***STELLAR***
   POSITION/ATTITUDE/HEADING DATA: APPLANIX POS MV WAVEMASTER WITH RTK CORRECTIONS FROM THE CAN-NET ESQUIMALT (BCES) BASE STATION.
   SOUNDING DATA: NORBIT iWBMS WIDEBAND MULTIBEAM SONAR SYSTEM.
3. SOUNDINGS ARE IN METRES AND REDUCED TO CHART DATUM (LLWLT=0m).
4. SOUNDINGS ARE REFERENCED TO PWGSC CONTROL POINT CM1 (ELEVATION = 19.782m).
5. HORIZONTAL POSITIONS ARE REFERENCED TO NAD83 CSRS DATUM.
6. CONTOUR SHOWN AT A 0.5m INTERVAL WITH INDEX CONTOURS AT 2.5m.
7. EXISTING STRUCTURES SHOWN ARE FOR REFERENCE ONLY.
8. THE INFORMATION SHOWN ON THIS PLAN REPRESENTS CONDITIONS AT TIME OF THE SURVEY.

LEGEND

2016-12-13 SURVEY
2016-12-01 SURVEY
2016-11-21 SURVEY
2016-02-24 SURVEY

MCCOI MARINE LTD.
Hydrographic Surveying & Marine Contracting
PO BOX 2091
SECHELT, B.C.
V0N 3A0
(604) 740-6616
www.mccoi-marine.com

No.	DATE	REVISION	BY	CH	AP

CLIENT: VANCOUVER PILE DRIVING MARINE GENERAL CONTRACTORS

PROJECT:
EGD WATERLOT REMEDIATION
PHASE 2 - SOUTH JETTY

DRAWING TITLE:
CALIBRATION BLOCK
BATHYMETRIC SURVEY
CONTOUR & PROFILE PLAN

SCALE:	AS SHOWN				
SURVEYED BY:	MF	DATE:	12/13/2016	MCCOI PROJECT No.	2015-32-M / VPDL PROJECT No. 316-215
DRAFTED BY:	MF	DATE:	12/14/2016	DRAWING No.	2015-32-M_817 REV -

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ESQUIMALT GRAVING DOCK

SAMPLE ELECTRICAL COMMISSIONING FORMS

Number of Pages: 3

Owner:	**PANELBOARD**
Project:	
	Distribution **Electrical**

Location: Equip. Cat.: ALTERNATE TAG EQUIPMENT TAG
System: Norm Pwr Sub-Category: Distribution PNL - xx

TECHNICAL DATA

☐ DATE / CHECKED BY: _____

	SPECIFIED	SHOP DRAWING	INSTALLED	VERIFIED CONTR. / COM.
Manufacturer				/
Model No.				/
Phase – Volts - Wires				/
# of Circuits				/
Bus Amperage / Bus Bracing				/
Enclosure Colour				/
Feeder Wire Size & Type				/

STATIC CHECKS

☐ DATE / CHECKED BY: _____

ENCLOSURE DETAILS	
- Flush or Surface	Flush___ Surface___
- Door Type	Door in Door___ Hinged___
BRANCH BREAKER	
- Bolt in or Plug in	Bolt In___ Plug In___
- Branch Lugs Torqued & Labelled?	Yes No
MISCELLANEOUS	
- Breaker Filler Pieces Installed?	Yes No
- Interior Clean?	Yes No

OPERATION CHECKS

☐ DATE / CHECKED BY: _____

Lamicoid Accurate?	Yes No
Directory Installed?	Yes No
MEASURED VALUES	
Line A ____ Amps	AB____ Volts / AN____Volts
Line B____ Amps	BC____ Volts / BN____ Volts
Line C____ Amps	CA____ Volts / CN____ Volts
Line N ____ Amps	

Signature: _____ Design Consultant: _____
Signature: _____ Commissioning Agent: _____

Owner:	**LOW VOLTAGE LIGHTING CONTROL**
Project:	**Lighting Control** **Electrical**

Location: Equip. Cat.: ALTERNATE TAG EQUIPMENT TAG
System: Lighting Sub-Category: Lighting Control LVRC - xx

TECHNICAL DATA ☐ DATE / CHECKED BY: _____

	SPECIFIED	SHOP DRAWING	INSTALLED	VERIFIED CONTR. / COM.
System Manufacturer				/
Cabinet Model No.				/
*Model No. of Prog. Relay				/
*Model No. of Low Volt. Relay				/
Power Supply				/

STATIC CHECKS ☐ DATE / CHECKED BY: _____

- Cabinet Label	Yes	No
- No. Of Relay Circuits		
- Wiring	Ok	Def.
- Barrier Separation	Yes	No
- Enclosure Clean	Yes	No
- Wiring Labeled	Yes	No
- Spare Relays	Yes	No , No. of
- Drip Hood	Yes	No
- LED Indicating	Yes	No
- Proper Mounting	Yes	No

OPERATION CHECKS ☐ DATE / CHECKED BY: _____

LVR Scanner Operation	Ok	Other
LED's Operating	Yes	No
Network Interface Control	Yes	No
Command On / Off	Yes	No
Flick to Warn	Yes	No
As-Built Wiring Diagram	Yes	No

Signature: _____ Contractor: _____
Signature: _____ Commissioning Agent: _____

Owner:	**LIGHTING CONTROL - ROOM DATA SHEET**
Project:	**Lighting Control Electrical**

Room Number	**Switch Quantity**	**Switch Type**	**Correct Operation**	**Luminaires as per Drawings**	**Luminaires Condition**	– **Light Level Reading** – **4 samples and calculated average (If Required)**
		□ Line □ Low Voltage				#1_____fc #2_____fc #3_____fc #4_____fc Average Light Level_____fc
		□ Line □ Low Voltage				#1_____fc #2_____fc #3_____fc #4_____fc Average Light Level_____fc
		□ Line □ Low Voltage				#1_____fc #2_____fc #3_____fc #4_____fc Average Light Level_____fc
		□ Line □ Low Voltage				#1_____fc #2_____fc #3_____fc #4_____fc Average Light Level_____fc
		□ Line □ Low Voltage				#1_____fc #2_____fc #3_____fc #4_____fc Average Light Level_____fc
		□ Line □ Low Voltage				#1_____fc #2_____fc #3_____fc #4_____fc Average Light Level_____fc
		□ Line □ Low Voltage				#1_____fc #2_____fc #3_____fc #4_____fc Average Light Level_____fc
		□ Line □ Low Voltage				#1_____fc #2_____fc #3_____fc #4_____fc Average Light Level_____fc

Signature: _____ Contractor: _____

Signature: _____ Commissioning Agent: _____

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ESQUIMALT GRAVING DOCK

STANDARDS FOR SURVEY

Number of Pages: 9

Esquimalt Graving Dock (EGD)
STANDARDS FOR SURVEYS

Revised 2012-02-28

1. INTRODUCTION

This standard is written to provide the British Columbia Land Surveyor (BCLS) a guideline for producing acceptable topographic survey for all EGD projects.

2. APPLICATION OF THE STANDARD

This standard applies to surveys that are intended to show new installation of structures, utilities and underground conduits including the existing structures, utilities and underground conduits in the vicinity of the project and as requested by EGD Representative.

The Surveyor in making topographic surveys uses accepted terrestrial and/or GPS surveying methods. Topographic surveys that additionally depict the location of property lines must also be in compliance with the current standard for property surveys and show all legal boundary evidence found.

3. DEFINITIONS

1) Benchmark (control point) is a relatively permanent material object, natural or artificial, bearing a marked point whose elevation above or below an adopted datum is known and whose horizontal coordinates are known in an accepted coordinate system (UTM NAD 83 CSRS Zone 10).
2) A Contour is an imaginary line on the ground, all points of which are of the same elevation above or below a specified datum.
3) The Parcel is the area designated by an EGD Representative and is usually, but not necessarily, given by a legal description of the property.
4) Utilities are services provided by governmental and private entities that provide the following: electric power, telephone, water, sanitary and storm sewer, gas, etc.
5) Acronyms and Definitions:
    - BCLS: British Columbia Land Surveyor
    - EGD: Esquimalt Graving Dock
    - NEZ: Northing, Easting, Elevation – Coordinates
    - PBM: Permanent Benchmark (Control point)
    - TBM: Temporary Benchmark (Control point)
    - Headwall: concrete wall structure on top of or on each side of culvert.

Esquimalt Graving Dock (EGD)
STANDARDS FOR SURVEYS

Revised 2012-02-28

4. RESEARCH AND INVESTIGATION

1) The Surveyor shall acquire the elevation and datum of all benchmarks to be used in the survey. The elevation used shall be based on a nationally accepted datum whenever practical or unless otherwise instructed by an EGD Representative. The EGD Representative shall specifically describe the parcel to be surveyed.
2) At least four (4) benchmarks shall be established using Global Positioning System and electronic survey total stations, in which the position of all survey works and detected objects shall relate.
3) The benchmarks shall be established on stable ground within 6 m (20 ft) adjacent to the project site or as directed by EGD Representative. The benchmarks shall have reference numbers, coordinates and heights above the established datum (geodetic and/or chart datum).

5. THE SURVEY

The survey shall be performed on the ground to obtain the information required in this standard and any additional information requested by EGD. The Surveyor shall select the equipment and procedures necessary to obtain the horizontal and vertical positional accuracy required by these standards.

6. DATA

The surveyor shall locate and show on the survey map the following information:

1) The location of permanent structures including retaining walls and culverts.
2) The location of street or road paving, entrances, driveway openings and sidewalks.
3) Elevations on the top of curbs, gutters and sidewalks.
4) EGD building numbers assigned to the parcel.
5) North arrow and scale of drawing.
6) Legend depicting the symbols and abbreviations used on the drawing.
7) Provide buildings footing corners, exterior corners, roof line corners and main floor elevations of all required building listed in Appendix A.
8) Location and elevation of existing structures, utilities, underground conduits or drainage courses on or near the surveyed parcel.

9) Schedule of all benchmarks with the reference numbers coordinates (UTM NAD83 CSRS Zone 10) and heights above the established datum (geodetic and/or chart). Description and location of the benchmarks shall also be submitted.

10) Original copy of the survey field logbooks or electronic logbook printouts data duly endorsed by the British Columbia Land Surveyor. All survey data from field logbooks or electronic notebooks shall include and clearly indicate corrections or errors done during surveying work.

11) Certificates showing that the surveying equipment used have been calibrated in the last twelve (12) months shall also be attached. These certificates shall also be submitted prior to start of work.

12) The surveyor map grid coordinate system shall be based on NAD 83 (North American Datum) UTM Zone 10.

13) Levels related to established datum (geodetic and/or chart).

14) All other items listed in **Appendix A**.

7. POSITIONAL ACCURACY

The following relative positional accuracies are provided as a guide for surveys.

	Vertical Positional Accuracy Feet	**Horizontal Positional Accuracy Feet**
Contour line 300 mm (1') interval	± 200 mm (0.65 ft)	± 300 mm (1 ft)
Contour line 600 mm (2') interval	± 400 mm (1.30 ft)	± 600 mm (2 ft)
Contour line 1.2 m (4') interval	± 800 mm (2.60 ft)	± 1.200 m (4 ft)
Contour line 1.5 m (5') interval	± 1.000 m (3.20 ft)	± 1.200 m (4 ft)
Contour line 3.0 m (10') interval	± 2.000 m (6.50 ft)	± 2.400 m (8 ft)
Floor elevations	± 10 mm (0.05 ft)	± 300 mm (1 ft)
Spot paving elevations	± 10 mm (0.05 ft)	± 300 mm (1 ft)
Spot ground elevations	± 50 mm (0.20 ft)	± 600 mm (2 ft)
Sewer invert elevations	± 10 mm (0.05ft)	± 300 mm (1 ft)
Underground utilities/conduits	± 10 mm (0.05ft)	± 300 mm (1 ft)
All underground services/structure	± 10 mm (0.05ft)	± 300 mm (1 ft)

Positional Accuracy is given at the 95 percent confidence level.

Esquimalt Graving Dock (EGD)
STANDARDS FOR SURVEYS

Revised 2012-02-28

8. ELECTRONIC DATA DISTRIBUTION

Surveyor to provide the survey data in an AutoCAD 2013 .dwg drawing file. The surveyor shall also provide a signed and sealed hard copy drawing. This drawing shall be the official map and shall be deemed to be correct and superior to the electronic data.

The electronic data file shall also contain a statement that the file is not a certified document and that the official document was issued and sealed by (*name and commission number of the BCLS*) on (*date*). Surveyor to also provide a table of the survey points data (NEZ) in electronic format (MS Excel, MS Word or PDF).

Esquimalt Graving Dock (EGD)
STANDARDS FOR SURVEYS

Appendix A - ITEMS TO BE INCLUDED IN SURVEY

Revised 2012-02-28

The following items marked with an **(X)** are to be included in the survey:

( ) Boundary survey of the parcel.

( ) Plot the location of easements and rights-of-way as shown on the recorded subdivision subdivision plan and all easements evidenced by a recorded document provided by EGD. The plan or document number of each shall be shown.

( ) Vicinity map with subject property highlighted.

(**X**) Observable evidence of recent earth moving work, borrow or fill (excavation perimeter, depth, changes in elevation, etc)

( ) Cross-section of offsite drainage courses for engineering studies.

(**X**) Spot elevations covering the entire survey limits showing high points, low points, grade changes, and at sufficient intervals to represent the general character of the terrain. Existing contours shall be drawn with major contour lines at 10m (25') intervals and minor contour lines at 2m (5') intervals unless otherwise noted.

( ) Elevations at the inside of walk, top of curb, and gutter at approximately one inch 3cm (1") intervals at the final map scale.

( ) Dimensions of curb, sidewalk, and gutter lines or ditch lines and centerline of all streets, alleys or roads adjoining the parcel. Indicate type of paving surface and condition.

( ) Location, width and elevation at both ends of all existing sidewalks. Include a description of the kind and general condition of the sidewalk.

( ) Location, diameter, and species of all trees over 10 cm diameter.

( ) Perimeter outline only of thickly wooded areas unless otherwise directed.

Esquimalt Graving Dock (EGD)
STANDARDS FOR SURVEYS

Appendix A - ITEMS TO BE INCLUDED IN SURVEY

Revised 2012-02-28

(**X**) Electric utilities – the location:

- ( ) power poles – 1 point at ground elevation
- ( ) power poles – 1 point at top of pole elevation
- ( ) guy wires – 1 points
- ( ) anchors – 1 points
- (**X**) Rectangular junction/pull boxes – 4 corners
- (**X**) Round junction/pull boxes – cover center
- (**X**) Underground conduits – all tie-ins (existing or new) and change of directions
- (**X**) vaults – 4 corners

(**X**) Storm, sanitary or combined sewers – the location of:

- (**X**) manholes – cover center
- (**X**) culverts – 2 centreline measurements to show direction of flow
- (**X**) headwalls – 4 corners
- (**X**) catch basins – 4 corners + 1 centre measurement at gutter line
- (**X**) clean-outs – center point
- (**X**) Include elevations of the top and bottom of manholes, culverts, headwall and catch basins.
- (**X**) Show type, size, and direction of flow and invert elevation of all pipes or culverts.

(**X**) Water – the location of:

- (**X**) all water valves – center point
- (**X**) all water valves – 4 corners of housing
- (**X**) standpipes – center point
- (**X**) regulators – center point
- (**X**) fire hydrants – 1 point at ground elevation
- ( ) fire hydrants – 1 point at top of hydrant elevation

( ) Gas – the location of:

- ( ) all valves – center point
- ( ) meters – center point
- ( ) gas line markers – center point
- ( ) Show elevation on top of any valves.

Esquimalt Graving Dock (EGD)
STANDARDS FOR SURVEYS

Appendix A - ITEMS TO BE INCLUDED IN SURVEY

Revised 2012-02-28

(**X**) Telephone – the location of:

- ( ) all poles – 1 point at ground elevation
- ( ) all poles – 1 point at top of pole elevation
- (**x**) manholes – center point
- (**x**) Rectangular junction/pull boxes – 2 opposite corners
- (**X**) Round junction/pull boxes – cover center

(**X**) Street/Roads – the location of:

- (**X**) all lamp poles – 1 point at ground elevation
- ( ) all lamp poles – 1 point at top of pole elevation
- (**X**) Rectangular junction/pull boxes – 4 corners
- (**X**) Round junction/pull boxes – cover center
- (**X**) road cross-section: Survey spot levels along cross-sections at maximum 5m (15') intervals up to 30m (100') beyond the edges of the road shoulder. The interval of the spot levels shall be varied based on the condition at site. If required, closer spacing shall be surveyed where the terrain is not uniform such as deep gullies and creek areas.

( ) Heating – the location of:

- ( ) steam manholes – center point
- ( ) vaults – 4 corners

(**X**) Location and dimensions of:

- ( ) tanks – 2 opposite corners minimum
- ( ) fences – corners/gates + changes of direction
- ( ) fences cross-section: Survey spot levels along cross-sections at maximum 5m (15') intervals up to 30m (100') beyond the edges of the fences lines. The interval of the spot levels shall be varied based on the condition at site. If required, closer spacing shall be surveyed where the terrain is not uniform such as deep gullies and creek areas.
- (**X**) obstructions – 2 opposite corners minimum

Esquimalt Graving Dock (EGD)
STANDARDS FOR SURVEYS

Appendix A - ITEMS TO BE INCLUDED IN SURVEY

Revised 2012-02-28

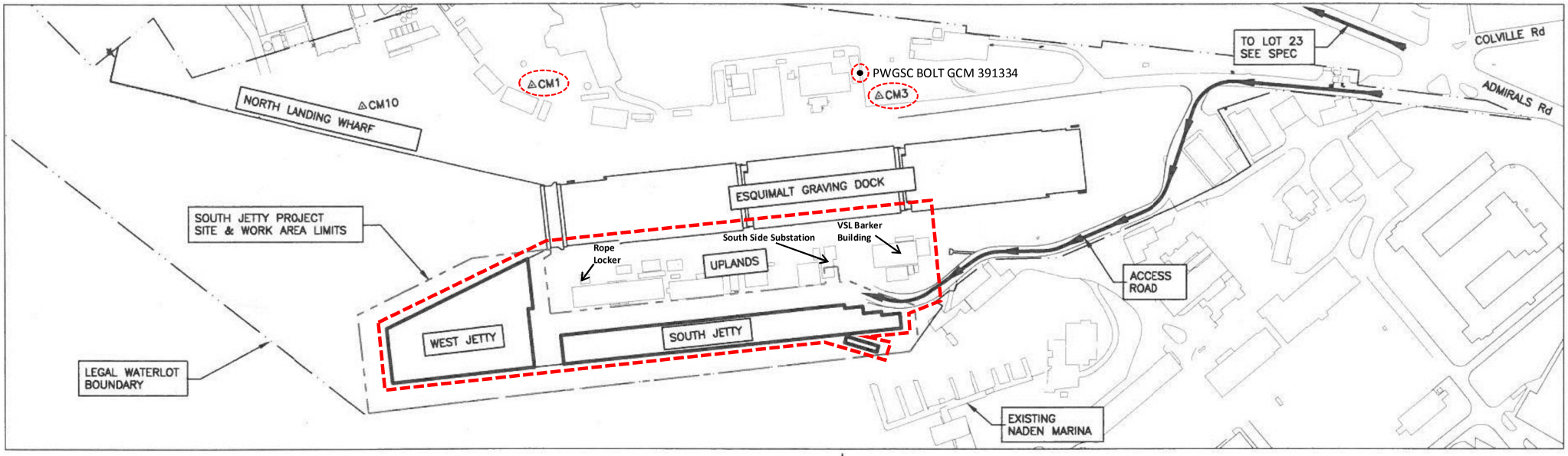
(**X**) Existing buildings – the location of:

- (**X**) South Side Substation (Both buildings – 4 corners)
- (**X**) Rope Locker (4 corners)
- (**X**) VSL Barker Building (4 corners)
- ( ) _____
- ( ) _____
- ( ) _____

( ) Location and description of any building or major structure on adjoining land that is not more than _____ feet outside the parcel being surveyed.

(**X**) Other – the location of:

- (**X**) Southerly edge of Burma Road
- (**X**) Perimeter of Existing Steel Pile Jetty
- (**X**) Perimeter of South Jetty including curb edge
- (**X**) Edge of drydock south side including Stop #1 through Stop #3
- (**X**) Westerly 25m of South Jetty Access Road
- (**X**) Tug Wharf, Gangway, and connection to South Jetty
- (**X**) Utility Trench Access (4 corners)
- (**X**) Retaining walls
- (**X**) Fire Boat Connections (4 corners)
- (**X**) Seawater Inlets (4 corners)
- (**X**) Cleats and Bollards (4 corners)
- (**X**) Kiosks (4 corners)
- (**X**) Control Monument 1 and Control Monument 3
- (**X**) PWGSC BOLT at Pumphouse



CONTROL MONUMENT ID	MONUMENT CONTROLLER	COORDINATES		
		NORTHING (Y)	EASTING (X)	ELEVATION IN METRES (Z)
CM 1	EGD	5364978.464	468379.84	17.846
CM 2	EGD	5364877.036	468657.811	7.562
CM 3	EGD	5364970.304	468613.214	7.787
CM 10	EGD	5364965.758	468266.364	2.256

(METERS)

AREA PLAN
1:2000

R.026729.002 South Jetty Reconstruction – Project Survey Area

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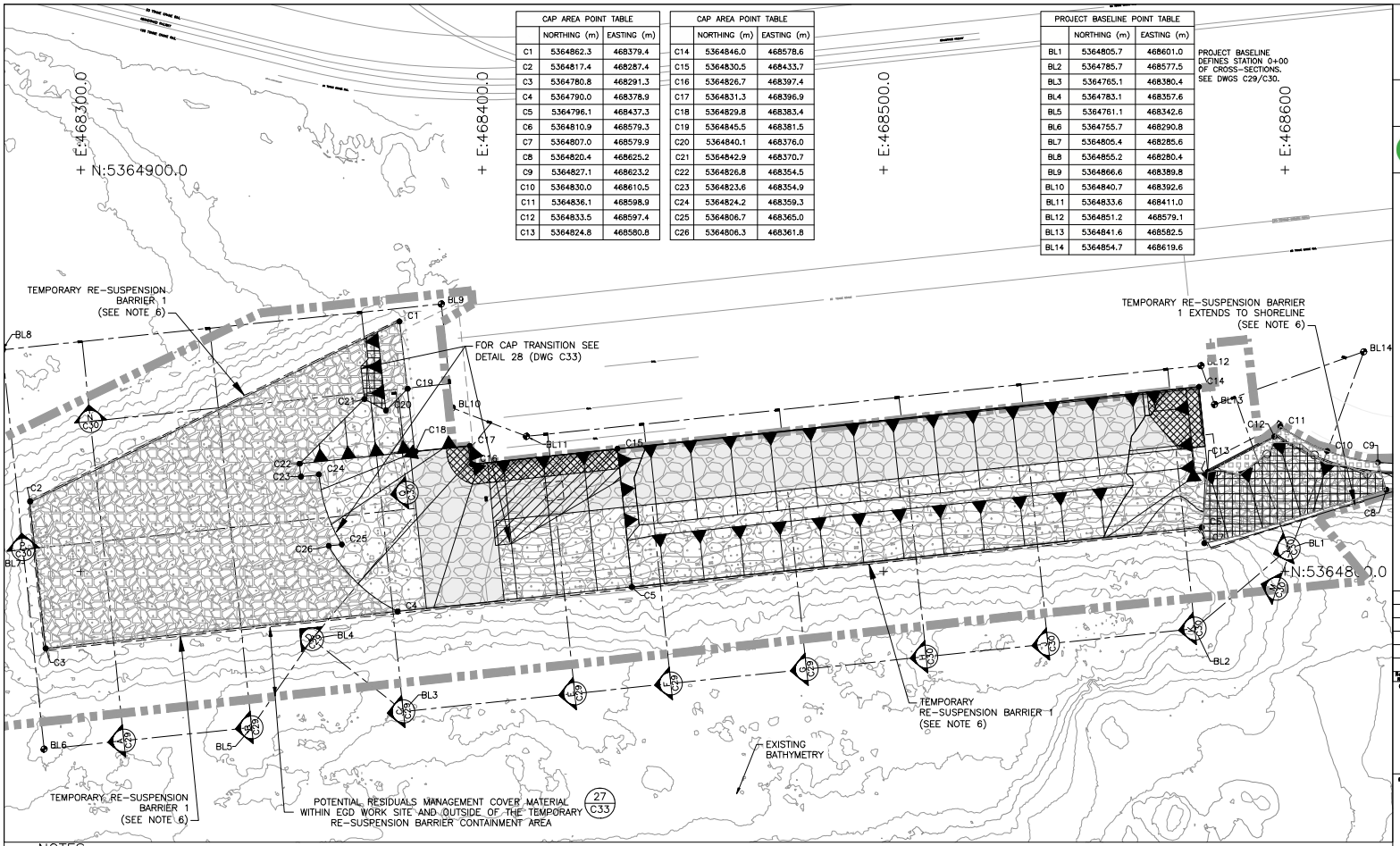
ESQUIMALT GRAVING DOCK

South Jetty Under Pier Sediment Remediation Reference Drawings

Number of Pages: 5



CAP AREA POINT TABLE		
	NORTHING (m)	EASTING (m)
C1	5364862.3	468379.4
C2	5364817.4	468287.4
C3	5364780.8	468291.3
C4	5364790.0	468378.9
C5	5364796.1	468437.3
C6	5364810.9	468579.3
C7	5364807.0	468579.9
C8	5364820.4	468625.2
C9	5364827.1	468623.2
C10	5364830.0	468610.5
C11	5364836.1	468598.9
C12	5364833.5	468597.4
C13	5364824.8	468580.8

CAP AREA POINT TABLE		
	NORTHING (m)	EASTING (m)
C14	5364846.0	468578.6
C15	5364830.5	468433.7
C16	5364826.7	468397.4
C17	5364831.3	468396.9
C18	5364829.8	468383.4
C19	5364845.5	468381.5
C20	5364840.1	468376.0
C21	5364842.9	468370.7
C22	5364826.8	468354.5
C23	5364823.6	468354.9
C24	5364824.2	468359.3
C25	5364806.7	468365.0
C26	5364806.3	468361.8

PROJECT BASELINE POINT TABLE		
	NORTHING (m)	EASTING (m)
BL1	5364805.7	468601.0
BL2	5364785.7	468577.5
BL3	5364765.1	468380.4
BL4	5364783.1	468357.6
BL5	5364761.1	468342.6
BL6	5364755.7	468290.8
BL7	5364805.4	468285.6
BL8	5364855.2	468280.4
BL9	5364866.6	468389.8
BL10	5364840.7	468392.6
BL11	5364833.6	468411.0
BL12	5364851.2	468579.1
BL13	5364841.6	468582.5
BL14	5364854.7	468619.6

PROJECT BASELINE DEFINES STATION 0+00 OF CROSS-SECTIONS. SEE DWGS C29/C30.

NOTES:

1. UNDERWATER AREA LOWER INTERTIDAL AND SUBTIDAL BATHYMETRY WITHIN THE TEMPORARY RE-SUSPENSION BARRIER CONTAINMENT AREA IS FROM FEBRUARY 2009, JUNE 2010 AND JANUARY 2011 CRA CANADA SURVEYS LTD. MULTI BEAM SURVEY. UPPER INTERTIDAL ELEVATIONS FROM SEPTEMBER 2009 AND JULY 2011 SURVEY BY FOCUS CORPORATION. OPEN WATER AREAS OUTSIDE OF THE TEMPORARY RE-SUSPENSION BARRIER CONTAINMENT AREA WERE DREDGED AS PART OF THE PHASE 1B OPEN-WATER REMEDIATION PROJECT. OPEN WATER BATHYMETRY SURVEY WAS CONDUCTED BY CRA CANADA SURVEYS, INC. FOLLOWING COMPLETION OF PHASE 1B WORK.
2. BASE MAP FROM GOLDER, JANUARY 2012.
3. STRUCTURE DETAILS FROM KLOHN CRIPPEN BERGER DECEMBER 2010 CONDITION INSPECTION REPORT FOR SOUTH JETTY PERIMETER, NADEN FLOATS, AND CFSA FLOATS.
4. REFERENCE DWG C1 FOR DATUM INFORMATION.
5. REFER TO TECHNICAL SPECIFICATIONS REGARDING WORK SEQUENCING AND REMEDIATION ZONES.
6. CONTRACTOR (AND 3RD PARTY VENDOR) SHALL DESIGN, INSTALL AND MAINTAIN TRBS IN ACCORDANCE WITH THE SPECIFICATIONS. CONTRACTOR TO PROVIDE TRB LAYOUT AND DESIGN DETAILS IN THE ENVIRONMENTAL PROTECTION PLAN.

LEGEND:

- BATHYMETRY IN METRES
- TEMPORARY RE-SUSPENSION BARRIER CONTAINMENT AREA (SEE DWG C32 FOR CONTROL POINTS)
- EGD WORK SITE BOUNDARY
- CAP SLOPE DESIGNATION
- ORDINARY HIGH WATER LINE
- TYPE 1 ENGINEERED CAP: 0.15-METRE ROCK ARMOUR LAYER OVER FILTER LAYER OVER SAND (TYPE 1) LAYER. SEE DETAIL 22 (DWG C33)
- TYPE 2 ENGINEERED CAP: 0.15-METRE ROCK ARMOUR LAYER OVER FILTER LAYER OVER SAND (TYPE 2) LAYER. SEE DETAIL 23 (DWG C33)
- TYPE 3 ENGINEERED CAP: 0.30-METRE ROCK ARMOUR LAYER OVER FILTER LAYER OVER SAND (TYPE 2) LAYER. SEE DETAIL 24 (DWG C33)
- TYPE 4 ENGINEERED CAP: 0.30-METRE ROCK ARMOUR LAYER OVER FILTER LAYER OVER SAND (TYPE 3) LAYER. SEE DETAIL 25 (DWG C33)
- TYPE 5 ENGINEERED CAP: 0.15-METRE ROCK ARMOUR. SEE DETAIL 26 (DWG C33)
- BASE LINE CONTROL POINT
- CAPPING AREA CONTROL POINT
- IMPERMEABLE GEOSYNTHETIC MATERIAL

CAPPING PLAN

SCALE 1: 500

SCALE : 1:500

0m 10 20 30 40 50m

0 10 20 30 40 50 60 70 80 90 100mm

P:\EGSC – A1 – B41X594

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

ANCHOR QEA

Klohn Crippen Berger

MATTHEW W. WOLTMAN — 12/11/14

Revision/ Révision	Description/Description	Date/Date
0	ISSUED FOR TENDER	2014/12/19

Client/Client

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

ESQUIMALT GRAVING DOCK WATERLOT PHASE 2 SOUTH JETTY UNDER-PIER SEDIMENT REMEDIATION

Consultant Signature Only

Designed by/Concept par
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Drawn by/Dessins par
CHRIS HEWETT

PWGSC Project Manager/Administrateur de Projets TPSGC
ANDREW MYLLY

Regional Manager, Environmental Services
COLLIN KINGMAN

Drawing title/Titre du dessin
ENGINEERED CAPPING PLAN

Project No./No. de projet	Sheet/	Revision no./
R.018400.002	C28	0

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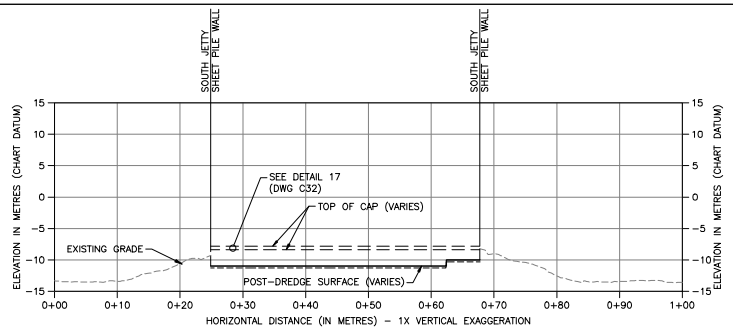

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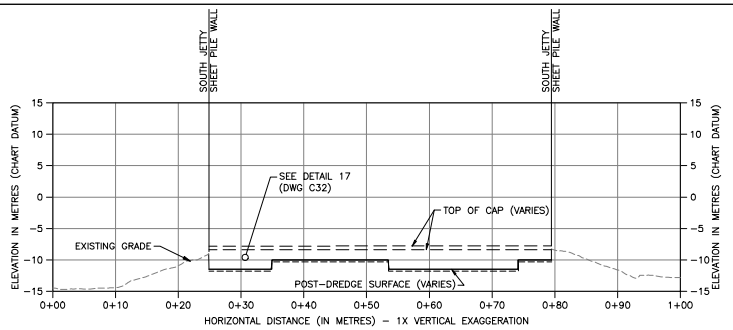

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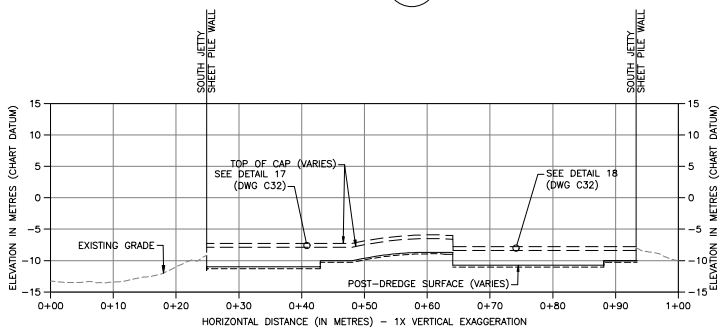

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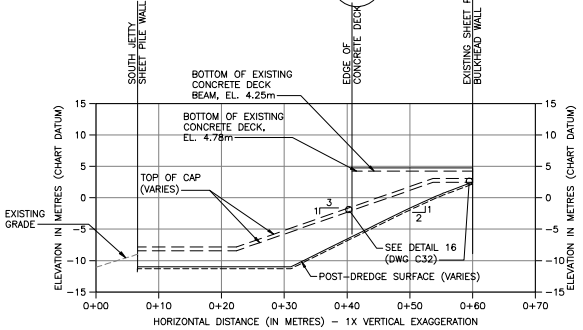

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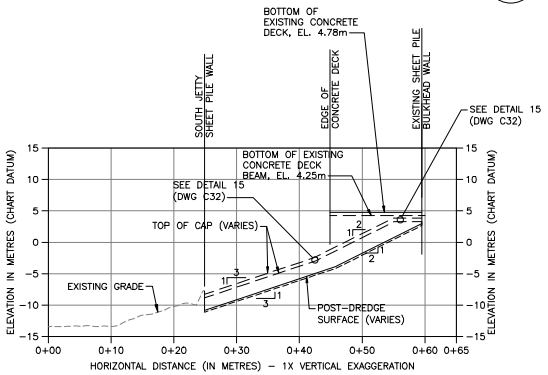

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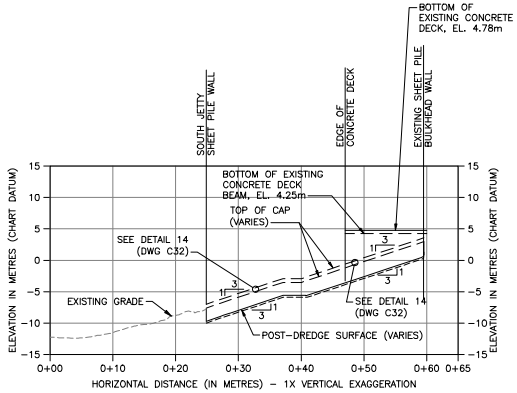

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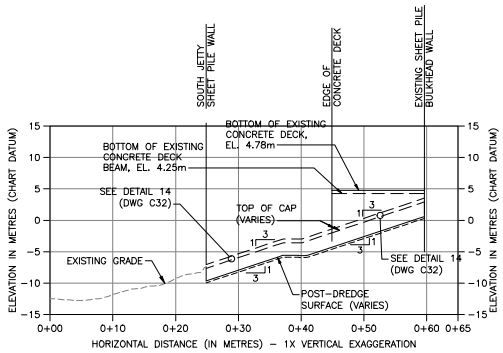

SECTION G
SCALE 1: 400 C28

CROSS SECTIONS
SCALE 1: 400

HORIZONTAL DATUM: UTM ZONE 10 GRID, NAD83.
VERTICAL DATUM: CHART DATUM (C.D.)

NOTES:
1. UNDERPIER AREA LOWER INTERTIDAL AND SUBTIDAL BATHYMETRY WITHIN THE TEMPORARY RE-SUSPENSION BARRIER CONTAINMENT AREA IS FROM FEBRUARY 2009, JUNE 2010 AND JANUARY 2011 CRA CANADA SURVEYS LTD. MULTI BEAM SURVEY. UPPER INTERTIDAL ELEVATIONS FROM SEPTEMBER 2009 AND JULY 2011 SURVEY BY FOCUS CORPORATION. OPEN WATER AREAS OUTSIDE OF THE TEMPORARY RE-SUSPENSION BARRIER CONTAINMENT AREA WERE DREDGED AS PART OF THE PHASE 1B OPEN-WATER REMEDIATION PROJECT. OPEN WATER BATHYMETRY SURVEY WAS CONDUCTED BY CRA CANADA SURVEYS, INC. ON 2014/03/05 FOLLOWING COMPLETION OF PHASE 1B WORK.
2. REFERENCE DWG C1 FOR DATUM INFORMATION.
3. TOP OF ENGINEERED CAP SURFACES REPRESENT MINIMUM PLACEMENT THICKNESS AND MAXIMUM OVERPLACEMENT ALLOWANCES.
4. TOP OF ENGINEERED CAP SHOWN ON CROSS SECTIONS IN 2H:1V DREDGE SLOPE AREAS OF THE AREAS OF WORK NEAR EXISTING SHEET PILE BULKHEAD WALL HAVE VARIABLE THICKNESS REQUIREMENTS THAT ARE NEEDED TO CONSTRUCT THE TYPE 3 SEDIMENT CAP TO A STABLE 3H:1V GRADE.
5. EXISTING TIMBER-PILED STRUCTURE NOT SHOWN FOR CLARITY.
6. CONTRACTOR SHALL REFERENCE THE 1985 STEEL-PILED DECK AS-BUILT DRAWINGS FOR DETAILS REGARDING CROSS SECTIONS THROUGH THE STEEL-PILED JETTY STRUCTURE, SHEETPILE BULKHEAD WALL, AND CONCRETE L-WALL.

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada
REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

ANCHOR QEA

Klohn Crippen Berger

No.	Revision/Revision	Description/Description	Date/Date
0		ISSUED FOR TENDER	2014/12/18

Client/client
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

ESQUIMALT GRAVING DOCK WATERLOT PHASE 2 SOUTH JETTY UNDER-PIER SEDIMENT REMEDIATION

Consultant Signature Only

Designed by/Concept par
MATT WOLTMAN

Drawn by/Dessiné par
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PWGSC Project Manager/Administrateur de Projets TPSGC
ANDREW MYLLY

Regional Manager, Environmental Services
COLLIN KINGMAN

Drawing title/Titre du dessin
ENGINEERED CAPPING
CROSS SECTIONS - SHEET 1

Project No./No. du projet	Sheet/	Revision no./
R.018400.002	C29	0

PWGSC – A1 – 841X594

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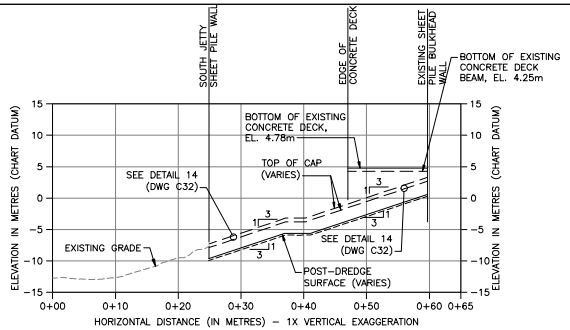

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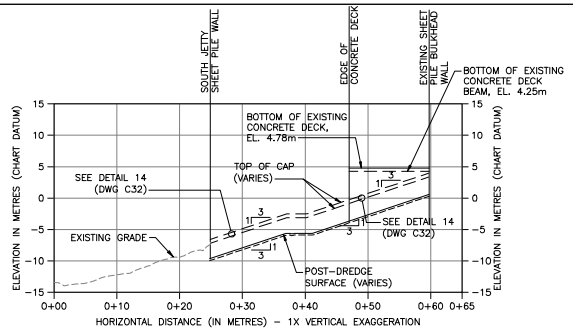

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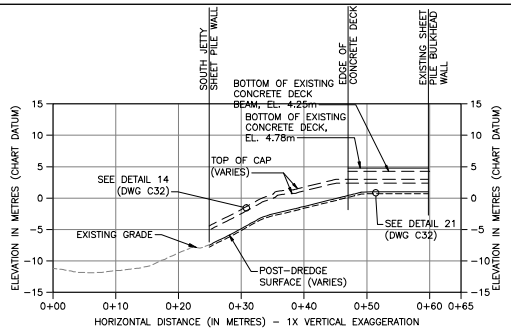

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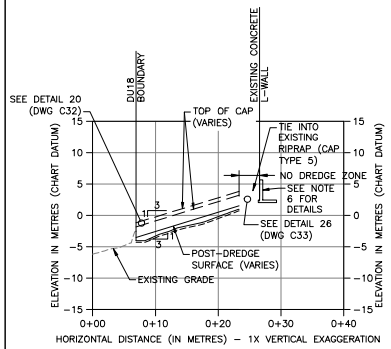

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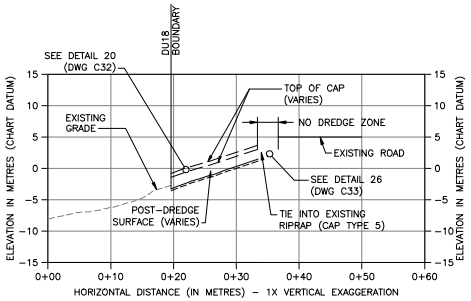

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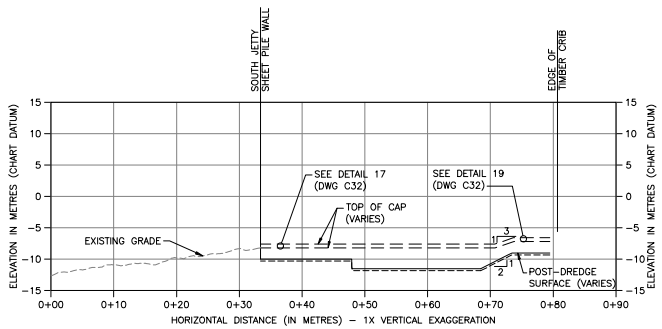

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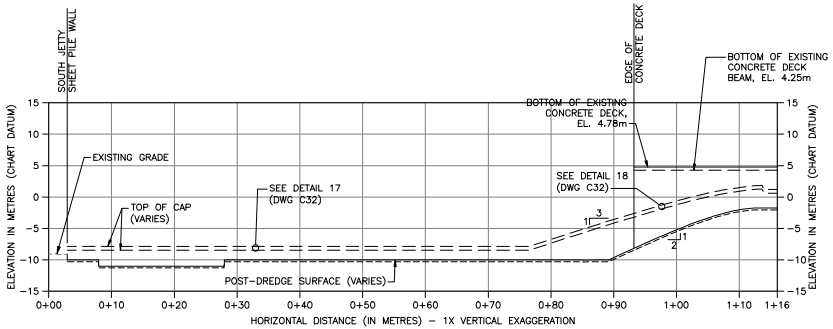

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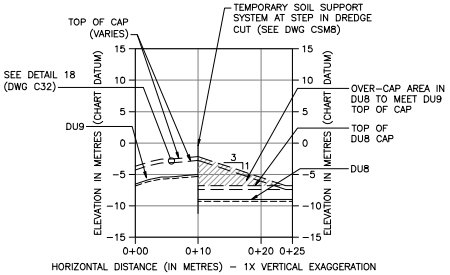

SECTION Q
SCALE 1: 400 C28

HORIZONTAL DATUM: UTM ZONE 10 GRID, NAD83.
VERTICAL DATUM: CHART DATUM (C.D.)

NOTES:
1. UNDERPIER AREA LOWER INTERTIDAL AND SUBTIDAL BATHYMETRY WITHIN THE TEMPORARY RE-SUSPENSION BARRIER CONTAINMENT AREA IS FROM FEBRUARY 2009, JUNE 2010 AND JANUARY 2011 CRA CANADA SURVEYS LTD. MULTI BEAM SURVEY. UPPER INTERTIDAL ELEVATIONS FROM SEPTEMBER 2009 AND JULY 2011 SURVEY BY FOCUS CORPORATION. OPEN WATER AREAS OUTSIDE OF THE TEMPORARY RE-SUSPENSION BARRIER CONTAINMENT AREA WERE DREDGED AS PART OF THE PHASE 1B OPEN-WATER REMEDIATION PROJECT. OPEN WATER BATHYMETRY SURVEY WAS CONDUCTED BY CRA CANADA SURVEYS, INC. ON 2014/03/05 FOLLOWING COMPLETION OF PHASE 1B WORK.
2. REFERENCE DWG C1 FOR DATUM INFORMATION.
3. TOP OF ENGINEERED CAP SURFACES REPRESENT MINIMUM PLACEMENT THICKNESS AND MAXIMUM OVERPLACEMENT ALLOWANCES.
4. TOP OF ENGINEERED CAP SHOWN ON CROSS SECTIONS IN 2H:1V DREDGE SLOPE AREAS NEAR EXISTING SHEET PILE BULKHEAD WALL HAVE VARIABLE THICKNESS REQUIREMENTS THAT ARE NEEDED TO CONSTRUCT THE TYPE 3 SEDIMENT CAP TO A STABLE 3H:1V GRADE.
5. EXISTING TIMBER-PILED STRUCTURE NOT SHOWN FOR CLARITY.
6. CONTRACTOR SHALL REFERENCE THE 1985 STEEL-PILED DECK AS-BUILT DRAWINGS FOR DETAILS REGARDING CROSS SECTIONS THROUGH THE STEEL-PILED JETTY STRUCTURE, SHEETPILE BULKHEAD WALL, AND CONCRETE L-WALL.

CROSS SECTIONS
SCALE 1: 400

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada
REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

ANCHOR QEA
Klohn Crippen Berger

Revision/ Revision	Description/Description	Date/Date
0	ISSUED FOR TENDER	2014/12/18

Client/client
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

ESQUIMALT GRAVING DOCK WATERLOT PHASE 2 SOUTH JETTY UNDER-PIER SEDIMENT REMEDIATION

Consultant Signature Only

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ANDREW MYLLY

Regional Manager, Environmental Services
COLLIN KINGMAN

Drawing title/Titre du dessin
ENGINEERED CAPPING CROSS SECTIONS - SHEET 2

Project No./No. du projet	Sheet/	Revision no./
R.018400.002	C30	0

PWGSC – A1 – 841X594
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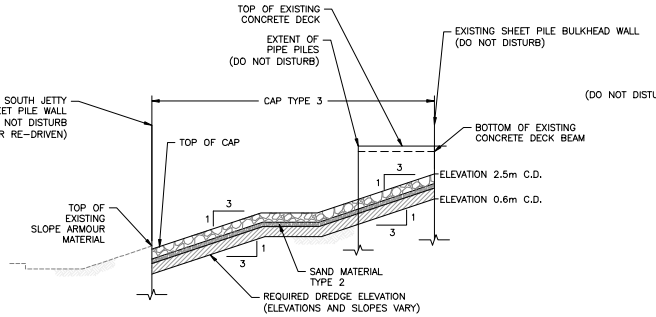
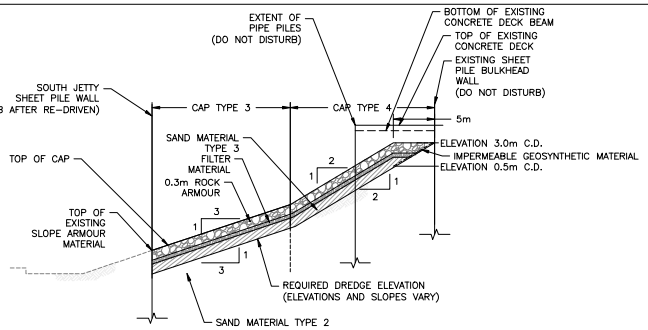


DETAIL 14 — NOT TO SCALE — C29/C30

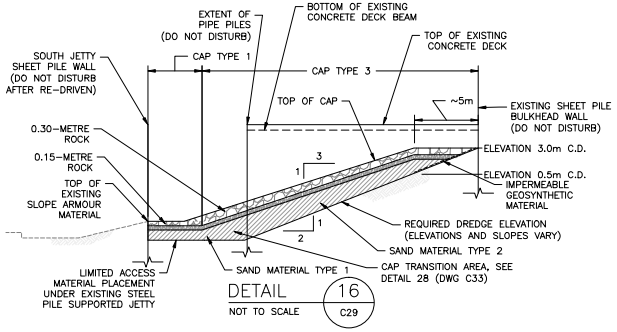
TYPE 3 ENGINEERED CAP



DETAIL 15 — NOT TO SCALE — C29

TYPE 3 AND TYPE 4 ENGINEERED CAP AND IMPERMEABLE GEOSYNTHETIC MATERIAL

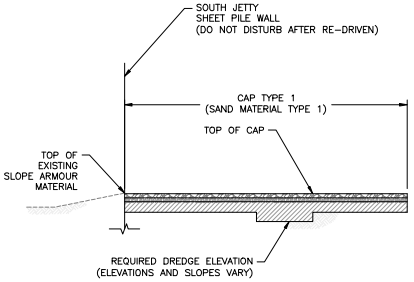
NOTE: IMPERMEABLE GEOSYNTHETIC MATERIAL REQUIRED FOR CAP TYPE 4 WHERE SAND MATERIAL TYPE 3 HAS A THICKNESS OF LESS THAN 1.0m NEAR EXISTING SHEET PILE BULKHEAD WALL.



DETAIL 16 — NOT TO SCALE — C29

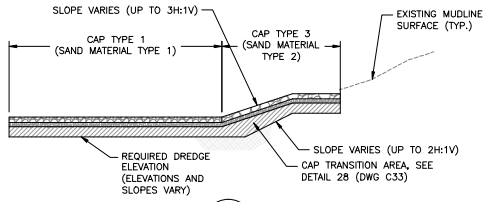
TYPE 1 AND TYPE 3 ENGINEERED CAP

NOTES:
1. IMPERMEABLE GEOSYNTHETIC MATERIAL REQUIRED FOR CAP TYPE 3 WHERE SAND MATERIAL TYPE 2 HAS A THICKNESS OF LESS THAN 1.0m NEAR EXISTING SHEET PILE BULKHEAD WALL.
2. CONTRACTOR SHALL PLACE A MINIMUM OF 1m OF SAND MATERIAL OVER ALL DREDGE AREAS EXCLUDING AREA REQUIRING IMPERMEABLE GEOSYNTHETIC MATERIAL.



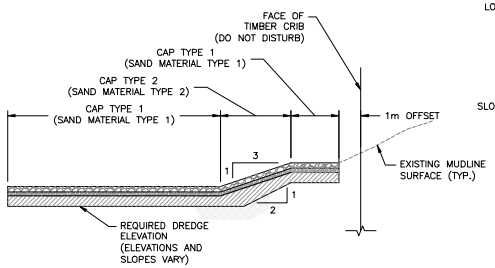
DETAIL 17 — NOT TO SCALE — C29/C30

TYPE 1 ENGINEERED CAP



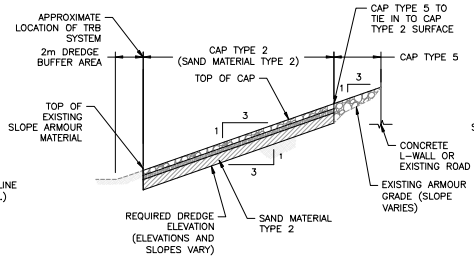
DETAIL 18 — NOT TO SCALE — C29/C30

TYPE 1 AND TYPE 3 ENGINEERED CAP



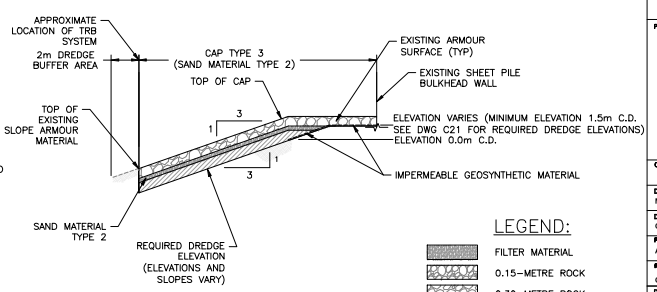
DETAIL 19 — NOT TO SCALE — C30

TYPE 1 ENGINEERED CAP



DETAIL 20 — NOT TO SCALE — C30

TYPE 2 AND TYPE 5 ENGINEERED CAP



DETAIL 21 — NOT TO SCALE — C30

TYPE 3 ENGINEERED CAP

LEGEND:
- FILTER MATERIAL
- 0.15-METRE ROCK
- 0.30-METRE ROCK
- SAND LAYER

NOTES:
1. EXISTING TIMBER-PILED STRUCTURE NOT SHOWN FOR CLARITY.
2. CONTRACTOR SHALL REFERENCE THE 1985 STEEL-PILES DECK AS-BUILT DRAWINGS FOR DETAILS REGARDING CROSS SECTIONS THROUGH THE STEEL-PILED JETTY STRUCTURE, SHEETPILE BULKHEAD WALL, AND CONCRETE L-WALL.

PWGSC – A1 – 8411X594

0 10 20 30 40 50 60 70 80 90 100mm

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
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SERVICES IMMOBILIERS

ANCHOR QEA

Klohn Crippen Berger

No.	Revision/Description/Description	Date/Date
0	ISSUED FOR TENDER	2014/12/19

Client/client

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

ESQUIMALT GRAVING DOCK WATERLOT PHASE 2 SOUTH JETTY UNDER-PIER SEDIMENT REMEDIATION

Consultant Signature Only

Designed by/Concept par
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Drawn by/Dessiné par
CHRIS HEWETT

PWGSC Project Manager/Administrateur de Projets TPSGC
ANDREW MYLLY

Regional Manager, Environmental Services
COLLIN KINGMAN

Drawing title/Titre du dessin
ENGINEERED CAPPING DETAILS - SHEET 1

Project No./No. du projet	Sheet/	Revision no./
R.018400.002	C32	0

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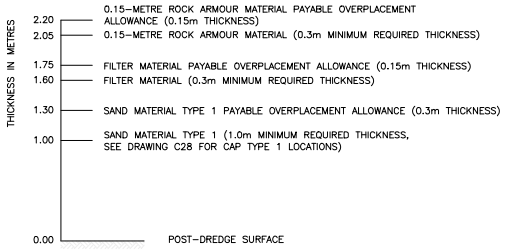
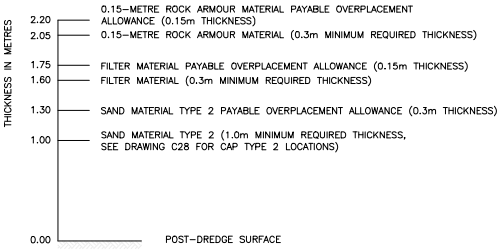


TYPE 1 ENGINEERED CAP: 0.15–METRE ROCK ARMOUR LAYER OVER FILTER MATERIAL OVER SAND LAYER

DETAIL 22 — NOT TO SCALE — C28

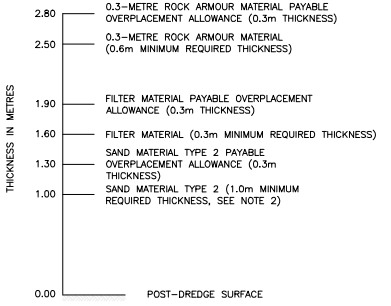
NOTE: MINIMUM REQUIRED THICKNESS AND PAYABLE OVERPLACEMENT ALLOWANCES SHOWN ON THE DETAIL REPRESENT GENERAL CONDITIONS REQUIRED TO MEET THE DESIGN AND GRADES AND ELEVATION REQUIREMENTS FOR PLACEMENT OF CAP TYPE 1 MATERIALS. THE MINIMUM REQUIRED THICKNESS AND PAYABLE OVERPLACEMENT ALLOWANCE FOR TYPE 1 SAND MATERIAL SHALL BE INCREASED IN SELECT AREAS OF THE EGD WORK SITE WHERE PLACEMENT OF ADDITIONAL TYPE 1 SAND MATERIAL IS REQUIRED TO MEET THE DESIGN GRADES AND ELEVATIONS SHOWN ON THE DRAWINGS. THE DEPARTMENTAL REPRESENTATIVE MAY DIRECT THE CONTRACTOR TO REMOVE EXCESSIVE OVERPLACEMENT MATERIAL THAT IS PLACED ABOVE THE DESIGN GRADES AND ELEVATIONS AT NO ADDITIONAL COST TO PWGSC. 1



TYPE 2 ENGINEERED CAP: 0.15–METRE ROCK ARMOUR LAYER OVER FILTER MATERIAL OVER SAND LAYER

DETAIL 23 — NOT TO SCALE — C28

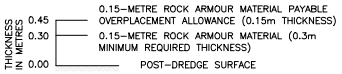
NOTE: MINIMUM REQUIRED THICKNESS AND PAYABLE OVERPLACEMENT ALLOWANCES SHOWN ON THE DETAIL REPRESENT GENERAL CONDITIONS REQUIRED TO MEET THE DESIGN AND GRADES AND ELEVATION REQUIREMENTS FOR PLACEMENT OF CAP TYPE 2 MATERIALS. THE MINIMUM REQUIRED THICKNESS AND PAYABLE OVERPLACEMENT ALLOWANCE FOR TYPE 2 SAND MATERIAL SHALL BE INCREASED IN SELECT AREAS OF THE EGD WORK SITE WHERE PLACEMENT OF ADDITIONAL TYPE 2 SAND MATERIAL IS REQUIRED TO MEET THE DESIGN GRADES AND ELEVATIONS SHOWN ON THE DRAWINGS. THE DEPARTMENTAL REPRESENTATIVE MAY DIRECT THE CONTRACTOR TO REMOVE EXCESSIVE OVERPLACEMENT MATERIAL THAT IS PLACED ABOVE THE DESIGN GRADES AND ELEVATIONS AT NO ADDITIONAL COST TO PWGSC. 1



TYPE 3 ENGINEERED CAP: 0.30–METRE ROCK ARMOUR LAYER OVER FILTER MATERIAL OVER SAND MATERIAL TYPE 2 LAYER

DETAIL 24 — NOT TO SCALE — C28

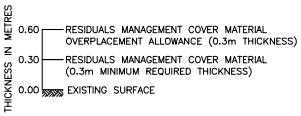
NOTES:
1. 1 MINIMUM REQUIRED THICKNESS AND PAYABLE OVERPLACEMENT ALLOWANCES SHOWN ON THE DETAIL REPRESENT GENERAL CONDITIONS REQUIRED TO MEET THE DESIGN AND GRADES AND ELEVATION REQUIREMENTS FOR PLACEMENT OF CAP TYPE 3 MATERIALS (EXCLUDING AREAS REQUIRING IMPERMEABLE GEOSYNTHETIC MATERIAL). THE MINIMUM REQUIRED THICKNESS AND PAYABLE OVERPLACEMENT ALLOWANCE FOR TYPE 2 SAND MATERIAL SHALL BE INCREASED IN SELECT AREAS OF THE EGD WORK SITE WHERE PLACEMENT OF ADDITIONAL TYPE 2 SAND MATERIAL IS REQUIRED TO MEET THE DESIGN GRADES AND ELEVATIONS SHOWN ON THE DRAWINGS. THE DEPARTMENTAL REPRESENTATIVE MAY DIRECT THE CONTRACTOR TO REMOVE EXCESSIVE OVERPLACEMENT MATERIAL THAT IS PLACED ABOVE THE DESIGN GRADES AND ELEVATIONS AT NO ADDITIONAL COST TO PWGSC.
2. REQUIRED THICKNESS OF SAND MATERIAL TYPE 3 VARIES BETWEEN 0.0 AND 1.0m IN AREAS REQUIRING IMPERMEABLE GEOSYNTHETIC MATERIAL NEAR EXISTING SHEET PILE BULKHEAD WALL.
3. REQUIRED THICKNESS OF FILTER MATERIAL VARIES BETWEEN 0.0 AND 0.3m IN AREAS REQUIRING IMPERMEABLE GEOSYNTHETIC MATERIAL NEAR EXISTING SHEETPILE BULKHEAD.



TYPE 5 ENGINEERED CAP: 0.15–METRE ROCK ARMOUR

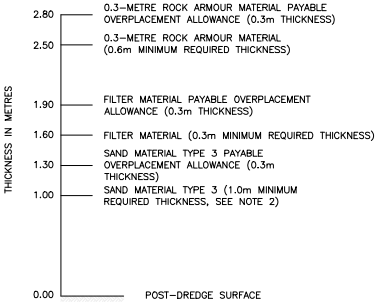
DETAIL 26 — NOT TO SCALE — C28/C30

NOTE: TOTAL ENGINEERED CAP PLACEMENT THICKNESS CAN VARY BETWEEN A MINIMUM TOTAL THICKNESS OF 0.0m AND UP TO 0.45m THICKNESS AND WILL BE PAYABLE. ADDITIONAL PLACEMENT ABOVE 0.45m WILL BE CONSIDERED EXCESSIVE OVERPLACEMENT AND WILL NOT BE PAID. THE DEPARTMENTAL REPRESENTATIVE MAY DIRECT THE CONTRACTOR TO REMOVE EXCESSIVE OVERPLACEMENT AT NO ADDITIONAL COST TO PWGSC.



RESIDUALS MANAGEMENT COVER PLACEMENT

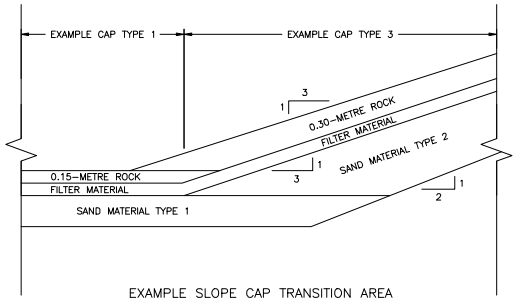
DETAIL 27 — NOT TO SCALE — C28



TYPE 4 ENGINEERED CAP: 0.30–METRE ROCK ARMOUR LAYER OVER FILTER MATERIAL OVER SAND MATERIAL TYPE 3 LAYER

DETAIL 25 — NOT TO SCALE — C28

NOTES:
1. TOTAL ENGINEERED CAP PLACEMENT THICKNESS CAN VARY BETWEEN A MINIMUM TOTAL THICKNESS OF 1.9m (EXCLUDING AREAS REQUIRING IMPERMEABLE GEOSYNTHETIC MATERIAL) AND UP TO 2.8m THICKNESS AND WILL BE PAYABLE. ADDITIONAL PLACEMENT ABOVE 2.8m WILL BE CONSIDERED EXCESSIVE OVERPLACEMENT AND WILL NOT BE PAID. THE DEPARTMENTAL REPRESENTATIVE MAY DIRECT THE CONTRACTOR TO REMOVE EXCESSIVE OVERPLACEMENT AT NO ADDITIONAL COST TO PWGSC.
2. REQUIRED THICKNESS OF SAND MATERIAL TYPE 2 VARIES BETWEEN 0.0 AND 1.0m IN AREAS REQUIRING IMPERMEABLE GEOSYNTHETIC MATERIAL NEAR EXISTING SHEET PILE BULKHEAD WALL.
3. REQUIRED THICKNESS OF FILTER MATERIAL VARIES BETWEEN 0.0 AND 0.3m IN AREAS REQUIRING IMPERMEABLE GEOSYNTHETIC MATERIAL NEAR EXISTING SHEETPILE BULKHEAD.



EXAMPLE SLOPE CAP TRANSITION AREA

DETAIL 28 — NOT TO SCALE — C32

NOTES:
1. CONTRACTOR SHALL DESCRIBE SEQUENCING OF CAP LAYER PLACEMENT AS PART OF THE CONSTRUCTION WORK PLAN.
2. CONTRACTOR SHALL PLACE A MINIMUM OF 1m OF SAND MATERIAL OVER ALL DREDGE AREAS EXCLUDING AREAS REQUIRING IMPERMEABLE GEOSYNTHETIC MATERIAL.

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada
REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

ANCHOR QEA

Klohn Crippen Berger

Revision/ Revision	Description/Description	Date/Date
1	ADDENDUM NO. 2	2015/03/20
0	ISSUED FOR TENDER	2014/12/19

Client/client

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

ESQUIMALT GRAVING DOCK WATERLOT PHASE 2 SOUTH JETTY UNDER-PIER SEDIMENT REMEDIATION

Consultant Signature Only

Designed by/Concept par
MATT WOLTMAN

Drawn by/Dessiné par
CHRIS HEWETT

PWGSC Project Manager/Administrateur de Projets TPSGC
ANDREW MYLLY

Regional Manager, Environmental Services
COLLIN KINGMAN

Drawing title/Titre du dessin
ENGINEERED CAPPING DETAILS - SHEET 2

Project No./No. du projet	Sheet/	Revision no./
R.018400.002	C33	1

PWGSC – A1 – 8411X594

0 10 20 30 40 50 60 70 80 90 100mm

DMSXXXXXX

F10

ESQUIMALT GRAVING DOCK

PRE-CONSTRUCTION CONDITION SURVEY – WSP (JAN 2016)

Number of Pages: 44

PACIFIC REGION – Professional and Technical Services (PTS)	Request for Information Form	Business Unit: ES	Page: 1 of 1
Title: Contractor Request for Information – EZ899-151108/001/PWY – PH2 - EGD Waterlot Remediation Project South Jetty Under-Pier Sediment Remediation			

RFI #: PH2 - 151

Project No.: R.018400.002 Project Name: EGD Waterlot Remediation Project - PH2 South Jetty Under-Pier Sediment Remediation

To: Canada - PWGSC Date: 2 February 2016

Attention: Rae-Ann Sharp, PWGSC Departmental Representative

Please find the attached Pre-construction Condition Survey with revisions to address ADV 109.

References – Specification item: Drawings:

Response required by:

Anticipated Change to – Contract Amount: ☐ Yes ☒ No Contract time: ☐ Yes ☒ No

From: Stephen Pinto @ MNQM Contracting Ltd.

(Name) (MNQM Contracting Ltd.)

REPORT N^{O} 151-10283-00

ESQUIMALT GRAVING DOCK PRE-CONSTRUCTION CONDITION SURVEY

DRAFT

SEPTEMBER 2015
UPDATED: JAN 20. 2016

WSP

ESQUIMALT GRAVING DOCK PRE-CONSTRUCTION CONDITION SURVEY

Quantum Murray LP

Report Final

Project no: 151-10283-00
Date: February 01, 2016

WSP Canada Inc.
Suite 400 - 401 Garbally Rd
Victoria, B.C. V8T 5M3
Phone: 250 384-5510
Fax: 250 3862844
www.wspgroup.com

February 01, 2016

Mr. Stephen Pinto, P.Ag. EP B.Sc.
Quantum Murray LP
110-2940 Jutland Road
Victoria, BC V8T 5K6

Subject : **Esquimalt Graving Dock Pre-Construction Condition Survey**

Dear Sir,

We are pleased to provide the attached Pre-condition Survey of the area that you are going to be working in at the PWGSC Esquimalt Graving Dock.

The survey was carried out in September 2015 with the exception of the Bulkhead wall that was inspected in January 2016.

II have incorporated your comments and those of PWGSC Advisory 109 dated January 28, 2016.

Please contact the writer if you have any questions.

.Yours truly,

Ian W. Martin, P.Eng.
Senior Project Manager

WSP Canada Inc.
Suite 400 - 401 Garbally Rd
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EXECUTIVE SUMMARY

Public Works and Government Services Canada (PWGSC) requires the remediation of contaminated marine sediments within the South Jetty under-pier area as Phase 2 of the Esquimalt Graving Dock (EGD) Water Lot Remediation Project in Constance Cove of Esquimalt Harbour on Vancouver Island, British Columbia. PWGSC also requires the demolition of the timber pile supported sections of the South Jetty at the EGD Facility, to provide access to the under-pier area for remediation.

WSP was tasked by Quantum Murray LP to conduct a Pre-construction Condition Survey in accordance with the specification for the remediation work. The purpose is to provide a baseline of the existing condition of works that are going to be remaining in place after the completion of the work. In particular the report was to identify existing damage to the existing structure and buildings.

A visual survey of both the under jetty and above deck conditions were visually examined where accessible.

Due to the lack of access and the lack of light the Bulkhead Wall was not examined completely during the original survey in September. The Bulkhead wall was visually examined from a boat on January 14th, 2016.

Of the elements that were examined they were general found to be in good repair. In some areas pile corrosion is more than found in the overall pile population.

The only place there is consistent damage in on the skins of the various buildings adjacent to the Concrete Jetty. Most of the damage is from objects being pushed or falling against the buildings.

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APPENDIX C BULKHEAD WALL PHOTOS

APPENDIX D REFERENCE DRAWING E11

1 BACKGROUND & CONTEXT

1.1 PROJECT SCOPE

Public Works and Government Services Canada (PWGSC) requires the remediation of contaminated marine sediments within the South Jetty under-pier area as Phase 2 of the Esquimalt Graving Dock (EGD) Water Lot Remediation Project in Constance Cove of Esquimalt Harbour on Vancouver Island, British Columbia. PWGSC also requires the demolition of the timber pile supported sections of the South Jetty at the EGD Facility, to provide access to the under-pier area for remediation.

1.2 REPORT SCOPE

WSP Canada Inc. (WSP) was tasked by Quantum Murray LP (the Contractor) to conduct a pre-construction survey covering the existing structures adjacent to the areas that are to be remediated. The prime objective of this report is to identify areas and element of the existing structure that show obvious damage prior to the commencement of the work by the contractor. The under Jetty examination includes:

- Steel Piled Deck Structure Including Piles
- Anchored Sheet Pile Bulkhead Wall
- Concrete Faced Timber Crib
- The Small L Wall
- Steel Sheet Pile Perimeter Wall and Attachment to Timber Jetty

The above deck survey includes

- Concrete Jetty Deck Surface
- Adjacent Buildings

1.3 ACCESS

Access to the underside of the jetty was provided by PWGSC Staff following their confined space protocols on September 16, 2015.

The first area examined was the west end of the anchored bulkhead wall and the South face of the timber crib wall and the piles around the existing high mast lighting.

The second manhole provided access to the small “L” wall and the east end of the anchored bulkhead wall.

In the afternoon the entire outside of the sheet pile enclosure wall was examined visually from a PWGSC operated boat. This was followed by accessing the underside of the crane pad for pile and deck condition. Access was not practical for the majority of the sheet pile wall, piles and Jetty deck due to a combination of cross bracing and tides. I addition lack of light would limit the detail of damage to de found.

On September 17th inspection of the underside of the jetty was attempted from the catwalk using the confined space protocol. Due to the lack of light and the distance from the wall the sheet pile wall inspection was not realistic. It was a good vantage point however to inspect portions of the perimeter sheet pile wall.

In the later morning a visual inspection of the perimeter sheet pile wall and its attachments was conducted.

A visual inspection of the jetty mounts, concrete deck and the adjacent buildings was conducted approaching noon

The follow up inspection of the bulkhead wall took place on January 14, 2016 from a small boat provided by Quantum Murray / Vancouver Pile. The inspection took place during the low day time tide of 2m. As a result the top of the riprap slope was only exposed in some areas.

1.4 LAYOUT GRID

For the purposes of this report the pile layout grid that is shown on Drawing E11 of the contract package is used to reference the individual piles that show evidence of damage during the survey. This is the most appropriate grid as it clearly identifies the pile locations after the removal of the timber pile structures. A Copy of this Drawing is attached in Appendix "D" for reference.

The photographs under the jetty in Appendices A & C have been referenced to the grid show on Drawing E11 according to the following Key: (East West Grid, North South Grid, Direction of Image).

1.5 GENERAL REPORT REMARKS

In general a number of photos exist and will be kept on file. Exceptional conditions are imbedded in the report where discussed.

Representative sample photographs have been provided in the Appendices to the report however there are more photographs on file at the WSP office if detail of existing damage is required in the future. This is particularly aimed at the adjacent buildings.

2 UNDER JETTY DECK CONDITION OBSEVATIONS

2.1 STEEL PILED DECK STRUCTURE INCLUDING PILES

2.1.1 CONCRETE DECK STRUCTURE

The Concrete Deck was in very good shape with no signs of cracking and or voids as a result of poor construction practices. It was noted that there was no visible efflorescence deposits on the underside of the concrete. There were no visible signs of damage in any of the concrete deck examined from the underside.

This finding was confirmed during the follow up visit on January 14, 2016.

The Two Access hatches through the concrete deck are in good repair. The galvanized support structure an hatch framing appear to be free from signs of breakdown. The ladders are also in good shape. The hatch covers are showing the expected signs of traffic wear & tear.

2.1.2 STEEL PILES

The steel piles were apparently coated when installed the majority of the piles appear to have deteriorated coating and as a result surface rusting is evident. It was observed that the coating is

generally intact in areas where it has been protected by overburden. The author has no knowledge of whether these piles are filled their entire length with concrete, a top plug or connected to the concrete deck in some other fashion.

One pile near the high mast lighting had a 1/8 inch thick layer of scale on it just above the mud line.

This seemed to be the exception rather than the rule. Due to access not all piles were examined during the inspection.

During the inspection on January 14th it was noted that other piles in the field were showing signs of corrosion and had scaling and spalling. The deterioration was mainly in the upper splash zone. These were random and not concentrated in any one area. The effectiveness of the corrosion protection system should be reviewed for these piles.

Consistently the coating on the piles has lost its integrity in the high tide to upper splash zone.

The pile all appear to be free from physical damage that might be caused by impact or scraping by an outside source such as a boat or large piece of machinery.

2.2 ANCHORED SHEET PILE BULKHEAD WALL

The east and west ends of the Sheet Pile Bulkhead Wall were examined via the manhole entrances to the underside of the jetty during the original inspection. In general the coated sheet pile wall was in good repair with the surface corrosion appearing at the interlocking joints. There was some rust staining in other areas on the sheet pile but the source appears to be from the cuts and welds in the whaler at the top of the wall as shown in photo below

The Inspection of January 14th showed no physical damage to the integrity of the Bulkhead Wall. There were however consistent signs of corrosion at the joints of the sheet pile and deterioration of the coating on the sheet pile. The top whaler was in relatively good shape. The worst case appears in the photo above taken during the September inspection.

The above photo shows the typical whaler condition and the general good condition of the concrete deck and support structure. There is some surface rusting of the tie back attachment.

The photo below shows the typical sheet pile condition with rusting at the joints

2.3 CONCRETE FACED TIMBER CRIB

The examination of the Concrete Timber Crib wall was successful and was generally in good repair considering its age. There is a pit in the south face if the wall which should be examined for possible repair once the timber pile structure is removed. This is illustrated in Photo A12 of Appendix A. From the observations there is no signs of spalling or cracking in the concrete facing if the timber crib.

2.4 THE SMALL L WALL

This retaining wall at the east end of the south jetty was examined through the access hatch at the east end of the jetty. This wall was in good condition and is showing no signs of distress. See Photos A14 & A15 of Appendix A

2.5 STEEL SHEET PILE PERIMITER WALL

2.5.1 SHEET PILE EXTERIOR

The perimeter Sheet pile wall installed in the previous phase of the cleanup is in very good condition and has no visible damage from impact or other misadventures. The top of the piling is restrained by a timber assembly which in turn also holds relatively new fender piles in pairs. A visual inspection was carried out from the water and a limited inside inspection was carried out from the catwalk under the jetty. The steel whaler securing the top of the sheet pile is in good condition

2.5.2 TIMBER WHALERS

The timber whaler assembly attaching the perimeter sheet pile to the fender piles is in near new condition. The fastenings are in very good shape. There may be some salvage value in this material if removed carefully

2.5.3 FENDER PILES

The recently installed fender piles are also in very good shape they are set in pairs every 10 ft. there is definitely some salvage value in these piles.

3 ABOVE JETTY DECK CONDITION OBSEVATIONS

3.1 CONCRETE JETTY DECK SURFACE

The existing concrete deck was examined visually for signs of damage that are presently evident.

Overall the deck is in good shape with no evident large cracks. Over the years a number of "temporary" buildings have been attached or placed on the deck mostly near the southern face of the concrete deck. These buildings were in the process of being removed or were already gone at the time of examination. There was some evidence of wood bull rails which had rotted behind or under the buildings but no evidence that the concrete deck had been compromised.

Where the temporary buildings have been removed there is staining or discoloration of the concrete and some painting spills.

There are occasional places where services have been fished through the deck to meet the needs of the building.

3.2 JETTY MOUNTS

All of the jetty mounts were given a examination to look for damage to the enclosure. All mounts appeared to be in good repair. There was no attempt to confirm whether the services at each mount were working as it is understood that the contractor is to remove and store the units.

3.3 ADJACENT BUILDINGS

The existing buildings are in general good repair and keep the weather out as intended. They are of industrial construction most with metal cladding of some sort. The skins show signs of normal wear and tear that could be expected where machinery and parts are being constantly moved adjacent to them. The best example is the Sheet Metal shop where steel plate and other steel goods have been stored and have fallen or been pushed against the siding.

4 SUMMARY

After reviewing the jetty components highlighted in the PWGSC specification it is the writers opinion that there is no significant signs of damage to the below deck components of the jetty The deterioration of the steel piles and the bulkhead wall components is as one would expect given the age of the structure.

It is recommended that the corrosion protection system be reviewed for integrity with respect to the piles that are showing signs of scaling

The above deck buildings are showing cosmetic damage as detailed in the report but no structural issues at the time of the inspection.

Respectfully Submitted

Ian W. Martin, P.Eng.

Senior Project Manager

Appendix A

UNDER JETTY PHOTOS

STEEL PILED DECK STRUCTURE INCLUDING PILES

Photo A1 - Typical Deck, Wall & Piles (GL 33-34, B, West)

Photo A2 - Typical U/S of Deck

Photo A3 Typical Pile with Surface Corrosion (GL 2, A, East)

Photo A4 – Typical Pile Corrosion in Spalsh Zone (GL 2, E, East)

Photo A5 Typical piles near existing boat access (GL 2-3, I+, North)

Photo A6 – Corrosion at Mud Line (GL 7, D, North)

Photo A7 – Bulkhead Wall near East End (GL 33-34, B-, West)

Photo A8 - Typical Corrosion at Joints. Note Rust Staining From Weld on Whaler Above (GL 33-34, B-, North)

Photo A9 – Whaler Weld & Cutting Corrosion (GL 33-34, B-, North)

Photo A10 Typical Tie Back and Whaler Assembly (GL, B-, North)

CONCRETE FACED TIMBER CRIB

Photo A11 - West Wall of Timber Crib (GL 1, a-, North)

Photo A12 - South Wall (Note Pit in Wall Face) (GL 1-2, A-, North)

Photo A13 - SW Corner of Concrete Faced Timber Crib (GL 1-2, A-, North)

Photo A14 – South Face of L Wall (GL 35+, F+, East)

THE SMALL L WALL

Photo A15 – West Face of Small L Wall (GL 35+, F+, North East)

STEEL SEET PILE PERIMETER WALL

Photo A16 - Typical Section of Perimeter Sheet Pile Wall

Photo A17 - Sheet Pile Wall (Note Typical Surface Corrosion)

Photo A18 – Typical Perimeter Sheet Pile Top Assembly

Appendix B

ABOVE DECK PHOTOS

CONCRETE DECK

Photo B1 – East End of Concrete Deck with Asphalt Approach

Photo B2 – Typical Deck Area

Photo B3 – Central Deck Area

Photo B4 – South Edge of Central Deck

Photo B5 – Central Deck Showing Staining & Penetrations

Photo B6 – Near High Mast Lighting – Mastic Staining

Photo B7 – Crane Pad Deck

Photo B8 – West End of Deck

JETTY MOUNTS

Photo B9 – Jetty Mount #3

Photo B10 – Jetty Mount #1 Water Side

Photo B11- Typical Skin Damage to Buildings

Photo B12 – Paint Shop

Photo B13 – Overview of Plate Shop

Photo B14 Damage at Plate Shop Doors

Photo B15 – Plate Shop Wall Damage

Photo B16 More Damage at Plate Shop Wall

Appendix C

BULKHEAD WALL PHOTOS

BULKHEAD WALL

Photo C1 – East End Bulkhead Wall (GL 33-34, B-, North)

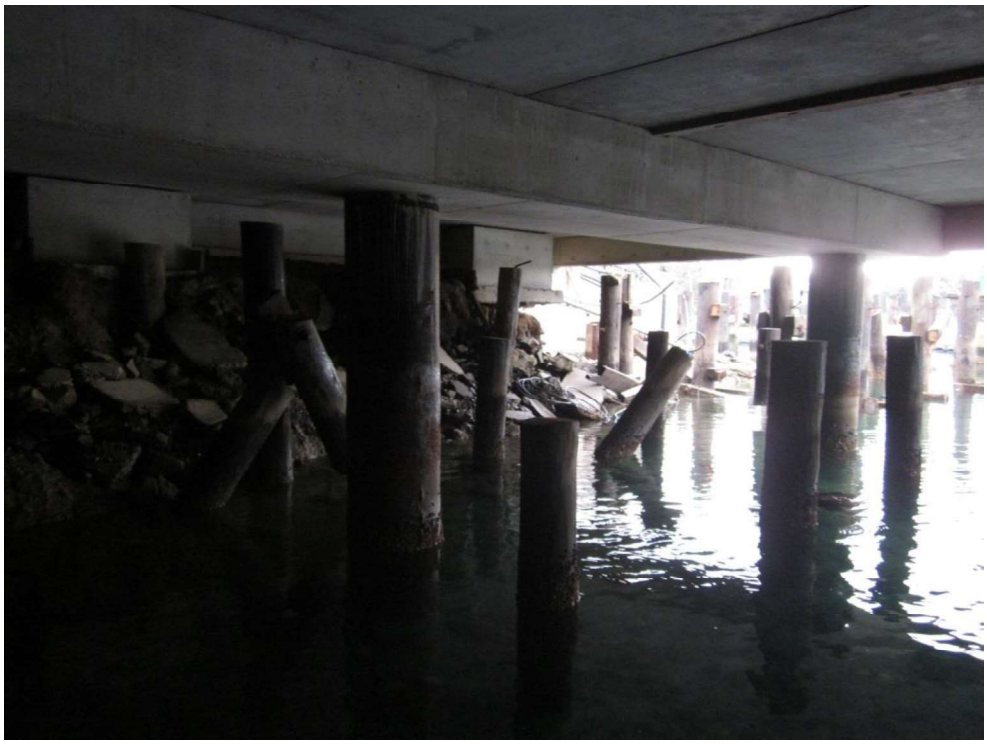


Photo C2 – Typical Underside of Deck (East End) (GL 33-34, C-, East)

Photo C3 – Typical Bulkhead Wall (Corrosion at Joints) (GL B-, North)

Photo C4 – Typical Tie Back (GL B-, North)

Photo C5 – Typical Configuration (GL 21-22, B-, North)

Photo C6 – Typical Wailer Installation (GL B-, North)

Photo C7 – East of high Mast Lighting Foundation (GL 8-9, B-, North)

Photo C8 – West End Abandon Sheet Pile Wall (GL 11-12, B-, North)

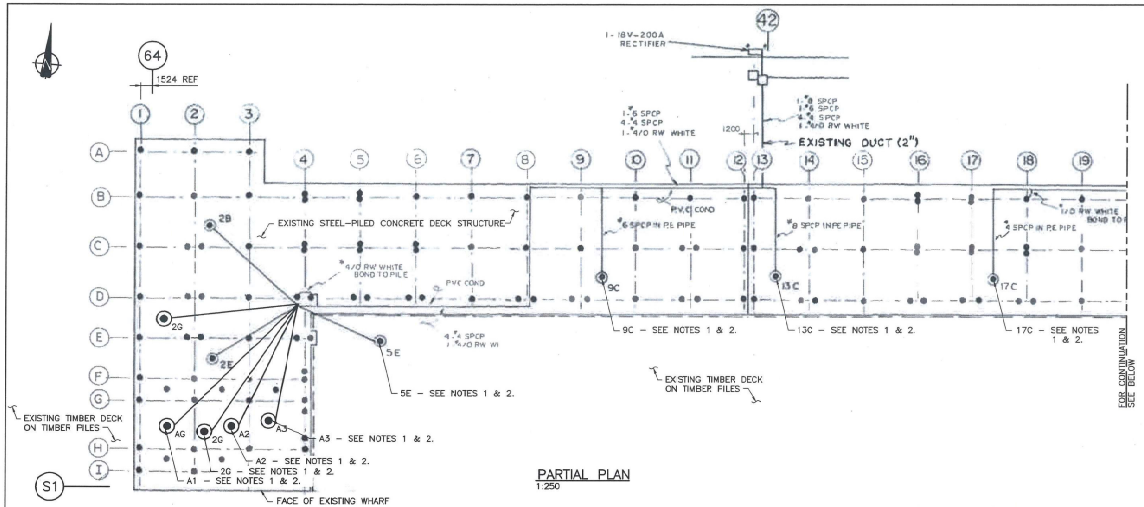
Photo C9 – Debris in Fill around High Mast lighting (GL 7, E, North)

Photo C10 – Fill East of High Mast lighting (GL 8-10, B-,West)

Photo c11- Overview of West End of Deck (GL 4, G, North East)

Appendix D

REFERENCE DRAWING E11



PARTIAL PLAN
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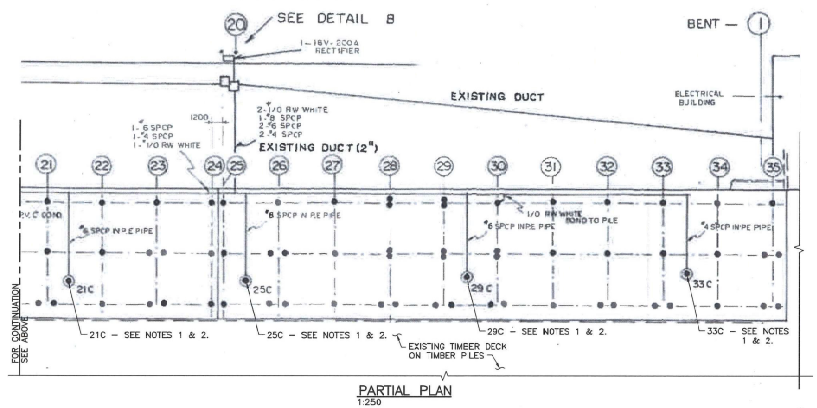

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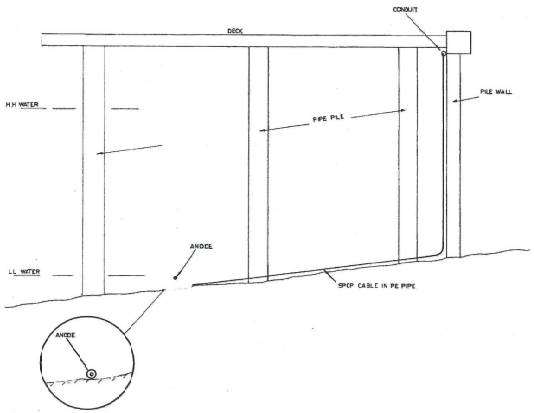
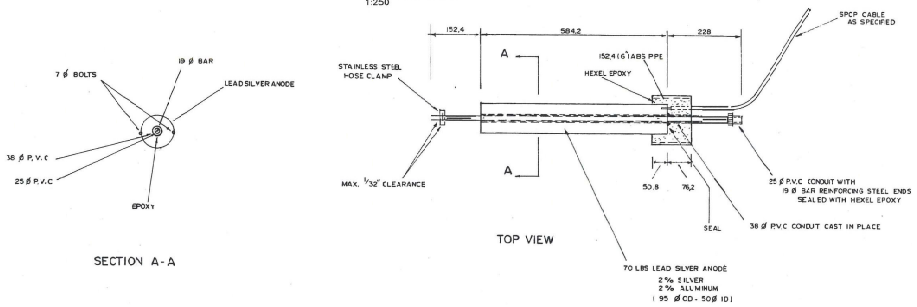
1:250



TYPICAL SECTION
N.T.S.



TYPICAL ANODE ASSEMBLY DETAILS
N.T.S.

LEGEND:

- LEAD SILVER ANODE
- EXISTING STEEL PIPE PILE

NOTES:

1. TEMPORARILY REMOVE, STORE AND REINSTATE ANODES TO ORIGINAL LOCATION AFTER DREDGING AND ENGINEERED CAPPING WORK ARE COMPLETED.
2. DO NOT DAMAGE THE INSULATION ON THE ANODE CABLE DURING REMOVAL AND REINSTATING.
3. DETAILS TAKEN FROM ESQUIMALT GRAVING DOCK IMPROVEMENTS, PROJECT NUMBER PR.100772 DRAWINGS 15 AND 16 OF 75, SUPPLEMENTED BY FIELD INFORMATION FROM ECC SEDIMENT REMEDIATION SOUTH JETTY UNDER-PIER EROSION PROTECTION RECORD DRAWINGS S15 (REFERENCE DRAWINGS).
4. REFER TO SPECIFICATION SECTION 02 41 13 FOR ICCP SYSTEM REQUIREMENTS.

CORROSION TESTING REQUIREMENTS:

1. INSPECT AND TEST THE ICCP SYSTEM BEFORE DISCONNECTING AND AFTER REINSTATEMENT TO CONFIRM THAT THE REINSTATED ICCP SYSTEM PROVIDES THE SAME OPERATIONAL PERFORMANCE LEVEL AS PREVIOUSLY EXISTED.

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada
REAL PROPERTY SERVICES
Pacific Region
SERVICES IMMOBILIERS

Klohn Crippen Berger

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
L. DUONG
39514
2014-12-18

Version / Revision	Description / Description	Date / Date
1	ISSUED FOR TENDER	2014-12-19

Client/client
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

ESQUIMALT GRAVING DOCK WATERLOT PHASE 2 SOUTH JETTY UNDER-PIER SEDIMENT REMEDIATION

Consultant Signature Only

Designed by/Concept par: GEOFF COOPER
Drawn by/Dessine par: ARNIE RIST
PWGSC Project Manager/Administrateur de Projets TPSGC: ANDREW NEILL
Regional Manager Environmental Services: COLLIN KINGMAN

Drawing title/Titre du dessin
SOUTH JETTY MODIFICATIONS TO CATHODIC PROTECTION SYSTEM

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ESQUIMALT GRAVING DOCK

GOLDER TECHNICAL MEMORANDUM

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TECHNICAL MEMORANDUM

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TO George Strazicich, PEng
PWGSC

CC Kate Ulmer/Don Sandys-Wunsch - Herold Engineering

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**GEOTECHNICAL REVIEW OF THE 99% COMPLETION PILE DESIGN
ESQUIMALT GRAVING DOCK SOUTH JETTY RECONSTRUCTION PROJECT
ESQUIMALT, B.C.**

Public Works and Government Services Canada (PWGSC) has retained the services of Golder Associates Ltd. (Golder) to provide geotechnical design and construction services for the proposed Esquimalt Graving Dock (EGD) South Jetty Reconstruction project. The work tasks of the subject assignment have been carried out in accordance with Golder's proposal dated 22 August 2016, prepared in response to PWGSCs' Terms of Reference dated 29 June 2016, under Standing Offer Agreement No. EZ899-141238/001/TPV for Geotechnical Engineering Services.

Golder has completed the following key tasks to date:

Task 1: Review of existing subsurface soil and rock information at the EGD South Jetty site

Task 2: Geotechnical review of the pile drawings prepared by Herold Engineering (Herold) in concert with the Design Criteria established by Klohn Crippen Berger (KCB) for the project

Task 3: Design recommendations for piles supporting the South Jetty based on design compression and tension loads provided by Herold

Task 4: Revisions to relevant sections of the piling specifications

The above four tasks cover the work described in Sections 2.1, 2.2 and 2.3 of PWGSCs Terms of Reference.

Based on our discussions with Herold, we understand that the factored design pile loads provided under Task 3 above correspond to the 475-yr seismic demand. We further understand that the structural analyses have been carried out in accordance with the Canadian Highway Bridge Code CSA S6-14 and guidelines given in ASCE Standard 61-14 on Seismic Design of Piers and Wharves.

Unless otherwise noted explicitly, all elevations reported in this Technical Memorandum are with reference to the Chart Datum.

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The results of the above-noted geotechnical review tasks, geotechnical comments and recommendations on foundation design, proposed changes to the Technical Specifications on Pile Foundations and path forward are summarized in this Technical Memorandum.

Our scope of work does not include investigation, review or assessment of archaeological, contaminated soil and groundwater, or bio-environmental services for the subject project.

1.0 BACKGROUND AND PROPOSED RECONSTRUCTION

PWGSC is planning to reconstruct the South Jetty at the Esquimalt Graving Dock (EGD) located at 825 Admiral Road, Esquimalt, BC and has engaged Herold and Golder to complete the 99% completion design completed by KCB in 2014. The intent is to complete the design and construction documents to a tender-ready status. The 99% completion design and construction documents prepared by KCB are based on geotechnical field investigations completed by Golder and KCB at different stages of the project supplemented with other available data on subsurface conditions. Site preparation and environmental remediation work involving decommissioning of the existing South and West timber pile supported jetties, dredging of the upper 1 to 3 m of contaminated soils, capping the exposed soils and filling to re-instate original ground conditions have been carried out already or are currently being carried out.

The EGD South Jetty site, locations of the existing timber crib, and existing timber pile and steel pile supported jetties are shown in Figure A-1 (ref. Figure 3 of Golder's Phase 2 – 99% Geotechnical Design Input Report, figure dated 24 March 2014) attached in Appendix A of this technical memorandum. We understand that the existing "L-shaped" Concrete Wharf that is supported on steel piles that were driven to bedrock and the adjacent timber crib to the north will be retained "as is". The existing timber pile supported jetties have been demolished already and they will be replaced by two steel-piled jetty structures referred to as the new "West Jetty" and new "South Jetty", which are located immediately to the west and south of the existing "L-Shaped" Concrete Wharf, respectively. The existing Tug Boat Wharf (floats and piles) near the east end of the South Jetty will be removed temporarily during the reconstruction, and reinstated with new mooring piles matching the existing footprint. The reconstruction work at the EGD will include installation of 204 new steel pipe piles driven and/or socketed to bedrock supporting the new "West Jetty" and new "South Jetty", 14 rock-socketed displacement control piles to be installed in front of (immediately to the west of) the existing timber crib, and 2 new steel pipe piles for the Tug Boat Wharf.

2.0 GEOTECHNICAL REVIEW OF KEY EXISTING INFORMATION

As part of the review completed by Golder, the following key existing information, available to Golder at the time of preparation of this Technical Memorandum, was reviewed:

- Herold's piles drawings (Revision A) dated 12 August 2016
- KCB's Design Criteria (Revision 3), dated 25 November 2010, for the EGD South Jetty Wharf Development
- Test holes TH84-2-1 to TH84-2-3 completed by Ker Priestman & Associates Ltd. in 1984
- Test holes (mud rotary drill holes, CPT/SCPTs, and Becker test holes) completed by KCB in 2002
- Test holes (mud rotary drill holes and CPTs) completed by KCB in 2009

- Test holes (sonic holes, mud rotary boreholes and CPTs) completed by Golder in 2009
- A single sonic hole completed by Golder in 2011
- Inferred stratigraphic cross-sections (2010 and 2014) prepared by Golder from the "EGD Waterlot – Supplementary Test Hole Investigation for Remedial Action Plan/Risk Management Plan" report dated 3 March 2010, and from the "Phase 2 – 99% Geotechnical Design Input Report" for EGD Waterlot (figures dated 24 March 2014)
- "Figure 3b – Elevation of Top of Glacial Deposits" from Golder's "EGD Waterlot – Supplementary Test Hole Investigation for Remedial Action Plan/Risk Management Plan" report dated 3 March 2010
- Seven geologic cross-sections A to G from KCB's "Site Investigation and Liquefaction Assessment Final Report" for EGD and South Landing Wharf dated 25 June 2002

It is important to note that a Geotechnical Design Report summarizing the design basis for the pile foundations proposed by KCB was not available for our review. The geotechnical input used to design the foundations, including key information such as site characterization details, geotechnical input parameters, soil-structure interaction studies undertaken to confirm the jetty performance under both static and seismic loading conditions, past piling experience at the site, and the basis for recommending driven piles to support the two jetties (with the exception of the 14 rock-socketed displacement control piles) form key information that was unavailable for review for a 99% completion design for a structure of this level of importance. In the absence of a geotechnical design report, considerable effort had to be spent re-analyzing the foundation support requirements for the proposed new South and West Jetties.

A brief summary of the key available information reviewed is provided in the sections below.

2.1 Existing Test Holes and Subsurface Information

A summary of the existing test holes and subsurface information available to Golder is provided in the sections below. The approximate locations of the test holes completed before/in 2009 are shown in Figure A-2 (ref. Figure 1 of KCB Geotechnical Data Report, 23 March 2010) attached in Appendix A of this technical memorandum.

2.1.1 Test Holes TH84-2-1 to TH84-2-3 Completed by Ker Priestman & Associates Ltd. (1984)

Three boreholes were drilled in 1984 by Ker Priestman & Associates Ltd. in front of the existing timber crib. TH84-2-1 and TH84-2-2 were located near the proposed rock-socketed displacement control piles, while TH84-2-3 was located approximately 30 m west of the rock-socketed displacement control piles.

Based on the test hole logs, inferred/possible bedrock (identified as "Bedrock?" in the logs) was encountered at elevation -14.9 m (chart datum) in test hole TH84-2-1. The borehole drilling stopped at elevation -14.9 m and did not advance into the formation to confirm bedrock. No glacial deposit overlying the bedrock was identified in this test hole.

In test hole TH84-2-2, Till was encountered at elevation -27.7 m (chart datum) and the test hole was terminated at elevation -27.9 m (0.15 m into Till). Bedrock was not encountered at this location.

Considering that TH84-2-1 and TH84-2-2 described above are only 3 to 4 m apart, the test holes indicate that the bedrock elevation drops by approximately 13 m (or more) over a horizontal distance of about 3 to 4 m in front of the timber crib at the proposed rock-socketed pile locations. The subsurface information reported in these two test holes appears to be anomalous. Alternatively, the results reflect the possible presence of shear zones with sharp changes in bedrock elevations. Based on KCB's 99% completion design, the design steel pipe pile toe elevations for the rock-socketed displacement control piles range from -22 m to -28 m. No additional test hole was drilled at the proposed rock-socketed pile locations to confirm the actual elevation of bedrock.

2.1.2 Test Holes Completed by KCB (2002)

Mud rotary drill holes and CPT/SCPTs were completed by KCB in 2002 in the new West Jetty and South Jetty areas. Becker test holes were also completed, but they were generally located north of the new South Jetty.

Four mud rotary drill holes DH02-01 to -04 were drilled. DH02-01 and -03 were terminated immediately when dense/stiff/hard material (inferred to be bedrock) was encountered, and rock coring/drilling was not carried out to confirm bedrock. DH02-02 and -04 were terminated within the clay strata without reaching bedrock. No glacial deposit was identified in all four drill holes. Nilcon vane shear tests were carried out in the silt and clay deposits encountered in DH02-01, -02, and -04. Cyclic/static simple shear tests were completed on three silt and clay samples recovered using Shelby tubes.

Nine CPTs including three SCPTs (with shear wave velocity V_s measurement) were completed in 2002. The cone was pushed to practical refusal to further penetration at each CPT/SCPT location.

Considering that the drill holes did not advance into the glacial deposit/bedrock and drill-outs were not carried out to confirm the cause of the CPT refusals (such as local obstructions, glacial deposit or bedrock?), the presence of glacial deposits and bedrock at KCB's 2002 test hole locations has not been confirmed.

2.1.3 Test Holes Completed by KCB (2009)

Five mud rotary drill holes DH09-01 to -05 and three CPTs labelled as CPT09-01 to -03 were completed by KCB in 2009 within the new West Jetty and South Jetty footprints. CPT09-01, -02, and -03 were paired (put down in close proximity) with drill holes DH09-03, -01, and -02, respectively. All drill holes except DH09-01 were advanced into the bedrock with rock coring to confirm bedrock. Nilcon vane shear tests were completed in the silt and clay deposits and standard penetration tests (SPTs) were conducted in the till-like deposits. One-dimensional consolidation tests, consolidated undrained triaxial tests, and cyclic simple shear tests were carried out on selected Shelby tube samples collected from the silt and clay deposits, and unconfined compression strength (UCS) tests were carried out on selected rock core samples. The elevations of the till-like deposits and bedrock encountered in KCB's 2009 drill holes, the SPT blow count values recorded in the till-like deposits, and the rock coring depths are summarized in Table 2-1 below.

Table 2-1: Summary of KCB (2009) Drill Holes

Drill Hole ID	Elevation of Till-like Deposits (Chart, m)	SPT Blow Count in Till-like Deposits (blow/0.3m)	Elevation of Bedrock (Chart, m)	Depth of Rock Coring (m)
DH09-01	NA	NA	NA	NA
DH09-02 (near the centre of the new South Jetty)	- 32.6	90, 67, 27, 38, 22	- 40.6	4.5
DH09-03 (near the centre of the new West Jetty)	- 42.3	>100, >100, >100, >100, 74, >100	- 50.5	8.3 (8.3 m of coring was reported, but it appeared in the drill log that only 4 m of coring was completed after drilling and SPT testing were carried out for the top 4.3 m of bedrock)
DH09-04 (near the northeast side of the new West Jetty)	- 18.3	>100	- 18.6	4.2
DH09-05 (near the east end of the new South Jetty)	-16.2	NA	- 18.1	3.7

KCB's 2009 drill holes indicate that the thickness of the till-like deposits (including the compact to dense soil layers sandwiched in-between the till-like layers) is approximately 8 m at DH09-02 and -03 located near the centre of the new South Jetty and West Jetty, respectively. The thickness of the till-like deposits reduces to approximately 0.3 m at DH09-04 located near the northeast side of the new West Jetty and reduces to approximately 2 m at DH09-05 located at the east end of the new South Jetty.

2.1.4 Test Holes Completed by Golder (2009)

Golder completed 4 mud rotary boreholes (GBH09-17, -22 to -24), 20 sonic boreholes (all 2009 GBHs except GBH09-17, -22 to -24), and 18 CPTs (GCPT09-01 to -11 and KCPT09-101 to -107) during the site investigation program carried out in 2009. The approximate locations of the test holes put down in the vicinity of the EGD South Jetty site are shown in the attached Figure A-2. A number of boreholes were advanced deep enough to reach the glacial deposits and/or bedrock. Direct shear tests were carried out on selected tube samples collected from the marine sediments.

The interpreted elevations of the different stratigraphic units and their approximate thicknesses were summarized in Table A-1 (ref. Table 2 of Golder's Supplementary Test Hole Investigation Report dated 3 March 2010) attached in Appendix A of this technical memorandum.

In addition, the inferred elevation contours of top of glacial deposits are shown in Figure A-3 (ref. Figure 3b of Golder's Report dated 3 March 2010).

As shown in Figure A-3, the elevation of top of glacial deposits was inferred to drop from elevation -13.1 m (equivalent to -15 m in Geodetic Datum used in the figure) at the northeast corner of the new West Jetty to below -43.1 m (equivalent to -45 m in Geodetic Datum as shown in the figure) at the southwest corner of the new West

Jetty. At the new South Jetty, the elevation of top of glacial deposits was inferred to range from approximately -13.1 m (equivalent to -15 m in Geodetic Datum) at the east end to -33.1 m (equivalent to -35 m in Geodetic Datum) at the west end of the new South Jetty.

The thicknesses of the glacial deposits overlying the bedrock were inferred to range from approximately 3 m to over 14 m, with the exception of the areas at the east end of the South Jetty (east of drill hole DH09-05 and north of the tug boat wharf), where the thickness of the glacial deposit was inferred to be approximately 2 m, and at the northern half of the new West Jetty where the thickness of the glacial deposit was inferred to be less than 0.5 m.

The overall number of the existing boreholes that were advanced to reach the bedrock at the site is relatively limited. For the new South Jetty, the bedrock elevations were inferred to range from approximately -18.1 m at DH09-05 near the east end of the new south jetty to approximately -44.3 m at GBH09-02 near the west end of the new South Jetty. For the new West Jetty, the bedrock elevations were inferred to range from approximately -12.6 m at GBH09-18 near the northeast corner of the new West Jetty to below -55 m near the southwest corner of the new West Jetty.

2.1.5 Test Hole Completed by Golder (2011)

A single sonic borehole BH11-01 was drilled by Golder in 2011. This sonic hole was located at the northeast corner of the new West Jetty. A till-like deposit of about 0.2 m thick was encountered at approximately -14.7 m elevation and bedrock was inferred to be encountered at about -14.9 m elevation.

2.1.6 Inferred Soil Stratigraphy Sections Prepared by Golder (2010 and 2014)

In 2010, Golder prepared a series of five soil stratigraphy sections (labelled as A-A' through E-E') for the South Jetty. In 2014, two additional soil stratigraphy sections, labelled as J-J' and K-K' were added. The approximate locations of the stratigraphy sections A-A' to E-E' and J-J'/K-K' are shown in Figures A-4 and A-1, respectively, attached in Appendix A. The soil stratigraphy sections, attached as Figures A-5 to A-11, identify the following key soil stratigraphic units:

- Unconsolidated Sediments
- Granular and/or Rock Fill
- Upper Marine Sediments (Fine-Grained)
- Upper Marine Sediments (Coarse-Grained)
- Victoria Clay
- Glacial Deposits
- Bedrock

The number of the test holes that were advanced to bedrock (or drilled a notable depth into the glacial deposits) at this site is relatively limited. As such, the top of the glacial deposits and bedrock shown in the cross-sections at many locations could only be inferred based on interpolation/extrapolation of available data.

2.1.7 Soil Stratigraphy Sections A-A to G-G Prepared by KCB (2002)

KCB presents seven soil stratigraphy sections – labelled as A-A to G-G in their "Site Investigation and Liquefaction Assessment Final Report" for EGD and South Landing Wharf dated June 25, 2002. The site plans showing the approximate locations of the test holes and cross-sections and the cross-sections A-A to G-G, provided in KCB's Report as Drawings B-1001 to B-1004, are attached in Appendix A of this Technical Memorandum as Figures A-12 to A-15 for reference.

KCB developed the soil stratigraphy sections based on the test holes completed during their 2002 site investigation and data from historical test holes completed prior to 2002 by the others. These stratigraphy sections do not identify glacial soils and the presence of bedrock at many test hole locations was inferred and labelled as "BEDROCK ?" in the sections.

Based on the information shown in Section A-A, bedrock at the proposed rock-socketed displacement control pile locations in front of the existing timber crib is inferred to be at approximately -20 m to -24 m elevation (chart), compared to the -22 m to -28 m steel pile toe elevations assigned to the rock-socketed displacement control piles in KCB's 99% completion design and construction documents.

2.2 Jetty Design Criteria (KCB, 2010)

The following provides brief excerpts from "Section 5 – Seismic Design Parameters" and "Section 6 - Geotechnical Design" of the Design Criteria (Revision 3) document prepared by KCB for the EGD South Jetty Wharf Development (25 November 2010):

Open-ended steel pipe piles:

- Ultimate geotechnical compression resistance of open-ended steel pipe piles shall be calculated in accordance with API methodology;
- Calculated outside shaft friction and annulus resistance shall be reduced to 80%;
- Calculated inside shaft friction shall be reduced to 30%;
- The piles shall be assumed to be unplugged;
- A geotechnical resistance factor of 0.5 shall be applied to the ultimate geotechnical compression resistance to obtain the factored geotechnical compression resistance;
- If the required embedment length places the pile toe below the estimated rock elevation, the design toe elevation shall be the estimated rock elevation; and
- Indicator piles with PDA and CAPWAP wave equation analyses shall be driven at the beginning of the project to confirm the factored pile resistance and termination criteria.

Rock-socketed "displacement control piles":

- Ultimate geotechnical resistance of rock-socketed piles shall be calculated in accordance with Duncan (1992) and Kulhawy (1993);

- For compression piles, a geotechnical resistance factor of 0.5 shall be applied to the ultimate friction resistance of the rock socket to obtain the factored geotechnical compression resistance. Tip resistance of the socket shall not be included; and
- For tension piles, a geotechnical resistance factor of 1.0 shall be applied to the weight of a 90 degree rock cone originating at the bottom of the rock socket. A geotechnical resistance factor of 0.4 shall be applied to the ultimate friction resistance of the socket to obtain the factored geotechnical tension resistance.

Laterally loaded piles:

- The soil-pile interaction shall be modeled using a set of soil-pile springs (p-y curves) attached to the pile along its length (using the computer program LPile Plus (Ensoft, 2005));
- API-recommended p-y curves shall be used for the non-liquefiable soils;
- For liquefiable soils, API-recommended p-y curves for soft clay shall be used, using the post-liquefaction residual strength of the liquefied soils as ultimate strength;
- Pile head conditions shall be taken as fixed, unless the fixed pile head moment exceeds the plastic moment; and
- Soil displacement shall be estimated based on limit equilibrium, Newmark-type analyses, supplemented by FLAC results from KCB's seismic analyses performed for this site in 2002 (under a previous project).

Seismic Design:

- Seismic design of the new South and West Jetties shall correspond to a no-collapse state of the structure when subjected to the 475-yr return period ground motions.

2.3 Herold Engineering Pile Drawings

Based on Herold Engineering Drawings (Revision A) dated August 12, 2016, the new "West Jetty" and "South Jetty" are to be supported on steel pipe piles to be installed into the competent glacial deposits underlying the loose/soft sediments or onto bedrock. The piles are to be driven as open-ended steel pipe piles with a hardened shoe that is flush with the outside face of the pile and have diameters ranging from 762 mm to 914 mm. Both pile sizes will have a wall thickness of 22 mm. Piles are specified in the drawings to be driven to practical refusal, defined as 25 mm of pile movement for 15 blows applied using a Delmag D150 impact hammer (or equivalent). Based on the information provided in the drawings, installation of piles with rock sockets are only considered for the piles immediately west of the existing timber crib for control of seismic lateral displacements. In total, 14 piles arranged in two rows of 7 piles each are shown. These piles are 762 mm-in diameter with 706 mm-diameter rock sockets with a minimum bond length of 3.2 m. The KCB's drawings and design criteria refer to these piles as "displacement control piles".

The existing tug boat facilities (floats and piles) near the east end of the south jetty are to be removed temporarily during reconstruction of the jetty, but it will be reinstated at the same location after construction of the South and

West Jetties. The drawings show two 914 mm-diameter steel pipe piles to be installed for the reinstated tug boat float.

The design pile diameters, pile top and toe elevations, and pile lengths are summarized in the tables on Herold's Drawing Sheet S19.

3.0 GEOTECHNICAL REVIEW AND VALIDATION OF THE PILE DESIGN

The geotechnical review and validation of the pile foundation design was carried out utilizing available information on subsurface conditions and the factored axial compression and tension loads provided by Herold for various load combinations. We understand that these design pile loads correspond to the load combinations and 475-yr design response spectra in CSA S6-14, and depth of fixity of piles established using the public domain computer code ETABS following guidelines given in ASCE 61-14. Based on discussions with Herold, we further understand that the pile loads correspond to values computed at the underside of the wharf and therefore they exclude the self-weight of piles. The factored design loads provided by Herold on January 19, 2017 for the new West Jetty and on 23 January 2017 for the new South Jetty are shown in Tables B-1 and B-2, respectively, in Appendix B of this Technical Memorandum.

The pile loads shown in Tables B-1 and B-2 indicate the following:

- Computed factored axial compression loads for the piles approach values as high as 5.5 MN/pile with approximately 40% of the piles comprising the new South and West Jetties (excluding the displacement control piles and tug boat float piles) reaching design compression loads in excess of 4 MN/pile. With a geotechnical resistance factor, ϕ, equal to 0.5 in compression, an ultimate geotechnical compression capacity in excess of 8 MN/pile and as high as 11 MN/pile are required to be developed.
- The perimeter piles are subject to factored axial tension loads that vary from 20 kN/pile to values as high as 1,885 kN/pile. With a geotechnical resistance factor, ϕ, equal to 0.3 in tension, a maximum ultimate geotechnical tension capacity of the order of 6 MN/pile are required to be developed. The piles with the largest tension loads are located towards the west end of the new West Jetty and these piles are embedded some 30 m to 40+ m in clay.

Based on our experience with the installation of piles using impact pile driving techniques at the CFB Esquimalt site and at the 443 Squadron site in Patricia Bay, and in the absence of the results from the pile load testing completed previously by the others for the existing steel-piled concrete wharf, we do not consider driving steel pipe piles into bedrock to achieve ultimate compression capacities of the order of 8 to 11 MN/pile to be a feasible option considering the following:

1) Undulating bedrock surface at the site at times with sharp drops in elevation over short horizontal distances
2) Strength and stiffness of the underlying bedrock. Based on the available test results of the 2 unconfined compression strength (UCS) tests completed by KCB in 2010, compressive strength values of 77 MPa and 54 MPa were obtained from the tested bedrock samples collected in DH09-04 (at 2.4 m depth below bedrock surface) and in DH09-05 (at 2.7 m depth below bedrock surface), respectively, and
3) Lack of till confinement in certain areas of the proposed new jetties to hold the piles in place during installation.

We acknowledge that installing the piles vertically with hardened tips attached to the pile toes would reduce the risk of pile toe damage during installation using impact hammers. We envisage that a change to the method of pile installation, should such a change is deemed necessary after installation and assessment of load carrying capacity of the indicator piles, would be costly and could result in significant delays to the project.

For the reasons noted above, we have classified the piles supporting the proposed new Jetties and the Tug Boat Wharf including the displacement control piles into three types:

Type-1: Piles that will be driven and embedded in the glacial deposits, or onto or a small distance into bedrock using impact methods and partially filled with concrete (in the upper 10 m)

Type-2: Piles that will be drilled into bedrock, socketed into bedrock, and completely filled with concrete along with a reinforcing steel cage

Type-3: Piles that will be driven and embedded in the glacial deposits, or onto or a small distance into bedrock using impact methods and not filled with concrete at all – such as the piles proposed for the Tug Boat Wharf

Based on our experience with installation of piles using impact driving methods, we consider it impractical or difficult to install and confirm the geotechnical load carrying capacity of piles when the available thickness of dense till or till-like soils is less than about 5 m. The pile design for the loads provided by Herold has been completed with the following additional considerations on ultimate geotechnical load carrying capacities that can be mobilized in the underlying soils:

- Ultimate geotechnical end bearing resistance of piles driven into glacial till or till-like soils = 2 MPa
- Ultimate geotechnical end bearing resistance of piles driven onto bedrock,
- or a small distance into bedrock = 7 MPa
- Ultimate shaft resistance in glacial till or dense till-like soils = 225 kPa
- Ultimate shaft resistance at the rock-grout interface of rock sockets = 1.4 MPa
- Ultimate end bearing resistance of rock sockets = 0 MPa
- Geotechnical resistance factors for piles in compression and tension of 0.5 and 0.3, respectively, with provision for PDA testing of driven piles and static load testing (or equivalent testing) of rock socketed piles.

In order to complete the foundation design, we have interpolated/extrapolated the available and limited subsurface data collected at various test hole locations and developed contour maps outlining the inferred top of glacial deposit (till/till-like) surface and top of bedrock surface. The accuracy of these contour plots varies with location, with improved accuracy at the actual test hole locations where both glacial deposits and bedrock have been confirmed, to upwards of ± 5 m where data is sparse and/or glacial deposit and bedrock have not been confirmed (eg. indicated in the borehole logs as “inferred till?” or “inferred bedrock?”, or in areas where the elevations have been extrapolated based on subsurface data from nearby test holes). The inferred glacial deposit surface and bedrock surface elevation contours (in Geodetic Datum) are shown on Figures 3-1 and 3-2, respectively. Also shown on these figures are the approximate plan locations of the test holes, with the confirmed/inferred/extrapolated elevation values (Geodetic Datum) used to develop the contours shown adjacent to the corresponding test hole locations. The limited test hole locations where glacial deposit and/or bedrock elevations have been confirmed by drilling/sampling are circled (in orange color) in the figures. Note that although

a large number of test holes have been drilled within the footprint of the proposed reconstruction of the South and West Jetties, the number of locations where glacial deposit and bedrock elevations have been confirmed is limited to less than 15.

The pile designs for the “displacement control piles” and the Tug Boat Wharf have not been confirmed since the design loads for these piles were still under review by Herold at the time of preparation of this technical memorandum.

Consistent with the KCB’s 99% completion design, Type-2 piles that are 762 mm in diameter having a wall thickness of 22 mm have been provided with sockets that are 706 mm in nominal diameter. Type-2 piles that are 914 mm in diameter having a wall thickness of 22 mm have been provided with sockets that are 850 mm in nominal diameter. All rock-socketed piles should be drilled into bedrock a distance equal to 1 m measured from the high side of bedrock with a sacrificial shoe that is designed to penetrate and develop a seal within granitic bedrock underlying the site. The wall and base of all rock sockets should be thoroughly cleaned using water jetting or other suitable techniques to remove soil debris adhering to the casings and rock surface or deposited in the socket. The sockets should thereafter be inspected using both optical and sonic imaging techniques to confirm the rock conditions surrounding the socket and approved as capable of supporting the design loads by qualified geotechnical personnel.

The soil inside the lower 5 m of Type-1 piles should not be cleaned after installation. The purpose of this recommendation is to minimize soil disturbance during cleaning of piles, thereby minimizing the risk of having a lower ultimate geotechnical resistance than required.

The maximum rated energy of the impact hammer selected to install Type-1 and Type-3 piles should be reduced by 50% during installation of the last 5 m of the pile. This is to minimize the risk of damage to pile toe during installation as Type-3 piles and a number of Type-1 piles will be seated on bedrock or a small distance into bedrock.

KCB specified in their design criteria that API method be used to calculate the ultimate geotechnical compression resistance of the steel pipe piles, with the calculated outside skin friction and annulus resistance be reduced to 80%. As a check, the geotechnical capacity of a selected pile located near the southwest corner of the new West Jetty (where great thickness of the overburden soils is present) is calculated using both the API method and LCPC method. For a 762 mm diameter pile located near CPT02-03, the shaft resistance (unfactored) in the upper marine sediments and Victoria Clay (approximately 42 m in total thickness at this pile location) estimated using the API method is about 4.4 MN/pile, whereas the resistance estimated using the LCPC method is approximately 1.7 MN/pile. Considering the significant variation in the capacities computed using the two methods and variations in site soil conditions, we have opted to use the conservatively estimated shaft resistance from the LCPC method for foundation design.

Foundation design parameters, established using the methods described above and the factored loads provided by Herold, are summarized in Tables C-1 to C-4 attached in Appendix C of this technical memorandum in terms of pile classification, casing toe elevation of each pile, design socket diameter, and design socket length (bond length). A plot showing the approximate layout of the classified pile types (1 and 2) for the new West and South Jetties is shown on the attached Figure C-1 for general reference. Note that the toe elevations of the pile casings and rock sockets inferred based on available data have been estimated based on the glacial deposit and bedrock contour maps prepared. The actual toe elevations of the piles and sockets may vary by as much as approximately ± 3 m (in average) from those shown in Tables C-1 to C-4 and provision should be made in the tender documents to accommodate such changes resulting from insufficient subsurface data.

Additional geotechnical review and analyses are currently being carried out by Golder taking into consideration such new information as additional historical test hole data and pile load tests carried out on driven 558 mm diameter steel pipe piles during construction of the existing concrete wharf. The new information was recently made available to Golder during discussions we had with Herold. Revisions to the pile design recommendations will be made and revised pile tables (Tables C-1 to C-4 and Figure C-1) will be issued on or before 3 March 2017.

3.1 Additional Geotechnical Review Tasks and Analyses (To Be Carried Out)

To date, we have only completed a preliminary review of the impact of soil liquefaction and associated consequences such as lateral and vertical soil displacements on the proposed new foundations.

Our review of soil stratigraphy sections across the subject areas of the site indicates that the area south of the Graving Dock and underlying the L-Shaped Concrete Wharf, are underlain by potentially liquefiable soils to depths of the order of 20+ m. While the existing tied-back sheet pile wall between the Graving Dock and the L-Shaped Concrete Wharf may likely reduce the liquefaction-induced soil displacements and the resulting impact on the L-Shaped Concrete Wharf, the adequacy of the 300 mm seismic gap between the L-Shaped Concrete Wharf and the new South Jetty needs to be confirmed by completing soil-structure analyses. We are currently in the process of completing some of the initial analyses required.

Our review of site soil conditions indicates that the proposed new West Jetty is predominantly underlain by cohesive fine-grained marine sediments and clay. As such, soil liquefaction effects are assessed to be less severe for the new West Jetty than for the new South Jetty. Nevertheless, the effects of kinematic loading on these piles need to be assessed and the design should be confirmed.

Also, we were awaiting confirmation of foundation loads for the “displacement control piles” and Tug Boat Wharf piles, and lateral loads for the new West and South Jetties piles at the time of preparation of this technical memorandum. The foundation design for these specific structures will be confirmed upon receipt of the detailed loading for these piled structures.

4.0 REVISIONS TO TECHNICAL SPECIFICATIONS – PILE FOUNDATIONS

The Technical Specifications for Pile Foundations were reviewed and modified to suit the pile design recommendations presented above in Section 3.0. The modifications include: re-classification of pile types (i.e. Type-1, Type-2 and Type-3 Piles), pile installation methodology, and pile testing requirements. The revised Technical Specifications are included in Appendix C of this Technical Memorandum.

5.0 PROPOSED PATH FORWARD

Considering the tight timelines established for the project, Golder has embraced the concept of installation of “Indicator Piles” earlier on in the construction phase (as proposed by KCB) to confirm the driveability of pipe piles and the ultimate geotechnical resistance that can be mobilised in the Type 1 and Type 2 piles.

The installation of a series of some twenty “Indicator Piles” distributed throughout the new jetties at the on-set of the construction phase will have a significant impact on the efficient installation of piles and hence the schedule and cost of jetty completion. The pile installation difficulties associated with restricted barge access to pile locations may be minimized by installing the “Indicator Piles” in blocks or stages. Alternatively, consideration may be given to completing an offshore drilling program to confirm soil and bedrock conditions at approximately two dozen locations distributed throughout the proposed new West and South Jetties, where adequate subsurface information does not exist.

In the absence of a supplementary geotechnical investigation, PWGSC may proceed cautiously to tender the design, by making an allowance for the pile and socket lengths to account for the variability in glacial deposits and bedrock surface elevations. For budgetary purposes, an allowance of ± 3 m to the pile casing length is proposed to those given in Tables C-1 to C-4. The actual increment to pile and socket lengths may be longer or shorter than the 3 m proposed herein and suitable addition/deletion clauses need to be included in the Tender Documents to reflect this uncertainty.

As noted in Section 3.0 above, additional geotechnical review and analyses are currently being carried out by Golder and the results and recommendations presented in this memorandum will be revised on or before 3 March 2017.

6.0 CLOSURE

We trust that the contents of this Technical Memorandum meet with your immediate requirements. Should you have questions or require clarification of contents, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. H. L. TSE # 36431 March 1, 2017

Leo Tse, MEng, PEng
Geotechnical Engineer

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA U. D. ATUKORALA March 1, 2017

Upul D. Atukorala, PhD, PEng
Principal and Senior Geotechnical Engineer

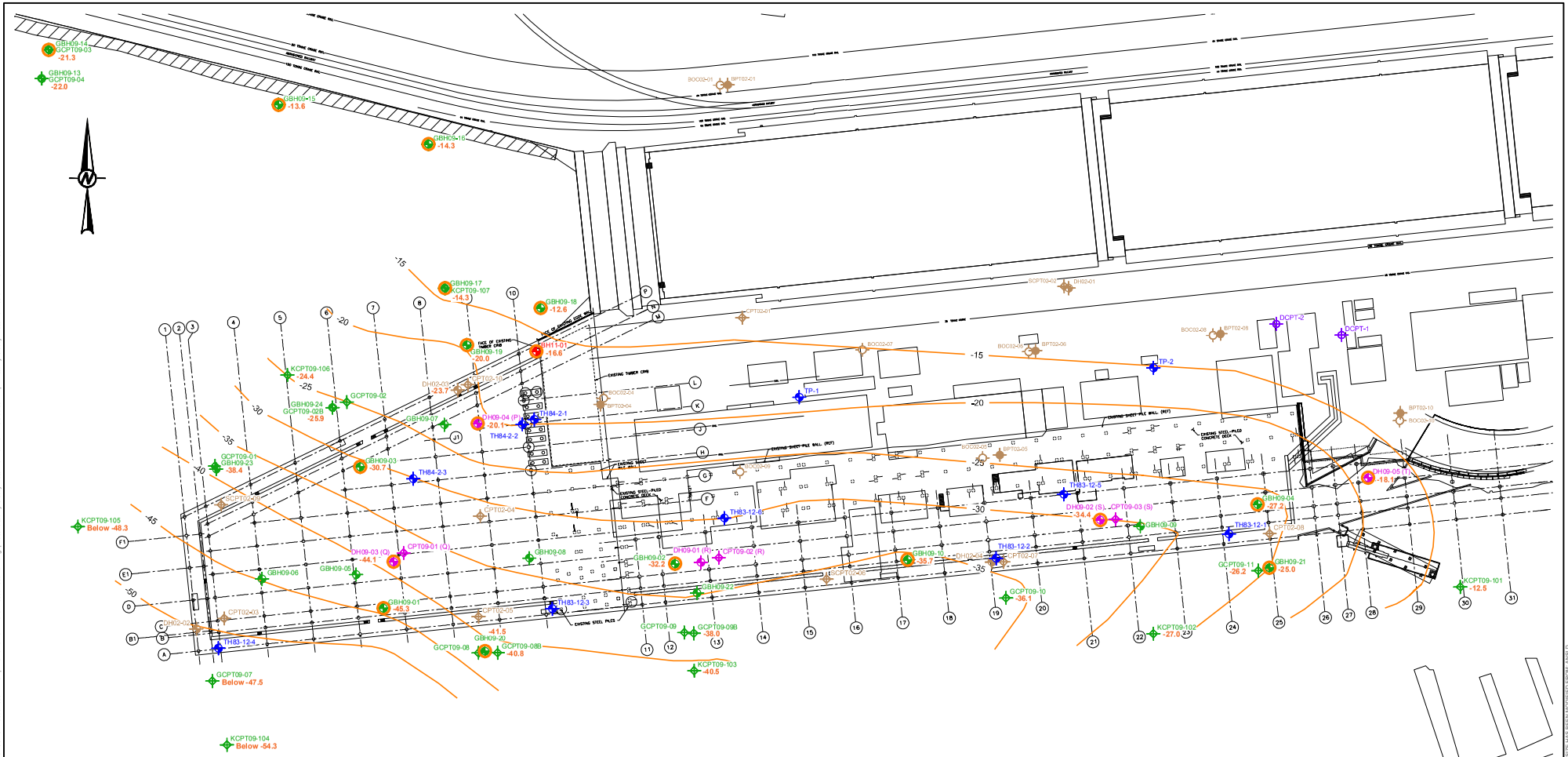
Sarah Morse

Sarah Morse, PEng
Project Manager and Senior Geotechnical Engineer

LT/UDA/nnv

Attachments: Figure 3-1: Inferred Elevation of Top of Glacial Deposits
Figure 3-2: Inferred Elevation of Bedrock
Appendix A – Existing Test Holes and Subsurface Information
Appendix B – Pile Design Loads Provided By Herold Engineering
Appendix C – Summary Tables and Revised Technical Specifications for Pile Foundations

\\golder.gds\gal\victoria\final\2013\1447\13-1447-0497 pwgsc wood creek quarry\1314470497-058-tm-rev0\1314470497-058-tm-rev0-99% pile design 01mar_17.docx



LEGEND

- 1983 AND 1984 TEST HOLE BY HARDY ASSOCIATES (1978) LTD AND KER PRIESTMAN & ASSOCIATES LTD.
- 1997 TEST HOLE BY TERRA ENGINEERING LTD.
- 2002 CLOSE-ENDED BECKER DRILL HOLE BY KCB.
- 2002 OPEN-ENDED BECKER DRILL HOLE BY KCB.
- 2002 MUD ROTARY DRILL HOLE BY KCB.
- 2002 CONE PENETRATION TEST BY KCB.
- 2009 MUD ROTARY DRILL HOLE BY KCB.
- 2009 CONE PENETRATION TEST BY KCB.
- 2009 MUD ROTARY OR SONIC BOREHOLE BY GOLDER.
- 2009 CONE PENETRATION TEST BY GOLDER.
- 2011 SONIC BOREHOLE BY GOLDER.
- TEST HOLE LOCATION WITH CONFIRMED ELEVATION OF TOP OF GLACIAL DEPOSIT
- -30.7 INFERRED / INTERPRETED ELEVATION OF TOP OF GLACIAL DEPOSIT (METRES*)
- INFERRED ELEVATION CONTOURS FOR TOP OF GLACIAL DEPOSIT (5m INTERVALS*)

NOTES

1. *** ALL ELEVATIONS (IN METRES) REFERRED TO GEODETIC DATUM.** CONVERSION AT THIS SITE: ELEVATION (GEODETIC) = ELEVATION (CHART) - 1.871 m
2. GLACIAL DEPOSITS SURFACE ELEVATIONS HAVE BEEN INFERRED FROM TEST HOLE DATA AT THE TEST HOLE LOCATIONS SHOWN. ACTUAL ELEVATIONS BETWEEN THE TEST HOLES AND AT TEST HOLE LOCATIONS WHERE TOP OF GLACIAL DEPOSITS COULD NOT BE CONFIRMED MAY VARY FROM THAT SHOWN.
3. ALL TEST HOLE LOCATIONS AND PILE LOCATIONS ARE APPROXIMATE ONLY.

REFERENCES

1. DRAWINGS BASE INFORMATION PROVIDED BY PUBLIC WORKS AND GOVERNMENT SERVICES CANADA. LOCATION OF EXISTING FACILITIES ARE APPROXIMATE ONLY.
2. TEST HOLE LOCATIONS OBTAINED FROM KLOHN CRIPPEN BERGER'S GEOTECHNICAL DATA REPORT DATED MARCH 23, 2010.
3. PILE LAYOUT OBTAINED FROM HEROLD ENGINEERING - PILE PLAN DRAWINGS S01 AND S02 (REVISION A) DATED AUGUST 12, 2016.
4. ORIGINAL ELEVATION CONTOURS OF TOP OF GLACIAL DEPOSITS OBTAINED FROM FIGURE 3B - GOLDER'S GEOTECHNICAL REPORT DATED MARCH 3, 2010.

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-27
DESIGNED	K. LAM
PREPARED	S. REDDY
REVIEWED	L. TSE
APPROVED	U. ATUKORALA

PROJECT
ESQUIMALT GRAVING DOCK
SOUTH JETTY RECONSTRUCTION PROJECT
ESQUIMALT, B.C.

TITLE
INFERRED ELEVATION OF TOP OF GLACIAL DEPOSITS

PROJECT NO.	PHASE	REV.	FIGURE
13-1447-0497	13000/13002	0	3-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI D
25mm

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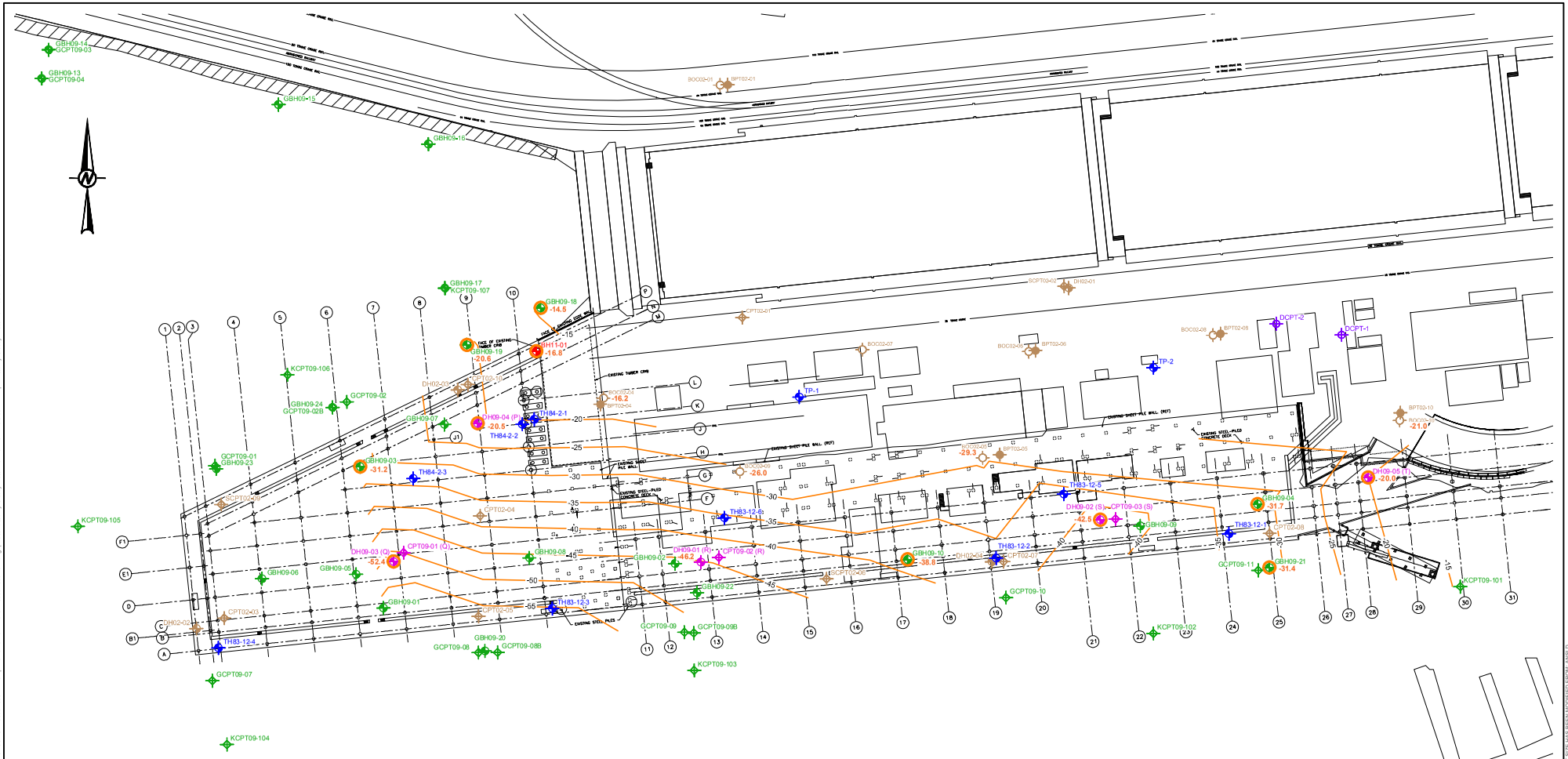

LEGEND

- 1983 AND 1984 TEST HOLE BY HARDY ASSOCIATES (1978) LTD AND KER PRIESTMAN & ASSOCIATES LTD.
- 1997 TEST HOLE BY TERRA ENGINEERING LTD.
- 2002 CLOSE-ENDED BECKER DRILL HOLE BY KCB.
- 2002 OPEN-ENDED BECKER DRILL HOLE BY KCB.
- 2002 MUD ROTARY DRILL HOLE BY KCB.
- 2002 CONE PENETRATION TEST BY KCB.
- 2009 MUD ROTARY DRILL HOLE BY KCB.
- 2009 CONE PENETRATION TEST BY KCB.
- 2009 MUD ROTARY OR SONIC BOREHOLE BY GOLDER.
- 2009 CONE PENETRATION TEST BY GOLDER.
- 2011 SONIC BOREHOLE BY GOLDER.
- TEST HOLE LOCATION WITH CONFIRMED ELEVATION OF TOP OF BEDROCK
- -30.7 INFERRED / INTERPRETED ELEVATION OF TOP OF BEDROCK (METRES*)
- INFERRED ELEVATION CONTOURS FOR TOP OF BEDROCK (5m INTERVALS*)

NOTES

1. *** ALL ELEVATIONS (IN METRES) REFERRED TO GEODETIC DATUM.** CONVERSION AT THIS SITE: ELEVATION (GEODETIC) = ELEVATION (CHART) - 1.871 m
2. BEDROCK SURFACE ELEVATIONS HAVE BEEN INFERRED FROM TEST HOLE DATA AT THE TEST HOLE LOCATIONS SHOWN USING LINEAR INTERPRETATION TECHNIQUE. ACTUAL ELEVATIONS BETWEEN THE TEST HOLES AND AT TEST HOLE LOCATIONS WHERE TOP OF BEDROCK COULD NOT BE CONFIRMED MAY VARY FROM THAT SHOWN.
3. ALL TEST HOLE LOCATIONS AND PILE LOCATIONS ARE APPROXIMATE ONLY.

REFERENCES

1. DRAWINGS BASE INFORMATION PROVIDED BY PUBLIC WORKS AND GOVERNMENT SERVICES CANADA. LOCATION OF EXISTING FACILITIES ARE APPROXIMATE ONLY.
2. TEST HOLE LOCATIONS OBTAINED FROM KLOHN CRIPPEN BERGER'S GEOTECHNICAL DATA REPORT DATED MARCH 23, 2010.
3. PILE LAYOUT OBTAINED FROM HEROLD ENGINEERING - PILE PLAN DRAWINGS S01 AND S02 (REVISION A) DATED AUGUST 12, 2016.

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-27
DESIGNED	K. LAM
PREPARED	S. REDDY
REVIEWED	L. TSE
APPROVED	U. ATUKORALA

PROJECT
ESQUIMALT GRAVING DOCK
SOUTH JETTY RECONSTRUCTION PROJECT
ESQUIMALT, B.C.

TITLE
INFERRED ELEVATION OF BEDROCK

PROJECT NO.	PHASE	REV.	FIGURE
13-1447-0497	13000/13002	0	3-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI D
25mm

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APPENDIX A -
Existing Test Holes and Subsurface Information

Technical Memorandum Table A-1

Table 2
Interpreted Stratigraphic Unit Elevations and Approximate Thicknesses

				Stratigraphic Unit:	Unconsolidated Sediments	Fill Materials		Upper Marine Sediments (Fine-Grained)		Upper Marine Sediments (Coarse-Grained)		Victoria Clay		Glacial Deposits		Bedrock
Test Hole ID	Facility Area	Approximate Mudline Elevation (m Geodetic)	Bottom of Hole Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Thickness (m)	Top Elevation (m Geodetic)	Top Elevation (m Geodetic)
GBH09-01	South Jetty (Southwest)	-8.7	-57.1	4.4			-13.0	4.3	Not Encountered		-17.3	28.0	-45.3	>11.8	below -57.1	
GBH09-02	South Jetty (South Side)	-4.5	-48.7	No Recovery to 1.2 m depth	-4.5	8.1	-12.6	2.2	Not Encountered		-14.8	17.4	-32.2	14.0	-46.2 (inferred)	
GBH09-03	South Jetty (Northwest)	-9.6	-36.0	No Recovery to 3.1 m depth			-12.7 or higher	at least 4.6	Not Encountered		-17.3 or lower	up to 13.4	-30.7	0.5	-31.2	
GBH09-04	South Jetty (South Side)	-4.3	-36.3	1.5	-5.8	0.3	Not Encountered		Not Encountered		-6.1	21.0	-27.2	4.6	-31.7	
GBH09-05	South Jetty (Southwest)	-9.2	-20.6	No Recovery to 2.3 m depth		at least 0.3	-11.8	5.6	Not Encountered		-17.4					
GBH09-06	South Jetty (Southwest)	-10.1	-20.8	No Recovery to 4.6 m depth			-14.7 or higher	at least 3.0	Not Encountered		-17.7					
GBH09-07	South Jetty (Northwest)	-9.6	-17.7	3.4	-13.0	0.6	-13.6	0.5	-14.7	1.1	-15.8					
GBH09-08	South Jetty (Southwest)	-9.2	-17.7	No Recovery to 2.4 m depth			-11.6 or higher	at least 3.1	-14.7	1.1	-15.8					
GBH09-09	South Jetty (South Side)	-6.2	-14.7	1.5	-7.6	1.3	-8.9	1.1	-10.0	1.6	-11.6					
GBH09-10	South Jetty (South Side)	-7.8	-42.4	0.5			-8.3	3.6	-11.9	2.0	-13.9	21.8	-35.7	3.1	-38.8	
GBH09-11	Munroe Head	-2.9	-22.7	Not Encountered	-2.9	13.1	-16.0	2.2	-18.1	1.5	-19.6					
GBH09-12	Munroe Head	-10.3	-21.6	Not Encountered	-10.3	6.4	Not Encountered		Not Encountered		Not Encountered		Not Encountered		-16.7	
GBH09-13/GCPT09-04	North Landing Wharf	-13.2	-19.5	1.8	-15.0	0.8	-15.8	1.2 (est.)	No Recovery		-17 (est.)	5 (est.)	-22.0			
GBH09-14/GCPT09-03	North Landing Wharf	-12.9	-27.0	1.2	-14.2	0.4	-14.6	1.5	-16.1	0.5	-16.6	4.7	-21.3	4.2	-25.5	
GBH09-15	North Landing Wharf	-12.5	-21.0	1.1			Not Encountered		Not Encountered		Not Encountered		-13.6	7.3	-20.9	
GBH09-16	North Landing Wharf	-12.2	-15.7	0.7	-12.9	1.4	Not Encountered		Not Encountered		Not Encountered		-14.3	1.2	-15.5	
GBH09-17/KCPT09-107	South Jetty (Northwest)	-12.8	-14.5	0.5			Not Encountered		-13.2	1.1	Not Encountered		-14.3			
GBH09-18	South Jetty (Northwest)	-12.1	-15.8	0.5			Not Encountered		Not Encountered		Not Encountered		-12.6	2.0	-14.5	
GBH09-19	South Jetty (Northwest)	-12.8	-23.1	0.9			Not Encountered		-13.7	0.9	-14.6	5.4	-20.0	0.6	-20.6	
GBH09-20	South Jetty (Southwest)	-13.9	-63.6	0.5			-14.4	1.9	Not Encountered		-16.3	25.2	-41.5	>22.1	below -63.6	
GBH09-21	South Jetty (South Side)	-12.2	-35.1	1.4			Not Encountered		Not Encountered		-13.6	11.4	-25.0	6.4	-31.4	
GBH09-22	South Jetty (South Side)	-9.1	-21.9	1.7			-10.8	3.8	Not Encountered		-14.6					
GBH09-23	South Jetty (Northwest)	-13.8	-28.5	Min. Recovery to 1.2 m depth			-14.2	3.4	Not Encountered		-17.6					
GBH09-24/GCPT09-02B	South Jetty (Northwest)	-13.2	-26.1	1.1	-14.3	0.9	-15.2	1.8 (est.)			-17 (est.)	9 (est.)	-25.9			
GCPT09-01	South Jetty (Northwest)	-13.6	-38.6	0.6			-14.2	3.4	Not Encountered		-17.6	20.8	-38.4			
GCPT09-05	North Landing Wharf	-13.6	-29.0	0.5	-14.1	2.7	-16.8	1.7	Not Encountered		-18.5	10.4	-28.9			
GCPT09-06	North Landing Wharf	-14.3	-30.3	0.5			-14.8	3.7	Not Encountered		-18.5	11.2	-29.7			
GCPT09-07	South Jetty (Southwest)	-14.0	-47.5	0.5			-14.5	3.6	Not Encountered		-18.1	>29.4	below -47.5			
GCPT09-08B	South Jetty (Southwest)	-14.1	-41.0	1.3			-15.4	1.2	Not Encountered		-16.5	24.3	-40.8			
GCPT09-09B	South Jetty (South Side)	-13.7	-38.1	1.2			Not Encountered		Not Encountered		-14.8	23.2	-38.0			
GCPT09-10	South Jetty (South Side)	-12.3	-37.7	2.0			Not Encountered		Not Encountered		-14.3	21.8	-36.1			
GCPT09-11	South Jetty (South Side)	-12.2	-26.4	1.4			Not Encountered		Not Encountered		-13.6	12.6	-26.2			
KCPT09-101	South Jetty (South Side)	-5.6	-13.3	1.0			Not Encountered		-6.6	2.0	-8.6	3.9	-12.5			
KCPT09-102	South Jetty (South Side)	-12.6	-27.3	1.8			Not Encountered		Not Encountered		-14.4	12.6	-27.0			
KCPT09-103	South Jetty (South Side)	-13.5	-40.6	1.5			Not Encountered		Not Encountered		-15.0	25.5	-40.5			
KCPT09-104	South Jetty (Southwest)	-14.0	-54.3	0.7			-14.7	3.4	Not Encountered		-18.0	>36.3	below - 54.3			
KCPT09-105	South Jetty (Northwest)	-13.4	-48.3	1.2			-14.6	3.9	Not Encountered		-18.5	>29.8	below - 48.3			
KCPT09-106	South Jetty (Northwest)	-13.7	-26.1	0.7			-14.4	2.5	Not Encountered		-16.9	7.5	-24.4			

Technical Memorandum Figure A-1

Elevations (in meters) referenced to Chart Datum

LEGEND

- SECTION LINE
- GBH09 — BOREHOLE LOCATIONS - GOLDER 2009
- SC09 — SEDIMENT CORE LOCATIONS - GOLDER 2009
- BH11 — BOREHOLE LOCATIONS - GOLDER 2011
- KCPT — CONE PENETRATION TEST LOCATIONS - KLOHN CRIPPEN 2009
- GCPT — CONE PENETRATION TEST LOCATIONS - GOLDER 2009
- BPT02 DH02 BOC02 CPT02 SCPT02 — SAMPLING LOCATIONS - KLOHN CRIPPEN 2002
- BATHYMETRY CHART DATUM CONTOUR - MAJOR (5m INTERVALS) CRA CANADA SURVEYS INC. (2009 AND 2010)
- BATHYMETRY CHART DATUM CONTOUR - MINOR (0.5m intervals) CRA CANADA SURVEYS INC. (2009 AND 2010)
- EXISTING TIMBER CRIB
- EXISTING TIMBER PILE SUPPORTED JETTY
- EXISTING STEEL PILE SUPPORTED JETTY

NOTE

FOR DETAILS OF SECTIONS A-A', C-C', D-D', E-E', J-J' AND K-K' REFER TO FIGURES 4a, 4c, 4d, 4e, 4j, and 4k.

REFERENCES

BASE OBTAINED FROM CLIENT.

CRIB LOCATION PROVIDED BY KLOHN CRIPPEN BERGER, CAD FILE: *Existing EGD Timber Jetty Base.dwg*, E-MAILED: AUGUST 9, 2010

SCALE 0 30 60 90 METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

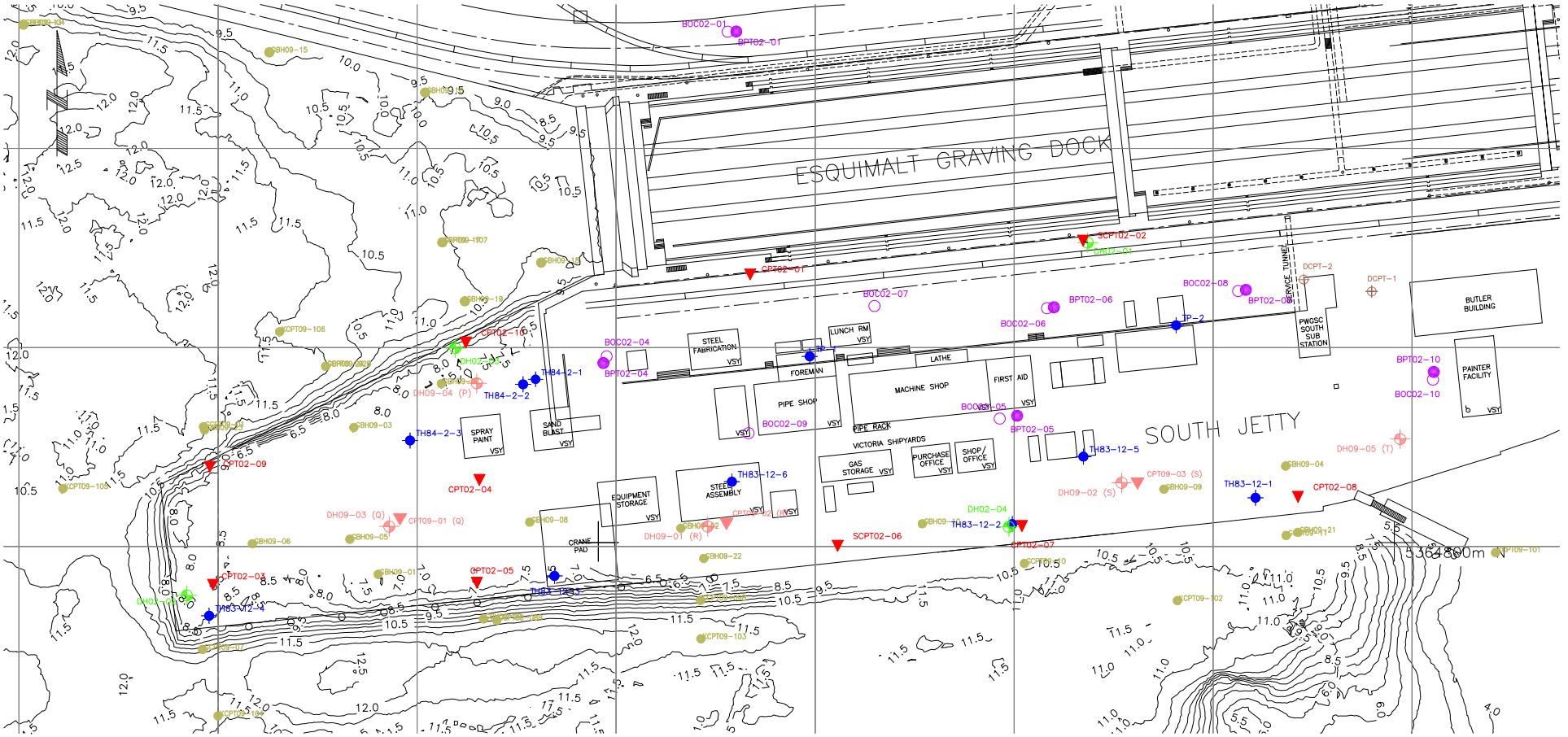
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE

SOUTH JETTY SECTION LOCATION PLAN

Golder Associates

PROJECT No.	13-1447-0478.1000.1001		FILE No.	1314470478-1001-03	
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN	
CADD	AMW	2013-12-09	FIGURE		
CHECK	SEM	2014-03-24		3	
REVIEW	RW	2014-03-24			



PLAN

LEGEND

- TH83-12-1 — 1983 AND 1984 TEST HOLE BY ASSOCIATED (1978) LTD.
- DCPT-1 — 1997 TEST HOLE BY TERRA ENGINEERING LTD.
- BPT02-01 — 2002 CLOSED-ENDED BECKER DRILL HOLE BY KCB.
- BOC02-01 — 2002 OPEN-ENDED BECKER DRILL HOLE BY KCB.
- DH02-01 — 2002 MUD ROTARY DRILL HOLE BY KCB.
- CPT02-01 — 2002 CONE PENETRATION TEST BY KCB.
- DH09-01 — 2009 MUD ROTARY DRILL HOLE BY KCB.
- CPT09-01 — 2009 CONE PENETRATION TEST BY KCB.
- GBH09-10 — 2009 SITE INVESTIGATION PROGRAM BY GOLDER ASSOCIATES (INCLUDING SONIC BORE HOLES, MUD ROTARY DRILL HOLES AND CONE PENETRATION TESTS)

NOTES:

1. BATHEMETRY CONTOURS (0.5m INTERVALS) PROVIDED BY CRA SURVEYS, FEBRUARY 2007.
2. DRAWING BASE INFORMATION PROVIDED BY PWGSC. LOCATION OF EXISTING FACILITIES ARE APPROXIMATE ONLY.
3. ELEVATIONS REFER TO CHART DATUM.

Technical Memorandum Figure A-2
Elevations (in meters) referenced to Chart Datum

0 1:500 25

NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

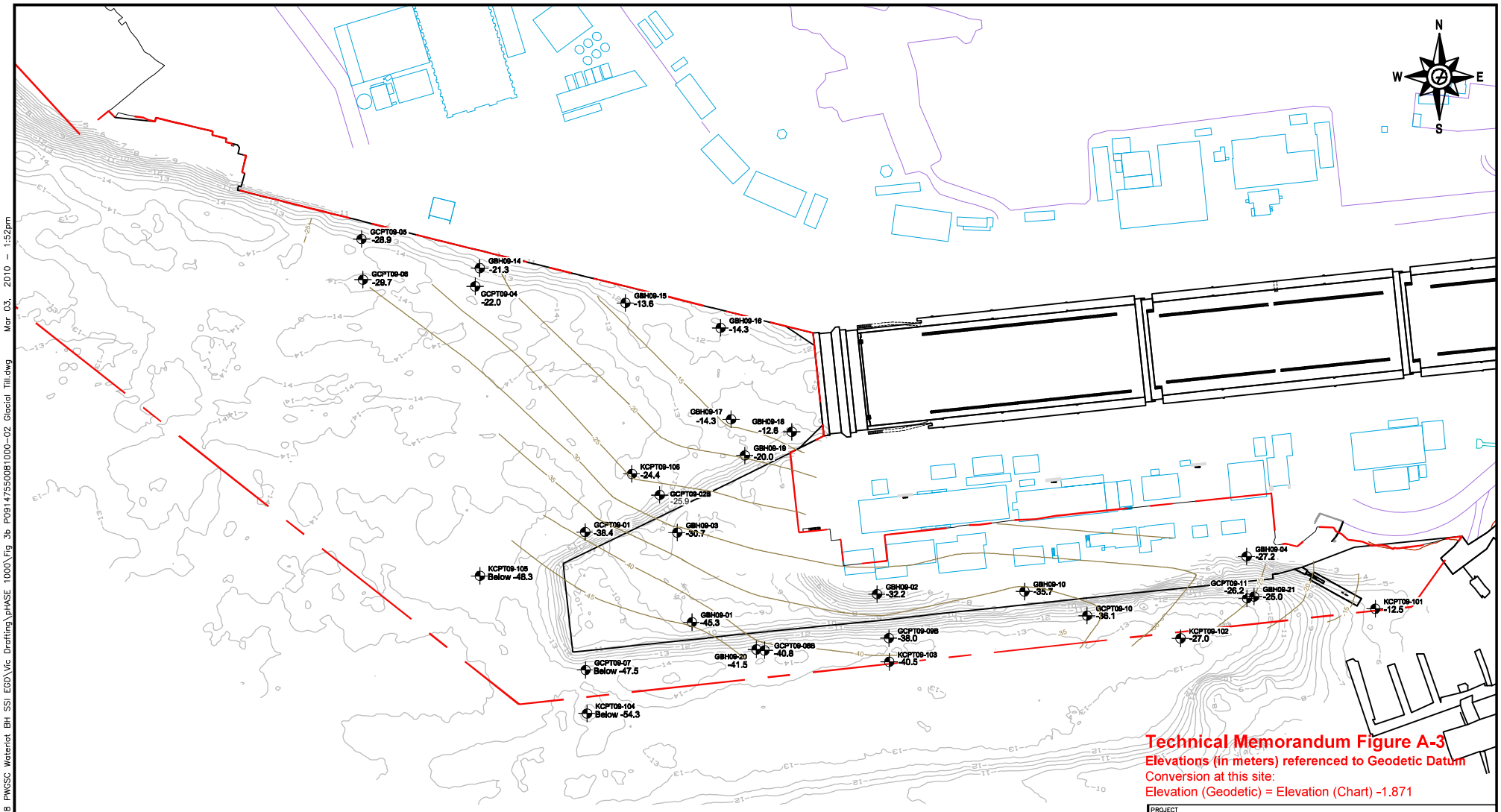
Klohn Crippen Berger

PROJECT: ESQUIMALT GRAVING DOCK
SOUTH JETTY WHARF DEVELOPMENT

TITLE: DRILL HOLE LOCATION PLAN

PROJECT No. P09614A01 | DWG. No. FIGURE 1 | REV.

CANCEL PRINTS BEARING PREVIOUS



Technical Memorandum Figure A-3
Elevations (in meters) referenced to Geodetic Datum
Conversion at this site:
Elevation (Geodetic) = Elevation (Chart) -1.871

LEGEND

- xx / ## — Testhole (2009 Investigation) with Elevation Top of Glacial Deposit
- -18 — Inferred Elevation Contours for Top of Glacial Deposit (5m Interval)
- Waterlot Boundary

NOTES

1. All Elevations (in metres) referenced to Geodetic Datum.
2. Bathymetry contours (0.5m intervals) provided by CRA Surveys, February 2009.
3. Drawing base information provided by Public Works and Government Services Canada
4. Soil unit surface elevations have been interpreted from testhole data at the testhole locations shown. Subsurface elevations between the testholes have been inferred and so may vary from that shown.

30 0 30
SCALE 1:1,500 METRES

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

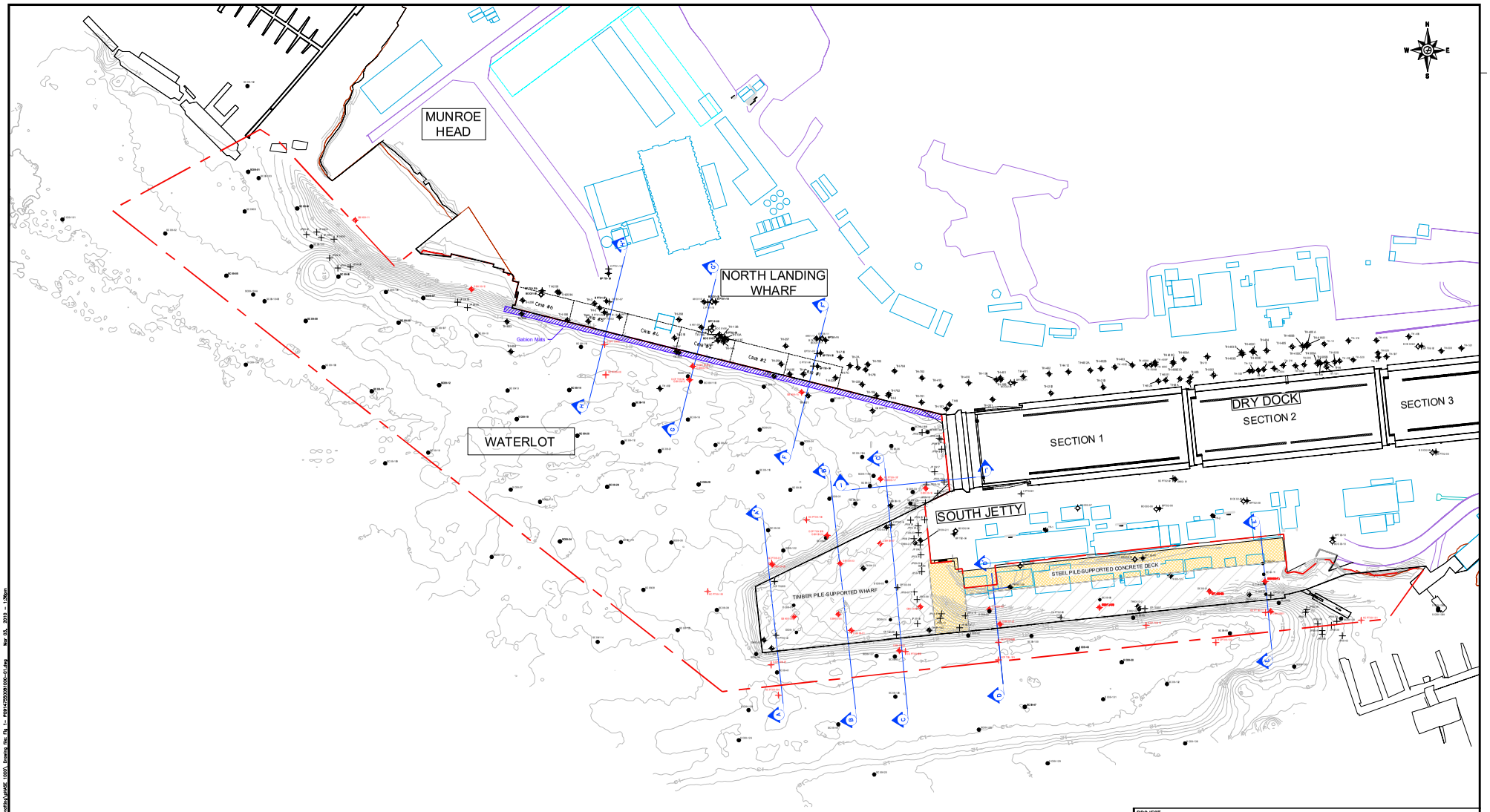
TITLE
ELEVATION OF TOP OF GLACIAL DEPOSITS

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No P09147550081000-02	
DESIGN	CNW	12 JAN 10	SCALE AS SHOWN	REV. 0
CADD	CLF	13 JAN 10		
CHECK	CNW	2 MAR 10		
REVIEW	JF	2 MAR 10		

FIGURE 3b

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\phASE 1000\Fig 3b P09147550081000-02 Glacial Till.dwg Mar 03, 2010 - 1:52pm



LEGEND

- GBH09-xx — Sonic or Mud Rotary Borehole (by Golder 2009)
- GCPT09-xx / KCPT09-xx — Cone Penetration Test (by Golder 2009)
- SCD9-xx / DCD9-xx — Sediment Core and Diver Core (by Golder 2009)
- JP09-xx — Jet Probe (by Golder 2009)
- TH-xx — Testholes (by Hardy Associates)
- BPT01-xx — Becker Penetration Test (by Golder 2001)
- BPT02-xx — Becker Penetration Test (by Klohn Crippen 2002)
- BOC01-xx — Becker Open Hole (by Golder 2001)
- BOC02-xx — Becker Open Hole (by Klohn Crippen 2002)
- AH02-01 — Hollow-stem Auger hole (by Golder 2001)
- DH02-01 — Mud Rotary Borehole (by Klohn Crippen 2002)
- SCPT02-xx / CPT02-xx — Cone Penetration Test (by Klohn Crippen 2002)
- Approximate Area of Timber Piling Under Jetty
- Approximate Area of Steel Pile-supported Concrete Deck
- Cross Section Locations
- Waterlot Boundary

NOTES

1. Bathymetry contours (0.5m intervals) provided by CRA Surveys, February 2009. Elevations (in metres) referenced to Geodetic Datum.
2. Drawing base information provided by Public Works and Government Services Canada

SCALE 20 0 20 METRES

Technical Memorandum Figure A-4

Elevations (in meters) referenced to Geodetic Datum

Conversion at this site:

Elevation (Geodetic) = Elevation (Chart) -1.871

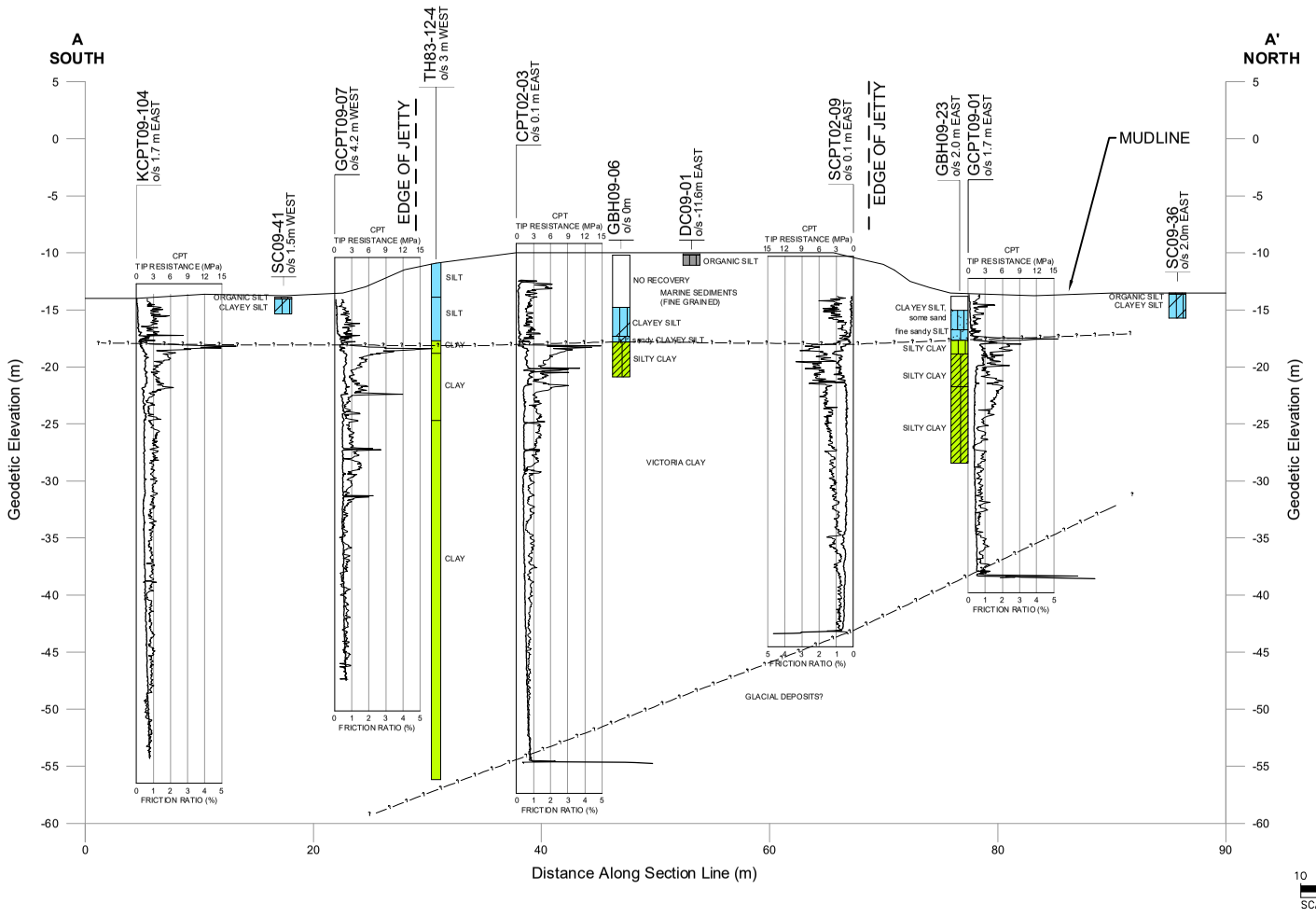
PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE: **TEST HOLE LOCATION PLAN**

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No.P091475500810000-01
DESIGN	CNW	3 NOV 09	SCALE AS SHOWN REV. 0
CADD	CLF	11 JAN 09	
CHECK	CNW	2 MAR 10	**FIGURE 1**
REVIEW	JF	2 MAR 10	

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot 89 859 000\Vis Drafting\plotdir 1000\ Drawing (dwg, Fig 1 - P091475500810000-01.dwg Mar 03, 2010 - 1:39pm



10 0 10
SCALE 1:400 METRES

LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

Technical Memorandum Figure A-5

Elevations (in meters) referenced to Geodetic Datum

Conversion at this site:

Elevation (Geodetic) = Elevation (Chart) -1.871

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C

TITLE

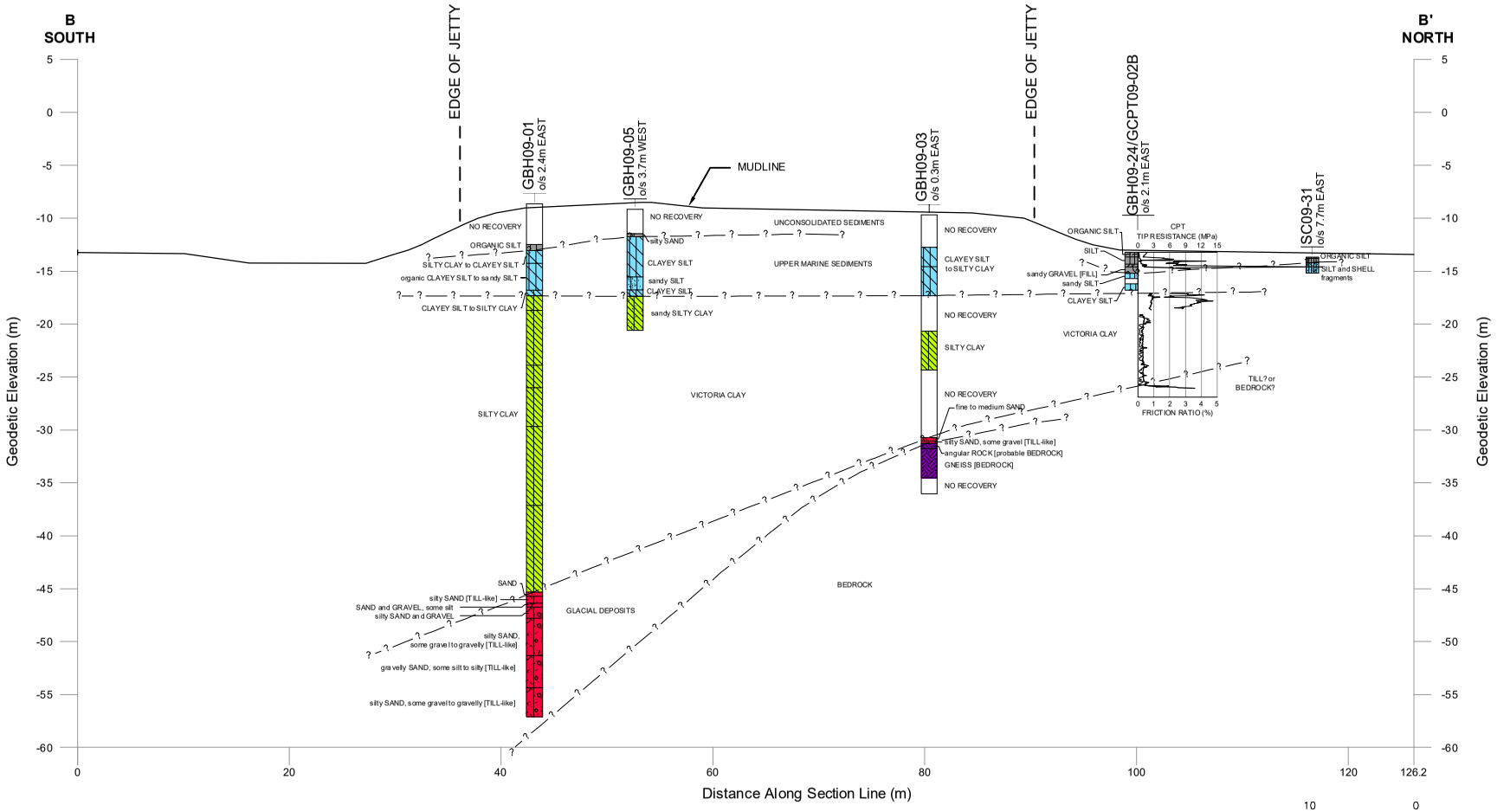
STRATIGRAPHIC CROSS-SECTION A-A'

Golder Associates
Victoria, BC

PROJECT	09-1475-5008		FILE No.	S09147550081000-03	
DESIGN	CNW	21 SEP 09	SCALE	AS SHOWN	REV. 0
CADD	TRE	30 DEC 09			
CHECK	CNW	2 MAR 10			
REVIEW	JF	2 MAR 10			

FIGURE 2a

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2a S09147550081000-03 A-A.dwg Mar 03, 2010 - 1:38pm



LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

Technical Memorandum Figure A-6

Elevations (in meters) referenced to Geodetic Datum

Conversion at this site:

Elevation (Geodetic) = Elevation (Chart) -1.871

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

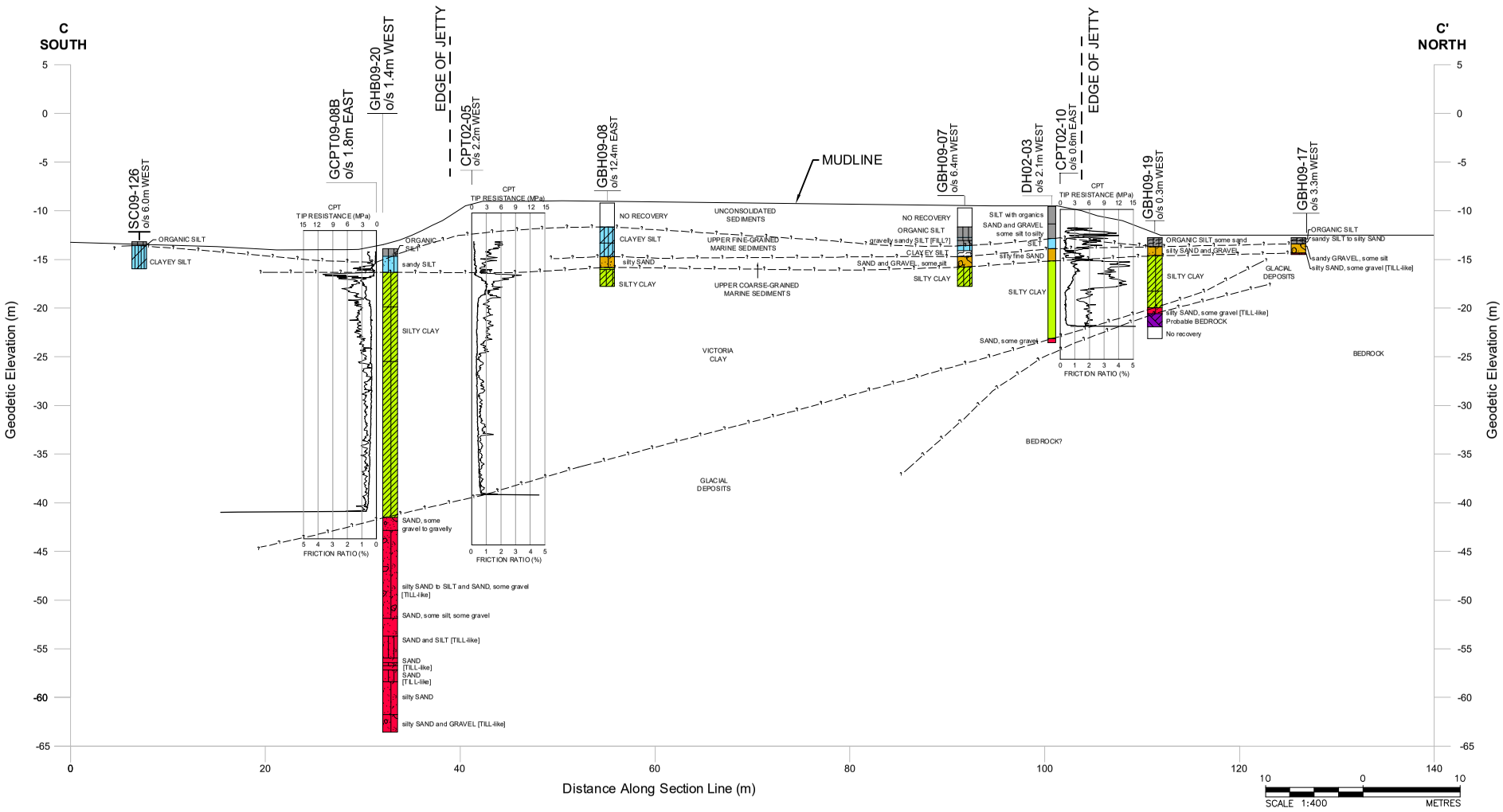
STRATIGRAPHIC CROSS-SECTION B-B'

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No. S09147550081000-01	
DESIGN	CNW	21 SEP 09	SCALE AS SHOWN	REV. 0
CADD	TRE	29 DEC 09		
CHECK	CNW	2 MAR 10		
REVIEW	JF	2 MAR 10		

FIGURE 2b

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\phASE 1000\Fig 2b S09147550081000-01 B-B.dwg Mar 03, 2010 - 1:39pm



LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- UPPER MARINE SEDIMENTS (COARSE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

Mudline profile was derived from bathymetric contours (interval = 0.5 m).

Technical Memorandum Figure A-7

Elevations (in meters) referenced to Geodetic Datum

Conversion at this site:

Elevation (Geodetic) = Elevation (Chart) -1.871

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

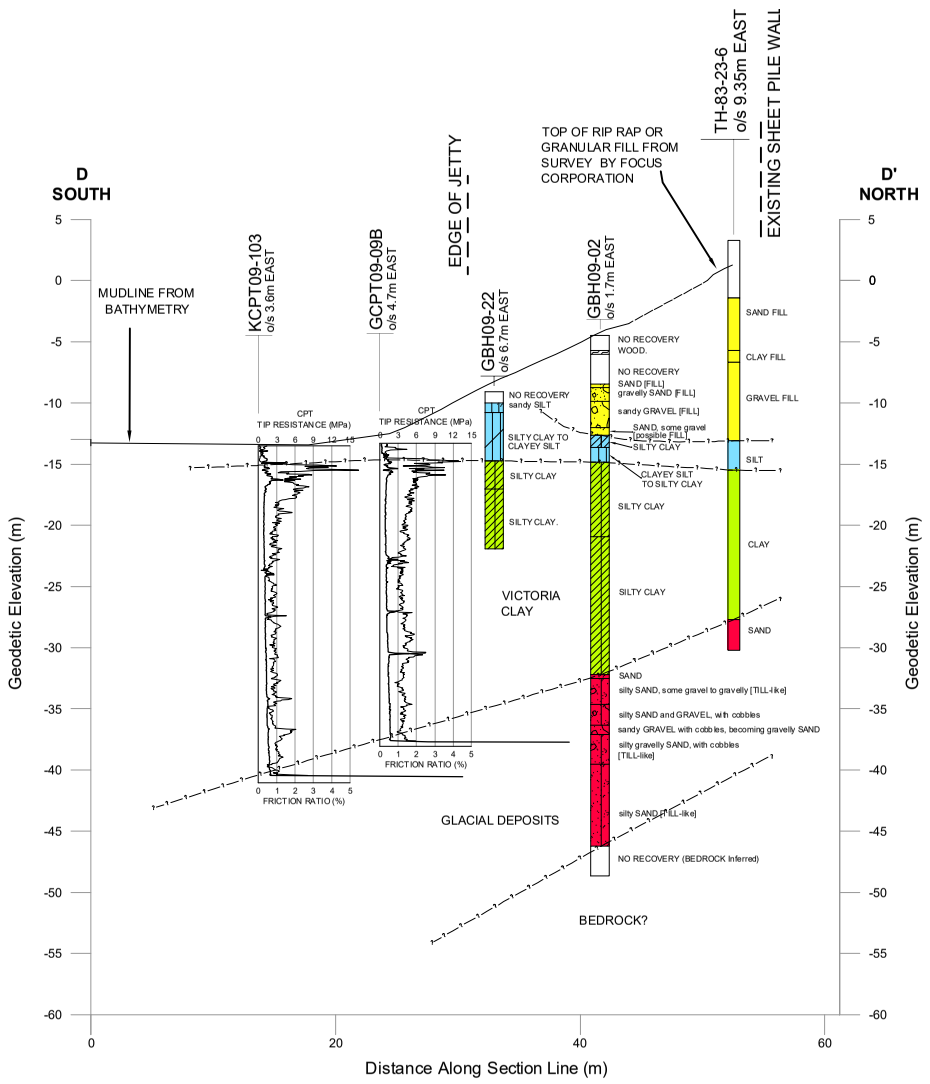
STRATIGRAPHIC CROSS-SECTION C-C'

Golder Associates
Victoria, BC

PROJECT No. 09-1475-5008			FILE No.	S09147550081000-02
DESIGN	CNW	21 SEP 09	SCALE	AS SHOWN
CADD	TRE	29 DEC 09	REV.	0
CHECK	CNW	2 MAR 10		
REVIEW	JF	2 MAR 10		

FIGURE 2c

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\phASE 1000\Fig 2c S09147550081000-02 C-C.dwg Mar 03, 2010 - 1:05pm



LEGEND

- UNCONSOLIDATED SEDIMENTS
- GRANULAR AND/OR ROCK FILL
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- VICTORIA CLAY
- GLACIAL DEPOSITS
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

1. Mudline profile was derived from bathymetric contours (interval = 0.5 m).
2. Rip Rap elevations from Focus Corportation: 03020056-104TS2.dwg, dated January 15, 2010

Technical Memorandum Figure A-8

Elevations (in meters) referenced to Geodetic Datum

Conversion at this site:

Elevation (Geodetic) = Elevation (Chart) -1.871

10 0 10

SCALE 1:400 METRES

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

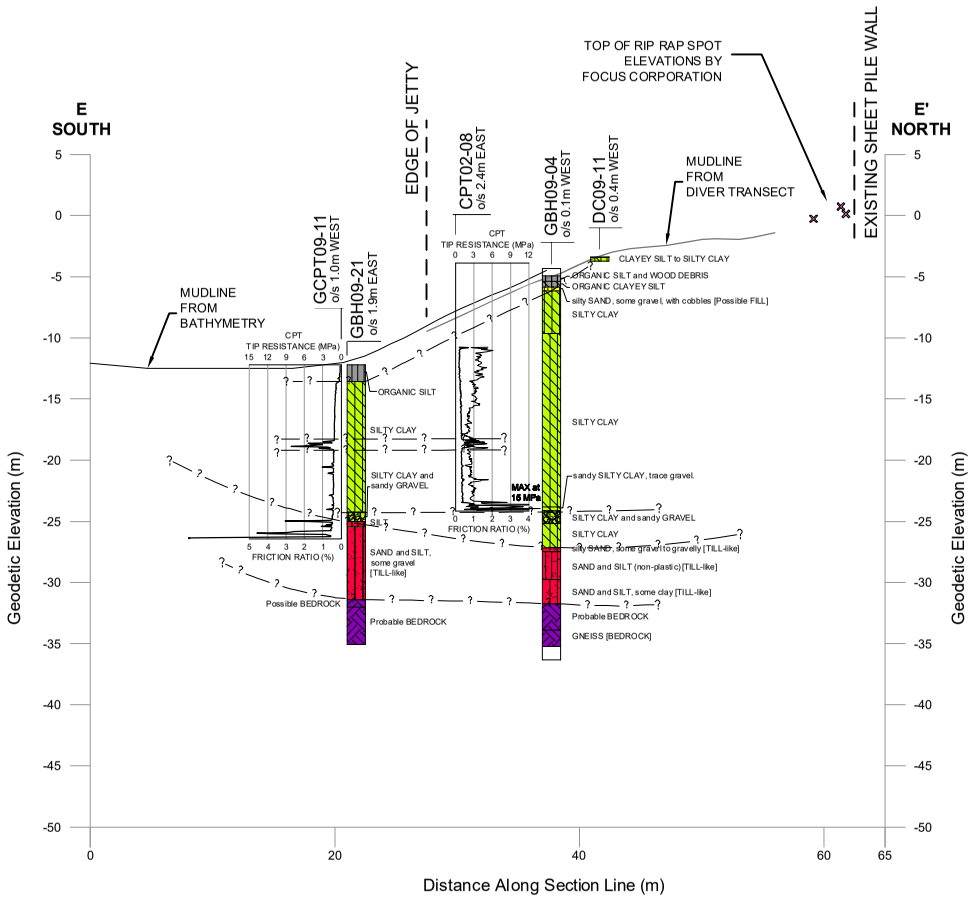
STRATIGRAPHIC CROSS-SECTION D-D'

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No.	S09147550081000-04	
DESIGN	CNW	21 DEC 09	SCALE	AS SHOWN	REV. 0
CADD	JEF	31 DEC 09			
CHECK	CNW	2 MAR 10			
REVIEW	JF	2 MAR 10			

FIGURE 2d

N:\Active\2009\1475\09-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\phASE 1000\ Drawing file: Fig 2d S09147550081000-04 D-D.dwg Mar 03, 2010 - 1:24pm



LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- GRANULAR AND/OR ROCK FILL
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

NOTES

Data concerning the various strata have been obtained at test hole locations only. The soil stratigraphy between the test holes has been inferred from geological evidence and so may vary from that shown. For detailed descriptions of stratigraphy at each borehole location, refer to the Record of Borehole sheets.

SOURCE

1. Mudline profile was derived from bathymetric contours (interval = 0.5 m).
2. Rip Rap elevations from Focus Corportation: 03020056-104TS2.dwg, dated January 15, 2010

Technical Memorandum Figure A-9

Elevations (in meters) referenced to Geodetic Datum

Conversion at this site:
Elevation (Geodetic) = Elevation (Chart) -1.871

10 0 10
SCALE 1:400 METRES

PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUPPLEMENTARY TEST HOLE INVESTIGATION FOR RAP/RMP
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

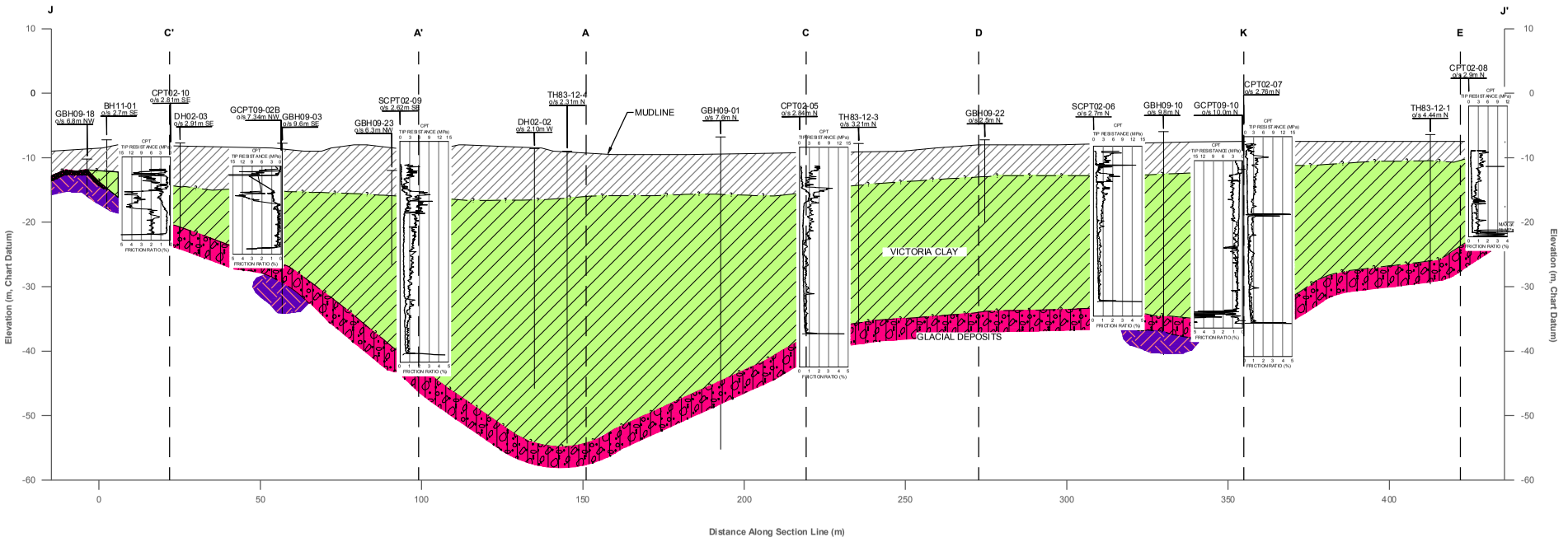
TITLE
STRATIGRAPHIC CROSS-SECTION E-E'

Golder Associates Victoria, BC

PROJECT No. 09-1475-5008			FILE No. S09147550081000-05		
DESIGN	CNW	21 SEP 09	SCALE	AS SHOWN	REV. 0
CADD	JEF	21 DEC 09			
CHECK	CNW	2 MAR 10			
REVIEW	JF	2 MAR 10			

FIGURE 2e

N:\Active\2008\1475\08-1475-5008 PWGSC Waterlot BH SSI EGD\Vic Drafting\pHASE 1000\Fig 2e S09147550081000-05 E-E.dwg



Technical Memorandum Figure A-10

Elevations (in meters) referenced to Chart Datum

LEGEND

- UNCONSOLIDATED SEDIMENTS / UPPER MARINE SEDIMENTS
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO- R_f

BHxx-xx o/s 1m NW
- TEST HOLE IDENTIFICATION
- OFFSET FROM SECTION LINE
- MUDLINE ELEVATION
- FINAL DEPTH OF BOREHOLE

NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN. FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY AT EACH BOREHOLE LOCATION, REFER TO THE RECORD OF BOREHOLE SHEETS.

FOR DETAILS OF SECTIONS A-A', C-C', D-D', E-E', AND K-K' REFER TO FIGURES 4a, 4c, 4d, 4e, AND 4k.

REFERENCE

MUDLINE PROFILE WAS DERIVED FROM BATHYMETRIC CONTOURS (INTERVAL = 0.5 m) PROVIDED BY CRA CANADA SURVEYS INC. (2009 AND 2010).

0 25 50 75

SCALE (2x VERTICAL EXAGGERATION) METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE

PROFILE J - J'

Golder Associates

PROJECT No.	13-1447-0478.1000.1001		FILE No.	1314470478-1001-04j	
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN	
CADD	AMW	2013-12-09	FIGURE		
CHECK	SEM	2014-03-24		4J	
REVIEW	RW	2014-03-24			

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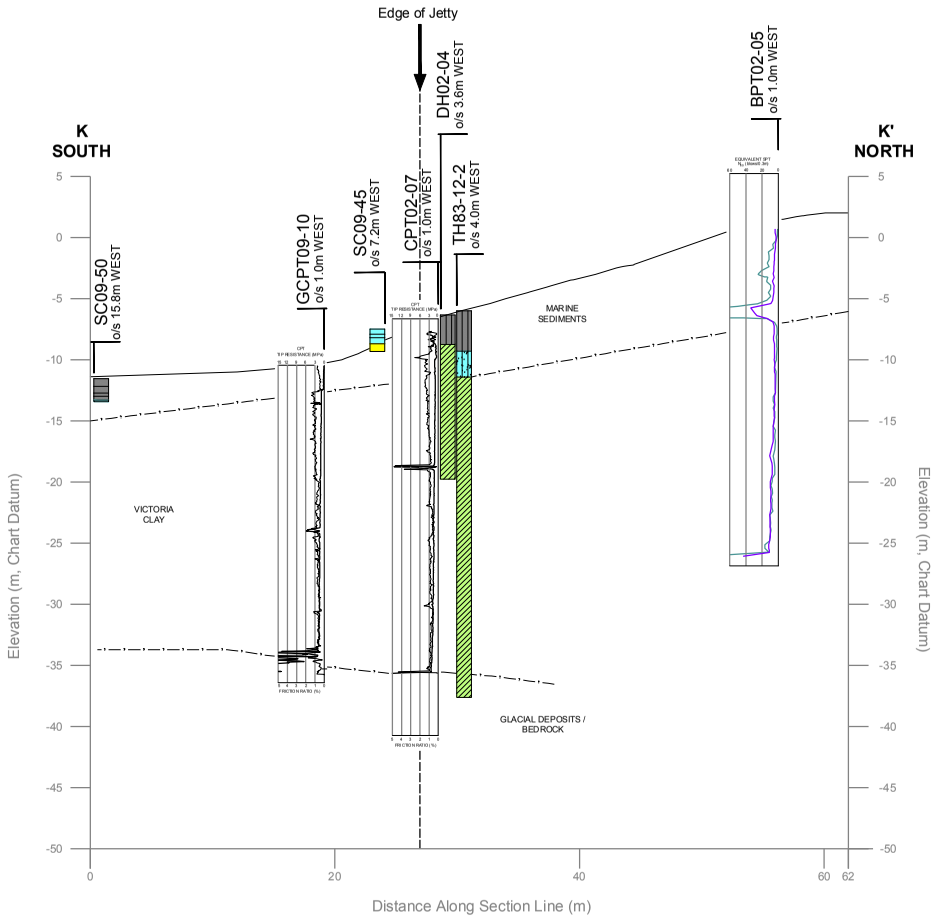

LEGEND

- UNCONSOLIDATED SEDIMENTS
- UPPER MARINE SEDIMENTS (FINE-GRAINED)
- GRANULAR AND/OR ROCK FILL
- VICTORIA CLAY
- GLACIAL DEPOSITS
- BEDROCK
- CPT TIP RESISTANCE - q_T
- CPT FRICTION RATIO - R_f
- BPT - HARDER METHOD
- BPT - SY METHOD
- BHxx-xx / o/s 1m NW — TEST HOLE IDENTIFICATION / OFFSET FROM SECTION LINE
- MUDLINE ELEVATION
- FINAL DEPTH OF BOREHOLE

NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN. FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY AT EACH BOREHOLE LOCATION, REFER TO THE RECORD OF BOREHOLE SHEETS.

REFERENCES

MUDLINE PROFILE WAS DERIVED FROM BATHYMETRIC CONTOURS (INTERVAL = 0.5 m) PROVIDED BY CRA CANADA SURVEYS INC. (2009 AND 2010).

RIP RAP ELEVATIONS FROM FOCUS CORPORTATION: *03020056-104TS2.dwg*, DATED JANUARY 15, 2010.

BPT DATA DIGITIZED FROM KLOHN CRIPPEN REPORT: *Esquimalt Graving Dock and South Landing Wharf - Site Investigation and Liquefaction Assessment*, DATED JUNE 25, 2002

0 8 16 24
SCALE METRES

Technical Memorandum Figure A-11

Elevations (in meters) referenced to Chart Datum

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW
1	2014-03-24	FINAL	SEM	AMW	SEM	RW

PROJECT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PHASE 2 - 99% GEOTECHNICAL DESIGN INPUT REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, BC

TITLE

STRATIGRAPHIC CROSS-SECTION K - K'

Golder Associates

PROJECT No.	13-1447-0478.1000.1001		FILE No.	1314470478-1001-04k	
DESIGN	SEM	2013-12-09	SCALE	AS SHOWN	
CADD	AMW	2013-12-09	FIGURE		
CHECK	SEM	2014-03-24		4K	
REVIEW	RW	2014-03-24			

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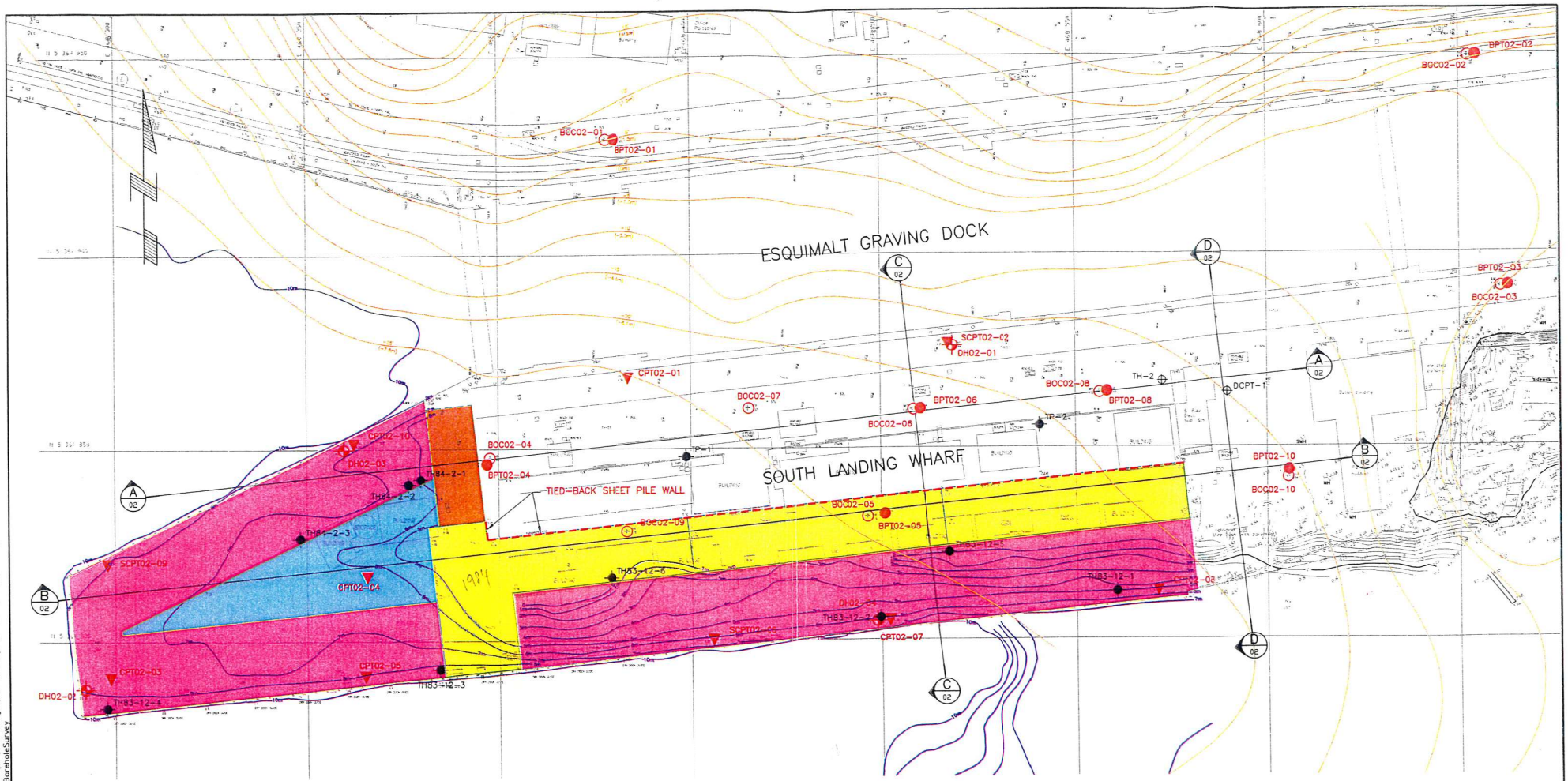


LEGEND

BPT02-01	CLOSED-ENDED BECKER DRILL HOLE
BOC02-01	OPEN-ENDED BECKER DRILL HOLE
DH02-01	MUD ROTARY DRILL HOLE
CPT02-01	CONE PENETRATION TEST
TH83-12-1	1983 AND 1984 TEST HOLES BY HARDY ASSOCIATES (1978) LTD.
DCPT-1	1997 TEST HOLES BY TERRA ENGINEERING LTD.
	BELOW DECK SOUNDING CONTOURS (2001)
	PRE-DEVELOPMENT CONTOURS (1920s)
	TIMBER JETTY
	TIMBER INFILL STRUCTURE
	TIMBER CRIB
	CONCRETE WHARF

NOTES:

1. SITE PLAN PROVIDED BY PWGSC. LOCATIONS OF FACILITIES ARE APPROXIMATE ONLY.
2. BELOW DECK SOUNDING CONTOURS WERE TAKEN FROM FORESHORE TECHNOLOGIES REPORT DATED JANUARY 19, 2001.
3. PRE-DEVELOPMENT CONTOURS WERE BASED ON PWGSC'S DRAWING No. 2 ORIGINAL CONSTRUCTION. NOTE INCONSISTENCIES WITH DIFFERENT CONTOURS AT THE EAST END OF THE SOUTH JETTY.
4. ELEVATIONS REFER TO CHART DATUM.

Technical Memorandum Figure A-12

Elevations (in meters) referenced to Chart Datum

0 50m

DRAWING NO.	REFERENCE DRAWING	NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

KLOHN CRIPPEN

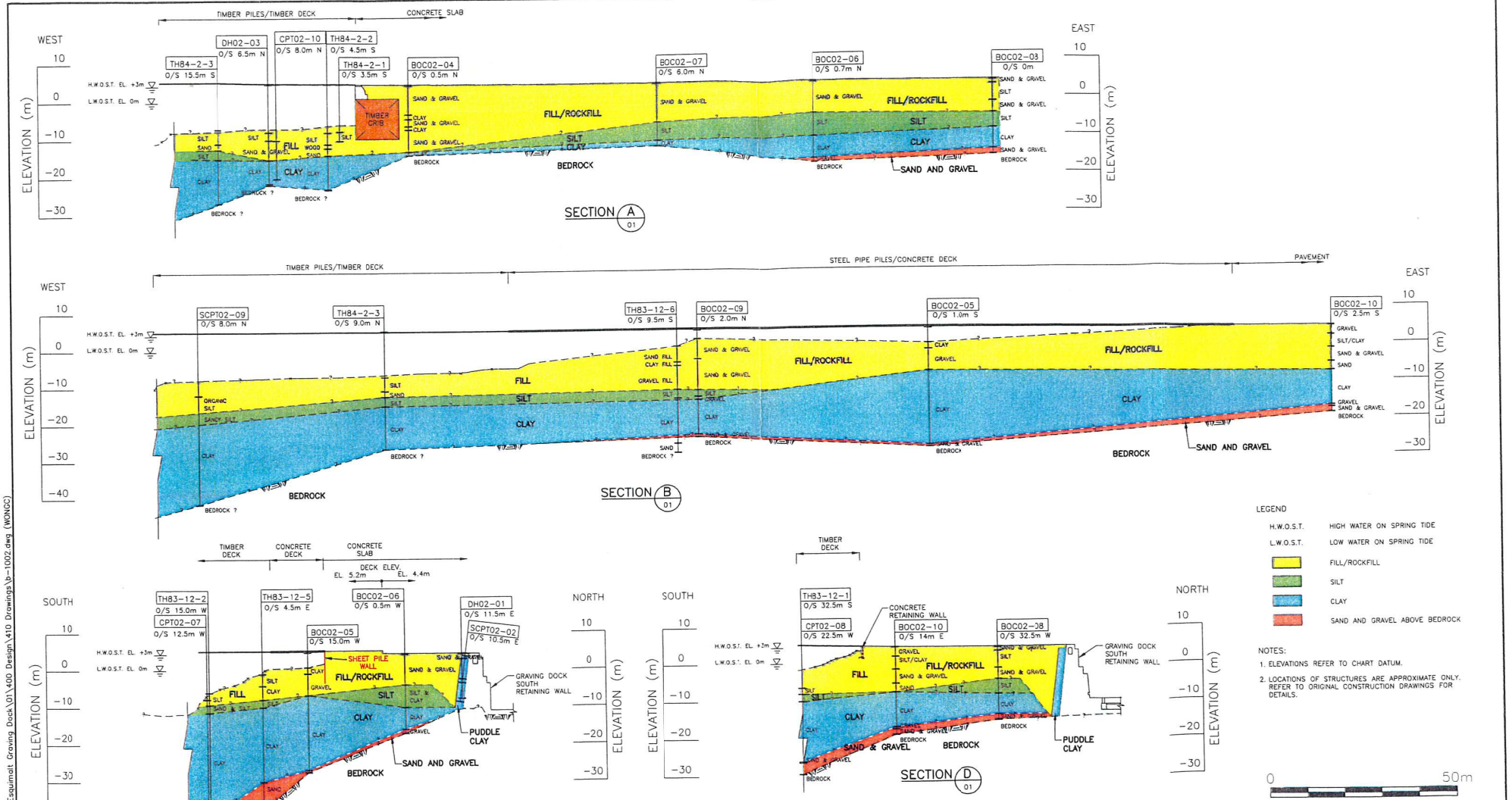
PROJECT: EGD AND SLW SITE INVESTIGATION

TITLE: TEST HOLE LOCATION PLAN

SCALE	PROJECT No.	DWG. No.	REV.
1:1000	PG9060 01	B-1001	–

CANCEL PRINTS BEARING PREVIOUS REVISION

Drawing File: G:\PG9060 PWGSC Esquimalt Graving Dock\01\400 Design\410 Drawings\b 1001R2.dwg (WONCC)
Xrefs: 1920topo1ref, golder, soundingutm, April2002BoreholeSurvey



Technical Memorandum Figure A-13

Elevations (in meters) referenced to Chart Datum

DT June 5, 2002

Scale: 1=4(P*S)
Drawing File: G:\G9060 PWGSC Esquimalt Graving Dock\01\400 Design\410 Drawings\b-1002.dwg (WONGC)
Xrefs: HA11002

DRAWING NO.	REFERENCE DRAWING	NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR AUTHORIZED PURPOSES AND NOT TO BE USED IN WHOLE OR IN PART FOR ANY OTHER PURPOSE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

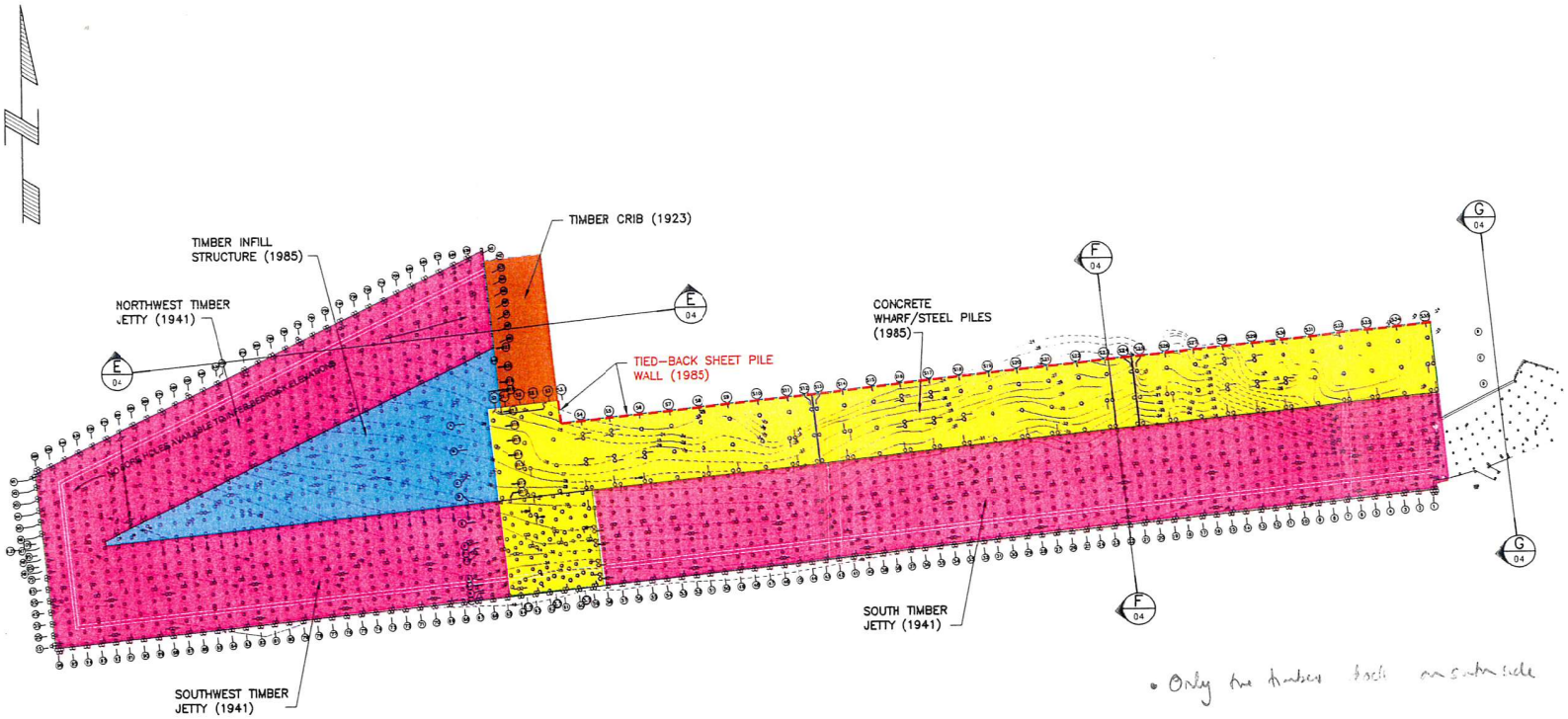
CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

KLOHN CRIPPEN

PROJECT: EGD AND SLW SITE INVESTIGATION

TITLE: GEOLOGIC SECTIONS A, B, C AND D

SCALE	PROJECT No.	DWG No.	REV.
1:1000	PG9060 01	B-1002	–



NOTES:

1. DRAWING TAKEN FROM HAY & COMPANY CONSULTANTS INC. REPORT DATED JUNE 2001, DRAWING No. RJC003–B03.
2. ELEVATIONS SHOWN REFER TO CHART DATUM.

Technical Memorandum Figure A-14
Elevations (in meters) referenced to Chart Datum

0 50m

DT June 5 2002

DRAWING NO.	REFERENCE DRAWING	NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA,STATEMENTS,CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

KLOHN CRIPPEN

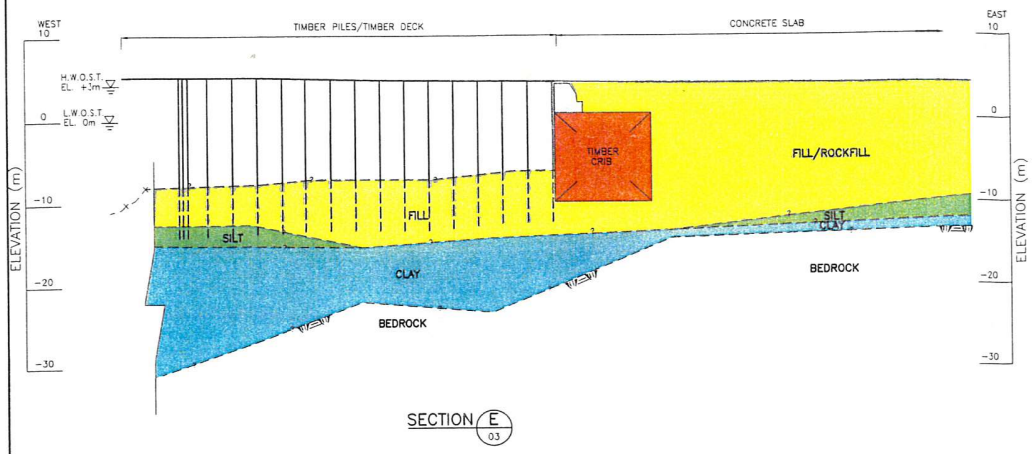
PROJECT: EGD AND SLW SITE INVESTIGATION

TITLE: PILE LAYOUT AND BEDROCK CONTOURS

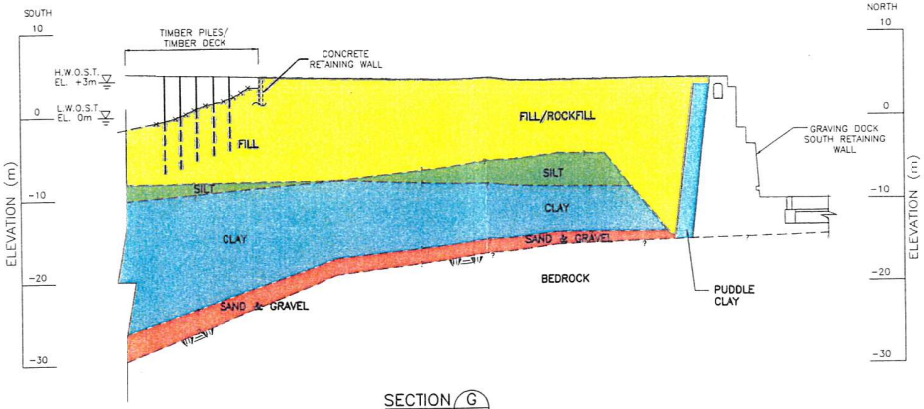
SCALE	PROJECT No.	DWG. No.	REV.
1:1000	PG9060 01	B–1003	–

CANCEL PRINTS BEARING PREVIOUS REVISION

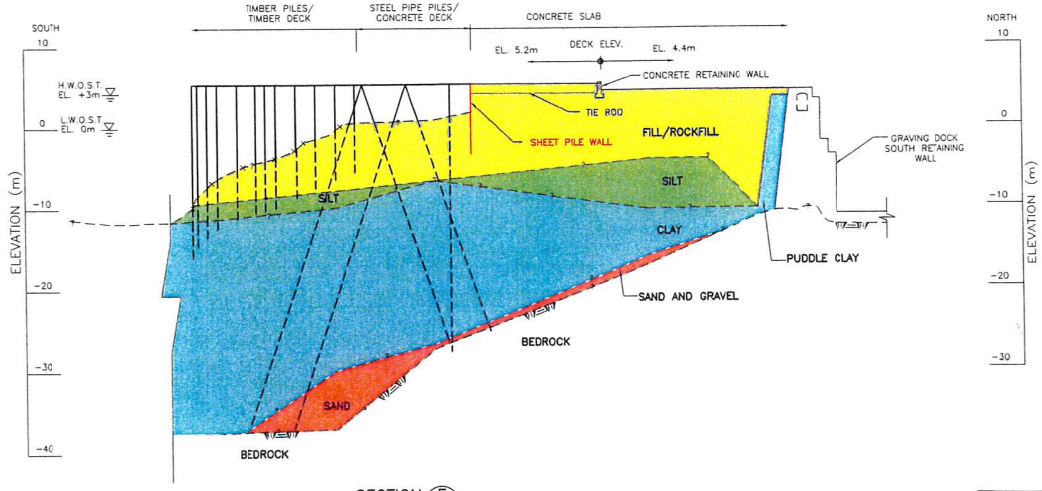
SCALE: 1"=41'-2"
DRAWING FILE: G:\PG9060 PWGSC Esquimalt Graving Dock\01\400 Design\410 Drawings\b-1003.dwg (WONGC)
Xrefs: BOUNDARY, FIG03 BEDROCK



SECTION E 03



SECTION G 03



SECTION F 03

NOTES:

1. ELEVATIONS REFER TO CHART DATUM.
2. PILE LOCATIONS ARE APPROXIMATE ONLY. SEE ORIGINAL CONSTRUCTION DRAWINGS FOR DETAILS.
3. LOCATIONS OF STRUCTURES ARE APPROXIMATE ONLY. REFER TO ORIGINAL CONSTRUCTION DRAWINGS FOR DETAILS.

Technical Memorandum Figure A-15

Elevations (in meters) referenced to Chart Datum

0 30m

DT June 25, 2002

DRAWING NO.	REFERENCE DRAWING	NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT: Public Works and Government Services Canada / Travaux publics et Services Gouvernementaux Canada

KLOHN CRIPPEN

PROJECT: EGD AND SLW SITE INVESTIGATION

TITLE: CROSS SECTIONS E, F AND G

SCALE	PROJECT No.	DWG. No.	REV
1:150	PG9060 01	B-1004	-

Scale: 1:41(1/2)
Drawing File: C:\PG9060 PWGSC Esquimalt Graving Dock\01\400 Design\410 Drawings\b-1004A.dwg (WONGC)
Xrefs: HA11002

APPENDIX B -
Pile Design Loads Provided By Herold Engineering

Technical Memorandum Table B-1

WEST JETTY PILES

(tension in red)

BAY	BAY	PILE DIA	ELEVATION OF TOP OF PILE	DESIGN TOE ELEVATION	DESIGN PILE LENGTH	ELEV DREDGING	ELEV ARMOUR	DESIGN COATING LENGTH	AXIAL LOAD LIVE kN	AXIAL LOAD DEAD kN	AXIAL SEISMIC max [Cor'T]	combo1 Fact 1.2D+1.6L Axial [kN]	combo2 Fact 1.2D+.5L+1.0E Axial [kN]	Mftop kNm kNm	Mfbot kNm	Vt at top of pile [kN]	fixity height from top of pile m	assumed elevation of fixity m	combo3 0.8D+1.0E
1	A	762	2.555	-52	55	-11	-8	22	389	705	1862	1468	2903	2100	2000	350	14.6	-12.1	-1298.0
1	B1	762	2.555	-56	59	-11	-8	21	481	822	2460	1756	3687	2100	2000	350	14.6	-12.1	-1802.4
1	D1	762	2.555	-56	59	-11	-8	21	621	956	2650	2141	4108	2100	2000	350	14.6	-12.1	-1885.2
1	E1	762	2.555	-55	58	-11	-8	21	596	926	2426	2065	3835	2100	2000	350	14.6	-12.1	-1685.2
1	F1	762	2.555	-55	58	-11	-8	21	420	777	2012	1604	3154	2100	2000	350	14.6	-12.1	-1390.4
1	P	762	2.555	-49	52	-11	-8	21	295	725	1959	1342	2977	2100	2000	350	14.6	-12.1	-1379.0
2	B1	762	2.555	-57	60	-11	-8	21	688	833	75	2100	1419	2100	2000	350	14.6	-12.1	591.4
2	D1	762	2.555	-56	59	-11	-8	21	911	984	105	2638	1741	2100	2000	350	14.6	-12.1	682.2
2	E1[E2]	762	2.555	-55	58	-11.0	-8.0	21	896	965	86	2592	1692	2100	2000	350	14.6	-12.1	686.0
2	F1	762	2.555	-54	57	-11.0	-8.0	21	606	798	80	1927	1341	2100	2000	350	14.6	-12.1	558.4
3	A	762	2.555	-54	57	-11.0	-8.0	21	739	821	1902	2168	3257	2100	2000	350	14.6	-12.1	-1245.2
3	B	762	2.555	-58	61	-11.0	-8.0	21	803	846	1676	2300	3093	2100	2000	350	14.6	-12.1	-999.2
3	C	762	3.4	-58	61	-11.0	-8.0	21	919	914	1509	2567	3065	2100	2000	350	14.6	-11.2	-777.8
3	D	762	3.4	-63	66	-11.0	-8.0	21	1104	1034	1819	3007	3612	2100	2000	350	14.6	-11.2	-991.8
3	E	762	3.4	-63	66	-11.0	-8.0	21	1144	1052	1777	3093	3611	2100	2000	350	14.6	-11.2	-935.4
3	F	762	3.4	-62	65	-11.0	-8.0	21	943	916	1547	2608	3118	2100	2000	350	14.6	-11.2	-814.2
3	M	762	3.4	-54	57	-11.0	-8.0	21	767	840	1439	2235	2831	2100	2000	350	14.6	-11.2	-767.0
3	N	762	2.555	-54	57	-11.0	-8.0	21	750	914	1025	2297	2497	2100	2000	350	14.6	-12.1	-293.8
3	P	762	2.555	-47	50	-11.0	-8.0	21	696	1074	804	2402	2441	2100	2000	350	14.6	-12.1	55.2
4	A	762	2.555	-55	58	-11.0	-8.0	21	1010	888	734	2682	2305	2100	2000	350	14.6	-12.1	-23.6
4	B	762	2.555	-58	61	-11.0	-8.0	21	1346	1103	56	3477	2053	2100	2000	350	14.6	-12.1	826.4
4	C	762	3.4	-58	61	-11.0	-8.0	21	1621	1279	204	4128	2549	2100	2000	350	14.6	-11.2	819.2
4	D	762	3.4	-63	66	-11.0	-8.0	21	2093	1581	161	5246	3105	2100	2000	350	14.6	-11.2	1103.8
4	E	762	3.4	-62	65	-11.0	-8.0	21	2213	1650	11	5521	3098	2100	2000	350	14.6	-11.2	1309.0
4	F	762	3.4	-61	64	-11.0	-8.0	21	2057	1528	161	5125	3023	2100	2000	350	14.6	-11.2	1061.4
4	G	762	3.4	-60	63	-11.0	-8.0	21	1532	1194	240	3884	2439	2100	2000	350	14.6	-11.2	715.2
4	M	762	3.4	-53	56	-11.0	-8.0	21	1320	1097	292	3428	2268	2100	2000	350	14.6	-11.2	585.6
4	N	762	2.555	-52	55	-11.0	-8.0	21	1182	1129	225	3246	2171	2100	2000	350	14.6	-12.1	678.2
4	P	762	2.555	-45	48	-11.0	-8.0	21	1029	1323	1073	3234	3175	2100	2000	350	14.6	-12.1	-14.6
5	A	762	2.555	-52	55	-11.5	-8.0	21	1013	889	733	2688	2306	2100	2000	350	14.6	-12.1	-21.8
5	B	762	2.555	-57	60	-11.5	-8.0	21	1346	1102	58	3476	2053	2100	2000	350	14.6	-12.1	823.6
5	C	762	3.525	-56	60	-11.5	-8.0	21	1616	1275	200	4116	2538	2100	2000	350	14.6	-11.1	820.0
5	D	762	3.525	-62	66	-11.5	-8.0	21	2070	1566	155	5191	3069	2100	2000	350	14.6	-11.1	1097.8
5	E	762	3.525	-61	65	-11.5	-8.0	21	2190	1641	32	5473	3096	2100	2000	350	14.6	-11.1	1280.8
5	F	762	3.525	-59	63	-11.5	-8.0	21	2209	1644	17	5507	3094	2100	2000	350	14.6	-11.1	1298.2
5	G	762	3.525	-58	62	-11.5	-8.0	21	2177	1604	125	5408	3138	2100	2000	350	14.6	-11.1	1158.2
5	M	762	3.525	-50	54	-11.5	-8.0	21	1650	1316	407	4219	2811	2100	2000	350	14.6	-11.1	645.8
5	N	762	2.555	-49	52	-11.5	-8.0	21	1249	1181	373	3416	2415	2100	2000	350	14.6	-12.1	571.8
5	P	762	2.555	-43	46	-11.5	-8.0	21	811	1197	851	2734	2693	2100	2000	350	14.6	-12.1	106.6
6	A	762	2.555	-50	53	-11.5	-8.0	22	1013	889	733	2688	2306	2100	2000	350	14.6	-12.1	-21.8
6	B	762	2.555	-54	57	-11.5	-8.0	21	1347	1103	58	3479	2055	2100	2000	350	14.6	-12.1	824.4
6	C	762	3.4	-54	57	-11.5	-8.0	21	1617	1276	200	4118	2540	2100	2000	350	14.6	-11.2	820.8
6	D	762	3.4	-60	63	-11.5	-8.0	21	2071	1566	154	5193	3069	2100	2000	350	14.6	-11.2	1098.8
6	E	762	3.4	-59	62	-11.5	-8.0	21	2184	1638	30	5460	3088	2100	2000	350	14.6	-11.2	1280.4
6	F	762	3.4	-58	61	-11.5	-8.0	21	2181	1633	15	5449	3065	2100	2000	350	14.6	-11.2	1291.4
6	G	762	3.4	-56	59	-11.5	-8.0	21	2148	1599	54	5356	3047	2100	2000	350	14.6	-11.2	1225.2
6	H	762	3.4	-55	58	-11.5	-8.0	21	1921	1446	173	4809	2869	2100	2000	350	14.6	-11.2	983.8
6	M	762	3.4	-47	50	-11.5	-8.0	21	1526	1256	376	3949	2646	2100	2000	350	14.6	-11.2	628.8
6	N	762	2.555	-47	50	-11.5	-8.0	21	1242	1204	345	3432	2411	2100	2000	350	14.6	-12.1	618.2
6	P	762	2.555	-40	43	-11.5	-8.0	21	793	1231	884	2746	2758	2100	2000	350	14.6	-12.1	100.8
7	A	762	2.555	-48	51	-11.5	-8.0	21	1012	889	733	2686	2306	2100	2000	350	14.6	-12.1	-21.8
7	B	762	2.555	-53	56	-11.5	-8.0	21	1347	1103	58	3479	2055	2100	2000	350	14.6	-12.1	824.4
7	C	762	3.525	-52	56	-11.5	-8.0	21	1618	1276	200	4120	2540	2100	2000	350	14.6	-11.1	820.8
7	D	762	3.525	-54	58	-11.5	-8.0	21	2072	1566	151	5194	3066	2100	2000	350	14.6	-11.1	1101.8
7	E	762	3.525	-52	56	-11.5	-8.0	21	2178	1634	27	5446	3077	2100	2000	350	14.6	-11.1	1280.2
7	F	762	3.525	-48	52	-11.5	-8.0	21	2166	1627	7	5418	3042	2100	2000	350	14.6	-11.1	1294.6
7	G	762	3.525	-43	47	-11.5	-8.0	21	2164	1622	14	5409	3042	2100	2000	350	14.6	-11.1	1283.6
7	H	762	3.525	-39	43	-11.5	-8.0	21	2094	1560	104	5222	3023	2100	2000	350	14.6	-11.1	1144.0
7	J	762	3.525	-35	39	-11.5	-8.0	21	1759	1337	233	4419	2717	2100	2000	350	14.6	-11.1	836.6
7	M	762	3.525	-33	37	-11.5	-8.0	21	1516	1220	343	3890	2565	2100	2000	350	14.6	-11.1	633.0
7	N	762	2.555	-31	34	-11.5	-8.0	21	1289	1188	299	3488	2369	2100	2000	350	14.6	-12.1	651.4
7	P	762	2.555	-30	33	-11.5	-8.0	21	803	1172	1009	2691	2817	2100	2000	350	14.6	-12.1	-71.4
8	A	762	2.555	-49	52	-11.5	-8.0	21	1012	888	733	2685	2305	2100	2000	350	14.6	-12.1	-22.6
8	B	762	2.555	-52	55	-11.5	-8.0	21	1347	1103	58	3479	2055	2100	2000	350	14.6	-12.1	824.4
8	C	762	3.4	-51	54	-11.5	-8.0	21	1618	1276	200	4120	2540	2100	2000	350	14.6	-11.2	820.8
8	D	762	3.4	-51	54	-11.5	-8.0	21	2070	1565	151	5190	3064	2100	2000	350	14.6	-11.2	1101.0
8	E	762	3.4	-48	51	-11.5	-8.0	21	2177	1633	24	5443	3072	2100	2000	350	14.6	-11.2	1282.4
8	F	762	3.4	-43	46	-11.5	-8.0	21	2168	1627	4	5421	3040	2100	2000	350	14.6	-11.2	1297.6
8	G	762	3.4	-39	42	-11.5	-8.0	21	2174	1630	10	5434	3053	2100	2000	350	14.6	-11.2	1294.0
8	H	762	3.4	-35	38	-11.5	-8.0	21	2111	1588	37	5283	2998	2100	2000	350	14.6	-11.2	1233.4
8	J	762	3.4	-31	34	-11.5	-8.0	21	1712	1334	158	4340	2615	2100	2000	350	14.6	-11.2	909.2
8	J1	762	3.4	-29	32	-11.5	-8.0	21	1251	1051	206	3283	2093	2100	2000	350	14.6	-11.2	634.8
8	M	762	3.4	-28	31	-11.5	-8.0	21	1014	927	390	2735	2009	2100	2000	350	14.6	-11.2	351.6
8	N	762	2.555	-27	30	-11.5	-8.0	21	937	934	513	2620	2102	2100	2000	350	14.6	-12.1	234.2
8	P	762	2.555	-26	29	-11.5	-8.0	21	631	909	572	2100	1978	2100	2000	350	14.6	-12.1	155.2
9	A	762	2.555	-46	49	-10.5	-8.0	21	858	808	733	2342	2132	2100	2000	350	14.6	-12.1	-86.6
9	B	762	2.555	-50	53	-10.5	-8.0	21	1308	1082	58	3391	2010	2100	2000	350	14.6	-12.1	807.6
9	C	762	3.525	-49	53	-10.5	-8.0	21	1619	1277	201	4123	2543	2100	2000	350	14.6	-11.1	820.6
9	D	762	3.525	-45	49	-10.5	-8.0	21	2097	1580	157	5251	3102	2100	2000	350	14.6	-11.1	1107.0
9	E	762	3.525	-42	46	-10.5	-8.0	21	2211	1653	25	5521	3114	2100	2000	350	14.6	-11.1	1297.4
9	F	762	3.525	-38	42	-10.5	-8.0	21	2130	1604	55	5333	3045	2100	2000	350	14.6	-11.1	1228.2
9	G	762	3.525	-34	38	-10.5	-8.0	21	1795	1396	153	4547	2726	2100	2000	350	14.6	-11.1	963.8
9	H	762	3.525	-31	35	-10.5	-8.0	21	1376	1134	36	3562	2085	2100	2000	350	14.6	-11.1	871.2
9	J	762	3.525	-27	31	-10.5	-8.0	21	1896	1442	131	4764	2809	2100	2000	350	14.6	-11.1	1022.6
9	K	762	3.498	-23	26	-10.5	-8.0	21	2381	1703	156	5853	3390	2100	2000	350	14.6	-11.1	1206.4
9	M	762	3.373	-22	25	-10.5	-8.0	21	2100	1564	376	5237	3303	2100	2000	350	14.6	-11.3	875.2
9	N	762	2.555	-22	25	-10.5	-8.0	21	1635	1397	258	4292	2752	2100	2000	350	14.6	-12.1	859.6
9	P	762	2.555	-22	25	-10.5	-8.0	21	976	1286	1232	3105	3263	2100	2000	350	14.6	-12.1	-203.2
10	A	762	2.555	-44	47	-10.5	-8.0	21	353	560	734	1237	1583	2100	2000	350	14.6	-12.1	-286.0
10	B	762	2.555	-42	45	-10.5	-8.0	21	635	777	58	1948	1308	2100	2000	350	14.6	-12.1	563.6
10	C	762	3.4	-40	43	-10.5	-8.0	21	809	906	200	2382	1692	2100	2000	350	14.6	-11.2	524.8
10	D	762	3.4	-39	42	-10.5	-8.0	21	1050	1050	158	2940	1943	2100	2000	350	14.6	-11.2	682.0
10	E	762	3.4	-36	39	-10.5	-8.0	21	1096	1072	31	3040	1865	2100	2000	350	14.6	-11.2	826.6
10	F	762	3.4	-33	36	-10.5	-8.0	21	1077	1059	44	2994	1853	2100	2000	350	14.6	-11.2	803.2
10	G	762	3.4	-30	33	-10.5	-8.0	21	1037	1042	175	2910	1944	2100	2000	350	14.6	-11.2	658.6
10	H	914	3.4	-28	31	-10.5	-8.0	21	1101	1143	183	3133	2105	2100	2000	350	14.6	-11.2	731.4
10	J	914	3.4	-26	29	-10.5	-8.0	21	1083	1140	37	3101	1947	2100	2000	350	14.6	-11.2	875.0
10	K	914	3.248	-24	27	-10.5	-8.0	21	1059	1117	57	3035	1927	2100	2000	350	14.6	-11.4	836.6
10	L	914	3.151	-22	25	-10.5	-8.0	21	860	962	48	2530	1632	2100	2000	350	14.6	-11.5	721.6
10	M	762	3.06	-20	23	-10.5	-8.0	21	533	712	383	1707	1504	2100	2000	350	14.6	-11.6	186.6
10	N	762	2.555	-19	22	-10.5	-8.0	21	416	671	826	1471	1839	2100	2000	350	14.6	-12.1	-289.2
10	P	762	2.555	-19	22	-10.5	-8.0	21	338	709	950	1392	1970	2100	2000	350	14.6	-12.1	-382.8

Base Shear 35700 kN

Technical Memorandum Table B-2

SOUTH JETTY PILES

tension in red

												combo1	combo2						Combo 3
BAY LINE	BAY LINE	PILE DIA	ELEVATION OF TOP OF PILE	DESIGN TOE ELEVATION	DESIGN PILE LENGTH	DESIGN COATING LENGTH	Elev dredging	Elev armour	AXIAL LOAD LIVE kN	AXIAL LOAD DEAD kN	Seismic max C or T	Fact 1.2D+1.6L Axial [kN]	Fact 1.2D+.5L+1.0E Axial [kN]	Mftop kNm	Mfbot kNm	Vt at top of pile [kN]	assumed fixity from top of pile m	assumed elevation of fixity [m]	0.8D+1.0E
11	A	762	2.555	-44	47	22	-10.5	-8.5	301	643	201	1253	1123	450	500	90	13.2	-10.6	313.40
11	B	762	2.555	-46	49	21	-9.8	-7.0	395	644	219	1405	1189	500	500	100	12.5	-9.9	296.20
11	C	914	3.4	-44	47	21	-8.5	-5.0	567	815	381	1885	1643	1450	1250	320	10.5	-7.1	271.00
11	C1	914	3.4	-42	45	21	-6.0	-4.0	651	860	567	2074	1925	1450	1250	320	10.5	-7.1	121.00
11	D1	914	3.4	-39	42	21	-5.0	-2.5	564	813	1135	1878	2393	2632	2500	1200	5.3	-1.9	-484.60
12	A	762	2.555	-44	47	21	-10.5	-8.5	794	990	202	2458	1787	450	500	90	13.2	-10.6	590.00
12	B	762	2.555	-47	50	21	-9.8	-7.0	968	980	156	2725	1816	500	500	100	12.5	-9.9	628.00
12	C	914	3.4	-46	49	21	-8.5	-5.0	1352	1232	248	3642	2402	1450	1250	320	10.5	-7.1	737.60
12	C1	914	3.4	-44	47	21	-6.0	-4.0	1504	1265	386	3924	2656	1450	1250	320	10.5	-7.1	626.00
12	D1	914	3.4	-40	43	21	-5.0	-2.5	1400	1198	868	3678	3006	2632	2500	1200	5.3	-1.9	90.40
13	A	762	2.555	-43	46	21	-10.5	-8.5	1093	1219	207	3212	2216	450	500	90	13.2	-10.6	768.20
13	B	762	2.555	-47	50	21	-9.8	-7.0	1316	1189	160	3532	2245	500	500	100	12.5	-9.9	791.20
13	C	914	3.4	-45	48	21	-8.5	-5.0	1829	1477	172	4699	2859	1450	1250	320	10.5	-7.1	1009.60
13	C1	914	3.4	-42	45	21	-6.0	-4.0	2030	1497	351	5044	3162	1450	1250	320	10.5	-7.1	846.60
13	D1	914	3.4	-41	44	21	-5.0	-2.5	1893	1414	891	4726	3534	2632	2500	1200	5.3	-1.9	240.20
14	A	762	2.555	-42	45	21	-10.5	-8.5	1034	1191	212	3084	2158	450	500	90	13.2	-10.6	740.80
14	B	762	2.555	-44	47	21	-9.8	-7.0	1263	1160	164	3413	2188	500	500	100	12.5	-9.9	764.00
14	C	914	3.4	-42	45	21	-8.5	-5.0	1764	1440	175	4550	2785	1450	1250	320	10.5	-7.1	977.00
14	C1	914	3.4	-38	41	21	-6.0	-4.0	1961	1459	357	4888	3088	1450	1250	320	10.5	-7.1	810.20
14	D1	914	3.4	-34	37	21	-5.0	-2.5	1814	1375	908	4552	3465	2632	2500	1200	5.3	-1.9	192.00
15	A	762	2.555	-42	45	21	-10.0	-7.5	1031	1189	215	3076	2157	450	500	90	13.2	-10.6	736.20
15	B	762	2.555	-41	44	21	-8.0	-5.3	1262	1159	166	3410	2188	500	500	100	12.5	-9.9	761.20
15	C	914	3.4	-39	42	21	-6.0	-4.0	1765	1440	178	4552	2789	1450	1250	320	10.5	-7.1	974.00
15	C1	914	3.4	-37	40	21	-5.3	-2.5	1963	1460	363	4893	3097	1450	1250	320	10.5	-7.1	805.00
15	D1	914	3.4	-34	37	21	-4.3	-2.0	1816	1376	923	4557	3482	2632	2500	1200	5.3	-1.9	177.80
16	A	762	2.555	-42	45	21	-10.0	-7.5	1032	1189	219	3078	2162	450	500	90	13.2	-10.6	732.20
16	B	762	2.555	-40	43	21	-8.0	-5.3	1263	1160	169	3413	2193	500	500	100	12.5	-9.9	759.00
16	C	914	3.4	-39	42	21	-6.0	-4.0	1766	1441	180	4555	2792	1450	1250	320	10.5	-7.1	972.80
16	C1	914	3.4	-36	39	21	-5.3	-2.5	1964	1460	368	4894	3102	1450	1250	320	10.5	-7.1	800.00
16	D1	914	3.4	-34	37	21	-4.3	-2.0	1817	1371	936	4552	3490	2632	2500	1200	5.3	-1.9	160.80
17	A	762	2.555	-42	45	21	-10.0	-7.5	1032	1189	221	3078	2164	450	500	90	13.2	-10.6	730.20
17	B	762	2.555	-40	43	21	-8.0	-5.3	1263	1160	171	3413	2195	500	500	100	12.5	-9.9	757.00
17	C	914	3.4	-39	42	21	-6.0	-4.0	1766	1441	182	4555	2794	1450	1250	320	10.5	-7.1	970.80
17	C1	914	3.4	-37	40	21	-5.3	-2.5	1964	1460	373	4894	3107	1450	1250	320	10.5	-7.1	795.00
17	D1	914	3.4	-35	38	21	-4.3	-2.0	1817	1376	947	4558	3507	2632	2500	1200	5.3	-1.9	153.80
18	A	762	2.555	-42	45	21	-10.0	-7.5	1032	1189	223	3078	2166	450	500	90	13.2	-10.6	728.20
18	B	762	2.555	-41	44	21	-8.0	-5.3	1263	1160	172	3413	2196	500	500	100	12.5	-9.9	756.00
18	C	914	3.4	-39	42	21	-6.0	-4.0	1766	1441	184	4555	2796	1450	1250	320	10.5	-7.1	968.80
18	C1	914	3.4	-37	40	21	-5.3	-2.5	1964	1460	375	4894	3109	1450	1250	320	10.5	-7.1	793.00
18	D1	914	3.4	-35	38	22	-4.3	-2.0	1817	1376	955	4558	3515	2632	2500	1200	5.3	-1.9	145.80
19	A	762	2.555	-42	45	21	-10.0	-7.5	1032	1190	225	3079	2169	450	500	90	13.2	-10.6	727.00
19	B	762	2.555	-41	44	21	-8.0	-5.3	1263	1160	174	3413	2198	500	500	100	12.5	-9.9	754.00
19	C	914	3.4	-39	42	21	-6.0	-4.0	1766	1441	185	4555	2797	1450	1250	320	10.5	-7.1	967.80
19	C1	914	3.4	-38	41	21	-5.3	-2.5	1964	1460	378	4894	3112	1450	1250	320	10.5	-7.1	790.00
19	D1	914	3.4	-36	39	21	-4.3	-2.0	1817	1371	961	4552	3515	2632	2500	1200	5.3	-1.9	135.80
20	A	762	2.555	-42	45	21	-10.0	-7.5	1032	1190	226	3079	2170	450	500	90	13.2	-10.6	726.00
20	B	762	2.555	-42	45	21	-8.0	-5.3	1263	1160	174	3413	2198	500	500	100	12.5	-9.9	754.00
20	C	914	3.4	-41	44	21	-6.0	-4.0	1766	1441	185	4555	2797	1450	1250	320	10.5	-7.1	967.80
20	C1	914	3.4	-39	42	21	-5.3	-2.5	1964	1460	379	4894	3113	1450	1250	320	10.5	-7.1	789.00
20	D1	914	3.4	-37	40	21	-4.3	-2.0	1817	1376	964	4558	3524	2632	2500	1200	5.3	-1.9	136.80
21	A	762	2.555	-42	45	21	-10.0	-7.5	1032	1190	226	3079	2170	450	500	90	13.2	-10.6	726.00
21	B	762	2.555	-42	45	21	-8.0	-5.3	1263	1160	174	3413	2198	500	500	100	12.5	-9.9	754.00
21	C	914	3.4	-42	45	21	-6.0	-4.0	1766	1441	185	4555	2797	1450	1250	320	10.5	-7.1	967.80
21	C1	914	3.4	-41	44	21	-5.3	-2.5	1964	1460	379	4894	3113	1450	1250	320	10.5	-7.1	789.00
21	D1	914	3.4	-39	42	21	-4.3	-2.0	1817	1376	964	4558	3524	2632	2500	1200	5.3	-1.9	136.80
22	A	762	2.555	-42	45	21	-10.0	-7.5	1032	1190	226	3079	2170	450	500	90	13.2	-10.6	726.00
22	B	762	2.555	-42	45	21	-8.0	-5.3	1263	1160	174	3413	2198	500	500	100	12.5	-9.9	754.00
22	C	914	3.4	-42	45	21	-6.0	-4.0	1766	1441	185	4555	2797	1450	1250	320	10.5	-7.1	967.80
22	C1	914	3.4	-41	44	21	-5.3	-2.5	1964	1460	379	4894	3113	1450	1250	320	10.5	-7.1	789.00
22	D1	914	3.4	-39	42	21	-4.3	-2.0	1817	1376	964	4558	3524	2632	2500	1200	5.3	-1.9	136.80
23	A	762	2.555	-38	41	21	-10.0	-7.5	1032	1189	226	3078	2169	450	500	90	13.2	-10.6	725.20
23	B	762	2.555	-38	41	21	-8.0	-5.3	1263	1160	174	3413	2198	500	500	100	12.5	-9.9	754.00
23	C	914	3.4	-38	41	21	-6.0	-4.0	1766	1440	185	4554	2796	1450	1250	320	10.5	-7.1	967.00
23	C1	914	3.4	-37	40	21	-5.3	-2.5	1964	1460	379	4894	3113	1450	1250	320	10.5	-7.1	789.00
23	D1	914	3.4	-36	39	21	-4.3	-2.0	1817	1375	964	4557	3523	2632	2500	1200	5.3	-1.9	136.00
24	A	762	2.555	-34	37	21	-10.0	-7.5	1067	1193	226	3139	2191	450	500	90	13.2	-10.6	728.40
24	B	762	2.555	-34	37	21	-8.0	-5.3	1296	1163	174	3469	2218	500	500	100	12.5	-9.9	756.40
24	C	914	3.4	-34	37	21	-6.0	-4.0	1808	1443	185	4624	2821	1450	1250	320	10.5	-7.1	969.40
24	C1	914	3.4	-35	38	21	-5.3	-2.5	2011	1461	379	4971	3138	1450	1250	320	10.5	-7.1	789.80
24	D1	914	3.4	-34	37	21	-4.3	-2.0	1871	1375	964	4644	3550	2632	2500	1200	5.3	-1.9	136.00
25	A	762	2.555	-33	36	21	-10.0	-7.5	1014	1203	223	3066	2174	450	500	90	13.2	-10.6	739.40
25	B	762	2.555	-34	37	21	-8.0	-5.3	1248	1177	172	3409	2208	500	500	100	12.5	-9.9	769.60
25	C	914	3.4	-36	39	21	-6.0	-4.0	1765	1465	184	4582	2825	1450	1250	320	10.5	-7.1	988.00
25	C1	914	3.4	-37	40	21	-5.3	-2.5	2060	1487	376	5080	3190	1450	1250	320	10.5	-7.1	813.60
25	D1	914	3.4	-36	39	21	-4.3	-2.0	1755	1403	956	4492	3517	2632	2500	1200	5.3	-1.9	166.40
26	A	762	2.555	-31	34	21	-7.5	-5.0	732	957	222	2320	1736	500	520	90	14.2	-11.6	543.60
26	B	762	2.555	-32	35	21	-5.0	-1.5	913	947	171	2597	1764	550	520	110	12.2	-9.6	586.60
26	C	914	3.4	-32	35	21	-2.5	0.0	1288	1192	183	3491	2257	1550	1300	350	10.2	-6.8	770.60
26	C1	914	3.4	-32	35	21	-2.0	1.5	1441	1229	374	3780	2569	1550	1300	350	10.2	-6.8	609.20
26	D1	914	3.525	-31	35	21	0.0	2.5	1318	1162	951	3503	3004	2850	2500	1300	5.1	-1.6	-21.40
27	A	762	2.555	-27	30	21	-7.5	-5.0	504	800	222	1766	1434	500	520	90	14.2	-11.6	418.00
27	B	762	2.555	-26	29	21	-5.0	-1.5	626	780	171	1938	1420	550	520	110	12.2	-9.6	453.00
27	C	914	3.4	-26	29	21	-2.5	0.0	879	977	183	2579	1795	1550	1300	350	10.2	-6.8	598.60
27	C1	914	3.4	-25	28	21	-2.0	1.5	988	1018	374	2802	2090	1550	1300	350	10.2	-6.8	440.40
27	D1	914	3.4	-25	28	21	0.0	2.5	860	963	951	2532	2537	2850	2500	1300	5.1	-1.7	-180.60
28	A	762	2.555	-24	27	21	-7.5	-5.0	753	967	222	2365	1759	500	520	90	14.2	-11.6	551.60
28	B	762	2.555	-24	27	21	-5.0	-1.5	932	956	171	2638	1784	550	520	110	12.2	-9.6	593.80
28	C	914	3.4	-22	25	21	-2.5	0.0	1314	1204	183	3547	2285	1550	1300	350	10.2	-6.8	780.20
28	C1	914	3.4	-22	25	21	-2.0	1.5	1479	1246	374	3862	2609	1550	1300	350	10.2	-6.8	622.80
28	D1	914	3.4	-20	23	21	0.0	2.5	1367	1185	951	3609	3057	2850	2500	1300	5.1	-1.7	-3.00
29	A	762	2.555	-22	25	21	-7.5	-5.0	1163	1258	236	3370	2327	500	520	90	14.2	-11.6	770.40
29	B	762	2.555	-21	24	21	-5.0	-1.5	1316	1191	181	3535	2268	550	520	110	12.2	-9.6	771.80
29	C	914	3.4	-20	23	21	-2.5	0.0	1723	1426	182	4468	2755	1550	1300	350	10.2	-6.8	958.80
29	C1	914	3.4	-20	23	21	-2.0	1.5	1512	1244	333	3912	2582	1550	1300	350	10.2	-6.8	662.20
29	D1'	914	3.4	-20	23	21	0.0	2.5	935	967	976	2656	2604	2850	2500	1300	5.1	-1.7	-202.40
30	A	762	2.555	-21	24	21	-4.0	-1.0	1216	1312	296	3520	2478	500	550	100	13.1	-10.6	753.60
30	B	762	2.555	-20	23	21	-1.3	0.0	1190	1138	188	3270	2149	550	550	110	12.5	-9.9	722.40
30	C	914	3.4	-20	23	21	0.0	1.5	1295	1199	41	3511	2127	1550	1500	350	10.9	-7.5	918.20
30	C1-	914	3.4	-20	23	21	1.0	3.0	534	670	517	1658	1588	1550	1500	350	10.9	-7.5	19.00
31	A	762	2.555	-20	23	21	-4.0	-1.0	510	825	386	1806	1631	550	550	100	13.8	-11.2	274.00
31	B	762	2.555	-20	23	21	-1.3	0.0	425	643	124	1452	1108	550	550	110	12.5	-9.9	390.40
31	C	914	3.4	-20	23	21	0.0	1.5	385	574	485	1305	1366	1550	1300	350	10.2	-6.8	-25.80

Base Shear 40720 kN

APPENDIX C -
Summary Tables and Revised Technical Specifications for Pile Foundations

Technical Memorandum Table C-1

Ultimate End Bearing Capacity in Till	2000	kPa
Ultimate End Bearing Capacity in Bedrock	7000	kPa
Ultimate Shaft Resistance in Till	225	kPa
Ultimate Shaft Resistance - Rock Grout Interface	1400	kPa
Geotechnical Resistance Factor - Compression	0.5	CSA S6-14
Geotechnical Resistance Factor - Tension	0.3	CSA S6-14

West Jetty Piles

From Herold Engineering

GRID LINE	BAY LINE	PILE DIA (mm)	PILE WALL (mm)	Pile Type	Socket Diameter (mm)	Socket Toe Elevation (m)	Steel Pile Toe Elevation (m)	Socket Length (m)	Maximum Factored Axial Demand - Compression (kN)	Maximum Factored Axial Demand - Tension (kN)
1	A	762	22	Type I	N/A	N/A	-59		2903	-1298
1	B1	762	22	Type I	N/A	N/A	-61		3687	-1802
1	D1	762	22	Type I	N/A	N/A	-54		4108	-1885
1	E1	762	22	Type I	N/A	N/A	-52		3835	-1685
1	F1	762	22	Type I	N/A	N/A	-50		3154	-1390
1	P	762	22	Type 2	706	-46	-44	2	2977	-1379
2	B1	762	22	Type I	N/A	N/A	-57		2100	0
2	D1	762	22	Type I	N/A	N/A	-54		2638	0
2	E1[E2]	762	22	Type I	N/A	N/A	-52		2592	0
2	F1	762	22	Type I	N/A	N/A	-49		1927	0
3	A	762	22	Type I	N/A	N/A	-60		3257	-1245
3	B	762	22	Type I	N/A	N/A	-58		3093	-999
3	C	762	22	Type I	N/A	N/A	-58		3065	-778
3	D	762	22	Type I	N/A	N/A	-54		3612	-992
3	E	762	22	Type I	N/A	N/A	-56		3611	-935
3	F	762	22	Type I	N/A	N/A	-55		3118	-814
3	M	762	22	Type I	N/A	N/A	-49		2831	-767
3	N	762	22	Type I	N/A	N/A	-48		2497	-294
3	P	762	22	Type 2	706	-44	-42	2	2441	0
4	A	762	22	Type I	N/A	N/A	-57		2682	-24
4	B	762	22	Type I	N/A	N/A	-58		3477	0
4	C	762	22	Type I	N/A	N/A	-58		4128	0
4	D	762	22	Type 2	706	-55	-53	2	5246	0
4	E	762	22	Type 2	706	-54	-51	3	5521	0
4	F	762	22	Type 2	706	-52	-50	2	5125	0
4	G	762	22	Type I	N/A	N/A	-47		3884	0
4	M	762	22	Type 2	706	-43	-41	2	3428	0
4	N	762	22	Type 2	706	-42	-40	2	3246	0
4	P	762	22	Type 2	706	-41	-39	2	3234	-15
5	A	762	22	Type I	N/A	N/A	-56		2688	-22
5	B	762	22	Type I	N/A	N/A	-57		3476	0
5	C	762	22	Type I	N/A	N/A	-57		4116	0
5	D	762	22	Type 2	706	-53	-51	2	5191	0
5	E	762	22	Type 2	706	-52	-50	3	5473	0
5	F	762	22	Type 2	706	-51	-48	3	5507	0
5	G	762	22	Type 2	706	-48	-45	3	5408	0
5	M	762	22	Type 2	706	-39	-37	3	4219	0
5	N	762	22	Type 2	706	-38	-36	2	3416	0
5	P	762	22	Type 2	706	-36	-34	2	2734	0
6	A	762	22	Type I	N/A	N/A	-55		2688	-22
6	B	762	22	Type I	N/A	N/A	-56		3479	0
6	C	762	22	Type I	N/A	N/A	-55		4118	0
6	D	762	22	Type 2	706	-52	-50	2	5193	0
6	E	762	22	Type 2	706	-50	-48	3	5460	0
6	F	762	22	Type 2	706	-48	-46	3	5449	0
6	G	762	22	Type 2	706	-45	-43	3	5356	0
6	H	762	22	Type 2	706	-39	-36	3	4809	0
6	M	762	22	Type 2	706	-34	-32	2	3949	0
6	N	762	22	Type 2	706	-33	-30	3	3432	0
6	P	762	22	Type 2	706	-31	-29	2	2758	0
7	A	762	22	Type I	N/A	N/A	-52		2686	-22
7	B	762	22	Type I	N/A	N/A	-53		3479	0
7	C	762	22	Type I	N/A	N/A	-54		4120	0
7	D	762	22	Type I	N/A	N/A	-52		5194	0
7	E	762	22	Type I	N/A	N/A	-49		5446	0
7	F	762	22	Type 2	706	-47	-45	2	5418	0
7	G	762	22	Type 2	706	-42	-39	2	5409	0
7	H	762	22	Type 2	706	-37	-34	3	5222	0
7	J	762	22	Type 2	706	-32	-29	3	4419	0
7	M	762	22	Type 2	706	-30	-28	3	3890	0
7	N	762	22	Type 2	706	-29	-27	3	3488	0
7	P	762	22	Type 2	706	-27	-25	2	2817	-71
8	A	762	22	Type I	N/A	N/A	-49		2685	-23
8	B	762	22	Type I	N/A	N/A	-52		3479	0
8	C	762	22	Type I	N/A	N/A	-51		4120	0
8	D	762	22	Type I	N/A	N/A	-49		5190	0
8	E	762	22	Type I	N/A	N/A	-45		5443	0
8	F	762	22	Type 2	706	-44	-42	2	5421	0
8	G	762	22	Type 2	706	-40	-37	3	5434	0
8	H	762	22	Type 2	706	-36	-33	3	5283	0
8	J	762	22	Type 2	706	-30	-27	3	4340	0
8	J1	762	22	Type 2	706	-27	-24	3	3263	0
8	M	762	22	Type 2	706	-26	-24	2	2735	0
8	N	762	22	Type 2	706	-26	-24	2	2620	0
8	P	762	22	Type 2	706	-26	-24	2	2100	0
9	A	762	22	Type I	N/A	N/A	-46		2342	-87
9	B	762	22	Type I	N/A	N/A	-50		3391	0
9	C	762	22	Type I	N/A	N/A	-49		4123	0
9	D	762	22	Type I	N/A	N/A	-46		5251	0
9	E	762	22	Type 2	706	-45	-43	2	5521	0
9	F	762	22	Type 2	706	-41	-38	2	5333	0
9	G	762	22	Type 2	706	-36	-34	2	4547	0
9	H	762	22	Type 2	706	-31	-29	2	3562	0
9	J	762	22	Type 2	706	-28	-25	3	4764	0
9	K	762	22	Type 2	706	-25	-21	4	5853	0
9	M	762	22	Type 2	706	-23	-20	4	5237	0
9	N	762	22	Type 2	706	-23	-20	3	4292	0
9	P	762	22	Type 2	706	-22	-20	3	3263	-203
10	A	762	22	Type I	N/A	N/A	-44		1583	-286
10	B	762	22	Type I	N/A	N/A	-42		1948	0
10	C	762	22	Type I	N/A	N/A	-41		2382	0
10	D	762	22	Type I	N/A	N/A	-41		2940	0
10	E	762	22	Type I	N/A	N/A	-40		3040	0
10	F	762	22	Type I	N/A	N/A	-36		2994	0
10	G	762	22	Type I	N/A	N/A	-32		2910	0
10	H	914	22	Type 2	850	-30	-28	2	3133	0
10	J	914	22	Type 2	850	-26	-24	2	3101	0
10	K	914	22	Type 2	850	-22	-20	2	3035	0
10	L	914	22	Type 2	850	-20	-18	2	2530	0
10	M	762	22	Type 2	706	-19	-17	2	1707	0
10	N	762	22	Type 2	706	-19	-17	2	1839	-289
10	P	762	22	Type 2	706	-19	-17	2	1970	-383

Technical Memorandum Table C-2

Ultimate End Bearing Capacity in Till	2000	kPa
Ultimate End Bearing Capacity in Bedrock	7000	kPa
Ultimate Shaft Resistance in Till	225	kPa
Ultimate Shaft Resistance - Rock Grout Interface	1400	kPa
Geotechnical Resistance Factor - Compression	0.5	CSA S6-14
Geotechnical Resistance Factor - Tension	0.3	CSA S6-14

South Jetty Piles

From Herold Engineering

GRID LINE	BAY LINE	PILE DIA (mm)	PILE WALL (mm)	Pile Type	Socket Diameter (mm)	Socket Toe Elevation (m)	Steel Pile Toe Elevation (m)	Socket Length (m)	Maximum Factored Axial Demand - Compression (kN)	Maximum Factored Axial Demand - Tension (kN)
11	A	762	22	Type I	N/A	N/A	-44		1253	0
11	B	762	22	Type I	N/A	N/A	-46		1405	0
11	C	914	22	Type I	N/A	N/A	-44		1885	0
11	C1	914	22	Type I	N/A	N/A	-42		2074	0
11	D1	914	22	Type I	N/A	N/A	-39		2393	-485
12	A	762	22	Type I	N/A	N/A	-44		2458	0
12	B	762	22	Type I	N/A	N/A	-47		2725	0
12	C	914	22	Type I	N/A	N/A	-46		3642	0
12	C1	914	22	Type I	N/A	N/A	-43		3924	0
12	D1	914	22	Type I	N/A	N/A	-39		3678	0
13	A	762	22	Type I	N/A	N/A	-44		3212	0
13	B	762	22	Type I	N/A	N/A	-45		3532	0
13	C	914	22	Type I	N/A	N/A	-44		4699	0
13	C1	914	22	Type I	N/A	N/A	-41		5044	0
13	D1	914	22	Type I	N/A	N/A	-37		4726	0
14	A	762	22	Type I	N/A	N/A	-44		3084	0
14	B	762	22	Type I	N/A	N/A	-43		3413	0
14	C	914	22	Type I	N/A	N/A	-42		4550	0
14	C1	914	22	Type I	N/A	N/A	-38		4888	0
14	D1	914	22	Type I	N/A	N/A	-35		4552	0
15	A	762	22	Type I	N/A	N/A	-42		3076	0
15	B	762	22	Type I	N/A	N/A	-41		3410	0
15	C	914	22	Type I	N/A	N/A	-40		4552	0
15	C1	914	22	Type I	N/A	N/A	-36		4893	0
15	D1	914	22	Type 2	850	-36	-34	2	4557	0
16	A	762	22	Type I	N/A	N/A	-41		3078	0
16	B	762	22	Type I	N/A	N/A	-39		3413	0
16	C	914	22	Type I	N/A	N/A	-38		4555	0
16	C1	914	22	Type 2	850	-37	-35	3	4894	0
16	D1	914	22	Type 2	850	-35	-32	3	4552	0
17	A	762	22	Type I	N/A	N/A	-39		3078	0
17	B	762	22	Type 2	706	-40	-38	2	3413	0
17	C	914	22	Type 2	850	-39	-37	2	4555	0
17	C1	914	22	Type 2	850	-37	-35	3	4894	0
17	D1	914	22	Type 2	850	-35	-33	2	4558	0
18	A	762	22	Type 2	706	-40	-38	2	3078	0
18	B	762	22	Type 2	706	-39	-37	2	3413	0
18	C	914	22	Type 2	850	-38	-36	2	4555	0
18	C1	914	22	Type 2	850	-37	-35	2	4894	0
18	D1	914	22	Type 2	850	-35	-33	2	4558	0
19	A	762	22	Type 2	706	-38	-36	2	3079	0
19	B	762	22	Type 2	706	-37	-35	2	3413	0
19	C	914	22	Type 2	850	-36	-34	2	4555	0
19	C1	914	22	Type 2	850	-36	-33	2	4894	0
19	D1	914	22	Type 2	850	-34	-32	2	4552	0
20	A	762	22	Type I	N/A	N/A	-38		3079	0
20	B	762	22	Type I	N/A	N/A	-37		3413	0
20	C	914	22	Type I	N/A	N/A	-36		4555	0
20	C1	914	22	Type I	N/A	N/A	-35		4894	0
20	D1	914	22	Type I	N/A	N/A	-33		4558	0
21	A	762	22	Type I	N/A	N/A	-39		3079	0
21	B	762	22	Type I	N/A	N/A	-40		3413	0
21	C	914	22	Type I	N/A	N/A	-39		4555	0
21	C1	914	22	Type I	N/A	N/A	-38		4894	0
21	D1	914	22	Type I	N/A	N/A	-35		4558	0
22	A	762	22	Type I	N/A	N/A	-38		3079	0
22	B	762	22	Type I	N/A	N/A	-39		3413	0
22	C	914	22	Type I	N/A	N/A	-39		4555	0
22	C1	914	22	Type I	N/A	N/A	-37		4894	0
22	D1	914	22	Type I	N/A	N/A	-31		4558	0
23	A	762	22	Type I	N/A	N/A	-36		3078	0
23	B	762	22	Type I	N/A	N/A	-36		3413	0
23	C	914	22	Type I	N/A	N/A	-36		4554	0
23	C1	914	22	Type I	N/A	N/A	-33		4894	0
23	D1	914	22	Type 2	850	-31	-29	2	4557	0
24	A	762	22	Type I	N/A	N/A	-33		3139	0
24	B	762	22	Type I	N/A	N/A	-33		3469	0
24	C	914	22	Type I	N/A	N/A	-33		4624	0
24	C1	914	22	Type 2	850	-32	-30	2	4971	0
24	D1	914	22	Type 2	850	-30	-28	2	4644	0
25	A	762	22	Type I	N/A	N/A	-29		3066	0
25	B	762	22	Type I	N/A	N/A	-29		3409	0
25	C	914	22	Type I	N/A	N/A	-29		4582	0
25	C1	914	22	Type 2	850	-31	-29	2	5080	0
25	D1	914	22	Type 2	850	-29	-27	2	4492	0
26	A	762	22	Type 2	706	-27	-25	2	2320	0
26	B	762	22	Type 2	706	-27	-25	2	2597	0
26	C	914	22	Type 2	850	-27	-25	2	3491	0
26	C1	914	22	Type 2	850	-27	-25	2	3780	0
26	D1	914	22	Type I	N/A	N/A	-25		3503	-21
27	A	762	22	Type 2	706	-25	-23	2	1766	0
27	B	762	22	Type 2	706	-25	-23	2	1938	0
27	C	914	22	Type 2	850	-25	-23	2	2579	0
27	C1	914	22	Type 2	850	-25	-23	2	2802	0
27	D1	914	22	Type I	N/A	N/A	-24		2537	-181
28	A	762	22	Type 2	706	-23	-21	2	2365	0
28	B	762	22	Type 2	706	-23	-21	2	2638	0
28	C	914	22	Type 2	850	-22	-20	2	3547	0
28	C1	914	22	Type 2	850	-22	-20	2	3862	0
28	D1	914	22	Type 2	850	-24	-21	3	3609	-3
29	A	762	22	Type 2	706	-19	-17	2	3370	0
29	B	762	22	Type 2	706	-19	-17	2	3535	0
29	C	914	22	Type 2	850	-20	-18	2	4468	0
29	C1	914	22	Type 2	850	-20	-18	2	3912	0
29	D1'	914	22	Type 2	850	-21	-19	2	2656	-202
30	A	762	22	Type 2	706	-17	-14	3	3520	0
30	B	762	22	Type 2	706	-16	-14	2	3270	0
30	C	914	22	Type 2	850	-16	-14	2	3511	0
30	C1-	914	22	Type 2	850	-16	-14	2	1658	0
31	A	762	22	Type 2	706	-14	-12	2	1806	0
31	B	762	22	Type 2	706	-14	-12	2	1452	0
31	C	914	22	Type 2	850	-14	-12	2	1366	-26

Technical Memorandum Table C-3

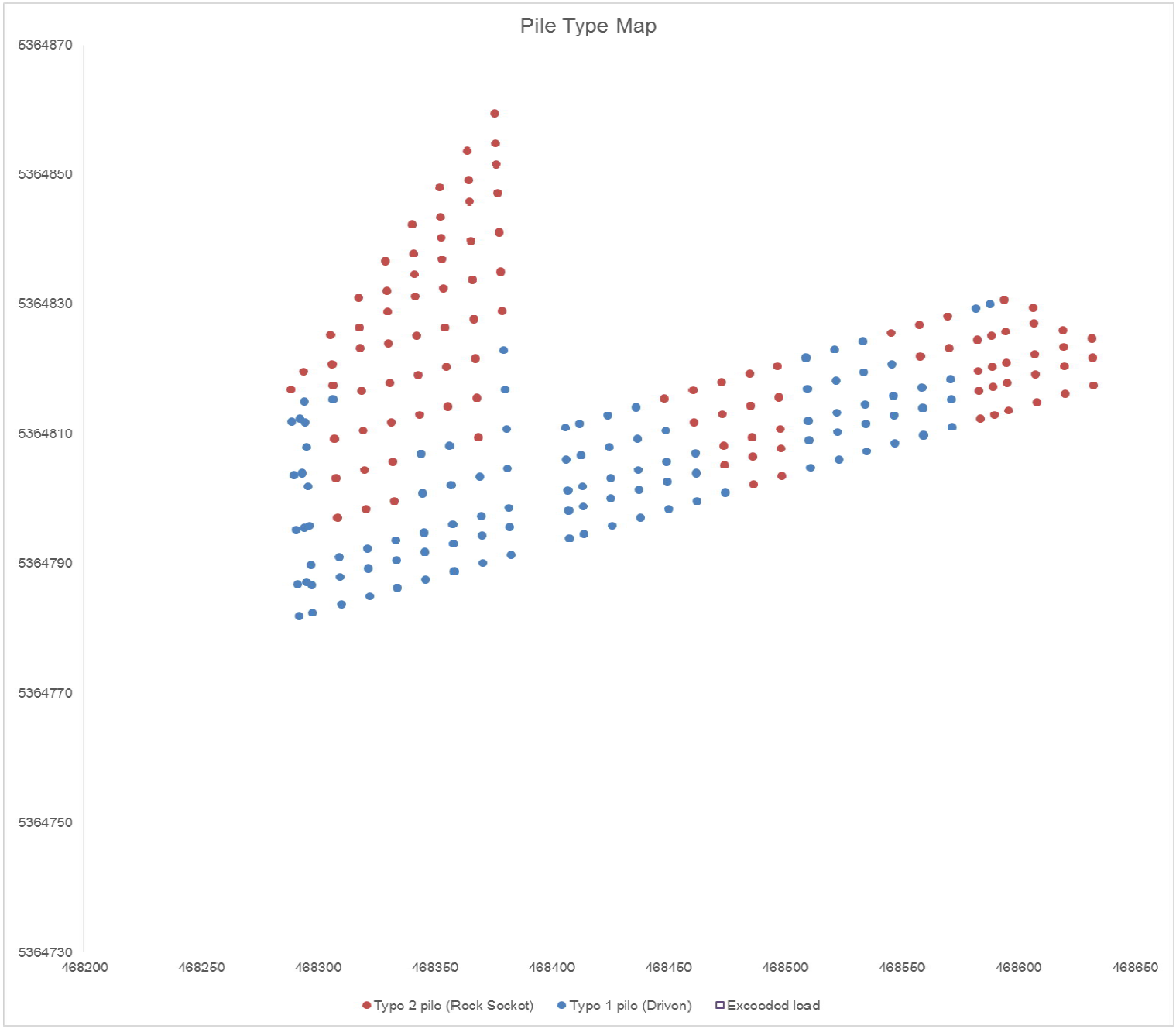
Displacement Control Piles								
GRID LINE	BAY LINE	PILE DIA (mm)	PILE WALL (mm)	**Pile Type**	**Socket Diameter (mm)**	**Socket Toe Elevation* (m)**	**Steel Pile Toe Elevation* (m)**	**Socket Length* (m)**
DCP-1	DCP-A	762	22	Type 2	706	-30	-27	3
DCP-1	DCP-B	762	22	Type 2	706	-28	-25	3
DCP-1	DCP-C	762	22	Type 2	706	-26	-23	3
DCP-1	DCP-D	762	22	Type 2	706	-24	-21	3
DCP-1	DCP-E	762	22	Type 2	706	-22	-19	3
DCP-1	DCP-F	762	22	Type 2	706	-22	-19	3
DCP-1	DCP-G	762	22	Type 2	706	-21	-18	3
DCP-2	DCP-A	762	22	Type 2	706	-30	-27	3
DCP-2	DCP-B	762	22	Type 2	706	-28	-25	3
DCP-2	DCP-C	762	22	Type 2	706	-25	-22	3
DCP-2	DCP-D	762	22	Type 2	706	-24	-21	3
DCP-2	DCP-E	762	22	Type 2	706	-22	-19	3
DCP-2	DCP-F	762	22	Type 2	706	-22	-19	3
DCP-2	DCP-G	762	22	Type 2	706	-21	-18	3

***Note: To be confirmed upon completion of geotechnical engineering analyses currently underway.**

Technical Memorandum Table C-4

Tug Boat Wharf Piles				
BAY LINE	PILE DIA (mm)	PILE WALL (mm)	**Pile Type**	**Steel Pile Toe Elevation* (m)**
T1	914	22	Type 3	-19
T2	914	22	Type 3	-15

***Note: To be confirmed upon completion of geotechnical engineering analyses currently underway.**



Technical Memorandum Figure C-1

G2

ESQUIMALT GRAVING DOCK

GOLDER TECHNICAL MEMORANDUM STABILITY ASSESSMENT OF CAPPING MATERIAL - EAST SLOPE

Number of Pages: 11

TECHNICAL MEMORANDUM

DATE 3 March 2017 **REFERENCE No.** 1314470497-059-TM-Rev0-13000

TO Patrick Truong
Public Works and Government Services Canada

CC Dan Berlin (Anchor QEA), Kate Ulmer (Herold Engineering)

FROM Sarah Morse **EMAIL** smorse@golder.com

ESQUIMALT GRAVING DOCK SOUTH JETTY REPLACEMENT PROJECT
STABILITY ASSESSMENT OF CAPPING MATERIAL SLOPE

Golder Associated Ltd. (Golder) was requested by Herold Engineering and Anchor QEA (Anchor) to carry out a stability assessment of the proposed final capping slopes proposed at the east end of the South Jetty as part of the South Jetty Reconstruction project. This Technical Memorandum provides a summary of the methodology followed and the results of our assessment.

1.0 PROPOSED SLOPE

Final capping designs for the slope located to the east of the new South Jetty are being prepared by Anchor. The proposed slopes and capping configurations are provided in Attachment 1. Based on the drawings provided and discussion with Anchor, we understand that contaminated sediments that were not removed during the Phase 2 remediation in the area of the proposed tug float landing will be removed during the South Jetty reconstruction and capped with an engineered cap design. The final geometry of the slopes will generally follow the existing grade with maximum 2H:1V slope in areas where the existing grade is steeper than 2H:1V. Details regarding cap composition are provided in Attachment 1. The minimum cap composition required is as follows:

- 0.3 m thickness of 0.15 m rock armour material
- 0.3 m thickness of filter material
- 0.5 m thickness of sand material

2.0 OVERVIEW OF SUBSURFACE STRATIGRAPHY

Subsurface soil and groundwater conditions inferred from our review of previous geotechnical reports are summarized below. For geotechnical analysis and discussion purposes, subsurface conditions have been grouped into the following stratigraphic units (in the order of increasing depth below ground surface) based on physical soil properties and inferred geologic origin:

- **Mixed Fill**: The imported fill materials are generally composed of sand and gravel mixtures and are present on both sides of the proposed retaining wall. The inferred relative density of the material is compact.

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Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

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- **Upper Marine Sediments**: The upper portion of this layer consists of soft to firm mixtures of silt, clay and fine sand typically ranging from silty clay to clayey silt to sandy silt. The deposits also contain varying quantities of shells and minor organic content. The upper portion of the marine sediments has been interpreted to be Holocene deposits of “Marine mud”. The lower portion of the marine deposits consist of loose to compact granular marine sediments ranging in composition from silty sand to silty sand which also contains varying quantities of shells. These have been inferred to be beach deposits derived from erosion of exposed glacial deposits.
- **Glaciomarine Sediments (Victoria Clay)**: Glaciomarine sediments known locally as *Victoria Clay* are composed of firm to stiff silty clay with minor sand and gravel. A stiff crust of brown to mottled grey and brown silty clay was observed in some, but not all of the test holes.
- **Glacial Soils (Till)**: Glacial till in this area consists of dense to very dense silt and sand with slightly plastic fines. These deposits are discontinuous and generally less than a few metres thick. The till deposits are typically underlain by bedrock. They are inferred to represent part of the Vashon Drift formation.

3.0 GEOTECHNICAL ASSESSMENT

3.1 Methodology

Golder has carried out a global stability analysis of the proposed slope based on the available geotechnical information, and the slope configurations and capping profiles provided by Anchor QEA. The models were adapted to reflect high, mean and low tide water levels. Analyses were carried out for the case with a 2H:1V slope as this is the steepest proposed configuration.

Global stability analyses were carried out using the computer software program Slope/W 2007. The Morgenstern-Price limit equilibrium method was selected to calculate the global stability factor of safety for a typical section along the proposed retaining wall.

3.2 Material Strength Parameters

A summary of the inferred soil properties used in the assessment is provided in Table 1. Material strength parameters were selected based on our interpretation of field and lab tests conducted by Golder, KCB and others at the EGD site.

Table 1: Inferred Soil Strength and Unit Weight and Model Parameters

Material Description	Unit Weight (kN/m³)	Model Parameters
Mixed Fill (sand and gravel)	20	Drained: ϕ'=33°, c'=0;
Upper Marine Sediments	17	Drained: ϕ'=33°, c'=0;
Victoria Clay	19	Undrained: Su=50kPa
Glacial Till	22	Drained: ϕ'=35°, c'=35;
Capping Material – Rock Armour	22	Drained: ϕ'=40°, c'=0;
Capping Material – Filter Material	21	Drained: ϕ'=38°, c'=0;
Capping Material - Sand	20	Drained: ϕ'=33°, c'=0;

3.3 Tidal and Groundwater Conditions

For the assessment presented below, the high water level was taken at El. 3.4 m (Chart Datum), mean water level at El. 1.9 m, and low tide at El. 0.0 m (Chart Datum), Lower Low Water Large Tide.

4.0 GEOTECHNICAL ANALYSIS RESULTS

Global stability analysis results are provided on Figures 1, 2 and 3, and summarized in Table 2 below.

Table 2: Summary of Global Analysis Safety Factors – Static Loading Conditions

Tide Conditions	Calculated Factor of Safety
Low Low Water Large Tide	1.43
Mean Water Level	1.40
High Water Level	1.41

The assessment indicates that the proposed slopes at maximum 2H:1V has a minimum calculated factor of safety of 1.4 under static loading conditions.

5.0 SEISMIC ASSESSMENT

The design seismic loads for this project correspond to an earthquake with a return period of 475 years, or a 10 percent probability of exceedance in 50 years, with a peak ground acceleration of 0.308g. The limit equilibrium pseudo-static analysis of the slope with the design earthquake loading applied results in a factor of safety less than 1. This indicates that during an earthquake equivalent to the design seismic loads, slope movement would be anticipated. The extent of the slope movement has not been assessed at this time. It is our understanding that the intent of the capping is to re-instate slopes to their existing grades, and that it is not PWGSC's objective to improve upon the stability of the existing slopes.

6.0 DISCUSSION

Our assessment indicates that the proposed slopes at maximum 2H:1V has a minimum calculated factor of safety of 1.4 under. A factor of safety of 1.5 is generally targeted for long-term static stability of slope designs. However, a lower minimum calculated factor of safety for static loading is generally considered acceptable at this location, given the consequences of surficial slope raveling are limited, the existing slopes are steeper and that it is our understanding that PWGSC's objective does not include improving the stability of the existing slopes.

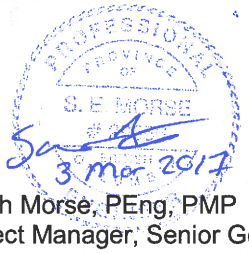
As discussed above, the analyses indicate that the factor of safety for the slope is less than 1 under the design earthquake loading conditions. This indicates that during an earthquake equivalent to the design seismic loads, slope movement would be anticipated. It is our understanding that displacement of this slope under seismic loading is acceptable to PWGSC.

7.0 CLOSURE

We trust that the information contained in this technical memorandum is suitable for your current needs. Please do not hesitate to contact us if you require further information.

Yours very truly,

GOLDER ASSOCIATES LTD.



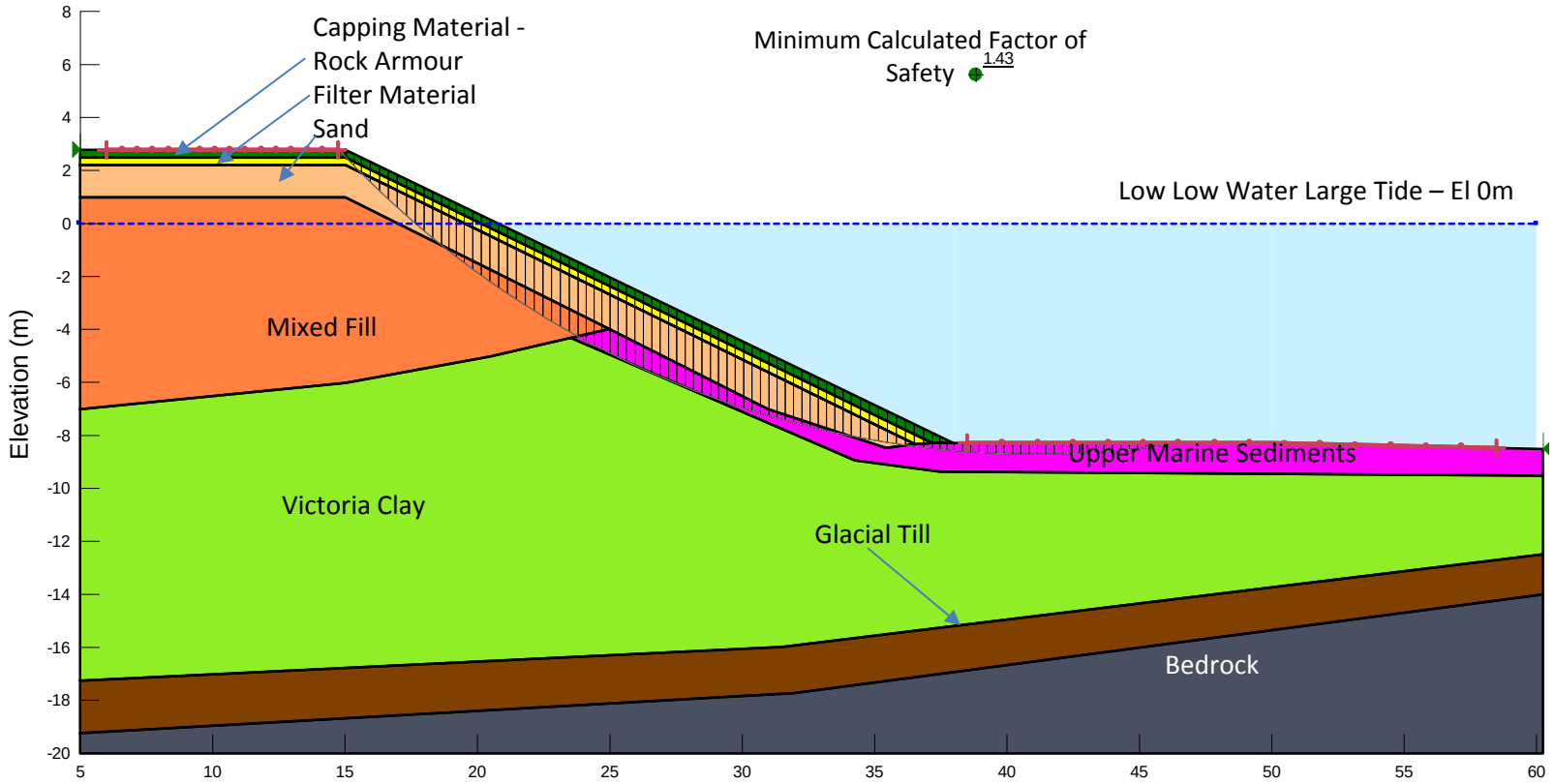
Sarah Morse, PEng, PMP
Project Manager, Senior Geotechnical Engineer

Upul Atukorala, PhD, PEng
Principal, Senior Geotechnical Engineer

SEM/UA/lmk

Attachments: Figures 1-3
Attachment 1 – Drawings

n:\final\2013\1447\13-1447-0497 pwgsc wood creek quarry\1314470497-059-tm-rev0-13000\1314470497-059-tm-rev0-13000-tm-rev0 cap stability assessment-3mar_17.docx



Material Description	Unit Weight (kN/m³)	Model Parameters
Mixed Fill (sand and gravel)	20	Drained: ϕ'=33º, c'=0;
Upper Marine Sediments	17	Drained: ϕ'=33º, c'=0;
Victoria Clay	19	Undrained: varies, see report.
Glacial Till	22	Drained: ϕ'=35º, c'=35;
Capping Material – Rock Armour	22	Drained: ϕ'=40º, c'=0;
Capping Material – Filter Material	21	Drained: ϕ'=38º, c'=0;
Capping Material - Sand	20	Drained: ϕ'=33º, c'=0;

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PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

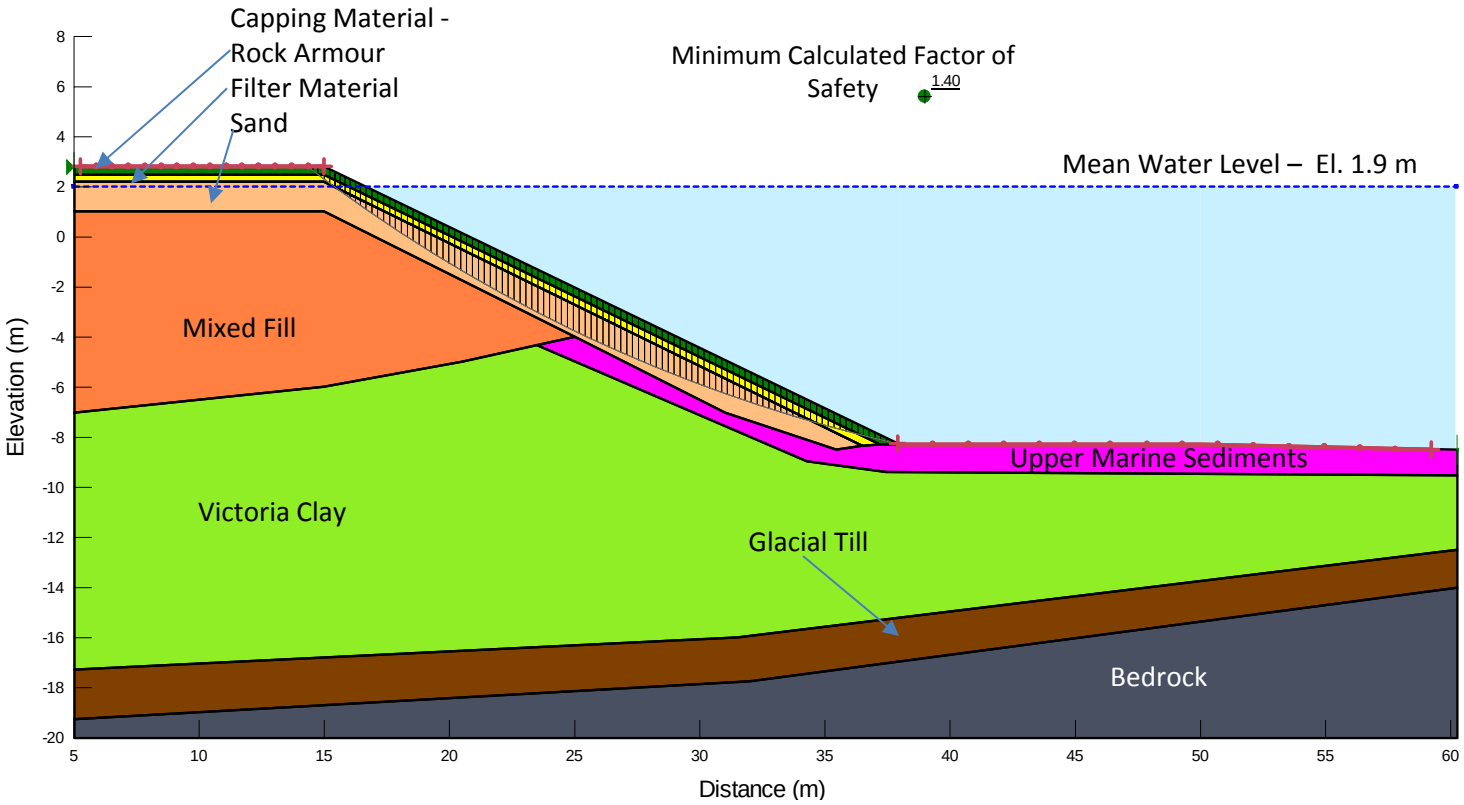
PROJECT
SOUTH JETTY RE-CONSTRUCTION
VICTORIA, BC

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-03
PREPARED	SEM
DESIGN	SEM
REVIEW	SEM
APPROVED	UA

TITLE
PROPOSED CAPPING SLOPE 2H:1V
STATIC CONDITION – LOW LOW WATER LARGE TIDE

PROJECT No.	Phase	Rev	FIGURE
1314470497	13000	0	1



Material Description	Unit Weight (kN/m³)	Model Parameters
Mixed Fill (sand and gravel)	20	Drained: ϕ'=33º, c'=0;
Upper Marine Sediments	17	Drained: ϕ'=33º, c'=0;
Victoria Clay	19	Undrained: varies, see report.
Glacial Till	22	Drained: ϕ'=35º, c'=35;
Capping Material – Rock Armour	22	Drained: ϕ'=40º, c'=0;
Capping Material – Filter Material	21	Drained: ϕ'=38º, c'=0;
Capping Material - Sand	20	Drained: ϕ'=33º, c'=0;

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PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

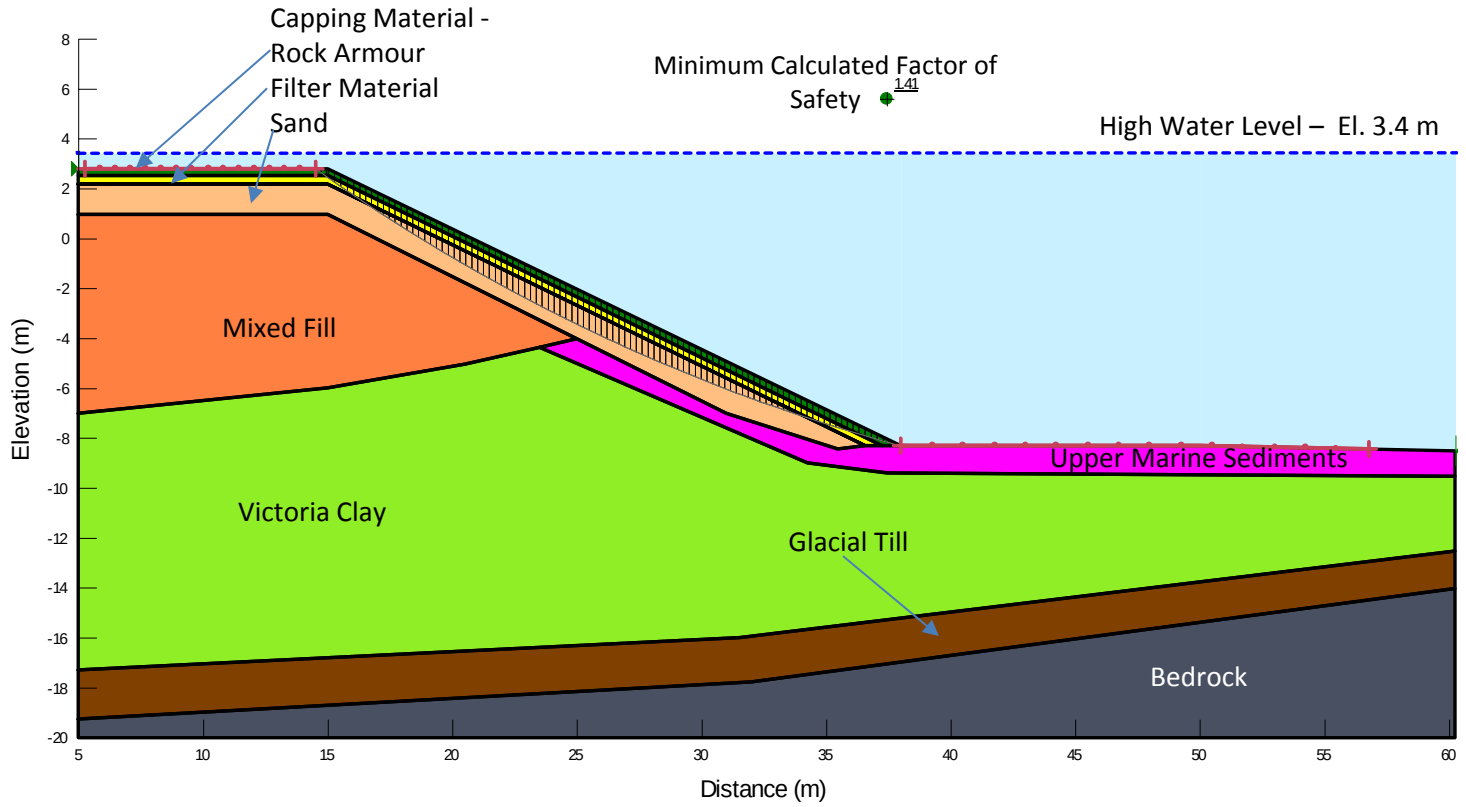
PROJECT
SOUTH JETTY RE-CONSTRUCTION
VICTORIA, BC

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-03
PREPARED	SEM
DESIGN	SEM
REVIEW	SEM
APPROVED	UA

TITLE
PROPOSED CAPPING SLOPE 2H:1V
STATIC CONDITION – MEAN WATER LEVEL

PROJECT No.	Phase	Rev	FIGURE
1314470497	13000	0	2



Material Description	Unit Weight (kN/m³)	Model Parameters
Mixed Fill (sand and gravel)	20	Drained: ϕ'=33º, c'=0;
Upper Marine Sediments	17	Drained: ϕ'=33º, c'=0;
Victoria Clay	19	Undrained: varies, see report.
Glacial Till	22	Drained: ϕ'=35º, c'=35;
Capping Material – Rock Armour	22	Drained: ϕ'=40º, c'=0;
Capping Material – Filter Material	21	Drained: ϕ'=38º, c'=0;
Capping Material - Sand	20	Drained: ϕ'=33º, c'=0;

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

PROJECT
SOUTH JETTY RE-CONSTRUCTION
VICTORIA, BC

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-03
PREPARED	SEM
DESIGN	SEM
REVIEW	SEM
APPROVED	UA

TITLE
PROPOSED CAPPING SLOPE 2H:1V
STATIC CONDITION – HIGH WATER LEVEL

PROJECT No.	Phase	Rev	FIGURE
1314470497	13000	0	3

CONTROL POINT TABLE		
	NORTHING (m)	EASTING (m)
1	5364824.7	468578.1
2	5364824.8	468580.8
3	5364831.1	468580.1
4	5364832.7	468595.1
5	5364830.3	468595.3
6	5364831.1	468602.2
7	5364828.8	468603.4
8	5364827.5	468606.2
9	5364824.9	468609.1
10	5364824.3	468614.9
11	5364822.4	468619.6
12	5364822.8	468622.4
13	5364819.3	468621.8
14	5364819.8	468620.4
15	5364818.6	468617.1
16	5364820.5	468615.2
17	5364822.1	468610.8
18	5364821.4	468608.3
19	5364823.2	468601.9
20	5364824.5	468596.1
21	5364820.1	468580.4
22	5364820.3	468578.3
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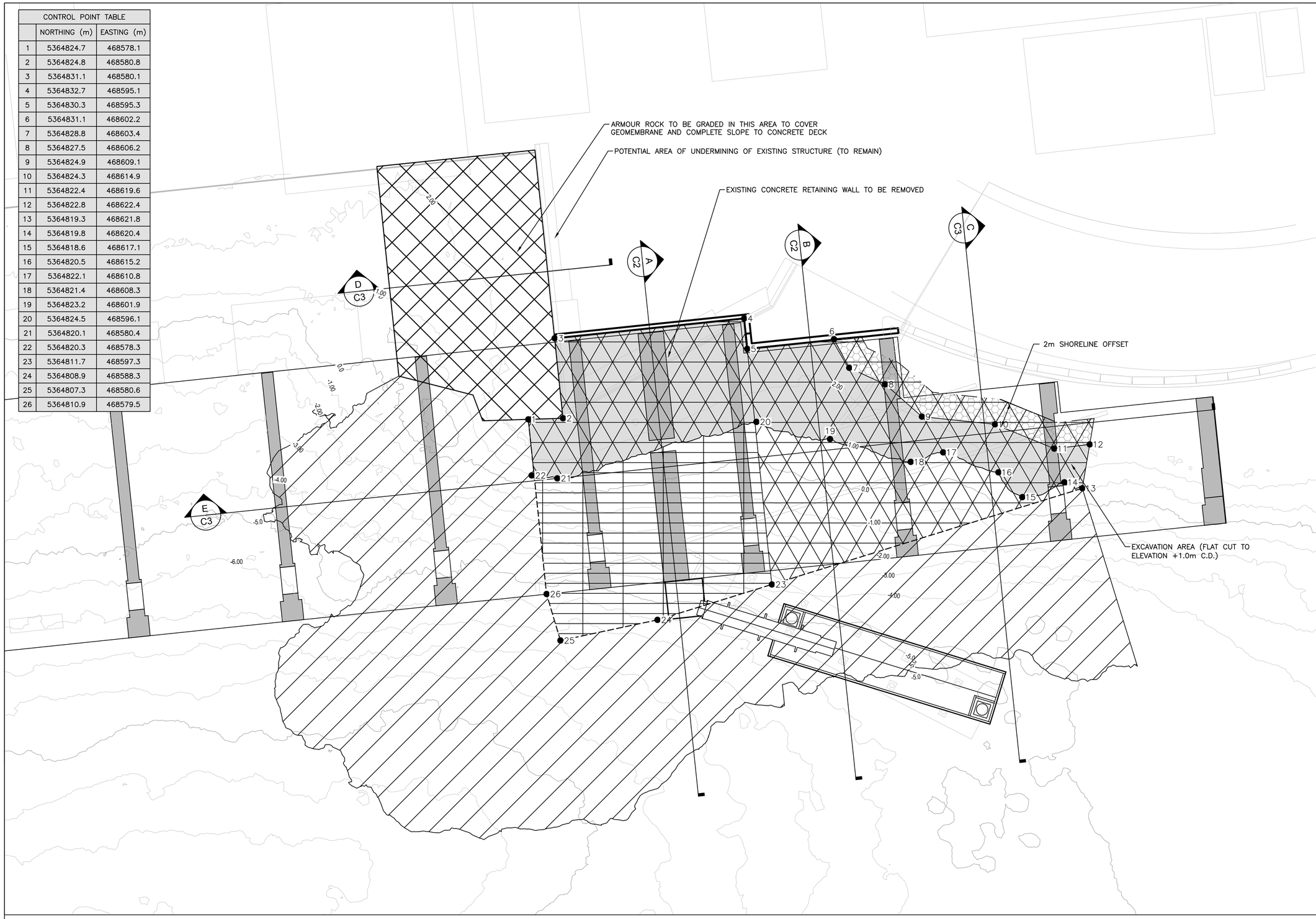

HORIZONTAL DATUM: UTM ZONE 10 GRID, NAD83.
VERTICAL DATUM: CHART DATUM (C.D.)

NOTES:

1. BASEMAP FROM GOLDER ASSOCIATES, DATED 2012. POST-CONSTRUCTION UNDERPIER SURVEYS FROM MCCOI MARINE, DATED DECEMBER 27, 2016.
2. +1.0m C.D. ELEVATION LINE TO BE VERIFIED BY CONTRACTOR'S PRE-CONSTRUCTION SURVEY.

EAST END SLOPE EXCAVATION AND ENGINEERED CAPPING PLAN

SCALE 1: 150

SCALE : 1:150
0m 3 6 9 12 15m

LEGEND:
- BATHYMETRY (1M AND 5M)
- EXISTING SHORELINE
- PROPOSED RETAINING WALL (HEROLD ENGINEERS)
- EXCAVATION AREA (TO ELEVATION +1.0m C.D.)
- CAP AREA – REQUIRED THICKNESS ON POST-EXCAVATION GRADE
- CAP AREA – 2H:1V SLOPE GRADE ON EXISTING SLOPES STEEPER THAN 2H:1V
- CAP AREA – 2H:1V SLOPE ON EXISTING GRADE
- AS-BUILT GEOMEMBRANE LOCATION
- DESIGN PILE ROW
- SHORELINE OFFSET AREA
- CAP SLOPE TRANSITION LINE

PWGSC – A1 – 841X594

0 10 20 30 40 50 60 70 80 90 100mm

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ANCHOR QEA

Revision/ Revision	Description/Description	Date/Date
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Client/client

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Project title/Titre du projet
ESQUIMALT GRAVING DOCK
825 ADMIRALS ROAD, VICTORIA, BC

SOUTH JETTY WHARF DEVELOPMENT

Consultant Signature Only

Designed by/Concept par
MATT WOLTMAN

Drawn by/Dessine par
CHRIS HEWETT

PWGSC Project Manager/Administrateur de Projets TPSGC
PATRICK TRUONG

Regional Manager, Environmental Services
.

Drawing title/Titre du dessin
EAST END SLOPE EXCAVATION AND ENGINEERED CAPPING PLAN

Project No./No. du projet	Sheet/	Revision no./
R.026729.002	C1	1

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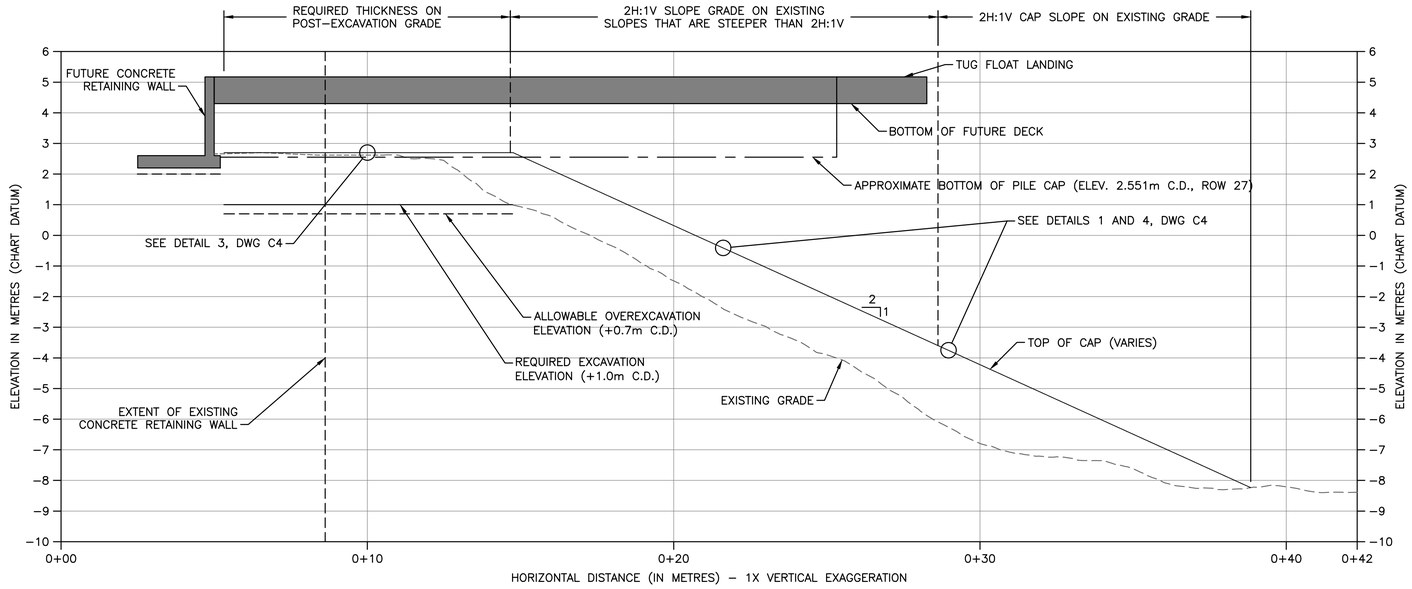

SECTION A
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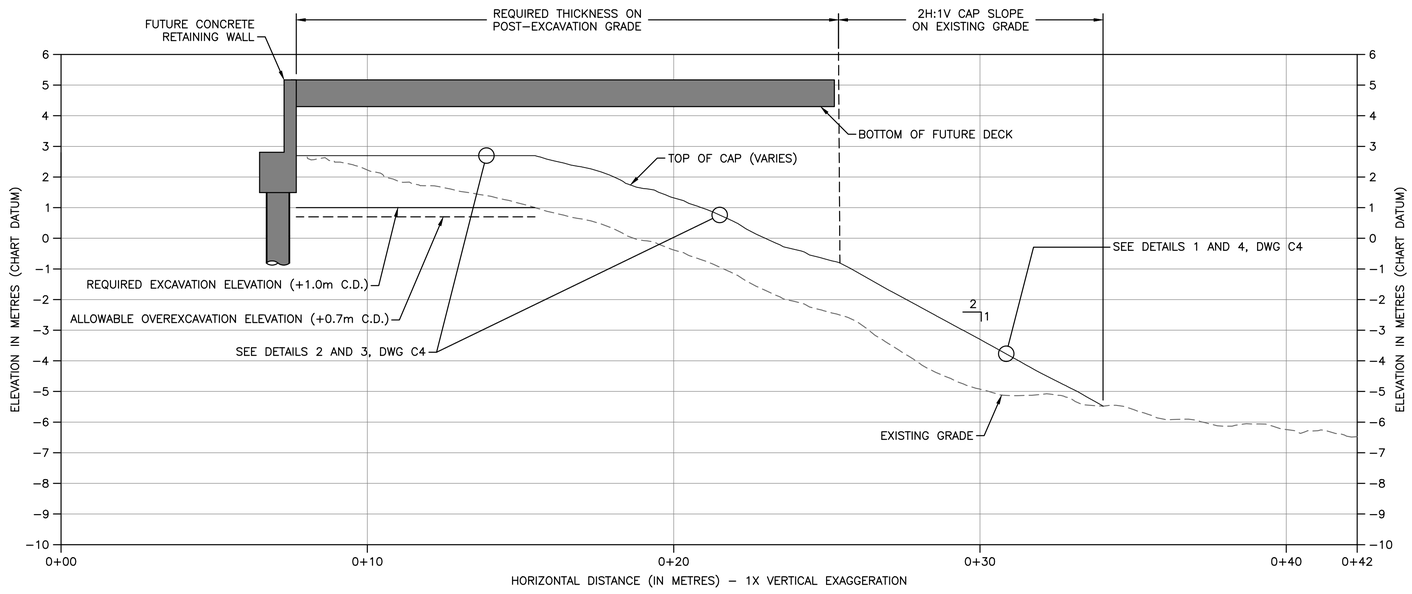
C1



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VERTICAL DATUM: CHART DATUM (C.D.)

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2. FOR EXCAVATION AND CAPPING DETAILS, SEE DWG C4.

CROSS SECTIONS
SCALE 1: 100

SCALE : 1:100
0m 2 4 6 8 10m

LEGEND:
- – – – POST–WORK SURVEY (MNQM, DECEMBER 27, 2016)
- ------ EXISTING GRADE (INTERPOLATED)
- ——— EXCAVATION TO ELEVATION +1m C.D.
- – – – ALLOWABLE OVEREXCAVATION ELEVATION (+0.7m C.D.)
- ——— TOP OF PROPOSED CAP SURFACE

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Regional Manager, Environmental Services
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ENGINEERED CAPPING
CROSS SECTIONS - SHEET 1

Project No./No. du projet	Sheet/	Revision no./
R.026729.002	C2	1

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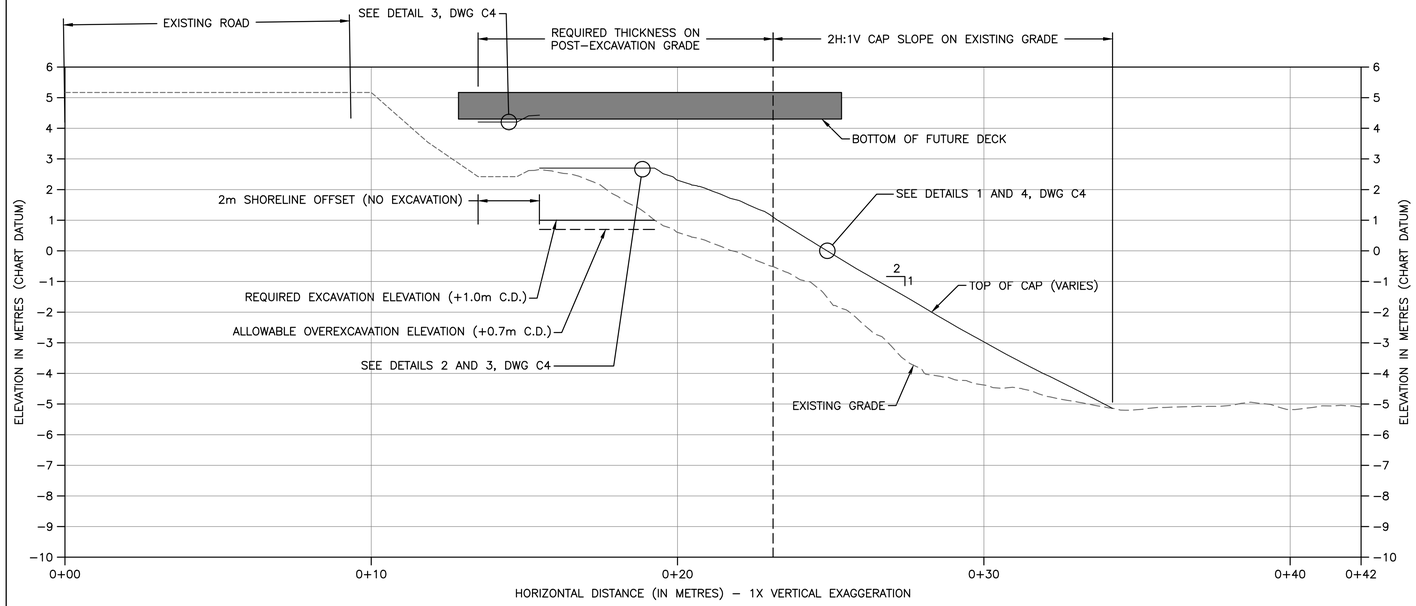

SECTION C
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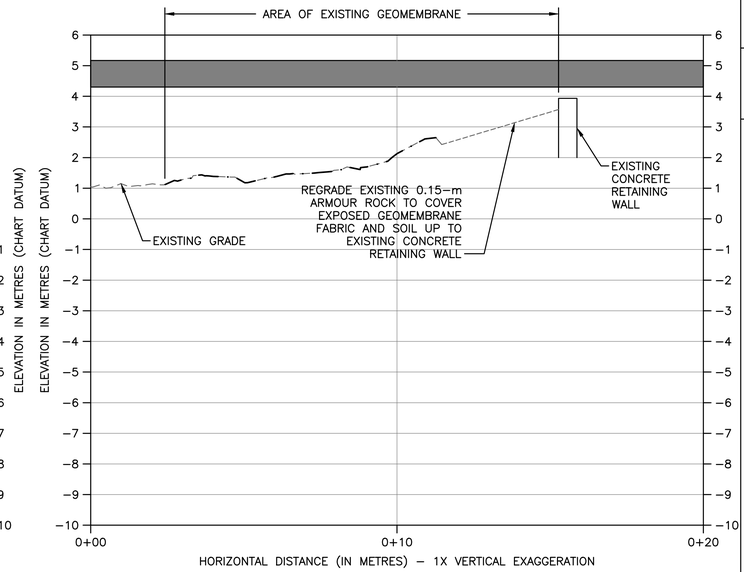
C1



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C1

SCALE : 1:100
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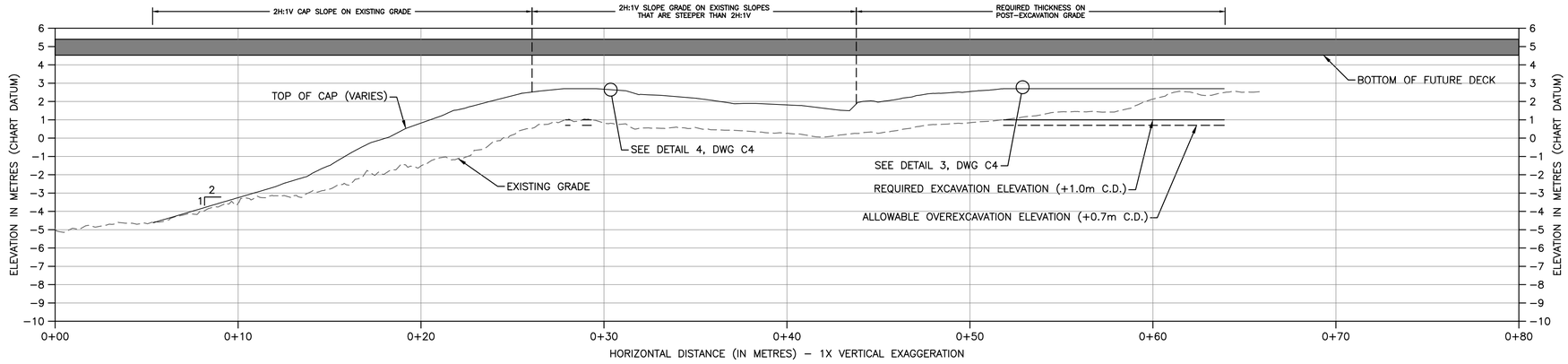

SECTION E
SCALE 1: 150
C1

SCALE : 1:150
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HORIZONTAL DATUM: UTM ZONE 10 GRID, NAD83.
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1. BASEMAP FROM GOLDER ASSOCIATES, DATED 2012. POST–CONSTRUCTION UNDERPIER SURVEYS FROM MCCOI MARINE, DATED DECEMBER 27, 2016.
2. FOR EXCAVATION AND CAPPING DETAILS, SEE DWG C4.

CROSS SECTIONS

SCALE: AS NOTED

LEGEND:
- – – – POST–WORK SURVEY (MNQM, DECEMBER 27, 2016)
- ------ EXISTING GRADE (INTERPOLATED)
- –·–·– GEOMEMBRANE PLACEMENT AREA
- ——— EXCAVATION TO ELEVATION +1m C.D.
- – – – ALLOWABLE OVEREXCAVATION ELEVATION (+0.7m C.D.)
- ——— TOP OF PROPOSED CAP SURFACE

PWGSC – A1 – 841X594

0 10 20 30 40 50 60 70 80 90 100mm

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Drawn by/Dessine par
CHRIS HEWETT

PWGSC Project Manager/Administrateur de Projets TPSGC
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Regional Manager, Environmental Services
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ENGINEERED CAPPING
CROSS SECTIONS - SHEET 2

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R.026729.002	C3	1

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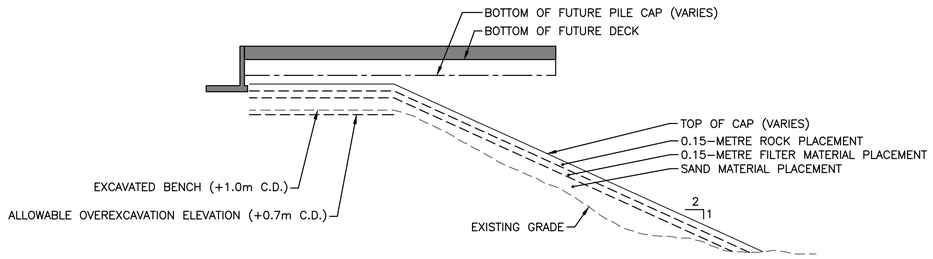
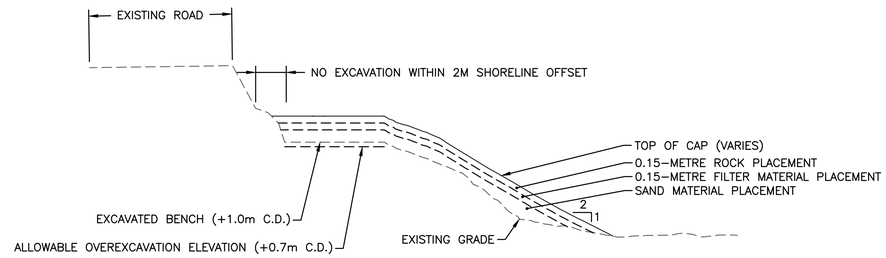


EAST END ENGINEERED CAP

DETAIL 1
NOT TO SCALE



EAST END ENGINEERED CAP WITH SHORELINE OFFSET

DETAIL 2
NOT TO SCALE

EAST END ENGINEERED CAP: 0.15–METRE ROCK ARMOUR LAYER OVER FILTER MATERIAL OVER SAND LAYER

DETAIL 3
NOT TO SCALE

EAST END ENGINEERED CAP: 2H:1V CAP SLOPE ON EXISTING GRADE

DETAIL 4
NOT TO SCALE

HORIZONTAL DATUM: UTM ZONE 10 GRID, NAD83.
VERTICAL DATUM: CHART DATUM (C.D.)

NOTES:
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Regional Manager, Environmental Services
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ENGINEERED CAPPING DETAILS

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R.026729.002	C4	1

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H1

ESQUIMALT GRAVING DOCK

SUB-SURFACE PROBING AND DIVE SURVEYS - GOLDER (NOV 2012)

Number of Pages: 95

November 1, 2012

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Sub-Surface Probing and Dive Surveys: Interpretive Report, Esquimalt Graving Dock, Esquimalt, BC

Submitted to:

Public Works and Government Services Canada
641 - 800 Burrard Street
Vancouver, BC
V6Z 2V8

REPORT

A world of capabilities delivered locally

Report Number: 10-1475-0002/7000/5000

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Golder Associates

Record of Issue

Company	Client Contact	Version	Date Issued	Method of Delivery	Comments
Public Works and Government Services Canada	Andrew Mylly	Draft	February 22, 2011	Electronic (pdf)	--
Public Works and Government Services Canada	Andrew Mylly	Final	November 1, 2012	Electronic (pdf) and hardcopy	Finalized based on comments received from PWGSC

Executive Summary

Golder Associates Ltd. (Golder) was retained by Public Works and Government Services Canada (PWGSC) to undertake tasks in support of remedial design for the Esquimalt Graving Dock (EGD) Waterlot sediment remediation project. EGD is located at 825 Admirals Road, Victoria, British Columbia. This report presents information collected during sub-surface probing surveys undertaken by divers beneath and surrounding the South Jetty, near the mouth of EGD, along the North Landing Wharf (NLW), in Pilgrim Cove, and near Munroe Head in the Canadian Forces Sailing Association (CFSA) Waterlot. This work has been undertaken in accordance with Golder's Final Workplan for 30% Remedial Design Support dated October 13, 2010, and Golder's Final Workplan for Under-Water Video Survey and Jet Probing dated January 6, 2011.

The purpose of this report is to provide supplementary information regarding the potential sediment thickness overlying hard material, such as "rip-rap" in near shore areas, or sediment thickness in areas where drilling investigations were limited by sensitive structures (*i.e.*, the NLW and mouth of the dry dock). This information will be used, in part, to support the development of a detailed remedial dredge plan for the project.

The scope of work included the following:

- Collation of factual field data collected during sub-surface probing and dive survey investigations conducted between February 2009 and January 2011;
- Preparation of a figure showing locations of dive survey transects, hand probe and jet probe testing and inferred depth to "hard bottom" below mudline; and,
- Preparation of fifteen schematic cross sections (five in the CFSA Waterlot off Munroe Head, five in Pilgrim Cove and five under the South Jetty) showing depth of shallow probe refusal and related observations, such as inferred contact with "rip-rap" or other materials forming a "hard bottom", based on review of probe data, surveys and other relevant test hole data (*e.g.*, boreholes, Cone Penetration Tests [CPTs], sediment cores, etc.).

Stratigraphic units encountered during previous sub-surface investigations at the Site included, Unconsolidated Sediments, Upper Fine- and Coarse- Grained Marine Sediments, Victoria Clay, glacial deposits, and bedrock.

Information from probe hole and selected sediment core and borehole locations was used to estimate depth to the bottom of "soft" or "loose" surficial sediments, which may represent the thickness of Unconsolidated Sediments overlying a denser or harder substrate layer (*e.g.,* fill, including rip-rap, till-like deposits, bedrock) that presents a "hard bottom" condition. At the hand probe and jet probe locations, probe refusals were also encountered within moderately stiff clay materials (*e.g.,* Victoria Clay). The presence of sand and gravel, cobbles, till-like soils, or Victoria Clay, at sediment core and borehole locations was inferred to represent a potential "hard bottom" condition for the purposes of interpretation of sub-surface conditions in this report.

The depth of probe refusal may be greater than the thickness of surficial sediment, since some variable penetration into the top of an underlying resistant layer may have occurred before probe refusal was encountered. For example, probing could encounter refusal on a cobble or boulder on the surface of a buried

riprap layer, or could penetrate some distance into accumulated sediment within the interstices between the rip-rap before encountering a refusal. Anomalous refusals may have occurred on timbers, cobbles/boulders, or other debris deposited within the softer sediment.

It should be noted that the materials that would cause probe penetration refusal in hand probe holes are not necessarily as coarse-grained or as dense as that required to cause jet probe refusal, since the force available for hand probe penetration is limited. For example, hand probes may have encountered refusal on or within compact sand or sand/gravel mixtures. Conversely, jet probes, which hydraulically scour sand and fine gravel particles during penetration, can advance some distance into sand and sand/gravel mixtures. Therefore, jet probe refusal is inferred to be due to the presence of coarse gravel, cobbles or boulders, or very dense soils.

The report discusses the observed and inferred sub-surface conditions in individual areas of interest within the EGD Waterlot including the CFSA Waterlot, Munroe Head, the NLW, the mouth of the EGD, the South Entrance Wall, the South Jetty, and Pilgrim Cove. Figures presented in the report indicate test hole locations and inferred depth to “hard bottom” below mudline, and schematic cross sections provide additional information on the actual material types that may have caused penetration refusal in probe holes to assist the interpretation of the type of “hard bottom” conditions encountered.

Study Limitations

This report was prepared for PWGSC and is intended to provide an assessment of surficial and sub-surface conditions for the subject Site.

The report is based on data and information collected during investigations conducted by Golder Associates Ltd. (Golder) personnel. It is based solely on the conditions of the subject property at the time of the site investigations conducted in 2009 and 2010, as described in this report. The data presented in this report represent conditions encountered at the locations investigated during this time period. Conditions may vary with location, depth, time, sampling methodology, analytical techniques and other factors. Golder makes no warranty, expressed or implied, and assumes no liability with respect to the use of the information contained in this report at the subject site, or any other site, for other than its intended purpose.

The findings and conclusions documented in this report have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care normally exercised by environmental and engineering professionals currently practising under similar conditions in the jurisdiction. Golder makes no other warranty, expressed or implied.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third part as a result of decisions made or action based on this report.

If new information is discovered during future work, including excavations, soil boring, or other investigations, Golder should be requested to re-evaluate the findings of this report and to provide amendments, as required, prior to any reliance upon the information presented herein.

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by Public Works and Government Services Canada (PWGSC) to undertake tasks in support of remedial design for the Esquimalt Graving Dock (EGD) Waterlot (herein referred to as the "Waterlot") proposed sediment remediation project. The EGD is located at 825 Admirals Road, Victoria, British Columbia.

This report presents information collected during sub-surface probing surveys undertaken by divers (South Coast Diving Ltd.) beneath and surrounding the South Jetty, near the mouth of the dry dock, along the North Landing Wharf (NLW), in Pilgrim Cove, and near Munroe Head in the Canadian Forces Sailing Association (CFSA) Waterlot. This work has been undertaken in accordance with Golder's Final Workplan for 30% Remedial Design Support dated October 13, 2010, and Golder's Final Workplan for Under-Water Video Survey and Jet Probing dated January 6, 2011. The purpose of this report is to provide supplementary information regarding the potential sediment thickness overlying hard material, such as "rip-rap" in near shore areas, or sediment thickness in areas where drilling investigations were limited by sensitive structures (*i.e.*, the NLW and mouth of the dry dock). This information will be used to develop a detailed remedial dredge plan for the project.

1.1 Proposed Remedial Alternative

Since January 2009, Golder and Anchor QEA LLC (Anchor) of Seattle, Washington, have been developing a strategy for the remediation and risk management of contaminated sediments present within the EGD Waterlot. This work has involved several phases of field investigation and a number of technical studies to support the assessment of remedial alternatives for the Waterlot.

The preferred remedial alternative for the Waterlot involves the following primary components:

- Remediation of the Waterlot in two phases. Phase 1 remediation will incorporate dredging the open Waterlot areas and Phase 2 will incorporate remediation of the contaminated sediments beneath the South Jetty. Phase 2 of the remediation will be undertaken as part of a separate project to reconstruct the South Jetty timber pile structure (South Jetty Wharf Redevelopment Project).
- Installation of a "temporary" sheet pile wall around the perimeter of the South Jetty to prevent re-suspension and migration of contaminated under-jetty sediments, into areas of the Waterlot dredged as part of Phase 1 of the remediation.
- Construction of compensatory habitat to off-set the temporary disruption of habitat associated with implementation of the EGD Waterlot Remediation Project. Dunn's Nook, located in Colwood, BC, was selected by PWGSC and the Department of National Defence as the preferred location for construction of compensatory habitat.
- Full extent practical removal of contaminated sediments within open Waterlot areas. This will be undertaken using a mechanical clamshell dredge, with smaller areas targeted for suction dredging in areas of sensitive infrastructure (specifically, protection of the sill at the mouth of the dry dock, and the north entrance concrete gravity wall).
- Dredging of "buffer zones", which extend approximately 30 to 50 m beyond the Waterlot boundary.
- Placement of "clean" sand material across dredged areas, as a strategy for managing risks associated with residual contamination generated by the physical dredging process (generated residuals).

- Remediation of contaminated sediments beneath the South Jetty (Phase 2) concurrent with future reconstruction of the jetty (South Jetty Wharf Redevelopment Project) to facilitate access. Remediation is proposed to comprise dredging of contaminated sediments to a specified depth, and placement of cover materials to manage undisturbed residual contamination which may be present and cannot be removed due to technical feasibility limitations.

A conceptual schedule for implementation of the remediation has been developed. In summary, the schedule is as follows:

- Installation of the temporary sheet pile wall around the South Jetty, beginning in October 2012 and ending in April 2013.
- Phase 1 dredging from June 2013 to March 2014.
- Habitat compensation construction in July and August 2013, and planting of marsh plants in February-2014.

The Phase 2 dredging is to be undertaken concurrent with the South Jetty Wharf Redevelopment Project, sometime within the next 5 to 10 years.

1.2 Scope of Work

The Scope of Work has been undertaken in accordance with Task 5000 (Sub-Surface Probing and Dive Surveys: Report) of Golder's approved final workplan for 30% Remedial Design Support, dated October 13, 2010, and Golder's approved final workplan for Under-Water Video Survey and Jet Probing, dated January 6, 2011. In summary:

- Collation of factual field data collected during sub-surface probing and dive survey investigations.
- Preparation of a figure showing locations of dive survey transects, hand probe and jet probe testing and depth to "hard bottom" below mud line.
- Preparation of fifteen schematic cross sections (five in the CFSA Waterlot off Munroe Head, five in Pilgrim Cove and five under the South Jetty) showing depth of shallow probe refusal and related observations, such as inferred contact with "rip-rap" or other materials forming a "hard bottom", based on review of probe data, surveys and other relevant test hole data (*e.g.*, boreholes Cone Penetration Tests [CPTs], sediment cores).

This report compiles the factual information and includes a discussion of interpreted sub-surface conditions and the inferred presence and location of "hard bottom' beneath and surrounding the South Jetty, near the mouth of the dry dock, along the NLW, in Pilgrim Cove and near Munroe Head in the CFSA Waterlot. Pilgrim Cove and CFSA Waterlot are optional future remediation areas, but are not currently proposed to be remediated as part of the EGD Waterlot Remediation Project.

2.0 BACKGROUND

The following phases of sub-surface investigations have been conducted at the Site:

- Dive Survey, Hand Probing and Sediment Sampling (February/March 2009);
- Sediment Coring Investigations (February 2009, July 2009 and September 2010);
- Sonic and Mud Rotary Drilling and Cone Penetration Testing Investigation (August – November 2009);
- Jet Probe Investigation of Near-Shore Sediment Thickness (October 2009);
- Assessment of North Landing Wharf Gabion Structure (including jet probing) (February 2010); and,
- Hand and Jet Probing and Dive Survey (January 2011).

Reference should be made to the following reports:

- Golder Associates Ltd. (2009b) Waterlot Supplemental Site Investigation Data Report, PWGSC Esquimalt Graving Dock, dated July 2, 2009.
- Golder Associates Ltd. (2010a) Esquimalt Graving Dock Waterlot - Supplementary Test Hole Investigation for Remedial Action Plan/Risk Management Plan, prepared for Public Works and Government Services Canada, dated March 3, 2010.
- Golder Associates Ltd. (2010b) Letter Report on 2010 Assessment of North Landing Wharf Gabion Structure, Esquimalt Graving Dock, Esquimalt, BC, prepared for Public Works and Government Services Canada, dated October 29, 2010.
- Golder Associates Ltd. (2012) Esquimalt Graving Dock Waterlot Detailed Site Investigation, prepared for Public Works and Government Services Canada, dated October 17, 2012 (draft).

2.1 Sub-Surface Stratigraphy

The following is a brief description of the stratigraphic units encountered starting from the mudline, during previous sub-surface investigations at the Site, as described in the Golder Supplementary Test Hole Investigation report (Golder, 2010a) and Golder Detailed Site Investigation (Golder, 202):

- **Unconsolidated Sediments:** comprising very soft organic silt to organic clayey silt and/or very loose sandy silt, generally black or grey and black in colour and typically containing shells and/or fibrous organics. This surficial stratigraphic unit is inferred to be part of the same geologic unit as the underlying Upper Fine-Grained Marine Sediments. These materials are referred to as Unconsolidated Sediments due to their very loose, saturated *in situ* condition, and are inferred to have been deposited recently.
- **Upper Fine-Grained Marine Sediments:** comprising soft to firm mixtures of silt, clay, and fine sand typically ranging from silty clay to clayey silt to sandy silt, with varying quantities of shells, and generally minor organic content. These materials are generally grey in colour and exhibit properties similar to that of consolidated fine-grained sediments.

- **Upper Coarse-Grained Marine Sediments:** comprising generally loose to compact granular sediments ranging from silty sand to silty sand and gravel and sand to sandy gravel, with varying quantities of shells. These are inferred to be beach deposits derived from erosion of exposed glacial deposits.
- **Victoria Clay:** comprising generally firm to stiff, grey silty clay with minor quantities of sand and gravel, includes an upper very stiff "crust" of brown to mottled grey and brown silty clay, in some of the test holes.
- **Glacial Deposits:** generally comprising dense to very dense, typically well-graded mixtures of sand, silt, gravel, and clay in varying proportions; may also contain cobbles and potential boulders. Inferred to represent glacial till.
- **Bedrock:** comprising strong to very strong meta-diorite and amphibolite of the Wark Gneiss, which may be highly fractured.

The above summary of stratigraphy should be considered in the interpretation of probe results.

3.0 SUB-SURFACE PROBING AND DIVE SURVEYS

3.1 Summary of Investigation Phases

Golder has previously undertaken three phases of dive survey investigations involving jet probing, hand probing and visual assessment of surficial sediment conditions, to support the EGD Waterlot RAP/RMP project. In addition to the dive surveys and associated assessment, sediment coring and drilling programs have also been undertaken at the Waterlot. The purpose of the dive survey investigations was to provide supplementary information regarding presence and thickness of sediments overlying potential "rip-rap" in shoreline areas of the Waterlot and thickness of sediment in areas adjacent to sensitive structures where drilling investigation was limited (*i.e.*, NLW gabions and mouth of the dry dock). This information will be used by Anchor in developing the dredge plan for the sediment remediation.

Supplementary dive survey and probing has been undertaken in the CFSA Waterlot and Pilgrim Cove as these have been identified by PWGSC as optional future remediation areas. The purpose of surveys in these areas was also to provide information regarding the presence and thickness of sediments overlying potential "rip-rap" or bedrock in shoreline areas.

Two different types of probes were used by divers during the investigations:

- Hand probing. 1.2 m or 2.4 m length probe pushed into the sediment by the divers and observations regarding resistance of probe penetration recorded.
- Jet probing. Jet probing comprised the use of a thin hollow probe assisted by water "jetting" from the probe tip to penetrate sediment.

For the purposes of assisting the interpretation of probe results, reference has also been made in this report to relevant test hole data available from investigations identified in Section 2.0.

The following sections provide a summary of the individual dive survey and probing investigation phases.

3.1.1 Dive Survey, Hand Probing and Sediment Sampling (February/March 2009)

Ten south-north oriented dive transects were surveyed beneath the South Jetty, including video survey, biophysical assessment, hand probing and diver assisted sediment sampling, to assess sediment and habitat conditions (see Figures 1 and 3 for probe and transect locations). The dive survey work was undertaken by South Coast Diving Ltd. (SCD) under the supervision of Golder. Information pertaining to the biophysical assessment and habitat survey was presented in the SSI (Golder, February/March 2009) and has been used by Archipelago Marine Research Ltd. and Golder for environmental assessment purposes.

Visual observations of substrate type and habitat were made during the video survey and used to identify the extent of exposed cobbles and boulders beneath the South Jetty and the presence or absence of fine sediment deposits. Hand-driven push probes were used to assess sediment depth or depth to possible "rip-rap", rock or other hard materials underlying surficial sediments. Probing was initially undertaken using a 1.2 m length probe; however, at a number of the locations probes were driven to full depth without reaching refusal. A 2.4 m length probe was subsequently made available for the remaining transects. Penetration ranged from 0.26 m to greater than 2.4 m ("full penetration"). Divers made observations of drive difficulty or level of resistance during probing to infer possible sediment type and inferred sources of probe refusal, *e.g.,* "rock", "wood" or "clay".

Selected images captured from the dive survey video footage are included in Appendix A.

3.1.2 Jet Probe Investigation of Near-Shore Sediment Thickness (October 2009)

Additional data was required to assess the presence of "rip-rap", rock and similar materials in near-shore areas to support Anchor's dredge design and calculation of sediment volumes for removal. The additional dive survey work included video surveys and jet probing at the west end of the South Jetty, at the mouth of the dry dock, at Munroe Head and adjacent to the west of the NLW. The dive survey work was undertaken by South Coast Diving Ltd. under the supervision of Golder. A total of forty-five locations were probed (see Figure 1). Observations of the presence of rip-rap, rock or other hard materials and/or the presence of surficial sediment were made during video surveys and probing. Inferred sources of probe refusal included "hard bottom", "timber", "stiff clay" or "rock-like" materials.

In a number of locations, sediment thickness slightly beyond the visible edge of surficial rip-rap exceeded two metres. This was consistent with rip-rap being placed on top of firm sediment in a substantially non-depositional environment. The visible extent of rip-rap may be substantially equivalent to the total extent of rip-rap in these locations.

3.1.3 Assessment of North Landing Wharf Gabion Structure (February 2010)

Golder conducted a dive survey to assess the position and extent of submerged, stone-filled wire-basket erosion protection mats (gabion mats) located in front of the NLW. The dive survey work was undertaken by South Coast Diving Ltd. under the monitoring of Golder. The mats are connected together with wire ties to create a single gabion structure that extends along most of the NLW. The assessment included a reconnaissance video, measurement of the width of the gabion mat structure, collection of sediment samples from five locations and sediment thickness probing using jet probes.

A proprietary equipment set was supplied by Northwest Geophysics of Redmond, Washington, through the Redmond, Washington (USA) Golder Associates office. The equipment included individual 1.52 m (5') lengths of nominal 1.9 cm diameter (3/4") galvanized steel pipe, threaded to allow varying probe lengths. The probe was coupled to lengths of nominal 5.08 cm (2") jacketed fire hose, supplied with seawater by a portable gasoline-powered 5.5 Hp, 5.08 cm (2") discharge, 11.4 L/S (180 gallon/minute) Honda (WH20X) pump. The pump and sections of additional supply hose were rented locally.

During the video survey, the diver probed areas of accumulated sediments including sediment–filled depressions in the gabions, sediment-obscured gabion edges, wall defects and/or the gap between the crest of the gabions and the toe of the wall by hand to assess the suitability of areas for diver coring.

Divers reported that surficial material included gravel and/or cobbles. Jet probing was carried out at fourteen locations along four transects oriented perpendicular to the NLW (see Figure 1); each of the fourteen jet probes encountered refusal (*i.e.,* did not reach full penetration). At five probe locations, divers reported probe refusal on what they believed to be solid rock. At another two of the jet probe locations, divers reported refusal on what they believed to be gravel. However, in most cases, divers found it difficult to determine the source of probe refusal.

Maximum and minimum probe penetration depths along the gabion toe were 1.81 m and 0.15 m, respectively with an average probe penetration of 0.88 m. Penetration depths at a distance of 6 m from the gabion crest (along transect) were 2.02 m (maximum) and 0.2 m (minimum) with an average probe penetration of 1.14 m. The maximum and minimum probe penetrations at a distance of 9 m from the gabion crest were 1.23 m and 0.23 m, respectively, with an average penetration of 0.87 m.

Based on diver observations and the varied depth of refusal, it is inferred that the sub-grade material contains cobbles or boulders that prevented probe penetration. Overall, on the order of one metre of penetration was achieved towards the east (the dock mouth). Probe results from the transect at lead line 2 (to the west) indicate somewhat less penetration (on the order of 0.2 to 0.8 m).

3.1.4 Limited Access Sediment Investigation, Pilgrim Cove (September 2010)

Golder conducted a sediment investigation in a limited access area of Pilgrim Cove (south and east of the small vessel docks) which involved advancing twelve solid steel rods into the sediment using a hand-held hammer-based ("pionjar") system to infer the thickness of surficial sediments prior to collecting sediment cores. The equipment was deployed by Rocky Mountain Soil Sampling Inc. (RMSS) from a modular (bolt-together) float unit.

The probes were advanced in two north-south transects south of the small vessel docks (A1 – A4, B1 – B4, see Figure 1) and one north-south transect along a concrete retaining wall at the east end of Pilgrim Cove (C1 – C4, see Figure 1). Positional information for probe location was collected by Golder on the modular float using a RTK GPS.

Probe depth to refusal ranged from 0.39 m below mudline (bml) to greater than 4.78 m bml (*i.e.,* full penetration).

3.1.5 Hand and Jet Probing and Dive Survey (January 2011)

Golder conducted a dive survey of the near-shore areas of the Canadian Forces Sailing Association (CFSA) Waterlot and Pilgrim Cove to provide additional information regarding the potential thickness of "soft" sediment overlying denser substrate such as bedrock, rip-rap or coarse granular fill in shoreline areas. The dive survey work was undertaken by South Coast Diving Ltd. under the monitoring of Golder. Two support vessels were present during the work: one Golder zodiac (from which positional information was obtained using the RTK GPS) and the South Coast Diving support vessel.

A proprietary equipment set was supplied by South Coast Diving Ltd. The equipment included individual 3.23 m (10.6') lengths of nominal 1.9 cm diameter (3/4") galvanized steel pipe, threaded to allow varying probe lengths. The probe was coupled to lengths of nominal 5.08 cm (2") jacketed fire hose, supplied with seawater by a portable gasoline-powered 5.5 Hp, 5.08 cm (2") discharge, 11.4 L/S (180 gallon/minute) Honda) pump. After completion of the video survey, the diver probed areas of accumulated sediments. Divers reported that surficial material included potential exposed bedrock, boulder, cobble (rip rap), gravel, silt and shell.

3.1.5.1 CFSA Waterlot

Jet and hand probing was undertaken as follows (see Figures 1 and 4 for locations):

- Section CFSA-A-A': five jet probes (JP-A-1 to JP-A-5) and two hand probes (HP-A-1 and HP-A-2);
- Section CFSA-B-B': three jet probes (JP-B-1 to JP-B-4) and four hand probes (HP-B-1 to HP-B-4);
- Section CFSA-C-C': four jet probes (JP-C-1 to JP-C-4) and three hand probes (HP-C-1 to HP-C-3);
- Section CFSA-D-D': two jet probes (JP-D-1 and JP-D-2) and two hand probes (HP-D-1 and HP-D-2); and,
- Section CFSA-E-E': three jet probes (JP-E-1 to JP-D-3) and one hand probe (HP-E-1).

3.1.5.2 Pilgrim Cove

Jet and hand probing was carried out as follows (see Figures 1 and 5 for locations):

- Section PC-F-F': three jet probes and 13 hand probes;
- Section PC-G-G': six jet probes and ten hand probes;
- Section PC-H-H': four jet probes and three hand probes;
- Section PC-L-L': two jet probes and six hand probes; and,
- Section PC-M-M': three jet probes and five hand probes.

An additional ten jet probes and 25 hand probes were advanced in areas near a concrete boat ramp structure and retaining wall at the eastern end of Pilgrim Cove and near the small vessel docks in the south-central area of Pilgrim Cove.

3.2 Survey Control

A number of different methods were used for collection of positional and elevation information for dive surveys and sediment and geotechnical investigations. Positional data was generated in the UTM coordinate system and elevation data was provided in Geodetic Datum. Elevation information was converted to Chart Datum by Golder using the conversion factor provided by Focus (Chart Datum Elevation = Geodetic Elevation + 1.871 m) for ease of use in marine applications and for design drawing development.

In general, surveyed positional information (northing and easting) was reported to the nearest millimetre; however, calculated coordinates and elevations (*i.e.,* those determined using measured offsets from known surveyed points) were generally reported to the nearest centimetre. Based on Golder's field observations, positional information for probe locations, including depth or elevation, should be considered approximate.

- CRA Canada Surveys Ltd. (CRA) carried out a multi-beam and side-scan sonar bathymetric survey within and extending approximately 20 m beyond the boundaries of the Waterlot to assess mudline elevations

(multi-beam) and identify bottom features, *e.g.,* presence of debris (side-scan sonar), in March 2009. Additional survey (multi-beam) of Waterlot areas was undertaken by CRA in February 2010, and of near-shore areas of the CFSA Waterlot and Pilgrim Cove in January 2011. Bathymetry contours prepared by CRA (in Chart Datum) are shown on Figure 1 and were used to generate surface profiles on Sections 1-1' through 5-5' and CFSA-A-A' through CFSA-E-E', PC-F-F' through PC-H-H', PC-L-L' and PC-M-M'. (Appendix B).

- Golder contracted Focus Geomatics (Focus), of Victoria, BC to conduct a survey of the "surveyor's high-water mark" and exposed shoreline at low tide at Munroe Head, beneath the South Jetty up to the sheet pile wall and at the east end of the South Jetty using a reflectorless total station. Focus also surveyed the above-water crest and toe of armouring at the west end of the South Jetty near the concrete crane pad. Shoreline contours generated in Chart Datum using Focus survey data are shown on Figure 1 and were used to generate surface profiles on Sections 1-1' through 5-5' and CFSA-A-A' through CFSA-E-E' (Appendix B).

- Ian Robertson, of PWGSC Geomatics was instructed by Andrew Mylly (PWGSC), to conduct a survey of shoreline areas in Pilgrim Cove during low tide. Contours of ground surface elevation were generated in Chart Datum using the survey data and were used to develop mudline profiles for Sections PC-F-F' through PC-H-H', PC-L-L' and PC-M-M' (Appendix B). A figure showing the survey of Pilgrim Cove, provided by PWGSC Geomatics, is included in Appendix C.

- In the November 2009 jet probe investigation, probe locations were recorded by Golder using a reflectorless total station (Leica TPS). Coordinates were gathered by measurement from a known on-shore point to a marker, such as a taut-line buoy, positioned by the diver over each jet probing location. The time, diver's depth on bottom (measured by pneumofathometer/bubble hose, accurate to within approximately +/- 150 mm), lateral coordinates, surface marker elevation, initial probe length, final probe length and probe identification number were recorded by Golder personnel.

  Golder checked station accuracy by measuring the locations of known objects with the total station. Actual accuracy is inferred to be less (*i.e.,* lower) than the checked accuracy against known targets for the following reasons:

  1) The total station took a measurement from a floating (bobbing), semi-spherical marker buoy or similar marker.

  2) The diver's depth by pneumofathometer was recorded to within approximately +/- 150 millimetres and assumes a specific seawater density.

  3) The diver's measurement of initial probe length and final probe length was based on visual inspection, underwater and at varying angles, of a tape measure graduated in 1.6 mm (1/16").

  4) While the diver attempted to drive the probe vertically (for example, by using a float at the top end of the probe to hold it oriented), small deviations from vertical may not have been detected.

Divers jet probed 45 locations in total. Coordinates were obtained for 43 locations using the reflectorless total station unit as described above; two locations were not within line of sight from the relevant shore station and thus could not be recorded with the survey equipment. With the exception of JP09-05 and JP09-06, lateral accuracy with respect to objects of known coordinates was indicated to be better than approximately five millimetres. To measure lateral location at JP09-05 and JP09-06, the total station was fired at relatively long range through, for example, a chain link fence. Check measurements on nearby shore points under similar conditions were accurate to within approximately 30 centimetres. At location JP09-29, the anchored tending vessel blocked the line of sight from the total station to the marker buoy. The position of a marker on the vessel bow approximately 5 metres north of, and 1.4 meters above, the marker buoy was recorded. When the surveyed location of JP09-11 was plotted on a Site plan, the probe location appeared offset from the anticipated position based on field observations. JP09-11 was positioned manually on the Site figure in the expected location based on field observations; positional data is considered very approximate.

Comparison of diver depth measurements to mudline elevations on waterlot bathymetric survey indicated an anomaly at jet probe location JP09-30. An unusually shallow diver depth was recorded in field notes for this location. JP09-30 depth data is considered approximate.

- In February 2009 Golder used a Leica Real Time Kinematic Global Positioning System (RTK GPS) to survey the horizontal location and elevation of reference points established on the outer edge of the South Jetty. Weighted level lines dropped from the surveyed reference point were used to determine depth to water and depth to mudline (and, therefore, elevation) and to determine the starting point of each transect. Screws were used to fix a tape measure at the transect start point and the tape was extended to the specified length using the position of under-jetty pilings as a reference point for the transect line. Pneumofathometer water depth readings (accurate to within approximately +/- 150 mm) taken at regular measured horizontal intervals along the transects were used to develop profiles for each transect and to determine mudline elevations for each of the diver core samples collected. The elevation information has been incorporated into Sections 1-1' through 5-5' (Appendix B).

- Prior to mobilising divers for the gabion mat survey (February 2010), Golder contracted Focus to install eleven reference points along the edge of the North Landing Wharf. The reference locations were surveyed in the UTM coordinate system and were surveyed using standard land survey methods. Golder dropped weighted lines (lead lines) from the established reference points and measured the depth to the harbour bottom at each position using a fibreglass tape measure with a lead weight on the end. The elevation, measured depth and calculated elevation were recorded at each reference location. Jet probing was carried out along four transects oriented perpendicular to the NLW; positions (northing and easting) were determined using measured horizontal offset distances from the NLW and the weighted lines as reference points.

  Based on studies of underwater archaeological surveys[1], Golder anticipates that a standard error of 25 mm or more is possible, and that up to 20% of diver reported measurements may be substantially in error (*i.e.*, diver may read off the wrong numeral). The inclinometer used for underwater work was selected for

[1] Holt, Peter. 2003. "An Assessment of Quality in Underwater Archaeological Surveys Using Tape Measurements". The International Journal of Nautical Archaeology (2003) 32.2: 246-25 1

visibility and for ease of use wearing cold water gloves. It is estimated to be accurate to within +/- 5 degrees. Diver depth measurements by pneumofathometer using an KMACS air control box are accurate to within approximately +/- 150 mm.

Golder compared measurements, referred to the video survey and plotted results to attempt to identify outlying data. Based on this assessment, the interpolation between measurement points, the roughness of the paths traversed by the tape, and the potential positional error related to simultaneous error in length, depth and/or slope, Golder suggests that recorded positions should be considered approximate. For example, for probe points 9 metres from the North Landing Wharf Wall, simultaneous bearing, inclinometer and tape measure errors could lead to a lateral error on the order of 1 metre. Overall, the potential lateral error at the gabion toe is on the order of 0.3 metres. For operations with a risk of gabion mat damage, such as excavation, a design safety margin of 0.5 metres or more may be advisable at the indicated gabion toe. In light of potential positional error and the documented historic movement of the gabions because of extreme propwash, local soundings or diver inspection should be considered shortly before beginning potentially destructive operations.

- In September 2010 and January 2011, Golder used an RTK GPS to survey the horizontal location and elevation of hand and jet probe holes. In September 2010, Golder staff surveyed the location of probes while the modular float was secured in position over the probe location; in January 2011, Golder staff navigated the zodiac to the location of a taut-line buoy placed in position by divers in the location of hand and jet probes and then surveyed the horizontal position of the probe and water elevation. The mudline elevations of probe locations were determined by subtracting the water depth at each location (measured using the diver's pneumofathometer, accurate to within approximately +/- 150 mm) from the surveyed water elevation.

4.0 DISCUSSION

The locations of the test holes associated with each of the investigations discussed above are presented on the attached Figure 1, which includes the following:

- Sediment sample locations;
- Hand and jet probe locations;
- Dive transect locations;
- Geotechnical test hole locations;
- Primary structural features; and,
- Contours of mudline bathymetry and above-water survey data in Chart Datum.

A summary of positional and elevation data (in Chart Datum) for each of the test holes is presented in the attached Table 1. Top (mudline) elevations of hand and jet probes were calculated using surveyed water elevations and diver-measured water depths at each location and the potential uncertainty associated with elevation measurements, discussed in Section 3.2, should be noted.

Table 1 also includes a summary of the estimated depth to the bottom of "soft" surficial sediments encountered at probe hole and selected sediment core and borehole locations. This may represent the thickness of Unconsolidated Sediments (as identified in Section 2.1), where this stratigraphic unit is underlain by a layer (could be native soil or fill materials) that presents a "hard bottom" condition. A "hard bottom" condition may not be present at shallow depths in cases where surficial Unconsolidated Sediments are found overlying soft to firm Upper Fine-Grained Marine Sediments (identified in Section 2.1).

At the hand probe and jet probe locations, the depth to probe refusal is generally inferred to represent the thickness of surficial sediment overlying some "hard bottom" condition, but probe refusals were also encountered within moderately stiff clay materials (*e.g.,* Victoria Clay). Table 1 includes a description of the inferred type of material encountered at refusal, based on diver's commentary. Due to uncertainty in the estimated top elevation of probe holes, based on diver measurements, together with the potential for error in the measurement of depth penetration of the probe, a potential vertical (elevation) inaccuracy in the order of +/- 0.5 m should be considered when interpreting data presented in this report.

It should be recognized that the depth of probe refusal may be greater than the thickness of surficial sediment, since some variable penetration into the top of an underlying resistant layer may have occurred before probe refusal was encountered. For example, probing could encounter refusal on a cobble or boulder on the surface of a buried riprap layer, or could penetrate some distance into accumulated sediment within the interstices between rock particles before encountering a larger particle on the path of the probe. It should also be noted that anomalous refusals may have occurred on timbers, cobbles/boulders, or other debris deposited within the softer sediment by anthropogenic activities, and so an individual probe refusal may not be indicative of the presence of a "hard bottom" condition.

It should be noted that the materials that would cause probe penetration refusal in hand probe holes are not necessarily as coarse-grained or as dense as that required to cause jet probe refusal, since the force available for hand probe penetration is limited. For example, hand probes may have encountered refusal on or within compact sand or sand/gravel mixtures. Conversely, jet probes, which hydraulically scour sand and fine gravel particles during penetration, can advance some distance into sand and sand/gravel mixtures. Therefore, jet probe refusal is inferred to be due to the presence of coarse gravel, cobbles or boulders, or very dense granular soils.

As shown on Figures 3, 4 and 5, hand and jet probes were generally advanced along dive transects perpendicular to shoreline areas. Hand and jet probes, as well as other test holes (*i.e.,* sediment cores and boreholes) advanced in investigation areas, are presented on Sections 1-1' to 5-5' (South Jetty, Figure 3), Sections CFSA-A-A' to CFSA-E-E' (CFSA Waterlot, Figure 4) and Sections PC-F-F' to PC-H-H', PC-L-L' and PC-M-M' (Pilgrim Cove, Figure 5). Where probe and test holes were not located directly on cross-section lines, the horizontal offset of the probe or test hole measured normal (perpendicular) to the section line is given beneath the location name on the prepared cross-sections.

Selected sediment cores, boreholes and CPTs have also been included in Table 1 and on prepared cross-sections to provide additional information on the actual material types that may have caused penetration refusal in probe holes and to help characterise the type of "hard bottom" conditions encountered. The presence of sand, gravel, cobbles, till-like soils, or Victoria Clay, at sediment core and borehole locations was inferred to represent a potential "hard bottom" condition for the purposes of sediment dredging activities.

The following sections discuss the observed and inferred sub-surface conditions in the areas of interest within the EGD Waterlot.

4.1 CFSA Waterlot

At the CFSA Waterlot, exposed cobbles and boulders were observed to extend from the uplands area of Munroe Head (Photographs 1 to 3, Appendix A) towards the northwest, into what is currently designated Sediment Management Area (SMA)-1B. From the start of each of the five sections in the CFSA Waterlot (Sections CFSA-A-A' to CFSA-E-E'), the exposed cobbles and boulders extended approximately 9 to 19 m into SMA-1B. Extending further to the northwest (between 18.5 and 26 m from the start of each section), fine sediment and shell accumulation was observed between exposed cobbles and boulders (Photograph 4). Beyond this and further to the northwest, fine sediment and shell was observed up to the end of each section, except for at approximately 34 m along Section CFSA-D-D' where exposed bedrock was noted (Photograph 5).

Anthropogenic debris (*i.e.,* a metal drum, rope, concrete anchor blocks and a plastic bucket) was observed at various locations along the sections (see Photographs 6 to 8). Detailed observations of biota and debris on Sections CFSA-A-A' to CFSA-E-E' are presented in Tables E-1 to E-5 in Appendix E.

At sediment core SC10-06, which was advanced approximately 30 m northwest from the uplands area of Munroe Head (see Figure 4), very soft, dark grey/black silt was encountered from the surface to a depth of approximately 0.2 m bml (elevation of approximately -8.8 m, Chart Datum). Underlying this layer, grey/brown silt was encountered to 3.91 m bml (approximately -12.5 m, Chart Datum), observed to be soft, becoming firm at 1.5 m and becoming stiff at 3.0 m bml with wood and gravel observed between 3.1 and 3.4 m bml.

Sediment collected from one core located in the fine sediment and shell area (SC10-05) was described as being very soft to soft, dark grey/black/brown silt to a maximum penetration depth of 1 m bml. Cobbles were noted at 1.05 m, which coincides with the refusal of jet probe JP-D-2 on a suspected gravel layer.

Along the shoreline of the CFSA in the area comprising exposed cobbles and boulders with fine sediment and shell, the jet and hand probes encountered refusal at depths between approximately 0.38 and 2.5 m. The only exceptions to the refusals in this area are two jet probes at approximately 25 m from the start of Section CFSA-B-B': JP-B-1 (encountered full penetration, with some resistance from a suspected gravel layer) and JP-B-4 (encountered refusal at 5.5m below mudline).

Along the shoreline of the CFSA, in the area comprising fine sediment and shell, the jet and hand probes encountered refusal at depths between 3.11 and 9.42 m below mudline.

Refusal in each of the sections was mainly characterised by divers as follows:

- Section CFSA-A-A': "gravel" and "solid rock";
- Section CFSA-B-B': "gravel" and "clay-like";
- Section CFSA-C-C': "gravel" and "rock";
- Section CFSA-D-D': "gravel" and "solid rock"; and,
- Section CFSA-E-E': "gravel" and "solid rock".

The inferred depth of the hard bottom below mudline is shown on Figures B-6 to B-10 (Appendix B).

4.2 Munroe Head

At Munroe Head, visible rock/armour extends across most of what is currently designated SMA-1B, with sediment accumulation observed primarily between cobbles.

At borehole GBH09-11, which was advanced near the crest of the submarine slope located southwest of the Munroe Head beach, fill materials ranging from sand to sandy gravel to angular rock fill (gravel to boulder-sized) was encountered from surface to a depth of about 13 m bml (approximately Elevation -14 m, Chart Datum).

Jet probes JP09-29 through JP09-35 were located approximately 15 to 30 m southwest of GBH09-11, near the toe of the submarine slope. The jet probes generally encountered refusal between approximately 5 and 6 m bml (except for JP09-29, which penetrated to approximately 2 m bml, and JP09-32 and 34, which did not encounter refusal over the full 6.1 m probe length). Refusal was characterised by divers as being "rock-like". Sediment collected from three cores located along the toe of the slope (SC09-04, SC09-06 and SC09-105) was described as being soft to firm silt to clayey silt with a maximum penetration depth between approximately 2 and 3 m bml.

At borehole GBH09-12, which was advanced midway down the submarine slope to the southeast of the Munroe Head beach, mixed fill materials (ranging in composition from sand/gravel mixtures to clayey silt to gravel/cobble mixtures to boulders) were encountered from surface to an approximate Elevation of -13.3 m (Chart Datum).

Jet probes JP09-05 and JP09-06, which were advanced at the toe of the slope approximately 10 m to the southwest of GBH09-12, met refusal on "rock-like" materials after about 2 m penetration (at an approximate Elevation of -13 m, Chart Datum). Sediment collected from two cores located along the toe of the slope (SC09-07 and SC09-106) was described as being soft to firm silt to clayey silt with a maximum penetration depth between 1.3 and 3.0 m bml.

The mudline bathymetry and penetration information suggests that the surface of the coarse-grained fill materials observed in GBH09-11 and GBH09-12 slopes down toward the level area of the seafloor and may continue sub-surface some distance beyond the contact with the overlying fine-grained sediments identified in the sediment cores. The inferred extent of exposed coarse-grained fill material (cobbles and boulders, "rip-rap") is shown on Figure 1.

4.3 North Landing Wharf

Diver observations and probing results indicate the space between the gabions and the wall of the NLW is filled with hard material, possibly concrete, under a thin (5 to 10 cm) veneer of loose material.

Based on a review of the dive video and diver comments, the surficial sediment in the vicinity of the gabions appears to generally be composed of sands and gravels. Grain size analyses carried out on two samples of surficial sediment collected from grab samples taken near the gabion toe indicated that the surficial material can be described as sandy gravel with some silt at DC10-05 (west end of NLW), and well-graded sand with some silt and trace to some gravel at DC10-01 (east end of NLW). Refer to grain size results presented in Appendix D.

Maximum penetration depths of jet probes advanced along the toe of the gabion mats (along the NLW) in February 2010 ranged from 0.15 m to 1.1 m, with an average probe penetration of 0.9 m.

Depths to refusal or inferred "hard bottom" at jet probe and test hole locations within approximately 10 m of the face of the NLW, generally ranged from approximately 0.5 m to 1.1 m bml, except for probe holes JP01 through JP05 at the west end of the NLW, which encountered refusals at depths ranging from 0.15 m to 0.6 m bml. Probe penetration was limited by a "hard bottom" inferred to be composed of coarse gravel and/or cobbles based on diver characterisation of refusal.

At boreholes GBH09-13 and GBH09-14, completed in the vicinity of jet probes JP06 to JP08, angular gravel with angular cobbles (rock fill) were encountered at depths of approximately 1.7 m and 1.2 m bml, respectively, underlying organic fine-grained sediments with variable sand content. Jet probes JP06 to JP08 met refusal at depths ranging from approximately 1.1 to 1.7 m bml. Further to the east, the surficial sediments are underlain by dense to very dense till-like materials (silt/sand/gravel mixtures) at a depth of 1.1 m bml in borehole GBH09-15, and underlain by angular gravel (rock fill) at a depth of 0.8 m bml in borehole GBH09-16.

4.4 Mouth of EGD

The thickness of surficial sediments encountered at boreholes GBH09-17 and GBH09-18 and at sediment core locations (SC09-26, SC09-33, and SC09-119C), located near the mouth of the EGD, range from 0.5 m to 0.8 m, whereas sediment core SC09-118B was advanced to 1.1 m without confirming a "hard bottom". The jet probes advanced in this area (JP09-01 through 04 and JP09-16 through 18) encountered refusal at depths ranging from 0.4 to 1.3 m bml.

The surficial sediments are underlain by compact to dense sandy gravel at GBH09-17, SC09-33 and SC09-119C, and dense sand and silt with some gravel (till-like material) at GBH09-18. At SC09-26, the surficial sediment is underlain by black sand suspected to be sand-blast grit.

4.5 South Entrance Wall

Jet probe JP09-15, located at the northwest corner of the South Entrance Wall, penetrated to a maximum depth of 1.1 m bml, whereas JP09-26, located 6 m further west, penetrated to a maximum depth of 2.5 m (both encountering refusal around El. -11.0 m to -11.1 m, Chart Datum). Jet probe JP09-25, located approximately 1 m west of the west face of the timber crib that forms the South Entrance Wall and 9 m south of the north face, encountered refusal on timber-like material at a depth of 2.1 m bml. Jet probes JP09-19 though 24, which were located in a south-north line approximately 5 m west of the west face of the timber crib, penetrated to maximum depths ranging from 1.7 m (JP09-21) to 3.8 m bml (JP09-20). Jet probes JP09-27 and JP09-28, which were located approximately 8 to 9 m west of the west face of the timber crib, penetrated to maximum depths of 5.8 m and 2.3 m, respectively.

4.6 South Jetty

The following sub-sections provide a discussion of the conditions encountered under the South Jetty, which has been divided into the following areas based on general differences in the sub-surface conditions:

- South Jetty, West;
- South Jetty, South Central; and,
- South Jetty, Southeast.

Figure 2 presents selected photographs taken beneath the South Jetty showing examples of the type of exposed shoreline observed beneath the jetty.

4.6.1 South Jetty, West

The subsurface conditions under the west end of the South Jetty (west of the timber crib forming the South Entrance Wall) generally comprise a significant thickness of Unconsolidated Sediments and Upper Fine-Grained Marine Sediments, overlying Victoria Clay (generally encountered below an approximate elevation of -13 m Chart). Consequently, a “hard bottom” stratum is not present in this area. Wood materials were observed in boreholes GBH09-05 and GBH09-07, and were the inferred cause of anomalous refusals in some of the probe holes.

4.6.2 South Jetty, South Central

Beneath the central portion of the South Jetty, to the south and southeast of the timber crib forming the South Entrance Wall, a mounded area of fill extends downward from a concrete structure that is suspended below the jetty deck. Granular fill materials comprising sand to sandy gravel were encountered to a depth of about 8 m bml (elevation -10.8 m, Chart datum), but were not encountered further south at borehole GBH09-22 (located near the south edge of the jetty).

The exposed ground surface at the top of the slope is covered with cobbles and boulders which are inferred to have been placed as "rip-rap" to protect the top of the fill from erosion (refer to Photograph 9 in Appendix A). The inferred extent of the exposed cobbles and boulders ("rip-rap") is shown on Figure 1. This rock fill material is inferred to extend down slope under the surficial sediments at least as far south as hand probe EP4 (refer to Figure B-1: Section 1-1' in Appendix B). A greater thickness of surficial sediments appears to have accumulated under the southern portion of the slope (refer to Section 1-1'), where hand probes EP2 and EP3 could be pushed to maximum penetration depths between 1.0 and 2.0 m bml, and hand probe EP1 under the south edge of the south central portion of the jetty did not encounter refusal within 2.4 m penetration depth.

Jet probes JP09-07 through 10 and JP09-12 through 14 generally met refusal in "rock-like" material (based on diver observations) at depths ranging from 1.7 m to 4.3 m bml.

4.6.3 South Jetty, Southeast

Surface and sub-surface information for the southeast portion of the South Jetty is presented graphically in Sections 2-2' through 5-5' (Figures B-2 to B-5, Appendix B). Selected photographs of the surficial materials (*e.g.,* gravel, cobbles and boulders) that are located at the top of the slope to the south of the existing sheet pile wall, are included in Appendix A (Photographs 10 though 14).

Penetration of hand probes generally ranged from 0.3 m to 1.7 m at locations where refusal was encountered. Refusal was typically characterised by divers as feeling "rock-like" or "solid" and is generally inferred to be due to the presence of rock fill (*e.g.,* buried rip-rap), which is consistent with the gravel fill materials encountered between 1.4 m and 2.7 m bml at GBH09-09. However, anomalous refusals may be due to anthropogenic debris within sediments (see Sections 3-3' through 5-5', Appendix B). Based on borehole and CPT information, it is expected that the rock fill material under most of the length of the southeast portion of the South Jetty is underlain by relatively soft fine-grained soils of the Upper Fine-Grained Marine Sediments unit (as encountered at GBH09-09 and GBH09-10).

Below the east end of the South Jetty, the surficial sediments appear to be generally underlain by firm to stiff Victoria Clay (as encountered below 1.8 m depth at GBH09-04). Refusal in hand probes located within approximately 20 m from the south edge of the jetty was typically characterised by divers as feeling like a "clay layer" (refer to Section 2-2'), and is inferred to correspond to the Victoria Clay deposit. Beyond the location of hand probes, gravel, cobbles and boulders were visible at the mudline surface beginning at approximately 22 m from the south edge of the South Jetty (see Photographs 15 through 17, Appendix A, and the inferred extent of exposed cobbles and boulders on Figure 1).

4.7 Pilgrim Cove

The following sub-sections provide a discussion of the conditions encountered in Pilgrim Cove, which has been divided into the following areas:

- Pilgrim Cove, South;
- Pilgrim Cove, East;
- Pilgrim Cove, North; and,
- Pilgrim Cove, Northwest.

See Figures 1 and 5 for hand and jet probe and cross section locations and Appendix B for the corresponding cross sections.

4.7.1 Pilgrim Cove, South

Along the southern shoreline of Pilgrim Cove, exposed bedrock was observed to extend from uplands areas to between approximately 3 to 6 m beyond the start of three sections (see Sections PC-F-F', PC-G-G' and PC-H-H' in Figures B-11, B-12 and B-13 in Appendix B and Figure 5). Photograph 18 shows an example of exposed bedrock at approximately 3 m along Section PC-G-G'. Exposed cobbles and boulders were observed beyond the extent of exposed bedrock along Section PC-F-F' extending from approximately three to 17.5 m from the start of the section, with bedrock outcrops observed at approximately 11.6 and 15.7 m along the section. Extending further to the west and northwest, fine sediment and shell accumulation was observed with exposed bedrock, cobbles and boulders between approximately 5 and 22 m from the start of each section (Photograph 19). Fine sediment and shell was observed up to the end of each section (Photograph 20), except for beyond approximately 44 m along Section PC-G-G', where exposed bedrock and fine sediment and shell accumulations over bedrock were observed, along with an elevation gain, extending to the end of the section. Bathymetry data indicates a submarine elevation gain at the end of Section PC-G-G', where a bedrock outcrop has been observed previously and marked with a piling for vessel safety.

At sediment core SC10-42, which was advanced approximately 34 m northwest from the uplands area along Section PC-F-F' (see Figure 5), dark grey, sandy silt was encountered from the surface to a depth of approximately 0.27 m bml (elevation of approximately -6.0 m, Chart Datum). Underlying this layer, grey, sandy silt was encountered to approximately 0.73 m bml (elevation of approximately -6.5 m, Chart Datum). Angular gravel was observed in the sediment core at a depth of approximately 0.65 m bml. Depth to refusal at SC10-42 was similar to the depth to refusal encountered at nearby hand probe HP-F-11 (1.0 and 0.98 m bml, respectively).

In sediment core SC10-41, located approximately 18 m from the start of Section PC-H-H', dark grey, silty sand was encountered from surface to a depth of approximately 0.24 m bml (elevation -6.0 m, Chart Datum), underlain by grey, sandy silt to a depth of approximately 1.69 m bml (elevation of approximately -7.4 m, Chart Datum), and grey silty clay to clayey silt with trace sand and shell fragments to a depth of approximately 2.08 m bml (elevation of approximately -7.8 m, Chart Datum). Hand probe HP-H-3, also located approximately 18 m along Section PC-H-H', encountered refusal at approximately 2.26 m bml, which was characterised by divers as being "solid rock".

Hand and jet probes advanced in areas comprising fine sediment and shell accumulation with exposed bedrock or cobbles and boulders encountered refusal at depths between approximately 0.05 and 2.23 m bml. Beyond approximately 44 m along Section PC-G-G', hand probes encountered refusal between approximately 0.18 m and 0.48 m bml.

In areas comprising fine sediment and shell, hand and jet probes encountered refusal between approximately 0.61 m and 3.54 m bml.

Refusal in each of the sections was generally characterised by divers as follows:

- Section PC-F-F': "hard" and "solid rock" to approximately 36 m from the start of the section and at jet probe JP-F-3 at approximately 52.5 m from the start of the section, with "clay-like" or full penetration between approximately 36 and 52.5 m.
- Section PC-G-G': "gravel" and "solid rock" to approximately 21 m from the start of the section and beyond approximately 44 m, and "clay-like" between approximately 21 and 44 m.
- Section PC-H-H': "rock" or "solid rock" to approximately 22 m from the start of the section, "clay-like" beyond approximately 22 m from the start of the section.

Seven hand probes and three jet probes were advanced in the area of the small vessel docks in southern Pilgrim Cove ("K" probes). Probes were advanced in areas of fine sediment and shell, beyond observed exposed bedrock (Photograph 21). Depth to refusal of hand probes was between 0.15 m and 1.8 m bml; depth to refusal in jet probes ranged from 2.34 to 3.85 m bml. Divers generally characterised refusal in hand and jet probes as "solid rock", with the exception of jet probe JP-K-1, for which refusal (at a depth of 3.85 m bml) was described as "clay-like".

Probes A1 – A4 and B1 – B4 were also advanced near the small vessel docks. Depth to refusal increased moving south to north, *i.e.,* away from the southern shoreline, from approximately 0.39 m bml to greater than 4.78 m bml. Refusal was generally characterised in the field as being "hard, possible bedrock". Sediment cores SC10-49, SC10-50-A2 and SC10-50-A4 were advanced in the same area as the probes and encountered silty sand to between approximately 0.70 and 1.73 m bml (elevation of between approximately -2.8 m and -3.0 m, Chart Datum), underlain by clayey silt to silty clay to a maximum depth of 3.34 m bml (elevation of approximately -4.6 m, Chart Datum).

The inferred depths to hard bottom below mudline for Sections PC-F-F', PC-G-G' and PC-H-H' are shown on Figures B-11, B-12 and B-13 respectively (Appendix B).

Detailed observations of biota and debris on Sections F-F' to H-H' are presented in Tables E-6 to E-8 in Appendix E; Photograph 22 (Appendix A) shows an example of a sea cucumber on Section PC-F-F'.

4.7.2 Pilgrim Cove, East

Seventeen hand probes and seven jet probes were advanced at the east end of Pilgrim Cove, along a concrete retaining wall running north to south (Photograph 23). Probes C1 – C4 were advanced in the same area. Probe locations ranged from approximately 1.5 m west of the concrete retaining wall, to approximately 13.5 m west of

the wall (see Figures 1 and 5). Surficial materials were generally described as fine sediment and shell (Photograph 24) with some cobbles and boulders (Photograph 25). Detailed observations of biota and debris along the concrete retaining wall at the east end of Pilgrim Cove are presented in Table E-9 in Appendix E.

Depth to refusal generally increased moving west (away from the retaining wall), ranging from 0.07 m bml at probe HP-I-12 to greater than 4.55 m bml (full penetration) at probe C3. Depth to refusal moving north to south was generally consistent, with the exception of the probes advanced at the southern end of the wall, which had maximum depth to refusal of 0.96 m bml (C1).

Depth to refusal in probes C1 to C4 generally increased moving south to north, ranging from 0.96 m bml to greater than 4.55 m bml (full penetration). In general, depths to refusal were greater in the hammer-driven probes (C1 – C4) than the hand and jet probes, which may indicate that the hammer-based probes were able to advance beyond materials that were causing refusal in the hand and jet probes.

4.7.3 Pilgrim Cove, North

Exposed bedrock, cobbles and boulders were observed in the uplands area along the northern shoreline of Pilgrim Cove (Photograph 26). Along Section PC-L-L' (Figure B-14, Appendix B), exposed cobbles and boulders extended from the uplands to approximately 5 m from the start of the section (Photograph 27). Along Section PC-M-M' (Figure B-15, Appendix B), exposed bedrock was observed extending from the uplands to approximately 3.5 m along the section (Photograph 28). Between approximately 3.5 and 10.6 m from the start of the two sections, fine sediment and shell accumulation was observed between exposed cobbles and boulders and overlying the bedrock. Beyond this and further to the south, fine sediment and shell was observed up to the end of each section (Photographs 29 and 30).

Hand and jet probes advanced along Sections PC-L-L' and PC-M-M' in areas comprising exposed cobbles and boulders or bedrock with fine sediment and shell, encountered refusal at depths between approximately 0.22 and 1.22 m bml. In the areas comprising fine sediment and shell, the jet and hand probes encountered refusal at depths between 1.1 and 2.5 m bml.

At sediment core SC10-46, which was advanced approximately 32 m from the start of Section PC-M-M' (see Figure 5), grey-brown sandy silt was encountered from the surface to a depth of approximately 0.1 m bml (elevation of approximately -4.64 m, Chart Datum). Underlying this layer, grey-brown clayey silt to silty clay was encountered to 4.30 m bml (approximately -8.8 m, Chart Datum).

Refusal in each of the sections was mainly characterised by divers as "rock", "solid rock" or "gravel" to approximately 13 m from the start of the sections, and as "clay-like" beyond approximately 13 m.

The inferred depths of the hard bottom below mudline for Sections PC-L-L' and PC-M-M' are shown on Figures B-14 and B-15 respectively (Appendix B).

Photograph 31 shows an example of observed biota (helmet crab) along Section PC-L-L'. Detailed observations of biota and debris on Sections PC-L-L' and PC-M-M' are presented in Tables E-10 and E-11 in Appendix E.

4.7.4 Pilgrim Cove, Northwest

At jet probe location JP09-40 (located south of the tug float at the east end of the South Jetty) refusal was inferred to be in stiff clay (penetration to approximately 1.7 m). Other jet probes located on the submarine slope south of the tug float, reached penetration depths between 1.8 and 4.5 m bml and were reported as "rock-like" at their terminal depths (possibly due to the presence of gravel or cobbles). Sandy sediment (possibly sand/gravel mixtures) was encountered at 1.0 m bml at CPT sounding KCPT09-101, located at on the flat bench off the end of the tug float (further east from the jet probes).

5.0 CLOSURE

This report has been provided in support of remedial design for the proposed sediment remediation project at the Esquimalt Graving Dock Waterlot. We trust this meets with your requirements and look forward to discussing the report with the project team.

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6.0 REFERENCES

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Table 1

Probe Hole and Test Hole Location and Depth to Bottom of Surficial Sediments
Sub-Surface Probing and Dive Surveys: Interpretive Report
Esquimalt Graving Dock, Esquimalt, BC

Investigation Area	Location ID	Study	Easting (x)	Northing (y)	Mudline Elevation (m, Chart Datum)	Depth to Bottom of Surficial Sediments (m below mudline)	Interpretations of Encountered Stratigraphy (based on diver observations, sediment and borehole logs, CPT plots)
Canadian Forces Sailing Association Waterlot	JP-E-1	Golder 2011 Probing	468030.998	5365045.352	-8.45	> 6.46	full penetration, clay-like layer around 6.46 m
	JP-E-2	Golder 2011 Probing	468027.851	5365045.434	-9.14	> 6.46	full penetration, little to no resistance
	HP-E-1	Golder 2011 Probing	468036.179	5365046.688	-6.52	0.98	pushed through suspected gravel layer, hit something solid (rock-like)
	JP-E-3	Golder 2011 Probing	468033.804	5365046.877	-7.19	> 6.46	full penetration, little to no resistance
	JP-A-1	Golder 2011 Probing	468033.577	5365059.344	-6.86	1.86	hit something solid (rock-like)
	HP-A-1	Golder 2011 Probing	468035.197	5365059.407	-5.62	0.38	-
	HP-A-2	Golder 2011 Probing	468033.207	5365059.650	-6.90	2.50	-
	JP-A-2	Golder 2011 Probing	468030.627	5365062.055	-7.49	3.11	hit something solid (rock-like)
	JP-A-3	Golder 2011 Probing	468028.635	5365063.601	-7.84	9.19	hit something solid (suspected gravel)
	SC10-06	Golder 2010 Sediment Cores	468024.454	5365064.016	-8.60	> 4.28	full penetration; wood and subrounded gravel observed in core between ~ 3.1 and 3.4 m below mudline
	JP-A-4	Golder 2011 Probing	468025.956	5365065.263	-8.17	9.42	hit something solid (rock-like)
	JP-A-5	Golder 2011 Probing	468021.276	5365066.759	-8.78	6.82	hit something solid (suspected gravel)
	HP-B-1	Golder 2011 Probing	468044.614	5365069.415	-1.80	1.23	-
	HP-B-2	Golder 2011 Probing	468043.095	5365070.217	-3.06	1.55	-
	HP-B-3	Golder 2011 Probing	468041.275	5365073.393	-4.25	1.29	hit something hard
	HP-B-4	Golder 2011 Probing	468040.305	5365073.909	-5.20	0.70	-
	JP-B-1	Golder 2011 Probing	468034.286	5365077.721	-7.60	> 6.46	full penetration, some resistance from suspected gravel layer
	JP-B-2	Golder 2011 Probing	468032.393	5365078.261	-8.24	5.00	hit clay-like layer, couldn't push past
	JP-B-3	Golder 2011 Probing	468027.883	5365080.414	-8.85	3.56	hit something solid (suspected gravel)
	JP-B-4	Golder 2011 Probing	468038.093	5365080.915	-7.62	5.52	hit clay-like layer, couldn't push past
	HP-C-1	Golder 2011 Probing	468050.902	5365086.556	-6.75	0.60	hit something solid (rock-like)
	HP-C-2	Golder 2011 Probing	468048.690	5365087.154	-7.34	0.60	hit something solid (rock-like)
	JP-C-1	Golder 2011 Probing	468048.086	5365087.290	-7.29	4.40	hit something solid (gravel)
	JP-C-2	Golder 2011 Probing	468045.763	5365089.823	-8.04	4.14	some resistance from clay layer, hit something solid (gravel)
	HP-C-3	Golder 2011 Probing	468043.530	5365091.945	-8.07	1.20	hit suspected gravel, pushed past, then hit something solid (rock-like)
	JP-C-3	Golder 2011 Probing	468040.461	5365093.457	-8.02	1.66	hit something solid (rock-like)
	JP-C-4	Golder 2011 Probing	468040.687	5365094.990	-7.84	1.68	pushed through suspected gravel layer, hit something solid (rock-like)
	JP-D-1	Golder 2011 Probing	468052.549	5365099.386	-7.21	2.81	full penetration
	SC10-05	Golder 2010 Sediment Cores	468049.950	5365100.110	-7.86	2.07	refusal at approximately 2.07 m; cobbles observed in core at ~1.05 m below mudline
	HP-D-1	Golder 2011 Probing	468047.696	5365100.395	-7.58	1.31	pushed through suspected gravel layer and wood, hit something solid
	JP-D-2	Golder 2011 Probing	468050.666	5365100.864	-7.26	1.53	pushed through suspected gravel layer, hit something solid (rock-like)
	HP-D-2	Golder 2011 Probing	468046.345	5365102.766	-7.30	0.65	pushed through gravel layer
Munroe Head (in order of west to east)	SC09-04	Golder February 2009 Sediment Cores	468035.112	5365025.504	-8.80	> 2.30	difficult location next to rip-rap slope, drove moderate, hard recovery
	SC09-105	Golder July 2009 Sediment Cores	468042.877	5365004.523	-9.74	> 3.11	drove easy, retrieval easy
	JP09-32	Golder 2009 Jet Probes	468040.196	5365011.101	-8.20	>6.09	full length of probe run without encountering refusal
	JP09-33	Golder 2009 Jet Probes	468045.811	5365012.433	-7.89	5.13	reported as rock-like at terminal depth
	JP09-34	Golder 2009 Jet Probes	468048.311	5365009.298	-8.48	>6.09	full length of probe run without encountering refusal
	JP09-31	Golder 2009 Jet Probes	468052.952	5364998.172	-12.20	5.53	reported as rock-like at terminal depth
	JP09-35	Golder 2009 Jet Probes	468055.322	5365008.550	-7.51	5.94	diver observed a "rock wall of riprap" located adjacent and north of his location.
	JP09-30	Golder 2009 Jet Probes	468057.475	5364992.615	-6.12	5.94	reported as rock-like at terminal depth
	SC09-06	Golder February 2009 Sediment Cores	468057.731	5364987.876	-12.86	> 2.03	drove hard, very hard recovery
	JP09-29	Golder 2009 Jet Probes	468064.416	5364993.144	-9.11	1.98	reported as rock-like at terminal depth
	GBH09-11	Golder 2009 Boreholes	468067	5365019	-0.98	0.00	gravel and sand with angular cobbles [Fill]
	SC09-106	Golder July 2009 Sediment Cores	468083.948	5364979.456	-12.14	> 2.96	drove straight, moderate retrieval
	SC09-07	Golder February 2009 Sediment Cores	468104.511	5364976.164	-12.16	> 1.35	drove moderate, easy recovery (dense sand seam)
	JP09-05	Golder 2009 Jet Probes	468123.477	5364973.853	-11.41	1.96	reported as rock-like at terminal depth
	JP09-06	Golder 2009 Jet Probes	468128.805	5364970.893	-11.44	1.67	reported as rock-like at terminal depth
	GBH09-12	Golder 2009 Boreholes	468131	5364981	-8.41	0.00	sand and gravel [Fill]

Table 1

Probe Hole and Test Hole Location and Depth to Bottom of Surficial Sediments
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Esquimalt Graving Dock, Esquimalt, BC

Investigation Area	Location ID	Study	Easting (x)	Northing (y)	Mudline Elevation (m, Chart Datum)	Depth to Bottom of Surficial Sediments (m below mudline)	Interpretations of Encountered Stratigraphy (based on diver observations, sediment and borehole logs, CPT plots)
North Landing Wharf (in order of west to east)	JP01	Golder 2010 Jet Probes	468174.18	5364962.10	-8.86	0.15	hit solid substrate
	JP02	Golder 2010 Jet Probes	468173.96	5364961.22	-9.16	0.15	rock-like
	JP03	Golder 2010 Jet Probes	468172.62	5364955.93	-9.46	0.20	hit solid substrate
	JP04	Golder 2010 Jet Probes	468171.95	5364953.28	-11.47	0.23	hit solid substrate
	JP05	Golder 2010 Jet Probes	468171.73	5364952.40	-12.07	0.59	hit solid substrate
	SC09-110	Golder July 2009 Sediment Cores	468191.321	5364949.175	-12.07	1.57	refusal at approximately 1.57 m in rocky substrate, core barrel damaged
	GCPT09-05	Golder 2009 CPTs	468204.39	5364950.51	-11.73	0.50	possible Fill
	JP06	Golder 2010 Jet Probes	468248.05	5364937.64	-10.98	1.08	hit solid substrate
	JP07	Golder 2010 Jet Probes	468248.79	5364940.55	-10.68	1.70	hit hard substrate (gravel)
	JP08	Golder 2010 Jet Probes	468249.58	5367943.46	-9.94	1.08	rock-like 0.25 m from left side of transect
	SC09-111C	Golder July 2009 Sediment Cores	468250.229	5364932.962	-11.77	> 1.74	hard to drive, clayey silt substrate
	GBH09-13	Golder 2009 Boreholes	468251.12	5364931.07	-11.33	1.75	gravel, angular cobbles [Fill]
	GCPT09-04	Golder 2009 CPTs	468251.12	5364931.07	-11.33	1.75	gravel, angular cobbles [Fill]
	GBH09-14	Golder 2009 Boreholes	468252.95	5364938.55	-11.06	1.22	angular gravel [Fill]
	GCPT09-03	Golder 2009 CPTs	468252.95	5364938.55	-11.06	1.22	angular gravel [Fill]
	JP09	Golder 2010 Jet Probes	468298.16	5364931.62	-10.00	0.97	rock-like
	JP10	Golder 2010 Jet Probes	468297.42	5364928.71	-10.64	0.53	rock-like
	JP11	Golder 2010 Jet Probes	468296.68	5364925.81	-11.38	1.12	rock-like
	SC09-17	Golder February 2009 Sediment Cores	468292.054	5364927.263	-11.71	> 2.44	drove easy, easy recovery
	GBH09-15	Golder 2009 Boreholes	468312.87	5364924.24	-10.62	1.07	Till-like (silty sand to sand and silt, some gravel to gravelly)
	SC09-117	Golder July 2009 Sediment Cores	468329.740	5364919.821	-10.32	1.38	suspect sandblast grit, gravel, some sand
	GBH09-16	Golder 2009 Boreholes	468351.95	5364913.97	-10.30	0.76	coarse angular gravel [Fill]
	JP12	Golder 2010 Jet Probes	468370.71	5364913.10	-9.52	0.55	hit something solid (gravel), diver could not push past
	JP13	Golder 2010 Jet Probes	468370.10	5364910.68	-10.04	1.16	hit hard substrate
	JP14	Golder 2010 Jet Probes	468369.36	5364907.77	-10.36	0.85	rock-like
Mouth of Esquimalt Graving Dock (in order of north to south)	SC09-118B	Golder July 2009 Sediment Cores	468374.156	5364904.044	-10.58	> 1.13	poor recovery and poor penetration
	JP09-04	Golder 2009 Jet Probes	468379.262	5364902.074	-10.31	1.27	reported as rock-like at terminal depth
	JP09-01	Golder 2009 Jet Probes	468388.649	5364898.937	-10.53	1.06	reported as rock-like at terminal depth
	JP09-03	Golder 2009 Jet Probes	468389.449	5364898.051	-10.71	1.06	reported as rock-like at terminal depth
	JP09-02	Golder 2009 Jet Probes	468390.070	5364892.802	-10.70	0.71	reported as rock-like at terminal depth
	SC09-26	Golder February 2009 Sediment Cores	468362.273	5364894.608	-10.93	0.52	drove hard, moderate recovery, black medium sand (suspect sandblast grit) below 0.52 m
	JP09-17	Golder 2009 Jet Probes	468386.119	5364880.395	-9.45	0.74	reported as rock-like at terminal depth
	SC09-119C	Golder July 2009 Sediment Cores	468352.469	5364878.159	-10.88	0.79	coarse sand and gravel
	GBH09-17	Golder 2009 Boreholes	468356.26	5364876.41	-10.89	0.61	compact to dense sandy gravel
	JP09-16	Golder 2009 Jet Probes	468391.446	5364874.842	-10.07	0.91	reported as rock-like at terminal depth
	JP09-18	Golder 2009 Jet Probes	468381.572	5364873.191	-9.71	0.41	reported as rock-like at terminal depth
	GBH09-18	Golder 2009 Boreholes	468381.22	5364871.27	-10.23	0.46	Till-like (sand and silt, some gravel)
	SC09-33	Golder February 2009 Sediment Cores	468374.059	5364869.230	-10.66	0.48	sand and gravel
South Entrance Wall (in order of north to south)	JP09-15	Golder 2009 Jet Probes	468381.011	5364863.374	-9.88	1.09	reported as rock-like at terminal depth
	SC09-120	Golder July 2009 Sediment Cores	468372.761	5364862.909	-10.17	> 2.40	drove straight, good recovery
	JP09-26	Golder 2009 Jet Probes	468375.294	5364861.575	-8.66	2.47	reported as rock-like at terminal depth
	DP14	Golder 2009 Diver Hand Probes	468373.97	5364859.46	-	> 1.2	full penetration, some resistance from crushed shell
	DP13	Golder 2009 Diver Hand Probes	468374.47	5364854.46	-	> 1.2	full penetration with mild resistance
	JP09-28	Golder 2009 Jet Probes	468372.863	5364853.805	-6.29	2.29	reported as rock-like at terminal depth
	JP09-25	Golder 2009 Jet Probes	468380.545	5364853.978	-6.03	2.11	diver reported feeling "timber-like" material at refusal
	JP09-24	Golder 2009 Jet Probes	468377.051	5364850.606	-6.99	3.73	reported as rock-like at terminal depth
	DP12	Golder 2009 Diver Hand Probes	468374.96	5364849.49	-	0.40	partial penetration
	JP09-23	Golder 2009 Jet Probes	468377.251	5364846.742	-6.99	3.58	reported as rock-like at terminal depth
	DP11	Golder 2009 Diver Hand Probes	468375.46	5364844.51	-	> 1.2	full penetration, some resistance, possible cobble
	JP09-27	Golder 2009 Jet Probes	468374.753	5364843.544	-7.07	5.79	reported as rock-like at terminal depth
	JP09-22	Golder 2009 Jet Probes	468378.123	5364840.160	-6.69	3.05	reported as rock-like at terminal depth
	DP10	Golder 2009 Diver Hand Probes	468375.96	5364839.53	-	> 1.2	full penetration, no resistance
	JP09-21	Golder 2009 Jet Probes	468378.569	5364834.580	-6.41	1.68	reported as rock-like at terminal depth
	DP9	Golder 2009 Diver Hand Probes	468376.45	5364834.55	-	> 1.2	full penetration, mild resistance
	DP8	Golder 2009 Diver Hand Probes	468376.95	5364829.55	-	0.84	partial probe
	JP09-20	Golder 2009 Jet Probes	468379.056	5364828.520	-5.53	3.78	reported as rock-like at terminal depth
	JP09-19	Golder 2009 Jet Probes	468379.035	5364825.430	-5.88	3.68	reported as rock-like at terminal depth
	DP7	Golder 2009 Diver Hand Probes	468377.45	5364824.56	-	> 1.2	full penetration with moderate resistance, angular cobble on surface

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South Jetty, West (in order of west to east)	AP1	Golder 2009 Diver Hand Probes	468310.96	5364782.45	-	> 1.2	full penetration, mild resistance
	AP2	Golder 2009 Diver Hand Probes	468310.48	5364787.28	-	> 1.2	full penetration, no resistance
	AP3	Golder 2009 Diver Hand Probes	468309.98	5364792.28	-	> 1.2	full penetration, resistance at 1.13m below substrate surface
	AP4	Golder 2009 Diver Hand Probes	468309.48	5364797.29	-	> 1.2	full penetration, no resistance
	AP5	Golder 2009 Diver Hand Probes	468308.99	5364802.29	-	> 1.2	full penetration
	AP6	Golder 2009 Diver Hand Probes	468308.49	5364807.28	-	0.85	feels like probe hit wood
	AP7	Golder 2009 Diver Hand Probes	468308.00	5364812.23	-	> 1.2	full penetration
	AP8	Golder 2009 Diver Hand Probes	468307.51	5364817.22	-	0.57	hit something hard, possibly rock
	AP9	Golder 2009 Diver Hand Probes	468307.01	5364822.21	-	> 1.2	full penetration, some resistance from shell (diver could hear shells breaking while probing substrate)
	AP10	Golder 2009 Diver Hand Probes	468306.57	5364826.69	-	> 1.2	full penetration, moderate resistance at 0.36m (shell)
	DC09-01	Golder 2009 Diver Cores	468308.53	5364806.87	-8.17	> 1.27	silt and shell fragments
	DC09-02	Golder 2009 Diver Cores	468310.01	5364791.96	-8.21	> 1.03	silt and shell fragments
	GBH09-06	Golder 2009 Boreholes	468308.56	5364800.68	-8.22	7.62	Victoria Clay
	GBH09-01	Golder 2009 Boreholes	468340.21	5364793.03	-6.78	8.69	Victoria Clay
	GBH09-03	Golder 2009 Boreholes	468334.15	5364829.85	-7.77	7.62	Victoria Clay
	GBH09-05	Golder 2009 Boreholes	468333.11	5364801.81	-7.29	8.23	Victoria Clay
	GBH09-07	Golder 2009 Boreholes	468356.13	5364840.86	-7.77	3.35	gravelly sandy silt [possible Fill]
	GBH09-19	Golder 2009 Boreholes	468361.98	5364861.63	-10.92	0.91	silty sand and gravel, Victoria Clay at 1.83 m
	CP1	Golder 2009 Diver Hand Probes	468361.96	5364796.72	-	> 1.2	full penetration, minimal resistance, feels like silt
	CP2	Golder 2009 Diver Hand Probes	468361.75	5364798.72	-	0.80	feels like hitting wood
	CP3	Golder 2009 Diver Hand Probes	468361.54	5364800.74	-	> 1.2	hit wood at 93 cm penetration, could push past wood, full penetration
	CP4	Golder 2009 Diver Hand Probes	468359.78	5364817.78	-	> 1.2	full penetration, feels like silt
	CP5	Golder 2009 Diver Hand Probes	468359.58	5364819.77	-	> 1.2	full penetration, easy, feels like silt
	CP6	Golder 2009 Diver Hand Probes	468359.37	5364821.76	-	> 1.2	full penetration, feels like silt
	DC09-03	Golder 2009 Diver Cores	468359.61	5364819.83	-7.49	> 1.20	silt and shell fragments
	DC09-04	Golder 2009 Diver Cores	468361.77	5364798.94	-7.09	> 1.34	silt and shell fragments
South Jetty, South Central (in order of west to east)	JP09-07	Golder 2009 Jet Probes	468374.830	5364814.148	-6.82	2.36	reported as rock-like at terminal depth
	JP09-08	Golder 2009 Jet Probes	468376.453	5364810.067	-6.39	3.40	reported as rock-like at terminal depth
	JP09-09	Golder 2009 Jet Probes	468376.658	5364796.761	-7.28	4.09	reported as rock-like at terminal depth
	GBH09-08	Golder 2009 Boreholes	468378.28	5364806.08	-7.33	5.49	sand, trace gravel, Victoria Clay at 6.61 m
	DP1	Golder 2009 Diver Hand Probes	468380.91	5364789.82	-	> 1.2	full penetration, minimal resistance, layer of clay/shell
	DP2	Golder 2009 Diver Hand Probes	468379.94	5364799.55	-	> 1.2	full penetration
	DP3	Golder 2009 Diver Hand Probes	468379.44	5364804.57	-	> 1.2	full penetration, mild resistance
	DP4	Golder 2009 Diver Hand Probes	468378.94	5364809.57	-	> 1.2	full penetration, some resistance (shell/clay layer), medium effort to use probe
	DP5	Golder 2009 Diver Hand Probes	468378.44	5364814.58	-	0.72	partial probe
	DP6	Golder 2009 Diver Hand Probes	468377.95	5364819.58	-	0.68	resistance
	JP09-12	Golder 2009 Jet Probes	468389.142	5364799.670	-6.50	2.70	reported as rock-like at terminal depth
	JP09-10	Golder 2009 Jet Probes	468389.962	5364802.220	-6.50	4.34	reported as rock-like at terminal depth
	JP09-14	Golder 2009 Jet Probes	468399.862	5364794.446	-6.42	1.75	reported as rock-like at terminal depth
	JP09-13	Golder 2009 Jet Probes	468403.025	5364801.104	-4.75	2.32	reported as rock-like at terminal depth
	EP1	Golder 2009 Diver Hand Probes	468417.40	5364793.45	-	> 2.4	full penetration, resistance near 2.4m
	EP2	Golder 2009 Diver Hand Probes	468416.95	5364797.85	-	0.75	hit gravel at 0.75m (could push past gravel to 1.05m)
	EP3	Golder 2009 Diver Hand Probes	468416.43	5364802.91	-	1.96	felt shells breaking (could push past shells to 1.96m)
	EP4	Golder 2009 Diver Hand Probes	468416.03	5364806.76	-	0.25	penetration to 0.25m, hit rock
	DC09-05	Golder 2009 Diver Cores	468416.31	5364803.54	-2.44	> 0.31	shell fragments and coarse sand, some gravel
	GBH09-02	Golder 2009 Boreholes	468416.27	5364804.61	-2.61	< 3.96 m	no recovery above 3.96 m (except for black creosote-soaked wood); sand to gravelly sand [Fill] below 3.96 m
	GBH09-22	Golder 2009 Boreholes	468422	5364797	-7.24	5.49	Victoria Clay

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South Jetty, Southeast (in order of west to east)	FP1	Golder 2009 Diver Hand Probes	468447.26	5364796.78	-	1.47	clay layer encountered at 1.3m, strong resistance past 1.3m
	FP2	Golder 2009 Diver Hand Probes	468446.83	5364801.37	-	1.05	hit gravel at 0.75m (could push past gravel to 1.05m)
	FP3	Golder 2009 Diver Hand Probes	468446.40	5364806.13	-	0.90	rock-like
	FP4	Golder 2009 Diver Hand Probes	468445.93	5364811.30	-	0.73	hit hard substrate
	FP5	Golder 2009 Diver Hand Probes	468445.47	5364816.32	-	1.25	mild resistance to 1.25 m, rock-like
	FP6	Golder 2009 Diver Hand Probes	468445.07	5364820.69	-	1.76	mild resistance to 1.76 m, rock-like
	FP7	Golder 2009 Diver Hand Probes	468444.64	5364825.39	-	0.00	substrate cobble and boulder (rip rap), no probing conducted
	GP1	Golder 2009 Diver Hand Probes	468477.77	5364800.00	-	1.55	rock-like
	GP2	Golder 2009 Diver Hand Probes	468477.45	5364804.66	-	1.46	lots of resistance at 1.46 m (suspect like light sediment overlying clay)
	GP3	Golder 2009 Diver Hand Probes	468477.12	5364809.43	-	1.61	rock-like at 1.61 m
	GP4	Golder 2009 Diver Hand Probes	468476.78	5364814.48	-	> 2.4	minimal resistance above 2.4 m
	GP5	Golder 2009 Diver Hand Probes	468476.44	5364819.46	-	1.70	penetration to 1.70 m, rock-like
	GP6	Golder 2009 Diver Hand Probes	468476.11	5364824.29	-	1.55	could not push past
	DC09-06	Golder 2009 Diver Cores	468477.12	5364809.97	-4.87	> 0.35	silt and shell fragments
	GBH09-10	Golder 2009 Boreholes	468476.90	5364805.67	-5.95	4.10	sand and silt, Victoria Clay at 6.10 m
	HP1	Golder 2009 Diver Hand Probes	468510.98	5364803.44	-	1.41	hit piece of wood, penetration to 1.41 m
	HP2	Golder 2009 Diver Hand Probes	468510.48	5364808.16	-	2.12	hit wood
	HP3	Golder 2009 Diver Hand Probes	468509.99	5364812.91	-	> 2.4	hit 2 layers of resistance, could push through
	HP4	Golder 2009 Diver Hand Probes	468509.50	5364817.52	-	1.09	hit rock
	HP5	Golder 2009 Diver Hand Probes	468509.03	5364822.06	-	1.73	hit 3 layers of resistance, hit something solid at 1.73 m
	HP6	Golder 2009 Diver Hand Probes	468508.51	5364827.01	-	0.26	hit something solid
	IP1	Golder 2009 Diver Hand Probes	468538.41	5364806.33	-	1.80	hit something solid (rock-like), 2 layers of medium resistance
	IP2	Golder 2009 Diver Hand Probes	468537.90	5364810.80	-	0.36	hit something solid (rock-like)
	IP3	Golder 2009 Diver Hand Probes	468537.35	5364815.50	-	1.08	hit something hard, rock-like throughout
	IP4	Golder 2009 Diver Hand Probes	468536.82	5364820.19	-	1.69	hit something solid (rock-like)
	IP5	Golder 2009 Diver Hand Probes	468536.26	5364825.03	-	1.15	went through 1 layer of medium resistance, hit something solid (rock-like)
	IP6	Golder 2009 Diver Hand Probes	468535.69	5364829.97	-	> 2.4	1 layer of resistance (clay layer, full penetration to 8 ft, 2.4 m)
	IP7	Golder 2009 Diver Hand Probes	468535.14	5364834.79	-	1.62	cobble (rip-rap) with silt, penetration to 1.62 m in clay, stopped due to frictional resistance
	DC09-07	Golder 2009 Diver Cores	468537.36	5364815.08	-3.99	> 0.35	silt and shell fragments
	GBH09-09	Golder 2009 Boreholes	468537.58	5364814.41	-4.28	1.45	gravel [Fill]
	JP1	Golder 2009 Diver Hand Probes	468568.51	5364812.24	-	1.32	too much resistance to push past 1.32 m, feels like clay
	JP2	Golder 2009 Diver Hand Probes	468567.97	5364817.67	-	1.10	1.10 m - resistance from clay layer
	JP3	Golder 2009 Diver Hand Probes	468567.42	5364823.20	-	0.82	resistance from clay (clay observed on probe) at 0.82 m penetration
	JP4	Golder 2009 Diver Hand Probes	468566.92	5364828.19	-	1.74	1.74 m - clay layer (resistance)
	DC09-08	Golder 2009 Diver Cores	468566.82	5364829.90	-0.51	> 0.35	silt and shell fragments
	DC09-09	Golder 2009 Diver Cores	468567.91	5364818.95	-3.55	> 0.35	silt and shell fragments
	DC09-10	Golder 2009 Diver Cores	468568.50	5364812.99	-6.16	> 0.35	silt and shell fragments
	DC09-11	Golder 2009 Diver Cores	468567.42	5364823.93	-1.51	> 0.35	clayey silt to silty clay
	GBH09-04	Golder 2009 Boreholes	468568.16	5364820.07	-2.44	1.52	silty sand, some gravel with cobbles [possible Fill]

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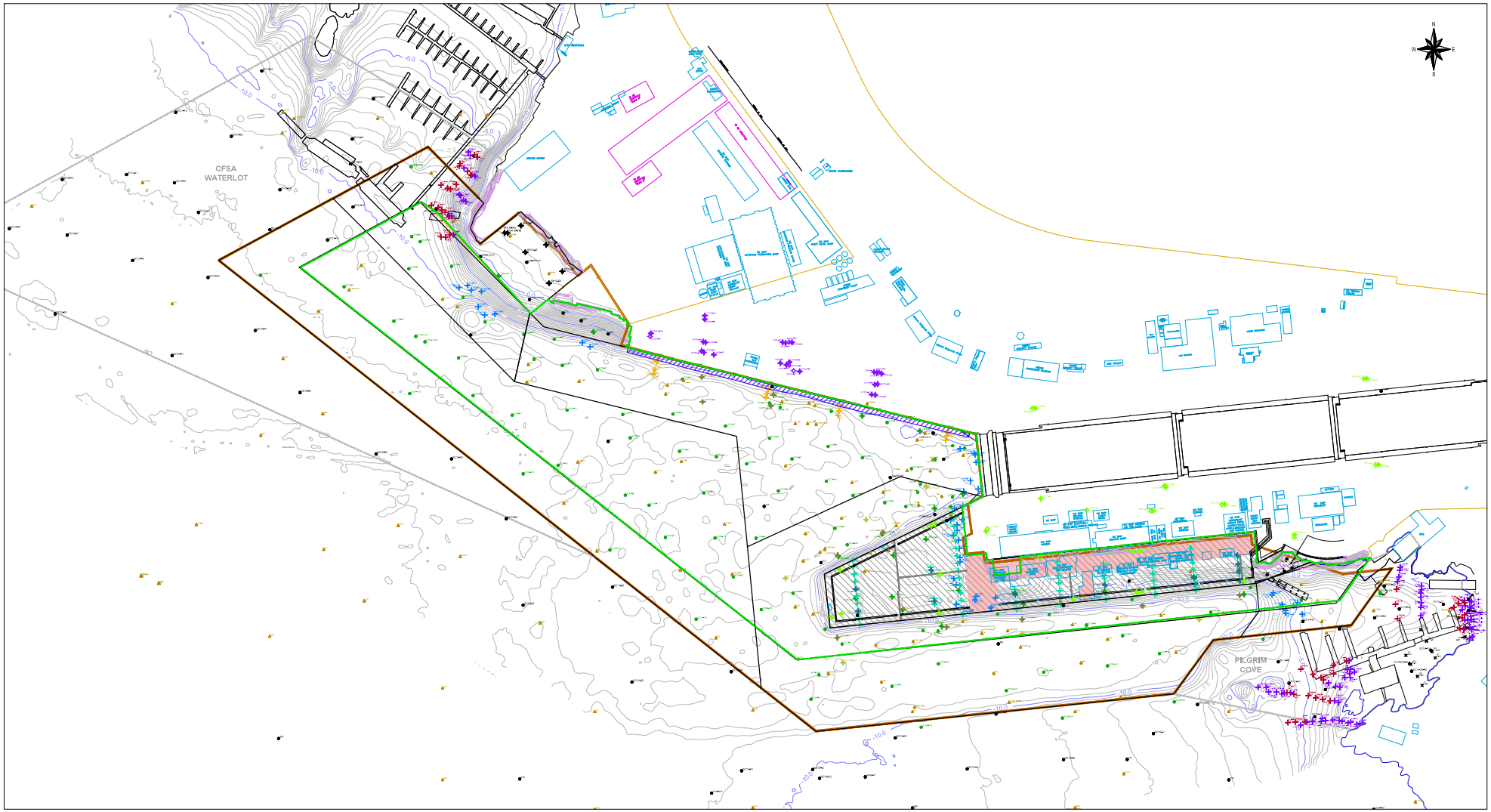
Pilgrim Cove	JP09-36	Golder 2009 Jet Probes	468590.998	5364804.454	-6.96	1.78	reported as rock-like at terminal depth
	JP09-37	Golder 2009 Jet Probes	468590.350	5364803.038	-7.23	4.37	reported as rock-like at terminal depth
	JP09-38	Golder 2009 Jet Probes	468597.112	5364796.590	-6.62	4.47	reported as rock-like at terminal depth
	JP09-39	Golder 2009 Jet Probes	468604.694	5364795.904	-5.35	4.34	reported as rock-like at terminal depth
	JP09-40	Golder 2009 Jet Probes	468599.577	5364790.930	-5.60	1.73	material suspected to be stiff clay - no progress but no "hard" refusal
	JP09-41	Golder 2009 Jet Probes	468599.541	5364792.819	-5.59	3.12	reported as rock-like at terminal depth
	JP09-42	Golder 2009 Jet Probes	468610.702	5364790.089	-3.74	2.15	reported as rock-like at terminal depth
	JP09-43	Golder 2009 Jet Probes	468607.646	5364798.030	-3.93	3.53	reported as rock-like at terminal depth
	HP-F-1	Golder 2011 Probing	468649.751	5364716.264	1.06	0.05	hit something hard (suspected bedrock)
	HP-F-2	Golder 2011 Probing	468647.644	5364715.674	0.57	0.25	hit something hard
	HP-F-3	Golder 2011 Probing	468643.491	5364717.002	0.24	0.40	hit something solid (rock-like)
	HP-F-4	Golder 2011 Probing	468641.713	5364716.553	0.07	0.97	hit something solid (rock-like)
	HP-F-5	Golder 2011 Probing	468637.645	5364717.563	-0.57	0.60	hit something solid (rock-like)
	HP-F-6	Golder 2011 Probing	468635.608	5364718.314	-0.61	0.08	hit something solid (rock-like)
	HP-F-7	Golder 2011 Probing	468631.298	5364718.369	-2.46	0.84	hit something solid (rock-like)
	HP-F-8	Golder 2011 Probing	468626.529	5364718.060	-3.33	2.35	hit something solid (rock-like)
	HP-F-9	Golder 2011 Probing	468624.176	5364719.676	-3.71	1.47	hit something solid (rock-like)
	HP-F-10	Golder 2011 Probing	468623.552	5364717.429	-4.50	0.61	hit something solid (rock-like)
	HP-F-11	Golder 2011 Probing	468617.568	5364717.480	-4.34	0.98	hit something solid (rock-like)
	HP-F-12	Golder 2011 Probing	468613.752	5364717.110	-5.03	> 2.5	hit something solid (rock-like)
	HP-F-13	Golder 2011 Probing	468609.701	5364714.985	-5.59	> 2.5	-
	JP-F-1	Golder 2011 Probing	468612.468	5364717.321	-4.63	3.63	hit clay-like substrate, couldn't push past
	JP-F-2	Golder 2011 Probing	468606.029	5364717.107	-4.88	3.54	pushed through clay-like substrate
	JP-F-3	Golder 2011 Probing	468601.025	5364716.806	-5.31	1.82	pushed through clay-like substrate, hit something hard
	SC10-42	Golder 2010 Sediment Cores	468619.131	5364720.665	-3.88	1.00	shell fragments, angular gravel at 0.65 m
	HP-G-1	Golder 2011 Probing	468635.057	5364730.287	-1.74	0.35	hit something solid (rock-like)
	HP-G-2	Golder 2011 Probing	468632.501	5364731.573	-1.78	2.23	hit something solid (rock-like)
	JP-G-1	Golder 2011 Probing	468629.675	5364731.626	-2.28	2.72	hit something solid (rock-like)
	JP-G-2	Golder 2011 Probing	468624.670	5364732.516	-3.54	3.03	pushed through clay-like substrate, hit something solid (rock-like)
	JP-G-3	Golder 2011 Probing	468619.823	5364733.500	-4.15	2.96	hit suspected gravel/clay layer, pushed past suspected shell layer
	JP-G-4	Golder 2011 Probing	468614.870	5364735.071	-4.73	2.52	hit clay-like substrate, couldn't push past
	JP-G-5	Golder 2011 Probing	468604.905	5364736.038	-5.42	2.04	pushed through gravel layer, hit clay-like substrate, couldn't push past
	HP-G-3	Golder 2011 Probing	468602.715	5364736.901	-5.53	> 2.5	pushed through silt and clay layers
	HP-G-4	Golder 2011 Probing	468598.555	5364736.942	-5.57	1.06	-
	JP-G-6	Golder 2011 Probing	468600.294	5364737.185	-5.49	2.09	hit clay-like substrate, couldn't push past
	HP-G-6	Golder 2011 Probing	468593.392	5364737.379	-4.89	0.48	hit something solid (rock-like)
	HP-G-7	Golder 2011 Probing	468596.851	5364736.166	-5.16	0.28	hit something solid (rock-like)
	HP-G-8	Golder 2011 Probing	468587.877	5364737.532	-5.17	0.18	hit something solid (rock-like)
	HP-G-9	Golder 2011 Probing	468586.333	5364740.616	-4.90	0.34	hit something solid (rock-like)
	HP-G-10	Golder 2011 Probing	468580.797	5364740.670	-5.18	0.44	hit something solid (rock-like)
	SC10-41	Golder 2010 Sediment Cores	468626.384	5364739.150	-3.85	2.32	silty clay to clayey silt, trace sand, contains shell fragments
	HP-H-1	Golder 2011 Probing	468636.243	5364740.771	-2.88	0.48	hit something solid (rock-like)
	HP-H-2	Golder 2011 Probing	468633.161	5364741.323	-3.21	1.44	hit something solid (rock-like)
	HP-H-3	Golder 2011 Probing	468628.493	5364743.588	-3.83	2.26	hit something solid (rock-like)
	JP-H-1	Golder 2011 Probing	468625.084	5364745.495	-3.80	2.97	hit clay-like substrate, couldn't push past
	JP-H-2	Golder 2011 Probing	468623.477	5364747.098	-4.16	3.03	hit clay-like substrate, couldn't push past
	JP-H-3	Golder 2011 Probing	468617.814	5364749.444	-4.68	2.98	hit clay-like substrate, couldn't push past
	JP-H-4	Golder 2011 Probing	468609.799	5364752.908	-5.28	2.40	hit clay-like substrate, couldn't push past
	HP-I-1	Golder 2011 Probing	468725.835	5364774.774	0.66	0.20	hit something solid (rock-like)
	HP-I-2	Golder 2011 Probing	468723.957	5364774.057	0.41	0.05	hit something solid (rock-like)
	HP-I-3	Golder 2011 Probing	468725.325	5364779.875	0.35	0.14	hit something solid (rock-like)
	HP-I-4	Golder 2011 Probing	468724.135	5364781.002	0.31	0.22	hit something solid (rock-like)
	HP-I-5	Golder 2011 Probing	468720.951	5364780.939	-0.05	> 2.5	full penetration
	HP-I-6	Golder 2011 Probing	468724.741	5364788.815	0.17	0.26	hit something solid (rock-like)
	HP-I-7	Golder 2011 Probing	468722.263	5364790.551	-0.44	0.37	hit something solid (rock-like)
	HP-I-8	Golder 2011 Probing	468719.007	5364793.210	-0.75	2.40	hit clay-like substrate, couldn't push past
	HP-I-9	Golder 2011 Probing	468725.075	5364786.395	0.17	0.20	hit something solid (rock-like)
	HP-I-10	Golder 2011 Probing	468722.749	5364786.035	-0.13	0.45	hit something solid (rock-like)
	HP-I-11	Golder 2011 Probing	468720.762	5364786.237	-0.52	> 2.5	full penetration
	HP-I-12	Golder 2011 Probing	468725.290	5364794.015	0.39	0.07	hit something solid (rock-like)
	HP-I-13	Golder 2011 Probing	468724.02	5364794.86	-0.55	0.18	-

Table 1

Probe Hole and Test Hole Location and Depth to Bottom of Surficial Sediments
Sub-Surface Probing and Dive Surveys: Interpretive Report
Esquimalt Graving Dock, Esquimalt, BC

Investigation Area	Location ID	Study	Easting (x)	Northing (y)	Mudline Elevation (m, Chart Datum)	Depth to Bottom of Surficial Sediments (m below mudline)	Interpretations of Encountered Stratigraphy (based on diver observations, sediment and borehole logs, CPT plots)
Pilgrim Cove (continued)	HP-I-14	Golder 2011 Probing	468720.979	5364795.633	-0.54	> 2.5	full penetration
	HP-I-15	Golder 2011 Probing	468725.199	5364798.609	-0.29	0.14	hit something solid (rock-like)
	HP-I-16	Golder 2011 Probing	468723.916	5364799.230	-0.35	0.22	hit something solid (rock-like)
	HP-I-17	Golder 2011 Probing	468720.493	5364799.301	-0.65	> 2.5	full penetration
	JP-I-1	Golder 2011 Probing	468713.246	5364794.827	-0.76	4.04	hit clay-like substrate, couldn't push past
	JP-I-2	Golder 2011 Probing	468716.343	5364797.444	-0.64	2.09	hit clay-like substrate, couldn't push past
	JP-I-3	Golder 2011 Probing	468720.608	5364797.888	-0.82	2.51	passed through gravel layer, hit clay-like substrate, couldn't push past
	JP-I-4	Golder 2011 Probing	468718.824	5364787.686	-0.63	3.54	hit clay-like layer, couldn't push past
	JP-I-5	Golder 2011 Probing	468720.523	5364789.649	-0.28	2.70	passed through gravel layer, hit clay-like substrate, couldn't push past
	JP-I-6	Golder 2011 Probing	468720.147	5364780.045	0.34	2.57	hit something solid (rock-like)
	JP-I-7	Golder 2011 Probing	468717.577	5364780.506	-0.09	2.56	hit clay-like substrate, couldn't push past
	SC10-48	Golder 2010 Sediment Cores	468716.471	5364787.702	-0.18	3.19	clayey silt to silty clay, wood at 0.6 m
	HP-K-1	Golder 2011 Probing	468643.175	5364747.092	-1.75	0.15	hit something solid (rock-like)
	HP-K-2	Golder 2011 Probing	468642.976	5364749.995	-1.97	1.80	hit something solid (rock-like)
	HP-K-3	Golder 2011 Probing	468641.341	5364752.606	-1.64	1.33	hit something solid (rock-like)
	HP-K-5	Golder 2011 Probing	468646.047	5364750.921	-1.40	1.02	hit something solid (rock-like)
	HP-K-6	Golder 2011 Probing	468643.436	5364752.898	-1.72	1.52	hit something solid (rock-like)
	HP-K-7	Golder 2011 Probing	468642.255	5364758.567	-2.59	> 2.5	full penetration
	HP-K-8	Golder 2011 Probing	468639.464	5364747.305	-1.61	1.65	hit something solid (rock-like)
	JP-K-1	Golder 2011 Probing	468640.861	5364758.348	-2.57	3.85	hit clay-like substrate, couldn't push past
	JP-K-2	Golder 2011 Probing	468631.787	5364755.292	1.87	2.78	hit something solid (rock-like)
	JP-K-3	Golder 2011 Probing	468631.917	5364749.714	-2.90	2.34	hit something solid (rock-like)
	HP-L-1	Golder 2011 Probing	468691.348	5364809.292	-0.28	0.43	hit something solid (rock-like)
	HP-L-2	Golder 2011 Probing	468691.356	5364806.631	-0.65	0.40	hit something solid (rock-like)
	HP-L-3	Golder 2011 Probing	468690.989	5364804.362	-0.93	0.34	hit something solid (rock-like)
	HP-L-4	Golder 2011 Probing	468690.996	5364801.533	-1.37	1.30	hit something solid (rock-like)
	HP-L-5	Golder 2011 Probing	468691.396	5364797.773	-1.67	2.50	hit clay-like substrate, couldn't push past
	JP-L-1	Golder 2011 Probing	468690.975	5364794.770	-1.89	> 2.5	hit clay-like substrate, couldn't push past
	JP-L-2	Golder 2011 Probing	468690.838	5364789.036	-1.95	1.32	hit clay-like substrate, couldn't push past
	HP-M-1	Golder 2011 Probing	468676.999	5364821.946	1.06	0.22	hit something solid (rock-like)
	HP-M-2	Golder 2011 Probing	468676.689	5364819.917	0.61	0.26	hit something solid (rock-like)
	HP-M-3	Golder 2011 Probing	468675.974	5364815.292	-0.17	1.22	hit something solid (rock-like)
	HP-M-4	Golder 2011 Probing	468675.178	5364812.207	-0.74	1.10	hit something solid (rock-like)
	JP-M-1	Golder 2011 Probing	468674.502	5364806.993	-1.44	> 2.5	hit clay-like layer, couldn't push past
	JP-M-2	Golder 2011 Probing	468673.778	5364796.808	-2.74	1.30	hit clay-like layer, couldn't push past
	JP-M-3	Golder 2011 Probing	468675.252	5364787.199	-2.71	1.08	hit clay-like layer, couldn't push past
	SC10-46	Golder 2010 Sediment Cores	468676.381	5364793.647	-2.67	4.28	clayey silt to silty clay, shell fragments to 0.6 m, fine grained sand seams to 0.71 m
	SC09-134	Golder July 2009 Sediment Cores	468610.001	5364799.565	-4.49	> 2.90	alternating 'easy-hard-easy' driving
	KCPT09-101	Golder 2009 CPTS (for KCB)	468621.040	5364798.580	-3.75	1.00	sandy soil inferred from CPT
	A1	Golder 2010 Site Investigation	468691.811	5364741.952	0.87	0.39	hit something hard, possibly bedrock
	A2	Golder 2010 Site Investigation	468688.618	5364747.991	0.53	2.32	hit something hard, possibly bedrock
	A3	Golder 2010 Site Investigation	468684.124	5364756.172	0.23	3.87	hit something hard, possibly bedrock
	A4	Golder 2010 Site Investigation	468680.814	5364762.201	0.51	4.24	hit something hard, possibly bedrock
	B1	Golder 2010 Site Investigation	468700.637	5364760.637	0.49	0.56	hit something hard, possibly bedrock
	B2	Golder 2010 Site Investigation	468698.485	5364764.791	0.36	> 4.14	full penetration, drove easy, slight resistance increasing with depth
	B3	Golder 2010 Site Investigation	468694.702	5364771.892	0.14	> 4.50	full penetration
	B4	Golder 2010 Site Investigation	468690.884	5364779.770	-0.87	> 4.78	full penetration
	C1	Golder 2010 Site Investigation	468720.790	5364774.744	0.86	0.96	hit something hard
	C2	Golder 2010 Site Investigation	468722.347	5364780.728	0.56	> 4.11	full penetration
	C3	Golder 2010 Site Investigation	468723.048	5364792.546	-0.04	> 4.55	full penetration
	C4	Golder 2010 Site Investigation	468723.03	5364800.15	0.18	> 4.34	full penetration



LEGEND

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- Borehole Locations - Golder 2010
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- Cone Penetration Test Locations - Golder 2009
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- Jet Probe Locations - Golder 2010
- Jet Probe Locations - Golder 2011
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- Sediment Core Sample Locations - Historical
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- Bathymetry Chart Datum Contour - Minor (0.5m interval(s) CRA Canada Surveys Inc. (2009 and 2010)
- Shoreline Chart Datum Contour - Major (1m interval(s) Focus Corporation (2009)
- Shoreline Chart Datum Contour - Minor (0.25m interval(s) Focus Corporation (2009)
- Optional Future Remediation Areas - CFSA Waterlot and Pilgrim Cove
- Site Boundary
- PWGSC Waterlot Boundary
- Inferred extent of exposed cobbles and boulders ("rip-rap") based on available information, *see NOTE 4
- Approximate extent of steel piles under South Jetty
- SMA(S) Sediment Management Areas (SMA) to be Remediated

25 0 25
SCALE 1:1,250 METRES

NOTES

1. Bathymetry contours provided by CRA Surveys, shown in CHART datum (0.5m intervals)
2. Other contours provided by FOCUS Corporation, shown in CHART datum (0.25m intervals)
3. Number below probe locations represents probe penetration depth in metres below mudline.
4. Refer to Sub-Surface Probing and Dive Surveys: Interpretive Report for discussion of the presence of exposed cobbles and boulders ("rip-rap").

REFERENCE

1. Base map courtesy of Public Works and Government Services Canada - EGD Basemap.dwg

PROJECT
PUBLIC WORKS GOVERNMENT SERVICES CANADA
SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT, B.C.

TITLE
PROBE AND TEST HOLE LOCATION PLAN

Golder Associates
Victoria, BC

PROJECT No. 10-1475-0002			FILE No P10147500027000-08
DESIGN	MS	15 FEB 11	SCALE AS SHOWN REV. 0
CADD	JEF	17 FEB 11	
CHECK	RSJ	26 OCT 12	FIGURE 1
REVIEW	JF	26 OCT 12	

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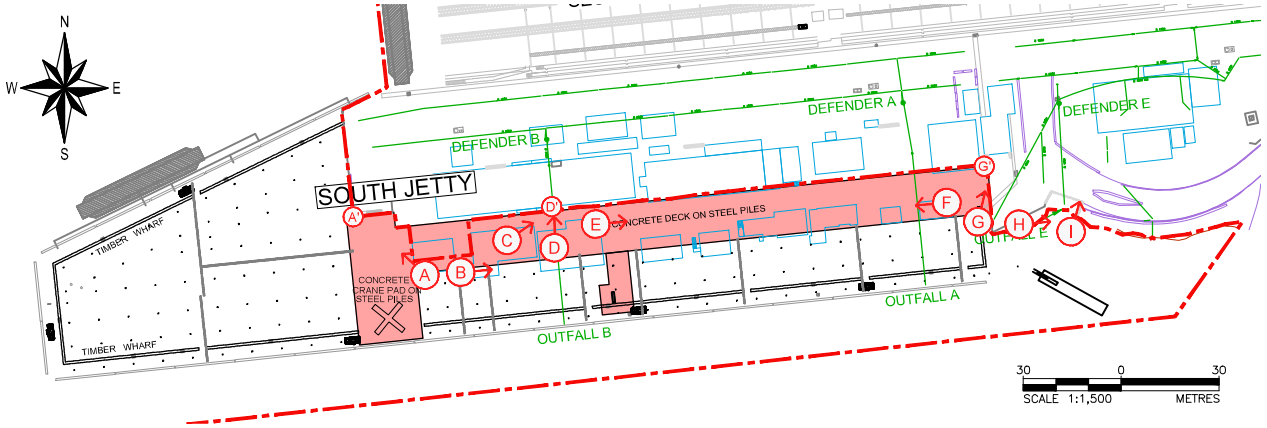

REFERENCE
Base map data courtesy of Public Works and Government Services Canada

NOTE
Photograph locations are approximate

PROJECT
PUBLIC WORKS GOVERNMENT SERVICES CANADA
SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT, B.C.

TITLE
SOUTH JETTY PLAN WITH PHOTOS

Golder Associates
Victoria, BC

PROJECT No. 10-1475-0002			FILE No. P101475000027000-09	
DESIGN	MS	16 AUG 10	SCALE AS SHOWN	REV. 0
CADD	CLF	17 AUG 10		
CHECK	RSJ	26 OCT 12		
REVIEW	JF	26 OCT 12		

FIGURE 2

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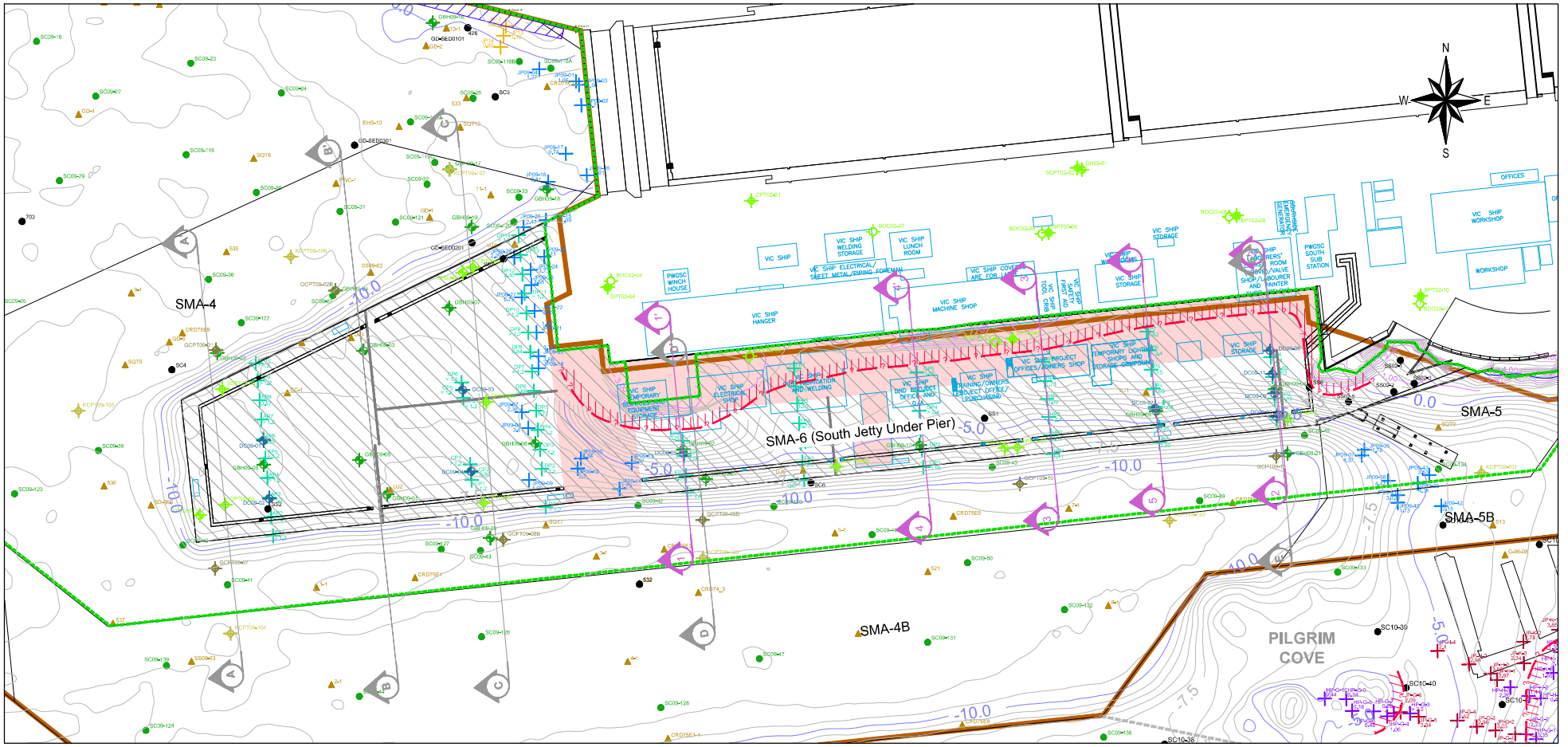

LEGEND

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- Jet Probe Locations - Golder 2010
- Jet Probe Locations - Golder 2011
- Hand Probe Locations - Golder 2009
- Hand Probe Locations - Golder 2011
- Probe Locations - Golder 2010
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- Sediment Core Sample Locations - Historical
- 2009 Stratigraphic Section Lines *see reference 1
- 2010 Section Lines
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- Approximate extent of steel piles under South Jetty
- SMA-4 — Sediment Management Areas (SMA) to be Remediated

20 0 20
SCALE 1:1,000 METRES

NOTES

1. Bathymetry contours provided by CRA Surveys, shown in CHART datum (0,5m intervals)
2. Other contours provided by FOCUS Corporation, shown in CHART datum (0,25m intervals)
3. Number below probe locations represents probe penetration depth in metres below mudline.
4. Refer to Sub-Surface Probing and Dive Surveys: Interpretive Report for discussion of the presence of exposed cobbles and boulders ("rip-rap").

REFERENCE

1. Sections A-A' through E-E' provided in the following report: Golder Associates Ltd., (2010) *Esquimalt Graving Dock Waterlot - Supplementary Test Hole Investigation for Remedial Action Plan/Risk Management Plan*, prepared for PWGSC, dated March 3, 2010.
2. Base map courtesy of Public Works and Government Services Canada - EGD Basemap.dwg

PROJECT
PUBLIC WORKS GOVERNMENT SERVICES CANADA
SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT, B.C.

TITLE
SOUTH JETTY SECTION PLAN

Golder Associates
Victoria, BC

PROJECT	10-1475-0002		FILE No. P10147500027000-10
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CADD	JEF	21 FEB 11	
CHECK	RSJ	26 OCT 12	FIGURE 3
REVIEW	JF	26 OCT 12	

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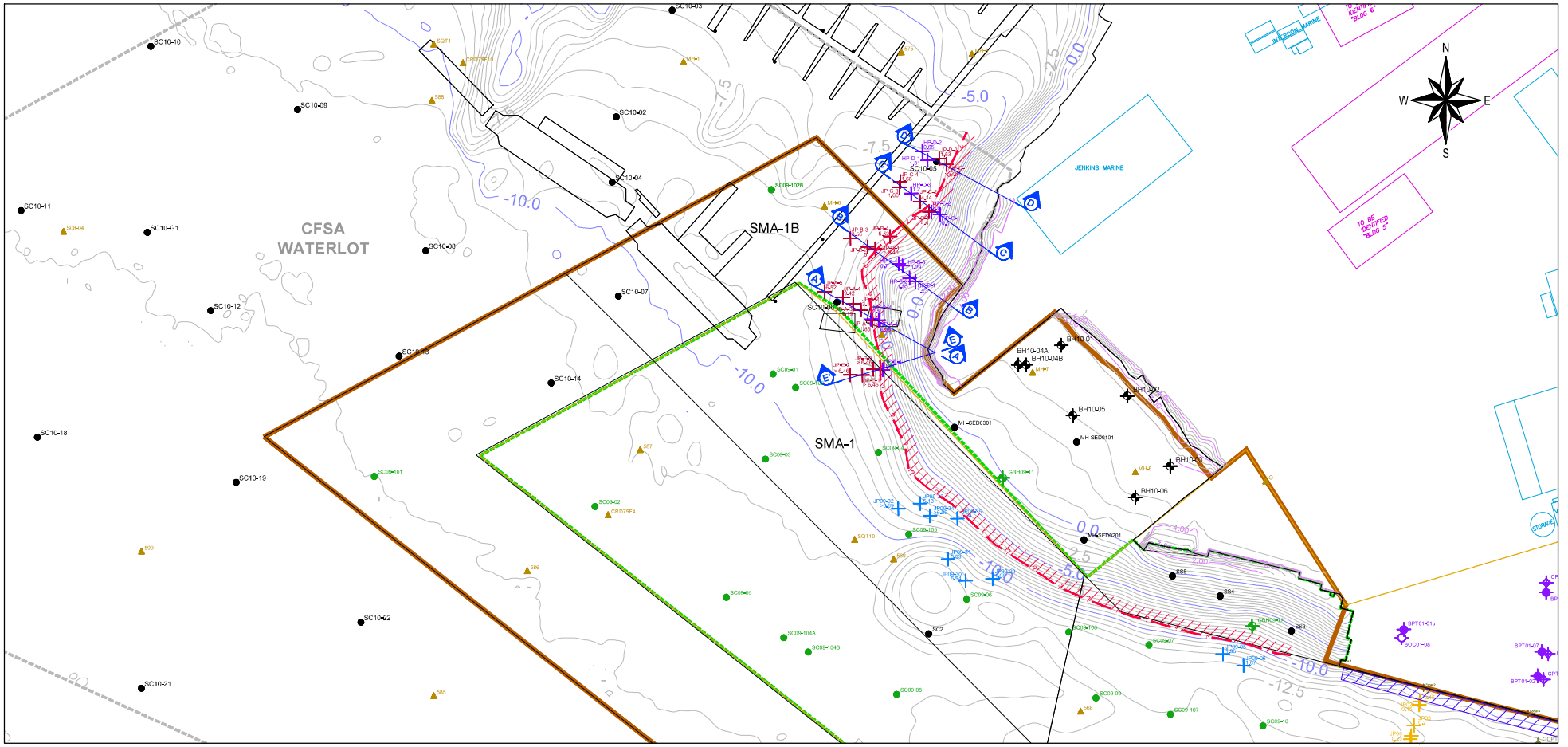
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SMA-1
JENKINS MARINE
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S
E
W
-5.0
-7.5
-10.0
-12.5
0.0
2.5
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SC10-10
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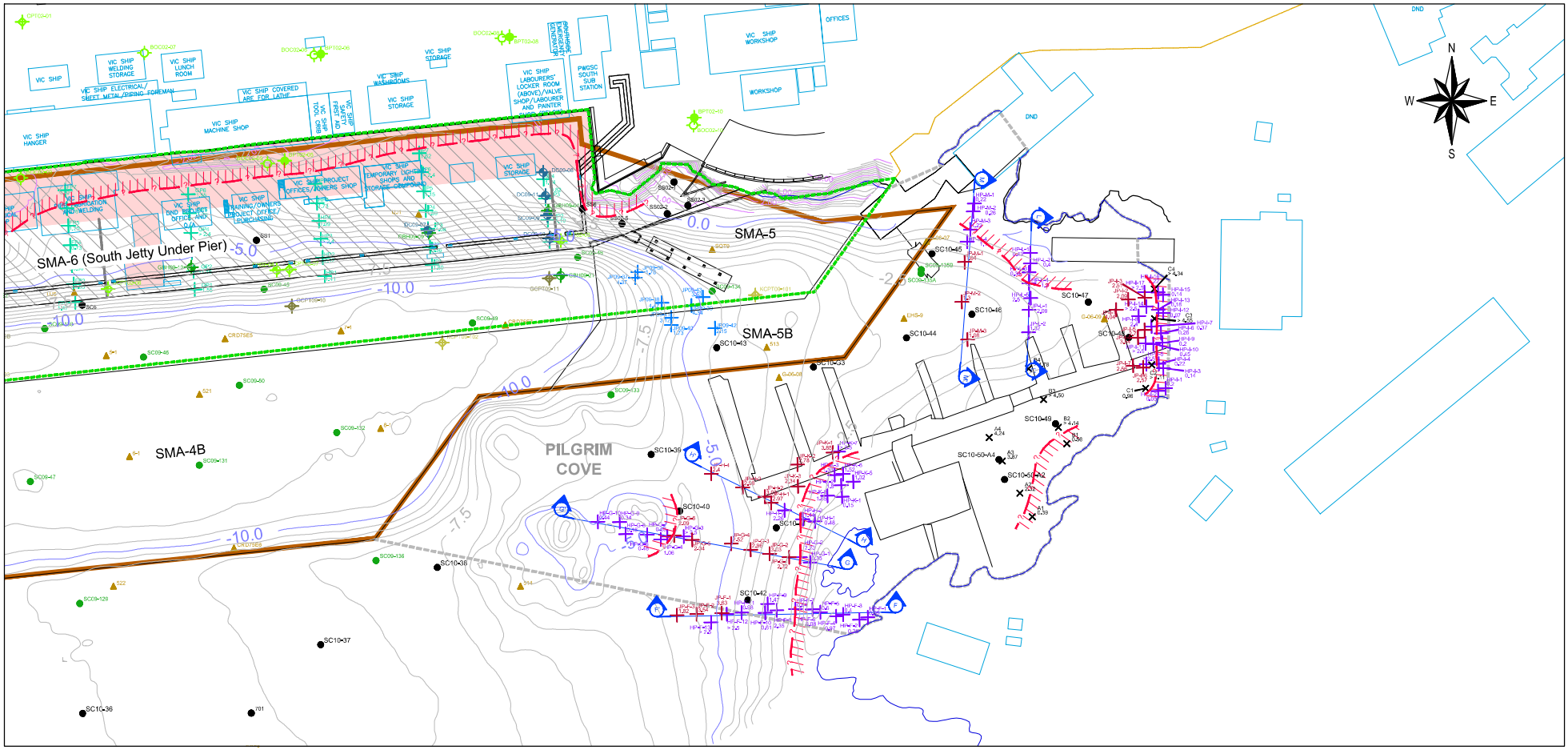

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- Jet Probe Locations - Golder 2011
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- PWGSC Waterlot Boundary
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- SMA-4 Sediment Management Areas (SMA) to be Remediated
- Approximate extent of steel piles under South Jetty

NOTES

1. Bathymetry contours provided by CRA Surveys, shown in CHART datum (0.5m intervals)
2. Other contours provided by FOCUS Corporation, shown in CHART datum (0.25m intervals)
3. Number below probe locations represents probe penetration depth in metres below mudline.
4. Refer to Sub-Surface Probing and Dive Surveys: Interpretive Report for discussion of the presence of exposed bedrock and/or cobbles and boulders ("rip-rap").

REFERENCE

1. Base map courtesy of Public Works and Government Services Canada - EGD Basemap.dwg

PROJECT
PUBLIC WORKS GOVERNMENT SERVICES CANADA
SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT, B.C.

TITLE
PILGRIM COVE SECTION PLAN

Golder Associates Victoria, BC

PROJECT	10-1475-0002		FILE	No\P10147500027000-12	
DESIGN	MS	15 FEB 11	SCALE	AS SHOWN	REV. 0
CADD	JEF	21 FEB 11			
CHECK	RSJ	26 OCT 12			
REVIEW	JF	26 OCT 12			

FIGURE 5

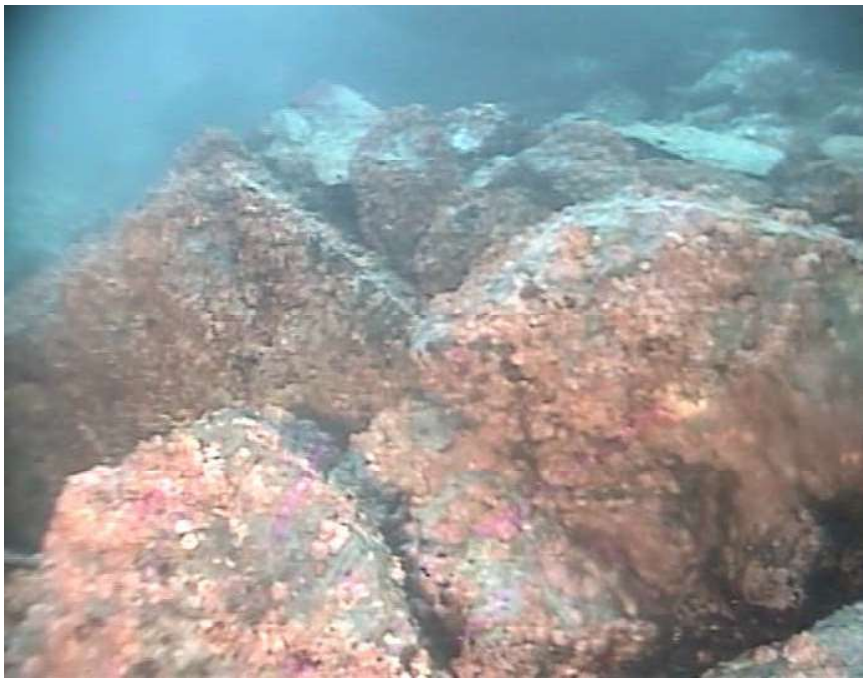
N:\Active\2010\1475\10-1475-0002 EGD\Vic Drafting\Phase 7000\P10147500027000-12 - Pilgrim Cove Section Plan.dwg Oct 29, 2012 - 10:47am

APPENDIX A

Images from Dive Survey Video

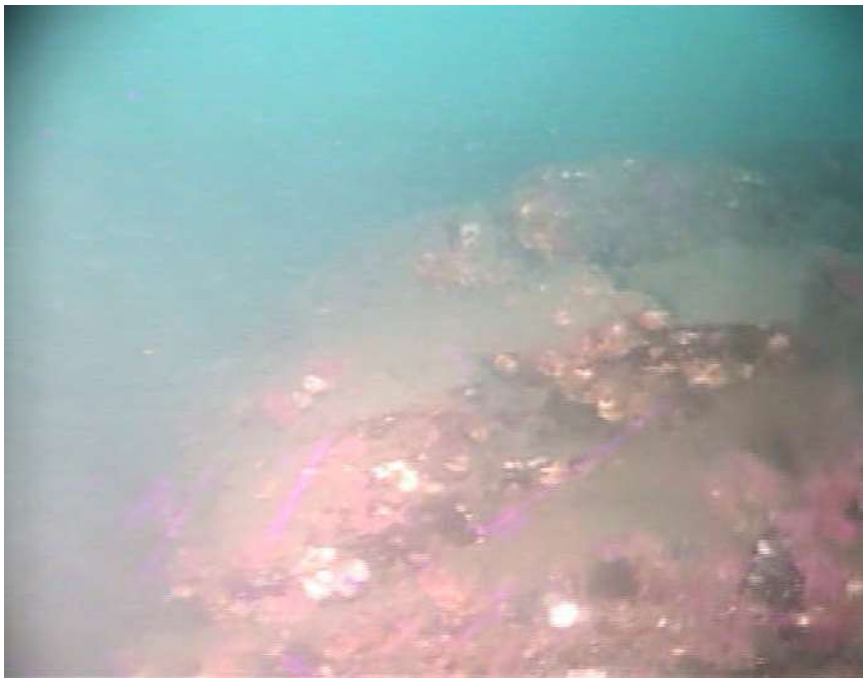
Photograph 1: Exposed cobbles and boulders or "rip-rap" at the southeast end of Section CFSA-A-A'.

Photograph 2: Exposed cobbles and boulders or "rip-rap" at approximately 10 m along Section CFSA-B-B'.

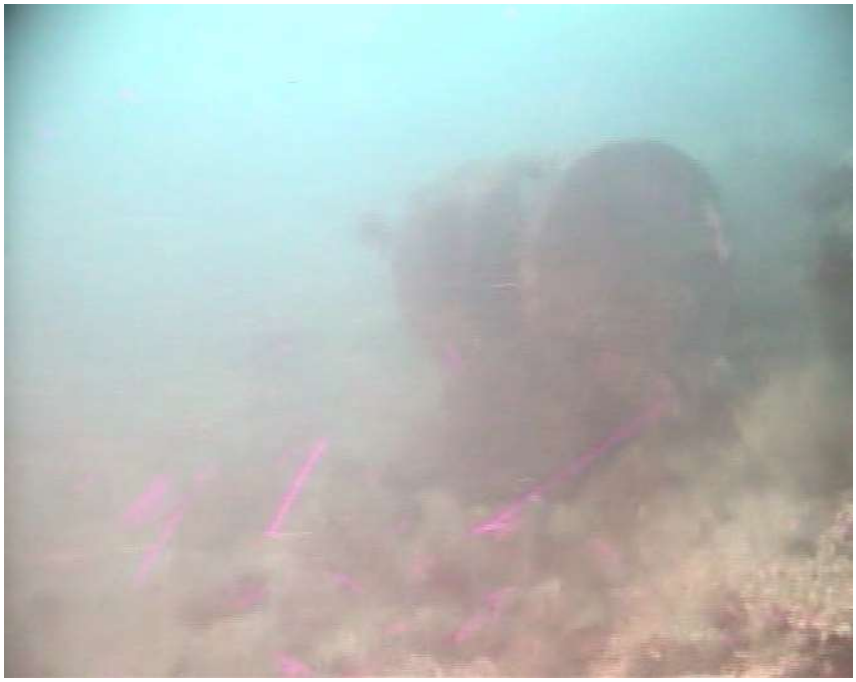


Photograph 3: Exposed cobbles and boulders ("rip rap") at approximately 7 m along Section CFSA-C-C'.

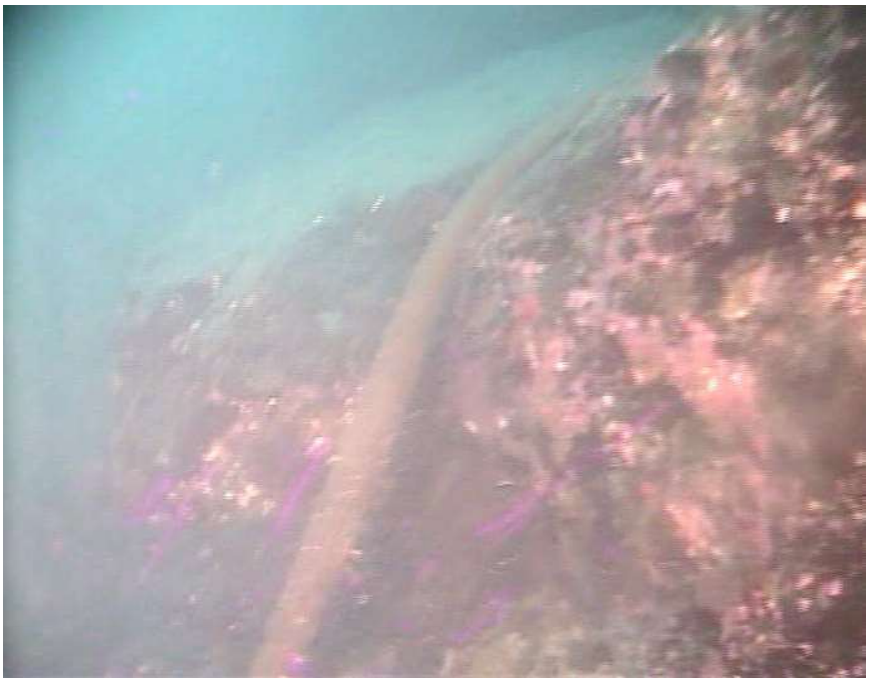
Photograph 4: Exposed cobbles and boulders with fine sediment and shell observed at approximately 14 m along Section CFSA-E-E'.



Photograph 5: Exposed bedrock observed approximately 34 m along Section CFSA-D-D'.



Photograph 6: Metal debris (barrel) at approximately 15 m along Section CFSA-B-B'.



Photograph 7: Rope at approximately 24 m along Section CFSA-B-B'.

Photograph 8: Concrete anchor observed at approximately 19.5 m along Section CFSA-D-D'.

Photograph 9: Rock Fill or "rip-rap" at the north end of dive transect E, approximately 16 m north of the south edge of the South Jetty, looking north toward the concrete structure (Section 1-1').

Photograph 10: Gravel and cobbles at the north end of dive transect G, approximately 30 m north of the south edge of the South Jetty (Section 4-4').

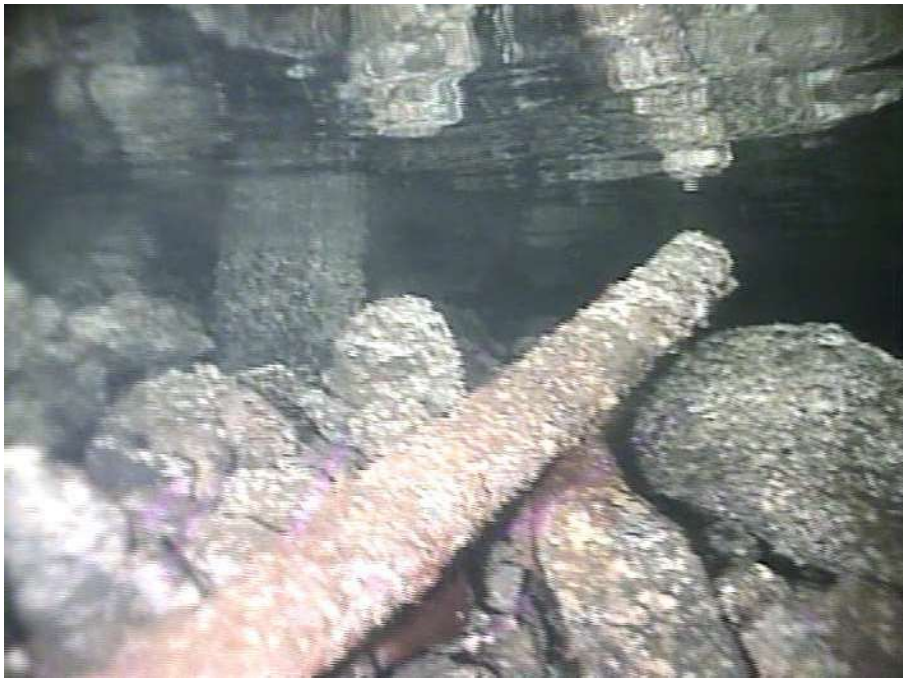
Photograph 11: Boulders at approximately 28 m from the south edge of the South Jetty on dive transect G, looking west (Section 4-4').

Photograph 12: Gravel and cobbles with boulders ahead on dive transect H, approximately 25 m from the south edge of the South Jetty, looking north (Section 3-3').

Photograph 13: Boulders above the waterline with the Sheet Pile Wall in the background, approximately 30 m from the south edge of the South Jetty on dive transect H (Section 3-3').

Photograph 14: Silt with gravel and cobbles on dive transect I, approximately 25 m from the south edge of the South Jetty, looking north (Section 5-5').

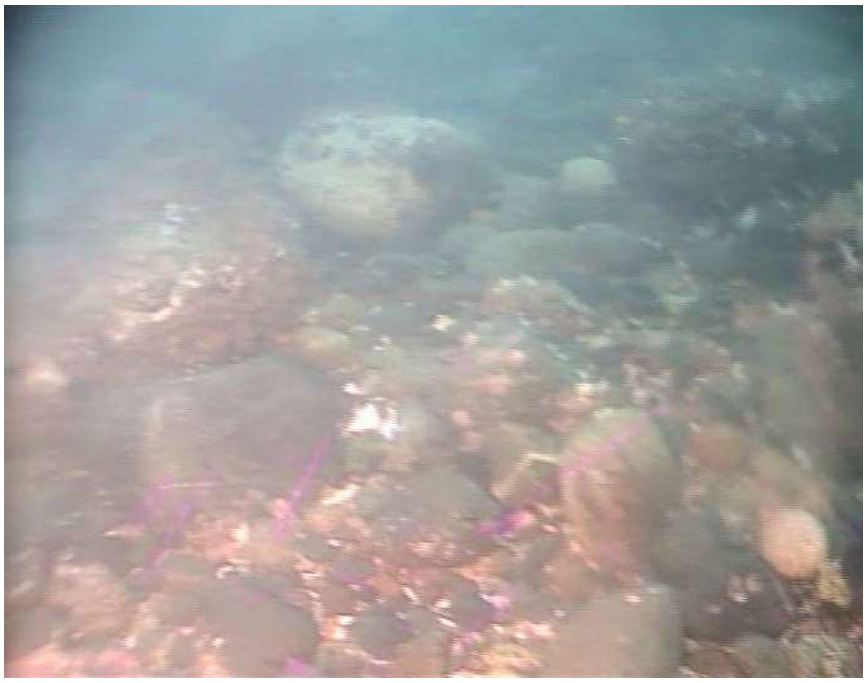
Photograph 15: Gravel and cobbles looking southeast downslope from dive transect J, approximately 26 m from the south edge of the South Jetty (Section 2-2').



Photograph 16: Boulders and possible anthropogenic debris at approximately 29 m from the south edge of the South Jetty on dive transect J, looking north (Section 2-2').

Photograph 17: Boulders above the waterline at the north end of dive transect J, approximately 30 m from the south edge of the South Jetty, looking north (Section 2-2').

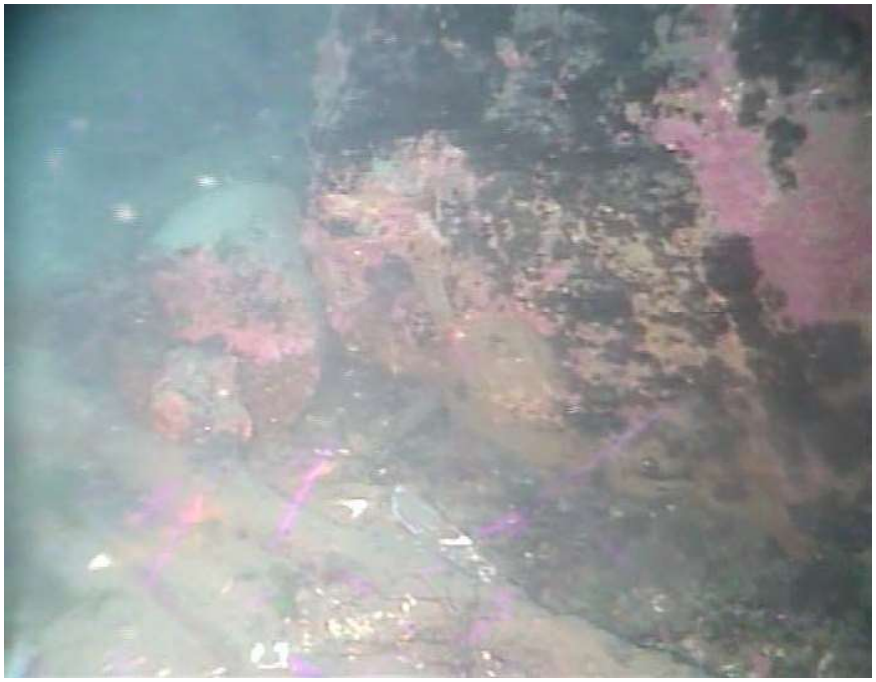
Photograph 18: Exposed bedrock at approximately 3 m along Section PC-G-G'.



Photograph 19: Exposed cobbles and boulders with fine sediment and shell at approximately 19 m along Section PC-F-F'.

Photograph 20: Fine sediment and shell at approximately 25 m along Section PC-F-F'.

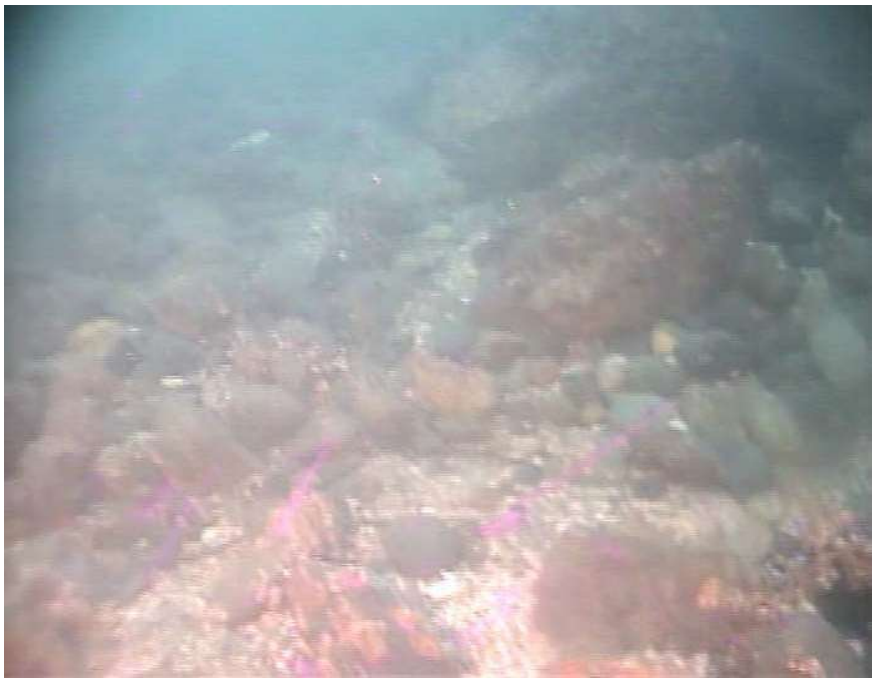
Photograph 21: Sea cucumber (Parastichopus californicus) observed along Section PC-F-F'.



Photograph 22: Contact between exposed bedrock and fine sediment and shell in the area of the small vessel docks in Pilgrim Cove.

Photograph 23: Concrete retaining wall at the east end of Pilgrim Cove.

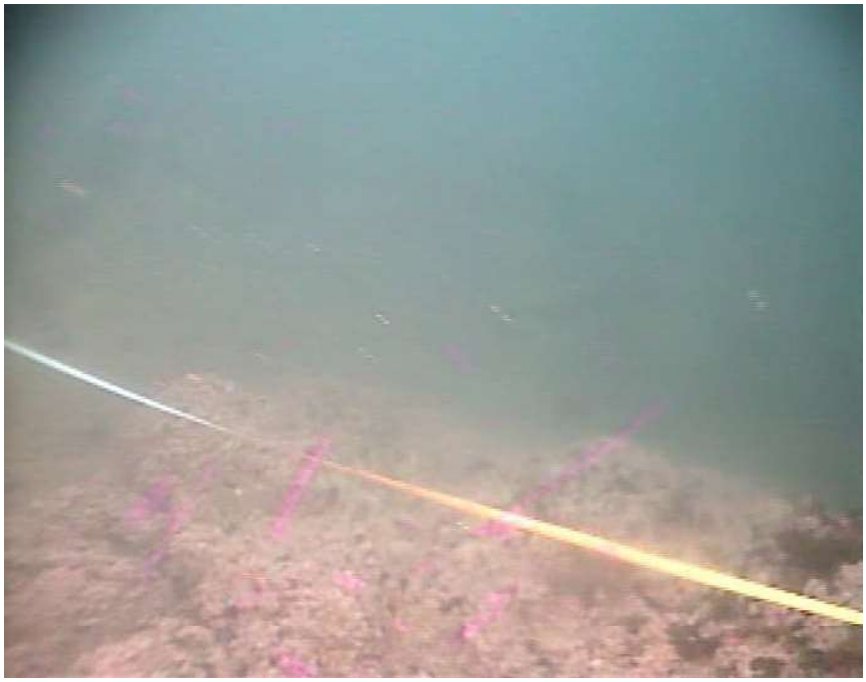
Photograph 24: Fine sediment and shell at the base of the concrete retaining wall at the east end of Pilgrim Cove.



Photograph 25: Fine sediment and shell at the base of the concrete retaining wall at the east end of Pilgrim Cove.

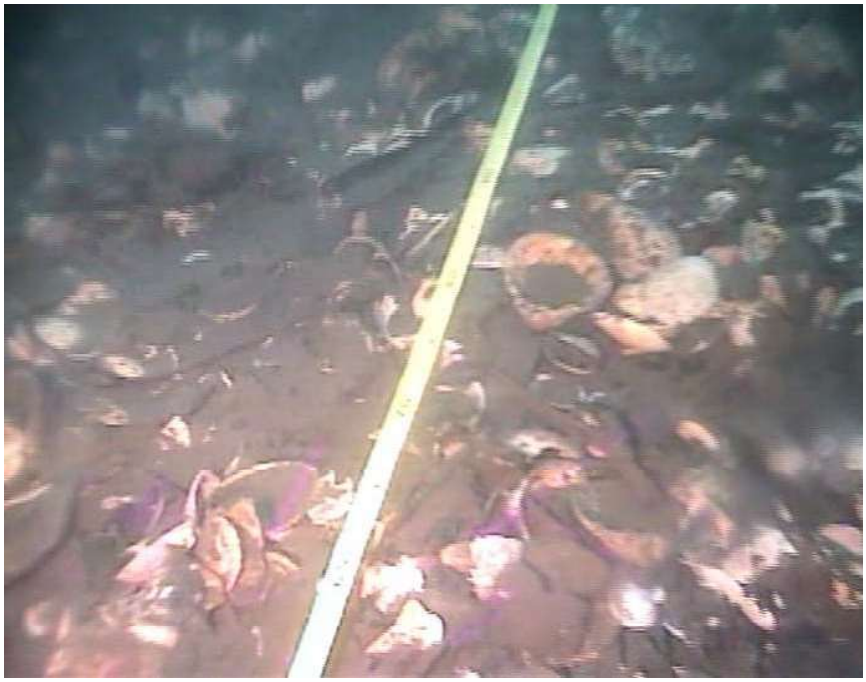
Photograph 26: Exposed cobbles and boulders next to bedrock at the start of Section PC-L-L'.

Photograph 27: Exposed cobbles and boulders at approximately 4 m along Section PC-L-L'.



Photograph 28: Exposed bedrock at approximately 3 m along Section PC-M-M'.

Photograph 29: Fine sediment and shell with wood debris at approximately 12 m along Section PC-L-L'.



Photograph 30: Fine sediment and shell at approximately 24 m along Section PC-M-M'.

Photograph 31: Helmet crab (Telmessus cheiragonus) observed along Section PC-L-L'.

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APPENDIX B

Schematic Cross Sections

- South Jetty: Sections 1-1' through 5-5'
- CFSA Waterlot: Sections CFSA-A-A' through CFSA-E-E'
- Pilgrim Cove: Sections PC-F-F' through PC-H-H', PC-L-L', PC-M-M'

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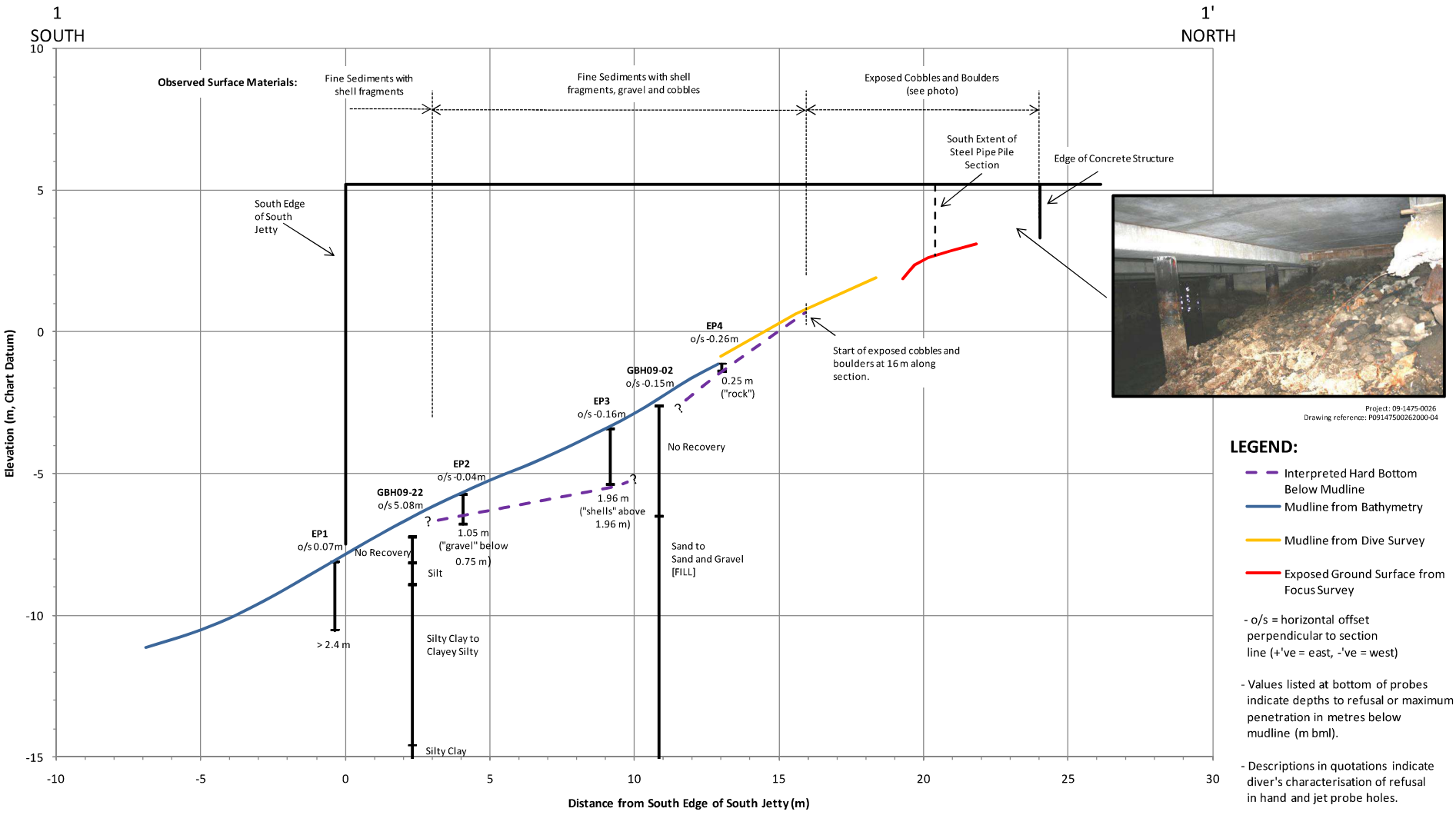

Project: 09-1475-0026
Drawing reference: P09147500262000-04

LEGEND:

- Interpreted Hard Bottom Below Mudline
- Mudline from Bathymetry
- Mudline from Dive Survey
- Exposed Ground Surface from Focus Survey

- o/s = horizontal offset perpendicular to section line (+'ve = east, -'ve = west)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

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ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

SECTION 1-1'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-1

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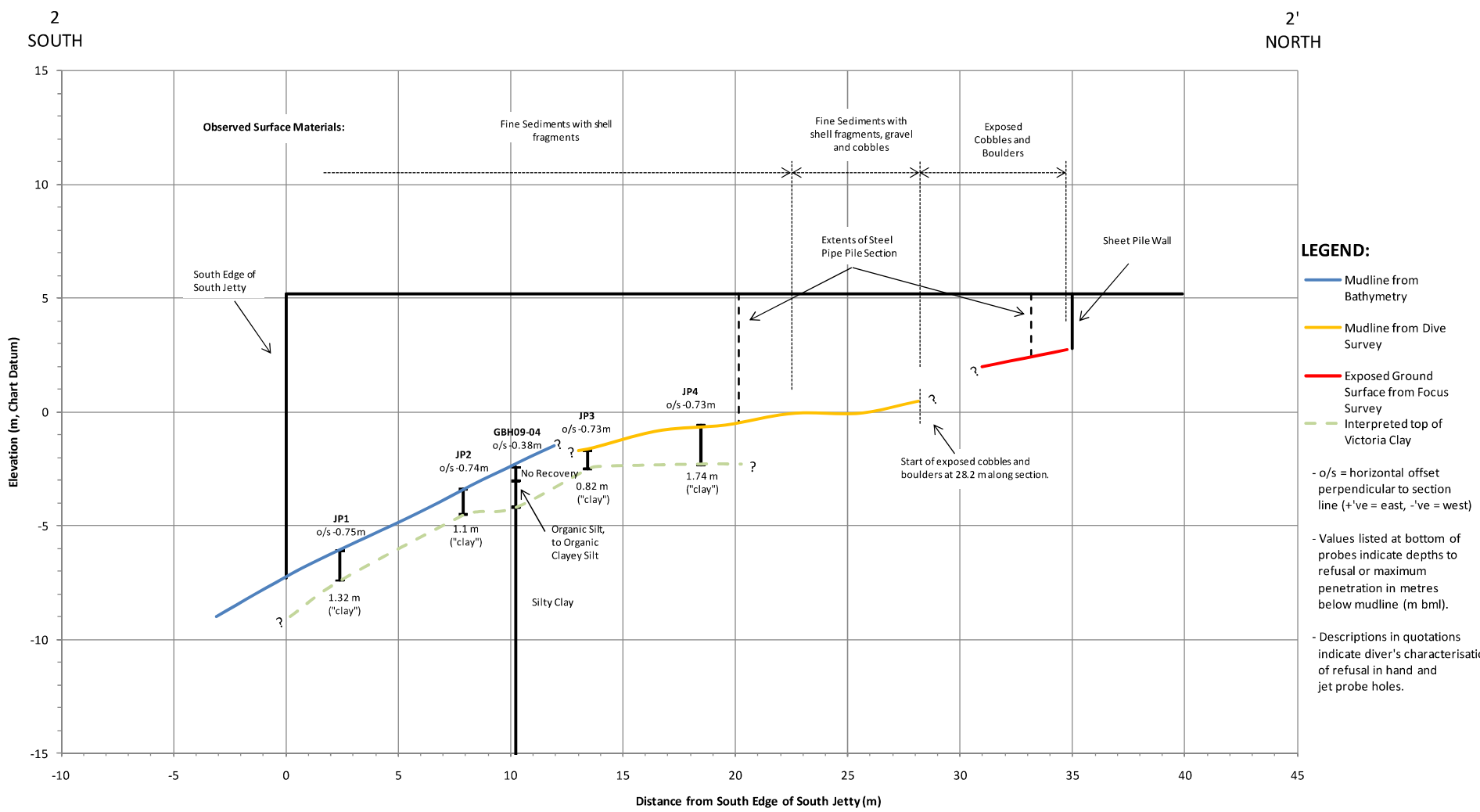

LEGEND:

- Mudline from Bathymetry
- Mudline from Dive Survey
- Exposed Ground Surface from Focus Survey
- Interpreted top of Victoria Clay

- o/s = horizontal offset perpendicular to section line (+'ve = east, -'ve = west)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

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TITLE

SECTION 2-2'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-2

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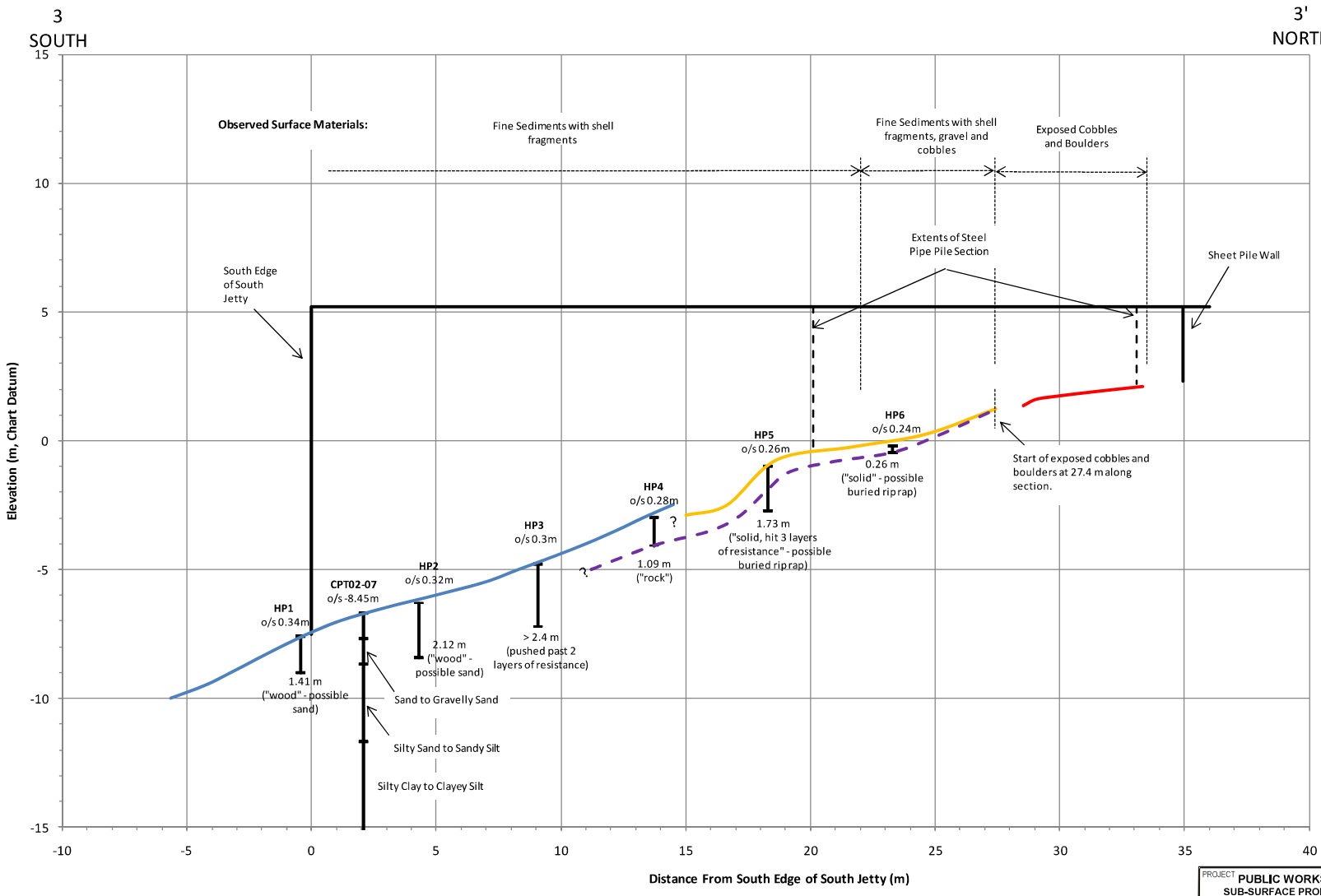

PROJECT
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ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE
SECTION 3-3'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-3

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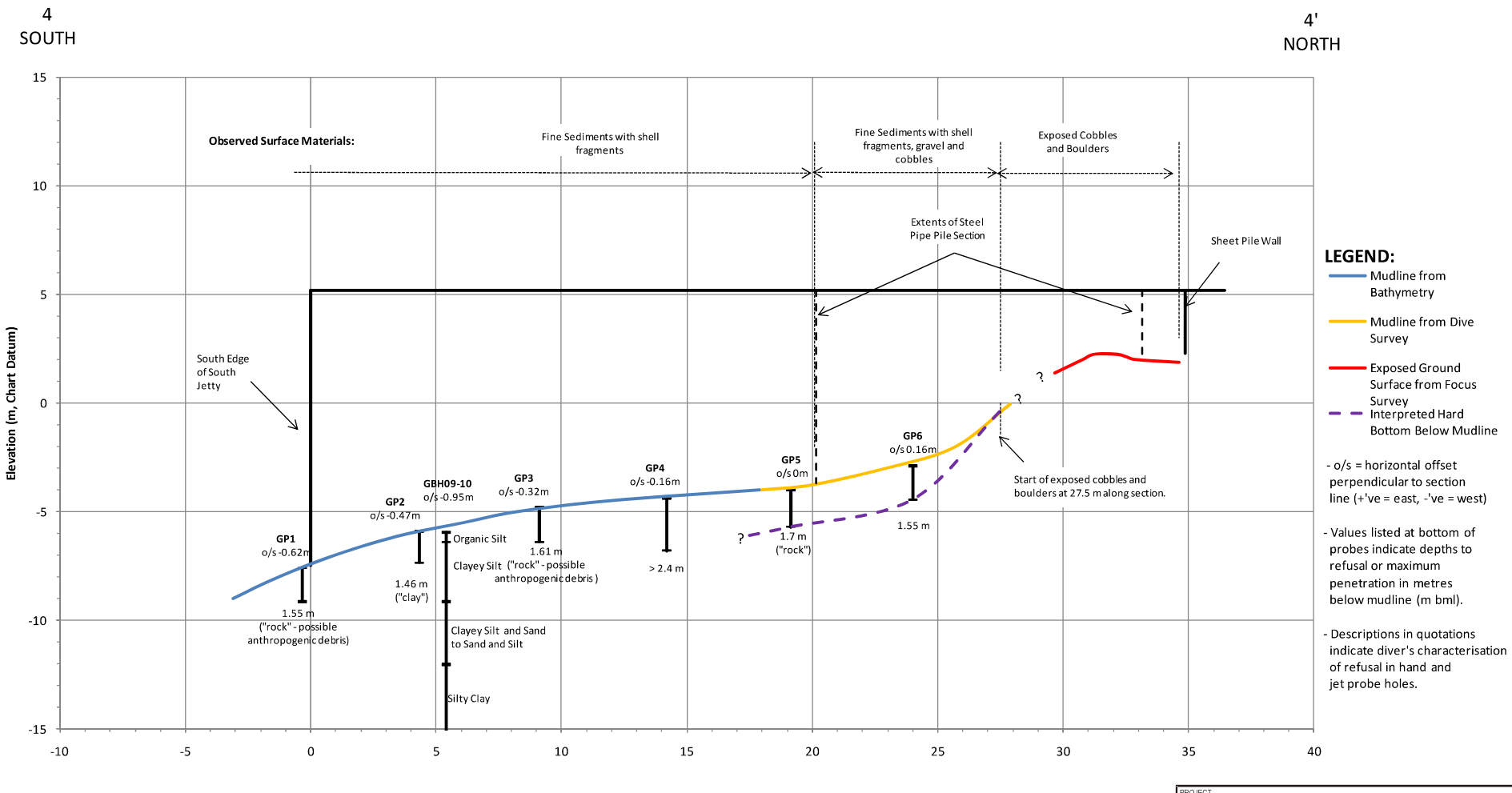

PROJECT
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ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

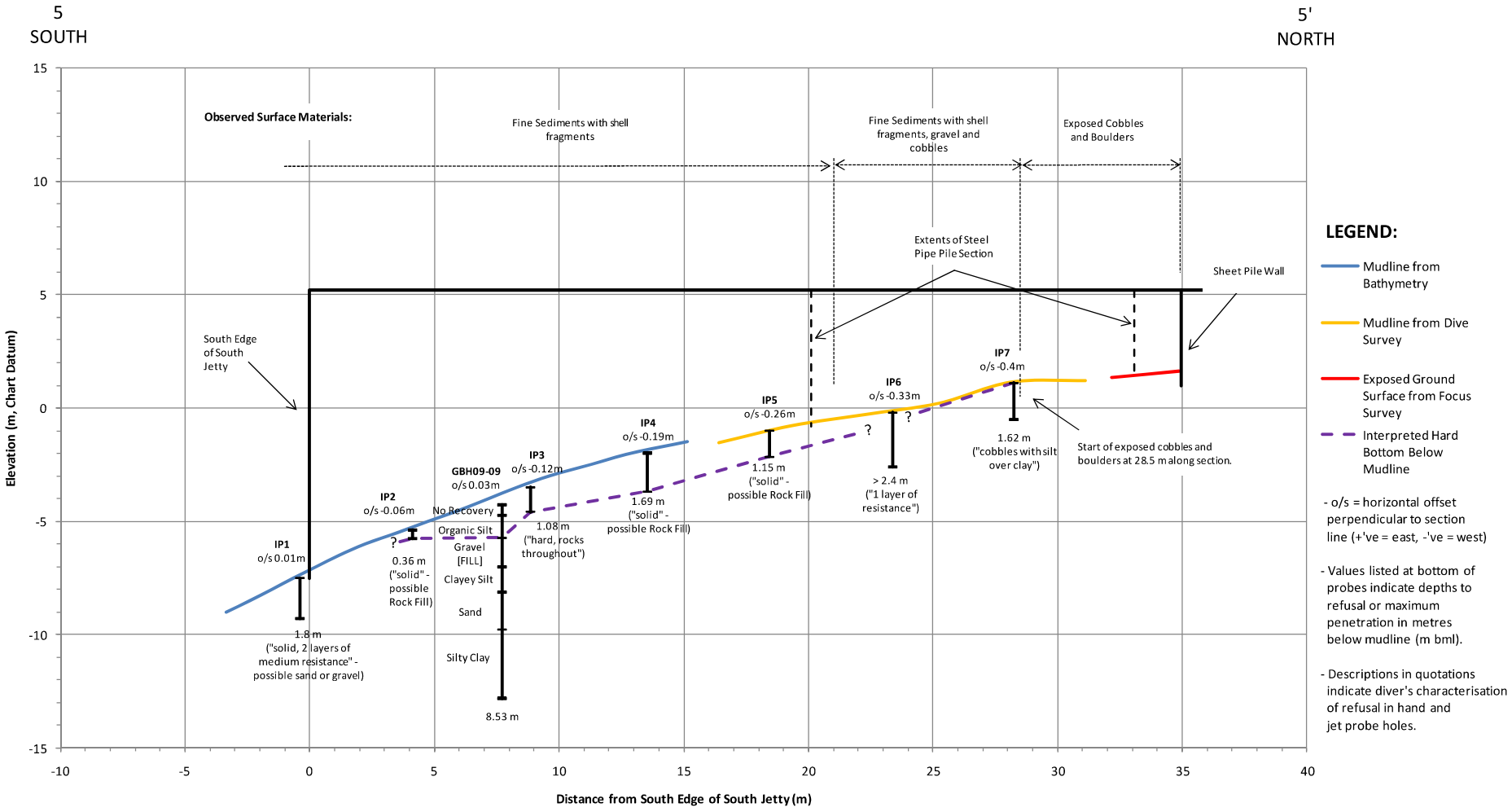
TITLE
SECTION 4-4'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-4

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



PROJECT
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ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

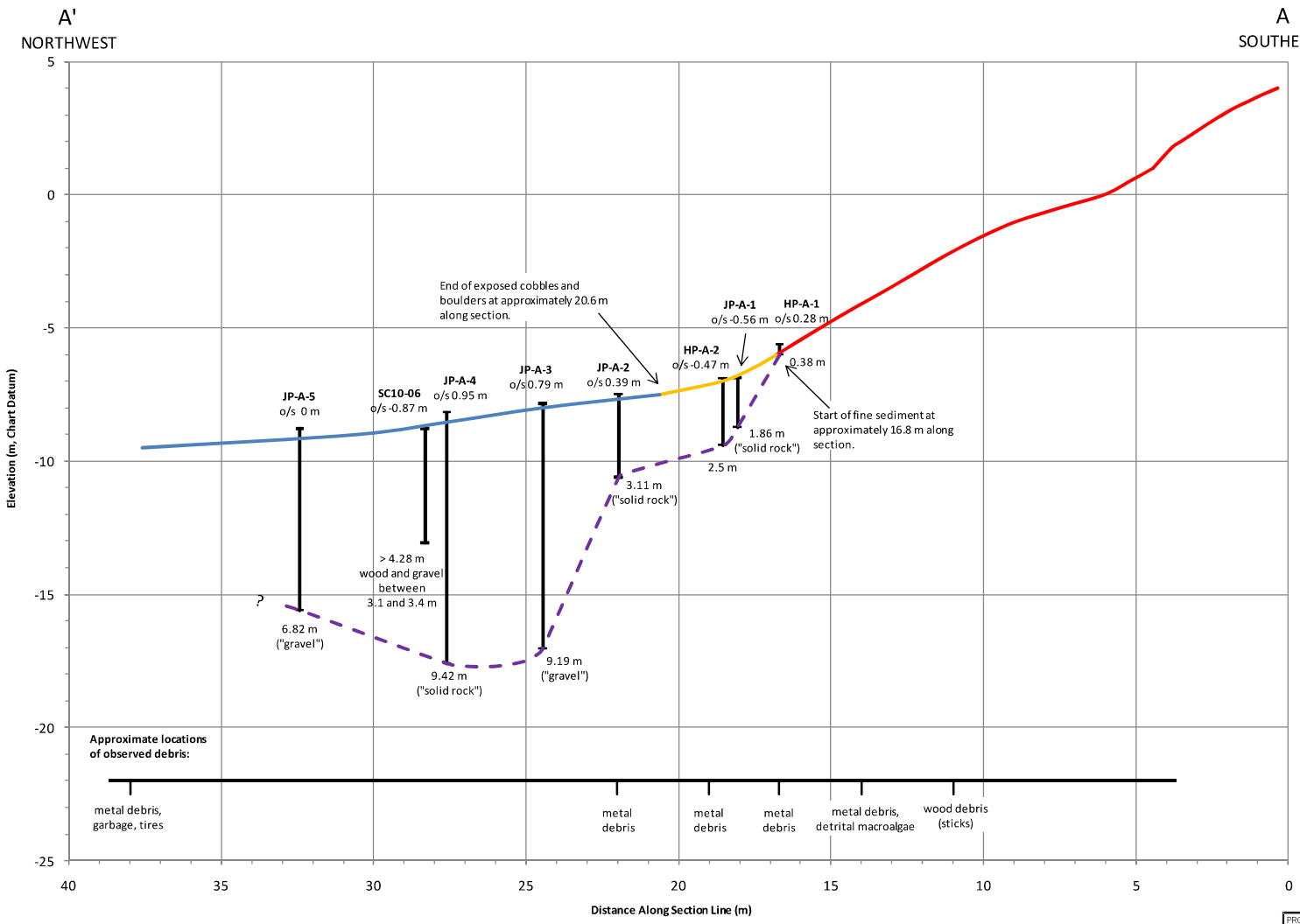
TITLE
SECTION 5-5'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-5

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



LEGEND:

- Exposed Cobbles and Boulders
- Exposed Cobbles and Boulders with Fine Sediment and Shell
- Fine Sediment and Shell
- Interpreted Hard Bottom Below Mudline

- HP = hand probe
- JP = jet probe
- o/s = horizontal offset perpendicular to section line (+'ve = north, -'ve = south)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in

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SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

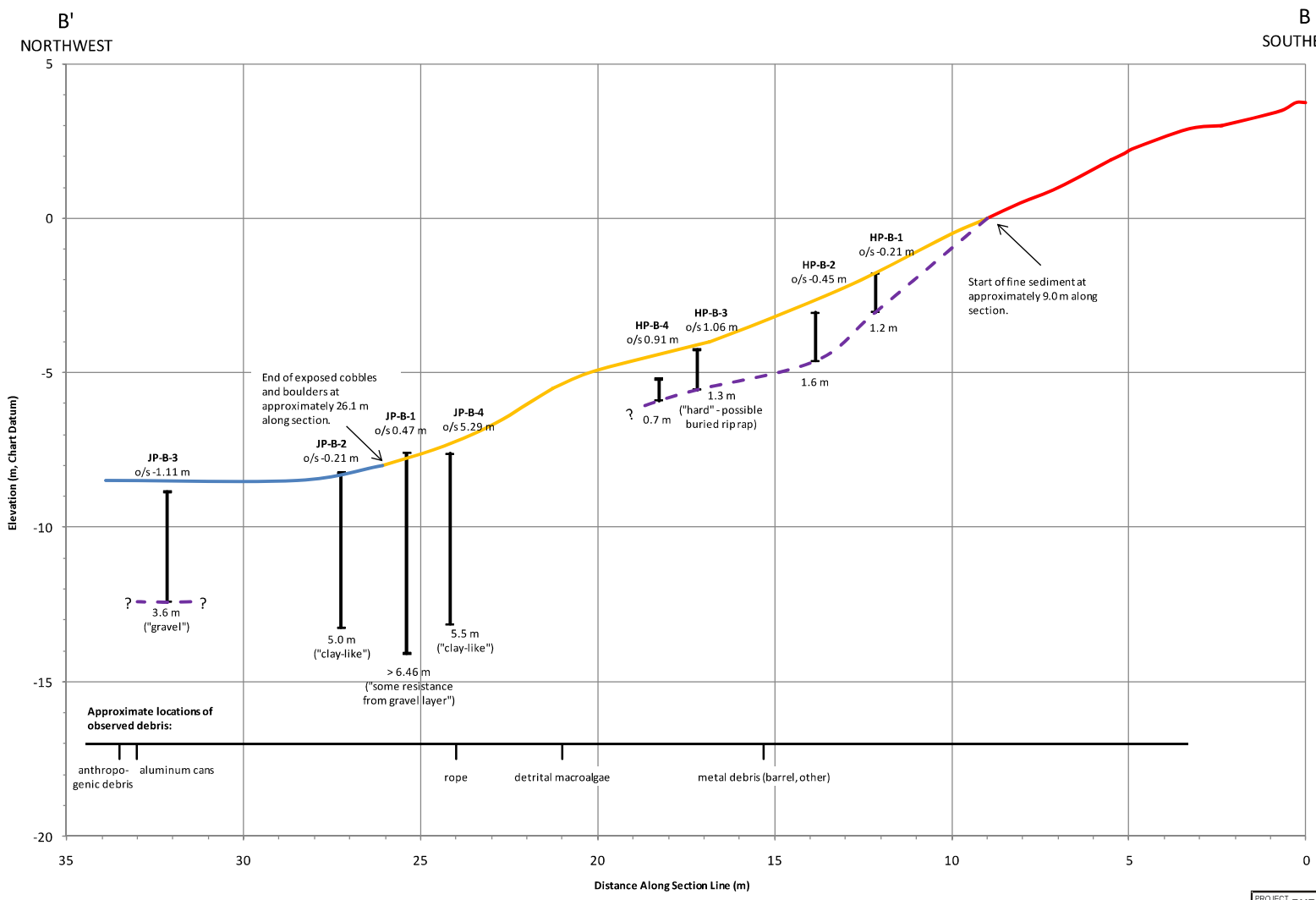
SECTION CFSA-A-A'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-6

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



LEGEND:

- Exposed Cobbles and Boulders
- Exposed Cobbles and Boulders with Fine Sediment and Shell
- Fine Sediment and Shell
- Interpreted Hard Bottom Below Mudline

- HP = hand probe
- JP = jet probe
- o/s = horizontal offset perpendicular to section line (+'ve = north, -'ve = south)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

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ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

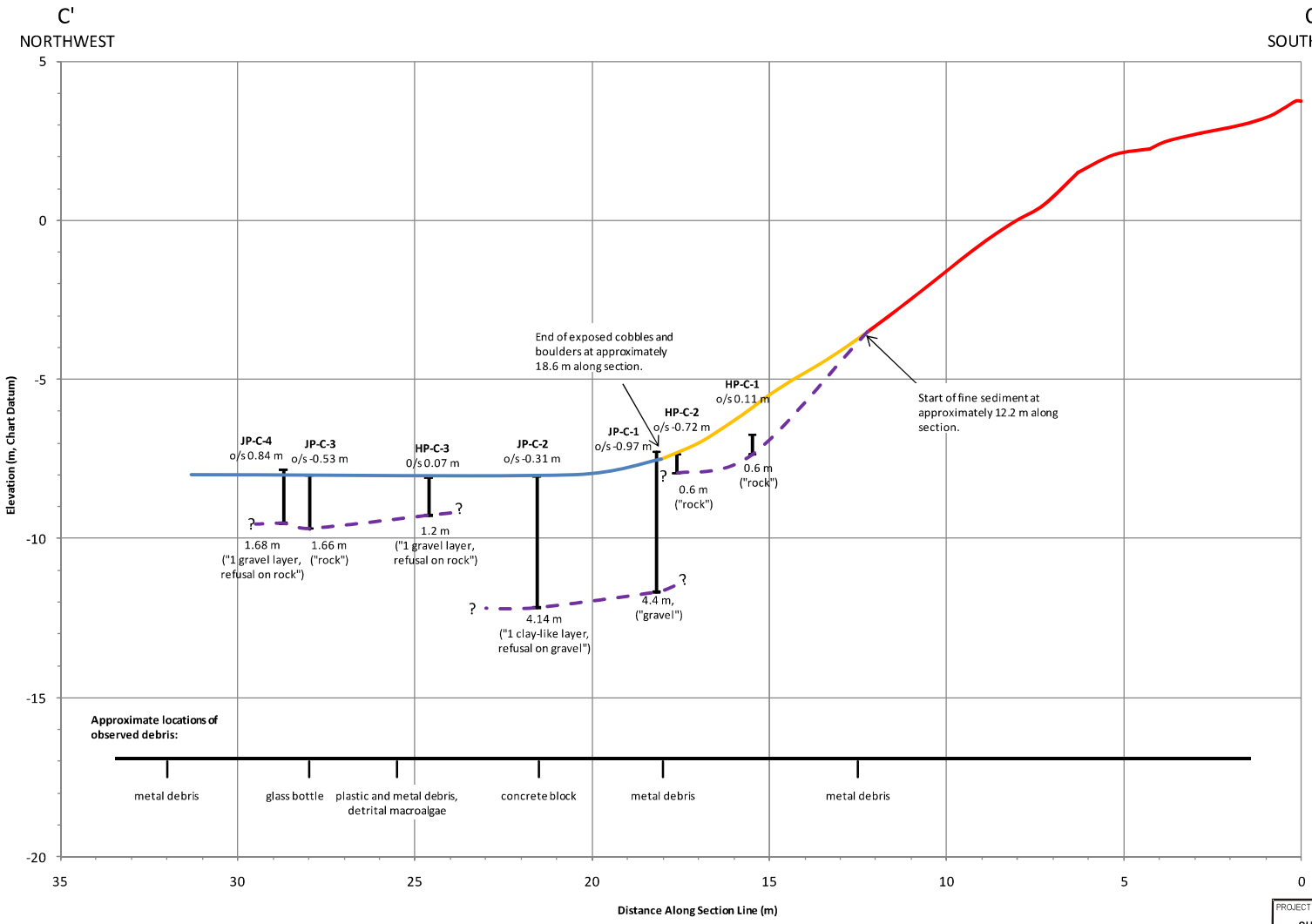
TITLE
SECTION CFSA-B-B'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-7

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



LEGEND:

- Exposed Cobbles and Boulders
- Exposed Cobbles and Boulders with Fine Sediment and Shell
- Fine Sediment and Shell
- Interpreted Hard Bottom Below Mudline

- HP = hand probe
- JP = jet probe
- o/s = horizontal offset perpendicular to section line (+'ve = north, -'ve = south)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

PROJECT
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ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

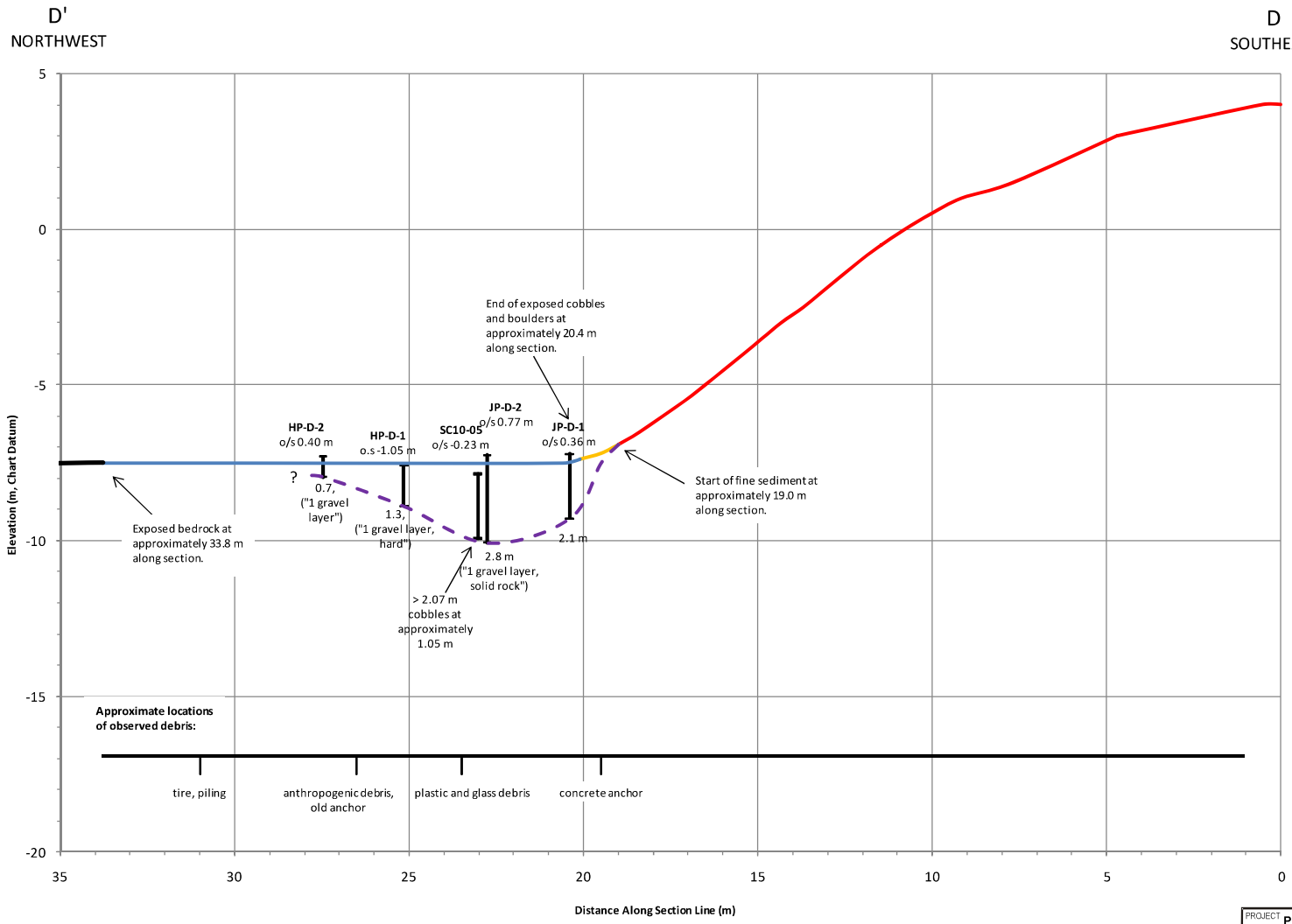
TITLE
SECTION CFSA-C-C'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-8

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



PROJECT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

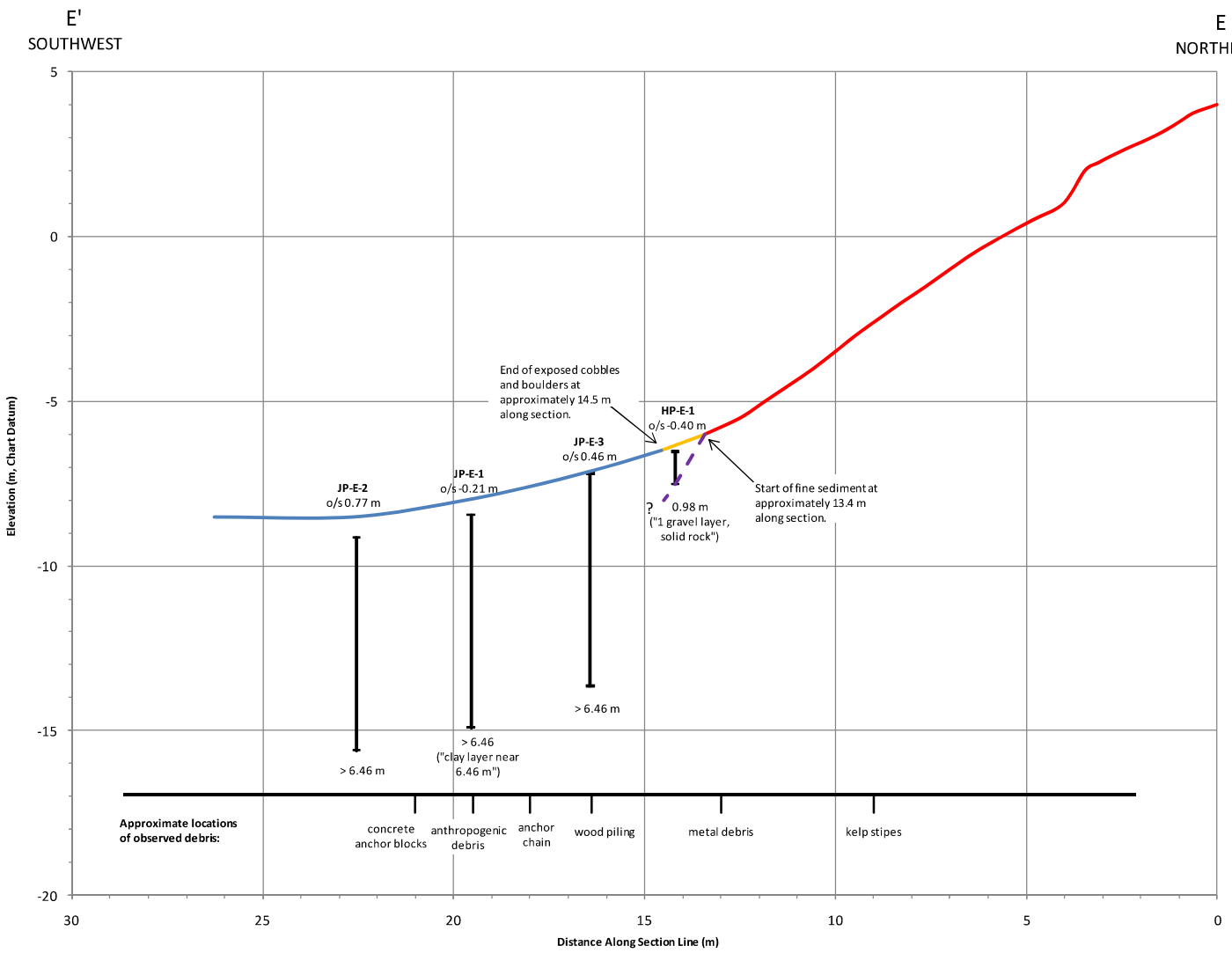
SECTION CFSA-D-D'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-9

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



LEGEND:

- Exposed Cobbles and Boulders
- Exposed Cobbles and Boulders with Fine Sediment and Shell
- Fine Sediment and Shell
- Interpreted Hard Bottom Below Mudline

- HP = hand probe
- JP = jet probe
- o/s = horizontal offset perpendicular to section line (+'ve = north, -'ve = south)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

PROJECT
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ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

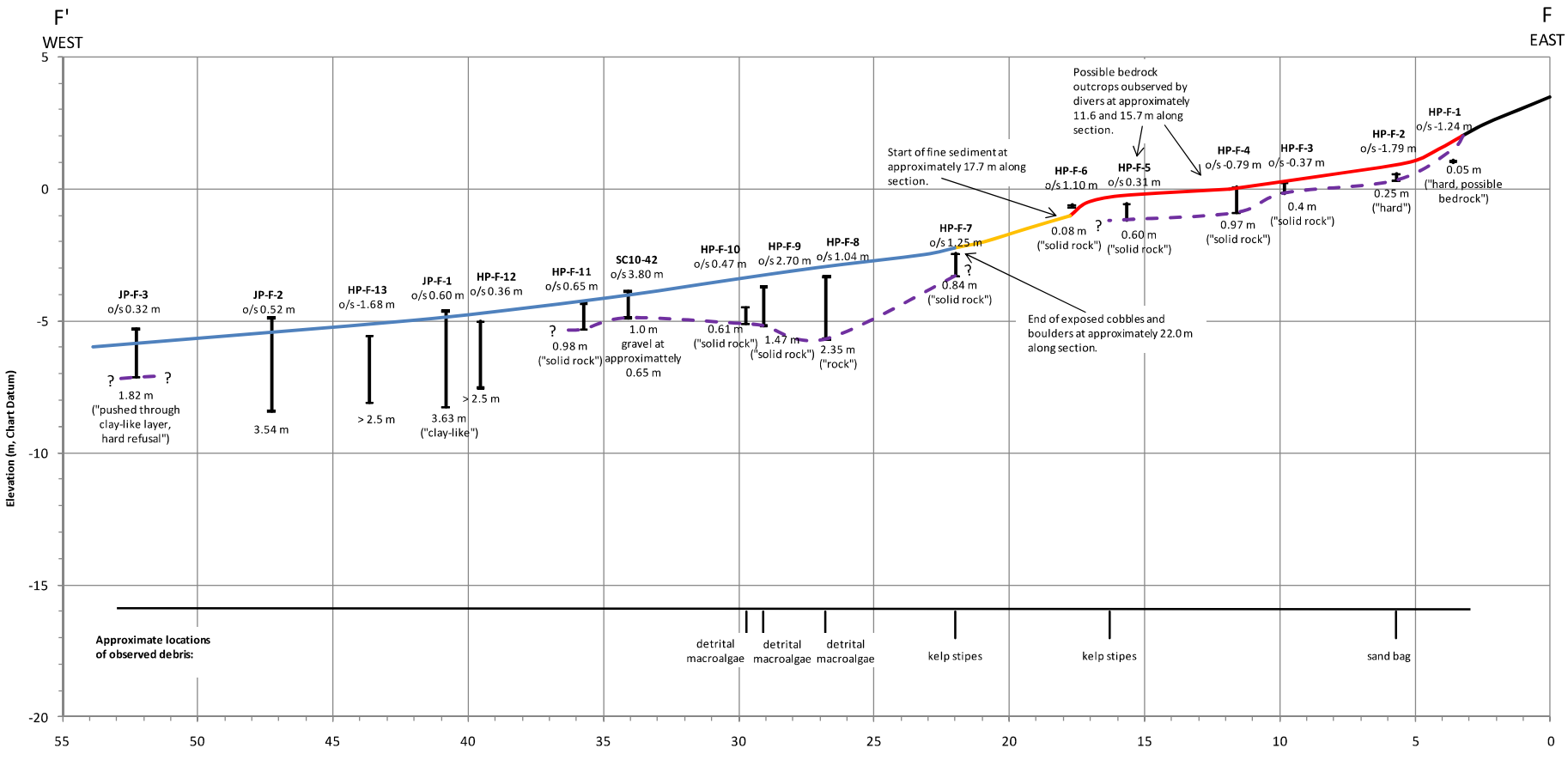
TITLE
SECTION CFSA-E-E'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	01/17/11	SCALE	None	REV.
Graphics	MS	01/26/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-10

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



LEGEND:

- Exposed Bedrock
- Exposed Cobbles and Boulders
- Exposed Cobbles and Boulders with Fine Sediment and Shell
- Fine Sediment and Shell
- Interpreted Hard Bottom Below Mudline

- HP = hand probe
- JP = jet probe
- o/s = horizontal offset perpendicular to section line (+'ve = north, -'ve = south)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

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ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

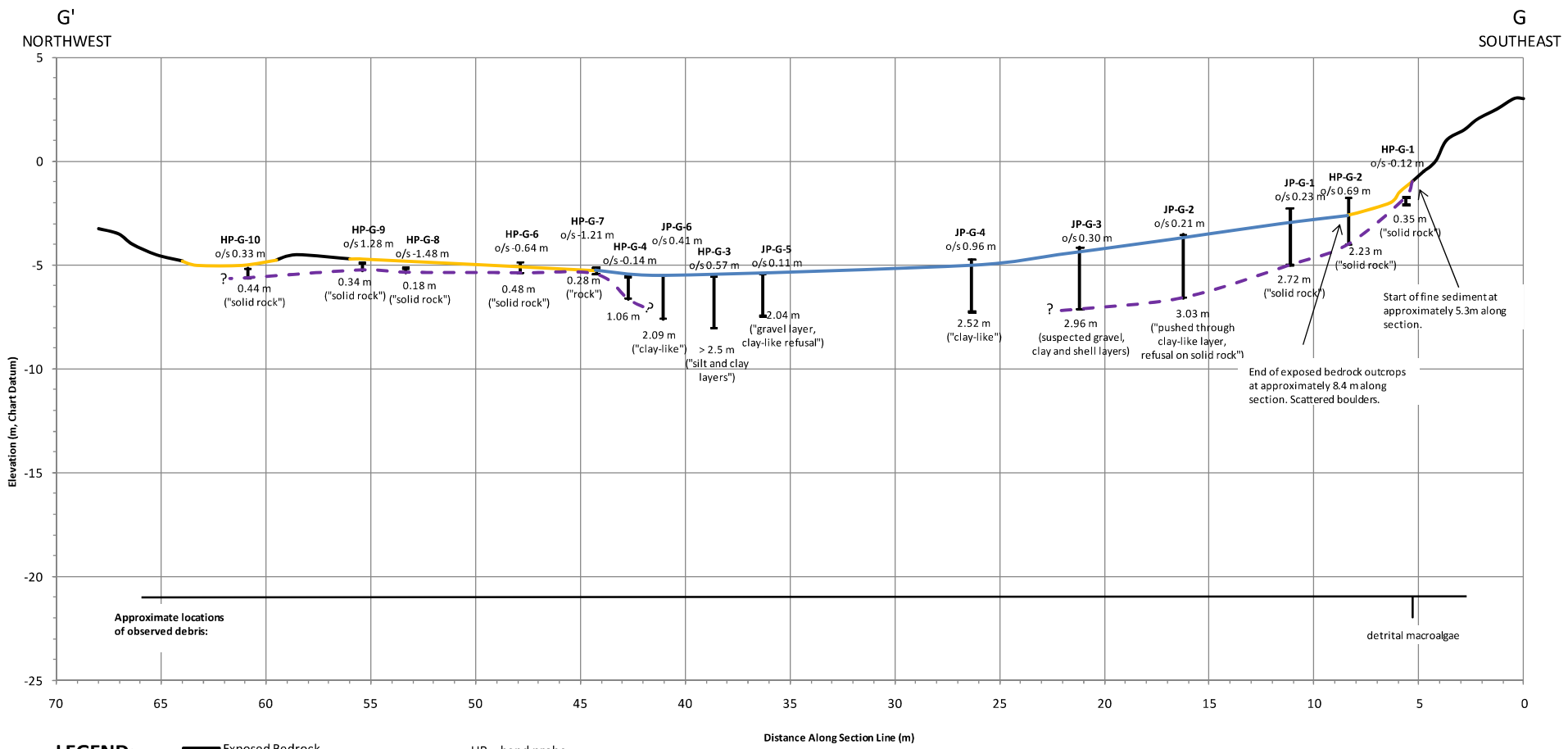
SECTION PC-F-F'

Golder Associates

PROJECT No.	10-1475-0002	FILE No.	—	
Analysis	MS	02/07/11	SCALE None	REV.
Graphics	MS	02/16/11		
Check	RJ	10/26/12		
Review	JF	10/26/12		

FIGURE B-11

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



LEGEND:

- Exposed Bedrock
- Bedrock Outcrops with Fine Sediment and Shell
- Fine Sediment and Shell
- Interpreted Hard Bottom Below Mudline

- HP = hand probe
- JP = jet probe
- o/s = horizontal offset perpendicular to section line (+'ve = north, -'ve = south)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

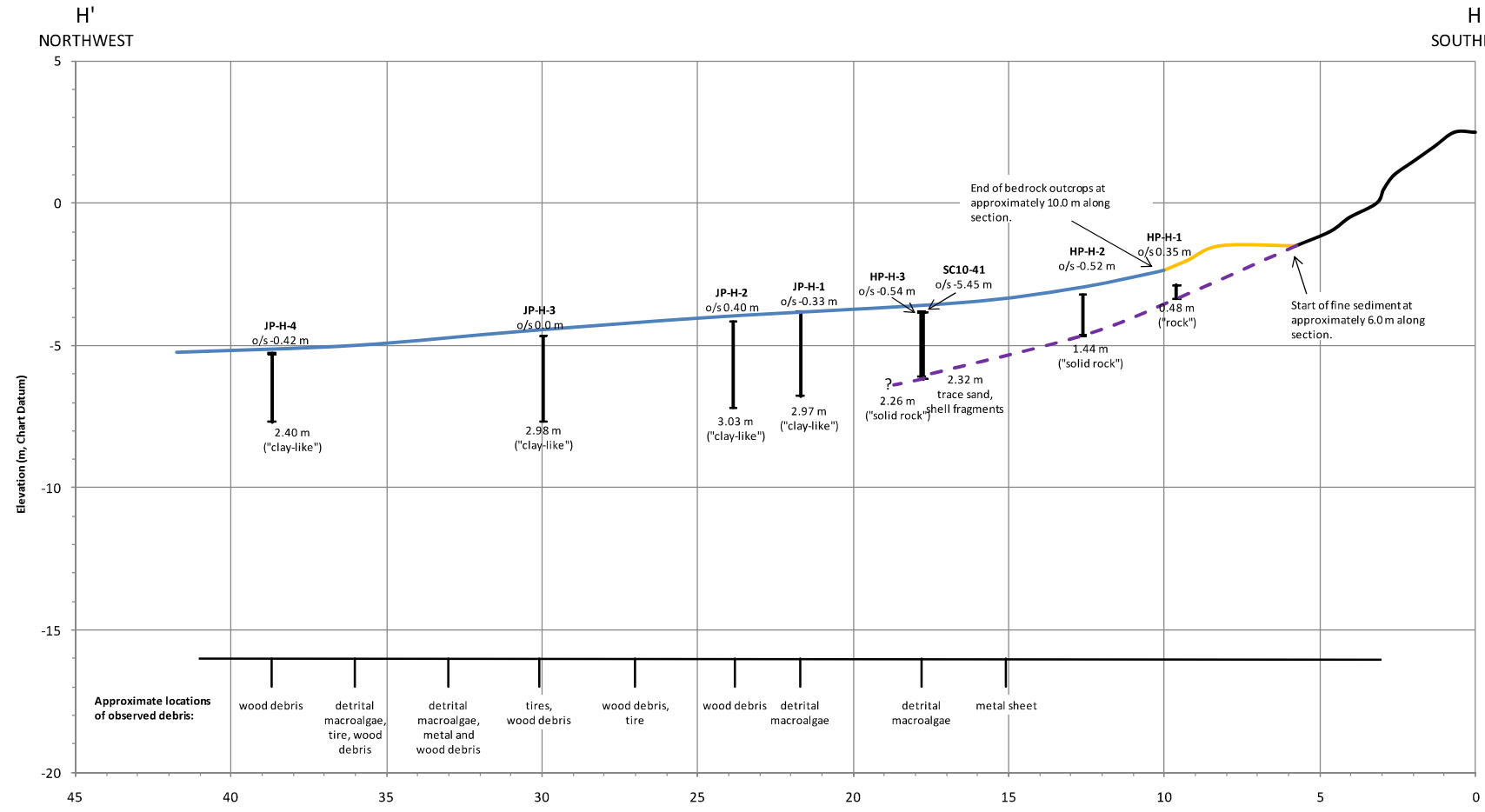
SECTION PC-G-G'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—
Analysis	MS	02/07/11	SCALE None	REV.
Graphics	MS	02/16/11		
Check	RJ	10/26/12		
Review	JF	10/26/12		

FIGURE B-12

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



LEGEND:

- Exposed Bedrock
- Bedrock Outcrops with Fine Sediment and Shell
- Fine Sediment and Shell
- Interpreted Hard Bottom Below Mudline

- HP = hand probe
- JP = jet probe
- o/s = horizontal offset perpendicular to section line (+'ve = north, -'ve = south)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

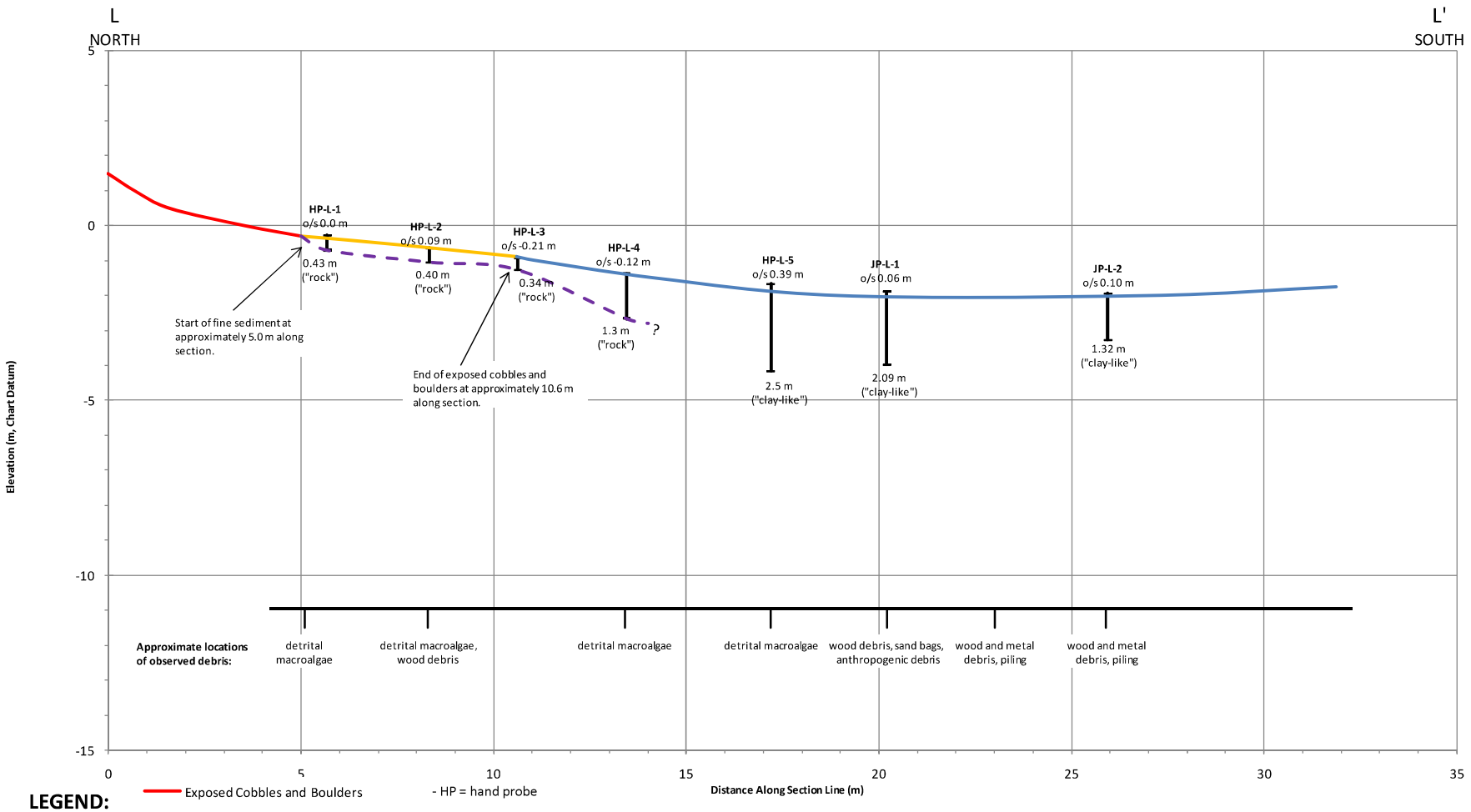
SECTION PC-H-H'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	02/07/11	SCALE	None	REV.
Graphics	MS	02/16/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-13

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



LEGEND:

- Exposed Cobbles and Boulders
- Exposed Cobbles and Boulders with Fine Sediment and Shell
- Fine Sediment and Shell
- Interpreted Hard Bottom Below Mudline

- HP = hand probe
- JP = jet probe
- o/s = horizontal offset perpendicular to section line (+'ve = east, -'ve = west)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

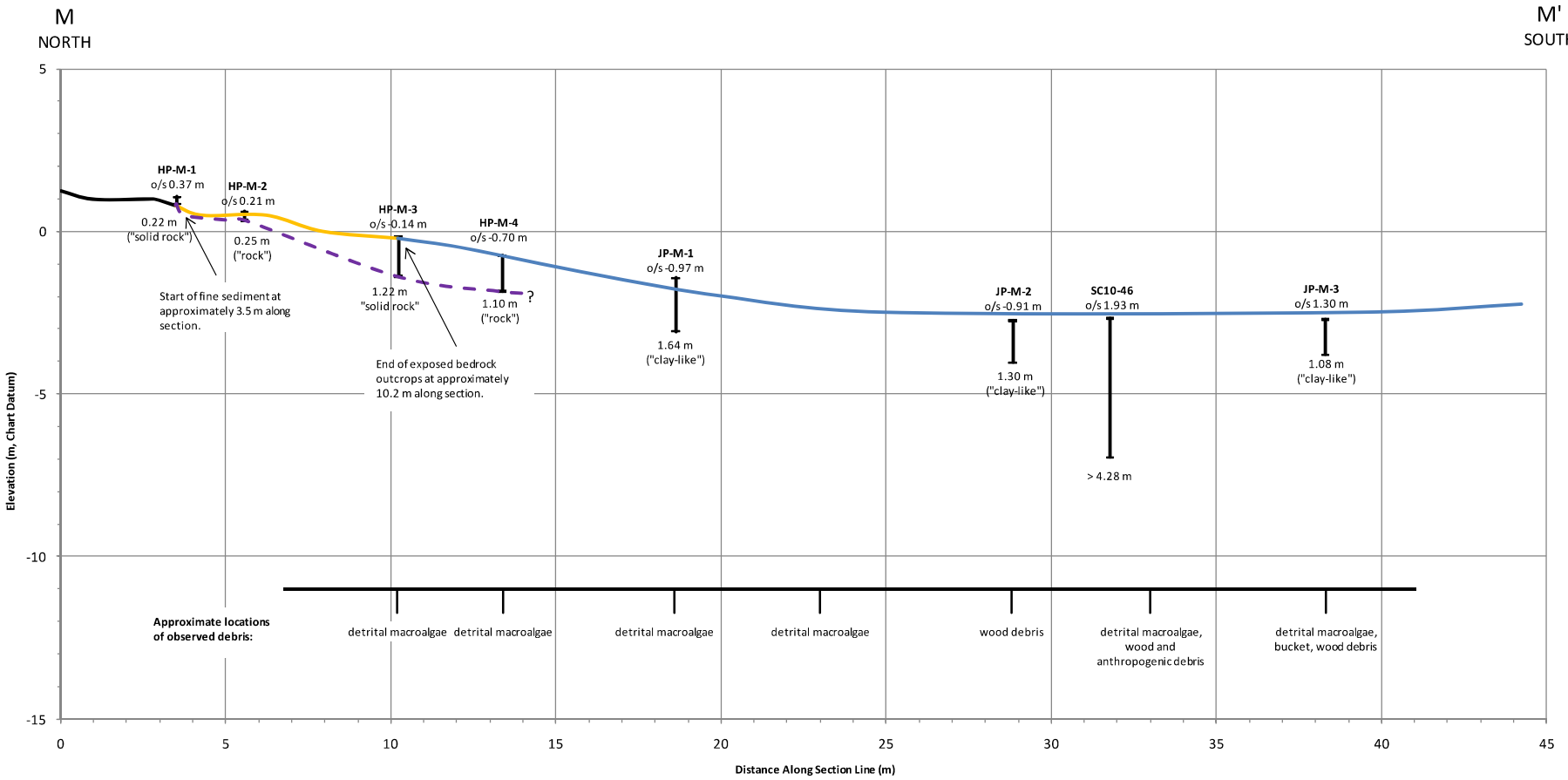
SECTION PC-L-L'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	02/07/11	SCALE	None	REV.
Graphics	MS	02/16/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-14

N:\Active\2010\1475\10-1475-0002 EGD\Ph 7000\Work in Progress\Task 5000 Sub-Surface Probing\B - Sections



LEGEND:

- Exposed Bedrock
- Bedrock Outcrops with Fine Sediment and Shell
- Fine Sediment and Shell
- Interpreted Hard Bottom Below Mudline

- HP = hand probe
- JP = jet probe
- o/s = horizontal offset perpendicular to section line (+'ve = east, -'ve = west)
- Values listed at bottom of probes indicate depths to refusal or maximum penetration in metres below mudline (m bml).
- Descriptions in quotations indicate diver's characterisation of refusal in hand and jet probe holes.

PROJECT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
SUB-SURFACE PROBING AND DIVE SURVEYS: INTERPRETIVE REPORT
ESQUIMALT GRAVING DOCK WATERLOT, ESQUIMALT, B.C.

TITLE

SECTION PC-M-M'

Golder Associates

PROJECT No.	10-1475-0002		FILE No.	—	
Analysis	MS	02/07/11	SCALE	None	REV.
Graphics	MS	02/16/11			
Check	RJ	10/26/12			
Review	JF	10/26/12			

FIGURE B-15

APPENDIX C

Public Works and Government Services Geomatics Survey of Pilgrim Cove

November 1, 2012
Report No. 10-1475-0002/7000/5000

Golder Associates

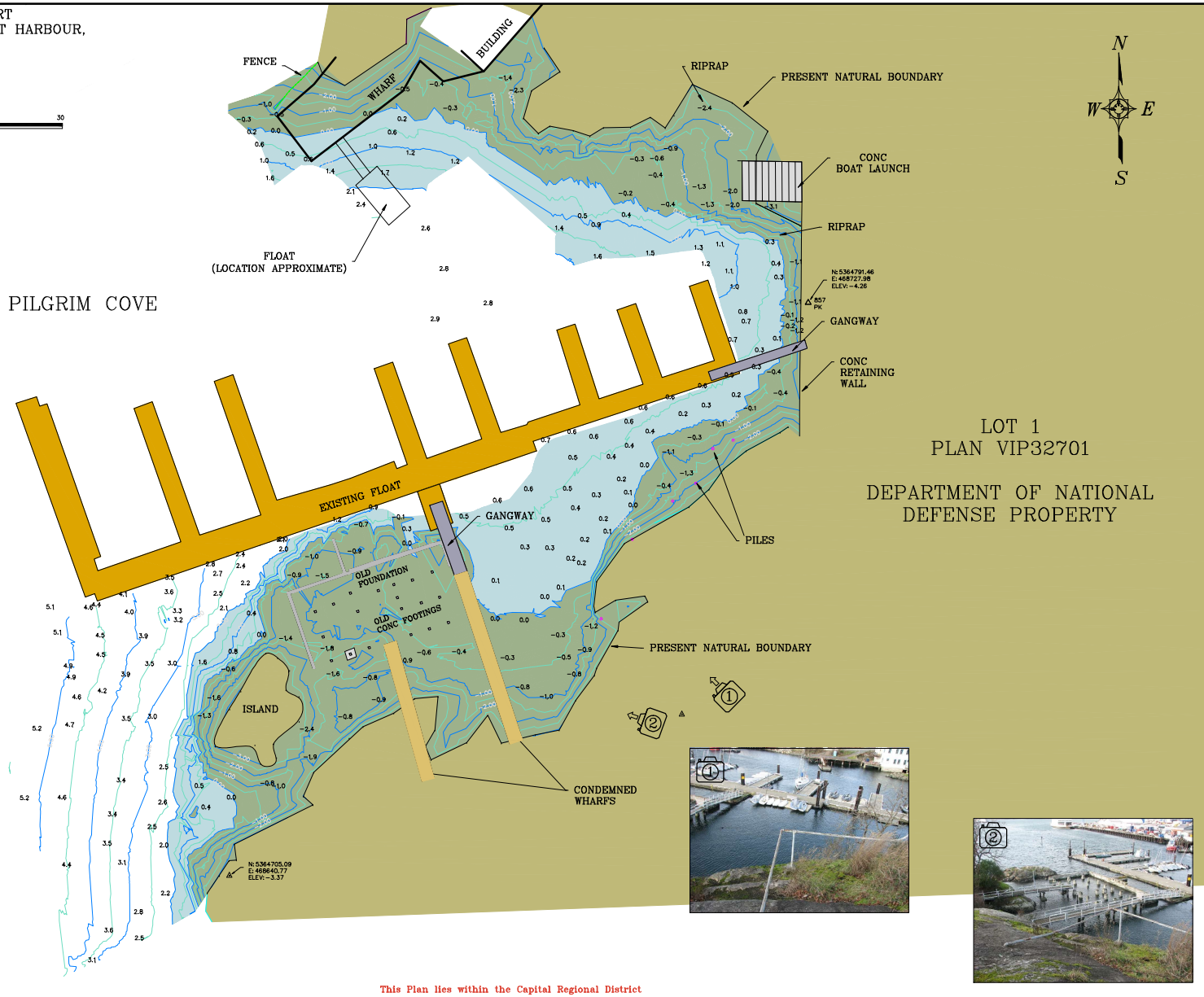
HYDROGRAPHIC PLAN OF PART OF PILGRIM COVE, ESQUIMALT HARBOUR, VICTORIA, BC

BCGS 92B.043

Scale 1:300

10 0 10 20 30

All distances are in metres



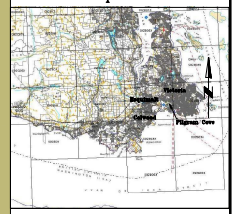
CERTIFIED CORRECT
DATED THIS 5th DAY OF January, 2011

Ian R. Robertson, B.C.L.S.

This Plan lies within the Capital Regional District

Public Works and Government Services Canada Geomatics Services
Travaux Publics et Services gouvernementaux Canada

Location Map BCGS 92B.043



All distances are average ground level

Depths are derived from Dual Frequency RTK GPS observations and are Referenced EGD Control Points EGD1 and EGD2 and referenced to Chart Datum. To convert from Chart Datum to Othometric (CGVD28), subtract 1.871m

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Date of Survey December 6-7, 2010 By I.R.Robertson, BCLS

SF#3240.01 FB#21, Pg 143-150

The Intended Plot Size of this Plan is 559 MM by 864 mm When Plotted at a Scale of 1:300

revisions		date
project		projet

Esquimalt Graving Dock Environmental Remediation Project: Pilgrim Cove Hydrographic and Shoreline Survey

drawing / dessin

Hydrographic Survey Plan

designed	concu
date	
drawn C. M. BRYENTON	dessine
date 2011-01-05	
approved I.R.ROBERTSON	approuve
date 2011-01-05	
Tender	Soumission
PWC Project Manager	Administrateur de projets TPC
project number	no. du projet
R.018400.001	
drawing no.	no. du dessin
SK#5248.00	

Plot Scale: 1:300

PWGSC ANSI D

S:\RPS-PTS\Project Files 1\Legal Projects 2010_2011\EGD 2010\Pilgrim Cove\DWG\SK5248.00_PILGREM COVE rev1.dwg

EDRM Document no. xxxxxx

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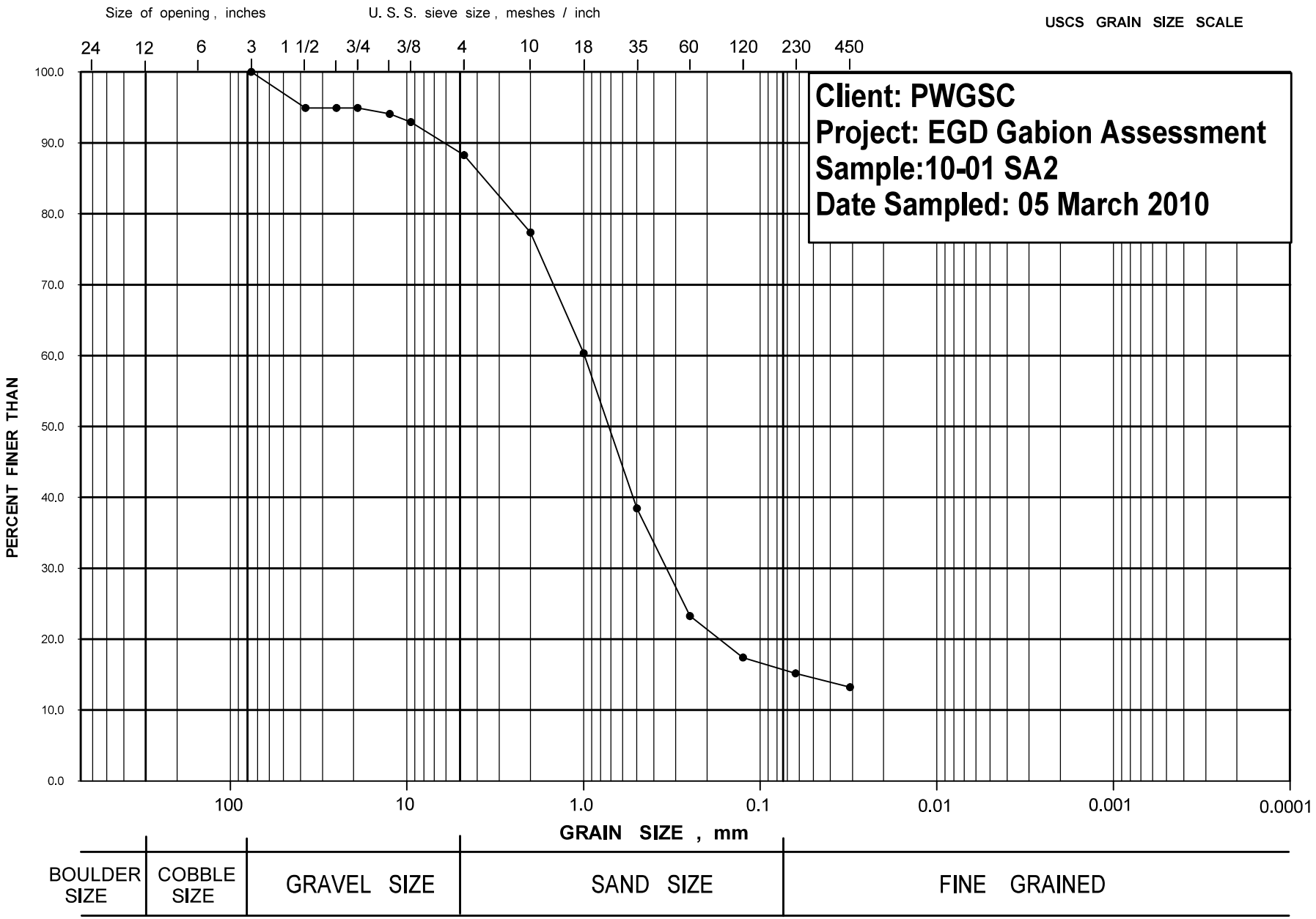
APPENDIX D

Grain Size Analyses – February 2010



Project No. 09-1475-0026-6000 Drawn ..... DGM Reviewed ..... PC Date ..... 25 Mar 10	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure F-2**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

Project #: 09-1475-0026 Phase: 6000

Short Title: 2010 ASSESSMENT OF NORTH LANDING WHARF GABION MATS

Tested by: DGM Date: 25/03/2010

Source: Esquimalt Harbour

Visual Description of Sample: Marine Sediments

Auger Hole		Sample :	10-01 SA2		Depth :		
	1st SIEVING		2nd SIEVING		Wash Sieving		
	Weight before sieving		Weight before sieving		Weight after wash		2090.2
	Total weight	2403.9	1/4 Pass #4		Residual #200		3.8
	Pass #4				Minus #200		317.5
Sieve (CAN)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
3"		0.0			0.0	76.0	100
1 1/2"	122.1	5.1			5.1	37.5	94.9
1"	0.0	0.0			0.0	25.0	94.9
3/4"	0.0	0.0			0.0	19.0	94.9
1/2"	20.4	0.8			0.8	12.5	94.1
3/8"	27.5	1.1			1.1	9.5	92.9
#4	111.9	4.7			4.7	4.8	88.3
#10	262.3	10.9			10.9	2.0	77.4
#18	409.8	17.0			17.0	1.0	60.3
#35	526.0	21.9			21.9	0.5	38.4
#60	364.9	15.2			15.2	0.250	23.3
#120	140.8	5.9			5.9	0.125	17.4
#230	53.6	2.2			2.2	0.063	15.2
#450	47.1	2.0			2.0	0.031	13.2
Pan	317.5	13.2			13.2		

REMARKS :

Reported by: _____ Reviewed by: _____

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other zones/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

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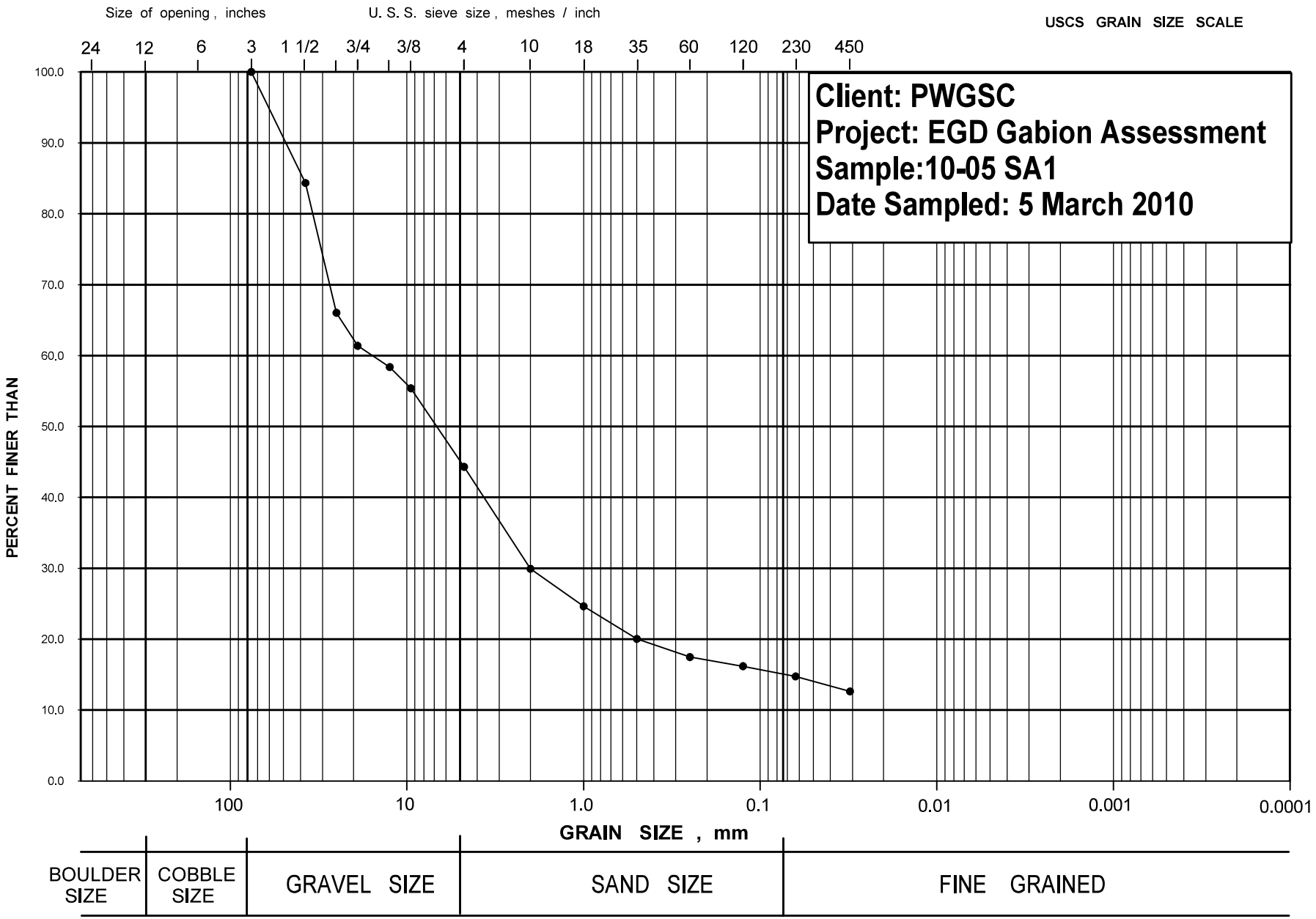

Project No. 09-1475-0026-6000 Drawn ..... DGM Reviewed ..... PC Date ..... 25 Mar 10	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure F-1**

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

ASTM C 136

Project #: 09-1475-0026 Phase: 6000

Short Title: 2010 ASSESSMENT OF NORTH LANDING WHARF GABION MATS

Tested by: DGM Date: 25/03/2010

Source: Esquimalt Harbour

Visual Description of Sample: Marine Sediments

Auger Hole		Sample :	10-05 SA1		Depth :		
	1st SIEVING		2nd SIEVING		Wash Sieving		
	Weight before sieving		Weight before sieving		Weight after wash		2445.5
	Total weight	2791.8	1/4 Pass #4		Residual #200		6.3
	Pass #4				Minus #200		352.6
Sieve (CAN)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
3"	0	0.0			0	76.0	100
1 1/2"	437.7	15.7			15.7	37.5	84.3
1"	511.0	18.3			18.3	25.0	66.0
3/4"	130.2	4.7			4.7	19.0	61.4
1/2"	83.3	3.0			3.0	12.5	58.4
3/8"	84.0	3.0			3.0	9.5	55.4
#4	309.2	11.1			11.1	4.8	44.3
#10	400.9	14.4			14.4	2.0	29.9
#18	148.2	5.3			5.3	1.0	24.6
#35	128.5	4.6			4.6	0.5	20.0
#60	71.1	2.5			2.5	0.250	17.5
#120	36.2	1.3			1.3	0.125	16.2
#230	39.6	1.4			1.4	0.063	14.8
#450	59.7	2.1			2.1	0.031	12.6
Pan	352.6	12.6			12.6		

REMARKS :

Reported by: _____ Reviewed by: _____

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other zones/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

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APPENDIX E

Biological and Other Observations

November 1, 2012
Report No. 10-1475-0002/7000/5000

Golder Associates

Table E-1: Section CFSA-A-A' Observations
Date Surveyed: January 10, 2011
CFSA Waterlot, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
4	Sea lettuce (*Ulva sp.*), filamentous brown algae barnacles	-
6	Sea lettuce (*Ulva sp.*), filamentous brown algae, encrusting coralline algae, barnacles	-
9	Sea lettuce (*Ulva sp.*), encrusting coralline algae, bladed kelp (*Laminaria spp.*), barnacles, sea cucumber (*Cucumaria miniata*), dungeness crab (*Cancer magister*)	-
11	Encrusting coralline algae, barnacles, sea cucumber (*Cucumaria miniata*)	Wood debris (sticks)
14	Encrusting coralline algae, barnacles	Metal debris, detrital macroalgae
16.5	Encrusting coralline algae, plumose anemone (*Metridium sp.*), sea star (*Pisaster brevispinus*)	Metal debris
19	Encrusting coralline algae	Metal debris
22	-	Metal debris
32	Clam siphon (Tresus nuttalii)	-
35	Coonstripe shrimp (*Pandalus danae*)	-
38	Coonstripe shrimp (*Pandalus danae*)	-
> 38	Plumose anemone (*Metridium sp.*)	Metal debris, garbage, tires

Table E-2: Section CFSA-B-B' Observations
Date Surveyed: January 10, 2011
CFSA Waterlot, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
4.5	Barnacles, sea lettuce (*Ulva sp.*)	-
6.5	Barnacles, sea lettuce (*Ulva sp.*), crab (*Pugettia sp.*)	-
9.5	Sea lettuce (*Ulva sp.*), filamentous brown algae, bladed kelp *(Laminaria spp.*), encrusting coralline algae, rock scallop (*Crassadoma gigantea*), nudibranch (*Aldisa albomarginata*), red rock crab (*Cancer productus*), sea cucumber (*Cucumaria miniata*)	-
12.5	Bladed kelp *(Laminaria spp.),* bladed kelp *(hedophyllum sp.),*	-
15.3	Filamentous brown algae, barnacles	Metal barrel, other metal debris
18	Barnacles	-
21	Filamentous brown algae, encrusting coralline algae	Detrital macroalgae
24	Encrusting coralline algae, sea cucumber (Cucumaria miniata), sea squirts (Cnemidocarpa finmarkiensis)	Rope (anchor line)
27	Encrusting coralline algae, sea squirts (*Cnemidocarpa finmarkiensis*)	Toe or rip rap
30	Anemone (Urticina sp.)	-
33	Dungeness crab (Cancer magister)	Aluminum cans
33.5	Coonstripe shrimp (*Pandalus danae*)	-
> 33.5	Coonstripe shrimp (*Pandalus danae*), plumose anemone (*Metridium sp.*), dungeness crab (*Cancer magister*), tube-dwelling anemone (*Pachycerianthus fimbriatus*)	Anthropogenic debris

Table E-3: Section CFSA-C-C' Observations
Date Surveyed: January 11, 2011
CFSA Waterlot, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
4	Sea lettuce (*Ulva sp.*), limpets, barnacles	Metal fencing material on foreshore near start of Section
6.5	Encrusting coralline algae, limpets, barnacles	-
9.5	Encrusting coralline algae, filamentous green and red algae, bladed kelp (*Laminaria spp.*)	-
12.5	Encrusting coralline algae, red algae, bladed kelp (*Costaria costata*), barnacles, white spotted greenling (*Hexagrammos stelleri*)	Metal debris
15.5	Encrusting coralline algae, barnacles	-
16.5	Encrusting coralline algae	-
17.5	Encrusting coralline algae	-
18	-	Metal debris
21.5	-	Concrete block
25.5	-	Anthropogenic debris (plastic bucket, metal debris), detrital macroalgae
28	-	Glass bottle
32	-	Metal debris

Table E-4: Section CFSA-D-D' Observations
Date Surveyed: January 11, 2011
CFSA Waterlot, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
6	Barnacles	-
8.5	Filamentous red algae, plumose anemone (*Metridium sp.*), sunflower star (*Pycnopodia helianthoides*)	-
11..5	Encrusting coralline algae, filamentous red algae, plumose anemone (Metridium sp.), sunflower star (*Pycnopodia helianthoides*), barnacles, whelks, tunicates (*Corella inflata*)	-
14	Encrusting coralline algae, plumose anemone (*Metridium sp*.), sea star (Pisaster brevispinus), limpets, barnacles	-
17	Encrusting coralline algae, plumose anemone (*Metridium sp.*),	-
19.5	Encrusting coralline algae, plumose anemone (*Metridium sp.*)	Large concrete anchor
20.5	Encrusting coralline algae	-
23.5	-	Anthropogenic debris (bucket, glass bottle, piece of PVC
26.5	-	Anthropogenic debris, old anchor
29.5	Kelp crab (Pugettia sp.)	-
> 29.5	-	Bedrock observed at approx 34m along Section (under gangway). Anthropogenic debris (tire, bedrock, plumose anemone (Metridium sp.), and a piling were observed beyond the end of the Section.

Table E-5: Section CFSA-E-E' Observations
Date Surveyed: January 12, 2011
CFSA Waterlot, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
3	Barnacles	-
6	Sea lettuce (*Ulva sp.*)	-
9	Encrusting coralline algae, bladed kelp (*Laminaria spp*.)	Bull kelp (*Nereocystis luetkeana*) stipes observed
11.5	Encrusting coralline algae, filamentous red algae, nudibranch (*Dirona albolineata*), plumose anemone (*Metridium sp.*)	-
13	Encrusting coralline algae, barnacles	Metal debris
14	Encrusting coralline algae, barnacles	-
16.4	Sea star (*Evasterias troschelii*), small sculpin (Family Cottidae)	Silt retained by wood piling forming a small plateau between 22 and 24m along the section
18	-	Anchor chain
19.5	-	Anthropogenic debris (old anchor, plastic fork)
21	-	Concrete anchor blocks

Table E-6: Section PC-F-F' Observations
Date Surveyed: January 17, 2011
Pilgrim Cove, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
3.6	barnacles, limpets	boulder rip rap transition, detrital eelgrass (*Zostera marina*)
5.7	filamentous brown algae, barnacles	sand bag
9.8	filamentous brown algae, filamentous red algae, barnacles	-
11.6	sea lettuce (*Ulva sp.*), bladed kelp (*Laminaria sp.*), wireweed	possible bedrock outcrop
15.7	sea lettuce (*Ulva sp.*), filamentous brown algae, encrusting coralline algae	possible bedrock outcrop
16.3	sea lettuce (*Ulva sp.*), bladed kelp (*Laminaria sp*), filamentous red algae, encrusting coralline algae, sea star (*Leptasterias hexactis*), anemone (undetermined species)	kelp stipes
22	sea lettuce (*Ulva sp.*), filamentous red algae, encrusting coralline algae, sea cucumbers (*parastichopus californicus*), plumose anemone (*Metridium sp.*), tunicates and sponges (undetermined species)	toe of rip rap slope, kelp stipes
24	sea lettuce (*Ulva sp.*), filamentous red algae, plumose anemone (*Metridium sp.*)	-
26.8	-	detrital macroalgae
29.1	plumose anemone (*Metridium sp.*)	detrital macroalgae
29.7	filamentous red algae	detrital macroalgae

Table E-7: Section PC-G-G' Observations
Date Surveyed: January 18 and 19, 2011
Pilgrim Cove, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
0	rockweed (*Fucus sp.*), barnacles, mussels (*Mytilus sp,*)	-
3	kelp stipes, sea lettuce (*Ulva sp.*), encrusting coralline algae	-
5.3	sea lettuce (*Ulva sp.*), plumose anemone (*Metridium sp.*)	toe of bedrock slope, detrital macroalgae
17	coonstripe shrimp (*Pandalus danae*)	-
29	nudibranchs (including, *Dirona albolineata*)	-

Table E-8: Section PC-H-H' Observations
Date Surveyed: January 18, 2011
Pilgrim Cove, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
1	rockweed (*Fucus sp.*), sea lettuce (*Ulva sp.*)	-
3.5	sea lettuce (*Ulva sp.*), kelp stipes, red algae (folios red algae), encrusting coralline algae	toe of first bedrock ledge
9	red algae (including, folios red algae and branching red algae), bladed kelp (*Laminaria sp.*), encrusting coralline algae	-
10	sea lettuce (*Ulva sp.*), encrusting coralline algae	toe of second bedrock ledge
12.6	sea lettuce (*Ulva sp.*)	-
15	sea lettuce (*Ulva sp.*), red algae (branching red algae), bladed kelp (*Laminaria sp.*)	large sheet of metal partially covered with silt
17.8	-	detrital macroalgae
21.7	sea lettuce (*Ulva sp.*)	detrital macroalgae
23.8	-	wood debris
27	blood star (*Henricia leviuscula)*	wood debris, tire
30	plumose anemone *(Metridium sp.)*	tires, wood block, wood debris
33	-	detrital macroalgae, metal debris, wood debris
36	-	detrital macroalgae, tire, wood debris
38.7	-	wood debris

Table E-9: Observations Along Concrete Retaining Wall
Date Surveyed: January 18, 2011
Pilgrim Cove, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
4	plumose anemone (*Metridium sp.*), barnacles	-
7	-	wood debris, detrital eelgrass (Zostera marina)
10	sea lettuce (*Ulva sp.*), red algae (folios),	wood debris
15	sea lettuce (*Ulva sp.*), barnacles	-
20	sea lettuce (*Ulva sp.*), plumose anemone	-
30	-	support pilings observed under base of concrete wall*

* Concrete wall appears to be supported by pilings rather than bedrock.

Table E-10: Section PC-L-L' Observations
Date Surveyed: January 20, 2011
Pilgrim Cove, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
0	barnacles, limpets	-
2	barnacles, limpets	-
5	sea lettuce (*Ulva sp.*), filamentous red algae, barnacles	detrital macroalgae, toe of rip rap slope
8.3	sea lettuce (*Ulva sp.*)	detrital macroalgae, wood debris
10.6	sea lettuce (*Ulva sp.*), folios red algae, encrusting coralline algae, helmet crab (*Telmessus cheiragonus*), dungeness crab (*Cancer magister*), sea star (undetermined species)	-
13.4	sea lettuce (*Ulva sp.*)	detrital macroalgae
17.2	sea lettuce *(Ulva sp.)*	detrital macroalgae
20.2	crab (*Cancer sp.*)	wood debris, sand bags, cans, plastic lid and bag
23	-	wood debris, metal debris, can, piling
25.9	folios red algae and anemone *(Urticina sp.)* on piling, graceful crab *(Cancer gracilis)*	wood and metal debris, can, piling

Table E-11: Section PC-M-M' Observations
Date Surveyed: January 20, 2011
Pilgrim Cove, Esquimalt, BC

Approximate Distance Along Section (m)	Biological Observations	Other Observations
0	rockweed (*Fucus sp.*), mussels (*Mytilus sp.*), barnacles	-
3.5	mussels (*Mytilus sp.*), barnacles, hermit crab (undetermined species)	-
5.6	filamentous brown algae, mussels (*Mytilus sp.*), barnacles	bedrock-silt transition
10.2	sea lettuce (*Ulva sp.*), filamentous red algae	detrital macroalgae
13.4	-	detrital macroalgae
18.6	crab (*Cancer sp.*)	detrital macroalgae
23	plumose anemone (*Metridium sp.*)	detrital macroalgae
28.8	coonstripe shrimp (*Pandalus danae*),	wood debris
33	-	detrital macroalgae, wood debris, plastic cup, metal wire, bucket
38.3	anemone (*Urticina sp.*) on piling, crab (*Cancer sp.*)	detrital macroalgae, bucket, wood debris

APPENDIX F

Dive Survey Video Files (on DVD)

- F-1: Dive Survey, South Jetty Transects (February/March 2009)
- F-2: Jet Probe Investigation of Near-Shore Sediment Thickness (October 2009)
- F-3: Assessment of North Landing Wharf Gabion Structure (February 2010)
- F-4: Dive Survey, CFSA Waterlot and Pilgrim Cove (January 2011)

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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