Department of National Defence (DND)

Environmental Effects Determination (EED) Report

Project: Esquimalt Harbour Remediation Project (EHRP) (C Jetty/ML Floats and Y Jetty/Lang Cove)

Prepared by: Golder Associates Ltd.

Date: 21 August 2018

Version: Final Rev0

Golder Project No: 18101029/2000/2001

Executive Summary

On behalf of Public Services and Procurement Canada (PSPC) and Department of National Defence (DND), Golder Associates Ltd. (Golder) has prepared this Environmental Effects Determination (EED) report for the Esquimalt Harbour Remediation Project (EHRP) located within the CFB Esquimalt Waterlot in Esquimalt Harbour, BC. The EED report consists of a review of the potential environmental effects of the EHRP, pursuant to Section 67 of the *Canadian Environmental Assessment Act*, 2012.

The objective of the EHRP is to remediate and risk manage historically contaminated sediments around existing infrastructure through dredging, excavating and material placement. The EHRP is comprised of two sub-projects: C Jetty/ML Floats (CJML) and Y Jetty/Lang Cove (YJLC). Both sub-project areas are located on the east side of Esquimalt Harbour in Constance Cove. The EED is based on the CJML design dated April 2018 and YJLC design dated June 2018.

The EHRP consists of the following components:

- Mobilization and demobilization;
- Contractor vessel mooring and anchoring;
- Structure demolition/removal, relocation and reinstatement;
- Dredging, excavating and debris removal;
- Stabilization of material;
- Material processing to segregate suspected unexploded ordnance (UXO)
- Dewatering of dredge material;
- Placement of material;
- In-water transportation;
- Offloading, stockpiling, processing;
- Upland transportation; and,
- Disposal.

Potential environmental effects of the EHRP on valued ecosystem components (VECs) were assessed, and mitigation measures have been identified to minimize these effects. Key mitigation measures include:

- Preparation and implementation of an Environmental Management Plan (EMP) by DND, including a Water Quality Monitoring Plan (WQMP), outlining environmental construction requirements and providing guidelines for protection of VECs during the projects.
- Development of an Environmental Protection Plan (EPP) by the contractor outlining measures to achieve environmental protection objectives identified in the EMP.
- Environmental monitoring by a qualified environmental monitor (EM) to oversee and report on the effectiveness of mitigation measures identified in this EED and compliance with conditions of potential permits/approvals.
- Placement of suitable substrate (i.e., angular rock) in a portion of the dredged areas to mitigate for removal of substrate with attached understory kelp.
- Potential relocation of Northern abalone (*Haliotis kamtschatkana)* that occur along the ML Floats shoreline adjacent to CJML sub-project area is proposed to help protect abalone from Project works.

A Request for Review was submitted by DND to Fisheries and Oceans Canada (DFO) in 2017. DFO determined that unavoidable serious harm to fish will occur in areas with understory kelp. Additionally, it was determined that infilling of a portion of the intertidal shoreline in the YJLC

Project area in Dredge Units 29 and 30 would result in serious harm. An application for authorization under paragraph 35(2)(b) has been prepared and submitted to DFO for review.

There are several Aboriginal groups with interests that extend into the EHRP sub-project areas, including the Esquimalt Nation and Songhees Nation whose Reserve lands are located along the east shore of Esquimalt Harbour. Other Aboriginal groups with potential interests include member First Nations of the Te'mexw Treaty Association, Saanich Nations and the Hul'qumi'num Treaty Group, as well as the Métis Nation British Columbia and the Métis Nation of Greater Victoria. DND has engaged with the Esquimalt Nation and Songhees Nation, making separate presentations on the EHRP to both Chief and Council's. These First Nations have expressed considerable support for the EHRP. Principal concerns raised by these First Nations include the implications of Health Canada's Seafood Consumption Advisory for the consumption of traditional foods; continuing access to the Esquimalt Harbour to harvest traditional resources and conduct other traditional activities; protection of archaeological sites; effects of proposed remediation activities on uncontaminated areas elsewhere in the Esquimalt Harbour; and economic opportunities for the Aboriginal businesses from the EHRP.

On the basis of this EED report, it has been determined that the EHRP is not likely to cause significant adverse environmental effects. Therefore the EHRP can proceed with application of the mitigation measures specified in the interaction tables in this report.

Table of Contents

Executive Summary .... **ii**

Part 1. Project Information **1**
- **1.1** Title of Proposed Project 1
- **1.2** Originating Directorate, Base, or Unit 1
- **1.3** Location of Proposed Project 1
- **1.4** Project Summary 3
- **1.5** Project Alternatives 4
- **1.6** Applicability of *CEAA, 2012* 4
- **1.7** EED Start Date 4
- **1.8** DGIEGPS EED number 4
- **1.9** Provincial and Municipal Government Involvement 5
- **1.10** Other Federal Department Involvement 5
- **1.11** Contacts 5
  - **1.11.1** EED Point of Contact 5
  - **1.11.2** Project OPI 5

Part 2. Environmental Effects Discussion **6**
- **2.1** Project Description 6
  - **2.1.1** Project Components 6
  - **2.1.2** Project Schedule 12
  - **2.1.3** Timing Windows for Protection of Fish 12
- **2.2** Identification of Valued Ecosystem Components (VECs) 12
- **2.3** Description of Valued Ecosystem Components 14
  - **2.3.1** Physical Components 14
  - **2.3.2** Biological Components 15
  - **2.3.3** Socio-Economic Components 36
- **2.4** Project Effects and Associated Mitigation Measures 46
- **2.5** Public Participation 65
- **2.6** Aboriginal Community Engagement 66
- **2.7** References 70

Part 3. Environmental Effects Determination **77**

Annex A. Design Drawings **78**

Annex B. Barge Dewatering Assessments **79**

Annex C. Biological Background Information **80**

Annex D. Underwater Noise Modelling **81**

List of Tables

Table 1: Description of EHRP Components ... 7
Table 2. Environmental Effects Matrix ... 13
Table 3: Marine Invertebrate Species at Risk in Esquimalt Harbour ... 24
Table 4: Anadromous and Marine Fish Species at Risk in Esquimalt Harbour ... 30
Table 5. Marine Mammal Species at Risk in Esquimalt Harbour. ... 33
Table 6. Bird Species at Risk Known or Have Potential to Occur in Esquimalt Harbour. ... 34
Table 7: Municipal Population by Remediation Site ... 36
Table 8: Significance Criteria Definitions ... 46
Table 9: Potential Effects of the Project on ECs with Mitigation Measures ... 47

List of Figures

Figure 1. Project Location ... 2
Figure 2. C Jetty and ML Float Project Area ... 10
Figure 3. Y Jetty and Lang Cove Project Area ... 11
Figure 4. C Jetty and ML Float Substrate Types ... 17
Figure 5. Y Jetty and Lang Cove Substrate Types ... 18
Figure 6. C Jetty and ML Float Marine Vegetation Types. ... 22
Figure 7. Y Jetty and Lang Cove Marine Vegetation Types. ... 23
Figure 8. C Jetty and ML Float Northern Abalone and Pacific Herring ... 27
Figure 9. Y Jetty and Lang Cove Pacific Herring ... 28
Figure 10. Socio-Economic Context ... 38
Figure 11: Y Jetty and Lang Cove Archaeological Resources ... 45

List of Acronyms and Abbreviations

AIA........archeological impact assessment
AOA........archeological overview assessment
Anchor QEA........Anchor QEA L.L.C
Archipelago……Archipelago Marine Research
BES……Balanced Environmental Services Inc.
CCME........Canadian Council of Ministers of the Environment
CD........chart datum
CDC........British Columbia Conservation Data Centre
CEAA, 2012........*Canadian Environmental Assessment Act, 2012*
CFB........Canadian Forces Base
COSEWIC........Committee on the Status of Endangered Wildlife in Canada
CRD........Capital Regional District
DCC........Defence Construction Canada
DFO........Fisheries and Oceans Canada
DND........Department of National Defence
EED........environmental effects determination
EHRP........Esquimalt Harbour Remediation Program
EM……Environmental Monitor
EMP……Environmental Management Plan
EPP……Environmental Protection Plan
Golder……Golder Associates Ltd.
HCA........*Heritage Conservation Act*
HHRA........human health risk assessment
MOE……British Columbia Ministry of Environment and Climate Change Strategy
PAH........polycyclic aromatic hydrocarbons
PCBs........polychlorinated biphenyls
PEL........probable effects level
PSPC........Public Services and Procurement Canada
QHM........Queen's Harbour Master
SARA........*Species at Risk Act*
SLR........ Consulting Ltd.
TEK........traditional ecological knowledge
TSS........total suspended solids
VEC........valued ecosystem component
WQMP……Water Quality Monitoring Plan

List of Units

°C........degrees Celsius
km........kilometre
m........metres
m^2........metres squared
NTU........nephelometric turbidity units

Part 1. Project Information

1.1 Title of Proposed Project

Esquimalt Harbour Remediation Project (EHRP), Project No. R.079731.001, Canadian Forces Base (CFB) Esquimalt, British Columbia (BC)

1.2 Originating Directorate, Base, or Unit

Directorate of Construction Project Delivery, Department of National Defence, CFB Esquimalt

1.3 Location of Proposed Project

The two sub-projects of the EHRP are both located on the east side of Esquimalt Harbour at CFB Esquimalt in Constance Cove (Figure 1).

The latitude and longitude of the sub-projects are:

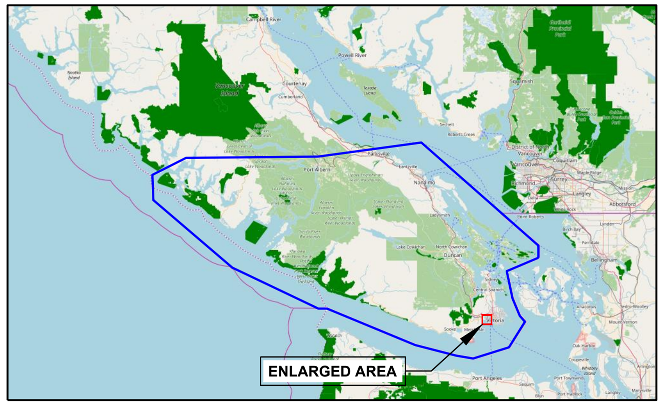
- C Jetty/ML Floats: 48°25'54"N, 123°25'51"W
- Y Jetty/Lang Cove: 48°25’58”N, 123°25'22"W

The EHRP is located within the Fisheries and Oceans Canada (DFO) Fisheries Management Subarea 19-2.

A separate proposed remediation project, called the Constance Cove Remediation Project, is located between the two sub-projects.

KEY MAP

INSET MAP - NOT TO SCALE



LEGEND

- REMEDIATION FOOTPRINT
- POTENTIAL AREA FOR PROCESSING FACILITY

REFERENCE

1. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
2. C JETTY AND ML FLOATS MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "xC Jetty Dredge_Tender_20180521.dwg"
3. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "AQ_Dredge Prism_20180618_Draft100PCT.DWG"
4. KEY PLAN IMAGE © OPENSTREETMAP CONTRIBUTORS. CAPTURED 2017-10-25.

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CLIENT

PUBLIC SERVICES AND PROCUREMENT CANADA

PROJECT

ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

TITLE

PROJECT LOCATION

CONSULTANT

GOLDER

YYYY-MM-DD	2018-08-20
DESIGNED	V. LAWRENCE
PREPARED	J. FARAH
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

PROJECT NO.	PHASE/TASK	REV.	FIGURE
18101029	2000/2001	0	1

25 mm

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1.4 Project Summary

DND, which administers Esquimalt Harbour, is implementing a remediation and risk management program in Esquimalt Harbour as part of a long-term strategy to address sediments that have been contaminated by historical industrial activities. The primary contaminants of potential concern resulting from historical industrial activities include arsenic, copper, lead, zinc, mercury, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins, furans and organochlorine pesticides. Tributyltin may also be present; however, it is not a driver for the remediation. In several areas, sediment contamination exceeding the Canadian Council of Ministers of the Environment (CCME) probable effects level (PEL) sediment quality guidelines (CCME 1999).

Due to the presence of contaminants in marine sediments, a Fisheries Notice (FN0807) Consumption Advisory for Esquimalt Harbour, dated October 9, 2009, recommended limiting consumption of Dungeness crab (*Metacarcinus magister*), red rock crab (*Cancer productus*), sea urchin (*Strongylocentrotus spp.*) roe and rockfish (*Sebastes spp.)* harvested from Esquimalt Harbour by recreational fishers and subsistence populations. A draft Human Health Risk Assessment for Esquimalt Harbour also identified a potential risk to Esquimalt Nation and Songhees Nation individuals from consumption of clams (class Bivalvia), mussels (*Mytilus spp.*) and shrimp (infraorder Caridae) (SLR 2010).

Several projects are planned or are underway to remediate sediment at various locations in Esquimalt Harbour. The focus of the EHRP is sediment remediation and risk management of two sub-projects: C Jetty/ML Floats (CJML) and Y Jetty/Lang Cove (YJLC).

The EHRP is proposed to consist of the following activities:

- Mobilization and demobilization;
- Contractor vessel mooring and anchoring;
- Structure demolition/removal, relocation and reinstatement;
- Dredging, excavating and debris removal;
- Stabilization of material;
- Material processing to segregate suspected unexploded ordnance (UXO)
- Dewatering of dredge material;
- Placement of material;
- In-water transportation;
- Offloading, stockpiling, processing;
- Upland transportation; and,
- Disposal.

The EED is based on the CJML design dated April 2018 and YJLC design dated June 2018 (refer to design drawings in Annex A). The CJML sub-project started in June 2018 and is expected to continue until April 2019. The YJLC sub-project is expected to be undertaken from December 2018 to the end of March 2020.

The EED has been updated from the previous 90% version (dated 6 December 2017) to a 100% version for YJLC.

A Letter of Advice has been issued by DFO for the CJML sub-project (DFO File Number 17-HPAC-01285), and an application for authorization under Paragraph 35(2)(b) of the *Fisheries Act* for portions of the YJLC sub-project is being reviewed by DFO.

1.5 Project Alternatives

For CJML, four site-wide alternatives were developed for evaluation (Anchor 2016a). These alternatives included varying degrees of remedial actions and risk management. The four project alternatives included:

- Alternative 1 – No action
- Alternative 2A – Maximum extent practicable removal and no action at marine railway
- Alternative 2B – Maximum extent practicable removal
- Alternative 3 – Maximum site-wide removal

Alternative 2B was chosen as the preferred option as it provides higher relative performance as measured against the financial, non-financial, and risk management factors.

For Y Jetty/Lang Cove, four site-wide alternatives were also developed for evaluation (Anchor QEA 2016b). These alternatives also included varying degrees of remedial actions and risk management. The four project alternatives included:

- Alternative 1 – No action
- Alternative 2 – Monitored natural recovery plus institutional controls
- Alternative 3A – Maximum extent practicable removal plus enhanced natural recovery
- Alternative 3B – Maximum site-wide removal

Alternative 3A was chosen as it provides higher relative performance as measured against the financial, non-financial, and risk management factors.

1.6 Applicability of *CEAA, 2012*

Subsection 4(2) of the *Canadian Environmental Assessment Act, 2012* (S.C. 2012; CEAA 2012) states that “The Government of Canada, the Minister or Agency, federal Authorities and responsible Authorities, in the administration of this *Act*, must exercise their powers in a manner that protects the environment and human health and applies the precautionary principal.”

Projects defined under Section 66 of CEAA, 2012 that are carried out on federal lands or those that are outside Canada and that are to be carried out or financially supported by a federal authority are considered in a careful and precautionary manner to avoid significant adverse environmental effects.

The EHRP physical activities are to be carried out in Canada on federal lands and meets the definition of a project under Section 66 of the CEAA, 2012. Therefore, this EED fulfills a federal requirement under Section 67 in determining whether carrying out the EHRP is not likely to cause significant adverse effects before the EHRP can proceed.

1.7 EED Start Date

2017-09-25

1.8 DGIEGPS EED number

2017-21-100946

1.9 Provincial and Municipal Government Involvement

The EHRP in-water works will take place within the Federal harbour limits of Esquimalt Harbour, and therefore neither Provincial nor Municipal government involvement is required for in-water works. Water from the dredged sediment that drains off during offloading and stockpiling will need meet water quality performance objectives set out in the Water Quality Monitoring Plan developed for the Project, or be collected and treated as necessary to comply with provincial and/or local water discharge regulations. Provincial requirements under the *Environmental Management Act* may apply to the disposal of contaminated dredged material transported outside of Esquimalt Harbour.

Municipal noise and nuisance bylaws may be applicable at the boundary between CFB Esquimalt and applicable municipalities (Township of Esquimalt, City of Colwood and Town of View Royal):

- The Township of Esquimalt, Maintenance of Property and Nuisance Regulation Bylaw, 2014, No. 2826.
- The Town of View Royal: Noise Bylaw No. 523, 2003.
- The City of Colwood: Colwood Noise Bylaw 1986, Bylaw No. 38.
- The City of Colwood: Nuisance (Controlled Substance) Bylaw No. 851, 2006

Street and traffic regulation bylaws may also apply if dredged material is transported overland by truck to the disposal location, for example:

- City of Colwood: Traffic and Highway Regulation Bylaw No. 1134.
- Township of Esquimalt: Streets and Traffic Regulation Bylaw, 2005, Bylaw No. 2607.

1.10 Other Federal Department Involvement

A Request for Review will be sent to DFO to verify that DFO concurs with the self-assessment determination that the Project is not likely to cause serious harm to fish.

A Notice of Works under the *Navigation Protection Act* will be submitted to Transport Canada.

1.11 Contacts

1.11.1 EED Point of Contact

a) Name, Rank, and Title: Tracy Cornforth, Environment Officer
b) E-mail Address: Tracy.Cornforth@forces.gc.ca

1.11.2 Project OPI

a) Name, Rank, and Title: Duane Freeman, Formation Environment Office
b) E-mail Address: Duane.Freeman@forces.gc.ca

Part 2. Environmental Effects Discussion

2.1 Project Description

2.1.1 Project Components

The following components are proposed for both EHRP sub-projects:

- Mobilization and demobilization;
- Contractor vessel mooring and anchoring;
- Structure demolition/removal, relocation and reinstatement;
- Dredging, excavating and debris removal;
- Stabilization of material;
- Material processing to segregate suspected unexploded ordnance (UXO)
- Dewatering of dredge material;
- Placement of material;
- In-water transportation;
- Offloading, stockpiling, processing;
- Upland transportation; and,
- Disposal.

Specific details for each of the project components based on Anchor QEA's 100% design specifications (Anchor QEA 2018a, b) are outlined in Table 1. Marine dredge and material placement footprint areas are depicted on Figures 2 and 3.

Table 1: Description of EHRP Components

Project Component	CJML	YJLC
Mobilization and demobilization	• Set up of off-site staging areas at Yew Point (optional DND-provided staging area) or another location to be determined by the contractor. • Set up of contractor processing facility, off-site offload facility and stockpile storage area (location to be determined by contractor). • Mobilization and demobilization of equipment. • Cleaning of work site, off-site staging areas and offload facility at completion of work.	• Set up temporary facilities at the Y Jetty Access Area. An upland area adjacent to Y Jetty will be made available for the contractor’s use. The Y Jetty Access Area may not be used for stockpiling of dredge material or debris unless accepted by the Departmental Representative (DR). • Staging of contractor materials from off site to complete the work either on barges within the Project Area or at an off-site location accepted by the DR. • Set up of contractor processing facility, off-site offload facility and off-site stockpile area (location to be determined by contractor). • Mobilization and demobilization of equipment. • Cleaning of work site, off-site staging areas and offload facility at completion of work.
Contractor vessel mooring and anchoring	• Berth moorage for the contractor’s floating equipment or other vessels will not be available to the contractor once the existing fender system at C Jetty has been modified or removed. The contractor will not have berthing at ML Floats. • The contractor may be allowed to drive temporary timber or steel piling to support mooring of the contractor’s floating equipment at a location agreed to by the DCC Representative.	• The contractor will not be allowed to moor construction equipment at the Y Jetty berths. • The contractor may be allowed to drive temporary timber or steel piling to support mooring of the contractor’s floating equipment at a location agreed to by the DR. When using steel piles the contractor will be responsible for all mitigation activities as well as obtaining all relevant and appropriate permits. • Anchoring of equipment may also be allowed (i.e. Processing barge near F-Jetty)
Structure demolition/removal, relocation and reinstatement	• **C Jetty**: To facilitate dredging, the existing fender system will be disconnected and temporarily relocated. The fender system will be reinstalled in its preconstruction location following dredging. • **Marine Railway**: The in-water and above water portions of the marine railway and timber wharf structures, including timber piles and foundations, between C Jetty and the ML Floats will be demolished. • **ML and SBU Floats**: To facilitate dredging under the ML Floats and the SBU Float (a float directly east of ML Float #3 which is included in the remediation area), the floats and timber pilings will be removed and temporarily relocated. All steel dolphin piles at the ML Floats will be left in place; however, a few steel piles at the SBU Float will be extracted and reinstated. - Timber piles and steel piles will be removed using vibratory methods. If vibratory methods are not used, an alternative similar method will be submitted to the Departmental Representative for review. - After extraction, sediment, marine invertebrates and other objects that are attached to the surface of the piles will be cleaned off inside of a silt curtain in the footprint of the dredge unit prior to dredging. - All structures will be reinstated in their existing locations and conditions, except in the case of a timber piling being damaged upon removal, in which case new treated timber replacement piles (or similar) will be installed. - Pile driving will be carried out using marine-based floating equipment. Vibratory pile driving is the proposed method for pile driving, if vibratory pile driving is not used, an alternative equivalent method will be submitted to the Departmental Representative for review.	• **Y Jetty Fender System**: To facilitate dredging in areas adjacent to and under Y Jetty, the existing Y Jetty fender system will be removed, cleaned, stored and reinstated in original location. Fender system includes timber fender piles and timber chocks. Salvaged timber fender piles will be reused except were the DR accepts that they are unsuitable for re-use. After timber piles are extracted, sediment and other objects that are attached to the surface of the piles will be cleaned off. • **Former Marine Railway**: the former marine railway which is almost completely buried in the seabed will be removed. This work includes structure dismantling, pile extraction and off-site disposal of steel rail tracks, rail track support system, timber piled foundation, timber framing, bolting material and miscellaneous timber and steel components. A silt curtain will be used around the perimeter of the demolition work for the underwater portion of the former marine railway. • For the **Y Jetty fender system** and **former marine railway**, vibratory piling hammer (with timber pile clamp) will be used to extract existing timber piles from the seabed except where an equivalent alternative method has been accepted by the DR. • There will be no structure demolition/removal, relocation and reinstatement at Lang Cove.

Project Component	CJML	YJLC
Dredging, excavation and debris removal	• Approximately 32,900 m^2 of sediment with a volume of 43,950 m^3 is proposed to be dredged in the CJML sub-project area. • Dredging of contaminated sediments will be conducted from the water using mechanical equipment. • Identified debris will be removed by methods determined by the contractor. • No dredging will be performed in the C Jetty underpier areas due to limited access. • No dredging will occur within 3 m of the toe of the existing riprap shoreline revetment to protect the revetment. • The dredge sediment and debris will be placed on a sealed (watertight) barge for transport to the off-site offload facility. • One contingency re-dredging pass may be required if testing indicates contaminated sediment remains that exceeds criteria for the EHRP. • Dredging of bedrock and rock outcrops within the sub-project areas is not considered feasible and is not required to meet remedial objectives. • Intertidal excavation will be undertaken in a portion of the Marine Railway.	• Sediment and debris will be removed from the seabed to a specific dredge cut thickness or elevation. • The dredge area, including side slopes, is estimated to be 31,200 m^2. The dredge volume, including contingency re-dredging, is estimated to be 51,400 m^3. • Debris includes identified debris and dredge debris (e.g. timber piles, pile stubs, logs, wire, cable, concrete, trash). Dredge debris includes timber piles or pile stubs that are not part of identified structures to be demolished or relocated and reinstated. • Dredging of contaminated sediments will be conducted using mechanical equipment. The bucket types and size is the contractor's choice provided that water quality requirements of the EMP and permit conditions are met. • Contractor is not required to remove the till or bedrock material. The intent of remedial dredging is to remove contaminated sediment and not to remove till or bedrock material, which is not contaminated sediment. • Identified debris will be removed by methods determined by the contractor. • Suspected unexploded ordnance (UXO) of an unknown quantity may be encountered during dredging operations. • The dredge sediment, including any incidental dredge debris, will be placed on a sealed (watertight) barge. • One contingency re-dredging pass may be required if testing indicates contaminated sediment remains that exceeds criteria for the Project. • Land-based excavation of Dredge Units 29 and 30 to remove shoreline riprap is allowed. • Salvaged riprap that is free of sediment and reusable, must be stockpiled on site, • No excavation will occur in Lang Cove.
Stabilization of Sediment	• No stabilization is required for CJML.	• Marine sediments to be removed from the Leachable Metals Area in Dredge Unit 9 north of Y Jetty have the potential for lead leachate concentrations to exceed the hazardous waste Leachate Quality Standard. • Material removed from the Leachable Metals Area must be stabilized within Esquimalt Harbour and subsequently disposed of as IL+ waste material after the results of post-stabilization TCLP analysis (that must be collected and analyzed by the contractor and accepted by the DR) indicate that the material no longer exceeds the hazardous waste Leachate Quality Standard for lead per the BC HWR regulations, Schedule 4 (Table 1 – Leachate Quality Standards). • No stabilization is required for sediment in Lang Cove.
Dewatering of dredge material	• Passive dewatering is not permitted within Water Quality Management Area A (WQMA-A), which encompasses Dredge Unit (DU) 14 located between C Jetty and ML Float #1, as outlined within the barge dewatering assessment (Annex B). • Passive dewatering is permitted in the remainder of the C Jetty and ML Floats dredge footprint (WQMA-B) provided that total suspended solids (TSS) is controlled (i.e. 75 mg/L TSS maximum). A TSS concentration of 40 mg/L will be used to manage day-to-day dredging within WQMA-A. • To facilitate dredge material dewatering, the contractor may elect to mix additives with the sediments to bind available water during offloading and/or stockpiling operations. • Any water from the dredged sediment that drains off during offloading and stockpiling will be collected and treated as necessary to comply with provincial and/or local water discharge regulations.	• Dredge sediment dewatering is not a requirement of the Project but can be implemented if desired by the contractor. • Dredged material may be either passively dewatered on the dredge barge or collected for treatment prior to discharge, depending on the area, following the decision framework outlined in Annex B. Results from recent dredging projects in Esquimalt Harbour suggest that some sediments may contain dissolved concentrations of metals, PAHs and PCBs that have the potential for acute toxicity to marine life under the evaluated conditions. Site-specific evaluation of each of the proposed dredge units for the Project was undertaken as part of a barge dewatering assessment to develop appropriate mitigation measures. The results of the assessment were incorporated into site-specific mitigation measures including the development of a Water Quality Monitoring Plan with a decision framework for managing dredging and dewatering. • Passive dewatering consists of drainage of dredge effluent water through filter media (such as filter fabric) back into the Work Zone.

<table>
<tr><th>Project Component</th><th>CJML</th><th>YJLC</th></tr>
<tr><td>Placement of material</td><td>• Following dredging and contingency re-dredging, a combination of different types of backfill material and engineered cap materials will be placed.
• Material will be placed in the water from a barge.</td><td>• Following dredging and contingency re-dredging, a combination of different types of backfill material and engineered cap materials will be placed.
• Material will be placed in the water from a barge. Riprap maybe placed from the shore.</td></tr>
<tr><td>In-water transportation</td><td colspan="2">• In-water transportation from the dredging location to the processing facility and the contractor off-site offload facility will occur in a sealed watertight barge with sidewalls. Route to be determined by contractor.</td></tr>
<tr><td>Offloading, stockpiling and processing</td><td colspan="2">• The contractor must provide a contractor off-site offload facility to be used to transfer materials between the contractor’s floating equipment and land.
• The dredged sediment and debris will be offloaded at the off-site offload facility and may be loaded directly onto trucks or rail cars or may be placed into a constructed stockpile storage area.
• Stockpiling of existing site armour for re-use and of clean material for engineered capping material placement may be permitted adjacent to the Y jetty steep shoreline DUs (DUs 29 and 30) upon acceptance by the DR.
• The contractor must provide a Processing Facility to segregate out all suspected UXO greater than 6 mm.
- Processing of sediment and debris to remove suspected UXO may occur before or after offloading. The contractor may perform processing on a floating platform in Esquimalt Harbour or at a processing facility at an upland site after offloading from the barge. The upland processing facility must be located within the area of responsibility for DND’s Explosive Ordnance Disposal Team based at the Pacific Fleet Diving Unit.</td></tr>
<tr><td>Upland transportation</td><td colspan="2">• Sediment and debris from the sediment stockpile will be transported by barge, truck or rail to the permitted disposal facility.
• The contractor will be responsible for the safe transport of all waste (e.g., contaminated sediment, effluent, and debris) in accordance with all applicable regulations and guidelines.
• Dredged material will be transported in accordance with applicable municipal, provincial or federal regulations and legislation, including applicable United States legislation if transported there for disposal.</td></tr>
<tr><td>Disposal</td><td colspan="2">• The disposal facility will be chosen by the contractor and may be located in Canada or the United States. The disposal facility must hold a valid permit from a facility regulator for the handling, processing, treatment, or disposal of contaminated material, and be accepted by DND. The facility regulator may be a provincial or territorial ministry, Indigenous and Northern Affairs Canada, a relevant First Nation Council, or a relevant state or federal authority in the United States, as defined in the Project specifications. No recycling of dredge material or debris is allowed. Any discharges of dewatering effluent at the receiving facility will be in accordance with the permit requirements of that facility.
• No material designated for the removal from the Project Area has been identified as Hazardous Waste Quality Materials under the British Columbia Hazardous Waste Regulation (BC HWR), with the potential exception for the Leachable Metals Area material. If hazardous waste is encountered during construction, it will be disposed of at a facility authorized to treat, destroy, and dispose of Class 9 Solid Waste, as defined by the Hazardous Waste Regulations (BC Reg. 63/88, including amendments up to BC Reg. 179/2016, (2016)) if disposal in BC is contemplated. Disposal outside BC will be carried out under the applicable laws and regulations at the receiving site.</td></tr>
</table>

LEGEND

- REMEDIATION FOOTPRINT
- APPROXIMATE AREA OF TEMPORARY MOORING PILES

REFERENCE(S)

1. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
2. C JETTY AND ML FLOATS MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "xC Jetty Dredge_Tender_20180521.dwg"
3. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "xY Jetty DP_Jun2017.dwg"

0 25 50

1:750 METRES

CLIENT
PUBLIC SERVICES AND PROCUREMENT CANADA

PROJECT
ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

CONSULTANT

GOLDER

YYYY-MM-DD	2018-08-20
DESIGNED	V. LAWRENCE
PREPARED	J. FARAH
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

TITLE
PROJECT AREA - C JETTY AND ML FLOATS

PROJECT NO.	PHASE/TASK	REV.	FIGURE
18101029	2000/2001	0	2

Path: \\golder.gds\gal\Victoria\CAD-GIS\Client\PSPC\Esquimalt_Harbour\99_PROJECTS\18101029_EHRP\02_PRODUCTION\2000\2001_EED\ | File Name: 18101029-2001-02.dwg | Last Edited By: pqajouhesh Date: 2018-08-20 Time:3:10:56 PM | Printed By: BMasongsong Date: 2018-08-20 Time:3:51:24 PM

25 mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

LEGEND

REMEDIATION FOOTPRINT

0 25 50

1:750 METRES

REFERENCE(S)

1. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
2. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "AQ_Dredge Prism_20180618_Draft100PCT.DWG"

CLIENT
PUBLIC SERVICES AND PROCUREMENT CANADA

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-20
DESIGNED	V. LAWRENCE
PREPARED	J. FARAH
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

PROJECT
ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

TITLE
PROJECT AREA - Y JETTY AND LANG COVE

PROJECT NO.	PHASE/TASK	REV.	FIGURE
18101029	2000/2001	0	3

25 mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

Path: \\golder.gds\gal\Victoria\CAD-GIS\Client\PSPC\Esquimalt_Harbour\99_PROJECTS\18101029_EHRP\02_PRODUCTION\2000\2001_EED\ | File Name: 18101029-2001-02.dwg | Last Edited By: ppajouhesh Date: 2018-08-20 Time:3:10:56 PM | Printed By: BMasongsong Date: 2018-08-20 Time:3:51:44 PM

2.1.2 Project Schedule

The CJML sub-project started in June 2018 and is expected to continue until April 2019.

The YJLC sub-project is expected to be undertaken from December 2018 to the end of March 2020.

2.1.3 Timing Windows for Protection of Fish

DFO recommends using timing windows for work in and near water to help protect fish and fish habitat. Timing windows vary by DFO management area in BC. The marine/estuarine timing window for the management area that the EHRP is in (Area 19) is as follows (DFO 2014a):

- Summer Work Window: 1 July – 1 October
- Winter Work Window: 1 December – 15 February

Work windows are intended to provide windows of least risk to sensitive fisheries resources that may use the area. For example, in Esquimalt Harbour 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.

All in-water work including sediment dredging, structure removal and reinstatement, and backfill and material placement are planned to occur both inside and outside of the timing window with the application of appropriate mitigation measures, with the exception of impact pile driving of steel piles should it occur. Impact pile driving of steel piles, if it occurs, will not take place between April 1 and May 31 due to potential effects from underwater noise on fisheries resources in Esquimalt Harbour. The April 1 to May 31 time period is particularly sensitive due to the potential for herring spawning and out-migration of juvenile salmon in Esquimalt Harbour. Vibratory pile driving and impact pile driving of timber piles will still occur outside the window.

2.2 Identification of Valued Ecosystem Components (VECs)

This EED considers changes to the biophysical environment caused by the EHRP, as well as resultant effects on the socio-economic environment by scoping for appropriate Valued Ecosystem Components (VECs) (Table 2). For the EHRP, the criteria used to select VECs were based on ecological importance and/or value to the existing environment, the relative sensitivity of environmental components to Project influences and their relative social, cultural, or economic importance. Also included are components of the socio economic environment that may be affected by a change in the environment as a result of the Project. VECs for the EHRP were chosen using the checklist below. Consideration was made for all aspects of the EHRP components.

Table 2. Environmental Effects Matrix

PROJECT COMPONENTS	VALUED ECOSYSTEM COMPONENTS (VEC)															
	PHYSICAL			BIOLOGICAL						SOCIAL AND CULTURAL						
	Atmosphere	Surface Water	Substrate	Marine Vegetation	Marine Invertebrates	Fish	Marine Mammals	Birds	Species at Risk	Transportation	Navigation	Commercial, Recreational and	Land/Marine Recreation	In-Air Noise, Light and Odour	First Nations Traditional Lands/Resources	Archaeology
Mobilization and demobilization	X	X						X			X	X		X	X	
Contractor vessel mooring and anchoring	X			X	X	X					X	X		X	X	
Structure demolition/removal, relocation, reinstatement	X	X		X	X	X	X	X	X		X	X		X	X	X
Dredging and debris removal	X	X	X	X	X	X	X	X	X		X	X		X	X	X
Excavation	X	X	X	X	X	X						X	X	X	X	X
Dewatering of dredge material	X	X		X	X	X	X	X	X		X	X		X	X	X
Placement of material	X	X		X	X	X	X	X	X		X	X		X	X	X
In-water transportation	X	X						X			X	X	X	X	X	
Offloading, stockpiling, processing	X	X						X						X	X	X
Upland transportation	X									X				X	X	
Disposal	X													X	X	

Legend: [*Blank*] = No Effect; [X] = Potential Adverse Effect

2.3 Description of Valued Ecosystem Components

2.3.1 Physical Components

2.3.1.1 Overview

Esquimalt Harbour is a sheltered marine body of water that is 3.4 km^2 in area with 20 km of shoreline (CRD 2016a). The harbour entrance, Royal Roads passage, connects to the Strait of Juan de Fuca. Over the past 160 years, various industries have operated in the harbour (CRD 2016a). Past and present industrial activities and log storage have physically impacted large portions of the harbour, resulting in sediment contamination and accumulation of wood debris on the seafloor (CRD 2016a). Some important natural features remain in the harbour including intertidal mud flats and pocket beaches (CRD 2016a).

2.3.1.2 Atmosphere

Esquimalt Harbour lies in the Coastal Douglas Fir Biogeoclimatic Zone which experiences warm dry summers and mild wet winters (Nuszdorfer et. al. 1991). The daily average temperature in Victoria (Victoria Marine Station # 1018642) ranges from 4.4 to 14.3°C, while average monthly precipitation ranges from 23.2 mm in summer months to 228.4 mm in winter months (Environment Canada [EC] 2010a).

2.3.1.3 Surface Water

The main body of Esquimalt Harbour has an average depth of 10 m below CD in open-water areas, and is deepest near the mouth of the harbour (16 m) and shallowest towards Price Bay at the northern extent of the harbour.

Surface water in Esquimalt Harbour exchanges with waters of the Strait of Juan de Fuca through the harbour entrance, Royal Roads passage, which is approximately 750 m across. The relatively wide entrance of the harbour allows the tidal regime of the harbour to match surrounding areas outside the harbour.

Part of the freshwater input into Esquimalt Harbour comes from Millstream Creek which flows into the harbour at the northwest end (MOE 2016a). Several other smaller creeks also flow into the harbour at the northwest end (MOE 2016a).

Tides/Currents

Based on Canadian Tide and Current Tables, Esquimalt Harbour's mean tide is 1.8 m (relative to chart datum) with a reported large tide of 3.1 m. The mean tide higher high water is 2.5 m, and the large tide higher high water is 3.4 m. The mean lower low water is 0.7 m, and the large tide lower low water is 0.1 m (DFO 2010a).

An investigation of currents and tidal effects in the harbour was conducted in 2010 (Golder 2011a). A vessel mounted acoustic doppler current profiler was towed along five survey lines to determine current speeds and direction over an entire tidal cycle. Exchange of water through the mouth of the harbour during peak flood and ebb tidal periods resulted in depth-averaged current speeds in excess of 1 m/s near the mouth of the harbour. For most of the harbour, the measured currents were shown to be typically weak and variable in direction (Golder 2011a).

Water Quality

There are limited sediment inputs to Esquimalt Harbour from upland areas, such as creeks and stormwater runoff; therefore, there is a low natural sediment deposition rate in Esquimalt Harbour. Migration of contaminated sediment in the harbour is primarily driven by propeller-induced re--suspension of seabed sediments resulting from vessels moving around the harbour. Once suspended in the water column, tidal and wave-driven currents cause these suspended sediments to drift within the surrounding harbour.

TSS and turbidity measurements collected in Esquimalt Harbour over a two month period (October to December 2010) indicate that Esquimalt is relatively clear (i.e., turbidity was less than 6.4 nephelometric turbidity units (NTU) for 95% of the measurements collected), although turbidity spikes of up to 400 NTU may occur possibly related to vessel prop-wash and wind and wave events (Golder 2011b).

Water quality data for Esquimalt Harbour are available from surface water samples collected during multiple separate investigations between 2005 and 2014. Dissolved concentrations of mercury (SLR 2008) and tributyltin (Golder 2006a, b) exceeded CCME water quality guidelines for the protection of aquatic life in a small number of the samples collected.

2.3.1.4 Substrate

Much of the shoreline of Esquimalt Harbour has been altered by dredging and filling to support industrial and naval activities; however, there is natural shoreline on the west and northeast sides (CRD 2016a). Past and present industrial activities and log storage have physically impacted portion of the harbour, causing contaminants to accumulate in the sediment and log debris to accumulate on the sea floor (CRD 2016a). The dominant subtidal substrate type in the harbour is fine sediment (gravel, sand, mud) (CRD 2016a). Other subtidal substrate types include wood debris and rock (CRD 2016a).

C Jetty and ML Floats

Intertidal and subtidal substrate in and adjacent to the CJML sub-project area was characterized in Jan/Feb 2016 (Figure 4; Golder 2016a). The remediation footprint is mostly subtidal in this sub-project area and mainly consisted of sand/silt/mud substrate with some cobble/gravel/sand. Along the shoreline, adjacent to the remediation footprint, is a riprap slope. To the east of ML Floats, and outside of the sub-project area, a bedrock outcrop was mapped on figures in Anchor QEA 2016c (Figure 4).

The highest chemistry concentrations in sediment within the CJML sub-project area are present in areas that historically have had the highest vessel activity including vessel berthing and maintenance (Anchor QEA 2017a). Metals, PAHs, and PCBs exceeded PELs in the sub-project area (Anchor QEA 2017a). Surface sediment contamination is generally low, with exception of the nearshore areas adjacent to the marine railway and ML Floats (Anchor QEA 2017a). Subsurface sediment concentrations are on average higher than surface sediment concentrations in areas where historical activities were conducted and subsequent deposition of clean sediment buried the historical contamination (Anchor QEA 2017a).

Majority of debris in CJML sub-project area was located around ML Floats which included remnants of old piers, concrete anchor footing, scaffolding and metal frames (Anchor QEA 2016c).

Y Jetty and Lang Cove

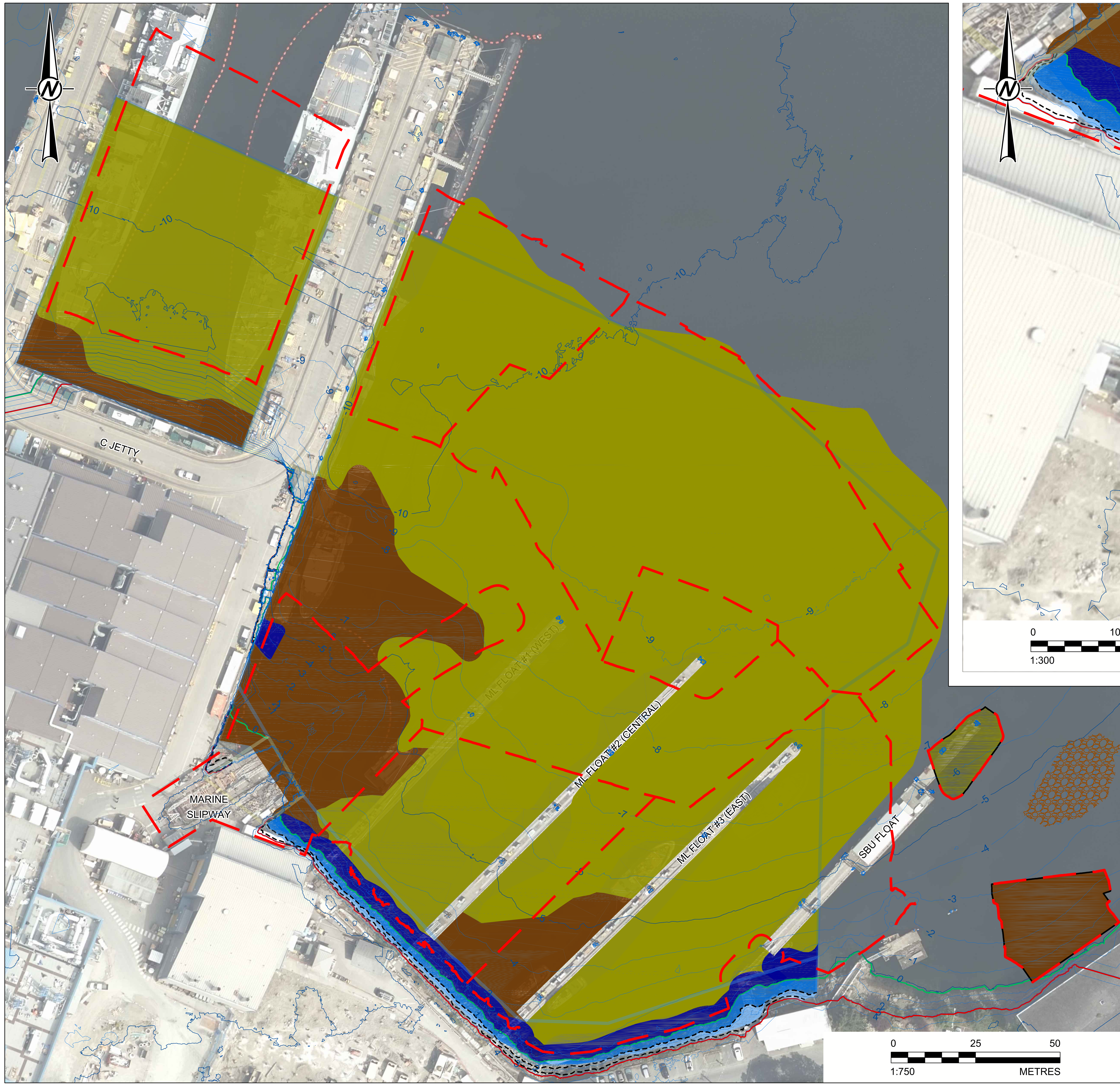
Intertidal and subtidal substrate in the YJLC sub-project area was characterized in Jan/Feb 2016 (Figure 5; Golder 2016a). Subtidal substrate in the Y Jetty area is mainly sand/silt/mud with several areas of cobble/gravel/sand. There are also boulder and bedrock outcrops. The intertidal area was composed of areas of sand/silt/mud, cobble/gravel/sand and boulder/riprap.

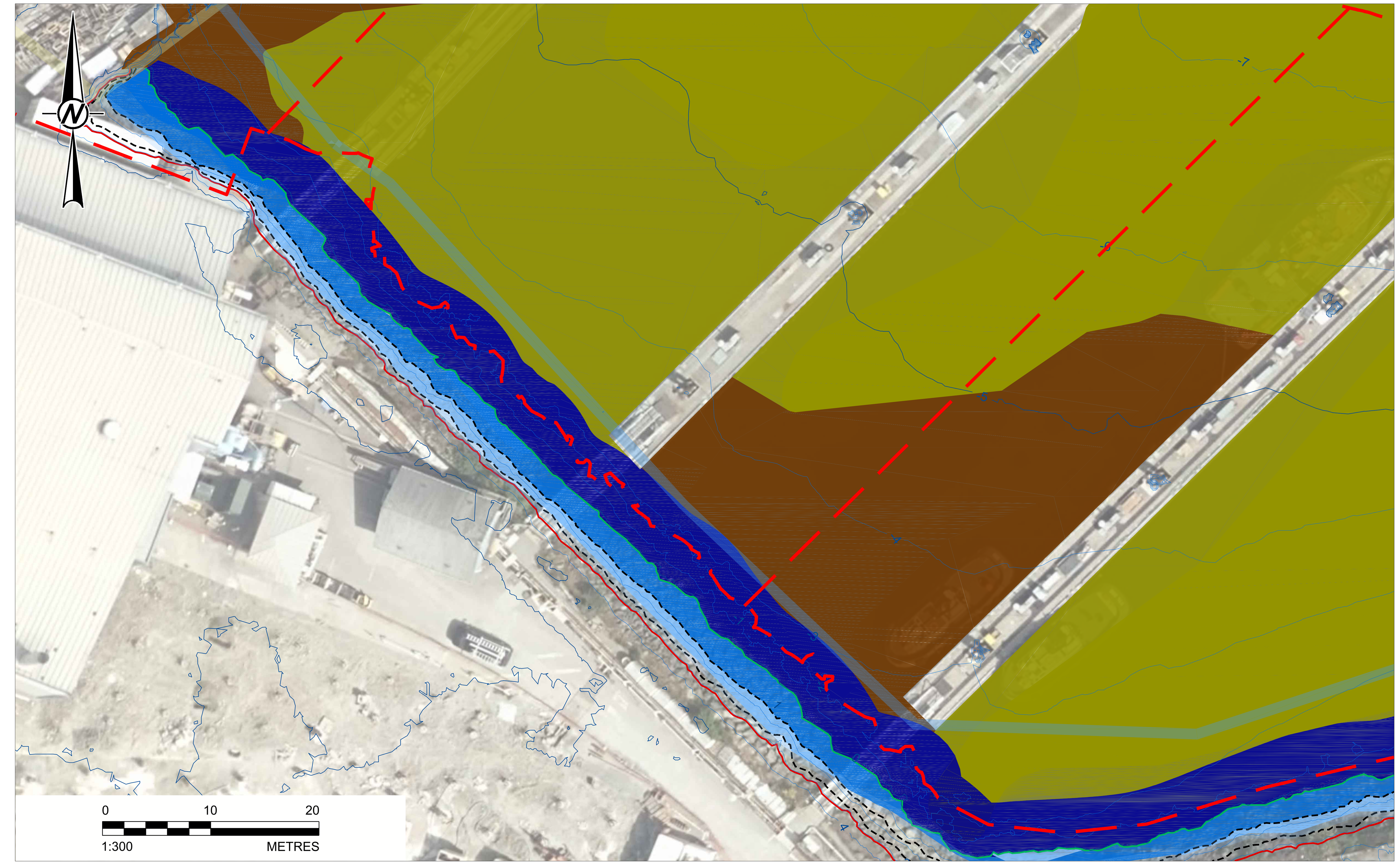
Debris is extensive and primarily consists of materials associated with the former jetty structure and marine railway including wood piles and steel railway tracks (Anchor QEA 2017b).

The subtidal area at South Lang Cove consisted of a mix of cobble/gravel/sand and sand/silt/mud. The intertidal area consisted predominantly rip-rap backshore with a mixed gravel, sand intertidal beach (Golder 2016a). This area is called Black Beach and is part of the habitat bank in Esquimalt Harbour (DFO 2011). A bedrock outcrop also exists in the intertidal area, and cobble and boulders are scattered throughout the beach.

The intertidal area at North Lang Cove consists of hard substrate which transitions to soft substrate in the subtidal area (Golder 2016a). A small boulder area was observed further offshore (Golder 2016a). Buried riprap counterweight also exists in Lang Cove which was originally intended for fish habitat banking purposes before it became buried (Anchor QEA 2017b).

Debris in the Lang Cove area consisted of timber piles and planks, as well as large concrete anchor blocks and mooring chains (Anchor QEA 2017b).





LEGEND

REMEDIATION FOOTPRINT

FROM TETRATECH:

BEDROCK

UPPER INTERTIDAL (3.1 TO 2.6 m CD):

HIGH HIGH WATER LEVEL

BEDROCK, BOULDER AND RIPRAP

MID INTERTIDAL (2.6 TO 1.6 m CD):

ELEVATION CONTOUR: 2.6 m CD

BEDROCK, BOULDER AND RIPRAP

LOW INTERTIDAL (1.6 TO 0.1 m CD):

ELEVATION CONTOUR: 1.6 m CD

BEDROCK, BOULDER AND RIPRAP

SUBTIDAL (LESS THAN 0.1 m CD):

ELEVATION CONTOUR: 0.1 m CD

SAND, SILT AND MUD

COBBLE, GRAVEL AND SAND

BEDROCK, BOULDER AND RIPRAP

REFERENCE(S)

1. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
2. SURFACE CONTOURS EXTRACTED FROM DIGITAL DATA DOWNLOADED FROM SLR CONSULTING'S EXAVAULT ESQUIMALT HARBOUR REMEDIATION PROJECT FTP SITE. ACCESSED 2016-03-03; FILENAME: "CONSTANCECOVEELEVATIONSURFACE.TIF". THE COMPOSITE SURFACE WAS USED AS-IS ASIDE FROM ADJUSTING TO CHART DATUM USING A CONVERSION VALUE OF 1.885 m.
3. FROM ANCHOR QEA/KLOHN CRIPPEN BERGER DIGITAL CAD FILES. "REQUIRED BACKFILL PLAN"; DWG. NO.: C-6; DATED: "2016-11-15"; REVISION 0: 60% DESIGN REVIEW':
   3.1. BEDROCK LIMITS FROM TETRATECH; FROM: "xBedrock_Tetratech.dwg"; LEGEND: "APPROXIMATE AREA OF BEDROCK ABOVE MUDLINE (2013-2016)"
4. DIGITAL CAD FILES OBTAINED FROM ANQOR QEA:
   4.1. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) "AQ_Y Jetty Dredge Prism_20170710_UTM10_NAD83_CD"
   4.2. C JETTY AND ML FLOAT MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) "xC Jetty Dredge_Tender_20180521.dwg"
5. APPROXIMATE LOCATION OF RIP RAP COUNTERWEIGHT AND EXISTING RIP RAP SLOPE PROTECTION (DO NOT DISTRUBED) DIGITIZED FROM ANCHOR QEA DRAWING "EXISTING CONDITIONS"; DATED: 2016/12/02; REVISION 0: ISSUED FOR REVIEW; DWG. NO.: G-1.

NOTE(S)

1. SURFACE CONTOURS SHOWN IN 1 m (MINOR) AND 5 m (MAJOR) INTERVALS. ELEVATIONS SHOWN RELATIVE TO CHART DATUM.

CLIENT
PUBLIC SERVICES AND PROCUREMENT CANADA

PROJECT
ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-20
DESIGNED	V. LAWRENCE
PREPARED	J. FARAH
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

TITLE
HABITAT CHARACTERIZATION - C JETTY AND ML FLOATS

PROJECT NO.	PHASE/TASK	REV.	FIGURE
18101029	2000/2001	0	4

FIGURE 4: Y JETTY LANG COVE SUBSTRATE AND UNDERSTORY KELP

LEGEND

MARINE FOOTPRINT

BATHYMETRIC CONTOUR (1m)

SUBSTRATE

SAND AND SILT

COBBLE, GRAVEL AND SAND

BOULDER AND/OR RIPRAP

BEDROCK

0 30 60

1:1,500 METRES

REFERENCE(S)

1. IMAGERY OBTAINED FROM THE CAPITAL REGIONAL DISTRICT WMS.
2. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "AQ_Y JETTY DREDGE PRISM_20180305_UTM10_N83_CD.DWG".

COORDINATE SYSTEM: NAD 1983 CSRS UTM ZONE 10N

CLIENT
PUBLIC SERVICES AND PROCUREMENT CANADA

PROJECT
ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-02
DESIGNED	VL
PREPARED	JP
REVIEWED	VL
APPROVED	BW

TITLE
HABITAT CHARACTERIZATION – Y JETTY AND LANG COVE

PROJECT NO.	PHASE	REV.	FIGURE
18101029	2000/2001	0	5

2.3.2 Biological Components

2.3.2.1 Overview

Despite the physical alteration of Esquimalt Harbour and contamination of sediment, several key biological resources remain in the harbour including kelp beds, bird foraging and nesting habitat, small eelgrass beds, Dungeness crab habitat, salmon spawning stream and herring spawning habitat (CRD 2016a).

Several marine biophysical surveys have been conducted in and adjacent to the sub-project areas to determine what biological resources occur in those areas. For the CJML sub-project area, the following surveys were undertaken:

- In the fall of 2012, Balanced Environmental Services Inc. (BES) conducted dive transect surveys in the sub-project area (BES 2012a).
- In the winter of early 2016, Golder characterized marine vegetation through towed video and dive transect surveys of the sub-project area (Golder 2016a). This survey was conducted at a time of year when marine vegetation may not have been at its peak density. Phase I and Phase II abalone surveys following protocols in DFO 2007 were conducted as part of these surveys.
- In the summer of 2016, Archipelago conducted towed video and dive surveys of a portion of the sub-project area that was originally outside of the sub-project area, and an adjacent area for a separate project (Archipelago 2016). A Phase II abalone survey following protocols in DFO 2007 was conducted as part of these surveys.

For the YJLC sub-project area, the following surveys were undertaken:

- In summer 2000, Archipelago conducted dive surveys in Lang Cove (Archipelago 2000).
- In the fall of 2012, Balanced Environmental Services Inc. (BES) conducted dive transects in the sub-project area (BES 2012b).
- In winter of early 2015, Golder conducted dive surveys of Lang Cove (Golder 2015a).
- In the winter of early 2016, Golder conducted towed video and dive surveys of the sub-project area (Golder 2016a). This survey was conducted at a time of year when marine vegetation may not have been at its peak density. Phase I and Phase II abalone surveys following protocols in DFO 2007 were conducted as part of these surveys.
- In the summer of 2016, Archipelago conducted towed video and dive surveys of a portion of the sub-project area and an adjacent area for a separate project (Archipelago 2016). A DFO Phase II abalone survey following protocols in DFO 2007 was conducted as part of these surveys.
- In the summer of 2017, Archipelago conducted surveys for eelgrass in Lang Cove (DCC pers. comm.).
- In the summer of 2018, Golder conducted surveys for kelp in YJLC and DU 16 and 17 of CJML (Golder 2018).

2.3.2.2 Marine Vegetation

<u>Overview</u>

Key marine vegetation in BC that provide food and shelter for numerous marine species includes kelp, eelgrass and tidal salt marsh vegetation. Kelp are brown algae that grow on rocky substrate.

Canopy forming species, *Nereocystis luetkeana* and *Macrocystis integrifolia*, can form large offshore or narrow, fringing beds along coastal BC. Understory kelp species, such as brown bladed kelps (e.g. sugar kelp [*Laminaria saccharina, recently renamed Saccharina latissima]* *and five rib kelp [Costaria costata])*, can also form beds on rocky substrate, and can form less dense patches on cobbles and boulders amongst softer substrates. Herring, salmon, surf smelt, sand lance, abalone, and sea urchins are among the important species to use kelp (Lucas et al. 2007).

Eelgrass is a marine flowering plant that forms beds mainly in soft sediments in the lower intertidal and shallow subtidal zones down to 6 m below CD. Eelgrass beds play an important ecological role in providing sediment stabilization and providing habitat for waterfowl, crab, herring and juvenile salmon (Lucas et al. 2007).

Tidal or salt marshes form along shallow-sloped coasts with a source of sediment from streams or rivers, or deposited along the shore by wave action and currents (CRD 2016b). These marshes provide habitat for various birds, invertebrates and fish including great blue herons, crab, herring and salmon (CRD 2016b).

The presence of kelp, eelgrass, and salt marsh plants in the two sub-project areas is outlined below.

C Jetty and ML Floats

No canopy forming kelp, eelgrass or saltmarsh vegetation have been observed in the CJML sub-project area; however, understory brown bladed kelp has been observed in a portion the area (BES 2012a; Archipelago 2016; Golder 2016a).

During dive transects in winter 2016, understory brown bladed five rib kelp was observed on boulder/cobble with 5 to 25% cover in a small area between C Jetty and ML Float #1 (Figure 6). During towed video surveys, understory brown bladed sugar kelp was observed in patchy distribution between C Jetty and ML Float #1 and east of the SBU Float on boulder/cobble. The areas within C Jetty, between ML Floats #2 and #3, and offshore of the ML Floats were generally devoid of any attached macroalgae.

In summer 2016, understory brown bladed kelp (mostly sugar kelp) was observed with mostly >75% cover east of SBU Float in Dredge Unit 16 (Archipelago 2016). Some understory kelp was also observed in Dredge Unit 17 (Archipelago 2016). Golder re-surveyed these two dredge units in summer 2018. In Dredge Unit 16, 50-75% cover of understory kelp was observed over a large portion of the area, while in Dredge Unit 17, no understory kelp was observed (Figure 6; Golder 2018).

Y Jetty and Lang Cove

No canopy forming kelps have been observed in the area; however, understory brown bladed kelp has been observed in several areas (BES 2012b; Archipelago 2016; Golder 2016a; Golder 2018). The survey by Golder in summer 2018 found understory kelp west of Y Jetty at 75-100% cover and in Lang Cove at 10-25% cover (Figure 7; Golder 2018).

Sparse eelgrass was observed in Lang Cove in 2000, but it has not been observed in subsequent surveys. In spring/summer 2000, two areas of eelgrass (*Zostera marina*) were observed in Lang Cove with sparse cover (<5%) (Archipelago 2004). One area was observed in southern Lang Cove (estimated at 810 m^2) which is adjacent to the sub-project area, and one in northern Lang Cove (estimated at 620 m^2) which partially overlaps with the sub-project area (Figure 7; Archipelago 2004). Elevation of eelgrass ranged from +0.3 to -0.9 m CD (Archipelago 2004). Surveys by Balanced in October 2012, and by Golder in February 2015 and February 2016 did not observe eelgrass in Lang Cove. A survey by Archipelago in June 2017 and by

Golder in 2018 also did not observe eelgrass in Lang Cove (DCC pers. comm.; Golder 2018). Eelgrass abundance varies seasonally with re-growth in the spring / summer and die-off in the winter. There is considerable annual variation in abundance due to a variety of factors, including (but not limited to) physical and chemical disturbance, changes in nutrient availability, and changes in-water quality parameters such as salinity and turbidity. These factors can result in long term changes in eelgrass abundance if the unfavourable conditions persist. Lack of eelgrass observations during recent surveys could be attributed to seasonality and the timing of the surveys, but other factors, including sediment contaminants, could result in eelgrass decline. Given the patchy, discontinuous nature of the eelgrass documented in Lang Cove in 2000, and the absence of eelgrass during recent surveys, the conditions for eelgrass growth may not be optimal.

A small area of tidal salt marsh vegetation was observed in south Lang Cove in the area called Black Beach. Within the western corner of the beach, there was an area of orache spearscale (*Atriplex patula*) and a small patch of salt grass (*Distichlis spicata*; approximately 2 m^2) (Golder 2016b). Black Beach is part of the habitat bank in Esquimalt Harbour (DFO 2011).

LEGEND

REMEDIATION FOOTPRINT

SUBSTRATE

SAND AND SILT

COBBLE, GRAVEL AND SAND

UNDERSTORY KELP

UNDERSTORY BLADED KELP (<50-75% COVER)

GOLDER WINTER 2016 SURVEY:

DIVE TRANSECT

5-25% COVER

TOWED VIDEO KELP OBSERVATION

REFERENCE(S)

1. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
2. C JETTY AND ML FLOATS MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "xC Jetty Dredge_Tender_20180521.dwg"
3. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA "AQ_Y JETTY Backfill Plan_20161121.dwg"
4. ARCHIPELAGO SPRING/SUMMER 2000 SURVEY: HAND-DIGITIZED FROM THE CAPITAL REGIONAL DISTRICT (CRD) HARBOURS ATLAS; ACCESSED 2016-12-06; BLADED KELPS (LAMINARIA SP.) AND EELGRASS (ZOSTERA SPP.)

0 25 50

1:750 METRES

CLIENT

PUBLIC SERVICES AND PROCUREMENT CANADA

PROJECT

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CONSULTANT

GOLDER

YYYY-MM-DD	2018-08-20
DESIGNED	V. LAWRENCE
PREPARED	J. FARAH
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

TITLE

MARINE VEGETATION TYPES - C JETTY AND ML FLOATS

PROJECT NO.	PHASE/TASK	REV.	FIGURE
18101029	2000/2001	0	6

FIGURE 4: Y JETTY LANG COVE SUBSTRATE AND UNDERSTORY KELP

LEGEND

MARINE FOOTPRINT
BATHYMETRIC CONTOUR (1m)

SUBSTRATE

Sand and Silt
Cobble, Gravel and Sand
Boulder and/or Riprap
Bedrock

UNDERSTORY KELP

10 - 25% Cover
>25 - 50% Cover
>50 - 75% Cover
>75 - 100% Cover

Location	Kelp Coverage (%)	Area (m^2)
North Lang Cove	10 - 25	1132.2
South Lang Cove	10 - 25	411.9
South Y Jetty	>75 - 100	3665.0

0 30 60
1:1,500 METRES

REFERENCE(S)
1. IMAGERY OBTAINED FROM THE CAPITAL REGIONAL DISTRICT WMS.
2. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "AQ_Y JETTY DREDGE PRISM_20180305_UTM10_N83_CD.DWG".
COORDINATE SYSTEM: NAD 1983 CSRS UTM ZONE 10N

CLIENT
PUBLIC SERVICES AND PROCUREMENT CANADA

PROJECT
ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-02
DESIGNED	VL
PREPARED	JP
REVIEWED	VL
APPROVED	BW

TITLE
MARINE VEGETATION – Y JETTY AND LANG COVE

PROJECT NO.	PHASE	REV.	FIGURE
18101029	2000/2001	0	7

2.3.2.3 Marine Invertebrates

Overview

Marine invertebrates harvested in BC include clams, shrimp, prawns, geoducks, sea cucumbers, crabs, krill, scallops and sea urchins (DFO 2014b). Harvestable marine invertebrate species known to occur in Esquimalt Harbour include clams, shrimp, prawn, sea cucumber, crab, scallop and sea urchin (SLR 2016). However, due to the presence of contaminants in marine sediments, a Fisheries Notice (FN0807) Consumption Advisory for Esquimalt Harbour, dated 9 October 2009, recommended limiting consumption of Dungeness crab), red rock crab, sea urchin roe and rockfish*)* harvested from Esquimalt Harbour by recreational fishers and subsistence populations. DFO has also enacted a permanent prohibited area (no harvesting for any purpose) on the basis of a sanitary closure, for any and all bivalve fishing within DFO Fisheries Management Subarea 19-2 – Esquimalt Harbour (DFO 2016a).

Two marine invertebrate species at risk occur in BC (MOE 2016b). These two species are outlined in Table 3 below along with their occurrence in Esquimalt Harbour.

Table 3: Marine Invertebrate Species at Risk in Esquimalt Harbour

Common Name	Scientific Name	BC CDC List	COSEWIC Status	SARA Schedule / Status	Occurrence in Esquimalt Harbour
Northern abalone	*Haliotis kamtschatkana*	Red	T	1-E	Known to occur in Esquimalt Harbour including near D Jetty and ML Floats.
Olympia oyster	*Ostrea lurida*	Blue	SC	1-SC	Past occurrence in Esquimalt Harbour, but none have been recently observed.

Notes:
CDC – Conservation Data Centre; COSEWIC – Committee on the Status of Endangered Wildlife in Canada; SARA – *Species at Risk Act*; SC – special concern; T – threatened; E=Endangered

The presence and potential presence of key marine invertebrates and invertebrate species at risk in the two sub-project areas are outlined below.

No records of marine invasive invertebrate species were found for Esquimalt Harbour, but they have been observed in coastal BC. The following marine invasive invertebrate species have been observed in BC (DFO 2018):

- Clubbed tunicate (*Styela clava*) has been observed in various locations in the Strait of Georgia
- European green crab (*Carcinus maenas*) has been observed along the west coast of Vancouver island
- Golden star tunicate (*Botryllus schlosseri*) has been observed in the Strait of Georgia and the west coast of Vancouver Island
- Japanese Skeleton Shrimp (*Caprella mutica*) has been observed in BC
- Pancake Batter Tunicate (*Didemnum vexillum*) has been observed in the Strait of Georgia and the west coast of Vancouver Island

- Violet tunicate (*Botrylloides violaceus*) is widely distributed in BC with reports from the Strait of Georgia, West Coast of Vancouver Island, the North Coast, and most recently Haida Gwaii

C Jetty and ML Floats

An area containing horse clams was identified within a transition zone of boulder/bedrock and mixed substrate habitat in the nearshore area between C Jetty and ML Float #1 during towed video surveys in winter 2016 (Golder 2016a). The area with horse clams was estimated to be 631 m^2, and the mean density of horse clams was estimated to be 0.56 clams/m^2.

Other invertebrates observed in this area by Golder included shrimp, red rock crab, kelp crab, Dungeness crab, graceful decorator crab, green sea urchin, burrowing sea cucumber, and rock scallop (Golder 2016a).

During surveys conducted in the sub-project area, Northern abalone were observed in the ML Floats area. Northern abalone were observed between ML Float 1 and 3 by BES in 2012 (2012a) and by Golder in 2016 (Golder 2016a) (Figure 8). Three northern abalone were observed along the ML Floats in the shallow subtidal zone in 2012 (BES 2012a); however, it is not known at what depth these abalone were found.

During the abalone habitat reconnaissance survey in winter 2016, abalone were observed in loose aggregations in the nearshore boulder habitat in the ML Floats. Abalone were found in areas of boulder (75 to 100%) and cobble (0 to 25%) habitat with varying cover of encrusting coralline (*Lithothamnion sp.*) algae (1 to 25%) (Golder 2016a). Low cover of macroalgae (<1%) was observed along the nearshore boulder habitat as well as where abalone were observed. Taxa observed included Japanese weed, sea lettuce, bladed brown kelp (*Laminaria sp.*) and red algae. Abalone were observed in the shallow subtidal zone ranging from 0.0 to 0.8 m below CD. The five abalone documented had a size range from 52 to 156 mm shell length (SL). Abalone predators were not observed, nor were abalone observed in association with urchins (Golder 2016a). The boulder/riprap where the abalone were observed extends down to approximately -2.2 m CD, and there is potential for abalone to extend down to this depth on the riprap.

The other areas surveyed as part of the abalone habitat reconnaissance were assessed based on habitat features where abalone were found in the ML Floats area because indicators of potential abalone habitat based on DFO guidance were not observed. Specifically, coverage by brown bladed kelps and other macroalgae was low (<5%) or absent. Based on the observations at ML Floats, the habitat features indicated that these areas had potential to be abalone habitat; however, abalone were not observed during the survey. In areas where abalone were not observed, an increase in silt was present on the boulder/bedrock substrate potentially indicating low water exchange and/ or prop wash. Other limiting factors could be predator presence such as Dungeness crab and red rock crab (COSEWIC 2009). No abalone were found on the potential abalone habitat on the boulders adjacent to C Jetty (Golder 2016a).

No Olympia oysters were observed during the surveys of the sub-project areas (BES 2012a; Golder 2016a; Archipelago 2016).

Y Jetty and Lang Cove

A multi-species clam area was documented in the eastern area of Lang Cove in January 2015 (Golder 2015a). Species observed included horse clam, piddock clam (*Zirfaea pilsbryi*) and Nuttall's cockle (*Clinocardium nuttalli*). The size of the clam area was estimated to be 14,656 m^2, and the mean density of horse clams was estimated to be 0.21 clams/m^2.

Other invertebrates observed in this area by Golder included rock scallop, blue mussel, Dungeness crab, red rock crab, shrimp, and decorator crab (Golder 2016a).

No abalone or Olympia oysters were observed during the surveys of the sub-project area (BES 2012b; Golder 2016a, 2018; Archipelago 2016). Potential northern abalone habitat was identified within Y Jetty; however, targeted dive surveys conducted in the area found no abalone (Golder 2016a). No potential abalone habitat was identified in Lang Cove; therefore, they are not expected to be present within this area (Golder 2016a). As indicated above, in potential abalone habitat areas where abalone were not observed, an increase in silt was present on the boulder/bedrock substrate potentially indicating low water exchange and/ or prop wash. Other limiting factors could be predator presence such as Dungeness crab and red rock crab (COSEWIC 2009).

LEGEND

REMEDIATION FOOTPRINT

DFO HERRING SPAWNING AREA SURVEYS

AREAS WHERE HERRING HAVE BEEN OBSERVED TO SPAWN

GOLDER WINTER 2016 SURVEY:

★ ABALONE OBSERVATION LOCATION

BALANCED ENVIRONMENTAL 2012 SURVEY:

★ ABALONE OBSERVATION LOCATION

REFERENCE(S)

1. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
2. C JETTY AND ML FLOATS MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "xC Jetty Dredge_Tender_20180521.dwg"
3. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "AQ_Y Jetty_Backfill and Cap Design_20170110.dwg"
4. DFO HERRING SPAWNING AREA SURVEYS: DIGITIZED HERRING SPAWN POLYGONS DOWNLOADED FROM FISHERIES AND OCEANS CANADA. ACCESSED 2016-12-07, GROUP 1.
5. GOLDER WINTER 2016 SURVEY: FROM GOLDER REPORT 1545562-008-R-REVA-3000.
6. ABALONE LOCATIONS OBTAINED FROM BALANCED ENVIRONMENTAL, DWG No. 5442-D-01.2, DATED 19-NOV-12. ORIGINAL SCALE 1:3000.

0 25 50

1:750 METRES

CLIENT

PUBLIC SERVICES AND PROCUREMENT CANADA

PROJECT

ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

CONSULTANT

GOLDER

YYYY-MM-DD	2018-08-20
DESIGNED	V. LAWRENCE
PREPARED	J. FARAH
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

TITLE

NORTHERN ABALONE AND PACIFIC HERRING - C JETTY AND ML FLOATS

PROJECT NO.	PHASE/TASK	REV.	FIGURE
18101029	2000/2001	0	8

LEGEND

REMEDIATION FOOTPRINT

DFO HERRING SPAWNING AREA SURVEYS

AREAS WHERE HERRING HAVE BEEN OBSERVED TO SPAWN

0 25 50
1:750 METRES

REFERENCE(S)

1. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
2. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "AQ_Dredge Prism_20180618_Draft100PCT.DWG"
3. DFO HERRING SPAWNING AREA SURVEYS: DIGITIZED HERRING SPAWN POLYGONS DOWNLOADED FROM FISHERIES AND OCEANS CANADA. ACCESSED 2016-12-07, GROUP 1.
4. GOLDER WINTER 2016 SURVEY: FROM GOLDER REPORT 1545562-008-R-REVA-3000.

CLIENT
PUBLIC SERVICES AND PROCUREMENT CANADA

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-20
DESIGNED	V. LAWRENCE
PREPARED	J. FARAH
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

PROJECT
ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

TITLE
PACIFIC HERRING - Y JETTY AND LANG COVE

PROJECT NO.	PHASE/TASK	REV.	FIGURE
18101029	2000/2001	0	9

2.3.2.4 Fish

<u>Overview</u>

A summary of key anadromous and marine species in Esquimalt Harbour is outlined below.

Anadromous Fish

Key anadromous fish that occur around southern Vancouver Island include five salmonid species: chinook salmon, chum salmon, coho salmon, pink salmon, sockeye salmon, anadromous rainbow trout (called steelhead), and anadromous coastal cutthroat trout. Several of these salmonid species have been observed in Esquimalt Harbour.

Millstream Creek has contained coho salmon, steelhead and anadromous coastal cutthroat trout in the past. According to Habitat Wizard, there are historical records of coho salmon, anadromous coastal cutthroat trout and steelhead at the mouth of Millstream Creek (MOE 2016a). The one record in Habitat Wizard for anadromous cutthroat trout was from 1977, and the last record for steelhead was in 1994 (MOE 2016a).

Salmon escapement data from DFO indicates that coho salmon were present in 2007 when the stream was last surveyed (DFO 2016b). According to the CRD (2016c), Millstream Creek may have supported limited coho salmon runs in the past, despite natural waterfall barriers that likely limited their numbers. Changes to the water flows of the stream due to extensive impervious surfaces have made these barriers almost impassible (CRD 2016c). Some restoration work has been done to create fishways that bypass the barriers, and coho salmon have returned (CRD 2016c). The spawning population of coho salmon is approximately 150 and is not currently restocked (CRD 2016c). Based on this information, coho may still spawn in Millstream Creek and may still occur in Esquimalt Harbour. Adult coho would migrate through Esquimalt Harbour to Millstream Creek, while juveniles might rear and migrate out through the harbour.

Marine Fish

Key pelagic and benthic fish observed in Esquimalt Harbour include the following species (species observations by BES 2012b, SLR 2016, Archipelago 2016, Golder 2016b, 2018):

- Forage fish: Pacific herring (*Clupea pallasii*) and Pacific sand lance (*Ammodytes hexapterus*)
- Roundfish: lingcod (*Ophiodon elongates*)
- Rockfish: canary rockfish (*Sebastes pinniger*), brown rockfish (*Sebastes auriculatus*), copper rockfish (*Sebastes caurinus*), quillback rockfish (*Sebastes maliger*), vermilion rockfish, yellowtail rockfish (*Sebastes flavidus*) and black rockfish (*Sebastes melanops*).
- Flatfish: rock sole (*Lepidopsetta bilineata*), starry flounder (*Platichthys stellatus*), English sole and C-O sole
- Elasmobranch: North Pacific spiny dogfish (*Squalus suckleyi or Squalus acanthias*)

Pacific herring is a migratory schooling fish that moves closer to the coast during spawning. Herring congregate in large schools in the vicinity of spawning areas over the winter awaiting final maturation (Schweigert et al. 2007). On the BC coast, herring spawn in late winter, from February to as late as July, with the majority of spawning occurring in March and early April (Schweigert et al. 2007). Pacific herring have been known to spawn at various locations in Esquimalt Harbour (DFO 2016c), and have been observed in the harbour in the summer of 2016 (SNC-Lavalin 2016).

Pacific sand lance is an inshore schooling forage fish that is found primarily near sand and gravel substrates in sheltered areas at depths less than 50 m (Schweigert et al. 2007). They are thought to forage and spawn in close proximity to their burrowing habitat (Schweigert et al.

2007). They spawn annually primarily in the fall in the intertidal or subtidal zones on bottom substrates (Schweigert et al. 2007). Pacific sand lance have been observed inshore of F-Jetty reef, and in Plumper Bay (SLR 2016).

Lingcod are unique to the west coast of North America where adults live on rocky bottom habitat at depths of 10 to 100 m (DFO 2001). Starting in October, adults migrate to nearshore spawning grounds where males establish nest sites in strong current areas in rock crevices or on ledges (DFO 2001). Spawning takes place between December and March with males defending the nest until eggs hatch in March/April (DFO 2010b). Larvae are pelagic until late May/early June when they settle in areas near kelp and eelgrass beds as juveniles (DFO 2001). By September, juveniles are found in a wider range of flat bottom areas, and by age 2 they begin to inhabit substrates more similar to adults (DFO 2001). In Esquimalt Harbour, lingcod have been observed at C1 Reef, D1 Reef, F-Jetty Reef, Natural Reef, Whale Rock, Grant Knoll and Lang Cove (BES 2012b, SLR 2016).

Rockfish are generally long lived and slow growing and some can live over 100 years (Lucas et al. 2007). Rockfish have a pelagic larval or juvenile stage, and adults live in subtidal, shelf, or slope benthic habitats (Lucas et al. 2007). Six species of rockfish have been observed in Esquimalt Harbour, and three more have potential to occur, according to SLR (2016). No rockfish conservation areas exist in Esquimalt Harbour (DFO 2015).

Four species of flatfish have been observed in Esquimalt Harbour, and five more have potential to occur, according to SLR (2016). Species observed include rock sole, starry flounder, English sole and C-O sole (SLR 2016). They inhabit various bottom types including mud, sand and rock.

One elasmobranch, the North Pacific spiny dogfish, has potential to occur in Esquimalt Harbour (SLR 2016).

Fish Species at Risk

Twenty-four anadromous and marine fish at risk occur in BC (MOE 2016b; Government of Canada 2016). These species are outlined in Annex C. Of these twenty-four fish, four are known or have the potential to occur in Esquimalt Harbour which are outlined in Table 4.

Table 4: Anadromous and Marine Fish Species at Risk in Esquimalt Harbour

Common Name (Scientific Name)	BC CDC Status	COSEWIC status	SARA Schedule/ Status	Range and Habitat	Potential to Occur in Esquimalt Harbour
Canary Rockfish (*Sebastes pinniger*)	-	T	-	Larvae and pelagic juvenile occupy the top 100 m for up to 3-4 months after live-birth (parturition) and then settle to a benthic habitat. Adults typically inhabit rocky bottom in 70-270 m depth on the continental shelf.	Observed at C1 and C2 Reefs (Golder 2016b).

Common Name (Scientific Name)	BC CDC Status	COSEWIC status	SARA Schedule/ Status	Range and Habitat	Potential to Occur in Esquimalt Harbour
Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*)	Blue	-	-	Requires small, low gradient coastal streams and estuarine habitats. In marine habitats, generally remains close to the coast, usually remaining within estuary.	Potential to occur. Last observed in Millstream Creek outlet in 1977 (MOE 2016a).
North Pacific Spiny Dogfish (*Squalus suckleyi*)	-	SC	-	Occur on the continental shelf from intertidal to shelf slope including estuarine waters. They are opportunistic predators with a wide prey base and are not associated with any particular substrate type.	Potential to occur Esquimalt Harbour (SLR 2016).
Quillback Rockfish (*Sebastes maliger*)	-	T	-	Occur throughout coastal waters of BC. Young are pelagic before settling after 1 to 2 months near shore. Juveniles occur in shallower waters near shore and are associated with a variety of habitats. Adults observed over hard, complex substrates with vertical relief.	Known to occur. Observed at F-Jetty Reef, Natural Reef, Duntze Hd, Yew Pt and C1 and C2 subtidal rocky reefs (SLR 2016; Golder 2016b).

Notes:
CDC – Conservation Data Centre; COSEWIC – Committee on the Status of Endangered Wildlife in Canada; SARA – *Species at Risk Act*; SC – special concern; T - threatened; "-" – not assessed.

The presence and potential presence of key anadromous and marine fish and fish species at risk in the two sub-project areas are outlined below.

C Jetty and ML Floats

No anadromous species were observed during BES (2012a) or Golder (2016a) surveys in this sub–project area; however, there is potential for adult and juvenile Pacific salmon to occur based on habitat requirements.

Marine species observed by Golder (2016a) included snake prickleback, shiner perch, pile perch (*Rhacochilus vacca*), tubesnout (*Aulorhynchus flavidus*), northern ronquil (*Ronquilus jordani*), blackeye goby (*Coryphopterus nicholsi*), bay pipefish (*Syngnathus griseolineatus*), and tidepool sculpin (*Oligocottus maculosus*). During surveys in 2012, black rockfish, pile perch, saddleback gunnel (*Pholis ornate*) and several unidentified sculpins (*Cottoidea* spp.) were observed (BES 2012a).

Pacific herring have been observed to spawn in the sub-project area in 1993 (Figure 8; DFO 2016c). Pacific herring were observed near the SBU Float in summer 2016 (Archipelago 2016).

Other key marine species observed in the sub-project area include rockfish. Rockfish observed in the sub-project area include black rockfish. Of the listed rockfish species, quillback rockfish have potential to occur based on habitat requirements, but it has not been observed. Pacific sand lance have not been observed in this sub-project area (BES 2012a, Golder 2016a, SLR 2016a). Lingcod have not been observed in the sub-project area by Golder (2016a), BES (2012a), or SLR (2016). North Pacific spiny dogfish have not been observed in this sub-project area (BES 2012a, Golder 2016a, SLR 2016a); however, there is potential for them to occur based on habitat requirements.

Y Jetty and Lang Cove

Juvenile salmonids were observed near Y Jetty in April 2018 (pers. comm. Mike Waters, DND). The species of salmonid was not identified.

Marine species observed during 2016 surveys in the YJLC sub-project area included whitespotted greenling (*Hexagrammos stelleri*), shiner perch (*Cymatogaster aggregata*), and striped seaperch (*Embiotoca lateralis*) in boulder/bedrock habitat, and kelp greenling (*Hexagrammos decagrammus*), snake prickleback (*Lumpenus sagitta*), and kelp perch (*Brachyistius frenatus*) in soft sediment habitat (Golder 2016a). In 2012, grunt sculpin (*Rhamphocottus richardsonii),* lingcod (*Ophiodon elongatus*), rock sole (*Pleuronectes bilineatus*), warbonnet (*Chirolophis* sp.), kelp greenling and several unidentified sculpins were observed in the Y Jetty/Lang Cove area (BES 2012b).

Pacific herring have been observed to spawn at the west side of the sub-project area in 1993 (Figure 9; DFO 2016c). Pacific herring were observed in the adjacent Constance Cove Remediation Project area in the summer of 2016 (Archipelago 2016).

Other key marine species observed in the sub-project area include Lincod and rockfish. Lingcod were observed in the YJLC sub-project area by BES (2012b). They were observed primarily in riprap areas (specific area not indicated). Black rockfish and yellowtail rockfish were observed during the summer 2018 survey (Golder 2018). Of the listed rockfish species, quillback rockfish have potential to occur based on habitat requirements, but it has not been observed. Pacific sand lance have not been observed in this sub-project area (BES 2012a, Golder 2016a, SLR 2016a). North Pacific spiny dogfish have not been observed in this sub-project area (BES 2012a, Golder 2016a, SLR 2016a); however, there is potential for them to occur based on habitat requirements.

2.3.2.5 Mammals

Overview

Seven marine mammal species are known or have potential to occur in Esquimalt Harbour based on habitat requirements and observations (Annex C). These species include harbour seal, California sea lion, Steller sea lion, Dall's porpoise, harbour porpoise, killer whale - southern resident population, and killer whale - west coast transient population. Four marine mammal species at risk have potential to occur in the Project area and are provided in Table 5.

Table 5. Marine Mammal Species at Risk in Esquimalt Harbour.

Common Name (Scientific Name)	BC CDC Status	COSEWIC Status	SARA Schedule / Status	Occurrence in Esquimalt Harbour
Harbour Porpoise – Pacific Ocean population (*Phocoena vomerina*)	Blue	SC	1/SC	Known to occur. Harbour porpoise have been observed in Esquimalt Harbour at various times by different sources (Hall 2004; SLR 2016).
Killer Whale - Northeast Pacific southern resident population (*Orcinus orca pop. 5*)	Red	E	1/E	Potential to occur. Pods of two to three killer whales (population unknown) were observed within Esquimalt Harbour by Queen's Harbour Master staff in January 2014 and September 2013 (QHM pers. comm. with DND, 2014). Killer whales were observed at the mouth of the harbour in Sept 2016 (A. Rippington, pers. comm.)
Killer Whale - West Coast transient population (*Orcinus orca pop. 3*)	Red	T	1/T	Potential to occur. Pods of two to three killer whales (population unknown) were observed within Esquimalt Harbour by Queen's Harbour Master staff in September 2013 and January 2014 (QHM pers. comm. with DND, 2014). Killer whales were observed at the mouth of the harbour in Sept 2016 (Andrew Rippington, pers. comm.)
Steller Sea Lion (*Eumetopias jubatus*)	Blue	SC	1/SC	Known to occur. Steller sea lions were observed in Esquimalt Harbour during dive surveys conducted along the North Landing Wharf in February of 2010 (Golder 2010). Twelve stellar sea lions were observed in the northern portion of Constance Cove near Inskip Island during the November 2015/2016 wildlife survey by SLR (SLR 2016).

Notes: CDC – Conservation Data Centre; COSEWIC – Committee on the Status of Endangered Wildlife in Canada; E – endangered; NAR – not at risk; SARA – *Species at Risk Act*; SC – special concern; T - threatened

Other aquatic and terrestrial mammals known to occur in Esquimalt Harbour include river otter, American mink, common raccoon, mule deer, and unidentified species of bats (SLR 2016).

C Jetty and ML Floats

There is potential for smaller marine mammals, including harbour seal, California sea lion, Steller sea lion, Dall's porpoise, and harbour porpoise, to occur in the sub-project area and larger marine mammals to occur further out in the harbour.

Y Jetty and Lang Cove

There is potential for smaller marine mammals, including harbour seal, California sea lion, Steller sea lion, Dall's porpoise, and harbour porpoise, to occur in the sub-project area and larger marine mammals to occur further out in the harbour.

2.3.2.6 Birds

Overview

Birds that are known to occur in Esquimalt Harbour include loons and grebes; cormorants; herons; swans, geese and dabbling ducks; diving ducks; plovers, sandpipers and allies; gulls and terns; alcids; passerines; and raptors (CRD 2016e; Bird Studies Canada 2016; SLR 2016).

No migratory bird sanctuaries (CRD 2016f) or Important Bird Areas (IBA Canada 2016) exist in Esquimalt Harbour. There are several bald eagle, osprey and great blue heron nests located around Esquimalt harbour.

Twenty-three bird species at risk are known to occur in the Capital Regional District (MOE 2016b). These species are outlined in Annex C. Of these twenty-three species, nine are known or have the potential to occur in Esquimalt Harbour (Table 6).

Table 6. Bird Species at Risk Known or Have Potential to Occur in Esquimalt Harbour.

Common Name (Scientific Name)	BC CDC Status	COSEWIC Status	SARA Schedule/ Status	Range and Habitat	Occurrence in Esquimalt Harbour
Barn Swallow (*Hirundo rustica*)	Blue	T	-	Nests in barns or other buildings, under bridges, wharves, in caves or cliff crevices, usually on vertical surface close to ceiling. Commonly reuses old nests. Flies over open land and water to forage on insects.	Potential to occur
Brandt's Cormorant (*Phalacrocorax penicillatus*)	Red	-	-	Forages mainly inshore coastal areas. Typically nests on flat or gently sloping surfaces on tops of rocky islands along coast.	Known to occur (SRL 2016)
Caspian Tern (*Hydroprogne caspia*)	Blue	NAR	-	Seacoasts, bays, estuaries, lakes, marshes, and rivers. Nests on sandy or gravelly beaches and shell banks along coasts or large inland lakes; sometimes with other water birds. Seasonal resident and probably breeds on Vancouver Island. Does not overwinter on Vancouver Island.	Potential to occur
Common Murre (*Uria aalge*)	Red	-	-	Nonbreeding: pelagic and along rocky seacoasts. Nests in the open or in crevices on broad and narrow cliff ledges, on stack (cliff) tops, and on flat, rocky, low-lying islands. Breeds on the northern tip of Vancouver Island and overwinters around Vancouver Island.	Known to occur (SLR 2016)
Double-crested Cormorant (*Phalacrocorax auritus*)	Blue	NAR	-	Forage habitat in BC includes marine bays, estuaries, and inlets and occasionally lakes close to coastal areas and large rivers. Preferred nesting habitat includes bare, rocky islands with sparse vegetation.	Known to occur (SLR 2016)

Common Name (Scientific Name)	BC CDC Status	COSEWIC Status	SARA Schedule/ Status	Range and Habitat	Occurrence in Esquimalt Harbour
Great Blue Heron, fannini subspecies (*Ardea herodias fannini*)	Blue	SC	1-SC	Nest in a wide variety of tree species; the Pacific population nests in quiet woodlots within 8 km (most within 3 km) of foraging habitats such as large eelgrass meadows, along rivers, and in estuarine and freshwater marshes.	Known to occur (SLR 2016)
Marbled Murrelet (*Brachyramphus marmoratus*)	Blue	T	1-T	Nests in mature/old growth coniferous forest near the coast. Feeds in the nearshore marine environment throughout the year, rarely farther than 5 km from shore.	Known to occur (SLR 2016)
Peregrine Falcon, anatum subspecies (*Falco peregrinus anatum*)	Red	SC	1-SC	Typically nest on rock cliffs above lakes or river valleys where abundant prey is nearby. Seabirds, shorebirds, waterfowl, other waterbirds, pigeons and songbirds are important prey.	Known to occur (Bird Studies Canada 2016)
Purple Martin (*Progne subis*)	Blue	-	-	Breeds but does not overwinter on Vancouver Island. Nest in natural cavities, nest boxes and holes in buildings. In recent years they have been almost entirely restricted to nest boxes and artificial holes in pilings in estuaries, bays, and harbours. Forages over areas surrounding nest site. Nest boxes previously located near DND Colwood (MOE 2016b).	Known to occur (MOE 2016b)

Notes:
CDC – Conservation Data Centre; COSEWIC – Committee on the Status of Endangered Wildlife in Canada; NAR – not at risk; SARA – *Species at Risk Act*; SC – special concern; T – threatened; “-“ – not assessed.

The presence and potential presence of bird and bird species at risk in the two sub-project areas are outlined below.

C Jetty and ML Floats

Bird species have not been recorded in this sub-project area in resources that were reviewed; however, there is potential for birds to forage in marine footprint, including bird species at risk. No eagle, osprey or heron nests were found within approximately 400 m of the marine footprint in the resources that were reviewed (DND 2016a, b; Pacific Navy News 2017). There is potential for barn swallows (a COSEWIC threatened species) to nest under structures in the sub-project area.

Y Jetty and Lang Cove

Bird species have not been recorded in this sub-project area in resources that were reviewed; however, there is potential for birds to forage in the marine footprint, including bird species at risk. No eagle, osprey or heron nests were found within approximately 1 km of the marine footprint in the resources that were reviewed (DND 2016a, b; Pacific Navy News 2017). There is potential for barn swallows (a COSEWIC threatened species) to nest under structures in the sub-project area.

2.3.3 Socio-Economic Components

2.3.3.1 Overview

Esquimalt Harbour is administered by DND and is governed by the Natural and Man-made Harbour Navigation and Use Regulations under the Canada Marine Act and local practices and procedures (Royal Canadian Navy 2017). 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 berthed or transiting warships (Figure 10; Royal Canadian Navy 2017).

The Esquimalt and Songhees First Nations have Reserve lands in Esquimalt Harbour. New Songhees 1A and the Esquimalt Reserve are located on the east side of Esquimalt Harbour and are home to a number of Songhees and Esquimalt members. As of 2016, there were 565 registered members of the Songhees First Nation, including 338 living on reserve (INAC 2016a). There were 309 registered members of the Esquimalt First Nation as of February 2016, 174 of whom live on the Esquimalt reserve in Esquimalt Harbour (INAC 2016b).

Esquimalt Harbour is surrounded by three Municipalities, the City of Colwood (Colwood) on the west side of the Harbour, the Town of View Royal (View Royal) in the north western portion of the harbour, and the Township of Esquimalt (Esquimalt) which is immediately east of the harbour and the municipality closest to the remediation sites. (Figure 10). Table 7 shows the 2011 population and total number of private dwellings in Esquimalt and Colwood.

Table 7: Municipal Population by Remediation Site

Municipality	Proximity to Project Areas	2011 Census Population	Total Private Dwellings
Township of Esquimalt	Adjacent to the sub-project areas	16,209	8,638
City of Colwood	Across Esquimalt Harbour from the sub-project areas	16,093	6,395

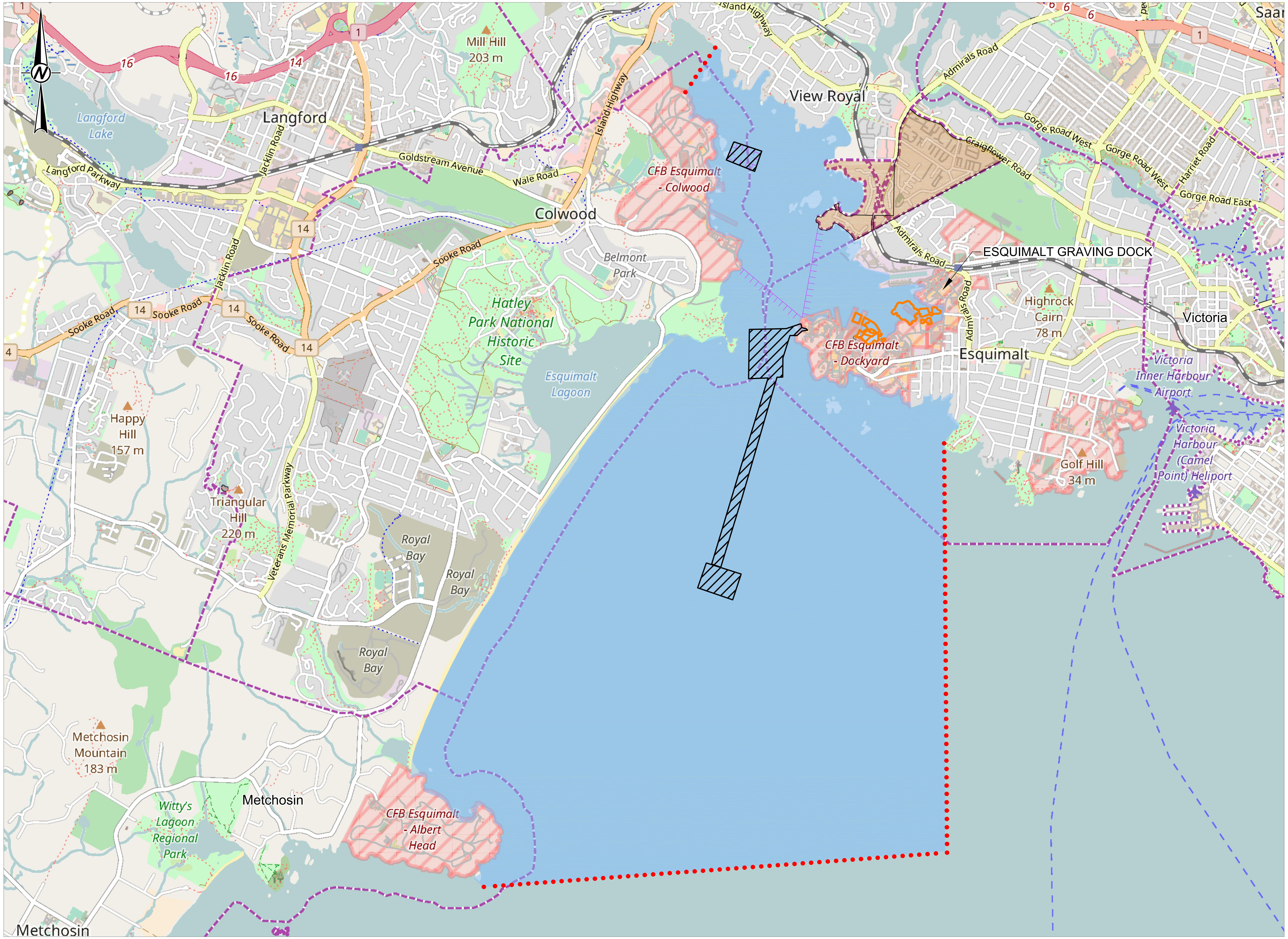
Source: Statistics Canada, 2012

All of the sub-project areas are located at existing developments in Esquimalt Harbour. The sub-project areas are currently used for the following purposes:

- C Jetty is the primary repair facility for DND in Esquimalt Harbour;
- Y Jetty is the principle berthing for mine counter defence vessels; and
- Lang Cove is the staging area for the petroleum response team.

All of the sub-project areas are located adjacent to DND facilities on CFB Esquimalt and DND property and the zoning for each sub-project area matches the current use.

2.3.3.2 Transportation
Esquimalt, View Royal and Colwood's road systems serve 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.



LEGEND

- REMEDIATION FOOTPRINT
- ANCHORAGE PROHIBITED
- CONTROLLED ACCESS ZONE / COMMERCIAL WATER LEASE AREA
- FIRST NATIONS RESERVE
- MUNICIPAL BOUNDARY
- NO FISHING

REFERENCE(S)

1. © OPENSTREETMAP CONTRIBUTORS.
2. RESERVE BOUNDARIES OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. PROJECT AREA:
   3.1. C JETTY AND ML FLOATS MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "xC Jetty Dredge_Tender_20180521.dwg"
   3.2. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "AQ_Dredge Prism_20180618_Draft100PCT.DWG"

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CLIENT
PUBLIC SERVICES AND PROCUREMENT CANADA

PROJECT
ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-20
DESIGNED	V. LAWRENCE
PREPARED	J. FARAH
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

TITLE
SOCIO-ECONOMIC CONTEXT

PROJECT NO.	PHASE/TASK	REV.	FIGURE
18101029	2000/2001	0	10

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2.3.3.3 Navigation

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 the Esquimalt Harbour Practices and Procedures (pursuant to the *Canada Marine Act*). The Queens Harbour Master (QHM) is the Transport Canada designated Harbour Authority for Esquimalt Harbour. All vessels entering or departing Esquimalt Harbour must contact the QHM Operations on marine VHF channel 10 or by telephone at (250) 363-2160.

The QHM is responsible for naval ship control within Esquimalt Harbour to ensure incoming vessels are berthed with due consideration to operational priority, repair and maintenance schedules, as well as international courtesy. The QHM has responsibility for all logistic requirements of Canadian and visiting warships in port. The Esquimalt Harbour Practices and Procedures promote safe and effective use, navigation, and environmental stewardship of the harbour and must be followed by all harbour users, including ships entering, berthing, departing, manoeuvring, or anchoring in the harbour (Royal Canadian Navy 2017).

Esquimalt Harbour is open to the public within the limitations regarding Controlled Access Zones that provide for security zones around warships berthed or moving in and out of the harbour. These zones include the harbour proper, and its approaches, bound to the south by Albert Head and the east by Saxe Point, as well as waters within 200 m (in any and all directions) from naval ships and DND Jetties, 500 m surrounding ships at anchor and 200 m around any vessels maneuvering within Esquimalt Harbour and approaches (Royal Canadian Navy 2017). The speed limit in Esquimalt Harbour is 7 knots.

Four types of vessels enter and exit Esquimalt Harbour, including naval ships accessing DND Jetties, commercial traffic accessing the Esquimalt Graving Dock, pleasure craft of all sizes, and recreational and commercial crab harvesting vessels (QHM, pers comm. 2016). Naval traffic generally includes DND vessels moving between jetties for fueling or maintenance purposes, or DND vessels arriving to and departing from berthing stations at DND Jetties. Commercial traffic generally consist of vessels accessing the Esquimalt Graving Dock, the largest solid-bottom commercial drydock on the west coast of the Americas and frequented by vessels of all sizes including fishing vessels and freighters.

Crab harvesting is only allowed outside of the controlled access zones and water lease areas. Fishing is not permitted in the harbour (QHM, pers comm. 2016). Anchoring is prohibited anywhere in the harbour except in the northern most part of the Inner Harbour. Ships at anchor must register with QHM Operations and cannot remain at anchor for longer than two weeks.

In addition to the designated harbour regulations, general regulatory measures to promote safe navigation of vessels apply within the harbour, including legislation under the *Canada Shipping Act, 2001* and directives in regard to vessel traffic management systems, pilotage, navigational aids, precautionary areas, and special operating instructions. Specific measures that are part of the general vessel traffic management systems to facilitate navigation include use of ship radar, carriage of an automated information system for larger vessels, and use of loudhailers on bridges of large ships to communicate with smaller vessels.

2.3.3.4 Commercial, Recreational and Aboriginal Fisheries

Esquimalt Harbour is located within DFO Fisheries Management Sub-Area 19-2. As a precautionary measure, DFO has closed Esquimalt Harbour (Subarea 19-2) to all fishing due to a fuel spill in Plumper Bay (DFO 2016d).

As per the Esquimalt Harbour Practices and Procedures, fishing or crabbing in Esquimalt Harbour would require pre-authorized approval of a harbour official (Royal Canadian Navy 2017). The Esquimalt Harbour Practices and Procedures also indicate that fishing and crabbing is prohibited in the entrance to Esquimalt Harbour, and in the area east of McCarthy Island (Royal Canadian Navy 2017). Fishing and crabbing shall only be conducted in areas that minimize impact on marine traffic, harbour use, and it shall be conducted in accordance with the Department of Fisheries and Oceans Canada licensing requirements (Royal Canadian Navy 2017). According to the QHM, commercial crab fishery activities occurred in Esquimalt Harbour in 2016 (QHM, pers comm. 2016). QHM estimated that there were fewer than six crab harvesters in Esquimalt Harbour (QHM, pers comm. 2016). Crab is harvested over approximately two months at the start of the DFO-regulated opening in mid-June.

Although recreational crab harvesting is permitted in parts of Esquimalt Harbour, a shellfish consumption advisory is in place for Esquimalt Harbour. This notice provides the recommended maximum weekly intake, in accordance with Health Canada (HC) recommendations for adults and toddlers, of Dungeness crab hepatopancreas and muscle, red rock crab hepatopancreas and muscle, sea urchin roe, and rockfish muscle (DFO 2016e).

Bivalve fishing is not permitted due to a biotoxin and sanitary contamination closure DFO 2016a).

Under the Douglas Treaty, the Esquimalt and Songhees Nations have fishing and hunting rights, which are practiced in Esquimalt Harbour. In meetings with DND, First Nations representatives have indicated that they have ongoing subsistence and cultural uses in the harbour. Both the Esquimalt and Songhees Nations assert Aboriginal rights and interests within the harbour area.

2.3.3.5 Land and Non-consumptive Marine Based Recreation

No national or provincial parks are located adjacent to the sub-project areas, but there are a number of waterfront parks in Esquimalt Harbour, including two National Historic Sites. Fort Rodd Hill and Fisgard Lighthouse National Historic Site is located on the west side of the entrance to the harbour. Another National Historic Site, Cole Island, is located at the north end of the harbour. Both sites are open to the public for day use recreation.

In addition to recreational fish and seafood harvesting, other water based recreation in Esquimalt Harbour includes recreational boating and kayaking and shoreline usage. Pleasure craft use the harbour year round (QHM, pers comm. 2016). The Pacific Fleet Kayak Club is based in Esquimalt Harbour with members kayaking in the harbour year round. In the summer, there is a youth sailing regatta, with up to 50 boats competing in the harbour. Recreational fishing is limited in the harbour and all visitors must report to the QHM upon arrival (QHM, pers comm. 2016). There are strict rules regarding anchoring, with a number of sections in the harbour off limits to anchoring (Figure 10).

2.3.3.6 In Air Noise, Light and Odour

Specific information regarding ambient noise, light and odour levels within DND lands is not available. However, the remediation sites are located in an active, working harbour with other marine maintenance, repair, and construction related business and military facility sites associated with CFB Esquimalt and the nearby Esquimalt Graving Dock, all contributing to an existing level of noise pollution, light trespass, nighttime sky glow and odour.

Residences are located approximately 300 m from the Project area. Neighbourhoods bordering Esquimalt Harbour and temporary human receptors in proximity of the Project area could experience noise and light effects from the existing working harbour activities, and Project activities, include nearby marine based and shore-based recreational users.

Noise bylaws for adjacent municipalities are available for the Township of Esquimalt, the City of Colwood and the Town of View Royal. The Township of Esquimalt Maintenance of Property Bylaw No. 2826, 2014 regulates the maintenance of property, unsightly property, and nuisance, including noise. The nuisance section of bylaw includes specific provisions regarding noise:

- Generally, no person shall make noise, cause, allow, or permit a noise or sound in the street, park, plaza, or similar place which disturbs or tends to disturb the quiet, peace, rest, enjoyment, comfort, or convenience of persons in the neighbourhood or vicinity. For greater certainty, these activities are prohibited, between the hours of 10:00pm and 7:00am on Monday to Friday and between the hours of 10:00pm and 9:00am on Saturday, Sunday, or Holidays.

The Bylaw to Regulate Noise within the City of Colwood (Bylaw No. 38) stipulates the following construction hours:

- Monday to Saturday before 07:00 or after 19:00 h, no person shall construct, erect, reconstruct, alter, repair, or demolish any building, structure, or thing or excavate or fill in any manner which disturbs the quiet, peace, rest, enjoyment, comfort or convenience of the neighbourhood or of persons in the vicinity. Such work is prohibited on Sundays and statutory holidays.
- No person shall, on any day, before 8:00h or after 17:00 h operate, or cause to be operated, any drills and or compressors for blasting. All operations of drills or compressors are prohibited on Sundays and statutory holidays.

The Town of View Royal Noise Bylaw (Bylaw No. 523) stipulates the following with regards to disturbance from noise:

- No person shall make or cause to be made any noise or sound in or on a highway or elsewhere in the Town which disturb, or tend to disturb the quiet, peace, rest, enjoyment, comfort, or convenience of the neighbourhood, or of persons in the vicinity, or which the Council believes are objectionable or liable to disturb the quiet, peace, rest, enjoyment, comfort or convenience of individuals or the public.

2.3.3.7 First Nation Traditional Lands/Resources

The Project Area is located within the asserted traditional territories of the Songhees Nation and the Esquimalt Nation. Consultation with the Songhees and Esquimalt Nations has been ongoing since 2006. Between 2006 and 2007, a First Nation Involvement Plan, including a traditional use and knowledge study, was undertaken as part of the Esquimalt Harbour Sediment Quality Project. The following provides a summary of work conducted between 2006 and 2007:

- Planning (August 2006): First Nations with potential interests in Esquimalt Harbour were identified and contacted based on background research and discussions with DND and PSPC.
- Data Collection (September to October 2006): The team worked with local First Nations to understand how and where people currently use the harbour, as well as how and where the harbour was used in the past and how and where First Nations anticipate using the harbour in the future. Data collection methods included formalized interviews with community Elders and expert knowledge holders that documented and mapped traditional use sites, as well as Traditional Ecological Knowledge (TEK), from the harbour. Collected information was

entered into a GIS database and the results summarized into a confidential report to PSPC, DND and the Esquimalt and Songhees Nations.

- Communication (September 2006 to February 2007): The results of the TEK were provided to the community for additional comment, and protocols were put in place for protecting confidential information. In addition, the results of the environmental studies for the Harbour were shared with First Nations. Support to First Nations in the review of the technical environmental studies and the participation in the overall engagement process was offered.
- Evaluation (February to March 2007): The team committed to working with First Nations to monitor the effectiveness of the engagement process and to track relationships as they developed. Progress against the following goals were measured: increased awareness of the harbour environment; increased ability of First Nations to be involved in harbour management; and, improved communication between DND and First Nations.

Since 2006, engagement for the project has been ongoing with the most recent meeting held in April 2016. See Section 2.1.3 for further information about Project related engagement activities. The confidential TEK identified a wide range of traditional and recreational use in Esquimalt Harbour as well as concerns regarding contamination and deterioration of the harbour environment and loss of access due to other activities in the harbour. While the TEK report is now almost 10 years old, concerns highlighted at recent consultation sessions reiterate the contamination issues highlighted in the TEK.

2.3.3.8 Archaeology

The EHRP is situated on federally owned land. Federal legislation applies to all properties that fall under federal jurisdiction, including lands belonging to federal departments such as DND, or locations where the federal government has some regulatory control. There is no comprehensive federal statute directing how (or whether) a given department is supposed to treat archaeological issues on its lands. However, CEAA, 2012 states that one of the purposes of the Act is “to ensure that projects…are considered in a careful and precautionary manner before federal authorities take action in connection with them, in order to ensure that such projects do not cause significant adverse environmental effects” (Section 4(1)(b)). Under CEAA, 2012, environmental effects include “any structure, site or thing that is of historical, archaeological, paleontological or architectural significance” (Section 5(1)(c)) and the current use of lands and resources for traditional purposes by Aboriginal persons (i.e., traditional use sites). Ship and airplane wreck sites may also be protected under federal statute if it is determined that they possess characteristics of national historic significance (Historic Sites and Monuments Board of Canada 2000).

While the Canadian Environmental Assessment Agency (2015) has developed technical guidelines that document the expected requirements for the protection of cultural heritage sites in an Environmental Assessment conducted under CEAA 2012, CEAA, 2012 does not contain statutory directives with respect to how these resources and features are to be ‘considered’ (i.e., managed). Given the absence of a federal regulations outlining how archaeological assessments are to be undertaken on federal lands, an archaeological overview assessment (AOA) (Golder 2015b), an archaeological impact assessment (AIA) (Golder 2016c) and an archaeological mitigation program (Golder n.d.) of portions of the Project area was conducted in general accordance with provincial regulations as described in the *Archaeological Impact Assessment Guidelines* (1998) developed by the British Columbia Archaeology Branch, Ministry of Forests, Lands and Natural Resource Operations. Under the terms of the British Columbia *Heritage Conservation Act* (*HCA*), all archaeological sites that predate AD 1846 are automatically protected. Heritage wrecks, consisting of the remains of vessels or aircraft after two or more years have passed since they sank, crashed, or were abandoned, are also protected under the *HCA*.

Esquimalt Harbour is a protected harbour setting with many previously registered archaeological sites representing a wide variety of site types, including precontact village sites with intact cultural deposits, as well as precontact shell midden sites, lithic scatters, subsistence features (*i.e*., roasting pits), wet sites (archaeological sites found below water table and in the intertidal zone) and associated human burials. Previous research has contributed to the development of a regional chronology that spans over 8,500 years for Vancouver Island and the Lower Mainland. There are also several important historical sites along Esquimalt Harbour, including the original location for the town of Esquimalt.

The EHRP is located within the traditional territories of the Songhees Nation and Esquimalt Nation. Both First Nations are concerned with the treatment of archaeological resources in the region, including ancestral remains which are often present in sites in this area.
The Golder (2015b) AOA and associated pedestrian field reconnaissance (PFR) included a review of the following locations proposed for remediation: A and B Jetty, C Jetty, D Jetty, F and G Jetty, Y Jetty, ML Floats, Small Boat Float and Lang Cove. An AOA and PFR was subsequently conducted of Plumper Bay and Thetis Cove (Golder 2016d).There are no recorded precontact archaeological sites located within the C Jetty, Y Jetty, ML Floats, Small Boat Float and Lang Cove sub-project areas; however, the precontact archaeological site DcRu-6 is located immediately north of the Lang Cove sub-project area. In addition, the archaeological overview assessment determined that there were locations with potential to contain undocumented precontact archaeological sites and heritage wrecks within portions of the C Jetty, Y Jetty and ML Floats and Lang Cove sub-project areas, including along formerly exposed surfaces of seabed which have been inundated by post-glacial sea-level change.

Considering the results of the AOA, Golder (2016d) undertook an AIA in the vicinity of Lang Cove. No precontact archaeological materials were encountered as a result of this assessment; however, the archaeological assessment conducted in Lang Cove resulted in the identification of the heritage wreck site DcRu-1259. This site includes several historical features, including a patent slip cradle and two heritage wrecks (Figure 11). One of the heritage wrecks has been identified as the pioneer coastal steamer, the *S.S. Barbara Boscowitz*; the second shipwreck, Lang Cove Wreck II, has not been identified by name.

In November 2016, Golder (n.d.) conducted detailed recording of the Lang Cove Wreck II feature, including 3D photogrammetry. The results of this mitigation will be to produce 3D images, and potentially a 3D model, of the Lang Cove Wreck II which can be used to help identify the ship and be used for future public interpretive purposes.

The patent slip cradle is related to the former Bullen's/Yarrows shipyard and includes a feature which might be the centre rails from the original Bullen's marine railway replaced in 1919, and the possible remains of a caisson used for underwater ship repair at about the same time. The activities of Bullen Brothers were centred on the construction and operation of the patent slip in Constance Cove. Virtually every ship of significance to British Columbia maritime history and active between 1893 and 1945 was hauled by the patent slip cradle.

The Lang Cove site has historic, scientific, and public significance. Historic and technological significance for the *S.S. Barbara Boscowitz* is due to it being one of the first substantial ships to be built complete with engines entirely in British Columbia. For over 20 years the ship was a leading participant in the economic development of the province, including sealing, salmon canning, and mining industries, and in the coastal trade and settlement in general. Both the patent slip cradle and the *S.S. Barbara Boscowitz* are scientifically significant as they embodied technologically advanced aspects of British Columbia's maritime history in the late 19th century, as well preserved examples of a site type otherwise poorly represented in the archaeological record in British Columbia, Canada and internationally. Public interest may be stimulated by the archaeological and historical significance of the site, and, although public access to the site will not be practical, there is potential for positive public engagement with interpretive displays.

Considering this, the following recommendations from the AIA and mitigation of DcRu-1259 in Lang Cove are carried forward:

- Avoidance of archaeological site DcRu-1259, including the S.S. Barbara Boscowitz, Lang Cove Wreck II, the Patent Slip Cradle, and other historical features and associated debris field.
- If avoidance is not possible, the following mitigation procedures are recommended at archaeological site DcRu-1259:
  - Archaeological monitoring during dredging activities at archaeological site DcRu-1259, including at S.S. Barbara Boscowitz, Lang Cove Wreck II, the Patent Slip Cradle and other historical features to document and record additional features and associated historical artifacts.

Based on the results of the AOA at the CJML and YJLC sub-project areas, the following has been recommended:

- Archaeological impact assessment at Y Jetty, including underwater archaeological testing prior to dredging at the north end of Y Jetty.
- Archaeological monitoring during machine sorting of soils and sediments removed during dredging activities conducted within these sub-project areas.

No further archaeological work is recommended within the remainder of Project area unless the proposed remediation activities expand significantly beyond those areas reviewed in the AOA (Golder 2015b) and subsequently sampled in the course of the AIA (Golder 2016c).

LEGEND

REMEDIATION FOOTPRINT

WRECK

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REFERENCE(S)

1. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
2. C JETTY AND ML FLOATS MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "AQ_C Jetty Dredge_20171016_UTM10-N83_Chart.dwg"
3. Y JETTY AND LANG COVE MATERIAL PLACEMENT AREAS (MARINE FOOTPRINT) OBTAINED FROM ANCHOR QEA DIGITAL CAD FILES. "xY Jetty DP-June2017_Simple.dwg"

CLIENT
PUBLIC SERVICES AND PROCUREMENT CANADA

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-20
DESIGNED	V. LAWRENCE
PREPARED	J. FARAH
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

PROJECT
ESQUIMALT HARBOUR REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

TITLE
ARCHAEOLOGICAL RESOURCES - Y JETTY AND LANG COVE

PROJECT NO.	PHASE/TASK	REV.	FIGURE
18101029	2000/2001	0	11

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2.4 Project Effects and Associated Mitigation Measures

This section outlines the effects assessment undertaken for the EHRP. The effects assessment includes potential effects that are likely to occur on VECs from project components/activities, significance of those potential effects, recommended measures to mitigate effects, and significance of potential residual adverse effects which may occur after mitigation measures have been applied.

Table 8 outlines the criteria that were used to assist in the determination of significance of effects on VECs.

Table 8: Significance Criteria Definitions

Criterion	Not Significant	Potentially Significant	Significant
Magnitude (of the effect)	**Low** - Effect is evident only at or nominally above baseline conditions.	**Moderate** - Effect exceeds regulatory criteria or published guideline values but is less than that shown to cause a harmful effect.	**High** - Effect exceeds values documented to cause a harmful effect.
Spatial Extent (of the effect)	**Low** - Effect is limited to the immediate project site/footprint.	**Moderate** - Effect extends into local areas beyond the project site/footprint boundary.	**High** - Effect will have impacts on a regional scale.
Duration (of the effect)	**Low** - Effect is evident only in the short term (i.e., during dredging).	**Moderate** - Effect is evident for up to a year following dredging	**High** - Effects will be evident for more than a year after dredging
Reversibility (of effect)	**High** - Effect is readily reversible (i.e., within days or weeks following dredging).	**Moderate** - Effect is reversible after dredging is finished (i.e., one growing season following dredging)	**Low** - Effect is permanent.

To indicate whether significant adverse effects are likely after mitigation measures are implemented, the following categories were used:

- "No" indicates that residual adverse effects are not likely to be significant because:
  - Potential residual effect(s) may result in only a slight decline, if any, in resource in study area during the life of the project. Research, monitoring and/or recovery initiatives would not normally be required; or
  - Potential residual effect(s) may result in only a slight decline, if any, in resource in study area during construction phase, but the resource should return to baseline levels.
- "Yes" indicates that residual adverse effects are likely to be significant because:
  - Potential effect(s) could affect long-term sustainability of the VEC and should be considered a management concern. Research, monitoring and/or recovery initiatives should be considered; or
  - Potential effect(s) could result in a decline in the VEC to lower-than-baseline but stable levels in the study area after project closure and into the foreseeable future. Regional management actions such as research, monitoring and/or recovery initiatives may be required.

The effects assessment, including affected VECs, description of effects, mitigation measures, and significance of residual effects, is contained in Table 9.

Table 9: Potential Effects of the Project on ECs with Mitigation Measures

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Atmosphere			
All components	Reduced Air Quality A reduction in air quality in and adjacent to sub-project areas may occur as a result of: • Exhaust emissions from machinery and vehicles. • Potential generation of dust from dredged material if weather is hot and dry, from material stockpiling and from demolition/removal work. Magnitude: Low Spatial extent: Moderate Duration: Low Reversibility: High	• A qualified environmental monitor (EM) will be on-site during Project activities as outlined in the EMP. • The contractor will prepare a Dust and Emissions Control Plan as part of the EPP. • Implement dust control measures (such as the use of water as a dust suppressant) as outlined in the design specification. • Implement dust control measures (such as the use of water as a dust suppressant) as outlined in the design specifications. • Vessels and equipment will be well maintained and in good working order. • Efforts will be made to minimize exhaust emissions. Vessels and equipment will use low sulphur fuels. Idling of vessels and equipment will be minimized.	No. Potential residual effects may result in a slight decrease in air quality during the EHRP, but these effects are expected to be temporary and not significant.

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Surface Water			
Mobilization and demobilization Structure demolition/removal, relocation and reinstallation Dredging and debris removal Excavation Dewatering of dredged material Placement of material In-water transportation Offloading, stockpiling, processing	Reduction in Water Quality Water quality in and adjacent to the sub-project areas may be negatively affected by: • Spills of deleterious substances • Suspension of solids from: - Structure demolition/removal, relocation and reinstatement - Dredging - Excavation - Dewatering of dredged material - Placement of material - In-water transportation - Offloading, stockpiling, processing • Release of contaminants from: - Creosote-treated pilings or old dock structures during removal, relocation and reinstatement - Re-suspension of contaminated sediments during dredging - Effluent during dewatering of dredged material - Water and/or sediment discharged during in-water transportation of dredged material	For indicated components, the following mitigation measures apply: • A qualified EM will be on-site during activities as outlined in the EMP. • A Water Quality Monitoring Plan (WQMP) will be developed for the EHRP that outlines performance objectives to be met and water quality monitoring requirements. • The contractor will prepare a Spill Prevention and Response Plan as part of the EPP. • The contractor will indicate in the EPP the procedures that they will undertake to meet the water quality performance objectives presented in the WQMP. For structure demolition/removal, relocation and reinstallation, the following additional measures apply: • Use silt curtain(s) around the perimeter of the pile extraction work at the YJLC Former Marine Railway. • A reasonable attempt will be made to remove the entire creosote-treated pile. • Piles will be removed in a manner that minimizes disturbance of seafloor habitats when possible (e.g., using vibratory methods) and to avoid bringing creosote-contaminated sediments to the surface. If the pile breaks off below the biologically-active zone in the sediment, it may not be advisable to dredge the remainder out, depending on the sensitivity of the habitat at the site. • Extracted timber piles and other timber components must be inspected to look for the presence of “Timberfume” chloropicrin fumigant vials. Piles and other timber components containing the vials must be decommissioned and disposed offsite in accordance with applicable provincial and federal legislation and as per the disposal methods indicated in the material safety data sheets (MSDS), and must not be re-used in the work. Precautions must be taken to ensure that the contents of the vials are not inadvertently released to the marine environment. • When cutting creosote timbers near or over water, ensure that all cuttings are contained and collected from the water, and ensure that any sheen or residue resulting from cutting creosote timbers is contained and cleaned up. • If timber piles are cleaned over water, cleaning will be conducted within the dredge area prior to dredging such that material (e.g., attached biological growth and sediment) is ultimately removed during dredging.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Surface Water			
	- Water and/or sediment discharged during offloading and stockpiling (including upland equipment decontamination) of dredged material directly into marine waters, overland or through stormwater system Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: High	• If timber piles are cleaned on a barge or at the contractor off-site offload facility, sediment and other attached objects that are cleaned off shall be disposed of at an appropriate disposal facility • Booms or other measures will be implemented to contain floating debris from pile removal and cleaning. • Treated piles should be stored in an area away from the water and surface runoff contacting treated piles should be directed away from the water. • Where feasible, alternatives to treated wood products such as treated timber pilings should be used during pilings and structure reinstatement (for pilings and structures being replaced). • Field treatment of re-used timber pile components exposed by cutting, trimming or other activities, when necessary, will be conducted in such a manner as to prevent the release of preservative (e.g., copper naphthenate or creosote) into the marine environment. • Used/decommissioned piles will be disposed of on land at a waste management facility that has been accepted by the DR and meets the requirements for a disposal facility described in the Project specifications. • Use allocated storage areas per the contract technical specifications. • Removed creosote treated piles will be inspected for excessive creosote. If excessive creosote is observed, new treated piles treated with creosote following best management practices in Hutton and Samis (2000) will be used instead. For dredging, the following additional measures apply: • Prior to dredging, the perimeter of the dredge area will be delineated using GPS chart plotting software, so that work occurs within the confines of the Project Areas. • A clean silt curtain (i.e., free of sediment) will be used during dredging and material placement as outlined in the EMP. The requirement of a silt curtain during material placement may be waived if water quality performance objectives presented in the WQMP are met. • The silt curtain will be a minimum of 5 m deep. • A Silt Curtain Control Plan will be developed by the contractor to describe how the silt curtain will be installed and maintained. • The barge will not be overloaded beyond the top of the side rails, to minimize loss of dredged material and to prevent barge listing or instability. • The contract specifications will include operational controls to minimize disturbance of substrates (for example: controlling the rate of ascent and descent of the bucket; making additional dredge passes rather than dragging bucket or beam to level underwater surfaces; not stockpiling material underwater). • Implementation of monitoring procedures outlined in the WQMP for water quality to verify that water quality guidelines are being met and enable management decisions to be made in the event that they are not met. For dewatering, the following additional measures apply: • Implementation of monitoring procedures outlined in the EMP and WQMP to verify that the performance objectives are being met and enable management decisions to be made in the event that the performance objectives are not met. • Dredge effluent water that is collected or transported out of the Project Area must not be returned to the Project Area for discharging. • Passive barge dewatering is not permitted outside of the Project Area. Passive dewatering is allowed within the Project Area provided the dewatering effluent meets the performance objectives in the WQMP. • Dewatering of dredged material will be managed as outlined in the WQMP. • Passive dewatering is not permitted during transport to the off-site offload facility. The contractor will collect, store, treat as necessary and discharge of effluent from barges in a manner that meets the water quality requirements of the EMP.	

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Surface Water			
		• To facilitate dewatering, the contractor may elect to mix additives with the sediments to bind available water. Additives, if used, will require proper storage, handling and containment. In the event that additives are used to facilitate dewatering of the dredged material, the decant water must be tested prior to discharge to verify that the added constituents will not be harmful to the receiving environment. Any leachate generated will need to be contained, treated and appropriately disposed of. • If the contractor chooses to dispose of water via a sanitary sewer system, the contractor will comply with applicable local sewer use bylaws/regulations. For excavation and material placement in intertidal areas, the following additional mitigation measures apply: • An EM will be on-site full time during intertidal excavation/material placement. • The contractor will develop an Erosion and Sediment Control Plan as part of the EPP which will detail installation of effective erosion and sediment control measures before starting work to control the potential for sediment transport outside of the work area. • Excavation will be undertaken from a tug/barge (i.e., no vehicles/machinery will be on the beach) • All contaminated sediment will be placed on a water tight barge. • All shoreline excavation activities below the higher high water large tide (3.39 m CD) must be performed within a silt curtain. • All contaminated sediment removed during excavation will be placed on a water tight barge with the exception of existing site armour for re-use from DUs 29 and 30 and clean material for engineered capping material placement adjacent to the Y Jetty steep shoreline, subject to acceptance by the DR. • Any sediment on the removed riprap must be cleaned off, contained, and disposed of appropriately. For in-water transport, the following additional mitigation measures apply: • Transport of dredge material and debris will be performed using a barge/vessel with sidewalls of sufficient height to fully contain the dredge material, water, and debris. • Watertight barges will be used if necessary (e.g., where direct dewatering discharges are not considered suitable). Where a watertight barge is not necessary, barge dewatering will be managed to meet dredge performance objectives outlined in the EMP such as through the use of filter fabric to cover drainage features (e.g., scuppers). • The contractor will be required to provide certification of seaworthiness from an independent Marine Surveyor for each haul barge that will be used on the Project. In the event that a barge is damaged during project activities and requires repair, a new certification of seaworthiness will be required. In addition, material transportation by barge will require the contractor to obtain authorization from the Queen's Harbour Master pursuant to the *Canada Marine Act* and from DND. For offloading, stockpiling, processing, the following additional measures apply: • The contractor will prepare a Sediment and Erosion Control Plan as a subcomponent of the EPP. • Inspection of offloading and stockpiling area prior to or during material transportation from the site may be conducted. Environmental records pertaining to the management of the sites will be made available by the contractor, if requested. • The contractor may elect to conduct additional testing of the dredged material to evaluate disposal options. In the event that additional testing is necessary, material will be stockpiled only in areas where stockpiling is already permitted (e.g., on the dredge barge, at the off-site offload facility, at the disposal facility). • No sediment, debris, or water transfer can begin at the off-site offloading facility until the spill prevention measures are reviewed by the DR and determined to be in place. • The contractor will offload in-water transportation barges in a manner that prevents spillage of waste or effluent to the water. A spill apron (or equivalent spill prevention measure) will be used during all offloading activities.	

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Surface Water			
		• Any spillage on the spill apron will be removed as soon as practicable and properly disposed. Any such spillage outside of the offloading facility and stockpile storage area will be promptly cleaned up. • Spillage of sediment or debris during offloading will be promptly cleaned up. If uncontrolled spillage occurs, all offloading operations will cease until the spillage is contained and cleaned up. • Construction of stockpile areas at the offload facility (no stockpiling will be permitted at the DND work site) using berms or other barrier devices to prevent uncontrolled spreading of debris and/or contaminated sediment. • Covering stockpiles to prevent erosion during periods of rain and/or wind. • The contractor will construct, operate, and maintain the off-site offloading and stockpile area such that all effluent drainage water, stormwater, or other form of discharges from stockpiled sediment and debris are collected for treatment and proper disposal. • No direct discharge of untreated effluent from the off-site offloading and stockpile area to the receiving waters will be allowed • Stockpiles will be managed to prevent uncontrolled runoff of water that has been in contact with the dredged material and to protect them from the weather. • Catch basins beneath stockpiles will be sealed and all water will be collected and stored on-site for treatment and/or off-site disposal. Other catch basins within the upland staging area but not directly beneath stockpiles will be protected with a below-grate inlet device (BGID) to collect sediment and debris from stormwater prior to discharge. The BGID will be inspected and maintained on a regular basis, with records available. • The contractor will be required to maintain a clean stockpile storage area and provide a wheel/truck wash to prevent vehicles from tracking contaminated soil or sediment off-site. • Equipment will be fuelled in a designated area that separates fuelling operations and protects the environment from accidental spills during fuelling. • Effluent from the off-site offloading and stockpile area will be collected, treated, and discharged to federal, provincial, and local laws and regulations. Discharge of water from off-site offloading and stockpile area may need a permit or temporary authorization from the regulatory agency applicable to the offloading/stockpile area. The contractor will retain a Qualified Professional to obtain the applicable authorizations. • If the contractor chooses to make arrangements to dispose of water via the nearby sanitary sewer system, this acceptance must be obtained prior to bid, and the contractor will be responsible for acquiring the permit for discharge. At a minimum, it must be demonstrated that this water meets Project discharge water quality requirements and/or local municipal sewer discharge limits. Meeting discharge requirements may require treatment prior to discharge. • The contractor may elect to construct a water treatment system and will demonstrate in the Construction Work Plan compliance with water quality requirements to discharge treated effluent back to the receiving waters. All water discharged to any surface water originating from the off-site offloading and stockpile area will meet Canadian Council of Ministers of the Environment (CCME) or BC Ministry of the Environment water quality guidelines (WQGs), or the more stringent of the two. Where these WQGs cannot be met or a WQG is not available, the contractor will propose an alternative effluent limit. If the off-Site offload facility is located in the U.S., water discharged will meet relevant laws and regulations in the U.S. regarding discharge to surface waters. The contractor will provide analytical test results to the DR prior to discharge and will account for time for the DR to review and accept the discharge as part of the completion of the work. For placement of material, the following additional measures apply: • Chemical testing of Backfill Material is required to assess the acid rock drainage (ARD) and metal leaching (ML) potential of the materials as this can negatively affect water quality. The following laboratory tests will be performed by an independent, certified testing laboratory, hired by the contractor: - ARD Potential: Acid Base Accounting (ABA) testing - ML Potential: Multi-Element Analysis (ICP-MS)	

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Surface Water			
		- Shake Flask Extraction (SFE) testing • Guidelines for ARD/ML have been developed for mine sites in Canada and can be used as general guidance in assessing ARD and ML potential for non-mining projects. Results of laboratory testing of metal leaching will be compared, as a screening benchmark, with provincial and federal ambient water quality guidelines for the protection of aquatic life (a Qualified Professional will determine which guidelines are applicable). Based on the results of the screening, the contractor will submit a letter of professional opinion regarding suitability of the backfill material for use in the Project area. One sample for every one thousand (1,000) m^3 (with an absolute minimum of one sample) of imported backfill material imported will be collected and analyzed per the above tests. The frequency of testing may be increased or decreased by the Departmental Representative if considered appropriate based on the results of testing or visual assessment of imported material. A minimum of one sample will be collected and analyzed for each backfill type if regardless of the volume. The laboratory utilized by the contractor must have the appropriate certification in accordance with ISO/IEC Standard 17025. The contractor will submit documentation showing that the proposed laboratory is certified for the specific parameters of concern and proposed analytical methods. • The contractor will employ placement means and methods that will avoid re-suspending sea bed sediment during placement activities, and prevent excessive mixing of the placed materials with the sea bed sediment. • During placement of in-fill substrate material in both WQMAs at YJLC, a silt curtain is not required, provided that performance objectives for TSS and turbidity are met. Additional measures as outlined in the WQMP will be required if objectives are not met. • The contractor will not place substrate by rapid dumping of a barge load.	

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Substrate			
Dredging and debris removal Excavation	<u>Alteration of Seafloor Beyond that Intended by the Project</u> Dredging may cause slope instability, resulting in physical alterations of the seafloor, if not conducted as per the design specifications. <u>Alteration of Habitat Bank Substrate</u> Habitat credits created by DND in Esquimalt Harbour were summarized by Golder in a technical memorandum provided to DND (Golder 2016b). This memo outlined the habitat offsets created by the construction of three rocky reefs in Esquimalt Harbour and historical credits held for intertidal sand and gravel beach and subtidal rocky reef created in Lang Cove. Project activities proposed for the EHRP will interact with the habitat previously accepted for habitat credit by DFO (1997, habitat authorization #HRTS 96-000148). Project activities are expected to cause temporary alteration of constructed habitat in the area, but effective implementation of mitigation measures outlined above is expected to avoid serious harm to commercial, recreational, or Aboriginal fisheries. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• The contractor will prevent excessive dredging and excavation, the removal of material outside of the dredge prism or below the payable over-dredge allowance, to avoid potentially adversely affecting slope and/or structural stability.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Marine Vegetation			
Contractor vessel mooring and anchoring Dredging and debris removal Excavation Placement of material	Removal or Damage of Marine Vegetation - Kelp Understory brown bladed kelp was observed in CJML DU 16 and in several areas of the YJLC sub-project area (Figures 6 and 7). The areas of understory kelp will be dredged and backfilled. A *Fisheries Act* Paragraph 35(2)(b) authorization application has been submitted to DFO for the loss of understory kelp with 50 to 100% cover. Removal or Damage of Marine Vegetation - Eelgrass The area identified for placement of natural recovery material overlaps slightly with an area previously documented with sparse eelgrass by Archipelago 2004; however, eelgrass has not been observed in Lang Cove during more recent surveys The placement of clean substrate is expected to improve the habitat by decreasing exposure to contamination, and may increase the area available for eelgrass colonization through raising the elevation of the substrate in some areas to a depth at which the eelgrass was originally found (i.e., a greater area will be at an elevation greater than -0.9 m CD). Removal or Damage of Marine Vegetation – Intertidal Marsh Vegetation A small amount of intertidal marsh vegetation will be removed in the Lang Cove area. This removal is expected to be small in nature due to the limited extent of the vegetation. Magnitude: Moderate Spatial extent: Low Duration: Low Reversibility: High	• Offsetting will include placement of angular rock in CJML DU 16 and portions of YJLC, and use of a rocky reef habitat bank previously construction in Esquimalt Harbour. • “No dredge/backfill zones” and “no anchoring zones” in areas with bedrock outcrops and kelp will be delineated using GPS chart plotting software before the EHRP begins to avoid accidental removal and damage of kelp. • The barge will not come to rest on the seafloor (no grounding) in areas where subsequent disturbance through dredging will not occur. Barge grounding will be only be permitted in nearshore areas where dredging will occur, provided water quality is managed according to the requirements outlined in the WQMP.	No
	Shading of Marine Vegetation Mooring/anchoring, dredging and backfilling may cause a temporary increase in turbidity within the water column which may shade marine vegetation and temporarily affect photosynthesis by algae (Bilotta and Brazier 2008; CCME 1999). Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• Follow mitigation measures outlined in the Surface Water VEC section above.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Marine Invertebrates			
Contractor vessel mooring and anchoring Structure demolition/removal, relocation and reinstatement Dredging and debris removal Dewatering of dredge material Placement of material	<u>Potential Mortality/Harm</u> Marine invertebrates that occur in the sub-project areas, such as clams and crab, may be physically harmed through removal of individuals in the benthic sediments or may be physically damaged by the dredging equipment. Placement of cover material in Lang Cove may bury benthic invertebrates. Loss of invertebrates is expected to be temporary, as recolonization of the area is expected after the EHRP is completed. Benthic organisms often recolonize newly placed material within weeks or months (Van Dolah et al. 1984; Newell et al. 1998; Cruz-Motta and Collins 2004). As well, many benthic invertebrate species are well adapted to burrow through a thin (~30 cm) layer of newly-deposited sediment and avoid suffocation (Fredette and French 2004; Bolam and Rees 2003; Newell et al. 1998). Refer to Species At Risk section below for effects assessment of Northern abalone. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• Follow mitigation measures outlined in Species at Risk – Invertebrates VEC for abalone • No other specific mitigation recommended	No
	<u>Change in Water Quality</u> Invertebrates in and adjacent to the in-water project areas could also be affected by an increase in turbidity/TSS through the abrasion of respiratory surfaces and interference of food intake for filter-feeding invertebrates (CCME 2002). Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• Follow mitigation measures outlined in the Surface Water VEC section above.	No
	<u>Change in Habitat Structure</u> Dredging, dewatering and backfilling may cause sediment to become suspended in the water column which could settle to the seafloor and clog interstitial spaces between gravel, cobbles, and boulders affecting invertebrate microhabitat (CCME 2002). Temporary removal of timber pilings will temporarily remove some invertebrate habitat. Permanent removal of the marine railways will permanently remove some invertebrate habitat as well. The amount of temporary and permanent removal of habitat is not likely to cause significant adverse environmental effects to marine invertebrates. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• Follow mitigation measures outlined in the Surface Water VEC section above.	No
	<u>Marine Invasive Species</u> Marine invasive species are a threat native species. They can be attached to boat hulls or in ballast water. Magnitude: High Spatial extent: Low Duration: High Reversibility: Low	• Verify that vessels are free of marine species attached to the hull or inside the vessel before entering Esquimalt Harbour to help avoid the spread of marine invasive species.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Fish			
Contractor vessel mooring and anchoring Structure demolition/removal, relocation and reinstatement Dredging and debris removal Excavation Dewatering of dredge material Placement of material	<u>Physical and Behavioural Effects from Decrease in Water Quality</u> Increased turbidity and/or TSS concentrations in the water column can result in a disruption of feeding by visual predators such as juvenile salmon (Berg and Northcote 1985), can cause gill abrasions (Birtwell 1999; Servizi and Martens 1987) and can cause respiratory distress in fish (Berg and Northcote 1985). Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: High	• Follow mitigation measures outlined in the Surface Water VEC section above.	No
	<u>Physical Harm to Herring Eggs</u> Pacific herring is a key marine fish species in BC that has spawned in and adjacent to the sub-project areas in the past. Herring may spawn, incubate and rear in the in-water project areas from late February to late June. Herring eggs attached to vegetation and have also been known to attach to structures in the water. In-water work is proposed to be conducted outside of the DFO marine/estuary winter work window of 1 December to 15 February for the area (Area 19). If herring spawn in the sub-project areas, they could be physically damaged by equipment through direct contact, or through removal of vegetation with attached eggs. Magnitude: Moderate Spatial extent: Low Duration: Moderate Reversibility: High	• After 15 February, a qualified EM will visually observe from the surface of the water for spawning herring (i.e., schools of herring depositing eggs or releasing milt) and herring eggs within the project areas. Monitoring for spawning herring and herring eggs will be undertaken every day that in-situ water quality monitoring is being conducted. Milt should be visible as white opaque water from the surface of the water, and attached eggs may be more visible on vegetation or equipment at low tide. Spawning herring may also attract birds and marine mammals which may be observed from the surface of the water. • If herring spawning is observed within the project areas, the EM will inform PSPC and work with potential to affect herring egg masses or emergent larvae will be stopped for 10 to 14 days. • If herring eggs are found on equipment, the EM will inform PSPC, and work will be stopped and will not resume until after eggs have hatched.	No
	<u>Physical Harm to Fish</u> If large schools of fish get trapped inside of the silt curtain, they may not be able to avoid equipment and they could be physically harmed by moving equipment. For intertidal excavation/backfill work, if a depression is made that is not connected to the harbour, fish could enter the depression at high tide and become stranded and may die at low tide. Magnitude: Moderate Spatial extent: Low Duration: Moderate Reversibility: High	• For work within a silt curtain, if large schools of fish are observed in the enclosed silt curtain, in-water work should be temporarily suspended, and the silt curtain opened to allow fish to escape. • For intertidal excavation/material placement, work should be planned and conducted in a manner so that fish cannot become stranded.	No
	<u>Fish Habitat Alteration – Soft Sediment</u> Soft sediment fish habitat will be temporarily disturbed during dredging; however, there is expected to be a net improvement in sediment quality after contaminated sediment and debris is removed. Backfill substrate will generally be similar to substrate that currently exists, and elevation changes are expected to be within 1 m of the current seabed. This substrate alteration is not likely to cause serious harm under the *Fisheries Act*. Magnitude: Moderate Spatial extent: Low	• Follow mitigation measures outlined in the Marine Vegetation VEC section above. • For intertidal excavation/material placement, the following measures apply: - Excavation/material placement area and depth will be delineated before works begin to avoid over-excavation/material placement, and to avoid impacting adjacent areas. - Material will be have similar grain size and gradation as existing	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Fish			
	Duration: Moderate Reversibility: High	- Material will be placed in dredged/excavated areas - Depth and slope of the intertidal will be similar to existing conditions	
	<u>Fish Habitat Alteration – Kelp</u> Understory brown bladed kelp was observed in CJML DU 16 and in several areas of the YJLC sub-project area (Figures 6 and 7). The areas of understory kelp will be dredged and backfilled. The loss of understory kelp may reduce spawning habitat for Pacific herring, as well as foraging and cover for various fish species. A Fisheries Act Paragraph 35(2)(b) authorization application has been submitted to DFO for the loss of understory kelp with 50 to 100% cover. There are also kelp reefs adjacent to the in-water project areas that provide fish habitat that could be accidently disturbed during various project activities. Magnitude: High Spatial extent: Low Duration: Moderate Reversibility: Moderate	• Offsetting will include placement of angular rock in CJML DU 16 and portions of YJLC, and use of a rocky reef habitat bank previously construction in Esquimalt Harbour. • “No dredge/backfill zones” and “no anchoring zones” in areas with bedrock outcrops and kelp will be delineated using GPS chart plotting software before the EHRP begins to avoid accidental removal and damage of kelp. • The barge will not come to rest on the seafloor (no grounding) in areas where subsequent disturbance through dredging will not occur. Barge grounding will be only be permitted in nearshore areas where dredging will occur, provided water quality is managed according to the requirements outlined in the WQMP.	No
	<u>Fish Habitat Alteration – Intertidal Shoreline</u> Dredge Units 29 and 30 are planned to be capped. These areas are along the shoreline in the upper intertidal and backshore area and consist mainly of riprap. The capping of this nearshore area will result in the permanent loss of 90 m^2 of upper intertidal riprap habitat for invertebrates and fish. A *Fisheries Act* Paragraph 35(2)(b) authorization application has been submitted to DFO for the shoreline infilling. Magnitude: Moderate Spatial extent: Low Duration: Permanent Reversibility: Low	• Offsetting will include the use of a rocky reef habitat bank previously construction in Esquimalt Harbour.	No
Structure demolition/removal, relocation and reinstatement Dredging and debris removal	<u>Mortality, Injury and Behaviour Changes from Underwater Noise</u> Assessment of the potential effects of underwater anthropogenic noise on fish requires acoustic impact thresholds for which to compare emitted sound levels and establish potential for injury. Currently, there are no legislated underwater noise criteria in Canada for assessing injury in fish. In absence of specific legislated criteria, assessing potential for injury to fish from underwater noise is typically based on ‘best available evidence’, as documented in the scientific literature and/or established by other government agencies. The US National Marine Fisheries Service (NMFS) have adopted interim acoustic threshold criteria specific to impact pile driving that are based on sound pressure levels (SPLs) that are known to potentially result in physical effects in fish (Stadler and Woodbury 2009). The current NMFS interim threshold for potential injury to fish is **206 dB re 1 µPa SPLpeak** (Stadler and Woodbury 2009; FHWG 2008). Underwater noise generated from dredging, structure removal, relocation and reinstatement (which includes pile driving), and backfill and material placement may affect fish behaviour. Impact pile driving also has the potential to exceed injury thresholds for fish (Caltrans 2001; Vagle 2003).	**Vibratory Pile Driving** • Vibratory methods will be used for pile removal and reinstatement where possible. If vibratory methods are not used, an alternative similar method will be submitted to the Departmental Representative for review. • Vibratory pile driving may take place year round with the following monitoring and mitigation measures for fish: - Sound levels must not exceed 206 dB re 1 µPa SPLpeak at 10 m from the piling. - Monitoring via underwater noise recordings by a qualified environmental monitor must be conducted at the start of pile driving within 10 m of the pile being driven to verify that underwater noise does not exceed 206 dB re 1 µPa SPLpeak. - If noise levels exceed this threshold, or fish mortality is observed, pile driving activities are to cease immediately. DFO must be notified about fish mortality per subsection 38(4) of the *Fisheries Act*.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Fish			
	Specific, systematic studies regarding the effects of underwater noise and vibrations of fish are limited. Popper and Hastings (2009) reviewed the available studies, which addressed the following potential effects mechanisms: behavioural responses; stress and other physiological responses; hearing loss and damage to auditory tissues; structural and cellular damage on non-auditory tissues; and mortality. Depending on the species of fish and the nature of the noise exposure (e.g., duration, peak pressure, rise times, accumulation of energy with time), underwater noise may result in: • Startle responses or migration out of areas (behavioural response). • Increased levels of corticosteroid levels, which is an indicator of stress. Stress may impair a fish's ability to avoid predation. • Hearing loss. Inability to hear may affect a fish's ability to respond to other noise cues and thus be more susceptible to predation or less able to find food items. • Tears or rupture of the swim bladder or other tissues, which may affect buoyancy or cause internal bleeding and ultimately mortality. Clamshell dredging produces continuous, non-pulsive underwater noise and produces in-water SPLs ranging from 150 to 162 dB (re to 1 µPa) at 1 m from the source (Richardson et al. 1995). This is below the injury threshold for fish (206 dB SPLpeak re 1 µPa) (Richardson et al. 1995; Stadler and Woodbury 2009; FHWG 2008); therefore injury to fish is not expected. Potential effects related to underwater noise from clamshell dredging will likely be restricted to behavioural disturbance. Vibratory pile driving of timber piles is expected to be used during this Project. Vibratory pile driving produces continuous, non-impulsive underwater noise. In-water SPLs for vibratory pile driving have been recorded in the range of 165 dB (re 1 µPa; Caltrans 2015) and are not expected to exceed the injury threshold for fish (206 dB SPLpeak re 1 µPa]) (Stadler and Woodbury 2009; FHWG 2008). Vibratory pile driving noise may cause changes to fish behaviour (Caltrans 2015). Should impact pile driving of steel piles occur, it would have the potential to create sound pressure levels which could exceed 206 dB SPLpeak re 1 (µPa) and may adversely affect fish through direct mortality, sub lethal injuries, or behavioural changes (Caltrans 2015; FHWG 2008; SLR 2014). Impact pile driving (by hammer) is typically louder than clamshell dredging or vibratory pile driving. In-water SPLs ranging from 131 to 135 dB (re 1 µPa) have been measured 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 reported SPLs for steel piles of equivalent dimensions as the timber piles proposed for the Projects, and standard noise attenuation losses in water (assuming simple spherical spreading), fish would not be expected to experience physical injury from sound pressures generated by impact pile-diving of steel piles unless they were <4 m from the source. Impact pile driving noise will also likely cause changes to fish behaviour. Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: High	- The work will only resume after additional measures (e.g. bubble curtain, timing) have been discussed with DFO and have been implemented to reduce noise levels below the threshold or after sensitive life history stages of fish have moved from the area. **Impact Pile Driving** • Impact pile driving of steel piles must not take place between April 1 and May 31 due to the potential for effects from underwater noise on fisheries resources in Esquimalt Harbour. The April 1 to May 31 time period is particularly sensitive due to the potential for herring spawning and out-migration of juvenile salmon in Esquimalt Harbour. • Impact pile driving of steel piles may occur outside of this window with mitigation measures. • Impact pile driving of timber piles may occur year round with monitoring and mitigation measures. • During impact pile driving, the following monitoring and mitigation shall be undertaken for fish: - Upon commencement of pile driving, or recommencement after a delay of 30 minutes or more, pile installation shall ramp-up by starting with less frequent impact strikes of lower force. This ramp-up period is designed to provide fish time to leave the area prior to generation of peak pressure and noise levels. - Sound levels must not exceed 206 dB re 1 µPa SPLpeak at 10 m from the piling. - Monitoring via underwater noise recordings by a qualified environmental monitor must be conducted continuously and within 10 m of the pile being driven to verify that underwater noise does not exceed 206 dB re 1 µPa SPLpeak. - If noise levels exceed this threshold, or fish mortality is observed, pile driving activities are to cease immediately. DFO must be notified about fish mortality per subsection 38(4) of the *Fisheries Act*. - The work will only resume after additional measures (e.g. bubble curtain, timing) have been discussed with DFO and have been implemented to reduce noise levels below the threshold or after sensitive life history stages of fish have moved from the area.	

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Marine Mammals			
Contractor vessel mooring and anchoring Structure demolition/removal, relocation and reinstatement Dredging and debris removal Dewatering of dredge material Placement of material	<u>Mortality, Injury and Behaviour Changes from Underwater Noise</u> The potential effects of underwater noise on marine mammals depends, to a degree, on the type of marine mammal involved as well as the characteristics of the sound emitted including the received sound level and the frequency content of the received sound signal relative to the hearing abilities of the animal (refer to Annex D). The potential zone of effect of anthropogenic sound is also influenced strongly by the properties of natural background (ambient) sound present in the area of exposure (Richardson et al. 1995) and local sound transmission properties which are determined by site-specific environmental factors such as seafloor bathymetry, substrate composition and water column characteristics. The potential for the Project to affect marine mammals is related to underwater noise generated from clamshell dredging and the installation of piles in the marine environment. Potential effects range from subtle changes in behaviour (i.e., avoidance) at low received levels to strong disturbance effects or temporary/ permanent hearing impairment at high received levels. There are currently no applicable underwater noise criteria for physical injury or behavioural disturbance in Canadian legislation (*Fisheries Act* or other). In absence of specific legislated underwater noise criteria in Canada, DFO bases its assessment of potential 'serious harm' to marine mammals on the best currently-available science. It also relies on the US standards employed by the National Marine Fisheries Service (NOAA 2016). For the assessment, the following National Marine Fisheries Service thresholds for marine mammal injury and behavioural disturbance from impulsive and non-pulsive sounds (NOAA 2016) were applied: • **Injury Thresholds: 190 dB re 1 µPa SPLrms for pinnipeds, and 180 dB re 1 µPa SPLrms for cetaceans.** • **Disturbance Threshold: 160 dB re 1 µPa SPLrms for all marine mammals**. Clamshell dredging produces in-water SPLs ranging from 150 to 162 dB (re to 1 µPa) at 1 m from the source (Richardson et al. 1995). These sounds are below the injury threshold for marine mammals. Vibratory pile driving of timber piles is expected to be used during this Project. Vibratory pile driving produces continuous, non-impulsive underwater noise. In-water SPLs for vibratory pile driving are not expected to exceed the injury threshold for marine mammals (190 dB re 1 µPa SPLrms for pinnipeds; 180 dB re 1 µPa SPLrms for cetaceans) (NOAA 2016; Caltrans 2015). Vibratory pile driving noise may cause changes to marine mammal behaviour. Behavioural disturbances of marine mammals are expected to be experienced only up to 2 m if vibratory methods are used. Should impact pile driving of steel piles occur, it would have the potential to create sound pressure levels which could exceed the injury thresholds for marine mammals (Southall et al. 2007). The underwater sound pressure levels caused by pile driving can be	**All In-Water Activities** • A qualified EM will be on-site during Project activities as outlined in the EMP. Marine mammal monitoring will be implemented during all in-water Project activities as a component of the environmental monitoring, with presence/ absence communicated to the contractor. **Vibratory Pile Driving** • Vibratory methods will be used for pile removal and reinstatement where possible. If vibratory methods are not used, an alternative similar method will be submitted to the Departmental Representative for review. **Impact Pile Driving** • Should impact pile driving be required for pile installation, the following mitigation measures will be implemented by the EM who will also be a certified Marine Mammal Observer with relevant marine mammal monitoring experience: - A marine mammal safety perimeter of 100 m for marine mammals will be established during impact pile driving. - This marine mammal safety perimeter is based on an injury threshold of 180 dB re 1µPa (RMS). If the threshold is exceeded at 100 m, the marine mammal safety perimeter will be widened to a new outer limit where underwater noise recordings demonstrate that the threshold is not exceeded. - Activities will cease if a marine mammal is observed within the marine mammal safety perimeter, and will only resume once the marine mammal has left the marine mammal safety perimeter or has not been re-sighted for 10 minutes. - Impact pile driving may only be carried out during daylight hours to enable effective visual monitoring of marine mammal exclusion zones. - Concurrent multiple underwater noise generating activities will be minimized where practicable (e.g., avoiding multiple pile driving activities at the same time). Where multiple underwater noise generating activities are planned they will be sequenced where possible to minimize cumulative underwater noise effects.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Marine Mammals			
	harmful to marine animals (Casper et al. 2012; Halvorsen et al. 2011; Halvorsen et al. 2012). The generation of underwater noise during pile driving and the probability of impact are dependent on the type of pile being driven, the type of hammer, substrate type, water depth and the species auditory capabilities (ICF Jones and Stokes and Illingworth and Rodkin Inc. 2009). Depending on the type of substrate, impact pile driving by hammer is typically louder than clamshell dredging or vibratory pile driving. In-water SPLs ranging from 131 to 135 dB (re 1 µPa) have been measured 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 reported values and standard noise attenuation losses in water (assuming simple spherical spreading), marine mammals would not be expected to experience physical injury/hearing impairment from sound pressures generated by pile-diving unless they were <18 m from the source. Behavioural disturbances of marine mammals are expected to be experienced up to 400 m from the pile should impact pile driving of steel piles occur, but only up to 2 m if vibratory methods are used. Magnitude: Low Spatial extent: Moderate Duration: Low Reversibility: High		
	<u>Physical Harm to Marine Mammals</u> If a marine mammal becomes trapped inside of the silt curtain, it may not be able to avoid equipment and they could be physically harmed by moving equipment. Magnitude: Moderate Spatial extent: Low Duration: Moderate Reversibility: High	• If a marine mammals is observed in the enclosed silt curtain area, in-water work should be temporarily suspended, and the silt curtain opened to allow it to escape.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Birds			
Mobilization and demobilization Structure demolition/removal, relocation and reinstatement Dredging and debris removal Excavation Dewatering of dredged material Placement of material In-water transportation	<u>Mortality or Injury from Harmful Substances</u> Migratory birds may forage or temporarily occur in surface waters in and adjacent to the Project Areas, and could be negatively affected if a harmful substance is deposited into surface waters. For example, spills of fuel or oil could negatively affect the health of birds occurring in the area. Oil can negatively affect birds by interfering with insulating properties of feathers and by damaging internal organs if ingested (NOAA 2016) Section 5 of the federal *Migratory Birds Convention Act* prohibits the deposit of substances harmful to migratory birds into waters or areas frequented by migratory birds. <u>Disturbing and Destruction of Birds and Nests</u> Section 34 of the provincial *Wildlife Act* prohibits the injury, molestation, or destruction of birds, bird eggs, and nests occupied by a bird or its eggs. Therefore, if a nest is removed when the nest is occupied by a bird or its egg, it would be considered an offence under the *Wildlife Act*. Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: High	• Follow mitigation measures outlined in the Surface Water VEC section above. • A qualified EM will be on-site during Project activities as outlined in the EMP. Monitoring for signs of nesting, injured or dead birds will be undertaken by a qualified EM. • The EPP will include contractor monitoring requirements for birds and triggers for modifying work. • Structures should be removed outside of the breeding season. Prior to removal, surveys for old nests should be undertaken. If old nests are found on structures to be removed, Canadian Wildlife Service and the Ministry of Environment should be consulted first before removal. • The breeding season is considered to be March 1 to August 31 for passerines, including barn swallows, according to MOE (2014) which also encompasses the regional nesting period for the area (Region A1) as indicated by Environment Canada and Climate Change (2016b). If structures are to be removed during the breeding season, non-intrusive surveys should be conducted to determine the presence of active nests immediately before structures are to be removed. If fully formed nests containing eggs or young are encountered, removal of the structures will be halted and Canadian Wildlife Service should be contacted.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Species at Risk – Birds			
Structure demolition/removal, relocation and reinstatement	<u>Disturbance and Destruction of Listed Species (Barn Swallow)</u> Barn swallows, listed under COSEWIC but not SARA, have potential to nest under the structures proposed to be demolished/removed. Section 6 of the Migratory Birds Regulations under the federal *Migratory Birds Convention Act* prohibits disturbing or destroying a migratory bird or its eggs except when authorized. The barn swallow is protected under this *Act* (Environment and Climate Change Canada 2016). Permits are only issued for certain activities such as for hunting and scientific purposes. Permits are not issued for nest disturbance or destruction during construction activities which is considered incidental take. Instead, best management practices are to be employed. Magnitude: Moderate Spatial extent: Low Duration: Low Reversibility: High	• Follow mitigation measures outlined in the Birds VEC section above.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Species at Risk – Invertebrates			
Structure demolition/removal, relocation and reinstatement Dredging and debris removal Placement of material	<u>Harm to a SARA Listed Species (Northern Abalone)</u> Northern abalone, a SARA Schedule 1 threatened species, have been observed amongst boulders near the shoreline of the ML Floats area from 0.0 to -0.8 m CD and could extend down to approximately -2.2 m CD to the bottom of the boulder slope in that area. Dredging will occur adjacent to this area, and backfill will be placed up to the toe of the boulder slope. Abalone could be affected by accidental contact with equipment and could be covered by sediment during sediment mobilization during dredging, material placement, and marine railway removal. Section 32 of SARA prohibits killing, harming, harassing, capturing or taking an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species. Magnitude: High Spatial extent: Low Duration: Low Reversibility: High	• To help protect abalone that occur adjacent to the sub-project area along the ML Floats shoreline, an additional abalone survey and potential relocation program is proposed to be undertaken before work begins in the sub-project area. A SARA permit for the relocation program will be obtained prior to work occurring in the ML Float area. Relocation activities will follow relocation protocols in the “Action Plan for the Northern Abalone (*Haliotis kamtschatkana*) in Canada” (DFO 2012) and other requirements as per the SARA Permit. • To help protect potential abalone habitat at ML Floats from siltation during dredging, mitigation measure outlined in the Surface Water VEC section will be followed. During material placement and structure removal, work shall be done in a way that does not cause sedimentation on potential abalone habitat.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Species at Risk – Fish			
Contractor vessel mooring and anchoring Structure demolition/removal, relocation and reinstatement Dredging and debris removal Dewatering of dredge material Placement of material	Quillback rockfish and coastal cutthroat trout (not SARA listed species) have been observed in the Esquimalt Harbour and have potential to occur in the sub-project areas based on habitat requirements. Effects to quillback rockfish and coastal cutthroat trout would be similar to the effects to fish. Refer to effects in the Fish VEC section above. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• To mitigate effects to these species, mitigation measures outlined in the Surface Water and Fish and Fish Habitat VEC sections will be followed.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Species at Risk – Marine Mammals			
Contractor vessel mooring and anchoring Structure demolition/removal, relocation and reinstatement Dredging and debris removal Dewatering of dredge material Placement of material	Several marine mammal species at risk have some potential to occur in the in-water project areas including harbour porpoise, killer whales, and Steller sea lions. These marine mammals have been observed in Esquimalt Harbour; however, Esquimalt Harbour is not considered important habitat for these species. Effects to these fish species would be similar to the effects to fish. Refer to effects in the Fish and Fish Habitat section above. Magnitude: Low Spatial extent: Moderate Duration: Low Reversibility: High	• Mitigation measures outlined for the Marine Mammals VEC will be implemented to mitigate effects to these marine mammal species at risk.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Transportation			
Upland transportation	<u>Increase in Traffic on Public Roads</u> Potential project use of public roads to remove dredged material is considered likely. If transportation of sediment and debris to the landfill is undertaken on public roads, the increase in traffic may affect traffic on these roads.	• The contractor will follow all relevant municipal bylaws when using public roads.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Navigation			
Mobilization and demobilization Contractor vessel mooring and anchoring Structure demolition/removal, relocation and reinstatement Dredging and debris removal Dewatering of dredge material Placement of material In-water transportation	<u>Change in Vessel Access</u> There is potential for changes to no access zones during the EHRP which may affect vessels in the harbour. <u>Increase in Vessel Traffic</u> There may be an increase in vessel traffic associated with in-water transportation of dredged material and in-water transportation of equipment and supplies to in-water project areas. This may affect other vessel traffic in the harbour by making it more difficult to navigate and transit the harbour. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• The contractor must submit a Navigation Control Plan describing means and methods by which vessel movements and harbour control procedures and practices will be completed and monitored. • The work will be conducted in accordance with the Esquimalt Harbour Practices and Procedures (Royal Canadian Navy 2017). • Material transported by barge into, within, and out of Esquimalt Harbour requires the contractor to coordinate directly with Queen's Harbour Master (QHM) pursuant to the *Canada Marine Act*. The DR requires 72-hour notification of all material transported by barge into or out of Esquimalt Harbour. Material barge transport movements within Esquimalt Harbour require a 24-hour notification to the QHM. • Work will be phased to minimize disruptions to other vessel traffic. • Additional emergency docking and navigation management procedures outlined in the Navigation Control Plan will be followed.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Commercial, Recreational, and Aboriginal Fisheries			
Mobilization and demobilization Contractor vessel mooring and anchoring Structure demolition/removal, relocation and reinstatement Dredging and debris removal Excavation Dewatering of dredge material Placement of material In-water transportation	<u>Changes in biophysical conditions for fish</u> There may be a temporary change in rearing, cover, spawning and foraging habitat for fish in the sub-project areas during the EHRP which might temporarily decrease the amount of fish in the sub-project areas. There may also be a temporary decrease in water quality in and adjacent to the sub-project areas that may affect fish. Overall, there is expected to be a benefit to fish after the EHRP is complete in that the quality of habitat will improve due to the removal of contaminated sediment. <u>Decrease in availability of fish and seafood resources for fishing</u> There may be a decrease in fish in the sub-project areas during the EHRP; however, it is not anticipated to affect fishing as fishing and crab harvesting should not occur within the 200 m buffer around the jetties. <u>Change in Navigability in the Harbour</u> Movement of EHRP associated marine vessels may affect crab harvesting outside of the sub-project areas. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• Implement mitigation measures outlined in Surface Water Quality and Fish VECs to mitigate any changes to biophysical conditions that may influence resource availability. • Implement mitigation measures outlined in Navigation VEC to mitigate changes in access.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Land and Marine Based Non-consumptive Recreation			
In-water transportation	<u>Increase in Vessel Traffic</u> There may be an increase in vessel traffic associated with in-water transportation of dredged material and in-water transportation of equipment and supplies to in-water project areas. This may affect recreational vessel traffic in the harbour by making it more difficult to navigate and transit the harbour. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• Follow mitigation measures for Navigation VEC above.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
In-Air Noise, Light and Odour			
All Project Components	Increase in In-Air Noise, Light and Odour There may be an increase in in-air noise, light and odour during the EHRP that may disturb the peace, rest, comfort or enjoyment of people in the vicinity of the sub-project areas. This effect is expected to be temporary as it will not extend beyond the duration of the EHRP. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• The contractor must comply with local ordinances regarding noise control while conducting activities at the Work Site • The contractor is to meet the intent of Township of Esquimalt, Colwood, and View Royal Noise By-laws at the Work Site boundary or modify work activities. Noise restrictions apply within the hours of 7:00 p.m. to 7:00 a.m. between Monday and Saturday and at all times on Sundays and statutory holidays. The contractor must undertake noisier work activities during daytime hours and modify activities based on noise monitoring and resident feedback. • Construction equipment must be operated with exhaust systems in good repair to minimize noise. • Make sure that noise control devices (i.e., mufflers and silencers) on construction equipment are properly maintained. • The contractor must implement use of lighting shrouds for work to be completed during night-time hours to minimize lighting disruptions to local residents. • An ambient noise monitoring program will be implemented to provide a baseline for assessing the effects of Project-related noise. In-air noise monitoring will also be conducted during each new Project activity. Additional in-air noise monitoring may be conducted on an as needed basis if complaints are received, to verify that specified bylaw noise levels are met. Complaints received about noise will be reviewed to evaluate the need to implement additional noise monitoring or modifications to activities. • Complaints received about odour will be reviewed to evaluate the need to implement odour monitoring or modifications to activities. H2S monitoring will be undertaken on an as needed basis if complaints are received.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
First Nations Traditional Activities			
All Project Components	The EHRP will take place in the traditional territory of the Esquimalt and Songhees First Nations. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• DND will continue to engage with the Songhees and Esquimalt First Nations regarding the project, including continued implementation of the First Nations Involvement Plan. • When possible, work with the Songhees and Esquimalt First Nations to schedule work to minimize disruptions. • Develop and implement a Project communications plan with the Songhees and Esquimalt First Nations outlining project notification procedures and processes for receiving input on work schedule.	No

Project Component(s)	Description of Potential Effects	Mitigation Measures	Residual Significant Effects
Archaeology			
Structure demolition/removal, relocation and reinstatement Dredging and debris removal Placement of material	Proposed project-related activities, notably dredging, have the potential to impact archaeological materials or other heritage resources located in the surface and sub-surface areas of seabed within the Project Area by disturbing or destroying cultural deposits and features, damaging artifacts, and destroying contextual information that is essential for interpreting site function and age. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: Low	Per the results of the archaeological overview assessment (AOA) and archaeological impact assessment (AIA) conducted for Lang Cove (Golder 2015b; Golder 2016c), the potential for precontact archaeological resources to be present within the Project Area is low to moderate. The archaeologically significant heritage wreck site DcRu-1259 is located in Lang Cove (Golder 2017). Mitigation measures for the protection of archaeological resources consist of: • Maintaining all floating equipment and vessels outside of the Exclusion Zone in Lang Cove, as indicated on the design drawings, to protect sensitive historically, archaeologically, architecturally, or paleontologically significant structures, sites, or things located within the Exclusion Zone. There must be no dredging, material placement, spudding, or anchoring in the Exclusion Zone. • Archaeological Chance Find Management Guidelines are to be followed during bulk handling of dredge material (e.g., dredging, offloading). • Monitoring of machine sorting of dredgeate during material processing activities for unexploded ordnance (UXO) will include provisions for the collection of observed historically, archaeologically, or paleontologically significant artifacts, features, and faunal materials, as well as human remains.	No

2.5 Public Participation

The EHRP will be conducted on DND administered lands within CFB Esquimalt. DND has conducted stakeholder consultations in advance of EHRP initiation and consulted with groups such as the Esquimalt Harbour Advisory Committee to identify and address public and other stakeholder concerns. A Public Communications Plan (Golder 2014b) has been prepared for the A/B Jetty Recapitalization Project by Golder on behalf of DCC and DND. This plan outlines the proposed process for keeping the public informed of key components of the EHRP.

The objectives of this Public Communications Plan includes the following:

- Clearly communicate the potential impacts and benefits of the EHRP on Esquimalt Harbour and on stakeholders.
- Establish realistic expectations for what this EHRP will achieve in the short term and the long term;
- Build on the relationships, past communications, and public involvement work conducted by DND, DCC, and PSPC; and
- Fulfill the requirements set by Federal agencies, including DND, DCC, PSPC and DFO, in support of regulatory approval for the EHRP.

The Public Communications Plan identifies stakeholders that are anticipated to be engaged for the EHRP. Through a review of past federal Projects within the Esquimalt Harbour, individuals and organizations have been identified who may have an interest in the EHRP, including the following four key audiences: regulatory agencies; adjacent businesses and residents; local governments and other government agencies; and Esquimalt Harbour users.

A review of key issues raised in previous federal public communication activities for the Esquimalt Harbour has been conducted. The review has identified anticipated concerns about the proposed EHRP activities that may affect these key audiences. Information packages were then designed to communicate important facts about the EHRP, and includes information on what steps have already occurred, what this EHRP will involve, why it is taking place, how potential impacts will be mitigated, and how the EHRP fits with other initiatives occurring in the Esquimalt Harbour. Communication channels have been developed to engage stakeholders and the public and include face-to-face meetings, print communications, public information sessions, an EHRP website and press releases. The goal of these communications are to reach target audiences and to communicate the EHRP’s planned remediation activities to stakeholders and members of the public in a relevant and timely manner.

The plan details proposed public communications activities to support necessary permitting for the EHRP to proceed, and provides an outline of recommended activities through the implementation period to anticipated close-out to monitor and respond to emerging issues or concerns once work is underway. The plan is designed as a flexible document that can be adjusted to meet emerging EHRP needs (Golder 2014b).

A Public Information Session (PIS) was held on 25 March 2015 at the Songhees Nation Wellness Centre in Esquimalt, BC, with a follow-up PIS held on 7 March 2017 at the same location. Prior to the events, the PIS was advertised in local newspapers, and a mail out was sent to local mayors, councils and residents inviting their participation. The PIS was facilitated by the Base Commander and key senior staff from Formation Safety and Environment at CFB Esquimalt and Golder public engagement staff. Poster boards and information handouts were prepared that summarized the planned remediation activities to stakeholders and members of the public.

2.6 Aboriginal Community Engagement

This section summarizes collected background information on the Aboriginal groups that may be affected by the DND Project. Included is a description of how DND determined which Aboriginal groups needed to be engaged. The Aboriginal groups that will be potentially affected are identified based on guidance from DND and publically available information from the federal government and the Province of British Columbia. Based on this information, DND concluded that the following groups and organizations have Aboriginal interests in the EHRP area:

- Esquimalt Nation
- Songhees Nation
- Te'mexw Treaty Association, representing the Malahat Nation, Scia'new (Beecher Bay) First Nation, Snaw-naw-as (Nanoose) First Nation, Songhees Nation, and the T'Sou-ke (Sooke) Nation
- Hul'qumi'num Treaty Group, representing the Cowichan Tribes, Halalt First Nation, Lake Cowichan First Nation, Lyackson First Nation, Penelakut Tribe, and Stz'uminus (Chemainus) First Nation
- Saanich Nations (Malahat First Nation, Pauquachin First Nation, Tsartlip First Nation, Tsawout First Nation and Tseycum First Nation)
- Métis Nation British Columbia
- Métis Nation of Greater Victoria

There are two First Nations communities with Indian Reserves (IRs) on Esquimalt Harbour and thus considered local to the EHRP area: the Esquimalt Nation on the Esquimalt IR) and the Songhees Nation on New Songhees IR 1A. These IRs are located on Plumper Bay on the east shore of the harbour, adjacent to the Esquimalt Graving Dock and approximately 700 m north of CFB Esquimalt.

The Esquimalt and Songhees Nations are Douglas Treaty Nations. The Douglas Treaties include a series of treaties signed in the 1850's by the Crown and Vancouver Island First Nations, including what are now the Esquimalt and Songhees Nations. Use of Esquimalt Harbour for the exercise of treaty rights or for other traditional purposes by the Esquimalt Nation and Songhees Nation has decreased since approximately 1960. Current use is related to non-harvesting activities; however, the Esquimalt Nation and Songhees Nation have indicated to DND that this current use does not reflect their past use or desired future use of the harbour for their "food basket," made up in part by seafood (i.e., ling cod, rockfish or rock cod, clams, mussels, sea urchin, crab, shrimp, and prawns) and waterfowl (i.e., duck and geese).

As part of the Te'mexw Treaty Association (TTA), the Songhees Nation is negotiating a final agreement with Canada and British Columbia through the British Columbia Treaty Commission (BCTC) process. There are five member First Nation that form the TTA: Malahat Nation, Scia'new (Beecher Bay) First Nation, Snaw-naw-as (Nanoose) First Nation, Songhees Nation, and the T'Sou-ke (Sooke) Nation. All of these First Nations have IRs located within the Capital Regional District, except for the Snaw-naw-as First Nation who have an IR situated on Nanoose Bay in the Regional District of Nanaimo.

The Esquimalt Nation is not participating in the BCTC process.

In addition to the Esquimalt Nation, Songhees Nation and the TTA, the federal Aboriginal and Treaty Rights Information System (ATRIS) maintained by Indigenous and Northern Affairs Canada and the First Nations Consultative Areas Database (accessed online March 1, 2016) maintained by the Province of British Columbia identifies Hul'qumi'num Treaty Group (HTG) member First Nations as having potential interests in Esquimalt Harbour, based on a large asserted marine (non-core) territory. Like the TTA, the First Nations of the HTG are collectively negotiating a final agreement with Canada and British Columbia through the BCTC process; the HTG are currently at Stage 4 of the six-stage BCTC process. The six member groups of the HTG are Cowichan Tribes, Halalt First Nation, Lake Cowichan First Nation, Lyackson First Nation, Penelakut Tribe, and Stz'uminus (Chemainus) First Nation. The closest HTG community to Esquimalt Harbour is located approximately 45 km to the north by the City of Duncan, BC. The HTG have indicated previously to DND that Esquimalt Harbour is a "lower priority" in relation to their interests, but have recommended that HTG member communities be notified about DND activities by letter.

In late 2016, ATRIS and the First Nations Consultative Areas Database (both accessed online December 5, 2016) identified the Saanich Nations, including the Malahat First Nation, Pauquachin First Nation, Tsartlip First Nation, Tsawout First Nation and Tseycum First Nation, as having potential interests in Esquimalt Harbour. Each of the five Saanich Nations have their own IRs located within the Capital Regional District. There have been no previous communications between DND and the five Saanich Nations.

It is not known if the Métis use Esquimalt Harbour, including the sub-project areas, for harvesting purposes. Métis Nation British Columbia (MNBC) is an Aboriginal organization routinely identified by the Canadian Environmental Assessment Agency for BC-based Projects subject to review under the *Canadian Environmental Assessment Act, 2012*. MNBC represents 34 chartered communities in BC, including the Métis Nation of Greater Victoria (MNGV); MNGV is the Métis local for the Capital Regional District, which includes Esquimalt Harbour. There have been no previous communications between DND and MNBC or other Métis representative groups.

2.6.1.1 First Nations Communications for the Project

This section describes the approach, methods and actions that DND undertook to engage Aboriginal Groups prior to and during the environmental assessment process. The comments and concerns of Aboriginal groups, and the process for addressing these comments and concerns are summarized.

DND recognizes the importance of effectively engaging Aboriginal groups with Aboriginal interests in the sub-project areas. The objective was to support positive, productive and long lasting relationships with affected Aboriginal communities that properly addressed applicable legal and regulatory requirements. DND has committed to providing Aboriginal groups opportunities where appropriate to engage in the EHRP and to provide meaningful input for consideration.

A First Nations Communications Plan (Golder 2014a) was prepared for the EHRP that provided for a communications stream between DND and First Nations that is separate from the Public Communications Plan (Golder 2014b). This plan details communication activities with First Nations from Fall 2014 through to EHRP implementation to support the preliminary draft EA and the necessary permitting for the EHRP to proceed, and provides an outline of recommended activities through to implementation close out (December 2022) to monitor for emerging issues or concerns once the EHRP work is underway. The Plan is intended as a living document that can be adjusted as the EHRP and DND communications with First Nations evolve.

Through a combination of formal correspondence, face-to-face meetings, and telephone / e-mail communications, the plan (and amendments, as necessary) accomplished the following measurable and tangible outcomes as a result of its implementation:

- Obtained and demonstrated the incorporation of meaningful First Nations feedback on the preliminary draft EA report for the EHRP, including mitigation measures, habitat offsetting, and environmental / archaeological management plans;
- Produced appropriate documentation of communications activities, First Nations interests and concerns, DND responses, and key outcomes;
- Met First Nations communications requirements and expectations of applicable federal / provincial agencies, such as DFO; and,
- Fostered First Nations support for the EHRP.

The plan anticipates that the HTG member First Nations, Saanich Nations and MNBC / MNGV will be formally notified of the EHRP, but that the focus of ongoing communications activities are with the Esquimalt Nation and Songhees Nation, in recognition of their unique history, interests, and concerns relative to Esquimalt Harbour (Golder, 2014a, 2014d). Meetings with the Chief of the Esquimalt Nation were held on 25 September and 13 November 2014. A presentation on the EHRP was made to the Chief and Council of the Esquimalt Nation on 7 March 2016 and to the Chief of the Esquimalt Nation on 19 July 2017. A meeting with the Chief of the Songhees Nation was held on 8 January 2015. A presentation on the EHRP for the Songhees Chief and Council was conducted on 4 February 2015 and to the Songhees Nation Executive Director on 19 July 2017.

2.6.1.2 Aboriginal Activities

Use of Esquimalt Harbour for the exercise of treaty rights or for other traditional purposes by the Esquimalt Nation and Songhees Nation has decreased since approximately 1960. Current use is related to non-harvesting activities; however, the Esquimalt Nation and Songhees Nation have indicated to DND that this current use does not reflect their past use or desired future use of the harbour for their “food basket,” made up in part by seafood (i.e., ling cod, rockfish or rock cod, clams, mussels, sea urchin, crab, shrimp, and prawns), as well as waterfowl such as ducks and geese.

2.6.1.3 Communication Results

Leadership from the Esquimalt Nation and Songhees Nation have been provided EHRP-related information for their review and comment, including mapping of the remediation areas. Separate face-to-face meetings on the EHRP were conducted with Chief and Council from the Esquimalt Nation and Songhees Nation. Draft environmental assessment documents were also provided to the Esquimalt Nation and Songhees Nation for their review and comment. DND has a standing offer with the Chief and

Council from both the Esquimalt and Songhees Nations to conduct a site visit to the proposed EHRP area. Comments provided by the First Nations from these communications are summarized below.

First Nations expressed considerable support for the EHRP. Specific concerns regarding proposed EHRP activities include how and where the dredged sediments from the EHRP will be disposed of and whether dredging and shipping activities associated with CFB Esquimalt and Esquimalt Graving Dock will further disturb contaminated sediments, possibly contaminating other locations in the Esquimalt Harbour. DND has committed to sending the contaminated sediments from the remediation areas to a permitted off-site facility for disposal. DND acknowledged that preliminary studies suggests contaminants can move limited distances over time. However, it is unlikely that that the sediments from the EHRP will contaminate other areas of Esquimalt Harbour over the next 50 years.

Both the Esquimalt and Songhees Nations expressed interest in the potential economic opportunities for their First Nations from this EHRP, including employment and training opportunities. The Esquimalt and Songhees Nations have in-house experience in conducting remediation activities.

DND has indicated that Defence Construction Canada (DCC) has contracting opportunities for the EHRP, including potential Aboriginal set-asides. DND will make DCC aware of the First Nation’s interest and as new contracting opportunities present themselves, DND will alert the Esquimalt and Songhees Nations.

Both the Esquimalt and Songhees Nations expressed considerable concern with the implications of Health Canada’s Seafood Consumption Advisory for the Esquimalt Harbour, especially as it relates to the consumption of their traditional foods from the harbour. These foods are an important part of the community member’s diet, and have a critical role in their traditional ceremonies. Traditional foods include not only those listed in the Seafood Consumption Advisory, but also waterfowl, clams and mussel, as well as several species of fish. There were also concern that the EHRP may interfere with fishing at the entrance to the Esquimalt Harbour.

DND acknowledges these concerns and indicated that this is one of the principal reasons for proceeding with the EHRP. While the Esquimalt Harbour will never be as it once was before industrialization, there should be significant improvements as a result of the EHRP that include the remediation of six highly contaminated locations within the Esquimalt Harbour, as well as construction of additional habitat for marine life in the Esquimalt Harbour. At their request, DND has also presented the First Nations with a draft poster board on the Seafood Consumption Advisory established by Health Canada. DND has also committed to investigating how to best accommodate fishing activities in Esquimalt harbour, respecting the fact that there are security requirements that will not allow private vessels to come too close to the Jetties; DND will raise this concern with the Queen’s Harbour Master at CFB Esquimalt.

Songhees Nations has community events that include activities on the Esquimalt Harbour. For instance, there is an annual canoe race from their IR through the entrance to Esquimalt Harbour. DND has indicated that they can accommodate this race if provided with proper notice; DND has alerted the Queen’s Harbour Master at CFB Esquimalt of this issue.

First Nations expressed a concern about the potential for previously unidentified archaeological sites to be impacted by the remediation activities in the sub-project areas. DND has completed archaeological overview assessments (Golder 2015c; Golder 2016d) of proposed remediation areas in Esquimalt Harbour for the EHRP, including for C Jetty/ML Floats and Y Jetty/Lang Cove. Subsequently, an AIA was completed for the upland portion of A/B Jetties in 2014 and at Lang Cove and the F/G Jetty in 2015 (Golder 2016c; Golder 2016d). Recommended archaeological mitigation was completed at Lang Cove in November 2016.

Not all First Nations communications as outlined by Golder (2014a) have taken place. However, First Nations have been engaged with details of the Project. DND has committed continuing to work with Aboriginal groups to identify potential adverse effects of the Project on Aboriginal interests. The future involvement of identified First Nations will be incorporated into the Project based on the results of the communication process.

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Part 3. Environmental Effects Determination

On the basis of this DND EED Report, it has been determined that the impact of this project on the environment is as follows:

☒ Project is not likely to cause significant adverse environmental effects. The project **can** proceed with application of the mitigation measures specified in the interaction tables in this report.

☐ The project is likely to cause significant adverse environmental effects that cannot be mitigated. The project **cannot** proceed without Governor in Council approval.

☐ Refer the project, through the chain of command and **only on the recommendation of Environmental Command and DGIEGPS**, to Governor in Council for a decision on whether the project is justified to proceed.

DND EED Report Prepared by:

COLLEGE OF APPLIED BIOLOGY
Virginia Chant
21 Aug 2018
Virginia Chant Lawrence
R.P. Bio
2441
CAB

Virginia Lawrence, BSc.
Biologist, Golder Associates Ltd.

__21-08-2018______
Date (dd-mm-yyyy)

DND EED Report Reviewed by:

BWernick

COLLEGE OF APPLIED BIOLOGY
Barbara Wernick
21 Aug 2018
R.P. Bio
CAB

Barbara Wernick, MSc, RPBio
Principal, Senior Environmental Scientist, Golder Associates Ltd.

__21-08-2018______
Date (dd-mm-yyyy)

____
Tracy Cornforth, Environmental Officer
Formation Safety and Environment, tracey.cornforth@forces.gc.ca

____
Date (dd-mm-yyyy)

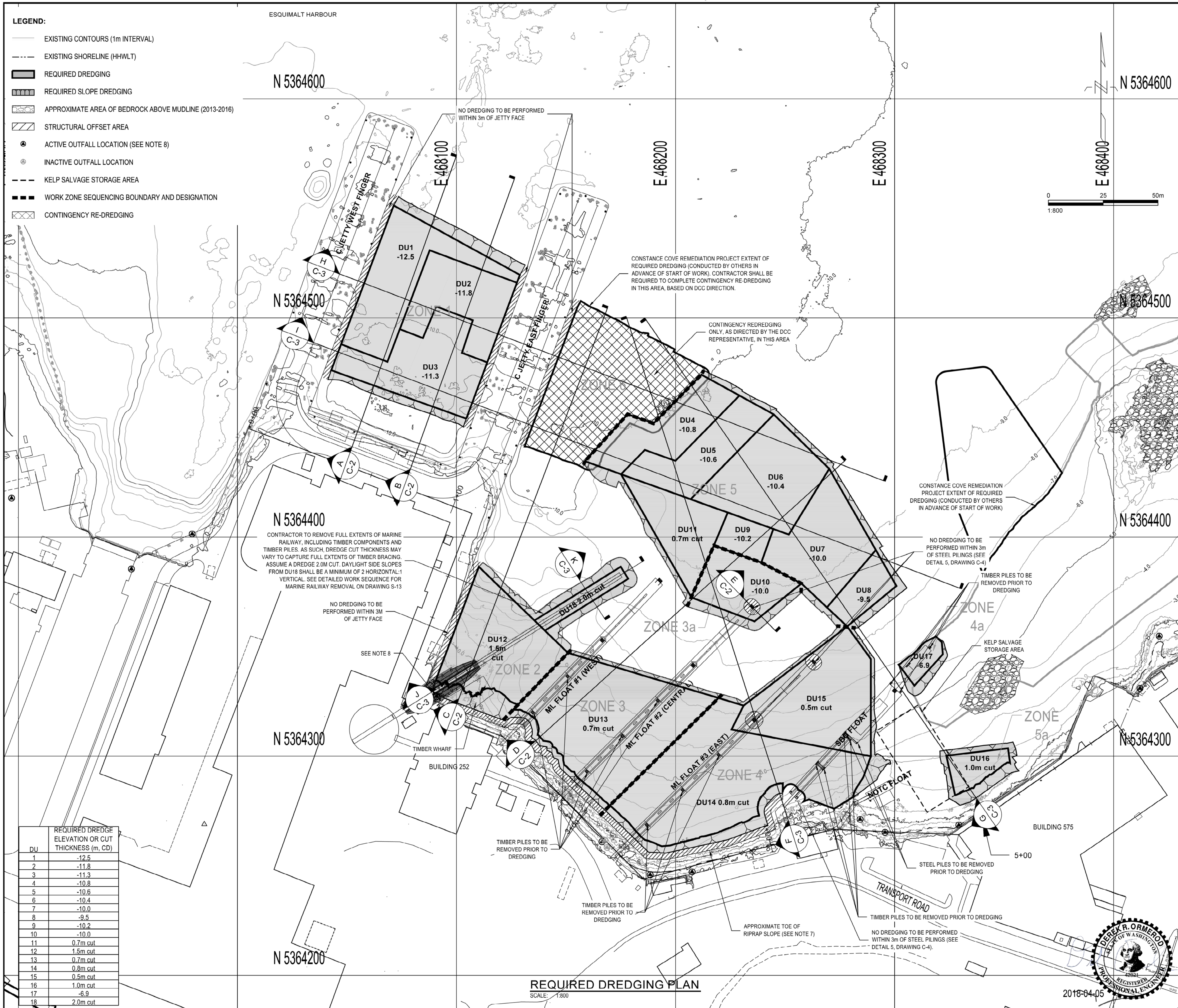
DND EED Report Accepted and Approved by:

The undersigned accepts the determination and recommendations of this environmental effects determination report. The undersigned also accepts the responsibility to incorporate the recommendations of the report into the project design and implementation.

____
Duane Freeman, Formation Officer
Formation Safety and Environment, duane.freeman@forces.gc.ca

____
Date (dd-mm-yyyy)

Annex A. Design Drawings



LEGEND:

- EXISTING CONTOURS (1m INTERVAL)
- EXISTING SHORELINE (HHWLT)
- REQUIRED DREDGING
- REQUIRED SLOPE DREDGING
- APPROXIMATE AREA OF BEDROCK ABOVE MUDLINE (2013-2016)
- STRUCTURAL OFFSET AREA
- ACTIVE OUTFALL LOCATION (SEE NOTE 8)
- INACTIVE OUTFALL LOCATION
- KELP SALVAGE STORAGE AREA
- WORK ZONE SEQUENCING BOUNDARY AND DESIGNATION
- CONTINGENCY RE-DREDGING

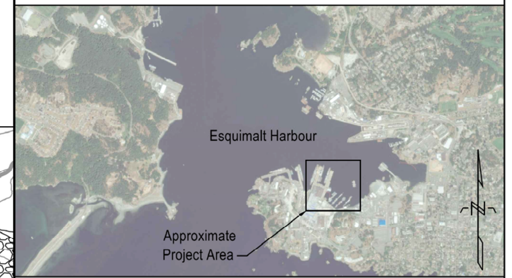
DU	REQUIRED DREDGE ELEVATION OR CUT THICKNESS (m, CD)
1	-12.5
2	-11.8
3	-11.3
4	-10.8
5	-10.6
6	-10.4
7	-10.0
8	-9.5
9	-10.2
10	-10.0
11	0.7m cut
12	1.5m cut
13	0.7m cut
14	0.8m cut
15	0.5m cut
16	1.0m cut
17	-6.9
18	2.0m cut

Government of Canada Gouvernement du Canada

LEVEL OF SECURITY | NIVEAU DE SÉCURITÉ
TO BE REVIEWED | À ÊTRE REVISER

ANCHOR QEA

Klohn Crippen Berger



SOURCE: BATHYMETRY FROM PWGSC SURVEYORS, DATED OCTOBER 2015.
HORIZONTAL DATUM: UTM ZONE 10N, NAD83.
VERTICAL DATUM: CHART DATUM (CD).
NOTES:

1. CONTRACTOR SHALL COMPLETE DREDGING ACTIVITIES ACCORDING TO SEQUENCING REQUIREMENTS DESCRIBED IN SPECIFICATIONS AND DRAWING G-2.
2. NO IN-WATER STOCKPILING OF SEDIMENT OR DEBRIS IS ALLOWED.
3. CONTRACTOR MEANS AND METHODS TO ACCOUNT FOR PROTECTION OF EXISTING STRUCTURES.
4. CONTRACTOR MEANS AND METHODS TO ACCOUNT FOR SHALLOW ELEVATIONS UNDER RANGE OF TIDAL CONDITIONS TO AVOID GROUNDING OF EQUIPMENT.
5. MARINE RAILWAY, TIMBER WHARF, ML FLOATS, SBU FLOAT, AND NOTC FLOAT LOCATIONS ARE APPROXIMATE.
6. DU CONTROL POINTS WILL BE PROVIDED ELECTRONICALLY TO THE CONTRACTOR.
7. CONTRACTOR SHALL VERIFY LOCATION OF TOE OF RIPRAP SLOPE PRIOR TO START OF DREDGING AND ENSURE THAT NO DREDGING OCCURS WITHIN THE 3-METRE OFFSET FROM THE TOE OF THE RIPRAP SLOPE.
8. CONTRACTOR SHALL PROTECT OUTFALLS FROM DAMAGE DURING CONSTRUCTION.
9. NOTWITHSTANDING THE TEMPORARY FENDERING PROTECTION REQUIRED BY THE SPECIFICATIONS, THE CONTRACTOR SHALL NOT ALLOW THEIR MARINE EQUIPMENT TO APPROACH WITHIN A 10-METRE RADIAL DISTANCE FROM THE STEEL PILE DOLPHINS (THAT WILL REMAIN IN PLACE AFTER FLOAT DISCONNECTION AND RELOCATION TO TEMPORARY MOORAGE) OR WITHIN A 10-METRE LATERAL DISTANCE FROM THE FACE OF C JETTY OR THE CONCRETE FLOATS REMAINING IN SERVICE, AT ANY TIME THROUGHOUT THE WORK. THIS REQUIREMENT RELATES TO MARINE DERRICKS, BARGES, AND TUGBOATS, BUT NOT TO MATERIALS HANDLING EQUIPMENT (SUCH AS CRANE BOOMS, BUCKETS, OR CONVEYORS) OR MARINE EQUIPMENT USED TO INSTALL OR REMOVE THE TEMPORARY FENDERING.

NO.	DATE	REVISION	APPR.
1	2018-04-05	ISSUED FOR CONSTRUCTION	
0	2017-12-08	ISSUED FOR TENDER	

SCALE | ÉCHELLE
1:800

LOCATION | EMPLACEMENT
C JETTY AND ML FLOATS
CFB ESQUIMALT

PROJECT | PROJET
EHRP PHASE 2A AND 2B
REMEDIATION PROJECT

TRADE | MÉTIER: CIVIL/ENVIRONMENTAL
DATE: 2018-04-05

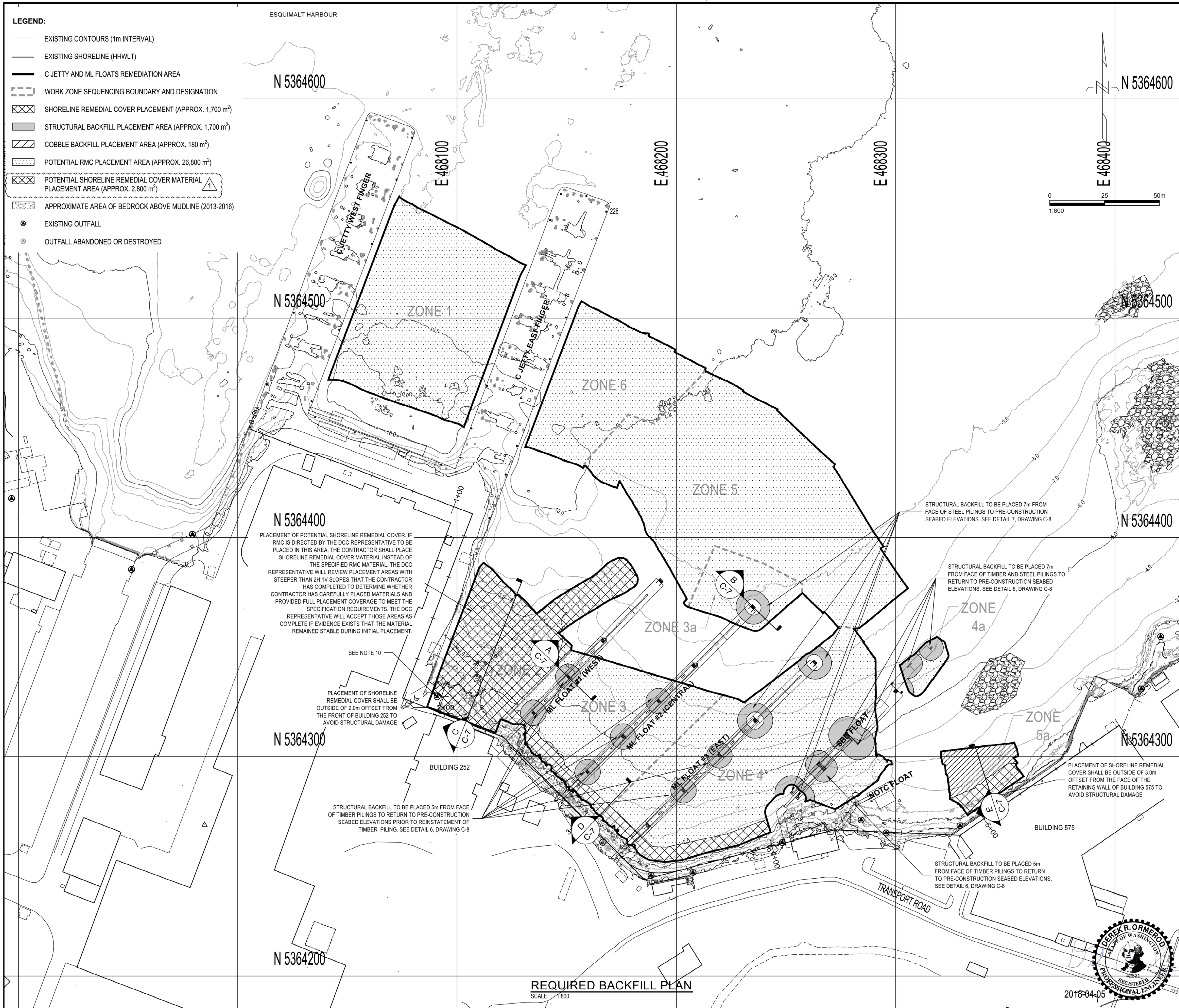
SUBJECT | SUJET
REQUIRED DREDGING PLAN

PRODUCTION	REVIEWED | REVU	
DESIGNED | ÉTUDIÉ: D. ORMEROD	XX | XX X.X.	DES O | AGENT CONC
DRAWN | DESSINÉ: C. HEWETT		PROJ MGR | GEST PROJ
CHECKED | VÉRIFIÉ: T. WANG		DES MGR | GEST CONC
COORDINATION: ----		FIRE | INCENDIE

WBS NO. | NO. OTP: L-23
PF NO. | NO. DP: EHR1899
DWG. NO. | NO. DESSIN: C-1

Canada

BORDER LAST UPDATED 2012-04-01
2018/Apr/02, 11:50am chewett REQUIRED DREDGING PLAN K:\Projects\0553-Public Works and Government Services Canada\EHRP Definition Phase\C Jetty\Construction Plans\0553-PL-C_1.dwg



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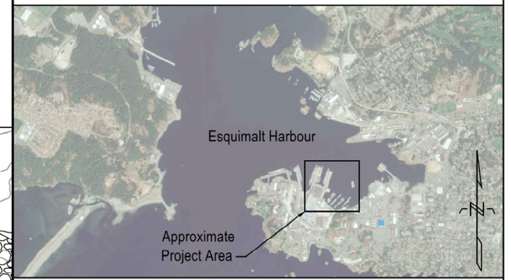
LEVEL OF SECURITY | NIVEAU DE SÉCURITÉ
TO BE REVIEWED | À ÊTRE REVISER

ANCHOR QEA
Klohn Crippen Berger



SOURCE: BATHYMETRY FROM PWGSC SURVEYORS, DATED OCTOBER 2015.
HORIZONTAL DATUM: UTM ZONE 10N, NAD83.
VERTICAL DATUM: CHART DATUM (CD).

NOTES:
1. CONTRACTOR SHALL COMPLETE BACKFILL MATERIAL PLACEMENT ACTIVITIES ACCORDING TO SEQUENCING REQUIREMENTS DESCRIBED IN SPECIFICATIONS AND ON DRAWING G-2.
2. WHEN PLACING BACKFILL MATERIAL ON SLOPES, ALL BACKFILL MATERIAL SHALL BE PLACED FROM THE BOTTOM (TOE) OF THE SLOPE UPWARD. BACKFILL MATERIAL SHALL BE PLACED IN LIFTS THAT ALLOW FOR THE COMPLETE COVERAGE OF THE DESIGNATED AREA AND MINIMIZES DISTURBANCES TO THE SEDIMENT SURFACE.
3. CONTRACTOR SHALL USE CAUTION WHEN PLACING SHORELINE REMEDIAL COVER ADJACENT TO BUILDINGS 575 AND 252 TO AVOID IMPACT WITH CONCRETE FOUNDATION, RETAINING WALL, OR SUPPORTING STEEL PILES OF BUILDINGS.
4. CONTRACTOR MEANS AND METHODS TO ACCOUNT FOR RANGE OF TIDAL ELEVATIONS WHEN PLACING BACKFILL MATERIAL IN THE SHALLOW NEARSHORE AREAS.
5. CONTRACTOR SHALL PLACE RMC MATERIAL IN AREAS IDENTIFIED BY THE DCC REPRESENTATIVE BASED ON DCC REPRESENTATIVE-CONDUCTED POST-DREDGE CONFIRMATION SAMPLING AND TESTING RESULTS.
6. PRIOR TO REINSTATEMENT OF ALL DEMOLISHED AND RELOCATED TIMBER PILING AT ML FLOATS, CONTRACTOR SHALL PLACE STRUCTURAL BACKFILL TO PRE-CONSTRUCTION SEABED ELEVATION WITHIN 5m OF THE FACE OF THE TIMBER PILING, AS SHOWN ON DRAWING C-7.
7. CONTRACTOR SHALL PLACE STRUCTURAL BACKFILL TO PRE-CONSTRUCTION SEABED ELEVATION WITHIN 7m OF THE FACE OF ALL PROTECTED STEEL PILINGS, AS SHOWN ON DRAWING C-7.
8. MARINE RAILWAY, TIMBER WHARF, ML FLOATS, SBU FLOAT, AND NOTC FLOAT LOCATIONS ARE APPROXIMATE.
9. CONTRACTOR SHALL VERIFY LOCATION OF TOE OF RIPRAP SLOPE. CONTRACTOR SHALL ONLY PLACE SHORELINE REMEDIAL COVER WITHIN THE RIPRAP OFFSET AREA. NO REMEDIAL COVER SHALL BE PLACED ON THE RIPRAP. ANY MATERIAL PLACED ON THE RIPRAP SLOPE SHALL BE REMOVED BY THE CONTRACTOR AT NO EXTRA COST TO THE CROWN.
10. CONTRACTOR SHALL PROTECT OUTFALLS FROM DAMAGE DURING CONSTRUCTION.
11. CONTRACTOR SHALL NOT PLACE BACKFILL MATERIAL ON RIPRAP.

NO.	DATE	REVISION	APPR.
1	2018-04-05	ISSUED FOR CONSTRUCTION	
0	2017-12-08	ISSUED FOR TENDER	

SCALE | ÉCHELLE
1:800

LOCATION | EMPLACEMENT
C JETTY AND ML FLOATS
CFB ESQUIMALT

PROJECT | PROJET
EHRP PHASE 2A AND 2B
REMEDIATION PROJECT

TRADE | MÉTIER: CIVIL/ENVIRONMENTAL
DATE: 2018-04-05

SUBJECT | SUJET
REQUIRED BACKFILL PLAN

PRODUCTION	REVIEWED | REVU	
DESIGNED | ÉTUDIÉ D. ORMEROD	XX | XX X.X.	DES O | AGENT CONC
DRAWN | DESSINÉ C. HEWETT		PROJ MGR | GEST PROJ
CHECKED | VÉRIFIÉ T. WANG		DES MGR | GEST CONC
COORDINATION ----		FIRE | INCENDIE

WBS NO. | NO. OTP: L-23
PF NO. | NO. DP: EHR1899
DWG. NO. | NO. DESSIN: C-6

DEREK R. ORMEROD
STATE OF WASHINGTON
REGISTERED PROFESSIONAL ENGINEER

Canada

DU	REQUIRED DREDGE ELEVATION OR CUT THICKNESS (m, CD)	WITHIN WQMA-A (SEE NOTE 7)
1	-10.0	NO
2	-9.8	NO
3	-9.5	NO
4	-9.3	NO
5	-9.5	NO
6	-9.0	NO
7	-8.6	NO
8	-7.8	NO
9*	-8.0	YES
10	-8.0	NO
11	-8.5	NO
12	-9.0	YES
13	-10.7	NO
14	1.5m cut	YES
15	1.8m cut	YES
16	0.5m cut	YES
17	2.4m cut	YES
18	-7.3	NO
19	-6.8	YES
20	-7.0	NO
21	-7.3	NO
22	-5.5	NO
23	2m cut	NO
24	2m cut	NO
25	1.3m cut	YES
26	1.5m cut	NO
27	1.3m cut	NO
28	0.8m cut	NO
29	1.0m cut	NO
30	1.0m cut	NO
31	1.4m cut	NO
32	1.5m cut	NO
33	1.4m cut	NO
34	1.5m cut	NO
35	1.8m cut	YES
36	0.5m cut	YES
37	1.5m cut	NO
38	1.3m cut	NO
39	0.5m cut	YES
40	1.5m cut	NO
41	1.3m cut	NO

*CONTAINS LEACHABLE METALS

NOTES:

1. CONTRACTOR MUST COMPLETE DREDGING ACTIVITIES ACCORDING TO SEQUENCING REQUIREMENTS DESCRIBED IN SPECIFICATIONS AND DRAWING G-2.
2. CONTRACTOR MEANS AND METHODS TO ACCOUNT FOR PROTECTION OF EXISTING STRUCTURES.
3. NO DREDGING WILL BE PERFORMED WITHIN 3m OF THE EXISTING BOAT RAMP AND WITHIN THE DREDGE OFFSET AREA.
4. CONTRACTOR MEANS AND METHODS TO ACCOUNT FOR SHALLOW BEDROCK ELEVATIONS UNDER RANGE OF TIDAL CONDITIONS TO AVOID GROUNDING OF EQUIPMENT.
5. BEDROCK SURVEY PROVIDED BY TETRA TECH (2015). DRILLING FOR BEDROCK DELINEATION CONDUCTED BY EBA ENGINEERING IN 2008 AND 2009. ADDITIONAL BEDROCK MAY BE PRESENT THAT WAS NOT IDENTIFIED BY SURVEYS.
6. DREDGING CONTROL POINTS WILL BE PROVIDED ELECTRONICALLY TO THE CONTRACTOR.
7. NO PASSIVE DEWATERING OR DISCHARGE FROM BARGES IS ALLOWED DURING DREDGING IN WATER QUALITY MANAGEMENT AREA "A" (WQMA-A) AS DEFINED IN THE ENVIRONMENTAL MANAGEMENT PLAN CONTAINED IN APPENDIX B OF THE SPECIFICATIONS AND SHOWN IN THE INSET TABLE ON THIS SHEET.
8. THE CONTRACTOR MUST NOT ALLOW THEIR MARINE EQUIPMENT TO APPROACH WITHIN A 10-METRE LATERAL DISTANCE FROM THE FACE OF Y JETTY AT ANY TIME THROUGHOUT THE WORK. THIS REQUIREMENT RELATES TO MARINE DERRICKS, BARGES, AND TUGBOATS, BUT NOT TO MATERIALS HANDLING EQUIPMENT (SUCH AS CRANE BOOMS, BUCKETS, OR CONVEYORS) OR MARINE EQUIPMENT USED TO INSTALL OR REMOVE THE TIMBER FENDER SYSTEM ELEMENTS.
9. NO VESSEL MOVEMENTS, DREDGING, SPUDDING, MATERIAL PLACEMENT, OR ANCHORING WITHIN EXCLUSION ZONE.

LEGEND:

- EXISTING CONTOURS (0.5m INTERVAL)
- EXISTING SHORELINE (HHWLT)
- ACTIVE OUTFALL LOCATION
- INACTIVE OUTFALL LOCATION
- BUOY LOCATION (TO BE REMOVED BY OTHERS PRIOR TO CONSTRUCTION)
- WORK ZONE BOUNDARY
- APPROXIMATE LOCATION OF STEEL RAILS
- DU15 1.5m cut — DREDGE UNIT BOUNDARY AND REQUIRED CUT THICKNESS (INSIDE WQMA-A, METRES)
- DU1 -10 — DREDGE UNIT BOUNDARY AND REQUIRED DREDGE ELEVATION (OUTSIDE WQMA-A, METRES, CD)
- DU27 1.3m cut — DREDGE UNIT BOUNDARY AND REQUIRED CUT THICKNESS (OUTSIDE WQM-A, METRES)
- REQUIRED SLOPE DREDGING AND APPROXIMATE DAYLIGHT LINE
- APPROXIMATE AREA OF BEDROCK ABOVE MUDLINE (NO DREDGING)
- DREDGE OFFSET AREA (NO DREDGING)
- EXCLUSION ZONE (DO NOT DISTURB, SEE NOTE 9)
- DREDGE AREA WITHIN THE FORMER MARINE RAILWAY
- LEACHABLE METALS AREA

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LEVEL OF SECURITY | NIVEAU DE SÉCURITÉ
TO BE REVIEWED | À ÊTRE REVISER

ANCHOR QEA

Klohn Crippen Berger

Esquimalt Harbour
Approximate Project Area

SOURCE: BATHYMETRY FROM PWGSC SURVEYORS, DATED OCTOBER 2015.
HORIZONTAL DATUM: UTM ZONE 10N, NAD83.
VERTICAL DATUM: CHART DATUM (CD).

NO.	DATE	REVISION	APPR.
D	2018/06/14	DRAFT 100% DESIGN REVIEW	
C	2018/03/19	ISSUED FOR 99% DESIGN REVIEW	
B	2017/07/21	ISSUED FOR 90% DESIGN REVIEW	
A	2016/12/02	ISSUED FOR 60% DESIGN REVIEW	

SCALE | ÉCHELLE
1:800

LOCATION | EMPLACEMENT
Y JETTY AND LANG COVE
CFB ESQUIMALT COLWOOD

PROJECT | PROJET
EHRP PHASE 2C AND 2D
Y JETTY AND LANG COVE

TRADE | MÉTIER: CIVIL/ENVIRONMENTAL
DATE: 2018/06/14

SUBJECT | SUJET
REQUIRED DREDGING PLAN

PRODUCTION	REVIEWED | REVU	
DESIGNED | ÉTUDIÉ: R. PICKERING	XX | XX: X.X.	DES O | AGENT CONC
DRAWN | DESSINÉ: C. HEWETT		PROJ MGR | GEST PROJ
CHECKED | VÉRIFIÉ: T. WANG		DES MGR | GEST CONC
COORDINATION: ----		FIRE | INCENDIE

WBS NO. | NO. OTP: L-23
PF NO. | NO. DP: R.097231.001
DWG. NO. | NO. DESSIN: C-1

Canada

BORDER LAST UPDATED 2012-04-01

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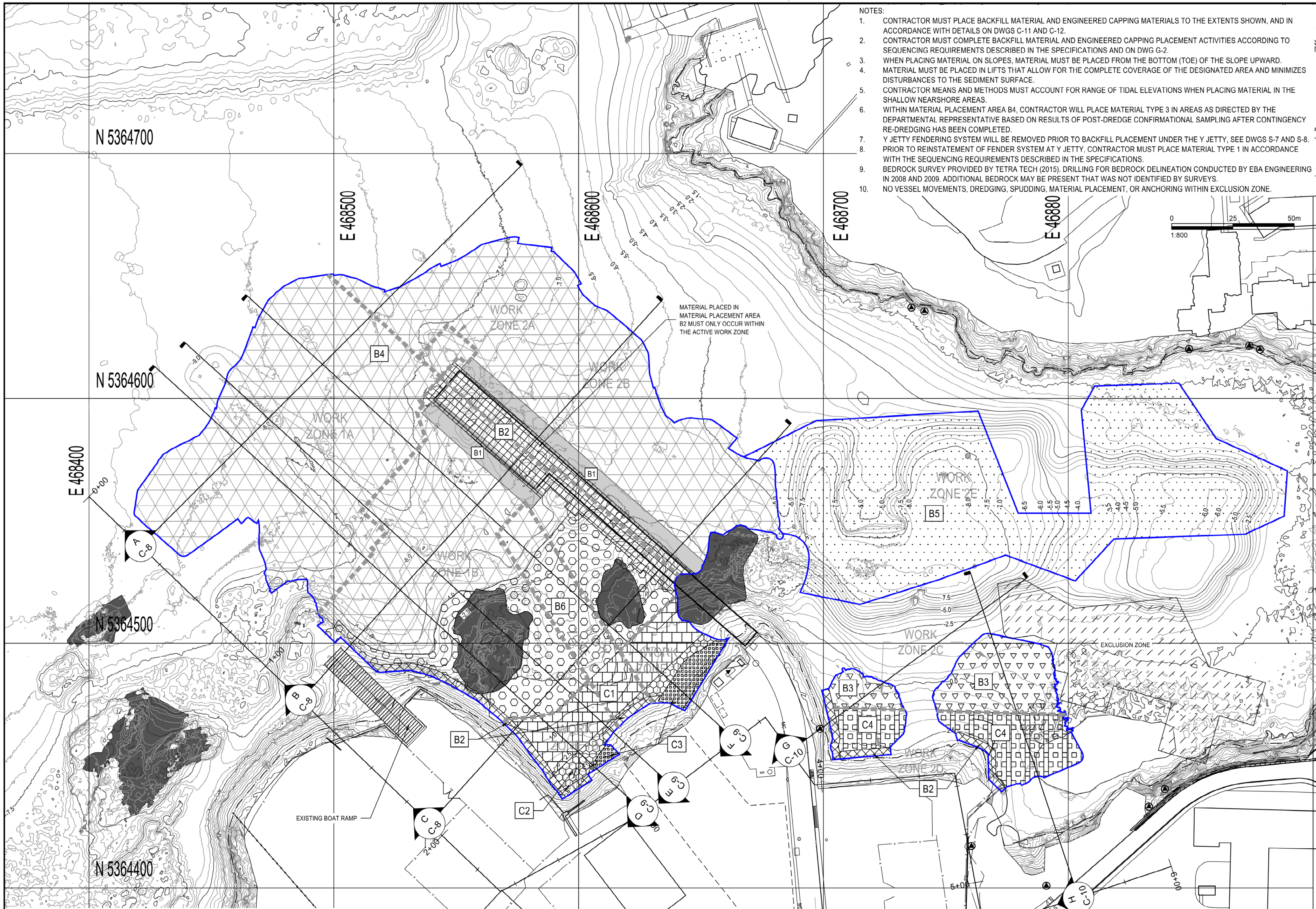

NOTES:

1. CONTRACTOR MUST PLACE BACKFILL MATERIAL AND ENGINEERED CAPPING MATERIALS TO THE EXTENTS SHOWN, AND IN ACCORDANCE WITH DETAILS ON DWGS C-11 AND C-12.
2. CONTRACTOR MUST COMPLETE BACKFILL MATERIAL AND ENGINEERED CAPPING PLACEMENT ACTIVITIES ACCORDING TO SEQUENCING REQUIREMENTS DESCRIBED IN THE SPECIFICATIONS AND ON DWG G-2.
3. WHEN PLACING MATERIAL ON SLOPES, MATERIAL MUST BE PLACED FROM THE BOTTOM (TOE) OF THE SLOPE UPWARD.
4. MATERIAL MUST BE PLACED IN LIFTS THAT ALLOW FOR THE COMPLETE COVERAGE OF THE DESIGNATED AREA AND MINIMIZES DISTURBANCES TO THE SEDIMENT SURFACE.
5. CONTRACTOR MEANS AND METHODS MUST ACCOUNT FOR RANGE OF TIDAL ELEVATIONS WHEN PLACING MATERIAL IN THE SHALLOW NEARSHORE AREAS.
6. WITHIN MATERIAL PLACEMENT AREA B4, CONTRACTOR WILL PLACE MATERIAL TYPE 3 IN AREAS AS DIRECTED BY THE DEPARTMENTAL REPRESENTATIVE BASED ON RESULTS OF POST-DREDGE CONFIRMATIONAL SAMPLING AFTER CONTINGENCY RE-DREDGING HAS BEEN COMPLETED.
7. Y JETTY FENDERING SYSTEM WILL BE REMOVED PRIOR TO BACKFILL PLACEMENT UNDER THE Y JETTY, SEE DWGS S-7 AND S-8.
8. PRIOR TO REINSTATEMENT OF FENDER SYSTEM AT Y JETTY, CONTRACTOR MUST PLACE MATERIAL TYPE 1 IN ACCORDANCE WITH THE SEQUENCING REQUIREMENTS DESCRIBED IN THE SPECIFICATIONS.
9. BEDROCK SURVEY PROVIDED BY TETRA TECH (2015). DRILLING FOR BEDROCK DELINEATION CONDUCTED BY EBA ENGINEERING IN 2008 AND 2009. ADDITIONAL BEDROCK MAY BE PRESENT THAT WAS NOT IDENTIFIED BY SURVEYS.
10. NO VESSEL MOVEMENTS, DREDGING, SPUDDING, MATERIAL PLACEMENT, OR ANCHORING WITHIN EXCLUSION ZONE.

LEGEND:

- EXISTING CONTOURS (0.5m INTERVAL)
- EXISTING SHORELINE (HHWLT)
- WORK ZONE BOUNDARY
- Y JETTY AND LANG COVE WORK SITE
- B3 — MATERIAL PLACEMENT TYPE, SEE MATERIAL PLACEMENT LEGEND TABLE, THIS DWG
- ACTIVE OUTFALL LOCATION
- INACTIVE OUTFALL LOCATION
- APPROXIMATE AREA OF BEDROCK ABOVE MUDLINE (TETRA TECH, 2013-2016)
- EXCLUSION ZONE (DO NOT DISTURB, SEE NOTE 10)

MATERIAL PLACEMENT LEGEND

MATERIAL PLACEMENT AREA	HATCH	DETAIL	BACKFILL MATERIAL TYPE(S)	GENERAL DESCRIPTION
B1		DETAILS 1 AND 2, DWG C-11	1	WASHED WELL-GRADED BASE (STRUCTURAL BACKFILL)
B2		DETAIL 3, DWG C-11	1	WASHED WELL-GRADED BASE (SHORELINE AND UNDERPIER BACKFILL)
B3		DETAIL 4, DWG C-11	2	COARSE WASHED SAND (NEARSHORE BACKFILL)
B4		DETAILS 5, DWG C-11	3	FINE GRAINED RIVER SAND (POST-DREDGE RESIDUALS MANAGEMENT COVER)
B5		DETAIL 6, DWG C-11	3	FINE GRAINED RIVER SAND (NATURAL RECOVERY BACKFILL COVER)
B6		DETAIL 7, DWG C-11	9, 5	GRAVEL-SAND (NEARSHORE BACKFILL), COBBLE AND GRAVEL (KELP HABITAT)

MATERIAL PLACEMENT LEGEND, CONTINUED

MATERIAL PLACEMENT AREA	HATCH	DETAIL	ENGINEERED CAP MATERIAL TYPES	GENERAL DESCRIPTION
C1		DETAIL 8, DWG C-12	4, 5, 2	LAYER 3, MATERIAL TYPE 2: COARSE WASHED SAND (NEARSHORE HABITAT BACKFILL)
				LAYER 2, MATERIAL TYPE 5: COBBLE AND GRAVEL (CAP FILTER LAYER)
				LAYER 1, MATERIAL TYPE 4: GAC-AMENDED GRAVELLY SAND (CAP ISOLATION LAYER)
C2		DETAIL 9, DWG C-12	6, 5, 2	LAYER 3, MATERIAL TYPE 2: COARSE WASHED SAND (NEARSHORE HABITAT BACKFILL)
				LAYER 2, MATERIAL TYPE 5: COBBLE AND GRAVEL (CAP FILTER LAYER)
				LAYER 1, MATERIAL TYPE 6: GAC-AMENDED GRAVELLY SAND (CAP ISOLATION LAYER)
C3		DETAILS 10, 12, AND 13, DWG C-12	6, 5, 7	LAYER 3, MATERIAL TYPE 7: RIPRAP (ARMOUR LAYER)
				LAYER 2, MATERIAL TYPE 5: COBBLE AND GRAVEL (CAP FILTER LAYER)
				LAYER 1, MATERIAL TYPE 6: GAC-AMENDED GRAVELLY SAND (CAP ISOLATION LAYER)
C4		DETAIL 11, DWG C-12	8, 5, 2	LAYER 3, MATERIAL TYPE 2: COARSE WASHED SAND (NEARSHORE HABITAT BACKFILL)
				LAYER 2, MATERIAL TYPE 5: COBBLE AND GRAVEL (CAP FILTER AND ARMOUR LAYER)
				LAYER 1, MATERIAL TYPE 8: GRAVELLY SAND (CAP ISOLATION LAYER)

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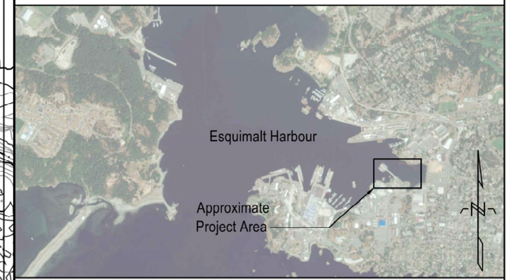
LEVEL OF SECURITY | NIVEAU DE SÉCURITÉ
TO BE REVIEWED | À ÊTRE REVISER

BORDER LAST UPDATED 2012-04-01

ANCHOR QEA

Klohn Crippen Berger



SOURCE: BATHYMETRY FROM PWGSC SURVEYORS, DATED OCTOBER 2015.
HORIZONTAL DATUM: UTM ZONE 10N, NAD83.
VERTICAL DATUM: CHART DATUM (CD).

NO.	DATE	REVISION	APPR.
D	2018/06/14	DRAFT 100% DESIGN REVIEW	
C	2018/03/19	ISSUED FOR 99% DESIGN REVIEW	
B	2017/07/21	ISSUED FOR 90% DESIGN REVIEW	
A	2016/12/02	ISSUED FOR 60% DESIGN REVIEW	

SCALE | ÉCHELLE
1:800

LOCATION | EMPLACEMENT
Y JETTY AND LANG COVE
CFB ESQUIMALT

PROJECT | PROJET
EHRP PHASE 2C AND 2D
Y JETTY AND LANG COVE

TRADE | MÉTIER
CIVIL/ENVIRONMENTAL

DATE
2018/06/14

SUBJECT | SUJET
REQUIRED BACKFILL MATERIAL AND ENGINEERED CAPPING PLAN

PRODUCTION	REVIEWED | REVU	
DESIGNED | ÉTUDIÉ: R. PICKERING	XX | XX: X.X.	DES O | AGENT CONC
DRAWN | DESSINÉ: C. HEWETT		PROJ MGR | GEST PROJ
CHECKED | VÉRIFIÉ: T. WANG		DES MGR | GEST CONC
COORDINATION: ----		FIRE | INCENDIE

WBS NO. | NO. OTP
L-23

PF NO. | NO. DP
R.097231.001

DWG. NO. | NO. DESSIN
C-7

Canada

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C-7

2018/Jun/08, 3:01pm chewett

Annex B. Barge Dewatering Assessments

27 October 2017 Reference No. 1545562-036-L-Rev0

Ms. Kristen Ritchot
Public Works and Government Services Canada
401 - 1230 Government Street
Victoria, BC
V8W 3X4

PRELIMINARY MODELING OF PREDICTED QUALITY OF DISCHARGE WATER DURING BARGE DEWATERING FOR THE ESQUIMALT HARBOUR REMEDIATION PROJECT - C JETTY AND ML FLOATS

Dear Ms. Ritchot:

Golder Associates Ltd. (Golder) was retained by Public Services and Procurement Canada (PSPC) to undertake an assessment of potential barge dewatering effluent quality in the areas of C Jetty and ML Floats as part of the Esquimalt Harbour Remediation Project (EHRP) (referred to hereafter as 'the Project'). This letter was prepared for Canada in accordance with the terms and conditions of the Public Works and Government Services Canada (PWGSC) Marine Sediment Task Authorization (reference EZ899 150978/002/PWY), dated 16 February 2015. The scope of work for this letter (Task 3: O-04 – Update the Environmental Management Plan (EMP) and Water Quality Monitoring Plan (WQMP) Documents) was outlined in Golder's "Workplan and Cost Estimate to Provide Environmental Permitting Services for the 90% design phase of the Esquimalt Harbour Remediation Project", dated 20 July 2017. Task Authorizations (TA) for the above work plans were provided by Public Services and Procurement Canada (PSPC) (PWGSC at the time) on 24 July 2017 under TA 700387663.

1.0 INTRODUCTION

Golder understands that the Department of National Defence (DND) is continuing its long-term program of remediation and risk management in Esquimalt Harbour to address sediment contamination associated with historical activities. This barge dewatering assessment addresses remediation at C Jetty and ML Floats (the "Project Area"), which will involve dredging and substrate placement.

The Basis of Design for the EHRP (Anchor QEA 2017) proposes the dredging of contaminated sediments within the Project Area by clamshell dredging methods. Dredged sediment will then be placed on a barge for transportation to an off-loading facility prior to transportation overland to a permitted uplands disposal site.

To support the assessment of dewatering requirements for the dredged material, this letter provides an assessment of the potential viability of discharge of water from dredged sediments to the marine environment during barge dewatering activities. Discharges posing a potentially unacceptable risk could trigger a shutdown of dredging operations and it is therefore desirable to identify potential controls to be employed during the dredging as part of project planning and then develop additional controls as needed, before dredging begins.

Golder Associates Ltd.
Suite 200 - 2920 Virtual Way, Vancouver, BC, V5M 0C4
Tel: +1 (604) 296 4200 Fax: +1 (604) 298 5253 www.golder.com

The assessment provided below is intended to assist the design team in identifying if specification of (for example) sealed barges for the project is required, resulting in the need for appropriate collection and treatment of the dewatering effluent prior to discharge. Alternatively, if discharge of untreated effluent to the marine environment is acceptable, appropriate controls will need to be implemented to manage concentrations of total suspended solids (TSS) in discharge water. The results of this assessment will be used to support the environmental assessment for the Project.

2.0 REGULATORY CONTEXT

The primary statute applicable to the discharge of dewater effluent from the dredge barge is the federal *Fisheries Act* and the provincial *Environmental Management Act*. Section 36 of the *Fisheries Act* is concerned with the control of substances that are harmful to fish ("deleterious substances") by way of a general prohibition against the deposit of such substances. While certain sector-specific regulations (e.g., Metal Mining Effluent Regulation [MMER]) define what a deleterious substance is for that sector, the properties defining a substance as being deleterious under the parent act are left to interpretation by experts. The 96-h LC_{50} rainbow trout toxicity test has been frequently applied by Environment and Climate Change Canada (ECCC), who have the administrative lead role for Section 36, as a defining endpoint where 96-h $LC_{50} \geq 100\%$ is required to comply. The *Fisheries Act* applies to the point of discharge.

3.0 SITE INFORMATION

The assessment is based on current understanding of relevant chemical fate processes and sediment chemistry data available for the Project Area. Physico-chemical information for sediments in the proposed dredge areas were provided to Golder by Anchor QEA (as per e-mail dated 3 November 2016 which we understand was obtained from a database maintained by SLR dated 16 May 2016). The available data are summarized in Table 1 by the dredge units as defined at the 90% design stage. For some dredge units, the number of samples is relatively small, and grainsize distribution and total organic carbon (TOC) data were not available for all samples. As well, it is unknown what the source of contaminants is, for metals in particular, and in what size fraction a majority of the contamination occurs.

Spatial characterization of the sediment was conducted by collecting surface sediment grab samples and using a drilling rig to collect subsurface sediment at intervals to create a depth profile. Higher concentrations of measured parameters were typically observed at the sediment surface, with concentrations generally declining with depth. In some dredge units (DUs) data from one drill core was accompanied by several grab samples that did not necessarily represent the full spatial extents of the DU.

The limited data set increases the level of uncertainty in the assessment and decreases the ability to understand the risk of either over- or under-predicting the potential for effects to water quality from discharge of decant water from the dredge barge. A standard practice of care in situations such as these is to increase the level of conservatism in the assessment to mitigate for that uncertainty.

4.0 MODELLING OVERVIEW

The model used in the present analysis was based on the model previously developed by Golder for use on similar projects such as the Esquimalt Graving Dock (EGD) Waterlot Sediment Remediation Project (Golder 2012) and remediation dredging at the Colwood Base for DND (Golder 2014, 2016). The model evaluated a scenario of re-suspension of sediment particles into overlying seawater on the dredged material barge, and desorption of organic substances from the particulate-associated phase into the dissolved phase prior to untreated discharge from the barge.

The output of the model consists of predicted chemical concentrations in dewatering effluent (including both particulate and dissolved phases) at the time of discharge.

5.0 MODEL THEORY AND FRAMEWORK: ORGANICS

Organic chemicals in sediment typically undergo some degree of desorption following sediment re-suspension. The dynamics of desorption of organic chemicals from sediment is generally well described, and has been shown by many investigators to be biphasic, with a portion occurring as “rapid phase” desorption and the remainder, often a substantial portion, occurring as “slow phase” desorption (e.g., Karickhoff 1980; Kan et al. 1998; Alexander 2000). “Slow phase” desorption is thought to be due to long-term physical or chemical changes in the conformation of sediment organic matter, resulting in entrapment of a portion of sorbed chemicals (Chen et al. 2000). The extent of entrapment is related to the residence time of the chemicals in the sediment, and historically-contaminated sediments often exhibit very low rates of chemical desorption (Chen et al. 1993).

The potential release of organic chemicals from historically-contaminated sediment is therefore best modelled as a function of chemical concentrations in the sediment, the amount of sediment released, and the duration of contact between re-suspended sediment and the water column (Sanchez et al. 2002; Thibodeaux 2005a,b).

For this analysis, we constructed a dynamic, time-dependent, multimedia model of organic chemical release during a re-suspension event (Thibodeaux et al. 2005b). This type of model gives a more accurate prediction of the short-term fate of sediment-associated chemicals than do equilibrium models. The model was specified to include two sediment-associated chemical compartments (rapid-desorbing and slowly-desorbing) and a dissolved compartment. For each time step, the model calculated the exchange of chemical between suspended sediment and water, according to the following set of mass-balance equations:

$$\Delta X_R / \Delta t = D_R f_W - D_R f_R \quad (1)$$

$$\Delta X_S / \Delta t = D_S f_W - D_S f_S \quad (2)$$

$$\Delta X_W / \Delta t = D_S f_S + D_R f_R - (D_S + D_R) f_W \quad (3)$$

Where:

X is the mass of chemical in a compartment,

D is a transport parameter for solid-water exchange,

f is the fugacity of chemical in the compartment, and

subscripts denote the rapidly-desorbing sediment fraction (R), slowly-desorbing sediment fraction (S), and water (W).

This model is specified in fugacity format, to take into account the relative capacities of re-suspended sediment and water to absorb contaminants. Fugacity is calculated as the chemical concentration in a compartment normalized to the compartment's sorptive capacity for that chemical. Sorptive capacity of re-suspended sediment is calculated as a function of the material's organic carbon content. Sorptive capacity of water is a function of the chemical's Henry's Law Constant.

The model was run through a number of time steps to represent the period of sediment suspension prior to discharge of water from dredged sediments placed on a barge. The model therefore evaluated the redistribution of chemicals from bedded sediment following re-suspension of dredged material on the barge, constrained by the duration of time actually available for this redistribution to take place (on the barge).

Model predictions were generated for a range of assumed TSS concentrations (5 to 75 mg/L). The maximum TSS concentration in the range was adopted from DFO and MELP (1992) to manage the potential for physical effects from particulates in the water column.

6.0 MODEL THEORY AND FRAMEWORK: METALS

Release of metals from sediment following re-suspension is generally much lower than that observed for organic substances, and the release of metals is governed by much more complex and less-well understood processes than those involved in desorption of organic contaminants (Eggleton and Thomas 2004).

A change in the chemical properties of the sediment–metal complexes during dredging can cause mobilization of metals, principally from sulphide-bound complexes (Calmano et al. 1993). However, in situations where sediment redox potential and pH do not change dramatically (i.e., in partially oxidized sediments such as those present in Esquimalt Harbour), the release of metals is generally negligible (Forstner et al. 1989; Reible et al. 2002). For example, Pieters et al. (2002) observed low metal mobilisation during dredging, although metal mobility differed between dredging techniques and was different for every metal examined. Van den Berg et al. (2001) and De Groote et al. (1998) also observed low mobilisation of metal contaminants into the dissolved phase during dredging, which was thought to be due to rapid scavenging of sulphide liberated metals by newly formed iron and manganese oxides/hydroxides. This is also in agreement with simulated dredging studies, where low or no metal contaminants were released and concentrations returned to background levels within hours (Bonnet et al. 2000).

For this model, release of metals from the solid phase into the dissolved phase during dredge dewatering was assumed to be negligible relative to the contribution of particulate-phase metals to total metals concentrations. Concentrations of chemical substances in the discharged water were therefore calculated from reported chemical concentrations in sediment (presented as normalized and non-normalized to percent fines) and assumed concentrations of suspended sediment in the discharged water (ranging from 5 to 75 mg/L TSS).

7.0 MODEL ASSUMPTIONS

For the purposes of this modelling analysis, the following assumptions were made:

- The available sediment chemistry data (as discussed in Section 3.0) were assumed to provide an accurate characterization of the sediment to be dredged.
- Contaminant concentrations for each DU (as discussed in Section 3.0) were assumed to be representative of sediment contaminant conditions on a barge during dredging of that DU.

- Measured organic chemicals were assumed to be in dissolved or particulate-associated phases, i.e., the volume of sediment to be dredged contains no non-aqueous phase liquid (NAPL).
- Measured organic chemicals were assumed to have the potential for release into the dissolved phase, i.e., none is associated with non-desorbing (permanently sequestered) phases.
- Pre-dredging concentrations of substances in overlying seawater were assumed to be negligible.
- The time available for desorption to occur (i.e., between the time of placement of material on the barge and the time of discharge of the overlying water) was assumed to be one hour.
- The mean suspended sediment concentration of the dredged material suspension (sediment and entrained seawater) during the desorption period was assumed to be 500 mg/L.
- As noted in Section 6.0, release of metals from the solid phase into the dissolved phase prior to effluent discharge was assumed to be negligible.
- Metals and polycyclic aromatic hydrocarbons (PAHs) were assumed to be associated with the fines (< 0.063 mm) fraction of the sediment (i.e., measured concentrations in sediment were normalized to percent fines), and the TSS in dredge discharge water was assumed to be entirely composed of this fines fraction. Where normalization to fines resulted in substantially inflated concentrations because the samples had low fines content (i.e., <10 to 15%), additional calculations were made using non-normalized data to assess how the predictions may change.

8.0 PRELIMINARY WATER QUALITY SCREENING

Predicted total concentrations of select[1] chemical substances in the discharged water were screened against numerical values representative of concentrations that would, in our opinion, ordinarily be considered acceptable for discharge into the marine environment, summarized in Table 2. The benchmarks for evaluating PAHs have previously been accepted in Vancouver Harbour and in Esquimalt Harbour for other dredging projects. For convenience, the rationale for the selected PAH concentrations are provided in the summary table.

Table 2 also provides the rationale for screening benchmarks for metals which were selected in the following order of priority:

- 10× CCME marine water quality guidelines[2];
- 10× BC marine water quality guidelines[3];
- 10× CCME freshwater quality guidelines[2];
- 10× BC freshwater quality guidelines[3]; and

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[1] Parameters for which the CCME probable effects level (PEL) sediment quality guidelines (SQGs) were exceeded by more than five times were selected for a more detailed analysis by dredge unit.

[2] Canadian Council of Ministers of the Environment (CCME), "Canadian Water Quality Guidelines for the Protection of Aquatic Life", updated 2007 (CCME 1999).

[3] BC MOE (British Columbia Ministry of Environment). 2016. British Columbia approved water quality guidelines: aquatic life, wildlife & agriculture. Summary Report. Available at: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/waterqualityguidesobjs/approved-wat-qual-guides/final_approved_wqg_summary_march_2016.pdf

- 10× US EPA acute marine water quality criteria[4].

Where available, acute (i.e., short-term exposure) guidelines were selected over chronic (i.e., long-term exposure) guidelines and data from toxicity testing with fish species were prioritized (vis-à-vis the requirements of Section 36 of the *Fisheries Act*).

Water quality guidelines (WQG) are not intended to be effluent limits, particularly for larger bodies of water such as Esquimalt Harbour, for several reasons, such as:

- WQG are often derived from conservative endpoints (e.g., lowest observed effects concentrations or LOECs), and the most sensitive species for which toxicity test data are available, and
- Safety factors, often 10 times, are often applied to add conservatism.

A common approach to defining effluent limits, therefore, is to multiply a given WQG by 10.

Tributyltin was not screened because only a chronic effects benchmark was available, which is not an appropriate basis for assessing potential effects of an acute exposure for this substance. Maximum mercury concentrations exceeded the PEL by more than 5 times for several DUs (DU 1, 3, 5, 7, 8, 12, 14, 15, and 16); however, barge discharge water concentrations for mercury weren't predicted because the environmental concern with mercury is related to bioaccumulation in methylmercury form rather than direct acute toxicity of the inorganic form.

9.0 MODEL INPUTS

Sediment chemistry data provided by Anchor QEA from the harbour-wide database were summarized by DUs (99% design) as delineated in CADD files provided by Anchor QEA on 17 October 2017. Specifically, the sea floor within C Jetty and east past the ML Floats to the shoreline adjacent to the NOTC Float was divided into 13 DUs. Data were available for surficial sediments and from depth; for this preliminary modeling exercise, the data were pooled and mean and maximum values calculated by DU (Table 1). Mean and maximum concentrations were conservatively normalized using the maximum percent fines within a DU. The mean total organic carbon (TOC) within each DU was used as a model input.

Metals (arsenic, cadmium, chromium, copper, lead, zinc) and PAHs (2-Methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene) with mean and/or maximum values greater than five times the probable effects level (PEL) sediment quality guideline (SQG; CCME 1999)[5] were retained for modelling, with the exception of acenaphthylene and dibenz(a,h)anthracene. These two PAHs do not have readily available WQGs and there is limited information to develop alternate benchmarks. Because these contaminants without benchmarks are co-located with other parameters that were modelled and assessed in this letter report, it is expected that mitigation measures implemented for these other parameters will also control potential effects of parameters that were not modelled.

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[4] U.S. Environmental Protection Agency, "National Recommended Water Quality Criteria", updated 2011 (US EPA 2011). Accessed online at: http://water.epa.gov/scitech/swguidance/standards/current/index.cfm

[5] Six times PEL was used to identify potential parameters of concern because this was the approach to identifying a remedial action objectives for the dredge design.

10.0 RESULTS AND UNCERTAINTY

Predicted total concentrations of the modelled substances in discharge water for each DU are presented in Tables 3 (metals) and 4 (PAHs). Predicted concentrations exceeding the screening value are highlighted. The following substances exhibited one or more predicted total concentrations in excess of the screening value.

10.1 Metals

10.1.1 Arsenic

Predicted total arsenic concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment arsenic concentrations (DU 14) and maximum arsenic concentrations (DU 14; Table 3A). However, this was in part influenced by the relatively low fines content of several samples; predicted concentrations using non-normalized data were lower and did not exceed the screening benchmark.

10.1.2 Copper

Predicted total copper concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment copper concentrations (DUs 14, 15 and 17) and maximum sediment copper concentrations (all DUs but 8; Table 3B). However, this was in part influenced by the relatively low fines content of several samples. When non-normalized sediment concentrations were screened, mean predicted copper concentrations exceeded the benchmark in one DU (DU 14). Maximum predicted concentrations exceeded the benchmark in seven DUs (DU 1, 3, 5, 14, 15, 16, 17 and 18), all at TSS concentrations greater than 20 mg/L.

We note in Table 1 the large difference between mean and max concentrations within some of the dredge units where modeled discharges exceed benchmarks. This may be indicative of localized areas of elevated levels of copper. Mean concentrations in sediments may be more realistic of concentrations contributing to copper in barge dewatering discharge because sediments will be mixed during collection, diluting the localized areas of high copper concentrations.

We also note that several predicted concentrations were higher than 300 µg/L, which is the limit for total copper in the MMER. Although this is not a mining project, this concentration provides an example of a federal regulation in which “deleteriousness” per the *Fisheries Act* is defined by a numerical limit.

10.1.3 Lead

Predicted total lead concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment lead concentrations (DU 9 and 14) and maximum sediment lead concentrations (DU 1, 3, 8, 9, 14, and 15; Table 3C). However, this is in part influenced by the relatively low fines content of several samples; predicted concentrations using non-normalized data are lower and the only exceedances of the screening benchmark were observed at maximum sediment lead concentrations in fewer DUs (DU 1, 3, 8, 9 and 15) when TSS was greater than 10 mg/L. Only a fraction of discharged lead is expected to be in the particulate phase, therefore these predicted total lead concentrations may not be bioavailable and do not necessarily represent a potential for adverse effects to marine life.

We do note, however that several predicted concentrations are higher than 200 µg/L, which is the maximum monthly mean limit for total lead in the MMER.

10.1.4 Zinc

Predicted total zinc concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment zinc concentrations (DU 14) and maximum zinc concentrations (DU 1, 3, 5, 14 and 15; Table 3D). However, this was in part influenced by the relatively low fines content of several samples; when non-normalized sediment concentrations are used, predicted zinc concentrations exceed the benchmark in two or more DUs for maximum sediment concentrations (DU 1, 3 and 5) at TSS concentrations greater than 20 mg/L. Only a fraction of discharged zinc is expected to be in the particulate phase, therefore these predicted total lead concentrations may not be bioavailable and do not necessarily represent a potential for adverse effects to marine life.

We do note however that several predicted concentrations are higher than 500 µg/L, which is the maximum monthly mean limit for total zinc in the MMER.

10.2 PAHs

Predicted concentrations in discharge water did not exceed respective screening values for: acenaphthene; benzo(a)pyrene; chrysene; fluorene; or 2-methynaphthalene (Table 4). For the remaining PAHs, predicted concentrations in discharge water exceeded at least one benchmark value at one or more TSS concentrations for DU 14 at mean sediment PAH concentrations and maximum sediment PAH concentrations (DU 1, 3, 14, 15 and 18).

At all DUs, the predicted PAH concentrations that exceeded screening values were influenced primarily by data from surficial samples with an estimated sediment surface penetration depth of 0.1 m. When the mean sediment concentration (a reasonable proxy for the sediment on the barge which will consist of a greater volume of material than is represented by a single sampling location) is used, screening values are not exceeded except at DU 14 (anthracene and pyrene). Concentrations of PAHs in DU 14 are influenced by the low proportion of fines (3.2%), which biased the predicted concentrations to be higher.

When these factors are taken into account, the predicated PAH concentrations of dewatering discharge at C Jetty and ML Floats are not expected to be of concern.

10.3 Uncertainties

The assessment conducted here was an *a priori* exercise with the objective of identifying the potential viability of discharge of untreated water from dredged sediments to the marine environment during passive barge dewatering activities. This assessment necessarily required the use of predictive tools such as desorption modelling. While these tools are useful and provide a reasonable estimate of likely conditions, it is important to identify major uncertainties and to consider the implications of these uncertainties on predictions made. The main uncertainties are as follows:

- **Sediment chemistry** – Available sediment chemistry data were assumed to provide an accurate characterization of sediment to be dredged for this preliminary assessment. However, as noted in Section 3.0, the dataset available for this assessment was limited in showing the vertical and horizontal extent of contamination in some DUs.
- **Representativeness of modelled conditions –** Modelled conditions were necessarily based on a series of assumptions, as stated throughout the letter report. Due to factors such as the uncertainties identified above, conservative assumptions were made; however, the direction of uncertainty (i.e., whether the model over or under predicts contaminant concentrations) cannot be verified at this time.

11.0 INTERPRETATION AND RECOMMENDATIONS FOR WATER QUALITY MANAGEMENT

Under the assumptions of the model stated above, and based on the available sediment chemistry data within the areas to be dredged that were modelled, the modelling analysis predicted that discharge water from dewatering of dredged sediment on the barges in the majority of the Site (all DUs except 14, which is discussed separately below) would likely be considered acceptable for discharge to the marine environment, subject to suitable control of TSS. Specifically, a TSS limit of 75 mg/L is recommended for managing physical rather than chemical impacts associated with suspended sediments (DFO and MELP 1992).

For DU 14, between C-Jetty and ML Floats and adjacent to the shoreline, the predicted concentration of copper in the discharge water exceeds the screening value for protection against acute lethality to fish at relatively low TSS concentrations regardless of whether fines- or non-fines normalized sediment chemistry data are used in the modelling. Dewatering effluent from this area is considered to be unsuitable for direct discharge to the marine environment without treatment or other management methods prior to disposal (discharge within a silt curtain is not an acceptable means of treatment as federal regulations expressly prohibit dilution as a treatment method). A TSS level of 40 mg/L is recommended as the TSS concentration to which barge dewatering effluent must be treated for sediments dredged from DU 14; this is the lowest TSS concentration at which the screening benchmark is not exceeded when non-fines normalized sediment chemistry data were evaluated.

12.0 NOTICE TO READER

This letter was prepared for Canada in accordance with the terms and conditions of the Public Works and Government Services Canada (PWGSC) Marine Sediment Task Authorization (reference EZ899-150978/002/PWY), dated 16 February 2015. The scope of work for this letter (Task 3: O-04 – Update the Environmental Management Plan (EMP) and Water Quality Monitoring Plan (WQMP) Documents) was outlined in Golder's "Workplan and Cost Estimate to Provide Environmental Permitting Services for the 90% design phase of the Esquimalt Harbour Remediation Project", dated 20 July 2017. Task Authorizations (TA) for the above work plans were provided by Public Services and Procurement Canada (PSPC) (PWGSC at the time) on 24 July 2017 under TA 700387663.

The inferences concerning the Site conditions contained in this letter are based on information obtained during the assessment conducted by Golder personnel, and are based solely on the condition of the property at the time of the Site reconnaissance, supplemented by historical and interview information obtained by Golder, as described in this letter.

This letter was prepared, based in part, on information obtained from historic information sources. In evaluating the subject Site, Golder has relied in good faith on information provided. We accept no responsibility for any deficiency or inaccuracy contained in this letter as a result of our reliance on the aforementioned information.

The findings and conclusions documented in this letter 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 professionals currently practicing under similar conditions in the jurisdiction.

With respect to regulatory compliance issues, regulatory statutes are subject to interpretation. These interpretations may change over time, these should be reviewed.

If new information is discovered during future work, the conclusions of this report should be re-evaluated and the letter amended, as required, prior to any reliance upon the information presented herein.

13.0 CLOSURE

We trust the information presented in this report is satisfactory for your current purposes. Should you have any questions or comments, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

COLLEGE OF APPLIED BIOLOGY
Barbara Wernick
27 Oct 17 BW
R.P. Bio
#1171
CAB

Barbara Wernick, MSc, RPBio
Principal, Senior Environmental Scientist

Ahmadreza Mehjoo, MSc, PEng, PMP
Principal, Project Director

PM/BGW/ARM/nnv

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TABLE 1: Summary of Physico-chemical Data Available for Sediment Samples Collected from the Proposed Remediation Areas for C Jetty and ML Floats

Parameter	CCME PEL	Dredge Unit (DU)																											
		1				3				5				7				8				9				12			
		n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max
Physical Characteristics																													
Total Organic Carbon (%)		12	0.92	2.9	9.48	2	0.86	2.0	3.05	3	0.5	1.3	2.3	1	3.1	3.1	3.1	1	3.6	3.6	3.6	-	-	2.3	-	3	0.4	1.5	2.6
Total fines (max clay + max silt) [%]		8	52.4	70.5	86	3	46.29	66.4	87	1	85.9	85.9	85.9	1	84	84	84	1	89	89	89	-	-	51.5	-	3	13.6	47.2	66.0
Metals (Total) (mg/kg dw)																													
Arsenic	41.6	32	4.02	14.7	92.7	18	4.66	17.5	46.9	11	4.75	13.2	29.4	9	5.15	15.0	28.5	6	6	13.9	21.5	4	5.06	9.1	18.7	4	7.19	12.7	18.4
Cadmium	4.2	32	1.03	2.2	12.3	18	1.18	2.2	7.03	11	0.11	2.0	10	9	1.2	1.8	3.11	6	1.21	1.4	1.76	4	1.37	1.9	2.19	4	1.23	1.4	1.61
Chromium	160	32	23.6	39.0	96.5	18	19.7	55.2	153	11	12.4	45.1	136	9	18.9	42.2	80.8	6	21.6	34.5	48.6	4	14.3	22.3	42.1	4	13.1	33.1	43
Copper	108	32	13.1	142.3	413	18	11.1	220.6	667	11	9.46	166.0	812	9	17	178.4	355	6	13.1	148.8	290	4	10.1	68.9	225	4	10.1	150.6	318
Lead	112	32	3.34	397.2	4200	18	3.1	1326	17100	11	2.06	265.0	1490	9	35.2	235.6	580	6	22.8	1650	8880	4	2.29	1179	4550	4	2.87	134	239
Mercury	0.7	32	0.03	2.2	6.35	18	0.02	3.2	29.2	11	0.02	1.3	7.28	9	0.1	2.5	8.15	6	0.17	2.6	5.52	4	0.05	0.6	1.66	4	0.05	3.1	7.93
Zinc	271	32	45.7	766.5	7190	18	37.5	1003	7970	11	19.9	462.9	2820	9	62.7	330.5	806	6	70.3	201.1	294	4	35.7	94.5	223	4	31	200.8	368
PAH (mg/kg dw)																													
2-Methylnaphthalene	0.201	20	0.01	0.77	13.9	13	0.01	0.09	0.42	6	0.01	0.06	0.13	9	0.01	0.20	1.3	6	0.0061	0.12	0.28	3	0.0032	0.02	0.04	4	0.001	0.03	0.05
Acenaphthene	0.0889	20	0.005	0.85	15	13	0.005	0.16	0.8	6	0.005	0.12	0.51	9	0.0029	0.15	0.74	6	0.0009	0.08	0.21	3	0.0005	0.02	0.05	4	0.0005	0.05	0.12
Acenaphthylene	0.128	20	0.005	0.06	0.37	13	0.005	0.06	0.3	6	0.005	0.07	0.15	9	0.002	0.05	0.11	6	0.0005	0.04	0.06	3	0.0005	0.02	0.04	4	0.0005	0.03	0.05
Anthracene	0.245	20	0.004	0.59	6.07	13	0.004	0.59	3.8	6	0.0048	0.41	1.3	9	0.0091	0.37	1.3	6	0.0012	0.18	0.36	3	0.001	0.06	0.16	4	0.001	0.13	0.3
Benzo(a)anthracene	0.693	20	0.01	1.15	13.5	13	0.01	1.11	5.6	6	0.01	0.63	1.5	9	0.02	0.62	1.6	6	0.0023	0.37	0.61	3	0.0013	0.16	0.44	4	0.0011	0.33	0.8
Benzo(a)pyrene	0.763	20	0.01	1.15	9.66	13	0.01	1.01	4.1	6	0.01	1.01	2.5	9	0.02	0.79	1.6	6	0.0027	0.47	0.78	3	0.0011	0.22	0.6	4	0.0015	0.45	0.9
Chrysene	0.846	20	0.01	1.18	11.4	13	0.01	1.46	7	6	0.01	0.76	1.8	9	0.02	0.79	2.1	6	0.0037	0.46	0.79	3	0.0018	0.22	0.6	4	0.0017	0.40	1
Dibenz(a,h)anthracene	0.135	20	0.005	0.16	1.06	13	0.005	0.16	0.58	6	0.005	0.13	0.34	9	0.0038	0.11	0.19	6	0.0005	0.07	0.13	3	0.0005	0.03	0.09	4	0.0005	0.07	0.14
Fluoranthene	1.494	20	0.01	4.20	60.5	13	0.01	3.33	21	6	0.01	1.85	4.6	9	0.03	1.28	3.2	6	0.0046	0.91	1.5	3	0.0018	0.40	1.1	4	0.0021	0.76	1.9
Fluorene	0.144	20	0.01	0.49	7.7	13	0.01	0.17	0.74	6	0.01	0.13	0.46	9	0.0044	0.16	0.74	6	0.0015	0.09	0.2	3	0.0013	0.02	0.06	4	0.001	0.05	0.13
Naphthalene	0.391	20	0.01	4.70	90.6	13	0.01	0.19	1.4	6	0.01	0.18	0.57	9	0.0062	0.26	1.7	6	0.0023	0.10	0.26	3	0.0011	0.02	0.04	4	0.001	0.04	0.08
Phenanthrene	0.544	20	0.01	1.55	18.3	13	0.01	1.10	4.6	6	0.01	0.85	3.2	9	0.02	1.03	4.1	6	0.0072	0.63	1.4	3	0.0042	0.19	0.51	4	0.0027	0.45	1.1
Pyrene	1.398	20	0.01	4.34	42.6	13	0.01	4.29	25	6	0.01	4.32	12	9	0.04	1.84	5.2	6	0.0063	1.00	1.6	3	0.0032	0.44	1.2	4	0.0035	0.92	1.9

Notes:

Where fines data was not collected for a DU, the mean of all fines data for C Jetty and ML FLoats was calculated. The mean % fines for these 52 total measurements was 51.5% total fines (silt+ clay; <0.02mm) and highlighted in red

Where total organic carbon (TOC) was not collected for a DU, the mean of all TOC data for C Jetty and ML Floats was calculated. The mean TOC for these 42 total measurements was 2.3% and highlighted in red

Yellow-highlighted cells have concentrations that are >five times PEL

TABLE 1: Summary of Physico-chemical Data Available for Sediment Samples Collected from the Proposed Remediation Areas for C Jetty and ML Floats

		Dredge Unit (DU)																							
	CCME	14				15				16				17				18				19			
Parameter	PEL	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max
Physical Characteristics																									
Total Organic Carbon (%)		2	0.7	1.9	3.2	3	0.8	3.2	4.7	10	0.6	2.4	4.4	3	0.4	1.9	3.8	1	3.4	3.4	3.4	4	0.4	0.9	1.5
Total fines (max clay + max silt) [%]		1	4.4	4.4	4.4	1	28.5	28.5	28.5	6	12.9	36.9	64.0	2	20.3	42.1	64.0	-	-	51.5	-	4	15.1	23.3	31.0
Metals (Total) (mg/kg dw)																									
Arsenic	41.6	7	2.65	130.4	443	16	3.49	11.7	32.7	13	1.31	11.9	23.3	5	3.7	10.9	19.5	4	5.4	10.8	26.5	3	8.26	11.2	15.9
Cadmium	4.2	7	0.99	1.7	2.57	17	0.59	2.9	4.07	13	0.09	1.9	3.01	5	0.73	1.3	1.77	4	0.3	1.3	3.2	3	1.73	2.1	2.95
Chromium	160	7	10.5	56.5	121	17	6.6	27.7	79.7	13	12.4	30.2	47.1	5	11.7	26.9	43.4	4	28	188.5	656	3	9.4	17.3	23.9
Copper	108	7	8.57	694.6	1850	17	5.37	194.0	687	13	6.76	210.3	1180	5	8.08	380.0	1570	4	38	133.8	408	3	8.1	80.5	162
Lead	112	7	6.93	269	515	17	2.7	423.9	2990	13	1.4	95.4	281	5	1.64	78.1	139	4	5.3	50.2	169	3	1.71	77.5	140
Mercury	0.7	7	0.05	6.5	22.8	17	0.02	1.4	4.08	13	0.01	1.4	6.86	5	0.01	1.1	2.55	4	0.08	0.5	1.56	3	0.05	1.0	1.63
Zinc	271	7	26.3	494.8	1080	16	17.9	207.7	666	13	22.3	175.8	581	5	22.3	156.6	314	4	49	100.8	238	3	24.4	106.8	184
PAH (mg/kg dw)																									
2-Methylnaphthalene	0.201	6	0.01	0.06	0.17	14	0	0.15	1.15	9	0.01	0.06	0.12	4	0.01	0.03	0.05	4	0.05	0.10	0.23	3	0.001	0.02	0.03
Acenaphthene	0.0889	6	0.005	0.09	0.3	14	0	0.26	2.53	9	0.005	0.07	0.13	4	0.005	0.06	0.12	4	0.005	0.03	0.12	3	0.0005	0.02	0.03
Acenaphthylene	0.128	6	0.005	0.05	0.1	14	0	0.18	1.47	9	0.005	0.07	0.13	4	0.005	0.04	0.08	4	0.005	0.04	0.13	3	0.0005	0.02	0.03
Anthracene	0.245	6	0.01	0.26	0.7	13	0	0.52	2.75	9	0.004	0.26	0.54	4	0.004	0.18	0.35	4	0.01	0.87	3.46	3	0.001	0.08	0.12
Benzo(a)anthracene	0.693	6	0.03	0.57	1.4	14	0	0.85	5.64	9	0.01	0.57	1.06	4	0.01	0.43	0.86	4	0.01	0.45	1.77	3	0.001	0.19	0.29
Benzo(a)pyrene	0.763	6	0.03	0.69	1.5	14	0	1.06	5.87	9	0.01	0.73	1.26	4	0.01	0.55	1.1	4	0.01	0.35	1.37	3	0.001	0.24	0.39
Chrysene	0.846	6	0.03	0.81	2.6	14	0	1.48	12.8	9	0.01	0.73	1.31	4	0.01	0.47	0.9	4	0.01	0.47	1.84	3	0.001	0.28	0.44
Dibenz(a,h)anthracene	0.135	6	0.005	0.10	0.23	14	0	0.14	0.73	9	0.005	0.11	0.17	4	0.005	0.12	0.31	4	0.005	0.05	0.18	3	0.0005	0.04	0.06
Fluoranthene	1.494	6	0.06	1.19	3.2	14	0	5.01	55	9	0.01	1.36	2.41	4	0.01	0.99	1.9	4	0.01	1.23	4.87	3	0.001	0.65	1.1
Fluorene	0.144	6	0.01	0.11	0.34	14	0	0.37	2.88	9	0.01	0.10	0.17	4	0.01	0.08	0.16	4	0.01	0.56	2.19	3	0.001	0.03	0.05
Naphthalene	0.391	6	0.01	0.06	0.2	14	0	0.18	1.58	9	0.01	0.07	0.11	4	0.01	0.04	0.07	4	0.01	0.08	0.27	3	0.001	0.02	0.04
Phenanthrene	0.544	6	0.05	0.81	2.4	14	0	4.04	45.1	9	0.01	0.78	1.5	4	0.01	0.58	1.1	4	0.01	1.36	5.4	3	0.0018	0.25	0.41
Pyrene	1.398	6	0.08	1.56	3.7	13	0	4.52	39	9	0.01	1.76	3.47	4	0.01	1.13	2.1	4	0.01	0.97	3.86	3	0.001	0.77	1.2

Notes:

Where fines data was not collected for a DU, the mean of all fines data for C Jetty and ML FLoats was calculated. The mean % fines for these 52 total measurements was 51.5% total fines (silt+ clay; <0.02mm) and highlighted in red

Where total organic carbon (TOC) was not collected for a DU, the mean of all TOC data for C Jetty and ML Floats was calculated. The mean TOC for these 42 total measurements was 2.3% and highlighted in red

Yellow-highlighted cells have concentrations that are >five times PEL

Table 2: Summary of Proposed Dredged Material Dewatering Discharge Benchmarks

Parameter	Proposed Benchmark (µg/L)	Approach	Rationale
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	510	Literature review*	The lower 95% confidence limit of the lowest available toxicity data point (a 96-h LC_{50} for brown trout; Holcombe et al. 1983, cited in CCME 1999) without a safety factor because the data point is lower than observed for other fish species, suggesting that acute toxicity to site-specific fin-fish would be unlikely.
Anthracene	5.0	Literature review	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) without a safety factor because the data point represents a no-effect level.
Benzo(a)anthracene	1.8	Literature review	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) without a safety factor because the data point represents a no-effect level.
Benzo(a)pyrene	5.6	Literature review	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) without a safety factor because the data point represents a no-effect level. Further weight of evidence assessment of available toxicity data indicated that the value is similar to the results of guppy and Japanese medaka tested in a 6-h acute toxicity test and thus would be protective of shorter term discharges. Other endpoints were determined not to apply.
Chrysene	8.6	QSAR	Based on methods of DiToro et al. (2000).
Fluoranthene	20	Literature review	The lowest available toxicity data point (a 24-h LC_{50} for fathead minnow; Kagan et al 1985) with a 10-fold safety factor.
Fluorene	82	Literature review	The lowest available toxicity data point (a 96-h LC_{50} for rainbow trout; Finger et al. 1985, cited in CCME 1999) with a 10-fold safety factor.
2-Methylnaphthalene	58	Literature review	The lowest available toxicity data point (a 96-h LC_{27} for cod embryos; Saethre et al. 1984) with a 10-fold safety factor. The safety factor was applied to address uncertainty introduced by the number of studies available and species assessed.
Naphthalene	100	Literature review	The lower 95% CL of the lowest available toxicity data point (a 96-h LC_{50} for rainbow trout embryos; Black et al. 1983, cited in CCME 1999) without a safety factor. A safety factor was not applied because the results of 24-h LC_{50} tests were greater than the selected benchmark, suggesting that acute toxicity to site-specific fin-fish at the point of discharge would be unlikely.
Phenanthrene	40	Literature review	The lower 95% CL of the second lowest available toxicity data point (a 96-h LC_{50} for rainbow trout embryos; Black et al. 1983; cited in CCME 1999) without a safety factor. The lowest available toxicity data point was not used because it was not considered to be directly applicable (i.e., it was for a 27-d rainbow trout embryo LC_{50}).
Pyrene	12.8	Literature review	The lowest available toxicity data point (a 96-h LC_{50} for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) with a 2-fold safety factor. Although the selected data point represented a no-effect level, the 2-fold safety factor was considered necessary because only one data point was available.

Parameter	Proposed Benchmark (µg/L)	Approach	Rationale
Metals			
Arsenic	125	CCME marine WQG X by 10	The WQG was derived based on the application of a 10-times safety factor to the LOEC of the most sensitive species for which toxicity data were available (a marine diatom, *Skeletonema costatum*). The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharges from metal mines (i.e., 500 µg/L).
Copper	30	BC marine maximum WQG X by 10	The WQG was derived based on acute toxicity to oyster and mussel larvae (96-h LC_{50} = 5.3-5.8 µg/L) (Singleton 1987). Adult stages of invertebrates are less sensitive to copper, as are fish. The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharges from metal mines (i.e., 300 µg/L).
Lead	140	BC marine maximum WQG	The WQG was adopted from USEPA (1985) and is approximately half the lowest marine LC50 of 315 µg/L for mummichog (*Fundulus heroclitus*) (Nagpal 1987). The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharge from metal mines (i.e., 200 µg/L)
Zinc	100	BC marine maximum WQG X by 10	The WQG was derived based on the application of a 5-times safety factor applied to chronic toxicity to two marine diatoms (Nagpal 1999). The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharges from metal mines (i.e., 500 µg/L).

Notes:

* The literature review included a search of available electronic databases (e.g., BIOSIS), on-line toxicological databases (e.g., USEPA ECOTOX) and data compilations used for regulatory purposes (e.g., CCME 1999, Nagpal 1993). Lethal concentration values resulting in 50% mortality (LC_{50}) were obtained for both freshwater and marine fish species as the expectation of the *Fisheries Act* is that at the point of discharge, the dewatering effluent with non-acutely lethal, operationally defined by Environment Canada and MOE as 96-h $LC_{50} \geq 100\%$ for rainbow trout. Invertebrates were excluded from the literature search because by nature dredging will be removed by the physical activity of the dredging. Phototoxic effects were not considered because by nature the water will contain some turbidity which will reduce UV penetration.

** The Target Lipid approach is based on a QSAR for PAH compounds developed by DiToro et al. (2000). The underlying principle of the Target Lipid approach is that the target lipid is the site of PAH action in the organism and that the target lipid has the same lipid-octanol linear free energy relationship irrespective of species. DiToro et al. (2000) derived a method for developing water quality criteria for narcotic chemicals (Type 1) and specifically for PAHs, based on using a single universal slope for the log LC_{50} versus log K_{ow} (octanol-water partitioning coefficient) QSAR for all species.

CCME – Canadian Council of Ministers of the Environment; CL – confidence limit; LOEC – lowest observed effects concentration; MMER – Metal Mining Effluent Regulation; QSAR – Quantitative Structure-Activity Relationship; WQG – water quality guideline.

Table 3: EHRP Preliminary Predicted Discharge Water Concentrations for Metals

A) Arsenic

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Arsenic (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**75**
Mean									
1	0.086	0.17	0.34	0.51	0.68	0.86	1.0	1.2	1.3
3	0.1	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.5
5	0.08	0.15	0.31	0.46	0.61	0.8	0.9	1.1	1.2
7	0.09	0.18	0.36	0.54	0.72	0.9	1.1	1.3	1.3
8	0.08	0.16	0.31	0.47	0.62	0.8	0.9	1.1	1.2
9	0.09	0.18	0.35	0.53	0.71	0.9	1.1	1.2	1.3
12	0.1	0.19	0.38	0.58	0.77	1.0	1.2	1.3	1.4
14	15	29	59	88	118	147	177	206	221
15	0.2	0.41	0.82	1.22	1.63	2.0	2.4	2.9	3.1
16	0.09	0.19	0.37	0.56	0.75	0.9	1.1	1.3	1.4
17	0.09	0.17	0.34	0.51	0.68	0.9	1.0	1.2	1.3
18	0.1	0.21	0.42	0.63	0.84	1.0	1.3	1.5	1.6
19	0.18	0.36	0.72	1.08	1.44	1.8	2.2	2.5	2.7
Maximum									
1	0.54	1.1	2.2	3.2	4.3	5.4	6.5	7.5	8.1
3	0.27	0.54	1.1	1.6	2.2	2.7	3.2	3.8	4.0
5	0.17	0.34	0.7	1.0	1.4	1.7	2.1	2.4	2.6
7	0.17	0.34	0.7	1.0	1.4	1.7	2.0	2.4	2.5
8	0.12	0.24	0.5	0.7	1.0	1.2	1.4	1.7	1.8
9	0.18	0.36	0.7	1.1	1.5	1.8	2.2	2.5	2.7
12	0.14	0.28	0.6	0.8	1.1	1.4	1.7	2.0	2.1
14	50	100	200	300	400	500	600	700	750
15	0.57	1.15	2.3	3.4	4.6	5.7	6.9	8.0	8.6
16	0.18	0.36	0.7	1.1	1.5	1.8	2.2	2.5	2.7
17	0.15	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.3
18	0.26	0.51	1.0	1.5	2.1	2.6	3.1	3.6	3.9
19	0.26	0.51	1.0	1.5	2.1	2.6	3.1	3.6	3.8

Highlighted cells exceed the screening benchmark of 125 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Arsenic (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.07	0.15	0.29	0.44	0.59	0.74	0.88	1.0	1.1
3	0.09	0.17	0.35	0.52	0.70	0.87	1.05	1.2	1.3
5	0.07	0.13	0.26	0.40	0.53	0.66	0.79	0.92	0.99
7	0.08	0.15	0.30	0.45	0.60	0.75	0.90	1.1	1.1
8	0.07	0.14	0.28	0.42	0.55	0.69	0.83	0.97	1.0
9	0.05	0.09	0.18	0.27	0.36	0.45	0.55	0.64	0.68
12	0.06	0.13	0.25	0.38	0.51	0.63	0.76	0.89	0.95
14	0.65	1.3	2.6	3.9	5.2	6.5	7.8	9.1	9.8
15	0.06	0.12	0.23	0.35	0.47	0.58	0.70	0.82	0.87
16	0.06	0.12	0.24	0.36	0.48	0.60	0.72	0.83	0.89
17	0.05	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.82
18	0.05	0.11	0.22	0.32	0.43	0.54	0.65	0.75	0.81
19	0.06	0.11	0.22	0.33	0.45	0.56	0.67	0.78	0.84
Maximum									
1	0.46	0.93	1.9	2.8	3.7	4.6	5.6	6.5	7.0
3	0.23	0.47	0.94	1.4	1.9	2.3	2.8	3.3	3.5
5	0.15	0.29	0.59	0.88	1.2	1.5	1.8	2.1	2.2
7	0.14	0.29	0.57	0.86	1.1	1.4	1.7	2.0	2.1
8	0.11	0.22	0.43	0.65	0.86	1.1	1.3	1.5	1.6
9	0.09	0.19	0.37	0.56	0.75	0.94	1.1	1.3	1.4
12	0.09	0.18	0.37	0.55	0.74	0.92	1.1	1.3	1.4
14	2.2	4.4	8.9	13.3	17.7	22	27	31	33
15	0.16	0.33	0.65	0.98	1.3	1.6	2.0	2.3	2.5
16	0.12	0.23	0.47	0.70	0.93	1.2	1.4	1.6	1.7
17	0.10	0.20	0.39	0.59	0.78	0.98	1.2	1.4	1.5
18	0.13	0.27	0.53	0.80	1.1	1.3	1.6	1.9	2.0
19	0.08	0.16	0.32	0.48	0.64	0.80	0.95	1.1	1.2

Highlighted cells exceed the screening benchmark of 125 µg/L

B) Copper

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Copper (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.83	1.7	3.3	5.0	6.6	8.3	9.9	12	12
3	1.3	2.5	5.1	7.6	10	13	15	18	19
5	0.97	1.9	3.9	5.8	7.7	9.7	12	14	14
7	1.1	2.1	4.2	6.4	8.5	11	13	15	16
8	0.84	1.7	3.3	5.0	6.7	8.4	10	12	13
9	0.67	1.3	2.7	4.0	5.4	6.7	8.0	9.4	10
12	1.1	2.3	4.6	6.8	9.1	11	14	16	17
14	78	157	314	470	627	784	941	1,098	1,176
15	3.4	6.8	14	20	27	34	41	48	51
16	1.6	3.3	6.6	9.9	13	16	20	23	25
17	3.0	5.9	12	18	24	30	36	42	45
18	1.3	2.6	5.2	7.8	10	13	16	18	19
19	1.3	2.6	5.2	7.8	10	13	16	18	19
Maximum									
1	2.4	4.8	9.6	14	19	24	29	34	36
3	3.8	7.7	15.3	23	31	38	46	54	58
5	4.7	9.5	18.9	28	38	47	57	66	71
7	2.1	4.2	8.5	13	17	21	25	30	32
8	1.6	3.3	6.5	9.8	13	16	20	23	24
9	2.2	4.4	8.7	13	17	22	26	31	33
12	2.4	4.8	9.6	14	19	24	29	34	36
14	209	418	835	1,253	1,670	2,088	2,506	2,923	3,132
15	12	24	48	72	96	120	144	169	181
16	9.2	18	37	55	74	92	111	129	138
17	12	25	49	74	98	123	147	172	184
18	4.0	7.9	16	24	32	40	48	55	59
19	2.6	5.2	10	16	21	26	31	37	39

Highlighted cells exceed the screening benchmark of 30 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Copper (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.71	1.4	2.8	4.3	5.7	7.1	8.5	10	11
3	1.1	2.2	4.4	6.6	8.8	11	13	15	17
5	0.83	1.7	3.3	5.0	6.6	8.3	10	12	12
7	0.89	1.8	3.6	5.4	7.1	8.9	11	12	13
8	0.74	1.5	3.0	4.5	6.0	7.4	8.9	10	11
9	0.34	0.69	1.4	2.1	2.8	3.4	4.1	4.8	5.2
12	0.75	1.5	3.0	4.5	6.0	7.5	9.0	11	11
14	3.5	6.9	14	21	28	35	42	49	52
15	0.97	1.9	3.9	5.8	7.8	9.7	12	14	15
16	1.1	2.1	4.2	6.3	8.4	11	13	15	16
17	1.9	3.8	7.6	11	15	19	23	27	28
18	0.67	1.3	2.7	4.0	5.4	6.7	8.0	9.4	10
19	0.4	0.81	1.6	2.4	3.2	4.0	4.8	5.6	6.0
Maximum									
1	2.1	4.1	8.3	12	17	21	25	29	31
3	3.3	6.7	13	20	27	33	40	47	50
5	4.1	8.1	16	24	32	41	49	57	61
7	1.8	3.6	7.1	11	14	18	21	25	27
8	1.5	2.9	5.8	8.7	12	15	17	20	22
9	1.1	2.3	4.5	6.8	9.0	11	14	16	17
12	1.6	3.2	6.4	9.5	13	16	19	22	24
14	9.3	19	37	56	74	93	111	130	139
15	3.4	6.9	14	21	27	34	41	48	52
16	5.9	12	24	35	47	59	71	83	89
17	7.9	16	31	47	63	79	94	110	118
18	2.0	4.1	8.2	12	16	20	24	29	31
19	0.81	1.6	3.2	4.9	6.5	8.1	9.7	11	12

Highlighted cells exceed the screening benchmark of 30 µg/L

C) Lead

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Lead (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	2.3	4.6	9.2	14	18	23	28	32	35
3	7.6	15	30	46	61	76	91	107	114
5	1.5	3.1	6.2	9.3	12	15	19	22	23
7	1.4	2.8	5.6	8.4	11	14	17	20	21
8	9.3	19	37	56	74	93	111	130	139
9	11	23	46	69	92	115	137	160	172
12	1.0	2.0	4.1	6.1	8.1	10	12	14	15
14	30	61	121	182	243	304	364	425	455
15	7.4	15	30	45	59	74	89	104	111
16	0.7	1.5	3.0	4.5	6.0	7.5	8.9	10.4	11
17	0.6	1.2	2.4	3.7	4.9	6.1	7.3	8.5	9.2
18	0.5	1.0	2.0	2.9	3.9	4.9	5.9	6.8	7.3
19	1.3	2.5	5.0	7.5	10	13	15	18	19
Maximum									
1	24	49	98	147	195	244	293	342	366
3	98	197	393	590	786	983	1,179	1,376	1,474
5	8.7	17	35	52	69	87	104	121	130
7	3.5	6.9	14	21	28	35	41	48	52
8	50	100	200	299	399	499	599	698	748
9	44	88	177	265	354	442	530	619	663
12	1.8	3.6	7.2	11	14	18	22	25	27
14	58	116	233	349	465	581	698	814	872
15	52	105	210	314	419	524	629	733	786
16	2.2	4.4	8.8	13	18	22	26	31	33
17	1.1	2.2	4.3	6.5	8.7	11	13	15	16
18	1.6	3.3	6.6	9.9	13	16	20	23	25
19	2.3	4.5	9.0	14	18	23	27	32	34

Highlighted cells exceed the screening benchmark of 140 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Lead (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	2.0	4.0	7.9	12	16	20	24	28	30
3	6.6	13	27	40	53	66	80	93	99
5	1.3	2.6	5.3	7.9	11	13	16	19	20
7	1.2	2.4	4.7	7.1	9.4	12	14	16	18
8	8.2	16	33	49	66	82	99	115	124
9	5.9	12	24	35	47	59	71	83	88
12	0.7	1.3	2.7	4.0	5.4	6.7	8.0	9.4	10
14	1.3	2.7	5.4	8.1	11	13	16	19	20
15	2.1	4.2	8.5	13	17	21	25	30	32
16	0.5	1.0	1.9	2.9	3.8	4.8	5.7	6.7	7.2
17	0.4	0.8	1.6	2.3	3.1	3.9	4.7	5.5	5.9
18	0.3	0.5	1.0	1.5	2.0	2.5	3.0	3.5	3.8
19	0.4	0.8	1.6	2.3	3.1	3.9	4.7	5.4	5.8
Maximum									
1	21	42	84	126	168	210	252	294	315
3	86	171	342	513	684	855	1,026	1,197	1,283
5	7.5	15	30	45	60	75	89	104	112
7	2.9	5.8	12	17	23	29	35	41	44
8	44	89	178	266	355	444	533	622	666
9	23	46	91	137	182	228	273	319	341
12	1.2	2.4	4.8	7.2	9.6	12	14	17	18
14	2.6	5.2	10	15	21	26	31	36	39
15	15	30	60	90	120	150	179	209	224
16	1.4	2.8	5.6	8.4	11	14	17	20	21
17	0.7	1.4	2.8	4.2	5.6	7.0	8.3	9.7	10
18	0.8	1.7	3.4	5.1	6.8	8.5	10	12	13
19	0.7	1.4	2.8	4.2	5.6	7.0	8.4	9.8	11

Highlighted cells exceed the screening benchmark of 140 µg/L

D) Zinc

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Zinc (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	4.5	8.9	18	27	36	45	53	62	67
3	5.8	12	23	35	46	58	69	81	86
5	2.7	5.4	11	16	22	27	32	38	40
7	2.0	3.9	7.9	12	16	20	24	28	30
8	1.1	2.3	4.5	6.8	9.0	11	14	16	17
9	0.92	1.8	3.7	5.5	7.3	9.2	11	13	14
12	1.5	3.0	6.1	9.1	12	15	18	21	23
14	56	112	223	335	447	558	670	782	838
15	3.6	7.3	15	22	29	36	44	51	55
16	1.4	2.7	5.5	8.2	11	14	16	19	21
17	1.2	2.4	4.9	7.3	9.8	12	15	17	18
18	0.98	2.0	3.9	5.9	7.8	9.8	12	14	15
19	1.7	3.4	6.9	10	14	17	21	24	26
Maximum									
1	42	84	167	251	334	418	502	585	627
3	46	92	183	275	366	458	550	641	687
5	16	33	66	98	131	164	197	230	246
7	4.8	9.6	19	29	38	48	58	67	72
8	1.7	3.3	6.6	9.9	13	17	20	23	25
9	2.2	4.3	8.7	13	17	22	26	30	32
12	2.8	5.6	11	17	22	28	33	39	42
14	122	244	488	731	975	1,219	1,463	1,707	1,828
15	12	23	47	70	93	117	140	163	175
16	4.5	9.1	18	27	36	45	54	64	68
17	2.5	4.9	9.8	15	20	25	29	34	37
18	2.3	4.6	9.2	14	18	23	28	32	35
19	3.0	5.9	12	18	24	30	36	42	45

Highlighted cells exceed the screening benchmark of 100 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Zinc (Not Normalized to Fines)								
TSS (mg/L)=>	5	10	20	30	40	50	60	70	75
Mean									
1	3.8	7.7	15	23	31	38	46	54	57
3	5.0	10	20	30	40	50	60	70	75
5	2.3	4.6	9.3	14	19	23	28	32	35
7	1.7	3.3	6.6	9.9	13	17	20	23	25
8	1.0	2.0	4.0	6.0	8.0	10	12	14	15
9	0.47	0.9	1.9	2.8	3.8	4.7	5.7	6.6	7.1
10	1.0	2.0	4.0	6.0	8.0	10	12	14	15
11	2.5	4.9	9.9	14.8	19.8	25	30	35	37
13	1.0	2.1	4.2	6.2	8.3	10	12	15	16
14	0.88	1.8	3.5	5.3	7.0	8.8	11	12	13
15	0.78	1.6	3.1	4.7	6.3	7.8	9.4	11	12
16	0.50	1.0	2.0	3.0	4.0	5.0	6.0	7.1	7.6
17	0.53	1.1	2.1	3.2	4.3	5.3	6.4	7.5	8.0
Maximum									
1	36	72	144	216	288	360	431	503	539
3	40	80	159	239	319	399	478	558	598
5	14	28	56	85	113	141	169	197	212
7	4.0	8.1	16	24	32	40	48	56	60
8	1.5	2.9	5.9	8.8	12	15	18	21	22
9	1.1	2.2	4.5	6.7	8.9	11	13	16	17
10	1.8	3.7	7.4	11	15	18	22	26	28
11	5.4	11	22	32	43	54	65	76	81
13	3.3	6.7	13	20	27	33	40	47	50
14	2.9	5.8	12	17	23	29	35	41	44
15	1.6	3.1	6.3	9.4	13	16	19	22	24
16	1.2	2.4	4.8	7.1	9.5	12	14	17	18
17	0.92	1.8	3.7	5.5	7.4	9.2	11	13	14

Highlighted cells exceed the screening benchmark of 100 µg/L

Table 4: EHRP Preliminary Predicted Discharge Water Concentrations for Polycyclic Aromatic Hydrocarbons (PAHs)

A) Acenaphthene

Dredge Unit:	**Predicted Discharge Water Total Concentrations (µg/L) for Acenaphthene (Fines Normalized Sediment Chemistry)**								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	1.8	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
9	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
12	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5
14	11	11	11	11	11	11	12	12	12
15	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.5	3.5
16	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
17	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
18	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
19	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Maximum									
1	32	32	32	32	32	33	33	33	33
3	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2
5	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.4
7	4.8	4.8	4.9	4.9	4.9	4.9	4.9	4.9	4.9
8	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
9	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
12	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
14	36	36	36	36	36	36	37	37	37
15	33	33	33	33	33	33	33	33	33
16	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
17	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9
18	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
19	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Highlighted cells exceed the screening benchmark of 510 µg/L

B) Anthracene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Anthracene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4
3	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
12	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
14	7.7	7.7	7.7	7.8	7.9	7.9	8.0	8.0	8.1
15	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.8
16	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
17	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
18	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2
19	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Maximum									
1	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.6	3.6
3	6.0	6.0	6.0	6.1	6.1	6.2	6.2	6.2	6.3
5	2.7	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.8
7	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2
8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
9	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
12	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8
14	21	21	21	21	21	21	22	22	22
15	8.6	8.7	8.8	8.8	8.9	9.0	9.1	9.2	9.3
16	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9
17	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
18	8.3	8.3	8.4	8.4	8.5	8.6	8.6	8.7	8.7
19	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Highlighted cells exceed the screening benchmark of 5 µg/L

C) Benzo(a)anthracene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo(a)anthracene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.03	0.04	0.05	0.06	0.08	0.09	0.11	0.12	0.13
3	0.08	0.09	0.10	0.11	0.13	0.14	0.15	0.16	0.17
5	0.06	0.06	0.07	0.08	0.08	0.09	0.10	0.11	0.11
7	0.05	0.05	0.06	0.06	0.07	0.08	0.09	0.09	0.10
8	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.05
9	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05
12	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07
14	0.78	0.84	0.97	1.10	1.23	1.36	1.49	1.62	1.68
15	0.13	0.14	0.17	0.20	0.23	0.26	0.29	0.32	0.34
16	0.04	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.10
17	0.04	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.08
18	0.05	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.11
19	0.07	0.08	0.08	0.09	0.10	0.10	0.11	0.11	0.12
Maximum									
1	0.37	0.45	0.61	0.77	0.92	1.1	1.2	1.4	1.5
3	0.41	0.44	0.50	0.57	0.63	0.70	0.76	0.83	0.86
5	0.14	0.15	0.17	0.19	0.20	0.22	0.24	0.26	0.26
7	0.12	0.13	0.15	0.17	0.19	0.20	0.22	0.24	0.25
8	0.04	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.09
9	0.07	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.13
12	0.09	0.09	0.11	0.12	0.13	0.14	0.16	0.17	0.17
14	1.9	2.1	2.4	2.7	3.0	3.3	3.7	4.0	4.1
15	0.85	0.95	1.2	1.3	1.5	1.7	1.9	2.1	2.2
16	0.08	0.08	0.10	0.12	0.13	0.15	0.17	0.18	0.19
17	0.07	0.08	0.09	0.10	0.12	0.13	0.14	0.16	0.16
18	0.20	0.22	0.25	0.28	0.32	0.35	0.39	0.42	0.44
19	0.12	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.18

Highlighted cells exceed the screening benchmark of 1.8 µg/L

D) Benzo(a)pyrene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo(a)pyrene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.03	0.03	0.05	0.06	0.07	0.09	0.10	0.11	0.12
3	0.06	0.06	0.07	0.09	0.10	0.11	0.12	0.13	0.14
5	0.07	0.08	0.09	0.10	0.11	0.13	0.14	0.15	0.16
7	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.11
8	0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.06
9	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06
12	0.04	0.04	0.05	0.06	0.06	0.07	0.08	0.08	0.09
14	0.72	0.80	0.96	1.1	1.3	1.4	1.6	1.7	1.8
15	0.12	0.14	0.18	0.22	0.25	0.29	0.33	0.37	0.39
16	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12
17	0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.09	0.09
18	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.07	0.08
19	0.07	0.08	0.08	0.09	0.10	0.11	0.11	0.12	0.13
Maximum									
1	0.21	0.27	0.38	0.49	0.61	0.72	0.83	0.94	1.00
3	0.23	0.25	0.30	0.35	0.39	0.44	0.49	0.53	0.56
5	0.18	0.19	0.22	0.25	0.28	0.31	0.34	0.37	0.38
7	0.09	0.10	0.12	0.14	0.16	0.18	0.20	0.21	0.22
8	0.04	0.04	0.05	0.06	0.07	0.08	0.08	0.09	0.10
9	0.07	0.08	0.09	0.10	0.11	0.13	0.14	0.15	0.15
12	0.08	0.08	0.10	0.11	0.12	0.14	0.15	0.16	0.17
14	1.6	1.7	2.1	2.4	2.8	3.1	3.4	3.8	3.9
15	0.68	0.79	0.99	1.2	1.4	1.6	1.8	2.0	2.1
16	0.07	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.21
17	0.07	0.08	0.09	0.11	0.13	0.15	0.16	0.18	0.19
18	0.12	0.13	0.16	0.18	0.21	0.24	0.26	0.29	0.30
19	0.12	0.12	0.14	0.15	0.16	0.17	0.19	0.20	0.21

Highlighted cells exceed the screening benchmark of 5.6 µg/L

E) Chrysene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Chrysene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.04	0.04	0.06	0.07	0.08	0.10	0.11	0.13	0.13
3	0.12	0.13	0.14	0.16	0.18	0.19	0.21	0.23	0.24
5	0.08	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.14
7	0.07	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.13
8	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.07
9	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07
12	0.05	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09
14	1.2	1.3	1.5	1.7	1.9	2.1	2.2	2.4	2.5
15	0.25	0.27	0.32	0.38	0.43	0.48	0.53	0.58	0.61
16	0.06	0.06	0.07	0.09	0.10	0.11	0.12	0.13	0.14
17	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.09	0.09
18	0.06	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.12
19	0.12	0.13	0.14	0.15	0.16	0.17	0.17	0.18	0.19
Maximum									
1	0.35	0.41	0.54	0.68	0.81	0.94	1.1	1.2	1.3
3	0.57	0.61	0.69	0.77	0.85	0.93	1.01	1.09	1.13
5	0.19	0.20	0.22	0.24	0.26	0.28	0.31	0.33	0.34
7	0.17	0.19	0.21	0.24	0.26	0.29	0.31	0.34	0.35
8	0.05	0.06	0.07	0.08	0.08	0.09	0.10	0.11	0.12
9	0.11	0.11	0.12	0.14	0.15	0.16	0.17	0.18	0.19
12	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.22	0.23
14	4.0	4.3	4.8	5.4	6.0	6.6	7.2	7.8	8.1
15	2.1	2.4	2.8	3.3	3.7	4.2	4.6	5.1	5.3
16	0.10	0.11	0.13	0.15	0.17	0.20	0.22	0.24	0.25
17	0.08	0.09	0.10	0.12	0.13	0.14	0.16	0.17	0.18
18	0.23	0.25	0.28	0.32	0.35	0.39	0.43	0.46	0.48
19	0.20	0.20	0.22	0.23	0.25	0.26	0.27	0.29	0.30

Highlighted cells exceed the screening benchmark of 8.6 µg/L

F) Fluoranthene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Fluoranthene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.47	0.50	0.55	0.59	0.64	0.69	0.74	0.79	0.81
3	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.4
5	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.96	0.97
7	0.43	0.44	0.46	0.47	0.49	0.50	0.52	0.53	0.54
8	0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33
9	0.30	0.30	0.31	0.32	0.33	0.34	0.34	0.35	0.36
12	0.39	0.40	0.41	0.42	0.43	0.44	0.45	0.47	0.47
14	7.5	7.6	7.9	8.1	8.4	8.7	8.9	9.2	9.3
15	3.4	3.4	3.6	3.8	4.0	4.1	4.3	4.5	4.6
16	0.43	0.44	0.46	0.48	0.51	0.53	0.55	0.57	0.58
17	0.36	0.37	0.39	0.40	0.42	0.43	0.45	0.46	0.47
18	0.62	0.64	0.66	0.68	0.71	0.73	0.75	0.78	0.79
19	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.4
Maximum									
1	6.8	7.2	7.9	8.6	9.3	10.0	10.7	11.4	11.7
3	7.0	7.1	7.4	7.6	7.8	8.1	8.3	8.6	8.7
5	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4
7	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.3	1.4
8	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0
12	1.0	1.0	1.0	1.1	1.1	1.1	1	1	1
14	20	20	21	22	23	23	24	25	25
15	37	38	40	42	44	46	47	49	50
16	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0
17	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9
18	2.5	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.1
19	2.1	2.1	2.1	2.2	2.2	2.2	2.3	2.3	2.3

Highlighted cells exceed the screening benchmark of 20 µg/L

G) Fluorene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Fluorene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
3	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
8	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
12	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
14	7.6	7.6	7.6	7.6	7.7	7.7	7.7	7.7	7.8
15	2.6	2.6	2.6	2.7	2.7	2.7	2.7	2.7	2.7
16	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
17	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
18	3.0	3.0	3.0	3.0	3.1	3.1	3.1	3.1	3.1
19	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Maximum									
1	9.0	9.1	9.2	9.2	9.3	9.4	9.5	9.6	9.6
3	2.6	2.6	2.6	2.7	2.7	2.7	2.7	2.7	2.7
5	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
8	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
12	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
14	23	23	23	23	23	23	23	23	23
15	21	21	21	21	21	21	21	21	21
16	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
17	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
18	12	12	12	12	12	12	12	12	12
19	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Highlighted cells exceed the screening benchmark of 82 µg/L

H) 2-Methylnaphthalene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for 2-Methylnaphthalene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
3	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
7	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6
8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
9	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
12	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
14	7.8	7.8	7.8	7.9	7.9	7.9	7.9	7.9	7.9
15	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
16	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
17	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
18	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
19	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Maximum									
1	34	34	34	34	34	35	35	35	35
3	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
7	9.7	9.7	9.7	9.8	9.8	9.8	9.8	9.8	9.8
8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
9	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
12	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
14	23	24	24	24	24	24	24	24	24
15	17	17	17	17	17	17	17	17	17
16	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
17	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
18	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
19	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

Highlighted cells exceed the screening benchmark of 58 µg/L

l) Naphthalene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Naphthalene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	35	35	35	35	35	35	35	35	35
3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
7	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
9	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
12	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
14	24	24	24	24	24	24	24	24	24
15	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
16	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
17	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
18	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
19	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Maximum									
1	669	669	670	671	672	673	674	675	676
3	29	29	29	29	29	29	29	29	29
5	14	14	14	15	15	15	15	15	15
7	36	36	36	36	36	36	36	36	36
8	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
9	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
12	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.5	2.5
14	78	78	78	78	78	78	78	78	78
15	69	69	69	69	69	69	69	69	69
16	2	2	2	2	2	2	2	2	2
17	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
18	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
19	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7

Highlighted cells exceed the screening benchmark of 100 µg/L

J) Phenanthrene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Phenanthrene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9
3	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7
5	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7
7	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6
8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
9	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7
12	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
14	22	22	23	23	23	23	23	24	24
15	12	12	12	12	12	13	13	13	13
16	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2
17	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
18	3.0	3.0	3.1	3.1	3.1	3.2	3.2	3.2	3.2
19	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Maximum									
1	8.8	8.9	9.1	9.3	9.6	9.8	10	10	10
3	6.7	6.8	6.8	6.9	6.9	7.0	7.0	7.1	7.1
5	6.2	6.2	6.2	6.3	6.3	6.4	6.4	6.4	6.5
7	6.1	6.1	6.2	6.2	6.3	6.3	6.4	6.4	6.5
8	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8
9	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
12	2.5	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.6
14	66	66	67	67	68	68	69	69	70
15	132	133	134	136	137	139	140	142	143
16	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.2
17	1.8	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9
18	12	12	12	12	12	13	13	13	13
19	3.4	3.4	3.4	3.4	3.4	3.5	3.5	3.5	3.5

Highlighted cells exceed the screening benchmark of 40 µg/L

K) Pyrene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Pyrene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9
3	1.6	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9
5	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.4
7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8
8	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
9	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
12	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
14	10.7	10.8	11.2	11.5	11.9	12.2	12.6	12.9	13.1
15	3.3	3.4	3.6	3.7	3.9	4.0	4.2	4.3	4.4
16	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8
17	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6
18	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7
19	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8
Maximum									
1	5.2	5.5	6.0	6.5	7.0	7.5	8.0	8.4	8.7
3	9.1	9.3	9.5	9.8	10	10	11	11	11
5	5.8	5.8	6.0	6.1	6.3	6.4	6.5	6.7	6.8
7	1.9	2.0	2.0	2.1	2.2	2.2	2.3	2.3	2.4
8	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6
9	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
12	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3
14	25	26	27	27	28	29	30	31	31
15	29	29	31	32	33	35	36	37	38
16	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.6	1.6
17	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.1	1.1
18	2.2	2.2	2.3	2.3	2.4	2.5	2.6	2.6	2.7
19	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.7

Highlighted cells exceed the screening benchmark of 12.8 µg/L

20 August 2018 Reference No. 18101029-007-L-Rev0

Ms. Kristen Ritchot
Public Services and Procurement Canada
401 - 1230 Government Street
Victoria, BC
V8W 3X4

PRELIMINARY MODELING OF PREDICTED QUALITY OF DISCHARGE WATER DURING BARGE DEWATERING FOR THE ESQUIMALT HARBOUR REMEDIATION PROJECT - Y JETTY AND LANG COVE

Ms. Ritchot:

Golder Associates Ltd. (Golder) was retained by Public Services and Procurement Canada (PSPC) to undertake an assessment of potential barge dewatering effluent quality in the areas of Y Jetty and Lang Cove as part of the Esquimalt Harbour Remediation Project (EHRP) (referred to hereafter as 'the Project'). This letter was prepared for Canada in accordance with the terms and conditions of the Public Works and Government Services Canada (PWGSC) Marine Sediment Task Authorization (reference EZ897 172925/002/VAN), dated 21 November 2017. The scope of work for this report was outlined in Golder's "Workplan and Cost Estimate for Environmental, Heritage and Engagement Support for the Esquimalt Harbour Remediation Project, Esquimalt Harbour, BC", dated 25 May 2018. Task Authorizations (TA) for the above work plans were provided by Public Services and Procurement Canada (PSPC) on 4 June 2018 under TA 700412027.

1.0 INTRODUCTION

Golder understands that the Department of National Defence (DND) is continuing its long-term program of remediation and risk management in Esquimalt Harbour to address sediment contamination associated with historical activities. This barge dewatering assessment addresses remediation at Y Jetty and Lang Cove (the "Project Area"), which will involve dredging and substrate placement.

The Basis of Design for the EHRP (Anchor QEA 2017) proposes the dredging of contaminated sediments within the Project Area by clamshell dredging methods. Dredged sediment will then be placed on a barge for transportation to an off-loading facility prior to transportation overland to a permitted uplands disposal site.

To support the assessment of dewatering requirements for the dredged material, this letter provides an assessment of the potential viability of discharge of water from dredged sediments to the marine environment during barge dewatering activities. Discharges posing a potentially unacceptable risk could trigger a shutdown of dredging operations and it is therefore desirable to identify potential controls to be employed during the dredging as part of project planning and then develop additional controls as needed, before dredging begins.

The assessment provided below will assist the design team in identifying if specification of (for example) sealed barges for the project is required, resulting in the need for appropriate collection and treatment of the dewatering effluent prior to discharge. Alternatively, if discharge of untreated effluent to the marine environment is acceptable, appropriate controls will need to be implemented to manage concentrations of total suspended solids (TSS) in discharge water. The results of this assessment will be used to support the environmental assessment for the Project.

2.0 REGULATORY CONTEXT

The primary statute applicable to the discharge of dewater effluent from the dredge barge is the federal *Fisheries Act* and the provincial *Environmental Management Act*. Section 36 of the *Fisheries Act* is concerned with the control of substances that are harmful to fish ("deleterious substances") by way of a general prohibition against the deposit of such substances. While certain sector-specific regulations (e.g., Metal and Diamond Mining Effluent Regulations (MDMER)) define what a deleterious substance is for that sector, the properties defining a substance as being deleterious under the parent act are left to interpretation by experts. The 96-h LC_{50} rainbow trout toxicity test has been frequently applied by Environment and Climate Change Canada (ECCC), who have the administrative lead role for Section 36, as a defining endpoint where 96-h $LC_{50} \geq 100\%$ is required to comply. The *Fisheries Act* applies to the point of discharge.

3.0 SITE INFORMATION

The assessment is based on current understanding of relevant chemical fate processes and sediment chemistry data available for the Project Area. Physico-chemical information for sediments in the proposed dredge areas were provided to Golder by Anchor QEA (as per e-mail dated 11 November 2016 which we understand was obtained from a database maintained by SLR data 16 May 2016), and as supplemented by sampling undertaken by Golder in 2018 (Golder 2018). The available data are summarized in Table 1 by the dredge units as defined at the 100% design stage. Data were not available for dredge units (DUs) 4, 5, 7, 18, 22, 24, 25, 29, 30, 32, 35, and 39. For some dredge units, the number of samples is relatively small, and grainsize distribution and total organic carbon (TOC) data were not available for all samples. As well, it is unknown what the source of contaminants is, for metals in particular, and in what size fraction a majority of the contamination occurs.

Spatial characterization of the sediment was conducted by collecting surface sediment samples and using a drilling rig to collect subsurface samples at intervals to create a depth profile. Higher concentrations of measured parameters were typically observed at the sediment surface, with concentrations generally declining with depth. In some DUs data from one drill core was accompanied by several grab samples that did not necessarily represent the spatial extent of the DU.

The limited data set increases the level of uncertainty in the assessment and decreases the ability to understand the risk of either over- or under-predicting the potential for effects to water quality from discharge of decant water from the dredge barge. A standard practice of care in situations such as these is to increase the level of conservatism in the assessment to mitigate for that uncertainty.

4.0 MODELLING OVERVIEW

The model used in the present analysis was based on the model previously developed by Golder for use on similar projects such as in support of the Esquimalt Graving Dock (EGD) Waterlot Sediment Remediation Project (Golder 2012) as well as remediation at Colwood Base for DND (Golder 2014, 2016). The model evaluated a scenario of re-suspension of sediment particles into overlying seawater on the dredged material barge, and desorption of organic substances from the particulate-associated phase into the dissolved phase prior to discharge from the barge.

The output of the model consists of predicted chemical concentrations in dewatering effluent (including both particulate and dissolved phases) at the time of discharge.

5.0 MODEL THEORY AND FRAMEWORK: ORGANICS

Organic chemicals in sediment typically undergo some degree of desorption following sediment re-suspension. The dynamics of desorption of organic chemicals from sediment is generally well described, and has been shown by many investigators to be biphasic, with a portion occurring as “rapid phase” desorption and the remainder, often a substantial portion, occurring as “slow phase” desorption (e.g., Karickhoff 1980; Kan et al. 1998; Alexander 2000). “Slow phase” desorption is thought to be due to long-term physical or chemical changes in the conformation of sediment organic matter, resulting in entrapment of a portion of sorbed chemicals (Chen et al. 2000). The extent of entrapment is related to the residence time of the chemicals in the sediment, and historically-contaminated sediments often exhibit very low rates of chemical desorption (Chen et al. 1993).

The potential release of organic chemicals from historically-contaminated sediment is therefore best modelled as a function of chemical concentrations in the sediment, the amount of sediment released, and the duration of contact between re-suspended sediment and the water column (Sanchez et al. 2002; Thibodeaux 2005a,b).

For this analysis, we constructed a dynamic, time-dependent, multimedia model of organic chemical release during a re-suspension event (Thibodeaux et al. 2005b). This type of model gives a more accurate prediction of the short-term fate of sediment-associated chemicals than do equilibrium models. The model was specified to include two sediment-associated chemical compartments (rapid-desorbing and slowly-desorbing) and a dissolved compartment. For each time step, the model calculated the exchange of chemical between suspended sediment and water, according to the following set of mass-balance equations:

$$\Delta X_R / \Delta t = D_R f_W - D_R f_R \tag{1}$$

$$\Delta X_S / \Delta t = D_S f_W - D_S f_S \tag{2}$$

$$\Delta X_W / \Delta t = D_S f_S + D_R f_R - (D_S + D_R) f_W \tag{3}$$

Where:

X is the mass of chemical in a compartment,

D is a transport parameter for solid-water exchange,

f is the fugacity of chemical in the compartment, and

subscripts denote the rapidly-desorbing sediment fraction (R), slowly-desorbing sediment fraction (S), and water (W).

This model is specified in fugacity format, to take into account the relative capacities of re-suspended sediment and water to absorb contaminants. Fugacity is calculated as the chemical concentration in a compartment normalized to the compartment's sorptive capacity for that chemical. Sorptive capacity of re-suspended sediment is calculated as a function of the material's organic carbon content. Sorptive capacity of water is a function of the chemical's Henry's Law Constant.

The model was run through a number of time steps to represent the period of sediment suspension prior to discharge of untreated water from dredged sediments placed on a barge. The model therefore evaluated the redistribution of chemicals from bedded sediment following re-suspension of dredged material on the barge, constrained by the duration of time actually available for this redistribution to take place (on the barge).

Model predictions were generated for a range of assumed TSS concentrations (5 to 75 mg/L). The maximum TSS concentration range was adopted from DFO and MELP (1992) to manage the potential for physical effects from particulates in the water column.

6.0 MODEL THEORY AND FRAMEWORK: METALS

Release of metals from sediment following re-suspension is generally much lower than that observed for organic substances, and the release of metals is governed by much more complex and less-well understood processes than those involved in desorption of organic contaminants (Eggleton and Thomas 2004).

A change in the chemical properties of the sediment–metal complexes during dredging can cause mobilization of metals, principally from sulphide-bound complexes (Calmano et al. 1993). However, in situations where sediment redox potential and pH do not change dramatically (i.e., in partially oxidized sediments such as those present in Esquimalt Harbour), the release of metals is generally negligible (Forstner et al. 1989; Reible et al. 2002). For example, Pieters et al. (2002) observed low metal mobilisation during dredging, although metal mobility differed between dredging techniques and was different for every metal examined. Van den Berg et al. (2001) and De Groote et al. (1998) also observed low mobilisation of metal contaminants into the dissolved phase during dredging, which was thought to be due to rapid scavenging of sulphide liberated metals by newly formed iron and manganese oxides/hydroxides. This is also in agreement with simulated dredging studies, where low or no metal contaminants were released and concentrations returned to background levels within hours (Bonnet et al. 2000).

For this model, release of metals from the solid phase into the dissolved phase during dredge dewatering was assumed to be negligible relative to the contribution of particulate-phase metals to total metals concentrations. Concentrations of chemical substances in the discharged water were therefore calculated from reported chemical concentrations in sediment (presented as normalized and non-normalized to percent fines) and assumed concentrations of suspended sediment in the discharged water (ranging from 5 to 75 mg/L TSS).

7.0 MODEL ASSUMPTIONS

For the purposes of this modelling analysis, the following assumptions were made:

- The available sediment chemistry data (as discussed in Section 3.0) were assumed to provide an accurate characterization of the sediment to be dredged.
- Contaminant concentrations for each DU (as discussed in Section 3.0) were assumed to be representative of sediment contaminant conditions on a barge during dredging of that DU.

- Measured organic chemicals were assumed to be in dissolved or particulate-associated phases, i.e., the volume of sediment to be dredged contains no non-aqueous phase liquid (NAPL).
- Measured organic chemicals were assumed to have the potential for release into the dissolved phase, i.e., none is associated with non-desorbing (permanently sequestered) phases.
- Pre-dredging concentrations of substances in overlying seawater were assumed to be negligible.
- The time available for desorption to occur (i.e., between the time of placement of material on the barge and the time of discharge of the overlying water) was assumed to be one hour.
- The mean suspended sediment concentration of the dredged material suspension (sediment and entrained seawater) during the desorption period was assumed to be 500 mg/L.
- As noted in Section 6.0, release of metals from the solid phase into the dissolved phase prior to effluent discharge was assumed to be negligible.
- Metals and polycyclic aromatic hydrocarbons (PAHs) were assumed to be associated with the fines (<0.063 mm) fraction of the sediment (*i.e.*, measured concentrations in sediment were normalized to percent fines), and the TSS in dredge discharge water was assumed to be entirely composed of this fines fraction. Where normalization to fines resulted in substantially inflated concentrations because the samples had low fines content (i.e., <10 to 15%), additional calculations were made using non-normalized data to assess how the predictions may change.

8.0 PRELIMINARY WATER QUALITY SCREENING

Predicted total concentrations of select[1] chemical substances in the discharged water were screened against numerical values representative of concentrations that would, in our opinion, ordinarily be considered acceptable for discharge into the marine environment, summarized in Table 2. The benchmarks for evaluating PAHs have previously been accepted in Vancouver Harbour and in Esquimalt Harbour for other dredging projects. For convenience, the rationale for the selected PAH concentrations are provided in the summary table.

Table 2 also provides the rationale for screening benchmarks for metals which were selected in the following order of priority:

- 10× CCME marine water quality guidelines[2];
- 10× BC marine water quality guidelines[3];

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1. Parameters for which the CCME probable effects level (PEL) sediment quality guidelines (SQGs) were exceeded by more than six times were selected for a more detailed analysis by dredge unit.
2. Canadian Council of Ministers of the Environment (CCME), "Canadian Water Quality Guidelines for the Protection of Aquatic Life", updated 2007 (CCME 1999).
3. BC MOE (British Columbia Ministry of Environment). 2016. British Columbia approved water quality guidelines: aquatic life, wildlife & agriculture. Summary Report. Available at: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/waterqualityguidesobjs/approved-wat-qual-guides/final_approved_wqg_summary_march_2016.pdf

- 10× CCME freshwater quality guidelines[2];
- 10× BC freshwater quality guidelines[3]; and
- 10× US EPA acute marine water quality criteria[4].

Where available, acute (i.e., short-term exposure) guidelines were selected over chronic (i.e., long-term exposure) guidelines and data from toxicity testing with fish species were prioritized (vis-à-vis the requirements of Section 36 of the *Fisheries Act*).

Water quality guidelines (WQG) are not intended to be effluent limits, particularly for larger bodies of water such as Esquimalt Harbour, for several reasons, such as:

- WQG are often derived from conservative endpoints (*e.g.*, lowest observed effects concentrations or LOECs), and the most sensitive species for which toxicity test data are available, and
- Safety factors, often 10 times, are often applied to add conservatism.

A common approach to defining effluent limits, therefore, is to multiply a given WQG by 10.

Tributyltin was not screened because only a chronic effects benchmark was available, which is not an appropriate basis for assessing potential effects of an acute exposure for this substance. Maximum mercury concentrations exceeded the PEL by more than six times for a number of DUs (Table 1); however, barge discharge water concentrations for mercury weren't predicted because the environmental concern with mercury is related to bioaccumulation in methylmercury form rather than direct acute toxicity of the inorganic form.

9.0 MODEL INPUTS

Sediment chemistry data provided by Anchor QEA from the harbour-wide database were summarized by DUs as delineated in CAD files provided by Anchor QEA on 18 June 2018. Specifically, sea floor at Y Jetty and in Lang Cove was divided into 29 DUs. Data were available for surficial sediments and from depth; for this preliminary modeling exercise, the data were pooled and mean and maximum values calculated by DU (Table 1). Mean and maximum concentrations were conservatively normalized using the maximum percent fines within a DU. The mean TOC within each DU was used as a model input. Where total organic carbon or percent fines weren't available for a DU, a mean of all provided sediment data for Y Jetty and Lang Cove was used in modeling calculations.

Metals (arsenic, copper, lead, zinc) and PAHs (2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene) with mean and/or maximum values greater than six times the probable effects level (PEL) sediment quality guideline

[4] U.S. Environmental Protection Agency, "National Recommended Water Quality Criteria", updated 2011 (US EPA, 2011). Accessed online at: http://water.epa.gov/scitech/swguidance/standards/current/index.cfm

(SQG; CCME 1999)[5] were retained for modelling, with the exception of acenaphthylene and dibenz(a,h)anthracene. These two PAHs do not have readily available WQGs and there is limited information to develop alternate benchmarks. Because these contaminants without benchmarks are co-located with other parameters that were modelled and assessed in this letter report, it is expected that mitigation measures implemented for these other parameters will also control potential effects of parameters that were not modelled.

10.0 RESULTS AND UNCERTAINTY

Predicted total concentrations of the modelled substances in discharge water for each DU are presented in Tables 3 (metals) and 4 (PAHs). Predicted concentrations exceeding the screening value are highlighted. The following substances exhibited one or more predicted total concentrations in excess of the screening value.

10.1 Metals

10.1.1 Arsenic

Predicted total arsenic concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean (DU-31, 34) and maximum arsenic concentrations (DU -12, 14, 15, 31, 33, 34; Table 3A). This was in part influenced by the relatively low fines content of several samples; predicted concentrations using non-normalized data were lower and exceeded the screening benchmark at DUs 33 and 34 for maximum concentrations at a TSS concentration of 50 mg/L or greater. Only a fraction of discharged arsenic is expected to be in the particulate phase, therefore these predicted total arsenic concentrations may not be bioavailable and do not necessarily represent a potential for adverse effects to marine life.

10.1.2 Copper

Predicted total copper concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment copper concentrations (DU 2, 9, 10, 11, 12, 13, 15, 17, 21, 23, 26, 27, 28, 31, 33, 34, 37, 38, and 40) and maximum sediment copper concentrations (all DUs but 1, 6, 16, 36, and 41; Table 3B). However, this is in part influenced by the relatively low fines content of several samples. When non-normalized sediment concentrations were screened, mean predicted copper concentrations exceeded the benchmark in 11 DUs (DU 11, 12, 21, 23, 26, 27, 31, 34, 37, 38, and 40) at TSS concentrations of 20 mg/L or greater. Maximum predicted concentrations exceeded the benchmark in 21 DUs (DU 2, 3, 8, 9, 11, 12, 13, 14, 15, 17, 21, 23, 26, 27, 28, 31, 33, 34, 37, 38, and 40) at TSS concentrations greater than 20 mg/L.

We note in Table 1 the large difference between mean and max concentrations within some of the dredge units where modeled discharges exceed benchmarks. This may be indicative of localized areas of elevated levels of copper. Mean concentrations in sediments may be more realistic of concentrations contributing to copper in barge dewatering discharge because sediments will be mixed during collection, diluting the localized areas of high copper concentrations.

[5] Six times PEL was used to identify potential parameters of concern because this was the approach to identifying a remedial action objectives for the dredge design.

We also note that several predicted concentrations were higher than 300 µg/L, which is the limit for total copper in the MDMER. Although this is not a mining project, this concentration provides an example of a federal regulation in which "deleteriousness" per the *Fisheries Act* is defined by a numerical limit.

10.1.3 Lead

Predicted total lead concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment lead concentrations (DU 9, 23, 27, 31, 38 and 40) and maximum sediment lead concentrations (DU 8, 9, 10, 12, 13, 15, 17, 19, 23, 26, 27, 28, 31, 34, 37, 38, and 40; Table 3C). However, this is in part influenced by the relatively low fines content of several samples; predicted concentrations using non-normalized data are lower and the only exceedances of the screening benchmark were observed at average sediment lead concentrations in DU 26 and maximum concentrations in several DUs (DU 8, 9, 23, 37, 33, and 40) when a TSS was 30 mg/L or greater. Anchor has designated DU 9 as a "Leachable Metals Area" as lead was found to be leachable in toxicity characteristic leaching procedure (TCLP) testing. For the other DUs, only a fraction of discharged lead is expected to be in the particulate phase, therefore these predicted total lead concentrations may not be bioavailable and do not necessarily represent a potential for adverse effects to marine life.

10.1.4 Zinc

Predicted total zinc concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment zinc concentrations (DU 2, 9, 10, 11, 12, 13, 15, 21, 23, 26, 27, 28, 31, 33, 37, 38, and 40) and maximum zinc concentrations (all DUs but 1, 6, 16, 20, 36, and 41; Table 3D). However, this was in part influenced by the relatively low fines content of several samples. When non-normalized sediment concentrations were screened, mean predicted copper concentrations exceeded the benchmark in five DUs (DU 11, 13, 21, 27, 31, 34, and 38) at TSS concentrations of 40 mg/L or greater. Maximum predicted concentrations exceeded the benchmark in 14 DUs (DU 2, 3, 8, 9, 11, 12, 13, 14, 15, 21, 23, 26, 27, 31, 33, 34, 37, and 38) at lower TSS concentrations.

We do note however that several predicted concentrations are higher than 500 µg/L, which is the limit for total zinc in the MDMER.

10.1.5 Acid-volatile Sulphide (AVS) and Simultaneously Extractable Metals (SEM)

Acid-volatile sulphide (AVS) and simultaneously extractable metals (SEM) data were available for a sediment sample in the DU 11, 13, 19, and 21. The difference between AVS and SEM can be used as an indicator of the potential for a given divalent metal (e.g., copper, zinc) to be bioavailable because sulphides are one of the constituents in sediments that can bind metals (Hansen et al. 1996). If sufficient AVS is available (i.e., AVS-SEM > 0), the select metals are unlikely to contribute to any observed acute toxicity in sediments (DiToro et al. 1992). Conversely, if the difference between AVS and SEM is less than zero, then toxicity due to SEM <u>may or may not occur</u> because other sediment constituents can also bind metals. The AVS-SEM for each of the four DUs was greater than zero (3.6 in DU 19 to 51.5 in DU 21) indicating that there was sufficient sulphide to bind the metals, particularly zinc because it has a lower affinity for sulphide complexing than other divalent metals (e.g., copper and lead; Brumbaugh and Arms 1996). This is an indication that zinc and copper in DU 21 or other subtidal sediments where sulphides are present may not be of concern during dewatering of dredged sediments.
This indicator is not applicable to oxygenated sediments such as may occur in intertidal areas.

10.2 PAHs

Predicted concentrations in discharge water did not exceed respective screening values for acenaphthene. Benzo(a)pyrene, fluorene, and 2-methylnaphthalene only exceeded screening values in samples collected from DU 28 (Table 4). For the remaining PAHs, predicted concentrations in discharge water exceeded at least one benchmark value at one or more TSS concentrations for one or more DUs at mean sediment PAH concentrations (DU 10, 23, 26, 28) and maximum sediment PAH concentrations (DU 1, 8, 9, 10, 12, 15, 17, 23, 24, 26, 28, and 33).

At all DUs, the predicted PAH concentrations that exceeded screening values were influenced primarily by data from surficial samples with an estimated sediment surface penetration depth of 0.5 m or less. Mixing occurs during dredging and therefore the mean sediment concentration may be a reasonable proxy for the concentrations of PAHs in the sediment as a whole on the barge which will consist of a greater volume of material than is represented by a single sampling location.

10.3 Uncertainties

The assessment conducted here was an *a priori* exercise with the objective of identifying the potential viability of discharge of untreated water from dredged sediments to the marine environment during passive barge dewatering activities. This assessment necessarily required the use of predictive tools such as desorption modelling. While these tools are useful and provide a reasonable estimate of likely conditions, it is important to identify major uncertainties and to consider the implications of these uncertainties on predictions made. Main uncertainties are summarized below:

- **Sediment chemistry** – Available sediment chemistry data were assumed to provide an accurate characterization of sediment to be dredged for this preliminary assessment. However, as noted in Section 3.0, the dataset available for this assessment was limited in showing the vertical and horizontal extent of contamination in some DUs.
- **Representativeness of modelled conditions –** Modelled conditions were necessarily based on a series of assumptions, as stated throughout the letter report. Due to factors such as the uncertainties identified above, conservative assumptions were made; however, the direction of uncertainty (i.e., whether the model over or under predicts contaminant concentrations) cannot be verified at this time.
- **Low sample numbers -** Low sample numbers (n= 1 to 3) in dredge units with exceedances of PAH benchmark values increases the uncertainty around making an accurate assessment of the entire dredge volume. For example, sediment in DU 28 was characterized by three samples. However, the highest PAH concentrations were also observed in this DU.
- **Physical sediment characteristics –** grainsize and total organic carbon was estimated for DUs where no data was available from pooled Y Jetty and Lang Cove data. There is no reason to assume that the physical characteristics of these DUs will vary from adjoining areas but the accuracy of these estimates cannot be verified so remains uncertain.

11.0 INTERPRETATION AND RECOMMENDATIONS FOR WATER QUALITY MANAGEMENT

Under the assumptions of the model stated above, and based on the available sediment chemistry data within the areas to be dredged that were modelled, the modelling analysis predicted that discharge water from dewatering of dredged sediment on the barges for a majority of DUs would likely be considered acceptable for discharge to the marine environment, subject to suitable control of TSS. Specifically, a TSS limit of 75 mg/L is recommended for managing physical rather than chemical impacts associated with suspended sediments (DFO and MELP 1992). This TSS level will be applied to dewatering of material dredged from the majority of DUs. DUs that need to be managed for potential effects from contaminants are discussed below.

For a subset of DUs (25, 26, 27, 31, 32, 34, 37, and 38), predicted mean metal (copper and zinc) concentrations exceed benchmark screening values for at least one parameter at lower TSS concentrations. The predicted concentration of copper in the discharge water exceeds the screening value for protection against acute lethality to fish at relatively low TSS concentrations regardless of whether fines- or non-fines normalized sediment chemistry data are used in the modelling. DU 9 contains leachable lead and therefore the exceedance of the benchmark screening value at relative low TSS concentrations and higher sediment concentrations is of potential concern. For DU 28, screening benchmarks for several PAH parameters were consistently exceeded. Dewatering effluent from these DUs (9, 25, 26, 27, 28, 31, 32, 34, 37, and 38) is considered to be unsuitable for direct discharge to the marine environment without treatment or other management methods prior to disposal (discharge within a silt curtain is not an acceptable means of treatment as federal regulations expressly prohibit dilution as a treatment method). A TSS level of 40 mg/L is recommended as the TSS concentration to which barge dewatering effluent for sediments from DUs 9, 25, 26, 27, 31, 32, 34, 37, and 38 must be treated; this is the TSS concentration at which predicted contaminant concentrations are near or lower than the screening benchmark when non-fines normalized sediment chemistry data were evaluated.

As noted previously, no data were provided for DUs 4, 5, 7, 18, 22, 24, 25, 29, 30, 32, 35, and 39 and these DUs were not specifically evaluated. For the purposes of defining water quality management requirements, it was assumed that DUs without data were similar to adjacent DUs where data were available and therefore that these DUs would fall into the Water Quality Management Area associated with adjacent DUs with available data.

12.0 NOTICE TO READER

This letter was prepared for Canada in accordance with the terms and conditions of the Public Works and Government Services Canada (PWGSC) Marine Sediment Task Authorization (reference EZ897-172925/002/VAN), dated 21 November 2017. The scope of work for this report was outlined in Golder's "Workplan and Cost Estimate for Environmental, Heritage and Engagement Support for the Esquimalt Harbour Remediation Project, Esquimalt Harbour, BC", dated 25 May 2018. Task Authorizations (TA) for the above work plans were provided by Public Services and Procurement Canada (PSPC) on 4 June 2018 under TA 700412027.

The inferences concerning the Site conditions contained in this letter are based on information obtained during the assessment conducted by Golder personnel, and are based solely on the condition of the property at the time of the Site reconnaissance, supplemented by historical and interview information obtained by Golder, as described in this letter.

This letter was prepared, based in part, on information obtained from historic information sources. In evaluating the subject Site, Golder has relied in good faith on information provided. We accept no responsibility for any deficiency or inaccuracy contained in this letter as a result of our reliance on the aforementioned information.

The findings and conclusions documented in this letter 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 professionals currently practicing under similar conditions in the jurisdiction.

With respect to regulatory compliance issues, regulatory statutes are subject to interpretation. These interpretations may change over time, these should be reviewed.

If new information is discovered during future work, the conclusions of this letter should be re-evaluated and the report amended, as required, prior to any reliance upon the information presented herein.

13.0 CLOSURE

We trust the information presented in this report is satisfactory for your current purposes. Should you have any questions or comments, please do not hesitate to contact the undersigned.

Golder Associates Ltd.

COLLEGE OF APPLIED BIOLOGY
Barbara Wernick
R.P. Bio
#1171
CAB

20 Aug 2018

Barbara Wernick, MSc, RPBio	Ahmadreza Mehjoo, MSC, PEng, PMP
Principal, Senior Environmental Scientist	*Principal, Project Director*

BW/AM/lih

Attachments: Table 1 – Summary of Physico-chemical Data Available for Sediment Samples Collected from the Proposed Remediation Areas for Y Jetty and Lang Cove
Table 2 – Summary of Proposed Dredged Material Dewatering Discharge Benchmarks

https://golderassociates.sharepoint.com/sites/26400g/deliverables/issued to client-reserved for wp/18101029-007-l-rev0/18101029-007-l-rev0-y jetty barge dewatering 20aug_18.docx

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Table 1
Summary of Physico-chemical Data Available for Sediment Samples
Collected from the Proposed Remediation Areas for Y Jetty and Lang Cove

			1				2				3				6				8				9				10				11				12				13			
Row Labels	CCME PEL	5x PEL	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max
Total Organic Carbon (%)	-	-	1	2.3	2.3	2.3	5	1.04	2.61	4	4	0.49	1.53	2.66	2	1.01	1.385	1.76	11	0.13	1.04	3.08	35	0.17	3.29	8.87	2	1.77	2.62	3.47	2	2.2	2.6	3	3	3.04	4.02	5.42			2.79	
Total Fines (max clay + max silt)	-	-	1	84	84	84	3	22.4	46.8	65	1	69	69	69	2	45.5	57.375	69.25	10	15	35.859	70.59	33	2	26.09	47	2	5	20.5	36	2	62	67.5	73				37.415				37.415
Metals (Total) (mg/kg dw)																																										
Arsenic	41.6	208	4	6	15.3	24.7	11	5.18	165.9	1070	12	3.67	79.0	676	7	3.63	5.64	12.7	17	3.17	39.0	473	40	2.9	55.5	681	2	45.1	50.85	56.6	3	7.63	393.5	817	11	6.4	227.3	1400	3	28.9	145.97	260
Cadmium	4.2	21	4	1.14	1.6	2.23	11	1.5	2.1	4.54	12	0.11	1.2	2.81	7	0.07	0.60	1.45	17	0.06	1.1	4.16	40	0.31	1.9	7.73	2	1.26	1.445	1.63	3	1.33	2.1	3.1	11	0.2	2.3	4.61	3	1.6	1.84	2.03
Chromium	160	800	4	21.1	31.1	41.2	11	19.2	50.2	108	12	12.5	27.6	72.6	7	11	17.10	23.1	17	10	21.8	67	40	10	34.6	83	2	37	40	43	3	12.3	49.6	76.6	11	12	67.5	131	3	55.7	58.43	63.5
Copper	108	540	4	13.7	113.7	226	11	11.6	352.3	1070	12	7.35	140.6	707	7	7.1	22.88	110	17	6.8	81.7	744	40	7.1	273.5	1680	2	213	247	281	3	16.3	427.8	798	11	8.2	473.9	1450	3	363	623.67	817
Lead	112	560	4	2.99	92.8	171	11	2.66	340.3	897	12	1.65	109.1	665	7	1.62	49.28	321	17	1.59	395.7	3030	40	1.8	992.2	5960	2	334	517.5	701	3	22.9	437.3	767	11	1.9	420.6	1260	3	396	680.67	1140
Mercury	0.7	3.5	4	0.05	1.4	3.29	11	0.02	2.2	5.65	12	0.02	0.9	4.45	7	0.01	0.42	2.83	17	0.01	1.6	12	40	0.03	4.1	16.8	2	2.12	2.195	2.27	3	0.28	2.4	4.99	11	0.05	3.2	9.43	3	2.67	3.64	5.54
Zinc	271	1355	4	53	167.2	278	11	36.6	1062.9	4000	12	20.3	434.8	2570	7	20.3	39.89	145	17	19	381.8	3520	40	20	774.7	4740	2	511	637	763	3	38.1	1622.7	3170	11	20	1124.3	5350	3	812	1730.67	2560
PAH (mg/kg dw)																																										
1-Methylnaphthalene																			9	0.005	0.230	1.49	33	0.005	2.601	43.7	2	0.25	0.405	0.56	1	0.02	0.02	0.02								
2-Methylnaphthalene	0.245	1.225	4	0.01	0.513	1.9	6	0.01	0.035	0.05	7	0.01	0.031	0.09	2	0.01	0.015	0.02	11	0.005	0.217	1.92	37	0.005	0.100	0.63	2	0.222	0.301	0.38	3	0.01	0.03	0.05	6	0.03	0.49	2.3	3	0.11	0.15	0.17
Acenaphthene	0.0889	0.4445	4	0.005	1.229	4.7	6	0.005	0.058	0.15	7	0.005	0.044	0.1	2	0.005	0.0175	0.03	11	0.005	0.484	4.11	37	0.005	0.333	3.16	2	0.66	0.845	1.03	3	0.005	0.08	0.16	6	0.005	1.50	4.25	3	0.1	0.16	0.22
Acenaphthylene	0.128	0.64	4	0.005	0.031	0.06	6	0.005	0.046	0.09	7	0.005	0.031	0.09	2	0.005	0.0275	0.05	11	0.005	0.124	0.633	37	0.005	0.097	0.396	2	0.785	0.7925	0.8	3	0.005	0.04	0.07	6	0.005	0.13	0.25	3	0.06	0.12	0.22
Anthracene	0.245	1.225	4	0.01	1.025	3.6	6	0.004	0.184	0.34	7	0.004	0.141	0.38	2	0.004	0.077	0.15	11	0.004	0.749	4.66	37	0.004	0.848	4.89	2	3.16	4.085	5.01	3	0.01	0.19	0.32	6	0.01	1.19	2.5	3	0.25	0.42	0.52
Benzo(a)anthracene	0.693	3.465	4	0.01	2.020	6.7	6	0.01	0.345	0.54	7	0.01	0.284	0.67	2	0.01	0.32	0.63	2	0.05	0.680	1.31	4	0.27	1.413	2.8					3	0.04	0.42	0.65	6	0.01	1.97	3.9	3	0.58	0.96	1.29
Benzo(a)pyrene	0.763	3.815	4	0.01	1.950	6.2	6	0.01	0.553	1	7	0.01	0.409	0.99	2	0.01	0.375	0.74	2	0.07	0.800	1.53	4	0.45	1.568	3					3	0.04	0.61	1	6	0.01	2.08	4.06	3	0.81	1.32	1.89
Chrysene	0.846	4.23	4	0.01	2.138	6.9	6	0.01	0.480	0.89	7	0.01	0.356	0.81	2	0.01	0.375	0.74	11	0.05	1.987	12.7	37	0.05	1.794	7.6	2	6	15.7	25.4	3	0.05	0.55	0.81	6	0.01	2.41	4.4	3	0.7	1.20	1.72
Dibenz(a,h)anthracene	0.135	0.675	4	0.005	0.301	0.93	6	0.005	0.088	0.17	7	0.005	0.064	0.14	2	0.005	0.0575	0.11	2	0.01	0.100	0.19	4	0.07	0.213	0.38					3	0.0063	0.11	0.18	6	0.005	0.37	0.71	3	0.14	0.24	0.37
Fluoranthene	1.494	7.47	4	0.01	4.903	17	6	0.01	0.792	1.5	7	0.01	0.624	1.4	2	0.01	0.605	1.2	11	0.01	4.379	29.9	37	0.01	3.982	18.6	2	12.3	70.65	129	3	0.12	1.11	1.8	6	0.01	4.01	8.4	3	1.24	2.25	3.1
Fluorene	0.144	0.72	4	0.01	0.958	3.6	6	0.01	0.063	0.14	7	0.01	0.056	0.13	2	0.01	0.02	0.03	11	0.01	0.464	3.68	37	0.02	0.774	11.9	2	1.12	1.425	1.73	3	0.01	0.08	0.14	6	0.01	0.89	2.2	3	0.12	0.23	0.31
Naphthalene	0.391	1.955	4	0.01	1.020	3.9	6	0.01	0.048	0.07	7	0.01	0.054	0.18	2	0.01	0.025	0.04	11	0.005	0.539	5.1	37	0.005	0.175	1.11	2	0.81	0.839	0.868	3	0.01	0.05	0.08	6	0.01	2.10	11	3	0.19	0.34	0.42
Phenanthrene	0.544	2.72	4	0.01	4.893	18	6	0.01	0.485	1.1	7	0.01	0.390	0.9	2	0.01	0.32	0.63	11	0.02	3.424	24.2	37	0.02	3.541	27.5	2	7.2	7.9	8.6	3	0.03	0.59	1.1	6	0.01	3.26	8	3	0.91	1.89	2.57
Pyrene	1.398	6.99	4	0.01	4.278	14	6	0.01	1.193	2.28	7	0.01	0.844	1.94	2	0.01	0.795	1.58	11	0.01	5.927	34.1	37	0.01	4.771	17.8	2	22.9	83.45	144	3	0.12	1.44	2.5	6	0.01	6.22	11.6	3	1.83	3.07	4.52

Notes:

Where fines data were not collected for a DU, the mean of all fines data for Y Jetty and Lang Cove was calculated. The mean % fines for these 77 total measurements was 37.415% total fines (silt+ clay; <0.02mm) and highlighted in red

Where total organic carbon (TOC) was not collected for a DU, the mean of all TOC data for Y Jetty and Lang Cove was calculated. The mean TOC for these 107 total measurements was 2.790% and highlighted in red
Yellow-highlighted cells have concentrations that are >five times PEL

Table 1
Summary of Physico-chemical Data Available for Sediment Samples
Collected from the Proposed Remediation Areas for Y Jetty and Lang Cove

Dredge Unit (DU)

			14				15				16				17				19			
Row Labels	CCME PEL	5x PEL	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max
Total Organic Carbon (%)	-	-	2	1.41	1.51	1.61	5	1.35	3.376	6	2	0.52	1.39	2.26	3	0.22	1.97	5.3	3	0.32	2.14	3.61
Total Fines (max clay + max silt)	-	-				37.415	2	19.4	22.2	25	2	52.7	66.335	79.97				37.415	3	36.6	48.6	56
Metals (Total) (mg/kg dw)																						
Arsenic	41.6	208	9	5	107.26	644	23	1.9	101.71	1160	4	4.78	13.0725	35.2	7	4.06	17.96	43.6	9	3.21	14.27	63.6
Cadmium	4.2	21	9	0.27	1.34	2.08	23	0.13	1.86	3.86	4	0.18	0.415	0.91	7	0.25	1.31	3.09	9	0.12	0.86	2.54
Chromium	160	800	9	12.8	33.28	69.8	23	8.33	53.54	127	4	10.6	28.025	49	7	19.9	32.09	49.5	9	15.1	23.81	61.1
Copper	108	540	9	11	145.96	538	23	7.2	329.71	1240	4	18	69.9	192	7	12.5	165.07	411	9	8.54	80.53	377
Lead	112	560	9	30	158.64	546	23	2.21	380.03	1180	4	5.3	49.16	179	7	1.84	381.03	1100	9	1.98	182.79	1110
Mercury	0.7	3.5	9	0.02	1.06	3.95	23	0.05	4.78	19.1	4	0.06	0.9825	3.65	7	0.02	5.95	20.7	9	0.02	2.30	12.2
Zinc	271	1355	9	31.5	425.61	2180	23	15.5	659.81	3220	4	22.1	92.2	244	7	24.8	248.23	610	9	20.8	157.17	864
PAH (mg/kg dw)																						
1-Methylnaphthalene																			1	0.03	0.030	0.03
2-Methylnaphthalene	0.245	1.225	7	0.02	0.08	0.18	16	0.0001	0.146	1.1	2	0.01	0.03	0.05	3	0.04	0.137	0.23	3	0.01	0.200	0.42
Acenaphthene	0.0889	0.4445	7	0.04	0.10	0.26	16	0.0001	0.316	2.6	2	0.005	0.0725	0.14	3	0.07	0.133	0.24	3	0.005	0.452	0.86
Acenaphthylene	0.128	0.64	7	0.04	0.06	0.11	16	0.0001	0.074	0.23	2	0.005	0.0475	0.09	3	0.005	0.067	0.19	3	0.005	0.085	0.16
Anthracene	0.245	1.225	7	0.05	0.29	1.01	16	0.0001	0.718	3.7	2	0.0079	0.25395	0.5	3	0.004	0.246	0.73	3	0.004	0.978	2.09
Benzo(a)anthracene	0.693	3.465	7	0.05	0.62	2.21	16	0.0001	1.503	11	2	0.01	0.54	1.07	3	0.01	0.470	1.39	3	0.01	1.750	4.04
Benzo(a)pyrene	0.763	3.815	7	0.05	0.89	3.66	16	0.0001	1.399	9.4	2	0.02	0.785	1.55	3	0.01	0.927	2.76	3	0.01	2.363	5.58
Chrysene	0.846	4.23	7	0.05	0.71	2.54	16	0.0001	1.386	7.1	2	0.02	0.54	1.06	3	0.01	0.530	1.57	3	0.01	1.720	3.85
Dibenz(a,h)anthracene	0.135	0.675	7	0.05	0.17	0.72	16	0.0002	0.191	1	2	0.006	0.118	0.23	3	0.005	0.113	0.33	3	0.005	0.302	0.63
Fluoranthene	1.494	7.47	7	0.05	1.13	4.08	16	0.0001	4.953	44	2	0.02	1.08	2.14	3	0.01	1.013	3.02	3	0.01	3.667	8.49
Fluorene	0.144	0.72	7	0.05	0.11	0.31	16	0.0001	0.226	1.4	2	0.01	0.095	0.18	3	0.02	0.100	0.25	3	0.01	0.393	0.78
Naphthalene	0.391	1.955	7	0.04	0.12	0.34	16	0.0002	0.798	9.1	2	0.01	0.09	0.17	3	0.39	1.007	2.22	3	0.01	0.213	0.46
Phenanthrene	0.544	2.72	7	0.05	0.80	2.39	16	0.0001	1.018	3.2	2	0.02	0.605	1.19	3	0.01	0.627	1.86	3	0.01	3.437	7.8
Pyrene	1.398	6.99	7	0.05	1.68	6.83	16	0.0003	5.320	39	2	0.05	1.395	2.74	3	0.01	1.927	5.76	3	0.01	4.803	11.6

	20				21				23				26				27			
Row Labels	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max
Total Organic Carbon (%)	2	0.31	2	3.69	2	2.2	2.55	2.9	2	0.8	2.595	4.39	3	0.29	2.71	5.12	7	0.48	6.10	10.6
Total Fines (max clay + max silt)	1	65	65	65	2	10.8	31.9	53				37.415	1	54.3	54.3	54.3	6	4	42.35	85.1
Metals (Total) (mg/kg dw)																				
Arsenic	6	3.03	23.00	58.5	3	50.2	245.2	629	6	6.42	86.11	308	8	3.6	110.67	347	12	8.9	139.0	457
Cadmium	6	0.07	1.13	1.95	3	2.07	2.4	2.63	6	1.19	2.10	3.18	8	1.68	2.49	3.1	12	0.34	3.0	7.9
Chromium	6	14	30.95	45.7	3	45.7	66.3	83.8	6	15.3	45.17	80.7	8	7.58	95.40	297	12	20	100.9	447
Copper	6	15.6	127.52	325	3	396	640.3	930	6	36.4	538.27	1490	8	11.8	1001.39	2500	12	78.5	2280.6	3880
Lead	6	4.06	302.94	1060	3	381	596.3	751	6	151	832.83	2220	8	12.8	613.79	1160	12	34.7	2035.3	5980
Mercury	6	0.06	3.96	13.3	3	2.73	4.8	7.1	6	1.23	10.45	30.1	8	0.57	24.64	63.7	12	0.83	108.7	197
Zinc	6	34.7	194.22	481	3	567	1625.7	2960	6	87.3	739.05	1930	8	25.9	933.38	1960	12	113	2118.1	7340
PAH (mg/kg dw)																				
1-Methylnaphthalene					1	0.14	0.140	0.14									5	0.005	0.219	0.5
2-Methylnaphthalene	3	0.01	0.127	0.21	3	0.15	0.210	0.25	2	0.03	1.320	2.61	3	0.01	0.217	0.49	8	0.005	0.224	0.5
Acenaphthene	3	0.005	0.335	0.62	3	0.24	0.417	0.68	2	0.02	2.760	5.5	3	0.005	1.028	2.62	8	0.005	0.373	0.73
Acenaphthylene	3	0.005	0.085	0.13	3	0.1	0.117	0.15	2	0.01	0.185	0.36	3	0.005	0.248	0.39	8	0.008	0.279	0.7
Anthracene	3	0.004	0.591	1.06	3	0.71	0.877	1.1	2	0.06	4.585	9.11	3	0.01	1.590	3.65	8	0.017	0.956	2.1
Benzo(a)anthracene	3	0.01	1.203	2.11	3	1.2	1.600	2	2	0.15	7.375	14.6	3	0.02	3.697	8.18	3	0.61	3.973	8
Benzo(a)pyrene	3	0.01	1.530	2.62	3	1.7	1.933	2.3	2	0.18	7.840	15.5	3	0.02	6.193	12.3	3	0.9	5.703	9.7
Chrysene	3	0.01	1.140	2.03	3	1.6	1.833	2.1	2	0.16	5.980	11.8	3	0.02	3.227	6.78	8	0.05	3.691	8.7
Dibenz(a,h)anthracene	3	0.005	0.252	0.43	3	0.21	0.273	0.32	2	0.02	0.995	1.97	3	0.005	0.845	1.67	3	0.14	0.793	1.3
Fluoranthene	3	0.01	2.577	4.58	3	3.3	4.133	5.6	2	0.28	20.340	40.4	3	0.04	8.940	20.8	8	0.11	6.410	19
Fluorene	3	0.01	0.270	0.48	3	0.33	0.480	0.73	2	0.03	3.455	6.88	3	0.01	0.897	2.24	8	0.02	0.546	2
Naphthalene	3	0.01	0.227	0.34	3	0.18	0.300	0.45	2	0.05	2.445	4.84	3	0.01	0.470	1.12	8	0.005	0.357	0.8
Phenanthrene	3	0.01	1.947	3.56	3	2.4	3.100	4.4	2	0.24	20.770	41.3	3	0.04	6.577	15.8	8	0.05	3.195	8.2
Pyrene	3	0.01	2.940	4.9	3	3.8	5.367	7	2	0.45	19.525	38.6	3	0.06	18.953	46.2	8	0.15	11.966	30

Notes:

Where fines data were not collected for a DU, the mean of all fines data for Y Jetty and Lang Cove was calculated. The mean % fines for these 77 total measurements was 37.415% total fines (silt+ clay; <0.02mm) and highlighted in red

Where total organic carbon (TOC) was not collected for a DU, the mean of all TOC data for Y Jetty and Lang Cove was calculated. The mean TOC for these 107 total measurements was 2.790% and highlighted in red
Yellow-highlighted cells have concentrations that are >five times PEL

Table 1
Summary of Physico-chemical Data Available for Sediment Samples
Collected from the Proposed Remediation Areas for Y Jetty and Lang Cove

			28				31				33				34			
Row Labels	CCME PEL	5x PEL	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max
Total Organic Carbon (%)	-	-			2.79				2.79		3	0.43	1.63	2.65	3	0.22	1.24	1.93
Total Fines (max clay + max silt)	-	-				37.415	1	6	6	6	2	73.4	77.255	81.11	2	39.41	49.205	59
Metals (Total) (mg/kg dw)																		
Arsenic	41.6	208	2	34.9	84.4	134	1	1070	1070	1070	18	4.19	287.7	2280	7	69.7	1193.24	2970
Cadmium	4.2	21	2	1.3	1.4	1.41	1	3.87	3.87	3.87	18	0.07	2.1	6.8	7	0.28	4.26	10
Chromium	160	800	2	51.1	53.4	55.8	1	71	71	71	18	9.76	29.7	87.2	7	21.7	79.86	163
Copper	108	540	2	204	310.5	417	1	1280	1280	1280	18	6.82	356.8	2420	7	72.1	1279.30	2840
Lead	112	560	2	388	598.5	809	1	801	801	801	18	1.41	218.5	1410	7	23.2	829.89	1970
Mercury	0.7	3.5	2	2.02	3.7	5.4	1	0.33	0.33	0.33	18	0.02	0.8	4.58	7	0.05	2.92	14.2
Zinc	271	1355	2	995	1032.5	1070	1	4270	4270	4270	18	16.7	1331.3	10300	7	193	4707.43	11900
PAH (mg/kg dw)																		
1-Methylnaphthalene																		
2-Methylnaphthalene	0.245	1.225	2	0.22	4.245	8.27	1	0.05	0.05	0.05	4	0.01	0.328	1.17	5	0.02	0.064	0.22
Acenaphthene	0.0889	0.4445	2	0.43	7.315	14.2	1	0.04	0.04	0.04	4	0.005	0.436	1.55	5	0.005	0.232	1.05
Acenaphthylene	0.128	0.64	2	0.19	0.435	0.68	1	0.05	0.05	0.05	4	0.005	0.019	0.03	5	0.005	0.028	0.06
Anthracene	0.245	1.225	2	1.17	19.535	37.9	1	0.06	0.06	0.06	4	0.0047	0.114	0.21	5	0.004	0.4658	2.08
Benzo(a)anthracene	0.693	3.465	2	2.21	18.505	34.8	1	0.17	0.17	0.17	4	0.01	0.260	0.45	5	0.02	0.904	3.89
Benzo(a)pyrene	0.763	3.815	2	1.88	20.290	38.7	1	0.15	0.15	0.15	4	0.01	0.333	0.6	5	0.02	1.16	5.1
Chrysene	0.846	4.23	2	3.21	18.905	34.6	1	0.19	0.19	0.19	4	0.01	0.300	0.53	5	0.02	0.894	3.74
Dibenz(a,h)anthracene	0.135	0.675	2	0.18	1.890	3.6	1	0.05	0.05	0.05	4	0.005	0.041	0.07	5	0.03	0.12	0.42
Fluoranthene	1.494	7.47	2	3.34	34.170	65	1	0.37	0.37	0.37	4	0.02	0.663	1.3	5	0.02	2.362	9.93
Fluorene	0.144	0.72	2	0.53	7.815	15.1	1	0.05	0.05	0.05	4	0.01	0.223	0.68	5	0.02	0.226	0.96
Naphthalene	0.391	1.955	2	0.54	5.420	10.3	1	0.05	0.05	0.05	4	0.01	1.095	4.11	5	0.01	0.102	0.44
Phenanthrene	0.544	2.72	2	2.14	64.570	127	1	0.29	0.29	0.29	4	0.01	0.483	0.89	5	0.02	1.728	7.52
Pyrene	1.398	6.99	2	11.5	56.250	101	1	0.32	0.32	0.32	4	0.04	0.593	1	5	0.02	1.874	7.95

	36				37				38				40				41			
Row Labels	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max
Total Organic Carbon (%)			2.79				2.79		2	1.97	2.84	3.71	2	4.55	5.235	5.92	1	0.18	0.18	0.18
Total Fines (max clay + max silt)				37.415				37.415	1	58.2	58.2	58.2				37.415				37.415
Metals (Total) (mg/kg dw)																				
Arsenic	2	4.69	28.0	51.4	5	2.5	141.64	348	5	57.7	312.54	645	5	11.8	24.6	66.4	3	3.84	7.4	13.5
Cadmium	2	0.41	0.6	0.82	5	0.2	1.876	3.02	5	0.83	1.808	2.83	5	2.19	2.674	3.24	3	0.18	0.5	1.12
Chromium	2	13.7	16.8	19.9	5	13	67.04	134	5	73.5	128.52	195	5	22.6	31.8	55.6	3	11.6	17.1	21.7
Copper	2	10.5	50.4	90.3	5	44	1160.6	2440	5	1590	3682	5870	5	262	424.4	943	3	43.5	50.8	64.8
Lead	2	2.36	47.0	91.7	5	25.5	538.88	947	5	931	1332.8	1680	5	685	1139.2	2490	3	7.74	54.6	140
Mercury	2	0.05	0.4	0.82	5	0.52	11.76	23.9	5	30.7	48	61.9	5	17.5	25.46	31.8	3	0.08	0.4	0.89
Zinc	2	24.5	141.8	259	5	50	1310.6	2410	5	1130	1904	2930	5	317	450.4	803	3	55.8	106.0	202
PAH (mg/kg dw)																				
1-Methylnaphthalene																				
2-Methylnaphthalene	2	0.001	0.006	0.01	4	0.05	0.143	0.3	2	0.21	0.24	0.27	2	0.08	0.12	0.16	3	0.02	0.02	0.02
Acenaphthene	2	0.0005	0.015	0.03	5	0.005	0.313	0.63	2	0.31	0.415	0.52	2	0.18	0.215	0.25	3	0.005	0.0074	0.01
Acenaphthylene	2	0.0005	0.005	0.01	3	0.005	0.042	0.07	2	0.24	0.34	0.44	2	0.14	0.18	0.22	3	0.005	0.013	0.03
Anthracene	2	0.001	0.076	0.15	5	0.01	0.600	1.3	2	0.72	1.02	1.32	2	0.57	0.745	0.92	3	0.01	0.02	0.03
Benzo(a)anthracene	2	0.002	0.061	0.12	5	0.11	1.368	2.9	2	2.81	2.83	2.85	2	1.22	1.33	1.44	3	0.04	0.07	0.11
Benzo(a)pyrene	2	0.0023	0.081	0.16	5	0.13	1.866	4.7	2	3.9	5.3	6.7	2	1.9	2.105	2.31	3	0.05	0.08	0.13
Chrysene	2	0.0027	0.146	0.29	5	0.11	1.502	3.2	2	2.64	2.775	2.91	2	1.31	1.395	1.48	3	0.05	0.077	0.12
Dibenz(a,h)anthracene	2	0.0005	0.015	0.03	5	0.005	0.257	0.63	2	0.66	0.705	0.75	2	0.22	0.245	0.27	3	0.05	0.05	0.05
Fluoranthene	2	0.0042	0.127	0.25	5	0.13	2.866	6.7	2	5.01	5.02	5.03	2	2.74	3.22	3.7	3	0.09	0.127	0.15
Fluorene	2	0.001	0.016	0.03	5	0.01	0.316	0.71	2	0.34	0.515	0.69	2	0.2	0.27	0.34	3	0.02	0.02	0.02
Naphthalene	2	0.001	0.016	0.03	5	0.01	0.200	0.39	2	0.4	0.48	0.56	2	0.13	0.23	0.33	3	0.01	0.01	0.01
Phenanthrene	2	0.0022	0.101	0.2	5	0.1	2.160	4.7	2	2.39	3.625	4.86	2	1.96	2.32	2.68	3	0.05	0.067	0.1
Pyrene	2	0.0069	0.163	0.32	5	0.35	3.810	10	2	7.29	10.595	13.9	2	3.6	3.99	4.38	3	0.08	0.143	0.22

Notes:

Where fines data were not collected for a DU, the mean of all fines data for Y Jetty and Lang Cove was calculated. The mean % fines for these 77 total measurements was 37.415% total fines (silt+ clay; <0.02mm) and highlighted in red

Where total organic carbon (TOC) was not collected for a DU, the mean of all TOC data for Y Jetty and Lang Cove was calculated. The mean TOC for these 107 total measurements was 2.790% and highlighted in red

Yellow-highlighted cells have concentrations that are >five times PEL

Table 2: Summary of Proposed Dredged Material Dewatering Discharge Benchmarks

Parameter	Proposed Benchmark (µg/L)	Approach	Rationale
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	510	Literature review*	The lower 95% confidence limit of the lowest available toxicity data point (a 96-h LC_{50} for brown trout; Holcombe et al. 1983, cited in CCME 1999) without a safety factor because the data point is lower than observed for other fish species, suggesting that acute toxicity to site-specific fin-fish would be unlikely.
Anthracene	5.0	Literature review	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) without a safety factor because the data point represents a no-effect level.
Benzo(a)anthracene	1.8	Literature review	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) without a safety factor because the data point represents a no-effect level.
Benzo(a)pyrene	5.6	Literature review	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) without a safety factor because the data point represents a no-effect level. Further weight of evidence assessment of available toxicity data indicated that the value is similar to the results of guppy and Japanese medaka tested in a 6-h acute toxicity test and thus would be protective of shorter term discharges. Other endpoints were determined not to apply.
Chrysene	8.6	QSAR	Based on methods of DiToro et al. (2000).
Fluoranthene	20	Literature review	The lowest available toxicity data point (a 24-h LC_{50} for fathead minnow; Kagan et al 1985) with a 10-fold safety factor.
Fluorene	82	Literature review	The lowest available toxicity data point (a 96-h LC_{50} for rainbow trout; Finger et al. 1985, cited in CCME 1999) with a 10-fold safety factor.
2-Methylnaphthalene	58	Literature review	The lowest available toxicity data point (a 96-h LC_{27} for cod embryos; Saethre et al. 1984) with a 10-fold safety factor. The safety factor was applied to address uncertainty introduced by the number of studies available and species assessed.
Naphthalene	100	Literature review	The lower 95% CL of the lowest available toxicity data point (a 96-h LC_{50} for rainbow trout embryos; Black et al. 1983, cited in CCME 1999) without a safety factor. A safety factor was not applied because the results of 24-h LC_{50} tests were greater than the selected benchmark, suggesting that acute toxicity to site-specific fin-fish at the point of discharge would be unlikely.
Phenanthrene	40	Literature review	The lower 95% CL of the second lowest available toxicity data point (a 96-h LC_{50} for rainbow trout embryos; Black et al. 1983; cited in CCME 1999) without a safety factor. The lowest available toxicity data point was not used because it was not considered to be directly applicable (*i.e.*, it was for a 27-d rainbow trout embryo LC_{50}).

Parameter	Proposed Benchmark (µg/L)	Approach	Rationale
Pyrene	12.8	Literature review	The lowest available toxicity data point (a 96-h LC_{50} for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) with a 2-fold safety factor. Although the selected data point represented a no-effect level, the 2-fold safety factor was considered necessary because only one data point was available.
Metals			
Arsenic	125	CCME marine WQG X by 10	The WQG was derived based on the application of a 10-times safety factor to the LOEC of the most sensitive species for which toxicity data were available (a marine diatom, *Skeletonema costatum*). The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharges from metal mines (*i.e.*, 500 µg/L).
Copper	30	BC marine maximum WQG X by 10	The WQG was derived based on acute toxicity to oyster and mussel larvae (96-h LC_{50} = 5.3-5.8 µg/L) (Singleton 1987). Adult stages of invertebrates are less sensitive to copper, as are fish. The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharges from metal mines (*i.e.*, 300 µg/L).
Lead	140	BC marine maximum WQG	The WQG was adopted from USEPA (1985) and is approximately half the lowest marine LC50 of 315 µg/L for mummichog (*Fundulus heroclitus*) (Nagpal 1987). The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharge from metal mines (*i.e.*, 200 µg/L)
Zinc	100	BC marine maximum WQG X by 10	The WQG was derived based on the application of a 5-times safety factor applied to chronic toxicity to two marine diatoms (Nagpal 1999). The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharges from metal mines (*i.e.*, 500 µg/L).

Notes:

* The literature review included a search of available electronic databases (*e.g.*, BIOSIS), on-line toxicological databases (*e.g.*, USEPA ECOTOX) and data compilations used for regulatory purposes (*e.g.*, CCME 1999, Nagpal 1993). Lethal concentration values resulting in 50% mortality (LC_{50}) were obtained for both freshwater and marine fish species as the expectation of the *Fisheries Act* is that at the point of discharge, the dewatering effluent with non-acutely lethal, operationally defined by Environment Canada and MOE as 96-h $LC_{50} \geq 100\%$ for rainbow trout. Invertebrates were excluded from the literature search because by nature dredging will be removed by the physical activity of the dredging. Phototoxic effects were not considered because by nature the water will contain some turbidity which will reduce UV penetration.

** The Target Lipid approach is based on a QSAR for PAH compounds developed by DiToro et al. (2000). The underlying principle of the Target Lipid approach is that the target lipid is the site of PAH action in the organism and that the target lipid has the same lipid-octanol linear free energy relationship irrespective of species. DiToro et al. (2000) derived a method for developing water quality criteria for narcotic chemicals (Type 1) and specifically for PAHs, based on using a single universal slope for the log LC_{50} versus log K_{ow} (octanol-water partitioning coefficient) QSAR for all species.

CCME – Canadian Council of Ministers of the Environment; CL – confidence limit; LOEC – lowest observed effects concentration; MMER – Metal Mining Effluent Regulation; QSAR – Quantitative Structure-Activity Relationship; WQG – water quality guideline.

Table 3: EHRP Preliminary Predicted Discharge Water Concentrations for Metals

A) Arsenic

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Arsenic (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**75**
Mean									
1	0.1	0.2	0.4	0.5	0.7	0.9	1.1	1.3	1.4
2	1.3	2.6	5.1	7.7	10	13	15	18	19
3	0.6	1.1	2.3	3.4	4.6	5.7	6.9	8.0	8.6
6	0.04	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.6
8	0.28	0.55	1.1	1.66	2.21	2.76	3.31	3.87	4.14
9	0.59	1.2	2.4	3.5	4.7	5.9	7.1	8.3	9
10	0.71	1.41	3	4	6	7	8	10	11
11	2.7	5.4	11	16	22	27	32	38	40
12	3.04	6.1	12.1	18.2	24.3	30.4	36.4	42.5	46
13	1.95	3.9	8	12	16	20	23	27	29
14	1.4	2.9	6	9	11	14	17	20	21
15	2.03	4.1	8.1	12.2	16.3	20.3	24.4	28	31
16	0.08	0.16	0.3	0.5	0.7	0.8	1.0	1.1	1.2
17	0.2	0.5	1.0	1	2	2	3	3	4
19	0.1	0.3	0.5	0.8	1.0	1.3	1.5	1.8	1.9
20	0.18	0.4	0.7	1.1	1.4	1.8	2.1	2.5	3
21	2.31	4.63	9.25	13.88	18.51	23.1	27.8	32.4	34.7
23	1.15	2.3	4.6	6.9	9.2	11.5	13.8	16.1	17.3
26	1.0	2.0	4.1	6	8	10	12	14	15
27	0.82	1.6	3.3	4.9	6.5	8.2	10	11	12
28	1.1	2.3	4.5	6.8	9.0	11.3	13.5	15.8	16.9
31	89.2	178.3	356.7	535	713	892	1070	1248	1338
33	1.77	3.55	7.09	10.6	14.2	17.7	21	25	27
34	10.1	20.2	40.4	60.7	80.9	101	121	142	152
36	0.4	1	1	2	3	4	4	5	6
37	1.9	3.8	7.6	11.4	15.1	18.9	22.7	26.5	28.4
38	2.7	5.4	10.7	16.1	21.5	26.9	32.2	37.6	40.3
40	0.33	0.66	1.31	2.0	2.6	3.3	3.9	4.6	4.9
41	0.1	0.2	0.4	1	1	1	1	1	1

Dredge Unit	**Predicted Discharge Water Total Concentrations (µg/L) for Arsenic (Fines Normalized Sediment Chemistry)**								
TSS (mg/L) =>	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**75**
Maximum									
1	0.1	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.2
2	8.2	16	33	49	66	82	99	115	123
3	4.9	10	20	29	39	49	59	69	73
6	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.4
8	3.35	6.7	13.4	20.1	26.8	33.5	40.2	46.9	50.3
9	7.2	14.5	29.0	43.5	58.0	72	87	101	109
10	0.8	1.6	3.1	4.7	6.3	7.9	9.4	11.0	11.8
11	5.60	11.19	22.38	33.58	44.8	56.0	67.2	78.3	83.9
12	18.7	37.4	74.8	112.3	149.7	187	225	262	281
13	3.5	7	14	21	28	35	42	49	52
14	9	17	34	52	69	86	103	120	129
15	23	46	93	139	186	232	278	325	348
16	0.2	0.4	1	1	2	2	3	3	3
17	1	1	2	3	5	6	7	8	9
19	0.6	1.1	2.3	3.4	4.5	5.7	6.8	8.0	8.5
20	0.5	0.9	1.8	2.7	3.6	4.5	5.4	6.3	6.8
21	5.93	11.87	23.7	35.6	47.5	59.3	71.2	83.1	89.0
23	4.12	8.232	16.5	24.7	32.9	41.2	49.4	57.6	61.7
26	3.2	6	13	19	26	32	38	45	48
27	2.7	5.4	11	16	21	27	32	38	40
28	1.8	3.6	7	11	14	18	21	25	27
31	89	178	357	535	713	892	1070	1248	1338
33	14.05	28.11	56.2	84.3	112	141	169	197	211
34	25	50	101	151	201	252	302	352	378
36	1	1	3	4	5	7	8	10	10
37	4.7	9.3	18.6	27.9	37.2	46.5	55.8	65.1	69.8
38	5.5	11.1	22.2	33.2	44.3	55.4	66.5	77.6	83.1
40	0.89	1.77	3.55	5.3	7.1	8.9	10.6	12.4	13.3
41	0.2	0.4	0.7	1	1	2	2	3	3

Highlighted cells exceed the screening benchmark of 125 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Arsenic (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.08	0.2	0.3	0.5	0.6	0.8	1	1	1
2	0.83	1.66	3.32	5.0	6.6	8.3	10.0	11.6	12.4
3	0.4	0.8	1.6	2.4	3.2	4.0	4.7	6	6
6	0.03	0.06	0.1	0.2	0.2	0.3	0.3	0.4	0.4
8	0.195	0.39	0.78	1.17	1.56	1.95	2.34	2.73	2.92
9	0.28	0.555	1.11	1.67	2.22	2.78	3.33	3.89	4.17
10	0.25	0.51	1.02	1.53	2.0	2.5	3.1	3.6	3.8
11	2.0	3.9	7.9	12	16	20	24	28	30
12	1.14	2.27	4.55	6.82	9.09	11.36	13.64	15.91	17.04
13	0.73	1.46	2.92	4.38	5.8	7.3	8.8	10.2	10.9
14	0.5	1.1	2.1	3	4	5	6	8	8
15	0.5	1.0	2.0	3.1	4.1	5	6	7	8
16	0.07	0.1	0.3	0.4	0.5	0.7	0.8	0.9	1.0
17	0.09	0.18	0.4	0.5	0.7	0.9	1.1	1.3	1.3
19	0.07	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.1
20	0.11	0.23	0.5	0.7	0.9	1.1	1.4	1.6	1.7
21	1.226	2.45	4.9	7.36	9.81	12.26	14.7	17.2	18.4
23	0.431	0.86	1.72	2.58	3.44	4.31	5.2	6.0	6.5
26	0.553	1.11	2.21	3.32	4.43	5.53	6.64	7.75	8.3
27	0.695	1.39	2.78	4.17	5.56	6.95	8.34	9.73	10.43
28	0.42	0.84	1.69	2.53	3.38	4.2	5.1	5.9	6.3
31	5.4	10.7	21.4	32.1	42.8	54	64	75	80
33	1.44	2.88	5.75	8.63	11.51	14.38	17.26	20.14	21.57
34	5.97	11.93	23.9	35.8	47.7	59.7	71.6	83.5	89.5
36	0.14	0.28	0.6	0.8	1.1	1.4	1.7	2.0	2.1
37	0.71	1.4	2.8	4.2	5.7	7.1	8.5	9.9	10.6
38	1.6	3.1	6.3	9.4	12.5	15.6	18.8	21.9	23.4
40	0.12	0.25	0.49	0.74	0.98	1.2	1.5	1.7	1.8
41	0.037	0.07	0.15	0.22	0.3	0.37	0.4	0.5	0.6

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Arsenic (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Maximum									
1	0.1	0.2	0.5	0.7	1.0	1.2	1.5	1.7	1.9
2	5.35	10.7	21.4	32.1	42.8	53.5	64.2	74.9	80.3
3	3.4	7	14	20	27	34	41	47	51
6	0.1	0.1	0.3	0.4	0.5	0.6	0.8	0.9	1.0
8	2.365	4.73	9.46	14.19	18.92	23.65	28.38	33.11	35.48
9	3.41	6.81	13.62	20.4	27.2	34.1	40.9	47.7	51.1
10	0.3	0.6	1.1	1.7	2.3	2.8	3.4	4.0	4.2
11	4.085	8.17	16.34	24.51	32.68	40.85	49.02	57.19	61.28
12	7.0	14.0	28.0	42.0	56.0	70.0	84.0	98.0	105.0
13	1.3	2.6	5.2	7.8	10.4	13.0	15.6	18.2	19.5
14	3.2	6.4	13	19	26	32	39	45	48
15	5.8	11.6	23.2	34.8	46	58	70	81	87
16	0.2	0.4	0.7	1.1	1	2	2	2	3
17	0.2	0.4	1	1	2	2	3	3	3
19	0.3	0.6	1.3	1.9	2.5	3.2	3.8	4.5	4.8
20	0.29	0.6	1.2	1.8	2.3	2.9	3.5	4.1	4.4
21	3.15	6.29	12.6	18.9	25.2	31.5	37.7	44.0	47.2
23	1.54	3.08	6.16	9.2	12.3	15.4	18.5	21.6	23.1
26	1.74	3.47	6.94	10.4	13.9	17.4	20.8	24.3	26.0
27	2.29	4.57	9.1	13.7	18.3	22.9	27.4	32.0	34.3
28	0.67	1.34	2.7	4.0	5.4	6.7	8.0	9.4	10.1
31	5.4	10.7	21	32	43	54	64	75	80
33	11.40	22.80	45.6	68.4	91.2	114.0	136.8	159.6	171.0
34	14.9	29.7	59.4	89.1	119	149	178	208	223
36	0.26	0.5	1.0	1.5	2.1	2.6	3.1	3.6	4
37	1.7	3.5	7.0	10.4	13.9	17.4	20.9	24.4	26.1
38	3.2	6.5	12.9	19.4	25.8	32.3	38.7	45.2	48.4
40	0.33	0.66	1.33	1.99	2.66	3.3	4.0	4.6	5.0
41	0.068	0.14	0.27	0.41	0.54	0.68	0.8	0.9	1.0

B) Copper

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Copper (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.7	1.4	2.7	4.1	5.4	6.8	8.1	9.5	10
2	2.7	5.4	11	16	22	27	33	38	41
3	1.0	2.0	4.1	6.1	8.2	10	12	14	15
6	0.2	0.3	0.7	1.0	1.3	1.7	2.0	2.3	2.5
8	0.6	1.2	2.3	3.5	4.6	5.8	6.9	8.1	8.7
9	2.9	5.8	12	17	23	29	35	41	44
10	3.4	6.9	14	21	27	34	41	48	51
11	2.9	5.9	11.7	17.6	23.4	29.3	35.2	41.0	43.9
12	6.3	12.7	25	38	51	63	76	89	95
13	8.3	16.7	33	50	67	83	100	117	125
14	2.0	4	8	12	16	20	23	27	29
15	6.6	13.2	26	40	53	66	79	92	99
16	0.4	0.9	1.7	2.6	3.5	4.4	5.2	6.1	6.6
17	2.2	4	9	13	18	22	26	31	33
19	0.7	1.4	2.9	4.3	5.8	7.2	8.6	10.1	10.8
20	1.0	2.0	3.9	6	8	10	12	14	15
21	6.0	12.1	24.2	36.2	48.3	60.4	72.5	84.6	90.6
23	7.2	14.4	28.8	43.2	57.5	72	86	101	108
26	9.2	18	37	55	74	92	111	129	138
27	13.4	27	54	80	107	134	161	188	201
28	4	8	17	25	33	41	50	58	62
31	107	213	427	640	853	1067	1280	1493	1600
33	2.2	4.4	9	13	18	22	26	31	33
34	10.8	21.7	43.4	65.0	87	108	130	152	163
36	0.7	1	3	4	5	7	8	9	10
37	15.5	31	62	93	124	155	186	217	233
38	31.6	63.3	127	190	253	316	380	443	474
40	5.7	11.3	23	34	45	57	68	79	85
41	1	1	3	4	5	7	8	10	10

Dredge Unit	**Predicted Discharge Water Total Concentrations (µg/L) for Copper (Fines Normalized Sediment Chemistry)**								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Maximum									
1	1	3	5	8	11	13	16	19	20
2	8.2	16	33	49	66	82	99	115	123
3	5.1	10	20	31	41	51	61	72	77
6	0.8	2	3	5	6	8	10	11	12
8	5.3	10.5	21.1	31.6	42	53	63	74	79
9	17.9	35.7	71	107	143	179	214	250	268
10	4	8	16	23	31	39	47	55	59
11	5	11	22	33	44	55	66	77	82
12	19	39	78	116	155	194	233	271	291
13	11	22	44	66	87	109	131	153	164
14	7	14	29	43	58	72	86	101	108
15	25	50	99	149	198	248	298	347	372
16	1.2	2.4	5	7	10	12	14	17	18
17	5	11	22	33	44	55	66	77	82
19	3	7	13	20	27	34	40	47	50
20	2.5	5	10	15	20	25	30	35	38
21	8.8	17.5	35	53	70	88	105	123	132
23	19.9	39.8	80	119	159	199	239	279	299
26	23.0	46	92	138	184	230	276	322	345
27	23	46	91	137	182	228	274	319	342
28	6	11	22	33	45	56	67	78	84
31	107	213	427	640	853	1067	1280	1493	1600
33	14.9	29.8	60	90	119	149	179	209	224
34	24	48	96	144	193	241	289	337	361
36	1	2	5	7	10	12	14	17	18
37	33	65	130	196	261	326	391	457	489
38	50	101	202	303	403	504	605	706	756
40	12.6	25.2	50	76	101	126	151	176	189
41	1	2	3	5	7	9	10	12	13

Highlighted cells exceed the screening benchmark of 30 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Copper (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.6	1.1	2	3	5	6	7	8	9
2	1.8	3.5	7.0	11	14	18	21	25	26
3	0.7	1.4	2.8	4	6	7	8	10	11
6	0.11	0.2	0.5	0.7	0.9	1.1	1.4	1.6	2
8	0.41	0.82	1.63	2.5	3.3	4.1	4.9	5.7	6.1
9	1.4	2.7	5.5	8.2	11	14	16	19	21
10	1.2	2.5	4.9	7	10	12	15	17	19
11	2.14	4.28	8.56	12.8	17.1	21.4	25.7	29.9	32.1
12	2.4	4.7	9.5	14.2	19	24	28	33	36
13	3.1	6.2	12.5	19	25	31	37	44	47
14	0.7	1.5	3	4	6	7	9	10	11
15	1.6	3.3	7	10	13	16	20	23	25
16	0.3	0.7	1	2	3	3	4	5	5
17	0.8	1.7	3.3	5.0	7	8	10	12	12
19	0.4	0.8	1.6	2	3	4	5	6	6
20	0.64	1.3	2.6	3.8	5.1	6.4	8	9	10
21	3.2	6.4	12.8	19.2	25.6	32.0	38.4	44.8	48.0
23	2.69	5.4	10.8	16.1	21.5	26.9	32.3	38	40
26	5.01	10.01	20	30	40	50	60	70	75
27	11.4	22.8	46	68	91	114	137	160	171
28	1.6	3.1	6	9	12	16	19	22	23
31	6	13	26	38	51	64	77	90	96
33	1.8	3.6	7.1	10.7	14	18	21	25	27
34	6.4	12.8	26	38	51	64	77	90	96
36	0.3	0.5	1.0	1.5	2	3	3	4	4
37	5.8	12	23	35	46	58	70	81	87
38	18.4	36.8	73.6	110.5	147	184	221	258	276
40	2.1	4.2	8.5	12.7	17.0	21	25	30	32
41	0.25	0.5	1.0	1.5	2.0	2.5	3.1	3.6	3.8

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Copper (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Maximum									
1	1	2	5	7	9	11	14	16	17
2	5.4	11	21	32	43	54	64	75	80
3	3.5	7	14	21	28	35	42	49	53
6	0.6	1.1	2	3	4	6	7	8	8
8	3.72	7.4	14.9	22.3	29.8	37	45	52	56
9	8.4	16.8	33.6	50.4	67.2	84	101	118	126
10	1.4	3	6	8	11	14	17	20	21
11	4.0	8	16	24	32	40	48	56	60
12	7.3	15	29	44	58	73	87	102	109
13	4.1	8	16	25	33	41	49	57	61
14	2.7	5	11	16	22	27	32	38	40
15	6.2	12	25	37	50	62	74	87	93
16	1.0	1.9	4	6	8	10	12	13	14
17	2.1	4	8	12	16	21	25	29	31
19	1.9	4	8	11	15	19	23	26	28
20	1.6	3.3	7	10	13	16	20	23	24
21	4.7	9.3	18.6	28	37	47	56	65	70
23	7.5	14.9	29.8	45	60	75	89	104	112
26	12.5	25.0	50	75	100	125	150	175	188
27	19.4	39	78	116	155	194	233	272	291
28	2	4	8	13	17	21	25	29	31
31	6	13	26	38	51	64	77	90	96
33	12.1	24.2	48.4	73	97	121	145	169	182
34	14.2	28	57	85	114	142	170	199	213
36	0.5	1	1.8	3	4	5	5	6	7
37	12	24	49	73	98	122	146	171	183
38	29	59	117	176	235	294	352	411	440
40	4.7	9.4	18.9	28.3	37.7	47	57	66	71
41	0.3	0.6	1.3	1.9	2.6	3.2	3.9	4.5	4.9

Highlighted cells exceed the screening benchmark of 30 µg/L

C) Lead

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Lead (Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	1	1	2	3	4	6	7	8	8
2	2.6	5.2	10	16	21	26	31	37	39
3	0.8	1.6	3	5	6	8	9	11	12
6	0.36	0.7	1.4	2.1	2.8	3.6	4.3	5	5
8	2.8	5.6	11.2	17	22	28	34	39	42
9	10.6	21.1	42	63	84	106	127	148	158
10	7.19	14.4	28.8	43.1	57.5	71.9	86.3	101	108
11	3.0	6.0	12.0	18	24	30	36	42	45
12	5.6	11.2	22	34	45	56	67	79	84
13	9.1	18	36	55	73	91	109	127	136
14	2.1	4	8	13	17	21	25	30	32
15	7.6	15.2	30	46	61	76	91	106	114
16	0.3	0.6	1	2	2	3	4	4	5
17	5.1	10	20	31	41	51	61	71	76
19	1.6	3	7	10	13	16	20	23	24
20	2.3	4.7	9	14	19	23	28	33	35
21	5.63	11.3	22.5	33.8	45.0	56.3	67.5	79	84
23	11.1	22.3	45	67	89	111	134	156	167
26	5.7	11	23	34	45	57	68	79	85
27	12.0	24	48	72	96	120	144	167	179
28	8.0	16	32	48	64	80	96	112	120
31	67	134	267	401	534	668	801	935	1001
33	1.3	3	5	8	11	13	16	19	20
34	7.0	14	28	42	56	70	84	98	105
36	0.6	1	3	4	5	6	8	9	9
37	7	14	29	43	58	72	86	101	108
38	11.5	22.9	45.8	69	92	115	137	160	172
40	15	30	61	91	122	152	183	213	228
41	0.7	1.5	3	4	6	7	9	10	11

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Lead (Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Maximum									
1	1	2	4	6	8	10	12	14	15
2	6.9	14	28	41	55	69	83	97	104
3	4.8	10	19	29	39	48	58	67	72
6	2.3	4.6	9	14	19	23	28	32	35
8	21	43	86	129	172	215	258	300	322
9	63	127	254	380	507	634	761	888	951
10	10	19	39	58	78	97	117	136	146
11	5	11	21	32	42	53	63	74	79
12	17	34	67	101	135	168	202	236	253
13	15	30	61	91	122	152	183	213	229
14	7	15	29	44	58	73	88	102	109
15	24	47	94	142	189	236	283	330	354
16	1.1	2	4	7	9	11	13	16	17
17	15	29	59	88	118	147	176	206	220
19	10	20	40	59	79	99	119	139	149
20	8	16	33	49	65	82	98	114	122
21	7.1	14	28	43	57	71	85	99	106
23	30	59	119	178	237	297	356	415	445
26	10.7	21	43	64	85	107	128	150	160
27	35	70	141	211	281	351	422	492	527
28	11	22	43	65	86	108	130	151	162
31	67	134	267	401	534	668	801	935	1001
33	8.7	17	35	52	70	87	104	122	130
34	17	33	67	100	134	167	200	234	250
36	1	2	5	7	10	12	15	17	18
37	13	25	51	76	101	127	152	177	190
38	14	29	58	87	115	144	173	202	216
40	33	67	133	200	266	333	399	466	499
41	1.9	3.7	7	11	15	19	22	26	28

Highlighted cells exceed the screening benchmark of 140 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Lead (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.5	1	2	3	4	5	6	6	7
2	1.7	3.4	6.8	10	14	17	20	24	26
3	0.5	1.1	2.2	3	4	5	7	8	8
6	0.25	0.5	1.0	1.5	2.0	2.5	3.0	3.4	3.7
8	2.0	4.0	7.9	11.9	15.8	20	24	28	30
9	5.0	9.9	19.8	30	40	50	60	69	74
10	2.59	5.2	10.4	15.5	20.7	25.9	31.1	36.2	38.8
11	2.2	4.4	8.7	13.1	17.5	22	26	31	33
12	2.1	4.2	8.4	12.6	16.8	21	25	29	32
13	3.4	6.8	14	20	27	34	41	48	51
14	0.8	1.6	3.2	5	6	8	10	11	12
15	1.9	3.8	7.6	11	15	19	23	27	29
16	0.2	0.5	1	1	2	2	3	3	4
17	1.9	3.8	7.6	11	15	19	23	27	29
19	0.9	1.8	3.7	5	7	9	11	13	14
20	1.5	3.0	6.1	9	12	15	18	21	23
21	2.98	6.0	11.9	17.9	23.9	29.8	35.8	41.7	44.7
23	4.2	8.3	16.7	25	33	42	50	58	62
26	3.1	6.1	12	18	25	31	37	43	46
27	10.2	20.4	41	61	81	102	122	142	153
28	3.0	6.0	12	18	24	30	36	42	45
31	4.0	8	16	24	32	40	48	56	60
33	1.1	2.2	4	7	9	11	13	15	16
34	4.1	8.3	17	25	33	41	50	58	62
36	0.2	0.5	1	1	2	2	3	3	4
37	2.7	5	11	16	22	27	32	38	40
38	6.7	13.3	26.7	40.0	53.3	67	80	93	100
40	5.7	11	23	34	46	57	68	80	85
41	0.27	0.55	1.09	1.6	2.2	2.7	3.3	3.8	4.1

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Lead (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Maximum									
1	1	2	3	5	7	9	10	12	13
2	4.5	9.0	18	27	36	45	54	63	67
3	3.3	6.7	13	20	27	33	40	47	50
6	1.6	3.2	6	10	13	16	19	22	24
8	15.2	30	61	91	121	152	182	212	227
9	29.8	60	119	179	238	298	358	417	447
10	4	7	14	21	28	35	42	49	53
11	3.8	8	15	23	31	38	46	54	58
12	6.3	13	25	38	50	63	76	88	95
13	6	11	23	34	46	57	68	80	86
14	2.7	5	11	16	22	27	33	38	41
15	5.9	12	24	35	47	59	71	83	89
16	0.9	2	4	5	7	9	11	13	13
17	5.5	11	22	33	44	55	66	77	83
19	5.6	11	22	33	44	56	67	78	83
20	5.3	11	21	32	42	53	64	74	80
21	3.8	8	15	23	30	38	45	53	56
23	11.1	22	44	67	89	111	133	155	167
26	5.8	11.6	23	35	46	58	70	81	87
27	30	60	120	179	239	299	359	419	449
28	4	8	16	24	32	40	49	57	61
31	4	8	16	24	32	40	48	56	60
33	7.1	14.1	28	42	56	71	85	99	106
34	10	20	39	59	79	99	118	138	148
36	0.5	1	2	3	4	5	6	6	7
37	5	9	19	28	38	47	57	66	71
38	8.4	17	34	50	67	84	101	118	126
40	12	25	50	75	100	125	149	174	187
41	0.7	1.4	2.8	4.2	5.6	7.0	8.4	9.8	10.5

Highlighted cells exceed the screening benchmark of 140 µg/L

D) Zinc

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Zinc (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	1	2	4	6	8	10	12	14	15
2	8.2	16	33	49	65	82	98	114	123
3	3.2	6	13	19	25	32	38	44	47
6	0.3	0.6	1	2	2	3	3	4	4
8	2.7	5.4	10.8	16.2	21.6	27	32	38	41
9	8	16	33	49	66	82	99	115	124
10	9	18	35	53	71	88	106	124	133
11	11	22	44	67	89	111	133	156	167
12	15	30	60	90	120	150	180	210	225
13	23	46	93	139	185	231	278	324	347
14	6	11	23	34	46	57	68	80	85
15	13	26	53	79	106	132	158	185	198
16	0.6	1	2	3	5	6	7	8	9
17	3	7	13	20	27	33	40	46	50
19	1	3	6	8	11	14	17	20	21
20	1.5	3.0	6	9	12	15	18	21	22
21	15.34	30.7	61.3	92.0	122.7	153.4	184.0	214.7	230
23	9.9	19.8	40	59	79	99	119	138	148
26	9	17	34	52	69	86	103	120	129
27	12.4	25	50	75	100	124	149	174	187
28	14	28	55	83	110	138	166	193	207
31	356	712	1423	2135	2847	3558	4270	4982	5338
33	8	16	33	49	66	82	98	115	123
34	39.9	80	160	239	319	399	479	559	598
36	2	4	8	11	15	19	23	27	28
37	18	35	70	105	140	175	210	245	263
38	16.4	33	65	98	131	164	196	229	245
40	6	12	24	36	48	60	72	84	90
41	1.4	3	6	9	11	14	17	20	21

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Zinc (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Maximum									
1	2	3	7	10	13	17	20	23	25
2	31	62	123	185	246	308	369	431	462
3	19	37	74	112	149	186	223	261	279
6	1	2	4	6	8	10	13	15	16
8	25	50	100	150	199	249	299	349	374
9	50	101	202	303	403	504	605	706	756
10	11	21	42	64	85	106	127	148	159
11	22	43	87	130	174	217	261	304	326
12	71	143	286	429	572	715	858	1001	1072
13	34	68	137	205	274	342	411	479	513
14	29	58	117	175	233	291	350	408	437
15	64	129	258	386	515	644	773	902	966
16	2	3	6	9	12	15	18	21	23
17	8	16	33	49	65	82	98	114	122
19	8	15	31	46	62	77	93	108	116
20	4	7	15	22	30	37	44	52	56
21	28	56	112	168	223	279	335	391	419
23	26	52	103	155	206	258	310	361	387
26	18	36	72	108	144	180	217	253	271
27	43	86	173	259	345	431	518	604	647
28	14	29	57	86	114	143	172	200	214
31	356	712	1423	2135	2847	3558	4270	4982	5338
33	63	127	254	381	508	635	762	889	952
34	101	202	403	605	807	1008	1210	1412	1513
36	3	7	14	21	28	35	42	48	52
37	32	64	129	193	258	322	386	451	483
38	25	50	101	151	201	252	302	352	378
40	11	21	43	64	86	107	129	150	161
41	3	5	11	16	22	27	32	38	40

Highlighted cells exceed the screening benchmark of 100 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Zinc (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	0.8	2	3	5	7	8	10	12	13
2	5.3	11	21	32	43	53	64	74	80
3	2.2	4	9	13	17	22	26	30	33
6	0.2	0.4	0.8	1	2	2	2	3	3
8	1.91	3.8	7.6	11.5	15.3	19.1	22.9	27	29
9	3.87	8	15	23	31	39	46	54	58
10	3.2	6	13	19	25	32	38	45	48
11	8.1	16	32	49	65	81	97	114	122
12	5.62	11	22	34	45	56	67	79	84
13	8.7	17	35	52	69	87	104	121	130
14	2.1	4	9	13	17	21	26	30	32
15	3.3	7	13	20	26	33	40	46	49
16	0.5	1	2	3	4	5	6	6	7
17	1.2	2.5	5	7	10	12	15	17	19
19	0.8	1.6	3	5	6	8	9	11	12
20	1.0	1.9	3.9	6	8	10	12	14	15
21	8.13	16.3	32.5	48.8	65.0	81.3	97.5	113.8	121.9
23	3.7	7.4	14.8	22.2	29.6	37	44	52	55
26	4.7	9	19	28	37	47	56	65	70
27	10.59	21.2	42	64	85	106	127	148	159
28	5.2	10.3	21	31	41	52	62	72	77
31	21.4	43	85	128	171	214	256	299	320
33	6.7	13	27	40	53	67	80	93	100
34	23.5	47.1	94	141	188	235	282	330	353
36	0.7	1	3	4	6	7	9	10	11
37	6.6	13	26	39	52	66	79	92	98
38	9.5	19	38	57	76	95	114	133	143
40	2.3	5	9	14	18	23	27	32	34
41	0.5	1.1	2	3	4	5	6	7	8

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Zinc (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Maximum									
1	1	3	6	8	11	14	17	19	21
2	20.0	40	80	120	160	200	240	280	300
3	13	26	51	77	103	129	154	180	193
6	1	1	3	4	6	7	9	10	11
8	17.6	35	70	106	141	176	211	246	264
9	23.7	47	95	142	190	237	284	332	356
10	3.8	8	15	23	31	38	46	53	57
11	16	32	63	95	127	159	190	222	238
12	27	54	107	161	214	268	321	375	401
13	13	26	51	77	102	128	154	179	192
14	11	22	44	65	87	109	131	153	164
15	16	32	64	97	129	161	193	225	242
16	1	2	5	7	10	12	15	17	18
17	3	6	12	18	24	31	37	43	46
19	4	9	17	26	35	43	52	60	65
20	2.4	4.8	10	14	19	24	29	34	36
21	14.8	29.6	59	89	118	148	178	207	222
23	9.7	19.3	39	58	77	97	116	135	145
26	9.8	20	39	59	78	98	118	137	147
27	36.7	73	147	220	294	367	440	514	551
28	5.4	11	21	32	43	54	64	75	80
31	21	43	85	128	171	214	256	299	320
33	51.5	103	206	309	412	515	618	721	773
34	59.5	119	238	357	476	595	714	833	893
36	1.3	3	5	8	10	13	16	18	19
37	12	24	48	72	96	121	145	169	181
38	15	29	59	88	117	147	176	205	220
40	4.0	8	16	24	32	40	48	56	60
41	1.0	2.0	4	6	8	10	12	14	15

Highlighted cells exceed the screening benchmark of 100 µg/L

Table 4: Preliminary Predicted Discharge Water Concentrations for Polycyclic Aromatic Hydrocarbons

A) Acenaphthene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Acenaphthene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
1	11	11	11	11	11	11	11	11	11
2	0.57	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
3	0.69	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
6	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
8	11	11	11	11	11	11	11	11	11
9	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
10	15	15	15	15	15	15	15	15	15
11	0.73	0.73	0.73	0.73	0.73	0.73	0.74	0.74	0.74
12	17	17	17	17	17	17	17	17	17
13	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
14	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
15	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
16	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
17	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
19	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
20	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
21	5.2	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.3
23	48	48	48	48	48	49	49	49	49
26	12	12	12	12	12	12	12	12	12
27	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3
28	119	119	119	119	120	120	120	120	120
31	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
33	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
34	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
36	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
37	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.2
38	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
40	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
41	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85

Dredge Unit:	**Predicted Discharge Water Total Concentrations (µg/L) for Acenaphthene (Fines Normalized Sediment Chemistry)**								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Maximum									
1	41	41	41	41	41	41	41	41	42
2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
3	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
6	0.51	0.51	0.51	0.52	0.52	0.52	0.52	0.52	0.52
8	89	89	89	89	89	89	89	89	89
9	35	35	35	35	35	35	35	35	35
10	19	19	19	19	19	19	19	19	19
11	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
12	48	48	49	49	49	49	49	49	49
13	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
14	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
15	53	53	53	53	53	53	53	53	53
16	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
17	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
19	12	12	12	12	12	12	12	12	12
20	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
21	8.5	8.5	8.5	8.6	8.6	8.6	8.6	8.6	8.6
23	96	96	96	96	97	97	97	97	97
26	30	30	30	30	30	30	31	31	31
27	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.5
28	231	231	231	232	232	233	233	233	234
31	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
33	20	20	20	20	20	20	20	20	20
34	23	23	23	23	23	23	23	23	23
36	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
37	10	10	10	10	10	10	10	10	10
38	5.3	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
40	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
41	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2

Highlighted cells exceed the screening benchmark = 510 µg/L

B) Anthracene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Anthracene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	2.2	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3
2	0.45	0.45	0.45	0.46	0.46	0.46	0.47	0.47	0.47
3	0.55	0.55	0.55	0.56	0.56	0.56	0.56	0.56	0.56
6	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34
8	4.2	4.2	4.2	4.2	4.2	4.2	4.3	4.3	4.3
9	2.3	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.4
10	18	18	18	18	18	19	19	19	19
11	0.41	0.41	0.41	0.41	0.42	0.42	0.42	0.43	0.43
12	3.3	3.3	3.4	3.4	3.4	3.4	3.5	3.5	3.5
13	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
14	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
15	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
16	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
17	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
19	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
20	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
21	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.8	2.8
23	20	20	20	20	20	20	20	20	20
26	4.5	4.5	4.5	4.6	4.6	4.6	4.7	4.7	4.7
27	0.77	0.78	0.79	0.8	0.81	0.82	0.83	0.84	0.85
28	78	78	79	79	80	80	81	81	81
31	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6
33	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.37	0.37
34	2.6	2.6	2.6	2.6	2.7	2.7	2.7	2.7	2.7
36	0.3	0.3	0.3	0.31	0.31	0.31	0.31	0.31	0.31
37	2.4	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.5
38	2.6	2.6	2.6	2.6	2.6	2.6	2.7	2.7	2.7
40	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7
41	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Anthracene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Maximum									
1	7.7	7.7	7.8	7.8	7.9	7.9	8.0	8.0	8.0
2	0.83	0.83	0.84	0.85	0.85	0.86	0.86	0.87	0.87
3	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
6	0.65	0.65	0.65	0.65	0.65	0.65	0.66	0.66	0.66
8	26	26	26	26	26	26	27	27	27
9	13	13	13	13	14	14	14	14	14
10	22	22	22	22	23	23	23	23	23
11	0.7	0.7	0.71	0.71	0.72	0.72	0.72	0.73	0.73
12	6.9	7.0	7.0	7.1	7.2	7.2	7.3	7.4	7.4
13	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
14	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
15	18	18	18	18	18	18	18	18	18
16	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
17	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
19	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
20	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
21	3.4	3.4	3.4	3.4	3.5	3.5	3.5	3.5	3.5
23	39	39	39	40	40	40	40	41	41
26	10	10	10	11	11	11	11	11	11
27	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.9	1.9
28	151	151	152	153	154	155	156	157	158
31	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6
33	0.66	0.66	0.66	0.66	0.67	0.67	0.67	0.67	0.68
34	12	12	12	12	12	12	12	12	12
36	0.6	0.6	0.6	0.61	0.61	0.62	0.62	0.62	0.63
37	5.2	5.2	5.2	5.3	5.3	5.3	5.4	5.4	5.4
38	3.3	3.3	3.4	3.4	3.4	3.4	3.4	3.5	3.5
40	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1
41	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6

Highlighted cells exceed the screening benchmark = 5 µg/L

C) Benzo(a)anthracene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo(a)anthracene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	0.2	0.21	0.23	0.26	0.28	0.31	0.33	0.35	0.37
2	0.039	0.041	0.047	0.052	0.057	0.063	0.068	0.073	0.076
3	0.05	0.052	0.056	0.06	0.064	0.068	0.073	0.077	0.079
6	0.062	0.064	0.068	0.073	0.078	0.082	0.087	0.092	0.094
8	0.17	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.24
9	0.18	0.19	0.22	0.25	0.28	0.31	0.34	0.37	0.39
11	0.042	0.045	0.051	0.057	0.062	0.068	0.074	0.08	0.082
12	0.26	0.29	0.34	0.39	0.44	0.5	0.55	0.6	0.63
13	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
14	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
16	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086
17	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
19	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
20	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
21	0.23	0.24	0.27	0.3	0.33	0.36	0.39	0.42	0.44
23	1.5	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.8
26	0.48	0.51	0.58	0.65	0.72	0.79	0.85	0.92	0.96
27	0.16	0.18	0.23	0.28	0.32	0.37	0.42	0.46	0.49
28	3.4	3.6	4.1	4.6	5.1	5.6	6.1	6.6	6.9
31	0.19	0.21	0.24	0.27	0.29	0.32	0.35	0.38	0.39
33	0.037	0.038	0.041	0.045	0.048	0.051	0.054	0.057	0.059
34	0.23	0.23	0.25	0.27	0.28	0.3	0.31	0.33	0.33
36	0.011	0.012	0.014	0.015	0.017	0.019	0.02	0.022	0.023
37	0.25	0.27	0.31	0.34	0.38	0.42	0.45	0.49	0.51
38	0.33	0.35	0.4	0.45	0.5	0.55	0.6	0.64	0.67
40	0.14	0.16	0.19	0.23	0.26	0.3	0.33	0.37	0.39
41	0.19	0.19	0.19	0.19	0.19	0.19	0.2	0.2	0.2

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo(a)anthracene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Maximum									
1	0.66	0.7	0.78	0.85	0.93	1.0	1.1	1.2	1.2
2	0.061	0.065	0.073	0.081	0.09	0.098	0.11	0.12	0.12
3	0.12	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19
6	0.12	0.13	0.14	0.14	0.15	0.16	0.17	0.18	0.19
8	0.33	0.34	0.35	0.37	0.39	0.41	0.43	0.45	0.46
9	0.35	0.38	0.44	0.5	0.56	0.62	0.68	0.74	0.77
11	0.065	0.07	0.079	0.088	0.096	0.11	0.11	0.12	0.13
12	0.51	0.56	0.67	0.77	0.88	0.98	1.1	1.2	1.2
13	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
14	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
15	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
16	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
17	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
19	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
20	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
21	0.28	0.3	0.34	0.38	0.41	0.45	0.49	0.53	0.55
23	2.9	3.1	3.5	3.8	4.2	4.6	5.0	5.4	5.6
26	1.1	1.1	1.3	1.4	1.6	1.7	1.9	2.0	2.1
27	0.32	0.37	0.46	0.56	0.65	0.74	0.84	0.93	0.98
28	6.4	6.8	7.8	8.7	9.6	11	12	12	13
31	0.19	0.21	0.24	0.27	0.29	0.32	0.35	0.38	0.39
33	0.063	0.066	0.072	0.077	0.083	0.088	0.094	0.099	0.1
34	0.98	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.4
36	0.022	0.024	0.027	0.03	0.033	0.036	0.04	0.043	0.044
37	0.53	0.57	0.65	0.73	0.8	0.88	0.96	1.0	1.1
38	0.33	0.36	0.4	0.45	0.5	0.55	0.6	0.65	0.67
40	0.15	0.17	0.21	0.25	0.28	0.32	0.36	0.4	0.42
41	0.29	0.29	0.3	0.3	0.3	0.3	0.31	0.31	0.31

Highlighted cells exceed the screening benchmark of 1.8 µg/L

D) Benzo(a)pyrene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo(a)pyrene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	0.14	0.16	0.18	0.2	0.23	0.25	0.27	0.3	0.31
2	0.047	0.051	0.06	0.068	0.077	0.086	0.094	0.1	0.11
3	0.054	0.057	0.063	0.069	0.075	0.081	0.086	0.092	0.095
6	0.054	0.057	0.062	0.068	0.073	0.079	0.084	0.089	0.092
8	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23
9	0.15	0.17	0.2	0.23	0.27	0.3	0.33	0.37	0.38
11	0.047	0.051	0.059	0.068	0.076	0.085	0.093	0.1	0.11
12	0.21	0.24	0.29	0.35	0.41	0.46	0.52	0.57	0.6
13	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
14	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
15	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
16	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093
17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
19	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
20	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
21	0.21	0.23	0.26	0.3	0.33	0.37	0.41	0.44	0.46
23	1.2	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.6
26	0.61	0.67	0.78	0.9	1.0	1.1	1.2	1.4	1.4
27	0.18	0.21	0.28	0.35	0.41	0.48	0.55	0.61	0.65
28	2.8	3.1	3.6	4.2	4.7	5.3	5.8	6.4	6.6
31	0.13	0.14	0.17	0.19	0.22	0.24	0.27	0.29	0.31
33	0.035	0.037	0.041	0.045	0.05	0.054	0.058	0.062	0.064
34	0.22	0.23	0.25	0.27	0.29	0.31	0.33	0.35	0.36
36	0.011	0.012	0.015	0.017	0.019	0.021	0.023	0.025	0.027
37	0.26	0.29	0.34	0.39	0.44	0.48	0.53	0.58	0.61
38	0.47	0.51	0.6	0.7	0.79	0.88	0.97	1.1	1.1
40	0.17	0.2	0.25	0.31	0.37	0.42	0.48	0.54	0.56
41	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo(a)pyrene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Maximum									
1	0.46	0.5	0.57	0.64	0.72	0.79	0.87	0.94	0.98
2	0.085	0.093	0.11	0.12	0.14	0.15	0.17	0.19	0.19
3	0.13	0.14	0.15	0.17	0.18	0.2	0.21	0.22	0.23
6	0.11	0.11	0.12	0.13	0.14	0.16	0.17	0.18	0.18
8	0.29	0.3	0.32	0.34	0.36	0.38	0.41	0.43	0.44
9	0.29	0.32	0.38	0.45	0.51	0.57	0.64	0.7	0.73
11	0.076	0.083	0.097	0.11	0.12	0.14	0.15	0.17	0.17
12	0.41	0.46	0.57	0.68	0.79	0.9	1.0	1.1	1.2
13	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
14	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
15	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
16	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
17	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
19	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
20	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
21	0.25	0.27	0.31	0.35	0.4	0.44	0.48	0.53	0.55
23	2.3	2.5	2.9	3.3	3.8	4.2	4.6	5.0	5.2
26	1.2	1.3	1.6	1.8	2.0	2.2	2.5	2.7	2.8
27	0.3	0.36	0.47	0.59	0.7	0.82	0.93	1.0	1.1
28	5.4	5.9	6.9	8.0	9.0	10	11	12	13
31	0.13	0.14	0.17	0.19	0.22	0.24	0.27	0.29	0.31
33	0.064	0.067	0.075	0.082	0.089	0.097	0.1	0.11	0.12
34	0.96	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6
36	0.022	0.024	0.029	0.033	0.037	0.042	0.046	0.05	0.052
37	0.66	0.72	0.84	0.97	1.1	1.2	1.4	1.5	1.5
38	0.59	0.65	0.76	0.88	0.99	1.1	1.2	1.3	1.4
40	0.19	0.22	0.28	0.34	0.4	0.46	0.53	0.59	0.62
41	0.26	0.26	0.26	0.26	0.27	0.27	0.27	0.28	0.28

Highlighted cells exceed the screening benchmark of 5.6 µg/L

E) Chrysene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Chrysene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	0.23	0.25	0.27	0.3	0.32	0.35	0.37	0.4	0.41
2	0.06	0.064	0.071	0.079	0.086	0.093	0.1	0.11	0.11
3	0.07	0.072	0.077	0.083	0.088	0.093	0.098	0.1	0.11
6	0.081	0.083	0.089	0.094	0.10	0.11	0.11	0.12	0.12
8	0.55	0.57	0.6	0.62	0.65	0.68	0.71	0.74	0.75
9	0.25	0.27	0.31	0.35	0.38	0.42	0.46	0.5	0.52
10	3.5	3.8	4.2	4.6	5.1	5.5	5.9	6.4	6.6
11	0.062	0.066	0.073	0.081	0.088	0.096	0.1	0.11	0.12
12	0.35	0.38	0.45	0.51	0.58	0.64	0.71	0.77	0.8
13	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
14	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
15	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
16	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097
17	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
19	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
20	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
21	0.29	0.31	0.34	0.37	0.41	0.44	0.48	0.51	0.53
23	1.3	1.4	1.6	1.7	1.9	2.0	2.2	2.3	2.4
26	0.47	0.5	0.56	0.62	0.67	0.73	0.79	0.85	0.88
27	0.16	0.19	0.23	0.27	0.32	0.36	0.4	0.45	0.47
28	3.9	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.4
31	0.24	0.26	0.29	0.32	0.35	0.38	0.42	0.45	0.46
33	0.047	0.049	0.053	0.056	0.06	0.064	0.067	0.071	0.073
34	0.25	0.26	0.27	0.29	0.3	0.32	0.33	0.35	0.36
36	0.03	0.032	0.036	0.04	0.044	0.048	0.051	0.055	0.057
37	0.31	0.33	0.37	0.41	0.45	0.49	0.53	0.57	0.59
38	0.36	0.38	0.43	0.48	0.53	0.57	0.62	0.67	0.69
40	0.16	0.18	0.22	0.25	0.29	0.33	0.37	0.4	0.42
41	0.23	0.23	0.23	0.23	0.23	0.24	0.24	0.24	0.24

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Chrysene (Fines Normalized Sediment Chemistry)								
Maximum									
1	0.75	0.79	0.88	0.96	1.0	1.1	1.2	1.3	1.3
2	0.11	0.12	0.13	0.15	0.16	0.17	0.19	0.2	0.21
3	0.16	0.16	0.18	0.19	0.2	0.21	0.22	0.24	0.24
6	0.16	0.16	0.18	0.19	0.2	0.21	0.22	0.23	0.23
8	3.5	3.6	3.8	4.0	4.2	4.4	4.5	4.7	4.8
9	1.1	1.1	1.3	1.5	1.6	1.8	2.0	2.1	2.2
10	5.7	6.1	6.8	7.5	8.2	8.9	9.6	10	11
11	0.091	0.096	0.11	0.12	0.13	0.14	0.15	0.16	0.17
12	0.64	0.7	0.82	0.94	1.1	1.2	1.3	1.4	1.5
13	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
14	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
15	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
16	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
17	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
19	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
20	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
21	0.33	0.35	0.39	0.43	0.47	0.51	0.55	0.59	0.61
23	2.6	2.7	3.1	3.4	3.7	4.0	4.3	4.6	4.8
26	0.98	1.0	1.2	1.3	1.4	1.5	1.7	1.8	1.9
27	0.39	0.44	0.54	0.64	0.74	0.85	0.95	1.1	1.1
28	7.1	7.5	8.5	9.4	10	11	12	13	14
31	0.24	0.26	0.29	0.32	0.35	0.38	0.42	0.45	0.46
33	0.083	0.087	0.093	0.10	0.11	0.11	0.12	0.13	0.13
34	1.1	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5
36	0.059	0.063	0.071	0.079	0.086	0.094	0.1	0.11	0.11
37	0.65	0.7	0.78	0.87	0.95	1.0	1.1	1.2	1.3
38	0.38	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.73
40	0.17	0.19	0.23	0.27	0.31	0.35	0.39	0.43	0.45
41	0.36	0.36	0.36	0.36	0.37	0.37	0.37	0.38	0.38

Highlighted cells exceed the screening benchmark of 8.6 µg/L

F) Fluoranthene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Fluoranthene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	2.2	2.3	2.3	2.4	2.4	2.5	2.6	2.6	2.6
2	0.41	0.42	0.43	0.44	0.45	0.47	0.48	0.49	0.5
3	0.52	0.52	0.53	0.54	0.55	0.56	0.57	0.58	0.58
6	0.55	0.56	0.56	0.57	0.58	0.59	0.6	0.61	0.61
8	5.2	5.2	5.3	5.4	5.4	5.5	5.6	5.6	5.6
9	2.3	2.3	2.4	2.5	2.6	2.7	2.7	2.8	2.9
10	66	67	69	71	73	75	77	79	80
11	0.51	0.52	0.54	0.55	0.57	0.58	0.6	0.61	0.62
12	2.4	2.4	2.5	2.6	2.7	2.9	3.0	3.1	3.1
13	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
14	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
15	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
16	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
17	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
19	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
20	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
21	2.7	2.7	2.8	2.9	3.0	3.0	3.1	3.2	3.2
23	19	19	19	20	20	21	21	22	22
26	5.4	5.4	5.6	5.8	5.9	6.1	6.3	6.4	6.5
27	1.1	1.2	1.2	1.3	1.4	1.5	1.5	1.6	1.6
28	29	29	30	31	32	33	34	35	35
31	2.0	2.0	2.0	2.1	2.2	2.2	2.3	2.4	2.4
33	0.44	0.44	0.45	0.46	0.47	0.48	0.49	0.49	0.5
34	2.8	2.8	2.9	2.9	3.0	3.0	3.0	3.1	3.1
36	0.11	0.11	0.11	0.12	0.12	0.12	0.13	0.13	0.13
37	2.4	2.5	2.5	2.6	2.7	2.8	2.8	2.9	3.0
38	2.7	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3
40	1.5	1.5	1.6	1.7	1.8	1.9	1.9	2.0	2.1
41	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6

Dredge Unit:	**Predicted Discharge Water Total Concentrations (µg/L) for Fluoranthene (Fines Normalized Sediment Chemistry)**								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Maximum									
1	7.7	7.8	8.0	8.2	8.5	8.7	8.9	9.1	9.2
2	0.78	0.79	0.81	0.84	0.86	0.88	0.91	0.93	0.94
3	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3
6	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2
8	36	36	36	37	37	38	38	38	39
9	11	11	11	12	12	12	13	13	13
10	121	122	126	129	133	137	140	144	146
11	0.84	0.85	0.87	0.9	0.92	0.95	0.97	1.0	1.0
12	5.0	5.1	5.3	5.5	5.8	6.0	6.2	6.4	6.5
13	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
14	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
15	45	45	45	45	45	45	45	45	45
16	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
17	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
19	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
20	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
21	3.7	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4
23	37	37	38	39	40	42	43	44	44
26	13	13	13	13	14	14	15	15	15
27	3.3	3.4	3.6	3.9	4.1	4.3	4.5	4.7	4.9
28	55	56	58	59	61	63	65	66	67
31	2.0	2.0	2.0	2.1	2.2	2.2	2.3	2.4	2.4
33	0.86	0.87	0.89	0.9	0.92	0.94	0.95	0.97	0.98
34	12	12	12	12	12	13	13	13	13
36	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.26	0.26
37	5.7	5.8	5.9	6.1	6.3	6.5	6.7	6.8	6.9
38	2.7	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.3
40	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
41	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Highlighted cells exceed the screening benchmark of 20 µg/L

G) Fluorene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Fluorene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
2	0.35	0.35	0.35	0.35	0.36	0.36	0.36	0.36	0.36
3	0.49	0.49	0.49	0.49	0.5	0.5	0.5	0.5	0.5
6	0.19	0.19	0.19	0.2	0.2	0.2	0.2	0.2	0.2
8	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9
9	4.7	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8
10	14	14	14	14	14	14	14	15	15
11	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.41
12	5.6	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7
13	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
14	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
16	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
17	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
19	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
20	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
21	3.3	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
23	34	34	34	34	34	34	34	34	34
26	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9
27	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
28	71	71	71	71	71	72	72	72	72
31	2.8	2.8	2.8	2.8	2.8	2.9	2.9	2.9	2.9
33	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
34	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
36	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
37	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
38	2.9	2.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0
40	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4
41	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Fluorene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Maximum									
1	18	18	18	18	18	18	18	18	18
2	0.78	0.78	0.78	0.78	0.79	0.79	0.79	0.79	0.79
3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
6	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
8	46	46	46	46	46	47	47	47	47
9	73	73	73	73	74	74	74	74	74
10	17	17	17	17	17	18	18	18	18
11	0.7	0.7	0.7	0.7	0.7	0.7	0.71	0.71	0.71
12	14	14	14	14	14	14	14	14	14
13	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
14	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
15	16	16	16	16	16	16	16	16	16
16	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
17	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
19	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
20	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
21	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2
23	67	67	67	67	67	68	68	68	68
26	14	14	14	14	15	15	15	15	15
27	3.7	3.7	3.7	3.7	3.7	3.8	3.8	3.8	3.8
28	136	137	137	137	138	138	139	139	139
31	2.8	2.8	2.8	2.8	2.8	2.9	2.9	2.9	2.9
33	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9
34	12	12	12	12	12	12	12	12	12
36	0.27	0.27	0.27	0.27	0.27	0.28	0.28	0.28	0.28
37	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5
38	3.9	3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
40	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
41	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8

Highlighted cells exceed the screening benchmark of 82 µg/L

H) 2-Methylnaphthalene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for 2-Methylnaphthalene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	5.1	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.2
2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
3	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
6	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
8	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
9	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
10	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
11	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
12	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4
13	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
14	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
15	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
16	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
17	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
19	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
20	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
21	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
23	26	26	26	26	27	27	27	27	27
26	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
27	0.85	0.85	0.86	0.86	0.86	0.86	0.87	0.87	0.87
28	79	79	79	79	79	80	80	80	80
31	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9	5.9
33	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
34	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
36	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
37	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
38	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.9	2.9
40	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
41	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for 2-Methylnaphthalene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Maximum									
1	19	19	19	19	19	19	19	19	19
2	0.57	0.57	0.57	0.57	0.57	0.58	0.58	0.58	0.58
3	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
6	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
8	47	47	47	47	47	47	47	47	47
9	7.9	7.9	8.0	8.0	8.0	8.0	8.0	8.0	8.0
10	7.8	7.8	7.8	7.8	7.8	7.9	7.9	7.9	7.9
11	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.52	0.52
12	30	30	30	30	30	30	30	30	30
13	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
14	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
15	25	25	25	25	25	25	25	25	25
16	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
17	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
19	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
20	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
21	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
23	52	52	52	52	52	52	53	53	53
26	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
27	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
28	154	154	154	154	155	155	155	155	155
31	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9	5.9
33	17	17	17	17	17	17	17	17	17
34	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
36	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
37	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
38	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
40	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
41	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4

Highlighted cells exceed the screening benchmark of 58 µg/L

l) **Naphthalene**

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Naphthalene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	27	27	27	27	27	27	27	27	27
2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
6	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
8	26	26	26	26	27	27	27	27	27
9	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
10	47	47	47	47	47	47	47	47	47
11	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
12	79	79	80	80	80	80	80	80	80
13	18	18	18	18	18	18	18	18	18
14	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
15	52	52	52	52	52	52	52	52	52
16	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
17	66	66	66	66	66	66	66	66	66
19	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
20	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
21	12	12	12	12	12	12	12	12	12
23	132	132	132	132	132	132	132	132	132
26	17	17	17	17	17	17	17	17	17
27	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
28	276	277	277	277	277	277	277	277	277
31	16	16	16	16	16	16	16	16	16
33	37	37	37	37	37	37	37	37	37
34	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
36	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
37	10	10	10	10	10	10	10	10	10
38	16	16	16	16	16	16	16	16	16
40	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
41	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Naphthalene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Maximum									
1	102	102	102	102	102	102	102	102	102
2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
3	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
8	250	250	250	250	251	251	251	251	251
9	40	40	40	40	40	40	40	40	40
10	48	48	48	48	48	48	48	48	48
11	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
12	417	417	417	418	418	418	418	419	419
13	21	21	21	21	21	21	21	21	21
14	26	26	26	26	26	26	26	26	26
15	598	598	598	598	598	598	598	598	598
16	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
17	145	145	145	145	145	145	145	145	145
19	19	19	19	19	19	19	19	19	19
20	13	13	13	13	13	13	13	13	13
21	17	17	17	17	17	17	17	17	17
23	261	261	261	261	261	261	261	261	261
26	40	40	40	40	40	40	40	40	40
27	9.1	9.1	9.1	9.1	9.2	9.2	9.2	9.2	9.2
28	525	526	526	526	526	527	527	527	527
31	16	16	16	16	16	16	16	16	16
33	139	139	139	139	139	139	139	139	139
34	24	24	24	24	24	24	24	24	24
36	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
37	20	20	20	20	20	20	20	20	20
38	18	18	18	18	18	18	18	18	18
40	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9
41	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Highlighted cells exceed the screening benchmark of 100 µg/L

J) Phenanthrene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Phenanthrene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	9.8	9.8	9.9	10.0	10	10	10	10	10
2	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2
3	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
6	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
8	18	18	18	18	18	18	18	18	18
9	8.9	8.9	9.0	9.1	9.2	9.2	9.3	9.4	9.4
10	33	33	33	33	33	33	34	34	34
11	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3
12	8.4	8.5	8.6	8.6	8.7	8.8	8.9	9.0	9.0
13	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
14	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
15	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
16	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
17	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
19	11	11	11	11	11	11	11	11	11
20	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
21	8.9	8.9	9.0	9.0	9.1	9.2	9.2	9.3	9.3
23	83	83	84	84	85	85	86	87	87
26	17	17	18	18	18	18	18	18	18
27	2.4	2.4	2.5	2.5	2.5	2.6	2.6	2.7	2.7
28	240	241	242	244	246	248	249	251	252
31	6.7	6.7	6.8	6.8	6.9	6.9	7.0	7.0	7.1
33	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5
34	9.1	9.1	9.1	9.2	9.2	9.2	9.2	9.3	9.3
36	0.38	0.38	0.38	0.38	0.39	0.39	0.39	0.39	0.39
37	8.0	8.1	8.1	8.2	8.2	8.3	8.3	8.4	8.4
38	8.5	8.5	8.6	8.7	8.7	8.8	8.9	8.9	8.9
40	4.6	4.7	4.7	4.8	4.8	4.9	5.0	5.0	5.1
41	3.3	3.3	3.4	3.4	3.4	3.4	3.4	3.4	3.4

Dredge Unit:	**Predicted Discharge Water Total Concentrations (µg/L) for Phenanthrene (Fines Normalized Sediment Chemistry)**								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Maximum									
1	36	36	36	37	37	37	37	37	38
2	2.5	2.5	2.5	2.6	2.6	2.6	2.6	2.6	2.6
3	3.3	3.3	3.3	3.3	3.3	3.3	3.4	3.4	3.4
6	2.5	2.5	2.5	2.6	2.6	2.6	2.6	2.6	2.6
8	127	127	127	128	128	128	129	129	129
9	69	69	70	70	71	72	72	73	73
10	35	35	36	36	36	36	37	37	37
11	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.4
12	21	21	21	21	21	22	22	22	22
13	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
14	16	16	16	16	16	16	16	16	16
15	15	15	15	15	15	15	15	15	15
16	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
17	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.8
19	25	25	25	25	25	25	25	25	25
20	11	11	11	11	11	11	11	11	11
21	13	13	13	13	13	13	13	13	13
23	165	165	166	168	169	170	171	172	173
26	42	42	42	42	43	43	43	44	44
27	6.2	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.8
28	472	473	477	480	484	487	490	494	495
31	6.7	6.7	6.8	6.8	6.9	6.9	7.0	7.0	7.1
33	2.6	2.6	2.6	2.6	2.6	2.7	2.7	2.7	2.7
34	40	40	40	40	40	40	40	40	40
36	0.74	0.75	0.75	0.76	0.76	0.77	0.77	0.78	0.78
37	18	18	18	18	18	18	18	18	18
38	11	11	12	12	12	12	12	12	12
40	5.3	5.4	5.4	5.5	5.6	5.7	5.7	5.8	5.8
41	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

Highlighted cells exceed the screening benchmark of 40 µg/L

K) Pyrene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Pyrene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Mean									
1	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.5
2	0.68	0.69	0.71	0.72	0.74	0.76	0.78	0.8	0.81
3	0.77	0.77	0.79	0.8	0.81	0.82	0.83	0.85	0.85
6	0.79	0.8	0.81	0.82	0.83	0.85	0.86	0.87	0.87
8	7.7	7.8	7.9	7.9	8.0	8.1	8.2	8.3	8.3
9	3.0	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7
10	85	87	89	91	94	96	98	100	102
11	0.73	0.74	0.76	0.78	0.8	0.82	0.84	0.86	0.87
12	4.0	4.1	4.3	4.4	4.6	4.8	4.9	5.1	5.2
13	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
14	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
15	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
16	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
17	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
19	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
20	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
21	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.5
23	19	20	20	21	21	22	22	23	23
26	12	13	13	13	14	14	14	15	15
27	2.3	2.3	2.5	2.6	2.8	2.9	3.0	3.2	3.3
28	52	53	54	56	57	59	60	62	63
31	1.9	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2
33	0.43	0.43	0.44	0.45	0.46	0.46	0.47	0.48	0.48
34	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.7	2.7
36	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.18
37	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.2
38	6.2	6.3	6.5	6.7	6.8	7.0	7.2	7.4	7.5
40	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.7
41	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Pyrene (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5.0	10	20	30	40	50	60	70	75
Maximum									
1	7.0	7.1	7.2	7.4	7.6	7.7	7.9	8.1	8.1
2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.5
3	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9	2.0
6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7
8	44	45	45	46	46	47	47	48	48
9	11	11	12	12	13	13	13	14	14
10	147	149	153	157	161	165	169	173	175
11	1.3	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5
12	7.5	7.7	8.0	8.3	8.6	8.9	9.2	9.5	9.7
13	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
14	12	12	12	12	12	12	12	12	12
15	44	44	44	44	44	44	44	44	44
16	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
17	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
19	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
20	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
21	5.0	5.1	5.2	5.3	5.5	5.6	5.7	5.9	5.9
23	38	39	40	41	42	43	44	45	46
26	30	31	32	32	33	34	35	36	36
27	5.7	5.9	6.2	6.6	6.9	7.3	7.6	8.0	8.1
28	93	95	98	100	103	106	108	111	112
31	1.9	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2
33	0.73	0.73	0.75	0.76	0.77	0.78	0.8	0.81	0.81
34	10	11	11	11	11	11	11	11	11
36	0.3	0.3	0.31	0.32	0.33	0.34	0.34	0.35	0.36
37	9.3	9.4	9.7	9.9	10	11	11	11	11
38	8.1	8.2	8.5	8.7	9.0	9.2	9.4	9.7	9.8
40	2.2	2.3	2.4	2.5	2.6	2.7	2.8	3.0	3.0
41	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1

Highlighted cells exceed the screening benchmark of 12.8 µg/L

Annex C. Biological Background Information

Table 1: Anadromous and Marine Fish Species at Risk in BC and their Potential to Occur in Esquimalt Harbour

Common Name (Scientific Name)	Population	BC CDC Status	COSEWIC status	SARA Schedule/ Status	Range and Habitat	Potential to Occur in Esquimalt Harbour
Basking Shark (*Cetorhinus maximus*)	Pacific population	-	E	1-E	Historically found in certain areas off BC in summer and fall, but rarely seen now. Occurred in areas that concentrate zooplankton including off headlands, around islands and in bays with strong tidal flow.	Unlikely to occur
Bluntnose Sixgill Shark (*Hexanchus griseus*)		-	SC	1-SC	Likely well distributed throughout BC waters including inlets, continental shelf and slope. Primarily benthic areas below 91 m, but observed at surface down to 2,500 m.	Unlikely to occur
Bocaccio (*Sebastes paucispinis*)		-	E	-	Shelf rockfish species. Mainly occurs in offshore waters near the edge of continental shelf. Adults occur over rocky high relief substrate from 60 to 340 m.	Unlikely to occur
Canary Rockfish (*Sebastes pinniger*)		-	T	-	Juveniles occupy shallow inshore waters. Larvae and pelagic juvenile canary rockfish occupy the top 100 m for up to 3-4 months after live-birth (parturition) and then settle to a benthic habitat. Adults typically inhabit rocky bottom in 70-270 m depth on the continental shelf. Canary rockfish are widely distributed throughout B.C. coastal waters. The prevalence of this species in recreational fishing in the Strait of Georgia indicates that they are probably well distributed in enclosed waters and inlets.	Observed at C1 and C2 Reefs (Golder 2016).
Chinook Salmon (*Oncorhynchus tshawytscha*)	Okanagan population	-	T	-	In the ocean, chinook may remain in coastal areas or complete extensive offshore migrations. Adult anadromous Okanagan chinook migrate from the Pacific Ocean to the mouth of the Columbia River between Washington State and Oregon, up the Columbia River, into Osoyoos Lake and the Okanagan River in Canada.	Unlikely to occur
Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*)		Blue	-	-	Requires small, low gradient coastal streams and estuarine habitats; well-shaded streams with water temperatures below 18°C are optimal. Some may spend entire life in freshwater (many of these live in lakes), but most are anadromous. In marine habitats, generally remains close to the coast, usually remaining within estuary.	Potential to occur. Last observed in Millstream Creek outlet in 1977 (MOE 2016a).
Coho Salmon (*Oncorhynchus kisutch*)	Interior Fraser population	-	E	-	Coho salmon that were spawned in the interior Fraser River have been recovered in fisheries from Alaska to Oregon. Most were gathered off the West Coast of Vancouver Island and in the Strait of Georgia.	Unlikely to occur
Darkblotched Rockfish (*Sebastes crameri*)		-	SC	-	Shelf and slope rockfish species. Widespread in continental shelf and slope waters along BC coast. Immature fish are pelagic and occur offshore in surface waters. Adults typically caught between 150 to 435 m.	Unlikely to occur
Eulachon (*Thaleichthys pacificus*)	Nass / Skeena Rivers population	Blue	SC	-	Distribution is limited to Pacific marine waters and the lower reaches of rivers draining into the Pacific. The 3-year period between hatching and spawning appears to be spent mainly in near-benthic habitats in open marine waters. Eulachon appear to live near the ocean bottom in waters of moderate depth (50-200 m. They are rarely captured in Georgia Strait as adults, and the few instances of capture appear to be related to their spawning migration to rivers.	Unlikely to occur

Common Name (Scientific Name)	Population	BC CDC Status	COSEWIC status	SARA Schedule/ Status	Range and Habitat	Potential to Occur in Esquimalt Harbour
Eulachon (*Thaleichthys pacificus*)	Central Pacific Coast population	Blue	E	-	Distribution is limited to Pacific marine waters and the lower reaches of rivers draining into the Pacific. The 3-year period between hatching and spawning appears to be spent mainly in near-benthic habitats in open marine waters. Eulachon appear to live near the ocean bottom in waters of moderate depth (50-200 m. They are rarely captured in Georgia Strait as adults, and the few instances of capture appear to be related to their spawning migration to rivers.	Unlikely to occur
Eulachon (*Thaleichthys pacificus*)	Fraser River population	Blue	E	-	Distribution is limited to Pacific marine waters and the lower reaches of rivers draining into the Pacific. The 3-year period between hatching and spawning appears to be spent mainly in near-benthic habitats in open marine waters. Eulachon appear to live near the ocean bottom in waters of moderate depth (50-200 m. They are rarely captured in Georgia Strait as adults, and the few instances of capture appear to be related to their spawning migration to rivers.	Unlikely to occur
Green Sturgeon (*Acipenser medirostris*)		Red	SC	1-SC	Range of in Canada spans the entire length of the Pacific Coast. Green sturgeon inhabit a range of environments throughout their life cycle, including freshwater streams, rivers, estuarine habitat, and marine waters. There are no known spawning populations of green sturgeon in Canada and they have been rarely caught in freshwater environments. When they enter their marine migratory phase they either occupy estuarine holding areas or undergo a northern migration. Limited tagging studies exist; however, tagged individuals from the Columbia River have been recaptured off the west coast of Vancouver Island.	Unlikely to occur
Longspine Thornyhead (*Sebastolobus altivelis*)		-	SC	1-SC	Occur along the continental slope from 500 to 1,600 m on soft sand or mud substrate.	Unlikely to occur
North Pacific Spiny Dogfish (*Squalus suckleyi*)		-	SC	-	Occur on the continental shelf from intertidal to shelf slope including estuarine waters. They are opportunistic predators with a wide prey base and are not associated with any particular substrate type.	Potential to occur in Esquimalt Harbour (SLR 2016).
Quillback Rockfish (*Sebastes maliger*)		-	T	-	Occur throughout coastal waters of BC. Young are pelagic before settling after 1 to 2 months near shore. Juveniles occur in shallower waters near shore and are associated with a variety of habitats. Adults observed over hard, complex substrates with vertical relief.	Known to occur. Observed at F-Jetty Reef, Natural Reef, Duntze Hd, Yew Pt (SLR 2016).
Rougheye Rockfish (*Sebastes aleutianus*)		-	SC	1-SC	Slope rockfish species. Occur along the continental slope and typically captured from 170 to 660 m deep. Occur on bottoms with soft substrates, in areas with frequent boulders, and on slopes greater than 20 degrees.	Unlikely to occur
Sockeye Salmon (*Oncorhynchus nerka*)	Sakinaw population	-	E	-	Sakinaw sockeye are endemic to Canada, in the sense that they reproduce and rear for two or three years (over half their life) exclusively within Sakinaw Lake, situated on the Sechelt Peninsula. Because they are anadromous, they also share marine migration corridors and foraging habitat in the north Pacific Ocean with many other sockeye salmon populations.	Unlikely to occur
Sockeye Salmon (*Oncorhynchus nerka*)	Cultus population	-	E	-	The population of Cultus Lake sockeye is located near the coast, in the eastern Fraser Valley of the Fraser River watershed, near the Canada-US boundary and approximately 112 km upstream of the Strait of Georgia.	Unlikely to occur

Common Name (Scientific Name)	Population	BC CDC Status	COSEWIC status	SARA Schedule/ Status	Range and Habitat	Potential to Occur in Esquimalt Harbour
Tope/Soupfin Shark (*Galeorhinus galeus*)			SC	1-SC	Prefer temperate continental shelf waters from close inshore, including shallow bays, to offshore waters up to 471 m deep. Recent observations are outside of inlets. Juveniles occur in shallow nearshore areas. It is now rarely seen in BC waters.	Unlikely to occur
White Sturgeon (*Acipenser transmontanus*)	Lower Fraser River population	Red	T	3-No Status	They spawn in three major river systems: the Fraser, Columbia, and Sacramento-San Joaquin rivers. Although they are primarily freshwater fishes, some individuals make forays into the sea and are known to enter rivers, estuaries, and bays along the Pacific Coast from southeastern Alaska to Baja California. In the mainstem lower Fraser River, White Sturgeon occur from the Fraser estuary upstream to a potential barrier (Hells Gate).	Unlikely to occur
Yelloweye Rockfish (*Sebastes ruberrimus*)	Pacific Ocean outside waters population		SC	1-SC	This population extends from at least southeast Alaska through to northern Oregon and includes the whole of the B.C. offshore, north and central coast waters.	Unlikely to occur
Yelloweye Rockfish (*Sebastes ruberrimus*)	Pacific Ocean inside waters population		SC	1-SC	This population includes the Strait of Georgia, Johnstone Strait and Queen Charlotte Strait. They are habitat specialists, exhibiting a solitary, demersal existence over substrates that are hard, complex and have some vertical relief. Observed form 19 to 232 m deep.	Unlikely to occur
Yellowmouth Rockfish (*Sebastes reedi*)			T	-	Slope rockfish species. Occurs on continental slope in BC at depths of 100 to 430 m.	Unlikely to occur

Table 2: Bird Species at Risk in the Capital Regional District and their Potential to Occur in Esquimalt Harbour

Common Name (Scientific Name)	BC CDC Status	COSEWIC status	SARA Schedule/ Status	Range and Habitat	Potential to Occur in Esquimalt Harbour
American Bittern (*Botaurus lentiginosus*)	Blue			Nests primarily in inland freshwater wetlands, sometimes in tidal marshes or in sparsely vegetated wetlands or dry grassy uplands. Breeding occurs primarily in wetlands with tall emergent vegetation. Sparsely vegetated wetlands and dry grassy uplands are sometimes used, as are tidal marshes in some areas. It is rare year-round on southern Vancouver Island.	Unlikely to occur
Band-tailed Pigeon (*Patagioenas fasciata*)	Blue	SC	1-SC	It was previously a summer visitor on southern Vancouver Island and the Lower Mainland, but now breeds there and appears to be expanding its range to the north and east. Most Pacific Northwest birds winter in California, although some remain year round in coastal areas. They occupy a variety of habitat types, including residential areas, but favour mature forest with a berry-rich shrub understory.	Unlikely to occur
Barn Owl (*Tyto alba*)	Red	T	1-SC	In North America, it reaches its northern limit in southwestern and south-central BC and southern ON. The western population is resident year-round in southern BC. On Vancouver Island, it occurs from Victoria to Nanaimo, and rarely north to Campbell River and the Gulf Islands. It prefers low elevation open country; especially agricultural areas, such as open fields, grasslands, farmsteads and orchards, sometimes along edges of open woodlands and grassy estuaries and occasionally spotted in suburban areas. Most often nests are located in human-made structures such as in wooden barns, concrete silos, church spires, airport hangers, water towers, bridges and nest boxes. Natural sites include hollow tree cavities, cliffs, river banks and disused hawk nests.	Unlikely to occur
Barn Swallow (*Hirundo rustica*)	Blue	T		Nests in barns or other buildings, under bridges, wharves, in caves or cliff crevices, usually on vertical surface close to ceiling. Commonly reuses old nests. Flies over open land and water and forages on insects. Usually forages within a few hundred meters of nest when breeding.	Potential to occur

Common Name (Scientific Name)	BC CDC Status	COSEWIC status	SARA Schedule/ Status	Range and Habitat	Potential to Occur in Esquimalt Harbour
Black Swift (*Cypseloides niger*)	Blue	E		Generally uncommon across most of southern and central BC, although it can be locally fairly common along the mainland coast north of Vancouver Island, on northern Vancouver Island. Breeds almost entirely on small ledges or in shallow crevices in steep rock faces and canyons, usually near or behind waterfalls. Foraging flocks range widely, however, and occur over all types of habitats (forests, towns, lakes, rivers, alpine meadows, mountain peaks). During clear weather, foraging individuals occur at very high altitudes and are not associated with any terrestrial or freshwater habitats.	Unlikely to occur
Brandt's Cormorant (*Phalacrocorax penicillatus*)	Red			Mainly inshore coastal zone, especially in areas having kelp beds; also around some offshore islands; less commonly, inshore on brackish bays; in winter, mostly around sheltered inlets and other quiet waters. Typically nests on flat or gently sloping surfaces on tops of rocky islands along coast.	Known to occur (SRL 2016).
Caspian Tern (*Hydroprogne caspia*)	Blue	NAR		Seacoasts, bays, estuaries, lakes, marshes, and rivers. Nests on sandy or gravelly beaches and shell banks along coasts or large inland lakes; sometimes with other water birds. Seasonal resident and probably breeds on Vancouver Island. Does not overwinter on Vancouver Island.	Potential to occur
Common Murre (*Uria aalge*)	Red			Nonbreeding: pelagic and along rocky seacoasts. Nests in the open or in crevices on broad and narrow cliff ledges, on stack (cliff) tops, and on flat, rocky, low-lying islands. Breeds on the northern tip of Vancouver Island and overwinters around Vancouver Island.	Known to occur (SLR 2016)
Common Nighthawk (*Chordeiles minor*)	Yellow	T	1-T	Breeds (but does not overwinter) on Vancouver Island. Nests in a wide range of open, vegetation-free habitats, including dunes, beaches, recently harvested forests, burnt-over areas, logged areas, rocky outcrops, rocky barrens, grasslands, pastures, peat bogs, marshes, lakeshores, and river banks.	Unlikely to occur
Double-crested Cormorant (*Phalacrocorax auritus*)	Blue	NAR		Forage in all coastal areas of British Columbia, utilizing marine habitats such as bays, estuaries, and inlets and occasionally freshwater habitats such as lakes close to coastal areas and large rivers such as the Fraser River. Bare, rocky islands with sparse vegetation are the preferred nesting habitats.	Known to occur (SLR 2016)
Great Blue Heron, fannini subspecies (*Ardea herodias fannini*)	Blue	SC	1-SC	Nest in a wide variety of tree species; the Pacific population nests in quiet woodlots within 8 km (most within 3 km) of foraging habitats such as large eelgrass meadows, along rivers, and in estuarine and freshwater marshes.	Known to occur (SLR 2016)
Green Heron (*Butorides virescens*)	Blue			Feeds in swamps, riparian zones along creeks and streams, also marshes, human-made ditches, canals, ponds, lake edges, open floodplains , backwater oxbow ponds, sloughs and side channels, salt marshes, mangrove swamps, pastures, mudflats, ponds in parks, and harbors. Although clearly prefers thick vegetation throughout range, will feed in open when food is available. In salt marshes, tends to hug creek banks; avoids open flats frequented by longer-legged herons. Nests in forest and swamp patches; may nest in dry woods or orchards, but usually near water. Breeds but does not overwinter on Vancouver Island.	Unlikely to occur
Marbled Murrelet (*Brachyramphus marmoratus*)	Blue	T	1-T	Nests often are in mature/old growth coniferous forest near the coast: on large mossy horizontal branch, mistletoe infection, witches broom, or other structure providing a platform high in mature conifer (e.g., Douglas-fir, mountain hemlock). Most nesting occurs in large stands of old growth. Feeds in the nearshore marine environment throughout the year, rarely farther than 5 km from shore. It frequents areas of turbulence and upwellings such as tidal rips, shelf edges, underwater sills, fiords, and narrow passages. It also occurs in sheltered habitats such as harbours, bays lagoons, inlets, kelp beds, and coves and tends to prefer relatively shallow waters.	Known to occur (SLR 2016)

Common Name (Scientific Name)	BC CDC Status	COSEWIC status	SARA Schedule/ Status	Range and Habitat	Potential to Occur in Esquimalt Harbour
Northern Goshawk, laingi subspecies (*Accipiter gentilis laingi*)	Red	T	1-T	Occurs in coastal BC, mainly on the Queen Charlotte Islands and Vancouver Island, and probably on other large coastal islands. Although goshawks may breed in younger, more even-aged stands, they tend to choose breeding areas which have stands with relatively large amounts of mature or old-growth trees or stand characteristics. High canopy closure is the single most consistent nesting habitat feature for goshawks across their range. Relatively closed stands provide protection from predators and promote more open spaces under the canopy that allows clear flight paths for striking prey. Small forest openings, such as where one or two trees have fallen and left more open air space near the nest tree, are often associated with nest sites. On Vancouver Island, nests were generally located on the bottom two-thirds of a slope, at lower elevations of moderate slopes.	Unlikely to occur
Northern Pygmy-Owl, swarthi subspecies (*Glaucidium gnoma swarthi*)	Blue			This subspecies is thought to occur throughout Vancouver Island and the Gulf Islands in appropriate forest habitats. Like the species, the subspecies is non-migratory (except for local movements), and breeding range includes wintering range. It is a habitat generalist; it is found in mature and old-growth coniferous, mixed or deciduous forests that have natural and man-made openings and sufficient numbers of natural or excavated cavities for nesting.	Unlikely to occur
Olive-sided Flycatcher (*Contopus cooperi*)	Blue	T	1-T	This species breeds but does not overwinter in Canada. Breeding occurs on Vancouver Island. They arrive at their breeding areas between April and June, and begin fall migration in late July. This species is most often associated with open areas containing tall trees or snags for perching. Open areas may be forest openings, forest edges near natural openings (such as rivers, muskeg, bogs or swamps) or human-made openings (such as logged areas), burned forest or open to semi-open mature forest stands.	Unlikely to occur
Peregrine Falcon, anatum subspecies (*Falco peregrinus anatum*)	Red	SC	1-SC	Typically nest on rock cliffs above lakes or river valleys where abundant prey is nearby. The anatum subspecies is the most common form to be found on the southern portion of the Coast Region (Fraser Lowlands as well as southern Vancouver Island and the Gulf Islands). Aeries described in BC are on the ledges of cliffs (6–260 m high) that overlook marine waters, large lakes and rivers. This falcon is also an urban adaptor and successful aeries have been established naturally or through reintroduction programs using building ledges or under high span bridges.	Potential to occur
Purple Martin (*Progne subis*)	Blue			Breeds but does not overwinter on Vancouver Island. Nest in natural cavities and woodpecker holes in trees and snags, and in holes in buildings. In recent years they have been almost entirely restricted to nest boxes and artificial holes in pilings in estuaries, bays, and harbours. Now restricted to six sites on southeast Vancouver Island (Victoria Harbour, Esquimalt Harbour, Cowichan River Estuary, Nanaimo River Estuary, Newcastle Island, and Ladysmith Harbour). Birds presumably forage over areas immediately surrounding nest site, although no information on typical travel distance while foraging	Known to occur
Short-eared Owl (*Asio flammeus*)	Blue	SC	1-SC	Prefers open areas such as grasslands, meadows in early succession (some shrubs or trees), marshlands, sloughs, beaches, sedge fields and previously forested areas that have been cleared. Suitable winter habitat includes marine foreshores, grasslands, fallow fields, etc. with a sufficient prey base and adequate roost sites. Breeding and over-wintering for this species occurs between the BC interior and the Lower Mainland. Migration may be driven by prey availability. In particular, the Fraser Estuary, Deer Lake (Burnaby), Colony Farm Regional Park, Pitt River floodplain and the agricultural areas of the Fraser Lowlands provide the essential old-field habitat and estuarine/freshwater marshlands utilized by this species. Periodically individuals may overwinter on southern Vancouver Island.	Potential to occur
Tufted Puffin (*Fratercula cirrhata*)	Blue			Nonbreeding: primarily pelagic. Can be found well out to sea all year. Nests on offshore islands or along the coast. Nests on slopes in ground burrows, sometimes under boulders and piles of rocks, occasionally under dense vegetation. Breeds along west and south coast of Vancouver Island.	Unlikely to occur

Common Name (Scientific Name)	BC CDC Status	COSEWIC status	SARA Schedule/ Status	Range and Habitat	Potential to Occur in Esquimalt Harbour
Vesper Sparrow, affinis subspecies (*Pooecetes gramineus affinis*)	Red	E	1-E	This subspecies breeds west of the Cascades in southwestern BC, western Washington, Oregon, and in northwestern California. It winters from central California west of the Sierra Nevadas to northwest Baja California. In Canada, the subspecies has only been reported on southeastern Vancouver Island and in the Lower Fraser Valley. It has declined from its formerly limited range, and the only known extant breeding population is located at the Nanaimo Airport. It is a grassland bird that prefers dry, open areas with short, sparse grass or herbaceous cover.	Unlikely to occur
Western Bluebird (*Sialia mexicana*) Georgia Depression population	Red			Breeding habitat included Garry oak meadows, hill summits, logged or burned forest, and farms and pastures. Foraging occurred in Garry oak woodlands, open meadows or weedy fields, farmlands, logged or burned forest, and suitable beaches. This population was extirpated, but have recently been reintroduced to the Cowichan Valley	Unlikely to occur
Western Screech-Owl, kennicottii subspecies (*Megascops kennicottii kennicottii*)	Blue	T	1-SC	This subspecies occurs at lower elevations throughout much of Vancouver Island, and in coastal forests west of the coastal ranges. It is primarily associated with riparian or low elevation forests, it can also be found in treed urban and suburban environments, and at the edge of forested habitats close to wetlands or fields. It nests in natural cavities in trees generally made by large woodpeckers, or in nest boxes.	Unlikely to occur

Table 3: Marine Mammals Known to Occur in the Victoria Area and Their Occurrence in Esquimalt Harbour

Common Name (Scientific Name)	BC CDC Status	COSEWIC Status	SARA Schedule/ Status	Occurrence in Esquimalt Harbour
California Sea Lion (*Zalophus californianus*)	Yellow	NAR	-	Known to occur. They are common in the greater Victoria area and are known to haul-out on man-made structures such as docks (Nightingale and Copley 2012). One was observed observed during 2015/2016 wildlife surveys by SLR (SLR 2016).
Common Minke Whale (*Balaenoptera acutorostrata*)	Yellow	NAR	-	Unlikely to occur. No records of observations in Esquimalt Harbour were found.
Dall's Porpoise (*Phocoenoides dalli)*	Yellow	NAR	-	Potential to occur. They are common in the greater Victoria area (Nightingale and Copley 2012) and occur in lets and bays around Vancouver Island (CWS 2004). No records of observations in Esquimalt Harbour were found.
Grey Whale – Eastern North Pacific population (*Eschrichtius robustus)*	Blue	SC	1/SC	Unlikely to occur. No records of observations in Esquimalt Harbour were found.
Harbour Porpoise – Pacific Ocean population (*Phocoena vomerina*)	Blue	SC	1/SC	Known to occur. Harbour porpoise have been observed in Esquimalt Harbour at various times by different sources (Baird and Geunther 1995; Hall 2004; QHM pers. comm. with DND, 2014; SLR 2016).
Harbour Seal (*Phoca vitulina*)	Yellow	NAR	-	Known to occur. Harbour seals were observed in February and October of 2010 by Golder staff (Golder 2010). Harbour seals were observed on several occasions during habitat surveys in Esquimalt Harbour in 2016 (Golder 2016). A large number of harbour seals were observed during 2015/2016 wildlife surveys by SLR (SLR 2016).
Humpback Whale *(Megaptera novaeangliae*)	Blue	SC	1/T	Unlikely to occur. No records of observations in Esquimalt Harbour were found.
Killer Whale - Northeast Pacific southern resident population (*Orcinus orca pop. 5*)	Red	E	1/E	Potential to occur. Pods of two to three killer whales (population unknown) were observed within Esquimalt Harbour by Queen's Harbour Master staff in January 2014 and September 2013 (QHM pers. comm. with DND, 2014).

Common Name (Scientific Name)	BC CDC Status	COSEWIC Status	SARA Schedule/ Status	Occurrence in Esquimalt Harbour
Killer Whale - West Coast transient population (*Orcinus orca pop. 3*)	Red	T	1/T	Potential to occur. Pods of two to three killer whales (population unknown) were observed within Esquimalt Harbour by Queen's Harbour Master staff in September 2013 and January 2014 (QHM pers. comm. with DND, 2014).
North American River Otter (*Lontra canadensis*)	Yellow	-	-	Known to occur. Common in the Victoria area including Esquimalt Harbour (CRD 2016).
Northern Elephant Seal (*Mirounga angustirostris*)	Red	NAR	-	Unlikely to occur. No records of observations in Esquimalt Harbour were found.
Northern Fur Seal (*Callorhinus ursinus*)	Red	T	-	Unlikely to occur. No records of observations in Esquimalt Harbour were found.
Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)	Yellow	NAR	-	Unlikely to occur. No records of observations in Esquimalt Harbour were found.
Sea Otter (*Enhydra lutris*)	Blue	SC	1/SC	Unlikely to occur. They are not found in harbours in the Capital Regional District (CRD 2016), and no records of observations in Esquimalt Harbour were found.
Steller Sea Lion (*Eumetopias jubatus*)	Blue	SC	1/SC	Known to occur. Steller sea lions were observed in Esquimalt Harbour during dive surveys conducted along the North Landing Wharf in February of 2010 (Golder 2010). Twelve stellar sea lions were observed in the northern portion of Constance Cove near Inskip Island during the November 2015/2016 wildlife survey by SLR (SLR 2016).

Notes

CDC – Conservation Data Centre; COSEWIC – Committee on the Status of Endangered Wildlife in Canada; SARA – Species at Risk Act; SC – special concern; T – threatened; E – endangered; NAR – not at risk; "-" – not assessed.

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Annex D. Underwater Noise Modelling

1.0 INTRODUCTION

Certain in-water work activities associated with the EHRP have the potential to cause underwater noise effects to fish and marine mammals. Depending on the level of underwater noise generated and how well the species can hear the sounds produced, potential effects could result in either acoustic injury or behavioural disturbance to fish and marine mammals. To assess the potential effects of EHRP generated underwater noise, EHRP sound levels are modeled and then compared against acoustic impact (injury) and disturbance (behavioural) thresholds for marine mammals and fish.

Acoustic modeling was undertaken to determine the potential area of influence for EHRP generated underwater noise. Underwater noise sources considered in the model included vibratory driving of steel piles and impact driving of steel and timber piles.

The area of influence determined by the model informs the environmental effects determination (EED) regarding the assessment of potential injury and behavioural related effects to marine mammals and fish and the environmental management plan (EMP) regarding the establishment of marine safety perimeters for marine mammals.

2.0 UNDERWATER NOISE EXPOSURE CRITERIA

2.1 Marine Mammals

The potential for acoustic injury and behavioural disturbance in marine mammals depends on the level of underwater noise produced and how well the species can hear the sounds produced, although not all regulatory thresholds address species-dependent hearing acuity. Auditory thresholds from underwater noise are expressed using two common metrics: sound pressure level (SPL), measured in dB re: 1 µPa, and sound exposure level (SEL), a measure of energy in dB re: 1 uPa^2s. SPL is an instantaneous value represented as either root-mean-square (SPL_{rms}) or peak sound pressure level (SPL_{peak}), whereas SEL is the total noise energy to which an organism is exposed over a given time period, typically one second for pulse sources.

Currently, DFO has no defined standard acoustic thresholds for assessing acoustic injury or behavioural disturbance in marine mammals. In absence of specific legislated underwater noise criteria in Canada, DFO bases its assessment of potential ‘serious harm’ to marine mammals on the best currently-available science. It also relies on the United States standards employed by the National Marine Fisheries Service (NMFS) (NOAA 2016). The following section provides an overview of acoustics threshold criteria applicable to marine mammals.

For modelling, the following NMFS thresholds for marine mammal injury and behavioural disturbance from impulsive sounds (NOAA 2016) were applied:

- For injury: 190 dB re 1 µPa SPL_{rms} for pinnipeds, and 180 dB re 1 µPa SPL_{rms} for cetaceans.
- For behavioural disturbance: 160 dB re 1 µPa SPL_{rms} for all marine mammals.

Also considered in the modeling were injury thresholds that account for acoustic intensity, duration, frequency content and number of impulse events, as recommended by an expert working group (Southall et al. 2007). These criteria include both SPL_{peak} and SEL metrics and have been accepted by many regulatory agencies, including DFO, as they consider frequency-dependence of hearing acuity for the following species groups:

- Low-frequency cetaceans (LFCs) – mysticetes (baleen whales).
- Mid-frequency cetaceans (MFCs) – some odontocetes (toothed whales).
- High-frequency cetaceans (HFCs) – odontocetes specialized for using high frequencies.
- Pinnipeds (PINN) - seals, sea lions, and walrus (in-water).

The Southall et al. (2007) injury criteria considered in this assessment include the following:

- Injury from single or multiple impulsive sound events over 24 hours: 186 dB re 1 μPa^2s SEL for pinnipeds, and 198 dB re 1 μPa^2s for cetaceans.
- Injury based on peak pressure (SPL_{peak}) of individual impulse events of 218 dB re 1 μPa for pinnipeds and 230 dB re 1 μPa for cetaceans.

It should be further noted that NMFS has recently proposed new draft criteria (NOAA 2015) that suggest using an assessment approach based on that of Southall et al. (2007), but with different weighting functions and thresholds. These criteria have not been considered in this assessment as they are currently in public review and are likely to be revised prior to being finalized. The current NMFS acoustic threshold levels, used for most sound sources, consist of the single SPL_{rms} threshold for cetaceans and the single SPL_{rms} threshold for pinnipeds regardless of sound source (i.e. they do not take into account of the hearing ability of different marine mammal groups or the differences among sound sources in terms of auditory impacts). The updated acoustic threshold levels will consist of several thresholds and when finalized will replace those currently in use by NMFS (NOAA 2016).

The most conservative marine mammal injury threshold was adopted in the model for each sound pressure metric for pinnipeds and cetaceans to determine the spatial limits of underwater noise effects and to determine an appropriate marine safety perimeter for marine mammals for the EHRP.

2.2 Marine Fish

Currently, there are no legislated underwater noise criteria in Canada for assessing injury in fish. In absence of specific legislated criteria, assessing potential for 'serious harm[1]' to fish from underwater noise is typically based on 'best available evidence', as documented in the scientific literature, available Best Management Practices (BMPs) and/or established by other government agencies.

The NMFS has adopted interim acoustic threshold criteria specific to impact pile driving that are based on SPL that are known to potentially result in physical effects in fish (FHWG 2008; Stadler and Woodbury 2009). The current NMFS interim SPL injury thresholds for fish are:

- SPL_{peak} for potential injury to fish is 206 dB re 1 uPa (FHWG 2008; Stadler and Woodbury 2009).

[1] includes the destruction of fish habitat or an alteration of fish habitat of a spatial scale, duration and intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes (*Fisheries Act* 1985)

3.0 NOISE MODEL PARAMETERS

Noise modeling was conducting using a two-dimensional model designed by NMFS specifically for pile driving activities (WSDOT 2009). Underwater noise levels were calculated on the basis of data and methods described in WSDOT's Advanced Training Manual, Biological Assessment Preparation for Transportation Projects Version 02-2015 (WSDOT 2015).

In accordance with guidance from the NMFS, this analysis used the Practical Spreading Loss Model which is based on the following formula for geometric spreading:

$$\mathbf{TL = 15 \times Log (R1/R2) + \alpha R}$$

Where:
TL: is the transmission loss in dB.
R1: is range in meters of the sound pressure level.
R2: is the distance from the source of the initial measurement.
αR: linear absorption and scattering loss

Solving for TL will provide the underwater sound pressure level at a given distance. To determine at what distance or range a known sound pressure level will occur, the equation must be solved for R1:

$$R1= (10(TL/15)) \bullet R2$$

The NMFS model was used to calculate the distance from the source generated sound levels would be expected to reach the injury and disturbance thresholds for marine mammals and fish. A default transmission loss constant of 15 was used, as indicated by the guidance, due to the lack of site-specific transmission loss information (WSDOT 2009). This is equivalent to a 4.5 dB attenuation rate per doubling of distance, which is within the range of attenuation rates recorded for several pile-driving projects in shallow waters (<10 m depth) in California (Caltrans 2015).

4.0 PILE DRIVING NOISE

Certain piling activities are known to generate high intensity underwater noise that can adversely affect marine animals, particularly whales and seals which rely on underwater sound as a primary method of navigation, orientation, communication and foraging. Pile-driving sounds result from a rapid release of energy when two objects hit one another. The characteristics of impact sounds depend primarily on the physical properties of the impacting objects. When a pile-driving hammer strikes a pile, sound from the impact radiates into the air and a transient stress wave, or pulse, propagates down the length of the pile. The impact will also create flexural (or transverse) stress waves in the wall of the pile which couple with the surrounding fluids (air and water) to radiate sound into the water and additional sound into the air. Moreover, the pulse propagating down the length of the pile may couple to the substrate at the water bottom and cause waves to propagate outward through the bottom sediment.

Typically, noise generated by impact pile driving consists of pulsed sounds that occur at intervals of approximately 1 to 3 seconds depending on the equipment used. The repetitive nature of the pile driving sounds does not allow for receivers to fully recover from one pulse before the next pulse is produced. In order to assess this type of sound source, the NMFS noise model and impact criteria are based upon the sound pressure in peak (SPL_{peak}) and rms (SPL_{rms}), and the sound exposure level (SEL) which take into account the number of pulses generated per day.

The proposed construction approach involves removal of existing timber piles (300-mm Ø), re-installation of old timber piles where possible, and installation of new timber piles (300-mm Ø), by vibratory hammer (Anchor 2016). In general, vibratory hammers generate lower sound levels than impact hammers, and the driving of timber piles generate lower sound levels than steel piles. Source levels used in the model were derived from available literature (Caltrans 2015; Illinworth and Rodkin 2007; WSDOT 2009) for similar pile types (300 mm timber and steel piles) and driving techniques (vibratory hammer, impact hammer, and drop hammer), as outlined in Table 1.

Table 1: Reference Sound Source Levels for Various Pile Types (single-strike)

Pile type / hammer type	Underwater Sound Source Levels		
	SPL_{peak} (dB re 1 µPa)	SPL_{rms} (dB re 1 µPa)	SEL (dB re 1 $µPa^2s$)
Timber (300-mm Ø) / drop hammer	177	165	157
Cast-in-steel shell (CISS) (300-mm Ø) / drop hammer	177	165	152
CISS (300-mm Ø) / impact hammer	200	184	174
Steel H-Type (thick) (300-mm Ø) / impact hammer	190	175	160
Steel H-Type (thin) (300-mm Ø) / impact hammer	195	183	170
Steel H-Type (300-mm) vibratory	165	150	150

Note: Sound levels measured at 10 m from pile.

5.0 RESULTS

Underwater noise modeling results are presented in Table 2. The injury threshold for fish will not be exceeded at any distance from the pile when using timber or steel piles with drop or vibratory hammers, but will be exceeded within 1 to 4 m from the pile when using steel piles with an impact hammer (Table 2). The injury threshold for marine mammals is expected to be exceeded within 1 m from the pile when using timber piles, and up to 18 m when impact-driving steel piles. Based on these results when using timber piles with a drop hammer, potential injury effects are not expected for fish or marine mammals, unless a marine mammal is located within 1 m from the source during active pile driving. Potential injury effects are expected for marine mammals up to 18 m from the steel pile when installing steel piles with an impact hammer.

Underwater noise from pile driving will exceed the behavioural disturbance threshold (160 dB re 1 µPa SPL_{rms}) for marine mammals up to 22 m for timber and cast-in-shell steel piles using a drop hammer, and at distances ranging between 341 to 398 m for various other types of steel piles using an impact hammer. These results suggest that behavioral effects are likely to occur, although they would be limited to Esquimalt Harbour. With the implementation of noise-reduction measures (e.g. bubble curtains, avoiding concurrent noise activities), this zone of disturbance may be further reduced.

Table 2: Distances to Fish and Marine Mammal Acoustic Thresholds for Various Pile Driving Methods

Pile type / hammer type	Distance (m) to Which Threshold Value Attenuates				
	Fish Threshold	Marine Mammal Thresholds			
	Injury	Injury			Behavioural
	206 SPL_{peak} (dB re 1 µPa)	218 SPL_{peak} (dB re 1 µPa)	180 SPL_{rms} (dB re 1 µPa)	186 SEL (dB re 1 mPa^2s)	160 SPL_{rms} (dB re 1 µPa)
Timber (300-mm Ø) / drop hammer	0	0	1	0	22
Cast-in-steel shell (CISS) (300-mm Ø) / drop hammer	0	0	1	0	22
CISS (300-mm Ø) / impact hammer	4	0	10	0	398
Steel H-Type (thick) (300-mm Ø) / impact hammer	1	1	18	2	100
Steel H-Type (thin) (300-mm Ø) / impact hammer	2	0	5	0	341
Steel H-Type (300-mm) vibratory	0	0	0	0	2

Marine Safety Perimeter

Marine safety perimeters are used to mitigate the potential effect of injury to marine mammals as a result of elevated underwater noise levels. Based on the model, sound levels generated by drop hammer driving of timber pile is below the injury thresholds for marine mammals, therefore no marine safety perimeter is required. The model predicts that the sound level from impact driving of steel piles will attenuate to the lowest injury threshold (180 SPL_{rms}) within 18 m from the pile. It is therefore recommended that a conservative 100 m marine safety perimeter be established during all impact driving of steel piles, should it occur for the EHRP.

6.0 PREDICTION CONFIDENCE

Prediction confidence in the underwater noise model is considered to be moderate based on the following factors:

- Pile driving activities were modeled using conservative source level values from similar pile types (size and material) and driving techniques (impact, hammer).
- The NMFS model is designed specifically for pulsive noise sources such as pile driving.
- Quality control checks were undertaken on all model runs to verify that model input parameters were correct, model output was plotted correctly and any calculations were checked.
- There are limitations of using a two-dimensional model with respect to sound attenuation in a three-dimensional environment. The spreading loss model used for the underwater noise assessment only provides an approximation to the actual spreading loss in the marine environment. The model assumes that sound travels in a homogeneous environment. It does not take into account potential propagation effects related to absorption / reflection that may occur as a result of sound interacting with local marine topographical features, nor effects related to refraction that may occur as a result of boundary layer effects / water column stratification. For example, physical aspects of the receiving environment (e.g. freshwater surface lens, in-field gradients in temperature, bottom topography) could cause sound levels to attenuate at

different rates than predicted by this geometric spreading-based model. Sophisticated sound field models do exist that that take into account the actual sound speed field in the ocean and the reflections from the sea surface and sea floor as the sound travels away from the source. However, these types of models require detailed site-specific inputs for the model with respect to existing oceanographic, bathymetric and substrate conditions, which were beyond the scope of the assessment. Nonetheless, the practical spreading loss model is commonly used to obtain an estimate of sound levels around a source when more complex models are not achievable.

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