

APPENDIX

1

GEOTECHNICAL REPORT,
2021

GEOTECHNICAL INVESTIGATION REPORT

CAP-AUX-MEULES WHARF EXTENSION, REINFORCEMENT AND NEW FENDERS

PUBLIC SERVICES AND PROCUREMENT CANADA (PSPC)

JULY 16, 2021





GEOTECHNICAL INVESTIGATION REPORT

CAP-AUX-MEULES WHARF EXTENSION, REINFORCEMENT AND NEW FENDERS

PUBLIC SERVICES AND PROCUREMENT
CANADA (PSPC)

WSP PROJECT NO.: 201-12004
DATE: JULY 16, 2021

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Subject: Geotechnical Investigation Report – Cap-Aux-Meules Wharf Extension, Reinforcement and New Fenders

Please find enclosed our Geotechnical Investigation Report completed by WSP Canada Inc. for the proposed Cap-Aux-Meules Wharf Extension, Reinforcement and New Fenders, in Cap-Aux-Meules, Quebec. The report presents observations, findings and recommendations from the geotechnical investigation and testing programs.

We trust this report meets your present requirements. If you have any questions, please contact the undersigned at your convenience.

Yours truly,

A handwritten signature in black ink that reads "Jonathan Steeves".

Jonathan Steeves, P.Eng.
Geotechnical Engineer | Atlantic Geotechnical

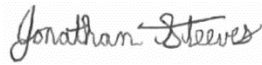
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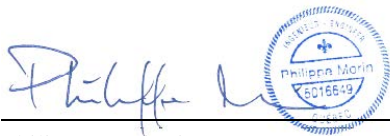


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1 INTRODUCTION AND BACKGROUND

WSP Canada Inc. (WSP) has been retained by the Public Services and Procurement Canada (PSPC) to complete a geotechnical investigation for the proposed expansion at the Cap-Aux-Meules Wharf in Cap-Aux-Meules, Quebec. The purpose of this investigation was to obtain information on subsurface soil and bedrock conditions at the site and provide geotechnical recommendations for site preparation, geotechnical foundation design and construction. Soil and bedrock samples were collected at various depths. Soil and bedrock samples were submitted for analysis of properties such as moisture, grain size, unit weight and uniaxial compressive strength (UCS).

Fieldwork for the subsurface investigation was carried out from April 28th to May 21st, 2021 and consisted of drilling five (5) boreholes at the approximate locations as shown on the attached Figure 1. This report presents the results of the field investigation and laboratory testing programs.

2 SITE DESCRIPTION

The Cap-Aux-Meules Wharf is located off Highway 199 in Cap-Aux-Meules, Quebec. The existing wharf structure of Madeline Pier is approximately 152m in length and 10m wide, constructed as a piled deck structure. The proposed extension, reinforcement, upgraded bollards and new fenders is to accommodate the new larger ferry (MV Villa De Teror), which is being used as an intermediate until the purpose-built vessel MV Jean Lapierre is operational in 2026. The extent of the project to accommodate the intermediate ferry MV Villa De Teror includes the construction of:

- Lateral reinforcement of the structures to resist larger berthing and mooring effects;
- Extension of the pier by installation of a new turning dolphin to accommodate the increased vessel length;
- Replacement of the marine fender systems to accommodate the larger vessel;
- Upgrade of mooring bollards to accommodate the preferred mooring arrangement and needs of the new vessel;

The construction of the Cap-Aux-Meules Wharf Extension is expected to be of conventional design and will consist of pipe piles driven into soil, concrete beams and decks, etc.

The borehole coordinates and seabed surface elevations are provided in Table 2-1 below.

Table 2-1 – Borehole Coordinates and Seabed Surface Elevations

Borehole ID	Northings (Metres)*	Eastings (Metres)*	Seabed Surface Elevation (Metres)*
BH-01	5249049.827	278124.299	-4.0
BH-02	5249018.858	278145.088	-6.5
BH-03	5248988.762	278164.843	-6.9
BH-04	5248947.266	278186.408	-6.3
BH-05	5248937.265	278193.039	-7.4

** Coordinates are referenced to WSP GPS coordinates (NAD83 MTM Zone 4) and Elevations are referenced to the existing Bathymetric survey data available to WSP.*

2.1 REVIEW OF EXISTING DATA

The review of existing data included the in-house files (confidential), hydrographic surveys, the general geological data within the harbour, and overview of the existing site.

- Available surficial soil mapping of the area indicates that the site consists of sand deposits. Further information gained by the logs from the Terratech (Aug 1997) Report shows that the glacial deposits are predominantly sand with silt more apparent at shallower depths as well as some organic content.
- Available bedrock geologic mapping of the proposed development indicate that the bedrock is of the Cap Aux Meules Formation which typically consists of sandstone. Review of Giles (Jan 2008) shows that the bedrock in the immediate vicinity of the Cap-Aux-Meules wharf is comprised of a large-scale red-brown sandstone that shows cross-stratification. With a faulted boundary present to the north of the wharf, with basalt present on the opposing side of the boundary. During the Terratech (Aug 1997) investigation, bedrock was not undeniably proven, but it is assumed that rockhead was approximately at 30m below

seafloor/riverbed level. Although due to the poor quality of the core samples and low RQD readings, the possibility of them being cobbles/boulders could not be ruled out either.

- The investigation locations range in elevation from approximately -7.4 to -4 metres, Chart Datum – Existing Bathymetric Survey Data Available To WSP. The topographic relief across the site is approximately 3.4 metres at the borehole locations.

2.2 LITERATURE REVIEW

This section of the report will detail previous investigations as well as any related information deemed useful and any literature related to the site area.

The most recent reports and data reviewed for this assignment include the following:

- New proposed wharf for ferry Port of Cap-aux-Meules, Terratech, August 1997.
- Windsor Group (Late Mississippian) stratigraphy, Magdalen Islands, Quebec: a rare eastern Canadian record of late Visean basaltic volcanism - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Geology-of-the-main-islands-of-the-Magdalen-Islands-archipelago-modified-after-Brisebois_fig3_231180823 [accessed 28 Apr, 2021]
- Cap-aux-Meules New Transverse Dock, As-Built Drawings, Tel Que Construit, October 20 1998.

The above reports and drawings are the most recent and relevant work that has been conducted at/near the site. In addition to the cited consultant reports, published geological, topographic, hydrographic and aerial photos of the areas were obtained from various government agencies.

3 INVESTIGATION PROCEDURE

3.1 BOREHOLE PROGRAM

The purpose of the geotechnical investigation was to develop an understanding of the subsurface soil, bedrock and groundwater conditions at the site. Subsurface investigation of the site was carried out from April 28th to May 21st, 2021 and included drilling five (5) boreholes (designated BH-01 through BH-05), at the locations shown on the attached Figure 1. The boreholes were drilled using a barge mounted drill rig and track mounted drill rig supplied by Logan Drilling Limited. The boreholes were drilled offshore and off the edge of the existing wharf and located with GPS equipment. All boreholes were terminated in sand (with the exception of BH-04 which was terminated in bedrock) to depths ranging between 11 to 18.8 metres below the ground surface/seafloor.

Soil samples were taken periodically at 600 mm increments using a 50 mm outside diameter split-spoon sampler, driven in accordance with standard penetration testing (SPT) resistance procedures (ASTM D1586). N values, described as the number of blows required to drive the sampler 305 mm (1 foot) into the soil, were recorded at each sample location and are plotted on the borehole logs (Appendix B). Diamond-bit core-drilling of bedrock was conducted using a 96 mm outside diameter HQ core barrel at borehole BH-04 only.

Soil and rock samples were transported to the laboratory for moisture, grain size analysis, unit weight and uniaxial compressive strength (UCS) tests. Rock core samples will be stored for a period of six months, after which it will be discarded, unless otherwise requested by the Client.

An explanation of the symbols and terms used in this report are enclosed in Appendix A. Borehole logs detailing the subsurface conditions and photo log are enclosed in Appendix B. Confirmatory laboratory index testing results are presented in Appendix C. The limitations of this report are presented in Appendix D.

3.2 GEOTECHNICAL CORE LOGGING PROCEDURE

WSP used the following core logging procedure for borehole BH-04. The cores were logged at the Project site. The following geotechnical logging processes were completed:

- Photographing core.
 - Identifying all fractures as well as driller and machine induced breaks within the core.
 - Logging drill hole identification data including site, hole identification, location, length.
 - Geotechnical logging of the solid core, including the rock type, the degree of weathering and/or alteration, solid core recovery and the Rock Quality Designation (RQD).
 - Selecting samples of varying rock lithologies, alteration and weathering for Uniaxial Compressive Strength (UCS) tests.
-

3.3 LABORATORY TESTING

Basic laboratory testing and/or visual examinations were carried out on selected soil and bedrock samples from the borehole investigation. Tests were performed in accordance with materials testing requirements and procedures outlined in the ASTM and CSA testing manuals, as applicable. All laboratory testing was carried out by Englobe at the request of WSP. Laboratory results can be found in Appendix C.

4 SUBSURFACE CONDITIONS

In summary, the subsurface conditions were found to be relatively similar in the subject boreholes with the exception of borehole BH-04, where bedrock was encountered. Each borehole contained a layer of silty sand with organics (i.e. marine deposits) which ranged in depth from 1.5 to 5.0 metres below the seabed. The marine deposits generally overlaid compact to dense silty sand and bedrock (BH-04 only). Further descriptions of the subsurface conditions are presented below.

Table 4-1 – Summary of Subsurface Conditions

Borehole ID	*Seabed Elevation (m)	Total Borehole Depth (m)	Thickness of Marine Deposits (m)	Depth to Sand (m)	Depth to Bedrock (m)
BH-01	-4.0	18.2	3.6	3.8	-
BH-02	-6.5	11.0	3.9	3.9	-
BH-03	-6.9	18.8	5.0	5.0	-
BH-04	-6.3	14.4	1.8	1.8	7.8
BH-05	-7.4	17.4	1.5	1.5	-

* Approximate seabed surface elevation referenced to Bathymetric survey of the harbour seafloor.

4.1 MARINE DEPOSITS

Sand with some silt/clay and trace to some organics (i.e. seabed sediment) was encountered from the surface of boreholes to depths ranging between 1.5 and 5.0 metres. The material generally consisted of sand with some silt/clay, with organics, was black to light grey/blue (BH-04 and BH-05 only) in colour and loose in compactness.

Samples for sieve analysis and moisture content were taken from select boreholes. Laboratory grain size analysis of one (1) select sample of the material indicated a particle size distribution (gradation) of 0 percent gravel, 88.2 percent sand, 11.8 percent silt/clay. Moisture content of the sample was 28.4 percent.

4.2 NATIVE SAND

Native sand was encountered in all boreholes below the marine deposits. The material was comprised of compact to dense sand with some silt/clay or silty clayey sand, trace gravel, sandstone cobbles, was saturated and grey to brown in colour.

Samples for sieve analysis and moisture content were taken from select boreholes. Laboratory grain size analysis of five (5) select samples of the material indicated a particle size distribution (gradation) of 0 to 2.8 percent gravel, 64.0 to 83.9 percent sand, 16 to 36.9 percent silt/clay. Moisture content of the samples ranged from 20 to 56 percent.

4.3 BEDROCK

Fractured and weathered sandstone bedrock was encountered in borehole BH-04 at a depth of 7.8 metres below the seabed surface. Generally, the bedrock was observed to be weak, fractured, weathered and grey to brown in color. The Rock Quality Designation (RQD) values of the core samples ranged from 22 to 44%, indicating very poor to poor quality rock.

Laboratory compressive strength testing of one (1) intact rock core sample indicated a uniaxial compressive strength (UCS) ranging of 25.4 MPa. Based on classification systems used in the Canadian Foundation Engineering Manual (4th Ed), Section 3.2.4.1, the fully-intact bedrock is generally weak (Grade R2). Rock core photos are included in Appendix B.

5 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

The existing wharf structure of Madeline Pier is approximately 152m in length and 10m wide, constructed as a piled deck structure. The proposed extension, reinforcement, upgraded bollards and new fenders is to accommodate the new larger ferry (MV Villa De Teror), which is being used as an intermediate until the purpose-built vessel MV Jean Lapierre is operational in 2026. The extent of the project to accommodate the intermediate ferry MV Villa De Teror includes the construction of:

- Lateral reinforcement of the structures to resist larger berthing and mooring effects;
- Extension of the pier by installation of a new turning dolphin to accommodate the increased vessel length;
- Replacement of the marine fender systems to accommodate the larger vessel;
- Upgrade of mooring bollards to accommodate the preferred mooring arrangement and needs of the new vessel;

The construction of the Cap-aux-Meules Wharf Extension is expected to be of conventional design and will consist of open pipe piles driven through dense sand. The piles will be filled with reinforced concrete for the wharf extension (new fenders). The piles for the turning dolphin will contain a soil plug of native soils which will be developed during the pile driving process. The following discussion and recommendations for the proposed wharf expansion are based on the observed subsurface conditions. As previously noted, the subsurface conditions encountered at the site generally consist of marine deposits overlying sand and sandstone bedrock (BH-04 only).

The following sections of the report discuss the geotechnical engineering aspects for the wharf expansion and provide geotechnical foundation recommendations. The recommendations are in accordance with the Canadian Foundation Engineering Manual (CFEM 2006). The structural design of the piles must conform to the requirements of Section 4 of the National Building Code of Canada (2015) and/or S06 of the Canadian Highway Bridge Design Code, where applicable.

5.2 DRIVEN STEEL PIPE PILES

5.2.1 DESIGN CRITERIA

It is understood that the wharf extension and new turning dolphin foundations will be supported on steel open pipe piles, driven into dense sand deposits. According to the information provided to us, the piles will be installed vertically or even at a 4V:1H batter. The wharf deck construction will consist of a concrete deck with concrete pile caps. The turning dolphin construction will consist of new mooring bollards and a 12-metre diameter turning dolphin. The proposed elevation for top of the concrete deck and turning dolphin will be approximately 4.3 metres.

Following discussions with the WSP structural design team we understand the pile dimensions and applied axial loads for the new piles are as outlined in Table 5-1.

Table 5-1 – Pile Dimensions and Axial Loads

Pile Location	Outside Pile Diameter (mm)	Axial Load in Compression (kN)	Axial Load in Tension (kN)
Wharf Extension (New Fenders)	508	875	228

New Turning Dolphin	610	1980	1135
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We understand the piles will be filled with reinforced concrete for the wharf extension (new fenders). The piles for the turning dolphin will contain a soil plug of native soils which will be developed during the pile driving process. As such, a plugging behavior was assumed for the geotechnical axial resistance calculations. Based on the historical geotechnical information and the newly acquired geotechnical data from WSP, results indicated an average soil stratum consisting of 4 metres of marine deposits overlying compact to dense sand. Material design parameters are noted in Table 5-2. Following design criteria outlined in the CFEM and using the interpreted design parameters, the geotechnical axial capacities and embedment depths have been calculated and are presented in Table 5-3 below.

Table 5-2 – Interpreted Material Design Parameters

Parameter	Marine Deposits (with organics)	Native Sand
Total Unit Weight (KN/m ³)	15	20
Submerged Unit Weight (KN/m ³)	5	10
Angle of Internal Friction	22°	32°
Coefficient of Active Earth Pressure, K _a	0.45	0.31
Coefficient of Passive Earth Pressure, K _p	2.22	3.22

Table 5-3 – Factored Geotechnical Axial Capacities (ULS)

Pile Location	Outside Pile Diameter (mm)	*Ultimate Geotechnical Axial Friction Resistance (kN)	*Ultimate Geotechnical Axial Pile Tip Resistance (kN)	Factored Geotechnical Axial Capacity in Compression ULS (kN)	Factored Geotechnical Axial Capacity in Tension ULS (kN)	Minimum Embedment Length into soil (m)	Approximate Elevation of Pile Tip with Seabed Surface of -7m (Chart Dat.)
Wharf Extension (New Fenders)	508	1000	1400	900	300	12	-19
New Turning Dolphin	610	3300	4000	2800	1180	18	-25

*Ultimate resistances are approximate values only. Factored geotechnical capacities should be used for design purposes.

For steel open pipe piles (plugged behavior) driven into cohesionless soils (i.e. sand), geotechnical resistance factors of 0.4 (compression) and 0.3 (tension) were used in accordance with the CFEM. Pile capacities are developed from the skin friction along the outside of the pile during the driving process, as well as end bearing at the pile tip (in compression only). Please note that the above resistance factors can only be considered if the piles are tested on site.

Lateral pile resistance was determined in collaboration with the WSP structural design team based on the subsurface soil conditions and recommended pile embedment. A n_h value of 9000 kN/m³ was used as a typical value for dense saturated sand from the Principles of Geotechnical Engineering (DAS 1999 4th Edition) for calculation of the soil spring constant (k_s). The lateral capacity (R_{ult}) was determined at different depths along the pile length.

Based on Meyerhof 1976 for driven piles in sands, the group reduction factor is generally >1.0 however for design purposes, a factor of 1.0 is recommended.

Rock socketing of piles into bedrock should be considered an alternate to driven piles in areas where bedrock is shallow and short embedment lengths are expected. This should be a design consideration for the area of borehole BH-04 as minimum embedment depths will likely not be achievable in this location. Rock socket details can be provided by WSP if required.

5.2.2 PILE INSTALLATION

Pile installation should be carried out by an experienced contractor with the appropriate equipment. A wave-equation analysis should be used in the selection of the appropriate hammer. It is recommended that driving caps be used to protect the piles and to avoid damage to the pile heads. Piles should be held securely and accurately in position while driving and the hammer blows should be delivered in the direct axis of the pile.

A protective driving shoe should be used to protect piles during hard driving in sand deposits with cobbles and/or boulders. The maximum cobble/boulder size was not determined during this investigation and shallow refusal of driven piles on cobbles or boulders is not anticipated. Where piles are refused above design elevations, pile extraction and drilling to clear obstructions should be undertaken prior to re-driving.

Due to generally consistent soil conditions observed at the project site, the possibility of piles encountering cobbles and boulders in the native sand deposits is not anticipated. If necessary, pre-drilling may be required for some piles that encounter obstructions. It is understood that pre-drilling may be required for certain fender piles to be installed through the existing breakwater armour stone. Pre-drilling is an acceptable method however the pre-drilling must not disturb the underlying native soils due to the capacity being achieved through skin friction along the outside of the pile. If the native soils are disturbed to a certain depth during pre-drilling, additional embedment length will be required, equivalent to the disturbed depth to achieve the above capacities.

The CFEM recommends that driving hammer energy be limited to 6×10^6 Joules for steel pipe piles, multiplied by the cross-sectional area of the pile. Geotechnical inspections are required during construction to record pile driving data and confirm acceptable pile depth and driving resistance.

Where adjacent piles are driven parallel to one another, we recommend a minimum pile spacing of three (3) times the outside diameter of the piles to avoid group reduction effects and potential “following” during installation. This requirement can be reviewed if the need for smaller spacing arises during design or construction.

The contractor should provide a method statement for his proposed system of pile installation and method of construction to the engineer for review and approval. The method statement should include details and sequence for pile installations.

5.2.3 PILE TESTING AND INSPECTION

Pile capacities and loadings shall be defined by an accepted pile inspection method. The above recommendations for pile axial capacities should be confirmed using PDA Testing. This should be undertaken on minimum of 10 % of the driven piles and we recommend that 48 to 72-hour re-tap testing be conducted. Pile testing reduces uncertainty in the estimate of soil parameters. As noted previously, the resistance factors used to determine the recommended geotechnical axial capacities can only be considered if the piles are tested on site.

Installation of the piles should be monitored in real time and proper field records established as per the CFEM. Field records including pile equipment, pile lengths, depths, location of splices, blow counts, stroke and blow rate should be taken. The engineer should be notified of any anomalies or problems during installation, such as damage to piles during driving and early refusal, so that design assumptions can be reviewed. Project specifications should be reviewed by the inspection entity to ensure field quality control and measurements are followed accordingly. All field-testing records should be submitted for analysis and evaluation by the engineer.

5.2.4 EARTHQUAKE DESIGN PARAMETERS

The subsurface conditions at the proposed site generally consist of marine deposits overlying compact to dense sand and/or bedrock (BH-04 only). According to the National Building Code of Canada (2015), the site designation for seismic analysis is Class “C” for very dense soil or soft rock. The applicable site coefficients are found in the tables of the same code.

The structural engineer should confirm the applicable site coefficients.

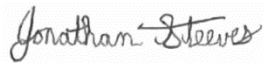
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As boreholes provide a localized representation of the total study area, subsurface conditions may vary between and/or beyond the borehole locations. If conditions encountered at the site vary significantly from the reported herein, we should be notified immediately so that our interpretations and recommendations can be reviewed and revised if necessary.

We trust this report meets your present requirements. If you have any questions with the information contained in the report, please do not hesitate to contact us at your convenience.

Yours truly,

A handwritten signature in black ink that reads "Jonathan Steeves". The signature is written in a cursive, flowing style.

Jonathan Steeves, P.Eng.
Geotechnical Engineer | Atlantic Geotechnical

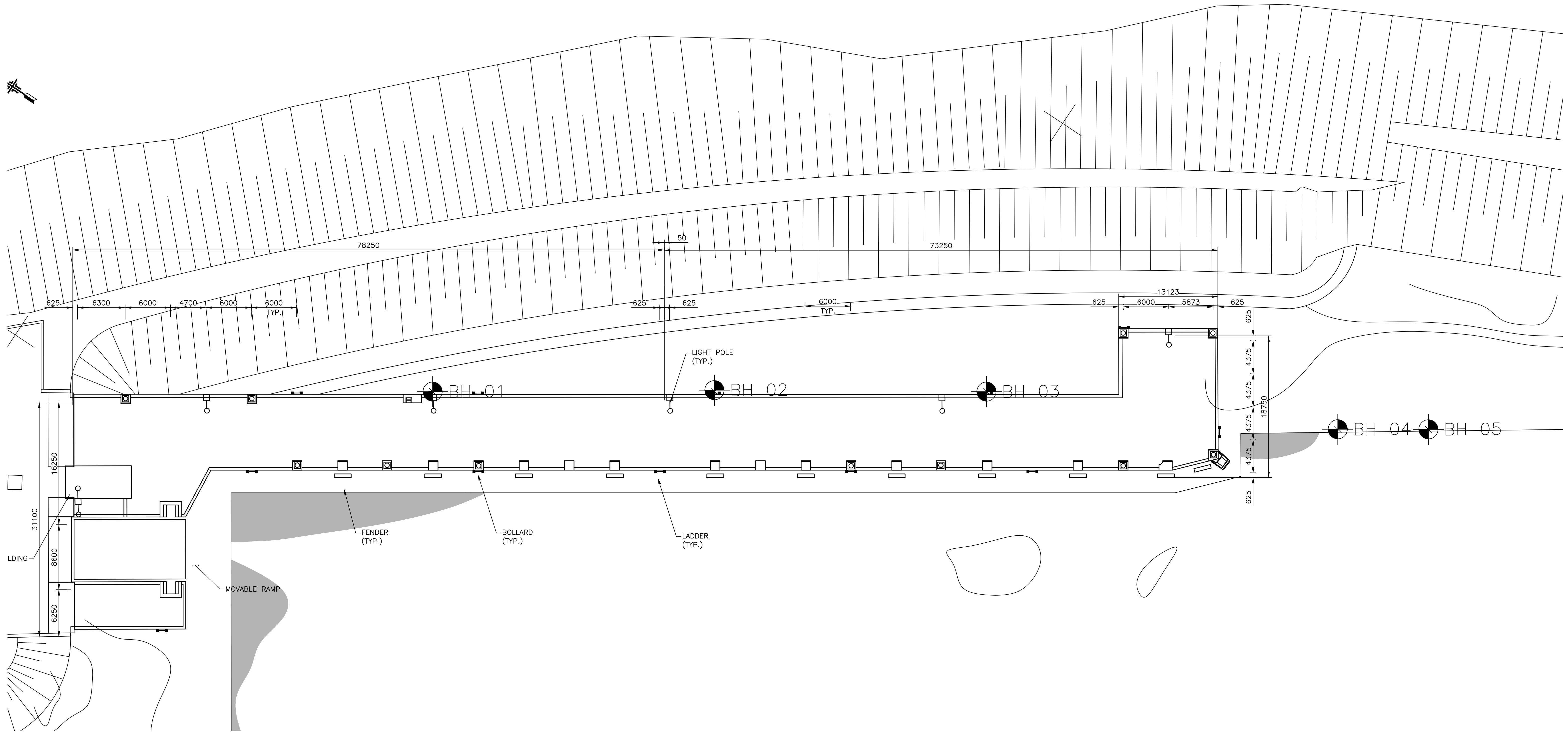


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Référence géodésique : NAD83 (SCRS)
Geodetic Reference : NAD83 (SCRS)

Projection : MTM
Projection : MTM

Fuseau : 4
Zone : 4



	COORD. EAST	COORD. NORTH
BOREHOLES N°	X	Y
BH 01	278124.299	5249049.827
BH 02	278145.088	5249018.858
BH 03	278164.843	5248988.762
BH 04	275186.408	5248947.266
BH 05	278193.039	5248937.265

—	BOREHOLE LOCATIONS	06 04 2021
revisions		date

CAP-AUX-MEULES
WARF EXTENSION
REINFORCEMENT

EXISTING CONDITONS
GEOTECHNICAL BORHOLES
PLAN VIEW

designed	—	conçu
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date

date

approved	—	approve
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Tender	Soumission
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PWGSC Project Manager Administrateur de projets TPSGC

project number	no. da projet

drawing no.	no. du dessin
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APPENDIX

A

BOREHOLE LOG
EXPLANATION FORM

BOREHOLE LOG EXPLANATION FORM

This explanatory section provides the background to assist in the use of the borehole logs. Each of the headings used on the borehole log, is briefly explained.

DEPTH

This column gives the depth of interpreted geologic contacts in metres below ground surface.

STRATIGRAPHIC DESCRIPTION

This column gives a description of the soil based on a tactile examination of the samples and/or laboratory test results. Each stratum is described according to the following classification and terminology.

<u>Soil Classification*</u>		<u>Terminology</u>	<u>Proportion</u>
Clay	<0.002 mm		
Silt	0.002 to 0.06 mm	"trace" (e.g. trace sand)	<10%
Sand	0.06 to 2 mm	"some" (e.g. some sand)	10% - 20%
Gravel	2 to 60 mm	adjective (e.g. sandy)	20% - 35%
Cobbles	60 to 200 mm	"and" (e.g. and sand)	35% - 50%
Boulders	>200 mm	noun (e.g. sand)	>50%

* Extension of MIT Classification system unless otherwise noted.

The use of the geologic term "till" implies that both disseminated coarser grained (sand, gravel, cobbles or boulders) particles and finer grained (silt and clay) particles may occur within the described matrix.

The compactness of cohesionless soils and the consistency of cohesive soils are defined by the following:

<u>COHESIONLESS SOIL</u>		<u>COHESIVE SOIL</u>	
Compactness	Standard Penetration Resistance "N", Blows / 0.3 m	Consistency	Standard Penetration Resistance "N", Blows / 0.3 m
Very Loose	0 to 4	Very Soft	0 to 2
Loose	4 to 10	Soft	2 to 4
Compact	10 to 30	Firm	4 to 8
Dense	30 to 50	Stiff	8 to 15
Very Dense	Over 50	Very Stiff	15 to 30
		Hard	Over 30

The moisture conditions of cohesionless and cohesive soils are defined as follows.

COHESIONLESS SOILS

Dry
Moist
Wet
Saturated

COHESIVE SOILS











DTPL - Drier Than Plastic Limit
APL - About Plastic Limit
WTPL - Wetter Than Plastic Limit
MWTPL - Much Wetter Than Plastic Limit

STRATIGRAPHY

Symbols may be used to pictorially identify the interpreted stratigraphy of the soil and rock strata.

MONITOR DETAILS

This column shows the position and designation of standpipe and/or piezometer ground water monitors installed in the borehole. Also the water level may be shown for the date indicated.

	Standpipe		Geotextile Material / Liner		Granular Backfill
	Piezometer		Borehole Seal (Bentonite Grout)		Granular (Filter) Pack
	Screened Interval		Cement Seal		Native Soil Backfill / Cave / Slough
	Borehole Seal (Peltonite, Bentonite or Hole Plug)				

Where monitors are placed in separate boreholes, these are shown individually in the "Monitor Details" column. Otherwise, monitors are in the same borehole. For further data regarding seals, screens, etc., the reader is referred to the summary of monitor details table.

SAMPLE

These columns describe the sample type and number, the "N" value, the water content, the percentage recovery, and Rock Quality Designation (RQD), of each sample obtained from the borehole where applicable. The information is recorded at the approximate depth at which the sample was obtained. The legend for sample type is explained below.

SS = Split Spoon	GS = Grab Sample
ST = Thin Walled Shelby Tube	CS = Channel Sample
AS = Auger Flight Sample	WS = Wash Sample
CC = Continuous Core	RC = Rock Core

$$\% \text{ Recovery} = \frac{\text{Length of Core Recovered Per Run}}{\text{Total Length of Run}} \times 100$$

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundness of the rock mass. It is obtained from the rock cores by summing the length of core recovered, counting only those pieces of sound core that are 100 mm or more in length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

RQD Classification

RQD (%)

Very poor quality	< 25
Poor quality	25 - 50
Fair quality	50 - 75
Good quality	75 - 90
Excellent quality	90 - 100

TEST DATA

The central section of the log provides graphs which are used to plot selected field and laboratory test results at the depth at which they were carried out. The plotting scales are shown at the head of the column.

Dynamic Penetration Resistance - The number of blows required to advance a 51 mm diameter, 60° steel cone fitted to the end of 45 mm OD drill rods, 0.3 m into the subsoil. The cone is driven with a 63.5 kg hammer over a fall of 750 mm.

Standard Penetration Resistance - Standard Penetration Test (SPT) "N" Value - The number of blows required to advance a 51 mm diameter standard split-spoon sampler 300 mm into the subsoil, driven by means of a 63.5 kg hammer falling freely a distance of 750 mm. In cases where the split spoon does not penetrate 300 mm, the number of blows over the distance of actual penetration in millimetres is shown as $\frac{x\text{Blows}}{\text{mm}}$

Water Content - The ratio of the mass of water to the mass of oven-dry solids in the soil expressed as a percentage.

W_P - Plastic Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.

W_L - Liquid Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.

REMARKS

The last column describes pertinent drilling details, field observations and/or provides an indication of other field or laboratory tests that were performed.

APPENDIX

B

BOREHOLE LOGS AND
PHOTO LOG



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BORING NUMBER BH-01

PAGE 1 OF 1

CLIENT Public Services and Procurement Canada

PROJECT NAME Wharf Extension - Madeleine Pier

PROJECT NUMBER 201-12004-00

PROJECT LOCATION Cap-aux-Meules Harbour, Cap-aux-Meules, QC

DATE STARTED 21/5/21 COMPLETED 21/5/21

GROUND ELEVATION -4 m Chart Dat. HOLE SIZE 125mm

DRILLING CONTRACTOR Logan Geotech Drilling Inc.

GROUND WATER LEVELS:

DRILLING METHOD Track Mounted Drill Rig

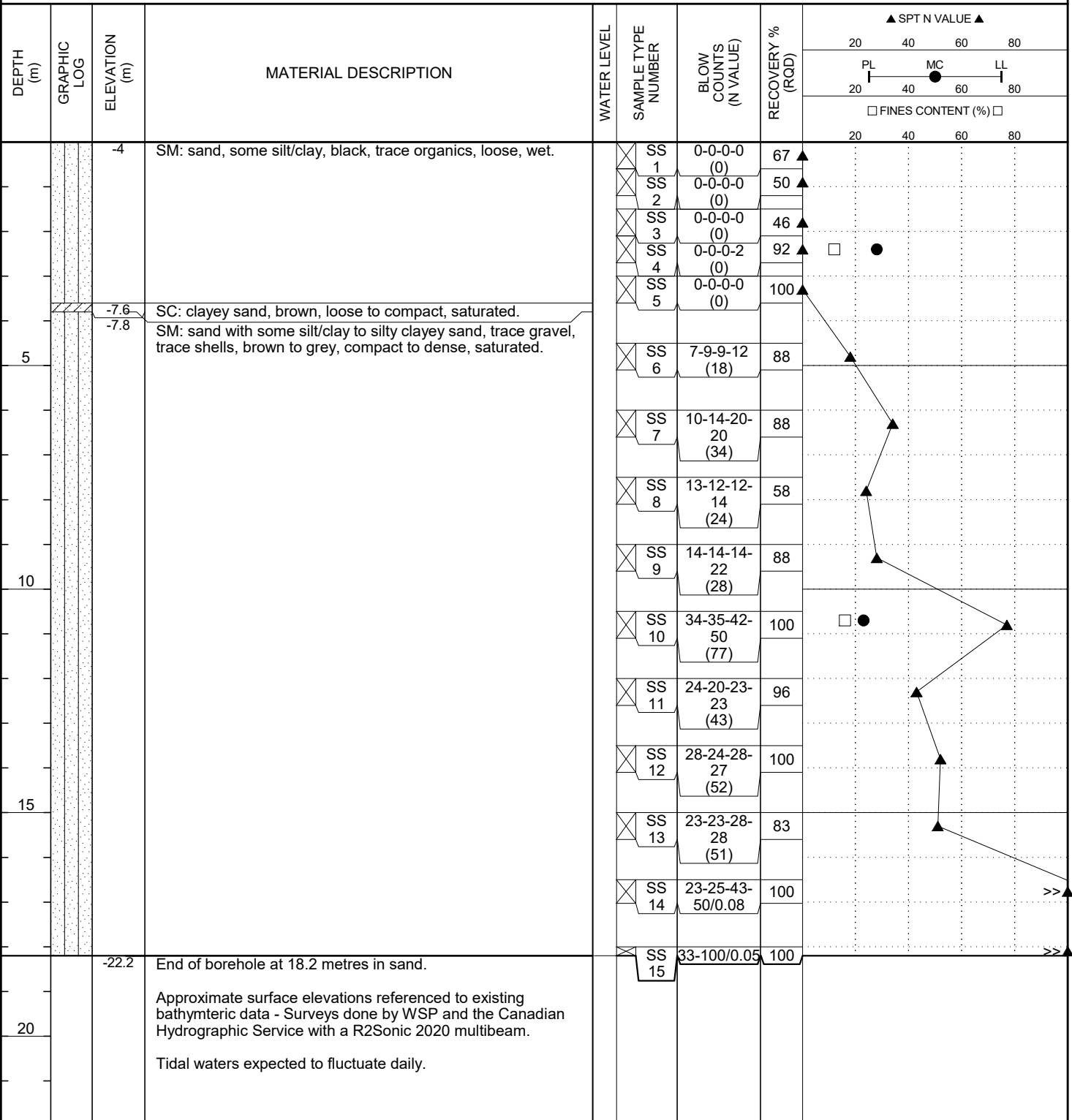
AT TIME OF DRILLING ---

LOGGED BY C. Phinney CHECKED BY M. Mazerolle

AT END OF DRILLING ---

NOTES

AFTER DRILLING ---



GEOTECH BH (N-VALUES) PSPC WHARF EXPANSION BH LOG.GPJ WSP_STANDARD_OCT2017.GDT 21/6/21



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BORING NUMBER BH-02

PAGE 1 OF 1

CLIENT Public Services and Procurement Canada

PROJECT NAME Wharf Extension - Madeleine Pier

PROJECT NUMBER 201-12004-00

PROJECT LOCATION Cap-aux-Meules Harbour, Cap-aux-Meules, QC

DATE STARTED 20/5/21 COMPLETED 20/5/21

GROUND ELEVATION -6.5 m Chart Dat. HOLE SIZE 125mm

DRILLING CONTRACTOR Logan Geotech Drilling Inc.

GROUND WATER LEVELS:

DRILLING METHOD Track Mounted Drill Rig

AT TIME OF DRILLING ---

LOGGED BY C. Phinney CHECKED BY M. Mazerolle

AT END OF DRILLING ---

NOTES

AFTER DRILLING ---

DEPTH (m)	GRAPHIC LOG	ELEVATION (m)	MATERIAL DESCRIPTION	WATER LEVEL	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)	▲ SPT N VALUE ▲	
								20 40 60 80	20 40 60 80
		-6.5	SM: sand, some silt/clay, black, trace organics, loose, wet.		SS 1	0-0-0-0 (0)	10	PL	MC
5		-10.4	SM: sand with some silt/clay to silty clayey sand, trace gravel, trace shells, grey to brown to buff, compact to dense, saturated.		SS 2	12-16-30-30 (46)	79		
					SS 3	16-20-22-30 (42)	100		
					SS 4	16-17-18-28 (35)	83		
10					SS 5	20-20-20-30 (40)	79		
					SS 6	30-40-82 (122)	100		
15		-17.5	End of borehole at 11 metres in sand. Approximate surface elevations referenced to existing bathymetric data - Surveys done by WSP and the Canadian Hydrographic Service with a R2Sonic 2020 multibeam. Tidal waters expected to fluctuate daily. When setting casing to 12m, a steel pile (25mm in thickness) was struck, borehole abandoned.						
20									

GEOTECH BH (N-VALUES) PSPC WHARF EXPANSION BH LOG.GPJ WSP STANDARD_OCT2017.GDT 21/6/21



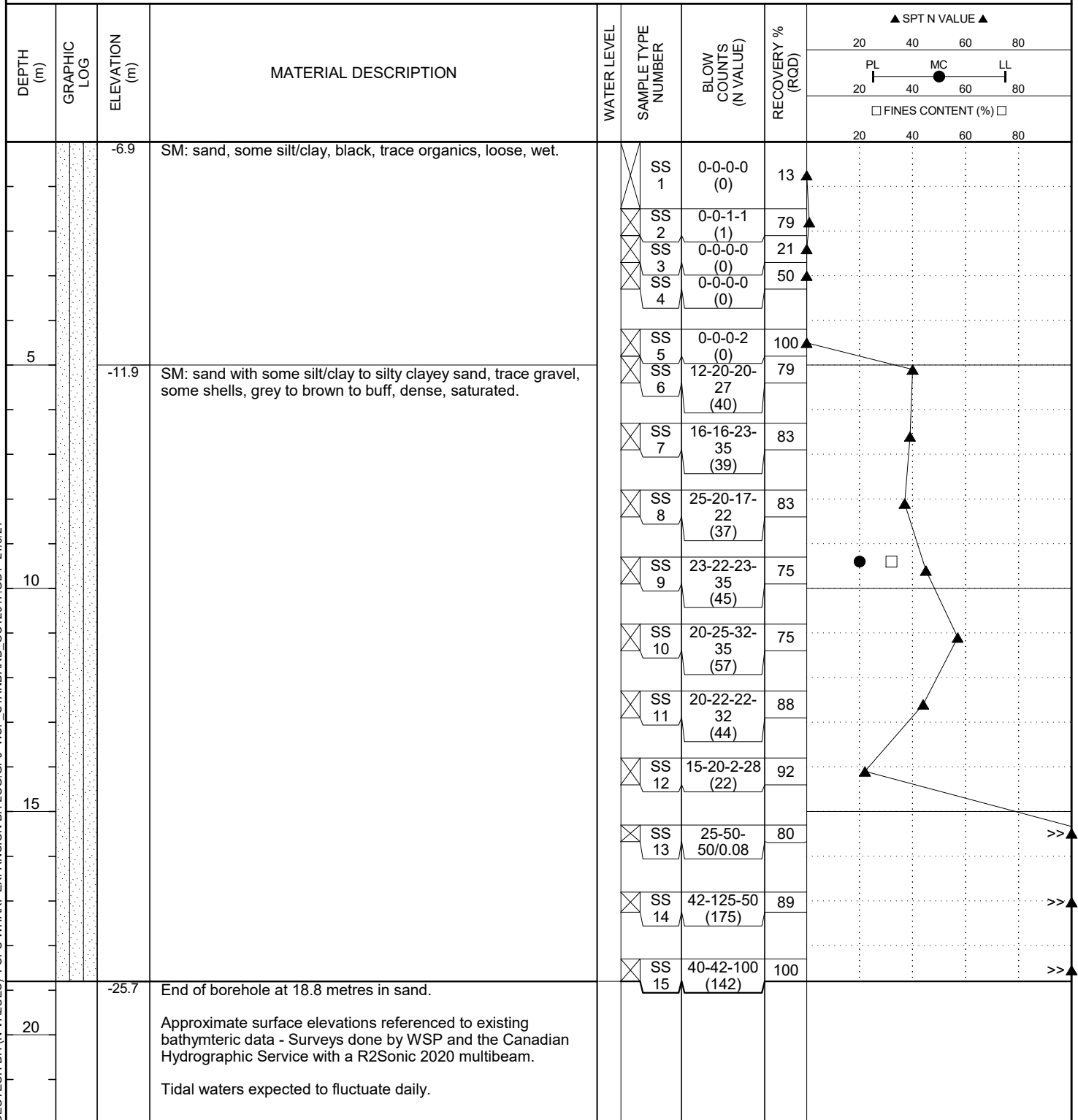
WSP Canada Inc.
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BORING NUMBER BH-03

PAGE 1 OF 1

CLIENT Public Services and Procurement Canada
PROJECT NUMBER 201-12004-00
DATE STARTED 18/5/21 **COMPLETED** 20/5/21
DRILLING CONTRACTOR Logan Geotech Drilling Inc.
DRILLING METHOD Track Mounted Drill Rig
LOGGED BY C. Phinney **CHECKED BY** M. Mazerolle
NOTES _____

PROJECT NAME Wharf Extension - Madeleine Pier
PROJECT LOCATION Cap-aux-Meules Harbour, Cap-aux-Meules, QC
GROUND ELEVATION -6.9 m Chart Dat. **HOLE SIZE** 125mm
GROUND WATER LEVELS:
AT TIME OF DRILLING ---
AT END OF DRILLING ---
AFTER DRILLING ---



GEOTECH BH (N-VALUES) PSC WHARF EXPANSION BH LOG.GPJ WSP STANDARD_OCT2017 GDT 21/6/21



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BORING NUMBER BH-04

PAGE 1 OF 1

CLIENT Public Services and Procurement Canada

PROJECT NAME Wharf Extension - Madeleine Pier

PROJECT NUMBER 201-12004-00

PROJECT LOCATION Cap-aux-Meules Harbour, Cap-aux-Meules, QC

DATE STARTED 5/5/21 COMPLETED 5/5/21

GROUND ELEVATION -6.3 m Chart Dat. HOLE SIZE 125mm

DRILLING CONTRACTOR Logan Geotech Drilling Inc.

GROUND WATER LEVELS:

DRILLING METHOD Barge Mounted Drill Rig

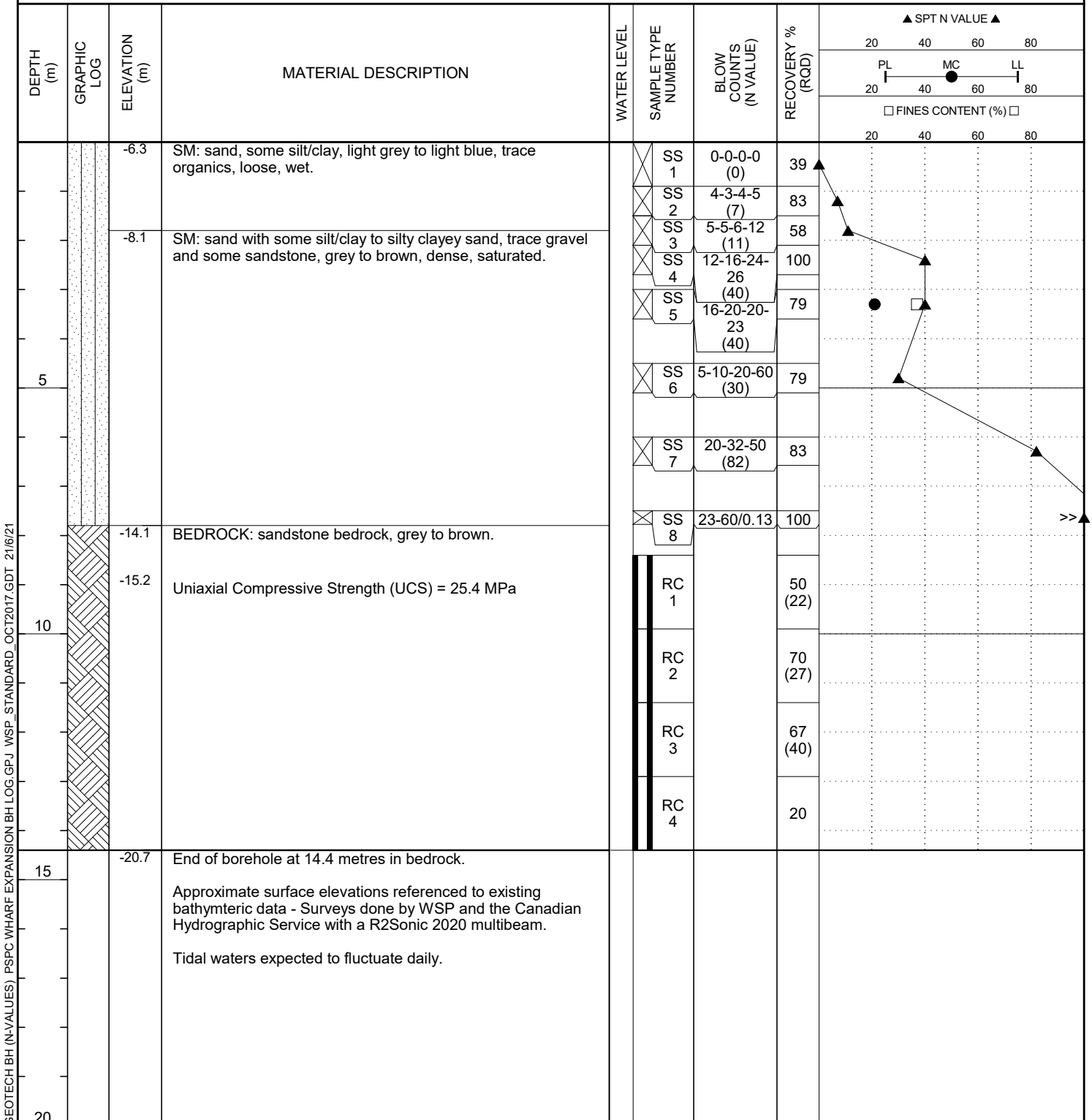
AT TIME OF DRILLING ---

LOGGED BY C. Phinney CHECKED BY M. Mazerolle

AT END OF DRILLING ---

NOTES

AFTER DRILLING ---





WSP Canada Inc.
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Telephone: (902) 835-9955

BORING NUMBER BH-05

PAGE 1 OF 1

CLIENT Public Services and Procurement Canada

PROJECT NAME Wharf Extension - Madeleine Pier

PROJECT NUMBER 201-12004-00

PROJECT LOCATION Cap-aux-Meules Harbour, Cap-aux-Meules, QC

DATE STARTED 28/4/21 COMPLETED 4/5/21

GROUND ELEVATION -7.4 m Chart Dat. HOLE SIZE 125mm

DRILLING CONTRACTOR Logan Geotech Drilling Inc.

GROUND WATER LEVELS:

DRILLING METHOD Barge Mounted Drill Rig

AT TIME OF DRILLING ---

LOGGED BY C. Phinney CHECKED BY M. Mazerolle

AT END OF DRILLING ---

NOTES

AFTER DRILLING ---

GEOTECH BH (N-VALUES) PSC WHARF EXPANSION BH LOG.GPJ WSP STANDARD OCT2017.GDT 21/6/21

DEPTH (m)	GRAPHIC LOG	ELEVATION (m)	MATERIAL DESCRIPTION	WATER LEVEL	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)	▲ SPT N VALUE ▲	
								20 40 60 80	20 40 60 80
		-7.4	SM: sand, some silt/clay, light grey to light blue, trace organics, black, compact to dense, wet.		SS 1	3-3-17-27 (20)	92		
					SS 2	15-22-35-50 (57)	100		
		-8.9	SM: sand with some silt/clay to silty clayey sand, trace gravel, grey to brown, dense, saturated.		SS 3	8-8-12-22 (20)	67		
					SS 4	22-25-50 (75)	100		
					SS 5	22-37-50 (87)	75		
5					SS 6	15-25-52-55/0.10	86		>>▲
					SS 7	27-18-35-60/0.05	85		>>▲
		-15.5	SM: sand with some silt/clay to silty clayey sand, trace gravel with some sandstone, brown to light brown, dense, saturated.		SS 8	27-50/0.03	43		>>▲
10					SS 9	25-50-70/0.13	82		>>▲
					SS 10	22-50-75/0.10	81		>>▲
15					SS 11	25-60-60/0.10	38		>>▲
					SS 12	62-100/0.10	100		>>▲
20		-24.8	End of borehole at 17.4 metres in sand. Approximate surface elevations referenced to existing bathymetric data - Surveys done by WSP and the Canadian Hydrographic Service with a R2Sonic 2020 multibeam. Tidal waters expected to fluctuate daily.						



Track Mounted Drill Rig with Overhang



Typical Silty Sand with
organics (seabed)



Typical Compact to
Dense Silty Sand



Bedrock Cores - BH-04

APPENDIX

C

LABORATORY TESTING
RESULTS



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GRADATION CURVES

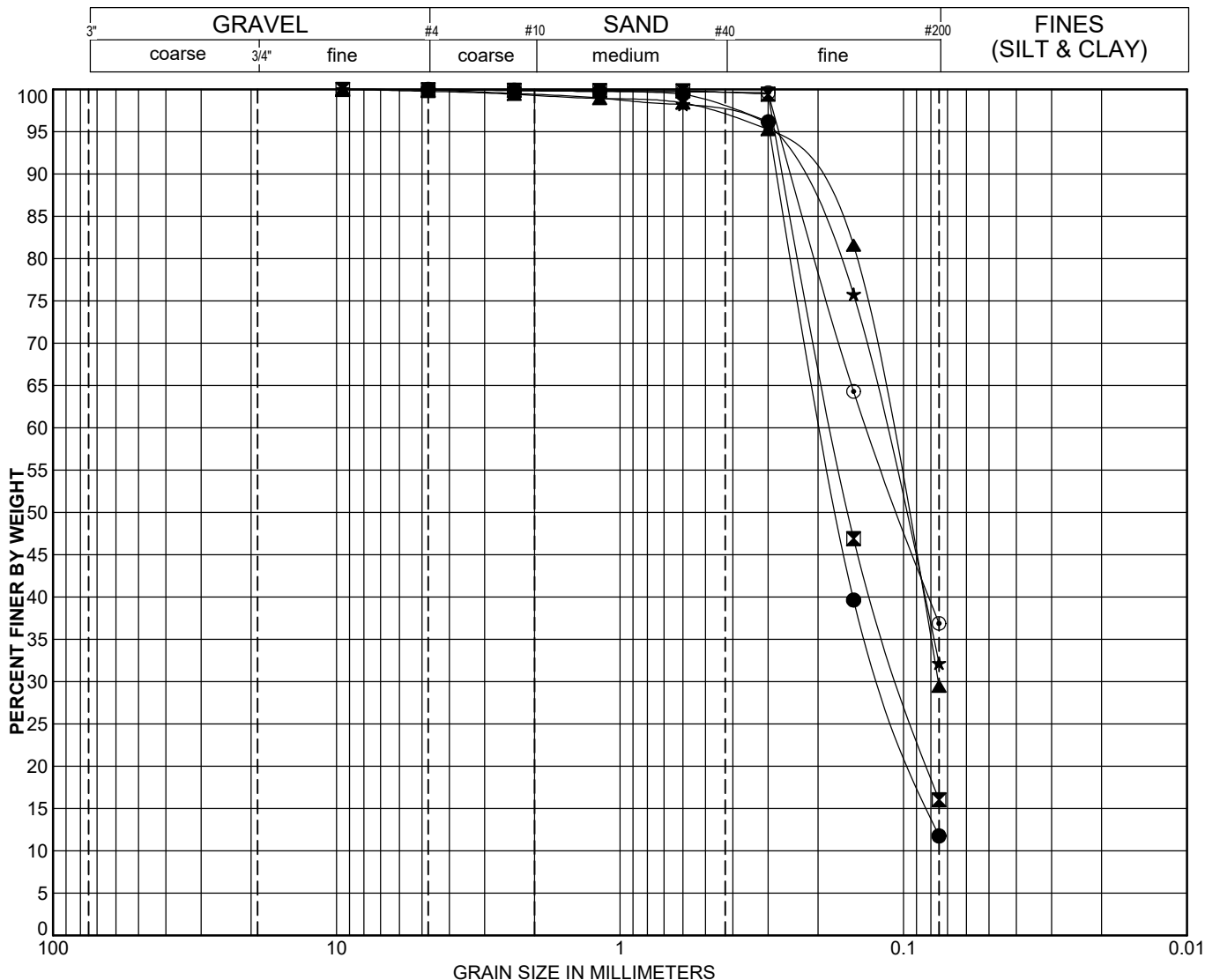
FIGURE No. 1 Page 1 of 2

CLIENT WSP Canada Inc.

PROJECT NAME PSPC CTMA#1

PROJECT NUMBER 201-12004

PROJECT LOCATION Quebec



Specimen Identification	Classification / Notes				MC%	LL	PL	PI	Cc	Cu
● BH1 2.1m	Sand, some silt/clay				28.4				1.01	2.7
▣ BH1 10.7m	Sand, some silt/clay				22.9					
▲ BH2 6.1m	Silty/clayey sand, trace gravel				21.0					
★ BH3 9.4m	Silty/clayey sand, trace gravel				20.0					
⊙ BH4 3.0m	Sand and silt/clay				20.8					
Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BH1 2.1m	4.75	0.19	0.118		0.0	88.2	11.8			
▣ BH1 10.7m	9.50	0.18	0.103		0.0	83.9	16.0			
▲ BH2 6.1m	9.50	0.11	0.076		0.2	70.3	29.4			
★ BH3 9.4m	9.50	0.12			0.1	67.7	32.2			
⊙ BH4 3.0m	4.75	0.13			0.0	63.1	36.9			

Reference Test Standard(s):

ASTM C136 / C136M-14 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM C117-13 - Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing



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GRADATION CURVES

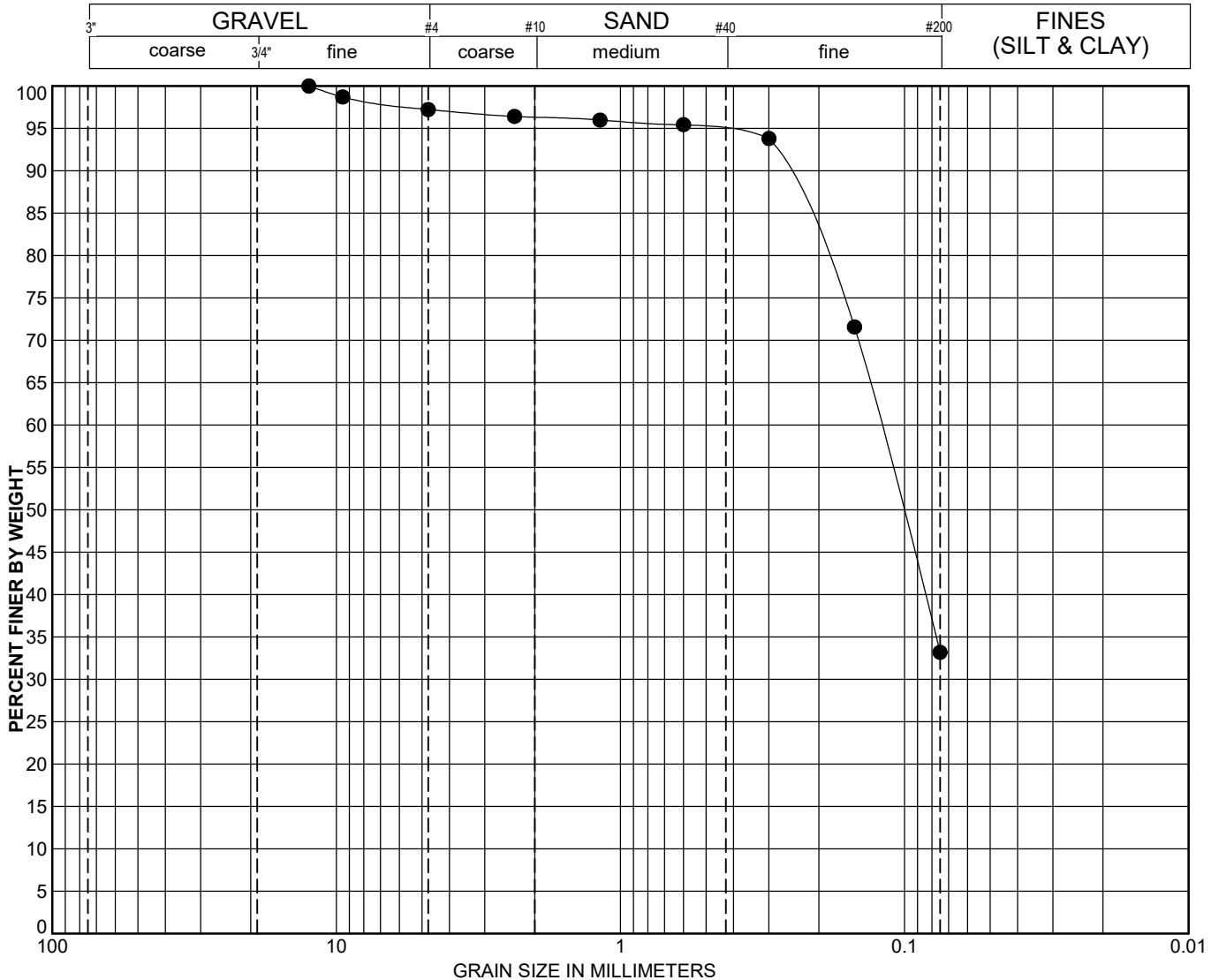
FIGURE No. 1 Page 2 of 2

CLIENT WSP Canada Inc.

PROJECT NAME PSPC CTMA#1

PROJECT NUMBER 201-12004

PROJECT LOCATION Quebec



Specimen Identification	Classification / Notes				MC%	LL	PL	PI	Cc	Cu
● BH5 12.8m	Silty/clayey sand, trace gravel				56.0					
Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BH5 12.8m	12.50	0.12			2.8	64.0	33.2			

Reference Test Standard(s):

ASTM C136 / C136M-14 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM C117-13 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing

SUMMARY OF LABORATORY RESULTS

CLIENT WSP Canada Inc.

PROJECT NAME PSPC CTMA#1

PROJECT NUMBER 201-12004

PROJECT LOCATION Quebec

Borehole	Depth (m)	Sample Type	Water Content (%)	% Gravel	% Sand	% Fines	Liquid Limit	Plastic Limit	Plasticity Index	UCS or Organic Content
BH1	2.13	SS	28.4	0.0	88.2	11.8				
BH1	10.67	SS	22.9	0.0	83.9	16.0				
BH2	6.10	SS	21.0	0.2	70.3	29.4				
BH3	9.45	SS	20.0	0.1	67.7	32.2				
BH4	3.05	SS	20.8	0.0	63.1	36.9				
BH5	12.80	SS	56.0	2.8	64.0	33.2				

Laboratory Testing Summary Table
PSPC CTMA #1 – 201-12004

Borehole ID, Sample ID	Density (km/m^3)	UCS (MPa)
BH4, 8.84m	2233	25.4

APPENDIX

D

REPORT LIMITATIONS





LIMITATIONS

Limited use

This Report was prepared for the PSPC solely for their exclusive use to provide an Assessment of current environmental conditions in association with the Site. WSP will not be responsible for any use of this report by any other party, for any decisions to be made based on it, or for the consequences thereof, unless written reliance is granted by WSP. Unless otherwise agreed in writing by WSP, it shall not be used to express or imply warranty as to the suitability of the property for a particular purpose. WSP disclaims responsibility of consequential financial effects on transactions or property values, or requirements for follow-up actions and costs.

Excerpts

The Report is intended to be used in its entirety. No excerpts may be taken to be representative of the findings in the assessment.

Information from others

In evaluating the Site, WSP has relied in good faith on information provided by others, as noted in the Report. WSP has assumed that the information provided is correct and WSP assumes no responsibility for the accuracy, completeness or workmanship of any such information.

Standard of care

This project has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by WSP and other engineering/scientific practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The conclusions presented in this Report are based on Work undertaken by trained professional and technical staff and the reasonable and professional interpretation using accepted engineering and scientific practices current at the time the work was performed. Conclusions presented in this report should not be construed as legal advice. WSP makes no other representations whatsoever, including those concerning the legal significance of its findings, or as to other legal matters touched on in the Report, including, but not limited to, ownership of any property, or the application of any law to the findings of the Assessment.

Limited scope

The Report summarizes WSP's review of available data in accordance with the principal components of the stated regulations, standards and guidelines and the scope, terms and conditions of the contract or proposal to which the Assignment was conducted. No other warranties are either expressed or implied with respect to the professional services provided under the terms of the contract or proposal and represented in this Report. Conditions may exist which were not detected given the nature of the inquiry WSP was retained to undertake with respect to the Site. Additional environmental studies and actions may be recommended.

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Changes over time

The Report is based on data and information collected at the time of this Assessment, as stated in the Report. Site use or conditions change and the information and conclusions in the Report may no longer apply following the date of this Report. If any conditions become apparent that differ significantly from that presented in this Report, we request that we be notified to reassess the conclusions and recommendations provided herein. WSP disclaims any obligation to update this Report for conditions that may be identified after the date of this Report; however, WSP reserves the right to amend or supplement this report based on additional information, documentation or evidence.

Variability between test locations

Conclusions are based on the Site conditions observed by WSP at the time the work was performed and may include information obtained at specific testing and/or sampling locations. It is recognized that overall conditions can only be extrapolated to an undefined limited area around these testing and sampling locations. The conditions that WSP interprets to exist between testing and sampling points may differ from those that actually exist. The accuracy of any extrapolation and interpretation beyond the sampling locations will depend on natural conditions, the history of Site development and changes through construction and other activities. In addition, analysis has been carried out for the identified chemical and physical parameters only, and it should not be inferred that other chemical species or physical conditions are not present. WSP cannot warrant against undiscovered environmental liabilities or adverse impacts off-Site.

Surveying

Benchmark and elevations used in this report are primarily to establish relative elevation differences between the specific testing and/or sampling locations and should not be used for other purposes, such as grading, excavating, construction, planning, development, etc.

Use for design and construction

Design recommendations given in this report are applicable only to the project and areas as described in the text and then only if constructed in accordance with the details stated in this report. The comments made in this report on potential construction issues and possible methods are intended only for the guidance of the designer. The number of testing and/or sampling locations may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. Contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.