Geotechnical Investigation

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Project Name:
Proposed Development
Blocks 201, 202, 203, 204 & 205 B,
Chaudière Island,
Ottawa, Ontario

Project Number:
OTT-00250193-S0

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Executive Summary

EXP Services Inc. (EXP) was retained by Windmill Dream Ontario Holding LP. to prepare a geotechnical report for the proposed development located within the Zibi development at Blocks 201, 202, 203, 204 & 205 B, Chaudière Island, Ottawa, Ontario (hereinafter referred to as the 'Site'). The Site is at the southern provincial border between Quebec and Ontario. The Site location plan is shown on Figure 1.

A hydrogeological assessment and a Phase Two Environmental Site Assessment (ESA) were conducted by EXP concurrently with this geotechnical investigation and the results of these assessments are reported in separate documents.

It is our understanding that the Blocks 201 to 203, 204 and 205B will have one or two levels (P1 or P2) of shared underground parking. Conceptual plans have been provided for block 204 and it is understood that development of this block will take place in 2022. The conceptual plans indicate that a twenty-two (22) story building with one or two levels (P1 or P2) of shared underground parking will be constructed with a footprint of 2,715 m^2. It is also understood that there are currently no conceptual plans for Blocks 201 to 203 and 205B and the size, shape, and location of any buildings on these blocks are unknown. Development of Blocks 201 to 203 and 205B are projected to occur approximately five years from now.

The fieldwork for this geotechnical investigation was undertaken between December 10 and 13, 2021 and consisted of fourteen (14) boreholes (MW/BH21-102 and MW/BH 21-104 to MW/BH21-116) advanced to auger refusal or termination depths ranging from 5.8 m to 9.8 m below existing grade. Boreholes MW/BH21-102 and MW/BH 21-104 to MW/BH21-105 were drilled within block 205B, boreholes BH21-106 to BH21-110 were drilled within block 204 and boreholes MW/BH 21-111 to MW/BH21-116 were drilled within Blocks 201 to 203.

Fifty (50) mm diameter monitoring wells with slotted section were installed in all fourteen (14) boreholes for long-term monitoring of the groundwater level and for the sampling of the groundwater as part of the Phase Two ESA/Hydrogeological Study.

The borehole information indicates that the subsurface conditions at the site consist of a surficial fill, which may include an asphaltic concrete layer, which is underlain by limestone bedrock that was generally contacted at depths of 1.0 m to 4.9 m (Elevation 53.0 m to Elevation 49.4 m). In borehole BH21-114 auger refusal occurred within the fill at 9.8 m (Elevation 44.5 m). Ariel photos from the geoOttawa database were consulted and what appears to be a channel was present at the approximate location of Borehole BH21-114 in 1928. A Ground Penetrating Radar (GPR) survey was carried out by USL-1 at the location of borehole BH21-114. The USL-1 report has been included as Appendix B. The survey noted a geophysical change near the location of borehole BH21-114 which may indicate the presence of a trench which runs in south/east to north/west alignment.

Multi-channel Analysis of Surface Waves (MASW) geophysical studies was completed on Block 206 in 2018 by Paterson group and is considered to be applicable for this site (Figure No. 2). The survey established that the shear wave velocity of the bedrock on Chaudière Island ranged at block 206 was 2,472 m/s. In 2019 EXP also carried out a MSAW as part of the geotechnical investigation for a proposed structure on Block 211. The MASW survey indicates that the average seismic shear wave velocity for Block 211 is 1,870 m/s. Based on a review of Table 4.1.8.4.A of the 2012 Ontario Building Code (OBC), for average shear wave velocities of 1,870 m/s or 2,472 m/s, for a foundation founded directly on the sound bedrock surface, the site can be classified as Class A for seismic site response.

It is anticipated that all subsurface soils on site including the fill and native soils will be excavated down to the bedrock and removed from site for the construction of the proposed new buildings. Since all subsurface soils will be excavated and removed from the site, liquefaction of the soils on site during a seismic event is not a concern.

From a geotechnical perspective there are no restrictions to raising the grades at the site since it is anticipated that all subsurface soils will be excavated down to the bedrock, removed from the site and replaced with either imported granular fill (compacted to the specified degree of compaction indicated in this report) or backfilled with concrete.

The geotechnical investigation revealed that it would be feasible to support the proposed buildings on spread and strip footings founded ccompetent, sound bedrock (free of weathered zones, loose material, clay seams, fractures and voids) and may be designed for a factored geotechnical resistance at Ultimate Limit State (ULS) 3.0 MPa. Further inspection and testing may result

in the ULS value being increased to 5.0 MPa. The Serviceability Limit State (SLS) bearing pressure of the bedrock, required to produce 25 mm settlement of the footing will be much larger than the recommended value for factored geotechnical resistance at ULS and ULS will govern the design. Settlements of footing designed for the above recommended factored geotechnical resistance at ULS and properly constructed are expected to be less than 10 mm.

In borehole BH21-114, drilled within Blocks 201 to 203, fill extended to depth of 9.8 m and the elevation of the bedrock was not established. Based on the aerial photographs and the MSAW results the borehole is located within a previous drainage channel or crevasse. The extents of the channel/crevasse have been estimated as part of the MASW survey. As part of the detailed geotechnical investigation, the elevation of the bedrock in the vicinity of the borehole must be established as well as the extent of the channel. For founding purposes, all fill must be removed from this area and replaced with 30 MP concrete to the proposed underside of footing elevation. Similar treatment will be required in areas where fill extended below the proposed founding level or in areas where bedrock need to be excavated to reach a sound founding medium.

For preliminary consideration, it is anticipated that underfloor and perimeter drainage systems will be required for the structures and should best established once the final concept plan is known (i.e., number of underground levels, etc.).

Excavations should be undertaken in accordance with the current Occupational Health and Safety Act (OHSA).

The upper levels of the limestone bedrock may be excavated using a hoe ram for removal of small quantities of the bedrock; however, this process is expected to be very slow. The excavation side slopes within the weathered and sound bedrock may be undertaken near vertical but may need be cut back at a 1H:1V gradient in zones of loose rock pieces/slabs.

The excavation of the limestone bedrock will likely require line drilling and blasting techniques. Contractors bidding on this project should decide on their own the most preferred rock removal method; hoe ramming or line drilling and blasting regardless of the depth and/or quantity of bedrock that requires excavation.

It is anticipated that the majority of fill required for construction will have to be imported to the site and conform to the Ontario Provincial Standard Specification (OPSS) requirements for Granular A, B Type II and Select Subgrade Material (SSM).

The above and other related considerations are discussed in greater detail in the main body of this report.

1. Introduction

EXP Services Inc. (EXP) was retained by Windmill Dream Ontario Holding LP.to prepare a geotechnical report for the proposed development located within the Zibi development at Blocks 201, 202, 203, 204 & 205 B, Chaudière Island, Ottawa, Ontario (hereinafter referred to as the 'Site'). The Site is at the southern provincial border between Quebec and Ontario. The Site location plan is shown on Figure 1.

A hydrogeological assessment and a Phase Two Environmental Site Assessment (ESA) were conducted by EXP concurrently with this geotechnical investigation and the results of these assessments are reported in separate documents.

It is our understanding that the Blocks 201 to 203, 204 and 205B will have one or two levels (P1 or P2) of shared underground parking. Conceptual plans have been provided for block 204 and it is understood that development of this block will take place in 2022. The conceptual plans indicate that a twenty-two (22) story building with one or two levels (P1 or P2) of shared underground parking will be constructed with a footprint of 2,715 m^2. It is also understood that there are currently no conceptual plans for Blocks 201 to 203 and 205B and the size, shape, and location of any buildings on these blocks are unknown. Development of Blocks 201 to 203 and 205B are projected to occur approximately five years from now.

This geotechnical investigation was undertaken to:

a) Establish the subsurface soil, bedrock and groundwater conditions at the fourteen (14) borehole locations;

b) Provide classification of the site for seismic site response in accordance with the requirements of the 2012 Ontario Building Code (as amended May 2, 2019) and assess the potential for liquefaction of the subsurface soils during a seismic event;

c) Comment on grade-raise restrictions;

d) Make preliminary recommendations regarding the most suitable type of foundations, founding depth and bearing pressure at serviceability limit state (SLS) and factored geotechnical resistance at ultimate limit state (ULS) of the founding strata and comment on the anticipated total and differential settlements of the recommended foundation type;

e) Provide general recommendations for shoring;

f) Comment on excavation conditions anticipated during the construction of a building including possible effects of groundwater on the excavation and dewatering requirement; and

g) Comment on backfilling requirements and assessment of the suitability of on-site soils for backfilling purposes from a geotechnical point of view; and

h) Provide preliminary pavement structures for the proposed surface parking and access roadway

The comments and recommendations given in this report are preliminary in nature and subject to modification once the final concept of the proposed development has been established and there must be updated.

2. Site Description

The subject site is situated on Chaudière Island located in the Ottawa River between Ottawa, Ontario to the south and Hull (Gatineau) Quebec to the north. Chaudière Island was once heavily industrialized, especially in the 19th century. Today the island is mostly built up and is partially being redeveloped. North of the island, a ring dam exists, where the former Chaudière Falls were located. The river is also diverted to several hydroelectric power stations.

The Chaudière Island is bounded by the Ottawa River along the north and west sides and the east leg of the Buchanan channel on the south side. The subject site consists of Blocks 201 to 203, Blocks 204 and Block 205B which are separated by Chaudire Private and Miwate Private roads. The site location is shown in Figure No. 1.

As indicated on the borehole logs included in as Figures Nos. 6 to 19, inclusive, the surface elevation of the Site ranges between approximately 53.5 to 54.8 meters above sea level (masl).

3. Geology of the Site

3.1 Surficial Geology

The surficial geology map (Map 1506A – Surficial Geology, Ontario-Quebec, Geological Survey of Canada, printed by the Surveys and Mapping Branch, 1982) indicates that beneath any fill, Chaudière Island is covered with a thin veneer of unconsolidated Quaternary sediments over bedrock.

3.2 Bedrock Geology

The bedrock geology map (Map 1508A – Generalized Bedrock Geology, Ottawa-Hull, Ontario and Quebec, Geological Survey of Canada, printed by the Surveys and Mapping Branch, 1979) indicates the bedrock at Chaudière Island consists of limestone of the Ottawa formation. The limestone contains shaley partings and interbeds with some sandstone in the basal part. The map indicates that faults are located approximately north, northeast and southwest of Chaudière Island.

4. Procedure

4.1 Fieldwork

The fieldwork for this geotechnical investigation was undertaken between December 10 and 13, 2021 and consisted of fourteen (14) boreholes (MW/BH21-102 and MW/BH 21-104 to MW/BH21-116) advanced to auger refusal or termination depths ranging from 5.8 m to 9.8 m below existing grade. Boreholes MW/BH21-102 and MW/BH 21-104 to MW/BH21-105 were drilled within block 205B, boreholes BH21-106 to BH21-110 were drilled within block 204 and boreholes MW/BH 21-111 to MW/BH21-116 were drilled within Blocks 201 to 203.

The locations and geodetic elevations of the boreholes were established by a survey crew from EXP. Prior to the fieldwork, the locations of the boreholes were cleared of any public and private underground services.

The boreholes were drilled with a CME-55 truck-mounted drill rig equipped with continuous flight hollow-stem auger equipment. Auger samples were typically obtained from the ground surface to a 0.6 m depth below existing grade. Standard penetration tests (SPTs) were performed at a 0.75 m depth interval and the soil samples were retrieved by the split-barrel sampler. All soil samples were visually examined in the field for textural classification, logged, preserved in plastic bags and identified

The bedrock was cored in all the boreholes except MW/BH21-114 by conventional rock coring method using a NQ core barrel. A careful record of any sudden drops of the core barrel, colour of the wash water and wash water return were recorded during the rock coring operation.

Fifty (50) mm diameter monitoring wells with slotted section were installed in all fourteen (14) boreholes for long-term monitoring of the groundwater level and for the sampling of the groundwater as part of the Phase Two ESA/Hydrogeological Study. The monitoring wells were installed in accordance with EXP standard practice, and the installation configuration is documented on the respective borehole log. The boreholes were backfilled upon completion of the field work and the installation of the monitoring wells.

All soil samples were visually examined in the field for textural classification, logged, preserved in plastic bags and identified. Similarly, the rock cores were visually examined, placed in a core box, identified and logged. On completion of the fieldwork, all the soil samples and the rock cores were transported to the EXP laboratory in Ottawa, Ontario.

4.2 Laboratory Testing Program

The soil samples were visually examined in the laboratory by a geotechnical engineer. The soil samples were classified in accordance with the Unified Soil Classification System (USCS) and the modified Burmeister System (as per the 2006 Fourth Edition Canadian Foundation Engineering Manual (CFEM)).

A summary of the soil laboratory testing program is shown in Table I.

Table I: Summary of Laboratory Testing Program

Type of Test	Number of Tests Completed
Soil Samples	
Moisture Content Determination	54
Bedrock Cores	
Unit Weight Determination	27
Unconfined Compressive Strength Test	27

5. Subsurface Conditions and Groundwater Levels

A detailed description of the subsurface conditions and groundwater levels from this geotechnical investigation are given on the attached Borehole Logs, Figure Nos. 6 to 19, inclusive. The borehole logs and related information depict subsurface conditions only at the specific locations and times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the locations where sampling was conducted. The passage of time also may result in changes in the conditions interpreted to exist at the locations where sampling was conducted.

Boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of potential environmental conditions.

It should be noted that the soil and rock boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling operations. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The "Note on Sample Descriptions" preceding the borehole logs form an integral part of this report and should be read in conjunction with this report.

A review of the borehole logs indicates the following subsurface conditions with depth and groundwater levels within the various blocks at the site.

5.1 Block 205B

Boreholes BH21-101 to BH 21-105 were drilled within Block 205B.

Asphaltic Concrete

A fifty (50) mm asphaltic concrete was contacted at surface in BH21-104.

Fill

Fill is present beneath the asphaltic concrete in borehole BH21-104 and beneath the surface in the remaining boreholes. This layer of fill generally extends to depths of 1.9 m to 2.9 m (Elevation 52.5 m to Elevation 51.8 m). The fill generally consists of sand and gravel. It was also found to generally contain brick, concrete, metal and wood fragments as well as charred debris. The fill is compact to very dense as indicated by SPT N-values of 16 to 88. In some boreholes, the SPT value is high for low sampler penetration; for example, N equals 50 blows for 75 mm sampler penetration. This may be a result of the sampler making contact with debris, cobbles or boulders within the fill. The moisture content of the fill ranges from 2 percent to 11 percent.

Limestone Bedrock

Auger refusal was met in all the boreholes at depths ranging between 1.9 m to 2.9 m below surface (Elevation 52.5 m to Elevation 51.8 m). Washboring and rock coring was used to advance all the boreholes to confirmed that refusal was met on bedrock. In borehole BH21-102 the refusal was proven to be due to a concrete slab, approximately 200 mm in thickness, contacted above the surface of the bedrock. This is likely due to previous structures that may have been located in this area and the extent of the concrete in this area is not known and must be established as part of the detailed investigation. In borehole BH21-105, between the approximate depth of 2.9 m and 3.2 m, what appears to be concrete mortar is in contact with the recovered bedrock. In borehole BH21-104, limestone bedrock was confirmed at a depth of 1.9 m (Elevation 52.5 m).

A summary of the auger refusal depths and the depth to bedrock, confirmed by coring, are shown in Table II.

Table II: Summary of Block 205B Auger and Soil Sampler Refusal and Bedrock Depths (Elevations) in Boreholes				
Borehole (BH) No.	Ground Surface Elevation (m)	Refusal Depth (Elevation) on Inferred Bedrock (m)	Depth (Elevation) of Bedrock Surface (m)	Comment wrt to Depth (Elevation) of Bedrock Surface
MW/BH21-102	54.78	2.9 (51.9)	3.1 (51.7)	Initial 0.2 m of sample is concrete. 8.9 m length of bedrock cored below 3.1 m depth
MW/BH21-104	54.44	1.9 (52.5)	1.9 (52.5)	7.1 m length of bedrock cored below 1.9 m depth
MW/BH21-105	54.71	2.9 (51.8)	2.9 (51.8)	Initial 0.3 m of sample is in contact with concrete mortar 6.0 m length of bedrock (with no concrete) cored below 3.2 m depth

Based on the bedrock coring results, the total core recovery (TCR) generally ranges from 92 percent to 100 percent. The rock quality designation (RQD) generally ranged from 59 percent to 100 percent indicating the bedrock quality ranging from fair to excellent. In borehole BH21-104, the first bedrock run had a RQD value of 32%, indicating a rock quality of poor. The RQD in the subsequent runs ranged from fair to excellent.

Unit weight determination and unconfined compressive strength tests were conducted on seven (7) rock core sections and the results are summarized in Table III. Photographs of the rock cores are shown in Appendix A.

Table III: Summary of Block 205B Unconfined Compressive Strength Test Results – Bedrock Cores				
Borehole (BH) No. – Run No.	Depth (m)	Unit Weight (kN/m^3)	Unconfined Compressive Strength (MPa)	Classification of Rock with respect to Strength
MW/BH21-102 - Run2	5.4 - 5.5	26.5	141.1	Very Strong
MW/BH21-102 - Run3	6.3 - 6.5	26.1	54.4	Strong
MW/BH21-102 - Run6	11.5 -11.7	26.5	116.8	Very Strong
MW/BH21-104 - Run2	3.3 - 3.5	26.7	126.7	Very Strong
MW/BH21-104 - Run4	6.2 - 6.4	26.5	157.5	Very Strong
MW/BH21-104 - Run5	8.3 - 8.5	26.6	152.3	Very Strong
MW/BH21-105 - Run4	8.0 - 8.2	26.5	133.8	Very Strong

A review of the test results in Table III indicates the strength of the rock may be classified as strong to very strong in accordance with the Canadian Foundation Engineering Manual (CFEM), Fourth Edition, 2006.

Groundwater Level Measurements

A total of three (3) monitoring wells were installed within Block 205B. A summary of the groundwater level measurements taken in the monitoring wells are shown in Table IV.

Table IV: Summary of Block 205B Groundwater Level Measurements

Borehole (BH) /Monitoring Well (MW) No.	Ground Surface Elevation (m)	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m
MW21-102	54.78	February 3, 2022 (49)	6.5 (48.3)	February 16, 2022 (62)	6.2 (48.6)
MW21-104	54.44	February 3, 2022 (51)	3.0 (51.4)	February 16, 2022 (64)	3.0 (51.4)
MW21-105	54.71	February 3, 2022 (51)	4.5 (50.2)	February 16, 2022 (64)	4.4 (50.3)

The groundwater level ranges from 3.0 m to 6.5 m (Elevation 51.4 m to Elevation 48.3 m) across Block 205B.

Water levels were determined in the boreholes and monitoring wells at the times and under the conditions noted above. Fluctuations in the level of groundwater may occur due to a seasonal variation such as precipitation, snowmelt, rainfall activities, and other factors not evident at the time of measurement and therefore may be at a higher level during wet weather periods.

Based on the water levels measured in the monitoring wells and in the Ottawa River the groundwater measurements noted above are considered to be representative of actual site conditions and correspond well with mean water levels within the Ottawa River. As a result, these water levels are suitable for use for building design.

5.2 Block 204

Boreholes BH21-106 to BH 21-110 were drilled within Block 204.

Asphaltic Concrete

A 50 mm asphaltic concrete was contacted at surface in borehole BH21-106.

Fill

Fill is present beneath the asphaltic concrete in borehole BH21-106 and beneath the surface in the remaining boreholes. This layer of fill generally extended to depths of 1.0 m to 3.2 m (Elevation 53.0 m to Elevation 51.4 m). The fill generally consists of sand and gravel. It was also found to generally contain brick, concrete, metal and wood fragments as well as charred debris. The fill is loose to very dense as indicated by SPT N-values of 6 to 85. In some boreholes, the SPT value is high for low sampler penetration; for example, N equals 50 blows for 50 mm sampler penetration. This may be a result of the sampler making contact with debris, cobbles or boulders within the fill. The moisture content of the fill ranges from 2 percent to 37 percent. The higher moisture contents may be the result of organic material (such as wood) embedded within the fill samples.

Limestone Bedrock

Auger refusal was met in all the boreholes at depths ranging between 1.0 m to 3.2 m (Elevation 53.0 m to Elevation 51.4 m). Washboring and rock coring was used to advance all the boreholes

A summary of the auger refusal depths and the depth to bedrock confirmed by coring the bedrock are shown in Table V.

Table V: Summary of Block 204 Auger and Soil Sampler Refusal and Bedrock Depths (Elevations) in Boreholes				
Borehole (BH) No.	Ground Surface Elevation (m)	Refusal Depth (Elevation) on Inferred Bedrock (m)	Depth (Elevation) of Bedrock Surface (m)	Comment wrt to Depth (Elevation) of Bedrock Surface
MW/BH21-106	54.09	1.1 (53.0)	1.1 (53.0)	4.8 m length of bedrock cored below 1.1 m depth
MW/BH21-107	53.92	1.0 (52.9)	1.0 (52.9)	10.9 m length of bedrock cored below 1.0 m depth
MW/BH21-108	54.59	3.2 (51.4)	3.2 (51.4)	3.5 m length of bedrock cored below 3.2 m depth
MW/BH21-109	53.64	1.0 (52.6)	1.0 (52.6)	8.0 m length of bedrock cored below 1.0 m depth
MW/BH21-110	53.51	1.0 (52.5)	1.0 (52.5)	11.0 m length of bedrock cored below 1.0 m depth

Based on the bedrock coring results, the total core recovery (TCR) generally ranges from 87 percent to 100 percent with lower values typically encountered at the bedrock surface and found to be as low as 61 percent. The rock quality designation (RQD) generally ranged from 55 percent to 99 percent indicating the bedrock quality ranging from fair to excellent. In borehole BH21-108 the first coring run had an RQD of 46 indicating a rock quality of poor. The RQD of the rock core in borehole BH21-108 improved with depth.

Unit weight determination and unconfined compressive strength tests were conducted on fourteen (14) rock core sections and the results are summarized in Table VI. Photographs of the rock cores are shown in Appendix A.

Table VI: Summary of Block 204 Unconfined Compressive Strength Test Results – Bedrock Cores				
Borehole (BH) No. – Run No.	Depth (m)	Unit Weight (kN/m^3)	Unconfined Compressive Strength (MPa)	Classification of Rock with respect to Strength
MW/BH21-106 - Run1	1.9 - 2.1	26.4	58.0	Strong
MW/BH21-106 - Run3	5.1 - 5.3	26.5	102.9	Very Strong
MW/BH21-107 - Run1	1.6 - 1.7	26.4	116.4	Very Strong
MW/BH21-107 - Run3	4.4 - 4.7	26.5	124.5	Very Strong
MW/BH21-107 - Run4	6.4 - 6.7	26.5	127.5	Very Strong
MW/BH21-107 - Run6	9.3 - 9.6	26.5	98.7	Strong
MW/BH21-108 - Run1	3.5 - 3.7	26.5	97.3	Strong
MW/BH21-108 - Run2	4.9 - 5.1	26.3	86.7	Strong

MW/BH21-109 - Run2	3.5 - 3.6	26.5	52.7	Strong
MW/BH21-109 - Run5	7.4 - 7.7	26.2	128.3	Very Strong
MW/BH21-110 - Run1	1.6 - 1 8	26.4	133.1	Very Strong
MW/BH21-110 - Run3	4.4 - 4.6	27.2	69.0	Strong
MW/BH21-110 - Run5	7.3 - 7.4	26.4	59.7	Strong
MW/BH21-110 - Run7	11.1 - 11.3	26.2	172.7	Very Strong

A review of the test results in Table VI indicates the strength of the rock may be classified as strong to very strong in accordance with the Canadian Foundation Engineering Manual (CFEM), Fourth Edition, 2006.

Groundwater Level Measurements

A total of five (5) monitoring wells were installed within Block 204. A summary of the groundwater level measurements taken in the monitoring wells are shown in Table VII.

Table VII: Summary of Block 204 Groundwater Level Measurements

Borehole (BH) /Monitoring Well (MW) No.	Ground Surface Elevation (m)	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m
MW21-106	54.09	February 3, 2022 (51)	3.7 (50.4)	February 16, 2022 (64)	3.3 (50.8)
MW21-107	53.92	February 3, 2022 (52)	4.1 (49.8)	February 16, 2022 (65)	3.8 (50.1)
MW21-108	54.59	February 3, 2022 (50)	5.7 (48.9)	February 16, 2022 (63)	5.4 (49.2)
MW21-109	53.64	February 3, 2022 (50)	Inaccessible	February 16, 2022 (63)	7.0 (46.6)
MW21-110	53.51	February 3, 2022 (50)	Inaccessible	February 16, 2022 (63)	7.0 (46.5)

The groundwater level ranges from 3.3 m to 7.0 m (Elevation 50.8 m to Elevation 46.5 m) across Block 204.

Water levels were determined in the boreholes and monitoring wells at the times and under the conditions noted above. Fluctuations in the level of groundwater may occur due to a seasonal variation such as precipitation, snowmelt, rainfall activities, and other factors not evident at the time of measurement and therefore may be at a higher level during wet weather periods.

Based on the water levels measured in the monitoring wells and in the Ottawa River the groundwater measurements noted above are considered to be representative of actual site conditions and correspond well with mean water levels within the Ottawa River. As a result, these water levels are suitable for use for building design.

5.3 Block 201-203

Boreholes BH21-111 to BH 21-116 were drilled within Blocks 201 to 203.

Fill

Fill is present beneath the surface in the boreholes. This layer of fill generally extended to depths of 1.0 m to 4.9 m (Elevation 52.9 m to Elevation 49.4m) except in borehole BH21-114 where the fill extended to a depth of 9.8 m (Elevation 44.5 m). The fill generally consists of sand and gravel. It was also found to generally contain brick, concrete, metal and wood fragments as well as charred debris. The fill is very loose to very dense as indicated by SPT N-values of 3 to 81. In some boreholes, the SPT value is high for low sampler penetration; for example, N equals 50 blows for 25 mm sampler penetration. This may be a result of the sampler making contact with debris, cobbles or boulders within the fill. The moisture content of the fill ranges from 3 percent to 97 percent. The higher moisture contents may be the result of organic material (such as wood) embedded within the fill samples.

Ariel photos from the geoOttawa database were consulted and what appears to be channel or crevasse was present at the approximate location of Borehole BH21-114 in 1928. A Ground Penetrating Radar (GPR) survey was carried out by USL-1 at the location of borehole BH21-114. The survey noted a geophysical change near the location of borehole BH21-114 which may indicate the presence of a trench which runs in south/east to north/west alignment. The approximate location and extents of the trench has been included in Figure No. 2 and the USL-1 geophysical survey has been included as Appendix B.

Limestone Bedrock

Auger refusal was met in all the boreholes at depths ranging between 1.0 m to 4.9 m (Elevation 52.9 m to Elevation 49.4m). Washboring and rock coring was used to advance all the boreholes, except Borehole BH 21-114, to confirmed that refusal was met on bedrock. As noted above, Borehole BH21-114 was terminated upon auger refusal at 9.8 depth (Elevation 44.5 m) and therefore the bedrock at this location and vicinity may extend to a deeper depth and must be established as part of the detailed investigation. A summary of the auger refusal depths and the depth to bedrock confirmed by coring the bedrock are shown in Table VIII.

Table VIII: Summary of Block 201-203 Auger and Soil Sampler Refusal and Bedrock Depths (Elevations) in Boreholes

Borehole (BH) No.	Ground Surface Elevation (m)	Refusal Depth (Elevation) on Inferred Bedrock (m)	Depth (Elevation) of Bedrock Surface (m)	Comment wrt to Depth (Elevation) of Bedrock Surface
MW/BH21-111	53.89	1.0 (52.9)	1.0 (52.9)	4.8 m length of bedrock cored below 1.0 m depth
MW/BH21-112	54.04	2.8 (51.2)	2.8 (51.2)	6.1 m length of bedrock cored below 2.8 m depth
MW/BH21-113	54.30	2.6 (51.7)	2.6 (51.7)	3.6 m length of bedrock cored below 2.6 m depth
MW/BH21-114	54.29	9.8 (44.5)	Not Established	Bedrock not established – Possible Crevasse/Channel
MW/BH21-115	54.23	2.4 (51.8)	2.4 (51.8)	3.8 m length of bedrock cored below 2.4 m depth
MW/BH21-116	54.29	4.9 (49.4)	4.9 (49.4)	4.3 m length of bedrock cored below 4.9 m depth

Based on the bedrock coring results, the total core recovery (TCR) generally ranges from 84 percent to 100 percent. The rock quality designation (RQD) ranged from 52 percent to 100 percent indicating the bedrock quality ranging from fair to excellent.

In boreholes BH21-112 and BH21-115 the first coring runs had an RQD values of 33 and 42, respectively, indicating a rock quality of poor.

Unit weight determination and unconfined compressive strength tests were conducted on six (6) rock core sections and the results are summarized in Table IX. Photographs of the rock cores are shown in Appendix A.

Table IX: Summary of Block 201 to 203 Unconfined Compressive Strength Test Results – Bedrock Cores

Borehole (BH) No. – Run No.	Depth (m)	Unit Weight (kN/m^3)	Unconfined Compressive Strength (MPa)	Classification of Rock with respect to Strength
MW/BH21-111 - Run2	3.3 - 3.4	26.5	124.4	Very Strong
MW/BH21-112 - Run2	4.4 - 4.6	26.3	146.1	Very Strong
MW/BH21-113 - Run2	4.6 - 4.7	26.4	90.5	Strong
MW/BH21-115 - Run1	3.9 - 4.1	26.2	103.6	Very Strong
MW/BH21-115 - Run3	5.7 - 5.9	26.5	151.8	Very Strong
MW/BH21-116 - Run2	7.5 - 7.7	26.4	122.2	Very Strong

A review of the test results in Table IX indicates the strength of the rock may be classified as strong to very strong in accordance with the Canadian Foundation Engineering Manual (CFEM), Fourth Edition, 2006.

Groundwater Level Measurements

A total of six monitoring wells were installed in Blocks 201 to 203. A summary of the groundwater level measurements taken in the monitoring wells are shown in Table X.

Table X: Summary of Block 201-203 Groundwater Level Measurements

Borehole (BH) /Monitoring Well (MW) No.	Ground Surface Elevation (m)	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m
MW21-111	53.89	February 3, 2022 (52)	3.9 (50.0)	February 16, 2022 (65)	3.6 (50.3)
MW21-112	54.04	February 3, 2022 (52)	2.8 (51.2)	February 16, 2022 (65)	2.8 (51.2)
MW21-113	54.30	February 3, 2022 (55)	3.8 (50.5)	February 16, 2022 (68)	3.6 (50.7)
MW21-114	54.29	February 3, 2022 (55)	Dry	February 16, 2022 (68)	Dry

Table X: Summary of Block 201-203 Groundwater Level Measurements					
Borehole (BH) /Monitoring Well (MW) No.	Ground Surface Elevation (m)	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m
MW21-115	54.23	February 3, 2022 (55)	2.8 (51.4)	February 16, 2022 (62)	2.7 (51.5)
MW21-116	54.29	February 3, 2022 (55)	7.4 (46.9)	February 16, 2022 (62)	7.4 (46.9)

The groundwater level ranges from 2.7 m to 7.4 m (Elevation 51.5 m to Elevation 46.9 m) across Blocks 201 to 203. The well in borehole BH21-114 was dry.

Water levels were determined in the boreholes and monitoring wells at the times and under the conditions noted above. Fluctuations in the level of groundwater may occur due to a seasonal variation such as precipitation, snowmelt, rainfall activities, and other factors not evident at the time of measurement and therefore may be at a higher level during wet weather periods.

Based on the water levels measured in the monitoring wells and in the Ottawa River the groundwater measurements noted above are considered to be representative of actual site conditions and correspond well with mean water levels within the Ottawa River. As a result, these water levels are suitable for use for building design.

RECOMMENDATIONS AND DISCUSSION

6. Site Classification for Seismic Site Response and Liquefaction Potential of Soils

6.1 Site Classification for Seismic Site Response

The borehole information indicates that the subsurface conditions at the site consist of a surficial fill, which may include an asphaltic concrete layer which is underlain by limestone bedrock that was generally contacted at depths of 1.0 m to 4.9 m (Elevation 54.3 m to Elevation 49.4 m). In borehole BH21-114 auger refusal on inferred bedrock was encountered at 9.8 m (Elevation 44.5 m). Concrete may be present at the base of the fill layer/the surface of the bedrock.

The anticipated founding depth of the footing is assumed to be approximately at 3.0 m to 6.0 m in depth, depending on the number of underground parking levels.

In 2018 Patterson investigation titled "Geotechnical Investigation - Proposed Mixed Use Development - Phase 1", a Multi-channel Analysis of Surface Waves (MASW) survey was carried out near block 206 and determined that the bedrock underlying the fill has a shear wave velocity of 2,472 m/s. The approximate location of the shear wave velocity line is included in Figure 2 and is considered to be applicable for this site. In 2019 EXP also carried out a MSAW as part of the geotechnical investigation for a proposed structure on Block 211. The MASW survey indicates that the average seismic shear wave velocity for Block 211 is 1,870 m/s. The results of the geophysical survey are included in Appendix C.

Based on a review of Table 4.1.8.4.A of the 2012 Ontario Building Code (OBC), for average shear wave velocities of 1,870 m/s or 2,472 m/s, for a foundation founded directly on the sound bedrock surface, the site can be classified as **Class A** for seismic site response.

6.2 Liquefaction Potential of Soils

It is anticipated that all subsurface soils on site, consisting of the existing fill, will be excavated down to the bedrock and removed from site for the construction of the proposed new buildings. Since all subsurface soils will be excavated and removed from the site, liquefaction of the soils on site during a seismic event is not a concern.

7. Grade Raise Restrictions

From a geotechnical perspective there are no restrictions to raising the grades at the site since it is anticipated that all subsurface soils will be excavated down to the bedrock, removed from the site and replaced with either imported granular fill (compacted to the specified degree of compaction indicated in this report) or backfilled with concrete. EXP however should be consulted to review the final grading plan.

8. Foundation Considerations

General Considerations

Based on a review of the available design information and borehole data, it is considered that the appropriate foundation to support the proposed buildings with multi-levels of underground parking is spread and strip footings founded on the sound limestone bedrock contacted below any fractured or weathered zones contacted. The design depth is 3.0 m to 6.0 m below the existing ground surface.

Spread and strip footings founded on the sound bedrock, competent and free of soil filled seams may be designed for a factored geotechnical resistance at Ultimate Limit State (ULS) of 3000 kPa and 5000 kPa depending on the amount of inspection and testing undertaken during construction. The factored ULS value includes a resistance factor of 0.5. Factored geotechnical resistance at ULS of 3000 kPa would require only visual inspection of the footing beds. The use of factored geotechnical resistance at ULS of 5000 kPa would require star drilling and probing of all the spread and strip footings (minimum 50 mm diameter hole may be used, with its depth equal to at least twice the footing width). The strip footings should be star drilled and probed at 3 m intervals. The Serviceability Limit State (SLS) bearing pressure of the bedrock, required to produce 25 mm settlement of the structure will be much larger than the recommended value for factored geotechnical resistance at ULS. Therefore, the factored geotechnical resistance at ULS will govern the design.

The factored sliding resistance at ULS between the underside of concrete and the top of the unweathered sound bedrock is 0.56 and includes a resistance factor of 0.8.

Settlements of footing designed for the above recommended factored geotechnical resistance at ULS and properly constructed are expected to be less than 10 mm.

All the footing beds should be thoroughly examined by a geotechnical engineer to ensure that the bedrock area is capable of supporting the design ULS value. Where fractured rock is encountered, sub-excavation may be undertaken to the underlying more competent bedrock. Alternatively, the footings may be redesigned to a reduced factored geotechnical resistance at ULS.

A minimum of 1.5 m of earth cover should be provided to exterior footings of heated structures to protect them from damage due to frost penetration. The frost cover should be increased to 2.1 m for unheated structures if snow will not be removed from the vicinity of the footing and 2.4 m of earth cover if snow will be removed from the vicinity of the footing. In areas where earth cover will be less than the required, rigid insulation may be used to protect the footings. Alternatively, a combination of earth cover and rigid insulation may also be used to protect the footings. For this project it is anticipated that the required earth cover for the footings of the proposed buildings will be satisfied, since the footings are anticipated to be at depths greater than 1.5 m below the final grade.

The recommended factored geotechnical resistance at ULS has been calculated by EXP from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field monitoring provided by an experienced geotechnical engineer to validate the information for use during the construction stage.

Blocks 201 to 203

In borehole BH21-114, drilled within Blocks 201 to 203, fill extended to depth of 9.8 m and the elevation of the bedrock was not established. Based on the aerial photographs and the MSAW results the borehole is located within a previous drainage channel or crevasse. The extents of the channel/crevasse have been estimated as part of the MASW survey. As part of the detailed geotechnical investigation, the elevation of the bedrock in the vicinity of the borehole must be established as well as the extent of the channel. For founding purposes, all fill must be removed from this area and replaced with 30 MP concrete to the proposed underside of footing elevation. Similar treatment will be required in areas where fill extended below the proposed founding level or in areas where bedrock need to be excavated to reach a sound founding medium.

8.1 Uplift Resistance for Footings

Rock anchors may be required for the footings to resist uplift forces. Additional design data can be provided as part of the detailed investigation once the location and number of parking levels of the proposed structures are known.

9. Floor Slab and Drainage Requirements

Based on the preliminary concept plans proposed for the site, the lowest floor level of the parking garages will be set at depths of 3.0 to 6.0 m (Elev. 51.8 m to 47.5 m). Based on the borehole information, the lowest floor slabs of the buildings will be generally founded on, or just above the limestone bedrock or on concrete infill as noted above. The lowest floor level may be constructed as slab-on-grades constructed on granular fill which will be used as backfill following the construction of the footings. The slab must be cast on a 200 mm thick of 19 mm stone or on granular A overlain by a vapour barrier to prevent capillary rise of the moisture into the slabs.

For preliminary consideration, it is anticipated that underfloor and perimeter drainage systems will be required for the structures and should best established once the final concept plan is known (i.e. number of underground levels, etc.).

10. Lateral Earth Pressures Against Basement Walls

10.1 Building with Permanent Drainage Systems

If the space between the subsurface walls and the rock face is to be backfilled, the subsurface walls will be subjected to lateral static earth pressure as well as lateral dynamic earth pressure during a seismic event. The subsurface basement walls will be subjected to lateral static earth pressure as well as lateral seismic (dynamic) earth pressure during a seismic event. The lateral static earth pressure that the subsurface walls would be subjected to may be computed from equations (i) and (ii) below and the lateral seismic (dynamic) earth force from equation (iii) given below.

The equations given below assume that the backfill against the subsurface walls will be free-draining granular material and that subsurface drains will be provided to prevent build-up of hydrostatic pressure behind the wall. Equation (i) will be applicable to the portion of the subsurface wall in the overburden (soil). Equation (ii) will be applicable to the portion of the subsurface wall in the bedrock where the earth pressure will be considerably reduced due to the narrow backfill between the subsurface wall and the rock face resulting in an arching effect (Spangler & Handy, 1984).

Lateral static earth pressure, p:

$$p = k(\gamma h + q) \quad \text{---------- (i)}$$

where

k = lateral earth pressure coefficient for 'at rest' condition = 0.50
γ = unit weight of backfill = 22 kN/m^3
h = depth of interest below ground surface (m)
q = any surcharge acting at ground surface (kPa)

Lateral static earth pressure (σ_n) due to narrow earth backfill between subsurface wall and rock face at depth z:

$$\sigma_n = \frac{\gamma B}{2\tan\delta}\left(1 - e^{-2k\frac{z}{B}\tan\delta}\right) + kq \quad \text{---------- (ii)}$$

where

γ = unit weight of backfill = 22 kN/m^3
B = backfill width (m)
z = depth from top of wall (m)
δ = friction angle between the backfill and wall and rock (assumed to be equal) = 17 degrees
k = lateral earth pressure coefficient for 'at rest' condition = 0.50
q = surcharge pressure including pressures from overburden (soil), traffic at ground surface and foundations from existing adjacent buildings (kPa)

The lateral dynamic earth force (dynamic thrust) due to seismic loading may be computed from the equation given below:

$$\Delta_{Pe} = \gamma H^2 \frac{a_h}{g} F_b \quad \text{----------(iii)}$$

where Δ_{Pe} = dynamic thrust in kN/m of wall

H = height of basement wall (m)

γ = unit weight of soil = 22 kN/m^3

$\frac{a_h}{g}$ = seismic coefficient = 0.32 (Ottawa area)

F_b = thrust factor = 1.0

The dynamic thrust acts approximately at 0.63H above the base of the wall.
All subsurface walls should be waterproofed.

11. Excavations and De-Watering Requirements

11.1 Excess Soil Management

Ontario Regulation 406/19 specifies protocols that are required for the management and disposal of excess soils. As set forth in the regulation, specific analytical testing protocols need to be implemented and followed based on the volume of soil to be managed and the requirements of the receiving site. The testing protocols are specific as to whether the soils are stockpiled or in situ. In either scenario, the testing protocols are far more onerous than have been historically carried out as part of standard industry practices. These decisions should be factored in and accounted for prior to the initiation of the project-defined scope of work. EXP would be pleased to assist with the implementation of a soil management and testing program that would satisfy the requirements of Ontario Regulation 406/19. Reference should be made to the Phase II ESA completed for the site in conjunction with this investigation to manage the excess soils

11.2 Excavations

11.2.1 Overburden Soil Excavation

Excavation of the soils may be undertaken using heavy equipment capable of removing debris as well as cobbles, boulders and within fill as well as the removal of fill and debris form the deep channel likely present in the vicinity of BH 21-114.

All excavations must be undertaken in accordance with the Occupational Health and Safety Act (OHSA), Ontario Reg. 213/91. Based on the definitions provided in OHSA, the subsurface soils on site are considered to be Type 3 and as such must be cut back at 1H:1V from the bottom of the excavation above the groundwater level. Within zones of persistent seepage and below the groundwater level in the soils, the excavation side slopes are expected to slough and eventually stabilize at a slope of 2H:1V to 3H:1V.

It is anticipated that due to the significant depth of the excavation for the proposed buildings and the proximity of the excavation to existing buildings and infrastructure, the excavations will likely have to be undertaken within the confines of a shoring system. The shoring system may consist of steel H soldier pile and timber lagging system, interlocking sheeting system and/or secant pile shoring system. The most appropriate type of showing will be best established once the final conceptual plans are available, especially where the development about the water channels.

The type of shoring system required would depend on a number of factors including:

- Proximity of the excavation to existing structures and infrastructure;
- Type of foundations of the existing adjacent buildings and the difference in founding levels between the foundations of new buildings and existing adjacent buildings; and
- The subsurface soil, bedrock and groundwater conditions.

A conventional shoring system consisting of soldier pile and timber lagging is more flexible compared to the interlocking steel sheeting system and the secant pile shoring system. In areas where there is concern for lateral yielding of the soils and the potential of settlement of nearby structures and infrastructure, the use of a steel interlocking sheeting system or secant pile system can be considered. The shoring system will require lateral restraint provided by tiebacks consisting of rock anchors. Due to the presence of cobbles and boulders in the subsurface soils, pre-drilling may be required for the installation of the soldier piles. The presence of cobbles and boulders in the subsurface soils should also be taken into consideration for other contemplated shoring systems.

The need for a shoring system, the most appropriate shoring system and the design and installation of the shoring system should be determined by the contractors bidding on this project. The design and installation of the shoring system should be undertaken by a professional engineer experienced in shoring design and by a contractor experienced in the installation of shoring systems. The shoring system should be designed and installed in accordance with OHSA and the 2006 CFEM (Canadian Foundation Engineering Manual (Fourth Edition)).

Soldier Pile and Timber Lagging System

A conventional steel H soldier pile and timber lagging shoring system must be designed to support the lateral earth pressure given by the expression below:

$P = k(\gamma h + q)$

where P = the pressure, at any depth, h, below the ground surface

k = applicable earth pressure coefficient; active lateral earth pressure coefficient = 0.33
'at rest' lateral earth pressure coefficient = 0.50

γ = unit weight of soil to be retained, estimated at 22 kN/m^3

h = the depth, in metres, at which pressure, P, is being computed

q = the equivalent surcharge acting on the ground surface adjacent to the shoring system

The pressure distribution assumes that drainage is permitted between the lagging boards and that no build-up of hydrostatic pressure may occur.

The shoring should be designed using appropriate 'k' values depending on the location of any settlement-sensitive infrastructure (roadways and underground services) and building structures. The traffic loads on the streets should be considered as surcharge. Soldier piles will need to extend into the sound rock below the soils. For guidance, if there is room to permit at least a 1.0 m of rock ledge around the perimeter of the excavation, the soldier piles could be toed into the upper levels of the rock provided that a rock bolt and plate arrangement is installed on the rock face to support the toe. The rock bolt should be designed to take the full toe pressure.

The shoring system as well as adjacent settlement sensitive structures and infrastructure should be monitored for movement (deflection) on a periodic basis during construction operations.

The shoring system will require lateral restraint by tiebacks in the form of grouted rock anchors designed as part of the detailed investigation once the location and number of parking levels of the proposed structures are known.

Many geologic materials deteriorate rapidly upon exposure to meteorological elements. Unless otherwise specifically indicated in this report, walls and floors of excavations must be protected from moisture, desiccation, and frost action throughout the course of construction.

Secant Pile Shoring System

The secant pile shoring system should be designed to resist 'at rest' lateral earth thrust in addition to the hydrostatic thrust as given by the expression below:

$$P_0 = K_O\, q\, (h_1 + h_2) + \frac{1}{2} K_0\, \gamma\, h_1^2 + K_0\, \gamma\, h_1 h_2 + \frac{1}{2} K_0\, \gamma'\, h_2^2 + \frac{1}{2} \gamma_w\, {h_2}^2$$

where:

P_0 = at rest' earth and water thrusts acting against secant pile wall (kN/m)

K_0 = 'at rest' lateral earth pressure coefficient = 0.50

q = surcharge acting adjacent to the excavation (kPa)

h_1 = height of shoring from the ground surface to groundwater table (m)

h_2 = height of shoring from groundwater table to the bottom of excavation (m)

γ = unit weight of the soil = 22 kN/m^3

γ' = submerged unit weight of soil = 11.2 kN/m^3

γ_w = unit weight of water = 9.8 kN/m^3

Secant pile walls consist of overlapping concrete piles that form a strong watertight barrier. They can be constructed with conventional drilling methods. Secant pile walls typically include both reinforced primary and un-reinforced secondary piles. The primary piles overlap the secondary piles, with secondary piles essentially acting as concrete lagging. The reinforcement in the primary piles generally consists of steel reinforcing bar cages or steel beams. The result is a continuous intersecting line of concrete piles that are placed before any excavation is performed.

The shoring systems should be tied back by rock anchors grouted into the sound bedrock. The factored ULS grout to rock bond of 700 kPa may be used for design of the anchors. This value assumes a grout with a minimum strength of 30 MPa is used and that the sides of the drilled holes are cleaned prior to the grouting operation. It is anticipated that the bedrock may contain near vertical seams and some horizontal fractures and therefore some grout loss when grouting anchors in the bedrock should be anticipated. The grout loss is expected to be higher in the fractured bedrock and lower in the sound bedrock. Difficulties may be encountered during the installation of the rock anchors due to the presence of debris (such as brick and wood) and boulders/cobbles within the fill.

If the rock anchors extend into adjacent properties, permission will be required from the adjacent property owners for the installation of the tiebacks. If permission is not granted, the shoring system may be braced by cross bracing or the use of rakers on the inside of the shored excavation.

Design anchors should be load tested to two times the design capacity. All anchors should be proof tested to 1.33 times the working load. The anchor should be locked off at working load plus an allowance for relaxation (usually 10 percent). When installing tie backs, casing would be required to advance through the fill and the native soil. The deflection of the shoring system should be carefully monitored during construction

A conventional steel H soldier pile and timber lagging shoring system must be designed to support the lateral earth pressure given by the expression below

11.2.2 Rock Excavation

The excavations are anticipated to extend into the bedrock surface and may be excavated using a hoe ram for removal of small quantities of the bedrock; however, this process is expected to be very slow. The excavation side slopes in the weathered and limestone bedrock may be undertaken near vertical but may need be cut back at a 1H:1V gradient in zones of loose rock pieces/slabs.

The excavation of the limestone bedrock to extensive depths below the bedrock surface will likely require line drilling and blasting techniques. Contractors bidding on this project should decide on their own the most preferred rock removal method; hoe ramming or line drilling and blasting.

Rock Support

Excavations within the weathered bedrock may be undertaken with near vertical sides subject to review by a geotechnical engineer. The weathered and fractured rock face may require support in the form of rock bolts to maintain the integrity of the rock face in conjunction with a wire mesh system and the shotcrete mentioned above. Excavations that will extend a significant depth into the bedrock will have to be undertaken in a staged approach with the rock excavated in a pre-determined depth interval (for example every 3 m). The exposed rock face in each stage will have to be examined by a geotechnical engineer to determine the number of rock bolts required. The rock bolt system should be installed in this manner to the bottom of the excavation.

Vibration Control

The vibration limits for blasting should be in accordance with City of Ottawa Special Provisions (SP No. 1201).

It is recommended that a pre-construction survey of adjacent building(s) and infrastructure be undertaken prior to any earth (soil) and rock excavation work as well as vibration monitoring during excavation, blasting and construction operations. Prior to the commencement of blasting, a detailed blast methodology should be submitted by the Contractor.

11.3 De-Watering Requirements and Impact of Groundwater Lowering on Adjacent Structures

A hydrogeological study has been carried out by EXP concurrently to the geotechnical and environmental studies. Please refer to this report for full details of this study.

A Permit to Take Water (PTTW) has been issued for the site.

12. Backfilling Requirements and Suitability of On-Site Soils for Backfilling Purposes

The soils to be excavated from the site will comprise of fill with a variable composition. From a geotechnical perspective, these soils are not considered suitable for reuse as backfill material in the interior or exterior of the building. Therefore, it is anticipated that the majority of the material required for backfilling purposes in the interior and exterior of the proposed buildings and in the service trenches will need to be imported and should preferably conform to OPSS 1010 (as amended by SSP110S13) for Granular B Type II. The generated bedrock may be also crushed and used as granular fill as per the practices that have been used for other projects within the Zibi development.

Management of excess soils generated from the site must be undertaken as per the recommendation stated in the Phase II ESA completed for this site

13. Tree Planting Restrictions

It is anticipated that all subsurface soils on site including the fill and native soils will be excavated down to the bedrock and removed from site for the construction of the proposed new buildings. Since all subsurface soils will be excavated and removed from the site, there are no tree planting restrictions from a geotechnical perspective.

14. Additional Recommendations and Studies

All earthwork activities from subgrade preparation to placement and compaction of engineered fill, fill in service trenches, placement and compaction of granular materials and asphaltic concrete, should be inspected by qualified geotechnicians to ensure that construction proceeds according to the project specifications.

All the footing beds should be examined by a geotechnical engineer to ensure that the founding surfaces are capable of supporting the design bearing pressure and that the footing beds have been properly prepared.

All the aspects related to the geotechnical aspects of the project should be submitted to EXP for review and comment.

15. General Comments

The comments and recommendations given in this report are preliminary in nature as they are based on the assumption that the above-described design concepts will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations or it may require additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint. This geotechnical report should be updated once final design for the proposed development is available.

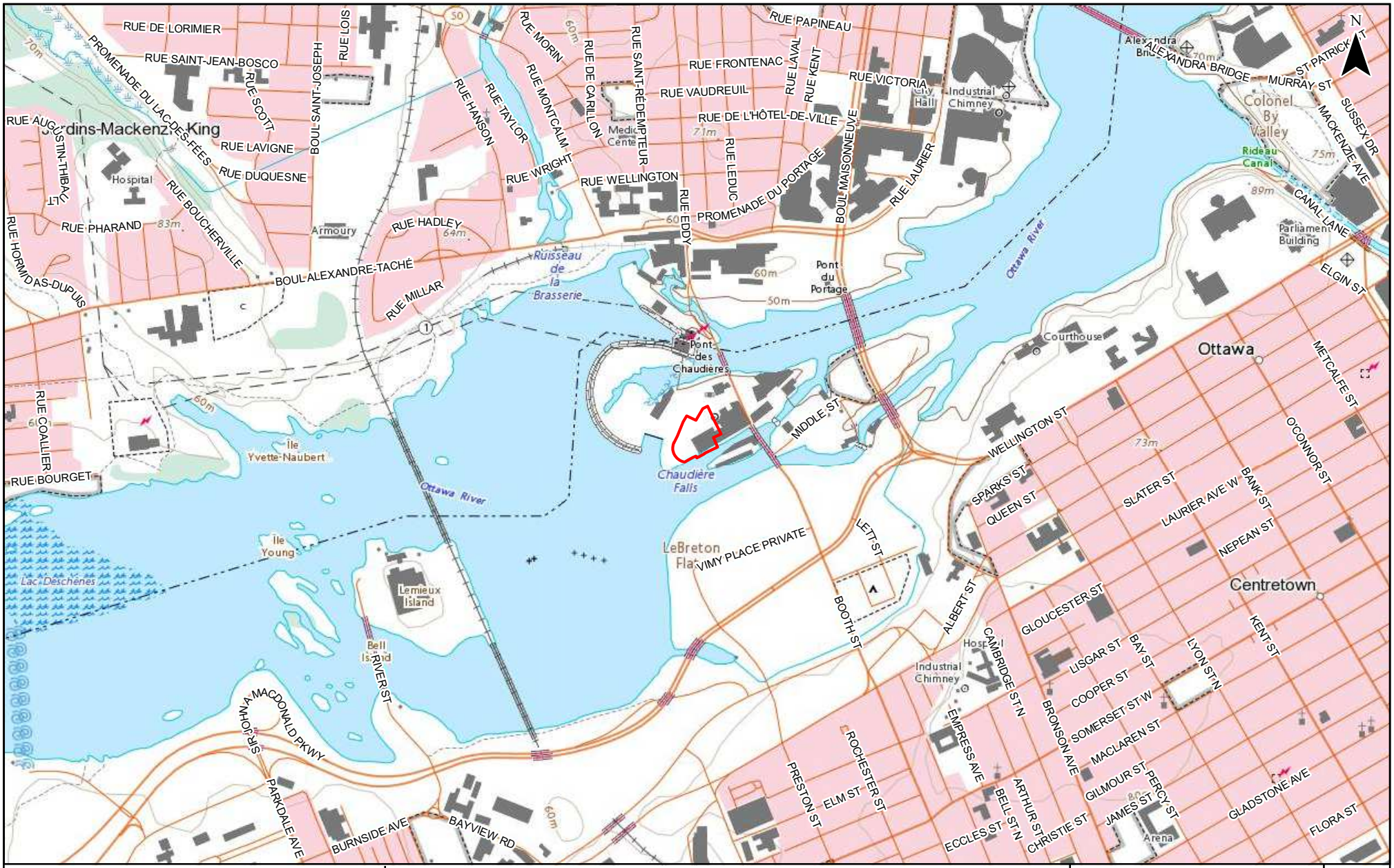
The information contained in this report is not intended to reflect on environmental aspects of the soils and groundwater. Reference is made to the Hydrogeological Assessment and Phase Two Environmental Site Assessment (ESA) reports completed by EXP for the site regarding the environmental aspects of the soil and groundwater.

We trust that the information contained in this report will be satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Daniel Wall, M. Eng., P.Eng.
Geotechnical Engineer
Earth and Environment

Ismail M. Taki, M.Eng., P.Eng.
Senior Manager, Eastern Region Services
Earth and Environment

Figures



SCALE:

0 150 300 450 600 750 m

LEGEND:

APPROXIMATE SITE BOUNDARY

SITE LOCATION PLAN

FIGURE: 1

GEOTECHNICAL INVESTIGATION
BLOCKS 201, 202, 203, 204 & 205B
CHAUDIÈRE ISLAND, OTTAWA

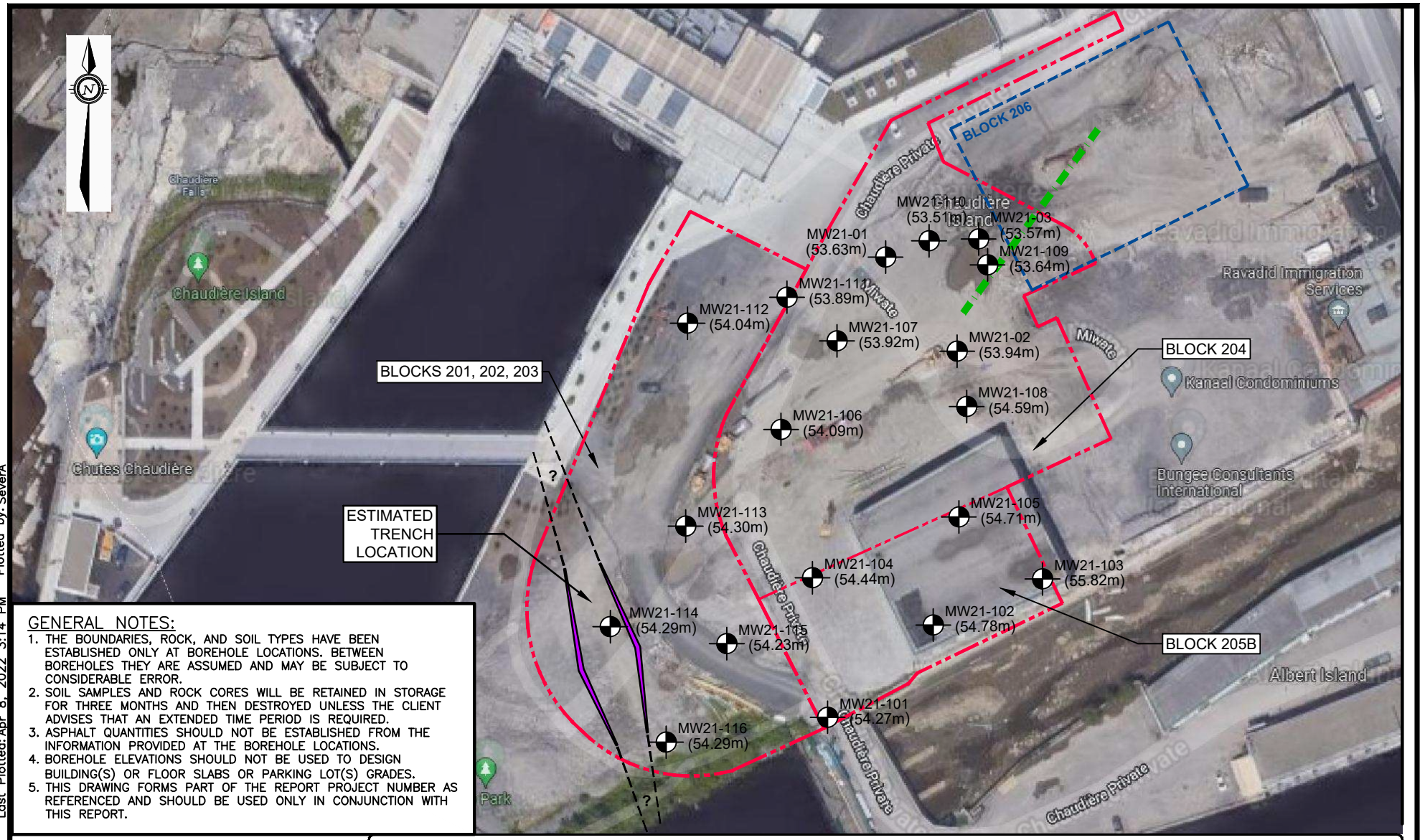
exp.

DRAWN BY: JA

CHECKED BY: PS

PROJECT NUMBER: OTT-00250193-S0

DATE: MARCH 2022



GENERAL NOTES:

1. THE BOUNDARIES, ROCK, AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. SOIL SAMPLES AND ROCK CORES WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. ASPHALT QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE BOREHOLE LOCATIONS.
4. BOREHOLE ELEVATIONS SHOULD NOT BE USED TO DESIGN BUILDING(S) OR FLOOR SLABS OR PARKING LOT(S) GRADES.
5. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.

LEGEND

- BLOCKS BOUNDARIES
- MW21-01 — BOREHOLE WITH MONITORING WELL
- APPROX. MASW LOCATION (Patterson, 2018)

0 10m 20m 50m

HORIZONTAL 1:1250

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DATE: APRIL 7, 2022
DESIGN: DW | CHECKED: IT
DRAWN BY: AS

GEOTECHNICAL INVESTIGATION

CHAUDIERE ISLAND, OTTAWA, ONTARIO

BOREHOLE LOCATION PLAN

project no. OTT-00250193-S0
scale 1:1,125
FIG 2

Filename: \\exp\data\OTT\OTT-00250193-S0\60 Execution\65 Drawings_Envi\OTT-00250193-S0_BHMW Locations.dwg
Last Saved: Apr 8, 2022 3:13 PM Last Plotted: Apr 8, 2022 3:14 PM Plotted by: SeverA

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N

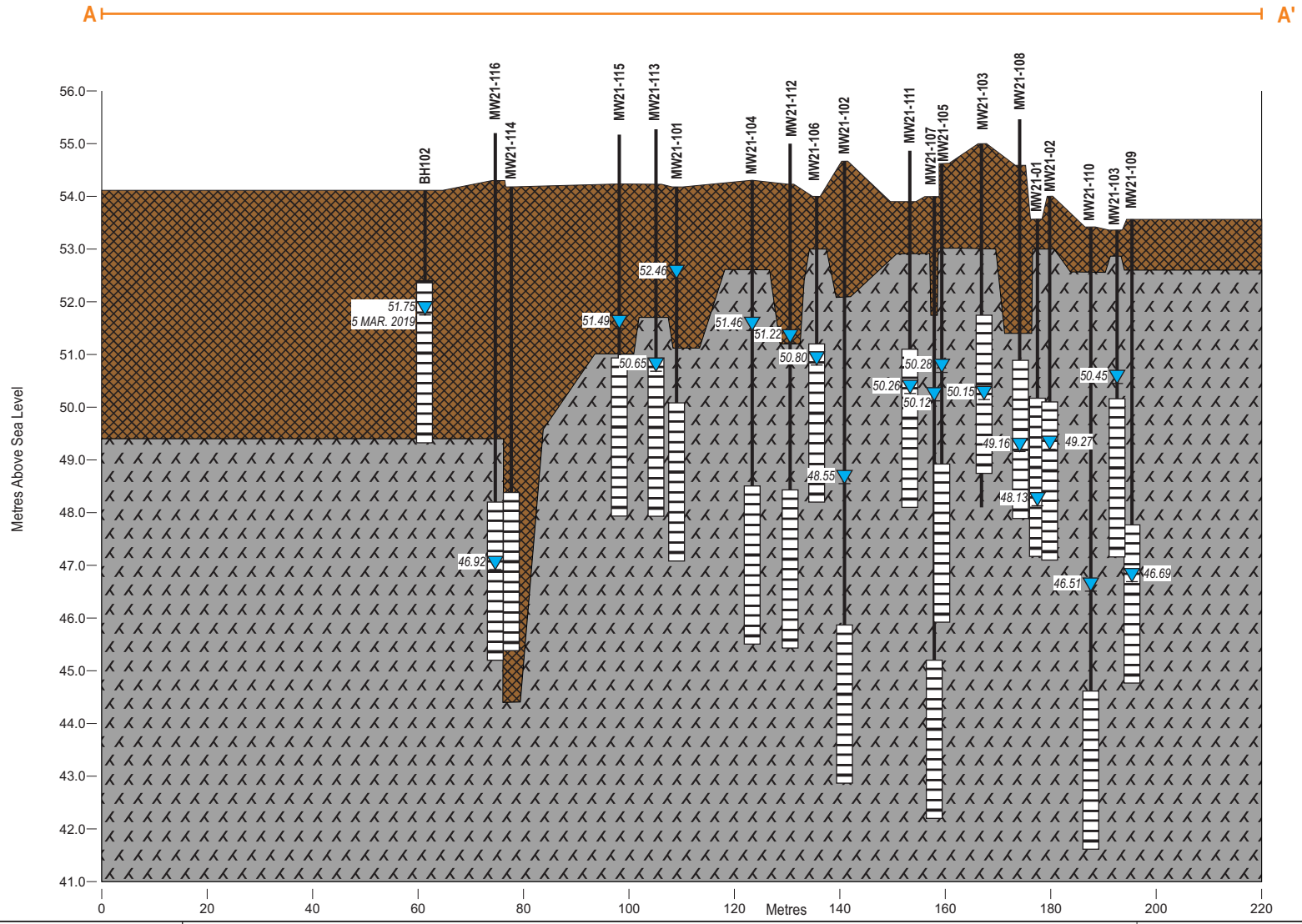
0 10 20 30 40 50 m

TITLE AND LOCATION:

CROSS SECTION PLAN

Chaudière Island, Ottawa

PROJECT No.: OTT-00250193-S0	DWN: JA
SCALE: AS NOTED	CHKD: LW
DATE: JANUARY 2022	FIG. No.: 3



SCALE:
10 X VERTICAL EXAGGERATION

SOURCE:
BASED ON FIELD MEASUREMENTS BY EXP STAFF

DRAWN BY	CHECKED BY
K.G.	L.W..

LEGEND:

- TEST HOLE
- SCREEN INTERVAL
- GROUND WATER ELEVATION (FEBRUARY 16, 2022)
- masl METRES ABOVE SEA LEVEL
- FILL
- LIMESTONE BEDROCK

CROSS SECTION A-A'

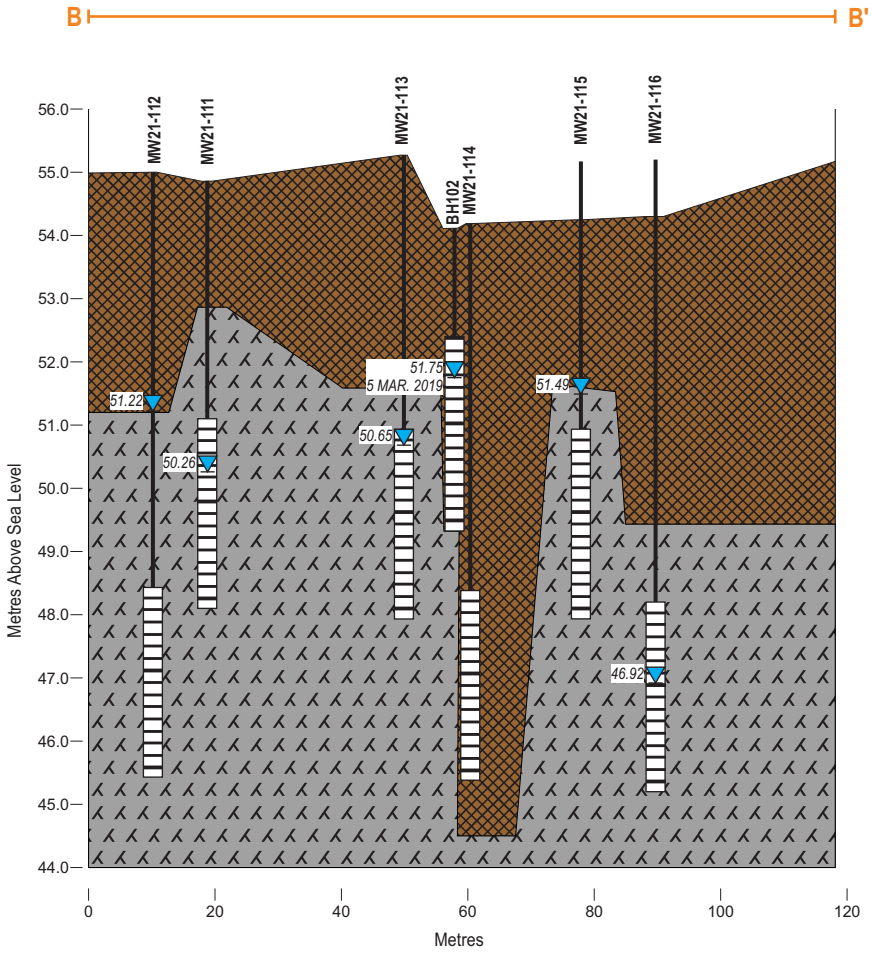
4

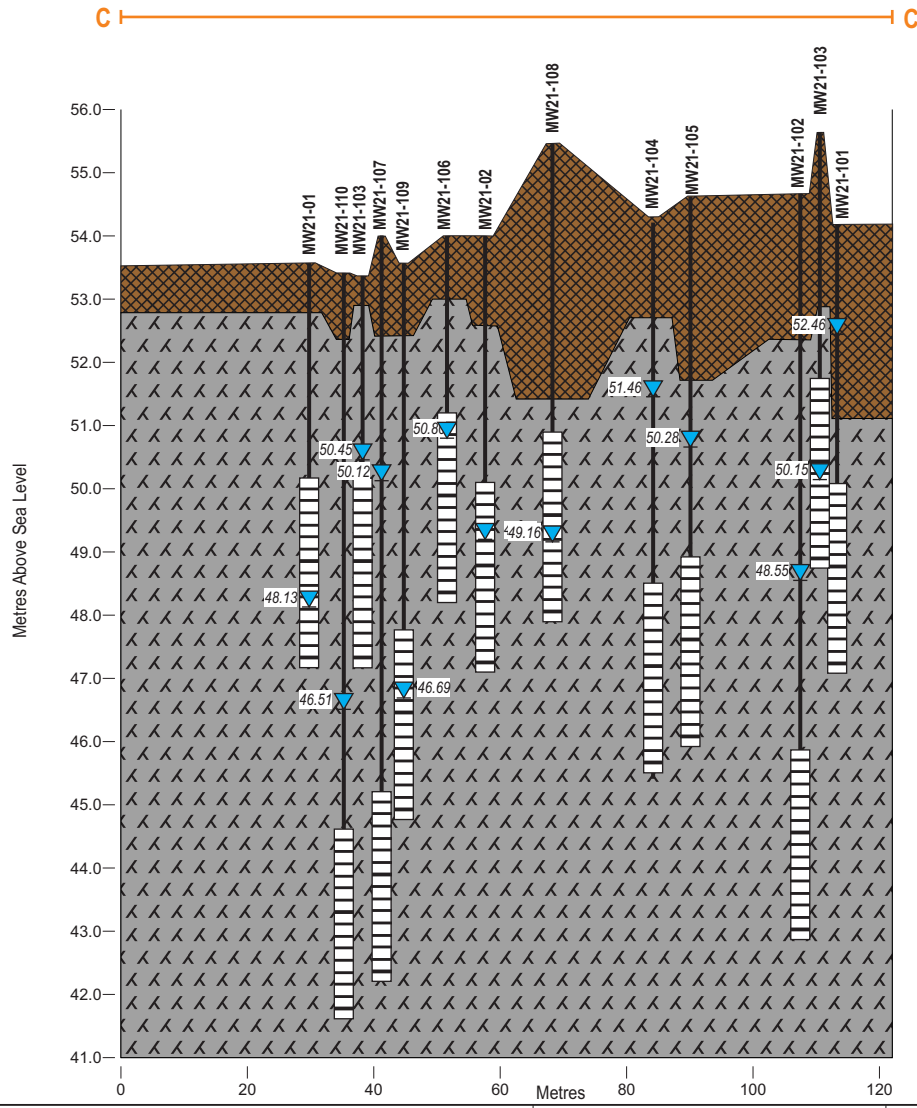
CHAUDIÈRE ISLAND,
OTTAWA, ONTARIO

PROJECT NUMBER: OTT-00250129-S0

DATE: MARCH 2022

250193-S0 SEC A-MAR22





SCALE:
10 X VERTICAL EXAGGERATION

SOURCE:
BASED ON FIELD MEASUREMENTS BY EXP STAFF

DRAWN BY	CHECKED BY
K.G.	L.W.

LEGEND:

- TEST HOLE
- SCREEN INTERVAL
- GROUND WATER ELEVATION (FEBRUARY 16, 2022)
- masl METRES ABOVE SEA LEVEL
- FILL
- LIMESTONE BEDROCK

CROSS SECTIONS B-B' AND C-C'

5

CHAUDIÈRE ISLAND,
OTTAWA, ONTARIO

PROJECT NUMBER: OTT-00250129-S0

DATE: MARCH 2022

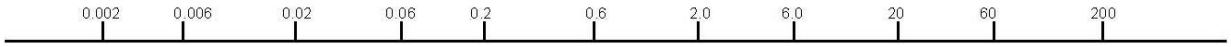
250193-S0 SEC B_C-MAR22

Notes On Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Societv for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by **exp** Services Inc. also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		



EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Log of Borehole MW21-102

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 6

Page. 1 of 2

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 16th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠
Auger Sample ▮▯
SPT (N) Value ○
Dynamic Cone Test ——
Shelby Tube ■
Shear Strength by Vane Test +S

Combustible Vapour Reading □
Natural Moisture Content ×
Atterberg Limits —○—
Undrained Triaxial at % Strain at Failure ⊕
Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		FILL Sand and gravel, with cobbles, boulders, brick and metal fragments and charred material, brown, moist, some odours or stains, (compact to very dense)	54.78	0
				1
				2
			51.9	3
		CONCRETE ~ 200 mm	51.7	
		LIMESTONE BEDROCK Limestone with shale partings, fair to good quality , grey, fresh to slightly weathered		4
				5
				6
			48.58	7
				8
				9
				10

Standard Penetration Test N Value: 20 40 60 80
Shear Strength kPa: 50 100 150 200
Combustible Vapour Reading (ppm): 250 500 750
Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

60 then 50/100 mm
0
0
34
5
16
35

SAMPLES: AS1, SS1, SS2, SS3, RUN 1, RUN 2, RUN 3, RUN 4, RUN 5

Natural Unit Wt. kN/m³

Continued Next Page

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	6.5	
'February 16th, 2022	6.2	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	2.9 - 4.5	92	63
2	4.5 - 6	100	59
3	6 - 7.5	98	66
4	7.5 - 9	100	75
5	9 - 10.5	98	79
6	10.5 - 12	100	88

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

Log of Borehole MW21-102

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 6

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa (20 40 60 80 / 50 100 150 200)	Combustible Vapour Reading (ppm) 250 500 750 / Natural Moisture Content % Atterberg Limits (% Dry Weight) 20 40 60	SAMPLES	Natural Unit Wt. kN/m³
		LIMESTONE BEDROCK Limestone with shale partings, fair to good quality , grey, fresh to slightly weathered *(continued)*	44.78	10				
				11				RUN 6
			42.8	12				
		Borehole Terminated at 12.0 m Depth						

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
February 3rd, 2022	6.5	
February 16th, 2022	6.2	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	2.9 - 4.5	92	63
2	4.5 - 6	100	59
3	6 - 7.5	98	66
4	7.5 - 9	100	75
5	9 - 10.5	98	79
6	10.5 - 12	100	88

Log of Borehole MW21-104

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 7

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 14th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠ | Auger Sample ▮▯ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits —○— | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		ASPHALT ~ 50mm	54.44	0
		FILL Sand and gravel, brown, moist, no odours, no stains, (compact)	54.4	
				1
				2
		LIMESTONE BEDROCK Limestone with shale partings, poor to excellent quality , grey, fresh to slightly weathered	52.5	
			51.44	3
				4
				5
				6
				7
				8
		Borehole Terminated at 9.0 m Depth	45.4	9

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60

28

23 then 50/0 mm

0

SAMPLES	Natural Unit Wt. kN/m³
AS1	
SS1	
SS2	
RUN 1	
RUN 2	
RUN 3	
RUN 4	
RUN 5	

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	3.0	
'February 16th, 2022	3.0	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1.9 - 3	96	32
2	3 - 4.5	92	73
3	4.5 - 6	98	61
4	6 - 7.5	100	92
5	7.5 - 9	100	97

Log of Borehole MW21-105

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 8

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 14th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test (S)
Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		ASPHALT ~ 50mm	54.71	0
		FILL Sand and gravel, with concrete fragments, brown, moist, odour and staining present, (very dense)	54.7	
			51.8	
		CONCRETE INFILLED LIMESTONE BEDROCK ~ 300 mm	51.5	3
		LIMESTONE BEDROCK Limestone with shale partings, fair to excellent quality , grey, fresh to slightly weathered	50.31	4
		Borehole Terminated at 8.9 m Depth	45.8	8

Standard Penetration Test N Value: 20 40 60 80
Shear Strength kPa: 50 100 150 200
Combustible Vapour Reading (ppm): 250 500 750
Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60

50/150 mm
43 then 50/75 mm
88
0
5
25
25

SAMPLES	Natural Unit Wt. kN/m³
AS1	
SS1	
SS2	
SS3	
RUN 1	
RUN 2	
RUN 3	
RUN 4	

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	4.5	
'February 16th, 2022	4.4	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	2.9 - 4.4	100	85
2	4.4 - 5.9	100	100
3	5.9 - 7.5	98	78
4	7.5 - 8.9	100	75

Log of Borehole MW21-106

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 9

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 14th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠ | Auger Sample ▮▯ | SPT (N) Value ○ | Dynamic Cone Test ——— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○⊣ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		ASPHALT ~ 50mm	54.09	0				
		FILL Sand and gravel, trace clay, brown, moist, no odours, no stains	54.0					AS1
			53.0	1	10 then 50/75 mm			SS1
		LIMESTONE BEDROCK Limestone with shale partings, fair to good quality , grey, fresh to slightly weathered		2				RUN 1
			50.79	3				RUN 2
				4				
				5				RUN 3
			48.2					
		Borehole Terminated at 5.9 m Depth						

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	3.7	
'February 16th, 2022	3.3	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1.1 - 2.6	100	68
2	2.6 - 4.3	100	69
3	4.3 - 5.9	100	87

Log of Borehole MW21-107

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 10

Page. 1 of 2

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 13th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠
Auger Sample ▮▯
SPT (N) Value ○
Dynamic Cone Test ——
Shelby Tube ■
Shear Strength by Vane Test +S

Combustible Vapour Reading □
Natural Moisture Content ×
Atterberg Limits —⊖—
Undrained Triaxial at % Strain at Failure ⊕
Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		ASPHALT ~ 50mm	53.92	0
		FILL Sand and gravel, with asphalt and wood fragments, brown to grey, moist, no odours, no stains	53.9	
			52.9	1
		LIMESTONE BEDROCK Limestone with shale partings, good to excellent quality , grey, fresh to slightly weathered		2
			50.12	3
				4
				5
				6
				7
				8
				9
				10

Standard Penetration Test N Value: 20 40 60 80
Shear Strength kPa: 50 100 150 200
Combustible Vapour Reading (ppm): 250 500 750
Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60

5 then 50/75mm

0

0

SAMPLES	Natural Unit Wt. kN/m³
AS1	
SS1	
RUN 1	
RUN 2	
RUN 3	
RUN 4	
RUN 5	
RUN 6	

Continued Next Page

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	4.1	
'February 16th, 2022	3.8	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1 - 2.6	97	76
2	2.6 - 4.3	100	99
3	4.3 - 5.8	100	98
4	5.8 - 7.4	100	90
5	7.4 - 8.9	97	97
6	8.9 - 10.4	100	91
7	10.4 - 11.9	100	93

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

Log of Borehole MW21-107

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 10

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		LIMESTONE BEDROCK Limestone with shale partings, good to excellent quality , grey, fresh to slightly weathered *(continued)*	43.92	10	20 40 60 80 / 50 100 150 200	250 500 750 / 20 40 60		
				11			RUN 7	
		Borehole Terminated at 11.9 m Depth	42.0					

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
February 3rd, 2022	4.1	
February 16th, 2022	3.8	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1 - 2.6	97	76
2	2.6 - 4.3	100	99
3	4.3 - 5.8	100	98
4	5.8 - 7.4	100	90
5	7.4 - 8.9	97	97
6	8.9 - 10.4	100	91
7	10.4 - 11.9	100	93

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

Log of Borehole MW21-108

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 11

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 15th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠ | Auger Sample ▮▯ | SPT (N) Value ○ | Dynamic Cone Test ——— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Sand and gravel, some clay, with concrete fragments and charred material, brown, moist, slight odour present, no stains, (loose to very dense)	54.59	0		0	AS1	
				1	85	5	SS1	
				2	12	0	SS2	
					6	0	SS3	
			51.4	3	50/75 mm	0	SS4	
		LIMESTONE BEDROCK Limestone with shale partings, poor to good quality , grey, fresh to slightly weathered		4			RUN 2	
				5			RUN 3	
			49.19	6			RUN 4	
		Borehole Terminated at 6.7 m Depth	47.9					

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	5.7	
'February 16th, 2022	5.4	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	3.2 - 4.5	61	46
2	4.5 - 6.1	98	88
3	6.1 - 6.7	87	67

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

Log of Borehole MW21-109

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 12

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 15th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test (S)
Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Crushed sand and gravel, brown, moist, no odours, no stains	53.64	0	6 then 50/100 mm		AS1	
			52.6	1			SS1	
		LIMESTONE BEDROCK Limestone with shale partings, fair to excellent quality , grey, fresh to slightly weathered		2			RUN 1	
				3			RUN 2	
				4				
				5			RUN 3	
				6				
▽			46.64	7			RUN 4	
				8			RUN 5	
		Borehole Terminated at 9.0 m Depth	44.6	9				

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	--	
'February 16th, 2022	7.0	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1 - 2.6	100	69
2	2.6 - 4.2	97	87
3	4.2 - 5.8	100	97
4	5.8 - 7.4	98	92
5	7.4 - 9	100	98

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

Log of Borehole MW21-110

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 13

Page. 1 of 2

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 15th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠
Auger Sample ▮▯
SPT (N) Value ○
Dynamic Cone Test ——
Shelby Tube ■
Shear Strength by Vane Test +S

Combustible Vapour Reading □
Natural Moisture Content ×
Atterberg Limits —○—
Undrained Triaxial at % Strain at Failure ⊕
Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Crushed sand and gravel, brown, moist, no odours, no stains	53.51	0	6 then 50/50 mm	×	AS1	
			52.5	1		×	SS1	
		LIMESTONE BEDROCK Limestone with shale partings, fair to excellent quality , grey, fresh to slightly weathered		2			RUN 1	
				3			RUN 2	
				4				
				5			RUN 3	
				6				
			46.51	7			RUN 4	
				8			RUN 5	
				9				
				10			RUN 6	

Continued Next Page

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	--	
'February 16th, 2022	7.0	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1 - 2.6	90	55
2	2.6 - 4.2	100	89
3	4.2 - 5.7	100	93
4	5.7 - 7.3	100	98
5	7.3 - 8.8	99	83
6	8.8 - 10.4	99	97
7	10.4 - 12	97	77

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

Log of Borehole MW21-110

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 13

Page. 2 of 2

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa (20 40 60 80 / 50 100 150 200)	Combustible Vapour Reading (ppm) 250 500 750 / Natural Moisture Content % Atterberg Limits (% Dry Weight) 20 40 60	SAMPLES	Natural Unit Wt. kN/m³
		LIMESTONE BEDROCK Limestone with shale partings, fair to excellent quality , grey, fresh to slightly weathered *(continued)*	43.51	10			RUN 7	
				11				
			41.5	12				
		Borehole Terminated at 12.0 m Depth						

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
February 3rd, 2022	--	
February 16th, 2022	7.0	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1 - 2.6	90	55
2	2.6 - 4.2	100	89
3	4.2 - 5.7	100	93
4	5.7 - 7.3	100	98
5	7.3 - 8.8	99	83
6	8.8 - 10.4	99	97
7	10.4 - 12	97	77

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

Log of Borehole MW21-111

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 14

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 13th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test
Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Sand and gravel, some clay, with brick fragments , brown, moist, slight odour/staining.	53.89	0	50/125 mm	5	AS1	
						0	SS1	
		LIMESTONE BEDROCK Limestone with shale partings, fair to good quality , grey, fresh to slightly weathered	52.9	1				RUN 1
				2				
			50.29	3				RUN 2
				4				
				5				RUN 3
			48.1					
		Borehole Terminated at 5.8 m Depth						

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	3.9	
'February 16th, 2022	3.6	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1 - 2.6	100	67
2	2.6 - 4.2	100	89
3	4.2 - 5.8	100	76

Log of Borehole MW21-112

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 15

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 13th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠ | Auger Sample ▮▯ | SPT (N) Value ○ | Dynamic Cone Test ——— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits |—○—| | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Sand and gravel, some clay, with wood fragments, brown, moist, no odours or stains, (compact to dense).	54.04	0		0	AS1	
				1	34	0	SS1	
				2	26	0	SS2	
					2 then 50/25mm	5	81.8 SS3	
		LIMESTONE BEDROCK Limestone with shale partings, poor to excellent quality , grey, fresh to slightly weathered	51.2 51.24	3			RUN 1	
				4				
				5			RUN 2	
				6				
				7			RUN 3	
				8			RUN 4	
		Borehole Terminated at 8.9 m Depth	45.1					

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	2.8	
'February 16th, 2022	2.8	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	2.8 - 4.3	100	79
2	4.3 - 5.8	97	33
3	5.8 - 7.4	100	80
4	7.4 - 8.9	100	94

Log of Borehole MW21-113

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 16

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 10th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test (S)
Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Sand and gravel, some clay, with brick fragments, brown, moist, no odours or stains, (compact to very dense).	54.3	0	50/75 mm		SS1	
				1	41	0	SS1A	
				2	14	0	SS2	
					24 then 50/25 mm	0	SS3	
		LIMESTONE BEDROCK Limestone with shale partings, fair to goodquality , grey, fresh to slightly weathered	51.7	3			RUN 1	
			50.7	4				
				5			RUN 2	
				6			RUN 3	
		Borehole Terminated at 6.2 m Depth	48.1					

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	3.8	
'February 16th, 2022	3.6	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	2.6 - 4.3	100	56
2	4.3 - 5.8	95	59
3	5.8 - 6.2	84	76

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

Log of Borehole MW21-114

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 17

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 10th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠
Auger Sample ▮▯
SPT (N) Value ○
Dynamic Cone Test ——
Shelby Tube ■
Shear Strength by Vane Test +S

Combustible Vapour Reading □
Natural Moisture Content ×
Atterberg Limits |—○—|
Undrained Triaxial at % Strain at Failure ⊕
Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Sand and gravel, some clay, with boulders, cobbles and wood fragments, brown, moist, no odours or stains, (very loose to very dense).	54.29	0			AS1	
				1	50 then 50/125 mm		SS1	
				2	23 then 50/100 mm		SS2	
				3	19		SS3	
				4	6		SS4	
				5	6		SS5	
				6	5		SS6	
		No recovery from 5.3 to 5.9 m depth. Reduced drilling reistance within this zone.		7	4		SS6A	
				8	39	97	SS7	
				9	8		SS8	
				10	4		SS9	
		No recovery from 8.4 to 8.7 m depth.		11	3		SS10	
			44.5					
		Auger Refusal at 9.8 m Depth						

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	--	
'February 16th, 2022	--	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole MW21-115

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 18

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 10th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠ | Auger Sample ▮▯ | SPT (N) Value ○ | Dynamic Cone Test ——— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits —○— | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Sand and gravel, some clay, with boulders, cobbles and charred debris, brown, moist, no odours or stains, (very loose to loose).	54.23	0		15	AS1	
				1	3	0	SS1	
				2	6	5	SS2	
			51.8		50/125 mm	5	SS3	
		LIMESTONE BEDROCK Limestone with shale partings, poor to excellent quality , grey, fresh to slightly weathered	51.53	3			RUN 1	
				4				
				5			RUN 2	
			48.0	6			RUN 3	
		Borehole Terminated at 6.2 m Depth						

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	2.8	
'February 16th, 2022	2.7	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	2.4 - 4.1	98	42
2	4.1 - 5.7	95	69
3	5.7 - 6.2	100	100

Log of Borehole MW21-116

Project No: OTT-00250193-S0

Project: Preliminary Geotechnical Investigation - Blocks 201, 202, 203, 204 & 205 B, Chaudière Island

Figure No. 19

Page. 1 of 1

Location: 4 Booth Street, Ottawa, ON

Date Drilled: 'December 10th, 2021

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: JE Checked by: PS

Split Spoon Sample ⊠ | Auger Sample ▮▯ | SPT (N) Value ○ | Dynamic Cone Test ——— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○⊣ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Sand and gravel, with charred debris and brick fragments, brown, moist to wet, no odours or stains, (loose to very dense).	54.29	0	0	AS1		
				1	81	5	SS1	
				2	12	5	SS2	
				3	8	5	SS3	
					8	15	SS4	
				4	20	35	SS5	
					5 then 50/100 mm	40	SS6	
		LIMESTONE BEDROCK Limestone with shale partings, fair quality , grey, fresh to slightly weathered	49.4	5			RUN 1	
				6				
				7			RUN 2	
			46.89	8				
							RUN 3	
			45.1	9				
		Borehole Terminated at 9.2 m Depth						

LOG OF BOREHOLE BH LOGS - BLOCK 201 - 205 - GEOTECHNICAL.GPJ TROW OTTAWA.GDT 9/27/22

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 50 mm diameter monitoring well installed as shown upon completion of drilling.
3. Field work was supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00250193-S0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
'February 3rd, 2022	7.4	
'February 16th, 2022	7.4	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	4.9 - 6.4	96	52
2	6.4 - 7.9	100	60
3	7.9 - 9.2	100	75

Appendix A – Bedrock Core Photographs

DRY BEDROCK CORES

EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

borehole no.	core runs	project	project no.
MW21-102	Run 1: 2.9 m - 4.5m Run 2: 4.5m - 6.0m Run 3: 6.0m - 7.5m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-1
Dec 16, 2021			

WET BEDROCK CORES

EXP Services Inc. **www.exp.com**
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

borehole no.	core runs	project	project no.
MW21-102	Run 1: 2.9m - 4.5m Run 2: 4.5m - 6.0m Run 3: 6.0m - 7.5m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 16, 2021		Rock Core Photographs	FIG A-2

DRY BEDROCK CORES

EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

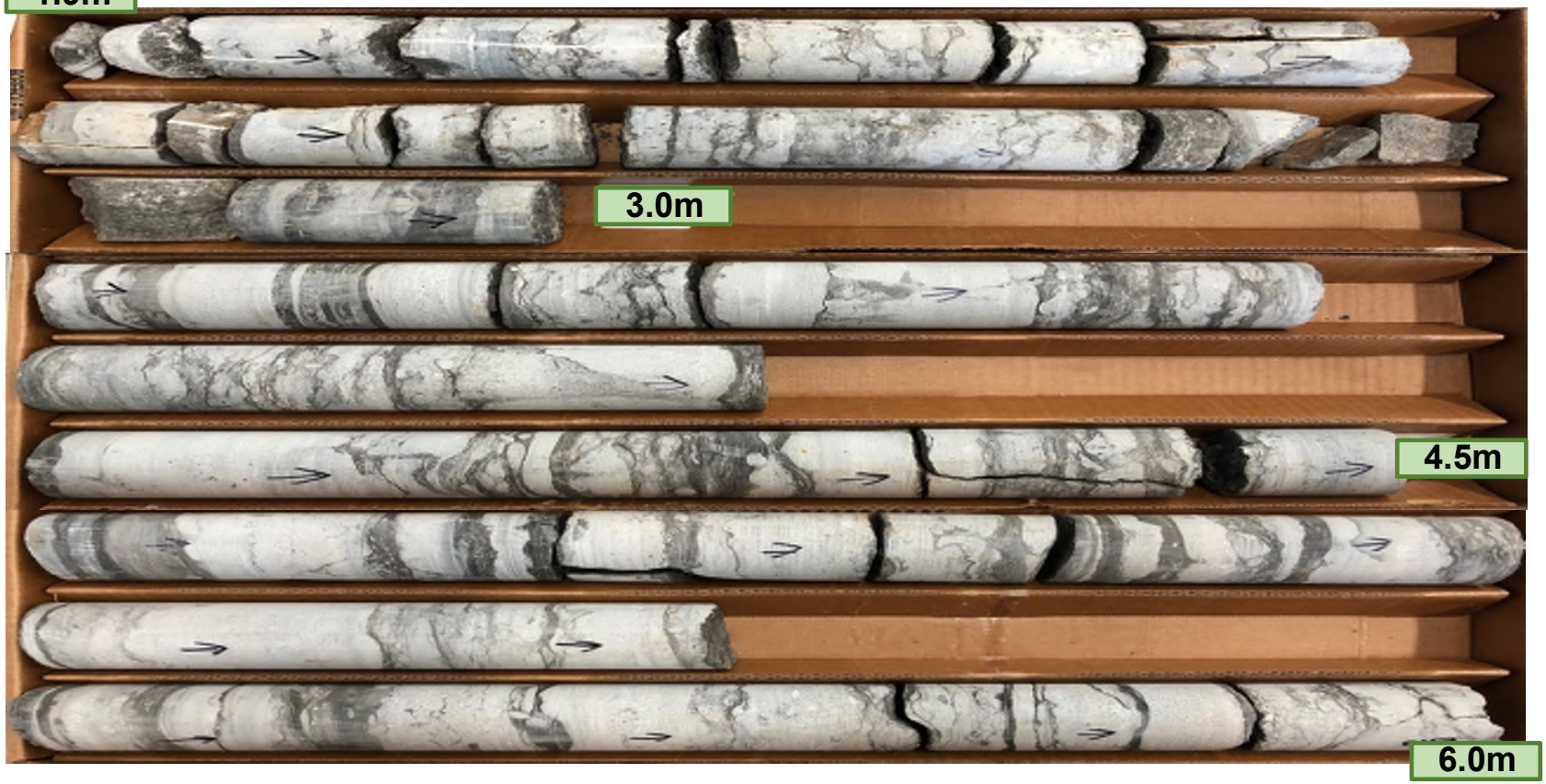
borehole no.	core runs	project	project no.
MW21-102	Run 4: 7.5m - 9.0m Run 5: 9.0m - 10.5m Run 6: 10.5m - 12.0 m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193
date cored		Rock Core Photographs	FIG A-3
Dec 16, 2021			

DRY BEDROCK CORES

EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

borehole no.	core runs	project	project no.
MW21-102	Run 4: 7.5m - 9.0m Run 5: 9.0m - 10.5m Run 6: 10.5m - 12.0 m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-SO
date cored Dec 16, 2021		Rock Core Photographs	FIG A-4

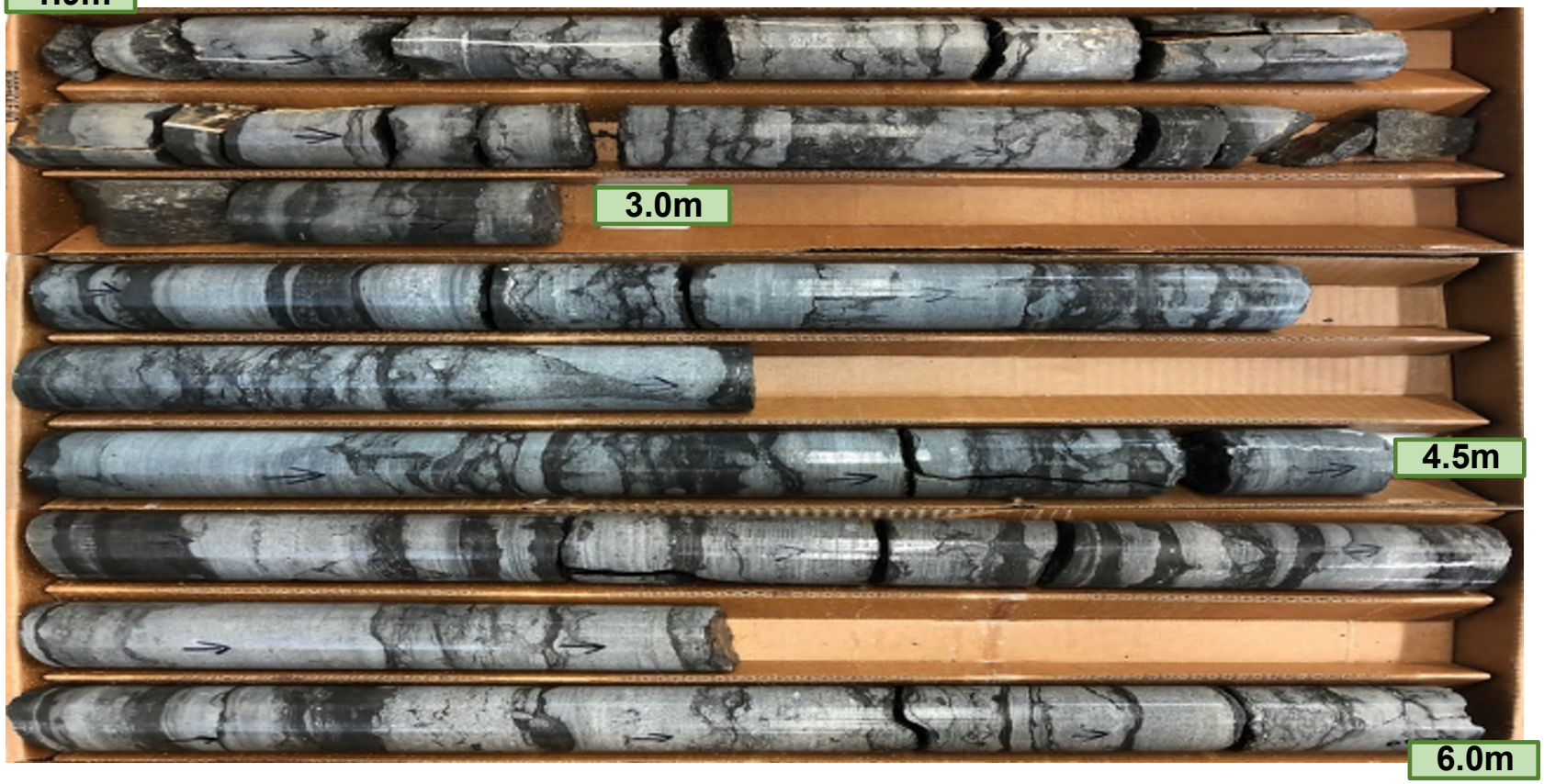
DRY BEDROCK CORES



EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

borehole no.	core runs	project	project no.
MW21-104	Run 1: 1.9m - 3.0m Run 2: 3.0m - 4.5m Run 3: 4.5m - 6.0m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-5
Dec 14, 2022			

WET BEDROCK CORES



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2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

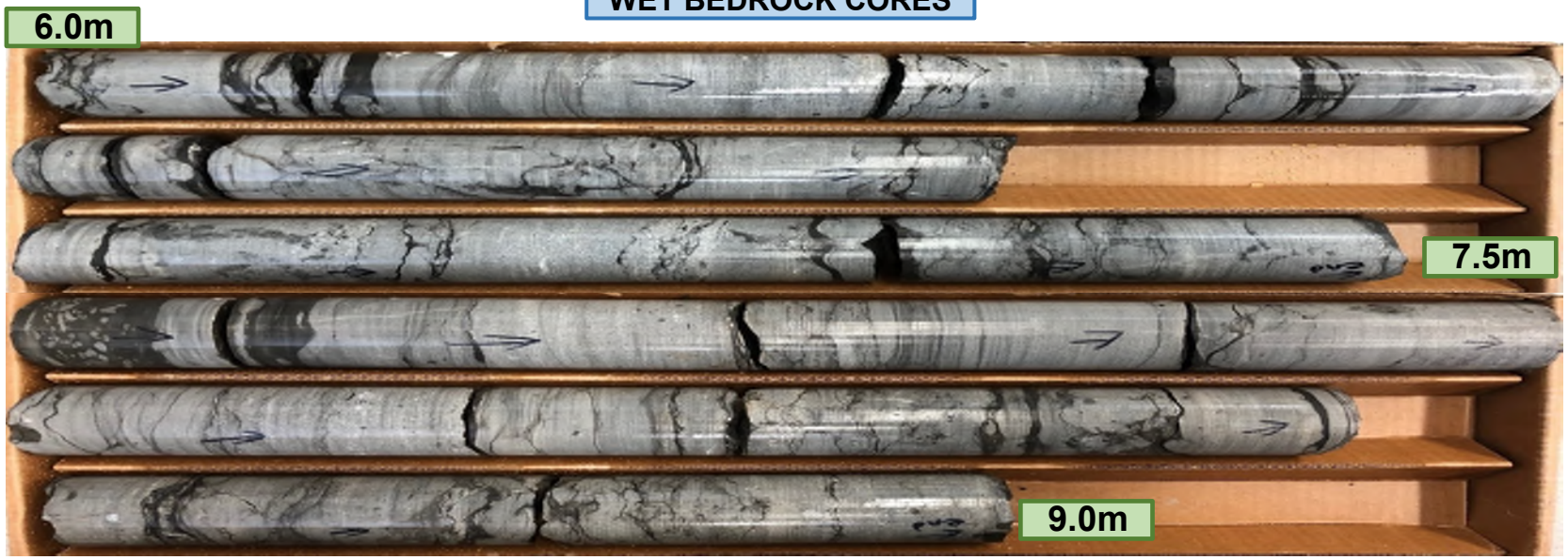
borehole no.	core runs	project	project no.
MW21-104	Run 1: 1.9m - 3.0m Run 2: 3.0m - 4.5m Run 3: 4.5m - 6.0m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-6
Dec 14, 2022			

DRY BEDROCK CORES

EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

borehole no.	core runs	project	project no.
MW21-104	Run 4: 6.0m - 7.5m Run 5: 7.5m - 9.0m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 14, 2022		Rock Core Photographs	FIG A-7

WET BEDROCK CORES



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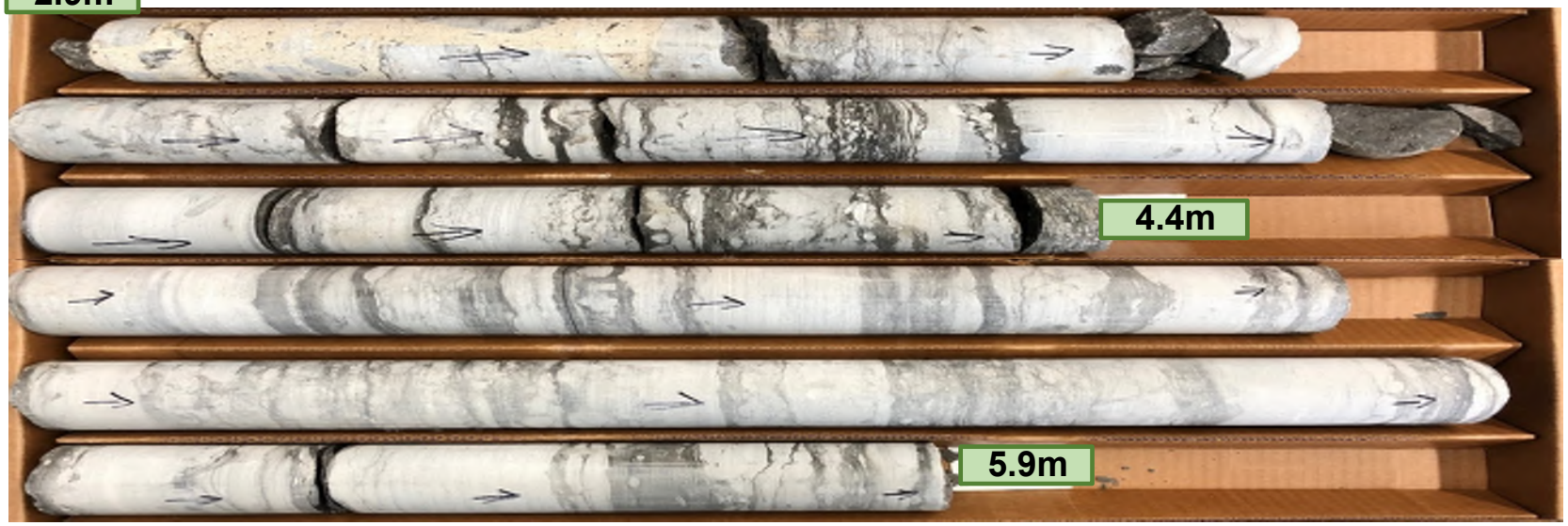
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

borehole no.	core runs	project	project no.
MW21-104	Run 4: 6.0m - 7.5m Run 5: 7.5m - 9.0m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 14, 2022		Rock Core Photographs	FIG A-8

DRY BEDROCK CORES



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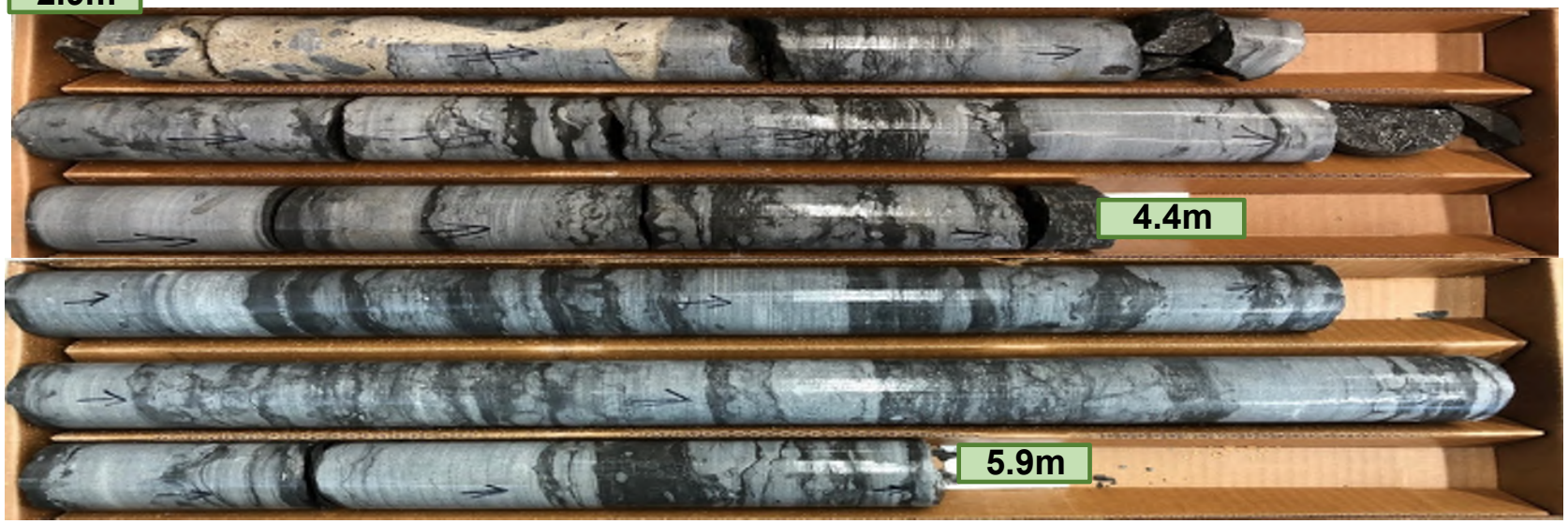
borehole no.	core runs	project	project no.
MW21-105	Run 1: 2.9m - 4.4m Run 2: 4.4m - 5.9m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 14, 2022		Rock Core Photographs	FIG A-9

WET BEDROCK CORES



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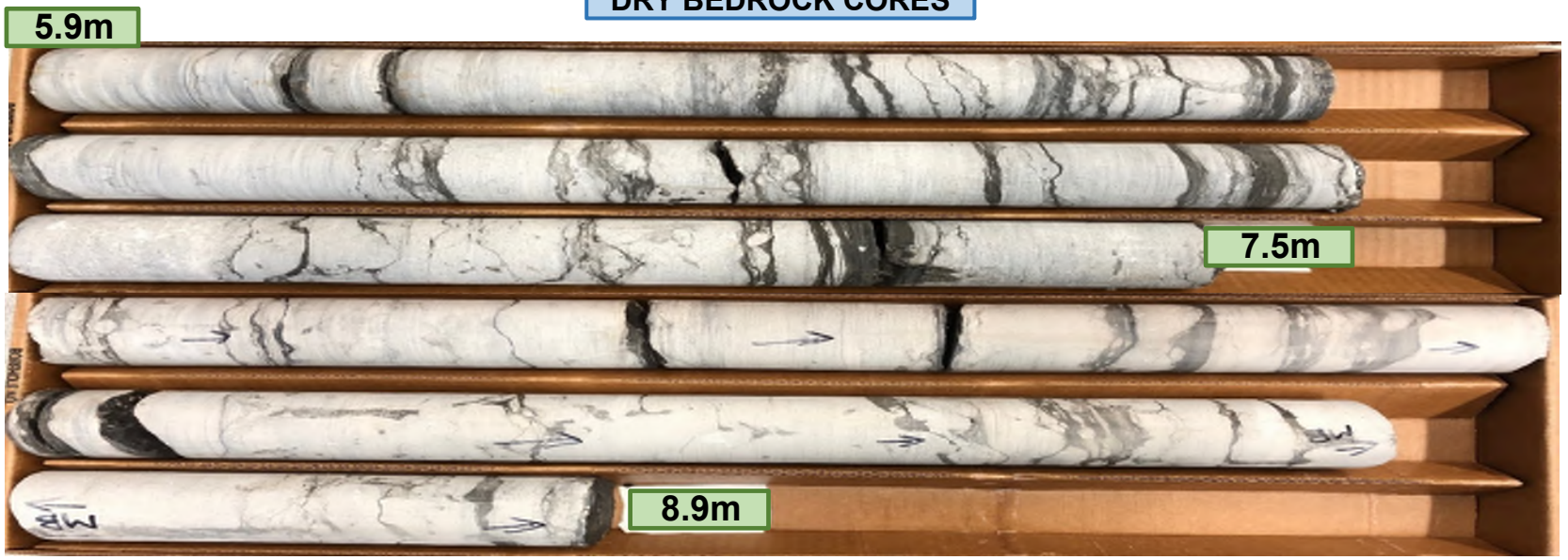
borehole no.	core runs	project	project no.
MW21-105	Run 1: 2.9m - 4.4m Run 2: 4.4m - 5.9m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 14, 2022		Rock Core Photographs	FIG A-10

DRY BEDROCK CORES



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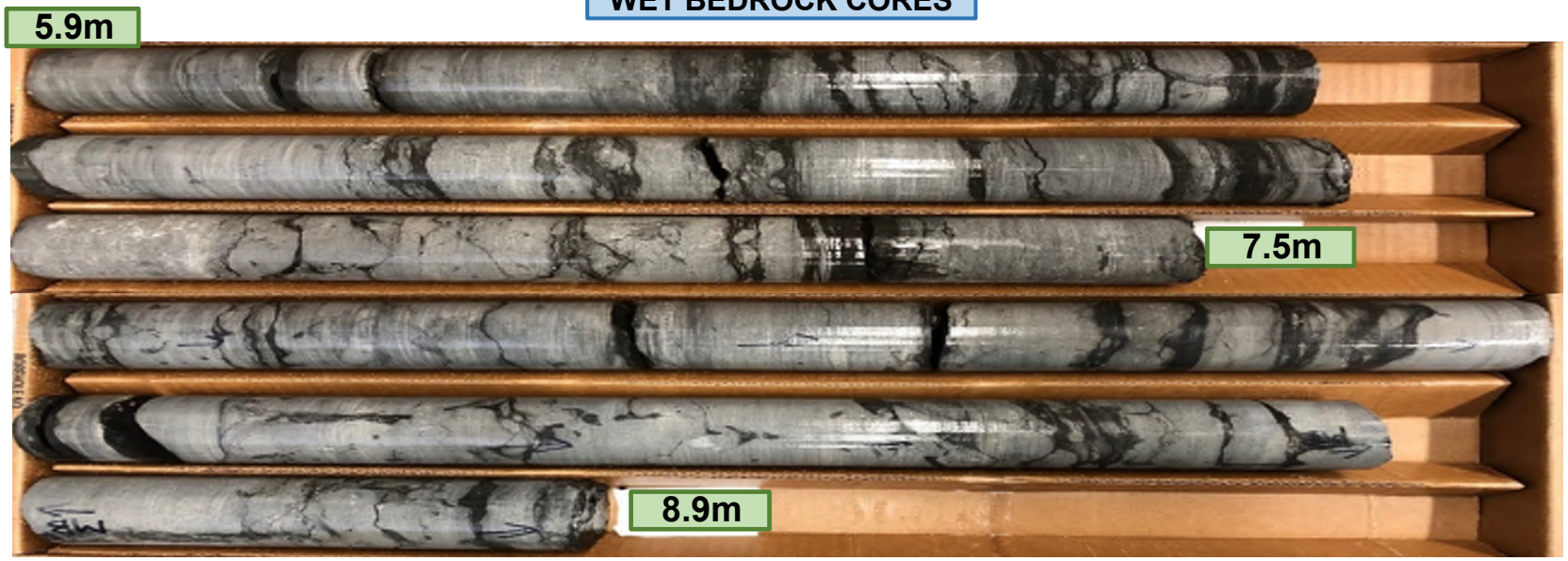
borehole no.	core runs	project	project no.
MW21-105	Run 3: 5.9m - 7.5m Run 4: 7.5m - 8.9m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 14, 2022		Rock Core Photographs	FIG A-11

WET BEDROCK CORES



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borehole no.	core runs	project	project no.
MW21-105	Run 3: 5.8m - 7.5m Run 4: 7.5m - 8.9m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 14, 2022		Rock Core Photographs	FIG A-12

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borehole no.	core runs	project	project no.
MW21-106	Run 1: 1.1m - 2.6m Run 2: 2.6m - 4.3m Run 3: 4.3m - 5.9m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-13
Dec 14, 2021			

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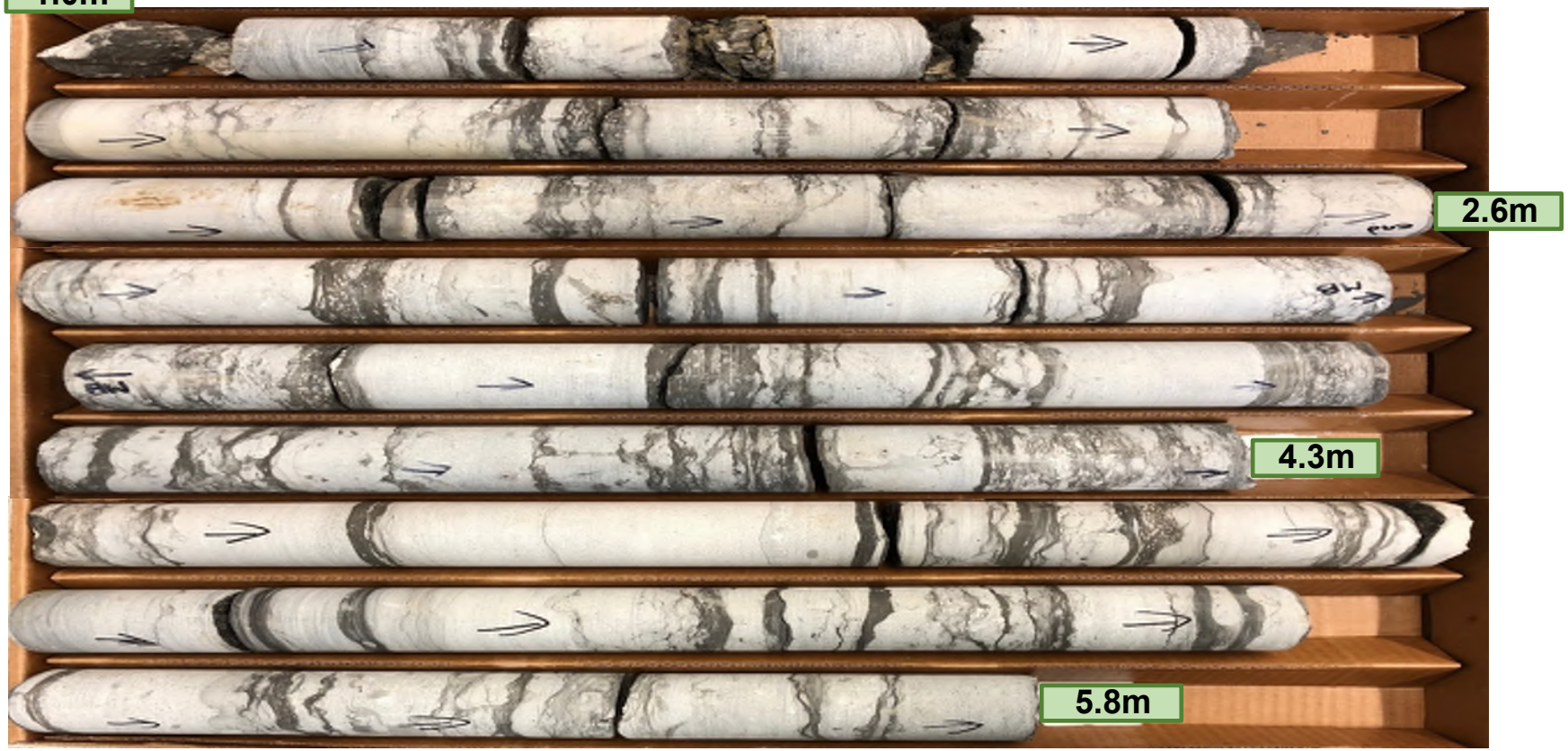
borehole no.	core runs	project	project no.
MW21-106	Run 1: 1.1m - 2.6m Run 2: 2.6m - 4.3m Run 3: 4.3m - 5.9m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-14
Dec 14, 2021			

DRY BEDROCK CORES



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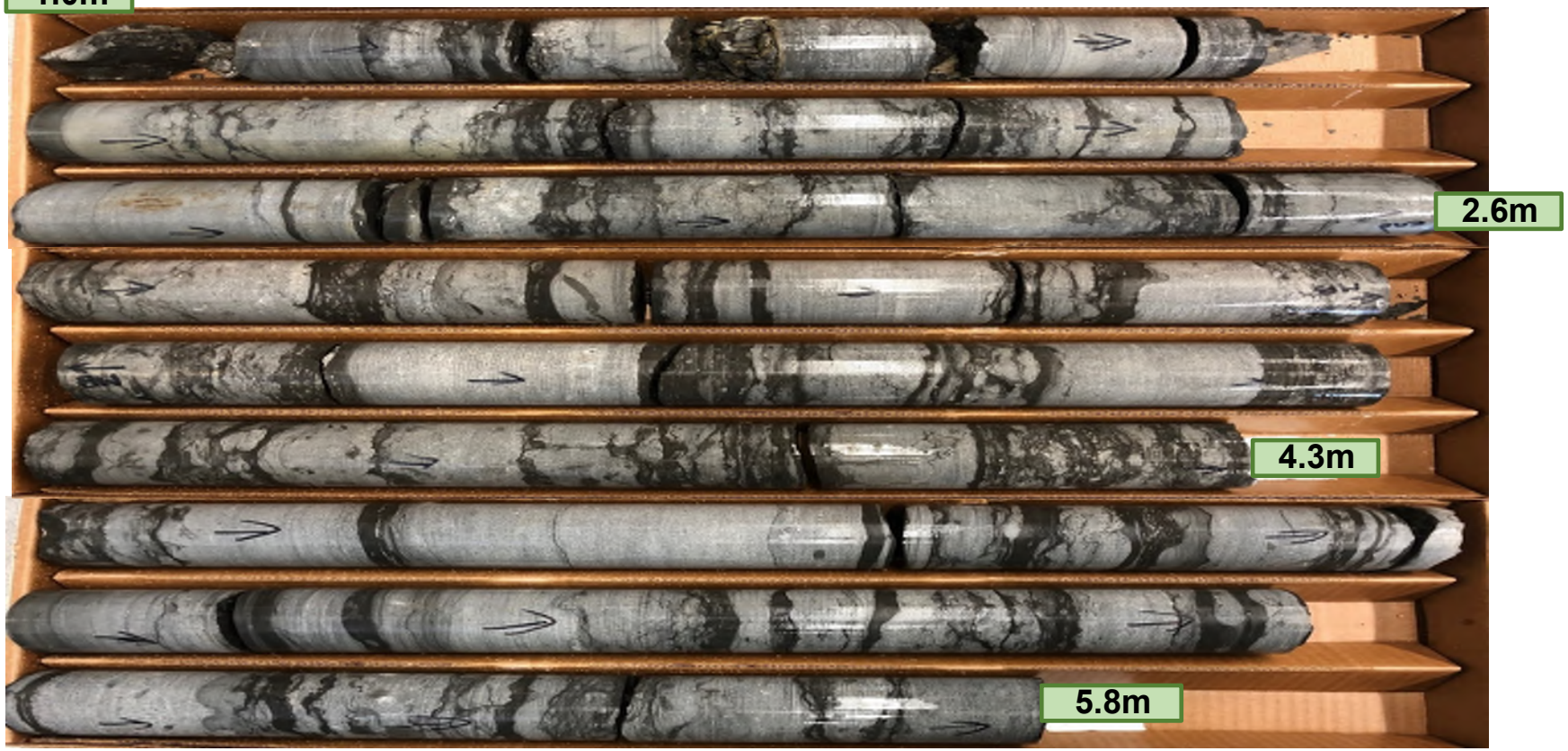
borehole no.	core runs	project	project no.
MW21-107	Run 1: 1.0m - 2.6m Run 2: 2.6m - 4.3m Run 3: 4.3m - 5.8m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 13, 2022		Rock Core Photographs	FIG A-15

WET BEDROCK CORES



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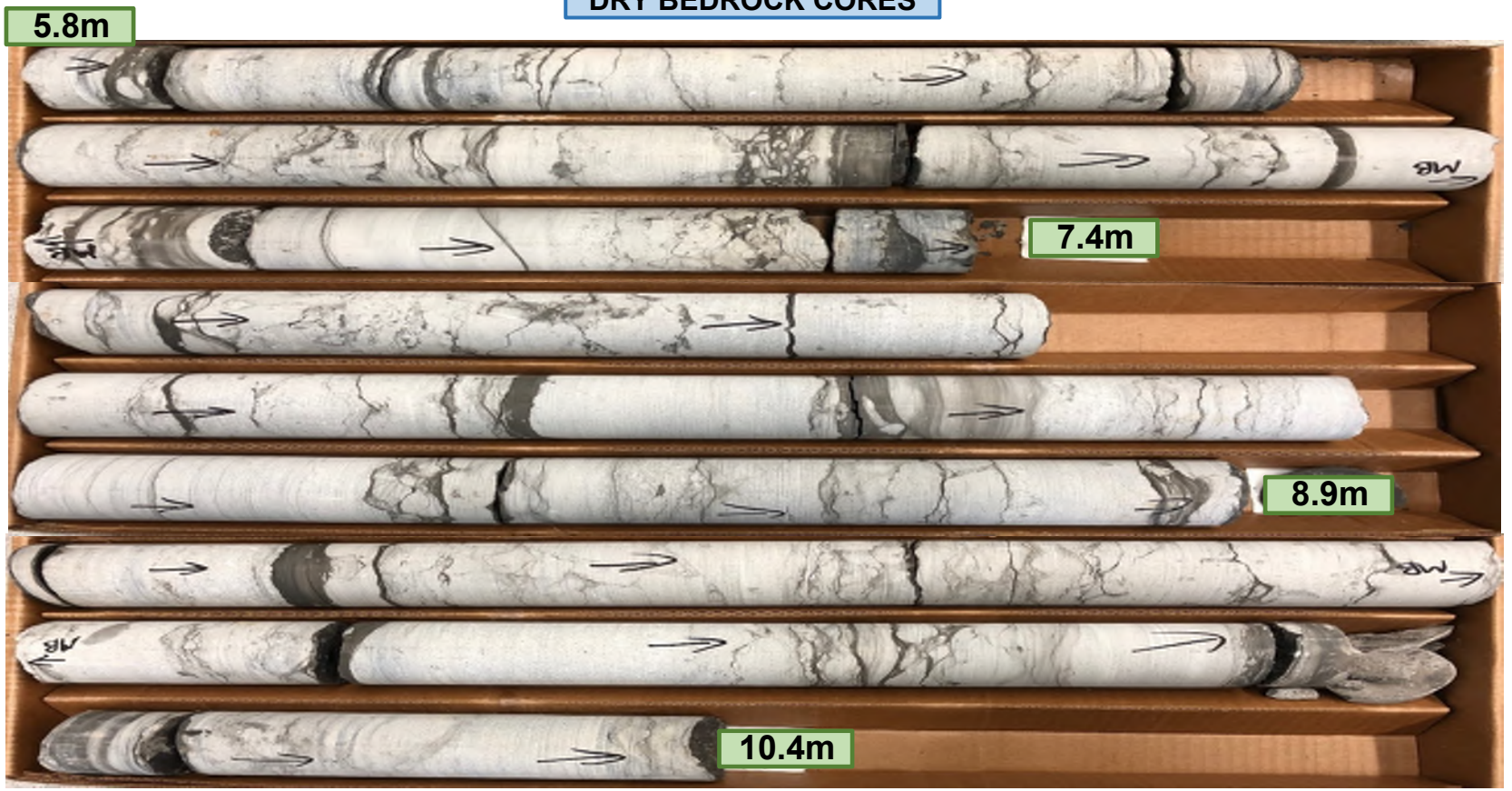
borehole no.	core runs	project	project no.
MW21-107	Run 1: 1.0m - 2.6m Run 2: 2.6m - 4.3m Run 3: 4.3m - 5.8m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-16
Dec 13, 2022			

DRY BEDROCK CORES



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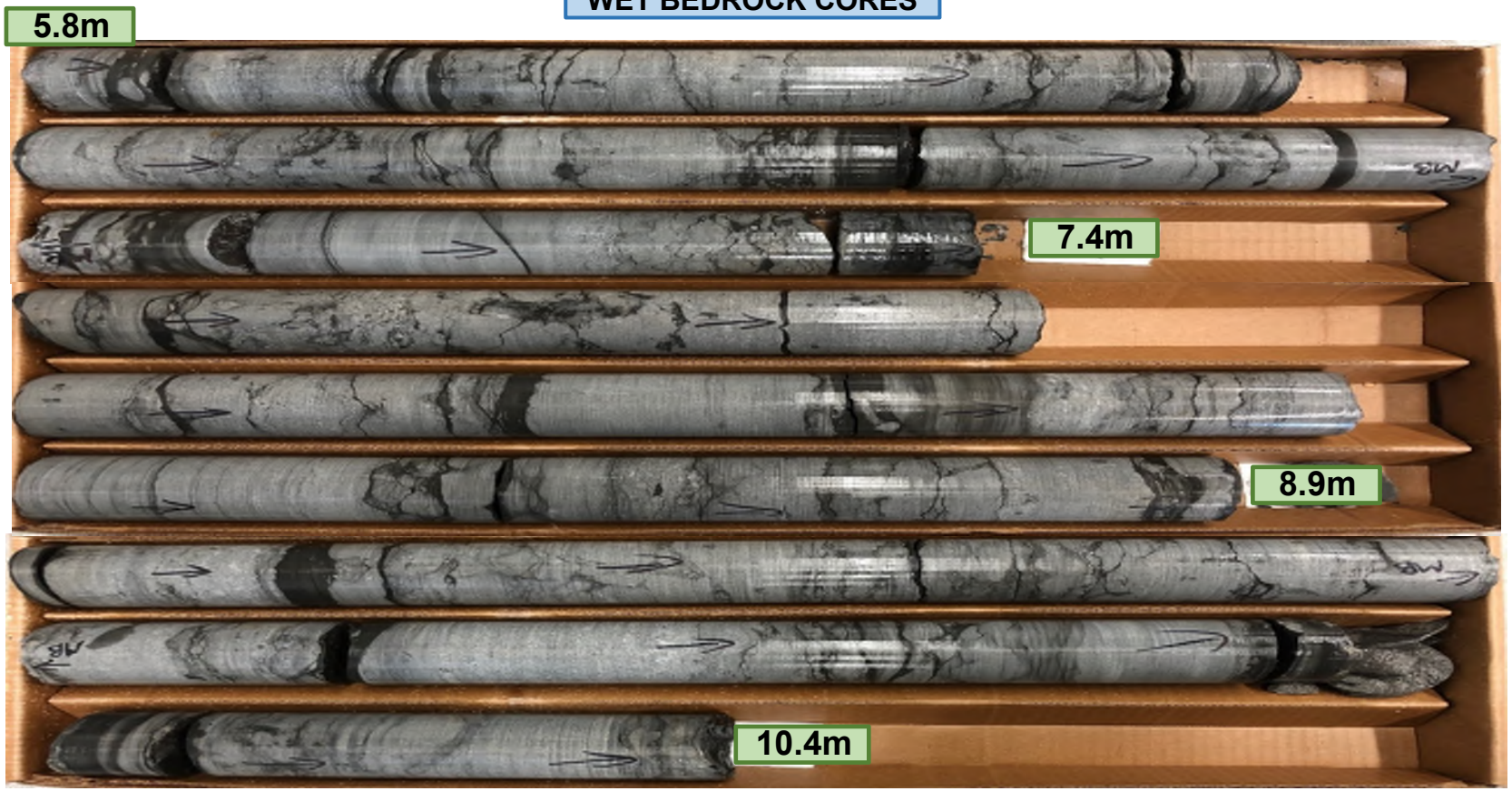
borehole no.	core runs	project	project no.
MW21-107	Run 4: 5.8m - 7.4m Run 5: 7.4m - 8.9m Run 6: 8.9m - 10.4m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 13, 2022		Rock Core Photographs	FIG A-17

WET BEDROCK CORES



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borehole no.	core runs	project	project no.
MW21-107	Run 4: 5.8m - 7.4m Run 5: 7.4m - 8.9m Run 6: 8.9m - 10.4m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-18
Dec 13, 2022			

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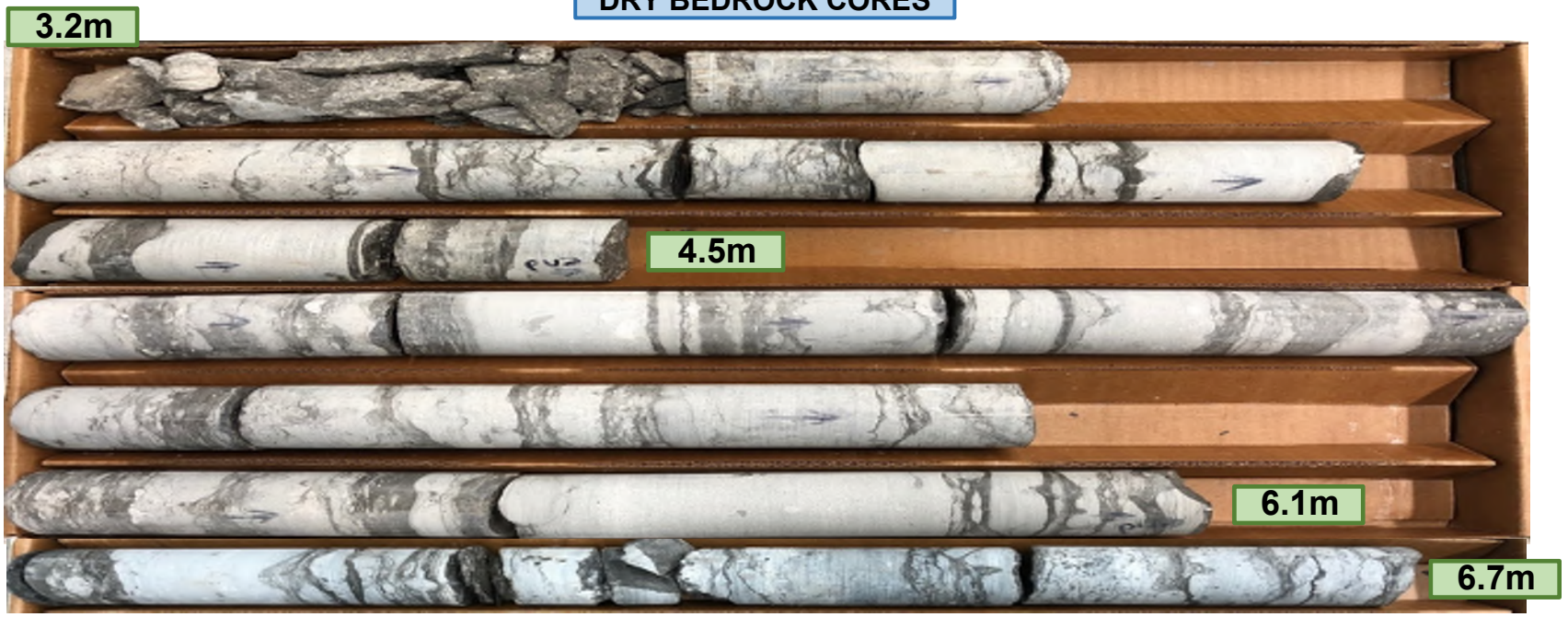
borehole no.	core runs	project	project no.
MW21-107	Run 7: 10.4m - 11.9m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-19
Dec 13, 2022			

DRY BEDROCK CORES



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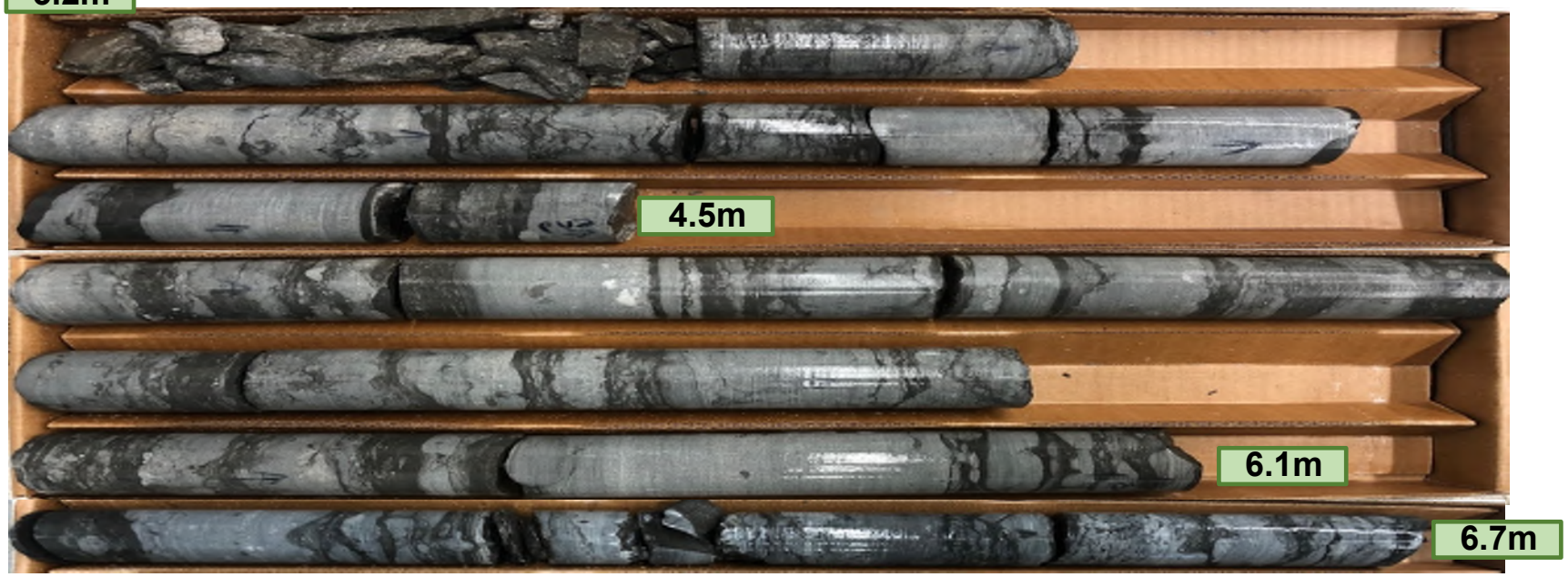
borehole no.	core runs	project	project no.
MW21-108	Run 1: 3.2m - 4.5m Run 2: 4.5m - 6.1m Run 3: 6.1m - 6.7m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-20
Dec 15, 2021			

WET BEDROCK CORES



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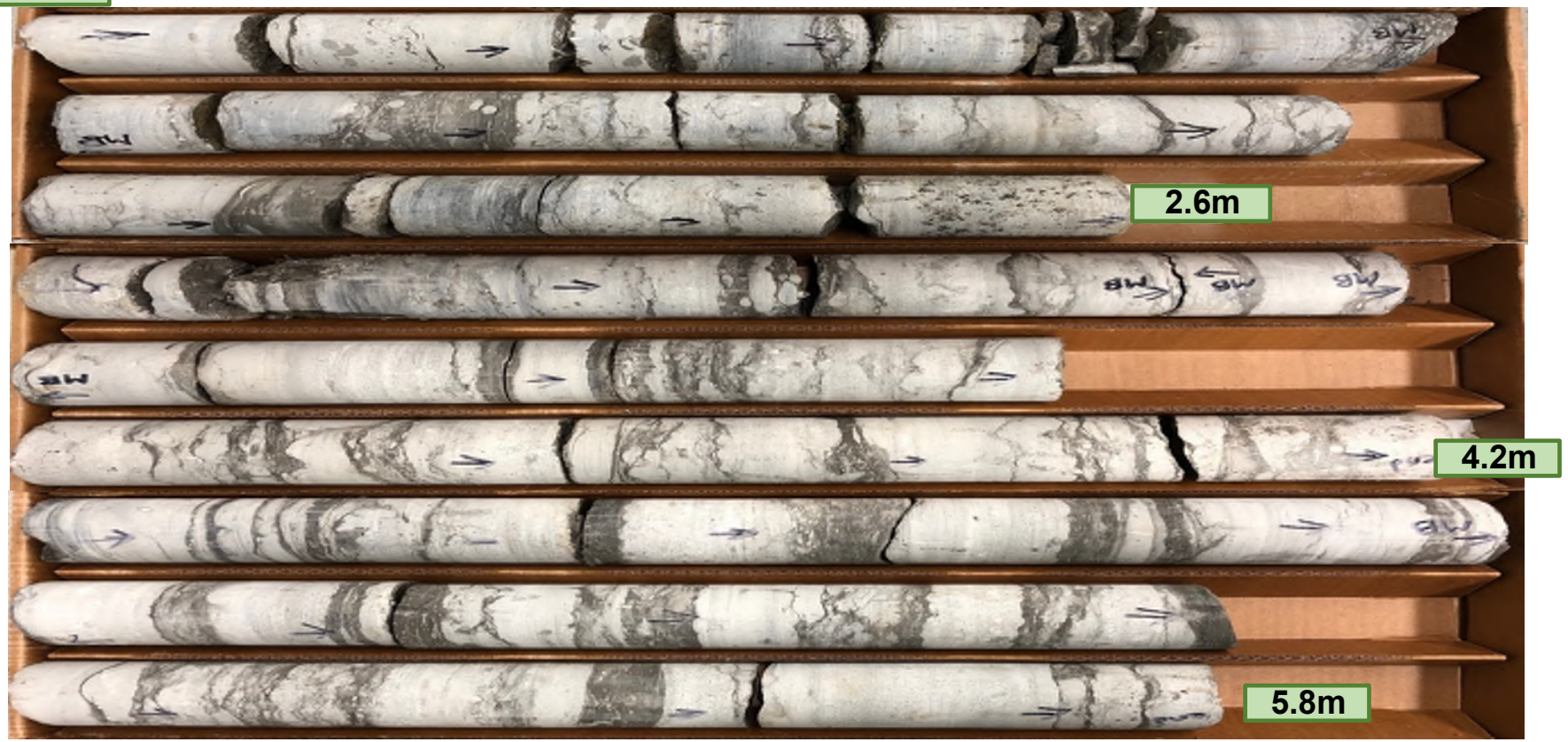
borehole no.	core runs	project	project no.
MW21-108	Run 1: 3.2m - 4.5m Run 2: 4.5m - 6.1m Run 3: 6.1m - 6.7m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-21
Dec 15, 2021			

DRY BEDROCK CORES



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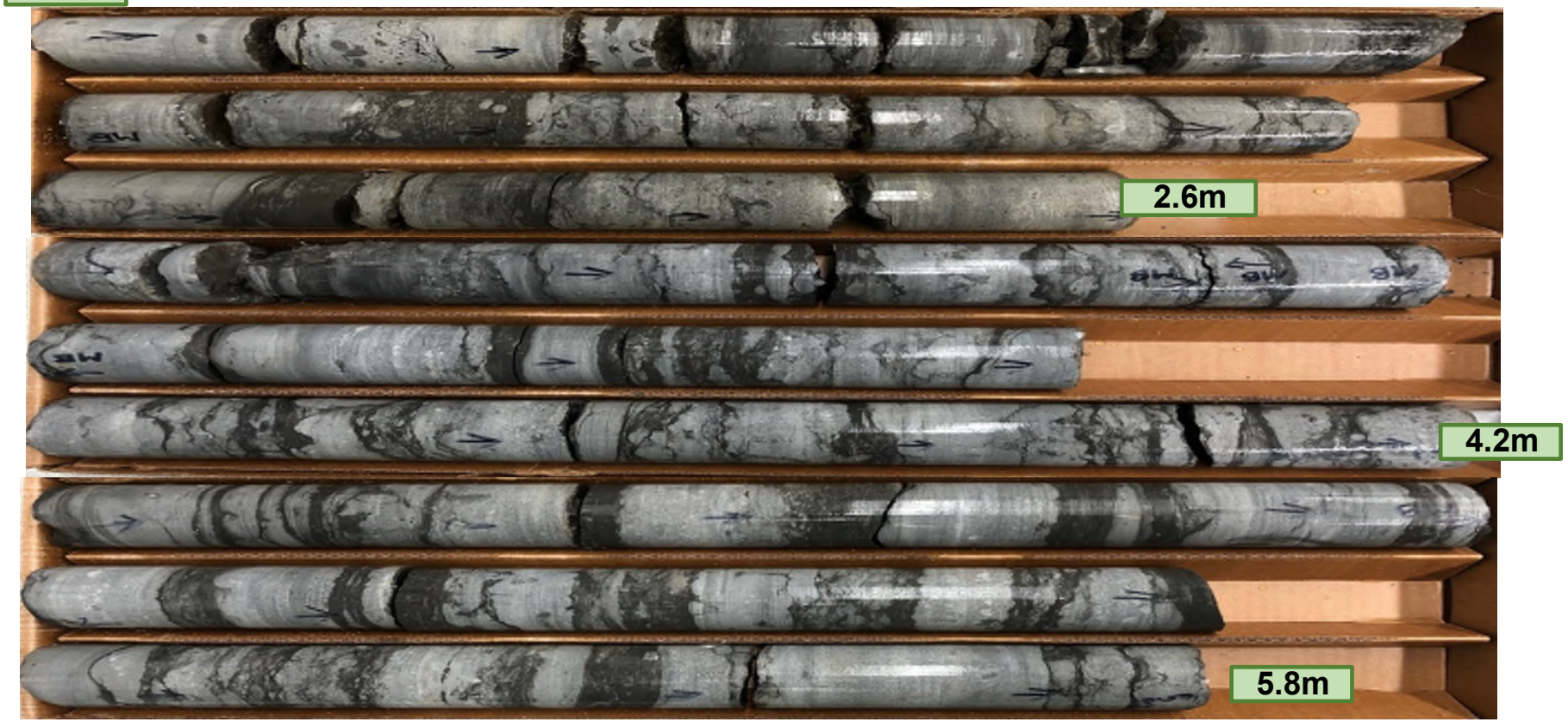
borehole no.	core runs	project	project no.
MW21-109	Run 1: 1.0m - 2.6m Run 2: 2.6m - 4.2m Run 3: 4.2m - 5.8m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-22
Dec 15, 2021			

WET BEDROCK CORES



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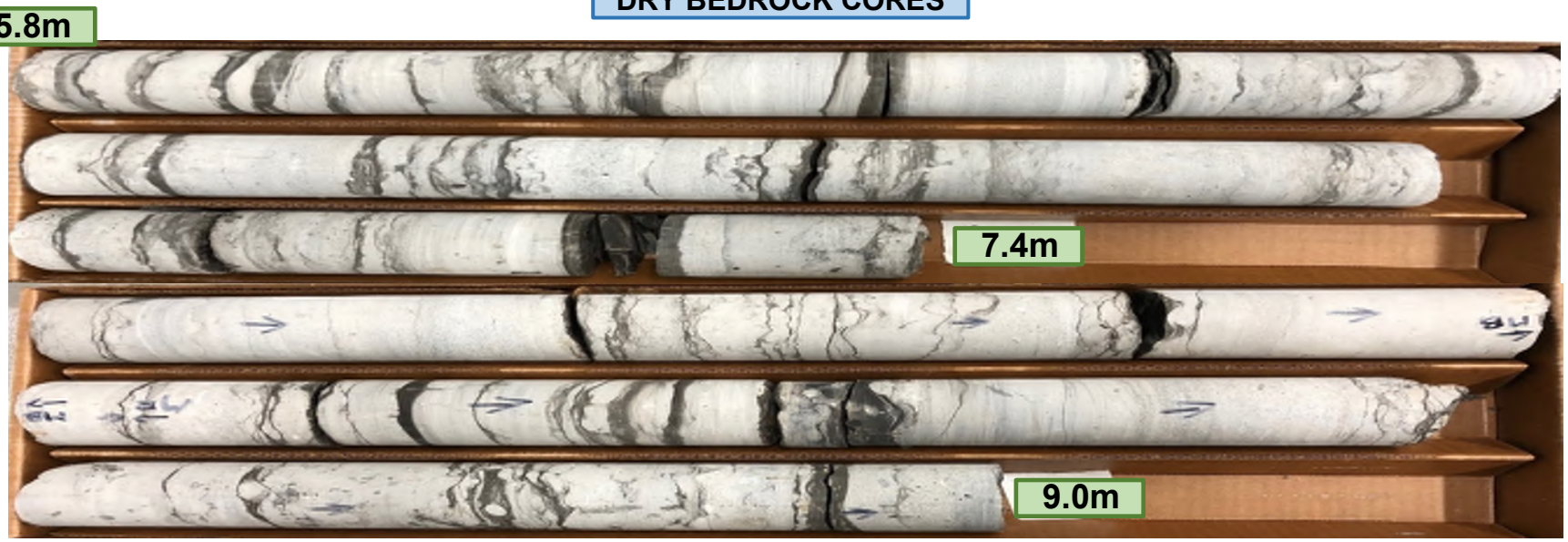
borehole no.	core runs	project	project no.
MW21-109	Run 1: 1.0m - 2.6m Run 2: 2.6m - 4.2m Run 3: 4.2m - 5.4m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-23
Dec 15, 2021			

DRY BEDROCK CORES



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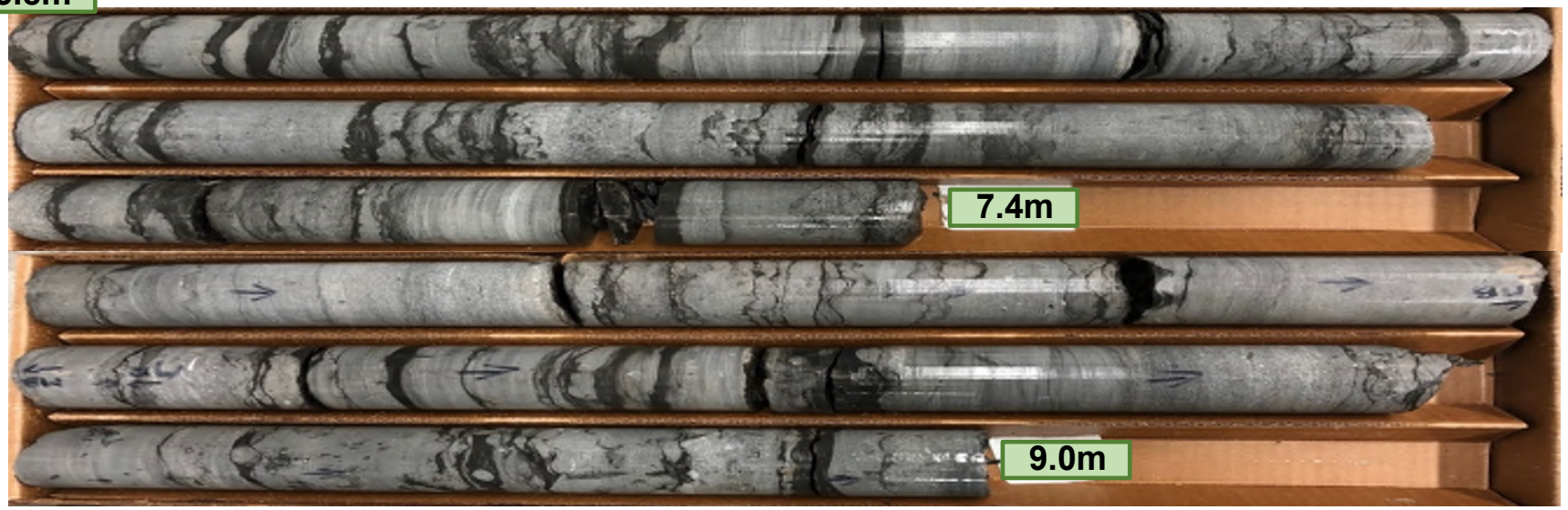
borehole no.	core runs	project	project no.
MW21-109	Run 4: 5.8m - 7.4m Run 5: 7.4m - 9.0m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 15, 2021		Rock Core Photographs	FIG A-24

WET BEDROCK CORES



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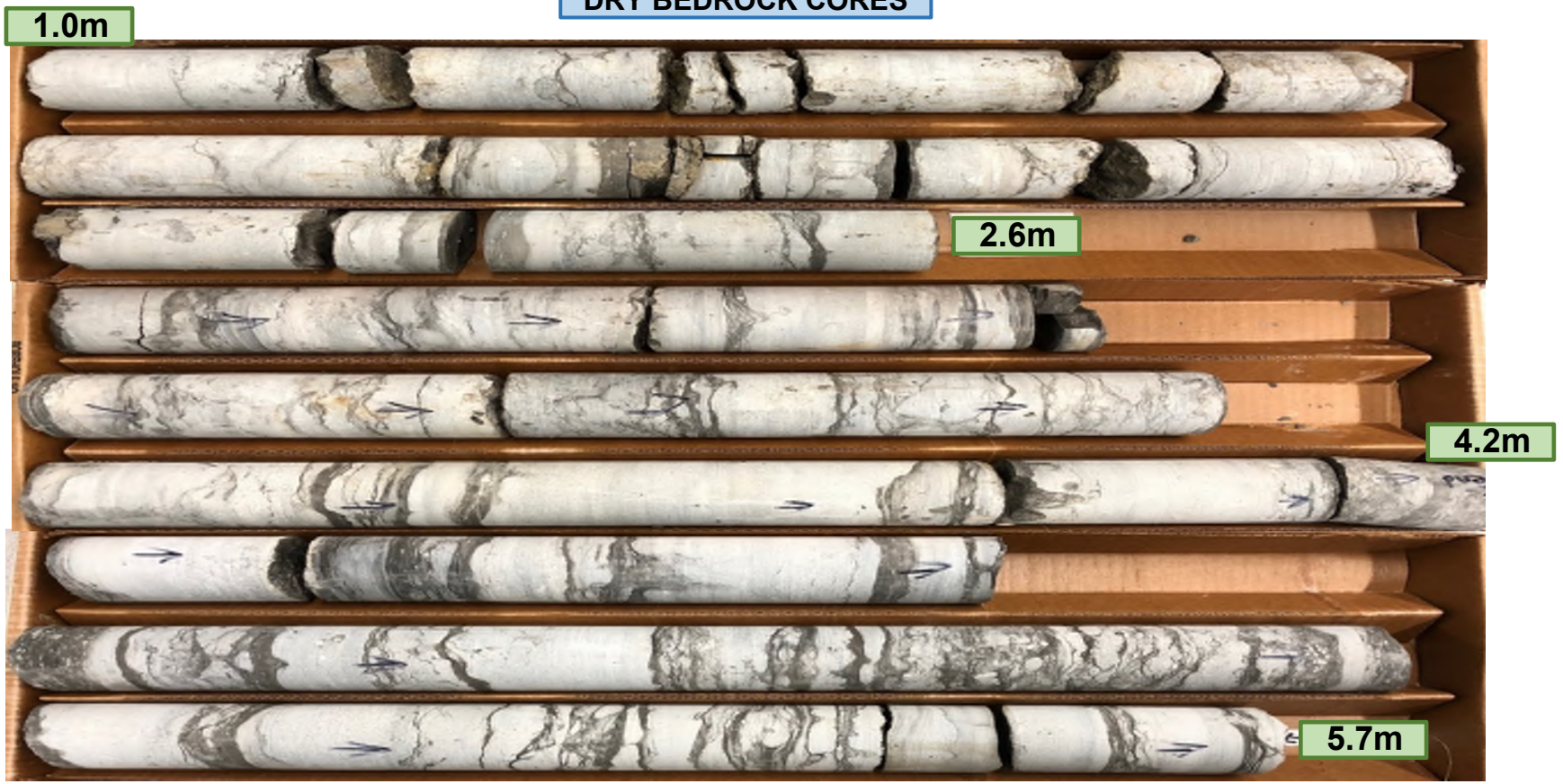
borehole no.	core runs	project	project no.
MW21-109	Run 4: 5.8m - 7.4m Run 5: 7.4m - 9.0m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 15, 2021		Rock Core Photographs	FIG A-25

DRY BEDROCK CORES



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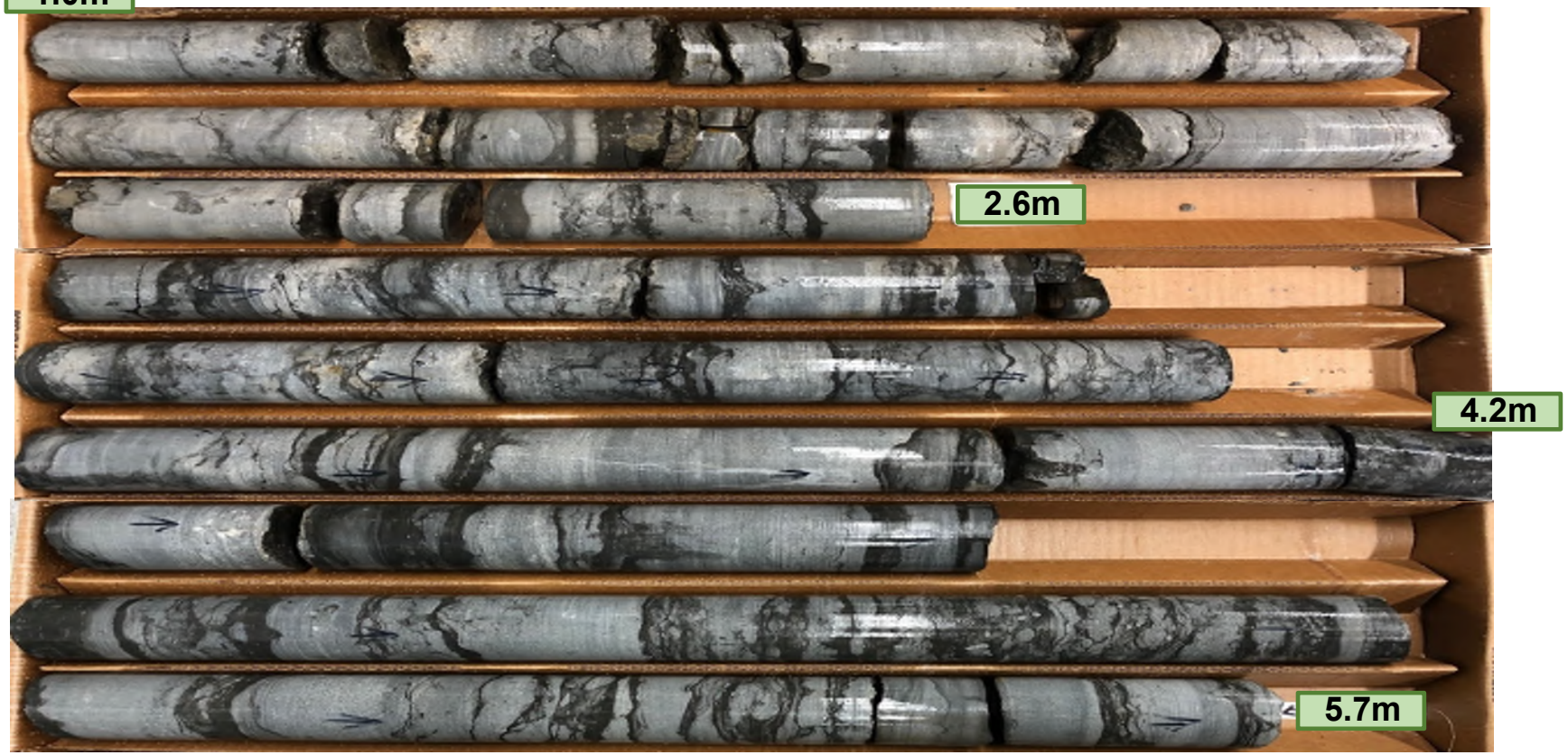
borehole no.	core runs	project	project no.
MW21-110	Run 1: 1.0m - 2.6m Run 2: 2.6m - 4.2m Run 3: 4.2m - 5.7m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 15, 2022		Rock Core Photographs	FIG A-26

WET BEDROCK CORES



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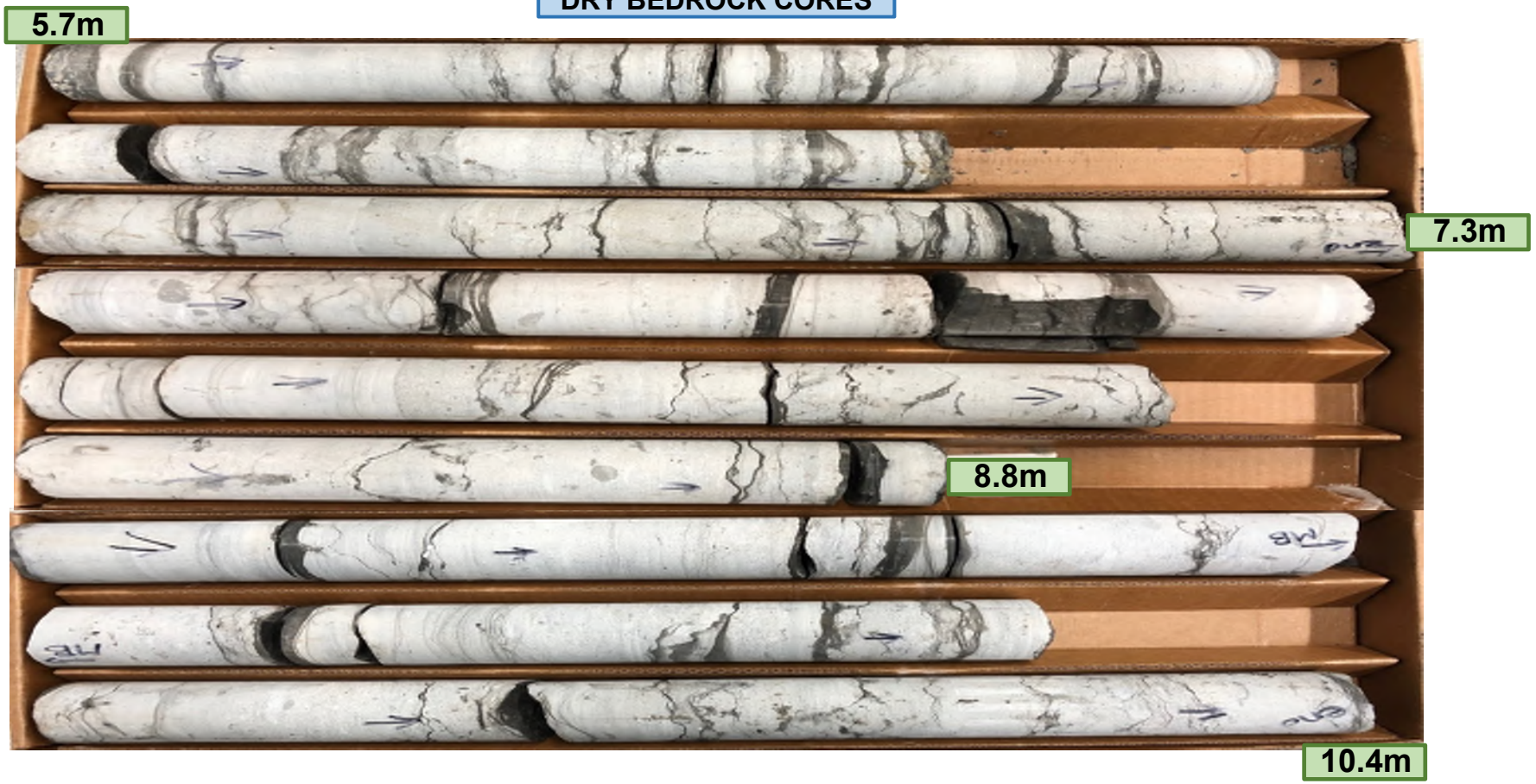
borehole no.	core runs	project	project no.
MW21-110	Run 1: 1.0m - 2.6m Run 2: 2.6m - 4.2m Run 3: 4.2m - 5.7m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-27
Dec 15, 2022			

DRY BEDROCK CORES



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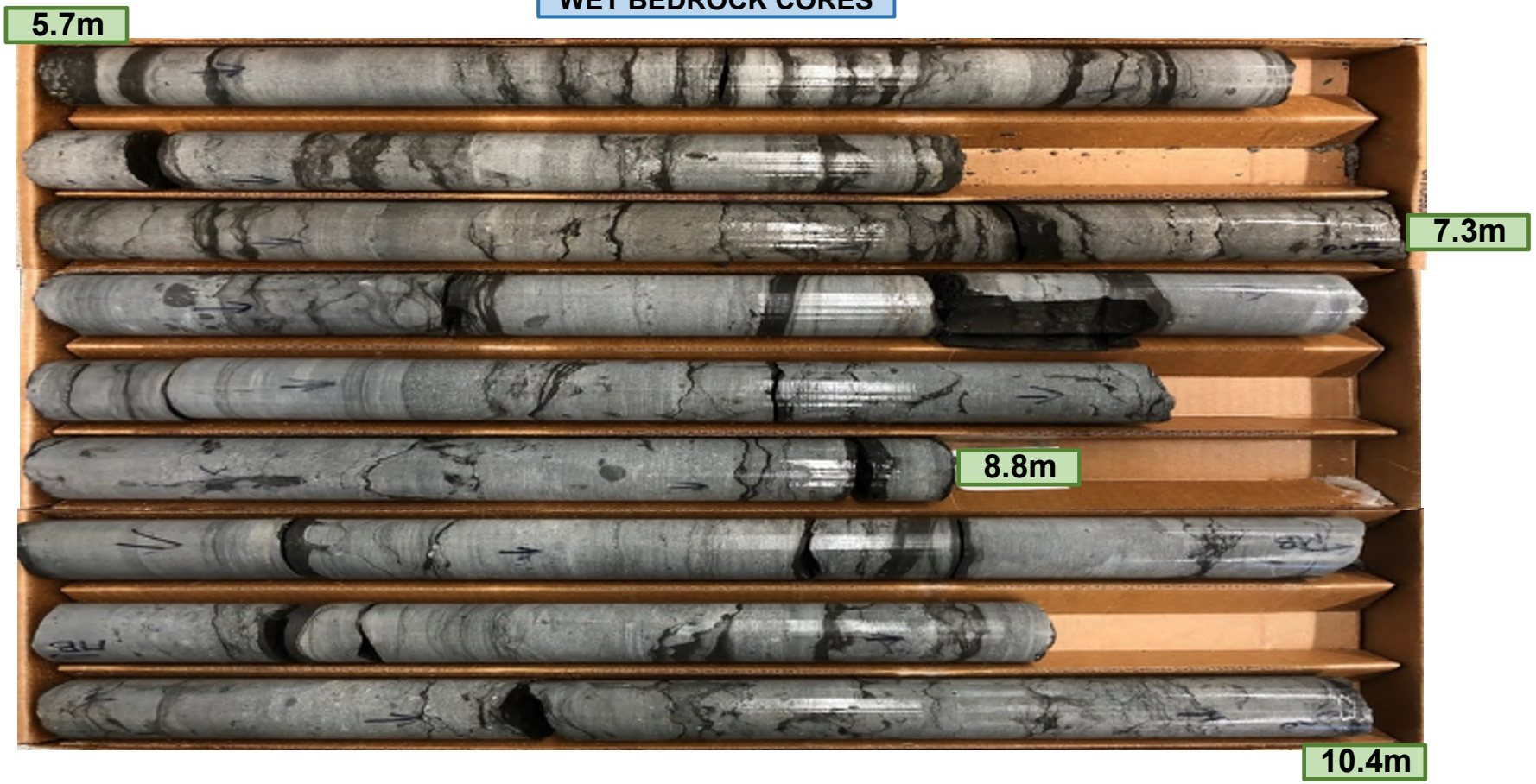
borehole no.	core runs	project	project no.
MW21-110	Run 4: 5.7m - 7.3m Run 5: 7.3m - 8.8m Run 6: 8.8m - 10.4m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-28
Dec 15, 2022			

WET BEDROCK CORES



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borehole no.	core runs	project	project no.
MW21-110	Run 4: 5.7m - 7.3m Run 5: 7.3m - 8.8m Run 6: 8.8m - 10.4m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-29
Dec 15, 2022			

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borehole no.	core runs	project	project no.
MW21-110	Run 7: 10.4m - 12.0m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-30
Dec 15, 2022			

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borehole no.	core runs	project	project no.
MW21-111	Run 1: 1.0m - 2.6m Run 2: 2.6m - 4.2m Run 3: 4.2m - 5.8m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 13, 2021		Rock Core Photographs	FIG A-31

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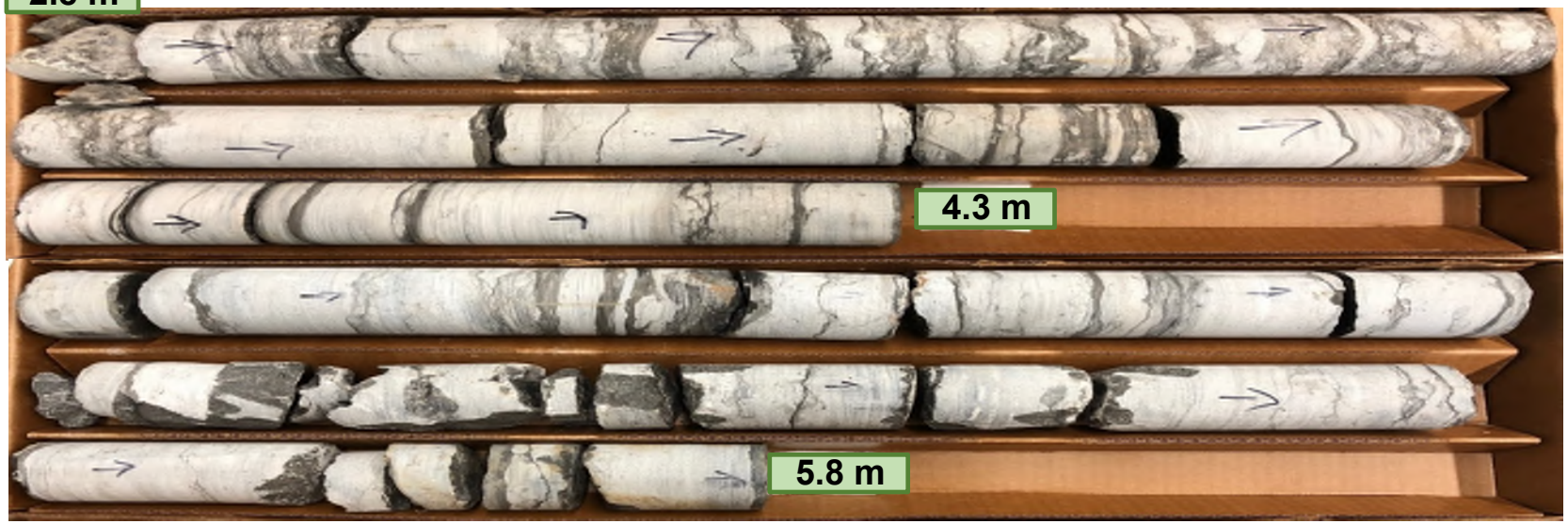
borehole no.	core runs	project	project no.
MW21-111	Run 1: 1.0m - 2.6m Run 2: 2.6m - 4.2m Run 3: 4.3m - 5.8m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-32
Dec 13, 2021			

DRY BEDROCK CORES



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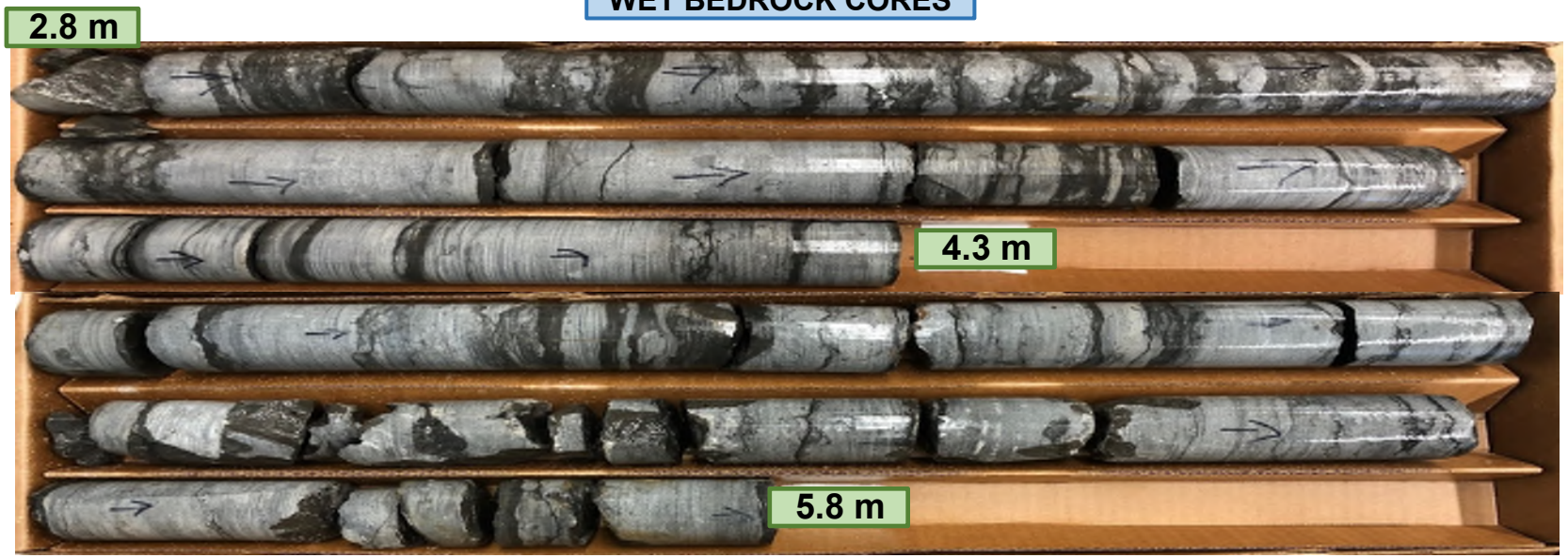
borehole no.	core runs	project	project no.
MW21-112	Run 1: 2.8m - 4.3m Run 2: 4.3m - 5.8m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 13, 2022		Rock Core Photographs	FIG A-33

WET BEDROCK CORES



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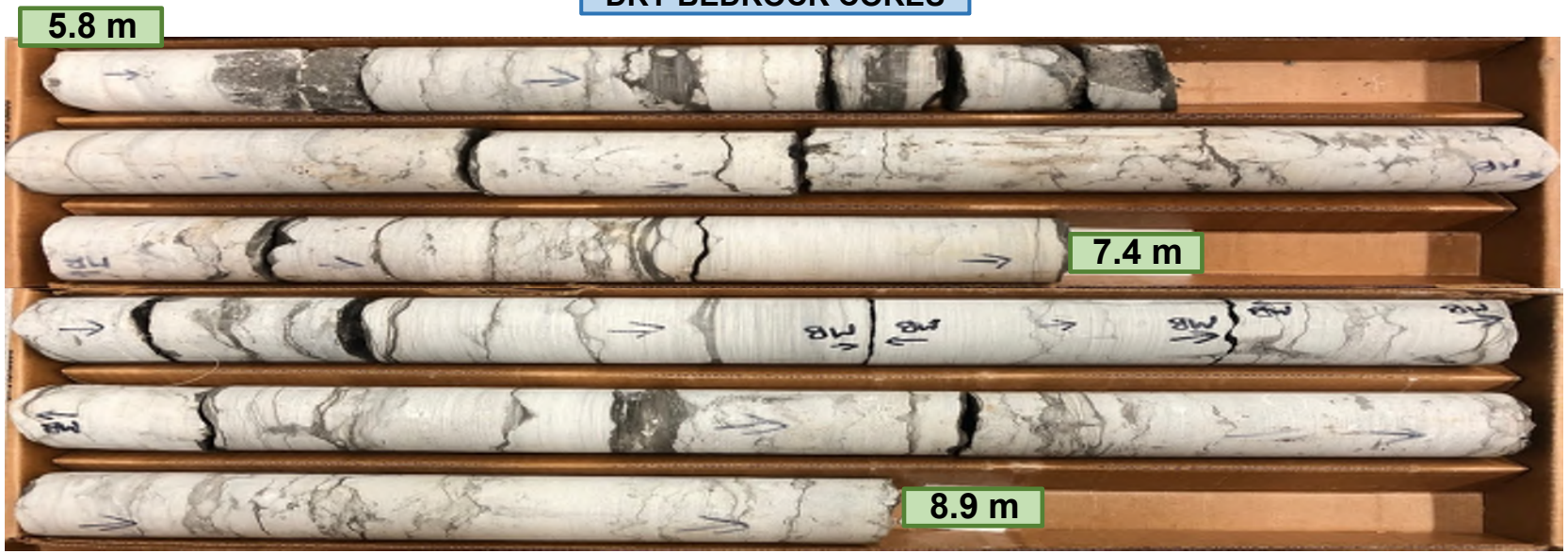
borehole no.	core runs	project	project no.
MW21-112	Run 1: 2.8m - 4.3m Run 2: 4.3m - 5.8m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 13, 2022		Rock Core Photographs	FIG A-34

DRY BEDROCK CORES



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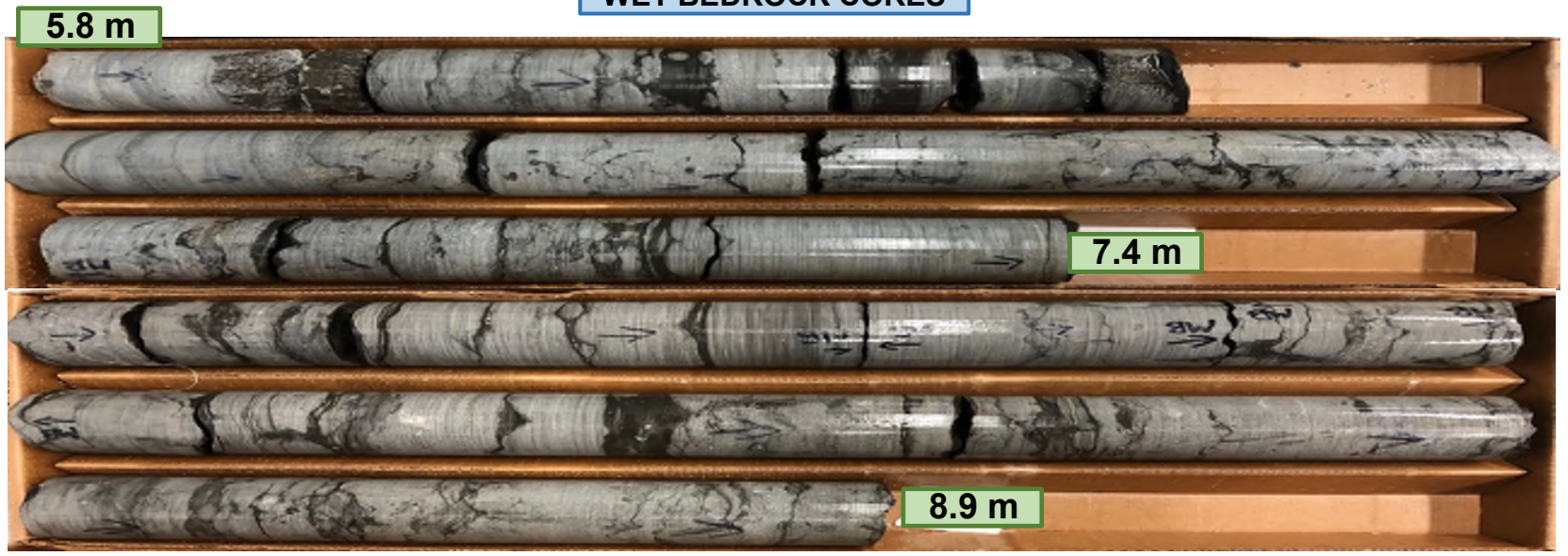
borehole no.	core runs	project	project no.
MW21-112	Run 3: 5.8 m - 7.4 m Run 4: 7.4 m - 8.9 m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 13, 2022		Rock Core Photographs	FIG A-35

WET BEDROCK CORES



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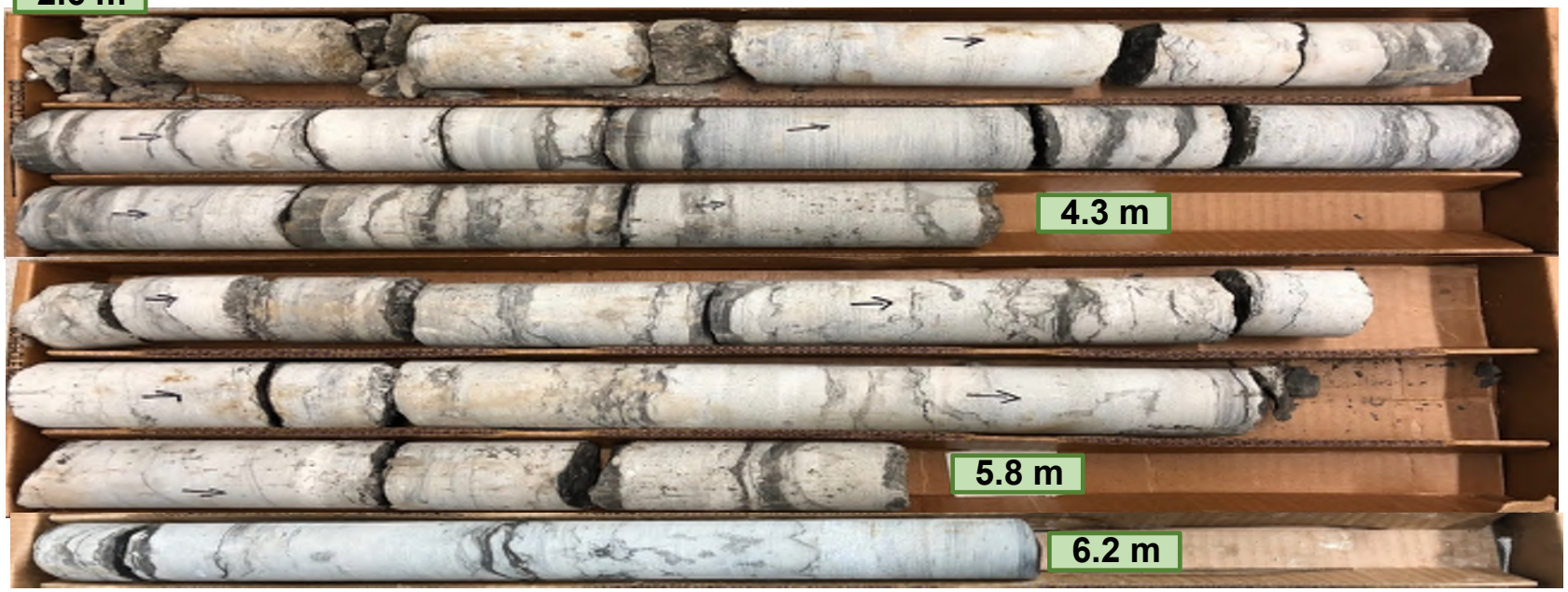
borehole no.	core runs	project	project no.
MW21-112	Run 3: 5.8 m - 7.4 m Run 4: 7.4 m - 8.9 m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored Dec 13, 2022		Rock Core Photographs	FIG A-36

DRY BEDROCK CORES



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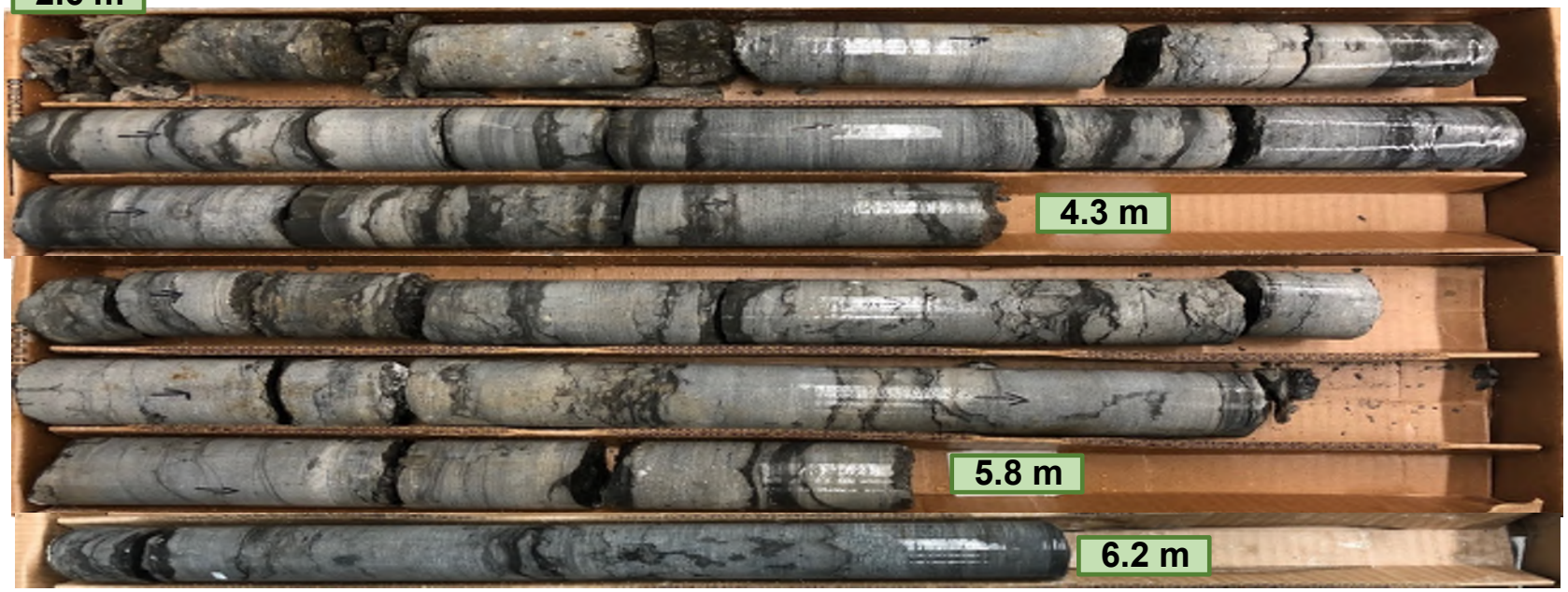
borehole no.	core runs	project	project no.
MW21-113	Run 1: 2.6 m - 4.3 m Run 2: 4.3 m - 5.8 m Run 3: 5.8 m - 6.2m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-37
Dec 10, 2021			

WET BEDROCK CORES



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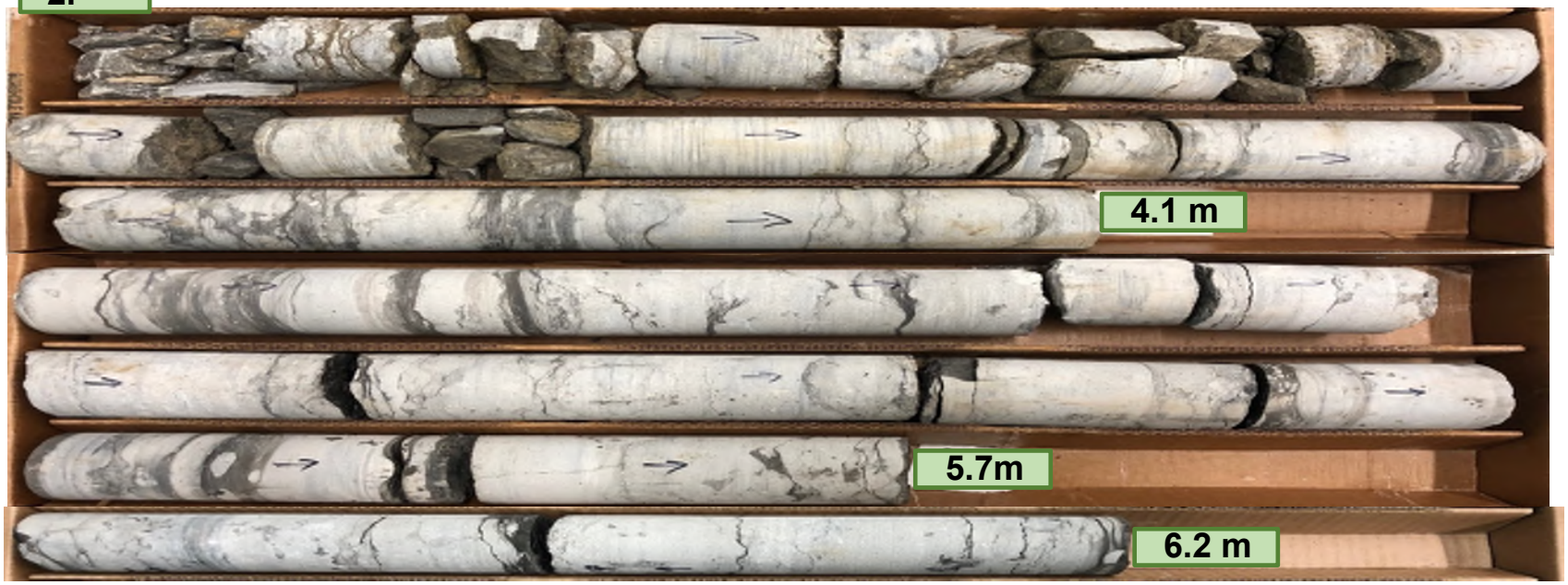
borehole no.	core runs	project	project no.
MW21-113	Run 1: 2.6 m - 4.3 m Run 2: 4.3 m - 5.8 m Run 3: 5.8 m - 6.2m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-38
Dec 10, 2021			

DRY BEDROCK CORES

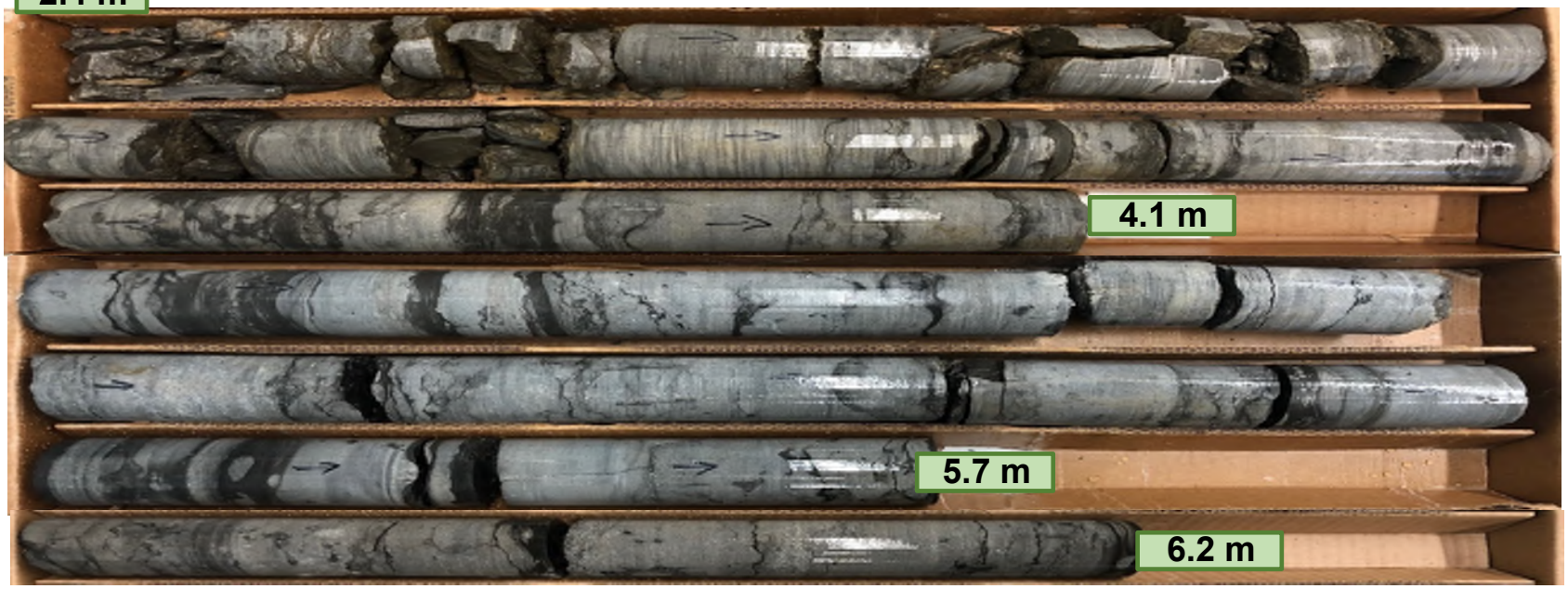
2.



EXP Services Inc. **www.exp.com**
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

borehole no.	core runs	project	project no.
MW21-115	Run 1: 2.4 m - 4.1m Run 2: 4.1 m - 5.7 m Run 3: 5.7 m - 6.2 m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-39
Dec 10, 2021			

WET BEDROCK CORES



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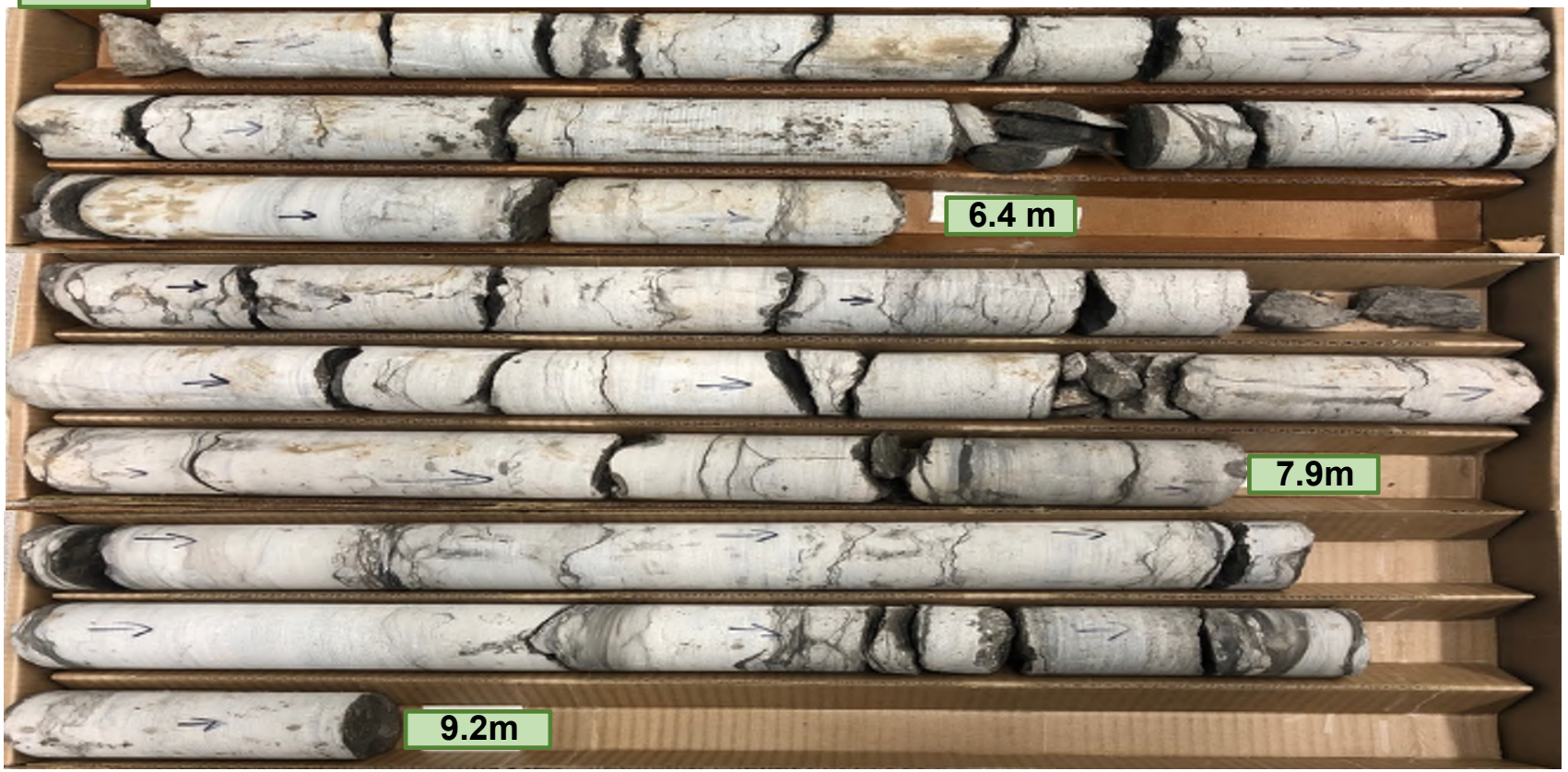
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

borehole no.	core runs	project	project no.
MW21-115	Run 1: 2.4 m - 4.1m Run 2: 4.1 m - 5.7 m Run 3: 5.7 m - 6.2 m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-40
Dec 10, 2021			

DRY BEDROCK CORES



EXP Services Inc. www.exp.com
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2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

borehole no.	core runs	project	project no.
MW21-116	Run 1: 4.9 m - 6.4 m Run 2: 6.4 m - 7.9 m Run 3: 7.9 m - 9. 2m	Location: Zibi Property Blocks 201 to 205B	OTT-00250193-S0
date cored		Rock Core Photographs	FIG A-41
Dec 10, 2021			

Appendix B – USL-1 Geophysical Survey

USL-1 UNDERGROUND SERVICE LOCATORS INC.

Contractor: EXP

Action requested: Geophysical survey.

Work site: ZIBI, (south/west), Ottawa, ON.

Areas of concern:

- Possible foundation walls buried underground in previously dilled sampling well location.

Information provided by contractor:

- Location of scan area.

Method

•Ground penetrating radar, (GPR), was used to detect the presence of walls buried underground.

•Location of items detected will be marked on ground with pink paint.

USL-1 geophysical report

- The specific signature of walls were not detected by the GPR in the scan area within 8 feet of the surface.
- A geophysical change was detected indicating what appeared to be a trench of sort traveling from south/east to north/west.
- The trench outline within the scan area was marked with pink paint. (see photos)

Supporting documentation

- Photos: 1 satellite, 6 ground.
- This written report is included within 1 page.

Date of survey: 18 Mar. 2022
Date of report: 27 Mar. 2022

Mike Thivierge
Geophysical Surveyor

USL-1
UNDERGROUND SERVICE LOCATORS INC.

100-1704 Carling Ave, Ottawa ON K2A 1C7 tel 613-226-8750 fax 613-226-8677 toll-free 877-248-3444 www.usl-1.com

USL-1
UNDERGROUND SERVICE LOCATORS INC.

100-1704 Carling Ave, Ottawa ON K2A 1C7 tel 613-226-8750 fax 613-226-8677 toll-free 877-248-3444 www.usl-1.com

100-1704 Carling Ave, Ottawa ON K2A 1C7 tel 613-226-8750 fax 613-226-8677 toll-free 877-248-3444 www.usl-1.com

USL-1
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Appendix C –Geophysics GPR Report

GEOPHYSICS GPR INTERNATIONAL INC.

100 – 2545 Delorimier Street
Longueuil (Québec)
Canada J4K 3P7

Tel. : (450) 679-2400
Fax : (514) 521-4128
info@geophysicsgpr.com
www.geophysicsgpr.com

May 21st, 2019

Transmitted by email: ismail.taki@exp.com
Our Ref.: GPR-19-01369

Mr. Ismail Taki, M.Eng., P.Eng.
Manager, Geotechnical
exp Services inc.
100 - 2650 Queensview Drive
Ottawa (ON) K2B 8H6

Subject: **Shear Wave Velocity Soundings for Site Classes Determination**
Chaudière Island, Ottawa (ON)
[Project: OTT-00250193]

Dear Sir,

Geophysics GPR International Inc. has been requested by **exp** Services Inc. to carry out seismic shear wave surveys on the Chaudière Island, in Ottawa (ON). The geophysical investigations used the Multi-channel Analysis of Surface Waves (MASW), the Extended SPatial AutoCorrelation (ESPAC), and the seismic refraction methods. From the subsequent results, the seismic shear wave velocities values were calculated.

The surveys were carried out, on May 3rd, by Mr. Alexis Marchand and Mr. Dominic Déraps, tech. The Figure 1 shows the regional location of the site and Figure 2 illustrates the location of the seismic spreads. Both figures are presented in the Appendix.

The following paragraphs briefly describe the survey design, the principles of the test methods, and the results in graphic and table format.

METHODS PRINCIPLES

MASW Survey

The *Multi-channel Analysis of Surface Waves* (MASW) and the *Extended SPatial AutoCorrelation* (ESPAC or MAM for *Microtremors Array Method*) are seismic methods used to evaluate the shear wave velocities of subsurface materials through the analysis of the dispersion properties of the Rayleigh surface waves ("ground roll"). The MASW is considered an "active" method, as the seismic signal is induced at known location and time in the geophones spread axis. Conversely, the ESPAC is considered a "passive" method, using the low frequency "signals" produced far away. The method can also be used with "active" seismic source records. The dispersion properties are expressed as a change of phase velocities with frequencies. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. The inversion of the Rayleigh wave dispersion curve yields a shear wave (V_S) velocity depth profile (sounding). Figure 3 schematically outlines the basic operating procedure for the MASW method.

Figure 4 illustrates an example of one of the MASW/ESPAC records, the corresponding spectrogram analysis and resulting 1D V_S model. The ESPAC method usually allows deeper Vs soundings, but generally with a lower resolution for the surface portion. Its dispersion curve can then be merged with the higher frequency one from the MASW to calculate a more complete inversion.

Seismic Refraction Survey

The method consists in measuring the propagation delays of the direct and refracted seismic waves (P and/or S) produced by an artificial source in the axis of a seismic linear spread. The seismic velocities of the materials can be directly calculated, then the refractors depths.

INTERPRETATION METHODS

MASW Surveys

The main processing sequence involved data inspection and edition when required; spectral analysis ("phase shift" for MASW, and "cross-correlation" for ESPAC); picking the fundamental mode; and 1D inversion of the MASW and ESPAC shot records using the SeisImagerSW™ software. The data inversions used a nonlinear least squares algorithm.

In theory, all the shot records for a given seismic spread should produce a similar shear-wave velocity profile. In practice, however, differences can arise due to energy dissipation, local surface seismic velocities variations, and/or dipping of overburden layers or rock. In general, the precision of the calculated seismic shear wave velocities (V_S) is of the order of 15% or better.

Seismic Refraction surveys

The General Reciprocal Method was used, with signal sources at both ends of the seismic spreads, to consider seismic wave propagation for two opposite directions. The seismic wave's arrival times were identified for each geophone. The measurements were realised to calculate the rock depth (using P waves).

More detailed descriptions of these methods are presented in *Shear Wave Velocity Measurement Guidelines for Canadian Seismic Site Characterization in Soil and Rock*, Hunter, J.A., Crow, H.L., et al., Geological Surveys of Canada, General Information Product 110, 2015.

SURVEY DESIGN

The seismic acquisition spreads were located on a possible filled crevasse (L1-East side), and over a shallow rock covered with fill material (L2-West side).

The East Side Seismic Section (L1), was 69 m long, using 3 metres geophones spacing for the principal spread, and 1 metre geophones spacing for the spread dedicated to shallow materials. Some possible side effects could have limited the effective depth of investigation.

The West Side Seismic Section (L2), was 57.5 m long, using 2.5 metres geophones spacing for the principal spread, and 0.5 metre geophones spacing for the spread dedicated to shallow materials.

The seismic records counted 4096 data, sampled at 1000 µs for the MASW surveys, and 4096 data, sampled at 50 µs for the seismic refraction. The records included a pre-trig portion of 10 ms. A stacking procedure was also used to improve the Signal / Noise ratio for the seismic records.

Unlike the refraction method, which allows producing a result point beneath each geophone, the shear wave depth sounding can be considered as the average of the bulk area within the geophone spread, especially for its central half-length. The seismic

records were made with a seismograph Terraloc MK6 (from ABEM Instrument), and the geophones were 4.5 Hz. A 10 kg sledgehammer was used as the energy source with impacts being recorded off both ends of the seismic spreads.

RESULTS

The $\overline{V}_{S30}$ value results from the harmonic mean of the shear wave velocities, from the surface to 30 metres deep. It is calculated by dividing the total depth of interest (30 metres) by the sum of the time spent in each velocity layer from the surface up to 30 metres. This value represents an equivalent homogeneous single layer response.

L1-East:

From seismic refraction, the rock depth calculation was not possible due to the site surrounding noise, and possibly due to the crevasse sides effects. The exp geotechnical boreholes results presented a rock between 11 and 13 metres deep. The seismic shear wave velocity of the sound shallow part of the rock was calculated between 1805 and 1820 m/s (cf. Figure 5). These results were used as initial parameters for the basic geophysical model, prior to the MASW dispersion curves inversions.

The MASW calculated velocities of the seismic shear wave (V_S) results are illustrated at Figure 6 and the numerical results are also presented at Table 1. Possibly due to sides effects limitations, the maximal resolvable V_S depth was approximately 15 to 18 metres deep. The seismic refraction results (V_S) were extrapolated until 30 metres deep to allow the $\overline{V}_{S30}$ value calculation.

The calculated $\overline{V}_{S30}$ value of the actual site is 756.0 m/s, corresponding to the Site Class "C" (cf. Table 1).

L2-West:

From seismic refraction, the rock depth was calculated between 2.3 and 6 metres deep (±1 metre). The exp geotechnical boreholes results presented the rock between 1.5 and 4 metres deep. The seismic shear wave velocity of the sound shallow portion of the rock was calculated between 1755 and 1985 m/s (cf. Figure 7), with and average of 1870 m/s. These results were used as initial parameters for the basic geophysical model, prior to the MASW dispersion curves inversions.

The MASW calculated velocities of the seismic shear wave (V_S) results are illustrated at Figure 8 and the numerical results are also presented at Table 2.

The calculated $\overline{V}_{S30}$ value of the actual site is 975.3 m/s, corresponding to the Site Class "B" (cf. Table 2). Less than 3 metres of unconsolidated material should take place between the rock and the lower part of the foundation to allow considering this Site Class. In the case than less than 1.15 metre could take place between the rock and the lower portion of the foundations, the Site Class "A" could be used.

CONCLUSION

Geophysical surveys were carried out on the Chaudière Island, in Ottawa (ON). The site was located north-east of Booth Street. As previous geotechnical boreholes revealed two different rock depths areas, two seismic surveys were produced to characterize each of them. The first was located over a possible filled crevasse (L1-East), while the second one was over a shallow rock covered with fill materials (L2-West). The seismic surveys used the MASW, ESPAC analysis methods, as well as the complementary seismic refraction method, to calculate the $\overline{V}_{S30}$ values for the Site Classes determination. The $\overline{V}_{S30}$ calculations are presented in Table 1 and Table 2.

The calculated $\overline{V}_{S30}$ value of the actual East Site area (possible crevasse) is 756 m/s corresponding to the Site Class "C" ($360 < \overline{V}_{S30} \leq 760$ m/s), as determined through the MASW, ESPAC and seismic refraction methods, Table 4.1.8.4.A of the NBC, and the Building Code, O. Reg. 332/12.

The calculated $\overline{V}_{S30}$ value of the actual West Site area is 975 m/s, corresponding to the Site Class "B" ($760 < \overline{V}_{S30} \leq 1500$ m/s). Nevertheless, the Site Classes A and B are not to be used if there is 3 metres or more of unconsolidated materials between the rock and the bottom of the spread footing or mat foundations. Considering the case than less than 1.15 metre of unconsolidated materials could take place between the rock and the lower portion of the foundations, the Site Class "A" could be used ($\overline{V}_{S30}$ * > 1500 m/s).

It must be noted that other geotechnical information gleaned on site; including the presence of liquefiable soils, soft clays, high moisture content etc. can supersede the Site Classification provided in this report based on the $\overline{V}_{S30}$ value.

The V_S values calculated are representative of the in-situ materials and are not corrected for the total and effective stresses.

P.Eng.

Jean-Luc Arsenault, M.A.Sc., P.Eng.
Senior Project Manager

LICENSED PROFESSIONAL ENGINEER
J.-L. ARSENAULT
100148122
PROVINCE OF ONTARIO

2019-05-21

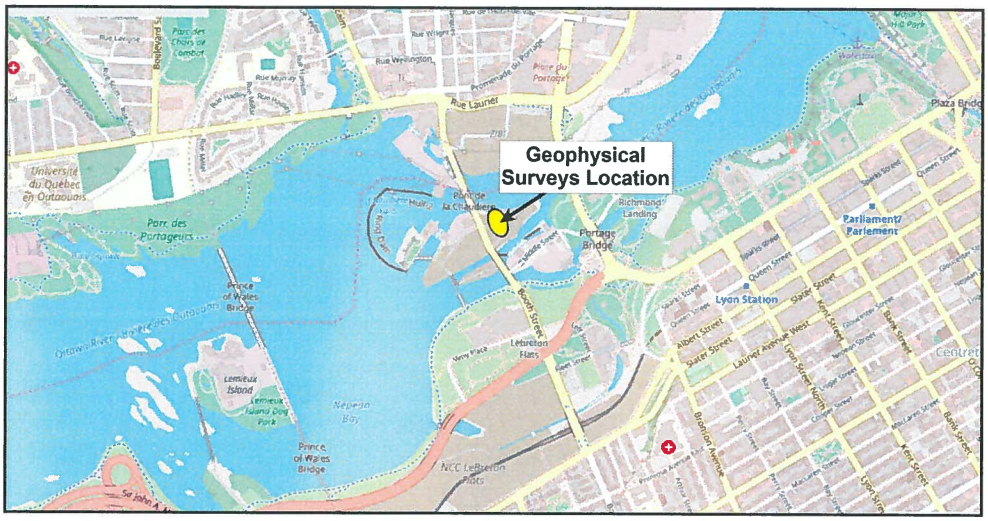


Figure 1: Regional location of the Site
(source: *OpenStreetMap©*)

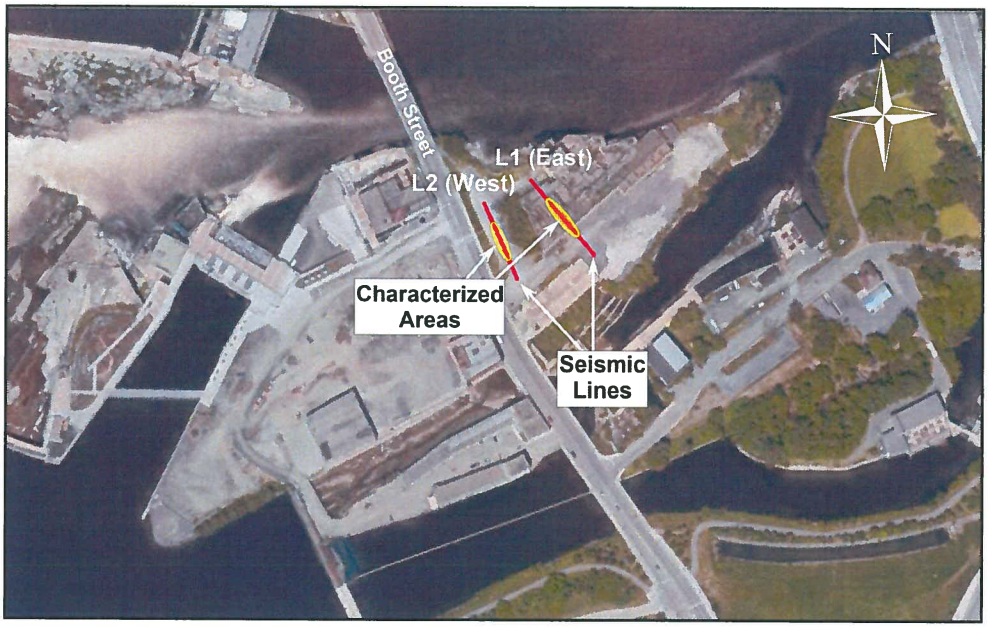


Figure 2: Location of the seismic spreads
(source: *Google Earth™*)

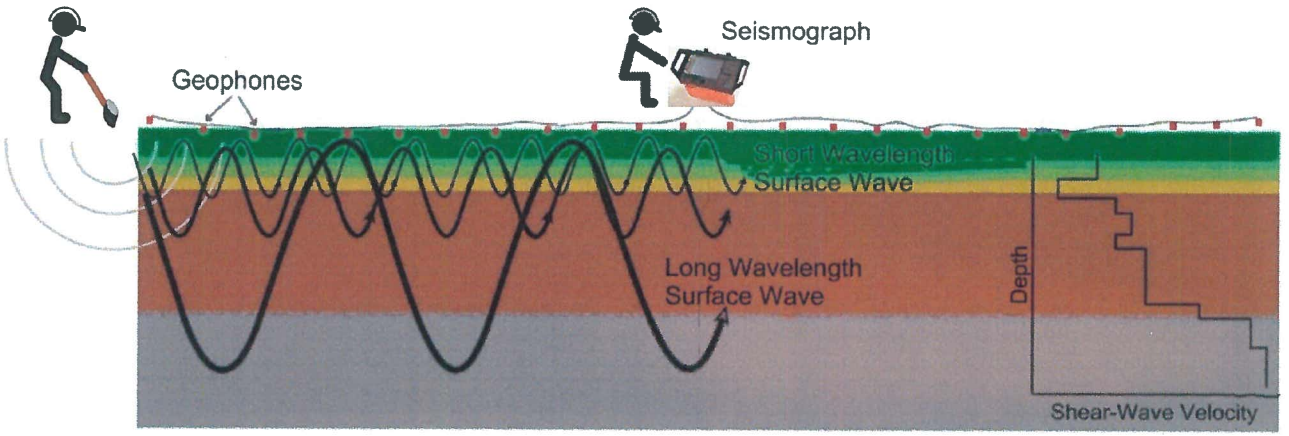


Figure 3: MASW Operating Principle

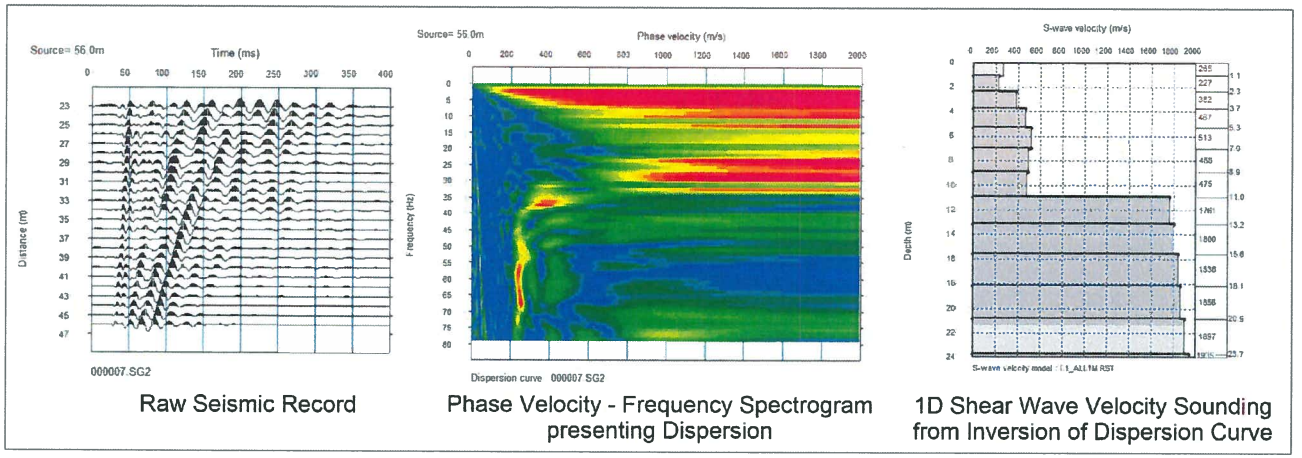
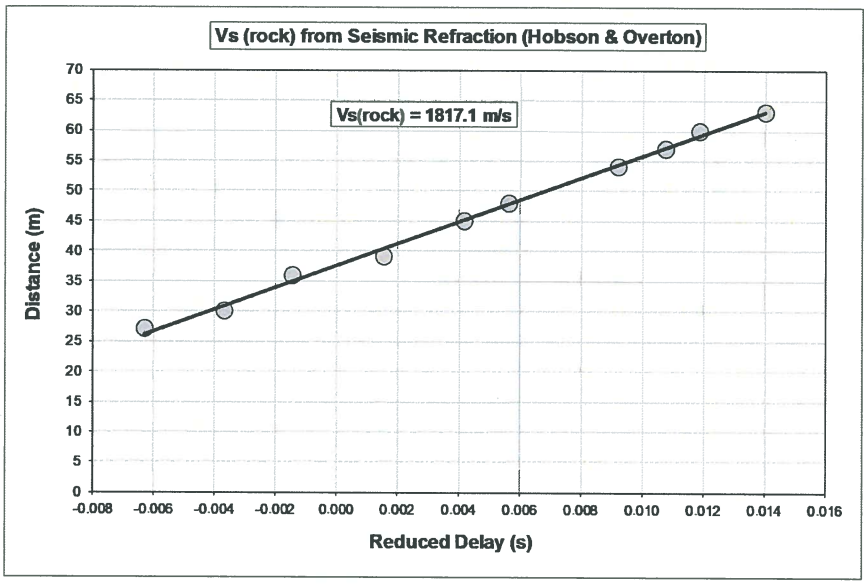


Figure 4: Example of a MASW/ESPAC record, Phase Velocity - Frequency curve and resulting 1D Shear Wave Velocity Model (L1-East ; dX = 1m)



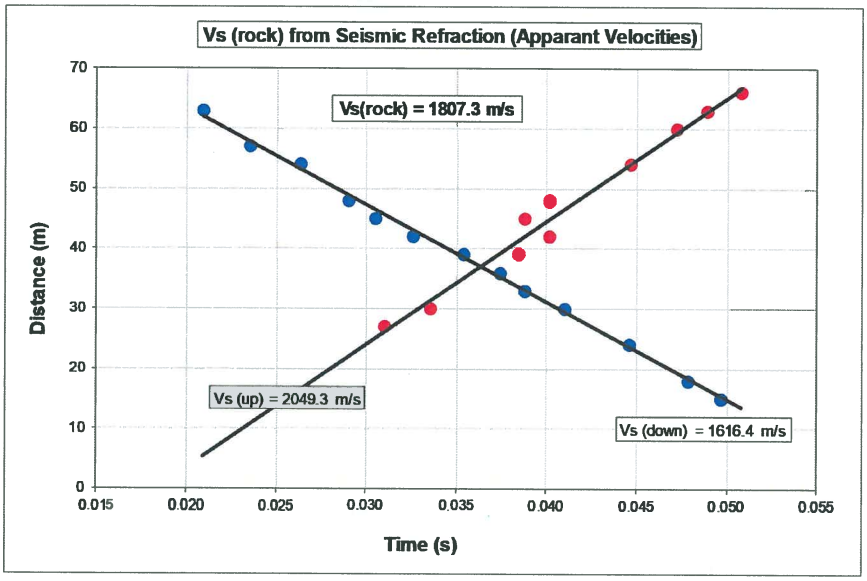


Figure 5: L1 (East) Rock V_S from Seismic Refraction

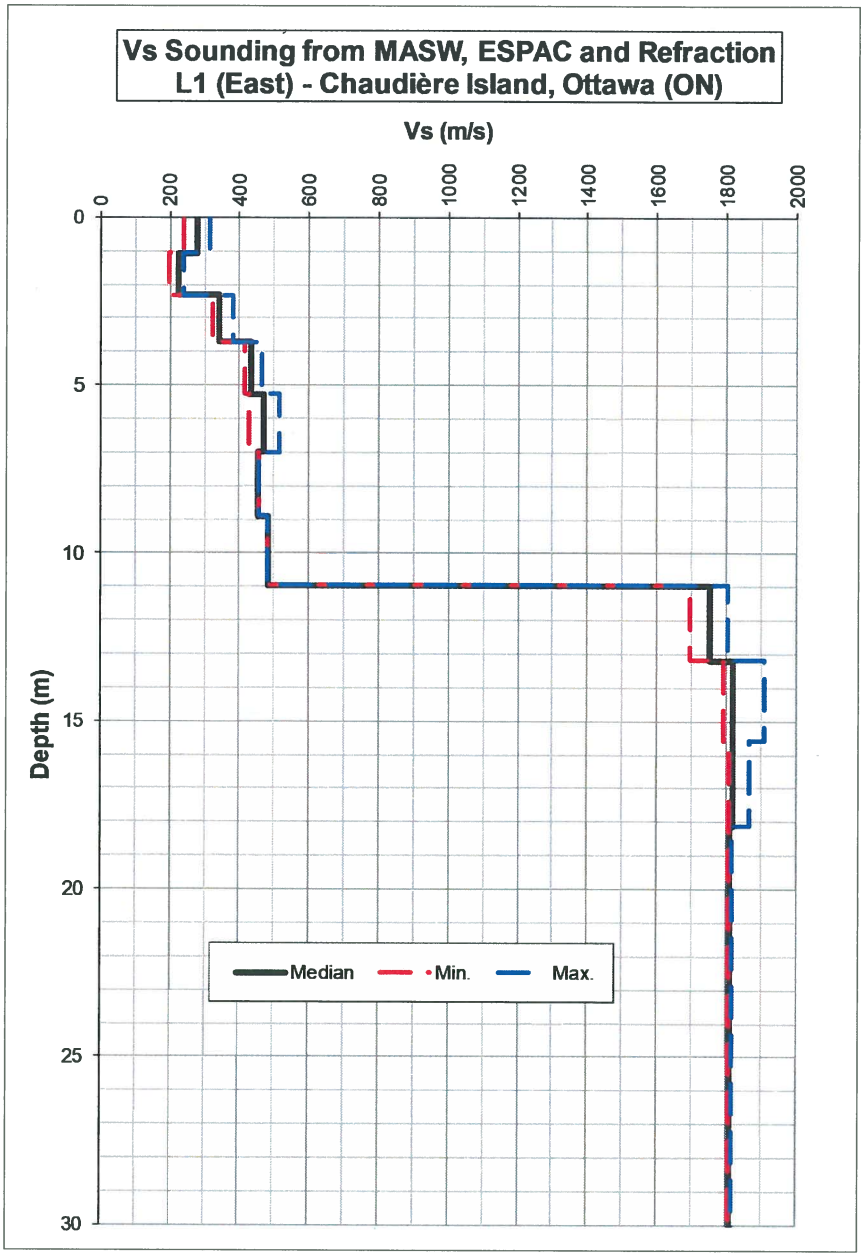
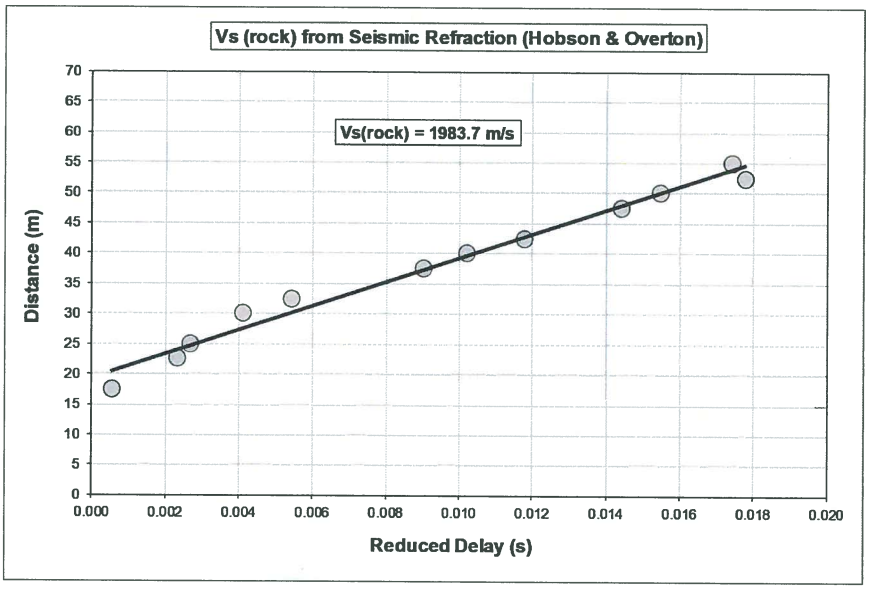


Figure 6: L1 (East) MASW Shear-Wave Velocities Sounding



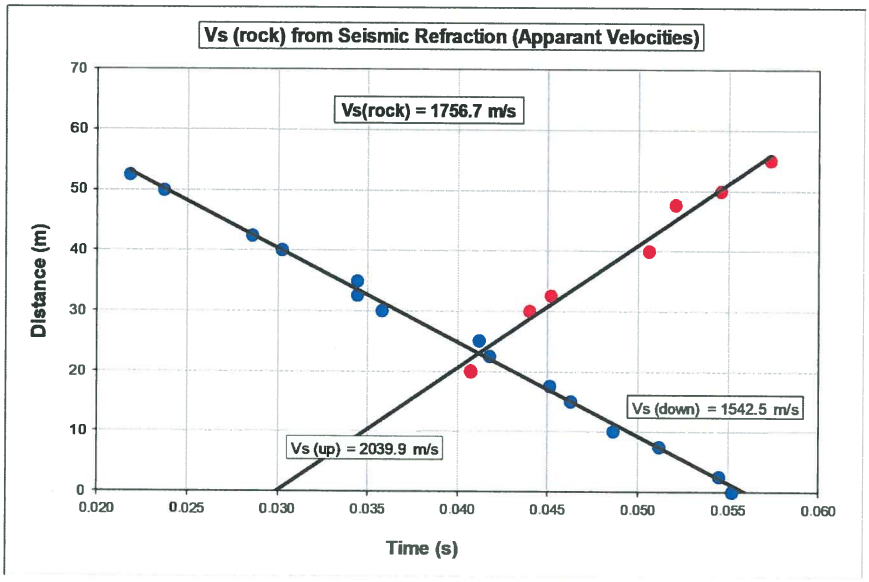


Figure 7: L2 (West) Rock V_S from Seismic Refraction

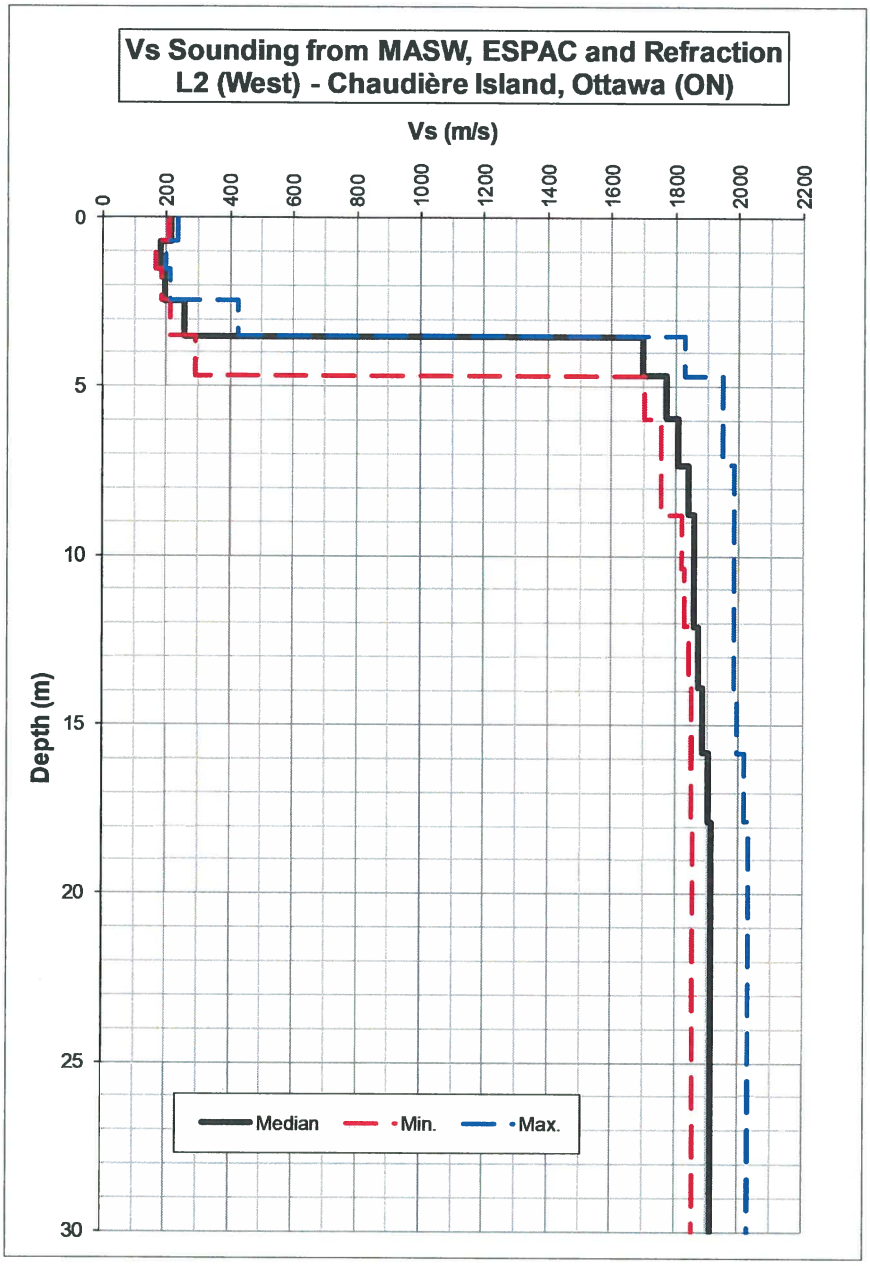


Figure 8: L2 (West) MASW Shear-Wave Velocities Sounding

TABLE 1
L1 (East) - V_{S30} Calculation for the Site Class (actual site)

Depth	Vs			Thickness	Cumulative Thickness	Delay for Med. Vs	Cumulative Delay	Vs at Given Deth
	Min.	Median	Max.					
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)
0	240.3	277.4	314.5					
1.07	197.6	225.8	240.7	1.07	1.07	0.003863	0.003863	277.4
2.31	322.8	341.7	382.8	1.24	2.31	0.005476	0.009338	247.1
3.71	413.4	434.3	467.0	1.40	3.71	0.004100	0.013439	276.0
5.27	426.7	470.9	515.2	1.57	5.27	0.003605	0.017044	309.5
7.01	456.5	456.5	456.5	1.73	7.01	0.003675	0.020720	338.1
8.90	482.7	482.7	482.7	1.90	8.90	0.004153	0.024872	357.9
10.96	1697.5	1751.2	1804.8	2.06	10.96	0.004269	0.029141	376.2
13.19	1792.8	1817.1	1910.4	2.23	13.19	0.001271	0.030412	433.6
15.58	1807.3	1817.1	1869.0	2.39	15.58	0.001315	0.031727	491.0
18.13	1807.3	1812.2	1817.1	2.55	18.13	0.001406	0.033133	547.2
20.85	1807.3	1812.2	1817.1	2.72	20.85	0.001501	0.034634	602.1
23.74	1807.3	1812.2	1817.1	2.88	23.74	0.001592	0.036225	655.2
26.79	1807.3	1812.2	1817.1	3.05	26.79	0.001683	0.037908	706.6
30				3.21	30.00	0.001774	0.039682	756.0

V_{S30} (m/s)	**756.0**
Site Class	**C**

TABLE 2
L2 (West) - V_{S30} Calculation for the Site Class (actual site)

Depth	Vs			Thickness	Cumulative Thickness	Delay for Med. Vs	Cumulative Delay	Vs at Given Depth
	Min.	Median	Max.					
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)
0	206.6	215.8	236.2					
0.71	167.9	183.2	196.9	0.71	0.71	0.003310	0.003310	215.8
1.54	186.8	196.6	211.7	0.82	1.54	0.004498	0.007808	197.0
2.47	211.2	255.2	425.7	0.93	2.47	0.004750	0.012558	196.9
3.52	290.9	1698.4	1827.8	1.04	3.52	0.004090	0.016648	211.2
4.67	1704.9	1771.8	1949.8	1.15	4.67	0.000679	0.017328	269.5
5.93	1756.7	1806.8	1950.1	1.26	5.93	0.000713	0.018041	328.9
7.31	1756.7	1840.7	1983.7	1.37	7.31	0.000760	0.018801	388.7
8.79	1821.5	1858.4	1983.7	1.48	8.79	0.000806	0.019607	448.4
10.38	1826.8	1857.2	1983.7	1.59	10.38	0.000857	0.020465	507.4
12.09	1842.6	1872.7	1983.7	1.70	12.09	0.000917	0.021382	565.3
13.90	1849.7	1887.5	1992.6	1.81	13.90	0.000968	0.022350	622.0
15.82	1853.6	1904.5	2015.3	1.92	15.82	0.001019	0.023369	677.2
17.86	1855.8	1915.9	2032.7	2.03	17.86	0.001067	0.024436	730.8
24.29	1867.7	1925.0	2040.3	6.43	24.29	0.003355	0.027791	873.9
30				5.71	30.00	0.002968	0.030760	975.3

V_{S30} (m/s)	**975.3**
Site Class	**B [1]**

[1]: The Site Classes A and B are not to be used if there is 3 metres or more of unconsolidated materials between the rock and the underside of footing or mat foundations.

Legal Notification

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