GEOTECHNICAL REPORT – PITT MEADOWS AFFORDABLE HOUSING AND CHILDCARE

March 18, 2022

Prepared for:

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Revision	Date	Description
A	February 4, 2022	Issued for review
0	March 18, 2022	Issued for use; subsequent groundwater level measurements included; Section 7.7 for Instrumentation and Monitoring added

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1.0 INTRODUCTION

This geotechnical report has been prepared for the Metro Vancouver Housing Corporation (MVHC) to support the design of the proposed Pitt Meadows Affordable Housing and Childcare building (the Project) located at 19125 119B Avenue in Pitt Meadows, British Columbia (the Site).

The purpose of the geotechnical assessment was to characterize the soil and groundwater conditions at the site, and to provide geotechnical recommendations to support the design and construction of the project. This report presents the results of our geotechnical exploration, engineering analyses, and design recommendations for the Project.

1.1 SCOPE OF WORK

The scope of work for geotechnical assessment included the following:

- Review of available geotechnical and geological information;
- Execution of a geotechnical subsurface exploration;
- Completion of geotechnical laboratory testing on representative subsurface soil samples; and
- Preparation of this geotechnical report.

Stantec's scope of work also included environmental soils and hydrogeology analysis. The results of the environmental and hydrogeology analyses are presented under separate covers.

Our assessment has been completed in general accordance with our proposal dated August 17, 2021. Acceptance of our proposal with signed authorization was received from MVHC by email on October 6, 2021.

This report should be read in conjunction with the Statement of General Conditions, which is included in **Appendix A**.

1.2 DOCUMENTS REVIEWED

The following is a list of reference geotechnical reports and construction drawings prepared for adjacent sites obtained by MVHC:

- Design drawings for 'The Wesbrooke Congregate Building', Drawing Nos. A3.1 and A3.2, Rev. RA, dated May 5, 2011, prepared by Ron Allen Architect Inc.
- Issued for Construction drawings for 'The Wesbrooke Congregate Building', Drawing Nos. S-5 and S-6, dated July 2011, prepared by Ron Allen Architect Inc.
- Report titled 'Geotechnical Engineering Review and Assessment – Proposed Casa Grande Congregate Housing', dated August 30, 2008, prepared by Jecth Consultants Inc.
- Issued for Building Permit drawings for 'City of Pitt Meadows Proposed Parking', titled 'Foundation Plan' and 'Ground Floor Plan', Drawing Nos. S201 to S204, Rev. 1, dated November 7, 2008, prepared by ICR Architecture and Project Consultants Inc.

- Report titled ‘Proposed Community Center Parkade – 12027 Harris Road, Pitt Meadows – Geotechnical Exploration and Preliminary Report’, dated August 9, 2007, prepared by Trow Consulting Engineering Ltd.
- General Revision drawings for ‘City of Pitt Meadows Proposed Parking’, titled ‘Foundation Plan’, Drawing No. S-2, Rev. 5, dated February 4, 2000, prepared by ICR Architecture and Project Consultants Inc.
- General Revision drawings for ‘City of Pitt Meadows Proposed Parking’, titled ‘Floor Plan’ Drawing No. A-2, Rev. 3, dated December 23, 1999, prepared by ICR Architecture and Project Consultants Inc.

1.3 PROJECT DOCUMENTS

The project is currently in the schematic design phase and being led by Ryder Architecture. At the time of this report preparation available documents for the proposed construction were limited to conceptual drawings titled ‘Pitt Meadows Civic Centre Feasibility Study’, Drawing Nos. A-0.01 to -1.02a, dated, July 10, 2020 which were included in the Invitation to Quote prepared by GBL Architects Inc.

1.4 CODES, STANDARDS AND GUIDELINES

The following codes and standards were used for the geotechnical work and for developing the design recommendations:

- British Columbia Building Code, BCBC (2018)
- National Building Code of Canada, NBCC (2015)
- Master Municipal Construction Document, MMCD Platinum Edition (2009)
- Canadian Foundation Engineering Manual (2006)

1.5 PROJECT DESCRIPTION

We understand the proposed development includes a 6 storey, wood-framed residential building that includes a day-care centre, and one level of underground parking. The footprint of the proposed parkade will be L-shaped (following the shape of the project site) and designed to maximize available parking. The above grade structure (Levels 1 to 6) will be rectangular and will be approximately 90 m long (north-south) and 40 m wide (east-west).

We understand that the underground parkade will extend below part of the existing parking lot for the existing senior’s community home to the west. The pavement will be restored for surface parking following construction of the parkade. For a typical one level parkade, we assume that the excavation will be extend approximately 3.5 m below the existing ground surface.

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 PHYSICAL SETTING

The Site is L-shaped and is approximately 95 m long (north-south), 60 m wide (east-west) at the north end, and 40 m in wide at the south end. The Site is bounded by 119b Avenue to the south, Wesbrooke senior's community home to the west, a townhouse complex to the north, and Pitt Meadows Family Recreation Center building and parking lot to the east.

The Site is currently undeveloped and an existing grass field and asphalt is present in the north half and a gravel parking lot in the south half.

Based topographic survey completed by Targe Land Surveying dated June 18, 2021, and visual observations, the Site is nearly flat, with approximate elevations ranging from El. 7.5 m to 8.0 m (Geodetic).

2.2 GEOLOGICAL SETTING

Surficial Geology Map 1484A (Armstrong and Hicock, 1976) indicates that the Site is located within the surficial geology unit "Se", Sumas Drift, which comprises outwash, ice-contact, and deltaic deposits, including raised proglacial deltaic gravel and sand up to 40 m thick. The Site is near the boundary with the surficial geology unit "Fc", which comprises overbank silty to silt clay loam normally up to 2 m thick overlying deltaic and distributary channel fill.

3.0 REVIEW OF AVAILABLE GEOTECHNICAL REPORTS

Review of the geotechnical report for the Wesbrooke Senior's Community Centre (Jecth Consultants Inc, 2008) indicated two Cone Penetration Test's (CPTs) and one auger borehole were completed on this property which is directly west of the Site. The CPTs were advanced to 31 m depth below existing ground surface and the auger borehole was drilled to 15.2 m below the ground surface. The subsurface conditions comprised the following in increasing depth. All values are approximate.

- 0 m to 1.8 m: loose silty sand,
- 1.8 m to 11.3 m: medium dense to dense sand, trace silt,
- 11.3 m to 12.2 m: medium stiff silt,
- 12.2 m to 15.5 m: loose to medium silty sand
- 15.2 m to 31 m: clayey silt /clay (inferred) with occasional sand lenses

Groundwater level was observed at approximately 3.5 m depth below existing ground surface.

The geotechnical report prepared for the Pitt Meadows Community Centre Parkade (Trow, 2007), which is located east of the Site, indicated three auger boreholes and three CPTs (one adjacent to each borehole) were completed to approximately 18.7 m depth below the existing ground surface. The subsurface conditions comprised the following in increasing depth. All values are approximate.

- 0 m to 10 m: sand with variable amounts of silt and gravel, dense, transitioning to compact with depth,
- 10 m to 13 m: silt and sandy silt,
- 13 m to 14.8 m: sand,
- 14.8 m to 18.7 m: soft to firm clayey silt

Groundwater level was observed at approximately 2.8 m to 3.0 m depth below existing ground surface.

4.0 GEOTECHNICAL SUBSURFACE EXPLORATION

4.1 FIELD WORK

Stantec carried out a geotechnical exploration program on November 26 and 29, 2021. The site exploration comprised ten solid-stem auger boreholes (AH21-01 to AH21-10), three standpipe piezometer installations, one Seismic Cone Penetration Test (SCPT), and one Cone Penetration Test (CPT). Target depth was 6 m below existing ground surface for the auger boreholes, and 30 m for the SCPT and CPT. The approximate locations of the test holes are shown on Figure 1 in **Appendix B**.

4.1.1 Utility Locate

In advance of the subsurface exploration, Stantec completed a BC 1 Call, reviewed the utility information on Pitt Meadows interactive online mapping tool ‘Mapview’, and coordinated with the City of Pitt Meadows and MVHC to obtain a Highway Use Permit for the field program.

We retained the services of a subcontracted utility locator, Quadra Utility Locating (based in Port Coquitlam, BC), to carry out on-site utility locating of the proposed drilling locations using Ground Penetrating Radar (GPR) and electromagnetic (EM) scanning equipment.

4.1.2 Dynamic Cone Penetration Tests

Dynamic cone penetration tests (DCPT) were conducted in boreholes AH21-01 to AH21-06. The DCPT is an in-situ test which uses a 63.5 kg hammer, free-falling from 760 mm height onto an anvil which is connected to 45 mm diameter AWJ steel rods. A disposable 60 mm diameter cone is connected to the bottom end of the AWJ rods. With each hammer blow, the cone penetrates the ground, and the “blow counts” are recorded for each 300 mm of penetration. The DCPT was terminated at 7.3 m depth below the existing ground surface in borehole AH21-01, and at 5.8 m depth in boreholes AH21-02 to AH21-06.

4.1.3 Cone Penetration Tests

CPTs were carried out at boreholes AH21-07 and AH21-08 using an integrated electronic piezocone penetrometer and data acquisition system. CPT involved advancing a piezocone into the soils at a near constant rate of 2 cm/s, while continuously recording tip resistance, sleeve friction, and pore water pressure.

At borehole AH21-07, the CPT was supplemented with seismic shear wave velocity measurements taken at 1 m intervals (i.e. seismic cone penetration test, SCPT). The shear wave velocity measurement is conducted by striking a steel I-beam placed between the drill rig and the ground, producing a shear wave at surface. A sensor attached to the piezocone detects the arrival time of the shear wave, and the shear wave velocity is calculated.

Due to gravelly fill near surface, both SCPT21-07 and CPT21-08 were drilled out to approximately 1.3 m depth prior to advancing the soundings.

CPT/SCPT plots are provided in **Appendix D**.

4.1.4 Borehole Drilling

Ten solid-stem auger boreholes were advanced. At locations where DCPT, CPT, or SCPT were performed, borehole drilling was completed after the in-situ testing.

Standpipe piezometers were installed in boreholes AH21-01, AH21-04, and AH21-06. Due to sloughing of sand within the boreholes, the standpipes were installed using hollow-stem augers.

A handheld GPS device with a horizontal accuracy of approximately +/-3 m was used to record as-drilled coordinates of the boreholes. The coordinates were adjusted where necessary based on field measurements of nearby landmarks or structures. Elevations were estimated based on handheld GPS.

Boreholes AH21-01 to AH21-06 and the accompanying DCPTs were carried out by Southland Drilling Co. Ltd. (based in Delta, BC), subcontracted to Stantec. Boreholes AH21-07 to AH21-10 and the CPT’s were carried out by Conetec Investigations Ltd. (based in Burnaby, BC), subcontracted to Stantec.

A summary of the geotechnical subsurface exploration is provided in **Table 1**.

Table 1 Summary of Geotechnical Exploration

Borehole ID	Coordinates[1]		Approximate Ground Surface Elevation[2] (m)	Borehole Details		
	Northing (m)	**Easting (m)**		**In-situ Testing Completed (Depth (m))**	**Borehole Depth (m)**	**Standpipe Piezometer Bottom Depth (m)**
AH21-01	5452036	522384	8.0	DCPT (7.3)	6.1	6.1
AH21-02	5452060	522385	8.0	DCPT (5.8)	6.1	-
AH21-03	5452017	522392	7.5	DCPT (5.8)	6.1	-
AH21-04	5451980	522409	7.5	DCPT (5.8)	6.1	6.1
AH21-05	5452015	522409	7.5	DCPT (5.8)	6.1	-
AH21-06	5452060	522408	8.0	DCPT (5.8)	6.1	5.2
AH21-07	5452040	522410	8.0	SCPT (30.0)	6.1	-
AH21-08	5451985	522382	7.5	CPT (30.0)	6.1	-
AH21-09	5452039	522361	7.5	-	6.1	-
AH21-10	5452061	522371	7.5	-	6.1	-

NOTES:

[1] Coordinates were obtained using a hand-held GPS device and are approximate.

[2] Existing ground surface elevations are approximate and based on onsite observations and handheld GPS

The geotechnical subsurface exploration was monitored by a Stantec geotechnical field engineer who located the test holes, selected the soil sampling depths, classified the soils, kept a detailed log of soil and groundwater conditions, and recorded the DCPT blow counts. Representative soil samples were collected from the solid-stem auger flights for laboratory classification and testing.

4.2 LABORATORY TESTING

The objective of the laboratory testing was to aid in the visual classification of the collected soil samples and to derive engineering parameters as required to support the geotechnical analyses.

The laboratory tests were performed in general accordance with the applicable ASTM test procedures and included visual classification, fines content, and natural moisture content. Results of the tests are included on the Borehole Records in **Appendix C**.

Analytical tests including pH, water soluble sulphate content, and electrical resistivity tests were carried out on selected soil samples to evaluate the corrosion potential of steel in contact with soils and the effect of sulphate exposure on concrete. Results of the analytical tests are provided in **Appendix E**.

5.0 SUBSURFACE CONDITIONS

5.1 SOIL CONDITIONS

The soil conditions encountered within the boreholes generally consisted of fill soils underlain by native deposits of sandy silt, silty sand, and poorly graded sand. The detailed borehole records are provided in **Appendix C**, and include an explanation of the symbols and terms used for soil descriptions. A general description of the soil layers encountered are provided below.

Topsoil

Topsoil consisting of dark brown organic sandy silt with rootlets was encountered at the existing ground surface in boreholes AH21-01 and AH21-02. The topsoil was approximately 0.3 m thick at both locations.

Asphalt

Asphalt was encountered at the existing ground surface of boreholes AH21-09 and AH21-10, with a thickness of 180 mm and 150 mm thick, respectively.

Fill Soils

Fill was encountered in all boreholes and generally consisted of gravel with sand, sand with gravel, and/or silty sand. Thickness of the fill ranged from approximately 0.2 to 0.4 m.

Sandy SILT (ML) and silty SAND (SM)

Sandy silt and silty sand deposits were encountered below the fill in all boreholes except borehole AH21-10. The silty sand / sandy silt extended to depths between 0.9 m and 2.0 m below ground surface.

In boreholes AH21-01, AH21-02, AH21-05, AH21-06, and AH21-07, the sandy silt or silty sand contained trace organics in the upper 0.3 m to 1.2 m of the layer. Based on the DCPT blow counts, the compactness of the sandy silt and silty sand deposits generally varied from very loose to loose in the upper 1 m and compact below. Measured moisture contents in the sandy silt and silty sand generally ranged from 20 to 43%.

Upper SAND (SP, SP-SM)

Poorly graded sand with variable amounts of silt and trace gravel was observed in all boreholes. The sand layer was encountered below the sandy silt and silty sand layers in all boreholes except at borehole AH21-10. In borehole AH21-10, the sand layer was encountered below the fill.

The sand extended to the termination depth of all boreholes except at borehole AH21-04. Measured fines content of samples of the sand ranged from 2% to 12%. Based on DCPT blow counts, the compactness of the sand varied from compact to dense, with compactness generally decreasing with depth below 3.5 to 4 m.

Based on the interpretation of the CPT/SCPT data, the upper sand layer extends to approximately 10.5 and 6.9 m below the existing ground surface in SCPT21-07 and CPT21-08, respectively.

Upper Clay or Silt

Brown lean clay was encountered underlying poorly graded sand with silt in borehole AH21-04 from approximately 5.9 m depth to the termination of the borehole. Measured moisture content of a sample of the lean clay was 36%.

Based on the interpretation of the CPT/SCPT data, fine-grained soils consisting of a mixture of clay or silt extends from approximately 10.5 to 12 m below the existing ground surface in SCPT21-07 and from approximately 6.9 to 10.5 m below the existing ground surface in CPT21-08. Occasional seams or layers of sand up to 1 m thick (approx.) were present within the deposit.

Lower SAND

Based on the interpretation of the CPT/SCPT data, the lower sand layer extends to approximately 14.3 m and 12.8 m below the existing ground surface in SCPT21-07 and CPT21-08, respectively.

Lower Clay or Silt

Based on the interpretation of the CPT/SCPT data, fine-grained soils consisting of a mixture of clay or silt is present below the lower sand layer, and extends to at least the termination depth of 30 m below the existing ground surface in. Occasional seams or layers of sand up to 1 m thick (approx.) were present within the deposit.

5.2 GROUNDWATER CONDITIONS

Groundwater levels were measured in the open boreholes prior to backfilling, as well as in the standpipes installed in boreholes AH21-01, AH21-04, and AH21-06. Groundwater levels were obtained six days after installation on December 2, 2021, with subsequent groundwater levels obtained on March 10, 2022. The measured groundwater depths and estimated elevations are summarized in **Table 2**.

Table 2 Summary of Groundwater Level Measurements

Borehole ID	Approximate Ground Surface Elevation[1] (m)	Approximate Groundwater Depth (Elevation) (m)			
		November 26, 2021 (open borehole)	November 29, 2021 (open borehole)	December 2, 2021 (standpipe)	March 10, 2022 (standpipe)
AH21-01	8.0	5.6 (2.4)	-	3.3 (4.7)	3.9 (4.1)
AH21-02	8.0	3.8 (4.2)	-	-	-
AH21-03	7.5	3.7 (3.8)	-	-	-
AH21-04	7.5	3.2 (4.3)	-	3.0 (4.5)	3.5 (4.0)
AH21-05	7.5	4.0 (3.5)	-	-	-
AH21-06	8.0	4.0 (4.0)	-	3.3 (4.7)	3.9 (4.1)
AH21-07	8.0	-	4.0 (4.0)	-	-

Borehole ID	Approximate Ground Surface Elevation[1] (m)	Approximate Groundwater Depth (Elevation) (m)			
		November 26, 2021 (open borehole)	November 29, 2021 (open borehole)	December 2, 2021 (standpipe)	March 10, 2022 (standpipe)
AH21-08	7.5	-	3.4 (4.1)	-	-
AH21-09	7.5	-	3.0 (4.5)	-	-
AH21-10	7.5	-	3.4 (4.1)	-	-

[1] Existing ground surface elevations are approximate and based on onsite observations and handheld GPS

Measurement from the standpipe piezometers indicate approximate depth to groundwater of 3.0 m to 3.3 m. Interpretation from the CPT/SCPT data indicated approximate depth to groundwater of 3.9 m and 1.8 m (approximate elevation of 4.1 m and 5.7 m) in SCPT21-07 and CPT21-08, respectively. Based on reports referenced in Section 3.0, the groundwater levels on adjacent sites generally varied between approximately 2.8 m and 3.5 m below the existing ground surface.

We anticipate the groundwater conditions at the site to vary seasonally and following periods of heavy precipitation.

5.3 POTENTIAL VARIATION OF SUBSURFACE CONDITIONS

The subsurface soil and groundwater conditions described above and shown on the Borehole Records are representative only at the test hole locations at the time of the exploration. Conditions can vary between the explored locations and at the time of construction.

6.0 DISCUSSION

6.1 SEISMIC HAZARD AND SITE CLASSIFICATION

6.1.1 Seismic Design Criteria

The governing Code for the design of buildings is the British Columbia Building Code (BCBC, 2018) and provisions of the National Building Code of Canada (NBCC, 2015).

6.1.2 Seismic Hazard and Site Classification

Site-specific seismic design parameters have been obtained from the interactive website maintained by the Geological Survey of Canada (GSC) in accordance with the provisions of BCBC (2018). The parameters are in the form of 5% damped horizontal spectral response acceleration, $S_a(T)$ where T is the period in seconds. The $S_a(T)$ values are determined for very dense soil or soft bedrock, taken as the reference ground condition corresponding to Site Class C.

The site-specific Peak Ground Acceleration (PGA) and $S_a(T)$ values for the 2,475-year return period ground motions at Site Class C conditions, obtained from the NBCC (2015) are shown in **Table 3** and additional details are provided in **Appendix F**.

Table 3 Sa(T) for 5% Damping at Site Class C, 2,475-Year Return Period, NBCC (2015)

Period, T (s)	Acceleration, S_a (g)
0.05	0.39
0.1	0.59
0.2	0.73
0.3	0.73
0.5	0.64
1.0	0.37
2.0	0.23
5.0	0.07
10.0	0.03
PGA	0.32

The subsurface sand soils at the Site are considered susceptible to liquefaction. For liquefaction assessment, the site class was evaluated using the time-weighted average of measured shear wave velocity (Vs) in the top 30 m depth below ground surface obtained at SCPT21-07. However, as discussed in subsequent sections of this report, ground improvement is recommended, and the recommended site class for structural design would be based on the post-ground densification conditions.

Based on the average shear wave velocity of 218 m/s obtained from the SCPT as shown in **Appendix D**, the site would be classified as Site Class D.

6.1.3 Liquefaction Assessment

Liquefaction assessment of the subsurface soils were carried out using the in-situ test results and the method developed by Boulanger and Idriss (2014). Peak Ground Acceleration (PGA) for the assessment was obtained by multiplying the Site Class C PGA in **Table 4** by the corresponding Site Coefficient F(PGA) for Site Class D, derived from BCBC (2018), Table 4.1.8.4-H.

Liquefaction assessment for coarse grained soils (e.g., sands and gravels) involves comparison of the cyclic shear stress in the ground induced by the earthquake loading (i.e., demand) to the soil shear resistance.

The earthquake loading, in the form of Cyclic Stress Ratio (CSR) was estimated using the following equation:

$$CSR = 0.65 \times \frac{a_{max}}{g} \times \frac{\sigma_v}{\sigma_v{}'} \times r_d$$

Where a_{max} is the Peak Horizontal Ground Acceleration (PGA) at the ground surface, g is the gravitational acceleration, σ_v is the total vertical stress, σ'_v is the effective vertical stress, and r_d is the shear stress reduction coefficient. Site-specific PGA for Class D conditions was estimated as 0.31g.

The Cyclic Resistance Ratio (CRR) was estimated using the CPT approach proposed by Boulanger and Idriss (2014).

Magnitude scaling and overburden stress correction factors were included in the calculation of CRR as per Boulanger and Idriss, (2014). The mean earthquake magnitude, Mw, for the 2,475-Year event is 6.9 based on the deaggregation data provided by the GSC.

The term “liquefaction” is used in reference to behavior of cohesionless soils such as sands, gravels, and low plasticity silts, while the term “cyclic softening” refers to the behavior of cohesive materials such as clay and higher plasticity silts. Silts are transitional in that they may exhibit sand-like or clay-like behavior depending on plasticity index (PI). Idriss and Boulanger (2008) provide guidance in terms of differentiating behavior of silts based on PI; silts with a PI less than four are considered “sand-like” and therefore potentially liquefaction susceptible, while silts with PI equal to or greater than seven are considered as “clay-like” material, and therefore, non-liquefaction susceptible (albeit potentially susceptible to cyclic softening). Soils with 4<PI<7 are treated as transitional and assumed susceptible to liquefaction without test results to prove otherwise.

Soils above the groundwater level are not susceptible to liquefaction. Based on the results of the exploration, the design groundwater level has been taken as 3.0 m depth below the existing ground surface.

Liquefaction assessment shows the following results:

- Soils above the groundwater level (up to approximately 3.0 m below the existing ground surface) are not susceptible to liquefaction
- Clayey silty soils below approximately 13 m depth are not susceptible to liquefaction
- Very loose to compact sands from 4 to 10.5 m and from 4.5 to 7 m depth in SCPT21-07 and CPT210-08, respectively, are estimated to liquefy under the design earthquake.

6.2 CONSEQUENCES OF LIQUEFACTION

Consequences of liquefaction could include the following:

- Ground settlement
- Large settlement or failure of shallow spread or strip foundations
- Uplift of lightly loaded buried structures
- Horizontal movement or lateral spreading of the ground, embankments, and slopes
- Deformation of buried pipelines

The structures would have to be designed to address the above noted consequences of liquefaction. Options include improvement of the ground to minimize the extent of liquefaction or designing the structures to mitigate the effects of liquefaction. Recommendation for this Project is to design the building foundations reinforced raft foundation following ground densification as discussed later in this report.

6.2.1 Post-Seismic Settlement

Post-seismic settlement was estimated using Idriss and Boulanger (2008). Settlement in each of the liquefiable layer was obtained and the cumulative settlement was estimated. The magnitude of the cumulative settlement increases towards the ground surface as contribution from each liquefiable layer is added. The cumulative post-seismic settlement is estimated to be up to 220 mm.

As discussed in Section 7.2, we recommend ground densification of the Site using Rapid Impact Compaction (RIC) prior to the construction of a reinforced raft foundation. Following the completion of ground densification, the cumulative post-seismic settlement is estimated to be in the order of 45 mm.

6.2.2 Lateral Spread

The magnitude of post-seismic the lateral displacement index (LDI) was estimated using Idriss and Boulanger (2008). Lateral spread (or lateral displacement) was estimated using the gently sloping ground condition using Zhang, et al. (2004). The ground slope was estimated from an approximately change in elevation of 0.5 m across a horizontal span of approximately 95 m from the north edge to south edge of the Site.

Post-seismic lateral movement of the ground across the Site is estimated to be up to 40 mm. Following the completion of ground densification, the post-seismic lateral movement of the ground is anticipated to be negligible.

6.3 SETTLEMENT

Settlement of subgrade occurs as result of the following modes:

- Elastic compression of the subgrade
- Primary and secondary consolidation of silts, clayey soils, organic soils and peat.

Settlement due to elastic compression is an immediate change in soil volume resulting from an increase in vertical stress due to applied loading. In general, settlements due to elastic compression will occur immediately as the load is applied, mostly during construction.

Interpretation of CPT data indicate the undrained shear strength of the clay or silt is in the order of 40 kPa at approximately 13 m depth increasing to 90 kPa at the termination depth of the soundings with calculated Over Consolidation Ratio (OCR) of approximately 1.5

We anticipate the net increase in stress on the subgrade soils due to gravity loads of the building following excavation of the underground parking level would be negligible, and post-construction consolidation settlement of the subgrade soils below the proposed structure would be less than 25 mm.

Confirmation of the settlement analysis is required once structural loads of the building are available.

6.4 SOIL CORROSIVITY

In addition, analytical tests including pH, water soluble sulphate content, and electrical resistivity tests were carried out on soil samples collected at approximate depths of 3.0 m and 3.7 m from boreholes AH21-06 and AH21-08, respectively. The purpose of the pH and conductivity tests was to assess the corrosion potential of steel in contact with soils. The purpose of the soluble sulphate tests was to assess the effect of sulphate exposure on concrete. The test results are presented in **Appendix E** and are summarized in **Table 4**.

The soil resistivity values are calculated from the conductivity test results. Resistivity, ρ, was calculated as the inverse of conductivity, σ, using the equation:

$$\rho\ (ohm - cm) = 10^{-6}/[\sigma\ (\mu S/cm)]$$

Table 4 Analytical Test Results

Borehole ID	Sample No.	Sample Depth (m)	Soil Description	pH	Soluble Sulphate (mg/kg)	Soluble Sulphate (%)	Soluble Conductivity (µS/cm)	Calculated Resistivity (ohm-cm)	Corrosivity Rating*
AH21-06	GS-05	3.0	Poorly graded Sand	6.25	<8.6	0.00086	70.8	14,124	Mildly Corrosive
AH21-08	GS-04	3.7	Poorly graded Sand	6.03	<8.6	0.00086	85.1	11,751	Mildly Corrosive
* Based on calculated soil resistivity and Section 2.1.1, Table 2.27, of the Handbook of Corrosion Engineering (Roberg 1999)									

Based on Section 2.4.4, Table 2.27, of the Handbook of Corrosion Engineering (Roberge, 1999), the calculated soil resistivity values in **Table 2 i**ndicate that corrosivity of the existing soils is mildly corrosive.

CSA A23.1:19, Table 3 specifies the following with respect to degree of sulphate exposure:

- Moderate exposure (Class S-3) when water soluble sulphate in soil sample is 0.10% to 0.20%.
- Severe exposure (Class S-2) when water soluble sulphate in soil sample is 0.20% to 2.0%.
- Very severe exposure (Class S-1) when water soluble sulphate in soil sample is greater than 2.0%

The water-soluble sulphate concentration is less than 0.10% for the soil samples tested. Therefore, it is anticipated that concrete in contact with these soils would have less than a moderate exposure to sulphate attack per CSA A23.1:19, Table 3. The concrete mix design (e.g., maximum water to cement ratio, minimum compressive strength at a given date, air content category, etc.) for concrete elements would have to be in accordance with Table 2 of CSA A23.1:19.

7.0 RECOMMENDATIONS

7.1 GENERAL

Based on the review of site conditions, the results of the geotechnical subsurface exploration and subsequent laboratory testing, we consider the following to be pertinent to the design and construction of the proposed building:

1. The very loose to compact sand layers below the groundwater level are liquefiable in the event of the 2,475-year return period design earthquake. Shallow spread foundations could fail by means of punching shear, resulting in potential collapse of the building. Accordingly, ground densification and supporting the building on a raft foundation is recommended to limit the effects of post-liquefaction settlement and lateral spread.

2. Temporary excavation shoring support may be required where insufficient space for a sloped excavation cannot be achieved.

3. Groundwater levels measured in the standpipe piezometers installed by Stantec ranged between 3 and 3.4 m below the existing ground surface. However, recorded groundwater measurements on the adjacent sites ranged between 2.8 and 3.5 m below existing ground surface. As excavation depths approximately 3.5 m are anticipated, temporary ground water control using well points is recommended.

The following sections provide our general recommendations to address the geotechnical aspects of the design. A review of these recommendations would be required once the building location, orientation, and structure loadings are further developed.

7.2 SITE PREPARATION

Site preparation activities include stripping of existing vegetation, topsoil, removal of asphalt and gravel fill. Following stripping, the parkade footprint would be excavated to a depth above design subgrade elevation where ground improvement would be completed. Following completion of ground improvement, the remaining soils would be excavated to subgrade. Compact sand is anticipated at subgrade elevation.

Any soft or loose soils or deleterious materials within the exposed subgrade should be sub-excavated to the discretion of the Stantec geotechnical engineer and replaced with structural fill as described in Section 7.4.

7.3 GROUND IMPROVEMENT

Considering the required depth of ground improvement, cost and local experience, ground improvement using Rapid Impact Compaction (RIC) is recommended. RIC is capable to densifying granular soils up to a depth of approximately 5 to 7 m. RIC uses a hydraulic hammer mounted on a tracked excavator to repeatedly impact the ground in a grid pattern, thereby increasing the density and stiffness of the soil.

For quality control, following completion of RIC, post-densification testing using CPT's would be required to assess results and verify that target resistance has been achieved. Specifications for post-densification testing will be provided prior to tender stage.

7.4 STRUCTURAL FILL

Any backfill, including site grading fill should consist of clean free draining granular material, such as river sand or 75 mm minus pit-run sand and gravel and should conform to the specifications of the Master Municipal Construction Document (MMCD). The fill should be placed in 300 mm loose lifts and should be compacted to at least 95% of the Modified Proctor maximum dry density (MPMDD).

Site review and testing by the geotechnical engineer would be required during construction to confirm that the fill used is suitable and is placed and compacted to the required specifications.

Any alternative fill materials or reuse of the excavated soils from the Site as backfill should be approved by the geotechnical engineer to confirm suitability prior to their use. If approved for reuse as backfill, the excavated granular soils from the Site should be neatly stockpiled and covered with polyethylene sheeting. This is to protect the material from excessive moisture and to prevent runoff entering the municipal storm sewer system following periods of precipitation.

7.5 FOUNDATION DESIGN

7.5.1 Shallow Foundations

Provided that site preparation and ground densification are carried out as described in the above sections, reinforced raft foundation for the proposed building may be designed for a factored Ultimate Limit State (ULS) bearing resistance of 150 kPa, which includes a geotechnical resistance factor of 0.5, and a Serviceability Limit State (SLS) factored bearing resistance of 75 kPa. The raft foundation may be design on a modulus of subgrade reaction, k_s, of 30 MPa/m, for a 0.3 m by 0.3 m area.

The raft slab should be underlain by a bedding layer consisting of minimum of 150 mm of 19 mm minus crushed gravel (MMCD, Section 31 05 17, Item 2.10), compacted to at least 95% MPMDD. All exterior portions of the raft foundation should be founded a minimum of 450 mm below the final exterior grades for frost protection.

7.5.2 Deep Foundations

Deep foundations were considered to support the proposed structure to eliminate the need for ground improvement by advancing the toe beyond the liquefiable zones. Closed ended driven steel pipe piles of 300 to 400 mm diameter were considered, which are typical pile sizes for this type of structure. However, after further evaluation, we do not consider driven steel piles of these diameters feasible in order to meet the seismic performance requirements for the proposed building. Larger diameter piles are not considered economical for this development.

7.6 TEMPORARY EXCAVATIONS AND DEWATERING

All temporary excavations should be carried out in accordance with Part 20 of the current WorkSafeBC regulations and be safe for worker entry. Considering that the subsurface soils consist of sandy fill and native soils, sloped cut or shoring of the excavations will be required as recommended in the following sections.

7.6.1 Temporary Sloped Excavation

Excavation depths in the order of 3.5 m are anticipated for construction of the underground parkade. Subsurface soils within the excavation depth are anticipated to be granular fill, silty sand and sandy silt, and poorly graded sand with variable amounts of gravel. The granular soils are typically very loose to loose in the upper 1 m and compact below.

Temporary sloped excavations should be cut at no steeper than 1.5H:1V (horizontal to vertical) to a maximum depth of 2 m. Below 2 m depth, temporary excavation should be cut at no steeper than 1H:1V. Alternatively, a combination of slope cuts and interlocking concrete blocks (up to 1.8 m high) placed along the base of the excavation is considered a feasible solution in order to minimize excavation footprint. The walls should be constructed at a slope of 1H:10V, inclined towards the retained soils. The walls should be embedded at least 0.3 m below the grade in front of the wall (i.e., below the below of the excavation).

Excavation side slopes should be covered with polyethylene sheets secured to the ground with nails immediately after the cut. This is to protect the slope from precipitation and associated ground surface run-off. The slopes should be regularly reviewed by the geotechnical engineer for signs of instability. If groundwater seepage occurs through the sides of the excavation, the slopes may undergo sloughing, in which case additional maintenance and monitoring would be necessary. If localized instability is noted during excavation, or if wet conditions are encountered, the side slopes should be flattened as required to maintain safe working conditions.

Excavated material should be stockpiled at a horizontal distance greater than the depth of the excavation, measured from the crest. Construction equipment and vehicles should be kept a minimum of 2 m from the crest of all excavations. The Contractor should inspect excavations regularly for signs of instability, and slopes should be flattened if required.

7.6.2 Temporary Shoring

Where a sloped excavation cannot be achieved due to space restrictions, temporary shoring would be required, such as a soil anchor wall system. The temporary wall facing is typically constructed as a shotcrete wall with steel wire mesh reinforcement.

Anchor spacing between 1.6 m and 1.8 m is anticipated, both vertically and horizontally. The typical anchor inclination is 10° to 15° below horizontal. Steeper inclination could be used where necessary to avoid buried utilities. If required, the bond length and the total length for each row of soil anchors, anchor spacing (horizontal and vertical), drill hole diameter, anchor type, and diameter will be determined during detailed design.

Anchors would be tested in compliance with the guidelines and recommendations provided in PTI (2006), including requirements for testing equipment and their calibration.

7.6.3 Temporary Construction Dewatering

Based on the results of our geotechnical exploration and data provided in the reports for the adjacent sites, groundwater could range between approximately 1.8 m and 3.9 m depth. Anticipated excavation depth for the parkade is 3.5 m. Accordingly, we recommend the groundwater table be lowered a minimum of 500 mm to a maximum of 1 m below the base of the excavation. Well point dewatering method is recommended. As the subgrade soils consist of a mixture of granular fill and native soils, attempts to dewater using sumps at the bottom of the excavation would likely cause sand boils, base heave, subgrade damage and instability of excavation walls.

The Contractor is responsible for the design of temporary well point dewatering.

Rising head hydraulic conductivity tests (rising head test) were completed by Stantec's hydrogeology team at the locations of the standpipe piezometers. The results of the rising head test and estimate hydraulic conductivity of the native sand are presented in Stantec's Hydrogeological Study Report.

In addition, we recommend that the construction works be completed over the summer season when groundwater levels would be at their lowest depth. Stantec should be notified if the groundwater conditions differ than anticipated during construction. Regular inspections of the excavation sidewalls should be conducted to verify sloughing and undermining of the adjacent building foundations are not occurring.

7.7 INSTRUMENTATION AND MONITORING

The Contractor should conduct a pre-construction survey of existing buildings, structures, and roadways nearby and adjacent to the Site to establish baseline data. Excavation, ground improvement, compaction of backfill, drilling of soil anchors and operation of construction equipment are the potential sources of construction induced vibration at the site.

The Contractor should carry out regular inspections to verify that excavation sidewalls are not sloughing and retrogressing towards the adjacent buildings and structures.

Geotechnical instrumentation should be installed to measure movement of existing infrastructure during construction, particularly where temporary excavation, ground improvement or dewatering is carried out near existing structures, utilities, and other infrastructure. Performance requirements should be established in consultation with the owner(s) of nearby buildings and infrastructure and should be listed in the specifications. The objective is for the Contractor to implement construction means and methods to avoid or limit movements or deflection to values lower than the threshold values. Instrumentation that could be considered includes the following:

- Continuous vibration monitoring during ground improvement at select locations.
- Survey Monuments: monuments or markers installed on the concrete foundations or on concrete slabs of the existing adjacent buildings and structures to monitor vertical and lateral deformation.
- Inclinometers: used to measure lateral deformation of the ground adjacent to slopes and excavations.

The Contractor should monitor all instruments during excavation and construction. Instrumentation should be monitored every 15 days for at least 30 days after backfill completion.

Stantec can provide a recommended instrumentation and monitoring plan once the site layout and excavation footprint and depth(s) are available.

7.8 LATERAL EARTH PRESSURES

Lateral earth pressure on buried walls have been estimated assuming the walls can rotate sufficiently to mobilize active earth pressure condition. This would require a wall top lateral deformation of about 0.001 to 0.004 times the wall height of the underground level (i.e.: 4 mm to 14 mm of lateral deformation for a 3.5 m high wall). It is also assumed that the hydrostatic pressure induced by the groundwater behind the walls is mitigated via drainage measures. A zone of free-draining backfill can be constructed behind the underground parkade wall to minimize build-up of groundwater and reduce hydrostatic pressure acting on the wall.

Recommended lateral earth pressure magnitudes are provided below. The pressure magnitudes are unfactored and each component should be multiplied using the load factors specified in BCBC (2018) for structural design:

- Static earth pressure: p_A= 4.9H, in kPa unit where H is the height of the wall in metre, measured from the top of wall to the bottom of the footing, triangular distribution.
- Compaction induced pressure: inverted triangular distribution with 20 kPa at the adjacent ground surface, decreasing to zero at 4 m depth.
- Incremental Seismic earth pressure: Δp_{AE} = 4.5H in kPa unit, inverted triangle distribution (maximum at the wall top and zero at the bottom).

The soil pressure and compaction induced pressure would be used for the static loading combination. The soil pressure and seismic incremental pressure would be used and compaction induced pressure would be ignored for the incremental seismic loading combination.

A summary of the soil parameters used in the estimation of the above noted pressures are presented in **Table 5**.

Table 5 Lateral Earth Pressure Parameters

Parameters	**Value**
Unit Weight of native very loose to compact sand	18 kN/m^3
Angle of Internal Friction for native very loose to compact sand, φ	33°
Peak Ground Acceleration, (g)	0.31g
Coefficient of Active Earth Pressure, K_a	0.27
Coefficient of Incremental Seismic Active Earth Pressure, ΔK_{AE}	0.25

Notes:

- Assumed no hydrostatic pressure behind wall via drainage measures.
- The incremental seismic earth pressure was estimated using the Mononobe-Okabe method as discussed in Canadian Foundation Engineering Manual (2006).

7.9 PERIMETER AND UNDERSLAB DRAINAGE

It is recommended that a perimeter drainage system, consisting of at least 150 mm diameter perforated rigid wall pipe, be placed around the perimeter of the building and below the reinforced raft foundation. Underslab drainage consisting of 150 mm drain-pipes should also be installed. The perimeter and underslab drainage system should be connected to a pumped sump or to a suitable outlet. The roof and surface runoff should be collected and directed to a storm sewer in a solid wall pipe, separate from the perimeter drainage.

The drainage pipes should be surrounded by a minimum of 150 mm of 19 mm drain rock (MMCD Section 31 05 17, Item 2.6 – Coarse) or 19 mm clear crush gravel (MMCD Section 31 05 17, Item 2.7 – Type 1). The invert elevation of the drain pipes should be at least 150 mm below the underside of the slabs. Final ground surfaces around the buildings should be graded to direct surface runoff away from building areas.

Elevator and sump pits should be designed as waterproof.

7.10 UTILITY TRENCHING AND BACKFILLING

Pipes and utilities installed using open cut trench excavation methods should be placed on a bedding layer having a thickness of at least 150 mm for pipe cushioning. We recommend that the granular bedding and surround material should extend at least 225 mm beyond both sides of the pipe and up to at least 150 mm above the top of the pipe.

Pipe bedding and surround materials should meet the MMCD requirements for imported granular bedding (MMCD, Section 31 05 1, Item 2.7). Alternatively, imported 25 mm clear crushed gravel (MMCD, Section 31 05 17, Item 2.6 – Coarse) can be used for pipe bedding and surround provided it is encapsulated in a non-woven geotextile to prevent migration of fines from adjacent fill and native soils. Non-woven geotextile with a tensile strength of 750 N and an “apparent opening size of 0.212 mm is recommended (Geotextile #4551 as supplied by Nilex or approved equivalent would meet these specifications).

The pipe bedding and surround material should be placed in maximum 150 mm loose lifts if hand-operated compaction equipment is used, and 300 mm thick loose lifts if heavy machine-operated equipment is used. The material must be compacted to 95% MPMDD.

Backfill above pipe bedding and surround zone should consist of Pit Run Gravel (MMCD Section 31 05 17, Item 2.3), or Pit Run Sand (MMCD Section 21 05 17, Item 2.4). Granular backfill materials should be compacted to at least 95% MPMDD.

Geotechnical engineer should review fill material, placement, lift thickness and compaction.

7.11 PAVEMENT DESIGN

Site preparation for the surface parking and roadways should be carried out as outlined in Section 7.3. Areas exhibiting deflection under wheel load should be over-excavated as necessary and replaced with compacted granular fill. Backfill for the over-excavated areas should be structural fill. Material specifications, placement method and compaction requirements of the structural fill are as specified in Section 7.4. Surface water runoff and groundwater seepage should be diverted away from the construction area.

Materials for the pavement structure, including subbase and base course and asphalt, would be as specified in the latest version of the MMCD. With subgrade preparation completed in the manner recommended above, the minimum recommended pavement structure for parking and roadway areas are as described in the following sections.

7.11.1 Subbase Course

Construct the subbase course to a compacted thickness of 300 mm above the approved subgrade. Compact the subbase to at least 95% MPMDD. Following compaction and testing, the subbase should be proof rolled. Geotechnical engineer should review the proof rolling. Areas exhibiting deflection under wheel load should be over-excavated as necessary and replaced with compacted granular fill.

7.11.2 Base Course

Place base course over subbase to 200 mm compacted thickness at the surface parkade and roadways. Compact the base course to at least 95% MPMDD.

7.11.3 Asphalt

Asphalt thickness of 75 mm is recommended for the surface parking and new roadways.

7.12 ADDITIONAL WORK FOR DETAILED DESIGN

The recommendations provided in this report are preliminary. Once the building excavation footprint and layout are finalized, we envisage our work during detailed design would include the following:

- Update the geotechnical report to account for any changes to the design as presented in this preliminary report
- Review of site layout to finalize site preparation activities such as excavation plans
- Confirmation of underground utilities and potential in-ground shoring support system (i.e., soil anchors) from the adjacent senior’s community centre.
- Review structural loads to finalize the foundation type, and settlement analysis
- Review structural loads to assess lateral capacity of foundations under static and seismic loading conditions
- Design and specifications for ground densification
- Provide recommendations for geotechnical engineering field reviews

8.0 CLOSURE

This report was prepared for the exclusive use of the Metro Vancouver Housing Corporation and its agents for specific application to the proposed Pitt Meadows Affordable Housing and Childcare building. Any use of this report or the material contained herein by third parties, or for other than the intended purpose, should first be approved in writing by Stantec.

Use of this report is subject to the Statement of General Conditions included in **Appendix A**. It is the responsibility of the Metro Vancouver Housing Corporation, who is identified as “the Client” within the Statement of General Conditions, and their agents to review the conditions and notify Stantec should any of them not be satisfied. Note that “Stantec” in the Statement of General Conditions specifically refers to Stantec geotechnical engineering in terms of this this multi-discipline Stantec project.

We trust that this report meets your present requirements. If you have any questions or require additional information, please do not hesitate to contact the undersigned.

Regards,

Stantec Consulting Ltd.

Reviewed by:

Stantec Permit #1002862

B. HUYNH
35703
2022-03-18

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Date: 2022.03.18 13:44:44 -07'00'

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9.0 REFERENCES

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Appendix A STATEMENT OF GENERAL CONDITIONS

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec's present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

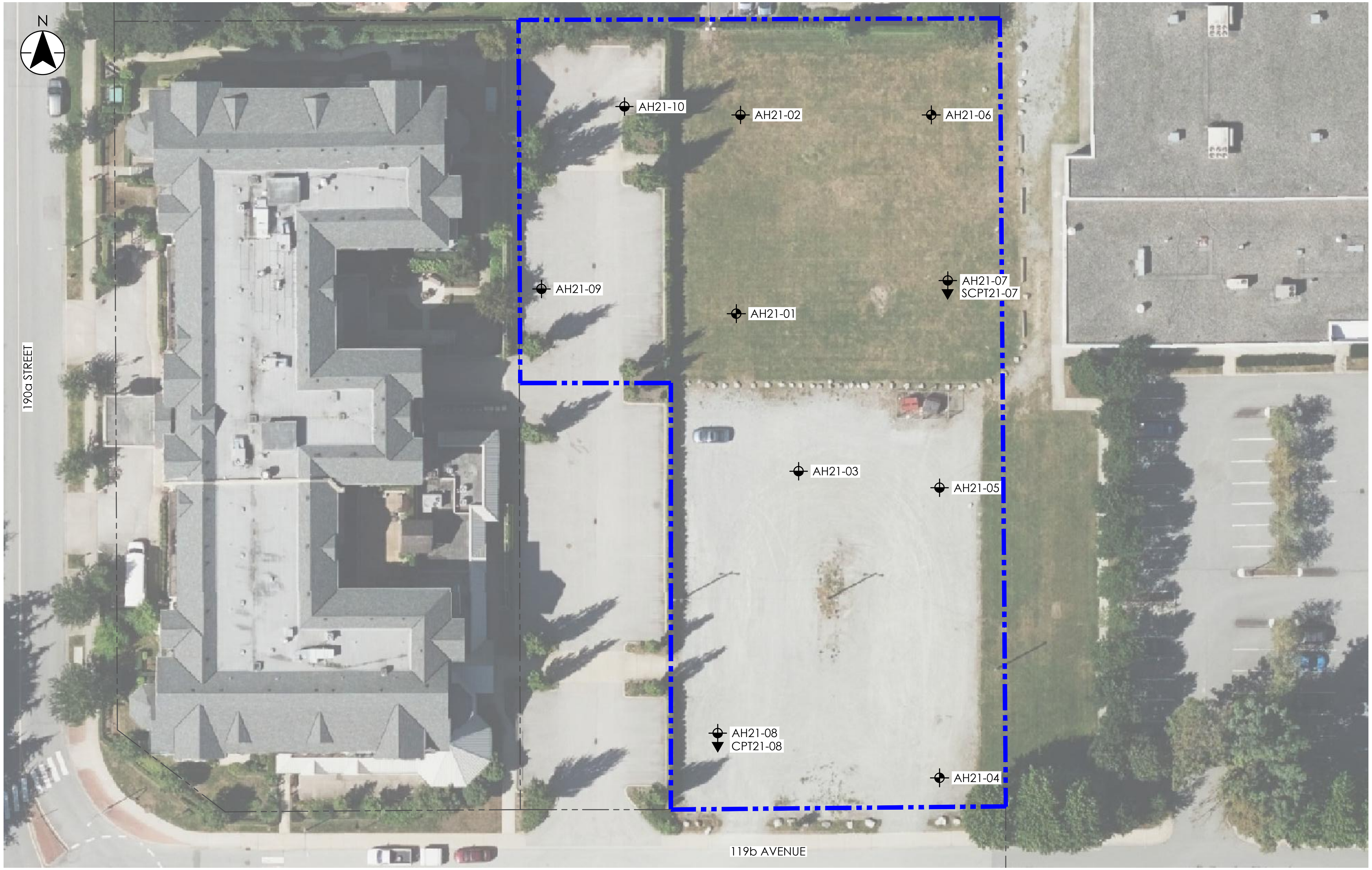
STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

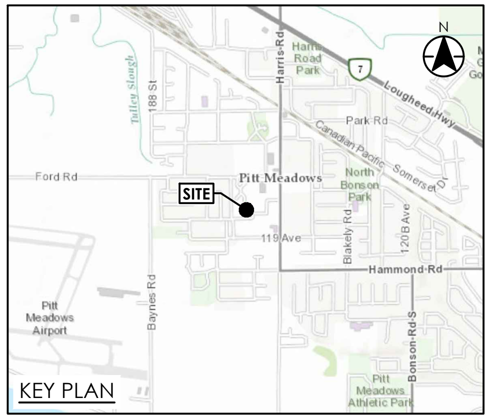
INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec will not be responsible to any party for damages incurred as a result of failing to notify Stantec that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec, sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc.), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec cannot be responsible for site work carried out without being present.

Appendix B BOREHOLE LOCATION PLAN





KEY PLAN

LEGEND

— · · —	PROJECT SITE
— — —	LOT LINE
▨	EXISTING BUILDING
⌖	AUGER HOLE LOCATION
⌖	AUGER HOLE LOCATION WITH STANDPIPE
▼	SEISMIC CONE PENETRATION TEST (SCPT) OR CONE PENETRATION TEST (CPT) LOCATION

SCALE IN METRES
0 5 10 15 20 25
1:500

Stantec

Sources
- LOT LINES FROM PARCELMAP BC OPEN DATA CATALOGUE

Project Information
Project No.: 123315738
Scale: 1:500
Date: 2020-JAN-10
Drawn by: G. HUYNH
Checked by: G. HUSTLER

Project Location
19125 119b AVENUE
PITT MEADOWS, BC

Client/Project
METRO VANCOUVER HOUSING CORPORATION

PITT MEADOWS AFFORDABLE HOUSING
AND CHILDCARE

Title
BOREHOLE LOCATION PLAN

Figure No.
1

Appendix C BOREHOLE RECORDS

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis

Rootmat	vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of visible and invisible fragments of decayed organic matter
Till	unstratified glacial deposit which may range from clay to boulders
Fill	material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure

Desiccated	having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of regular alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

Terminology describing soil types

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris)

Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on Page 2. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

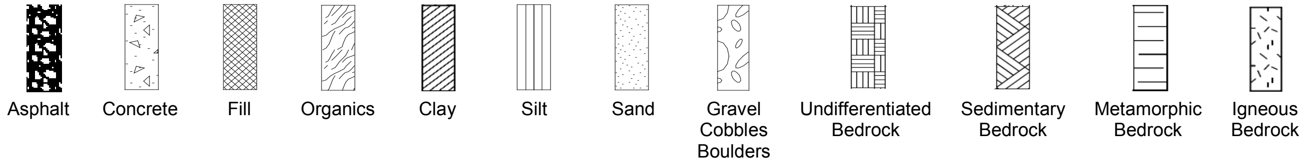
Terminology describing consistency of cohesive soils

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kg/cm^2 or kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



SAMPLE TYPE

AS, BS, GS	Auger sample; bulk sample; grab sample
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
SO	Sonic tube
SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby Tube or thin wall tube
SV	Shear vane
RC *HQ, NQ, BQ, etc.*	Rock Core; samples obtained with the use of standard size diamond coring bits.

WATER LEVEL

▼	**Measured**: in standpipe, piezometer, or well
▽	**Inferred**: seepage noted, or; measured during or at completion of drilling

RECOVERY FOR SOIL SAMPLES

The recovery is recorded as the length of the soil sample recovered in the direct push, split spoon sampler, Shelby Tube, or sonic tube.

N-VALUE

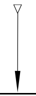
Numbers in this column are the field results of the Standard Penetration Test (SPT): the number of blows of a 140-pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50 for 75 mm or 50/75 mm). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60-degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Total Core Recovery (TCR) denotes the sum of all measurable rock core recovered in one drill run. The value is noted as a percentage of recovered rock core based on the total length of the drill run.

Solid Core Recovery (SCR) is defined as total length of solid core divided by the total drilled length, presented as a percentage. Solid core is defined as core with one full diameter.

Rock Quality Designation (RQD) is a modified core recovery that incorporates only pieces of solid core that are equal to or greater than 10 cm (4") along the core axis. It is calculated as the total cumulative length of solid core (> 10 cm) as measured along the centerline of the core divided by the total length of borehole drilled for each drill run or geotechnical interval, presented as a percentage. RQD is determined in accordance with ASTM D6032.

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock quality

Rock Mass Quality	Rock Quality Designation Number (RQD)	Alternate (Colloquial) Rock Mass Quality	
Very Poor Quality	0-25	*Very Severely Fractured*	*Crushed*
Poor Quality	25-50	*Severely Fractured*	*Shattered or Very Blocky*
Fair Quality	50-75	*Fractured*	*Blocky*
Good Quality	75-90	*Moderately Jointed*	*Sound*
Excellent Quality	90-100	*Intact*	*Very Sound*

Terminology describing rock strength

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

Terminology describing rock with respect to discontinuity and bedding spacing

Spacing (mm)	Discontinuities Spacing	Bedding
>6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Stantec

BOREHOLE RECORD

AH21-01

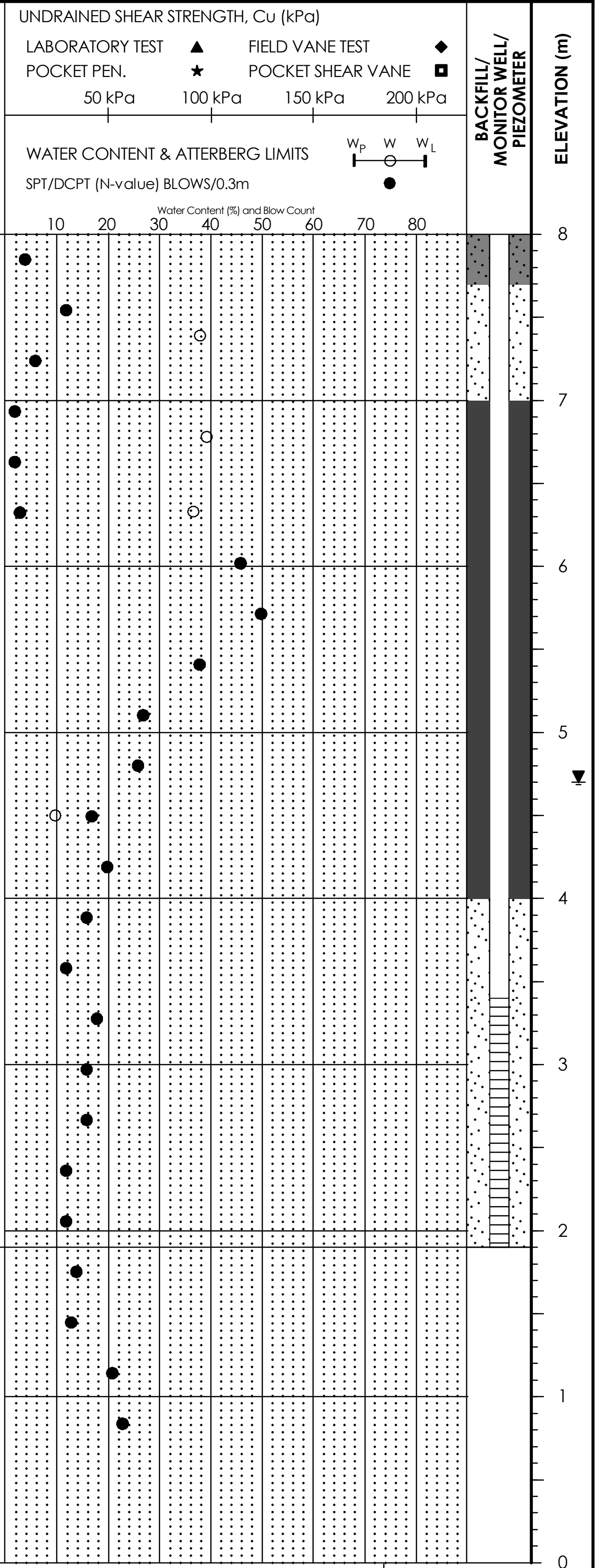
CLIENT: **Metro Vancouver Housing Corporation**
PROJECT: **Pitt Meadows Affordable Housing and Childcare**
LOCATION: **19125 119B Avenue, Pitt Meadows**
DATE BORED: **November 26, 2021**

BH COORDINATES
[UCS 10U]
5452036.0N 522384.0E
WATER LEVEL: **3.3 m on December 1, 2021**

PROJECT NO. : **123315738**
BH ELEVATION: **8m**
DATUM: **Geodetic**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION (USCS)	STRATA PLOT
0	8.0	TOPSOIL: organic sandy silt with rootlets	TOPSOIL
0.3	7.7	FILL: gravel with sand	FILL
0.5	7.5	Dark brown sandy SILT (ML) - moist - trace organics - trace gravel - brown, free of organics below 0.8 m - free of gravel below 1.5 m	ML
2.0	6.0	Grey poorly graded SAND (SP) - moist - medium sand - trace gravel - wet below 4.0 m - free of gravel below 4.7 m	SP
6.1	1.9	End of borehole AH21-01 at 6.1 m. - target depth reached End of DCPT at 7.3 m.	

SAMPLES TYPE	NUMBER	RECOVERY (mm) or TCR %	N-VALUE or RQD %	OTHER TESTS / REMARKS
			4	
			12	
GS	1		6	
			2	
GS	2		2	
GS	3		3	Percent Passing #200: 57%
			46	
			50	
GS	4		38	
			27	
			26	
GS	5		17	Percent Passing #200: 5%
			20	
			16	
GS	6		12	
			18	
GS	7		16	
			16	
			12	
GS	8		12	
			14	
			13	
			21	
			23	



▼ Water Level Measured On Date Indicated

BACKFILL SYMBOL
▨ ASPHALT
▨ GROUT
▨ CONCRETE
■ BENTONITE
☒ DRILL CUTTINGS
▨ SAND
▨ SLOUGH

Drilling Contractor: Southland Drilling Co. Ltd.
Drilling Method: Solid Stem Auger
Completion Depth: 6.1 m

Logged By: GH
Reviewed By: BH

Stantec

BOREHOLE RECORD

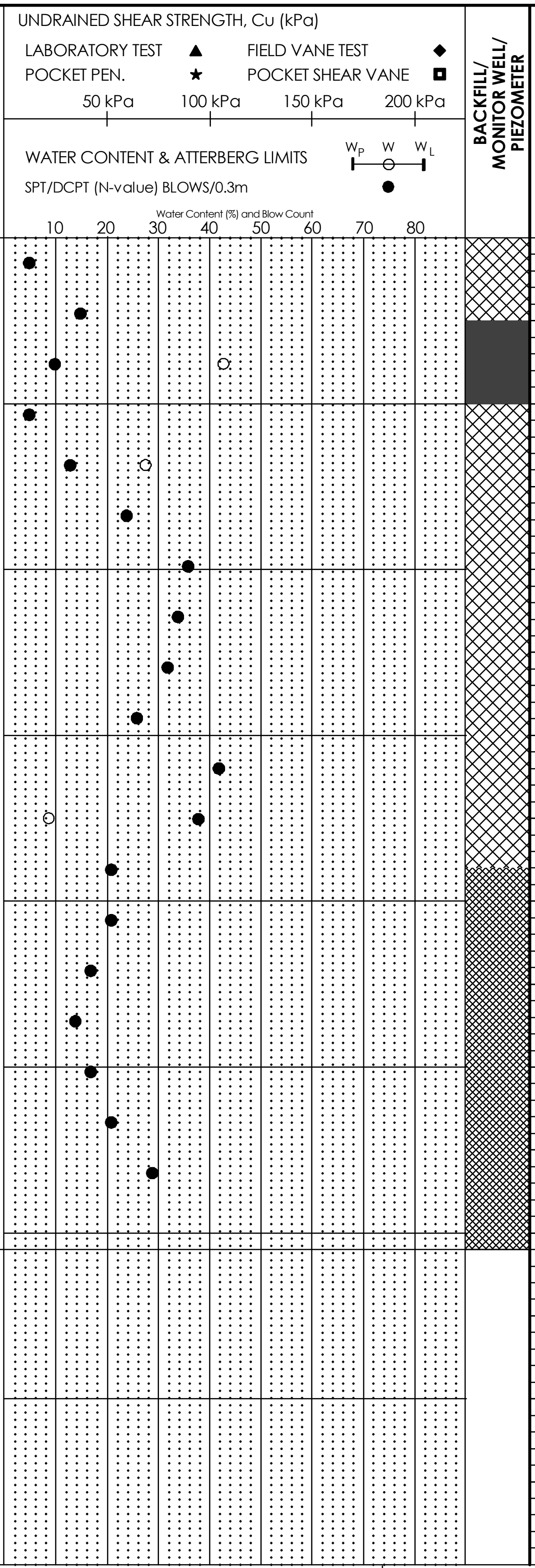
AH21-02

CLIENT: **Metro Vancouver Housing Corporation**
PROJECT: **Pitt Meadows Affordable Housing and Childcare**
LOCATION: **19125 119B Avenue, Pitt Meadows**
DATE BORED: **November 26, 2021**

BH COORDINATES
[UCS 10U]
5452060.0N 522385.0E
WATER LEVEL: **3.7 m on November 26, 2021**

PROJECT NO.: **123315738**
BH ELEVATION: **8m**
DATUM: **Geodetic**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION (USCS)	TYPE	NUMBER	RECOVERY (mm) or TCR %	N-VALUE or RQD %	OTHER TESTS / REMARKS
0	8.0	TOPSOIL: organic sandy silt with rootlets				5	
	7.7	FILL: sand with gravel	GS	1		15	
	7.5	Brown sandy SILT (ML) - moist - trace organics	GS	2		10	
1						5	
	6.8	Light brown SILTY SAND (SM) - moist - fine sand	GS	3		13	
	6.5	Brown poorly graded SAND (SP-SM) with silt - moist - medium sand - trace gravel				24	
			GS	4		36	
2						34	
		- grey below 2.4 m	GS	5		32	
						26	
3						42	
			GS	6		38	Percent Passing #200: 12%
▽						21	
4	4.0	Grey poorly graded SAND (SP) - wet - medium sand - trace gravel	GS	7		21	
						17	
						14	
5		- free of gravel below 4.8 m	GS	8		17	
						21	
						29	
6	1.9		GS	9			
		End of borehole AH21-02 at 6.1 m. - target depth reached - water level measured in open borehole					



▽ Water Level Observed During Drilling

BACKFILL SYMBOL ▩ ASPHALT ▩ GROUT ▨ CONCRETE
■ BENTONITE ☒ DRILL CUTTINGS ⁘ SAND ▩ SLOUGH

Drilling Contractor: Southland Drilling Co. Ltd.	Logged By: GH
Drilling Method: Solid Stem Auger	Reviewed By: BH
Completion Depth: 6.1 m	Page 1 of 1

BOREHOLE RECORD

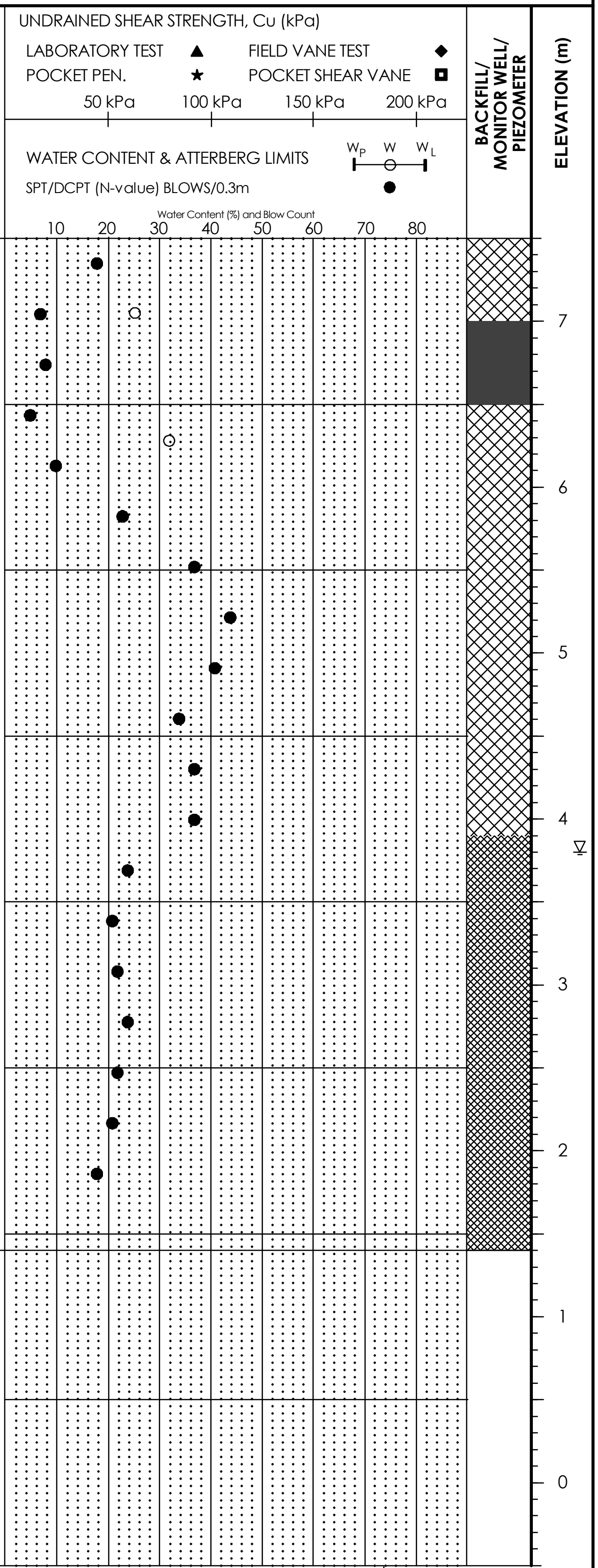
AH21-03

CLIENT: **Metro Vancouver Housing Corporation**
PROJECT: **Pitt Meadows Affordable Housing and Childcare**
LOCATION: **19125 119B Avenue, Pitt Meadows**
DATE BORED: **November 26, 2021**

BH COORDINATES
[UCS 10U]
5452017.0N 522392.0E
WATER LEVEL: **3.7 m on November 26, 2021**

PROJECT NO. : **123315738**
BH ELEVATION: **7.5m**
DATUM: **Geodetic**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION (USCS)	TYPE	NUMBER	RECOVERY (mm) or TCR %	N-VALUE or RQD %	OTHER TESTS / REMARKS
0	7.5	FILL: gravel with sand				18	
	7.3	Brown sandy SILT (ML) - moist - fine sand - trace gravel	GS	1		7	
						8	
1						5	
			GS	2			Percent Passing #200: 68%
						10	
	6.0	Brown poorly graded SAND (SP) - moist - fine sand				23	
			GS	3			
2		- grey, medium sand below 2.0 m - trace gravel, 2.0 m to 3.7 m				37	
						44	
			GS	4		41	
3						34	
						37	
			GS	5		37	
		- wet below 3.7 m				24	
4			GS	6		21	
						22	
						24	
			GS	7			
5						22	
						21	
			GS	8		18	
6	1.4	End of borehole AH21-03 at 6.1 m. - target depth reached - water level measured in open borehole					
7							
8							



⊻ Water Level Observed During Drilling

BACKFILL SYMBOL ▩ ASPHALT ▩ GROUT ▨ CONCRETE
■ BENTONITE ☒ DRILL CUTTINGS ⁙ SAND ▩ SLOUGH

Drilling Contractor: Southland Drilling Co. Ltd.	Logged By: GH
Drilling Method: Solid Stem Auger	Reviewed By: BH
Completion Depth: 6.1 m	Page 1 of 1

BOREHOLE RECORD

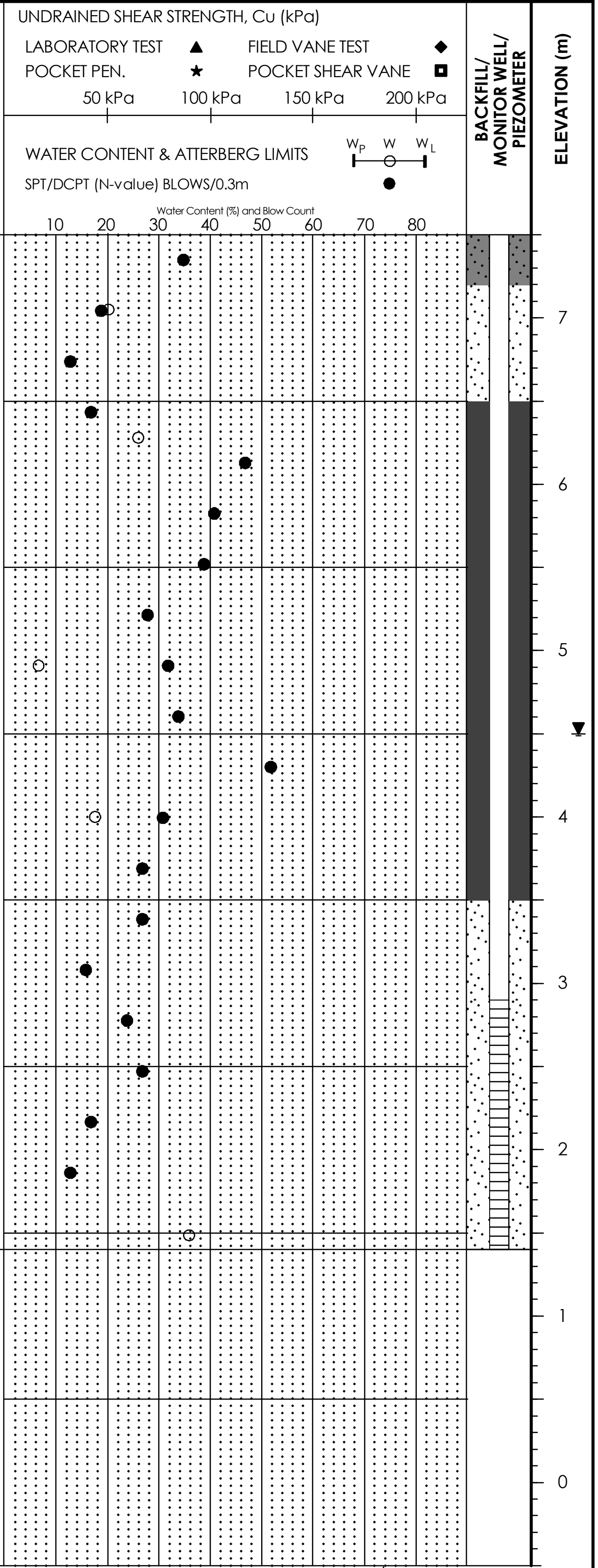
AH21-04

CLIENT: **Metro Vancouver Housing Corporation**
PROJECT: **Pitt Meadows Affordable Housing and Childcare**
LOCATION: **19125 119B Avenue, Pitt Meadows**
DATE BORED: **November 26, 2021**

BH COORDINATES
[UCS 10U]
5451980.0N 522409.0E
WATER LEVEL: **3.0 m on December 1, 2021**

PROJECT NO. : **123315738**
BH ELEVATION: **7.5m**
DATUM: **Geodetic**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION (USCS)	STRATA PLOT	TYPE	NUMBER	RECOVERY (mm) or TCR %	N-VALUE or RQD %	OTHER TESTS / REMARKS
0	7.5							
	7.3	FILL: gravel with sand	▩				35	
		Brown silty SAND (SM) - moist - fine sand - trace gravel		GS	1		19	
	6.5						13	
1		Brown sandy SILT (ML) - moist - trace gravel					17	
				GS	2			
	5.8						47	
		Grey poorly graded SAND (SP) - moist - medium sand - trace gravel					41	
2	5.3			GS	3		39	
		Grey silty SAND (SM) - moist - medium sand - trace gravel					28	
				GS	4		32	Percent Passing #200: 15%
3	4.5						34	
		Grey poorly graded SAND (SP-SM) with silt - moist - medium sand - trace gravel - wet below 3.2 m					52	
				GS	5		31	Percent Passing #200: 7%
							27	
4							27	
				GS	6		16	
							24	
5							27	
				GS	7		17	
	1.6						13	
6	1.4	Brown lean CLAY (CL) - moist		GS	8			
		End of borehole AH21-04 at 6.1 m. - target depth reached						
7								
8								



▼ Water Level Measured On Date Indicated

BACKFILL SYMBOL: ▩ ASPHALT · ▩ GROUT · ▨ CONCRETE · ■ BENTONITE · ☒ DRILL CUTTINGS · ⁚ SAND · ▩ SLOUGH

Drilling Contractor: Southland Drilling Co. Ltd.	Logged By: GH
Drilling Method: Solid Stem Auger	Reviewed By: BH
Completion Depth: 6.1 m	Page 1 of 1

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Stantec

BOREHOLE RECORD

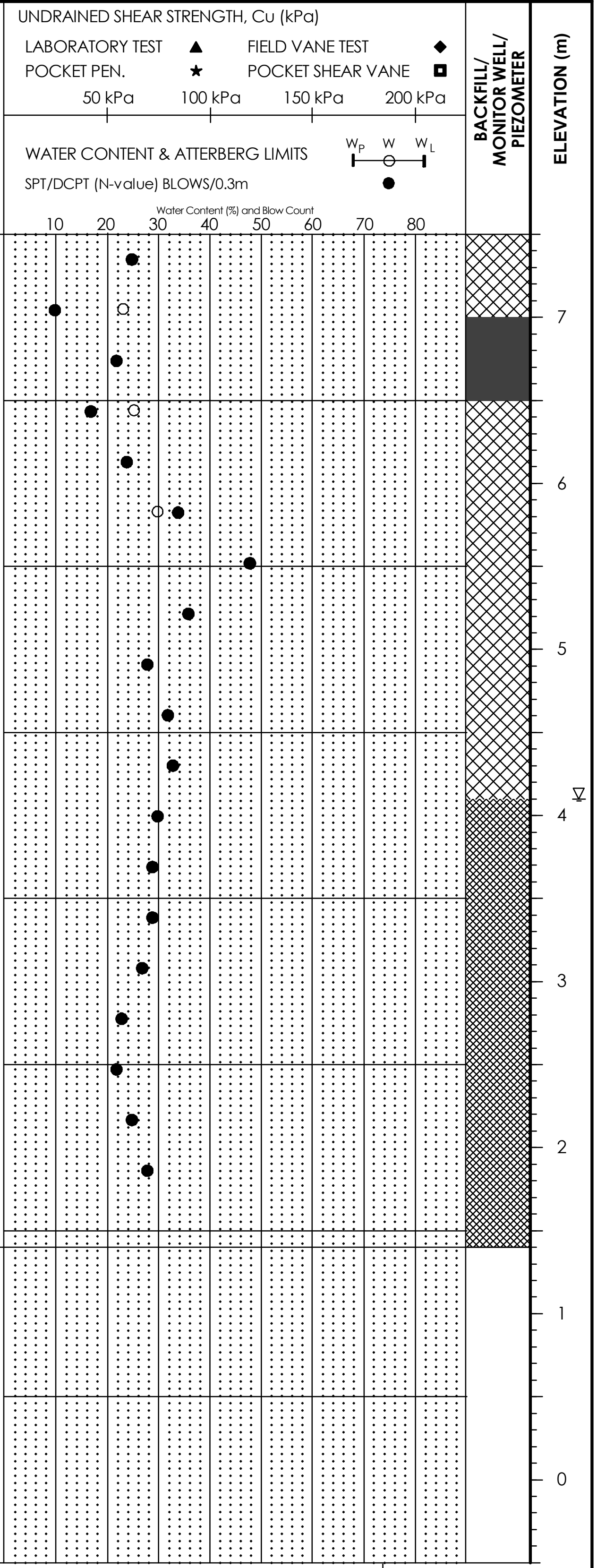
AH21-05

CLIENT: **Metro Vancouver Housing Corporation**
PROJECT: **Pitt Meadows Affordable Housing and Childcare**
LOCATION: **19125 119B Avenue, Pitt Meadows**
DATE BORED: **November 26, 2021**

BH COORDINATES
[UCS 10U]
5452015.0N 522409.0E
WATER LEVEL: **3.4 m on November 26, 2021**

PROJECT NO. : **123315738**
BH ELEVATION: **7.5m**
DATUM: **Geodetic**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION (USCS)	STRATA PLOT	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) or TCR %	SAMPLES N-VALUE or RQD %	OTHER TESTS / REMARKS
0	7.5							
	7.3	FILL: gravel with sand					25	
		Brown silty SAND (SM) - moist - fine sand - trace clay - trace organics to 0.6 m		GS	1		10	
							22	
1				GS	2		17	
							24	
	5.7			GS	3		34	
2		Grey poorly graded SAND (SP) - moist - medium sand - trace gravel					48	
							36	
				GS	4		28	
							32	
3							33	
∇		- wet below 3.4 m					30	
				GS	5		29	
4							29	
				GS	6		27	
							23	
5							22	
				GS	7		25	
							28	
6	1.4	End of borehole AH21-05 at 6.1 m. - target depth reached - water level measured in open borehole						
7								
8								



∇ Water Level Observed During Drilling

BACKFILL SYMBOL
- ▨ ASPHALT
- ■ BENTONITE
- ☒ DRILL CUTTINGS
- ▩ GROUT
- ⁘ SAND
- ▧ CONCRETE
- ▦ SLOUGH

Drilling Contractor: Southland Drilling Co. Ltd.	Logged By: GH
Drilling Method: Solid Stem Auger	Reviewed By: BH
Completion Depth: 6.1 m	Page 1 of 1

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BOREHOLE RECORD

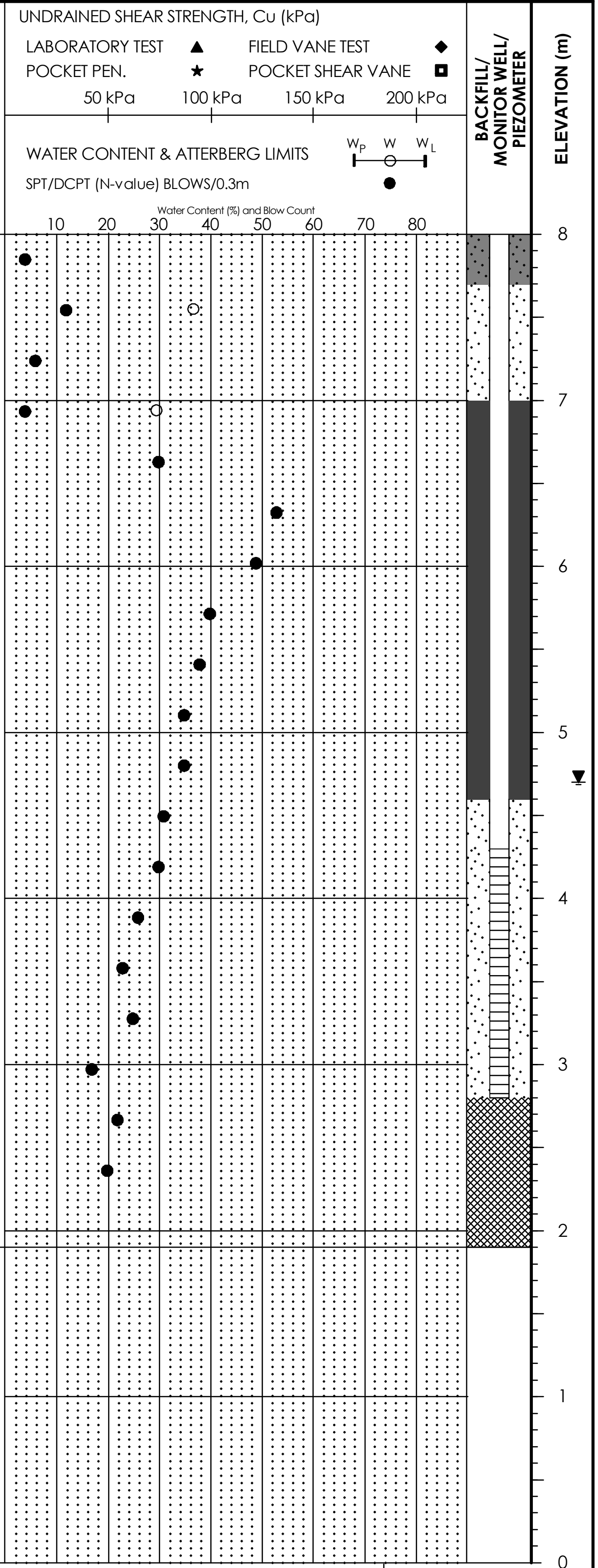
AH21-06

CLIENT: **Metro Vancouver Housing Corporation**
PROJECT: **Pitt Meadows Affordable Housing and Childcare**
LOCATION: **19125 119B Avenue, Pitt Meadows**
DATE BORED: **November 26, 2021**

BH COORDINATES
[UCS 10U]
5452060.0N 522408.0E
WATER LEVEL: **3.3 m on December 1, 2021**

PROJECT NO.: **123315738**
BH ELEVATION: **8m**
DATUM: **Geodetic**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION (USCS)	STRATA PLOT	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) or TCR %	SAMPLES N-VALUE or RQD %	OTHER TESTS / REMARKS
0	8.0	FILL: silty sand with organics					4	
	7.7	Dark brown sandy SILT (ML) - moist - trace organics		GS	1		12	
							6	
1				GS	2		4	
							30	
	6.5	Brown poorly graded SAND (SP) - moist - medium sand - trace gravel - grey, free of gravel below 1.8 m		GS	3		53	
2							49	
							40	
				GS	4		38	
							35	
3				GS	5		35	
							31	
		- brown, trace gravel, 3.7 m to 4.3 m					30	
4		- wet below 4.0 m		GS	6		26	
							23	
							25	
5				GS	7		17	
							22	
							20	
6	1.9			GS	8			
		End of borehole AH21-06 at 6.1 m - target depth reached						
7								
8								



▼ Water Level Measured On Date Indicated

BACKFILL SYMBOL ▨ ASPHALT ▨ GROUT ▨ CONCRETE
■ BENTONITE ⊠ DRILL CUTTINGS ⁘ SAND ▩ SLOUGH

Drilling Contractor: Southland Drilling Co. Ltd.	Logged By: GH
Drilling Method: Solid Stem Auger	Reviewed By: BH
Completion Depth: 6.1 m	Page 1 of 1

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Stantec

BOREHOLE RECORD

AH21-07

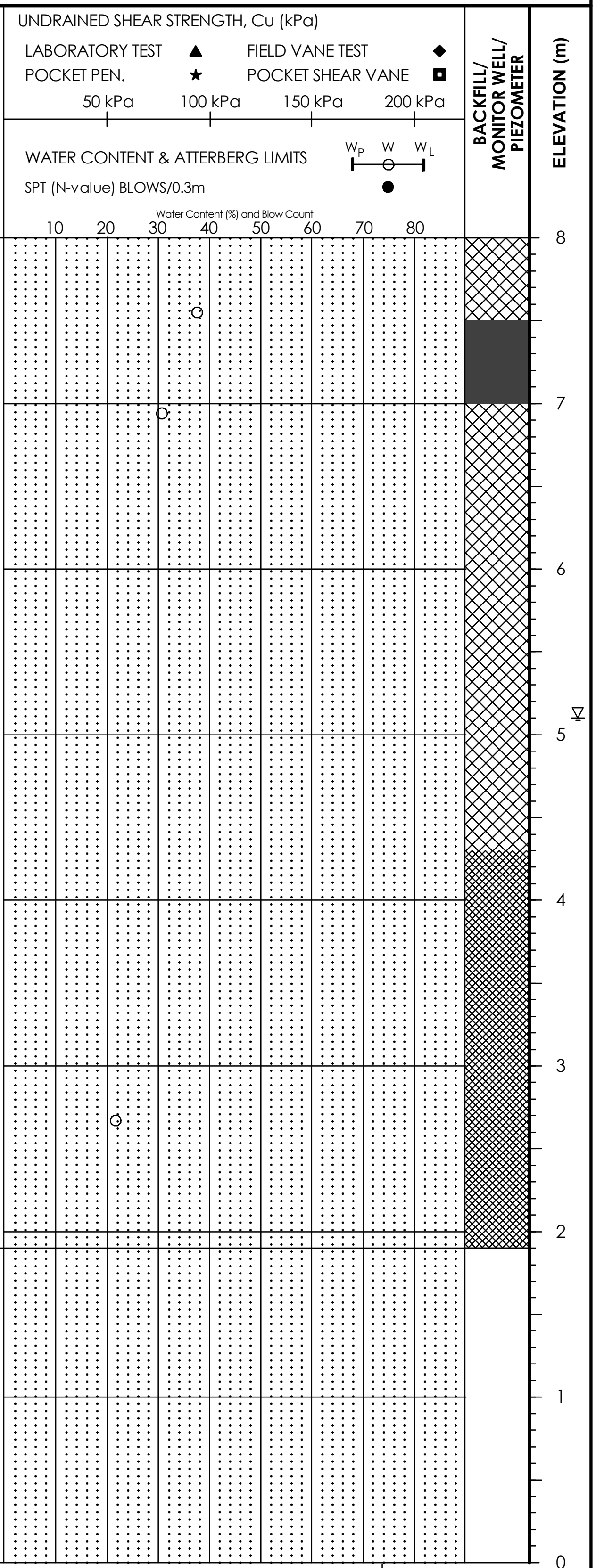
CLIENT: **Metro Vancouver Housing Corporation**
PROJECT: **Pitt Meadows Affordable Housing and Childcare**
LOCATION: **19125 119B Avenue, Pitt Meadows**
DATE BORED: **November 29, 2021**

BH COORDINATES
[UCS 10U]
5452040.0N 522410.0E
WATER LEVEL: **2.9 m on November 29, 2021**

PROJECT NO. : **123315738**
BH ELEVATION: **8m**
DATUM: **Geodetic**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION (USCS)	STRATA PLOT
0	8.0	FILL: silty sand with gravel	
0.3	7.7	Dark brown sandy SILT (ML) - moist - trace organics	
0.6	7.4	Brown SILTY SAND (SM) - moist - fine sand	
1.5	6.5	Grey poorly graded SAND (SP) - moist - medium sand - trace gravel - trace silt - free of gravel below 3.7 m - wet below 4.0 m	
6.1	1.9	End of borehole AH21-07 at 6.1 m. - target depth reached - water level measured in open borehole	

SAMPLES TYPE	NUMBER	RECOVERY (mm) or TCR %	N-VALUE or RQD %	OTHER TESTS / REMARKS
GS	1			
GS	2			
GS	3			
GS	4			
GS	5			
GS	6			Percent Passing #200: 2%



⊻ Water Level Observed During Drilling

BACKFILL SYMBOL ▨ ASPHALT ▨ GROUT ▨ CONCRETE
■ BENTONITE ▨ DRILL CUTTINGS ▨ SAND ▨ SLOUGH

Drilling Contractor: Conetec Investigations Ltd.	Logged By: GH
Drilling Method: Solid Stem Auger	Reviewed By: BH
Completion Depth: 6.1 m	Page 1 of 1

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Stantec

BOREHOLE RECORD

AH21-08

CLIENT: **Metro Vancouver Housing Corporation**

PROJECT: **Pitt Meadows Affordable Housing and Childcare**

LOCATION: **19125 119B Avenue, Pitt Meadows**

DATE BORED: **November 29, 2021**

BH COORDINATES

[UCS 10U]

5451985.0N 522382.0E

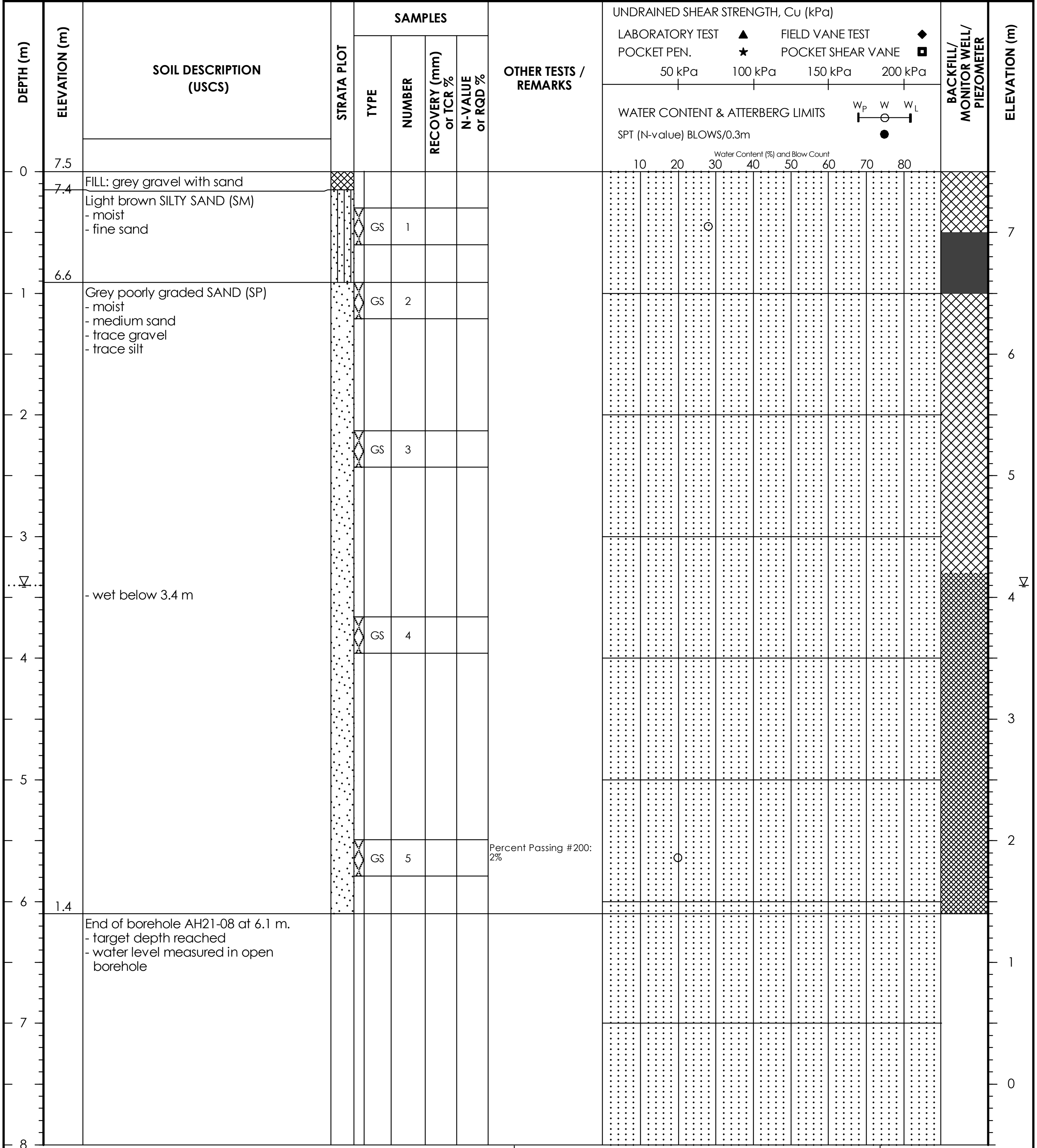
WATER LEVEL: **3.4 m on November 29, 2021**

PROJECT NO. : **123315738**

BH ELEVATION: **7.5m**

DATUM: **Geodetic**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION (USCS)	SAMPLES TYPE	SAMPLES NUMBER	RECOVERY (mm) or TCR %	N-VALUE or RQD %	OTHER TESTS / REMARKS
0	7.5						
	7.4	FILL: grey gravel with sand					
		Light brown SILTY SAND (SM) - moist - fine sand	GS	1			
	6.6	Grey poorly graded SAND (SP) - moist - medium sand - trace gravel - trace silt	GS	2			
			GS	3			
		- wet below 3.4 m					
			GS	4			
			GS	5			Percent Passing #200: 2%
6	1.4	End of borehole AH21-08 at 6.1 m. - target depth reached - water level measured in open borehole					



⊻ Water Level Observed During Drilling

BACKFILL SYMBOL ▩ ASPHALT ▨ GROUT ▧ CONCRETE

■ BENTONITE ☒ DRILL CUTTINGS ⁙ SAND ▩ SLOUGH

Drilling Contractor: Conetec Investigations Ltd.	Logged By: GH
Drilling Method: Soild Stem Auger	Reviewed By: BH
Completion Depth: 6.1 m	Page 1 of 1

Stantec

BOREHOLE RECORD

AH21-09

CLIENT: **Metro Vancouver Housing Corporation**
PROJECT: **Pitt Meadows Affordable Housing and Childcare**
LOCATION: **19125 119B Avenue, Pitt Meadows**
DATE BORED: **November 29, 2021**

BH COORDINATES
[UCS 10U]
5452039.0N 522361.0E
WATER LEVEL: **3.0 m on November 29, 2021**

PROJECT NO. : **123315738**
BH ELEVATION: **7.5m**
DATUM: **Geodetic**

ELEVATION (m)	SOIL DESCRIPTION (USCS)	TYPE	NUMBER	RECOVERY (mm) or TCR %	N-VALUE or RQD %	OTHER TESTS / REMARKS
7.5	ASPHALT (180 mm)					
7.3	FILL: gravel with sand	GS	1			
6.9	Brown silty SAND (SM) - moist - fine sand	GS	2			
6.3	Grey poorly graded SAND (SP) - moist - medium sand - trace gravel	GS	3			
	- wet below 3.0 m	GS	4			
		GS	5			
1.4	End of borehole AH21-09 at 6.1 m. - target depth reached - water level measured in open borehole					

UNDRAINED SHEAR STRENGTH, Cu (kPa)
LABORATORY TEST ▲ FIELD VANE TEST ◆
POCKET PEN. ★ POCKET SHEAR VANE ◘
50 kPa 100 kPa 150 kPa 200 kPa
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
SPT (N-value) BLOWS/0.3m ●
Water Content (%) and Blow Count
10 20 30 40 50 60 70 80

BACKFILL/ MONITOR WELL/ PIEZOMETER

DEPTH (m): 0 1 2 3 4 5 6 7 8
ELEVATION (m): 7 6 5 4 3 2 1 0

⊻ Water Level Observed During Drilling

BACKFILL SYMBOL ▓ ASPHALT ▒ GROUT ◩ CONCRETE
■ BENTONITE ☒ DRILL CUTTINGS ⁚ SAND ▩ SLOUGH

Drilling Contractor: Conetec Investigations Ltd.	Logged By: GH
Drilling Method: Soild Stem Auger	Reviewed By: BH
Completion Depth: 6.1 m	Page 1 of 1

Stantec

BOREHOLE RECORD

AH21-10

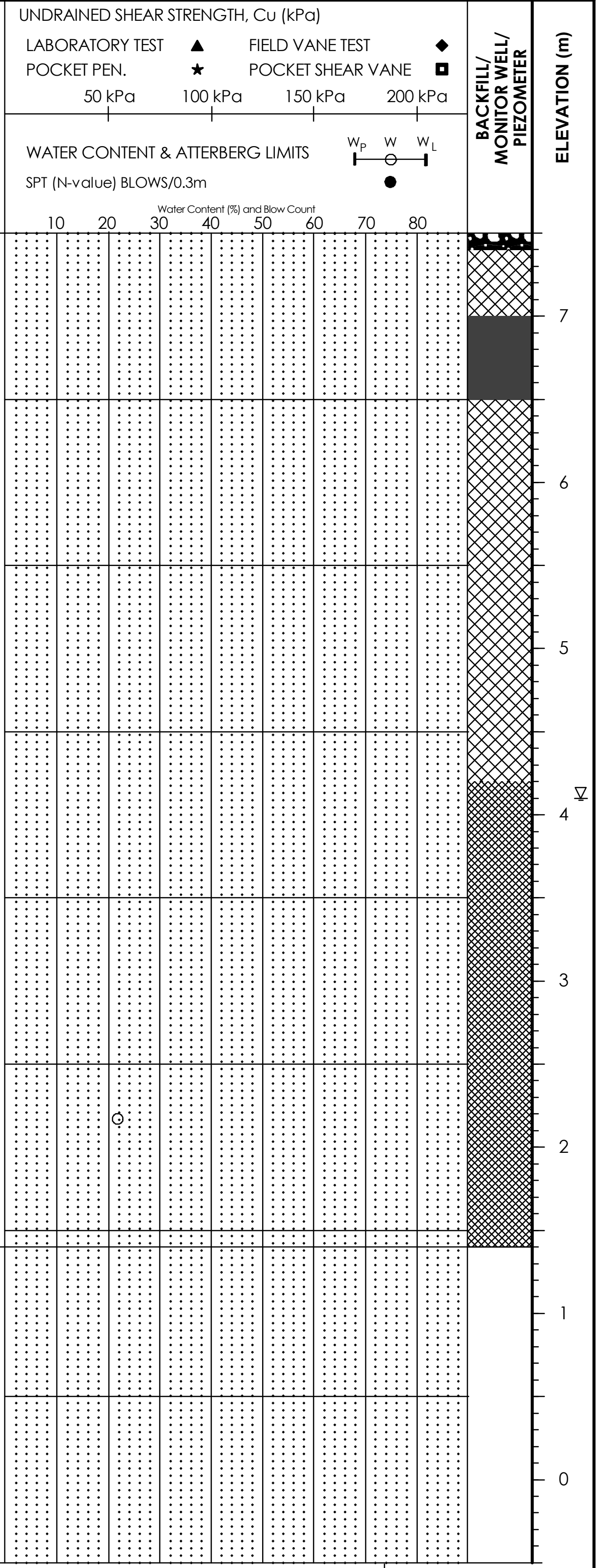
CLIENT: **Metro Vancouver Housing Corporation**
PROJECT: **Pitt Meadows Affordable Housing and Childcare**
LOCATION: **19125 119B Avenue, Pitt Meadows**
DATE BORED: **November 29, 2021**

BH COORDINATES
[UCS 10U]
5452061.0N 522371.0E
WATER LEVEL: **3.4 m on November 29, 2021**

PROJECT NO. : **123315738**
BH ELEVATION: **7.5m**
DATUM: **Geodetic**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION (USCS)
0	7.5	ASPHALT (150 mm)
	7.4	FILL: gravel with sand
	7.0	Brown poorly graded SAND (SP) - moist - fine sand - grey, medium sand, trace gravel and silt below 0.9 m - wet below 3.4 m
6	1.4	End of borehole AH21-10 at 6.1 m - target depth reached - water level measured in open borehole

SAMPLES TYPE	NUMBER	RECOVERY (mm) or TCR %	N-VALUE or RQD %	OTHER TESTS / REMARKS
GS	1			
GS	2			
GS	3			
GS	4			
GS	5			Percent Passing #200: 3%



⊻ Water Level Observed During Drilling

BACKFILL SYMBOL: ▨ ASPHALT, ▨ GROUT, ▨ CONCRETE, ■ BENTONITE, ☒ DRILL CUTTINGS, ▨ SAND, ▨ SLOUGH

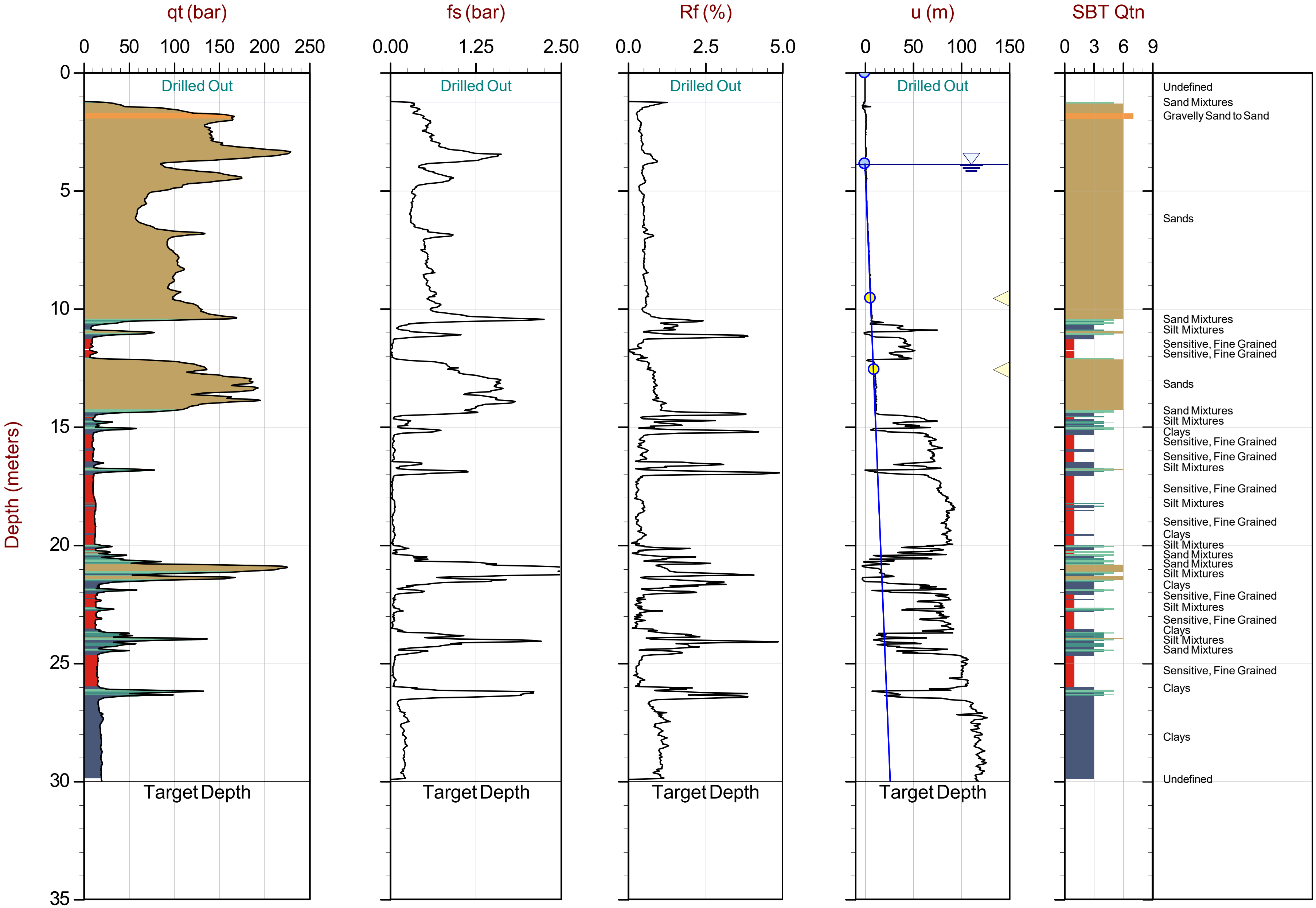
Drilling Contractor: Conetec Investigations Ltd.	Logged By: GH
Drilling Method: Soild Stem Auger	Reviewed By: BH
Completion Depth: 6.1 m	Page 1 of 1

Appendix D CONE PENETRATION TEST PLOTS

Stantec

Job No: 21-02-23368
Date: 2021-11-29 08:09
Site: 19125 119B Avenue

Sounding: SCPT21-07
Cone: 650:T1500F15U35 Area: 15cm2



Max Depth: 30.000 m / 98.42 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 21-02-23368_SP07.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 5452040m E: 522410m
Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved ◁ Dissipation, Ueq assumed — Hydrostatic Line

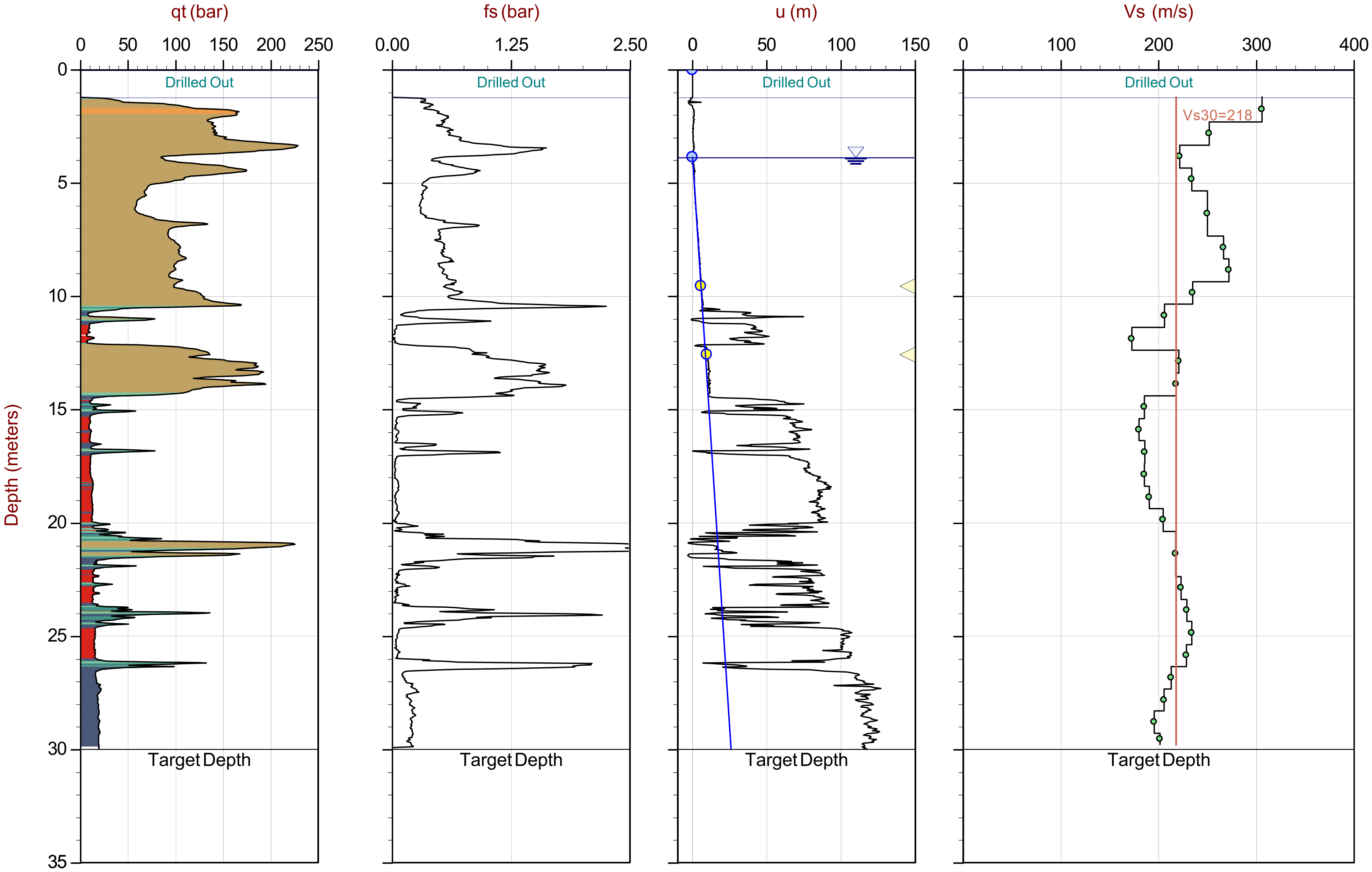
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Stantec

Job No: 21-02-23368
Date: 2021-11-29 08:09
Site: 190a St and 190b Ave

Sounding: SCPT21-07
Cone: 650:T1500F15U35 Area: 15cm2



Max Depth: 30.000 m / 98.42 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 21-02-23368_SP07.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 5452040m E: 522410m
Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved ◁ Dissipation, Ueq assumed — Hydrostatic Line

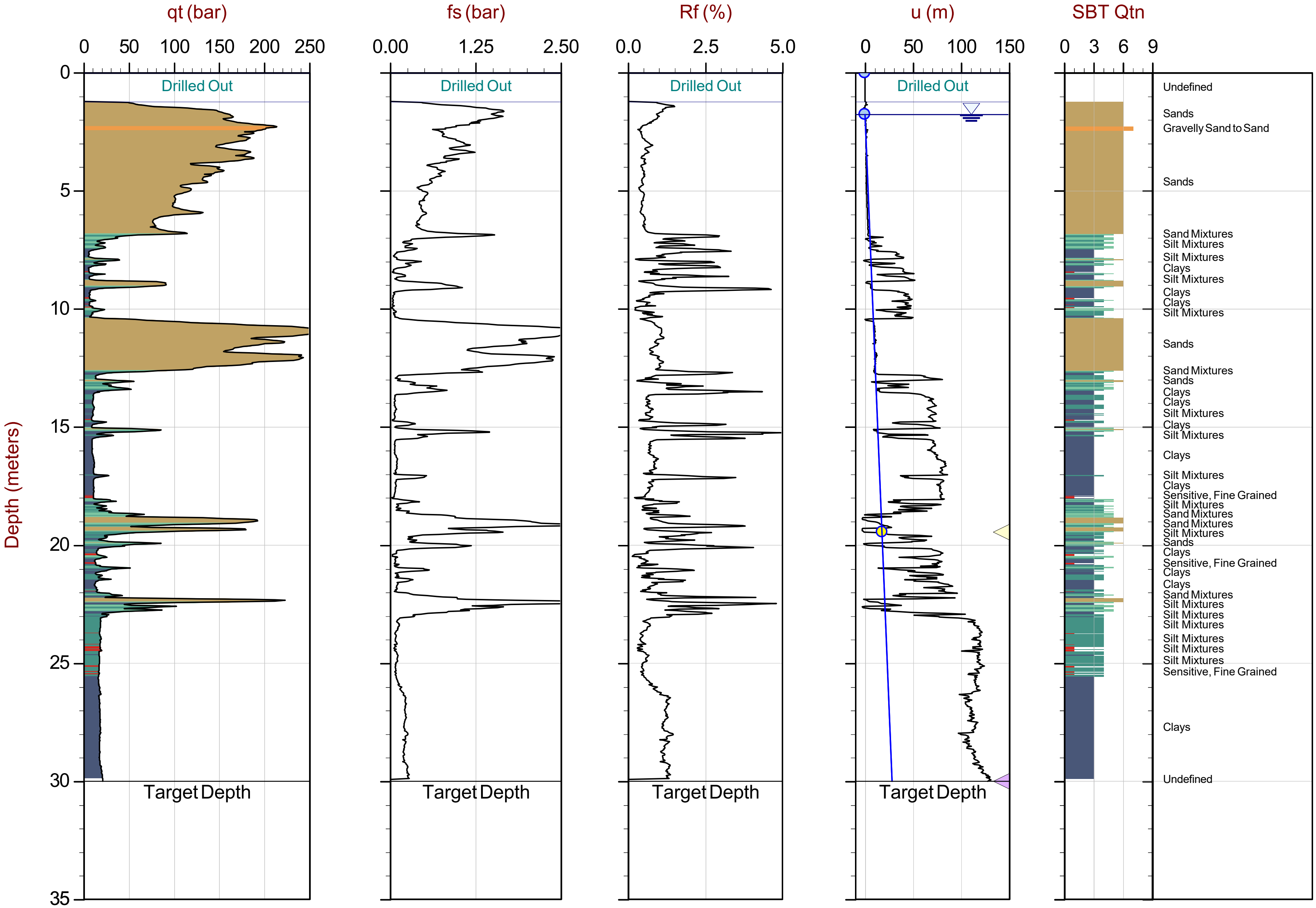
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Stantec

Job No: 21-02-23368
Date: 2021-11-29 11:04
Site: 19125 119B Avenue

Sounding: CPT21-08
Cone: 650:T1500F15U35 Area: 15cm2



Max Depth: 30.000 m / 98.42 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 21-02-23368_CP08.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 5451981m E: 522390m
Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved ◁ Dissipation, Ueq assumed — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Appendix E LABORATORY TEST RESULTS

Your Project #: 123315738.200 001
Site Location: 19125 119B AVENUE, PITT MEADOWS
Your C.O.C. #: 08502125

Attention: Greg Hustler

STANTEC CONSULTING LTD
Metrotower III
Suite 500, 4730 Kingsway
BURNABY, BC
CANADA V5H 4M1

Report Date: 2022/01/12
Report #: R3120954
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C196460
Received: 2021/12/08, 14:35

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (soluble)	2	2021/12/31	2022/01/05	BBY6SOP-00011	SM 23 4500-Cl- E m
Soluble Chloride Ion Calc. (mg/kg)	2	N/A	2022/01/05	BBY WI-00033	Auto Calc
Conductivity (Soluble)	2	2021/12/31	2022/01/05	BBY6SOP-00029	SM 23 2510 B m
pH (2:1 DI Water Extract)	2	2022/01/04	2022/01/04	BBY6SOP-00028	BCMOE BCLM Mar2005 m
Saturated Paste	2	2021/12/31	2022/01/05	BBY6SOP-00030	BC Lab Manual 2015 m
Sulphate (soluble) (soil)	2	2021/12/31	2022/01/05	BBY6SOP-00017	SM 23 4500-SO42- E m
Soluble Sulphate (SO4) Ion Calc. (mg/kg)	2	N/A	2022/01/05	BBY WI-00033	Auto Calc

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 123315738.200 001
Site Location: 19125 119B AVENUE, PITT MEADOWS
Your C.O.C. #: 08502125

Attention: Greg Hustler

STANTEC CONSULTING LTD
Metrotower III
Suite 500, 4730 Kingsway
BURNABY, BC
CANADA V5H 4M1

Report Date: 2022/01/12
Report #: R3120954
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C196460
Received: 2021/12/08, 14:35

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Geraldlyn Gouthro, Key Account Specialist
Email: geraldlyn.gouthro@bureauveritas.com
Phone# (780)577-7173
==
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RESULTS OF CHEMICAL ANALYSES OF SOIL

Bureau Veritas ID		AMK612			AMK612			AMK613		
Sampling Date		2021/11/26			2021/11/26			2021/11/29		
COC Number		08502125			08502125			08502125		
	UNITS	**AH21-06 GS05**	**RDL**	**QC Batch**	**AH21-06 GS05 Lab-Dup**	**RDL**	**QC Batch**	**AH21-08 GS04**	**RDL**	**QC Batch**
ANIONS										
Soluble Sulphate (SO4)	mg/L	<20	20	A464519				<20	20	A464519
Soluble Chloride (Cl)	mg/L	<10	10	A464514				11	10	A464514
Calculated Parameters										
Soluble Chloride (Cl)	mg/kg	<4.3	4.3	A460557				4.9	4.3	A460557
Soluble Sulphate (SO4)	mg/kg	<8.6	8.6	A460697				<8.6	8.6	A460697
Physical Properties										
Soluble (2:1) pH	pH	6.25	N/A	A462956				6.03	N/A	A462956
Soluble Parameters										
Soluble Conductivity	uS/cm	70.8	5.0	A464668	70.8	5.0	A464668	85.1	5.0	A464668
Saturation %	%	42.9	N/A	A463860				42.8	N/A	A463860

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

GENERAL COMMENTS

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
A462956	Soluble (2:1) pH	2022/01/04			99	97 - 103			0.47	N/A		
A463860	Saturation %	2022/01/05					0	%	0	30	103	75 - 125
A464514	Soluble Chloride (Cl)	2022/01/05	99	75 - 125	99	80 - 120	<10	mg/L	NC	30	76	75 - 125
A464519	Soluble Sulphate (SO4)	2022/01/05			105	80 - 120	<20	mg/L			100	75 - 125
A464668	Soluble Conductivity	2022/01/05			103	70 - 130	<5.0	uS/cm	0	35	88	75 - 125

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

David Huang, M.Sc., P.Chem., QP, Scientific Services Manager

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

08502125

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Edmonton, AB: 9331-48 St. T6B 2R4 Toll Free (800) 386-7247
Winnipeg, MB: D-675 Berry St. R3H 1A7 Toll Free (866) 800-6208

CHAIN OF CUSTODY RECORD

ENV COC - 00013v2

C196460_COC

Invoice Information	Invoice to (requires report) ☐	Report Information (if differs from invoice)		Project Information	
Company:	Stantec	Company:		Quotation #:	
Contact Name:	Greg Hustler	Contact Name:		P.O. #/ AFE#:	
Street Address:	500 - 4515 Central Blvd	Street Address:		Project #:	123315738.200.001
City:	Burnaby Prov: BC Postal Code: V5H 0C6	City:	Prov: Postal Code:	Site #:	
Phone:	236-808-6532	Phone:		Site Location:	19125 119B Avenue, Pitt Meadows
Email:	greg.hustler@stantec.com	Email:		Site Location Province:	BC
Copies:	ben.huynh@stantec.com	Copies:		Sampled By:	Greg Hustler

Rush Confirmation #:

Regulatory Criteria

☐ AT1 ☐ CCME ☐ Drinking Water - Canada ☐ Drinking Water - Manitoba

☐ Saskatchewan ☐ Drinking Water - Alberta ☒ Other N/A

SAMPLES MUST BE KEPT COOL (<10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

Regular Turnaround Time (TAT)

☒ 5 to 7 Day ☐ 10 Day

Rush Turnaround Time (TAT) Surcharges apply

☐ Same Day ☐ 1 Day
☐ 2 Day ☐ 3 Day
☐ 4 Day

Date Required: YY MM DD

	Sample Identification	Date Sampled YY	MM	DD	Time (24hr) HH	MM	Matrix	1 FIELD FILTERED	2 FIELD PRESERVED	3 LAB FILTRATION REQUIRED	4 BTEX F1	5 VOCs	6 BTEX F1-F2	7 BTEX F1-F4	8 Routine water	9 Regulated metals - total	10 Regulated metals - dissolved	11 Mercury - total	12 Mercury - dissolved	13 Salinity 4	14 Sieve (75 micron)	15 Texture (% sand, silt, clay)	16 Basic class II landfill	17	18	19	20	21 # OF CONTAINERS SUBMITTED	22 HOLD - DO NOT ANALYZE	Comments
1	AH21-06 GS05	21	11	26			soil	Chloride (soluble), Conductivity (Soluble), pH (2:1 DI Water Extract), Saturated Paste, Soluble Sulphate (SO4) Ion Calc																						
2	AH21-08 GS04	21	11	29			soil	Chloride (soluble), Conductivity (Soluble), pH (2:1 DI Water Extract), Saturated Paste, Soluble Sulphate (SO4) Ion Calc																						
3																														
4																														
5																														
6																														
7																														
8																														
9																														
10																														
11																														
12																														

*UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BUREAU VERITAS STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS AND CONDITIONS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVNA.COM/TERMS-AND-CONDITIONS OR BY CALLING THE LABORATORY LISTED ABOVE TO OBTAIN A COPY

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present		✓		18	18	18
Seal intact		✓				
Cooling media present		✓				

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present						
Seal intact						
Cooling media present						

LAB USE ONLY	Yes	No	°C	1	2	3	Temperature reading by:
Seal present							
Seal intact							
Cooling media present							

	Relinquished by: (Signature/ Print)	Date YY	MM	DD	Time HH	MM		Received by: (Signature/ Print)	Date YY	MM	DD	Time HH	MM	Special Instructions
1	Greg Hustler	21	12	08			1	Geidy Martha Tuso	2021	12	08	14	35	
2	Wil de Castro	21	12	08			2							

Appendix F SEISMIC HAZARD DATA

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 49.221N 122.693W **User File Reference:** Pitt Meadows MV Housing 2021-12-10 15:19 UT

Requested by: Viet Tran, Stantec

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.386	0.266	0.192	0.085
Sa (0.1)	0.588	0.407	0.294	0.131
Sa (0.2)	0.733	0.513	0.373	0.168
Sa (0.3)	0.729	0.514	0.376	0.169
Sa (0.5)	0.642	0.451	0.325	0.139
Sa (1.0)	0.369	0.254	0.178	0.072
Sa (2.0)	0.228	0.152	0.104	0.039
Sa (5.0)	0.074	0.044	0.026	0.009
Sa (10.0)	0.026	0.015	0.009	0.003
PGA (g)	0.318	0.223	0.162	0.072
PGV (m/s)	0.479	0.325	0.224	0.086

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

Seismic Hazard Deaggregation

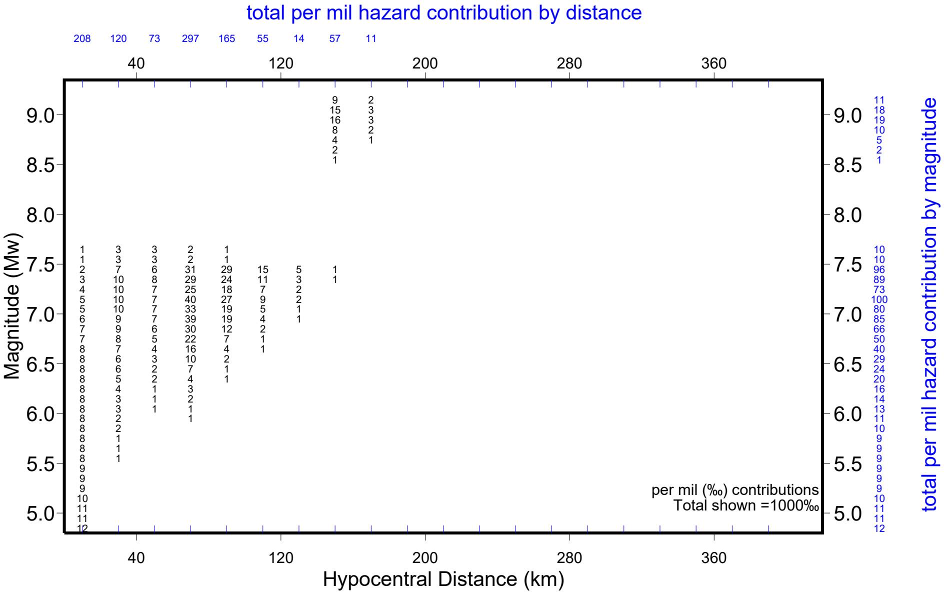
calculated by the Canadian Hazards Information Service

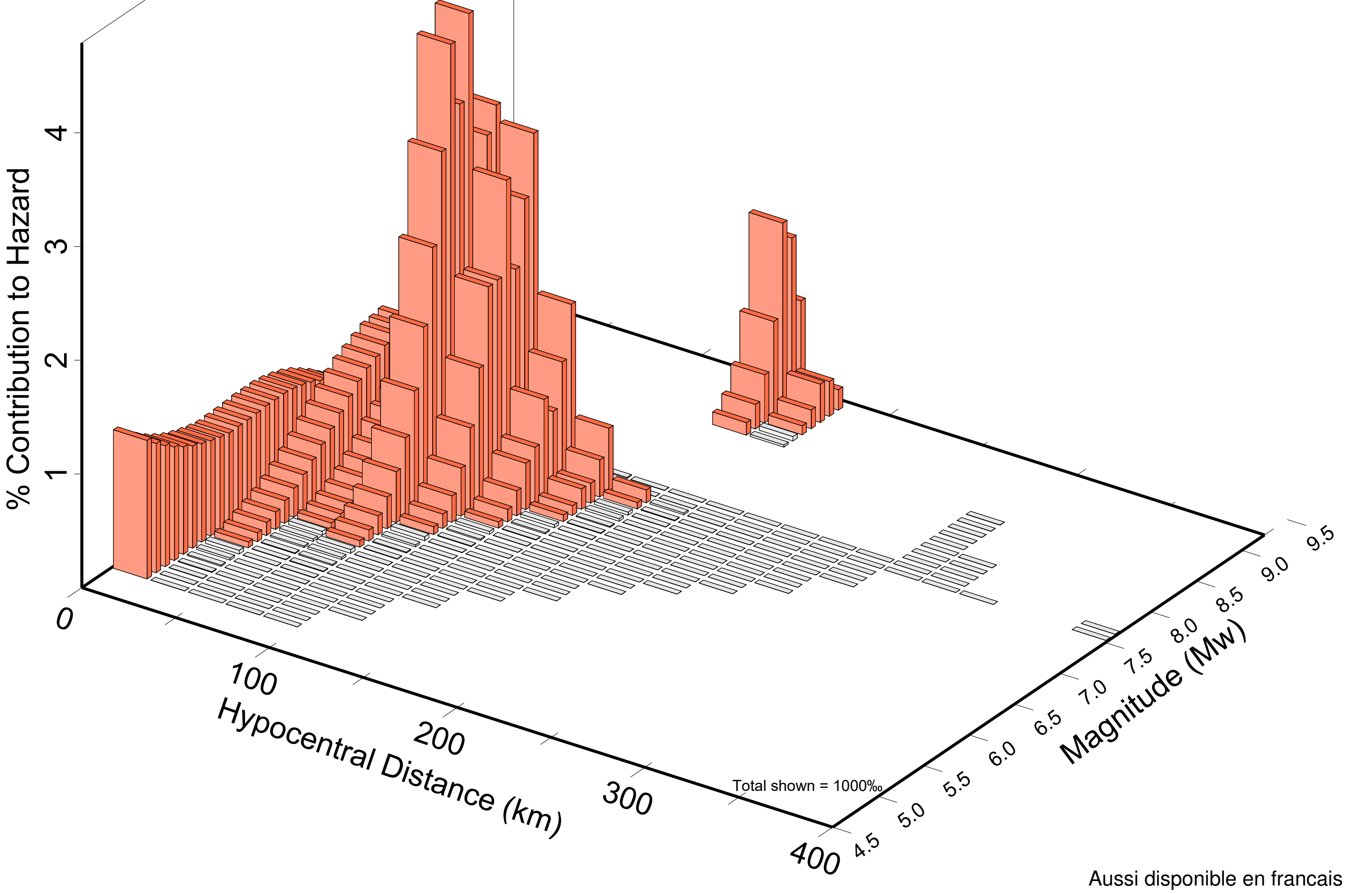
INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Michael Yuan, Stantec 2022/01/10
For site , BC at 49.221 N 122.693 W
For ground motion parameter peak ground acceleration (PGA)
at a probability of 0.000404 per annum, seismic hazard = 0.314 g
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 6.94 Mean distance 63 km
Mode magnitude (Mw) 7.150 Mode distance 70 km
Deaggregation of mean hazard

Model: SWCan_2015clC.model





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