RFP-MCC-2313
Design / Build of Two Fire Stations
Addendum #1

To All Bidders of RFP-MCC-2313:
Please note: the following addendum applies to RFP-MCC-2313 and shall be taken into consideration when preparing bid documents.

1. Replace Section 12 with the below:

   12. Contact

   All questions relating to this RFP document package are to be directed to:

   Name: Shelby Hum
   Title: Accounts Payable
   Phone: 902-667-3204
   Email: shelbyhum@cumberlandcounty.ns.ca

   Should any question raised by a bidder necessitate an addendum to this proposal, notice of addendum will be posted on the Provincial (www.gov.ns.ca/tenders) and Municipality of the County of Cumberland (www.cumberlandcounty.ns.ca) websites.

   Note: Questions will only be accepted up to and including Friday, October 27, 2023. Any questions received after this date will not be accepted.

2. **Information Document – Springhill Industrial Park Fire Station, Geotechnical Report**
   The Springhill Industrial Park Fire Station Geotechnical Report has been included as an information document.

A signed copy of each Addendum must also be included with the bid submission. Failure to include this Addendum may be cause for rejection. If you have any questions, please contact Shelby Hum at shelbyhum@cumberlandcounty.ns.ca
ALL OTHER SPECIFICATIONS, TERMS AND CONDITIONS REMAIN UNCHANGED.

Acknowledgement by Bidder:

Company Name: _____

Print Name: _____

Signed: _____

Date: _____

End of Addendum #1

FINAL REPORT

Springhill Industrial Park Fire Station
Springhill, Nova Scotia

Geotechnical Report

Submitted to:

Municipality of the County of Cumberland

1395 Blair Lake Road
Upper Nappan, NS,
B4H 3Y4
Email: rmacisaac@cumberlandcounty.ns.ca

Submitted by:

WSP Canada Inc.
1 Spectacle Lake Drive, Dartmouth, Nova Scotia, B3B 1X7

CA0009380.8200

September 2023

Distribution List

Municipality of the County of Cumberland

WSP Canada Inc.

Study Limitations

Important Information and Limitations of this Report

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The report is of a summary nature and is not intended to stand alone without reference to the instructions given to WSP Canada Inc. by the Client, communications between WSP Canada Inc. and the Client, and to any other reports prepared by WSP Canada Inc. for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations, and opinions expressed in this report, reference must be made to the whole of the report. WSP Canada Inc. cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations, and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety, and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional, rather than abrupt. Accordingly, WSP Canada Inc. does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling, and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical, and hydrogeologic conditions that WSP Canada Inc. interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal, and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying, or frost. Unless otherwise indicated, the soil must be protected from these changes during construction.

Sample Disposal: WSP Canada Inc. will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills, or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of WSP Canada Inc.'s report. WSP Canada Inc. should be retained to review the final design, project plans, and documents, prior to construction, to confirm that they are consistent with the intent of WSP Canada Inc.'s report.

During construction, WSP Canada Inc. should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of WSP Canada Inc.'s report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations, and opinions contained in WSP Canada Inc.'s report. Adequate field review, observation, and testing during construction are necessary for WSP Canada Inc. to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, WSP Canada Inc.'s responsibility is limited to interpreting accurately, the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that WSP Canada Inc. be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that WSP Canada Inc. be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required, either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. WSP Canada Inc. takes no responsibility for the effects of drainage, unless specifically involved in the detailed design and construction monitoring of the system.

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1.0 INTRODUCTION AND BACKGROUND

At the request of the Municipality of the County of Cumberland, WSP has completed a geotechnical investigation for the new proposed single storey fire station and associated parking space located at Corner of Miners Memorial Dr and Memorial Crescent in Springhill, Nova Scotia.

This report provides information from the borehole investigation as it relates to the site development and building and pavement design. The purpose of the current geotechnical investigation was to obtain additional subsurface soil and bedrock conditions and provide specific recommendations for site development and options for foundation design.

Fieldwork for the subsurface investigation was carried out on August 17th and 18th, 2023 and consisted of drilling seven (7) boreholes at the locations shown on the attached site plans in Appendix A. The boreholes are designated as BH23-01 to BH23-06 including a second borehole advanced adjacent to BH23-03 (BH23-03B). This report presents the results of the field investigation and laboratory test results.

A list of symbols and classifications is enclosed in Appendix B. Borehole logs detailing the subsurface conditions are enclosed in Appendix C. Soil and rock sample photographs are enclosed in Appendix D . Confirmatory geotechnical laboratory testing results are enclosed in Appendix E.

2.0 SITE DESCRIPTION

2.1 General

The subject area consists of an open grass covered site located on the corner of Memorial Crescent and Miners Memorial Drive in Springhill, Nova Scotia. The site is part of the historical Springhill Coal Mining complex and specifically served as the site of the mine entrances and surface operations. Site topography exhibits a slope, generally ascending from northwest to southeast, with less than 5 metres difference in elevation across the site. Appendix A Includes a site plan depicting the approximate location of historic mine workings, the proposed building and pavement area footprint, as well as the positions of completed borehole locations. All coordinates given in this report are referenced to North American Datum 1983 (NAD83), Universal Transverse Mercator (UTM) Grid Projection Zone 20T. Vertical levels are referenced to existing ground surface elevations.

2.2 Geology

Regional geological mapping indicates that the site overburden soil consists of Wisconsinan-aged ground moraine[1], described as 3-30m of compact mainly silty till from both local and distance (clayey) source material. Bedrock geology of the site belongs to the Springhill Mines Formation of the Cumberland group. This formation dates to the Late Carboniferous period and consists of grey fluvial sandstones, grey mudstones with frequent thin coal seams and rare limestones.

2.2.1 Historic Mine Workings

Provincial records indicate that the site is part of the historic Springhill Coal Mining complex. Specifically, the northeastern extent of the site served as the location of the mine entrances and surficial operational buildings and contain remnants of demolition activity. The current investigation found deleterious concrete with rebar and wood fragments across the site (details are provided in Section 4.3.1 and 4.3.2).

[1] Nova Scotia Geosciences and Mines Branch. (n.d.). Geoscience Atlas. Retrieved February 20, 2023, from https://fletcher.novascotia.ca/DNRViewer/?viewer=Geoscience

The site is also adjacent to two sets of historic mine workings: the No.2 group towards the northwest and No.7 group towards the southwest. Elevations of the mine workings vary; No.7 mine seams are located at least 150 meters below the ground surface (mbgs), sloping downward from southeast to northwest. The No.2 mine seams however sit near bedrock surface just northwest of the site, also sloping downward from southeast to northwest (B. Herteis, personal communication, August 18, 2023). Site plans showing the position of No.2 and No.7 mine workings are included in Figure 1 and 2 of Appendix A respectively.

The current investigation did not uncover any underground remnants of mine operations on site.

3.0 INVESTIGATION PROCEDURE

3.1 Drilling Equipment and Procedures

The subsurface investigation was conducted from August 17th to 18th, 2023 and involved drilling seven (7) boreholes:

- BH23-01, -02, -03 and -03B were drilled to investigate the subsurface of the fire station building structure.
- BH23-04, -05, and -06 were drilled to investigate the subsurface of pavement structure.

The approximate locations are shown in Figures 1 and 2 of Appendix A. In general, boreholes were terminated at depths of between 6 to 11 mbgs for building investigation boreholes and 3 mbgs for pavement investigation boreholes. The only exception was BH23-03 which terminated at 1.7 mbgs due to refusal on concrete with rebar.

The borehole drilling program included standard penetration testing using split-spoon samplers, bedrock coring, and logging of subsurface conditions. In all locations, the soil was drilled using a 125 mm hole diameter solid stem auger on a track-mounted CME 45 drill rig supplied by Logan Drilling Inc. Boreholes BH23-01 and BH23-03B were further advanced by HQ sized rotary diamond coring where the soil became too stiff for auger advancement or where bedrock was encountered. Upon completion of drilling, boreholes were backfilled with sand.

Borehole location centre coordinates were recorded on a Samsung S21 FE cellular phone through the “Field Maps” application accurate to ±3 m (NAD 83). A summary of completed borehole locations is shown in Table 1

Table 1: Summary of Borehole Locations

Borehole ID	Total Depth (mbgs)	Northing (m)	Easting (m)
BH23-01	10.9	5055106	416933
BH23-02	6.1	5055076	416951
BH23-03	1.7	5055113	416966
BH23-03B	10.0	5055119	416969
BH23-04	3.3	5055132	416961
BH23-05	3.0	5055106	416994
BH23-06	3.0	5055119	416967

Note: Coordinates referenced to North American Datum 1983 (NAD83), Universal Transverse Mercator (UTM) Grid Projection Zone 20T (Collected August 2023).

3.2 Soil Sampling and Logging

In all seven (7) borehole locations, soil samples were collected periodically at 600 mm increments using a 50 mm (2”) outside diameter split spoon sampler. Samplers were driven in accordance with Standard Penetration Testing (SPT) resistance procedures (ASTM D1586). N-values, described as the number of blows required to drive the sampler 305 mm (1 ft) into the soil, were recorded at each sample interval. Variation in N-values and subsurface conditions are shown in attached borehole logs in Appendix C.

The overburden soils encountered were classified based on the Unified Soil Classification System (USCS), as described in ASTM D2487. The soils were further described according to WSP’s Soil Description System, which is designed to capture engineering attributes in addition to those covered in the USCS. Further details of the method of soil classification and the symbols, abbreviations, and terms used are provided in Appendix B.

Select split spoon samples were submitted to WSP’s E&I geotechnical laboratory in Dartmouth, Nova Scotia for physical properties testing, including natural moisture content and gradation.

3.3 Rock Sampling and Logging

Bedrock depth was confirmed at one (1) borehole location, BH23-01, by sampling a continuous 3 m length of rock. Sampling in bedrock was performed using an HQ sized (63.5mm) core barrel. Rock samples were organized in core boxes and then photographed in a wetted condition. Dry-condition photos were not taken as the weather did not allow for samples to dry in a timely manner.

Geotechnical logging of the sampled rock core was carried out by WSP field supervisor. The following descriptors were recorded:

- Rock type and description
- Total Core Recovery (TCR)
- Solid Core Recovery (SCR)
- Rock Quality Designation (RQD)

Further details of the lithological and geotechnical rock description terminology are provided in Appendix B.

No laboratory tests were performed on rock samples.

3.4 Geotechnical Laboratory Testing

Confirmatory geotechnical laboratory testing of select soil samples for gradation, Atterberg Limit determination and moisture content was completed by WSP E&I in Dartmouth, Nova Scotia. Tests were performed in accordance with materials testing requirements and applicable ASTM procedures including the following:

- Moisture content determination (as per ASTM D2216)
- Atterberg limits determination (as per ASTM D4318)
- Grain size distribution (mechanical sieve and/or hydrometer, as per ASTM D6913 and ASTM D7928)

Geotechnical laboratory results are attached in Appendix E. It should be noted that soil samples in boreholes were retrieved using samplers with inner diameters ranging from approximately 35 mm to 64 mm; consequently, recovered soil samples may not reflect the coarser fraction of the in-situ deposits (i.e., particle sizes greater than 35 mm to 64 mm).

4.0 SUBSURFACE CONDITIONS

4.1 General

The general soil stratigraphy at the site can be summarized as a topsoil layer overlying a very loose to loose inferred coal fill up to a depth of approximately 3 mbgs. The fill was underlain by a cohesive, very stiff to dense inferred till with a frequent presence of cobbles at > 6 mbgs. A bedrock depth of 7.1 mbgs was confirmed at BH23-01. Subsurface water was encountered in two borehole locations, both associated with a void in the fill layer.

Individual subsurface strata and groundwater depths are further described in the following sections of this report, and a summary of subsurface conditions are shown in Table 2 below.

Table 2: Summary of Subsurface Conditions

Borehole ID	Total Depth (mbgl)	Depth to Bottom of Stratum (mbgs)				Depth to Bedrock
		Topsoil	Coal Fill	Clay Till	Gravel and Cobbles	
BH23-01	10.9	1.1	3.0	6.3	7.1	7.1
BH23-02	6.1	0.2	2.7	6.1	ne	ne
BH23-03	1.7	1.0	1.7	ne	ne	ne
BH23-03B	10.0	1.0	3.0	6.1	7.8	*7.8
BH23-04	3.3	0.3	3.3	ne	ne	ne
BH23-05	3.0	0.4	3.1	ne	ne	ne
BH23-06	3.0	0.2	3.0	ne	ne	ne

Notes: mbgs– metres below ground surface.
ne – not encountered.
*inferred bedrock depth from retrieval of 0.5m of rock.

4.2 Topsoil

Topsoil was encountered at ground surface in all seven (7) borehole locations and had thicknesses ranging from 0.2 to 1.1m. Topsoil was generally described as grass and rootmat overlying brown, non-cohesive, silty sand with trace rootlets. Based on SPT N-values, the compactness of the topsoil can be described as loose. No laboratory index testing was performed on topsoil samples.

4.3 Fill

4.3.1 Concrete Fill

Concrete was observed at or near ground surface in an area adjacent to BH23-02 (shown in Figures 1 and 2 of Appendix A). The borehole location was relocated 13 m southwest of the planned location after SPT refusal was reached at surface and manual shovel excavation found refusal at < 0.3 mbgl continuously all the way to the completed BH23-02 borehole location.

Furthermore, BH23-03 in the northeastern portion of the site, adjacent to the historical location of mine operational buildings, was terminated when the auger refused within a pinkish grey concrete slab with rebar. The concrete was encountered at a depth of 1 mbgs with a thickness of at least 0.7 m.

4.3.2 Coal Fill

Coal fill was encountered directly under topsoil in all seven (7) borehole locations and extended to depths of between 2.7 to 3.3 mbgs with thicknesses of between 0.7 to 3.0 m. Two voids were identified in the coal fill layer at the following locations:BH23-03B at a depth of 3.0 to 3.3 mbgs; and BH23-06 at a depth of 1.9 to 2.3 mbgs. Some wood fragments were also found in BH23-01.

The coal fill was generally described as black to blackish brown silty sand with some red (brick) or pinkish grey (concrete) gravel. The fill was non-cohesive, and generally dry to moist. Based on SPT N-values, the compactness of the silty sand can be described generally as very loose to loose. It should be noted that higher N-values recorded in borehole logs may represent the presence of coarse-grained gravel or cobbles rather than the consistency of the soil matrix.

Results of water content testing on two coal fill samples are summarized in Table 3. No Atterberg Limit testing was completed on coal fill.

Table 3: Laboratory Test Results for Coal Fill

Borehole ID	Sample ID	Depth (mbgl)	Moisture Content (%)	Grain Size Distribution		
				% Gravel	% Sand	% Fines
BH23-01	SS3	1.5-2.1	27.2	15	63	22
BH23-02	SS2	0.6-1.2	19.1	12	54	34

Notes: mbgs– metres below ground surface.

4.4 Clay Till

Clay till was encountered in three (3) borehole locations at depths of between 6.1 to 6.3mbgs. These boreholes represent the only boreholes to be advanced deeper than 6 mbgs and terminated on competent soil or bedrock. The cohesive till was generally described as brown to reddish brown sandy silty clay with trace to no gravel, and had a moisture content below its plastic limit (w < PL). Based on SPT N-values, the consistency of the till was described as very stiff to hard.

A summary of index testing (moisture content, particle size distribution) conducted on non-cohesive till samples are presented in Table 4.

Table 4: Laboratory Test Results for Clay Till

Borehole ID	Sample ID	Depth (mbgl)	Moisture Content (%)	Atterberg Limits			Grain Size Distribution		
				Plastic Limit (%)	Liquid Limit (%)	Plasticity Index	% Gravel	% Sand	% Fines
BH23-01	SS6	3.6-4.2	20.9	21	32	11	10	29	60
BH23-01	SS8	5.2-5.8	16.1	-	-	-	-	-	-
BH23-03B	SS5	3.7-4.3	13.8	17	26	9	11	30	59

4.5 Gravel and Cobbles

A sandy gravel and cobble layer was encountered directly over bedrock in two (2) borehole locations BH23-01 and BH23-03B at depths of 7.1 and 7.8 mbgs respectively. These two locations represent the only boreholes advanced to reach bedrock surface. The gravel and cobble layer was generally described as sandy gravel transitioning with depth to gravel and cobbles with few boulders. It should be noted that the composition of the soil matrix is inferred and could not be confirmed. This layer was resistant to auger advancement and was instead cored, resulting in the washout of sand and fine particles by drill fluid. Sand presence was observed in the drill fluid upon its return to surface. The retrieved gravel and cobble granular material was described as very light grey with occasional red or black gravel.

No laboratory testing was performed on the gravel and cobble layer.

4.6 Bedrock

Bedrock depth was confirmed in one (1) borehole BH23-01 where a minimum of 3 meters of bedrock was retrieved, confirming a bedrock depth of 7.1 mbgs. Furthermore, in borehole BH23-03B, bedrock depth was inferred to be approximately 7.8 mbgs based on the recovery of less than 0.5 meters of rock before the borehole was terminated. The sampled bedrock was described as very to slightly weathered, light grey, medium grained sandstone (greywacke) and assigned the following rock qualifiers.

- Total Core Recovery (TCR) = 100%
- Solid Core Recovery (SCR) = 70 to 78%
- Rock Quality Designation (RQD) = 100%

It should be noted that the bedrock surface (the first 0.3m of bedrock) in both borehole locations appeared highly weathered with a significant presence of clay fault material.

No laboratory testing was performed on bedrock samples.

4.7 Groundwater

Subsurface water was encountered in BH23-02 and BH23-03B at depths of 1.9 and 3.2 mbgs respectively. The water in both locations was encountered adjacent or within a void in the coal fill layer and likely caused by surface infiltration through the sandy fill layer. Please note that these subsurface water depths are unlikely to be representative of groundwater conditions. No groundwater monitoring wells were installed as a part of the current investigation.

Groundwater levels can be expected to fluctuate seasonally and in response to precipitation events and freeze/thaw cycles.

5.0 GEOTECHNICAL RECOMMENDATIONS

5.1 General

This section of the report provides engineering guidance related to the geotechnical design aspects of the project based on our interpretation of the available information described herein and project requirements. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and form their own interpretation of the factual data as it affects their proposed construction techniques, schedule, safety, and equipment capabilities. Reference should be made to the Limitations of this Report, which forms an integral part of this document.

It is understood that the development will consist of a new single storey fire hall and associated parking lot. A conceptual plan of the proposed site layout is shown on the site plan included in Appendix A. It is assumed that the building foundations will be of conventional design, consisting of spread and strip footings. WSP has included recommendations for shallow foundation construction.

As noted previously, the subsurface conditions at the site consisted of loose topsoil overlying coal fill up to a depth of 3.2 mbgs. The fill was underlain by cohesive, very stiff to hard silty clay (inferred native till) material with presence of cobbles at approximately 6 mbgs, directly above bedrock.

Some of the recommendations below are preliminary in nature and can be confirmed once specific design information is available.

5.2 Site Preparation and Earthworks

5.2.1 Building Area

Site preparation for the building area should consist of removal of all organic soils, fill materials (if encountered) and loose/wet soils from within proposed building foundation and structural bearing areas.

Excavation for foundations should be taken to an approximate 3m depth (based on the boreholes) to a competent stratum (i.e. native clay till). Following initial excavations, a proof-roll (minimum 10-tonne vibratory drum roller) of the exposed subgrade should be conducted by qualified geotechnical personnel. Any soft/wet areas encountered at the time of the proof-roll will require removal and replacement with an approved structural fill. Further recommendations for fill placement using on-site materials are discussed below.

Imported structural fill (if required) should consist of a well-graded quarried or pit-run material, free of organics, and have a maximum particle size of 150-mm (larger particles sizes may be warranted for deeper fills). During fill placement, lift thickness should be compatible with type of compaction equipment and material used (i.e. gradation, particle size, etc.). Generally, material should be placed in compacted lifts not to exceed 300-mm and compacted to 100 percent of the material's Standard Proctor Maximum Dry Density (SPMDD) for structural applications (ASTM D698 procedure). Water and loose/soft soils should be removed prior to fill placement. Fill material, compaction equipment, lift thicknesses, etc. are to be evaluated for approval by the Geotechnical Engineer prior to fill placement.

Where placement of engineered fill for foundation subgrade is required, excavations should be taken beyond the edge of the foundation structure equivalent to the depth of engineered fill below the foundation (plus 1.2 metres) to allow for splay of bearing.

Quality control inspection and testing is recommended during foundation construction by qualified geotechnical personnel. Assessment of subgrade will be required prior to placement of fill materials (if required).

5.2.2 Asphalt Pavement Area

Site Preparation recommendations for the Asphalt Pavement Area can be found in Section 5.9.1.

5.3 Re-Use of On-Site Material and Backfilling

The surface topsoil and coal fill should be stripped to a depth of at least 3 mbgs and wasted or re-used in non-structural applications. Portions of the on-site silty clay till may also be suitable for non-structural backfill applications. However, till sampled in select locations (BH23-01) exhibited high moisture content and may need to by dried or mixed with dryer materials prior to re-use.

Difficulties with compaction and/or backfill performance should be anticipated for clay tills where water content is above the optimum for compaction purposes. Use of proper construction methods during excavation, handling and stockpiling of the on-site materials will be required to prevent additional and excessive water content in the soil. All backfill materials must be approved by qualified geotechnical personnel prior to use.

Backfill should be placed in lifts not to exceed 300 mm and compacted to 95 percent of the material's SPMDD. Structural backfill, i.e., concrete spread footing backfill, should be compacted to a higher approved standard (98 to 100 percent of the material's SPMDD - ASTM D698). Any material used as backfill must have a moisture content of ±2% of optimum, to be evaluated by the geotechnical consultant during placement.

5.4 Slopes

Excavated "cut" slopes should be no steeper than 3:1 horizontal to vertical (H:V) for long-term stability (1.5:1 slopes may be acceptable for short-term stability, upon approval from the geotechnical consultant). Fill slopes using compacted onsite sand or similar material should be no steeper than 2.5:1 H:V.

All permanent exposed soil slope faces should be protected using vegetation, gravel, riprap (i.e., broken rock), etc. Control of groundwater using drainage systems (i.e., toe drains) may be required to prevent deterioration of slopes. Any change in soil conditions from those reported herein would require re-evaluation of the above recommendations.

5.5 Erosion and Sediment Control

Erosion and sedimentation control measures (e.g. silt fences, check dams, settling ponds, etc.) should be provided, as required, for the site as part of the detailed design activity in accordance with municipal and Nova Scotia Environment's requirements. Application of these control measures should be utilized to minimize soil erosion.

Due to the significant fine-grained soils encountered during the investigation, geotextiles should be placed on any exposed fine-grained material, either undisturbed or where used as fill material, when placing engineered fill, i.e., NSDPW crushed rock. Utilization of geotextiles will prevent fines migration into granular fill and ensure proper separation is maintained during construction to reduce sedimentation.

5.6 Groundwater Control

During construction, surface runoff and/or groundwater may be encountered. Controlling water at the building site will minimize softening and loosening of the exposed subgrade. Typical de-watering techniques may include grading excavations to sump locations to dispose of water by pumping. If necessary, soft/wet soils can be over excavated and replaced by an imported rock fill. Proper erosion and sedimentation control measures should be provided to limit site disturbance, as in accordance with provincial and municipal regulations.

5.7 Geotechnical Design

Concrete spread or strip footings may be set directly on native till (stiff to hard silty clay) or engineered fill above till (if required).

Bearing capacity estimates for Serviceability Limit State (SLS – un-factored geotechnical resistance) and factored Ultimate Limit State (ULS – geotechnical resistance factor of 0.5) design are provided as follows and are based on criteria in the Canadian Foundation Engineering Manual (4th edition).

For spread/strip footings founded on native till or engineered fill, as approved by the Geotechnical Engineer:

- SLS : 150 kPa
- ULS : 225 kPa

Total and differential settlement at the allowable SLS design stresses are expected to be less than 25 mm and 19 mm, respectively, for footings set on engineered fill.

Assessment of the foundation bearing surface (footing subgrade) will be required to confirm the recommended bearing pressures noted above. The footing subgrade should be inspected by qualified geotechnical personnel during bearing surface preparation; compaction and proof rolling of the bearing surface will likely be required prior to placing concrete.

Bearing capacity estimates generally assume that the foundation footing depth (Df) is at least 1.2 metres, and that the confining soil weight is included in the estimates. Footings should be founded at a minimum depth of 1.2 metres below exterior grade elevation for frost protection.

If loosening/softening of the footing subgrade occurs due to water seepage, construction traffic, etc., removal and replacement with an approved granular material (i.e. Type 2, or equivalent) and geotextile may be required.

5.8 Preliminary Soil Design Parameters

Recommended preliminary soil design parameters for foundation and retaining wall design (if required) are provided in Table 5 below. If site conditions vary from the above at time of construction, WSP should be contacted immediately to re-evaluate the below design parameters.

Table 5: Preliminary Soil Design Parameters

Parameter	Till SILTY CLAY (Cl)	NSDPW Type 2 Sand and Gravel
Total Unit Weight, γ_k (kN/m^3)	19	22
Submerged Unit Weight (kN/m^3)	9	12
Angle of Internal Friction, Φ	28°	36°
Coefficient of Active Earth Pressure, K_a	0.36	0.26
Coefficient of Passive Earth Pressure, K_p	2.77	3.85
Cohesion, c (kPa)	5	0

Retaining walls, if any, should be designed for anticipated surcharges from structures, vehicle loads, sloping backfill, etc. The above parameters assume horizontal placement of backfill behind retaining walls. If inclined backfill lifts are to be placed behind the retaining walls, the geotechnical engineer should be contacted for appropriate revision of design parameters.

5.9 Asphalt Pavement

5.9.1 Excavation and Subgrade Preparation

To prepare the site for parking/driveway areas, partial sub-excavation of fill deposits will be required. The depth of excavation will be depended on site grading requirements. WSP can provide specific sub-excavation recommendations once the grade is finalized.

The exposed fill/till subgrade should be compacted with a minimum of 5 passes from a 10-tonne vibratory drum roller and proof-rolled under the supervision of qualified geotechnical personnel, prior to placement of additional subgrade fill and/or granular materials.

The finished subgrade is to be compacted to 95 percent of the Standard Proctor Maximum Dry Density (SPMDD), as outlined above under “site preparation” in Section 5.2. If soft/wet areas are encountered in the subgrade, additional rock fill and/or geotextile/geogrid may be required for stabilization. Prior to placement of the pavement structure, a proof roll with a loaded tandem truck of the finished subgrade should be conducted under the direction of the Geotechnical Engineer to confirm satisfactory conditions. A 2 to 3 percent (minimum) crown/slope is recommended for runoff to catch basin locations.

5.9.2 Pavement Cross-Section

It is understood that the site will include a paved parking lot/driveway area, which will support light vehicle traffic (cars and light trucks) and heavy vehicle traffic (i.e. fire engine’s). Recommended asphalt pavement cross-sections are described in Table 6 below.

Table 6: Pavement Cross-Sections

Material	Light Duty Areas	Heavy Duty Areas
Type C-HF Asphalt Surface	75 mm	40 mm
Type B-HF Asphalt Base	-	60 mm
NSDPW Type 1 Gravel	150 mm	150 mm
Geogrid	Miragrid 5XT or equivalent	Miragrid 5XT or equivalent
NSDPW Type 2 Gravel	300 mm	500 mm
Geotextile	Mirafi RS380i or equivalent	Mirafi RS380i or equivalent

All granular material is to be compacted to 100 percent of the Standard Proctor Maximum Dry Density (SPMDD). Asphalt pavement should be compacted to a minimum 92 percent of the Maximum Theoretical Bulk Density. The pavement materials should be provided and constructed in accordance with the Municipal Specifications or other equivalent specifications.

5.10 Seismic Site Classification

The majority of material encountered within the upper 30 mbgl at the site consisted of very stiff to hard soils and rock. Therefore, in accordance with the National Building Code of Canada 2020 (NBCC 2020), a recommended site designation for seismic analysis of 'C' should be considered.

The applicable site coefficients are found in the tables of the same code. The structural engineer should confirm the applicable site coefficients.

It should be noted that investigative depths were not advanced to the minimum 30 m depth for seismic site classification. Therefore, stratigraphy beyond termination depths at the borehole locations was inferred based on extrapolation the bedrock stratum from the confirmed depth at BH23-01.

5.11 Frost Protection

The maximum seasonal frost penetration depth was calculated for the near-surface soils in accordance with CFEM. A mean freezing index of 500 to 750 Degree Days Celsius (°C days) was used for the location. The average seasonal frost penetration depth is estimated to be approximately 1.2 m. The estimated frost penetration depth assumes a uniform soil type without topsoil and snow cover. Any shallow foundations should have a minimum soil cover of at least 1.2 m for frost protection purposes. The depth of electrical and fibre optic cables, can be designed by others.

Rigid insulation can be used to reduce the required thickness of the soil cover for frost protection if the recommended minimum soil cover cannot be achieved. The insulation supplier should be consulted for the detailed design of insulations. There are several products with differing specifications, but generally, 25 mm (1 inch) of insulation decreases the frost penetration depth by 300 mm (1 foot). The insulation used for frost protection should be placed at a minimum depth of 0.6 m below the finished ground surface, and the top 0.6 m of backfill should be ignored for equivalent frost penetration calculation purposes.

6.0 CLOSURE

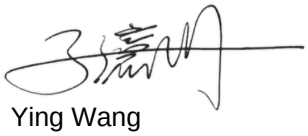
This report has been prepared for the sole benefit of The Municipality of the County of Cumberland and is not intended for use by others. This report may not be reproduced without the prior written permission of WSP and The Municipality of the County of Cumberland. Contractors undertaking work must draw their own interpretations of the factual investigation results provided in this report as it affects constructions, costs, procedures and scheduling.

As boreholes provide a localized representation of the total study area, subsurface conditions may vary between and/or beyond the borehole locations. If conditions encountered at the site vary significantly from those reported herein, WSP should be notified immediately for review and revision of our interpretations and recommendations if necessary.

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

Signature Page

WSP Canada Inc.



Ying Wang
Associate Geotechnical Engineer



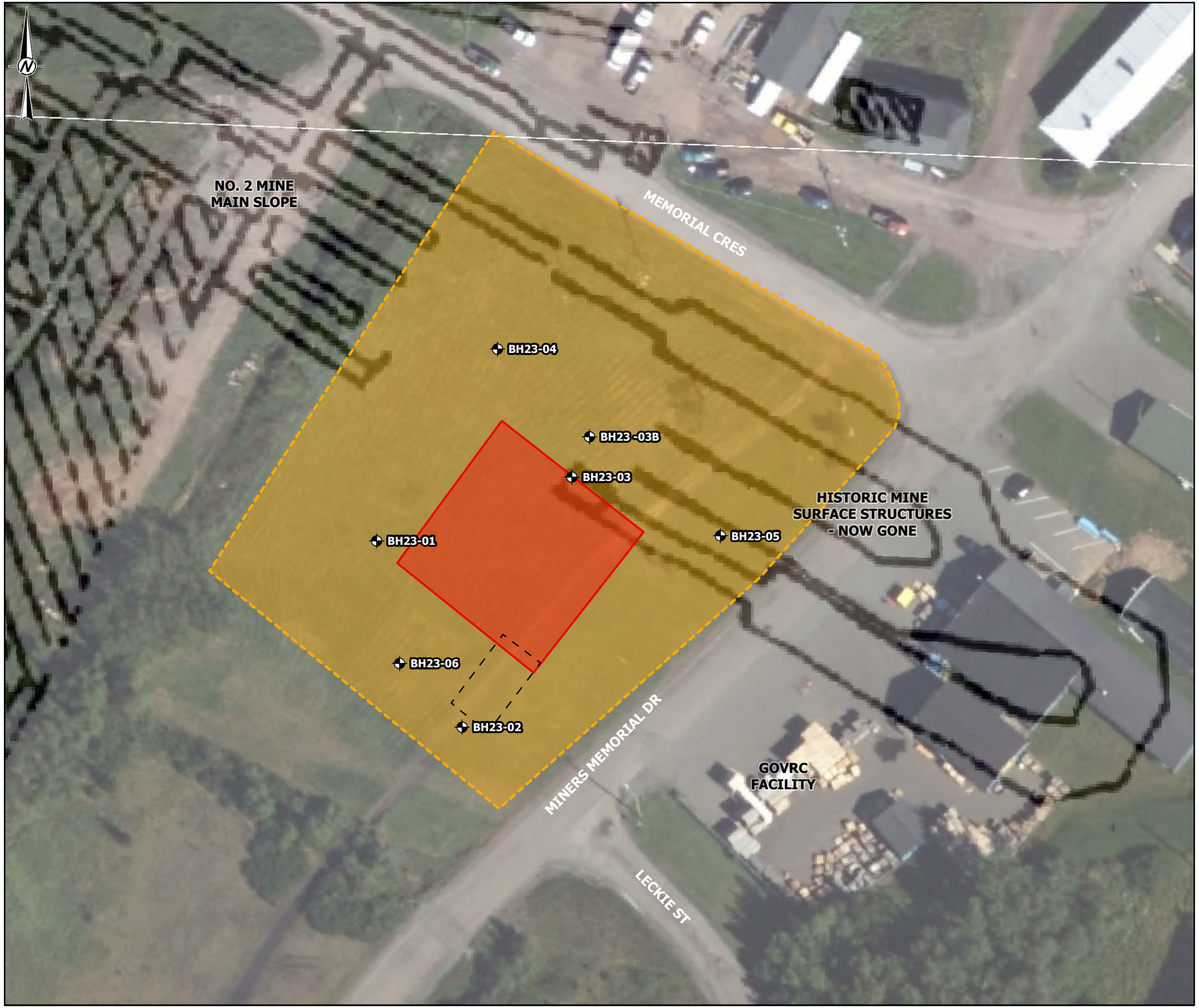
Jørn Landva
Senior Geotechnical Engineer

YW/JL/ha

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APPENDIX A

Site Plan



LEGEND

- COMPLETED BOREHOLE LOCATION
- NO.2 MINE WORKINGS
- PROPOSED BUILDING AREA
- PROPOSED PAVEMENT AREA
- SURFICIAL CONCRETE ENCOUNTERED



0 15 30

1:600 METRES

REFERENCE(S)

1. PROVINCE OF NOVA SCOTIA, ESRI, HERE, GARMIN, FAO, NOAA, USGS, NRCAN, PARKS CANADA
PROJECTED COORDINATE SYSTEM: NAD 1983 UTM ZONE 20N

CLIENT

THE MUNICIPALITY OF THE COUNTY OF CUMBERLAND

PROJECT

SPRINGHILL INDUSTRIAL PARK FIRE STATION GEOTECHNICAL INVESTIGATION REPORT

TITLE

SITE PLAN - NO. 2 MINE WORKINGS

CONSULTANT

wsp

YYYY-MM-DD	2023-09-18
DESIGNED	VMB
PREPARED	VMB
REVIEWED	CR
APPROVED	JL

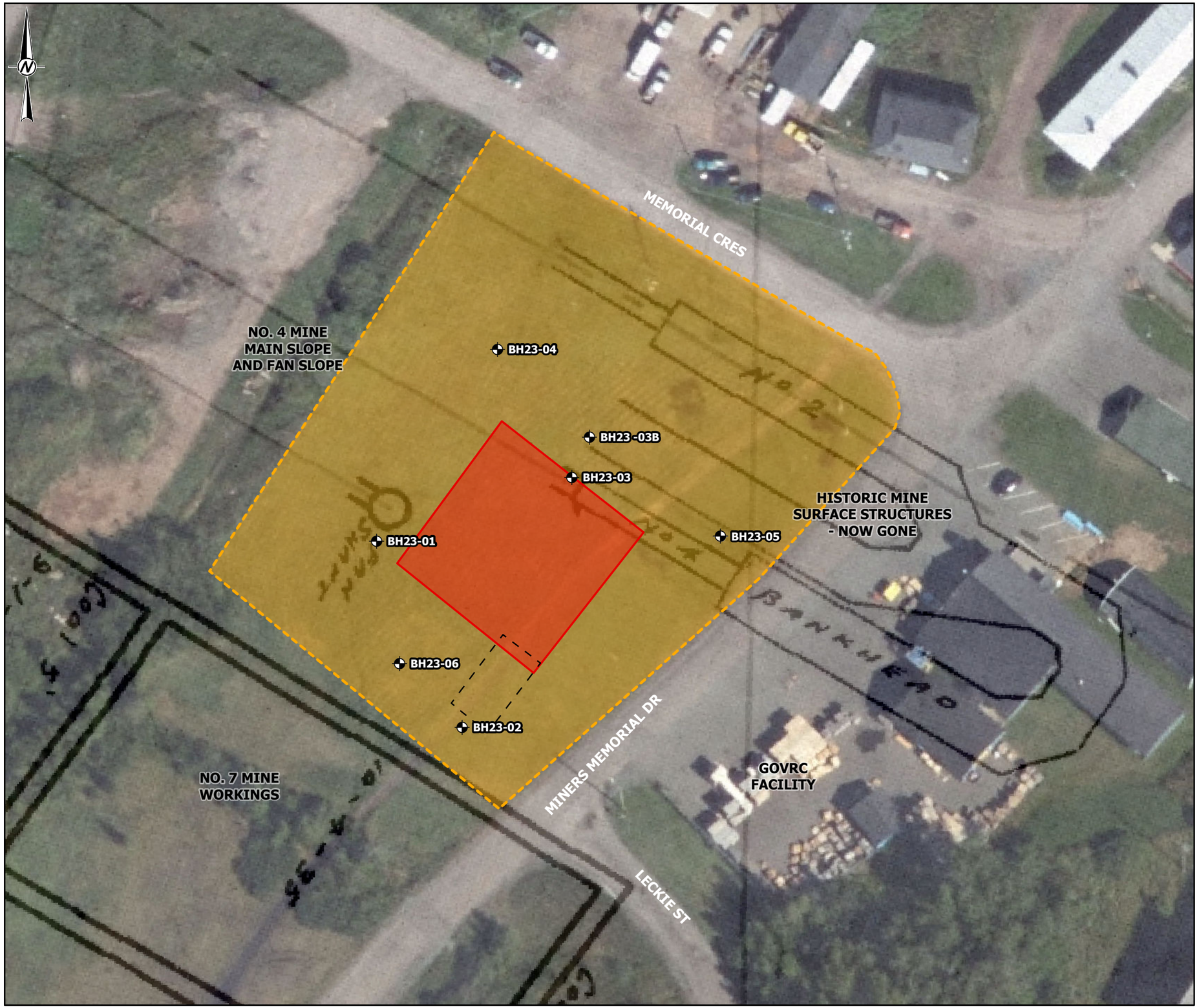
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LEGEND

- COMPLETED BOREHOLE LOCATION
- NO.7 MINE WORKINGS
- PROPOSED BUILDING AREA
- PROPOSED PAVEMENT AREA
- SURFICIAL CONCRETE ENCOUNTERED



0 15 30

1:600 METRES

REFERENCE(S)

1. PROVINCE OF NOVA SCOTIA, ESRI, HERE, GARMIN, FAO, NOAA, USGS, NRCAN, PARKS CANADA
PROJECTED COORDINATE SYSTEM: NAD 1983 UTM ZONE 20N

CLIENT

THE MUNICIPALITY OF THE COUNTY OF CUMBERLAND

PROJECT

SPRINGHILL INDUSTRIAL PARK FIRE STATION GEOTECHNICAL INVESTIGATION REPORT

TITLE

SITE PLAN - NO. 7 MINE WORKINGS

CONSULTANT

wsp

YYYY-MM-DD	2023-09-18
DESIGNED	VMB
PREPARED	VMB
REVIEWED	CR
APPROVED	JL

PROJECT NO.	CONTROL	REV.	FIGURE
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APPENDIX B

Abbreviations and Terminology for Soil and Rock Description

METHOD OF SOIL CLASSIFICATION

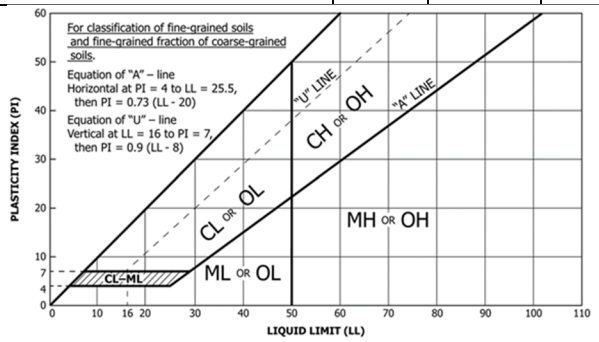
The WSP Canada Soil Classification[1] System is based on the Unified Soil Classification System (USCS) (after ASTM D2487)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$		$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content [6,9]	USCS Group Symbol [3,5,7]	Primary Group Name [2]
INORGANIC (Organic Content <30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Clean Gravels with <5% fines [3] (by mass)	Well Graded	≥4	(and)	≥1 to ≤3	≤30%	GW	Well-graded GRAVEL [4,6]
				Poorly Graded	<4	(and/or)	<1 or >3		GP	Poorly graded GRAVEL [4,6]
			Gravels with >12% fines [3] (by mass)	Below A Line	n/a				GM	SILTY GRAVEL [4,6]
				Above A Line	n/a				GC	CLAYEY GRAVEL [4,5,6]
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Clean Sands with <5% fines [7] (by mass)	Well Graded	≥6	(and)	≥1 to ≤3		SW	Well-graded SAND [6,8]
				Poorly Graded	<6	(and/or)	<1 or >3		SP	Poorly graded SAND [6,8]
			Sands with >12% fines [7] (by mass)	Below A Line	n/a				SM	SILTY SAND [6,8]
				Above A Line	n/a				SC	CLAYEY SAND [5,6,8]

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content [B,H]	USCS Group Symbol [A]	Primary Group Name [A]
				Dilatancy	Dry Strength	Shine Test	Thread Diameter (mm)	Toughness (of 3 mm thread)			
INORGANIC (Organic Content <30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Nonplastic or PI and LL plot **below A-Line** on Plasticity Chart below) [C]	Liquid Limit <50 [D]	Rapid	None to Low	Dull to None	3 to >6	Low/can't roll 3 mm	<15%	ML	SILT [H]
				None to Slow	Low to Medium	Dull to Slight	3 to 6	Low	15% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50 [D]	None to V.Slow	Low to Medium	Slight	3 to 6	Low to Medium	<15%	MH	ELASTIC SILT[H]
				None	Medium to High	Dull to Slight	1 to 3	Low to Medium	15% to <30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot **above A-Line** on Plasticity Chart below) [A]	Liquid Limit <50 [D]	None to Medium Slow	Medium to High	Slight to Shiny	1 to 3	Medium	<15%	CL	LEAN CLAY [A,E,F,G,H]
				None to V.Slow	Medium to High	Slight to Shiny	1 to 3	Medium	15% to <30%	OL	ORGANIC CLAY [E,F,G]
			Liquid Limit ≥50 [D]	None	High to V.High	Shiny	<1	High	<15%	CH	FAT CLAY [E,F,G,H]
				None	High	Shiny	<1 to 1	High	15% to <30%	OH	ORGANIC CLAY [E,F,G]
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures	Relatively lightweight, possibly spongy. Some water may squeeze from sample. Some shrinkage may occur on air drying. Sand fraction may be visible. Low to high dilatancy. Thread weak near plastic limit. Low to medium dry strength.						30% to <75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat	Lightweight, spongy. Much water squeezes from sample. Shrinks considerably on air drying (i.e., very high water content). Plant structure identiable to altered.						75% to 100%		PEAT

Coarse-Grained Soil Note(s):

1. Based on the material passing the 75 mm sieve.
2. If field sample contains or drilling observations indicate cobbles or boulders or both, add, "with cobbles" or "with cobbles and boulders". Include notes on the depth(s) encountered, and sizes if possible.
3. Gravels with 5% to 12% fines require dual symbols:
   (GW-GM) Well-graded GRAVEL with silt,
   (GW-GC) Well-graded GRAVEL with clay,
   (GP-GM) Poorly graded GRAVEL with silt,
   (GP-GC) Poorly graded GRAVEL with clay.
4. If soil contains ≥15% sand, add "with sand" to Group Name.
5. If fines classify as CL-ML, use dual symbol (GC-GM) or (SC-SM) for Group Symbol.
6. If the soil has an organic content (OC) 15%≤OC<30% the prefix "Organic" should be added before the Group Name. If the soil has an organic content 3%≤OC<15% add "with organic fines" to Group Name. If the soil contains >0% to ≤3% organics, the descriptor "trace organics" may be added.
7. Sands with 5% to 12% fines require dual symbols:
   (SW-SM) Well-graded SAND with silt,
   (SW-SC) Well-graded SAND with clay,
   (SP-SM) Poorly graded SAND with silt,
   (SP-SC) Poorly graded SAND with clay.
8. If soil contains ≥15% gravel, add "with gravel" to Group Name.



Fine-Grained Soil Note(s):

- **A.** If Atterberg limits plot above the A-line but in the 'hatched' area on the plasticity chart, soil is a (CL-ML) SILTY CLAY.
- **B.** If the soil contains >0% to ≤3% organics, the descriptor "trace organics" may be added.
- **C.** If fine-grained materials are nonplastic (i.e., a plastic limit (PL) cannot be measured), soil is a (ML) SILT.
- **D.** If soil has a liquid limit (LL) >30% to <50%, the term 'medium plasticity' may be included in the description, but the Group Name/Symbol is not changed.
- **E.** If soil contains 15% to <30% +No.200, add "with sand" or "with gravel".
- **F.** If soil contains ≥30% +No.200 mainly sand, add "Sandy" to Group Name.
- **G.** If soil contains ≥30% +No.200 mainly gravel, add "Gravelly" to Group Name.
- **H.** If the soil has an organic content (OC) 3%≤OC<15% add "with organic fines" to Group Name.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

GRADATIONAL COMPONENT TERMS

% (by mass)	Term
≤ 5	Use “trace”
> 5 to ≤ 12	Use “few”
> 12 to <30	Use “little”
≥ 30 to <50	Use “some”
≥ 50	Use “mostly”

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); Nd:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven, pushed tube sampler, or geoprobe macro-core – note size
DS	Denison type sample
FS	Foil Sample
GS	Grab Sample
MC	Modified California Samples – note sample diameter and hammer weight
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split-spoon sampler (50 mm OD); larger sizes use MC
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT ‘N’ (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT ‘N’ in general accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT ‘N’ ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT ‘N’ value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT ‘N’ value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT ‘N’[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT ‘N’ in general accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT ‘N’ values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
NP	nonplastic
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING CLASSIFICATION

Fresh (W1): no visible sign of rock material weathering.

Slightly Weathered (W2): discoloration indicates weathering of rock mass material on discontinuity surfaces. **Less than 5%** of rock mass is altered or weathered.

Moderately Weathered (W3): less than 50% of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

Highly Weathered (W4): more than 50% of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

Completely Weathered (W5): 100% of the rock mass is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact.

Residual Soil (W6): all rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole, a discontinuity with a 90^{o} angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

AXJ Axial Joint
BD Bedding
BC Broken Core
CC Continuous Core
CL Closed
CO Contact
CU Curved
CT Coated
FLT Fault
FOL Foliation
FR Fracture
GO Gouge
IN Infilled
IR Irregular
JN Joint
KV Karstic Void
K Slickensided
LC Lost Core
MB Mechanical Break
PL Planar
PO Polished
RO Rough
SA Slightly Altered
SH Shear
SM Smooth
SR Slightly Rough
SY Stylolite
UN Undulating
VN Vein
VR Very Rough

ISRM Intact Rock Material Strength Classification

Grade	Description	Approx. Range of Uniaxial Compressive Strength (MPa)
R0	Extremely weak rock	0.25 – 1.0
R1	Very weak rock	1.0 – 5.0
R2	Weak rock	5.0 – 25
R3	Medium strong rock	25 – 50
R4	Strong rock	50 -100
R5	Very strong rock	100 -250
R6	Extremely strong rock	>250

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING CLASSIFICATION

Fresh (W1): no visible sign of rock material weathering.

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Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
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Term	Size*
Very Coarse Grained	Greater than 60 mm
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Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole, a discontinuity with a 90^{o} angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

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CL Closed
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CU Curved
CT Coated
FLT Fault
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GO Gouge
IN Infilled
IR Irregular
JN Joint
KV Karstic Void
K Slickensided
LC Lost Core
MB Mechanical Break
PL Planar
PO Polished
RO Rough
SA Slightly Altered
SH Shear
SM Smooth
SR Slightly Rough
SY Stylolite
UN Undulating
VN Vein
VR Very Rough

ISRM Intact Rock Material Strength Classification

Grade	Description	Approx. Range of Uniaxial Compressive Strength (MPa)
R0	Extremely weak rock	0.25 – 1.0
R1	Very weak rock	1.0 – 5.0
R2	Weak rock	5.0 – 25
R3	Medium strong rock	25 – 50
R4	Strong rock	50 -100
R5	Very strong rock	100 -250
R6	Extremely strong rock	>250

APPENDIX C

Borehole Logs

RECORD OF BOREHOLE: BH23-01

CLIENT:	Municipality of Cumberland	DATE:	August 18, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055105.7 m E: 416933.0 m
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:	Lantech Drilling	HORZ DATUM:	NAD83

DEPTH (m)	DRILL RIG	DRILL METHOD	MATERIAL PROFILE: DESCRIPTION	USCS	STRATA PLOT	ELEV. / DEPTH (m)	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	SAMPLES: NUMBER	TYPE	REC %	BLOWS	N-VALUE	SAMPLE DESCRIPTION	GROUNDWATER OBSERVATIONS	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL OBSERVATIONS
0	Track Mounted Drill Rig	Solid Stem Auger	TOPSOIL; Grass and rootmat overlying (SM) SILTY SAND, and non plastic fines; brown, trace (0-5%) presence of roots; non-cohesive, moist, loose.	SM		0.00	0	60	40	NP	1	SS	8	1-2-2-2	4	(SM) SILTY SAND, and non plastic fines; brown, trace (0-5%) presence of roots; non-cohesive, moist, 0.05m rootmat.		0	60	40	NP	
1							0	60	40	NP	2	SS	25	1-3-3-2	6	(SM) SILTY SAND, and non plastic fines; brown, trace (0-5%) presence of roots; non-cohesive, moist.						
			INFERRED FILL; (SM) SILTY SAND, and fines, trace gravel; black; non-cohesive, moist, very loose to loose. Coal fill.			1.10																
2							5	55	40		3	SS	50	1-1-1-1	2	(SM) SILTY SAND, and fines, trace gravel; black; non-cohesive, moist, Coal.		5	55	40		
			- 2.20 to 2.27 m: Wood fragments					70	25		4	SS	63	1-1-6-5	7	(SM) SILTY SAND; black; non-cohesive, moist, Coal wood in tip.						
3			(Cl) sandy SILTY CLAY, medium plasticity, fine to coarse sand; brown, TILL; cohesive, w < PL, very stiff to hard. Sand coarsening with depth.	Cl		3.04	0	20	80	M	5	SS	87	5-5-16-1	21	(Cl) sandy SILTY CLAY, medium plasticity; brown, TILL; cohesive, w < PL.						
4							5	20	75	M	6	SS	102	7-16-18-2	34	(Cl) sandy SILTY CLAY, medium plasticity, trace gravel; brown, TILL; cohesive, w < PL, Gravel increasing with depth.						
								20	80	M	7	SS	83	9-16-20-3	36	(Cl) sandy SILTY CLAY, medium plasticity, coarse sand; brown, TILL; cohesive, w < PL, Sand coarse with depth.		0	20	80	M	
5							5	20	75	M	8	SS	8	26-48-39-40	87	(Cl) sandy SILTY CLAY, medium plasticity, coarse sand, trace gravel; brown, TILL; cohesive, w < PL, Sand coarse with depth.						
6							50	30	20	M	9	SS	36	45-50/ 10cm		(GC) sandy CLAYEY GRAVEL, coarse sand, medium plasticity fines; brown with light grey, TILL; cohesive, w < PL, Crumbly rock at tip.						
		HQ Coring	(GP-GM) sandy GRAVEL and cobbles, gravel red black and light grey, cobbles very light grey. - 6.40 to 6.70 m: 0.3m Boulder			6.30																
7			BEDROCK; Very weathered GREYWACKE. - 7.10 to 7.20 m: grey clayey sand possible fault material. - 7.35 to 7.45 m: light grey clayey sand possible fault material.			7.10																7.10 - 7.20 m: Grey clay directly over bedrock sampled as GS1
8			BEDROCK; Fresh, grey, very strong, GREYWACKE.			7.88					1	RC	100									
9																						
10																						

Continued on Next Page

DEPTH SCALE: 1:51

HAMMER TYPE: Automatic

REV: 0

LOGGED: Ying Wang DATE: Aug 18, 2023

CHECKED: Clayton Rogers DATE: Sep 18, 2023

RECORD OF BOREHOLE: BH23-01

CLIENT: Municipality of Cumberland
PROJECT: Springhill Fire Station
PROJECT NO: CA0009380.8200
LOCATION: Springhill NS

DATE: August 18, 2023
INCLINATION: 90.0°
CONTRACTOR: Lantech Drilling

ELEVATION: Data Not Available
COORDINATES: N: 5055105.7 m E: 416933.0 m
COORD SYS: UTM Zone 20N
HORZ DATUM: NAD83

DEPTH (m)	DRILL RIG	DRILL METHOD	MATERIAL PROFILE: DESCRIPTION	USCS STRATA PLOT	ELEV. / DEPTH (m)	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	SAMPLES: NUMBER	TYPE	REC %	BLOWS	N-VALUE	SAMPLE DESCRIPTION	GROUNDWATER OBSERVATIONS	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL OBSERVATIONS
	Track Mounted Drill Rig	HQ Coring	BEDROCK; Fresh, grey, very strong, GREYWACKE.							2	RC	100									
11			End of hole at 10.92 m.																		
12																					
13																					
14																					
15																					
16																					
17																					
18																					
19																					
20																					

DEPTH SCALE: 1:51
HAMMER TYPE: Automatic

REV: 0

LOGGED: Ying Wang DATE: Aug 18, 2023
CHECKED: Clayton Rogers DATE: Sep 18, 2023

RECORD OF BOREHOLE: BH23-02

CLIENT:	Municipality of Cumberland	DATE:	August 17, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055075.8 m E: 416951.5 m
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:	Lantech Drilling	HORZ DATUM:	NAD83

DEPTH (m)	DRILL RIG	DRILL METHOD	MATERIAL PROFILE: DESCRIPTION	USCS	STRATA PLOT	ELEV. / DEPTH (m)	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	SAMPLES: NUMBER	TYPE	REC %	BLOWS	N-VALUE	SAMPLE DESCRIPTION	GROUNDWATER OBSERVATIONS	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL OBSERVATIONS
0	Track Mounted Drill Rig	Solid Stem Auger	TOPSOIL; Grass and rootmat overlying topsoil.			0.00																
			INFERRED FILL; (SM) SILTY SAND, trace gravel; black with light red; non-cohesive, moist, very loose to compact. Coal with brick.	SM		0.15	5	70	25		1	SS	42	1-4-4-12	8	(SM) SILTY SAND, trace gravel; black with light red; non-cohesive, 0.15m tppsoil overlying Coal with brick fill.							
1							5	70	25		2	SS	73	12-10-7-8	17	(SM) SILTY SAND, trace gravel; black with light red; non-cohesive, Coal with brick.							
																		5	70	25		
2							0	80	20		3	SS	42	2-2-1-1	3	(SM) SILTY SAND, medium to coarse; black; non-cohesive, wet.	17Aug23 15:03					1.90 m: GW encountered before void over cohesive till. 8/17/2023 3:03:38 PM
							0	30	70	M	4	SS	42	4-0-1-1	1	(Cl) sandy SILTY CLAY, medium plasticity; brown, TILL; cohesive, w > PL.						
3			(Cl) sandy SILTY CLAY, medium plasticity, trace gravel; brown, TILL; cohesive, w < PL, very stiff to hard.	Cl		2.72																
							5	30	65	M	5	SS	42	6-13-14-2	27	(Cl) sandy SILTY CLAY, medium plasticity, trace gravel; brown, TILL; cohesive, w < PL.						
4							5	40	55	M	6	SS	102	14-29-17-22	46	(Cl) SILTY CLAY and SAND, medium plasticity, trace gravel; brown, TILL; cohesive, w < PL to w > PL.						
																		5	30	65	M	
5							5	20	75	M	7	SS	71	30-44-50/ 23mm		(Cl) sandy SILTY CLAY, medium plasticity, trace gravel; brown to tannish brown, TILL; cohesive, w < PL.						
6							5	20	75	M	8	SS	42	2-5-19-24	24	(Cl) sandy SILTY CLAY, medium plasticity, trace gravel; brown, TILL; cohesive, w < PL.						
			End of hole at 6.05 m.																			
7																						
8																						
9																						
10																						

DEPTH SCALE: 1:51

HAMMER TYPE: Automatic

REV: 0

LOGGED: Ying Wang DATE: Aug 17, 2023

CHECKED: Clayton Rogers DATE: Sep 18, 2023

RECORD OF BOREHOLE: BH23-03

CLIENT:	Municipality of Cumberland	DATE:	August 17, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055113.0 m E: 416966.0 m
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:		HORZ DATUM:	NAD83

DEPTH (m)	DRILL RIG	DRILL METHOD	MATERIAL PROFILE: DESCRIPTION	USCS	STRATA PLOT	ELEV. / DEPTH (m)	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	SAMPLES: NUMBER	TYPE	REC %	BLOWS	N-VALUE	SAMPLE DESCRIPTION	GROUNDWATER OBSERVATIONS	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL OBSERVATIONS
0			TOPSOIL; Grass and rootmat overlying SILTY SAND, trace gravel; brown, trace presence of roots; non-cohesive, dry to moist, loose.	SM		0.00	0	60	40	NP	1	SS	33	1-2-2-2	4	(SM) SILTY SAND, and non plastic fines; brown, trace (0-5%) presence of roots; non-cohesive, dry.						
							5	60	35		2A					(SM) SILTY SAND, trace fine gravel; brown; non-cohesive, moist.						
1			FILL; Concrete block with rebar.			1.00	40	30	30		2B	SS	33	2-10-18-21	28	(GM) sandy SILTY GRAVEL; light grey with blackish brown; non-cohesive, dry, Coal fill.						
																						1.50 - 1.70 m: Rebar coiled around auger. Borehole moved 2m northeast and advanced as BH23-03B.
							30	50	20		3	SS	4	50/0.08m		(SM) gravelly SILTY SAND; tannish brown; non-cohesive, dry.						
2			End of hole at 1.70 m. Auger refused on concrete with rebar, relocated to BH23-03B																			
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

DEPTH SCALE: 1:51

HAMMER TYPE:

REV: 0

LOGGED: Ying Wang DATE: Aug 17, 2023

CHECKED: Clayton Rogers DATE: Sep 18, 2023

RECORD OF BOREHOLE: BH23-03B

CLIENT:	Municipality of Cumberland	DATE:	August 17, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055118.9 m E: 416969.0 m
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:	Lantech Drilling	HORZ DATUM:	NAD83

DEPTH (m)	DRILL RIG	DRILL METHOD	MATERIAL PROFILE: DESCRIPTION	USCS	STRATA PLOT	ELEV. / DEPTH (m)	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	SAMPLES: NUMBER	TYPE	REC %	BLOWS	N-VALUE	SAMPLE DESCRIPTION	GROUNDWATER OBSERVATIONS	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL OBSERVATIONS
0	Track Mounted Drill Rig	Solid Stem Auger	TOPSOIL; Grass and rootmat overlying (SM) SILTY SAND, and non plastic fines; brown, trace presence of roots; non-cohesive, dry to moist, loose.			0.00												5	60	35		
1			INFERRED FILL; (SM) SILTY SAND, trace gravel; black; non-cohesive, moist, very loose. Coal fill.	SM		1.00	5	60	35		1	SS	42	0-1-0-1	1	(SM) SILTY SAND, trace gravel; black; non-cohesive, moist, Black coal fill.		5	60	35		
2											2	SS	0	1-1-0-1	1							
3			Void with water.			3.00											17Aug23 09:56					3.00 m: Void possibly larger. 1.2m of SPT above showed little to no resistance.
			(CI) sandy SILTY CLAY, medium plasticity; brown to reddish brown, TILL; cohesive, w < PL, hard, Gravel content increasing with depth.	CI		3.30	0	40	60	M	4	SS	42	0-0-6-8	6	(CI) SILTY CLAY and SAND, medium plasticity, and fine to coarse SAND; brown; cohesive, w < PL to w ~ PL.						3.20 m: Water in void. 8/17/2023 9:56:23 AM
4							10	30	60	M	5	SS	100	9-9-12-5	21	(CI) sandy SILTY CLAY, medium plasticity, some gravel; brown; cohesive, w < PL, Sand finer with depth. Top 0.2 cavein not sampled.						
5							15	30	55	M	6	SS	102	9-13-12-2 6	25	(CI) gravelly sandy SILTY CLAY, medium plasticity; brown to reddish brown, unweathered; cohesive, w < PL, Sand finer with depth. Top 0.2 not sampled.		15	30	55	M	
6							5	60	35	M	7	SS	10	30/30/ 110m m		(SC) CLAYEY SAND, medium plasticity fines, trace gravel; light tannish brown; cohesive, w < PL.						
			(GP-GM) sandy GRAVEL and Cobbles, very light grey. - 6.35 to 7.80 m: Encountered Cobbles.	GP-GM		6.10	5	70	25		8	SS	10	0	36-50/ 100m m	(SM) SILTY SAND, trace gravel; brown; non-cohesive, dry.		5	70	25		
7																						
8		HQ Coring	BEDROCK; Very weathered GREYWACKE.			7.83							0									
9											9	SS	0	11-15-5-1 3	20							9.40 - 10.00 m: Auger cuttings sampled in bag.
10			End of hole at 10.00 m.																			

DEPTH SCALE: 1:51

HAMMER TYPE: Automatic

REV: 0

LOGGED: Ying Wang DATE: Aug 17, 2023

CHECKED: Clayton Rogers DATE: Sep 18, 2023

RECORD OF BOREHOLE: BH23-04

CLIENT:	Municipality of Cumberland	DATE:	August 17, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055132.3 m E: 416961.0 m
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:	Lantech Drilling	HORZ DATUM:	NAD83

DEPTH (m)	DRILL RIG	DRILL METHOD	MATERIAL PROFILE: DESCRIPTION	USCS	STRATA PLOT	ELEV. / DEPTH (m)	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	SAMPLES: NUMBER	TYPE	REC %	BLOWS	N-VALUE	SAMPLE DESCRIPTION	GROUNDWATER OBSERVATIONS	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL OBSERVATIONS
0	Track Mounted Drill Rig	Solid Stem Auger	TOPSOIL; Grass and rootmat overlying (SM) SILTY SAND, and non plastic fines; brown, trace (0-5%) presence of roots; non-cohesive, dry, loose.	SM		0.00	0	60	40	NP	1A	SS	50	1-2-3-4	5	(SM) SILTY SAND, and non plastic fines; brown, trace (0-5%) presence of roots; non-cohesive, dry.		0	60	40	NP	
						0.30	5	55	40		1B					(SM) SILTY SAND, and fines, trace gravel; black; non-cohesive, moist, Coal.						
1			INFERRED FILL; (SM) SILTY SAND, trace gravel; blackish brown; non-cohesive, moist. Fill becomes cohesive at 2.12m					75	20		3	SS	67	1-1-1-1	2	(SM) SILTY SAND; blackish brown light; non-cohesive, moist.						
2								75	20		3	SS	50	4-5-5-4	10	(SM) SILTY SAND; blackish brown light; non-cohesive, moist.		5	75	20		
							5	65	30		4	SS	33	1-1-2-1	3	(SC) CLAYEY SAND, trace gravel; blackish brown light; cohesive, moist.						
3											5	SS	0	0-0-0-1	0							
			End of hole at 3.34 m.																			
4																						
5																						
6																						
7																						
8																						
9																						
10																						

DEPTH SCALE: 1:51

HAMMER TYPE: Automatic

REV: 0

LOGGED: Ying Wang DATE: Aug 17, 2023

CHECKED: Clayton Rogers DATE: Sep 18, 2023

RECORD OF BOREHOLE: BH23-05

CLIENT: Municipality of Cumberland
PROJECT: Springhill Fire Station
PROJECT NO: CA0009380.8200
LOCATION: Springhill NS

DATE: August 17, 2023
INCLINATION: 90.0°
CONTRACTOR: Lantech Drilling

ELEVATION: Data Not Available
COORDINATES: N: 5055105.5 m E: 416994.0 m
COORD SYS: UTM Zone 20N
HORZ DATUM: NAD83

DEPTH (m)	DRILL RIG	DRILL METHOD	MATERIAL PROFILE: DESCRIPTION	USCS	STRATA PLOT	ELEV. / DEPTH (m)	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	SAMPLES: NUMBER	TYPE	REC %	BLOWS	N-VALUE	SAMPLE DESCRIPTION	GROUNDWATER OBSERVATIONS	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL OBSERVATIONS
0	Track Mounted Drill Rig	Solid Stem Auger	TOPSOIL; Grass and rootmat overlying (SM) SILTY SAND, and non plastic fines; brown, trace (0-5%) presence of roots; non-cohesive, dry, loose.	SM		0.00	0	60	40	NP	1	SS	70	1-2-2-3	4	(SM) SILTY SAND, and non plastic fines; brown, trace (0-5%) presence of roots; non-cohesive, dry.		0	60	40	NP	
						0.35																
1			INFERRED FILL; (SM) SILTY SAND, and fines, trace gravel; black to brownish black; non-cohesive, moist, loose. Coal fill.				5	55	40		2	SS	50	3-3-4-5	7	(SM) SILTY SAND, and fines, trace gravel; black; non-cohesive, Coal.						
2			- 2.30 to 2.44 m: Concrete cobble				5	75	20		3	SS	30	50 (0 mm)		(SM) SILTY SAND, trace gravel; black; non-cohesive, moist, Coal sand fill. Coarser with depth.		5	55	40		
3							5	75	20		4	SS	50	1-2-0-1	2	(SM) SILTY SAND, trace gravel; black with light brown; non-cohesive, moist, Misc fill under concrete.						
			End of hole at 3.04 m.																			
4																						
5																						
6																						
7																						
8																						
9																						
10																						

DEPTH SCALE: 1:51
HAMMER TYPE: Automatic

REV: 0

LOGGED: Ying Wang
DATE: Aug 17, 2023
CHECKED: Clayton Rogers
DATE: Sep 18, 2023

RECORD OF BOREHOLE: BH23-06

CLIENT:	Municipality of Cumberland	DATE:	August 17, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055118.6 m E: 416966.8 m
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:	Lantech Drilling	HORZ DATUM:	NAD83

DEPTH (m)	DRILL RIG	DRILL METHOD	MATERIAL PROFILE: DESCRIPTION	USCS	STRATA PLOT	ELEV. / DEPTH (m)	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	SAMPLES: NUMBER	TYPE	REC %	BLOWS	N-VALUE	SAMPLE DESCRIPTION	GROUNDWATER OBSERVATIONS	FIELD GRADATION %: GRAVEL	SAND	FINES	PLASTICITY	ADDITIONAL OBSERVATIONS
0	Track Mounted Drill Rig	Solid Stem Auger	TOPSOIL; Grass and rootmat overlying topsoil.			0.00																
			INFERRED FILL; (SM) gravelly SILTY SAND, some fines; blackish brown with red and pinkish grey gravel; non-cohesive, mouist, loose. Coal fill with brick and concrete.	SM		0.15	10	60	30		1	SS	58	1-2-3-4	5	(SM) SILTY SAND, some gravel; black with red; non-cohesive.						
1							60	30	10		2	SS	16	5-6-3-9	9	(GP-GM) sandy GRAVEL, poorly graded, some fines; brown with light pinkish grey; non-cohesive, Broken concrete recovered.		60	30	10		
							10	60	30		3	SS	33	6-7-4-0 /0mm	11	(SM) SILTY SAND, some gravel; black with red; non-cohesive, Fill with brick.						
2			Void.			1.98																
			INFERRED FILL; (SM) SILTY SAND, some gravel; black with red; non-cohesive, moist, loose. Coal fill with brick.	SM		2.30	10	60	30		4	SS	17	2-3-2-2	5	(SM) SILTY SAND, some gravel; black with red; non-cohesive, Fill with brick.		10	60	30		
3			End of hole at 3.03 m. No GW																			
4																						
5																						
6																						
7																						
8																						
9																						
10																						

DEPTH SCALE: 1:51

HAMMER TYPE: Automatic

REV: 0

LOGGED: Ying Wang DATE: Aug 17, 2023

CHECKED: Clayton Rogers DATE: Sep 18, 2023

APPENDIX D

Soil and Rock Sample Photos

RECORD OF BOREHOLE: BH23-01

CLIENT:	Municipality of Cumberland	DATE:	August 18, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055105.7 ft E: 416933.0 ft
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:	Lantech Drilling	HORZ DATUM:	NAD83



BH23-01 SS1



BH23-01 SS2

DEPTH SCALE: 1:50

REV: 0

LOGGED: Ying Wang DATE: Aug 18, 2023

CHECKED: Clayton Rogers DATE: Aug 19, 2023

RECORD OF BOREHOLE: BH23-01

CLIENT:	Municipality of Cumberland	DATE:	August 18, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055105.7 ft E: 416933.0 ft
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:	Lantech Drilling	HORZ DATUM:	NAD83



BH23-01 SS3



BH23-01 SS4

DEPTH SCALE: 1:50

REV: 0

LOGGED: Ying Wang DATE: Aug 18, 2023

CHECKED: Clayton Rogers DATE: Aug 19, 2023

Photo Sample 2 P - Letter / Golder - 1 Metric Global / Golder CA Auto (common in Canada) / 2023-09-11

RECORD OF BOREHOLE: BH23-01

CLIENT:	Municipality of Cumberland	DATE:	August 18, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055105.7 ft E: 416933.0 ft
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:	Lantech Drilling	HORZ DATUM:	NAD83



BH23-01 SS5



BH23-01 SS6

DEPTH SCALE: 1:50

REV: 0

LOGGED: Ying Wang DATE: Aug 18, 2023

CHECKED: Clayton Rogers DATE: Aug 19, 2023

RECORD OF BOREHOLE: BH23-01

CLIENT:	Municipality of Cumberland	DATE:	August 18, 2023	ELEVATION:	Data Not Available
PROJECT:	Springhill Fire Station			COORDINATES:	N: 5055105.7 ft E: 416933.0 ft
PROJECT NO:	CA0009380.8200	INCLINATION:	90.0°	COORD SYS:	UTM Zone 20N
LOCATION:	Springhill NS	CONTRACTOR:	Lantech Drilling	HORZ DATUM:	NAD83



BH23-01 7.88 m - 10.92 m

REV: A

LOGGED: Ying Wang DATE: Aug 18, 2023

CHECKED: DATE:

APPENDIX E

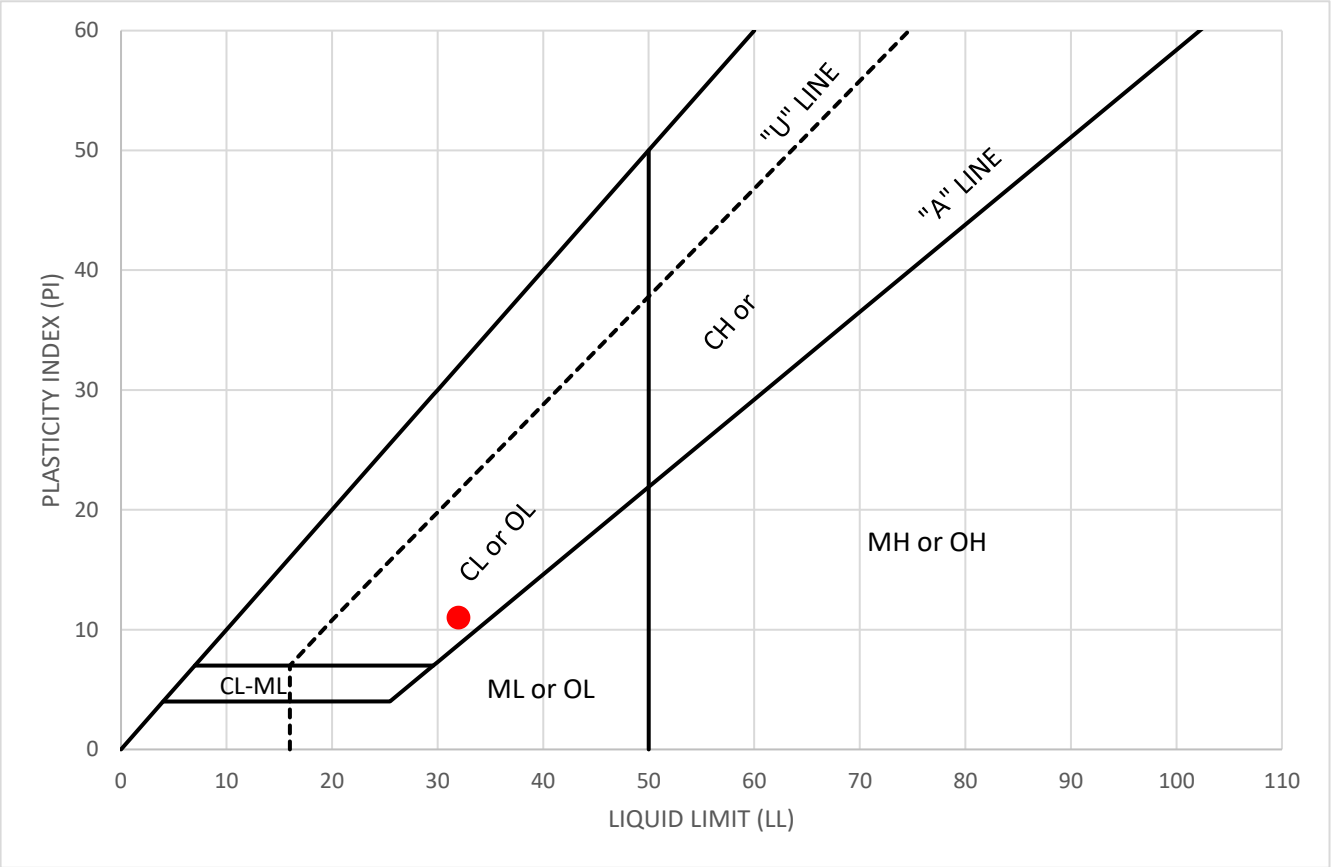
Geotechnical Laboratory Results

ATTERBERG LIMITS

Contract No: CA0009380.8200 **Project #:** TV222023.33
Project: Springhill Fire Station **Sample:** BH23-01 SS6
Sample Type / Source: Site Sample

Date Sampled: August 18, 2023 **Sampled By:** WSP

Date Received: **Standard:** ASTM D4318



Plastic Limit	**21**
Liquid Limit	**32**
Plasticity Index	**11**

Comments:

WSP E&I Canada Limited

Tested by, B.Slauenwhite **Reviewed by,**

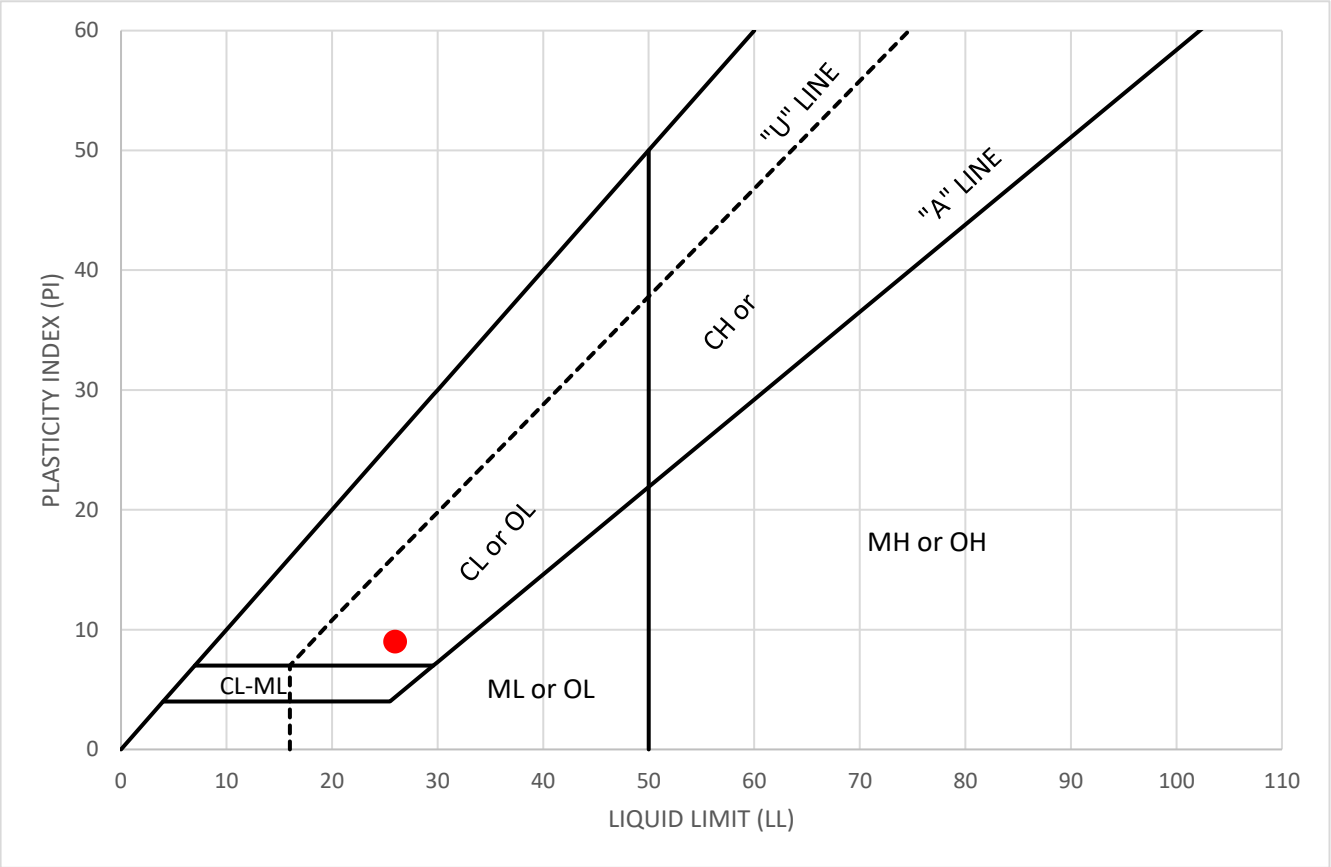
Gordon Shupe, P.Eng

ATTERBERG LIMITS

Contract No: CA0009380.8200 **Project #:** TV222023.33
Project: Springhill Fire Station **Sample:** BH23-3B SS5
Sample Type / Source: Site Sample

Date Sampled: August 18, 2023 **Sampled By:** WSP

Date Received: **Standard:** ASTM D4318



Plastic Limit	**17**
Liquid Limit	**26**
Plasticity Index	**9**

Comments:

WSP E&I Canada Limited

Tested by, B.Slauenwhite **Reviewed by,**

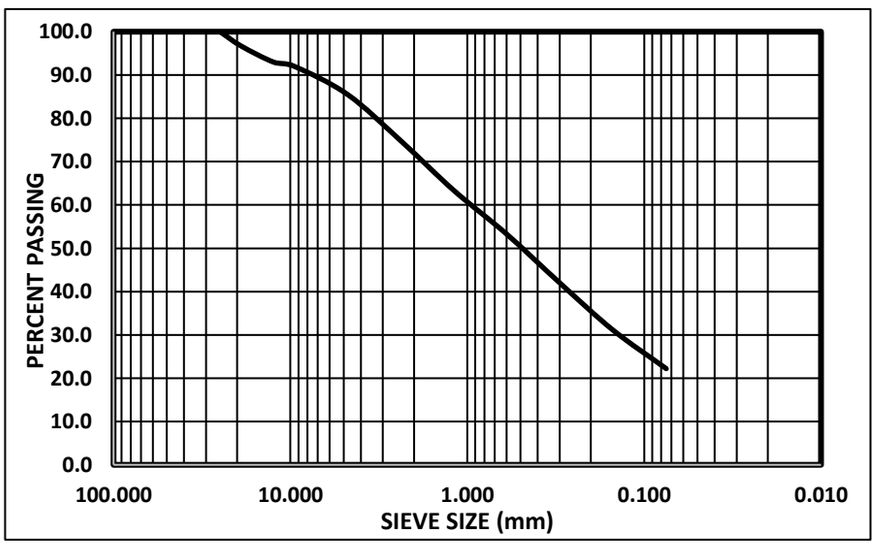
Gordon Shupe, P.Eng

Gradation Summary

Contract No. :	CA0009380.8200	**Project No. :**	TV222023.33
Project Engineer :		**Quarry:**	Site Sample
Location :	Springhill Fire Station	**Material:**	Subgrade
County :		**Sample:**	BH23-01 SS3
Contractor :		**Sampled By:**	WSP

Date	Sample Identification	Sieve Size (mm) / Cumulative Percent Passing											Notes
		25.000	19.000	12.500	9.500	4.750	2.360	1.180	0.600	0.300	0.150	0.075	
18-08-23	BH23-01 SS3	100	96.7	93.0	92.0	85.5	74.7	63.2	53.3	42.0	31.1	22.2	
Specification Band		-	-	-	-	-	-	-	-	-	-	-	
Tolerance Band		-	-	-	-	-	-	-	-	-	-	-	
Average		**100**	**96.7**	**93.0**	**92.0**	**85.5**	**74.7**	**63.2**	**53.3**	**42.0**	**31.1**	**22.2**	
Material		**Gravel**				**Sand**						**Silt/ Clay**	
%		**14.5**				**63.3**						**22.2**	

Comments :
Moisture: 27.2%



Reviewed:
Gordon Shupe, P.Eng

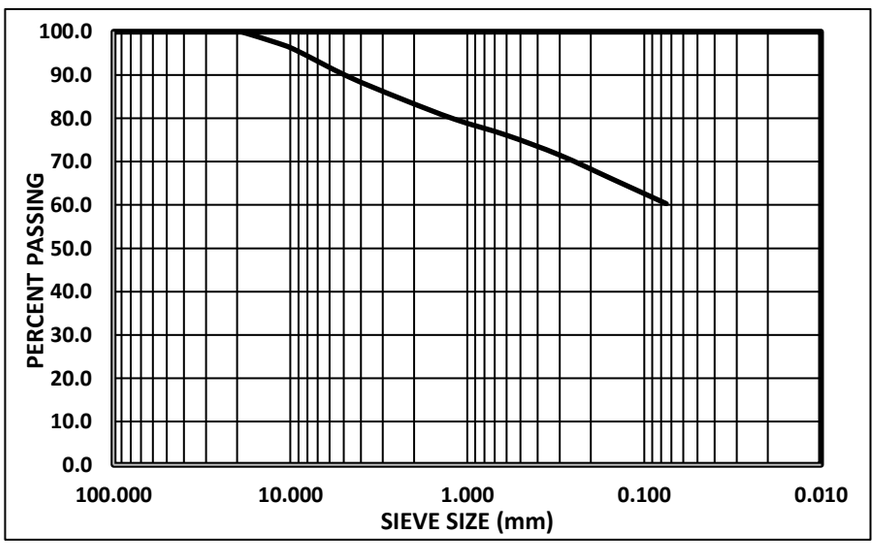
WSP E&I Canada Limited
50 Troop Avenue Suite 300
Dartmouth, Nova Scotia B3B 1Z1

Gradation Summary

Contract No. :	CA0009380.8200	**Project No. :**	TV222023.33
Project Engineer :		**Quarry:**	Site Sample
Location :	Springhill Fire Station	**Material:**	Subgrade
County :		**Sample:**	BH23-01 SS6
Contractor :		**Sampled By:**	WSP

Date	Sample Identification	Sieve Size (mm) / Cumulative Percent Passing											Notes
		25.000	19.000	12.500	9.500	4.750	2.360	1.180	0.600	0.300	0.150	0.075	
18-08-23	BH23-01 SS6		100	97.7	95.9	89.7	84.5	79.8	76.1	71.5	65.9	60.3	
Specification Band		-	-	-	-	-	-	-	-	-	-	-	
Tolerance Band		-	-	-	-	-	-	-	-	-	-	-	
Average			100	97.7	95.9	89.7	84.5	79.8	76.1	71.5	65.9	60.3	
Material		Gravel				Sand						Silt/ Clay	
%		10.3				29.4						60.3	

Comments :
Moisture: 20.9%



Reviewed:
Gordon Shupe, P.Eng

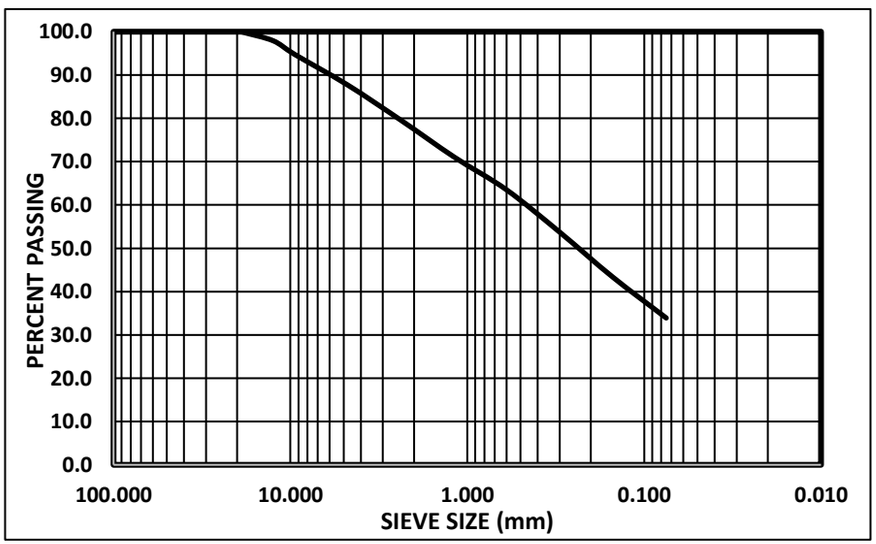
WSP E&I Canada Limited
50 Troop Avenue Suite 300
Dartmouth, Nova Scotia B3B 1Z1

Gradation Summary

Contract No. :	CA0009380.8200	**Project No. :**	TV222023.33
Project Engineer :		**Quarry:**	Site Sample
Location :	Springhill Fire Station	**Material:**	Subgrade
County :		**Sample:**	BH23-02 SS2
Contractor :		**Sampled By:**	WSP

Date	Sample Identification	Sieve Size (mm) / Cumulative Percent Passing											Notes
		25.000	19.000	12.500	9.500	4.750	2.360	1.180	0.600	0.300	0.150	0.075	
17-08-23	BH23-02 SS2		100	97.9	94.8	87.7	79.5	71.0	63.5	53.7	43.3	33.9	
Specification Band		-	-	-	-	-	-	-	-	-	-	-	
Tolerance Band		-	-	-	-	-	-	-	-	-	-	-	
Average			100	97.9	94.8	87.7	79.5	71.0	63.5	53.7	43.3	33.9	
Material		Gravel				Sand						Silt/ Clay	
%		12.3				53.8						33.9	

Comments :
Moisture: 19.1%



Reviewed:
Gordon Shupe, P.Eng

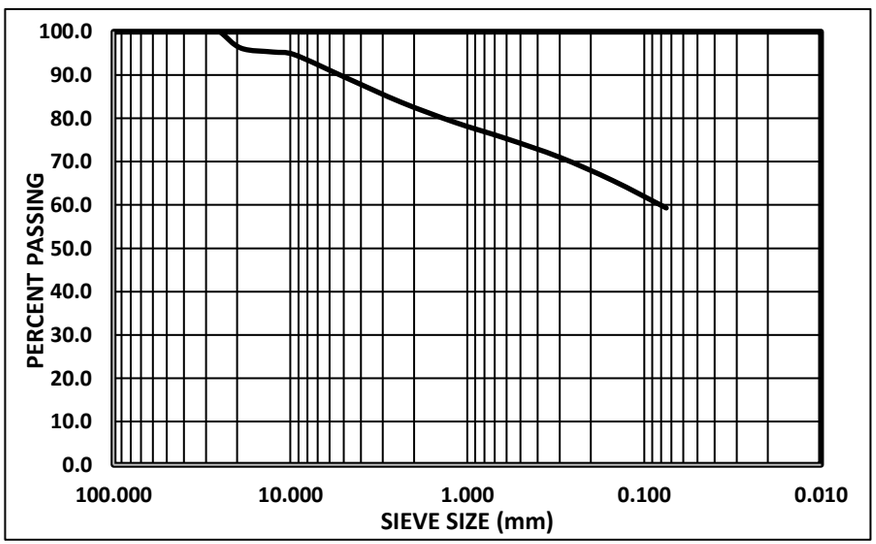
WSP E&I Canada Limited
50 Troop Avenue Suite 300
Dartmouth, Nova Scotia B3B 1Z1

Gradation Summary

Contract No. :	CA0009380.8200	**Project No. :**	TV222023.33
Project Engineer :		**Quarry:**	Site Sample
Location :	Springhill Fire Station	**Material:**	Subgrade
County :		**Sample:**	BH23-03B SS5
Contractor :		**Sampled By:**	WSP

Date	Sample Identification	Sieve Size (mm) / Cumulative Percent Passing											Notes
		25.000	19.000	12.500	9.500	4.750	2.360	1.180	0.600	0.300	0.150	0.075	
17-08-23	BH23-03B SS5	100	96.2	95.3	94.7	89.2	83.7	79.1	75.3	71.0	65.6	59.3	
Specification Band		-	-	-	-	-	-	-	-	-	-	-	
Tolerance Band		-	-	-	-	-	-	-	-	-	-	-	
Average		**100**	**96.2**	**95.3**	**94.7**	**89.2**	**83.7**	**79.1**	**75.3**	**71.0**	**65.6**	**59.3**	
Material		**Gravel**				**Sand**						**Silt/ Clay**	
%		**10.8**				**29.9**						**59.3**	

Comments :
Moisture: 13.8%



Reviewed:
Gordon Shupe, P.Eng

WSP E&I Canada Limited
50 Troop Avenue Suite 300
Dartmouth, Nova Scotia B3B 1Z1

Moisture Content Test Report

Report Date: September 08, 2023

Client		Project	
Name:	WSP	**Name:**	(TV222023) WSP Materials Testing
Address:	1 Spectacle Lake Dr. Dartmouth, Nova Scotia B3B1X7	**Address:**	Nova Scotia
Attention:	Clayton Rogers	**Phase:**	.33 **Task:**
PO Number:		**Manager:**	Gordon Shupe
Sample Date:	9/6/2023 by Victoria Brewer	**Lab/Ref. #:**	NS626992
Source:	CA0009380.8200	**Description:**	Springhill Fire Department

Test Method:

Scale ID: **Oven Temp (C):**

OvenID:

Lab ID	Boring Number	Approx Max Grain Size (Visual)	Depth(m)	Water Content(%)
BH23-01	SS3	37.5mm		27.2
BH23-01	SS6	37.5mm		20.9
BH23-01	SS8	37.5mm		16.1
BH23-02	SS2	37.5mm		19.1
BH23-03B	SS5	37.5mm		13.8

Distribution:

Reviewed By: Gordon Shupe

Reporting of these test results constitutes a testing service only. Field data and concrete test specimens were provided by WSP Canada Inc.

WSP E&I Canada Ltd. - 50 Troop Avenue, Unit 300, Dartmouth, NS, Canada, B3B 1Z1 - phone: 902 468 2848



wsp.com