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Solicitation No. - N° de l'invitation EW038-201920/A	**Amendment No. - N° modif.** 008
Client Reference No. - N° de référence du client PCA-EW038-201920	**Date** 2019-12-13
GETS Reference No. - N° de référence de SEAG PW-$PWU-201-11726	
File No. - N° de dossier PWU-9-42151 (201)	**CCC No./N° CCC - FMS No./N° VME**
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This amendment has been raised to include Addendum #007

JASPER STAFF HOUSING CONSTRUCTION

5 PLEX

ADDENDUM No. 7

CLARIFICATIONS

A. There is no geotechnical report for the 5plex building site. A recent geotechnical report of a site within Jasper is included with Addendum #7, to provide bidders with an idea of what type of soils can be expected to be encountered. The geotechnical report is not to be relied upon for design purposes. The primary difference for the site at 902 Patricia Street is that large boulders up to 2m in diameter, in the long direction, can be expected during the excavation of the building foundation.

END OF ADDENDUM No. 7

(Total 1 pages)

Geotechnical Investigation

Jasper Staff Apartments
901—913 Turret Street
Jasper, AB
Project # EA6414

Prepared for:

1x1 Architecture Inc.
120 Fort Street, Winnipeg, MB R3R 1C7

10-Oct-19

Geotechnical Investigation

Jasper Staff Apartments

901 – 913 Turret Street, Jasper, AB

Project # EA6414

Prepared for:
1x1 Architecture Inc.
120 Fort Street, Winnipeg, MB R3R 1C7

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10-Oct-19

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APPENDIX A — Figure 1 – Borehole Location Plan
Borehole Logs (BH19-01 to BH19-05)
Explanation of Terms and Symbols

1.0 Introduction

1.1 General

Wood Environment & Infrastructure Solutions (Wood) was retained by 1x1 Architecture Inc. (1x1 Architecture) to conduct a geotechnical investigation for the proposed Jasper Staff Apartments Project located at 901 to 913 Turret Street in Jasper, Alberta. The purpose of the investigation was to provide subsurface information and geotechnical engineering recommendations for subgrade preparation, foundation design and geotechnically related aspects for the proposed development.

This report summarizes the results of the field and laboratory work, and provides discussion and recommendations for the design and construction of foundation systems, basement excavation and design, slabs-on-grade, site grading, pavement, backfilling procedures, and cement type for subsurface concrete.

Authorization to proceed with the scope of work, defined in Wood's proposal PN5321R1, was received from 1x1 Architecture through an email dated 5 September 2019.

1.2 Site and Project Description

It is understood that Parks Canada Agency is planning to develop a staff housing apartment on Lots at 901 to 913 Turret Street in Jasper, Alberta. Currently, the project site contains two four-plexes, a duplex, and a 4-car garage. It is understood that the existing buildings will be demolished prior to the proposed development.

It is further understood that the proposed development is expected to consist of a two- to three-storey apartment building with a basements and associated parking lots. The building design and layout for the proposed development has not been completed at the time of this report.

The site is generally flat lying, with a gentle north facing slope at the north end of the property.

A site plan showing the locations of boreholes advanced during this investigation is presented on Figure 1 in Appendix A.

2.0 Geotechnical Investigation

Prior to the borehole drilling, Wood conducted underground utility clearance at the borehole locations through Alberta One Call and private utility locating services. Due to an inability to locate the precise locations of underground water and sewer lines in the south side of the property, all boreholes were drilled in the north side of the site.

On 19 September 2019, five (5) boreholes (BH19-01 to BH19-05) were drilled on the site and auger refusal was encountered in all the boreholes at depths varying from 2.0 to 4.5 m below existing ground surface.

The as-built borehole locations and elevations were surveyed by McElhanney Ltd. after the drilling.

The boreholes were drilled using a truck-mounted drill rig with continuous flight 150 mm diameter solid-stem augers. Supervision of drilling, soil sampling, and logging of the soil strata was performed by Wood geotechnical personnel. Detailed borehole logs summarizing the sampling, field testing, groundwater and subsurface conditions encountered at the borehole locations are presented in Appendix A.

The soil conditions encountered during drilling were described in accordance with the Modified Unified Soil Classification System as per the Explanation of Terms & Symbols in Appendix A. Soil sampling and evaluation of in-situ soil consistency and relative density consisted of the following:

- Disturbed auger samples were obtained at depth intervals varying from 0.3 m to 1.5 m for moisture content determinations. The moisture content profiles are shown on the borehole logs.

- Standard Penetration Tests (SPTs) were conducted at 1.5 m depth intervals to evaluate the consistency or relative density of the soil strata, and to collect samples for moisture content determination. SPT results, defined as the number of blows required to drive the standard SPT split-spoon sampler 300 mm into the soil, were recorded and are noted on the borehole logs as the SPT 'N' values.

The depth to slough (collapsed soil) and groundwater level in all boreholes were measured upon drilling completion. A slotted 25-mm diameter PVC standpipe was installed in boreholes BH19-02 and BH19-04 for short term groundwater level monitoring. The annulus of the boreholes with standpipes were backfilled with drill cuttings and a 0.5 m thick bentonite cap to ground surface. The remaining boreholes were backfilled with a combination of auger cuttings and a surficial bentonite cap.

The water levels in the standpipes were measured again on 4 October 2019, 15 days after drilling completion.

Following completion of the field drilling program, a laboratory testing program was conducted on selected soil samples and consisted of moisture content determinations, grain size analysis, and water soluble sulphate concentration tests. The results of the laboratory program are noted on the attached borehole logs.

3.0 Subsurface Soil Conditions

3.1 General Stratigraphy

The generalized stratigraphy encountered at the borehole locations consisted of organic topsoil, underlain in descending order by sand, and cobbles and boulders. Detailed descriptions of the soil conditions encountered in the boreholes are provided on the borehole logs in Appendix A.

A general description of soil types encountered at the borehole locations is presented in the succeeding subsections.

3.1.1 Organic Topsoil

A layer of organic topsoil with a thickness of about 200 mm to 300 mm was encountered at the ground surface in all boreholes. The topsoil generally contained trace sand and was black and damp.

It should be noted that the topsoil depth may be thicker or thinner between borehole locations. If accurate topsoil or organics thicknesses are required for stripping volume estimate, it is recommended that additional shallow probe holes or test pits be excavated on a more closely spaced grid pattern across the site.

3.1.2 Sand

Sand was encountered below the topsoil in all boreholes and extended to depths varying between 1.8 m and 4.4 m below existing grade. The sand was generally silty, brown, fine to medium grained, compact to dense, and contained trace to some gravel. Some clay was encountered immediately below the topsoil layer. Possible cobbles were encountered in borehole BH19-03 at a depth of about 1.2 m. Properties measured in the sand were as follows:

- Moisture content varied between 3 and 11 percent with the majority ranging from 4 to 6 percent.
- SPT 'N' values varied typically between 12 and 32 indicating compact to dense relative density.
- Three particle size distribution analyses conducted on samples of the sand yielded particle size distributions of:
  - Gravel: 13% to 29%

- Sand: 50% to 64**%**
- Clay and Silt: 10% to 37%

3.1.3 Cobbles and Boulders

Cobbles and boulders were encountered below the sand in all boreholes and extended to the termination depths varying from 2 m to 4.5 m below existing grade. Auger refusal and SPT refusal were encountered in all boreholes. Dark red sandstone and grey quartzite chips were retrieved from the boreholes.

Although no intact cobble or boulder samples were collected during the investigation, based on test pits excavated on nearby project sites, boulders with diameters ranging from 200 mm to 1000 mm are common in the project site area.

3.2 Groundwater and Sloughing Conditions

Accumulations of collapsed soils (slough) and groundwater levels were measured approximately ten minutes following drilling completion at each of the borehole locations. Moderate sloughing was observed in boreholes BH19-05. No water seepage was encountered in any boreholes. Groundwater levels in the standpipes were measured 15 days following drilling. Measured slough and groundwater levels are summarized in **Table 1**.

Table 1: Measured Slough and Groundwater Levels

Borehole (m)	Depth to Top of Slough at Drilling Completion (m)	Groundwater Level BGS* at Drilling Completion (m)	Groundwater Level BGS on 4 October 2018 (m)	Well Screen Interval BGS (m)
BH19-01	None	None	No Standpipe	-
BH19-02	None	None	Dry	0.9-1.8
BH19-03	None	None	No Standpipe	-
BH19-04	None	None	Dry	1.5-2.4
BH19-05	2.1	None	No Standpipe	-

*BGS: below ground surface

It should be recognized that the groundwater level is dependent on meteorological cycles and surface drainage on a regional scale. Higher groundwater levels than those observed in this investigation may be encountered following spring thaw and periods of prolonged precipitation.

3.3 Water Soluble Sulphates

Three (3) water soluble sulphate concentration tests were performed on soil samples obtained from the site. **Table 2** below summarizes the results of the water soluble sulphate concentration tests.

Table 2: Water Soluble Sulphate Concentrations

Borehole	Depth (m)	Material Type	Water-Soluble Sulphate (%)
BH19-01	0.3	Sand	0.01
BH19-02	0.8	Sand	0.002
BH19-04	1.5	Sand	0.001

4.0 Frost Action

The silty sand encountered at the site is expected to be moderately frost susceptible. The estimated average depth of frost penetration for the near surface soils is 2.5 m for a mean annual Air Freezing Index (AFI) of 1,050 degree-days Celsius and 3.0 m for a 50 year return period AFI of 1,600 degree-days.

The 50-year return period frost penetration depth is generally used for design purposes.

The estimated frost penetration depth is for a uniform soil type with no insulative cover. If the area is covered with turf or significant snow cover, the frost penetration depth will be less.

5.0 Geotechnical Appraisal

The subsurface soil and groundwater conditions observed in the boreholes are considered suitable for the proposed development.

For the proposed two- to three-storey apartment building development, the structural components may be supported on shallow foundations bearing on native sand, or on cobbles and boulders on this site. Pile foundations such as driven steel or straight-shaft drilled cast-in-place concrete piles are not recommended due to the presence of cobbles and boulders on the site. The geotechnical design parameters presented in this report are therefore limited to shallow foundations.

The existing compact to dense sand is suitable to support concrete floor slabs and pavements on this site. Surficial organic soils should be removed and replaced with an engineered fill.

It should be noted that basement construction and installation of underground utilities such as water mains and sanitary sewers may require excavation into the cobbles and boulders layer on this site. There may be some challenges during construction to provide a uniform foundation subgrade to reduce differential settlement of foundations.

6.0 Recommendations

6.1 Site Preparation, Grading and Drainage

6.1.1 Subgrade Preparation

The areas for the proposed building footprint and for paved accessways and parking areas should be stripped of all existing topsoil and existing pavement. The existing floor slabs or basements should also be removed in the development area. Where loose, soft or disturbed areas are identified, the area should be excavated to expose a stable subgrade and then should be backfilled with engineered fill.

Following preparation, the subgrade should be proof-rolled to check for soft spots. The proof-roll should be conducted with an axle load of 80 kN to check for soft, loose or non-uniform areas. Any such areas detected should be over-excavated to a minimum additional depth of 300 mm and replaced with engineered fill material.

6.1.2 Engineered Fill

Engineered fill may be required to bring the sidewalks and pavement subgrade up to design grade. Well-graded gravel would be the preferable material for engineered fill. Alternatively, the native sand on the site is considered suitable for use as fill, provided that selective excavation and stockpiling are carried out to ensure that native soils used for backfilling are not contaminated with topsoil or other unsuitable materials.

Fill under concrete slabs (interior or exterior) and structures should be placed in compacted lift thicknesses not exceeding 150 mm, with each lift compacted to a minimum of 98 percent of the standard Proctor maximum dry density (SPMDD) and at moisture contents within ±2 percent of the Optimum Moisture Content (OMC) at the time of compaction.

General site grading fill should be placed in compacted lift thicknesses not exceeding 150 mm, with each lift compacted to a minimum of 95 percent of the SPMDD and at moisture contents within ±2 percent of the OMC at the time of compaction.

If gravel is to be used for engineered fill, as a minimum it should consist of 80 mm minus pit run meeting Alberta Transportation Designation 6, Class 80. Other gravels may be considered but would need to be approved by a qualified geotechnical engineer. Gradation limits for Alberta Transportation Designation 6, Class 80 for use as engineered fill are provided in **Table 3**.

Table 3: Gradation Limits for Alberta Transportation Designation 6 Class 80

Sieve	Percent Passing
80 mm	100
50 mm	55-100
25 mm	38-100
16 mm	32-85
4.75 mm	20-65
0.315 mm	6-30
0.08 mm	2-10

All fill soils should be free from any organic materials, contamination, deleterious construction debris, and stones greater than 80 mm in diameter. Environmental screening should be conducted on any fill source of unknown origin and history. Fill construction and compaction should be monitored on a full-time basis, including regular field density testing during placement at a frequency of a minimum of 1 test per 300 m^2 per lift.

The engineered fill should extend at least 1 m beyond the footprint of any building footprint or pavement. Fill soils should be compacted uniformly over the area that will provide support for building structural elements or pavement to reduce potential for differential settlement. Fill should not be frozen at the time of placement; nor should the fill be placed on a frozen subgrade or allowed to freeze during construction.

6.1.3 Drainage

The prepared subgrade should be shaped to reduce the potential for ponding of water under the building footprint. Excess water should be drained or pumped from the site as quickly as possible, both during construction and over the long-term use of the site.

Finished grades within 2 m of the building perimeter should be designed to provide surface drainage at approximately a 2 percent grade away from the structure. The upper 0.3 m of backfill around the buildings should consist of compacted clay to act as a seal against the ingress of runoff water. Roof and other drains should discharge at least 2 m clear of the building perimeter.

Permanent site surface drainage should be developed at early stages of construction to improve site trafficability and reduce future frost effects in the subgrade. It is recommended that the finished subgrade be sloped at a minimum gradient of 1 percent toward catch basins or adjacent roadways to drain any surface water away from the roadways and structures.

6.1.4 Winter Construction

Fill placement and compaction during the winter months is not recommended since the required degrees of compaction cannot be attained using frozen fill soils, or fill which appears to be unfrozen but is at subfreezing temperatures. Even gravels, which give an appearance of being not affected by frozen conditions, can contain ice crystals which limit the degree of compaction that could be attained. A high degree of compaction during the winter months can only be achieved in fill soils that are unfrozen and are not allowed to freeze during placement and compaction. This would necessitate that all fill soils are unfrozen.

It should also be noted that unless the fill placement area is hoarded and heated, the addition of water to the fill to promote its compaction would not be possible at freezing temperatures.

6.2 Shallow Foundation

6.2.1 Design

Footings founded in the native sand or cobbles and boulders at a minimum depth of 1.5 m may be designed using recommended serviceability limit state (SLS) bearing pressure values of 300 kPa and 400 kPa for strip and square footings respectively. The recommended serviceability bearing resistance values are based on limiting the settlement to less than 25 mm, and are applicable to strip footings to a maximum dimension of 1.2 m wide or square footings measuring 2 x 2 m. If very strict settlement tolerances are required, or if larger footings are proposed, the footing sizes and settlement potential should be reviewed by Wood.

The corresponding unfactored ultimate limit state (ULS) bearing pressure values are 900 kPa and 1,200 kPa for strip and square footings, respectively. The unfactored ULS bearing pressure should be multiplied by a geotechnical resistance factor of 0.5 to arrive at the factored ULS bearing values, per the recommendations in the current Canadian Foundation Engineering Manual.

6.2.2 Footing Construction

The following geotechnical comments are provided pertaining to construction of shallow footings on this site:

- For adequate frost protection, exterior building footings for heated structures must be at least 1.5 metres below the final grade. Interior footings should be founded at a minimum depth of 1 m below site grade. It is understood that the proposed building will have a basement and be heated.
- Unheated structures, such as unheated garages, or building with minimal heat transfer to the subgrade footings should have at least 3 m of soil cover for adequate frost protection. Alternatively, the foundations may be placed at shallower depths and insulated with rigid Styrofoam (e.g. Styrofoam SM or equivalent).
- Excavation for footings and/or basement will highly likely encounter cobbles and boulders on the site. As a result, the base of the excavation may become irregular. It will be important that if cobbles and boulders are left in place, the surrounding soil should not be disturbed or, if boulders are removed, the void should be cleaned of disturbed soil and either filled with compacted granular material or concrete.
- The bearing surfaces should be protected from rain, snow and the ingress of free water, as the foundation soils may experience loss of bearing strength.
- The foundation soils beneath the footings must not be allowed to freeze during construction or during the service life of the building. Footings founded on frozen soil during construction may settle when the founding soils thaw. Bearing soils that become frozen during construction should

be removed and replaced with concrete fill, or the embedment depths should be extended to unfrozen native soils.

- It is possible that during construction, groundwater seepage or rainfall may be encountered. In either of these cases, drainage of footing excavations will be required to facilitate footing construction. It is anticipated that dewatering can be achieved by gravity drainage into small sumps or perimeter ditches within the excavations, which could be pumped out as required. The crests of the foundation excavations should be graded such as to direct surface water runoff away from the excavations.
- A geotechnical engineer or qualified technician should be on-site to confirm that the exposed bearing surface prior to casting the mud slab is in competent soil as identified in the geotechnical report and is suitably prepared as discussed above.

6.3 Excavations

For this project, it is expected that excavations will be required for a basement and service trenches. The following recommendations are provided, assuming that the excavation depth will not exceed 4 m below existing grade. Based on this assumed excavation depth and the soil conditions encountered at the borehole locations, such excavations will primarily extend into sand, and cobbles and boulders.

For open unsupported short-term excavations within 4 m depth, the side slopes should be cut back at inclinations no steeper than 2H:1V in the sand and no steeper than 1.5H:1V in the cobbles and boulders. Flatter slopes may be required if localized loose sand zones encountered. Short term excavations are those which will remain open for a period of 2 months or less.

The presence of cobbles and boulders will have considerable influence on the stability of excavation slopes. Small earth falls of cobbles and boulders are a source of danger to workers and must be guarded against.

As a minimum, excavations should comply with Regulations set forth by the Alberta Occupational Health and Safety Act. The stability of all excavations should be monitored by the excavation contractor on an on-going basis. Where tension cracks, or ravelling soils are detected, these conditions should be brought to the immediate attention of Wood so that engineered solutions to the problem areas can be appropriately determined.

Stockpiles of materials and excavated soil should be placed away from the slope crest by a minimum distance equal to the depth of excavation. Similarly, wheel loads should be kept back at least 1 m from the crest of the excavation. Surface drainage should be directed away from crest of the excavation.

The stability of excavation slopes may decrease with time and therefore construction should be directed at minimizing the length of time the excavation is left open.

Excavation should be completed by qualified contractors, utilizing equipment suitable for excavating cobbles and boulders.

6.4 Floor Slabs

6.4.1 Subgrade Preparation

Slab-on-grade basement floors may be supported on the compact to dense sand or the cobbles and boulders encountered on site. Preparation of the exposed subgrade should be undertaken as described is Subsection 6.1.1.

A minimum thickness of 200 mm of clean, well-graded crushed gravel is recommended beneath the grade supported basement slab. Coarse material greater than 50 mm in diameter should be avoided directly beneath the floor slab to prevent stress concentrations in the slab. The gravel base course should be compacted to a uniform dry density of 100 percent of SPMDD within ±2% of the OMC. A recommended typical gradation (Alberta Transportation Designation 4, Class 20) for stable granular material, for use as base course under floor slabs is provided in **Table 4**.

Where provisions for handling radon extraction are required, the gravel layer should be enveloped by a non-woven geotextile layer above and below, and a poly barrier (or equivalent) directly below the concrete slab.

Table 4: Gradation Requirement for Granular Backfill
Alberta Transportation Designation 4 Class 20

Sieve	Percent Passing
20 mm	100
10 mm	35-77
5 mm	15-55
1.25 mm	0-30
0.08 mm	0-10

The percent fracture by weight (2 faces) should be at least 40 percent. Other appropriate materials, which fall outside the above recommended gradation limits, may be suitable and should be evaluated by a geotechnical engineer prior to use.

Alternatively, consideration can be given to using a 200 mm thick layer of 19 mm washed gravel beneath the slabs.

Grade supported basement slabs should be allowed to “float” on a prepared subgrade, and be independent of structural components supported by building foundations. Equipment and piping support placed on floor slabs should be designed to allow re-levelling if the equipment is sensitive to settlement. Provisions to provide flexibility in piping and electrical conduit connections are recommended

6.4.2 Exterior Grade Supported Sidewalks and Concrete Aprons

Subgrade preparation for sidewalk and concrete aprons should be carried out as recommended in Subsection 6.1.1. The silty fine sand subgrade is considered to be moderately frost susceptible given access to water, and may develop ice lenses and undergo volume change (heave). Therefore, it will be important to provide adequate site drainage as per Subsection 6.1.3.6.1.1 Exterior sidewalks and apron slabs should be free-floating and should not be dowelled into grade beams, or interior slabs.

Consideration can be given to installing rigid insulation below the sidewalks or aprons (driveways) if frost heave is a concern. Additional measures to reduce the risk of frost heave include sloping the aprons or sidewalks away from the building and sealing the interface between the basement walls and the exterior concrete flatwork to limit seepage of surface runoff into the subgrade soils. Where pavement areas are adjacent to walls or grade beams, a separation strip should be installed at the interface.

6.5 Lateral Earth Pressures

6.5.1 Soil Parameters

The determination of lateral earth pressures will be required for the design of the basement walls. **Table 5** below provides the recommended coefficients for the active, and “at rest” earth pressure cases, and total unit weights for various soil backfill types.

Table 5: Earth Pressure Coefficients, Soil Unit Weights and Wall Friction Angles

Soil Type		Active Pressure Coefficient Ka	"At Rest" Pressure Coefficient Ko	Total Unit Weight γ (kN/m3)	Friction Angle Between Soil and Concrete (°)
Gravel or Sand Fill	Well Compacted	0.30	0.47	22	17
	Moderately Compacted	0.35	0.52	21	15

The above earth pressure coefficients are for non-sloping (i.e. level) backfill configuration above the top of the basement wall. To determine the factored resistance, a resistance factor (Φ) of 0.5 should be applied to the horizontal passive resistance.

Based on the investigation results and the permeable nature of the soils on site, groundwater on this site may not be a significant factor for the basement wall design.

The "at rest" (K_o) earth pressure should be used in the case of unyielding walls. To attain active earth pressure (K_a) conditions, the displacement at the top of the wall should be in the order of 0.002 of the wall height for granular backfill.

6.5.2 Load Factors

For the Limit States Design procedure for walls, the following Load Factors should be applied to the loads calculated from the pressure distributions given above:

- For earth loads acting on walls, a Load Factor of 1.25 is recommended for dead and sustained loads.
- For hydrostatic loads acting on walls, a Load Factor of 1.1 is recommended.
- For live surcharge loads acting on walls, the Load Factor of 1.5 should be used.

6.6 Pavements

The pavement structures and construction procedure recommendations provided in this section area applicable for access roadways, parking areas frequently used by cars and light trucks (e.g. single axle delivery trucks, waste disposal trucks, etc.). In areas where truck traffic is expected, such as drive lanes, the heavier traffic pavement specifications should be used.

Prior to placing base gravel, the subgrade should be prepared as outlined in Subsection 6.1.1. If soft or loose subgrades are encountered some subgrade improvement for paving areas would typically include thicker gravel fill and/or geotextiles or geogrids, the extent of which would be best determined during construction. **Table 6** outlines the recommended light vehicle and heavy vehicle pavement section for access roadways, parking lots and aprons.

Table 6: Preliminary Pavement Sections

Pavement Component	Minimum Thicknesses (mm)	
	Light Traffic/ Parking Area (assumed 1.44 x 10^4 ESALs[1])	Heavy Truck Traffic/Drive Lanes (assumed 3.6 x 10^4 ESALs)
Hot Mix Asphalt	75	100

Base Course Crushed Granular[2] (20 mm minus)	250	300

1. Equivalent Single Axle Loads over 20-year design period
2. Alberta Transportation Designation 2, Class 20 (see Table 4)

Outlined below are additional construction recommendations pertaining to pavement sections:

- The granular base course should be placed in maximum 150 mm thick lifts (or reduced lift thicknesses as governed by the compaction equipment) and uniformly compacted to a minimum 100 percent of SPMDD at ± 2 percent of OMC to the bottom of the asphalt design elevation.
- All asphalt should conform to, and be placed in accordance with, the current applicable Alberta Transportation asphalt specifications.

Concrete pavement sections should be provided for any areas where the front wheels of garbage trucks will bear during unloading of dumpsters, and for any areas where trailer "dollies" will bear on the pavement. Asphalt pavement used in such areas is at high risk of rutting, and normally develops ruts and cracks within a short time.

6.7 Concrete Type

As indicated in Subsection 3.3 the degree of exposure to sulphate attack on subsurface concrete was rated as 'negligible", as defined by CAN/CSA A23.1-09. Based on the testing results, General Use (GU) cement may be used in the manufacture of concrete in contact with soil at this site.

All concrete design and construction should be carried out in accordance with current CAN/CSA A23.1 specifications. Air entrainment is recommended for all concrete exposed to freeze-thaw cycles or groundwater to enhance durability.

If imported material is required to be used at the site and will be contact with concrete, it is recommended that the fill soil be tested for sulphate concentration to determine whether the above-stated recommendations remain valid.

6.8 Seismic Site Classification

The seismic response of the site is classified according to the National Building Code of Canada 2010 (NBCC), which categorizes the soil conditions into 6 types - Class 'A' to 'F'. The site is categorized as Class 'C' according to the NBCC 2010. Shear wave velocity data was not obtained from this site, and borings were not advanced to 30 m depth. The seismic classification is based on the SPT 'N' values within the depths drilled at the site, as well as on the assumption that the soil and bedrock strength below the depths drilled is at least as high as that encountered at the borehole termination depths.

7.0 Geotechnical Testing and Inspection

All engineering design recommendations presented in this report are based on the limited number of boreholes advanced on the site, and on the assumption that an adequate level of inspection will be provided during construction and that all construction will be carried out by a suitably qualified contractor experienced in foundation and earthworks construction. An adequate level of inspection is considered to be:

- for earthworks including backfill, full time monitoring and compaction testing; and
- for shallow foundations, review of the foundation design and inspection of all bearings surfaces prior to concrete placement.

Wood requests the opportunity to review the design drawings and monitor the installation of the new foundation to confirm that the recommendations have been correctly interpreted. Wood would be pleased to provide any further information that may be needed during design and to advise on the geotechnical aspects of specifications for inclusion in contract documents.

8.0 Closure

Recommendations presented herein are based on a geotechnical evaluation of the findings in the five boreholes drilled during the field investigation on the site. If conditions other than those reported are noted during subsequent phases of the work, Wood should be notified and given the opportunity to review the current recommendations considering any new findings. Recommendations presented herein may not be valid if an adequate level of inspection is not provided during construction, or if relevant building code requirements are not met.

Soil conditions, by their nature, can be highly variable across a construction site. The placement of fill and prior construction activities on a site can contribute to variable near surface soil conditions. A contingency amount should be included in the construction budget to allow for the possibility of variations in soil conditions, which may result in modifications of the design, and/or changes in construction procedures.

This report has been prepared for the exclusive use of 1X1 Architecture Inc. for specific application to the development described within this report. Any use that a third party makes of this report, or any reliance or decisions based on this report are the sole responsibility of those parties. It has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warrantee is given.

Respectfully submitted,

Wood Environment & Infrastructure Solutions,
a division of Wood Canada Limited

PROFESSIONAL ENGINEER NILS REUTER ALBERTA

Oct 10 2019

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Geotechnical Engineer

PROFESSIONAL ENGINEER YONGGENG YE ALBERTA

Oct 10 2019

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Reviewed by:

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Senior Associate, Geotechnical Engineer

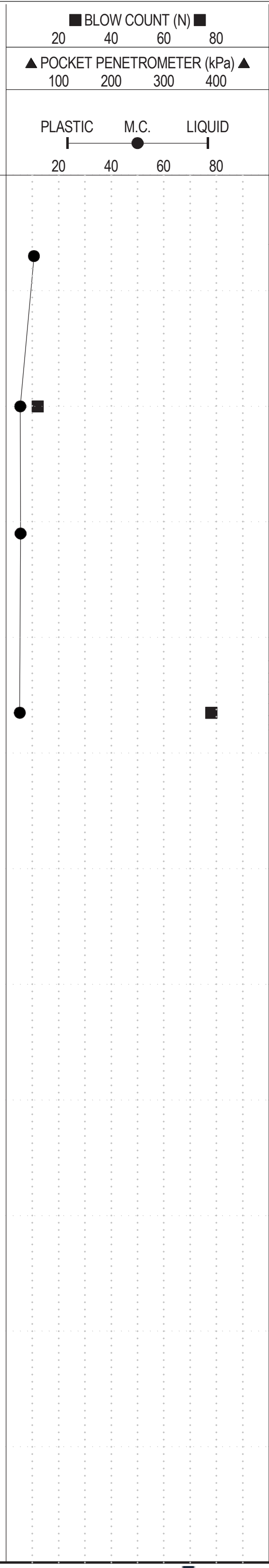
APEGA Permit to Practice Number: P-04546

Appendix A

CLIENT: 1x1 Architecture	DRILLED BY: Mobile Augers	BORE HOLE NO: **BH19-01**
PROJECT: Jasper Staff Apartments	DRILLING METHOD: Solid Stem Auger	PROJECT NO: EA16414
SITE: 901-913 Turret Street	N: 5858689 E: 426548 ZONE: 11U	ELEVATION: 1067.53 m

SAMPLE TYPE: Shelby Tube; No Recovery; SPT (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Cold Patch Asphalt; Bentonite; Drill Cuttings; Gravel; Slough; Sand



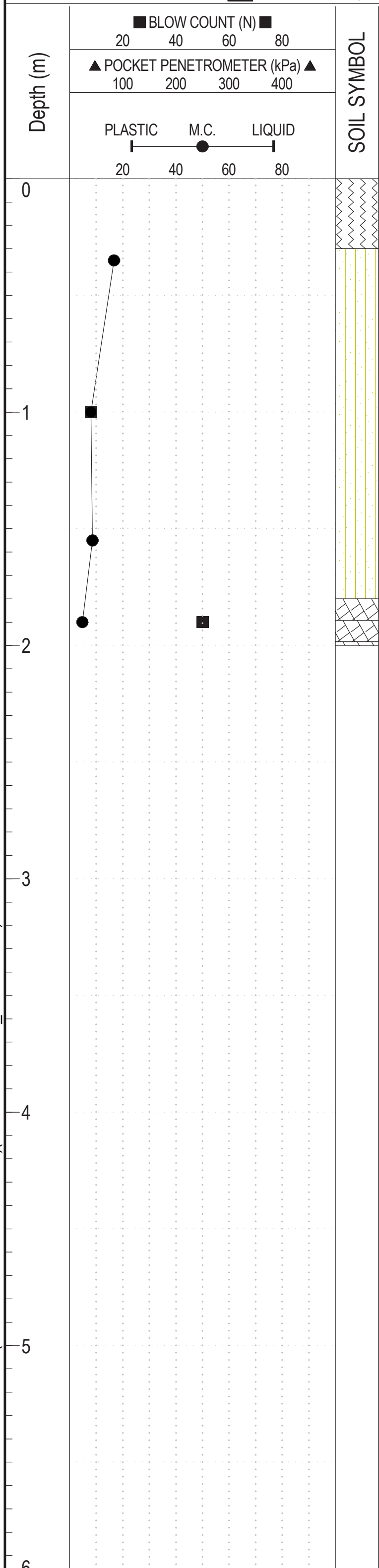
Depth (m)	MUSCS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT (N)	COMMENTS	ELEVATION (m)
0	OR	**TOPSOIL** organic, trace sand, black, damp					
	SM	**SAND** silty, some clay, trace gravel, fine grained, compact, brown, damp	Grab	G1		SO_4 = 0.01%	1067
		... trace silt, trace clay, below 0.8 m					
1			SPT	D1	12		
			Grab	G2		Sieve @ 1.5 m: Gravel = 20% Sand = 67% Fines = 13%	1066
2		... suspected cobbles at 1.9 m					
	BR	**BOULDERS AND COBBLES** grey, hard	SPT	D2	78/225		
		... Auger refusal at 2.4 m					1065
		BOREHOLE TERMINATED AT 2.4 m DEPTH No water and slough observed during drilling. Borehole remained open and dry at drilling completion. Borehole backfilled with drill cuttings and sealed with bentonite at the surface.					
3							
							1064
4							
							1063
5							
							1062
6							

Wood E&I Solutions Plc.	LOGGED BY: NR	COMPLETION DEPTH: 2.4 m
5681 70 Street	ENTERED BY: NR	COMPLETION DATE: September 19, 2019
Edmonton, AB T6B3P6	REVIEWED BY. YY	

CLIENT: 1x1 Architecture	DRILLED BY: Mobile Augers	BORE HOLE NO: **BH19-02**
PROJECT: Jasper Staff Apartments	DRILLING METHOD: Solid Stem Auger	PROJECT NO: EA16414
SITE: 901-913 Turret Street	N: 5858697 E: 426539 ZONE: 11U	ELEVATION: 1067.53 m

SAMPLE TYPE: Shelby Tube, No Recovery, SPT (N), Grab Sample, Split-Pen, Core

BACKFILL TYPE: Cold Patch Asphalt, Bentonite, Drill Cuttings, Gravel, Slough, Sand



MUSCS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT (N)	SLOTTED PIEZOMETER	COMMENTS	ELEVATION (m)
OR	**TOPSOIL** organic, trace sand, black, damp						
	SAND some gravel, trace clay, trace silt, fine grained, loose, brown, damp	Grab Sample	G1				1067
SM		SPT (N)	D1	8		SO_4 = 0.002%	
	... suspected cobbles @ 1.6 m	Grab Sample	G2				1066
BR	**BOULDERS AND COBBLES** grey, hard ... Auger Refusal at 2.0 m	SPT (N)	D2	50/125			

BOREHOLE TERMINATED AT 2.4 m DEPTH
No water and slough observed during drilling.
Borehole remained open and dry at drilling completion.
Installed monitoring well to 1.8 m depth, slotted 0.9 m. Well backfilled with drill cuttings and sealed with bentonite at the surface.
Water monitoring well dry on October 4, 2019.

ELEVATION (m): 1065, 1064, 1063, 1062

Wood E&I Solutions Plc. **5681 70 Street** **Edmonton, AB T6B3P6**	LOGGED BY: NR	COMPLETION DEPTH: 2 m
	ENTERED BY: NR	COMPLETION DATE: September 19, 2019
	REVIEWED BY. YY	Page 1 of 1

CLIENT: 1x1 Architecture	DRILLED BY: Mobile Augers	BORE HOLE NO: **BH19-03**
PROJECT: Jasper Staff Apartments	DRILLING METHOD: Solid Stem Auger	PROJECT NO: EA16414
SITE: 901-913 Turret Street	N: 5858698 E: 426494 ZONE: 11U	ELEVATION: 1067.49 m

SAMPLE TYPE: Shelby Tube, No Recovery, SPT (N), Grab Sample, Split-Pen, Core

BACKFILL TYPE: Cold Patch Asphalt, Bentonite, Drill Cuttings, Gravel, Slough, Sand

Plot legend: ■ BLOW COUNT (N) ■ 20 40 60 80; ▲ POCKET PENETROMETER (kPa) ▲ 100 200 300 400; PLASTIC M.C. LIQUID 20 40 60 80

Depth (m)	MUSCS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT (N)	BACKFILL DETAILS	COMMENTS	ELEVATION (m)
0	OR	**TOPSOIL** organic, trace sand, black, damp ... trace gravel at 0.15 m				Bentonite		
	SM	**SAND** silty, trace gravel, medium grained, compact, brown, moist	Grab Sample	G1		Drill Cuttings		1067
1		... some gravel, trace silt below 0.9 m ... suspected cobbles at 1.1 m ... dense at 1.3 m	SPT (N)	D1	13		auger drilling difficult at 1.1 m	
			SPT (N)	D2	32		Sieve @ 1.5 m: Gravel = 25% Sand = 65% Fines = 10%	1066
2		... compact at 2.0 m	SPT (N)	D3	26			1065
3	BR	**BOULDERS AND COBBLES** grey, hard ... Auger refusal at 3.2 m	SPT (N)	D4	84/250			
		BOREHOLE TERMINATED AT 3.2 m DEPTH No water and slough observed during drilling. Borehole remained open and dry at drilling completion. Borehole backfilled with drill cuttings and sealed with bentonite at the surface.						1064
4								1063
5								1062
6								

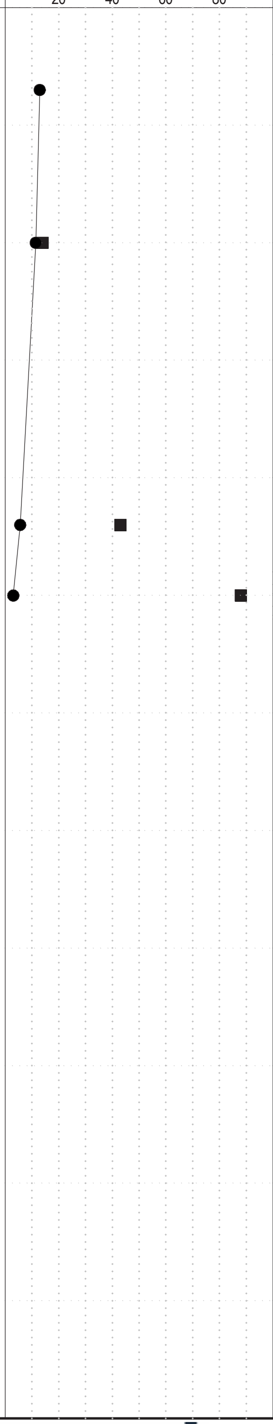
Wood E&I Solutions Plc. **5681 70 Street** **Edmonton, AB T6B3P6**	LOGGED BY: NR ENTERED BY: NR REVIEWED BY. YY	COMPLETION DEPTH: 3.2 m COMPLETION DATE: September 19, 2019

CLIENT: 1x1 Architecture	DRILLED BY: Mobile Augers	BORE HOLE NO: **BH19-04**
PROJECT: Jasper Staff Apartments	DRILLING METHOD: Solid Stem Auger	PROJECT NO: EA16414
SITE: 901-913 Turret Street	N: 5858697 E: 426472 ZONE: 11U	ELEVATION: 1067.97 m

SAMPLE TYPE: Shelby Tube, No Recovery, SPT (N), Grab Sample, Split-Pen, Core

BACKFILL TYPE: Cold Patch Asphalt, Bentonite, Drill Cuttings, Gravel, Slough, Sand

Chart headings: Depth (m) | ■ BLOW COUNT (N) ■ 20 40 60 80 | ▲ POCKET PENETROMETER (kPa) ▲ 100 200 300 400 | PLASTIC M.C. LIQUID 20 40 60 80 | SOIL SYMBOL | MUSCS | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | SPT (N) | SLOTTED PIEZOMETER | COMMENTS | ELEVATION (m)



Depth (m)	MUSCS	SOIL DESCRIPTION	SAMPLE NO	SPT (N)	COMMENTS	ELEVATION (m)
0	OR	**TOPSOIL** organic, trace sand, black, damp				
		SAND some gravel, trace clay, trace silt, fine grained, compact, brown, moist	G1			
1	SM		D1	14		1067
					SO_4 = 0.001%	
2		... gravelly, dense, damp below 2.0 m	D2	43		1066
	BR	**BOULDERS AND COBBLES** grey, hard ... Auger refusal at 2.6 m	D3	88/250		
3						1065
4						1064
5						1063
6						

BOREHOLE TERMINATED AT 2.6 m DEPTH
No water and slough observed during drilling.
Borehole remained open and dry at drilling completion.
Installed monitoring well to 2.4 m depth, slotted 0.9 m. Well backfilled with drill cuttings and sealed with bentonite at the surface.
Water monitoring well dry on October 4, 2019.

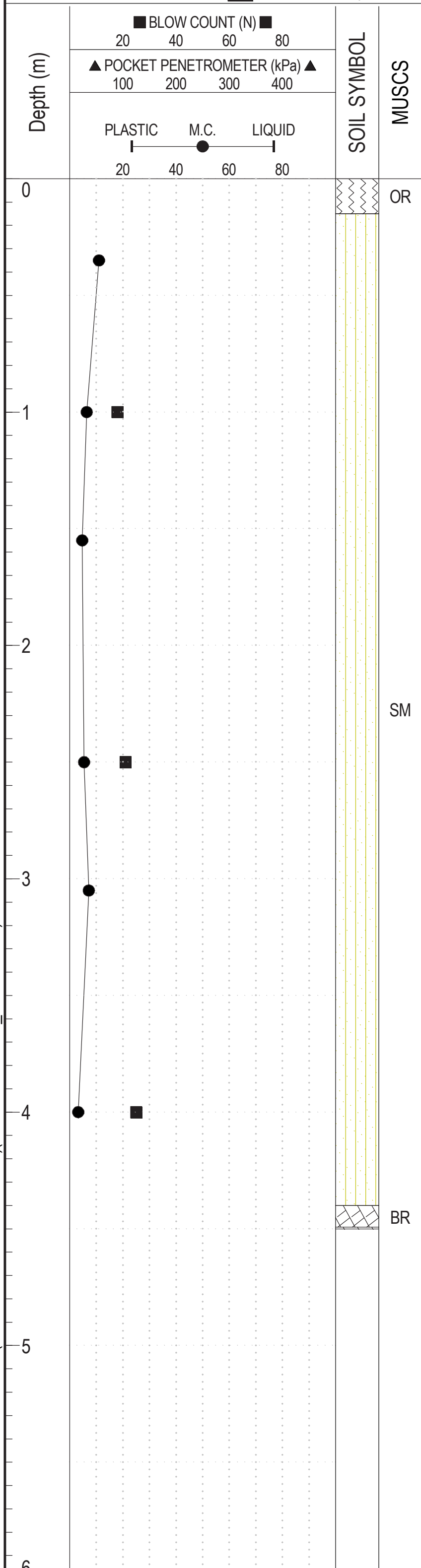
EA16414 BH LOGS.GPJ 19/10/07 03:58 PM (2018-WOOD LIBRARY.GLB)(GEOTECHNICAL_2018 WOOD)

wood.	**Wood E&I Solutions Plc.**	LOGGED BY: NR	COMPLETION DEPTH: 2.6 m
	5681 70 Street	ENTERED BY: NR	COMPLETION DATE: September 19, 2019
	Edmonton, AB T6B3P6	REVIEWED BY. YY	

CLIENT: 1x1 Architecture	DRILLED BY: Mobile Augers	BORE HOLE NO: **BH19-05**
PROJECT: Jasper Staff Apartments	DRILLING METHOD: Solid Stem Auger	PROJECT NO: EA16414
SITE: 901-913 Turret Street	N: 5858687 E: 426452 ZONE: 11U	ELEVATION: 1068.08 m

SAMPLE TYPE: Shelby Tube, No Recovery, SPT (N), Grab Sample, Split-Pen, Core

BACKFILL TYPE: Cold Patch Asphalt, Bentonite, Drill Cuttings, Gravel, Slough, Sand



Depth (m)	MUSCS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT (N)	BACKFILL DETAILS	COMMENTS	ELEVATION (m)
0	OR	**TOPSOIL** organic, trace sand, black, damp				Bentonite		1068
	SM	**SAND** silty, trace clay, trace gravel, fine grained, compact, brown, damp	Grab Sample	G1		Drill Cuttings	Sieve @ 0.3 m: Gravel = 3% Sand = 60% Fines = 37%	
		... trace silt below 0.7m						
1			SPT	D1	18			1067
			Grab Sample	G2				
2								1066
			SPT	D2	21			
3			Grab Sample	G2				1065
4			SPT	D2	25			1064
	BR	**BOULDERS AND COBBLES** grey, hard ... Auger refusal at 4.5 m						
		BOREHOLE TERMINATED AT 4.5 m DEPTH Moderate sloughing observed during drilling. Borehole remained open to 2.1 m and was dry at drilling completion. Borehole backfilled with drill cuttings and sealed with bentonite at the surface.						
5								1063
6								

wood.

Wood E&I Solutions Plc.
5681 70 Street
Edmonton, AB T6B3P6

LOGGED BY: NR	COMPLETION DEPTH: 4.5 m
ENTERED BY: NR	COMPLETION DATE: September 19, 2019
REVIEWED BY. YY	

EXPLANATION OF TERMS AND SYMBOLS

The terms and symbols used on the borehole logs to summarize the results of field investigation and subsequent laboratory testing are described in these pages.

It should be noted that materials, boundaries and conditions have been established only at the borehole locations at the time of investigation and are not necessarily representative of subsurface conditions elsewhere across the site.

TEST DATA

Data obtained during the field investigation and from laboratory testing are shown at the appropriate depth interval.

Abbreviations, graphic symbols, and relevant test method designations are as follows:

*C	Consolidation test	*ST	Swelling test
D_R	Relative density	TV	Torvane shear strength
*k	Permeability coefficient	VS	Vane shear strength
*MA	Mechanical grain size analysis and hydrometer test	w	Natural Moisture Content (ASTM D2216)
		w_l	Liquid limit (ASTM D 423)
N	Standard Penetration Test (CSA A119.1-60)	w_p	Plastic Limit (ASTM D 424)
N_d	Dynamic cone penetration test	E_f	Unit strain at failure
NP	Non plastic soil	γ	Unit weight of soil or rock
pp	Pocket penetrometer strength (kg/cm²)	γ_d	Dry unit weight of soil or rock
*q	Triaxial compression test	ρ	Density of soil or rock
q_u	Unconfined compressive strength	ρ_d	Dry Density of soil or rock
*SB	Shearbox test	C_u	Undrained shear strength
SO_4	Concentration of water-soluble sulphate	→	Seepage
		▼	Observed water level

* The results of these tests are usually reported separately

Soils are classified and described according to their engineering properties and behaviour.

The soil of each stratum is described using the Unified Soil Classification System[1] modified slightly so that an inorganic clay of "medium plasticity" is recognized.

The modifying adjectives used to define the actual or estimated percentage range by weight of minor components are consistent with the Canadian Foundation Engineering Manual[2].

Relative Density and Consistency:

Cohesionless Soils		Cohesive Soils		
Relative Density	SPT (N) Value	Consistency	Undrained Shear Strength c_u (kPa)	Approximate SPT (N) Value
Very Loose	0-4	Very Soft	0-12	0-2
Loose	4-10	Soft	12-25	2-4
Compact	10-30	Firm	25-50	4-8
Dense	30-50	Stiff	50-100	8-15
Very Dense	>50	Very Stiff	100-200	15-30
		Hard	>200	>30

Standard Penetration Resistance ("N" value)
The number of blows by a 63.6kg hammer dropped 760 mm to drive a 50 mm diameter open sampler attached to "A" drill rods for a distance of 300 mm.

1 "Unified Soil Classification System", Technical Memorandum 36-357 prepared by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S. Army. Vol. 1 March 1953.
2 "Canadian Foundation Engineering Manual", 4th Edition, Canadian Geotechnical Society, 2006.

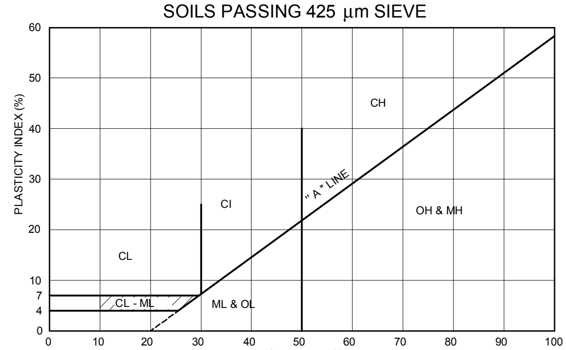
MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	COLOUR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		RED	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 4$; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			GP		RED	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12 %	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (LITTLE OR NO FINES)	SW		RED	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6$; $C_C = \frac{(D_{60})^2}{D_{10} \times D_{60}} = 1$ to 3	
			SP		RED	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12 %	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			SC		YELLOW	CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)	
		$W_L < 50\%$	MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDS OR SILTY SOILS		
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS		
		$30\% < W_L < 50\%$	CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$W_L > 50\%$	CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$W_L < 50\%$	OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINES CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$W_L > 50\%$	OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBEROUS TEXTURE	

SPECIAL SYMBOLS

LIMESTONE		OILSAND	
SANDSTONE		SHALE	
SILTSTONE		FILL (UNDIFFERENTIATED)	

PLASTICITY CHART FOR SOILS PASSING 425 µm SIEVE



SOIL COMPONENTS

FRACTION	U.S. STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
GRAVEL	PASSING	RETAINED	PERCENT	DESCRIPTOR
COARSE	76mm	19mm	35-50	AND
FINE	19mm	4.75mm		
SAND			20-35	Y/EY
COARSE	4.75mm	2.00mm		
MEDIUM	2.00mm	425µm	10-20	SOME
FINE	425µm	75µm		
FINES (SILT OR CLAY BASED ON PLASTICITY)	75µm		1-10	TRACE

NOTES:

1. ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U.S. STANDARD A.S.T.M. E.11
2. COARSE GRAIN SOILS WITH 5 TO 12% FINES GIVEN COMBINED GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5 AND 12% FINES.

OVERSIZED MATERIAL

ROUNDED OR SUBROUNDED:	NOT ROUNDED:
COBBLES 76mm TO 200mm	ROCK FRAGMENTS > 76mm
BOULDERS > 200mm	ROCKS > 0.76 CUBIC METRE IN VOLUME

wood.