THURBER ENGINEERING LTD.

PRELIMINARY GEOTECHNICAL INVESTIGATION
RICHMOND GREEN PARK, CALGARY, ALBERTA

Report
to
The City of Calgary

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February 10, 2021

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1. INTRODUCTION

1.1 General

This report presents the results of a preliminary geotechnical investigation program carried out by Thurber Engineering Ltd. (Thurber) on behalf of The City of Calgary (The City) within an existing baseball field located at the southeast quadrant of 33 Avenue and 29 Street S.W. in Calgary, Alberta.

The geotechnical investigation program was completed under The Scope and Fee Schedule No. 18-2006-A05-S19 (Rev. 5) dated December 3, 2020. A description of the project and the required geotechnical scope of work were discussed during a conference call meeting with The City on October 19, 2020.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions, the Special Conditions and Consulting General Conditions under the Master Agreement between Thurber and the City of Calgary, and the conditions described in Section 5.

1.2 Background and Potential Development

It is understood that The City intends to subdivide and sell a portion of the Richmond Green Park for redevelopment by a third party(s) for potential mid to high-rise, mixed-use building(s). Although details of the proposed development are not known, it is expected that the proposed building development may include basements and/or underground parkades depending on the suitability of the subsurface conditions.

A preliminary geotechnical investigation program was required to delineate the subsurface conditions and provide a feasibility assessment for the potential development. Preliminary geotechnical design parameters and construction considerations for shallow and deep foundation options are also required for planning purposes.

The site location is presented in Figure 1 in Appendix A.

1.3 Scope of Work

The scope of work for this assignment was described in The Scope and Fee Schedule Rev. 5 accepted by The City on December 3, 2020. Specifically, the geotechnical investigation scope included the following tasks:

- Review of existing geotechnical and geological information for the project site;
- Site reconnaissance to identify existing conditions and access conditions/constraints for the drilling program;
- Perform underground utility locate clearances and private utility locate clearances;
- Conduct a test hole drilling program to assess the subsurface conditions at the project site;
- Complete laboratory testing on soil samples recovered during the drilling program; and
- Provide preliminary geotechnical foundation design and construction recommendations for the potential development.

A combined Environmental Site Assessment (ESA) Phases I and II program was also included in our scope of work which will be presented in a separate report.

2. METHODOLOGY

2.1 Desktop Review

Several geotechnical investigation programs were completed by Thurber and others in the vicinity of the project site, including the following:

- Currie Reservoirs Rehabilitation (2006)
- Foundation Recommendations for Fuel Storage Facility at Maintenance Depot 4 (1987)
- Bridge and Pedestrian Overpass at Crowchild Trail and 33 Avenue S.W. (1980)
- 33 Avenue S.W. Upgrading from Crowchild Trail to Richmond Road (1978)
- District Depot 4A (1978)

The above referenced geotechnical investigation programs were mostly completed between the project site and Crowchild Trail, within or adjacent to the existing Richmond Green Golf Course. The subsurface conditions encountered in these programs were fairly consistent with clay fill over clay/clay till over gravel, sand and/or silt layers. Some of the test holes extended to the top of bedrock at depths ranging from about 6 m to 12 m. It is important to note that the topography of the Richmond Green area slopes down from 29 Street S.W. towards Crowchild Trail with a total relief of about 7 m. This may explain the variable depths to top of bedrock encountered in the test holes.

Although no indications of significant cut or fill placement were identified within the project area, there may have been some re-grading work completed adjacent to Sarcee Road, along the west side of the site. There is also evidence of grading for the construction of the adjacent ball diamonds and golf course to the east of the site area. It is noted based on historical air photos and the existing topography that the adjacent ball diamonds site was likely in cut.

The clay fill was generally described as containing organics and soft to firm consistency. The clay and clay till were generally described as low to medium plastic, stiff to very stiff consistency, although some soft layers were also encountered. Bedrock was generally described as weathered, weak sandstone.

The groundwater levels measured in the installed standpipe piezometers were highly variable ranging from about 2 m below grade to dry at a depth of about 15 m below grade. Considering that these past geotechnical programs were completed more than ten years before this study, ground disturbance completed more recently may have impacted current groundwater levels. Therefore, the recorded groundwater levels from previous programs are expected to be outdated and should not be relied upon for design or planning purposes.

2.2 Field Drilling Program

Prior to the drilling program, five test hole locations were selected and located on-site by Thurber. Existing underground utilities were marked by members of Alberta One-Call as well as a sub-contracted private locator prior to drilling.

The field drilling program was carried out from December 8 to 11, 2020 and was supervised by Mr. Alex Eddie, M.Sc., M.Eng., P.Eng. of Thurber. The program was completed in conjunction with the ESA Phase II program supervised by Ms. Lindsey Blaine, P.Eng.

All test holes were advanced using a combination of auger drilling and ODEX method due to the presence of gravel under the clay till and above the bedrock. All test holes were advanced into bedrock with termination depths ranging from 13.7 m to 20.7 m below the existing grade using a track-mounted drill rig, contracted from, and operated by Earth Drilling Co. Ltd. of Calgary, Alberta. Coordinates of the test holes were taken using a Trimble GPS unit with a vertical and horizontal accuracy of approximately 10 cm. The as-built test hole locations are shown on Figure 1 in Appendix A.

The soil stratigraphy encountered in each test hole was visually logged, noting material type, soil layer thickness, any zones of seepage, and sloughing ground conditions. Standard Penetration Tests (SPTs) were performed at select depths with blow counts recorded on the test hole logs. Disturbed soil samples were obtained from the split spoons and augers for further testing at the laboratory. Highly disturbed gravel samples from the ODEX method were also collected. Pocket penetrometer readings (c_{pen}) were taken on cohesive samples to estimate the soil's consistency.

Each test hole location was installed with two PVC standpipes in separate holes (one installed within overburden soils and the other one installed into bedrock) to satisfy the ESA Phase II water sampling requirement. The two holes were spaced approximately 2 m apart. Groundwater levels were taken the following week after completion of drilling. Another set of readings was taken about one month after completion of installation. The PVC standpipes were backfilled with sand, drill cuttings, bentonite chips and bentonite pellets with flushed-mounted protectors installed at grade.

Test hole logs are attached in Appendix B, which present the soil and groundwater conditions encountered at each location along with the laboratory test results. An explanation of the symbols and terms used on the test hole logs and of the Unified Soils Classification System has also been included.

2.3 Laboratory Test Program

Laboratory testing including visual classification, determination of the natural moisture content, water-soluble sulphate content, Atterberg limits and organic content were carried out on select soil samples recovered during the field drilling program. Laboratory test reports are attached in Appendix C. A summary table presenting the moisture contents measured in the soil samples is attached in Appendix D.

3. SITE DESCRIPTION

3.1 Surface Conditions

The project site was bounded by 33 Avenue S.W. to the north, 29 Street S.W. to the west and 34 Avenue S.W. to the south. Another baseball field was located immediately adjacent to the east with the Richmond Green Golf Course located between the project site and Crowchild Trail.

The existing topography was generally flat across the site, but the site grade was elevated compared to the adjacent ball field on the east side. The test holes were located within an existing baseball field covered with grass and bounded partially by trees and pathway. At the time of the field drilling program, the site was covered with about 25 mm to 50 mm of snow.

3.2 Subsurface Conditions

The subsurface conditions encountered in the test holes generally comprised of a thin layer of topsoil, overlying sand/silt, over clay and clay till underlain by bedrock.

A general description of the soil units encountered in the test holes are provided below. All depths reference the existing ground surface. A detailed description of subsurface stratigraphy at each test hole location is presented on the logs in Appendix B.

3.2.1 Topsoil

The site comprised a surficial topsoil layer with thicknesses summarized in Table 1.

Table 1. Topsoil Thickness Summary

Test Hole	Topsoil Thickness (mm)
TH20-1	150
TH20-2	100
TH20-3	100
TH20-4	100
TH20-5	100

It is important to note that a detailed survey of the topsoil thickness was not within the scope of the geotechnical program. The above topsoil thicknesses were representative of the conditions encountered at the test hole locations only. Thicker or thinner topsoil may be present in other areas of the site and will need to be further investigated during design and/or construction. Laboratory test results for organic contents are included in Appendix C that show a low level of organics in three samples collected at depths ranging from 0.8 m to 2.3 m.

3.2.2 Sand and Silt

Beneath the surficial topsoil was a sand and silt layer extending to between 0.6 m and 2.7 m below ground surface. This was identified as potentially being fill material. Note that it was difficult to identify the potential presence of fill, since any fill materials would have been left in place for many years and their appearance could be similar to native materials.

This layer was generally described as containing varying amounts of sand and silt, trace to no gravel, non-plastic and dry to damp in moisture condition. Two SPTs were completed with N values of 18 and 19 indicating a compact density state.

3.2.3 Clay and Clay Till

Clay and clay till were encountered below the sand and silt layer extending to depths ranging from 6.7 m to 9.8 m below ground surface. They were generally described as containing trace to some gravel and becoming gravelly at greater depths, trace sand to sandy, low to medium plasticity, stiff to very stiff, brown to grey colour, damp to moist in moisture condition. SPT N values ranged from 11 to 42, generally getting stiffer with depth. Based on three Atterberg Limit tests, the clay and clay till had a liquid limit between 30 and 31, and a plastic limit between 15 and 16.

Fine grained sand and/or silt layers less than one metre thick were also identified within the clay at both TH20-2 and TH20-4.

3.2.4 Gravel and Sand

Below the clay and clay till was a thick gravel and sand layer extending to the top of bedrock at depths ranging from 12.3 m to 19.1 m below ground surface. The gravel and sand were described as containing varying amount of gravel and sand content, mixed with trace to no fines and dry to damp in moisture condition. It is important to note that the gravel and sand samples were collected from the ODEX method which may have crushed larger sized gravels, and potentially cobbles and/or boulders into smaller pieces. Hence, the presence of larger sized gravels, cobbles and/or boulders as well as the gradation of the gravel materials could not be confirmed.

3.2.5 Bedrock

Bedrock was encountered at depths from 12.3 m and 19.1 m below ground surface. It was described as weathered claystone and/or sandstone. Similar to the comment described for gravel materials, the bedrock samples retrieved from the ODEX method were highly disturbed and crushed into small pieces. Hence, detailed descriptions, such as bedrock strength, discontinuities, etc. could not be provided. Such detailed descriptions would require bedrock coring which was not included as part of the scope of work.

3.3 Groundwater Conditions

The water levels in the piezometers were measured on December 15, 2020 about one week after completion of drilling. Another set of readings was taken on January 14, 2021, about one month after completion of drilling. Both sets of readings are presented in Table 2.

Table 2. Groundwater Level (GWL) Readings

Test Hole	Piezometer Installation Depths (mbgs)	GWL in Shallow Piezometers (mbgs)		GWL in Deep Piezometers (mbgs / elevations)	
		December 15, 2020	January 14, 2021	December 15, 2020	January 14, 2021
TH20-1	10.2 (shallow) / 20.7 (deep)	Dry	Dry	14.67 / 1110.13	14.74 / 1110.06
TH20-2	9.1 (shallow) / 16.8 (deep)	Dry	Dry	13.19 / 1110.71	13.38 / 1110.52
TH20-3	10.7 (shallow) / 13.6 (deep)	Dry	Dry	Dry	Dry
TH20-4	8.2 (shallow) / 13.7 (deep)	Dry	Dry	13.34 / 1111.33	12.61 / 1112.06
TH20-5	7.6 (shallow) / 14.5 (deep)	Dry	Dry	13.12 / 1110.28	13.19 / 1110.21

"mbgs" is denoted as metres below ground surface.

It should be noted that water levels observed in the test holes may not have fully stabilized at the time of measurement. The local water table in Calgary is known to fluctuate seasonally and in response to climatic conditions, with higher groundwater levels typically during the spring and summer seasons. In general, the depth to groundwater from existing grade should be expected to be influenced by local snowmelt and precipitation events.

Further observations of the water levels within the installed piezometers should be taken prior to the design phase and construction to assess seasonal variations.

3.4 Methane and Radon

Methane gas was not encountered from readings collected in the standpipes following the completion of the test hole drilling.

It is noted that an assessment of the potential for Radon gas was not included in the scope of this investigation. If necessary, such an assessment will require input from a Radon specialist. Concrete slab-on-grade recommendations related to Radon gas mitigation are provided in Section 4.4.

4. PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

4.1 General

The subsurface conditions encountered in the test holes are generally consistent with those encountered in the past geotechnical investigation programs with the exception of a thicker and denser gravel and sand layer between the clay till and bedrock. Overall, the encountered subsurface conditions are considered suitable for the potential building development.

The predominant stiff to very stiff clay/clay till encountered within the upper about 6.7 m to 9.8 m with a low groundwater level are considered feasible for underground basement and/or parkade development. If the underground development will extend into the underlying gravel encountered below the clay/clay till, temporary shoring is expected to be required unless there will be adequate space to cut flatter side slopes. Temporary shoring may also be required to maximize the extent of the excavation and protection to the existing facilities, depending on the required excavation depths and proximity to the existing roadways.

Shallow foundations founded on the native stiff to very stiff clay and clay till are considered suitable for building development with light to moderate loading conditions, provided that the footings will be adequately sized to support the design loads and address settlement considerations. Pile foundations founded within gravel and/or bedrock may be required to support higher design loads, such as foundations supporting high-rise buildings.

Preliminary foundation design recommendations for both shallow and pile foundations are provided in the following sub-sections.

4.2 Pile Foundation

4.2.1 General

Both bored cast-in-place concrete piles and driven steel piles are considered suitable foundation options to support mid to high-rise buildings. Bored cast-in-place concrete piles are commonly selected to support buildings in the Calgary area which may be founded on either the native clay till, gravel or the underlying bedrock, depending on the magnitude of the design loads.

Driven steel piles are less common to support buildings in the Calgary area that are generally used at sites where subsurface materials are prone to excessive sloughing (such as wet, loose sand or other deleterious materials, or high groundwater level). Given the more favourable overburden soils and a low groundwater level encountered at this site, bored cast-in-place concrete piles are expected to be more preferred over driven steel piles. Further, installation of driven steel piles would generate noise and vibration which are considered unfavourable due to the proximity of the existing residential and commercial areas. If driven steel piles are selected, they may be driven to refusal into the underlying gravel or bedrock to maximize their vertical geotechnical capacities.

If the site grade will be raised with fills, the design pile lengths will need to be extended since no shaft resistance can be relied upon for the pile lengths within any existing and new fills. Further recommendations with respect to suitability of fill materials underneath shallow foundations are provided in Section 4.3.

4.2.2 Bored Cast-in-Place Concrete Piles

On a preliminary basis, the factored ULS parameters presented in Table 3 may be considered for estimation of the required lengths of bored cast-in-place concrete piles to resist axial compressive loads. Note that the recommended parameters are based on the average conditions encountered in the five test holes completed in this program. The designer should refer to the depths of the different soil/bedrock types encountered in the closest test holes.

Table 3. Design Parameters for Cast-In-Place Concrete Piles (Axial Compressive Loading)

Soil Type (Depth below Existing Grade)	Factored ULS Shaft Friction (kPa)	Factored ULS End Bearing (kPa)
Overburden Soils or any Future Fills within the upper 1.5 m	0	0
Native Clay and Clay Till	23	330
Native Gravel and Sand (between Clay Till and bedrock)	26	900
Bedrock (minimum 2.0 m rock socket length is required)	75	1,500

A minimum pile embedment depth of 6 m is recommended to reduce the risk of frost jacking.

A geotechnical resistance factor of 0.4 is included in the above design parameters to calculate the ULS factored compressive values of shaft resistance and end bearing. Uplift capacity of the piles should be calculated based on shaft friction only, using shaft friction of 75% of the values in the above table.

Note that the base resistance may only be considered if there are means available to clean the pile base. If base cleaning is not possible, then end bearing should be ignored. Bored piles should have a shaft diameter not less than 400 mm. Typically, it is difficult to ensure a clean base in pile bores drilled with diameter less than 400 mm.

Settlement of piles based in the stiff to very stiff clay till, gravel or socketed into bedrock are expected to be small (less than 25 mm) and hence the ULS loads are expected to govern the pile design.

It is important to note that where the piles will extend into the underlying gravel and sand, temporary casings are expected to be required during pile boring to control potential sloughing within the granular materials. Further, although not encountered in the test holes due to the ODEX method used to penetrate through the gravels, cobbles or boulders may be present which may hamper the pile boring. The contractor should be equipped to bore through such obstructions if encountered. Where the piles will extend into the underlying bedrock, the contractor should be equipped to bore through strong bedrock such as using core barrel with bedrock auger teeth.

As discussed above, the test holes completed in this program were not intended for design purposes. Additional test holes are required to verify the above preliminary design and construction recommendations.

4.2.3 Driven Steel Piles

Given the depth to gravel (6.7 m to 9.8 m) and bedrock (12.3 m to 19.1 m), steel piles may be driven to practical refusal into gravel or bedrock (less than 2 mm/blow over the final 150 mm of driving) to maximize their capacities. For piles driven to practical refusal using an appropriately sized hammer, a factored ULS compression capacity equal to 80 MPa/m^2 multiplied by the pile steel cross-section area is available. Such piles should be expected to settle less than 25 mm.

With the existing geotechnical information, it is difficult to accurately estimate the pile refusal depths, which depends on the hammer size, pile size, presence of cobbles/boulders, density of gravel and bedrock strength. Additional test holes and/or driving of test piles are required for an accurate estimate of the required pile length to reach practical refusal.

To reduce the risk of premature refusal during pile driving, piles should be equipped with driving shoes to improve driveability. Size of the driving shoes should be equal to or less than the outside pile dimensions to minimize reduction of shaft resistance.

It is recommended that PDA testing (Pile Driving Analyzer) be performed on at least 15% of the production piles at the start of the pile driving operations to verify the actual hammer energy, steel stresses during driving and as a further assessment that the pile capacities are achieved.

4.2.4 Laterally Loaded Piles

The lateral capacity of a pile is primarily dependent on the soil type in the upper 2 m to 4 m of the soil profile. Lateral pile analysis should be performed to obtain the lateral capacity, deflection and bending moments.

For preliminary structural design of laterally loaded piles, the pile may be modeled as a beam on an elastic medium. The horizontal modulus of subgrade reaction (k_s) may be calculated as follows:

$$k_s = \frac{E_s}{d}$$

Where:

d = external diameter of the pile (in metres)

E_s = modulus of elasticity, with the recommended values provided in Table 4

Table 4. Modulus of Elasticity for Lateral Loads

Soil (depth below existing grade)	E_s (MPa)
Overburden Soils (upper 2.0 m)	0 – 15 (increasing linearly with depth)
Native Clay and Clay Till	25
Gravel and Sand	50
Bedrock	100

The above method is suitable for preliminary design only. For detailed design, it is recommended that lateral pile analysis be completed using software, such as L-Pile, to assess the pile lateral response after the design loads and pile configurations are known.

4.3 Shallow Foundations – Spread and Strip Footings

4.3.1 Design and Construction Recommendations

A shallow foundation system comprising spread and/or strip footings is considered as a feasible foundation option for multi-storey buildings subject to light to moderate loading conditions. The footings should be founded on the native stiff to very stiff clay beneath any topsoil and any existing fill material. On a preliminary basis, the following parameters may be considered for estimation of footing sizes:

- Factored Ultimate Limit State (ULS) bearing capacities of 220 kPa for strip footings and 250 kPa for spread footings are considered available for footings founded on native stiff to very stiff clay/clay till. A Geotechnical Resistance Factor of 0.5 has been included in the factored ULS values.
- Strip and spread footings should not be founded on any existing fill materials or native materials that contain organics soil. Based on the organic content tests completed on the native materials, they contain negligible organic content and are therefore considered acceptable to support the footings. It is recommended that the actual subgrade

conditions be reviewed by additional test holes within the building footprints and verified during construction.

- The Serviceability Limit State (SLS) bearing capacities will need to be checked for conformance once the design loads and footing sizes have been established.
- A minimum strip footing width of 0.6 m is recommended. A minimum 1.5 m square spread footing is recommended.
- Footings supporting the heated building should be founded below the frost depth at 2 m below finished site grade. Insulation is unlikely to be required at this footing depth. Otherwise, the footings should be insulated to reduce the frost depth.
- Structural engineered fill, if necessary underneath the footings, should comprise an imported well graded granular backfill placed in compacted lifts not exceeding 150 mm in thickness and compacted to not less than 100% of SPMDD and ±2% of Optimum Moisture Content.
- General engineered fill (including low to medium plastic clay or sand or gravel with no organics) is typically not recommended to be placed under footings due to the potential of additional settlement and/or reduced bearing capacity. If general engineered fill will be placed under the footings, the expected foundation performance must be reviewed and accepted by the foundation designers with input from a geotechnical engineer to estimate the potential of additional settlement within the engineered fill and/or reduced bearing capacity. The surficial sand and silt encountered in the test holes are highly frost susceptible and should not be placed under the footings.
- Footing excavations must be protected at all times from freezing temperatures, the ingress of free water, disturbance by construction traffic, and excessive drying. It is recommended that exposed bearing surfaces be protected with a mud slab if foundations are not constructed promptly after excavation.

4.4 Concrete Slabs on Grade

Subgrade preparation under slabs on grade should follow the recommendations provided in Section 4.6. Any fill required to raise the site grade under the slabs should be reviewed and confirmed its suitability prior to placement. Engineered fill consisting of the native low to medium plastic clay or the underlying native sand/gravel are considered suitable to be placed under concrete slabs on grade, and compacted to the standards recommended in Section 4.6. The surficial sand/silt materials are considered highly frost susceptible and should not be used as backfill nor be left in place under concrete slabs on grade. If settlement under the concrete slabs on grade needs to be limited, structural engineered fill consisting of imported well-graded granular backfill should be considered under the slabs.

A minimum of 150 mm of clean, well-graded sand or gravel is recommended beneath the slab for leveling and drainage purposes. This material will need to be imported since the native sand and gravel are not expected to be suitable. Coarse material greater than 50 mm in diameter should be avoided directly beneath the slab to prevent stress concentrations within the slab. The granular leveling course should be compacted to a uniform dry density of at least 98% of Standard Proctor Maximum Dry Density.

Where provisions for handling radon extraction are required, as outlined in the National Building Code Article 6.2.1.1, these should generally follow the requirements of EPA 625/R-92/016. This specifies a minimum of 100 mm of coarse aggregate meeting Size #5 specification (i.e. 100 percent passing 37.5 mm, not more than 5 percent passing a 9.5 mm sieve) as defined in ASTM C-33-90 be provided directly below the floor slab. 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. Note that our preference is to specify a minimum thickness of 150 mm of gravel for ease of placement and compaction. Consideration for the thickness of gravel may also need to be given to the size of piping below the slab, if required.

Slabs in non-heated areas (i.e. exterior slabs or slabs in unheated buildings) will be subject to frost heave. In many cases this is acceptable for non-sensitive slabs such as sidewalks, ramps, etc. Where movement and/or cracking of slabs due to frost action is to be avoided, the slab should either have insulation protection or alternatively should be supported on piles. Frost action is further discussed in Section 4.5.

4.5 Frost Protection

The frost penetration depth at the site can be taken as 2 m below ground surface. The project site soils are considered to be in the frost group F3 (clay and clay till) and F4 (silt and silty sand) which have high potential to exhibit frost effects such as heaving upon freezing and softening upon thawing. The soil beneath and/or adjacent to the reinforced concrete slab foundation should be protected from freezing during and after construction to prevent the potential for heaving and cracking of the foundation elements.

For design purposes, frost heave in non-heated, un-insulated areas (such as concrete sidewalks, or concrete aprons near the truck bay entrances and exits) in the order of 50 mm should be expected in the surficial sand/silt or clay materials unless the soil is removed and replaced with engineered granular fill. This assumes that any surface runoff will be adequately diverted away from the development area.

Building foundations should be constructed to bear beneath the frost depth of 2 m and on native material with no organics or on structural engineered fill consisting of an imported well graded gravel material. As noted above, building foundations may be founded on general engineered fill depending on the expected foundation performance to be reviewed by the foundation designers. The sand and silt material encountered on site (identified with <4% LOI) are highly frost susceptible and therefore, should not be placed under foundations. They may be used as general engineered fill for other areas such as landscaping.

Buried pipes with less than 2 m of soil cover should be protected with insulation to avoid damage or breakage as a result of frost action.

4.6 Site Preparation

Details of the development are not known at the time of preparing this report. General recommendations for site preparation are provided in this section which should be reviewed after the details become available.

At the start of construction, the entire plan area of the new construction works should be stripped of all vegetation, organic soils, and/or soils (fill or native) containing organics, as well as any soft, loose, wet, disturbed, or otherwise unsuitable materials. These deleterious soils are not considered acceptable to structurally support the new buildings.

Following initial site stripping of deleterious materials and removal of any unacceptable bearing material, the site should then be inspected. A proof-roll, bearing inspection, or compaction testing via nuclear densometer should take place once acceptable bearing elevation is reached to identify loose or soft areas requiring further sub-excavation. Sub-excavated areas should be backfilled with suitable material consisting of either general engineered fill (outside of building footprints) or structural engineered fill (within building footprints). As noted above, if general engineered fill will be placed within the building footprints, the potential of additional settlement and/or reduced bearing capacity will need to be reviewed and accepted by the foundation designers.

Any intermittent gravels and sands, if encountered on site, are susceptible to disturbance and deterioration if exposed to weathering or as a result of excessive drying, precipitation, surface runoff, or construction disturbance. The exposed subgrades should be protected at all times from freezing, free water, and excessive drying. Any subgrade soils which deteriorate due to weathering or other factors should be restored by removal and replacement with an appropriate fill material.

The existing site soils comprising silt, sand and clay are considered suitable for use as general engineered fill materials; however, some moisture conditioning (wetting and/or drying) should be expected. This material should be free from organics and verified during construction. Where fill is required beneath any foundations, it should be placed as structural fill consisting of imported well graded gravel material. As noted above, general engineered fill (low to medium plastic clay, sand or gravel with no organics) may be placed under foundations depending on the expected performance of the foundations to be reviewed and accepted by the foundation designers. All material to be imported for placement within the building footprints should be approved by a qualified geotechnical engineer prior to importing.

Structural engineered fill, if necessary within the building footprints, should comprise an imported well graded granular backfill placed in compacted lifts not exceeding 150 mm in thickness and compacted to not less than 100% of SPMDD and ±2% of Optimum Moisture Content.

In general, engineered fill materials may be used within the above grade parking areas and under concrete slabs-on-grade, and should be placed in layers no thicker than 150 mm in compacted thickness and should be compacted to a minimum 98% of SPMDD at Optimum Moisture Content (OMC) to +2% of OMC. If engineered fill materials will be placed underneath footings, the compaction requirement will need to be reviewed by the foundation engineers in relation to the expected foundation performance.

Fill soils placed in landscaped areas or around the building perimeters should be compacted to a minimum of 95% of SPMDD.

Backfill materials should not be placed in a frozen state or placed on a frozen subgrade.

Utility bedding and backfilling should be in accordance with the requirements of the supplier, as well as the current City of Calgary specifications.

4.7 Construction Excavations and Dewatering

4.7.1 Temporary Cut Slopes

It is understood that the proposed development may include underground parkade or basements that may require deep excavations. If there will be adequate space, the excavations may be completed with side slopes cut at an appropriate slope angle. Otherwise, some form of shoring support may be required to maximize the extent of the excavation and protect the existing roadways and facilities.

It is assumed that excavations into the underlying gravel and sand materials, encountered below a depth of 6.7 m in the test holes, will not be required. The recommendations provided herein are based on excavations within the surficial sand/silt and clay materials only.

Temporary cut slopes greater than 1.5 m deep should be excavated no steeper than 1H:1V. If silt, sand and gravel are found to be present within the excavations, the side slopes may need to be flattened to no steeper than 2H:1V. Temporary cut slopes must be inspected regularly for signs of instabilities and flattened as necessary. All temporary excavations should be made in compliance with the Alberta Occupational Health and Safety regulations.

Any stockpiled material or surcharge load should be kept well back from the edge of the excavation by a minimum distance equal to the depth of the excavation. If heavy equipment will operate adjacent to an open excavation, the applied loads should be assessed by a geotechnical engineer to confirm that an adequate factor of safety is maintained.

Depending on the length of time the excavation is left open, it may be necessary to tarp the slopes to protect them from weathering. Construction excavations should be carefully inspected for evidence of any instability, such as cracks, bulging, or soil loss from seepage prior to allowing workers to enter the excavations. Regular inspections must be carried out during construction. If signs of instabilities are observed, the excavation side slopes must be flattened accordingly.

4.7.2 Temporary Shoring

The design and construction of temporary shoring is generally the responsibility of the contractor but typically it would consist of steel H-piles and timber lagging. The holes for the steel H-piles may need to be pre-augured and the piles cemented into position depending on the depth of embedment. General recommendations are provided in this sub-section which will need to be confirmed with additional test holes.

On a very preliminary basis, the following lateral earth pressure coefficients and unit weights may be considered for design of a temporary shoring system.

Table 5. Lateral Earth Pressure Coefficients and Unit Weights

Soil Layer	γ (kN/m^3)	ϕ^o	K_o	K_a	K_p
Clay / Silt / Sand	18	28	0.53	0.36	2.8
Clay Till	21	32	0.47	0.31	3.3

4.7.3 Dewatering

The recommendations provided in this sub-section are based on the groundwater seepage condition and readings collected in the five test holes completed in this program. Additional test holes and further groundwater level monitoring must be completed to assess the groundwater seepage condition and level.

Based on the conditions encountered in the test holes, groundwater seepage is not expected for excavations above a depth of about 6 m. Therefore, groundwater flow into the excavation (above 6 m depth) is expected to be relatively low and would only be from “perched” water tables that may develop following periods of heavy rain, or during periods of seasonally high water levels.

It is expected that a gravity system comprised of a perimeter ditch within the excavation, leading to strategically placed sumps should be suitable for handling the dewatering requirements during construction. Other dewatering methods may also be considered.

It will be necessary to confirm the quality of the water to be pumped and the degree of treatment, if any, that will be required. As a minimum, the contractor should expect a requirement to retain the water temporarily with holding tanks to remove solids prior to discharged in the City’s storm water system.

Depending on the depth of the foundation level, a permanent sub-drainage system may be required beneath the floor slab to accommodate potential high water levels. This should consist of a minimum of 200 mm of crushed drainage gravel with perforated, 100 mm sub-drain pipes, wrapped in filter fabric, installed around the perimeter of the slab, and at 6 m spacing across the full slab area. The sub-drain lines should maintain a positive slope towards a common sump(s).

4.8 Seismic Criteria

It is a requirement of the 2015 National Building Code of Canada (NBCC) to classify sites with regards to deflections and loading of structures due to earthquake motion. To classify sites in accordance with Table 4.1.8.4A of the 2015 NBCC, information with respect to average properties of soils within the upper 30 m is required. For preliminary design, such information was gathered within the drilling depths of the test holes.

Based on information from the test holes drilled on site, and in accordance with Table 4.1.8.4.A in the 2015 NBCC, this site is considered Site Class “C”.

4.9 Cement Type

Three tests were conducted to determine the water-soluble sulphate content of the soil recovered from test hole TH20-1, TH20-3 and TH20-5 at depths ranging from 0.6 m to 0.9 m. The tests indicated sulphate concentrations ranging between 0.00% and 0.09% which are considered “negligible” for potential degree of sulphate attack on concrete as summarized in Table 6.

While there are no specific requirements for the concrete related to sulphate exposure from the site soils based on the limited tests conducted, the designer should design in accordance with CSA A23.1–14 and determine the appropriate concrete exposure class. Any imported fill soils to be placed in contact with concrete should also be tested for water soluble sulphates.

Table 6. Richmond Green Geotechnical Investigation - SO_4 Content

Test Hole	Depth (m)	SO_4 Content (%)
TH20-1	0.8	0-0.09
TH20-3	0.9	0-0.09
TH20-5	0.6	0-0.09

Suitable grout and concrete should be selected for the bored cast-in-place piles or shallow foundation option considering freeze-thaw effects and groundwater conditions. Grout and concrete should be selected to meet the structural engineer's strength requirements for each foundation option.

5. USE OF REPORT

This report has been prepared for The City of Calgary and their agents. The City of Calgary shall at all times be entitled to fully use and rely on this report, including all attachments, drawings, and schedules, for the specific purpose for which the report was prepared, in each case notwithstanding any provision, disclaimer, or waiver in the report that reliance is not permitted.

The City of Calgary shall at all times be entitled to provide copies of the report to City Council, City of Calgary regulatory boards, City of Calgary employees, officers, agents, affiliates, advisors, consultants, parties contracting with The City of Calgary, lenders and assignees and other governmental authorities and regulatory bodies having jurisdiction, each of whom shall also be similarly entitled to fully use and rely on the report in the same manner and to the same extent as The City of Calgary for the specific purpose for which the report was prepared.

The above statement governs over that presented in the Statement of Limitations and Conditions.

6. LIMITATIONS

As noted above, this report is intended for a general evaluation of the geotechnical conditions and planning purposes. A supplemental geotechnical investigation program is required for design and construction purposes. Therefore, differences may exist between the recommendations in this report and the final design, in the contract documents, or during construction. In such instances, Thurber Engineering Ltd. should be contacted immediately to address these differences.

If this report will be included as part of the future design and construction document for information purposes, designers and contractors undertaking or bidding the work should examine the factual results of the investigation, satisfy themselves on the adequacy of the information for design and construction, and make their own interpretation on the suitability of the data as it may affect their proposed scope of work, cost, schedules, safety, and equipment capabilities.

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

THURBER

APPENDIX A

Figure 1: Test Hole Location Plan

LEGEND:

TEST HOLE LOCATION	⊕
PROPOSED SITE	―

NOTES:

1 DRAWING MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 30311 DATED FEBRUARY 2021 AND IS SUBJECT TO ANY LIMITATIONS DESCRIBED THEREIN.

2 AIR PHOTO BASE FROM CITY OF CALGARY 0.1 m/PIXEL (2017).

3 PROPOSED SITE TRACED FROM CLIENT SUPPLIED FILE "2020-10-19 Richmond Green Site.pdf" EMAILED OCTOBER 19, 2020.

0 50 100 150 200 m

3TM 114° NAD 83

Calgary

RICHMOND GREEN PHASE I/II ESA
GEOTECHNICAL INVESTIGATION

TEST HOLE LOCATION PLAN

FIGURE 1

DRAWN BY	ICB
DESIGNED BY	AJE
APPROVED BY	MCL
SCALE	1:2 500
DATE	DECEMBER 18, 2020
FILE No.	30311-A1B

THURBER ENGINEERING LTD.

THURBER

APPENDIX B

Modified Unified Soils Classification

Symbols and Terms used on the Test Hole Logs

Test Hole Logs

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

1. VISUAL TEXTURAL CLASSIFICATION OF MINERAL SOILS

CLASSIFICATION	APPARENT PARTICLE SIZE
Boulders	Greater than 200 mm
Cobbles	75 mm to 200 mm
Gravel	5 mm to 75 mm
Sand	Not Visible to 5 mm
Silt	Non-Plastic particles, not visible to the naked eye
Clay	Plastic particles, not visible to the naked eye

2. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	APPROXIMATE UNDRAINED SHEAR STRENGTH	
Very Soft	Less than 10 kPa	
Soft	10 - 25 kPa	
Firm	25 - 50 kPa	
Stiff	50 - 100 kPa	
Very Stiff	100 - 200 kPa	Modified from National Building Code
Hard	200 - 300 kPa	
Very Hard	Greater than 300 kPa	

3. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	STANDARD PENETRATION TEST (SPT) (Number of Blows per 300 mm)	
Very Loose	0 - 4	
Loose	4 - 10	
Compact	10 - 30	Modified from National Building Code
Dense	30 - 50	
Very Dense	Over 50	

4. LEGEND FOR TEST HOLE LOGS

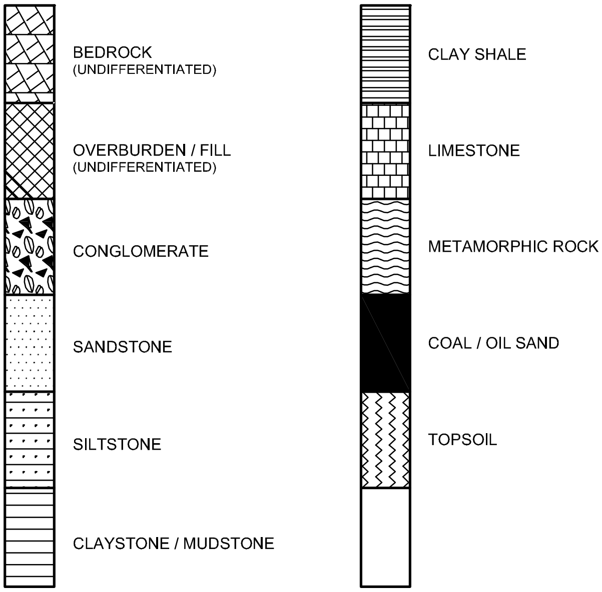
SYMBOL FOR SAMPLE TYPE

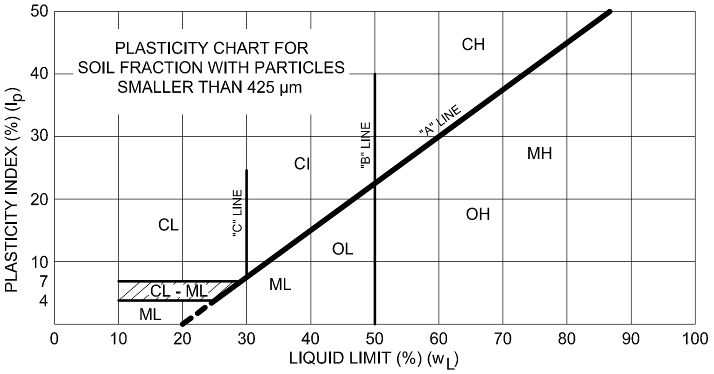
■	Shelby Tube	▤	A- Casing
⧄	SPT	▥	Grab
⊠	No Recovery	◫	Core

● MC - Moisture Content (% by weight) as determined by sample
▼ Water Level
CPen - Shear Strength determined by pocket penetrometer
Cvane - Shear Strength determined by pocket vane
Cu - Undrained Shear Strength determined by unconfined compression test

MAJOR DIVISION			SYMBOL	THURBER LOG SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA		
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75 µm)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN 4.75 mm	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		WELL GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	Determine percentages of gravel and sand from grain size curve. Depending on percentages of fines (fraction smaller than 75 µm) coarse grained soils are classified as follows: Less than 5% GW, GP, SW, SP More than 12% GM, GC, SM, SC 5% to 12% Borderline cases requiring use of dual symbols	$C_u = \frac{D_{60}}{D_{10}} > 4$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			GP		POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR GW	
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4	Above "A" line with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			GC		CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7	
	SANDS MORE THAN HALF COARSE GRAINS SMALLER THAN 4.75 mm	CLEAN SANDS (LITTLE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		$C_u = \frac{D_{60}}{D_{10}} > 6$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			SP		POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR SW	
		SAND WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4	Above "A" line with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			SC		CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7	
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75 µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$w_L < 50\%$	ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)		
		$w_L > 50\%$	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS			
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$w_L < 30\%$	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS			
		$30\% < w_L < 50\%$	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS			
		$w_L > 50\%$	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS			
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$w_L < 50\%$	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW AND MEDIUM PLASTICITY			
		$w_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY, ORGANIC SILTS			
HIGHLY ORGANIC SOILS			PT		PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE		

SPECIAL SYMBOLS





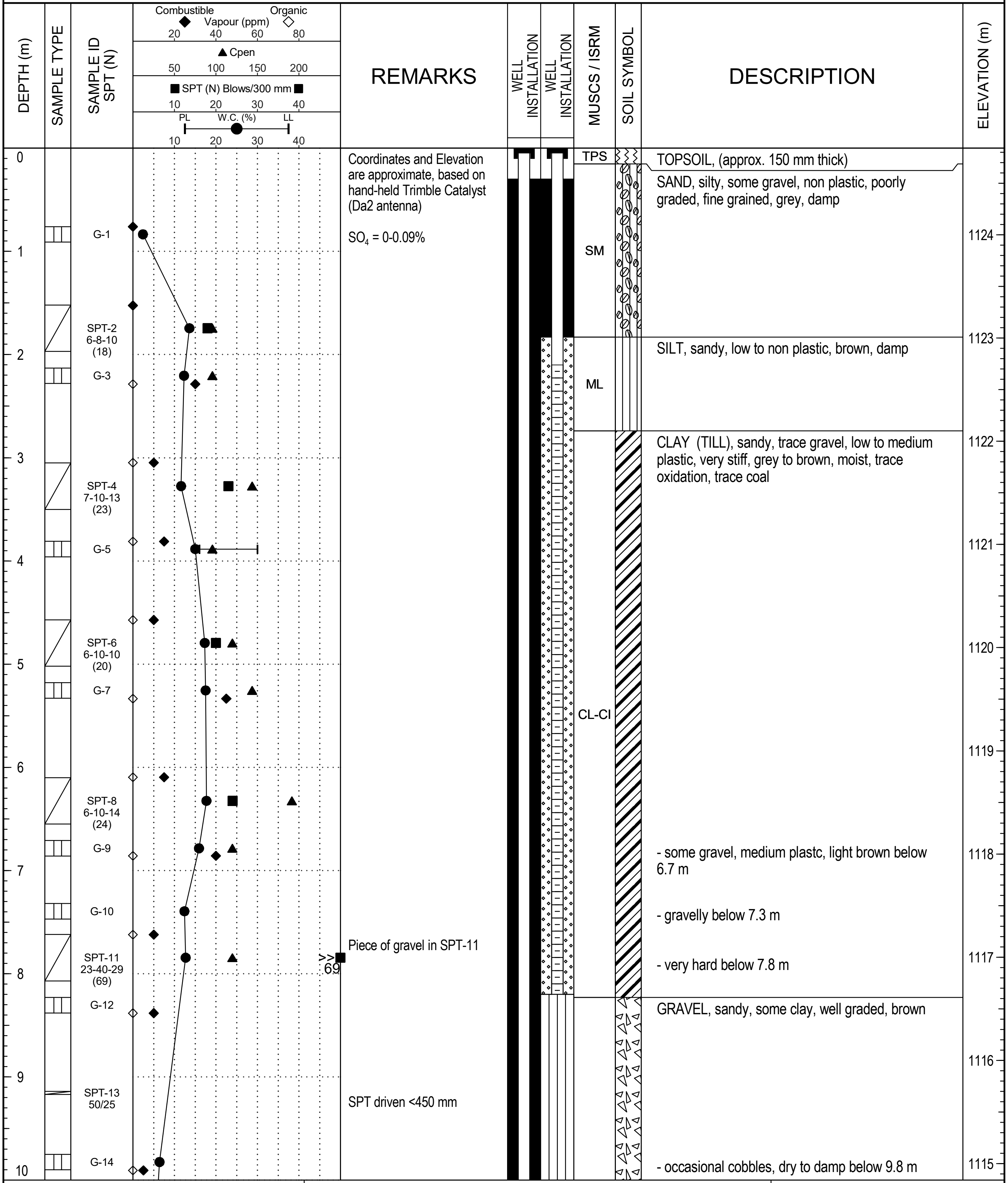
MODIFIED UNIFIED SOIL CLASSIFICATION SYSTEM

(MODIFIED BY PFRA, 1985)

THURBER ENGINEERING LTD.

CLIENT: City of Calgary
PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation
TEST HOLE NO: **TH20-1**
PROJECT NO: 30311
3TM 114° NAD 83, Northing: 5654109.0 m, Easting: -8963.1 m
ELEVATION: 1124.8 m

SAMPLE TYPE: ▥ Grab Sample ◪ Standard Penetration Test
BACKFILL TYPE: ■ Bentonite ⁘ Sand ▥ Slough



REMARKS

Coordinates and Elevation are approximate, based on hand-held Trimble Catalyst (Da2 antenna)

SO_4 = 0-0.09%

Piece of gravel in SPT-11

SPT driven <450 mm

DESCRIPTION

TOPSOIL, (approx. 150 mm thick)

SAND, silty, some gravel, non plastic, poorly graded, fine grained, grey, damp

SILT, sandy, low to non plastic, brown, damp

CLAY (TILL), sandy, trace gravel, low to medium plastic, very stiff, grey to brown, moist, trace oxidation, trace coal

- some gravel, medium plastc, light brown below 6.7 m

- gravelly below 7.3 m

- very hard below 7.8 m

GRAVEL, sandy, some clay, well graded, brown

- occasional cobbles, dry to damp below 9.8 m

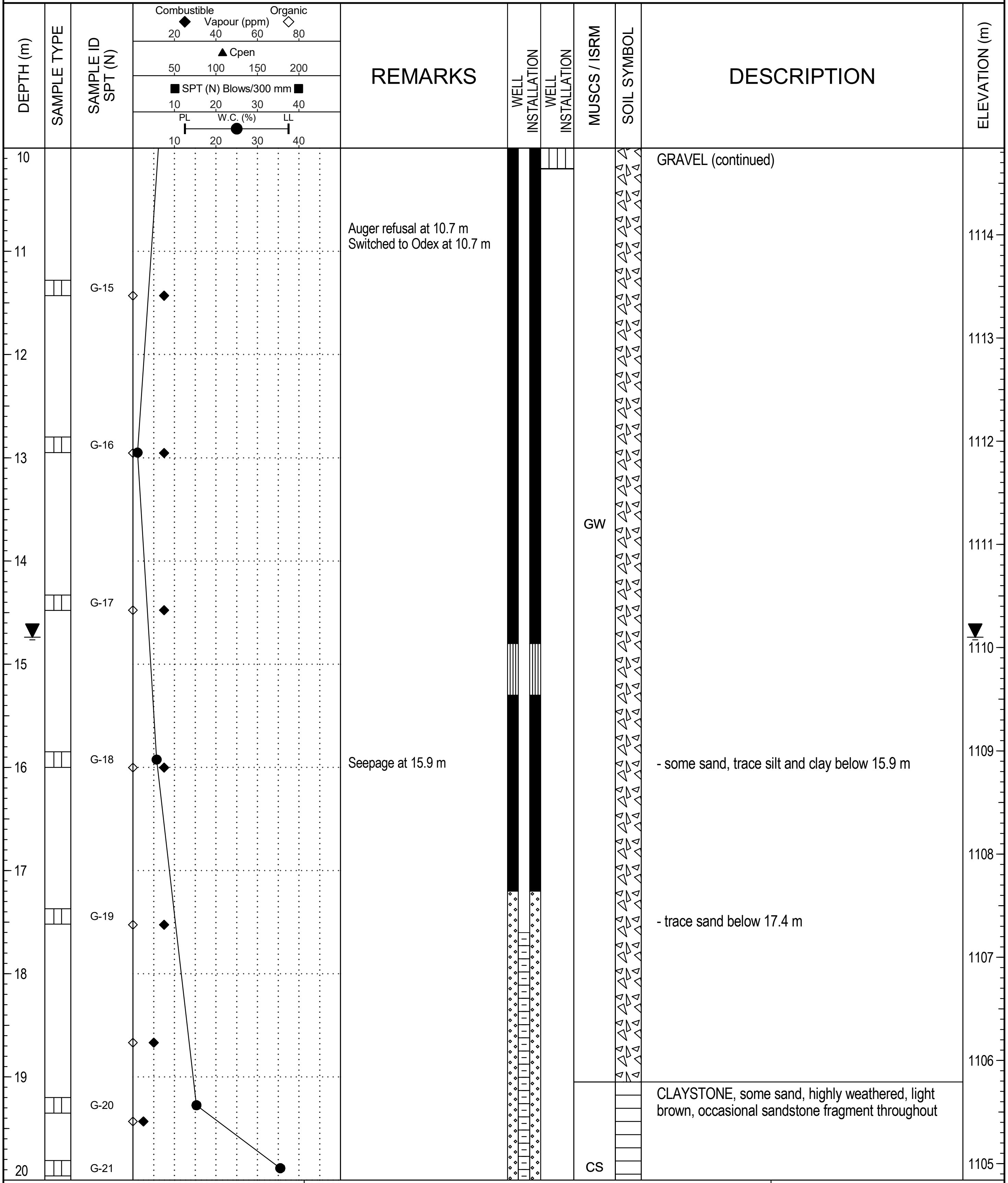
THURBER ENGINEERING LTD.

DRILLING CO.: Earth Drilling Co. Ltd.
RIG TYPE: Diedrich D120 Track
COMPILED BY: CHN
COMPLETION DEPTH: 20.7 m
DRILL METHOD: Solid Stem Auger/ODEX
REVIEWED BY: MCL
COMPLETION DATE: 2020-12-08
INSPECTOR: AJE

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-1**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654109.0 m, Easting: -8963.1 m	ELEVATION: 1124.8 m

SAMPLE TYPE: ▥ Grab Sample ◪ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁘ Sand ▥ Slough



REMARKS

Auger refusal at 10.7 m
Switched to Odex at 10.7 m

Seepage at 15.9 m

DESCRIPTION

GRAVEL (continued)

- some sand, trace silt and clay below 15.9 m

- trace sand below 17.4 m

CLAYSTONE, some sand, highly weathered, light brown, occasional sandstone fragment throughout

THURBER ENGINEERING LTD.

DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 20.7 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-08
INSPECTOR: AJE		Page 2 of 3

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-1**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654109.0 m, Easting: -8963.1 m	ELEVATION: 1124.8 m

SAMPLE TYPE: ▥ Grab Sample ◪ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁘ Sand ▥ Slough

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	Combustible ◆ Vapour (ppm) ◇ Organic 20 40 60 80 ▲ Cpen 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL W.C. (%) LL 10 20 30 40	REMARKS	WELL INSTALLATION	WELL INSTALLATION	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	ELEVATION (m)
20									CLAYSTONE (continued)	
	◪	SPT-22 50/50		SPT driven <450 mm					END OF HOLE at 20.7 m - seepage at 15.9 m - groundwater level at 14.63 m below ground surface upon completion Deep Well: - 50 mm dia. PVC monitoring well installed to 20.7 m - bottom 3.1 m machine slotted - backfilled with sand to 17.2 m - backfilled with coated bentonite pellets to 15.3 m - slough to 14.8 m - backfilled with bentonite chips to 0.3 m - flushmount steel protector at surface - groundwater level at 14.67 m below ground surface on 2020-12-15 - groundwater level at 14.74 m below ground surface on 2021-01-14 Shallow Well: - drilled to 10.2 m - slough from 10.2 m to 8.2 m - 50 mm dia. PVC monitoring well installed to 8.2 m - bottom 6.1 m machine slotted - backfilled with sand from 8.2 m to 1.8 m - backfilled with bentonite chips from 1.8 m to 0.3 m - flushmount steel protector installed at surface - dry on 2020-12-15 - dry on 2021-01-14	1104
21										
22										1103
23										1102
24										1101
25										1100
26										1099
27										1098
28										1097
29										1096
30										1095

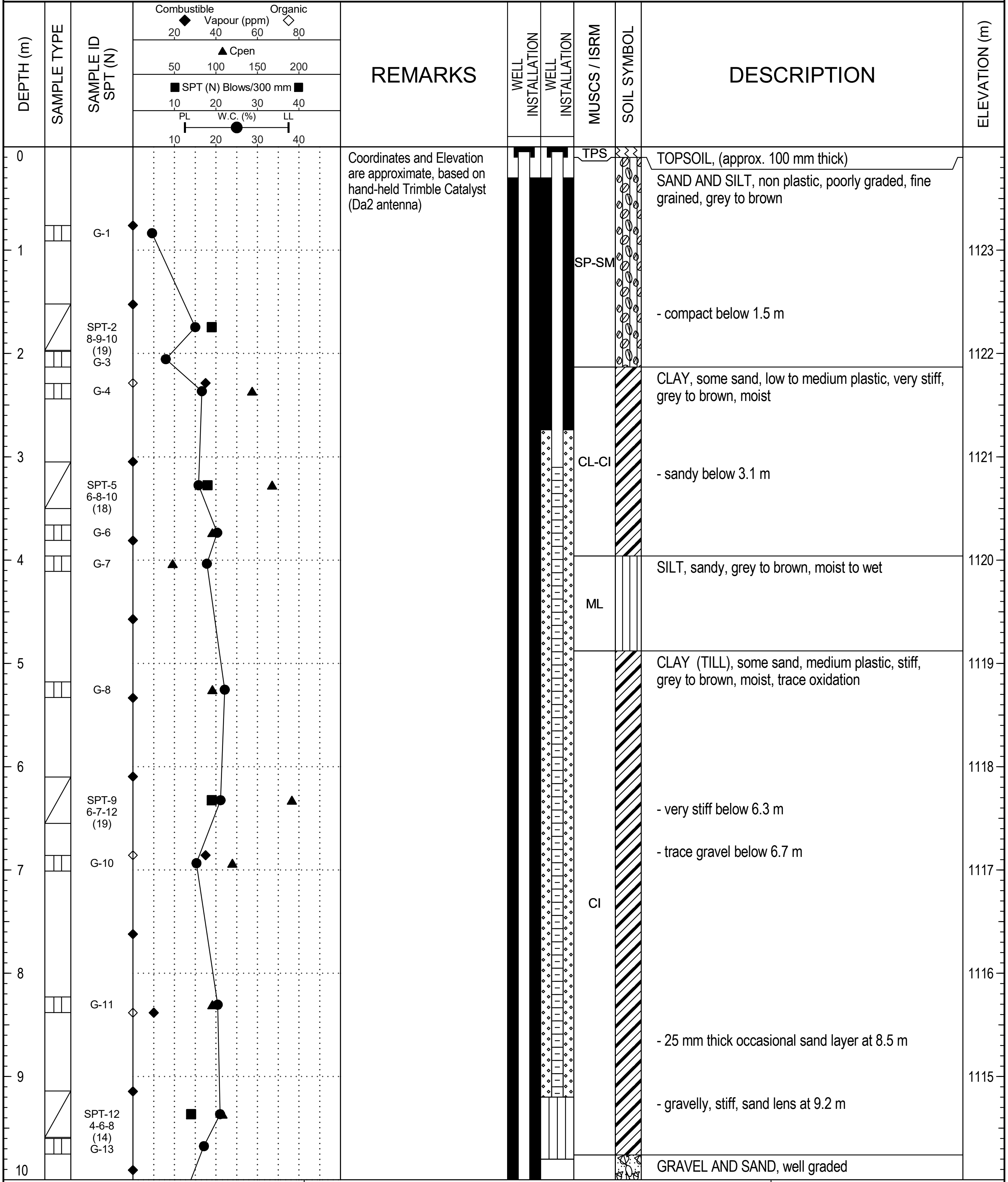
THURBER ENGINEERING LTD.

DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 20.7 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-08
INSPECTOR: AJE		

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-2**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654243.7 m, Easting: -8953.7 m	ELEVATION: 1124.0 m

SAMPLE TYPE: ▥ Grab Sample ◪ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁙ Sand ▥ Slough



REMARKS

Coordinates and Elevation are approximate, based on hand-held Trimble Catalyst (Da2 antenna)

DESCRIPTION

TOPSOIL, (approx. 100 mm thick)

SAND AND SILT, non plastic, poorly graded, fine grained, grey to brown

- compact below 1.5 m

CLAY, some sand, low to medium plastic, very stiff, grey to brown, moist

- sandy below 3.1 m

SILT, sandy, grey to brown, moist to wet

CLAY (TILL), some sand, medium plastic, stiff, grey to brown, moist, trace oxidation

- very stiff below 6.3 m

- trace gravel below 6.7 m

- 25 mm thick occasional sand layer at 8.5 m

- gravelly, stiff, sand lens at 9.2 m

GRAVEL AND SAND, well graded

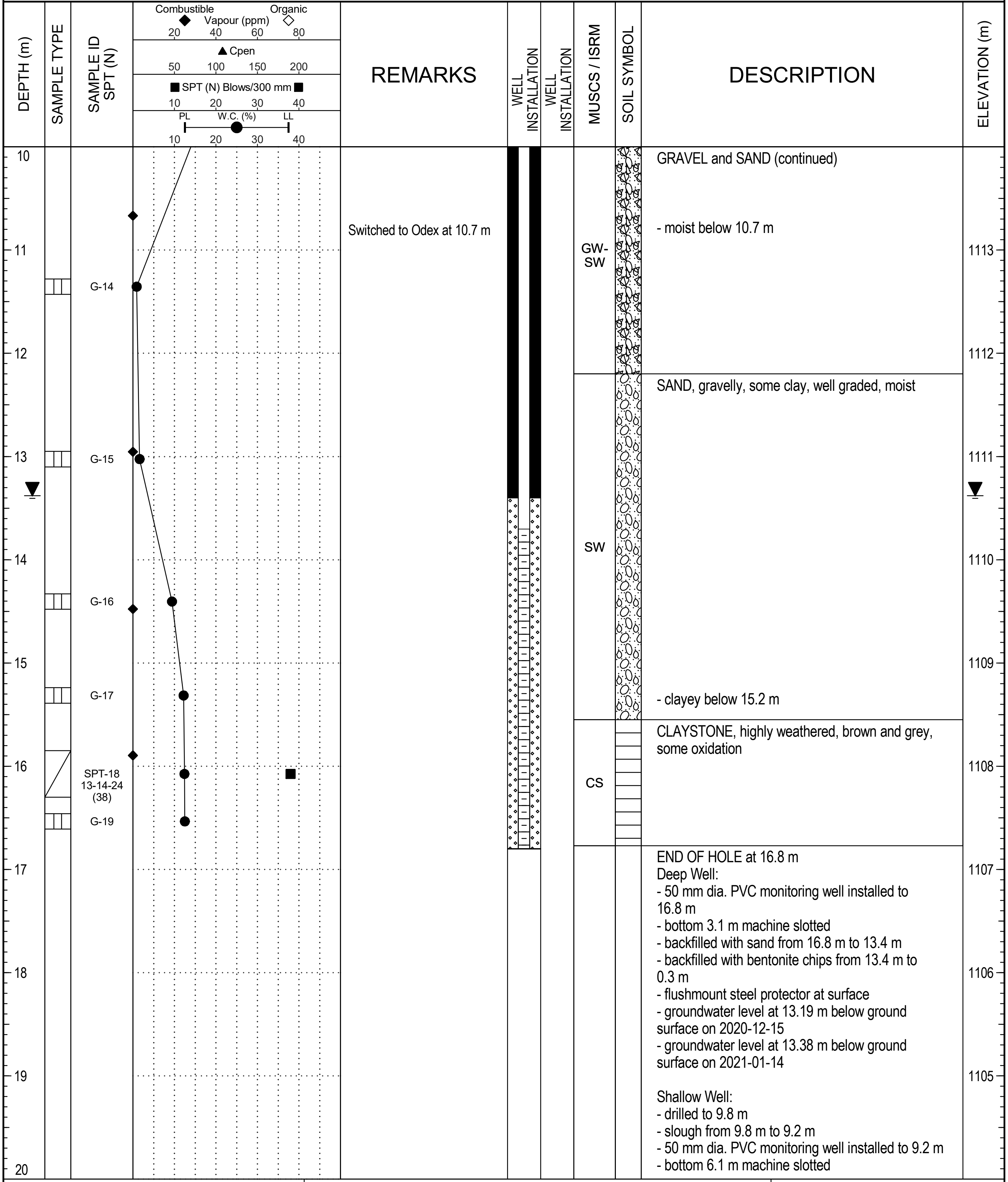
THURBER ENGINEERING LTD.

DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 16.8 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-10
INSPECTOR: AJE		Page 1 of 3

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-2**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654243.7 m, Easting: -8953.7 m	ELEVATION: 1124.0 m

SAMPLE TYPE: ▥ Grab Sample ◿ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁘ Sand ▥ Slough



REMARKS

Switched to Odex at 10.7 m

DESCRIPTION

GRAVEL and SAND (continued)

- moist below 10.7 m

SAND, gravelly, some clay, well graded, moist

- clayey below 15.2 m

CLAYSTONE, highly weathered, brown and grey, some oxidation

END OF HOLE at 16.8 m
Deep Well:
- 50 mm dia. PVC monitoring well installed to 16.8 m
- bottom 3.1 m machine slotted
- backfilled with sand from 16.8 m to 13.4 m
- backfilled with bentonite chips from 13.4 m to 0.3 m
- flushmount steel protector at surface
- groundwater level at 13.19 m below ground surface on 2020-12-15
- groundwater level at 13.38 m below ground surface on 2021-01-14

Shallow Well:
- drilled to 9.8 m
- slough from 9.8 m to 9.2 m
- 50 mm dia. PVC monitoring well installed to 9.2 m
- bottom 6.1 m machine slotted

DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 16.8 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-10
INSPECTOR: AJE		Page 2 of 3

THURBER ENGINEERING LTD.

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-2**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654243.7 m, Easting: -8953.7 m	ELEVATION: 1124.0 m

SAMPLE TYPE: ▥ Grab Sample ◪ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⛶ Sand ▥ Slough

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	Combustible ◆ Vapour (ppm) ◇ Organic 20 40 60 80 ▲ Cpen 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL W.C. (%) LL 10 20 30 40	REMARKS	WELL INSTALLATION	WELL INSTALLATION	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	ELEVATION (m)
20									- backfilled with sand from 9.2 m to 2.7 m - backfilled with bentonite chips from 2.7 m to 0.3 m - flushmount steel protector installed at surface - dry on 2020-12-15 - dry on 2021-01-14	
21										1103
22										1102
23										1101
24										1100
25										1099
26										1098
27										1097
28										1096
29										1095
30										

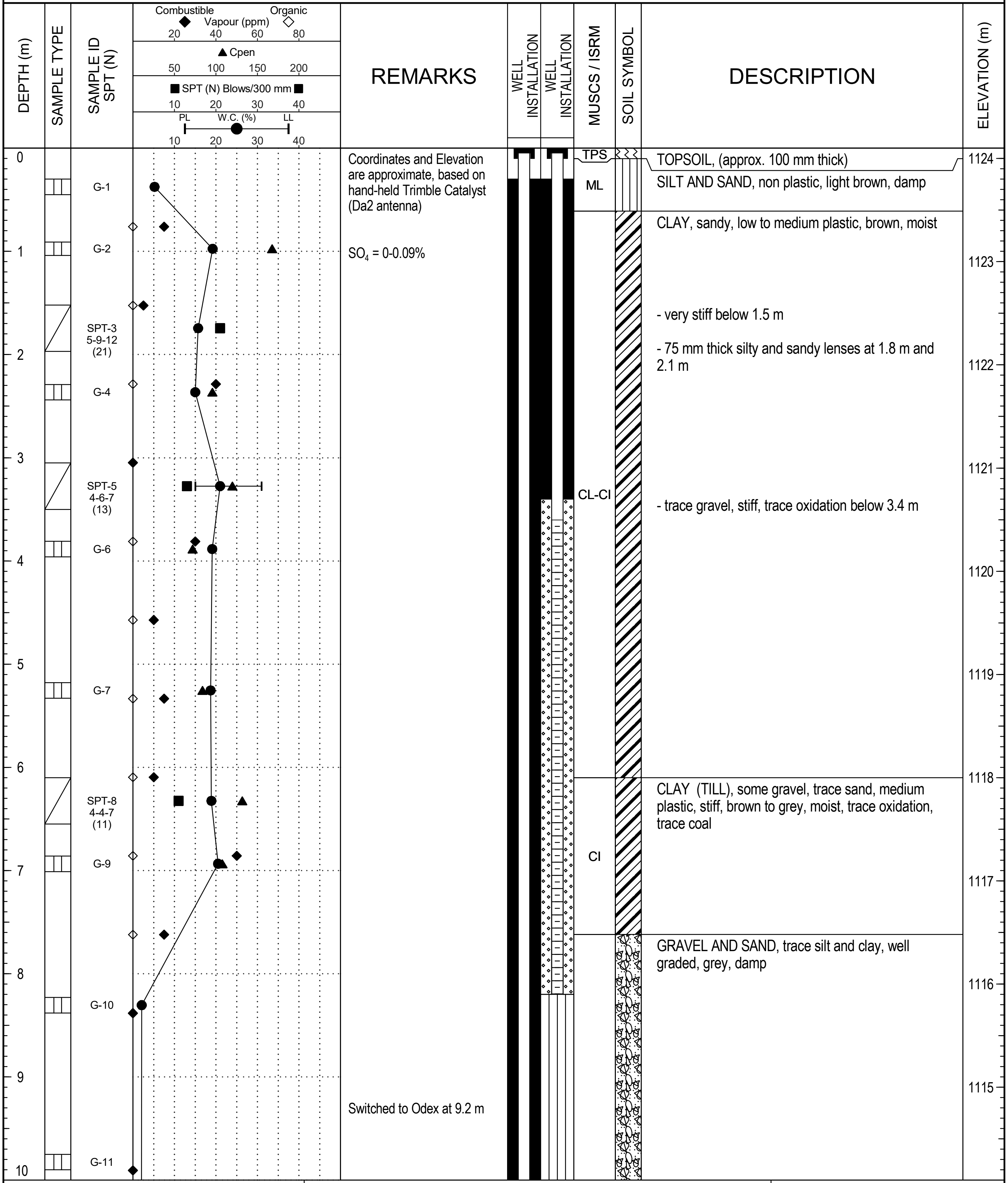
THURBER ENGINEERING LTD.

DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 16.8 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-10
INSPECTOR: AJE		Page 3 of 3

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-3**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654279.9 m, Easting: -9037.4 m	ELEVATION: 1124.1 m

SAMPLE TYPE: ▥ Grab Sample ◪ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁙ Sand ▥ Slough



REMARKS

Coordinates and Elevation are approximate, based on hand-held Trimble Catalyst (Da2 antenna)

SO_4 = 0-0.09%

Switched to Odex at 9.2 m

DESCRIPTION

TOPSOIL, (approx. 100 mm thick)

SILT AND SAND, non plastic, light brown, damp

CLAY, sandy, low to medium plastic, brown, moist

- very stiff below 1.5 m

- 75 mm thick silty and sandy lenses at 1.8 m and 2.1 m

- trace gravel, stiff, trace oxidation below 3.4 m

CLAY (TILL), some gravel, trace sand, medium plastic, stiff, brown to grey, moist, trace oxidation, trace coal

GRAVEL AND SAND, trace silt and clay, well graded, grey, damp

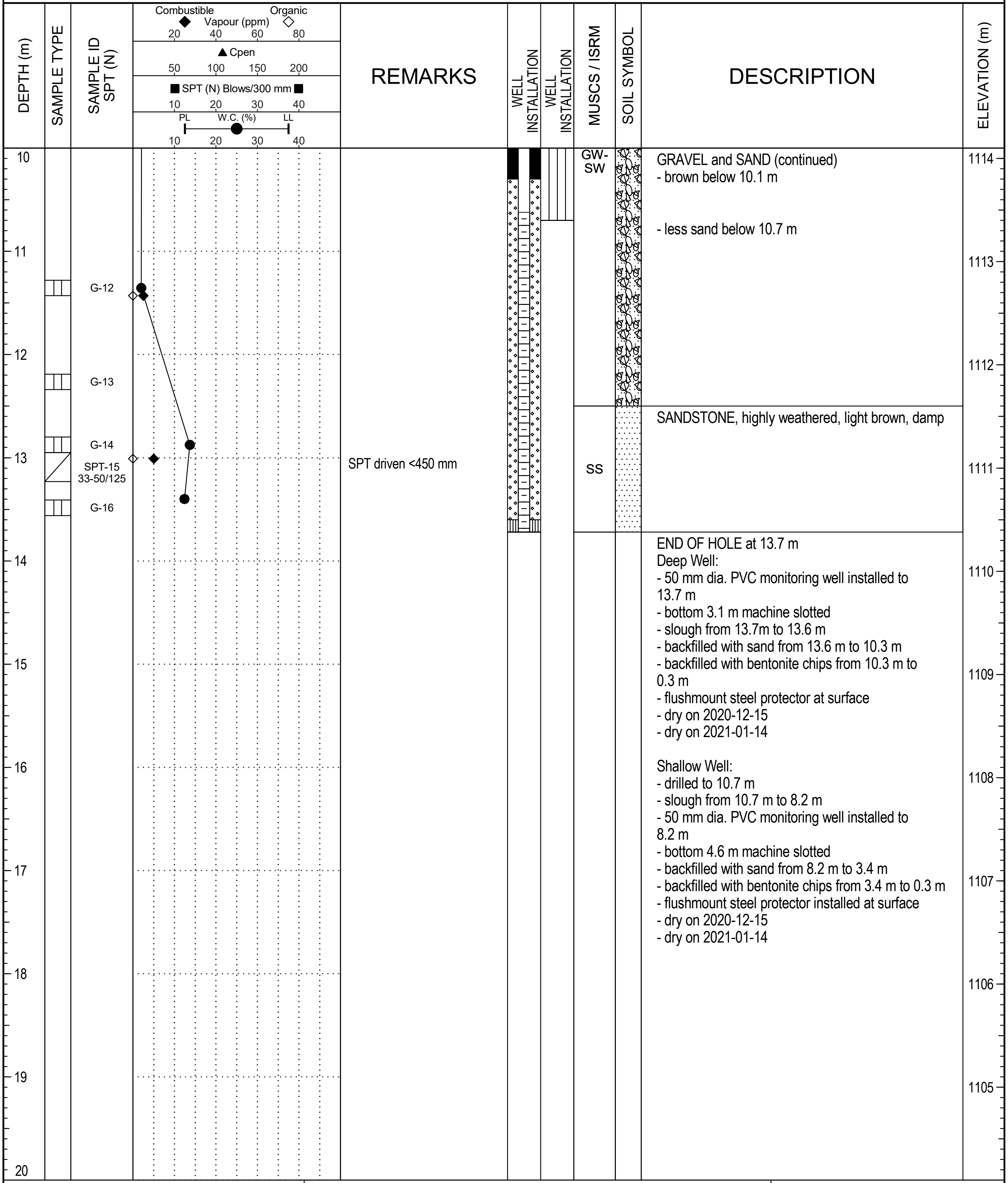
DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 13.7 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-11
INSPECTOR: AJE		

THURBER ENGINEERING LTD.

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-3**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654279.9 m, Easting: -9037.4 m	ELEVATION: 1124.1 m

SAMPLE TYPE: ▥ Grab Sample ◩ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁘ Sand ▥ Slough



REMARKS:

SPT driven <450 mm

DESCRIPTION:

GRAVEL and SAND (continued)
- brown below 10.1 m

- less sand below 10.7 m

SANDSTONE, highly weathered, light brown, damp

END OF HOLE at 13.7 m
Deep Well:
- 50 mm dia. PVC monitoring well installed to 13.7 m
- bottom 3.1 m machine slotted
- slough from 13.7m to 13.6 m
- backfilled with sand from 13.6 m to 10.3 m
- backfilled with bentonite chips from 10.3 m to 0.3 m
- flushmount steel protector at surface
- dry on 2020-12-15
- dry on 2021-01-14

Shallow Well:
- drilled to 10.7 m
- slough from 10.7 m to 8.2 m
- 50 mm dia. PVC monitoring well installed to 8.2 m
- bottom 4.6 m machine slotted
- backfilled with sand from 8.2 m to 3.4 m
- backfilled with bentonite chips from 3.4 m to 0.3 m
- flushmount steel protector installed at surface
- dry on 2020-12-15
- dry on 2021-01-14

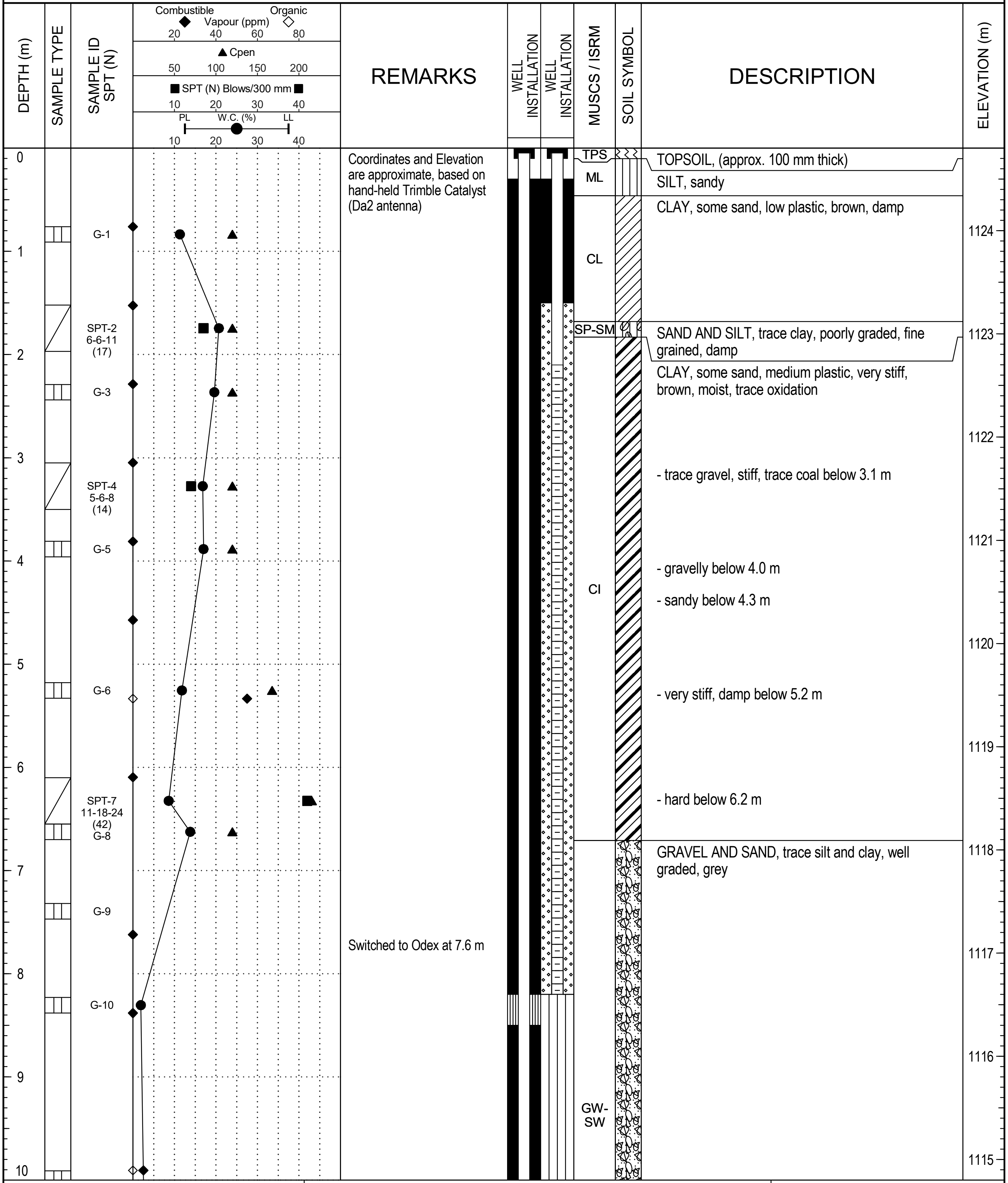
THURBER ENGINEERING LTD.

DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 13.7 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-11
INSPECTOR: AJE		Page 2 of 2

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-4**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654144.5 m, Easting: -9055.2 m	ELEVATION: 1124.8 m

SAMPLE TYPE: ▥ Grab Sample ◪ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁙ Sand ▥ Slough



REMARKS

Coordinates and Elevation are approximate, based on hand-held Trimble Catalyst (Da2 antenna)

Switched to Odex at 7.6 m

DESCRIPTION

TOPSOIL, (approx. 100 mm thick)

SILT, sandy

CLAY, some sand, low plastic, brown, damp

SAND AND SILT, trace clay, poorly graded, fine grained, damp

CLAY, some sand, medium plastic, very stiff, brown, moist, trace oxidation

- trace gravel, stiff, trace coal below 3.1 m

- gravelly below 4.0 m

- sandy below 4.3 m

- very stiff, damp below 5.2 m

- hard below 6.2 m

GRAVEL AND SAND, trace silt and clay, well graded, grey

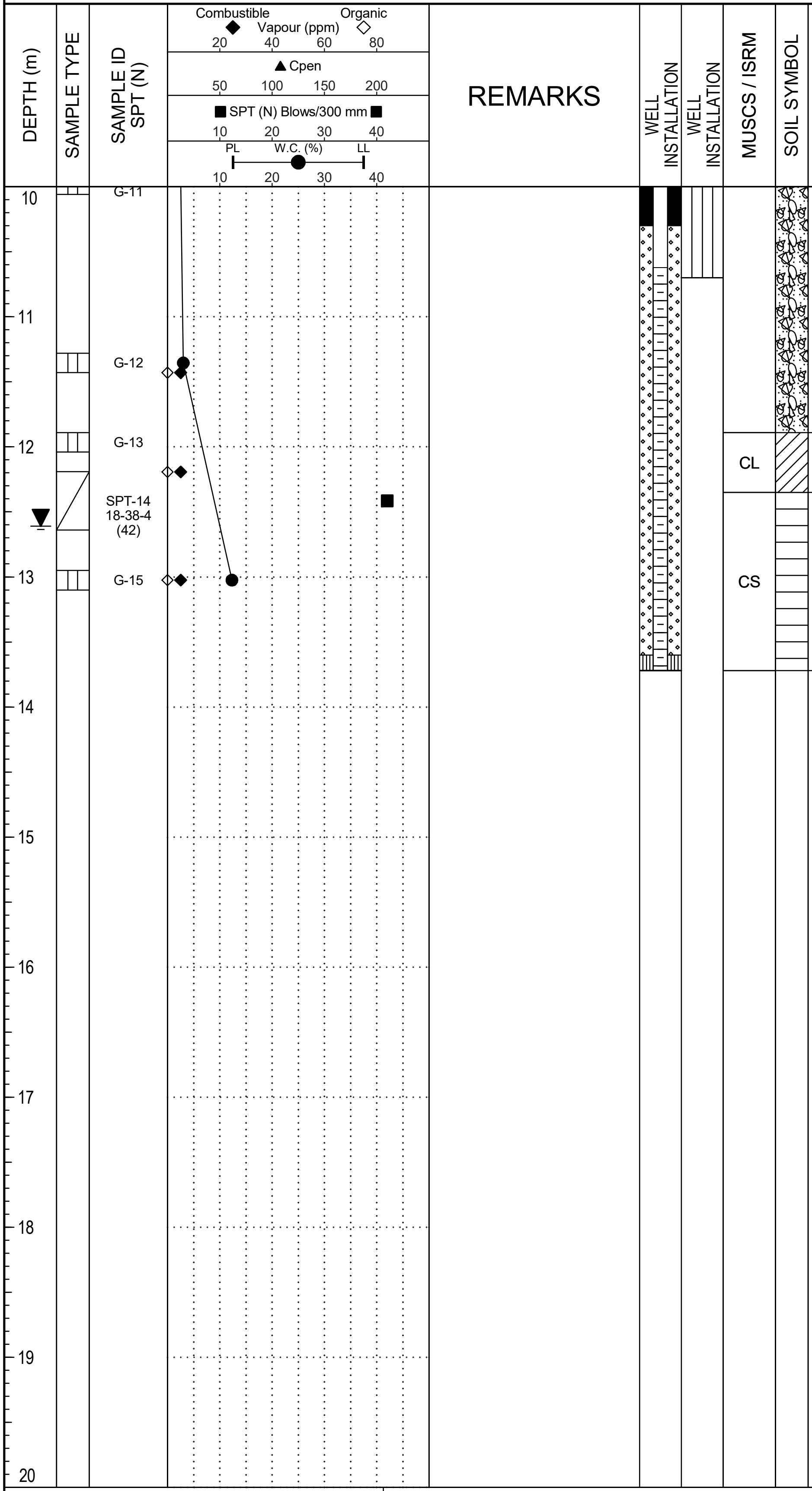
THURBER ENGINEERING LTD.

DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 13.7 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-09
INSPECTOR: AJE		

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-4**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654144.5 m, Easting: -9055.2 m	ELEVATION: 1124.8 m

SAMPLE TYPE: ▥ Grab Sample ◪ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁙ Sand ▥ Slough



DESCRIPTION

GRAVEL and SAND (continued)

CLAY, reddish brown

CLAYSTONE, weathered, greenish grey

END OF HOLE at 13.7 m
Deep Well:
- 50 mm dia. PVC monitoring well installed to 13.7 m
- bottom 3.1 m machine slotted
- slough from 13.7 m to 13.6 m
- backfilled with sand from 13.6 m to 10.3 m
- backfilled with bentonite chips from 10.3 m to 8.5 m
- slough from 8.5 m to 8.2 m
- backfilled with bentonite chips from 8.2 m to 0.3 m
- flushmount steel protector at surface
- groundwater level at 13.34 m below ground surface on 2020-12-15
- groundwater level at 12.61 m below ground surface on 2021-01-14

Shallow Well:
- drilled to 10.7 m
- slough from 10.7 m to 8.2 m
- 50 mm dia. PVC monitoring well installed to 8.2 m
- bottom 6.1 m machine slotted
- backfilled with sand from 8.2 m to 1.5 m
- backfilled with bentonite chips from 1.5 m to 0.3 m
- flushmount steel protector installed at surface
- dry on 2020-12-15
- dry on 2021-01-14

ELEVATION (m)

▼

1114
1113
1112
1111
1110
1109
1108
1107
1106
1105

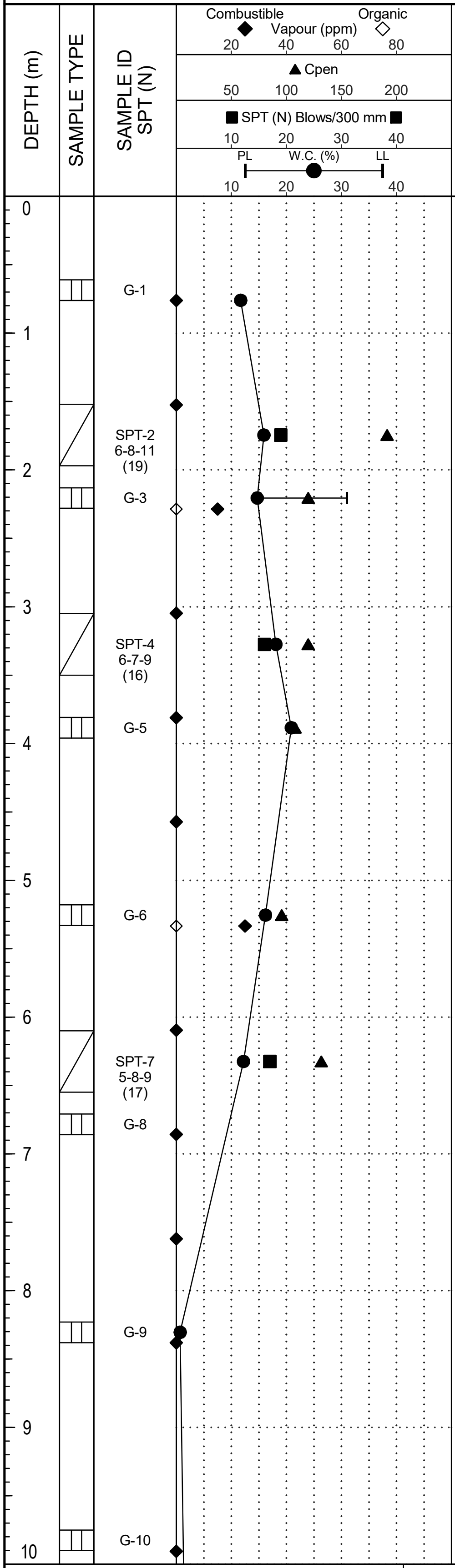
THURBER ENGINEERING LTD.

DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 13.7 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-09
INSPECTOR: AJE		Page 2 of 2

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-5**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654184.4 m, Easting: -8996.7 m	ELEVATION: 1124.1 m

SAMPLE TYPE: ▥ Grab Sample ◿ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁘ Sand ▥ Slough

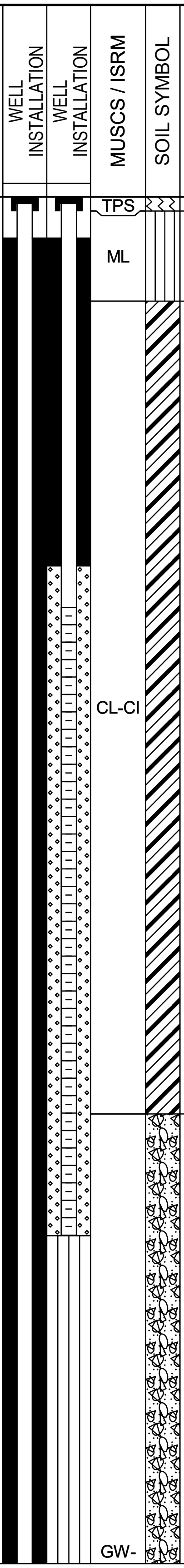


REMARKS

Coordinates and Elevation are approximate, based on hand-held Trimble Catalyst (Da2 antenna)

SO_4 = 0-0.09%

Switched to Odex at 7.6 m



DESCRIPTION

TOPSOIL, (approx. 100 mm thick)

SILT, sandy, light grey, damp

CLAY (TILL), some sand, trace gravel, low to medium plastic, very stiff, greyish brown, moist, trace oxidation, trace coal

- sandy to 3.7 m

- 25 mm thick sand seam at 6.0 m

- gravelly below 6.4 m

GRAVEL AND SAND, well graded, damp
- some clay to 7.3 m

ELEVATION (m)
1124
1123
1122
1121
1120
1119
1118
1117
1116
1115

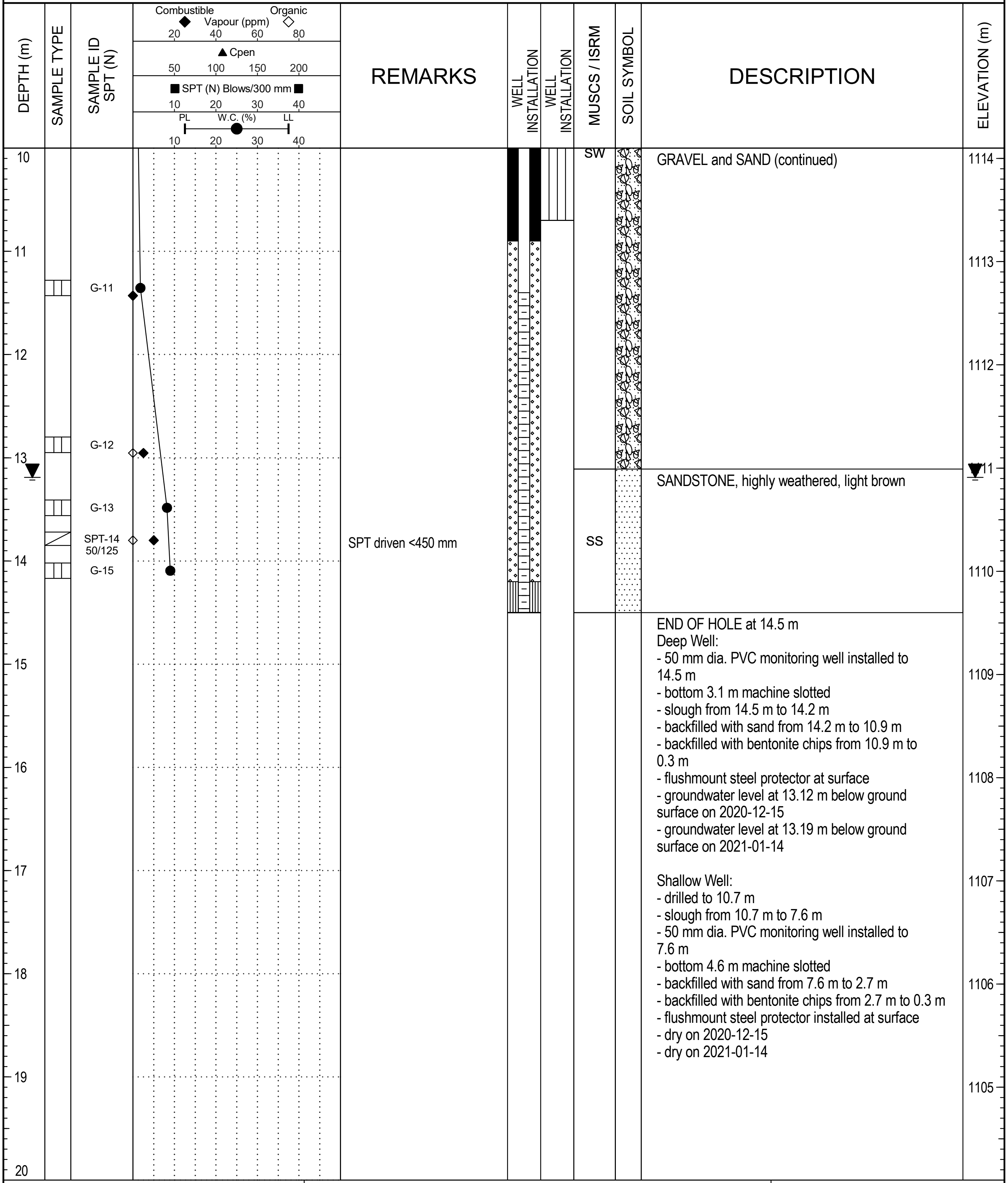
DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 14.5 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-09
INSPECTOR: AJE		Page 1 of 2

THURBER ENGINEERING LTD.

CLIENT: City of Calgary	PROJECT: Richmond Green Phase I/II ESA and Geotechnical Investigation	TEST HOLE NO: **TH20-5**
PROJECT NO: 30311	3TM 114° NAD 83, Northing: 5654184.4 m, Easting: -8996.7 m	ELEVATION: 1124.1 m

SAMPLE TYPE: ▥ Grab Sample ◪ Standard Penetration Test

BACKFILL TYPE: ■ Bentonite ⁙ Sand ▥ Slough



SPT driven <450 mm

GRAVEL and SAND (continued)

SANDSTONE, highly weathered, light brown

END OF HOLE at 14.5 m
Deep Well:
- 50 mm dia. PVC monitoring well installed to 14.5 m
- bottom 3.1 m machine slotted
- slough from 14.5 m to 14.2 m
- backfilled with sand from 14.2 m to 10.9 m
- backfilled with bentonite chips from 10.9 m to 0.3 m
- flushmount steel protector at surface
- groundwater level at 13.12 m below ground surface on 2020-12-15
- groundwater level at 13.19 m below ground surface on 2021-01-14

Shallow Well:
- drilled to 10.7 m
- slough from 10.7 m to 7.6 m
- 50 mm dia. PVC monitoring well installed to 7.6 m
- bottom 4.6 m machine slotted
- backfilled with sand from 7.6 m to 2.7 m
- backfilled with bentonite chips from 2.7 m to 0.3 m
- flushmount steel protector installed at surface
- dry on 2020-12-15
- dry on 2021-01-14

THURBER ENGINEERING LTD.

DRILLING CO.: Earth Drilling Co. Ltd.		
RIG TYPE: Diedrich D120 Track	COMPILED BY: CHN	COMPLETION DEPTH: 14.5 m
DRILL METHOD: Solid Stem Auger/ODEX	REVIEWED BY: MCL	COMPLETION DATE: 2020-12-09
INSPECTOR: AJE		

APPENDIX C

Laboratory Test Reports

THURBER ENGINEERING LTD.
Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8   T. (403) 253-9217   F. (403) 252-8159   www.thurber.ca

ATTERBERG LIMITS REPORT

Client: City of Calgary
Project: Richmond Green Geotechnical Investigation
Project No.: 30311

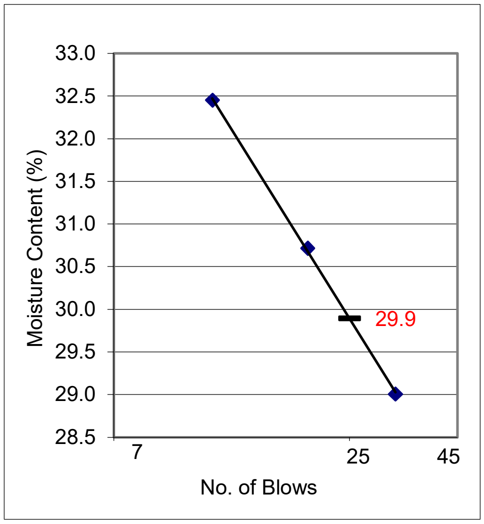
Date Tested: 11-Dec-20
Date Sampled: 08-Dec-20
Tested By: AMM

Sample Source:
Sample Location: TH20-1

Sample No.: G5
Series No.:
Depth: 12.5-13ft

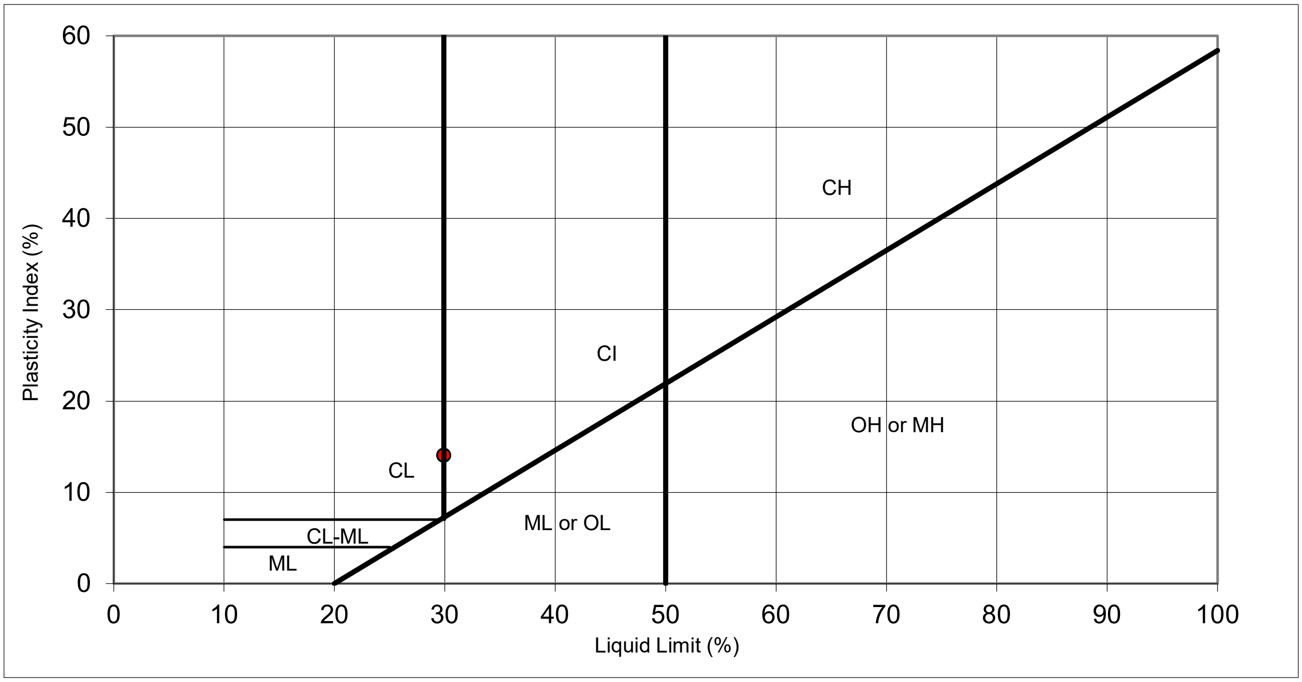
LIQUID LIMIT

Trial No.	1	2	3	4
No of Blows	32	20	12	
Container No.				
Wt. of Container - g	1.07	1.06	1.15	
Wet Soil + Container - g	11.21	10.89	12.70	
Dry Soil + Container - g	8.93	8.58	9.87	
Moisture Content (%)	29.0	30.7	32.5	



PLASTIC LIMIT

	1	2		AVERAGE
Container No.				
Wt. of Container - g	1.03	1.12		
Wet Soil + Container - g	5.64	5.43		
Dry Soil + Container - g	5.01	4.84		
Moisture Content (%)	15.8	15.9		**15.8**



Remarks:

Checked By:

Liquid Limit - %: **30**
Plastic Limit - %: **16**
Plasticity Index -%: **14**
Classification: **CL**

Tested in accordance with ASTM Designation D4318 unless otherwise noted

ATTERBERG LIMITS REPORT

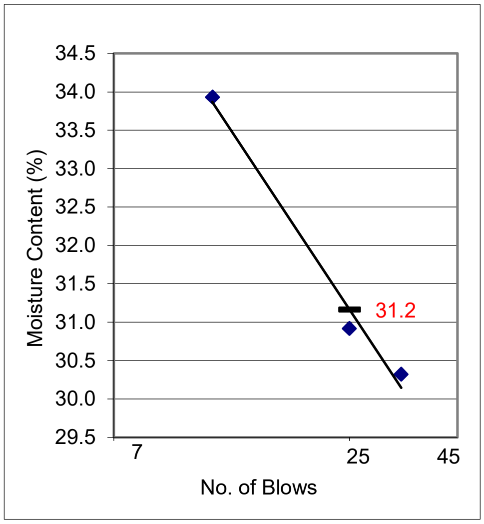
THURBER ENGINEERING LTD.
Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

Client:	City of Calgary	Date Tested:	16-Dec-20
Project:	Richmond Green Geotechnical Investigation	Date Sampled:	08-Dec-20
Project No.:	30311	Tested By:	RL

Sample Source:		Sample No.:	SPT5
Sample Location:	TH20-3	Series No.:	
		Depth:	10-11.5ft

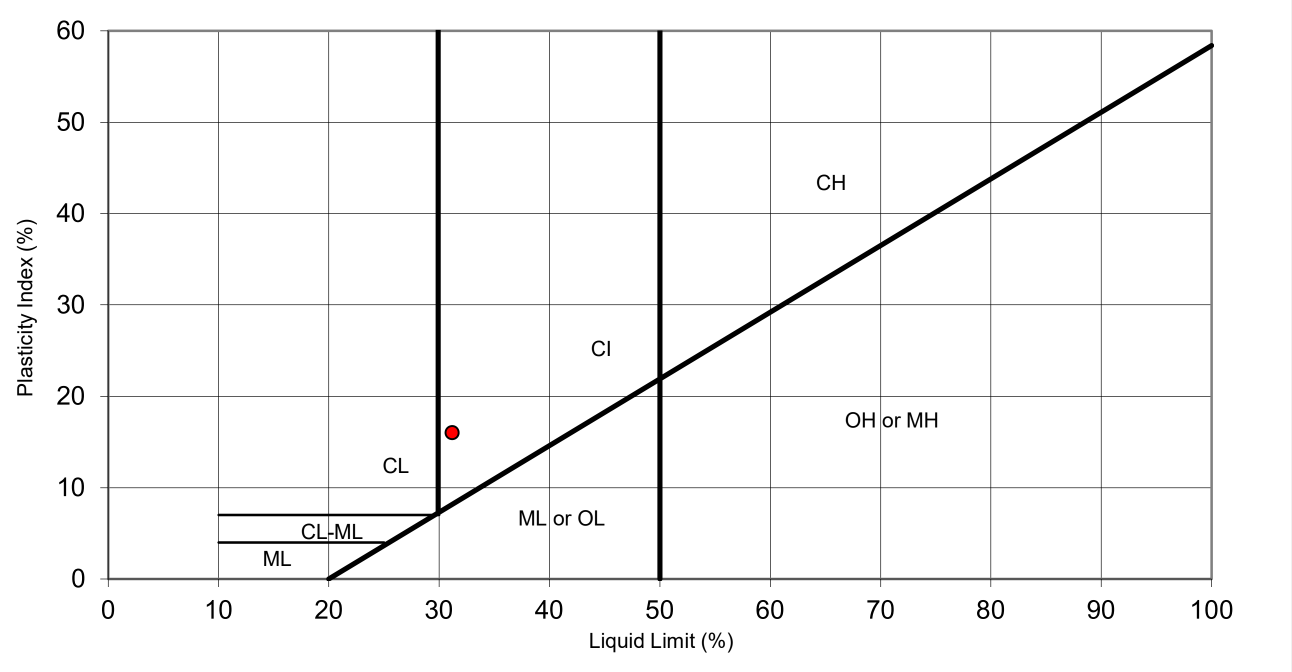
LIQUID LIMIT

Trial No.	1	2	3	4
No of Blows	33	25	12	
Container No.				
Wt. of Container - g	1.03	1.04	1.01	
Wet Soil + Container - g	24.54	23.44	28.48	
Dry Soil + Container - g	19.07	18.15	21.52	
Moisture Content (%)	30.3	30.9	33.9	



PLASTIC LIMIT

	1	2		AVERAGE
Container No.				
Wt. of Container - g	1.04	1.03		
Wet Soil + Container - g	6.37	6.57		
Dry Soil + Container - g	5.68	5.83		
Moisture Content (%)	14.9	15.4		**15.1**



Remarks:

Checked By:

Liquid Limit - %:	31
Plastic Limit - %:	15
Plasticity Index -%:	16
Classification:	CI

Tested in accordance with ASTM Designation D4318 unless otherwise noted

THURBER ENGINEERING LTD.
Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

ATTERBERG LIMITS REPORT

Client: City of Calgary
Project: Richmond Green Geotechnical Investigation
Project No.: 30311

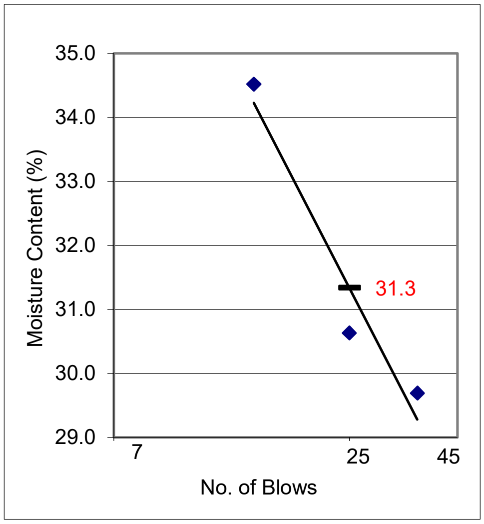
Date Tested: 16-Dec-20
Date Sampled: 08-Dec-20
Tested By: RL

Sample Source:
Sample Location: TH20-5

Sample No.: G3
Series No.:
Depth: 7-7.5ft

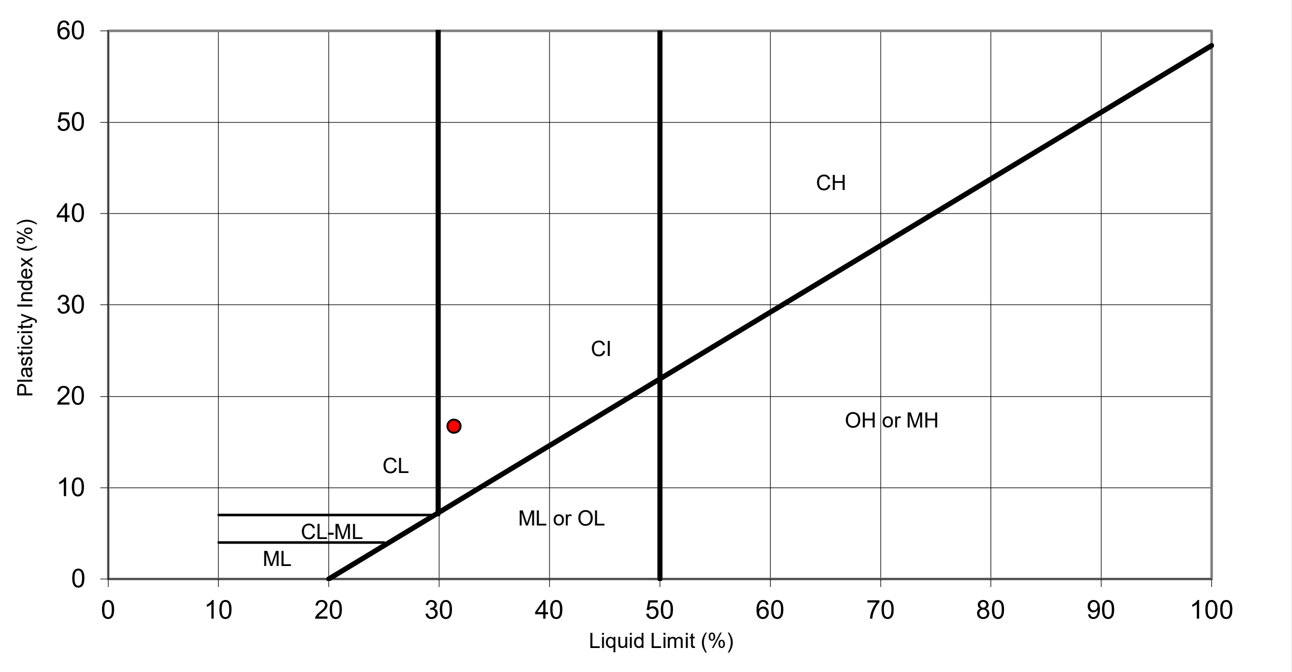
LIQUID LIMIT

Trial No.	1	2	3	4
No of Blows	36	25	15	
Container No.				
Wt. of Container - g	1.08	1.08	1.08	
Wet Soil + Container - g	21.13	28.33	25.20	
Dry Soil + Container - g	16.54	21.94	19.01	
Moisture Content (%)	29.7	30.6	34.5	



PLASTIC LIMIT

	1	2		AVERAGE
Container No.				
Wt. of Container - g	1.05	1.04		
Wet Soil + Container - g	6.03	6.87		
Dry Soil + Container - g	5.40	6.12		
Moisture Content (%)	14.5	14.8		14.6



Remarks:

Checked By:

Liquid Limit - %:	31
Plastic Limit - %:	15
Plasticity Index -%:	17
Classification:	CI

Tested in accordance with ASTM Designation D4318 unless otherwise noted

Thurber Engineering Ltd.
ATTN: LINDSEY BLAINE
#180, 7330 FISHER ST SE
CALGARY AB T2H 2H8

Date Received:	12-DEC-20
Report Date:	21-DEC-20 14:29 (MT)
Version:	FINAL

Client Phone: 403-253-9217

Certificate of Analysis

Lab Work Order #: L2539871

Project P.O. #:	NOT SUBMITTED
Job Reference:	30311
C of C Numbers:	17-852304
Legal Site Desc:	Richmond Green

Dhaliwal

Inayat Dhaliwal
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2539871-1 TH20-2 @ 7.5FT							
Sampled By: LRB on 10-DEC-20							
Matrix: Soil							
Total Carbon, TOC and TIC in soil							
Total Organic Carbon Calculation							
Total Organic Carbon	1.75		0.88	%		21-DEC-20	
Organic Matter by LOI at 375 deg C.							
Organic Matter	<1.0		1.0	%	18-DEC-20	21-DEC-20	R5320085
Loss on Ignition @ 375 C	<1.0		1.0	%	18-DEC-20	21-DEC-20	R5320085
L2539871-2 TH20-4 @ 5FT							
Sampled By: LRB on 09-DEC-20							
Matrix: Soil							
Total Carbon, TOC and TIC in soil							
Total Organic Carbon Calculation							
Total Organic Carbon	1.22		0.73	%		21-DEC-20	
Organic Matter by LOI at 375 deg C.							
Organic Matter	1.0		1.0	%	18-DEC-20	21-DEC-20	R5320085
Loss on Ignition @ 375 C	<1.0		1.0	%	18-DEC-20	21-DEC-20	R5320085
L2539871-3 TH20-5 @ 2.5FT							
Sampled By: LRB on 10-DEC-20							
Matrix: Soil							
Total Carbon, TOC and TIC in soil							
Total Organic Carbon Calculation							
Total Organic Carbon	1.9		1.0	%		21-DEC-20	
Organic Matter by LOI at 375 deg C.							
Organic Matter	2.4		1.0	%	18-DEC-20	21-DEC-20	R5320085
Loss on Ignition @ 375 C	2.7		1.0	%	18-DEC-20	21-DEC-20	R5320085

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-TIC-PCT-SK	Soil	Total Inorganic Carbon in Soil	CSSS (2008) P216-217

A known quantity of acetic acid is consumed by reaction with carbonates in the soil. The pH of the resulting solution is measured and compared against a standard curve relating pH to weight of carbonate.

ALS Test Code	Matrix	Test Description	Method Reference**
C-TOC-CALC-SK	Soil	Total Organic Carbon Calculation	CSSS (2008) 21.2

Total Organic Carbon (TOC) is calculated by the difference between total carbon (TC) and total inorganic carbon. (TIC)

ALS Test Code	Matrix	Test Description	Method Reference**
C-TOT-LECO-SK	Soil	Total Carbon by combustion method	CSSS (2008) 21.2

The sample is ignited in a combustion analyzer where carbon in the reduced CO2 gas is determined using a thermal conductivity detector.

ALS Test Code	Matrix	Test Description	Method Reference**
IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO3 Equivalent	Calculation
OM-LOI-SK	Soil	Organic Matter by LOI at 375 deg C.	CSSS (1978) p. 160

The dry-ash method involves the removal of organic matter by combustion at 375 degrees C for a minimum of 16 hours. Samples are dried prior to combustion.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA

Chain of Custody Numbers:

17-852304

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L2539871 Report Date: 21-DEC-20 Page 1 of 2

Client: Thurber Engineering Ltd.
#180, 7330 FISHER ST SE
CALGARY AB T2H 2H8

Contact: LINDSEY BLAINE

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
C-TIC-PCT-SK	**Soil**							
Batch R5319447								
WG3463092-1 DUP		**L2539871-1**						
Inorganic Carbon		2.67	2.65		%	0.7	20	18-DEC-20
WG3463092-4 IRM		**08-109_SOIL**						
Inorganic Carbon			102.7		%		80-120	18-DEC-20
WG3463092-2 LCS		**0.5**						
Inorganic Carbon			96.8		%		90-110	18-DEC-20
WG3463092-3 MB								
Inorganic Carbon			<0.050		%		0.05	18-DEC-20
C-TOT-LECO-SK	**Soil**							
Batch R5320027								
WG3462455-2 IRM		**08-109_SOIL**						
Total Carbon by Combustion			97.8		%		80-120	18-DEC-20
WG3462455-4 LCS		**SULFADIAZINE**						
Total Carbon by Combustion			101.7		%		90-110	18-DEC-20
WG3462455-3 MB								
Total Carbon by Combustion			<0.05		%		0.05	18-DEC-20
OM-LOI-SK	**Soil**							
Batch R5320085								
WG3463762-3 IRM		**SAL2001**						
Organic Matter			95.8		%		80-120	21-DEC-20
Loss on Ignition @ 375 C			95.2		%		80-120	21-DEC-20
WG3463762-2 MB								
Organic Matter			<1.0		%		1	21-DEC-20
Loss on Ignition @ 375 C			<1.0		%		1	21-DEC-20

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

THURBER

APPENDIX D

Table D1 - Soil Sample Moisture Content Summary

Table D1. Richmond Green Geotechnical Investigation - Soil Sample Moisture Content Summary

Test Hole	Depth (m)	Water Content (%)	Test Hole	Depth (m)	Water Content (%)
TH20-1	0.76	2.4	TH20-3	0.30	5.2
TH20-1	1.52	13.6	TH20-3	0.91	19.2
TH20-1	2.13	12.3	TH20-3	1.52	15.7
TH20-1	3.05	11.6	TH20-3	2.29	15.0
TH20-1	3.81	15.0	TH20-3	3.05	21.0
TH20-1	4.57	17.3	TH20-3	3.81	19.1
TH20-1	5.18	17.5	TH20-3	5.18	18.7
TH20-1	6.10	17.7	TH20-3	6.10	18.9
TH20-1	6.71	15.9	TH20-3	6.86	20.5
TH20-1	7.32	12.4	TH20-3	8.23	2.1
TH20-1	7.62	12.7	TH20-3	11.28	2.0
TH20-1	9.75	6.4	TH20-3	12.80	13.7
TH20-1	12.95	1.1	TH20-3	13.40	12.4
TH20-1	15.85	5.7	TH20-4	0.76	11.3
TH20-1	19.20	15.3	TH20-4	1.52	20.7
TH20-1	19.81	35.5	TH20-4	2.29	19.6
TH20-2	0.76	4.6	TH20-4	3.05	16.8
TH20-2	1.52	15.0	TH20-4	3.81	17.0
TH20-2	1.98	7.9	TH20-4	5.18	11.8
TH20-2	2.29	16.6	TH20-4	6.10	8.6
TH20-2	3.05	15.8	TH20-4	6.55	13.8
TH20-2	3.66	20.3	TH20-4	8.23	1.9
TH20-2	3.96	17.8	TH20-4	11.28	3.0
TH20-2	5.18	22.1	TH20-4	12.95	12.3
TH20-2	6.10	21.1	TH20-5	0.76	11.7
TH20-2	6.86	15.3	TH20-5	1.52	15.9
TH20-2	8.23	20.4	TH20-5	2.13	14.7
TH20-2	9.14	21.0	TH20-5	3.05	18.1
TH20-2	9.60	17.1	TH20-5	3.81	20.9
TH20-2	11.28	0.9	TH20-5	5.18	16.2
TH20-2	12.95	1.6	TH20-5	6.10	12.2
TH20-2	14.33	9.4	TH20-5	8.23	0.7
TH20-2	15.24	12.2	TH20-5	11.28	1.8
TH20-2	15.85	12.4	TH20-5	13.41	8.2
TH20-2	16.46	12.5	TH20-5	14.02	9.0