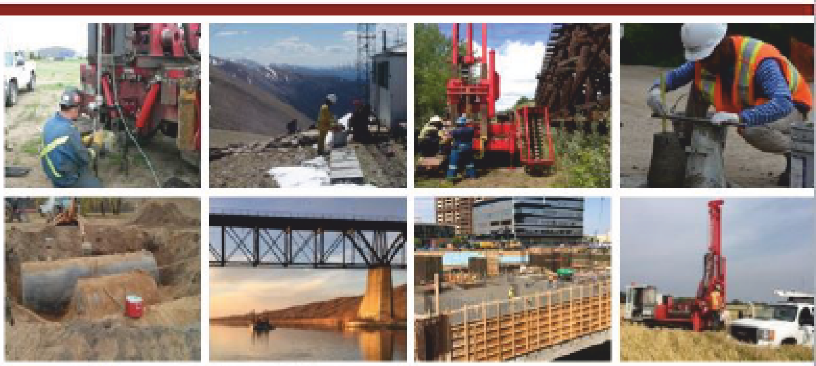
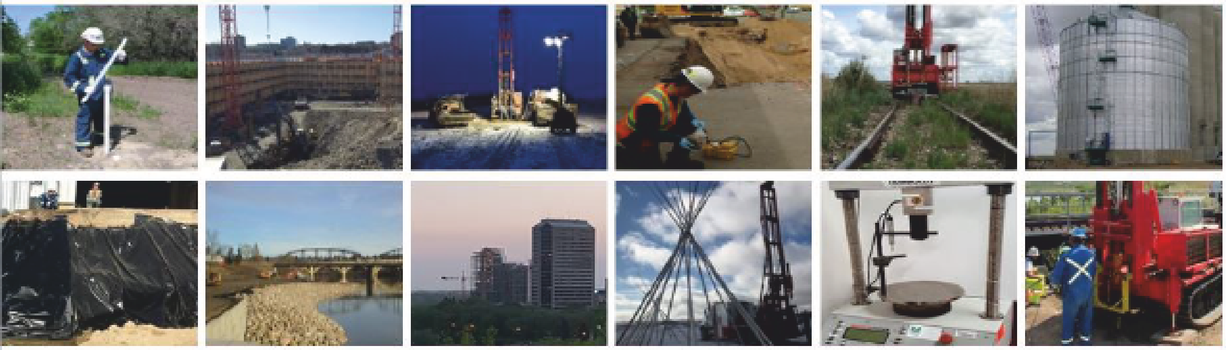
GEOTECHNICAL INVESTIGATION

GEOTECHNICAL INVESTIGATION
PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION
SOUTH OF SASKATOON, SASKATCHEWAN

PMEL FILE NO. 18682
FEBRUARY 7, 2022





PREPARED FOR:
102015575 Saskatchewan Ltd. C/O BCL Engineering Ltd.

ATTENTION: Mr. Darren Hagen / Matt Scott, P. Eng.

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PROJECT:	Geotechnical Investigation Proposed Edgemont Estates East Residential Subdivision South of Saskatoon, Saskatchewan PMEL File No. 18682 February 7, 2022
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1 INTRODUCTION

1.1 GENERAL

The following report has been prepared on the subsurface soil conditions existing at the site of the proposed Edgemont Estates East residential subdivision to be constructed south of Saskatoon, Saskatchewan.

The terms of reference for this investigation were presented in P. Machibroda Engineering Ltd. (PMEL) Proposal No. 18682 dated October 22, 2021. Written authorization to proceed with this investigation was provided in the signed Consulting Agreement between 102015575 Saskatchewan Ltd. (Darren Hagen) and PMEL, dated October 29, 2021.

1.2 SITE LOCATION

The subject site is located just south of Saskatoon, Saskatchewan. The site is bound by Grasswood Road/low density residential development to the north, Range Road 3052/agricultural land to the east, low density residential development to the west and agricultural land to the south.

The study area is relatively flat-lying with a gradual slope to the west; the elevations at our test locations ranged from about 502 to 508 m. A Site Plan showing the location of the study area and test locations has been shown on Drawing No. 18682-1.

2 FIELD INVESTIGATION

The field test drilling, soil sampling, piezocone penetration testing (CPTu) and monitoring well installation was conducted between November 26 and 30, 2021. Groundwater monitoring was conducted on December 16, 2021 and January 10, 2022.

The coordinates and ground surface elevation at each test location were provided by BCL Engineering Ltd.

2.1 FIELD DRILLING PROGRAM

Twenty boreholes, located as shown on the Site Plan, Drawing No. 178682-1, were dry drilled using our truck-mounted, continuous flight auger drilling rig. The boreholes were 150 mm in diameter and extended to depths of 3 to 6 m below the existing ground surface.

Borehole logs, as shown on Drawing Nos. 18682-2 to 21, inclusive, were compiled during test drilling to record the soil stratification, the groundwater conditions, the position of unstable sloughing soils and the depths at which cobblestones and/or boulders were encountered.

Disturbed samples of auger cuttings, collected during test drilling, were sealed in plastic bags to minimize moisture loss. The soil samples were taken to our laboratory for analysis.

2.2 PIEZOCONE PENETRATION TESTING

Four CPTu's, located as shown on the Site Plan, Drawing No. 18682-1, were conducted during the field investigation. The CPTu soundings were extended to depths of 18.4 to 18.6 m below existing ground surface.

The piezocone penetration tests consisted of pushing a cone, on the end of a series of rods, into the ground at a constant rate while near continuous measurements were recorded at the cone tip (i.e., q_t). Local side friction resistance measurements (i.e., f_s) were recorded on a friction sleeve located directly behind the cone tip. Pore-water pressure response (u) generated from the advancement of the cone into the soil was measured via a pore pressure filter located between the cone tip and friction sleeve. The piezocone tip had an apex angle of 60° and a 15 cm^2 base area. The friction sleeve had a perimeter area of 225 cm^2.

The equipment and procedures for conducting the cone penetration testing were undertaken in accordance with ASTM D-5778, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Testing of Soils".

The test plots recorded during the cone soundings have been presented in Appendix B.

3 SOIL AND GROUNDWATER CONDITIONS

3.1 SOIL PROFILE

The general soil profile consisted of organic topsoil (100 to 300 mm) overlying predominantly sand (in sixteen of the twenty boreholes; silt was encountered surficially in the remaining four boreholes), followed by variable deposits of silt, sand and clay to a depth of at least 18.7 m, the maximum depth investigated. The sand was loose to compact, poorly graded, fine grained and moist initially, becoming wet below the groundwater table. The silt was firm to stiff, low to medium plastic and moist to wet. The clay deposits were firm to very stiff, medium to highly plastic and moist.

3.2 GROUNDWATER CONDITIONS, SLOUGHING

Groundwater seepage and sloughing conditions were encountered during test drilling. The depths at which groundwater seepage and sloughing conditions were encountered have been shown on the borehole logs. A summary of the groundwater levels recorded in the monitoring wells installed during this investigation has been presented in Table I.

TABLE I RECORDED GROUNDWATER LEVELS

Borehole No.	Monitoring Well Rim Elevation (m)	Ground Surface Elevation (m)	Groundwater Depth (m)		Groundwater Elevation (m)	
			Dec. 16/21	Jan. 10/22	Dec. 16/21	Jan. 10/22
21-2	506.66	505.61	2.48	2.49	503.13	503.12
21-4	505.60	504.89	DRY (>2.8)	DRY (>2.8)	DRY (<502.09)	DRY (<502.09)

TABLE I RECORDED GROUNDWATER LEVELS (CONTINUED)...

Borehole No.	Monitoring Well Rim Elevation (m)	Ground Surface Elevation (m)	Groundwater Depth (m)		Groundwater Elevation (m)	
			Dec. 16/21	Jan. 10/22	Dec. 16/21	Jan. 10/22
21-6	504.61	503.51	2.25	2.27	501.26	501.24
21-10	508.41	507.33	2.82	2.82	504.51	504.51
21-12	507.02	505.98	DRY (>3.6)	DRY (>3.6)	DRY (<503.42)	DRY (<503.42)
21-14	505.39	504.36	DRY (>3.0)	DRY (>3.0)	DRY (<501.36)	DRY (<501.36)
21-17	504.84	503.77	3.79	3.82	499.98	499.95
21-20	504.96	503.92	2.98	2.96	500.94	500.96

Upon review of Table I, the groundwater table was recorded at a depth of 2.27 to 3.82 m below existing grade on January 10, 2021 (elevation of 499.95 to 504.51 m). Groundwater levels should be expected to fluctuate seasonally by as much as 1 m (with the highest groundwater level in the spring and/or during/following spring thaw and/or periods of precipitation).

A groundwater contour map (interpreted/estimated groundwater levels as of January 10, 2022) has been shown plotted on Drawing No. 18682-1A.

3.3 COBBLESTONES AND BOULDERS

Cobblestones and/or boulders were not encountered within the depth of exploration.

4 LABORATORY ANALYSIS

The soil classification and index tests performed during this investigation consisted of a visual classification of the soil, moisture contents, Atterberg limits, unit weights, water-soluble sulphate contents and grain size distribution analysis.

The results of the soil classification and index tests conducted on representative samples of soil have been plotted on the drill logs alongside the corresponding depths at which the samples were recovered, as shown on Drawing Nos. 18682-2 to 21, inclusive.

The results of grain size distribution analyses have been shown plotted in Appendix C.

5 DESIGN RECOMMENDATIONS

Based on the foregoing outline of soil test results, the following foundation considerations and design recommendations have been presented.

5.1 DESIGN CONSIDERATIONS

It is understood that the subdivision will encompass an area of 161 acres and will consist of 127 residential lots with associated roadways/buried utilities.

The subsurface soil conditions consisted predominantly of sand (silt at some locations) overlying variable deposits of silt, clay and sand. The groundwater table was recorded at a depth of 2.27 to 3.82 m below existing grade on January 10, 2021 (elevation of 499.95 to 504.51 m). Groundwater levels should be expected to fluctuate seasonally by as much as 1 m (with the highest groundwater level in the spring and/or during/following spring thaw and/or periods of precipitation).

It is understood that houses, garages and decks will be constructed within the proposed subdivision. It is anticipated that basements will preferably be constructed (where feasible). Where basement construction is not feasible due to high groundwater conditions, structural floors over (shallower) crawlspaces or at-grade structures with grade-supported concrete slabs are recommended.

To minimize the potential for groundwater-related issues, all basements/crawlspaces should be based at least 1 m above the groundwater table (refer to Drawing No. 18682-1A for a groundwater elevation contour map). Existing topographical information along with future site grading plans should be used to determine whether or not basements/crawlspaces are feasible and to determine where structures should be situated within given lots to satisfy the groundwater clearance criteria.

The subgrade soils are frost susceptible and the potential depth of frost penetration could range from about 2 to 3 m, depending on surface cover and severity of the winter.

Footings or concrete raft foundations should be viable foundation alternatives for the anticipated structures within the proposed subdivision. The magnitude of frost-related differential movements can be reduced by ensuring adequate site/foundation drainage and utilizing strategically placed extruded polystyrene insulation adjacent to the foundations.

A deep foundation system consisting of helical screw piles is expected to be the most practical/economical deep foundation alternative for the anticipated structures to be constructed within the proposed subdivision.

Recommendations have been prepared for site preparation; excavations and dewatering; site classification for seismic site response; limit states resistance factors and serviceability; footings; concrete raft foundations; deep foundations; foundation drainage; foundation walls; floors; foundation concrete; and, traffic structures.

5.2 SITE PREPARATION

All trees, vegetation, roots, organic topsoil and deleterious materials should be removed from the construction area. Topsoil thicknesses ranging from 100 to 300 mm were encountered in our boreholes during test drilling. Due to the large aerial extent of the site, deeper thicknesses of topsoil may be encountered, particularly in vegetated or low-lying areas. Staining and root intrusion from the overlying organic material and roots may be encountered during excavation within the subsurface mineral soils.

If these conditions are suspected, a representative of the Geotechnical Consultant should inspect the site during excavation to verify the depth of organic topsoil which should be removed in preparation of the site for construction. Additional information regarding topsoil composition and soil structure is presented in Appendix D.

The general intent of initial site preparation is to make the subgrade suitably stable for construction activities. It is recommended that the subgrade soils within the development footprint are compacted to the below specified densities.

Building Areas	96 percent standard Proctor density at optimum moisture content;
Traffic Areas	100 percent standard Proctor density at optimum moisture content;
Landscape Areas	90 percent standard Proctor density at optimum moisture content.

Soils which meet the required compaction level should be stable to support construction activities. It is anticipated that conventional site preparation (scarifying, moisture conditioning and re-compacting the soils) will suffice at this site. Soils which are unstable during site preparation and fail to achieve the required compaction will require additional treatment, which may include: over-excavation and replacement and/or geosynthetic stabilization. The need for additional treatment should be reviewed by the Geotechnical Consultant during the field construction with respect to the actual conditions and project requirements.

In areas with variable subgrade soils, proof rolling may be an acceptable alternative to density testing and should be reviewed by the Geotechnical Consultant.

Fill, required to bring the subgrade surface to the design elevation in construction areas, should preferably consist of imported granular material, locally available sand or non-expansive fine-grained soil (i.e., low to medium plastic). All proposed subgrade fill should be approved by the Geotechnical Consultant prior to placement. The fill should be placed in thin lifts (maximum 150 mm loose) and uniformly compacted to 96 percent of standard Proctor density at optimum moisture content.

Excavations are susceptible to settlement and should be adequately backfilled and compacted. The magnitude of settlement is directly related to the level of compaction of the backfill material. Well compacted fills will settle a small percentage of the fill thickness whereas poorly compacted fills can settle appreciably, particularly if frozen soils are incorporated in the backfill. Efforts should be made to meet the specified compaction level in areas sensitive to settlement.

The site should be graded to provide positive site drainage away from all work areas and structures prior to, during and following construction.

5.3 EXCAVATIONS AND DEWATERING

Temporary excavations should be designed and excavated in accordance with current Saskatchewan Occupational Health and Safety Regulations. The Contractor is solely responsible for protecting the excavation by shoring, sloping, benching and/or other means as required to maintain the stability of both the excavation sides and the bottom.

The groundwater table was recorded at a depth of 2.27 to 3.82 m below existing grade on January 10, 2021 (elevation of 499.95 to 504.51 m). Groundwater levels should be expected to fluctuate seasonally by as much as 1 m (with the highest groundwater level in the spring and/or during/following spring thaw and/or periods of precipitation).

Excavation below the water table should be avoided wherever practical. Excavations below the groundwater table will encounter construction difficulties associated with groundwater seepage and sloughing conditions, particularly where saturated sand/silt soils are encountered (these soils will flow into excavations). De-watering of the excavations will be required during construction. De-watering should be conducted over the time period for which the excavations are left open. A sump (or multiple sumps, if required) should be set up at the deepest excavation points and the floor of the excavation sloped to the sump(s) to handle groundwater seepage and precipitation runoff. A self-actuated sump pump(s) should be operated on a continuous basis and should be discharged well away from the excavations. If conventional dewatering methods are ineffective, dewatering wells may be required.

Sideslopes should be no steeper than 1.5H : 1V above the groundwater table and no steeper than 3H : 1V to 4H : 1V below the groundwater table (as measured from the bottom of the excavation). Slope flattening will be required if unstable conditions are encountered during excavation. Continuous visual monitoring of the sideslopes should be undertaken to assess whether flatter sideslopes are required to maintain stability.

The stability of the excavation will be affected by wetting and drying of the exposed excavation walls, the length of time that the excavation remains open and the consistency and structure of the subgrade soils.

Excavated soil should be stockpiled away from the crest of the excavation to minimize potential sloughing of the excavation walls due to the soil surcharge loading. Similarly, equipment and construction materials should also be placed away from the crest of the excavation.

Depending on lateral constraints, excavations at this site may be completed with unbraced, sloped side walls. If there is insufficient room for excavation cuts, due to close proximity to other structures, then a temporary shoring system would be required.

5.4 SITE CLASSIFICATION FOR SEISMIC SITE RESPONSE

Based on the consistency of the subgrade soils encountered at the subject site and Table 4.1.8.4A of the 2015 National Building Code, the site classification for seismic site response falls within Class D.

5.5 LIMIT STATES RESISTANCE FACTORS AND SERVICEABILITY

The National Building Code of Canada (NBCC, 2015) requires the use of limit states design for the design of buildings and their structural components, including the design of shallow and deep foundations.

It is expected that the designer is familiar with the limit states design method and only a brief discussion will be presented. For a detailed discussion, it is recommended to review the NBCC (2015) and/or the Canadian Foundation Engineering Manual (CFEM, 2006).

Limit states are defined as those conditions under which a structure ceases to fulfill the function for which it was designed (i.e., unsatisfactory performance). In limit states design, two conditions are assessed with respect to performance, these are:

- ultimate limit states (ULS), and
- serviceability limit states (SLS)

Ultimate limit states are concerned with the collapse mechanisms of the structure (i.e., safety), whereas serviceability limit states consider mechanisms that restrict or constrain the intended use, function or occupancy of the structure.

As per NBCC (2015), the factored soil resistance utilized for foundation design may be determined using the following resistance factors applied to the ultimate resistance values presented in the following subsections of the report.

Shallow foundations:

- Compressive Resistance, $\Phi = 0.5$
- Sliding, Based on Friction ($c=0$), $\Phi= 0.8$

Deep foundations:

- Compressive Resistance, $\Phi = 0.4$
- Tensile Resistance, $\Phi = 0.3$

The above resistance factors have been provided to reflect that semi-empirical methods were used to derive the soil bearing resistances presented in this report using the laboratory and in-situ data collected during this investigation.

To satisfy serviceability limit states, a settlement analysis of the foundation must also be evaluated to ensure the structures are not negatively impacted by excessive settlement at the design load. Estimated foundation settlements have been provided in Sections 5.6, 5.7 and 5.8.2.

Piles exposed to lateral loads are typically designed to restrict lateral deflection of the pile head to tolerable limits. Lateral pile head deflection can be determined using the concepts presented in Section 5.8.3.

5.6 FOOTINGS

A footing foundation based within naturally deposited, undisturbed soil above the elevation of the groundwater table should perform satisfactorily. If the foundation is constructed during freezing conditions, the subgrade soil at the design footing elevation must be protected from freezing. If it is not practical to keep the subgrade from freezing then a deep foundation system should be constructed.

To minimize the potential for groundwater-related issues, all basements/crawlspaces should be based at least 1 m above the groundwater table (refer to Drawing No. 18682-1A for a groundwater elevation contour map). It is recommended that groundwater monitoring be conducted following spring thaw, as groundwater levels will be higher at that time and will likely better represent potential long-term groundwater levels. Existing topographical information along with future site grading plans should be used to determine whether or not basements/crawlspaces are feasible, to determine where structures should be situated within given lots to satisfy the groundwater clearance criteria and to determine at what depths footings should be based. Based on existing topography, full-depth basements will be feasible at some locations whereas basements/crawlspaces may not be feasible at other locations (unless site grading/filling is completed).

The following minimum recommendations should be incorporated into the design of a footing foundation. The recommendations are applicable to footings supporting vertical concentric loading only; footings subject to eccentric/unbalanced loading will require additional assessment.

1. Footings should be founded on naturally deposited, undisturbed soil (footings shall not be based on fill unless approved by the Geotechnical Consultant).

2. For permanently heated, at-grade structures (i.e., no basement or crawlspace), the footings should be based at a minimum depth of 1.8 m below finished grade. Where a heated basement or crawl-space is constructed, footings should be based at a minimum depth of 1.2 m below finished grade. These minimum depths are applicable only where the building envelope insulation is designed to allow heat loss to the foundation. If insulation is placed beneath the floor slab, an uninsulated strip width of at least 1 m is recommended adjacent to all exterior grade beams/foundation caps to allow for heat loss to the foundation. In unheated areas and/or where heat loss from the building to the foundation is not allowed, footings should be based below the potential depth of frost penetration (i.e., 3 m) or protected against frost action with strategically placed extruded polystyrene insulation.

3. If site topography/groundwater conditions do not allow for the construction of footings that meet the criteria outlined in point 2 above, the footings should be protected from frost action using extruded polystyrene insulation. Footing depths will vary within the subdivision depending on local topography and groundwater conditions, but all footings should be based at a minimum depth of 0.75 m below finished ground surface. The extents and thickness of insulation necessary to protect the foundation from frost will depend on heat-loss effects from the overlying building. In all cases, a continuous layer of insulation should be placed over the exterior face of the foundation wall/grade beam, extending vertically a minimum of 300 mm above grade. The lateral section of insulation should be based a minimum of 300 mm below finished grade to provide protection from damage and positively sloped to promote drainage away from the foundation. Suggested recommendations for insulation thickness/length have been summarized below (heat loss to the foundations must be allowed, as discussed above).

    - For footings supporting continually heated structures (heated to at least 18˚C year-round), the insulation should be a minimum of 50 mm in thickness and should extend laterally a minimum of 1.8 m beyond the perimeter of the footing foundation.

- For footings supporting continually heated structures (heated to a nominal temperature of at least 7°C year-round), the insulation should be a minimum of 75 mm in thickness and should extend laterally a minimum of 2.4 m beyond the perimeter of the footing foundation.
- For footings supporting unheated structures or seasonally heated structures, the insulation should be a minimum of 125 mm in thickness and should extend laterally a minimum of 2.4 m beyond the perimeter of the footing foundation. In this case, the insulation will need to be placed on all sides of the foundations rather than just the external face and the supported walls must have an insulated layer directly above the foundation wall/grade beam to prevent frost from short-circuiting through the wall.
- In all cases, the thickness and lateral extent of the insulation should be increased by 1/3 (33 percent) at the building corners.
- If insulation is not utilized, frost-related movements should be expected and must be accepted to the Owner.

4. Footings based on naturally deposited, undisturbed soil may be designed to exert an unfactored ULS bearing pressure of 250 kPa and an SLS bearing pressure of 65 kPa (to limit settlements to less than 25 mm). A maximum spread footing dimension of 1.5 m and a maximum strip footing width of 1 m was considered to determine the SLS bearing pressure; for larger footing sizes, an updated settlement analysis will be required.

5. A representative of the Geotechnical Consultant should inspect the footing excavations prior to construction of the footings to verify that adequate soil conditions exist. After inspection, placement of a mud slab or well compacted layer of crushed granular base course material (minimum 75 mm thickness) over the prepared foundation level is recommended to provide protection from disturbance.

6. A minimum strip footing width of 500 mm is recommended. A minimum dimension of 1,000 mm is recommended for square and rectangular footings.

7. If the subgrade soil is disturbed during excavation below the design depth, then the disturbed soil should be removed to an undisturbed, level surface. Fill, required to raise the subgrade elevation to the underside of the footings, should be concrete

8. Footings should not be constructed on desiccated, frozen or wet subgrade soil. Frost should not be allowed to penetrate beneath the footings prior to, during or after construction.

9. The finished grade should be landscaped to provide for positive site drainage away from the structure.

5.7 CONCRETE RAFT FOUNDATIONS

The following minimum recommendations should be incorporated into the design of a reinforced concrete raft foundation. Conceptual raft foundation details have been shown on Figure No. 1.

1. All deleterious and organic material should be removed from the raft footprint. After removal of any unsuitable material and/or overexcavation required to reach the design subgrade level, scarify and compact the surface of the subgrade to 96 percent of standard Proctor density at optimum moisture content.

2. Overexcavate and replace soft areas with structural granular fill placed and compacted in thin lifts (150 mm loose) to 96 percent of standard Proctor density at optimum moisture content. High-strength geogrid/geotextile may be required to provide soil stabilization and separation where soft/wet/loose soil conditions are encountered. The need for special measures (i.e., over-excavation, geotextile, geogrid, and/or additional gravel fill) in soft/wet/loose areas must be subject to review by the Geotechnical Consultant during field construction.

3. Subgrade fill, if required, should preferably consist of locally available sand soils or imported granular fill, placed in thin lifts (maximum 150 mm loose) and compacted to 96 percent of standard Proctor density at optimum moisture content.

4. If possible, grade the subgrade surface to promote drainage to the outer edges of the foundation (allowing overland drainage away from the foundation) with a minimum cross slope of 5 percent.

5. A minimum of 300 mm of granular base course fill is recommended beneath the underside of the raft (Saskatchewan Ministry of Highways and Infrastructure Type 33 aggregate or approved equivalent). The granular fill should extend laterally away from the edge of the raft a distance at least equal to the fill thickness. The granular fill should be placed in thin lifts (maximum 150 mm loose) and compacted to 98 percent of standard Proctor density at optimum moisture content.

6. The slab thickenings, bearing on compacted granular fill over the prepared subgrade soil, may be designed to exert an unfactored ULS bearing pressure of 250 kPa. The SLS bearing pressure to limit foundation settlements to 25 mm or less is 65 kPa. The estimated settlement is based on typical slab thickening dimensions of 1 m or less. If a lesser settlement is required and/or larger slab thickening dimension will be constructed, PMEL should be re-evaluate the recommended SLS bearing capacity.

7. Extruded polystyrene insulation is recommended alongside the thickened edge foundation to minimize potential movements due to frost. The insulation should be placed adjacent to the foundation and should be positively sloped to direct water away from the foundation. For heated buildings, a vertical sheet of insulation should also be placed above the horizontal insulation, extending up to the insulated exterior wall. For unheated structures, the insulation should extend beneath the entire floor slab area. Recommended insulation details (thickness, extents etc.) have been shown on Figure I. If insulation is not utilized, frost-related movements should be expected and must be accepted to the Owner.

FIGURE 1A:
GENERAL INSULATED FOUNDATION CONCEPT

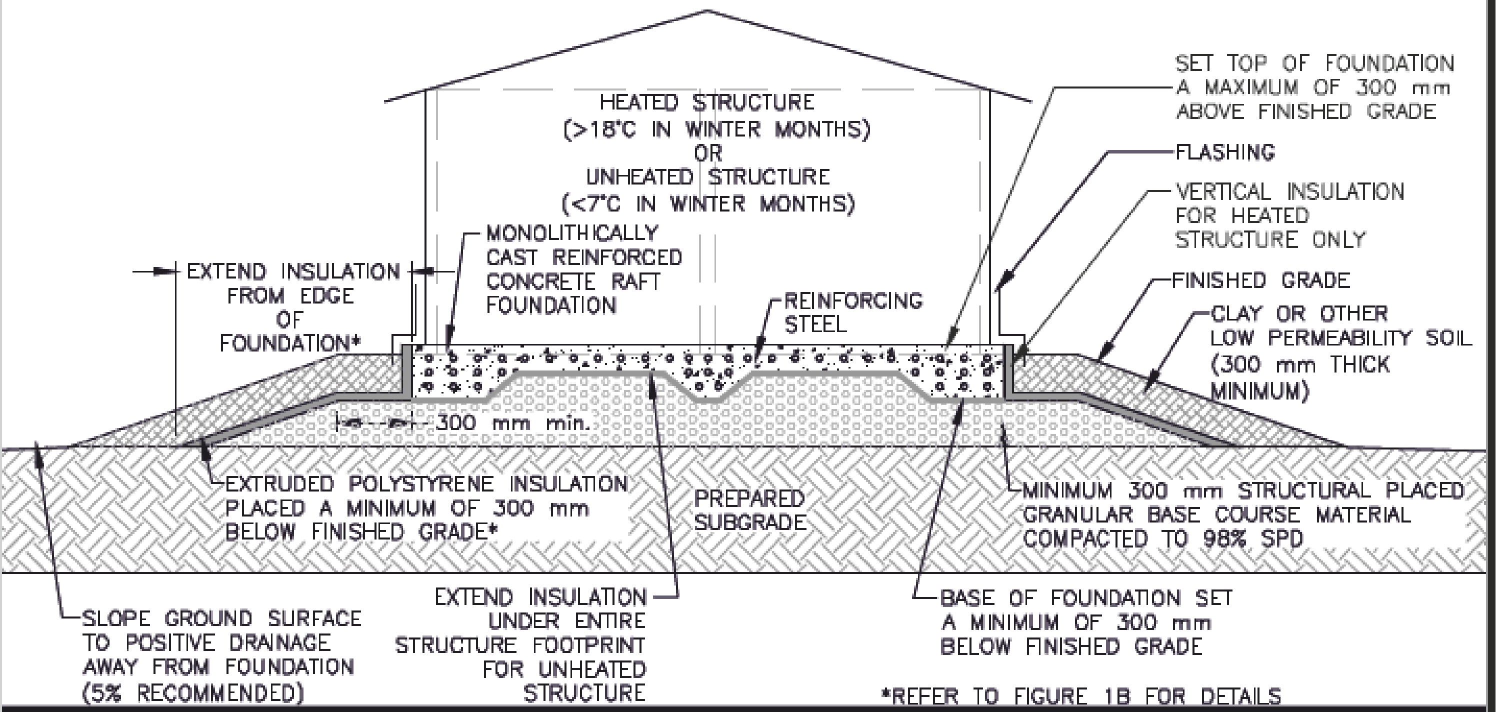
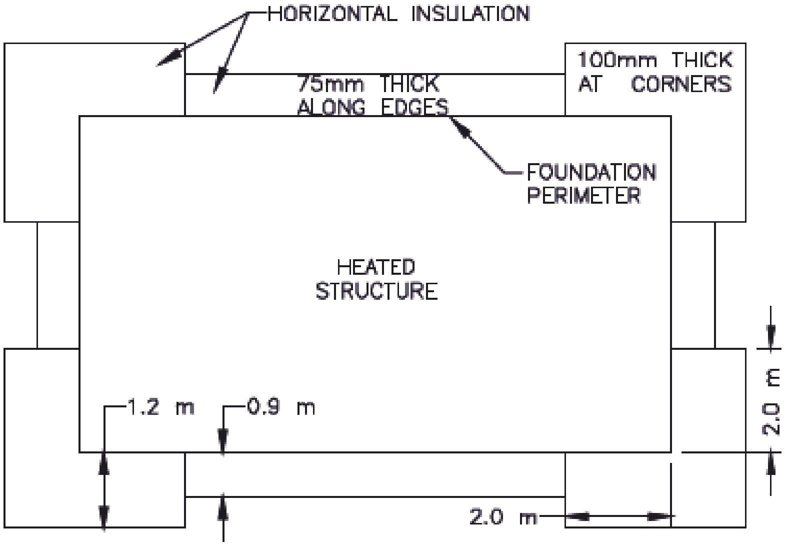


FIGURE 1B:
EXTENTS OF INSULATION



FOR UNHEATED BUILDING, INSULATION THICKNESS = 200 mm AND LATERAL EXTENT FROM FOUNDATION PERIMETER = 2.7 m; INSULATION MUST EXTEND UNDER THE ENTIRE STRUCTURE FOOTPRINT

NOTE:
1. THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

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DRAWING TITLE: CONCRETE RAFT FOUNDATION

PROJECT: PROPOSED EDGEMONT ESTATES
EAST RESIDENTIAL SUBDIVISION
SOUTH OF SASKATOON, SK

APPROVED BY: CZ

DRAWN BY: TP

DRAWING NUMBER: 18682-FIGURE1

DATE: JANUARY, 2022

SCALE: NOT TO SCALE

8. Reinforce the concrete slab and articulate the slab at regular intervals to provide for controlled cracking.

9. Separation joints should be used to isolate the raft from any structures/utilities that are not supported by the raft.

10. Provide positive site drainage away from the foundation.

11. The foundation should not be constructed on desiccated, wet, or frozen subgrade soil or base. Frost should not be allowed to penetrate beneath the foundation just prior to or during construction.

5.8 DEEP FOUNDATIONS

5.8.1 HELICAL SCREW PILES

Helical screw piles are installed by rotating a steel pipe, equipped with one or more helix flightings, into the ground. For single helix screw piles, pile capacity is derived from shearing resistance along the pile shaft (i.e., shaft resistance) as well as end bearing capacity of the helix. For multi-helix piles, pile capacity may be derived from the sum of the shearing resistance along the portion of pile shaft above the uppermost helix and end bearing capacity of each helix. The helical plates should be spaced a minimum of 3 helix diameters apart.

The ULS and SLS soil resistance values for design of screw piles have been presented below.

TABLE II SHAFT RESISTANCE (SCREW PILES)

Depth (m) [1]	Shaft Resistance (kPa)	
	Unfactored ULS	SLS
0 to 2	0	0
Below 2	25	10

[1] Depth below existing ground level.

TABLE III END BEARING RESISTANCE (SCREW PILES)

Depth (m) [1]	End Bearing Resistance (kPa)	
	Unfactored ULS	SLS
Below 5	650	225

[1] Depth below existing ground level.

[2] Torque monitoring must be conducted to confirm that soil conditions are as expected.

Notes:

1. For the purposes of this report, design depths have been referenced to existing grade. The structural engineer must consider finished grade elevation relative to existing grade. If existing grade is altered significantly, PMEL should be consulted to confirm the design parameters.

2. The uppermost (embedded) 2 m of the pile shaft should be neglected in terms of axial capacity.

3. Piles beneath a heated building (i.e., continuously ≥ 15°C) may be designed to have helixes based a minimum depth of 6 m below existing grade, provided the building envelope insulation is designed to allow heat loss to the foundation (i.e., uninsulated floor) and the piles will not be exposed to a prolonged period of freezing conditions prior to the initial heating of the building (i.e., during construction). Where insulation is placed beneath the floor slab, an uninsulated strip width of at least 1 m is recommended adjacent to all exterior grade beams/foundation caps.

4. In unheated areas and/or where heat loss from the building to the foundation is not allowed, screw piles should be based a minimum depth of 8 m below existing ground surface to provide protection from frost action. Alternately, strategically placed insulation and/or piles that incorporate a bond breaker over the pile shaft within the depth of frost penetration (i.e., outer polyethylene sleeve that is isolated from the shaft and allowed to move freely with potential ground movements) could be considered to minimize risk of frost jacking and reduce required pile lengths. PMEL can review potential alternatives upon request.

5. When determining the compressive shaft resistance of the pile shaft, the portion of the pile shaft within 1D above the uppermost helix should be discounted due to interaction effects between the pile shaft and helix. For piles subject to tensile loads, the zone of zero shaft resistance should be increased to 2D above the uppermost helix.

6. Compressive end bearing capacity may be calculated utilizing the effective soil contact area of the helix (i.e., overall cross-sectional area for the lowest helix, helix area minus shaft area for upper helixes). Piles subject to tensile loads should use the effective area of the helix (i.e., helix area minus shaft area) when determining uplift pile capacity.

7. A minimum centre-to-centre pile spacing of 2.5D is recommended, where D=helix diameter. Lesser spacings may be acceptable, but must be approved by the Geotechnical Consultant.

8. The helical plate shall be normal to the central shaft (within 3 degrees) over its entire length. Multiple helixes (if applicable) should be spaced at increments of the helix pitch to ensure that all helixes travel the same path during installation.

9. Continuous monitoring of the installation torque should be undertaken during installation to determine whether the screw pile has been damaged during installation and to monitor the consistency of the subsurface soils.

10. Screw piles should be designed on the basis of conventional static analysis using the resistance values presented above. Installation torque should be used for monitoring purposes only and not to determine pile capacity.

11. The installation of screw piles typically disturbs the upper portion of the soils, often resulting in poor to no contact with the adjacent soils in this zone. As such, additional measures may be required if screw piles are required to resist lateral loading (i.e., pre-boring and backfilling of the annular space with lean mix concrete, construction of a buried pile cap/grade beam over the screw pile, use of larger diameter pile shafts etc.). If screw piles are required to resist lateral loads, the design details should be reviewed with the Geotechnical Consultant.

12. A representative of the Geotechnical Consultant should inspect and document the installation of each screw pile on a continuous basis.

5.8.2 PILE SETTLEMENT

With regards to serviceability of pile foundations, assuming good construction practices are followed and the appropriate resistance factors are applied; the settlement of individual piles at the design load will be small and should be within tolerable limits. The estimated pile settlement at working loads should be in the order of 10 to 20 mm for screw piles.

The above is applicable to individual piles and small pile groups. Although not anticipated, foundation settlement should be evaluated where large pile groups are employed to carry the foundation load (i.e., breadth of foundation or pile cap is a similar dimension as depth of piles).

Pile foundations designed utilizing the provided SLS bearing capacities would perform similarly to pile foundations designed using the provided ULS capacities.

5.8.3 LATERAL THRUST FORCES

Pile deflection typically governs the design of laterally loaded piles. Subgrade reaction theory may be utilized to estimate lateral pile deflection. The estimated coefficients of horizontal subgrade reaction of the subgrade soils have been presented in Table IV.

TABLE IV ESTIMATED COEFFICIENTS OF HORIZONTAL SUBGRADE REACTION

Depth (m)	Coefficient of Horizontal Subgrade Reaction, Ks, (kN/m^3)
0 to 1.5D	0
1.5D to 2	3,500z/D
Below 2	6,000/D

Where D = pile diameter and z = depth (m). For large diameter piles (i.e. exceeding 1 m) the zone of zero horizontal subgrade reaction should not exceed 1.5 m.

For the purposes of this report, design depths have been referenced to existing grade. The structural engineer must consider finished grade elevation relative to existing grade. If existing grade is altered significantly, PMEL should be consulted to confirm the design parameters.

The response of a pile to lateral loads is highly nonlinear. Methods that assume linear behaviour, such as horizontal subgrade reaction theory, are only applicable where pile deflections are small, loading is static and pile materials are linear; these conditions do not exist in most cases and soil-pile interaction modeling (i.e., p-y method) is required to accurately model the pile behaviour. If a more detailed lateral analysis is deemed warranted, PMEL can model the interaction between the soil and the pile, in accordance with the p-y method. Specific pile details (i.e., loading, type, diameter, length, etc.) will be required in order to perform the analysis.

The installation of screw piles typically disturbs the upper portion of the soils, often resulting in poor to no contact with the adjacent soils in this zone. As such, additional measures may be required if screw piles are required to resist lateral loading (i.e., pre-boring and backfilling of the annular space with lean mix concrete, construction of a buried pile cap/grade beam over the screw pile, (use of larger diameter pile shafts) etc.). If screw piles are required to resist lateral loads, the design details should be reviewed with the Geotechnical Consultant.

5.8.4 GRADE BEAMS AND PILE CAPS

Grade beams and pile caps should be reinforced at both top and bottom throughout their entire length/cross section. Grade beams and pile caps exposed to frost action should be constructed to allow for a minimum of 100 mm of net void space between the underside of the grade beam and the subgrade soil (compressible void form). The finished grade/floor finish adjacent to all pile caps and grade beams should be such that water runoff is not allowed to infiltrate and collect in the void space.

5.9 FOUNDATION DRAINAGE

The finished grade must be landscaped to provide for positive site drainage away from the proposed structure, and site grades should be maintained as high as feasible. A perimeter weeping tile drainage system (installed at the base of the perimeter foundation) is recommended to reduce the potential for external water infiltration below the foundation.

An internal sub-surface drainage system should be constructed below all basements and within all crawlspaces to allow for controlled collection and discharge of water that may accumulate below the basement/within the crawlspace.

Many drainage system configurations are possible, but generally consist of clean, drainage aggregate (less than 3% fines) in conjunction with grading the subgrade surface to collection points (i.e., sump pits) and/or utilizing perforated drainage pipes to transmit water to collection points. The drainage system should be positively sloped to sump pits equipped with automatic sump pumps (or drained by gravity) to discharge water a suitable location well away from the proposed structure. Non-woven geotextiles should be utilized to separate the drainage aggregate from the subgrade soils. The drainage pipes and clean drainage aggregate should be fully encapsulated in non-woven geotextile capable of transmitting a flow of not less than 50 litres per second per square metre (ASTM D-4491). The sub-surface drainage system should incorporate provisions for mitigation of radon gas (i.e., traps in lines entering the sump, sealed sumps, etc.). A backup power supply for the sump pump(s) is recommended in the event of a power outage. Details for drainage systems should be reviewed by the geotechnical consultant prior to finalizing the design.

5.10 FOUNDATION WALLS

Foundation retaining walls should be designed to resist lateral earth pressure exerted by the soil as well as the horizontal pressure induced by any surcharge loading. The surcharge loading should be calculated on the basis of actual loads.

Backfill should be uniformly placed and compacted to minimize settlements as much as practical while limiting development of compaction induced pressures on the wall to an acceptable level.

Where the existing soils are used to backfill the foundation walls, the lateral earth pressure may be calculated on the basis of an equivalent fluid pressure distribution of 16 kN/m^3 (add hydrostatic pressure if a functional drainage system is not installed).

Where clean granular fill (i.e., less than 5 percent material finer than 0.071 mm) is used to backfill the foundation walls, the lateral earth pressure may be calculated on the basis of an equivalent fluid pressure distribution of 10 kN/m^3 (add hydrostatic pressure if a functional drainage system is not installed). In this case, the slope of the clean, granular backfill material must be no steeper than 45 degrees as measured from the base of the wall.

To prevent hydrostatic pressures from developing behind the wall, a drainage system should be incorporated into the design of the wall. A perforated drainage pipe should be installed with the invert elevation at or below the base of the foundation. The perimeter drainage system should be drained to a sump pit(s). The sump pit(s) should be equipped with an automatic sump pump. The perforated drainage pipe should be at least 100 mm in diameter and installed on non-woven geotextile capable of transmitting a flow of not less than 50 litres per second per square metre (ASTM D-4491). The geotextile should be placed on naturally deposited, undisturbed soil or free-draining sand as may be required for leveling. The geotextile should be used to encapsulate at least 300 mm of clean, granular drainage aggregate above the invert of the drainage pipe. The clean drainage aggregate should meet the aggregate gradation requirements shown in Table V.

TABLE V CLEAN, DRAINAGE AGGREGATE

Grain Size (mm)	Percent Passing
25.9	100
9.5	50 – 95
5.0	35 – 70
2.0	20 – 45
0.425	0 – 20
0.150	0 – 8
0.071	0 – 3

All water collected in the drainage system must be discharged in accordance with local regulations.

If a drainage system is not installed at the base of the wall, the wall must also be designed to withstand hydrostatic pressures.

The uppermost 500 mm of the backfill should consist of clay or other low permeability material.

5.11 FLOORS

5.11.1 GRADE-SUPPORTED CONCRETE SLABS

Provided that some slab movements and cracking can be tolerated, the following minimum provisions should be incorporated into the design of conventional, heated, grade-supported, cast-in-place, at-grade reinforced concrete slabs subject to light loading.

1. Prepare the site in accordance with Section 5.2. Level and compact the upper 150 mm of subgrade soil to 96 percent of standard Proctor density at optimum moisture content.

2. Subgrade fill, if required, should preferably consist of imported granular material or locally available sand soils, placed in thin lifts (maximum 150 mm loose) and uniformly compacted to 96 percent of standard Proctor density at optimum moisture content.

3. Soft subgrade areas should be excavated and replaced with suitable soil compacted to 96 percent of standard Proctor density at optimum moisture content. High-strength geogrid/geotextile may be required to provide soil stabilization and separation where soft/wet soil conditions are encountered. The need for special measures (i.e., over-excavation, geotextile, geogrid, and/or additional gravel fill) in soft/wet areas must be subject to review by the Geotechnical Consultant during field construction.

4. To provide a level working surface and uniform subgrade support, provide a layer of crushed granular base course material beneath the slab (150 mm minimum).

5. All structural fill should be placed and uniformly compacted in thin lifts (maximum 150 mm, loose) to 98 percent of standard Proctor density at optimum moisture content.

6. Isolate the slab from foundation walls, columns, etc., by means of separation joints.

7. Reinforce the concrete slab and articulate the slab at regular intervals to provide for controlled cracking.

8. Provide positive site drainage away from the proposed structure.

9. Floor slabs should not be constructed on desiccated, wet, or frozen subgrade soil or base.

10. Frost should not be allowed to penetrate beneath the floor slab just prior to, during or after construction.

11. A soil gas membrane (i.e., radon gas and moisture resistant) should be installed between the underside of the floor slab and the granular fill.

If slab movements and cracking cannot be tolerated, the slabs should be structurally supported on piles (refer to Section 5.11.2).

5.11.2 STRUCTURAL FLOORS

It is anticipated that structural floors over crawlspaces may be constructed for some structures. The crawlspaces should be covered with a soil gas membrane (i.e., radon gas and moisture resistant), followed by 50 mm of sand or lean mix concrete to hold it tightly to the soil surface.

The crawl space should be forced-air ventilated during warm weather and heated during cold temperatures. The depth of the crawlspaces should be based at least 1 m above the groundwater table (refer to previous discussions) and a drainage system is recommended within the crawlspace (refer to Section 5.9).

5.11.3 SLABS EXPOSED TO FREEZING CONDITIONS

Grade-supported concrete slabs exposed to freezing conditions (i.e., exterior slabs/sidewalks, slabs within unheated building areas, etc.) will be subject to differential movements associated with frost action. The potential for differential movements associated with frost action can be minimized by placing sub-horizontal extruded polystyrene insulation below the slabs/sidewalks. Where applicable, the insulation should butt-up to the grade beam to direct heat to the underside of the slab. The insulation should have a minimum thickness of 75 mm and should extend sub-horizontally to a minimum distance of 1.8 m beyond the outer edges of the slab. If differential movements cannot be tolerated, the slab should be structurally supported on piles.

5.11.4 SOIL GAS (RADON) MITIGATION

The following minimum provisions should be incorporated into the design of a subsurface depressurization system.

1. Provide a minimum of 150 mm of clean, crushed aggregate (permeable layer) beneath the underside of the slab. The permeable layer should be lightly compacted using light weight vibratory compaction equipment and should meet the following gradation.

TABLE VI AGGREGATE FOR PERMEABLE LAYER

Grain Size (mm)	Percent Passing
37.5	100
25	50 – 95
19	35 – 70
12.5	20 – 45
9.5	0 – 20
% Fracture (Minimum)	60

2. A rough-in for the potential for future soil gas mitigation is recommended (in accordance with NBCC 2015, 9.13.4.2). The rough-in consists of an inlet through the slab to allow for depressurization (venting) of a permeable layer placed below the floor slab. Encase the aggregate (i.e., top and bottom) with a non-woven geotextile (Nilex 4551 or equivalent). The geotextile will provide separation between the aggregate and underlying soils (to prevent mixing of materials). Placing geotextile between the aggregate and bottom of floor slab may aid in preventing damage to the vapour barrier. The geotextile should be placed as per the manufacturer's specifications.

3. A suction pit, measuring 1.2 m square and 200 mm deep, should be constructed beneath the floor slab in approximately the centre of the building footprint. Alternatively, perforated drainage pipe could be placed below the floor slab (minimum of three lines extending the length of the building). A 100 mm (minimum) diameter pipe should be connected to the suction pit or perforated drainage pipe, that extends through the floor slab and is stubbed off within the building interior.

4. To minimize the potential for soil gas entering the building, it is recommended that a soil gas membrane be placed below the floor slab (in direct contact with the floor slab) and that all drain pipes should be equipped with traps to prevent entry of radon and/or other soil gases through the floor drains (as per NBCC 2015).

5.12 FOUNDATION CONCRETE

The results of water-soluble sulphate testing on soil samples recovered from the subject site have been summarized in Table VII.

TABLE VII WATER-SOLUBLE SULPHATE TEST RESULTS

Borehole No.	Depth (m)	Soil Type	Water Soluble Sulphate (%)	Class of Exposure	Degree of Sulphate Exposure
21-3	1.5	Clay	0.90	Severe	S-2
21-6	3.0	Clay	0.81	Severe	S-2
21-9	0.75	Silt	<0.05	Negligible	-
21-20	0.75	Silt	0.09	Negligible	-

An examination of Table VII revealed that the measured sulphate concentration of the tested soils was less than 0.05 percent to 0.90, which is considered negligible to severe in terms of potential degree of sulphate attack. As such, it is recommended to utilize sulphate resistant cement for all foundation concrete in contact with the subgrade soils. All concrete at this site should be manufactured in accordance with current CSA standards.

5.13 TRAFFIC STRUCTURES

5.13.1 DESIGN CBR

The subgrade soils near surface consisted predominately of sand. Silt was encountered near surface in four of the twenty boreholes. The Group Index and correlated soaked California Bearing Ratio (CBR) values for the sand and silt soils ranged from 4 (sandy silt) to 15 (sand, trace silt). Based on the results of the laboratory testing, a design soaked CBR value of 7 was utilized for design of the roadways.

It is understood that subgrade fill will be placed in some areas of the site. It is anticipated that the on-site subgrade will be utilized as fill. However, if imported fill (not consistent with the silt/sand subgrade encountered during our field investigation) is utilized, additional laboratory testing should be conducted to confirm the CBR of the imported fill. Based on the results of the laboratory testing, the proposed pavement structure may have to be modified.

5.13.2 DESIGN TRAFFIC LOADING

BCL Ltd. has reported that the subdivision will be divided into approximately 130 lots with 2 access roads. It is understood that a Traffic Impact Assessment is in the process of being completed by KGS for the development. KGS reported, via email on January 13, 2022, that there will be a maximum number of 1300 vehicles per day on the roads.

The roadway design has been based off the design traffic assumptions presented in Table VIII. Based on the reported traffic volumes, a total N_{15} of 325,577 ESALs was calculated for the proposed Roadway. A detailed breakdown of the traffic volume calculation has been included in Appendix E.

TABLE VIII TRAFFIC INFORMATION

Item	Value	Note
Design Life	15 years	As per the RM of Corman Park Country Residential Paved Roads specification
Number of Lanes per direction	1	Two-way traffic - One lane per direction
Directional Split	50%	Traffic will travel equally in each direction.
Design AADT - Year 1	496	Approximate assumed value based on expected growth rate (low population at Year 0)
Design AADT - Year 15	1,300	As per email dated January 17, 2022, 1300 vehicles per day.
Percent Growth Rate	10% - Year 0 to 10	Year 10 is assumed to be build out of the development
	0% - Year 10 to 15	
Percent Commercial Truck Traffic	5% - Year 0 to 5	Years 0 to 5 – high percentage of truck traffic due to construction of residences
	3% - Year 5 to 10	Years 5 to 10 – construction assumed to slow as development is nearing build out
	0.5% - Year 10 to 15	Years 10 to 15 – few to no construction trucks, truck traffic consists mainly of garbage/recycling trucks, septic trucks, fire trucks, delivery trucks, etc.
Truck Traffic Distribution	90%/10%*	*Single Unit Trucks/Tractor Semi-Trailer Combinations
Bus Traffic Passes, Daily	8	It was reported that there will be 8 bus passes per day during the school year. It is estimated that there is approximately 40 weeks in the school year.
ESALs per Unit – Trucks	3.0/6.3*	*Single Unit Trucks/Tractor Semi-Trailer Combinations
ESALs per Unit – Buses	5	

5.13.3 RECOMMENDED PAVEMENT STRUCTURE

The R.M. of Corman Park Country Residential Paved Road Construction Standard requires the roadway to be designed in accordance with the Saskatchewan Ministry of Highways and Infrastructure's Shell curve method.

Based on the CBR ratings and design traffic loading (as summarized in Sections 5.13.1 and 5.13.2), the following asphalt concrete pavement structure has been presented in Table IX.

TABLE IX THICKNESS DESIGN FOR PAVEMENT STRUCTURES

Pavement Structure	Thickness (mm)
Asphalt Concrete (150-200A)*	80
Granular Base(Min CBR = 65)	150
Granular Sub-Base (Min CBR = 20)	150 (see Note 1)
Geotextile / Geogrid**	As Required (see Note 1)
Prepared Subgrade	(600)
Total Thickness (mm)	**380**

*Asphalt Concrete type as per the R.M. of Corman Park Residential Paved Road Construction Standard.
** Combigrid 40/40, EasyGrid 4-150GC, or equivalent

Note:

1. It should be noted that silt soils are generally poor as subgrade support for roadways, and will have a CBR of less than 7. As such, it is recommended that a proof roll/visual subgrade review be conducted following completion of subgrade preparation/prior to placement of the sub-base layer. Where silt/soft soils are encountered, it is recommended that a geotextile/geogrid combination (such as Combigrid 40/40, EasyGrid 4-150GC, or equivalent) be placed between the subgrade and sub-base as it will provide subgrade reinforcement and extend/improve the performance of the structure. Where a geotextile is placed, the sub-base thickness should be increased to 200 mm to minimize potential for damage of the geotextile during placement of the sub-base fill.

5.13.4 PAVEMENT CONSTRUCTION RECOMMENDATIONS

The following minimum recommendations should be incorporated into the design of the asphalt concrete pavement structures. It should be noted that the R.M. of Corman Park has roadway construction standards. Detailed construction specifications (subgrade preparation, material type and compaction specifications, etc.) have been outlined in the R.M. of Corman Park Country Residential Paved Road Construction Standard (www.rmcormanpark.ca/DocumentCenter/View/1812/Country-Residential-Paved-Road). As such, the pavement should be designed in accordance with both the recommendations provided below and the construction specifications provided in the R.M. Paved Road Construction Standard.

In the event there is a discrepancy between the recommendations presented in our report and the R.M. of Corman Park Construction Standards, PMEL should be notified to review our recommendations.

1. Prepare the site in accordance with the R.M. of Corman Park Country Residential Paved Road Construction Standard.

2. Subgrade fill, if required, may consist of imported granular material or locally available sand soils. Subgrade fill should be placed in thin lifts (150 mm loose, maximum) and compacted to 100 percent of standard Proctor density at optimum moisture content.

3. Level and compact the upper 600 mm of subgrade soil to 100 percent of standard Proctor density at optimum moisture content. Soft subgrade areas should be excavated and replaced with suitable soil compacted to 100 percent of standard Proctor density at optimum moisture content. The subgrade should be graded to promote drainage to the ditches. The surface of the subgrade should be smooth drum rolled to create a smooth surface prior to placement of the sub-base.

4. If encountered, all cobblestones/boulders having a dimension of greater than or equal to 8 cm shall be removed from the upper 150 mm of the subgrade.

5. It is recommended that a visual review/proof roll be conducted on the subgrade following preparation (i.e., leveling and compaction). Based on the results of the proof roll, over-excavation, high strength geotextile/geogrid, and/or additional granular fill may be required.

6. Sub-base fill should be placed in 120 mm (maximum) thick lifts. The subbase should be compacted to 100 percent of standard Proctor density at optimum moisture content. The granular base course material should meet the aggregate gradation requirements in Table X.
    a) Where geotextile/geogrid is utilized, a minimum initial sub-base lift thickness of 200 mm should be placed (by end dump method) over the geotextile/geogrid to reduce the potential for damage to the geotextile. Construction traffic should be restricted to travelling on the sub-base to avoid damage to the geogrid/geotextile and underlying subgrade. Heavy duty construction equipment capable of compacting the entire 200 mm lift of sub-base must be utilized for compaction of the sub-base layer.

7. All granular base course placed above the sub-base should be placed in thin lifts (150 mm loose) and compacted to 100 percent of standard Proctor density at optimum moisture content. The granular base course material should meet the aggregate gradation requirements in Table X.

8. A prime coat shall be placed on the finished final lift of Granular Base Course within 24 hours, weather permitting.

9. The asphalt concrete mix design and construction shall meet the specifications as outlined in the R.M. of Corman Park Country Residential Paved Road Construction Standard.

10. If the asphalt concrete will be placed in multiple lifts, it is recommended that the top lift of asphalt concrete be deferred by two years to allow opportunity to correct any settlement or initial pavement deficiencies/defects and to restore the roadway serviceability following the initial construction traffic.

11. Positive surface drainage is recommended to reduce the potential for moisture infiltration through the pavement structure.

12. Surface water should be prevented from seeping back under the outer edges of the traffic structure. Where possible, grades should be designed such that the granular materials can freely discharge into ditches.

TABLE X AGGREGATE GRADATION REQUIREMENTS

Grain Size (mm)	Percent Passing	
	Sub-Base Course*	Base-Course *
50.0	100	100
18.0	--	100
12.5	--	75 – 100
5.0	--	50 – 75
2.0	0 – 80	32 – 52
0.900	--	20 – 35
0.400	0 – 45	15 – 25
0.160	0 – 20	8 – 15
0.071	0 – 8	6 – 11
Plasticity Index (%)	0 – 6	0 – 6
% Fracture (Min)	--	50
Lightweight Pieces (Max,%)	--	5

*As per the R.M. of Corman Park Residential Paved Road Construction Standard

13. Periodic maintenance, such as crack sealing, will be required for asphalt concrete pavement.

If soil embankments are constructed, the following additional recommendations should be considered.

1. All common borrow used for embankment construction should consist of imported granular material or locally available sand soils. Silt soils should not be utilized as embankment fill.

2. Positive surface drainage is recommended to minimize the potential for moisture infiltration into the subgrade soil. Ditches and culverts should be provided where necessary to provide adequate site drainage. Surface water should be prevented from seeping back under the outer edges of the road structure. The embankments should be constructed with a shoulder height of at least 1.0 m above ditchbottom elevation.

3. For sand or granular fill borrow materials, embankment slopes should be no steeper than 3 Horizontal to 1 Vertical (3H : 1V). Similarly, ditch sideslopes should be no steeper than 3H : 1V.
4. Erosion protection is recommended for all embankment sideslopes. The slopes should be covered with topsoil and seeded to encourage vegetation growth. Alternately, erosion control products could be considered, but would be subject to prior approval by the RM of Corman Park and PMEL.
5. The final road grade should be elevated a minimum of 600 mm above the average terrain to minimize snow accumulation on the road.

5.13.5 OPTIONAL CONSTRUCTION CONSIDERATIONS

Placement of geotextile/geogrid (such as Combigrid 40/40, EasyGrid 4-150GC, or equivalent) between the subgrade and granular sub-base for the first 50 to 100 m south of Grasswood Road at each access approach may help reduce pavement damage related to differing pavement structures, stopping, turning, etc. Geogrid between the base and sub-base course could also be considered. If utilized, the geotextile/geogrid should be laid flat with no bunching and overlapped by a minimum of 600 mm. The use of higher strength asphalt concrete and/or increasing the asphalt concrete thickness could also be considered within the above-mentioned transition zone.

6 LIMITATIONS

The presentation of the summary of the borehole logs and foundation design recommendations has been completed as authorized. Twenty, 150 mm diameter boreholes were dry drilled using our continuous flight, solid stem auger drilling equipment. Borehole logs were compiled during test drilling which, we believe, were representative of the subsurface conditions at the borehole locations at the time of test drilling.

Four piezocone penetration tests were conducted during the field investigation. The inferred subsoil stratigraphy has been shown on the attached CPTu plots.

Variations in the subsurface conditions from that shown on the borehole logs/CPTu plots at locations other than the exact test locations should be anticipated. If conditions should differ from those reported here, then we should be notified immediately in order that we may examine the conditions in the field and reassess our recommendations in the light of any new findings.

The Terms of Reference for this geotechnical investigation did not include any environmental assessment of the site. No detectable evidence of environmentally sensitive materials such as hydrocarbon odour was detected during the actual time of the field test drilling program. If, on the basis of any knowledge, other than that formally communicated to us, there is reason to suspect that environmentally sensitive materials may exist, then additional boreholes should be drilled and samples recovered for chemical analysis.

The subsurface investigation necessitated the drilling of deep boreholes. The boreholes were backfilled with bentonite chips at the completion of test drilling. Please be advised that some settlement of the backfill materials will occur which may leave a depression or an open hole. It is the responsibility of the client to inspect the site and backfill, as required, to ensure that the ground surface at each Borehole location is maintained level with the existing grade.

It is recommended that the monitoring wells should be decommissioned once they are no longer needed. PMEL will not accept any future liability associated with inadequate decommissioning of monitoring wells. Costs for decommissioning the monitoring wells can be provided by PMEL upon request.

This report has been prepared for the exclusive use of 102015575 Saskatchewan Ltd. (Darren Hagen), BCL Engineering Ltd. and their agents for specific application to the proposed Edgemont Estates East residential subdivision to be constructed south of Saskatoon, Saskatchewan. It has been prepared in accordance with generally accepted geotechnical engineering practices and no other warranty, express or implied, is made.

Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, is the responsibility of such Third Party. Governing Agencies such as municipal, provincial, or federal agencies having jurisdictions with respect to this development and/or construction of the facilities described herein have full jurisdiction with respect to the described development. Any other unspecified subsequent development would be considered Third Party and would, therefore, require prior review by PMEL. PMEL accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

The acceptance of responsibility for the design/construction recommendations presented in this report with respect to the foundation system are contingent on adequate and/or full-time inspection (as required, based on site conditions at the time of construction) by a representative of the Geotechnical Consultant. PMEL will not accept any responsibility on this project for any unsatisfactory performance if adequate and/or full-time inspection is not performed by a representative of PMEL.

This report has been digitally secured with personal passwords to lock the document. Due to the possibility of digital modification, only those reports sent directly by PMEL can be relied upon without fault.

We trust that this report fulfills your requirements for this project. Should you require additional information, please contact us.

P. MACHIBRODA ENGINEERING LTD.

C.C ZUBROWSKI
MEMBER 12138
2022-02-08
YR. MN. DAY

Cory Zubrowski, P. Eng.

Association of Professional Engineers &
Geoscientists of Saskatchewan
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2022-02-08

Jennifer Krasowski, P. Eng.

CZ/JK

DRAWINGS

KEY PLAN
NOT TO SCALE

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LEGEND

⊕ –PMEL BOREHOLE
⊗ –BENCHMARK
⊚ –PMEL BOREHOLE (MONITORING WELL INSTALLED)
▲ –PMEL PIEZOCONE PENETRATION TEST

P. MACHIBRODA ENGINEERING LTD.

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DRAWING TITLE:
SITE PLAN
BOREHOLE AND PIEZOCONE LOCATIONS

PROJECT:
PROPOSED EDGEMOUNT ESTATES EAST
RESIDENTIAL SUBDIVISION, SOUTH OF SASKATOON, SK

APPROVED BY: CZ
DRAWN BY: TP
DATE: JANUARY, 2022
DRAWING NUMBER: 18682-1
SCALE: AS SHOWN

KEY PLAN
NOT TO SCALE

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LEGEND

—— 502.0 ——	- GROUNDWATER ELEVATIONS (m) (JANUARY 10, 2022)

P. MACHIBRODA ENGINEERING LTD.

CONSULTING
GEOENVIRONMENTAL
GEOTECHNICAL
ENGINEERS

806 – 48th STREET EAST
SASKATOON, SK
S7K 3Y4

DRAWING TITLE:
GROUNDWATER CONTOUR MAP

PROJECT:
PROPOSED EDGEMOUNT ESTATES EAST
RESIDENTIAL SUBDIVISION, SOUTH OF SASKATOON, SK

APPROVED BY: CZ
DRAWN BY: TP
DATE: JANUARY, 2022
DRAWING NUMBER: 18682-1A
SCALE: AS SHOWN

P.MACHIBRODA
ENGINEERING LTD.

BOREHOLE 21-1

DRAWING NUMBER: 18682-2

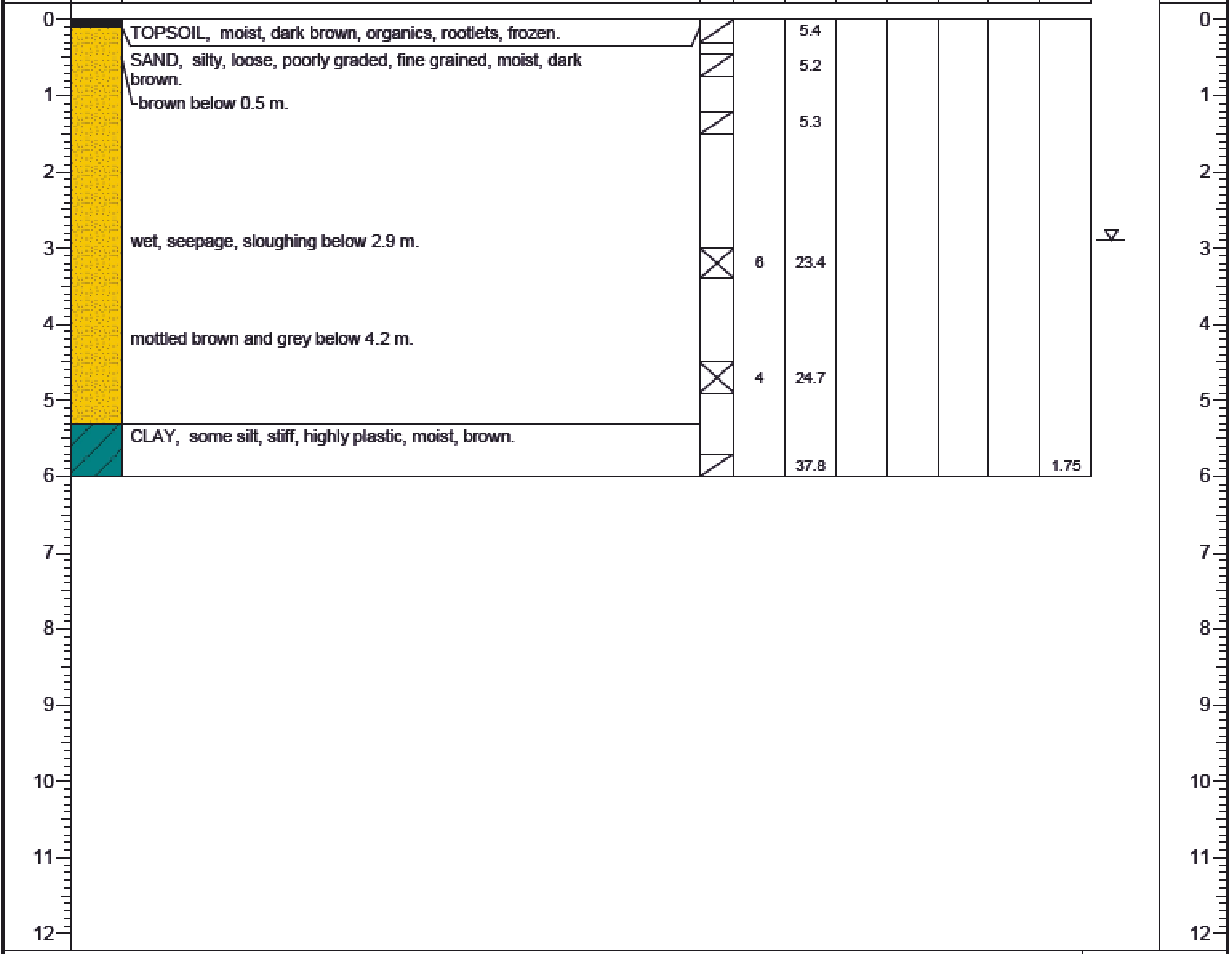
PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 507.22 **DATE DRILLED:** NOV 26/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling



DEPTH (m)	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)		DEPTH (m)
0		TOPSOIL, moist, dark brown, organics, rootlets, frozen.	⧄		5.4							0
		SAND, silty, loose, poorly graded, fine grained, moist, dark brown.	⧄		5.2							
1		brown below 0.5 m.	⧄		5.3							1
2												2
3		wet, seepage, sloughing below 2.9 m.									▽	3
			☒	6	23.4							
4		mottled brown and grey below 4.2 m.										4
			☒	4	24.7							
5												5
		CLAY, some silt, stiff, highly plastic, moist, brown.										
6			⧄		37.8					1.75		6
7												7
8												8
9												9
10												10
11												11
12												12

NOTES:
1. Borehole sloughed to 2.9 m Immediately After Drilling.

SHEET 1 OF 1

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-2

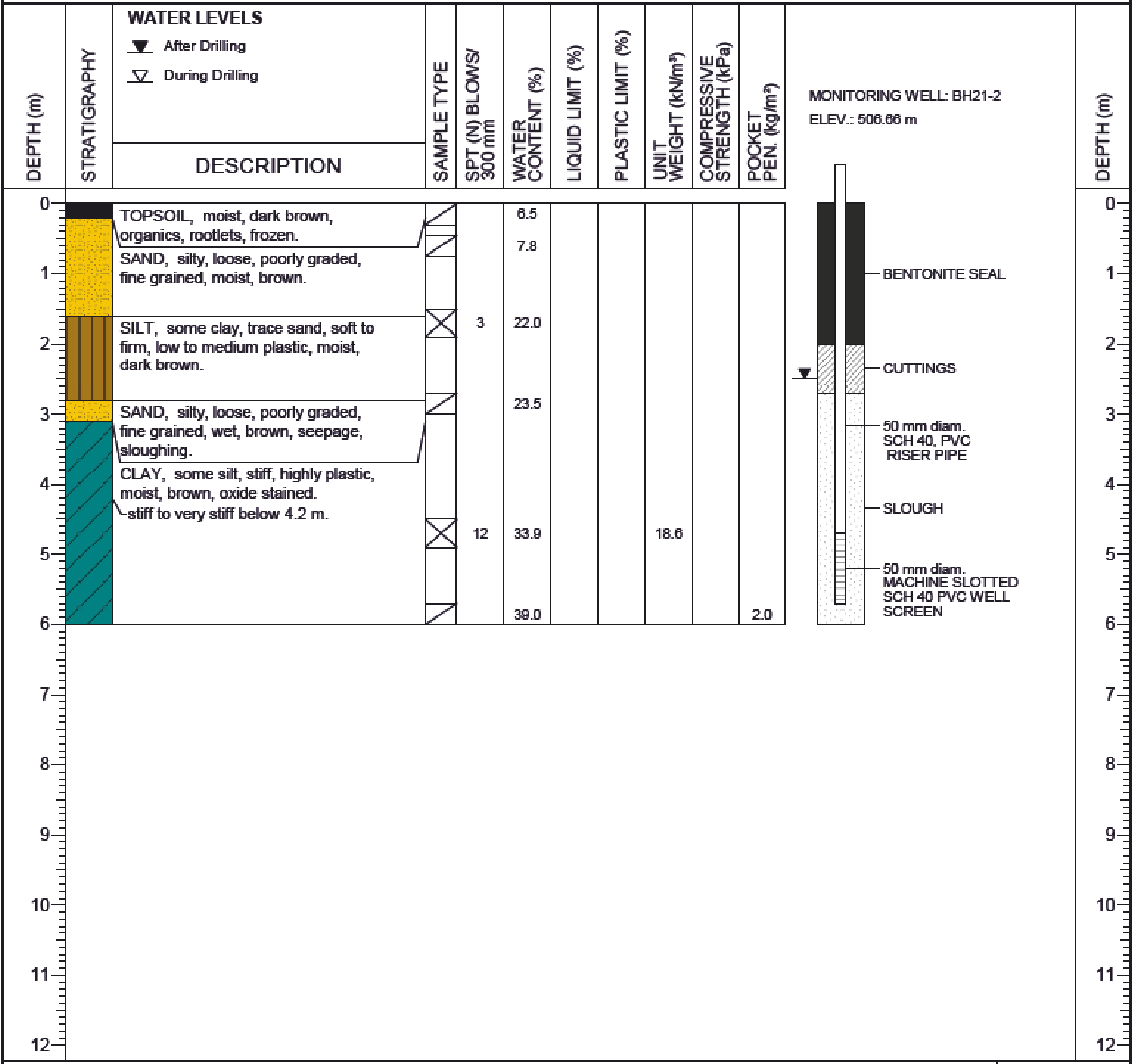
DRAWING NUMBER: 18682-3

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 506.61 **DATE DRILLED:** NOV 26/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE



TOPSOIL, moist, dark brown, organics, rootlets, frozen.

SAND, silty, loose, poorly graded, fine grained, moist, brown.

SILT, some clay, trace sand, soft to firm, low to medium plastic, moist, dark brown.

SAND, silty, loose, poorly graded, fine grained, wet, brown, seepage, sloughing.

CLAY, some silt, stiff, highly plastic, moist, brown, oxide stained.
- stiff to very stiff below 4.2 m.

SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)
⧄		6.5					
⧄		7.8					
☒	3	22.0					
⧄		23.5					
☒	12	33.9			18.6		
⧄		39.0					2.0

NOTES:
1. Borehole sloughed to 2.7 m Immediately After Drilling.
2. Recorded Groundwater Level at 2.49 m on Jan 7/22.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH2-18682.bor

P.MACHIBRODA
ENGINEERING LTD.

BOREHOLE 21-3

DRAWING NUMBER: 18682-4

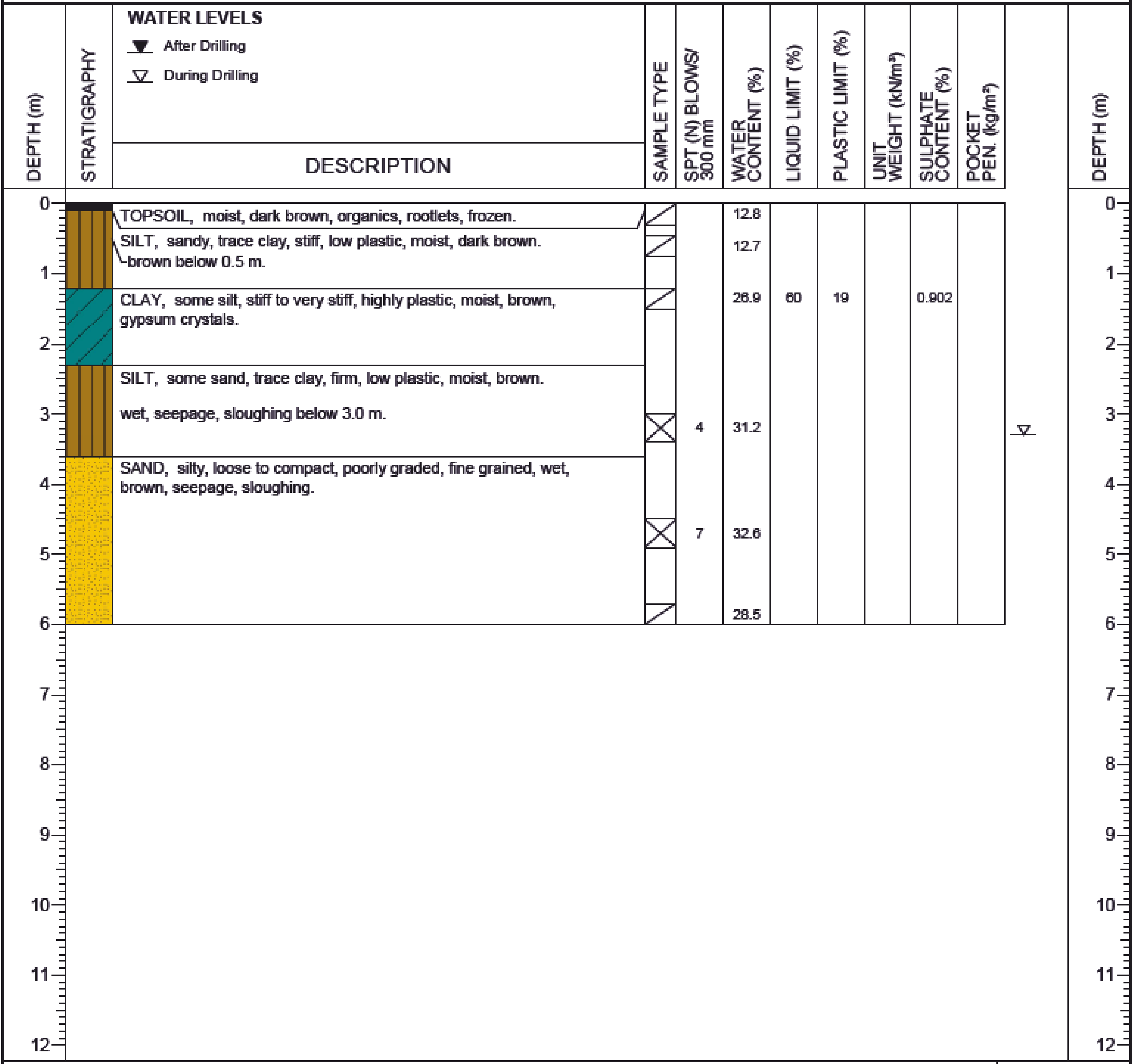
PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 505.58 **DATE DRILLED:** NOV 26/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling



DESCRIPTION
TOPSOIL, moist, dark brown, organics, rootlets, frozen.
SILT, sandy, trace clay, stiff, low plastic, moist, dark brown. -brown below 0.5 m.
CLAY, some silt, stiff to very stiff, highly plastic, moist, brown, gypsum crystals.
SILT, some sand, trace clay, firm, low plastic, moist, brown. wet, seepage, sloughing below 3.0 m.
SAND, silty, loose to compact, poorly graded, fine grained, wet, brown, seepage, sloughing.

SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	SULPHATE CONTENT (%)	POCKET PEN. (kg/m²)
⧄		12.8					
⧄		12.7					
⧄		26.9	60	19		0.902	
☒	4	31.2					
☒	7	32.6					
⧄		28.5					

NOTES:
1. Borehole sloughed to 3.3 m Immediately After Drilling.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH3-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-4

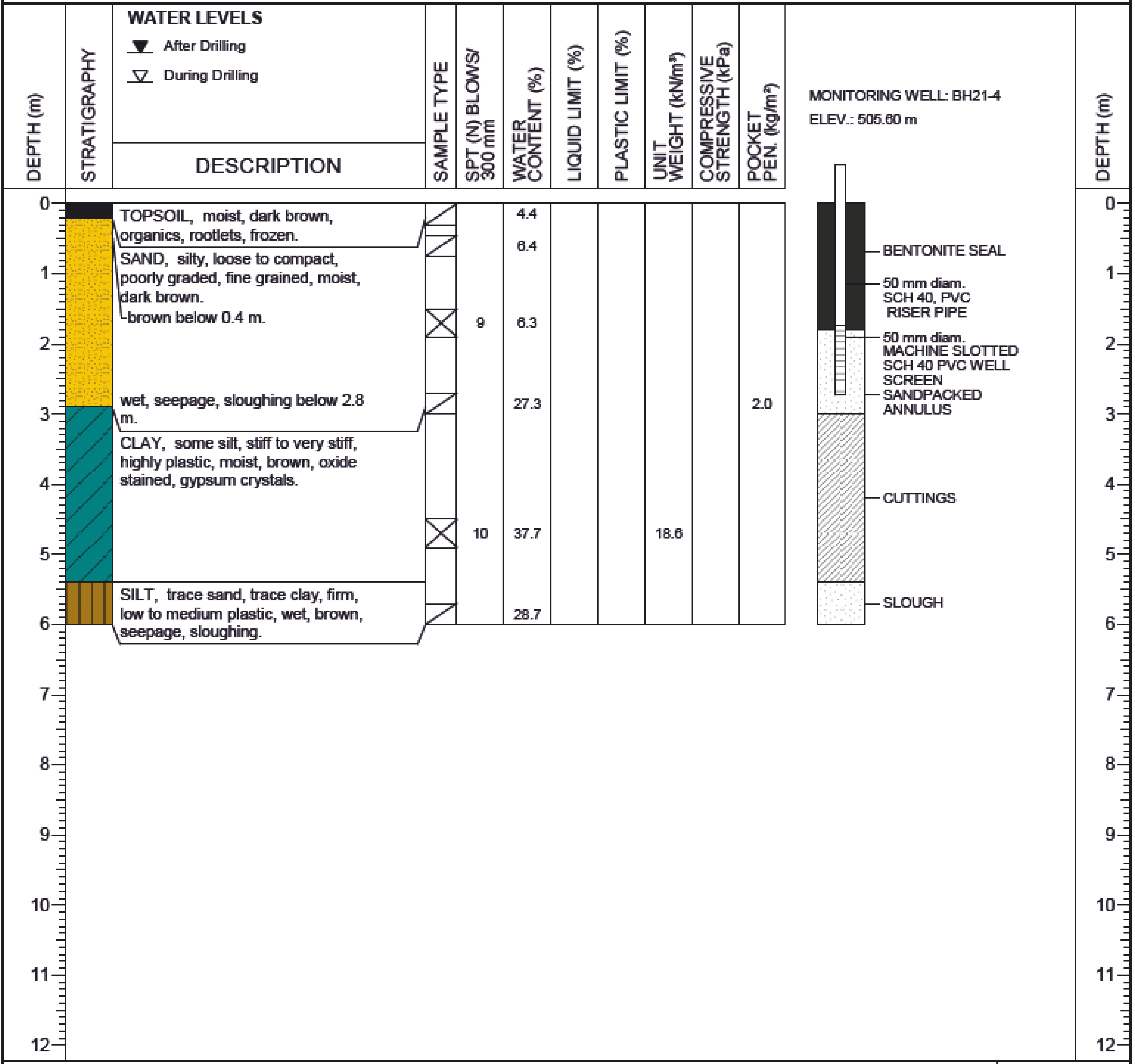
DRAWING NUMBER: 18682-5

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 504.89 **DATE DRILLED:** NOV 26/21

SAMPLE TYPE: ◿ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE



TOPSOIL, moist, dark brown, organics, rootlets, frozen.

SAND, silty, loose to compact, poorly graded, fine grained, moist, dark brown.
- brown below 0.4 m.
- wet, seepage, sloughing below 2.8 m.

CLAY, some silt, stiff to very stiff, highly plastic, moist, brown, oxide stained, gypsum crystals.

SILT, trace sand, trace clay, firm, low to medium plastic, wet, brown, seepage, sloughing.

SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)
◿		4.4					
◿		6.4					
☒	9	6.3					
◿		27.3					2.0
☒	10	37.7			18.6		
◿		28.7					

NOTES:
1. Borehole sloughed to 5.4 m Immediately After Drilling.
2. Recorded Groundwater Level Dry on Jan 7/22.

SHEET 1 OF 1

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-5

DRAWING NUMBER: 18682-6

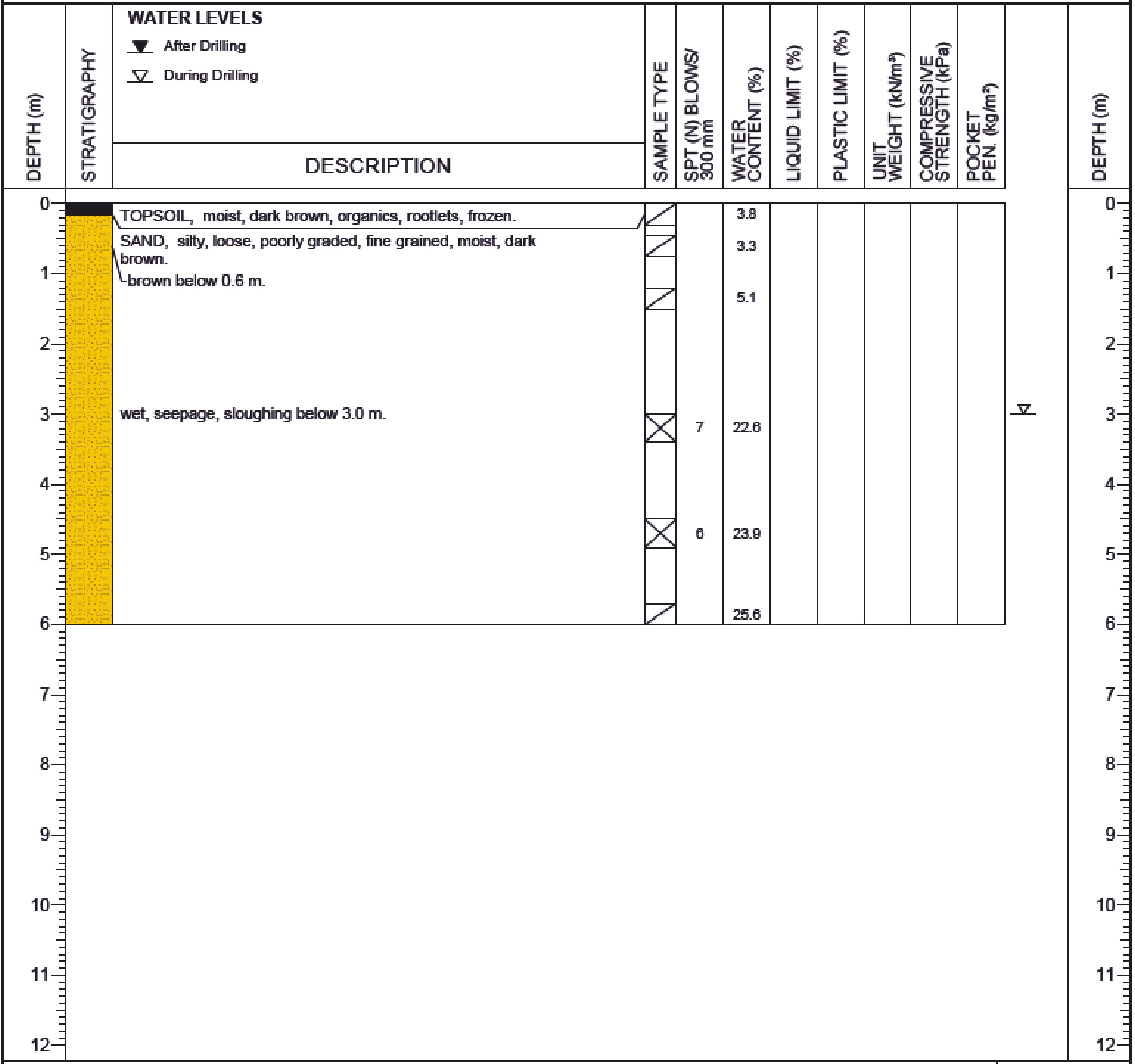
PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 504.51 **DATE DRILLED:** NOV 26/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling



TOPSOIL, moist, dark brown, organics, rootlets, frozen.

SAND, silty, loose, poorly graded, fine grained, moist, dark brown.
brown below 0.6 m.
wet, seepage, sloughing below 3.0 m.

SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)
⧄		3.8
⧄		3.3
⧄		5.1
☒	7	22.6
☒	6	23.9
⧄		25.6

NOTES:
1. Borehole sloughed to 3.0 m Immediately After Drilling.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH5-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-6

DRAWING NUMBER: 18682-7

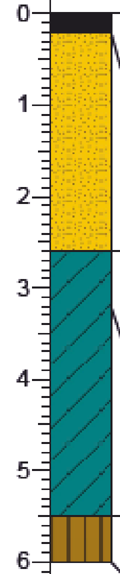
PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 503.51 **DATE DRILLED:** NOV 26/21

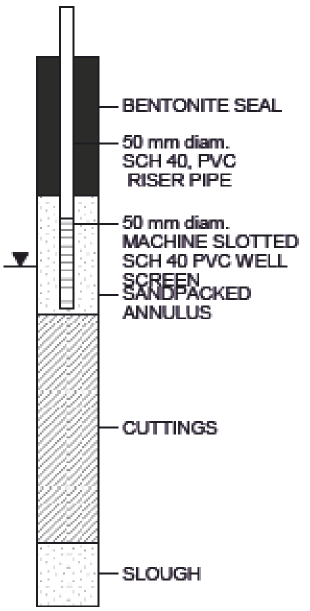
SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling



DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	SULPHATE CONTENT (%)	POCKET PEN. (kg/m²)
TOPSOIL, moist, dark brown, organics, rootlets, frozen.	⧄		3.5					
SAND, silty, loose to compact, poorly graded, fine grained, moist, brown.	⧄		4.4					
wet, seepage, sloughing below 1.6 m.	☒	7	22.6					
CLAY, some silt, trace sand, stiff, medium plastic, moist, brown, oxide stained, gypsum crystals. -silty, wet, seepage, sloughing 3.2 to 4.4 m.	⧄		26.6	41	11		0.811	1.5
highly plastic below 4.4 m.	☒	9	37.6			18.1		
SILT, some sand, some clay, firm, low to medium plastic, wet, brown.	⧄		32.4					

MONITORING WELL: BH21-6
ELEV.: 504.61



NOTES:
1. Borehole sloughed to 5.3 m Immediately After Drilling.
2. Recorded Groundwater Level at 2.27 m on Jan 7/22.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH6-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-7

DRAWING NUMBER: 18682-8

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 503.85 **DATE DRILLED:** NOV 30/21

SAMPLE TYPE: ◿ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling

DEPTH (m)	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)		DEPTH (m)
0	■	TOPSOIL, moist, dark brown, organics, rootlets, frozen.	◿		4.6							0
	▨	SAND, silty, loose to compact, poorly graded, fine grained, moist, dark brown.	◿		6.4							
1	▨	brown below 0.3 m.	◿		7.6							1
2	▨											2
	▨	wet, seepage, sloughing below 2.6 m.	◿		24.4						▽	
3												3
4												4
5												5
6												6
7												7
8												8
9												9
10												10
11												11
12												12

NOTES:
1. Borehole sloughed to 2.6 m Immediately After Drilling.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH7-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-8

DRAWING NUMBER: 18682-9

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 505.98 **DATE DRILLED:** NOV 30/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling

DEPTH (m)	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)
0	■	TOPSOIL, moist, dark brown, organics, rootlets, frozen.	⧄		4.7					
	▨	SAND, silty, loose to compact, poorly graded, fine grained, moist, brown.	⧄		5.0					
1	▨		⧄		5.8					
2	▨									
3	▨		⧄		12.9					

NOTES:
1. Borehole open and dry Immediately After Drilling.

SHEET 1 OF 1

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-9

DRAWING NUMBER: 18682-10

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 505.95 **DATE DRILLED:** NOV 30/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling

DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	SULPHATE CONTENT (%)	% FINES	
TOPSOIL, moist, dark brown, organics, rootlets, frozen.	⧄		26.9						
SILT, trace sand, trace clay, firm, low to medium plastic, moist, dark brown.	⧄		18.6	27	15		0.093	50.2	
-brown below 0.6 m.									
SAND, silty, loose to compact, poorly graded, fine grained, moist, brown.	⧄		19.0						
wet, seepage, sloughing below 2.1 m.									▽
	⧄		24.3						

NOTES:
1. Borehole sloughing to 2.3 m Immediately After Drilling.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH9-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-10

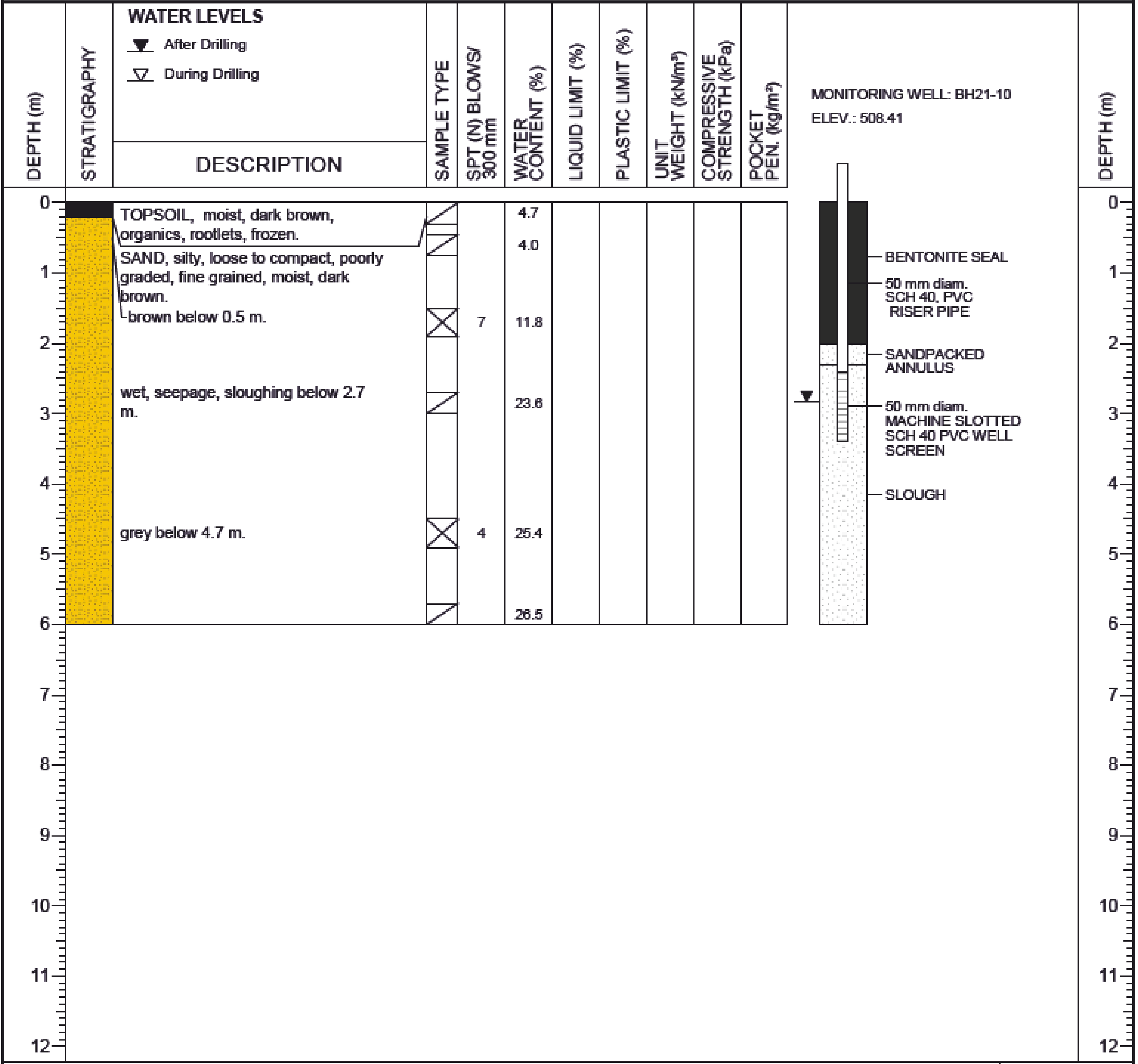
DRAWING NUMBER: 18682-11

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 507.33 **DATE DRILLED:** NOV 26/21

SAMPLE TYPE: ◿ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE



TOPSOIL, moist, dark brown, organics, rootlets, frozen.

SAND, silty, loose to compact, poorly graded, fine grained, moist, dark brown.
- brown below 0.5 m.

wet, seepage, sloughing below 2.7 m.

grey below 4.7 m.

SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)
◿		4.7
◿		4.0
☒	7	11.8
◿		23.6
☒	4	25.4
◿		26.5

NOTES:
1. Borehole sloughed to 2.3 m Immediately After Drilling.
2. Recorded Groundwater Level at 2.82 m on Jan 7/22.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH10-18682.bor

P.MACHIBRODA
ENGINEERING LTD.

BOREHOLE 21-11

DRAWING NUMBER: 18682-12

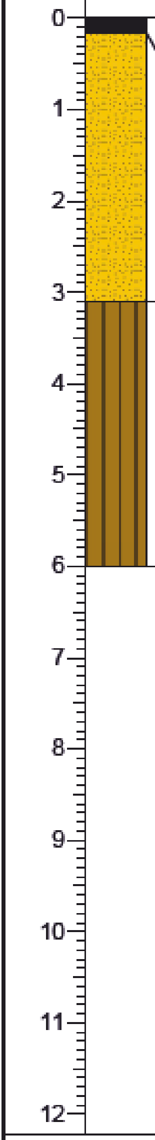
PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 506.32 **DATE DRILLED:** NOV 26/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling



DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)		DEPTH (m)
TOPSOIL, moist, dark brown, organics, rootlets, frozen.	⧄		5.6							0
SAND, silty, loose to compact, poorly graded, fine grained, moist, brown.	⧄		7.4	23	20					
										1
	☒	10	13.8							
										2
wet, seepage, sloughing below 2.7 m.									▽	
	⧄		22.5							3
SILT, some sand, trace clay, firm, low plastic, wet, brown, seepage, sloughing,										
										4
	☒	9	33.3							
										5
some clay, trace sand, stiff, medium plastic, grey below 5.5 m.										
	⧄		31.4							6
										7
										8
										9
										10
										11
										12

NOTES:
1. Borehole sloughed to 2.7m Immediately After Drilling.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH11-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-12

DRAWING NUMBER: 18682-13

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

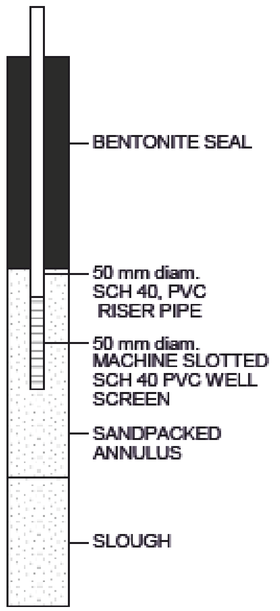
NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 505.98 **DATE DRILLED:** NOV 26/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling

DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)
TOPSOIL, moist, dark brown, organics, rootlets, frozen.	⧄		4.4					
SAND, silty, loose to compact, poorly graded, fine grained, moist, dark brown.	⧄		3.7					
-brown below 0.5 m.	⧄		5.1					
wet, seepage, sloughing below 3.1 m.	☒	10	22.0					
silt seam, some clay, trace sand, firm, medium plastic, moist to wet, dark brown 4.2 to 4.6 m.	☒	9	26.2					
-grey below 4.6 m. -olive grey below 5.3 m.	⧄		22.9					

MONITORING WELL: BH21-12
ELEV.: 507.02



NOTES:
1. Borehole sloughed to 4.6 m Immediately After Drilling.
2. Recorded Groundwater Level Dry on Jan 7/22.

SHEET 1 OF 1

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-13

DRAWING NUMBER: 18682-14

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 506.12 **DATE DRILLED:** NOV 26/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling

DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)	
TOPSOIL, moist, dark brown, organics, rootlets, frozen.	⧄		4.9						
SAND, silty, compact, poorly graded, fine grained, moist, dark brown. brown below 0.6 m.	⧄		4.4						
	☒	11	5.9						
	⧄		6.5					2.0	
moist to wet below 4.1 m.									
CLAY, some silt, stiff to very stiff, highly plastic, moist, brown, oxide stained.	☒	9	36.9			18.3		2.0	
									▽
SAND, silty, loose to compact, poorly graded, fine grained, wet, brown, seepage, sloughing.	⧄		28.3						

NOTES:
1. Borehole sloughed to 5.7 m Immediately After Drilling.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH13-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-14

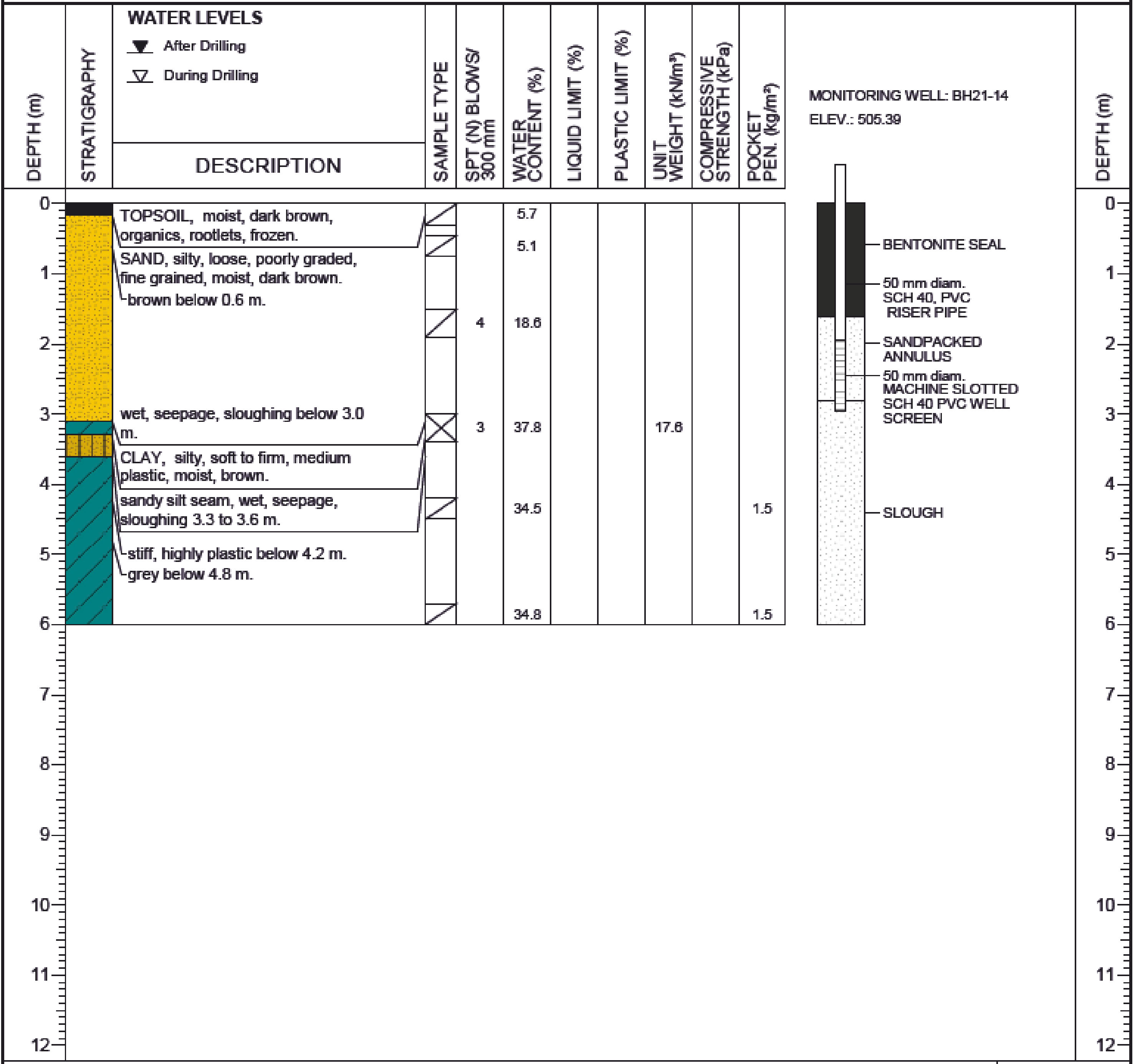
DRAWING NUMBER: 18682-15

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 504.36 **DATE DRILLED:** NOV 29/21

SAMPLE TYPE: ◸ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE



TOPSOIL, moist, dark brown, organics, rootlets, frozen.

SAND, silty, loose, poorly graded, fine grained, moist, dark brown.
-brown below 0.6 m.

wet, seepage, sloughing below 3.0 m.

CLAY, silty, soft to firm, medium plastic, moist, brown.

sandy silt seam, wet, seepage, sloughing 3.3 to 3.6 m.

-stiff, highly plastic below 4.2 m.
-grey below 4.8 m.

NOTES:
1. Borehole sloughed to 3.8 m Immediately After Drilling.
2. Recorded Groundwater Level Dry on Jan 7/22.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH14-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-15

DRAWING NUMBER: 18682-16

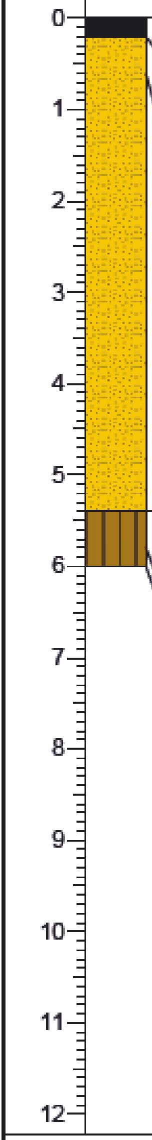
PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 502.67 **DATE DRILLED:** NOV 29/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling



DESCRIPTION

TOPSOIL, moist, dark brown, organics, rootlets, frozen.

SAND, silty, loose, poorly graded, fine grained, moist, dark brown.
- brown below 0.6 m.
- wet, seepage, sloughing below 2.2 m.
- mottled brown and grey below 3.1 m.

SILT, some clay, trace sand, firm, low to medium plastic, wet, brown, seepage, sloughing.
- grey below 5.8 m.

SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)		DEPTH (m)
⧄		16.0							
⧄		9.1							
☒	5	22.0							
								▽	2
☒	7	28.3							
⧄		29.1							
⧄		33.7							

NOTES:
1. Borehole sloughed to 2.2 m Immediately After Drilling.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH15-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-16

DRAWING NUMBER: 18682-17

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 506.39 **DATE DRILLED:** NOV 29/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling

DEPTH (m)	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)		DEPTH (m)
0		TOPSOIL, moist, dark brown, organics, rootlets, frozen.	⧄		5.4							0
		SAND, silty, loose to compact, poorly graded, fine grained, moist, brown.	⧄		3.8							
1												1
			☒	9	4.4							
2		some silt below 1.9 m.										2
			⧄		5.7							
3												3
4		oxide stained below 4.0 m.										4
			☒	10	10.2							
5		wet, seepage, slopughing below 5.2 m.									▽	5
			⧄		28.1							
6												6
7												7
8												8
9												9
10												10
11												11
12												12

NOTES:
1. Borehole sloughed to 5.2 m Immediately After Drilling.

SHEET 1 OF 1

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-17

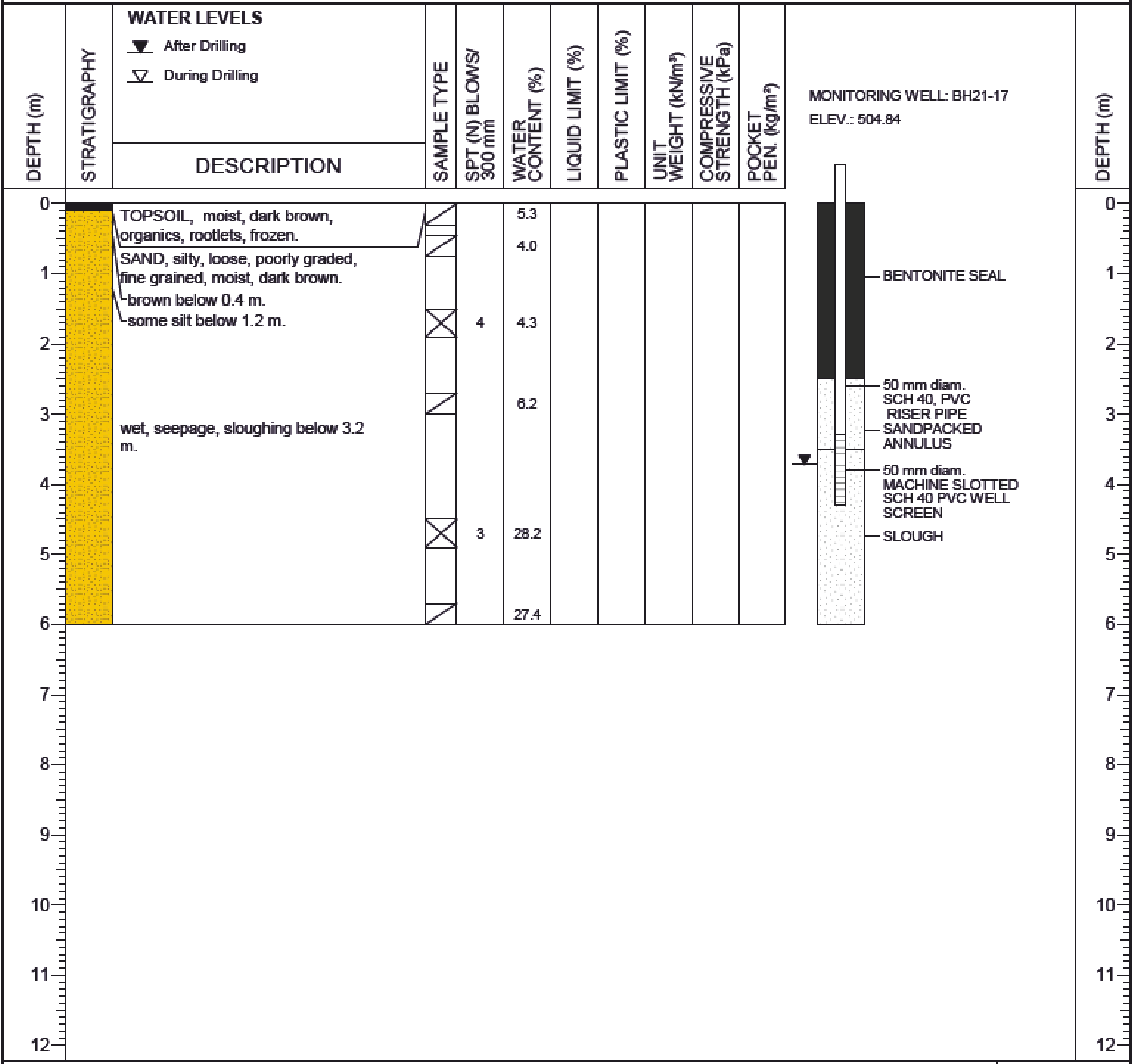
DRAWING NUMBER: 18682-18

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 503.77 **DATE DRILLED:** NOV 29/21

SAMPLE TYPE: / CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE



DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)
TOPSOIL, moist, dark brown, organics, rootlets, frozen.	/		5.3					
SAND, silty, loose, poorly graded, fine grained, moist, dark brown.	/		4.0					
-brown below 0.4 m. -some silt below 1.2 m.	☒	4	4.3					
	/		6.2					
wet, seepage, sloughing below 3.2 m.								
	☒	3	28.2					
	/		27.4					

NOTES:
1. Borehole sloughed to 3.5 m Immediately After Drilling.
2. Recorded Groundwater Level at 3.82 m on Jan 10/22.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH17-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-18

DRAWING NUMBER: 18682-19

PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 505.28 **DATE DRILLED:** NOV 29/21

SAMPLE TYPE: ◸ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling

DEPTH (m)	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	POCKET PEN. (kg/m²)	DEPTH (m)
0	■	TOPSOIL, moist, dark brown, organics, rootlets, frozen.	◸		5.7						0
1 2 3	▨	SAND, silty, loose to compact, poorly graded, fine grained, moist, dark brown. brown below 0.5 m.	◸ ◸ ◸		4.7 4.2 10.7						1 2 3

4 5 6 7 8 9 10 11 12

NOTES:
1. Borehole open and dry Immediately After Drilling.

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-19

DRAWING NUMBER: 18682-20

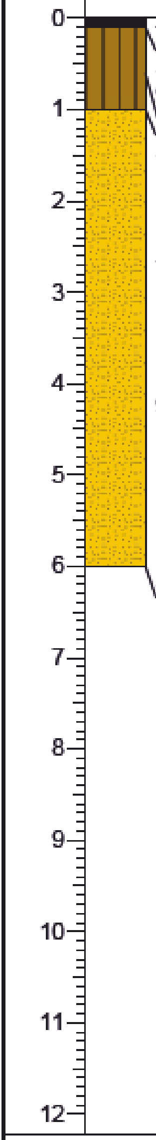
PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 502.25 **DATE DRILLED:** NOV 29/21

SAMPLE TYPE: ⧄ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling



DESCRIPTION	SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	COMPRESSIVE STRENGTH (kPa)	% FINES	
TOPSOIL, moist, dark brown, organics, rootlets, frozen.	⧄		23.0					64.0	
SILT, some clay, trace sand, firm to stiff, medium plastic, moist, dark brown.	⧄		21.1						
brown below 0.6 m.									
SAND, silty, loose to compact, poorly graded, fine grained, moist, brown.	☒	8	21.1						
loose below 2.2 m.									
wet, seepage, sloughing below 2.7 m.									▽
	☒	3	32.4						
grey below 4.2 m.	⧄		30.5						
mottled grey with traces black, trace organic inclusions below 5.9 m.	⧄		31.7						

NOTES:
1. Borehole sloughed to 2.7 m Immediately After Drilling.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH19-18682.bor

P.MACHIBRODA ENGINEERING LTD.

BOREHOLE 21-20

DRAWING NUMBER: 18682-21

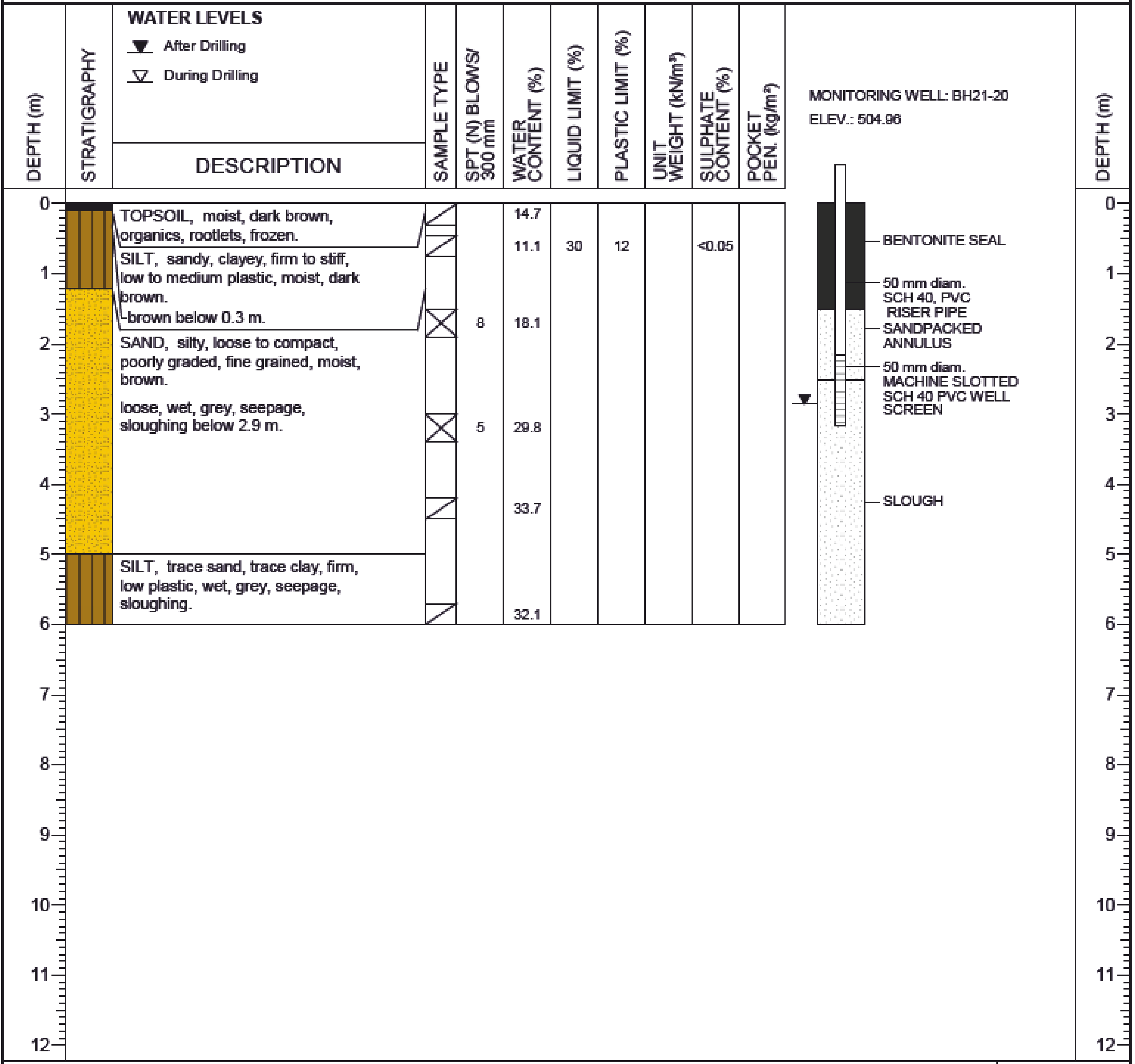
PROJECT: PROPOSED EDGEMONT ESTATES EAST RESIDENTIAL SUBDIVISION

LOCATION: SOUTH OF SASKATOON, SK

NORTHING (m): N/A **EASTING (m):** N/A **ELEVATION (m):** 503.92 **DATE DRILLED:** NOV 29/21

SAMPLE TYPE: ◪ CUTTINGS ☒ SPLIT SPOON ■ SHELBY TUBE

WATER LEVELS
▼ After Drilling
▽ During Drilling



DESCRIPTION

TOPSOIL, moist, dark brown, organics, rootlets, frozen.

SILT, sandy, clayey, firm to stiff, low to medium plastic, moist, dark brown.
-brown below 0.3 m.

SAND, silty, loose to compact, poorly graded, fine grained, moist, brown.
loose, wet, grey, seepage, sloughing below 2.9 m.

SILT, trace sand, trace clay, firm, low plastic, wet, grey, seepage, sloughing.

SAMPLE TYPE	SPT (N) BLOWS/ 300 mm	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	UNIT WEIGHT (kN/m³)	SULPHATE CONTENT (%)	POCKET PEN. (kg/m²)
◪		14.7					
◪		11.1	30	12		<0.05	
☒	8	18.1					
☒	5	29.8					
◪		33.7					
◪		32.1					

NOTES:
1. Borehole sloughed to 2.5 m Immediately After Drilling.
2. Recorded Groundwater Level at 2.96 m on Jan 10/22.

SHEET 1 OF 1

02-08-2022 Z:\2021 Projects\NEWLOG\18682-GEO-SOUTH OF SASKATOON, SK\DWG\BH20-18682.bor

APPENDIX A

Explanation of Terms on Borehole Logs

CLASSIFICATION OF SOILS

Coarse-Grained Soils: Soils containing particles that are visible to the naked eye. They include gravels and sands and are generally referred to as cohesionless or non-cohesive soils. Coarse-grained soils are soils having more than 50 percent of the dry weight larger than particle size 0.080 mm.

Fine-Grained Soils: Soils containing particles that are not visible to the naked eye. They include silts and clays. Fine-grained soils are soils having more than 50 percent of the dry weight smaller than particle size 0.080 mm.

Organic Soils: Soils containing a high natural organic content.

Soil Classification By Particle Size

Soil Type	Particles of Size
Clay	< 0.002 mm
Silt	0.002 – 0.060 mm
Sand	0.06 – 2.0 mm
Gravel	2.0 – 60 mm
Cobbles	60 – 200 mm
Boulders	>200 mm

TERMS DESCRIBING CONSISTENCY OR CONDITION

Coarse-grained soils: Described in terms of compactness condition and are often interpreted from the results of a Standard Penetration Test (SPT). The standard penetration test is described as the number of blows, N, required to drive a 51 mm outside diameter (O.D.) split barrel sampler into the soil a distance of 0.3 m (from 0.15 m to 0.45 m) with a 63.5 kg weight having a free fall of 0.76 m.

Compactness Condition	SPT N-Index (blows per 0.3 m)
Very loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	Over 50

Fine-Grained Soils: Classified in relation to undrained shear strength.

Consistency	Undrained Shear Strength (kPa)	N Value (Approximate)	Field Identification
Very Soft	<12	0-2	Easily penetrated several centimetres by the fist.
Soft	12-25	2-4	Easily penetrated several centimetres by the thumb.
Firm	25-50	4-8	Can be penetrated several centimetres by the thumb with moderate effort.
Stiff	50-100	8-15	Readily indented by the thumb, but penetrated only with great effort.
Very Stiff	100-200	15-30	Readily indented by the thumb nail.
Hard	>200	>30	Indented with difficulty by the thumbnail.

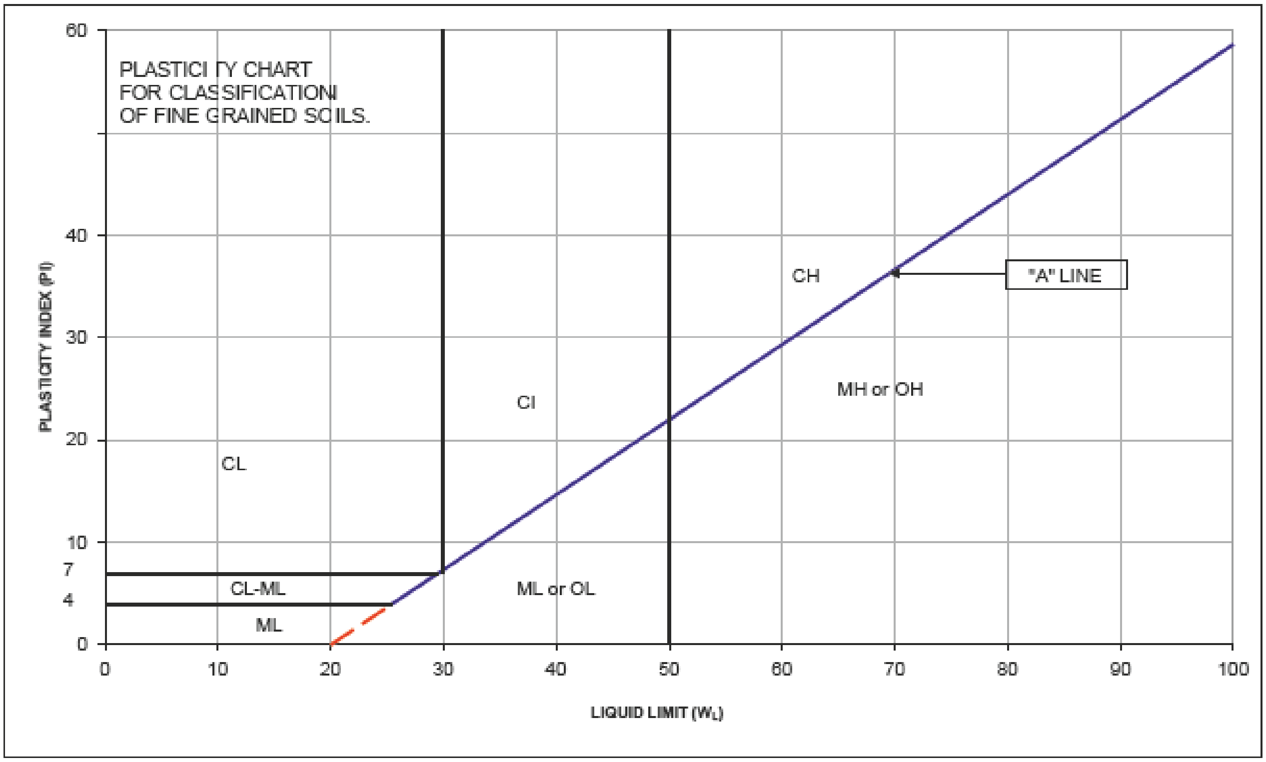
Organic Soils: Readily identified by colour, odour, spongy feel and frequently by fibrous texture.

DESCRIPTIVE TERMS COMMONLY USED TO CHARACTERIZE SOILS

Poorly Graded - predominance of particles of one grain size.
Well Graded - having no excess of particles in any size range with no intermediate sizes lacking.
Mottled - marked with different coloured spots.
Nuggety - structure consisting of small prismatic cubes.
Laminated - structure consisting of thin layers of varying colour and texture.
Slickensided - having inclined planes of weakness that are slick and glossy in appearance.
Fissured - containing shrinkage cracks.
Fractured - broken by randomly oriented interconnecting cracks in all 3 dimensions

SOIL CLASSIFICATION SYSTEM (MODIFIED U.S.C.)

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR AND OFTEN FIBROUS TEXTURE
COARSE-GRAINED SOILS(MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE SIZE)	GRAVELS More than half coarse fraction larger than No. 4 sieve size	CLEAN GRAVELS	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES <5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}} = 1$ to 3
			GP	POORLY-GRADED GRAVELS AND GRAVEL-SAND MIXTURES <5% FINES	NOT MEETING ALL ABOVE REQUIREMENTS FOR GW
		DIRTY GRAVELS	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR PI < 4
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE "A" LINE WITH PI > 7
	SANDS More than half coarse fraction smaller than No. 4 sieve size	CLEAN SANDS	SW	WELL-GRADED SANDS, GRAVELLY SANDS MIXTURES <5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$ $C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}} = 1$ to 3
			SP	POORLY-GRADED SANDS OR GRAVELLY SANDS <5% FINES	NOT MEETING ALL GRADATION REQUIREMENTS FOR SW
		DIRTY SANDS	SM	SILTY SANDS, SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR PI < 4
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE "A" LINE WITH PI >7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSING NO. 200 SIEVE SIZE)	SILTS Below "A" line on plasticity chart; negligible organic content		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	$W_L < 50$
			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	$W_L > 50$
	CLAYS Above 'A' line on plasticity chart; negligible organic content		CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	$W_L < 30$
			CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	$W_L >30 < 50$
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	$W_L > 50$
	ORGANIC SILTS & ORGANIC CLAYS Below "A" line on plasticity chart		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	$W_L < 50$
			OH	ORGANIC CLAYS OF HIGH PLASTICITY	$W_L > 50$



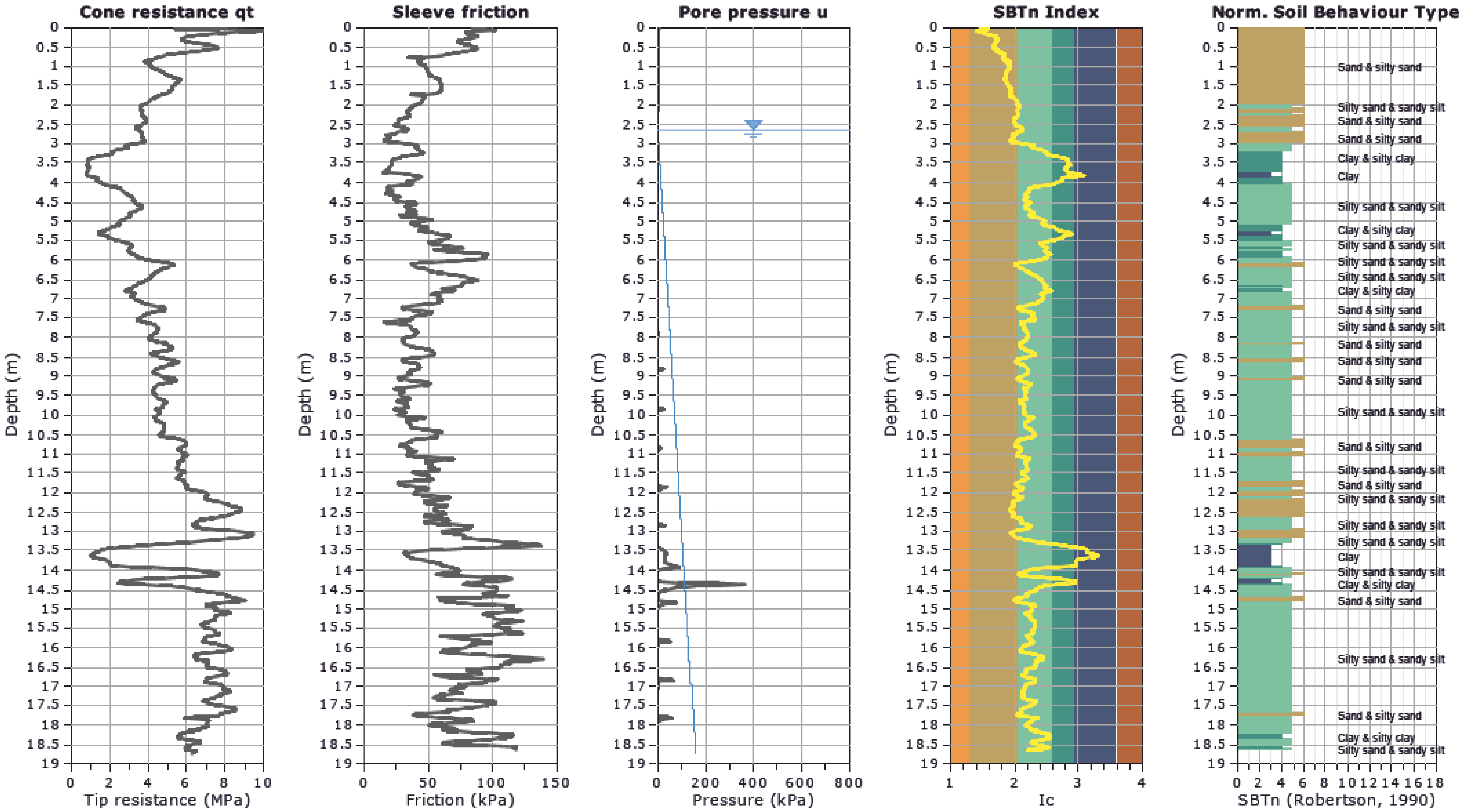
APPENDIX B

CPTu Plots

P. Machibroda Engineering Ltd.
806-48th Street East
Saskatoon, Saskatchewan S7K 3Y4
www.machibroda.com

Project: **Proposed Edgemont Estates East Residential Subdivision**
Location: **South of Saskatoon, SK**

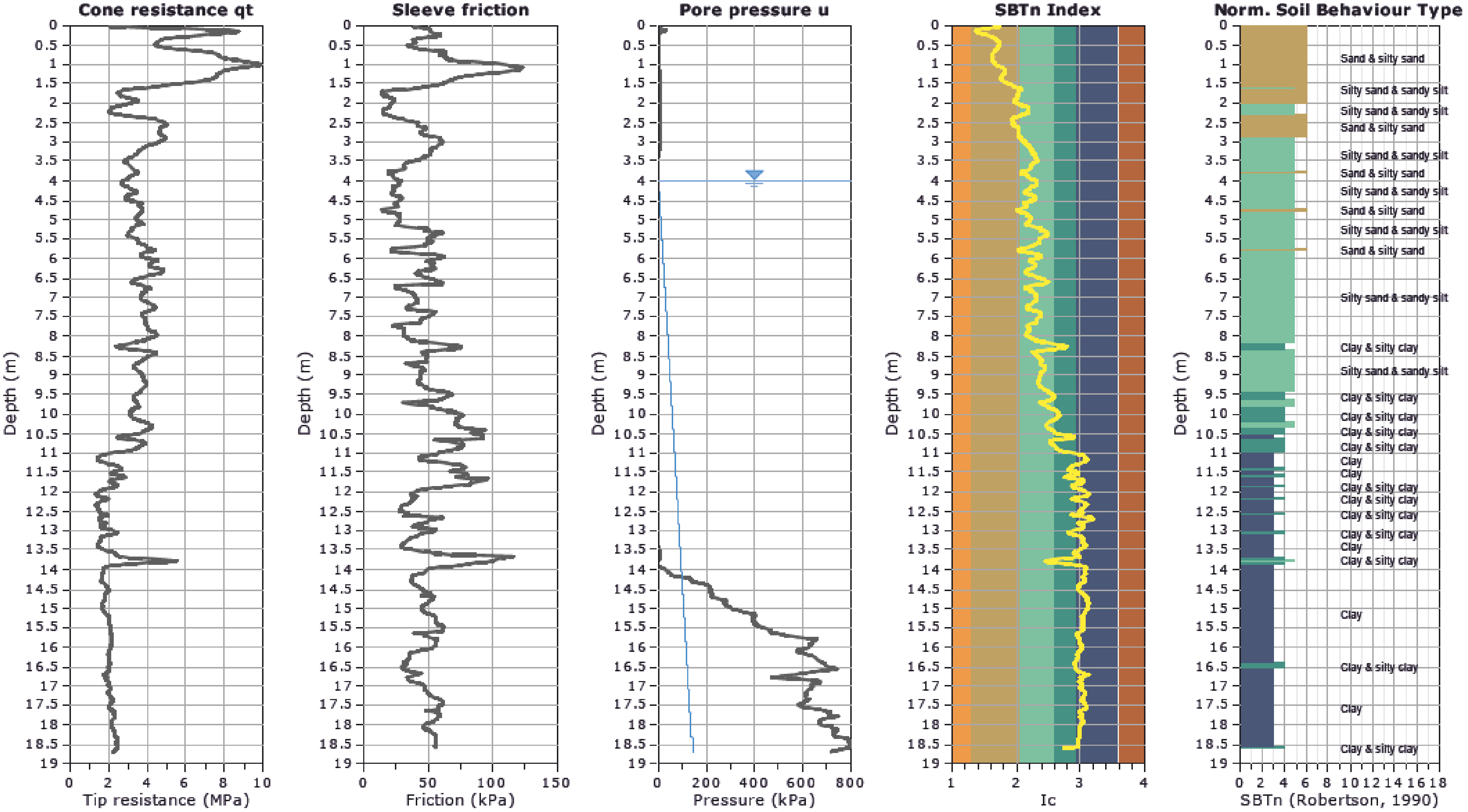
CPT: 21-7
Total depth: 18.74 m, Date: 11/29/2021
Surface Elevation: 503.90 m
Cone Type: Vertek 15 cm^2
Cone Operator: PMEL



P. Machibroda Engineering Ltd.
806-48th Street East
Saskatoon, Saskatchewan S7K 3Y4
www.machibroda.com

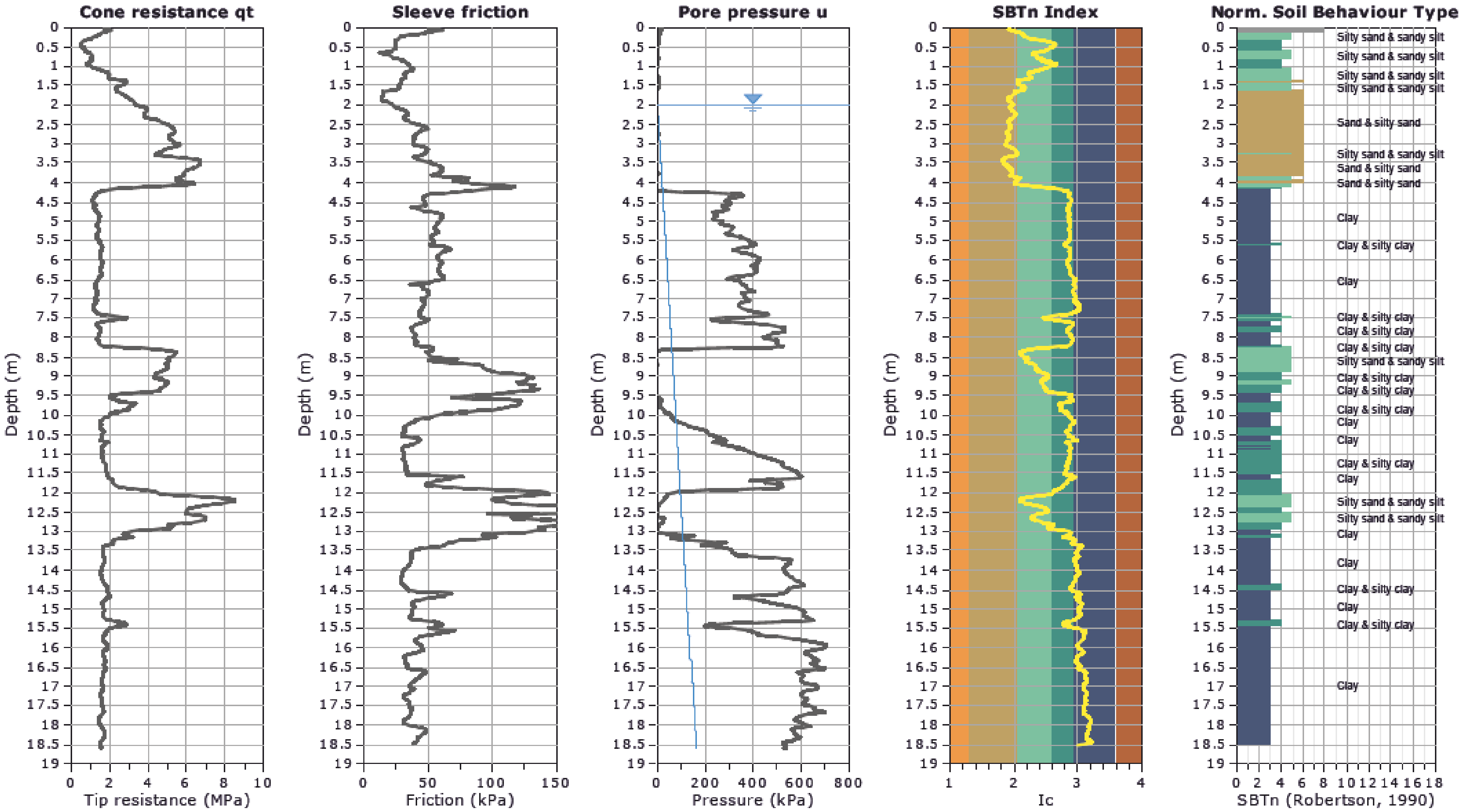
CPT: 21-8
Total depth: 18.70 m, Date: 11/29/2021
Surface Elevation: 506.00 m
Cone Type: Vertek 15 cm^2
Cone Operator: PMEL

Project: **Proposed Edgemont Estates East Residential Subdivision**
Location: **South of Saskatoon, SK**



CPT: 21-9
Total depth: 18.60 m, Date: 11/29/2021
Surface Elevation: 506.00 m
Cone Type: Vertek 15 cm^2
Cone Operator: PMEL

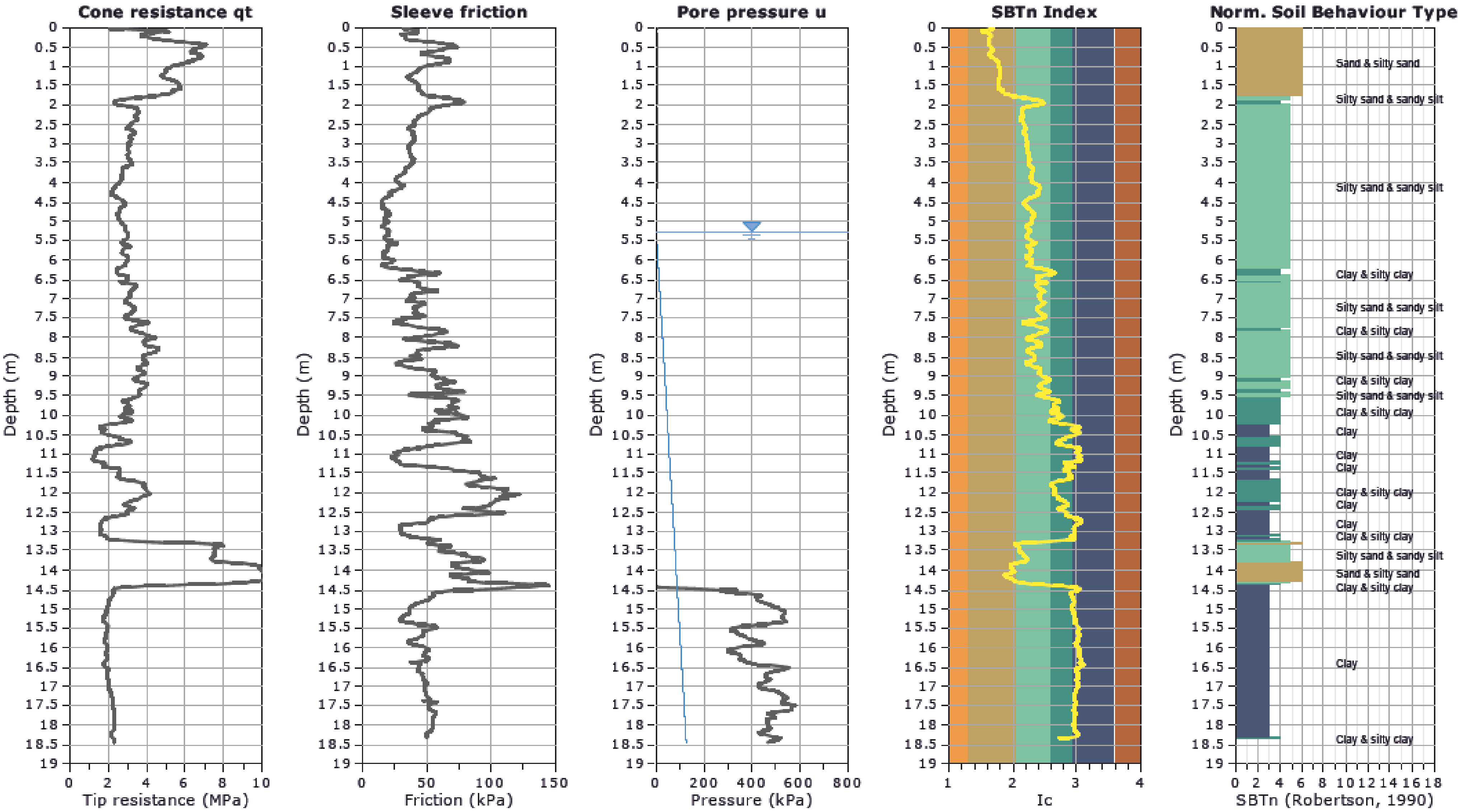
Project: **Proposed Edgemont Estates East Residential Subdivision**
Location: **South of Saskatoon, SK**



P. Machibroda Engineering Ltd.
806-48th Street East
Saskatoon, Saskatchewan S7K 3Y4
www.machibroda.com

CPT: 21-18
Total depth: 18.44 m, Date: 11/29/2021
Surface Elevation: 505.30 m
Cone Type: Vertek 15 cm^2
Cone Operator: PMEL

Project: **Proposed Edgemont Estates East Residential Subdivision**
Location: **South of Saskatoon, SK**



APPENDIX C

Grain Size Distribution Analysis
Test Results

P.MACHIBRODA ENGINEERING LTD.

ASTM C136: GRAIN SIZE ANALYSIS

Project: Edgemont Estates East Residential Subdivision
Location: South of Saskatoon, SK
Project No.: 18682
Date Tested: January 6, 2022
Borehole No: 21-1
Sample No.: 3
Depth: 1.5

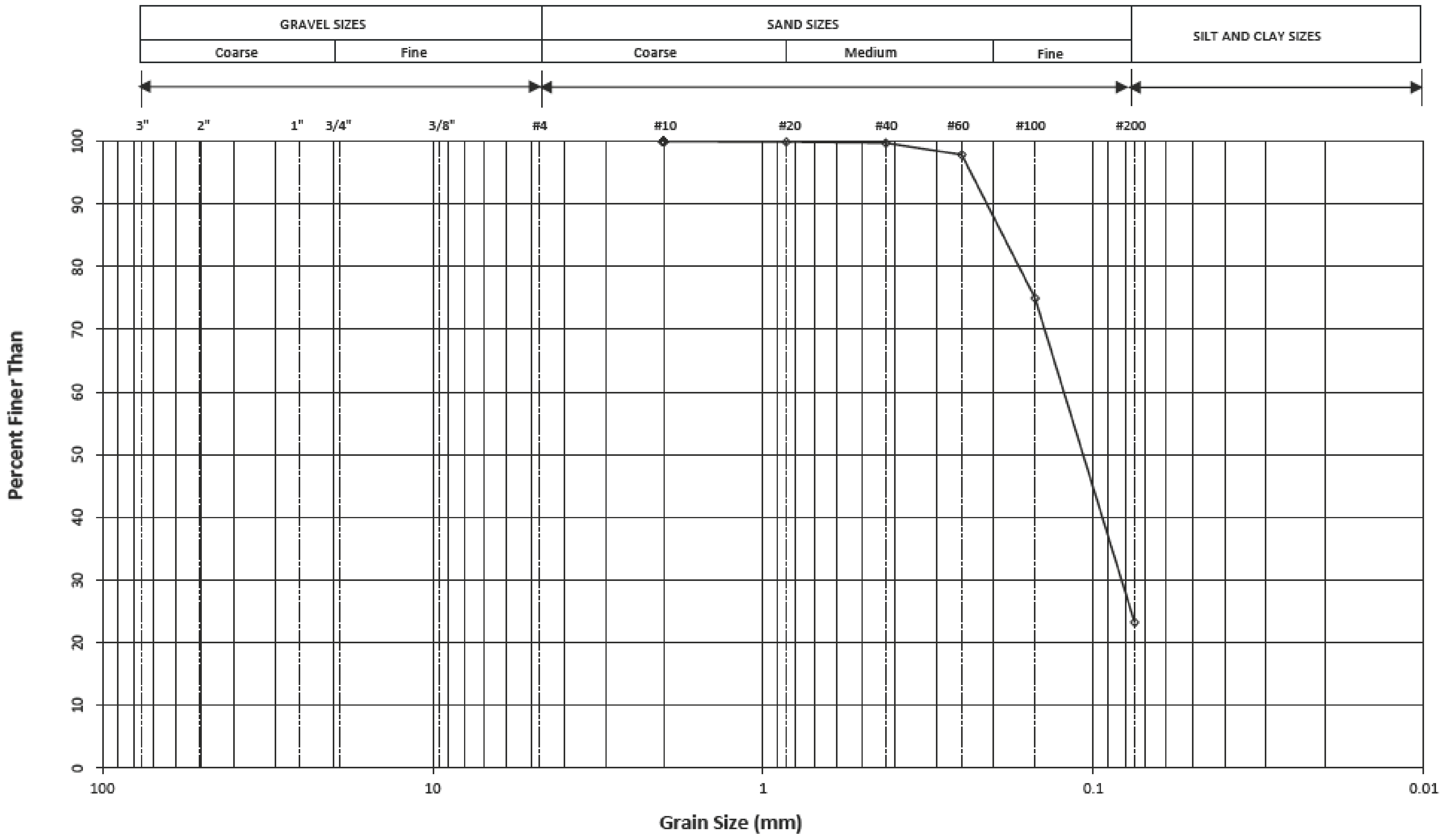
Sieve Analysis:

Sieve	Diameter mm	% Finer
	76.200	100
	63.500	100
	50.000	100
	37.500	100
	25.000	100
	19.000	100
	12.500	100
	9.500	100
	4.750	100
	2.000	100
	0.850	100
	0.425	100
	0.250	98
	0.150	75
	0.075	23

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt and Clay Sizes
0	77	23

Remarks:



CERTIFIED BY CCIL
Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

DRAWING NO.

Appendix C-1

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE
WITH ASTM C136 AND C117 CSTANDARDS
P. MACHIBRODA ENGINEERING LTD.

PER

P.MACHIBRODA ENGINEERING LTD.

ASTM C136: GRAIN SIZE ANALYSIS

Project: Edgemont Estates East Residential Subdivision
Location: South of Saskatoon, SK
Project No.: 18682
Date Tested: January 6, 2022
Borehole No: 21-6
Sample No.: 57
Depth: 1.5-1.9

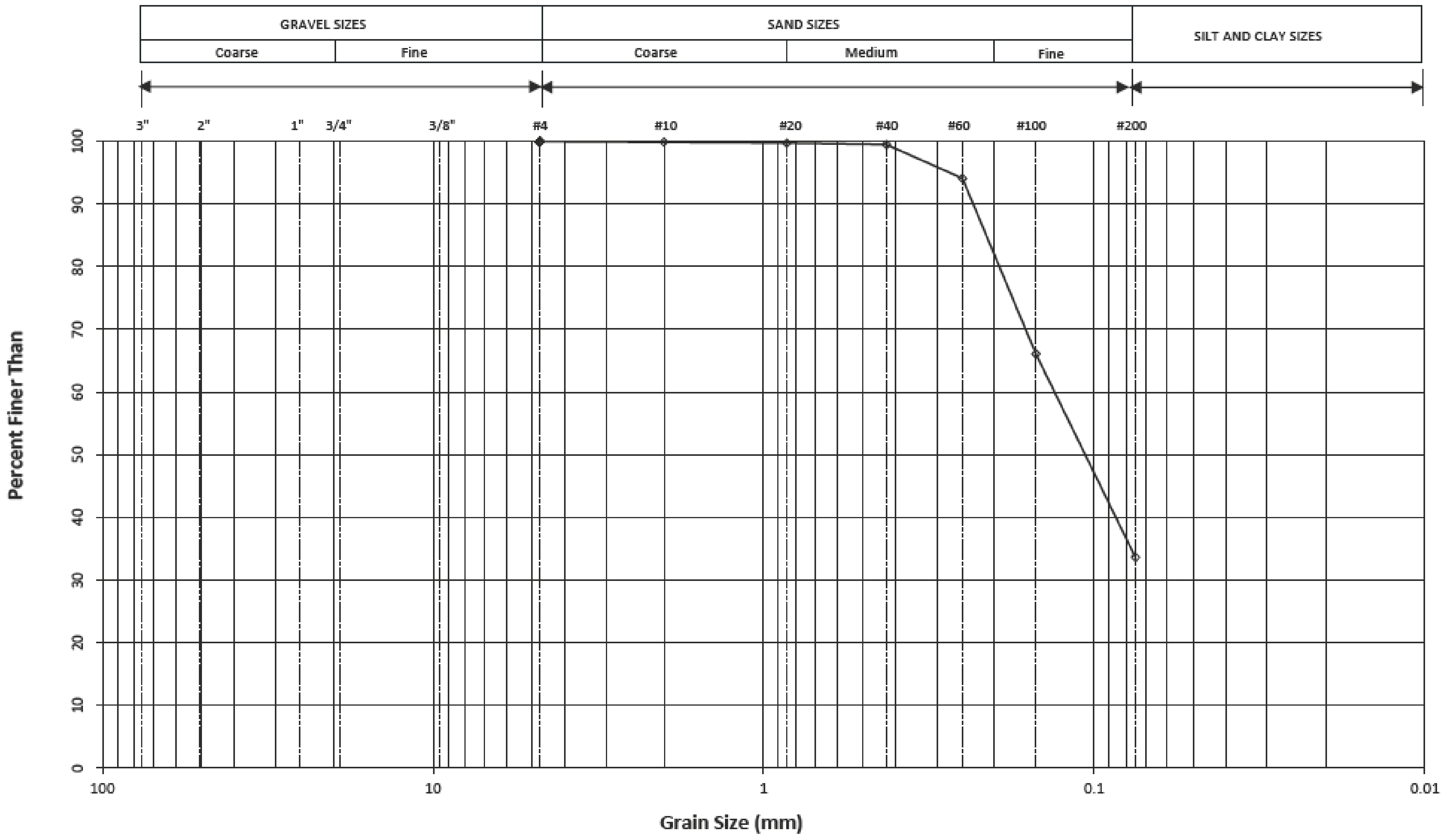
Sieve Analysis:

Sieve	Diameter mm	% Finer
	76.200	100
	63.500	100
	50.000	100
	37.500	100
	25.000	100
	19.000	100
	12.500	100
	9.500	100
	4.750	100
	2.000	100
	0.850	100
	0.425	100
	0.250	94
	0.150	66
	0.075	34

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt and Clay Sizes
0	66	34

Remarks:



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DRAWING NO.

Appendix C-2

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE WITH ASTM C136 AND C117 CSTANDARDS
P. MACHIBRODA ENGINEERING LTD.

PER

P.MACHIBRODA ENGINEERING LTD.

ASTM C136: GRAIN SIZE ANALYSIS

Project: Edgemont Estates East Residential Subdivision
Location: South of Saskatoon, SK
Project No.: 18682
Date Tested: January 6, 2022
Borehole No: 21-7
Sample No.: 104
Depth: 3.0

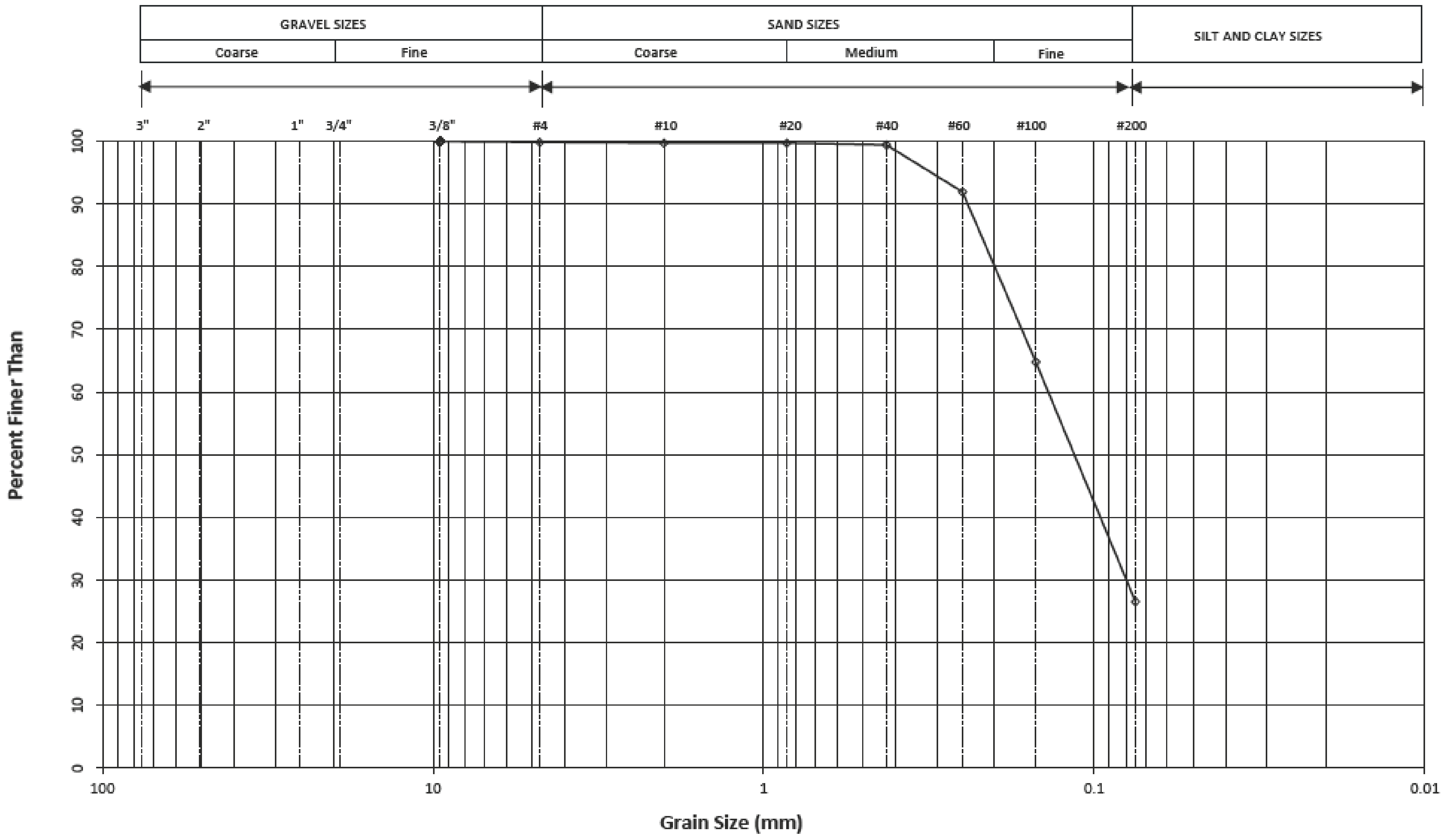
Sieve Analysis:

Sieve	Diameter mm	% Finer
	76.200	100
	63.500	100
	50.000	100
	37.500	100
	25.000	100
	19.000	100
	12.500	100
	9.500	100
	4.750	100
	2.000	100
	0.850	100
	0.425	99
	0.250	92
	0.150	65
	0.075	26

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt and Clay Sizes
0	73	27

Remarks:



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DRAWING NO.

Appendix C-3

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE
WITH ASTM C136 AND C117 CSTANDARDS
P. MACHIBRODA ENGINEERING LTD.

PER

P.MACHIBRODA ENGINEERING LTD.

AASHTO T 88: PARTICLE SIZE ANALYSIS OF SOILS

Project:	Edgemont Estates East Residential Subdivision
Location:	South of Saskatoon, SK
Project No.:	18682
Date Tested:	January 5, 2022
Borehole No.:	21-8
Sample No.:	110
Depth (m):	0.8

Sieve Analysis:

Sieve	Diameter mm	% Finer
1.5"	38.1	100
1"	25.4	100
3/4"	19.1	100
1/2"	12.7	100
3/8"	9.5	100
# 4	4.75	100
# 10	2	100
# 20	0.85	100
# 40	0.425	99.5
#60	0.25	95.3
# 100	0.15	76.7
# 200	0.075	36.5

Hydrometer Analysis:

Dispersing Agent:

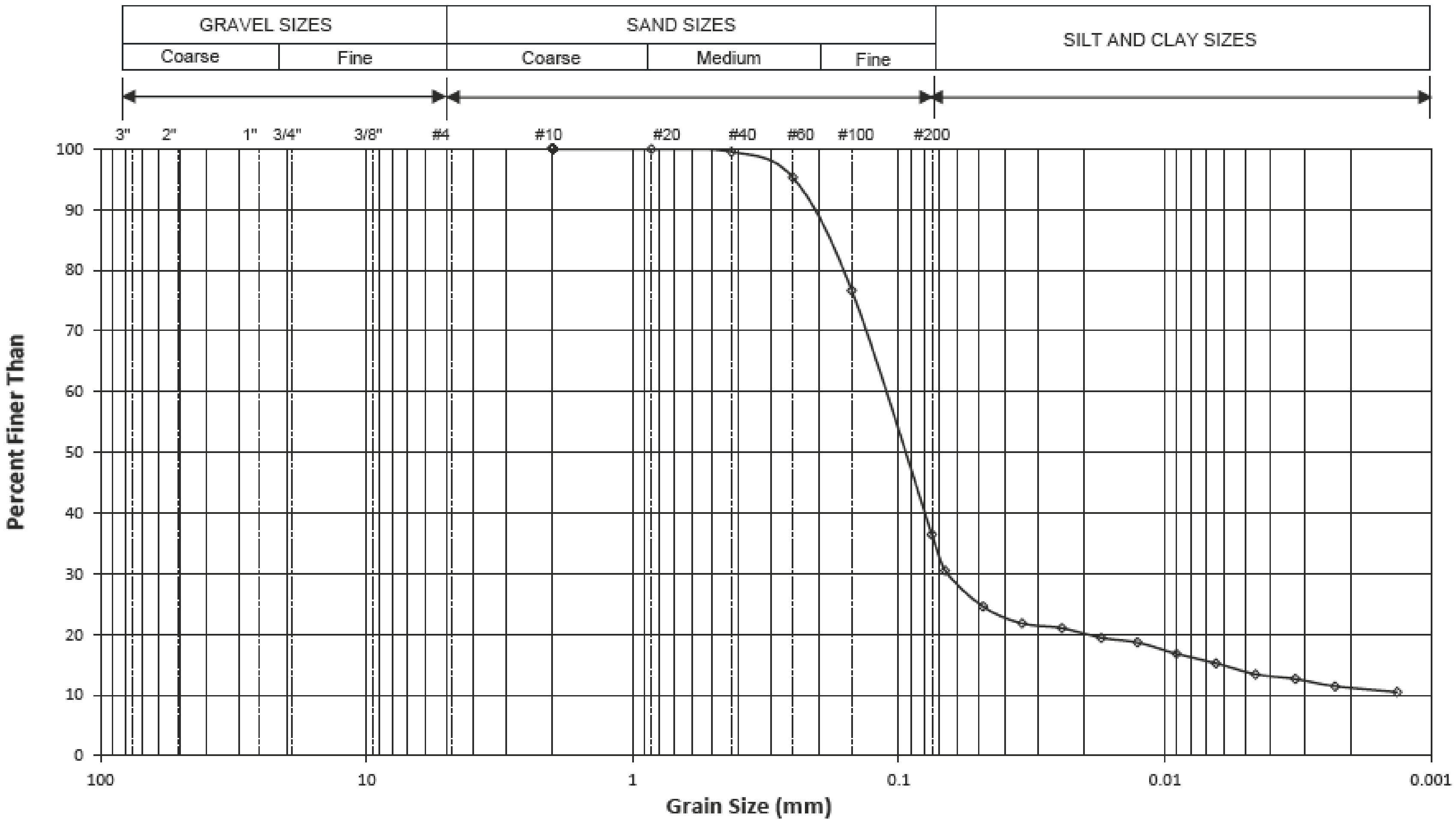
Sodium Hexametaphosphate

Diameter mm	% Finer
0.0670	30.6
0.0482	24.6
0.0344	21.8
0.0244	21.1
0.0173	19.5
0.0127	18.7
0.0090	16.8
0.0064	15.2
0.0046	13.5
0.0032	12.7
0.0023	11.5
0.0013	10.5

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt Sizes	% Clay Sizes
0	63	26	11

Remarks:



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Drawing No.

Appendix C-4

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE
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PER Preston Schergevitch

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ENGINEERING LTD.

ASTM C136: GRAIN SIZE ANALYSIS

Project: Edgemont Estates East Residential Subdivision
Location: South of Saskatoon, SK
Project No.: 18682
Date Tested: January 6, 2022
Borehole No: 21-11
Sample No.: 39
Depth: 1.5-1.9

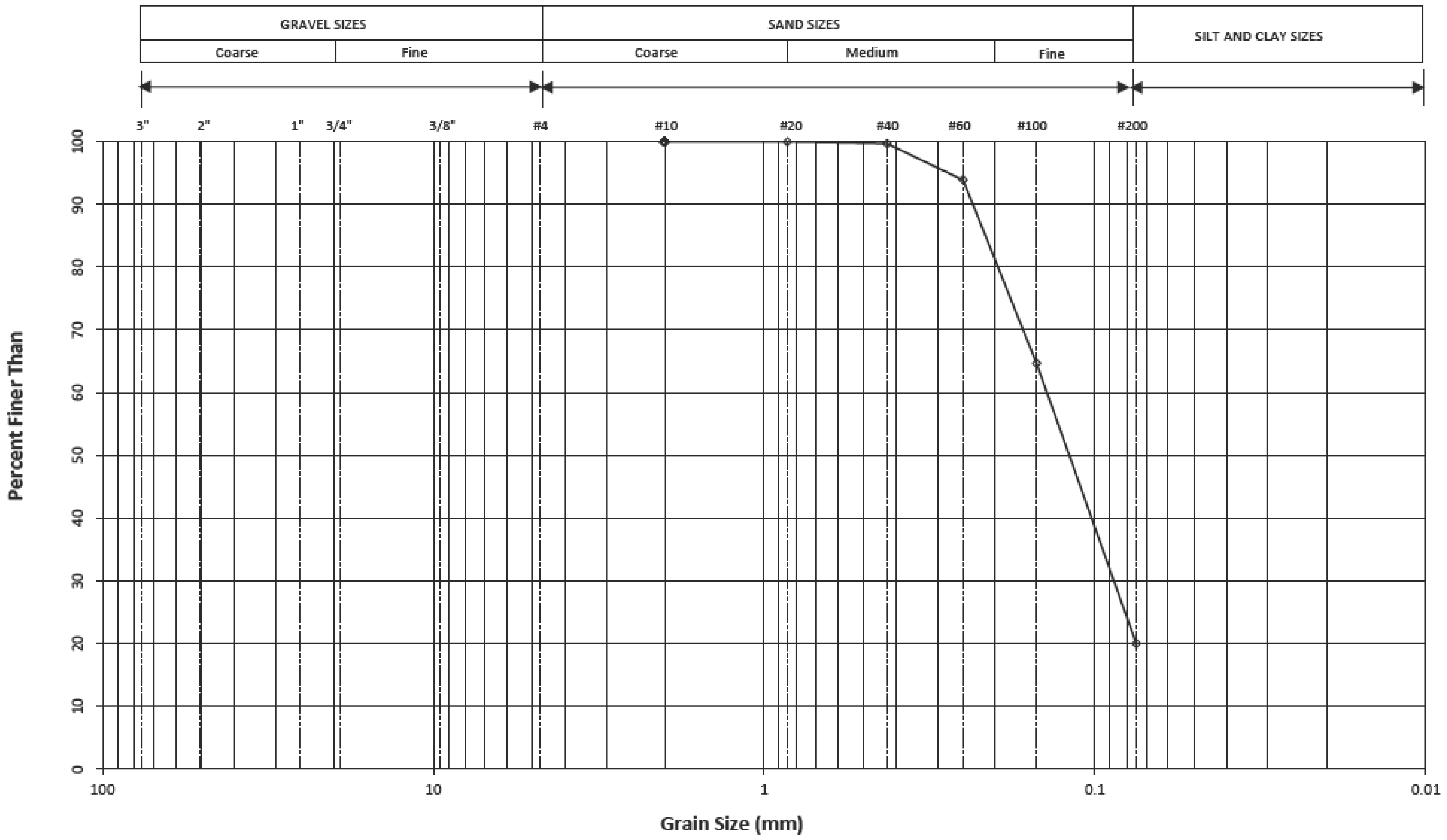
Sieve Analysis:

Sieve	Diameter mm	% Finer
	76.200	100
	63.500	100
	50.000	100
	37.500	100
	25.000	100
	19.000	100
	12.500	100
	9.500	100
	4.750	100
	2.000	100
	0.850	100
	0.425	100
	0.250	94
	0.150	65
	0.075	20

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt and Clay Sizes
0	80	20

Remarks:



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Appendix C-5

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE
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ASTM C136: GRAIN SIZE ANALYSIS

Project: Edgemont Estates East Residential Subdivision

Location: South of Saskatoon, SK

Project No.: 18682

Date Tested: January 6, 2022

Borehole No: 21-14

Sample No.: 69

Depth: 1.5-1.9

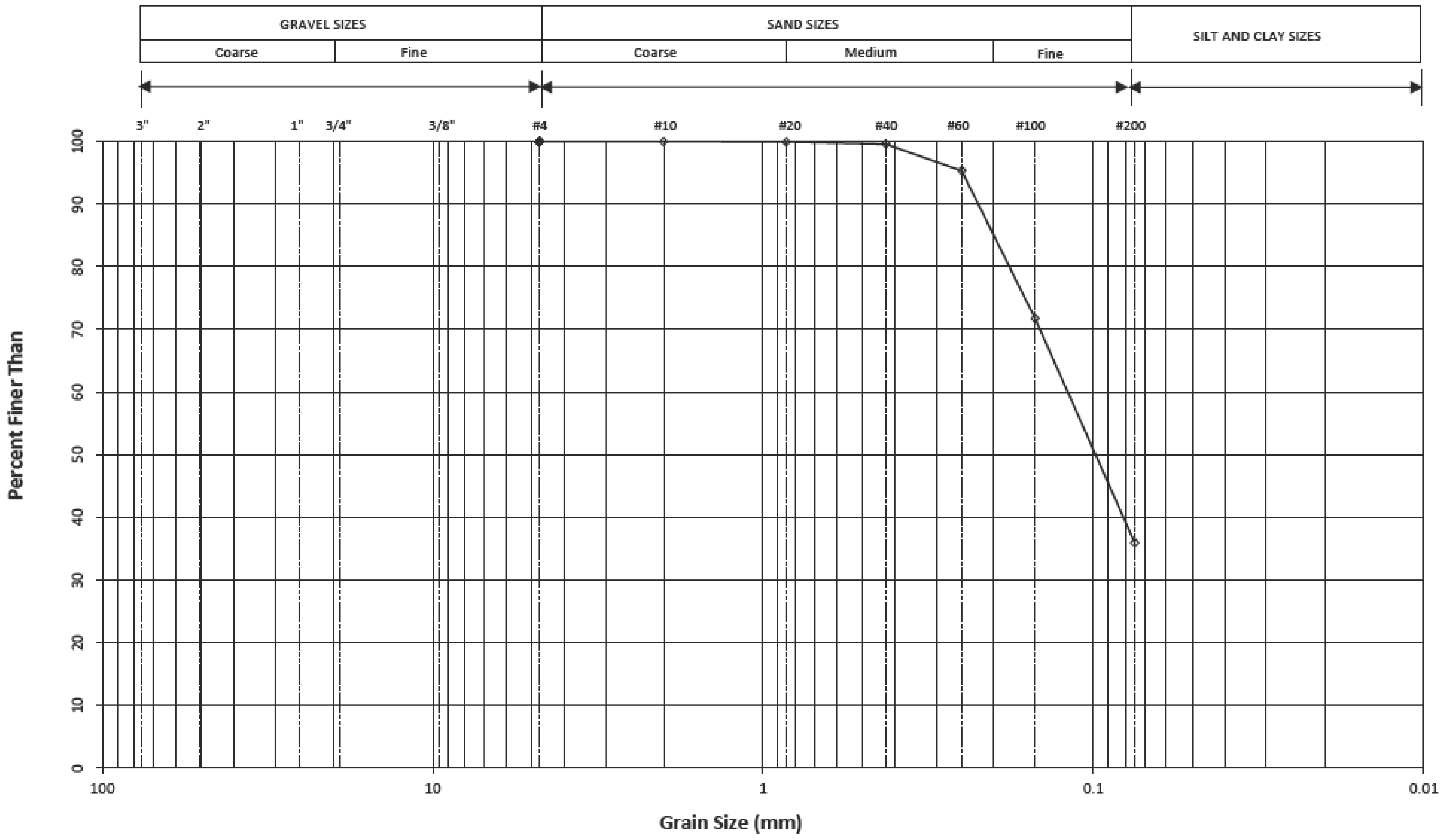
Sieve Analysis:

Sieve	Diameter mm	% Finer
	76.200	100
	63.500	100
	50.000	100
	37.500	100
	25.000	100
	19.000	100
	12.500	100
	9.500	100
	4.750	100
	2.000	100
	0.850	100
	0.425	100
	0.250	95
	0.150	72
	0.075	36

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt and Clay Sizes
0	64	36

Remarks:



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Appendix C-6

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE WITH ASTM C136 AND C117 CSTANDARDS
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AASHTO T 88: PARTICLE SIZE ANALYSIS OF SOILS

Project: Edgemont Estates East Residential Subdivision
Location: South of Saskatoon, SK
Project No.: 18682
Date Tested: January 5, 2022
Borehole No.: 21-15
Sample No.: 62
Depth (m): 0.8

Sieve Analysis:

Sieve	Diameter mm	% Finer
1.5"	38.1	100
1"	25.4	100
3/4"	19.1	100
1/2"	12.7	100
3/8"	9.5	100
# 4	4.75	100
# 10	2	100
# 20	0.85	100
# 40	0.425	99.3
#60	0.25	88.8
# 100	0.15	49.0
# 200	0.075	17.6

Hydrometer Analysis:

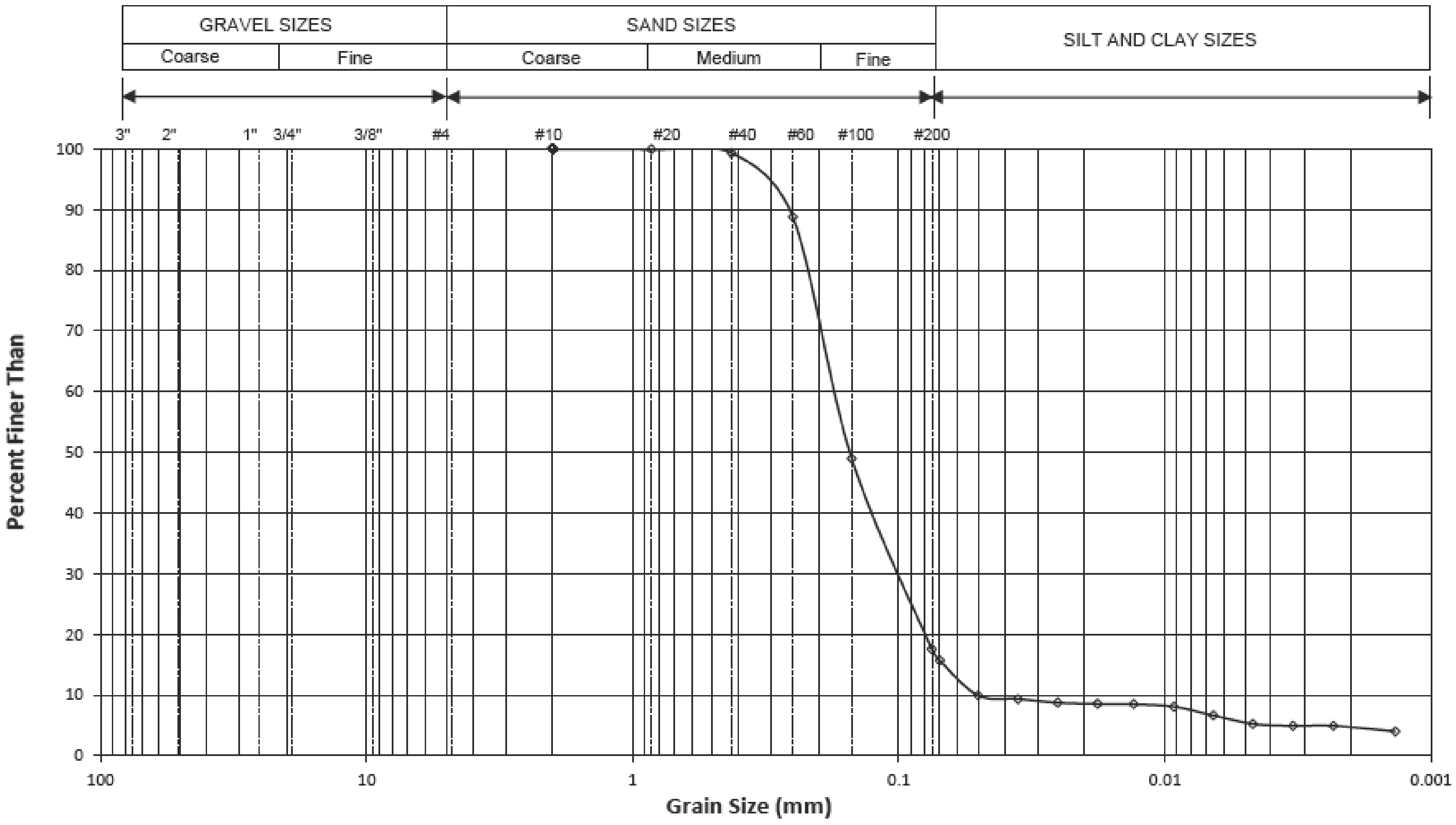
Dispersing Agent:
Sodium Hexametaphosphate

Diameter mm	% Finer
0.0700	15.7
0.0503	10.0
0.0357	9.4
0.0253	8.8
0.0179	8.6
0.0131	8.5
0.0092	8.1
0.0066	6.7
0.0047	5.3
0.0033	4.9
0.0023	4.9
0.0014	4.0

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt Sizes	% Clay Sizes
0	82	13	5

Remarks:



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Appendix C-7

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE
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ASTM C136: GRAIN SIZE ANALYSIS

Project: Edgemont Estates East Residential Subdivision
Location: South of Saskatoon, SK
Project No.: 18682
Date Tested: January 6, 2022
Borehole No: 21-17
Sample No.: 82
Depth: 3.0

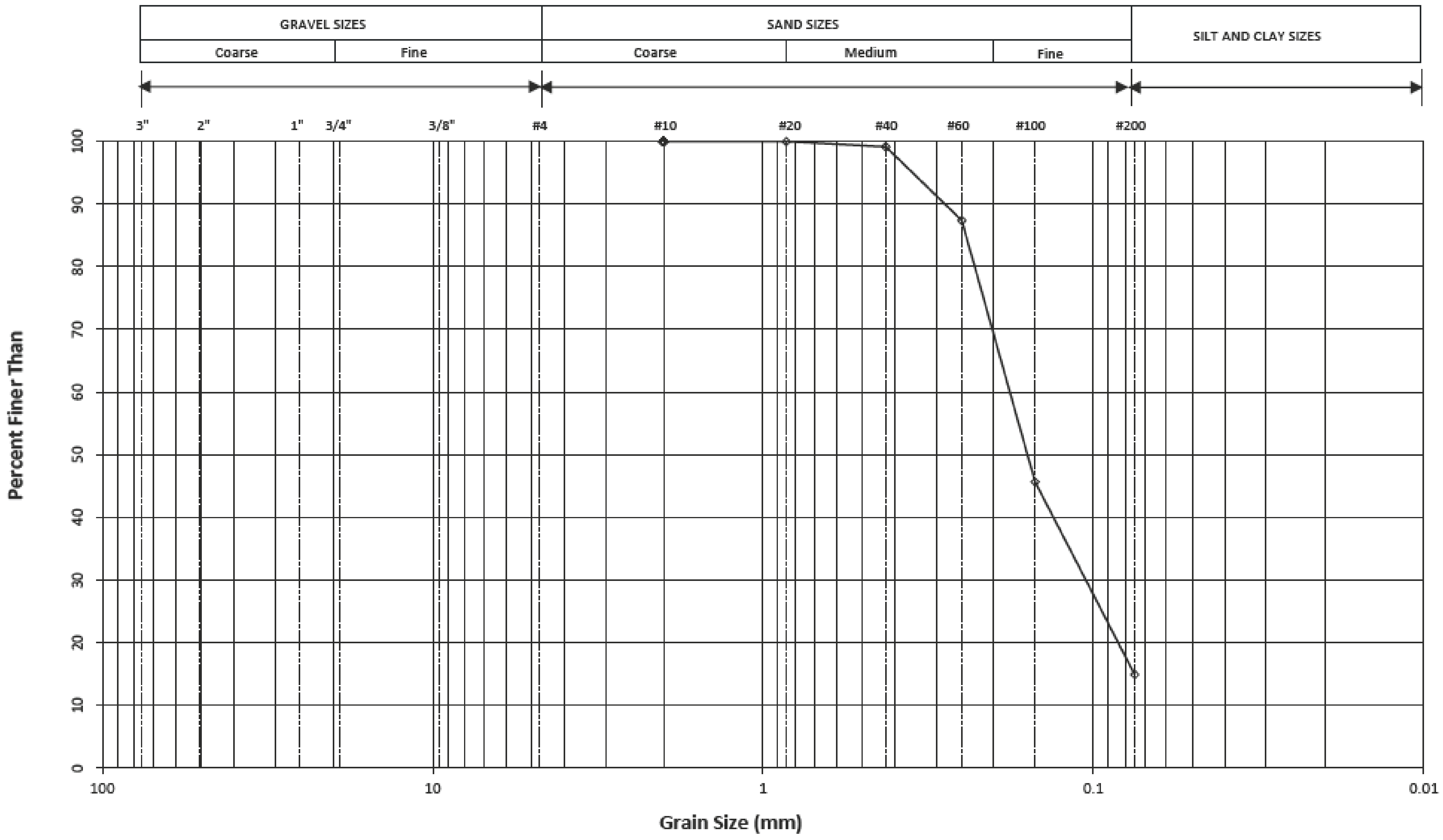
Sieve Analysis:

Sieve	Diameter mm	% Finer
	76.200	100
	63.500	100
	50.000	100
	37.500	100
	25.000	100
	19.000	100
	12.500	100
	9.500	100
	4.750	100
	2.000	100
	0.850	100
	0.425	99
	0.250	87
	0.150	46
	0.075	15

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt and Clay Sizes
0	85	15

Remarks:



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Appendix C-8

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE WITH ASTM C136 AND C117 CSTANDARDS
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AASHTO T 88: PARTICLE SIZE ANALYSIS OF SOILS

Project: Edgemont Estates East Residential Subdivision
Location: South of Saskatoon, SK
Project No.: 18682
Date Tested: January 5, 2022
Borehole No.: 21-20
Sample No.: 92
Depth (m): 0.8

Sieve Analysis:

Sieve	Diameter mm	% Finer
1.5"	38.1	100
1"	25.4	100
3/4"	19.1	100
1/2"	12.7	100
3/8"	9.5	100
# 4	4.75	100
# 10	2	100
# 20	0.85	100
# 40	0.425	99.7
#60	0.25	97.5
# 100	0.15	87.8
# 200	0.075	66.0

Hydrometer Analysis:

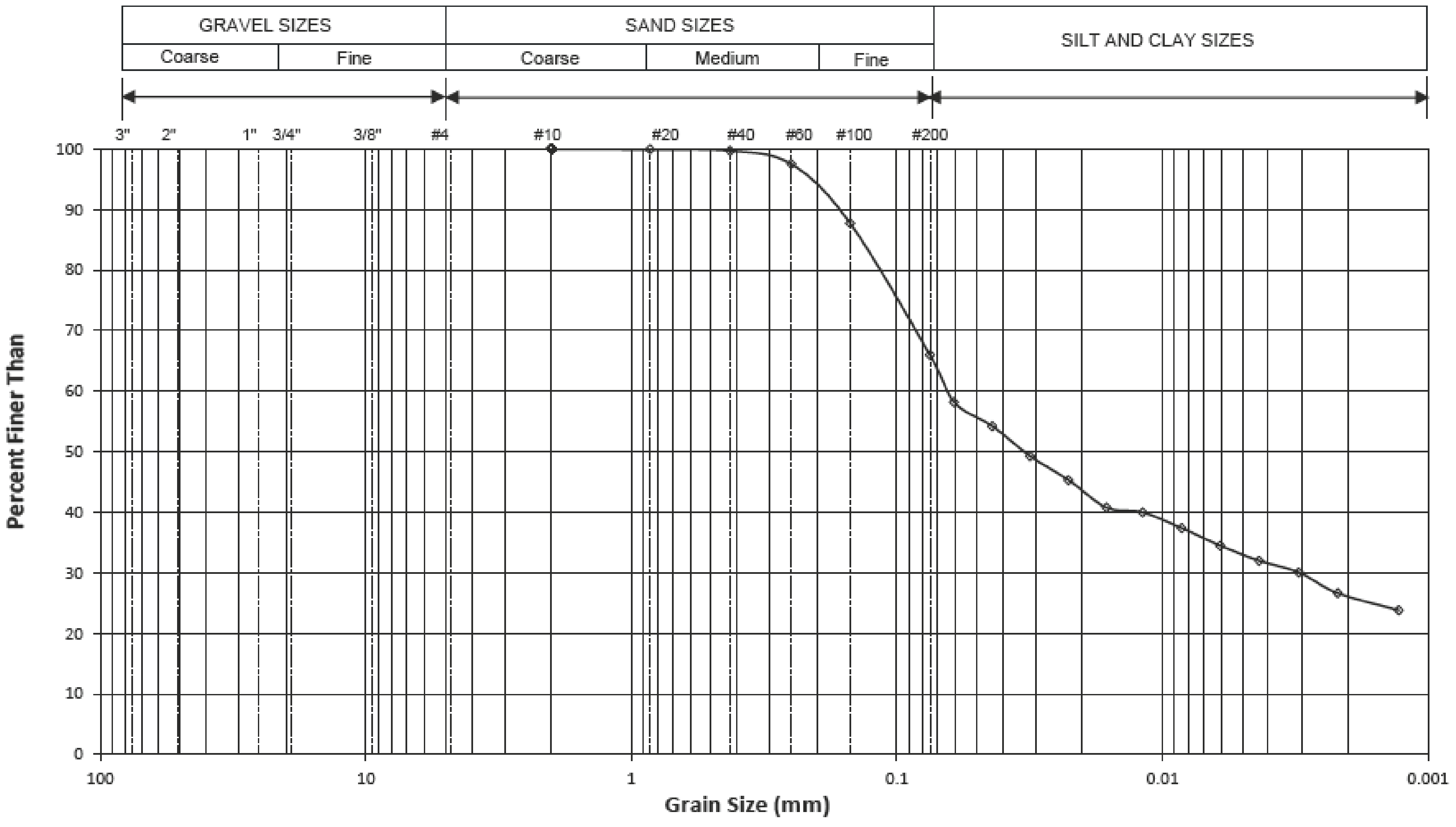
Dispersing Agent:
Sodium Hexametaphosphate

Diameter mm	% Finer
0.0609	58.2
0.0437	54.3
0.0315	49.3
0.0226	45.3
0.0162	40.8
0.0119	40.0
0.0085	37.4
0.0061	34.5
0.0043	32.0
0.0031	30.1
0.0022	26.7
0.0013	23.8

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt Sizes	% Clay Sizes
0	34	40	26

Remarks:



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Drawing No.

Appendix C-9

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE
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ASTM C136: GRAIN SIZE ANALYSIS

Project: Edgemont Estates East Residential Subdivision
Location: South of Saskatoon, SK
Project No.: 18682
Date Tested: January 6, 2022
Borehole No: 21-20
Sample No.: 93
Depth: 1.5-1.9

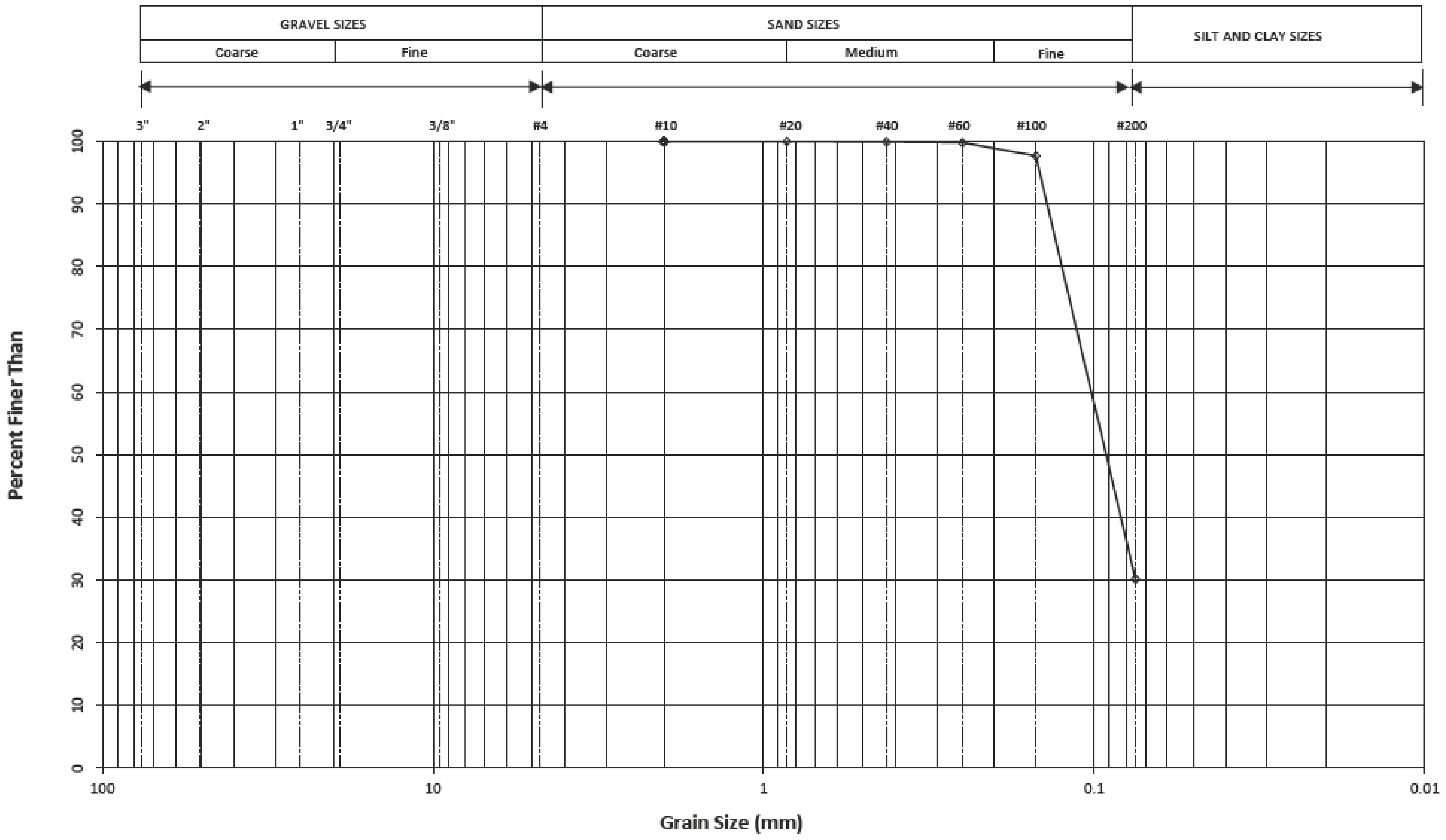
Sieve Analysis:

Sieve	Diameter mm	% Finer
	76.200	100
	63.500	100
	50.000	100
	37.500	100
	25.000	100
	19.000	100
	12.500	100
	9.500	100
	4.750	100
	2.000	100
	0.850	100
	0.425	100
	0.250	100
	0.150	98
	0.075	30

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt and Clay Sizes
0	70	30

Remarks:



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Appendix C-10

WE CERTIFY TESTING PROCEDURES ARE IN ACCORDANCE
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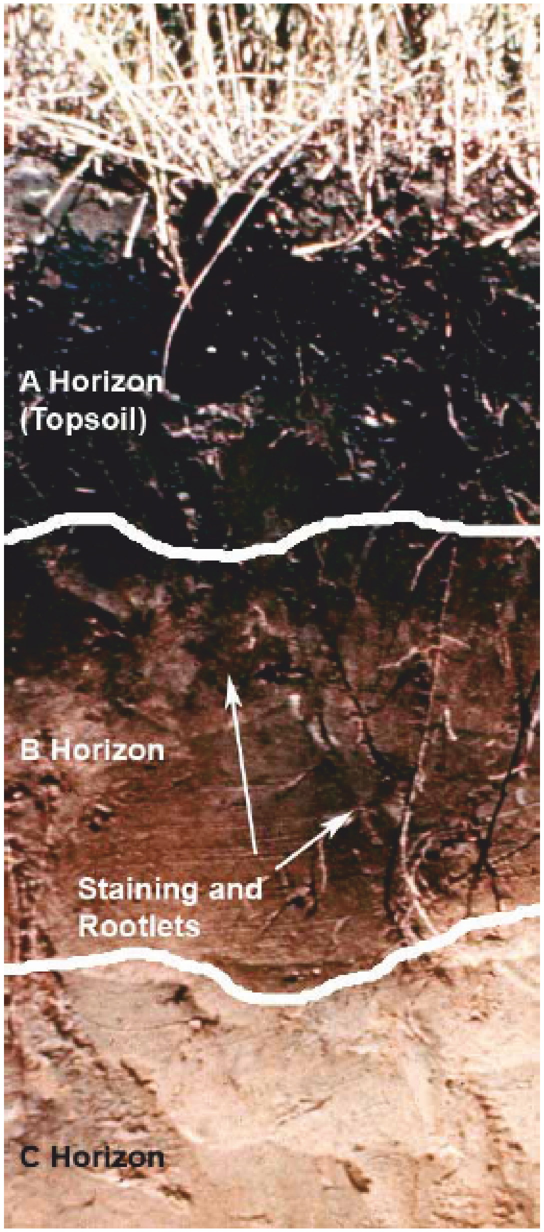
APPENDIX D

Topsoil, Organic Matter and Organics



A Horizon

The A horizon is the topsoil layer of the soil strata. It is characterized by a build up of organic matter, and a lower unit weight than subsequent layers. The organic matter content of this layer is typically 4-10% by mass.

The colour of this horizon varies from dark black to brown, depending on surface vegetation and climatic conditions.

B Horizon

Typically reddish brown in colour and contains accumulations of matter that have been washed down from the A Horizon. The B horizon is generally composed of clay that has been washed out of the A Horizon, but can also contain iron, calcium and sodium deposits as well.

C Horizon

Unweathered parent soil.

Topsoil is a mixture of mineral soil and organic matter. The organic matter is developed from decaying biological material (leaves, grass, trees, animals, etc.) and contributes to the brown to black colour of the soil. Following the topsoil is the B horizon which is a transition layer, where staining from the overlying topsoil is common. This results in a darker colour of the soil immediately below the organic topsoil layer. Depending on the surface vegetation, rootlets may be present below the depth of topsoil. However it should be recognized that these rootlets are not the same as organic matter in topsoil.

Physically speaking in comparison to mineral soil, topsoil has a significantly lower bulk density and a lower unit weight as compared to the underlying parent soil. This is due to larger pore spaces and non mineral materials in the soil matrix. Along with lower density, topsoil is often spongy and colloidal/fibrous. The following figure is of a typical prairie soil. Each horizon is labelled accordingly to demonstrate a typical soil profile.

Reference

Henry L. 2003. Henry's Handbook of Soil and Water, Henry Perspectives, Saskatoon, SK.

APPENDIX E

Detailed Traffic Structure Design

TRAFFIC INFORMATION

1) Design Traffic Loading (ESALs)

BCL Ltd. has reported that the subdivision will be divided into approximately 130 lots with 2 access roads. It is understood that a Traffic Impact Assessment is in the process of being completed by KGS for the development. KGS reported, via email on January 13, 2022, that there will be a maximum number of 1300 vehicles per day on the roads.

The roadway design has been based off the following design traffic loading assumptions.

TABLE E1 Traffic Volume

Item	Value	Note
Design Life	15 years	As per the RM of Corman Park Country Residential Paved Roads specification
Number of Lanes per direction	1	2 way traffic - 1 lane per direction
Directional Split	50%	Traffic will travel equally in each direction.
Design AADT - Year 1	496	Approximate assumed value based on expected growth rate (low population at Year 0)
Design AADT - Year 15	1,300	As per email dated January 17, 2022, 1300 vehicles per day.
Percent Growth Rate	10% - Year 0 to 10 0% - Year 10 to 15	Year 10 is assumed to be build out of the development
Percent Commercial Truck Traffic	5% - Year 0 to 5 3% - Year 5 to 10 0.5% - Year 10 to 15	Years 0 to 5 – high percentage of truck traffic due to construction of residences Years 5 to 10 – construction assumed to slow as development is nearing build out Years 10 to 15 – few to no construction trucks, truck traffic consists mainly of garbage/recycling trucks, septic trucks, fire trucks, delivery trucks, etc.
Truck Traffic Distribution	90%/10%	*Single Unit Trucks/Tractor Semi-Trailer Combinations
Bus Traffic Passes, Daily	8	It was reported that there will be 8 bus passes per day during the school year. It is estimated that there is approximately 40 weeks in the school year.
ESALs per Unit – Trucks	3.0/6.3*	*Single Unit Trucks/Tractor Semi-Trailer Combinations
ESALs per Unit – Buses	5	

Based on the above assumption, the following truck traffic volume is assumed to use the roadway over the design life:

TABLE E2 Cumulative Truck Traffic

Year	Growth Rate (per year)	AADT	AADT - Design Lane[2]	Percent Commercial Traffic	Total Trucks - Design Lane (per day)[3]	Total Trucks - Design Lane (per year)[4]	Cumulative Truck Traffic
0	10%	496	248.2	5%	12.4	4,529.7	4,529.7
1	10%	547	273.3	5%	13.7	4,987.4	9,517.0
2	10%	602	300.9	5%	15.0	5,491.3	15,008.4
3	10%	663	331.3	5%	16.6	6,046.2	21,054.6
4	10%	730	364.8	5%	18.2	6,657.2	27,711.8
5	10%	803	401.6	3%	12.0	4,398.0	32,109.8
6	10%	884	442.2	3%	13.3	4,842.4	36,952.2
7	10%	974	486.9	3%	14.6	5,331.7	42,283.9
8	10%	1,072	536.1	3%	16.1	5,870.5	48,154.3
9	10%	1,181	590.3	3%	17.7	6,463.7	54,618.0
10	0%	1,300	649.9	0.5%	3.2	1,186.1	55,804.1
11	0%	1,300	649.9	0.5%	3.2	1,186.1	56,990.3
12	0%	1,300	649.9	0.5%	3.2	1,186.1	58,176.4
13	0%	1,300	649.9	0.5%	3.2	1,186.1	59,362.5
14	0%	1,300	649.9	0.5%	3.2	1,186.1	60,548.7
15	0%	1,300	649.9	0.5%	3.2	1,186.1	61,734.8

Where:

[1] 'AADT' = AADT(20XX) * (1+Growth Rate)

[2] 'AADT-Design Lane' = 'AADT' * 'Directional Split' * 'Load Distribution Factor (Truck)'

[3] 'Total Trucks - Design Lane (per day)' = 'AADT - Design Lane' * 'Percent Commercial Traffic'

[4] 'Total Trucks - Design Lane (per year)' = 'Total Trucks - Design Lane' * 365

Load Equivalency Factor, LEF

TABLE E3 Weight ESALs, Commercial

Vehicle Type	Assumed Percent Vehicle Type	Corresponding ESALs per Unit (primary weights) - Based on DDSM
Single unit Trucks	90.0	3
Tractor Semi-Trailer Cominations	10.0	6.3
	Weighted ESALs =	3.33

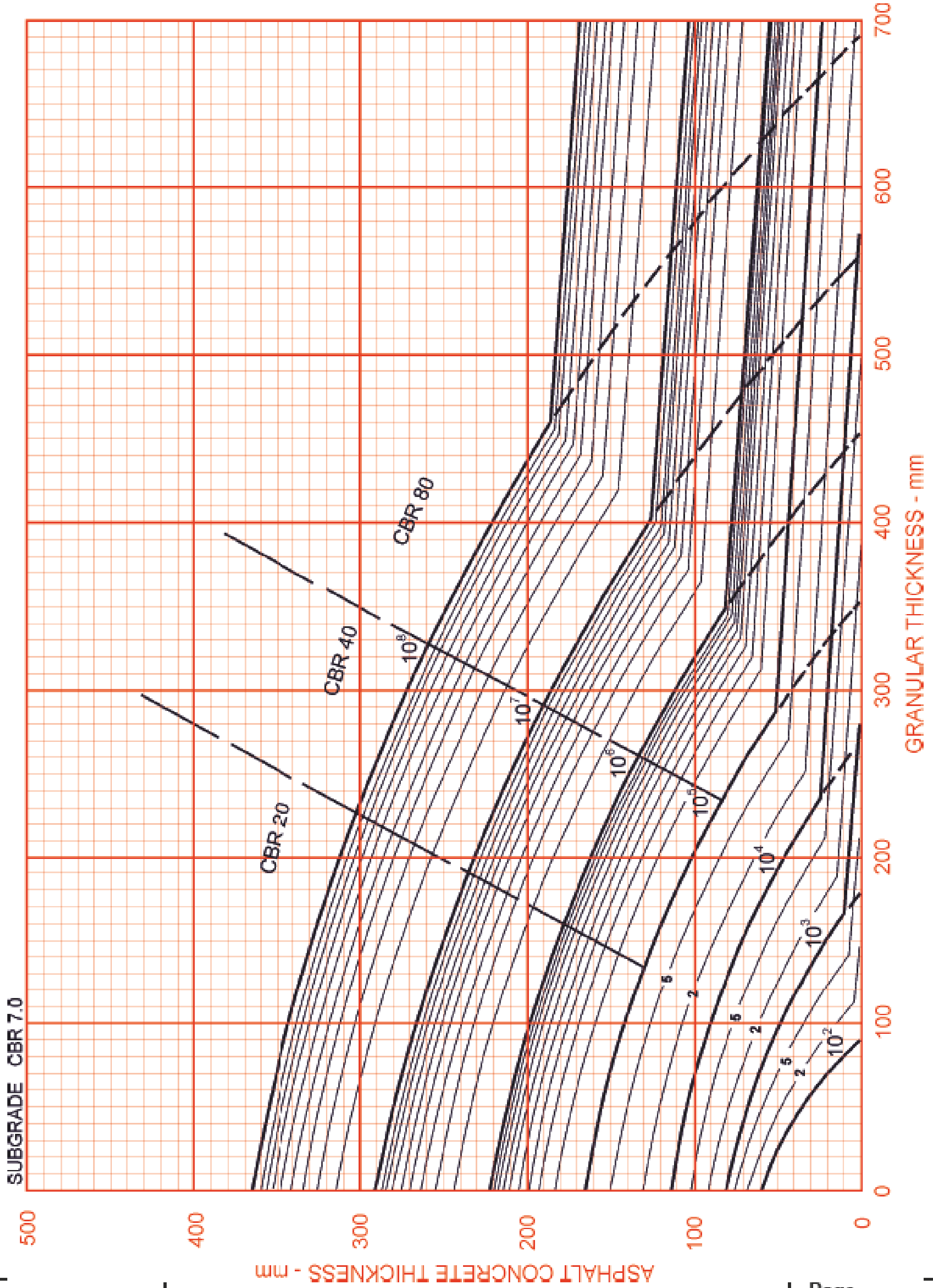
Bus Traffic

It was reported that there will be 8 bus passes per day per week day during the school year. It is estimated that there is approximately 40 weeks in the school year. As such, the following number of buses are assumed over the design life:

24000 buses/design life (8 bus passes per day*5 days/school week * 40 school weeks/year*15 years)

Design ESALS/lane

Commercial =	205,577	(Weighted ESALs * 15 Year Cumulative Truck Traffic from Table E2)
Buses =	120,000	(Bus ESAL from Table EI *buses/design life)
Design ESALs/Lane =	325,577	


SUBGRADE CBR 7.0
CBR 20
CBR 40
CBR 80
10^8
10^7
10^6
10^5
10^4
10^3
10^2
5
2
5
2
5
2
GRANULAR THICKNESS - mm
0
100
200
300
400
500
600
700
ASPHALT CONCRETE THICKNESS - mm
500
400
300
200
100
0