GEOTECHNICAL INVESTIGATION

BIRCHCLIFF RURAL SUBDIVISION

SE 17-39-1-W5M
LACOMBE COUNTY, ALBERTA

PREPARED FOR

LONGVIEW PLANNING & DESIGN
CALGARY, ALBERTA

LONGVIEW
Planning + Design

PREPARED BY

PARKLAND GEOTECHNICAL CONSULTING LTD.

RED DEER, ALBERTA

Parkland GEO

PROJECT No.: RD3452

AUGUST 2010

Environmental Geotechnical and Materials Engineering
Red Deer • Sherwood Park • Grande Prairie • Airdrie • Peace River

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

Longview Planning & Design is proposing to develop a new rural residential subdivision in Lacombe County, Alberta. Parkland Geotechnical Consulting Ltd. (ParklandGEO) was requested to perform a geotechnical investigation of the site for the proposed project. The scope was outlined in ParklandGEO's proposal dated November 17, 2009 (File#PRO1745). Authorization to proceed with this investigation was give by Mrs. Kristi Beunder of Longview Planning & Design. This report summarizes results of the field and laboratory testing programs and presents geotechnical recommendations for general site development.

2.0 SITE DESCRIPTION

The proposed rural subdivision site is located west of Highway 20, within SE 17-39-1-W5M, Lacombe County, Alberta. The site location is shown on the Key Plan, Figure 1. The site plan for the 48 acre property is shown on the Site Plan, Figure 2. The site is a mixture of natural prairie grasses and trees typical of the Aspen Parklands. There is a private residential acreage located to the southeast; and the summer Village of Birchcliff is located on the eastern shore of Sylvan Lake is located to the west. The area to the north and east is primarily agricultural (crop) lands. Jarvis Bay Provincial Park and the Town of Sylvan Lake are located to the south. An aerial photograph of the site is shown on the 2007 Aerial Photograph, Figure 3.

The site grades towards the southwest towards Sylvan Lake with an elevation difference between boreholes ranging from 973.51 m in the northeast corner to 950.48 m in the southwest corner. Site contours are shown on the Contour Plan, Figure 4. Site photographs are shown on the Site Photographs, Figures 5 and 6.

3.0 FIELD AND LABORATORY PROGRAMS

On March 3, 2010, ten boreholes were drilled at the site on an approximate 150 m grid at the locations shown on the Site Plan, Figure 2. The boreholes were drilled to depths of 2.9 to 7.5 m. The soil encountered was logged according to the Modified Unified Soil Classification System. Soil samples were taken at 1.0 m intervals in order to determine the soil moisture profile. All soil samples were returned to ParklandGEO's Red Deer soil laboratory for selected testing to determine the soil properties.

The groundwater levels were measured at completion of drilling, on March 19, 2010. The local ground surface elevations at the borehole locations were surveyed by ParklandGEO.

4.0 SOIL CONDITIONS

The general soil profile was, in descending order: topsoil; glacial till; sand and silt and bedrock. The detailed soil conditions encountered at the borehole locations are described on the borehole logs in Appendix A. The soil test results and definitions of the terminology and symbols used on the borehole logs are provided on the explanation sheets also in Appendix A. The following is a brief description of the soil types encountered.

4.1 SURFICIAL TOPSOIL

A topsoil layer 90 to 250 mm thick was encountered in all boreholes. The topsoil was organic, black and moist. It is likely that topsoil thicknesses will vary between boreholes and thicker deposits may be present. The topsoil was moderately organic, black and moist, and it is considered to be weak and highly compressible when subjected to loads.

4.2 CLAY TILL

Glacial clay (till) was encountered in all boreholes, except Borehole 2. The till extended to depths between 2.7 and 3.8 m in Boreholes 3, 6 and 9 and beyond the depths drilled in Boreholes 1, 4, 5, 7, 8 and 10. The till was a variable mixture of silt, sand, and clay with trace gravel, and occasional rust stains, coal inclusions and water bearing sand lenses. The local till is known to have inclusions of boulders and may have been encountered in Borehole 4. The till was low to medium plastic, stiff to very stiff, with moisture contents ranging from 13 to 23 percent with an average moisture content of 17.3. Based on local experience, the estimated Optimum Moisture Content (OMC) of clay till is about 15 percent. Therefore, the soil moisture contents of the till are considered to be at or slightly above OMC.

4.3 SILT AND SAND

Silt and sand was encountered below the topsoil in Boreholes 1 and 2 and below the clay till in Boreholes 3 and 6. The thickness of the silt and sand layers in Boreholes 1, 2 and 3 was 0.5 m, 4.7 m, and 1.3 m respectively. The silt and sand extended beyond the depths drilled in Borehole 6. The sand deposits were fine grained, poorly graded and non plastic with varying proportions of silt. The silt and sand were considered to be compact to very dense, and the relative density increases with depth, suggesting this material was probably very weathered sandstone bedrock. The sand had moisture contents ranging from 10 to 15 percent..

4.4 BEDROCK

Weathered bedrock was encountered below the silt, sand and clay till deposits in Boreholes 2, 3 and 9 at depths ranging from 2.7 m to 4.8 m which corresponds to an elevation between 961.69 to 968.91 m. The bedrock surface roughly mirrors the ground surface topography. The bedrock in this area consists of sandstone. The bedrock is considered to be an intact weak rock with a relative density of a very dense hard soil. The competency of the local bedrock increases with depth.

4.5 WATER SOLUBLE SULPHATE

Soil samples were taken at a depth of 2.0 m for water soluble sulphate concentration tests in all boreholes. The concentrations of sulphates are expressed as a percent of the dry mass of soil. The concentrations of water soluble sulphates were 0.04 percent which indicates a “negligible potential for sulphate attack on buried concrete in direct contact with soil."

5.0 GROUNDWATER LEVELS

Groundwater measurements were taken upon drilling completion and on March 19, 2010. The following table summarizes the observed the groundwater conditions.

TABLE 1
GROUNDWATER MEASUREMENTS

Borehole #	Ground Elevation (m)	Water Levels		Elevations
		At Completion	March 19, 2010	March 19, 2010
1	960.8	Dry	Destroyed	Destroyed
2	968.89	Dry	Dry	-
3	973.51	Dry	Dry	-
4	953.66	Dry	Dry	-
5	958.47	Dry	1.97	956.5
6	967.29	Dry	Dry	-
7	950.48	Dry	Dry	-
8	953.16	Wet	2	951.16
9	964.09	Dry	2.2	961.89
10	953.05	Wet	5.76	947.29

The observed groundwater level is considered to be near the seasonal average. The groundwater table varied with topography between 2 and 6 m below grade and the groundwater elevations ranged from 962 m to 947 m flowing towards Sylvan Lake to the southwest. Local groundwater is dependent on infiltration of surface water for their recharge, groundwater conditions are expected to be most adverse after snow-melt and periods of heavy or prolonged precipitation.

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 GEOTECHNICAL EVALUATION

The proposed Birchcliff subdivision development is a rural subdivision. It is understood that the proposed development will tied into the new regional wastewater pipeline proposed for Sylvan Lake. Most of the site will be left in a relatively natural condition with minimal grading. Service trenches are expected to be located in road side ditches with occasional road crossings. Service crossing could be open cut trenches or drilled by HDD method. Grading will be required for the roadways and may be proposed on some of the lots with steeper grades. The local road will be paved, although final paving may be staged. A rural road section with road side ditches will be provided.

The subsurface conditions at this site are considered to be suitable for the proposed residential development. Construction considerations are expected to be similar to those common in Lacombe County. The main geotechnical concerns regarding soil conditions and foundations at the site are:

- The final grading will impact the thickness of fills placed at the site and it is anticipated that some of the shallower depressions will be in-filled in areas proposed for housing. Placement of fill below footing elevation will need to be carefully addressed and monitored to minimize the potential for foundation problems due to settlement. Good documentation of deep fills is highly recommended.

- The native subgrade will be relatively stable for road embankment construction under normal conditions, but the level of subgrade will be relatively low, which is typical for clay. Like most clays the native subgrade soils will be prone to softening when wet, so roadbed and pavement construction requirements may be significantly impacted by weather conditions at the time of construction.

- The surficial sands, where present, are considered to be relatively stable and have favourable engineering properties for use as site fill, trench backfill and road base subgrade, but will require moisture conditioning prior to placement and compaction.

- The silty soils will be moderately frost susceptible if they are present and given access to free water or groundwater within the zone of seasonal frost (estimated to an average depth of 2.5 m). However, the depth to the local water table for much of the site is relatively deep and will reduce potential heave in these frost susceptible soils. The sand and silt soils have a limited potential for frost action so there is a potential for differential heave in areas with sharp sand and silt to clay transitions. Construction personnel should be advised of this situation in an attempt to identify these transitions during construction

- Concerns about trench settlement should influence the layout of the underground services in the proposed subdivision to minimize or handle the potential for non-uniform subgrade due to trenching below roadways. Trench settlement can be minimized using trenchless methods such as HDD.

- The silty and sandy surficial soil, where present, is relatively sensitive to disturbance which can result in potential problems during grading and road construction depending on actual weather and ground conditions. An observational approach based on the actual conditions at the time of construction is considered the best way to optimize costs by identifying problem areas before construction activity leads to subgrade failure.

- The general residential foundation conditions at this site are considered to be good. Conventional footings will be capable of supporting light foundation loads for houses. The site is also suited to several pile options.

6.2 SITE PREPARATION

It is recommended that all vegetation and topsoil be stripped from areas which need to be graded. Topsoil could be stockpiled for future use at the site. It is understood that the development grading will be undertaken with a cut and fill operation to minimize costs, and the native soil is expected to be used as fill to raise lower areas of the site for economic reasons. The majority of lot areas that can be kept in a more natural state will not be graded.

Fill required to bring the site up to grade should be: select sand; well graded coarse gravel; or low to medium plastic, inorganic clay. Most of the native surficial silt, sand and clay soils are considered to be suitable for this purpose. Moisture conditioning of the native soils may be required prior to use as fill in order to achieve the desired levels of density.

The engineered fill placed during site grading at this site should be compacted to at least 95 percent of SPMDD. Uniformity of compaction is most important. The lift thicknesses should be governed by the ability of the selected compaction equipment to uniformly achieve the recommended density. It is recommended that a maximum lift thickness of 200 mm for granular fill and 150 mm for clay fill be utilized.

Special consideration must be given to deep fill areas below proposed residential structures (where fill is greater than 1.0 m below final grade). The engineered fill placed below structures should be uniformly compacted to at least 99 percent of SPMDD at a moisture content within 2 percent of OMC. The control of moisture content is considered to be important for the relatively dry, silty fill, because future wetting of the available fill soils may cause significant settlement. These settlements could occur long after original construction depending on changes in the groundwater regime due to development (ie. lawn watering, servicing, etc.) and on normal seasonal conditions. If these density levels cannot be achieved using common fill during site grading, the footing bearing surfaces should be sub cut and underlain with select granular fills compacted to at least 99 percent. The depth of subcut should be determined at the time of construction and will depend on factors such as; age of fill, initial compaction, depth of fill, water table, footing configuration and loads. To reduce settlement potential and compactive effort needed to achieve maximum density, it is recommended that granular fill be placed at moisture contents zero to 2 percent below OMC.

If subgrade conditions are soft, a thicker initial lift may be required to form a working base for subsequent construction. This condition is best addressed in the field at the time of construction. If subgrade conditions warrant the use of subgrade improvement gravel, it is possible, for lower lifts, to use less expensive select coarse gravel with a maximum aggregate size of 150 mm.

6.3 SLOPE ISSUES

Based on available contour information, the surface grades are generally less than 15 percent. General municipal development guidelines typically allow unrestricted development on sloping sites where slopes are no steeper than 15 percent or about 6.5H:1V. As a visual example, this limit is roughly equivalent to the front to back side slope on a typical house with a walk-out basement. Therefore, it should be understood that this limit is not considered to be an inflexible restriction. It is set as a “threshold” to trigger a site specific geotechnical review of a proposed development based on actual soil conditions.

It is expected that new home Owners will want to make use of the local topography to improve views and provide for walk-out structures. Some proposed buildings sites may incorporate areas with local slopes greater than 15 percent. At this point in the development process, ParklandGEO cannot provide detailed recommendations to cover all development and construction contingencies. However, the overall assessment remains that slope issues will not be a significant obstacle to safe construction of residences on this property provided reasonable design and construction practices are followed. The site has slopes with typical slope angels flatter than 15 percent (6.5H:1V). Localized slope areas are expected up to 3H:1V. The soil conditions at the site are a stable stiff clay till and partially overlying very dense silty sand deposits. Under normal dry conditions the local clay till soils exhibit relatively high cohesive strength and can result in steep slopes. However, if disturbed and/or wetted, these clay soils lose cohesive strength leading to slope movements in steeper faces. Under normal long term groundwater conditions the slopes around these small hills are expected to be stable up to angles of 3H:1V. Development around slopes areas steeper than 3H:1V is still possible but will require measures such as regrading to flatten slope angles or provision of set backs protect permanent structures near the toe and crest areas of the steeper grades.

Further site specific assessment may be required depending on where future lot Owners want to situate their houses relative to the steeper slopes. It is recommended that proposed permanent structures within 5 m of the toe or crest of a localized slope greater than 3H:1V should be subject to site specific review by a qualified geotechnical engineer. It is normal practice in cases like this to have a geotechnical review of the proposed house grading plan as part of the building permit process. The intent of the review is to determine whether the Owners plans follow the general geotechnical recommendations; and if they do not, to provide site specific geotechnical design input for the project, based on the location and proposed design configuration of the house structure relative to the local slopes.

6.4 BASEMENT FOUNDATIONS

6.4.1 Footings

The site soil conditions are considered well suited for conventional strip and spread footings. Footings based on native silt and sand and clay till deposits or engineered fill uniformly compacted to at least 98 percent SPMDD may be designed based on a maximum allowable bearing pressure of 100 kPa for strip footings and 125 kPa for spread footings placed on undisturbed inorganic soil free from loosened material. The silt and sand is expected to be easily disturbed, so it is suggested to finish the final 25 to 50 mm of excavation by hand after footing forms are placed to minimize disturbance to the bearing surface. The design and construction of residential foundations should conform to Alberta Building Code. In general, excavations should be protected against surface water runoff and ingress of groundwater; footing bases should not be allowed to dry out excessively during construction; and the bearing soil should be protected against freezing during and after construction.

6.4.2 Grade Supported Slabs

Floor slabs should rest on at least 150 mm of free draining, granular base. Suitable materials would include coarse sand or crushed gravel with less than 10 percent passing the 0.080 mm sieve. The drainage layer below the slab should be compacted uniformly to at least 95 percent of SPMDD.

Small vertical subgrade movements may be experienced therefore, provisions should be made for movements between partitions and adjoining columns or load bearing walls. In addition, where partitions are placed under structural members a space should be left at the top of the partition to allow vertical movement (at least 25 mm). Columns in basements which support floor joists should be adjustable. Water lines should be installed carefully to minimize the potential for breakage and leaks below slabs. Heating ducts below grade should be insulated to prevent drying of the subgrade soils.

6.4.3 Basement Subdrainage System

A permanent subdrainage system (weeping tile drain) is recommended around the outside perimeter of basements. Lateral drains below the house are recommended in areas where the average groundwater table is within 1 m of the underside of slabs to reduce the hydrostatic pressures against foundation walls and floor slabs. The weeping drain should be surrounded with granular material to prevent the fine grained native soil from being washed into the drain. The granular filter may consist of free draining crushed rock or washed rock placed around the perforated drain pipe and wrapped with a coarse concrete sand or suitable geotextile.

Infiltration flows into most weeping tile drains are expected to be light to moderate because the native soil, particularly the sand, is relatively permeable. The largest flows will occur during periods of heavy precipitation and will be greatest for basements excavated into very sandy soils which are perched on lower permeable clays. Groundwater infiltration flows can be significantly increased by poor site drainage around houses, improperly directed roof leaders and poorly graded or compacted backfill.

6.4.4 Basement Excavations

Basement excavations in the native sand and silt and clay till soils are only expected to be able to stand near vertical for short periods of time. For excavations deeper than 1.5 m, side slopes should be cut back to 1H:1V. If space does not permit the slopes to be cut back, some form of temporary shoring must be installed to protect workers in the excavation.

The latest edition of the Construction Safety Regulations of the Occupational Health and Safety Act of Alberta should be followed. All temporary surcharge loads should be kept back from the excavated faces a distance of at least one-half the depth of the excavation. All vehicles delivering materials to the site should be kept back from excavated faces a distance equal to half the excavated height or at least 1.0 m.

For proposed basements excavated during wet weather or with elevations close to the groundwater table elevation, construction traffic from tractor dozer type equipment could cause the disturbance of clay subgrades resulting in a significant weakening of the subgrade. In this case, excavation is best carried out with backhoe or "Gradall" equipment.

6.4.5 Basement Backfill

Backfill soils are capable of exerting significant horizontal pressures onto a basement wall. It is recommended the backfilling be delayed until the concrete has gained enough strength to support the horizontal loads. The top and bottom of the wall should be braced prior to backfilling. Therefore, it is recommended to place the basement floor slab and floor joists prior to backfilling around walls. Backfill should be brought up evenly around the building perimeter to minimize differential horizontal pressures on the basement walls.

Rather than heavily compacting the backfill around the basements, it is recommended to nominally compact the backfill (90 - 95 percent of SPMDD) recognizing that settlement of the backfill will occur, particularly after the first freeze/thaw and moisture infiltration cycle. Backfill around basement walls should be sloped to shed water away from the structure with a recommended slope of at least 5 percent. The slope of the backfill should be checked periodically to maintain the slope of the ground surface away from the wall. Roof leaders from houses and garages may be discharged onto the ground surface well clear of the foundation walls to help reduce wet weather infiltration of water into the sub-drainage weeping tile system.

6.5 SERVICE TRENCH INSTALLATION

6.5.1 Service Trench Excavation

It is expected that the majority of buried services will be installed within 4.0 m of final ground surface. Therefore, some excavations may extend below the groundwater table. Where excavations are proposed in the local silt and sand or clay till soils, conventional trenched excavations with sloping sides and/or moveable shields are considered to be feasible. Open excavations at this site will require relatively flat side-slopes, particularly if wet conditions are encountered due to rain or runoff. Given the availability of space around the site, an open excavation is expected to be most economical. Side-slopes deeper than 1.5 m should be at least 1H:1V or flatter. If excavations are required in silt and sand below the water table, very flat side slopes and/or dewatering measures such as sumps or well points may be required. The degree of stability of excavated trench walls decreases with time and, therefore, construction should be directed at minimizing the length of time service trenches are left open.

Surface grading should be undertaken so that surface water is not allowed to pond adjacent to service trenches. Surcharge loads, including excavation spoil, should be kept back from the crest of the excavation a minimum distance equal to the excavation depth. Monitoring and maintenance of the slopes should be carried out on a regular basis.

Installation of underground services and utilities requires an observational approach be adopted which should combine past local experience, contractor's experience and geotechnical input. It would be desirable for the selected excavation contractor to be experienced in similar conditions and/or, alternatively, to excavate test pits in advance of construction to familiarize field personnel with subsurface conditions. Quality workmanship is essential, because disturbed wet, cohesionless soils at depth are very expensive measures to rehabilitate.

Notwithstanding any of the above comments, excavations should be carried out in accordance with Alberta Occupational Health and Safely Regulations.

6.5.2 Pipe Bedding

Minor deflections of the trench bedding are expected. Underground utility pipes should be of a type which will maintain watertight joints (i.e. rubber gasket) after minor shifting has occurred. Bedding requirements are a function of the class of pipe and trench configuration, as well as site specific geotechnical considerations. In general, granular pipe bedding should be relatively well graded sand or sand gravel mixture which can be readily compacted around the pipe to achieve a high frictional strength. Bedding soils must have an appropriate gradation so that migration of natural soils into the granular system is minimized. Uniform or gap-graded sands and gravels should not be used as bedding materials unless adequate provision is made to surround such soils with a filter fabric or graded granular filter compatible with the existing subsoils.

In the event of significant groundwater seepage or wet base conditions, additional measures may be required. Typically these measures include placement of a working mat of free draining gravel and filter cloth after lowering of the water table and removal of disturbed soils. This layer of gravel is intended to be a safe working base and the thickness required will be based on keeping groundwater below the working surface. The function of the geotextile in pipe bedding applications is to act as a separation barrier between the coarse bedding materials and the native fine grained soils, therefore it needs to be strong enough to withstand construction activity.

6.5.3 Trench Backfill

Soil used for trench backfill should be free of frozen material, organics, and any other undesirable debris. It is expected that native soils will be used at the site for economic reasons. The native soils are typically silt and sand and clay till materials which are considered suitable for use as trench backfill. Wetter lacustrine soils are considered less than ideal due to high moisture contents.

To minimize fill settlement under self-weight, it is recommended to use soil with a moisture content within 5 percent of OMC. When excavated soils are excessively wet, the material should be dried or blended prior to use as trench backfill. Suitable replacement soils would include local or imported sand borrow materials with an appropriate moisture content relative to OMC.

Lift thicknesses for backfill should be governed by the ability of the selected compaction to achieve specified density throughout the entire lift. Uniformity is of most importance. The nominal lift thickness for select granular fill is 200 mm. Clay backfill should be placed in thin lifts with a nominal compacted thickness of 150 mm. This is especially important when backfilling very stiff clay soils. The backfill should be uniformly compacted to a minimum of 95 percent of the SPMDD. For road areas, the backfill should be compacted throughout the depth of the fill to a minimum 97 percent of SPMDD.

Some settlement of the compacted backfill in trenches under self-weight is expected to occur. The magnitude and rate of settlement would be dependent on the backfill soil type, the moisture condition of the backfill at the time of placement, the depth of the service trench, drainage conditions and the initial density achieved during compaction. Density monitoring of backfill placement is recommended to encourage better attention to quality workmanship in placement.

Fill materials with variable moisture contents recompacted as trench backfill would not be expected to provide uniform roadway subgrades for the support of pavement sections. If trench settlement in road areas is a concern, it is suggested to consider a deep subgrade preparation of the upper 0.5 to 1.0 m of the subgrade to help make the subgrade more uniform. Design considerations required for roadway subgrade construction on recompacted and natural materials in this subdivision are discussed in the following section of this report.

To minimize the effects of potential settlements on completed roadway surfaces, it is recommended that staged asphalt pavement construction be adopted and that placement of final asphalt concrete surfacing materials be delayed as long as possible, subsequent to completion of trench backfilling.

6.5.4 Horizontal Directional Drilling

Directional drilling may be considered for service installations and roadway crossings. Soil conditions for directional drilling vary along the route. The silt and sand and clay till subgrades common to the area will be well suited for directional drilling. Difficult “hard” drilling conditions may be encountered in the shallow bedrock formations. Usually wet “mud” drilling technics are used to deal with these harder conditions.

Although not noted during the field investigation, sand and gravel stringers and cobbles are commonly found within the local till deposits. In the event that such conditions are encountered, specialized cutting bits are available which can handle coarse gravel and cobbles.

For preliminary purposes the profile constraints for direction drilling should be taken as a maximum directional change of 15^{O} per 15 m of length and a maximum practical total length of 500 m. Longer drill shots and slight curvature variations are possible depending on the equipment available to different contractors.

6.6 CONCRETE

Water-soluble sulphate concentrations from the samples tested indicated negligible potential for chemical attack of subsurface concrete. Therefore, General Use (Type GU) hydraulic cement is suitable for use in all subsurface concrete in contact with native soil at the site in accordance with CSA Standard CAN3-A23.1-M04. The recommended minimum 28 day compressive strength is 25 MPa with a water cement ratio of 0.5. All concrete exposed to a freezing environment either during or after construction should be air entrained.

6.7 GENERAL ROAD BED PREPARATION

6.7.1 Subgrade and Roadbed Preparation

Prior to construction, it is recommended to clear the road alignment of all topsoil and other softened or weak soil. It is understood that the site grades will generally be maintained or raised slightly. The exposed subgrade should be scarified and uniformly recompacted to at least 95 percent of Standard Proctor Maximum Dry Density (SPMDD - ASTM D698). If subgrade, weather and/or groundwater conditions are unfavourable, it may be required to use select gravel to start the embankment foundation. When compacting the embankment materials, close supervision of compaction efforts is recommended to protect against over-compaction which may cause subgrade failure.

Site preparation should be monitored by experienced geotechnical personnel to verify that the exposed surficial soils are uniform and stable. Any soft areas encountered should be sub-excavated and replaced with a suitable fill material. The depth of excavation should be sufficient to remove the soft material or to bridge over the material to give proper support to the pavement. If wet soils that meet the requirements for general fill are encountered; drying and recompaction of the soils may be a possible option to replacement.

Ideally, all exposed and buried organics should be excavated and removed from the road alignment. Testing for organic content may be required to avoid over-excavation of darker subgrade soils with acceptable organic contents which are sometimes present around old county roads. Unsuitable organic soils are generally defined as having more than 10 percent organics by weight. If it is not economically feasible to remove deep organics and the Owner is willing to accept a lower standard of performance, it may be possible to leave some or all of the organics in place depending on the final road grades as discussed in Section 6.7.6 below.

6.7.2 Soft Subgrade Conditions

If excessive soft subgrade conditions are encountered, the site preparation procedures should be reviewed based on the actual subgrade conditions and final grades for the area. Subgrade problems are most often encountered during periods of snowmelt or heavy precipitation when the groundwater table is shallowest and when surface water does not evaporate or infiltrate into the subgrade. Wetting of the exposed surface will substantially weaken the subgrade.

In the worse cases, soft material should be replaced with a thick layer of coarse granular fill for subgrade improvement. The excavation of sensitive soils should be performed by a large tracked backhoe rather than dozer equipment to minimize disturbance to the subgrade. The recommended type of subgrade improvement fill is a relatively clean coarse graded gravel. Since granular subbase coarse will likely not be proposed for subgrade improvement, the use of a filter fabric separation barrier is strongly recommended. The initial lift of gravel should be nominally compacted in a manner to minimize disturbance to the soft subgrade. The decision to add subgrade improvement gravel and filter cloth should be made at the time of construction.

6.7.3 Subgrade Fill Materials and Placement

The site can be brought up to design grade level using an approved fill. Fill required to bring the site up to grade should be low to medium plastic, inorganic clay or well graded select granular material such as sand or gravel. Sand which is uniformly graded, or which contains more than 12 percent passing the 0.080 mm sieve, should not be used without further review. The type of fill material and placement procedures selected should be compatible with the expose subgrade soils.

TABLE 2
COARSE GRADED GRAVEL

Sieve Size (mm)	Percent Passing by Weight	
150	-	100
75	100	75-100
50	85-100	-
25	60-85	60-85
5.0	20-50	20-50
0.080	0-10	0-10

Engineered fill placed should be compacted to at least 97 percent of SPMDD. The lift thicknesses should be governed by the ability of the selected compaction equipment to uniformly achieve the recommended density. It is recommended to use lifts with a maximum thickness of 200 mm for granular fill and 150 mm for clay fill. Granular fill is best compacted with large smooth drum vibratory rollers. Clay fill is best compacted with large vibratory or static "pad-foot" or "sheepsfoot" rollers. To reduce compactive effort needed to achieve maximum density it is recommended to place granular fill at moisture contents 0 to 2 percent below OMC and clay fill at moisture contents about 2 percent above OMC.

6.7.4 Surface Drainage

Site grading during and after construction is an important consideration. The road bed and pavement surface should be sloped and graded to effectively remove all surface water as rapidly as possible during and after construction. Water should not be allowed to pond on the exposed subgrade. To minimize the occurrence of standing water, surface grades and cross slopes in the order of 2 percent are recommended. Allowing water to pond on the base or pavement surface will lead to infiltration of water into the subgrade which could result in weakening of the subgrade soils and may lead to distress/failure of the overlying pavement. The pavement grades should be set as high as possible to minimize sub-cutting and provide greater separation between the surface and the groundwater table. If the soft wet areas persist either due to weather or subgrade conditions the provision of additional sub-drainage along the alignment should be considered.

As a general guideline, the road side ditches should be designed to maintain groundwater levels at least 1.0 m below the top of subgrade along the road alignment. In areas of very shallow groundwater table and low road elevation, the use of subdrains may be required if road side ditches cannot maintain groundwater out of the road embankment.

6.7.5 Filter Fabric

As a general rule, if the subgrade is too soft to undertake a conventional subgrade preparation, the use of filter fabric should be considered. If a geotextile is required to act as a separation barrier between the subgrade and subgrade improvement gravel, the recommended geotextile specification would be:

TABLE 3
MINIMUM FILTER CLOTH SPECIFICATION

Test Parameter	Specification
Minimum Grab Tensile Strength	850 N
Maximum Elongation at Break	30 percent
Minimum Mullen Burst Strength	2500 kPa
Minimum Tear Strength	400 N
Maximum Equivalent Opening Size 150	600 microns

Woven fabrics typically have more favourable stress/strain characteristics (30% elongation at failure) than non-woven filter fabrics (100 % elongation at failure). Therefore, the woven fabric will mobilize more strength as the subgrade deflects under construction traffic loads. Non-woven fabrics would be suitable for use as a separation barrier in subdrainage trenches. Proposed geosynthetic filter fabrics should be reviewed based on the proposed end use. A slightly less robust geotextile could be given consideration if initial field performance ratings dictate. If sand fill is used on top of the native subgrade, a filter fabric is not required because there is limited potential for upward migration of fines and no need for a separation barrier.

6.7.6 Minimum Fill Thickness Over Unsuitable Materials

Unsuitable materials are considered to be organic soils (organic contents over 10 percent); debris; and weak, wet inorganic soils. Areas of buried organics or unsuitable soils may be encountered between the borehole locations. It is recommended that the minimum requirement for this road is to remove all organics within 1.0 m of final grade as per typical Alberta Transportation practice. Any areas of existing roadway which show signs of subgrade distress during construction should be investigated by test pits/boreholes to determine the presence and influence of shallow buried organic or unsuitable soils.

6.7.7 Sideslopes and Cutslopes

If shallow embankments or roadside ditches are proposed, embankment sideslopes no steeper than 3H:1V should be used for preliminary design purposes. This slope angle is generally accepted as the steepest slope that is possible to maintain with self-propelled mowers. If granular embankment fills are used, it may be possible to slightly steepen the embankments provided the slopes are well vegetated to protect against erosion. The comments above are based on local experience. For any major embankments or cuts, these preliminary recommendations should be reviewed before finalizing designs. The appropriate time for this review is after the gradeline, right-of-way restrictions and possible fill materials have been determined.

6.7.8 Frost Considerations

The expected typical depth of frost penetration is 2 m for both the native clay and clay fill materials. Shallower and deeper frost penetration will occur on a less frequent basis. The silty subgrade is considered to be moderately to highly frost susceptible, and potential for ice lens formation is high due to the high moisture contents and shallow groundwater table. To minimize frost related problems, possible recommendations include:

- setting final road grades at least 2.0 m above the water table.
- installing a sub-drainage system to lower the groundwater table in areas where physical separation is not possible.
- replacing the frost susceptible subgrade with less frost susceptible fill such as sands and gravels with lower moisture contents and favourable grain size characteristics.

Special attention should be paid in the areas of clay to sand subgrade transitions. Sharp transitions can lead to significant differential frost heave during the winter and early spring. If any sharp transitions are identified during construction, the actual conditions should be reviewed for possible subgrade modification.

6.7.9 Subgrade Values for Pavement Design

The typical estimated soaked CBR value for the clay till is estimated to be between 3 and 5 which is indicative of a relatively low level of subgrade support. The use of locally available clay till for embankment construction is likely to provide a subgrade with a similar level of support.

As previously discussed, subgrade softening may be encountered depending on local weather and groundwater conditions at the time of construction. If soft conditions are encountered, it is assumed that the subgrade will be improved with coarse gravel to support construction activities.

6.8 FLEXIBLE PAVEMENT DESIGN

Two flexible pavement designs are proposed for this residential subdivision:

- A residential collector roads section using a Design Traffic of 2×10^6 Equivalent Single Axle Loads (ESAL's).
- A light traffic section for the local residential streets using an Design Traffic of 9×10^5 ESAL's.

These design traffic numbers are based on the City of Red Deer Design Guidelines for a design period of 20 years. The proposed pavement design sections for this subdivision are based on the assumption of a stable subgrade which meets the City of Red Deer Guidelines criteria of CBR =

4; or a subgrade which has been improved to an equivalent level as described in Section 6.7. The majority of surficial soils across these quarters section are expected to meet this minimum subgrade support condition, but there is the potential for some localized soft areas. Based on the preceding assumptions the following flexible pavement sections are proposed:

TABLE 4
FLEXIBLE PAVEMENT DESIGN

Pavement Sections	Local Residential		Residential Collector	
Design traffic (ESAL's)	9 x 10^5		2 x 10^6	
Asphalt Concrete	75 mm	75 mm	100 mm	100 mm
20 mm Crushed Base Gravel	300 mm	150 mm	350 mm	150 mm
Subbase Gravel (minimum)	-	200 mm	-	300 mm

The performance of the proposed pavement design sections will be, in part, dependent on achieving an adequate level of compaction in subgrade and pavement materials. The recommended levels of compaction for the granular materials in the pavement section should be a minimum of 98 percent of SPMDD. The asphalt concrete should be compacted to a minimum of 97 percent of Marshall density based on a 50 blow laboratory Marshall test. Pavement materials should conform to the following asphalt specifications.

TABLE 5
ASPHALT CONCRETE

Parameter	Specification
Stability (kN minimum)	8.0
Flow (mm)	2 - 4
Air Voids (percent)	3 - 5
VMA (minimum percent)	14.5
Asphalt Cement (penetration grade)	150-200 (A)

Aggregate materials for base and subbase gravel should be composed of sound, hard, durable particles free from organics and other foreign material. A copy of the Alberta Transportation aggregate specification is provided in Appendix A.

TABLE 6
RECOMMENDED AGGREGATE SPECIFICATIONS

	AT Specifications
Asphalt Gravel	Designation 1, Class 16
Crushed Base Gravel	Designation 2, Class 20 or 25
Subbase Gravel	Designation 2, Class 40

Based on availability of local materials at the time of tendering or construction, alternate materials could be considered upon review by the geotechnical engineer.

The road surface should be sloped and graded to effectively remove all surface water as rapidly as possible. To minimize the occurrence of surface water ponding in the roadways, finished surface grades and cross slopes in the order of two percent are recommended. Allowing water to pond on the pavement surface will lead to infiltration of water into the subgrade which could result in weakening of the subgrade soils.

No special pre-design considerations are given to thickening the pavement section over backfilled trenches. The settlement of trenches is caused mainly by the long term self weight of the fill, not the short term live loads from traffic. The road section or the thickness of granular subbase placed in the road bed should be determined by the level of support expected from the subgrade based on field observations. To minimize distress to pavement structures, trench backfill should be compacted to the higher density levels as previously recommended. To minimize the effects of potential settlements on completed roadway surfaces, it is recommended that staged asphalt pavement construction be adopted and that placement of final asphalt concrete surfacing materials be delayed as long as possible subsequent to completion of trench backfilling.

6.9 INSPECTION

It is recommended that on-site inspection and testing be performed to verify that actual site conditions are consistent with assumed conditions which meet or exceed design criteria. Based on the Alberta Building Code, adequate levels of inspection include: testing of engineered fill, review of all completed bearing surfaces for footings and full time inspection during the construction deep foundations.

7.0 CLOSURE

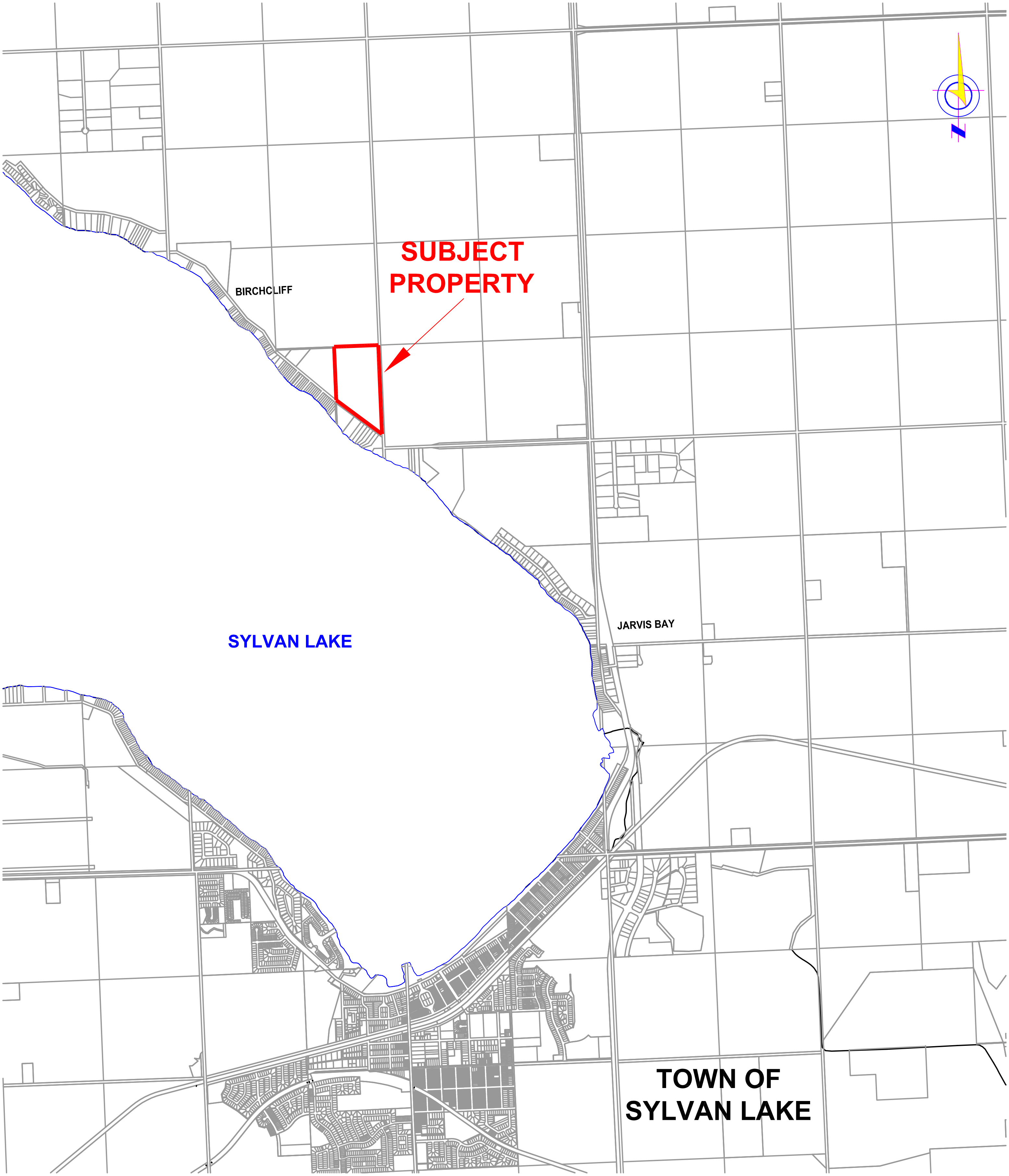
This report is based on the findings at ten borehole locations. If different subsoil and groundwater conditions are encountered, this office must be notified and recommendations submitted herein will be reviewed and revised as required. This report has been prepared for the exclusive use of **Longview Planning & Design** and their approved agents for the specified application to the proposed Birchcliff development at SE 17-39-1-W5M, Lacombe County, Alberta. This report has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made. The General Terms and Conditions of this report are attached and should be considered part of this report.

Respectfully submitted,
PARKLAND GEOTECHNICAL CONSULTING LTD.
A.P.E.G.G.A. Permit # 07312

August 31, 2010

Phillip Auclair, E.I.T.	Mark Brotherton, P.Eng.
Geo-Environmental Engineer	Principal Geotechnical Engineer

FIGURES



ParklandGEO

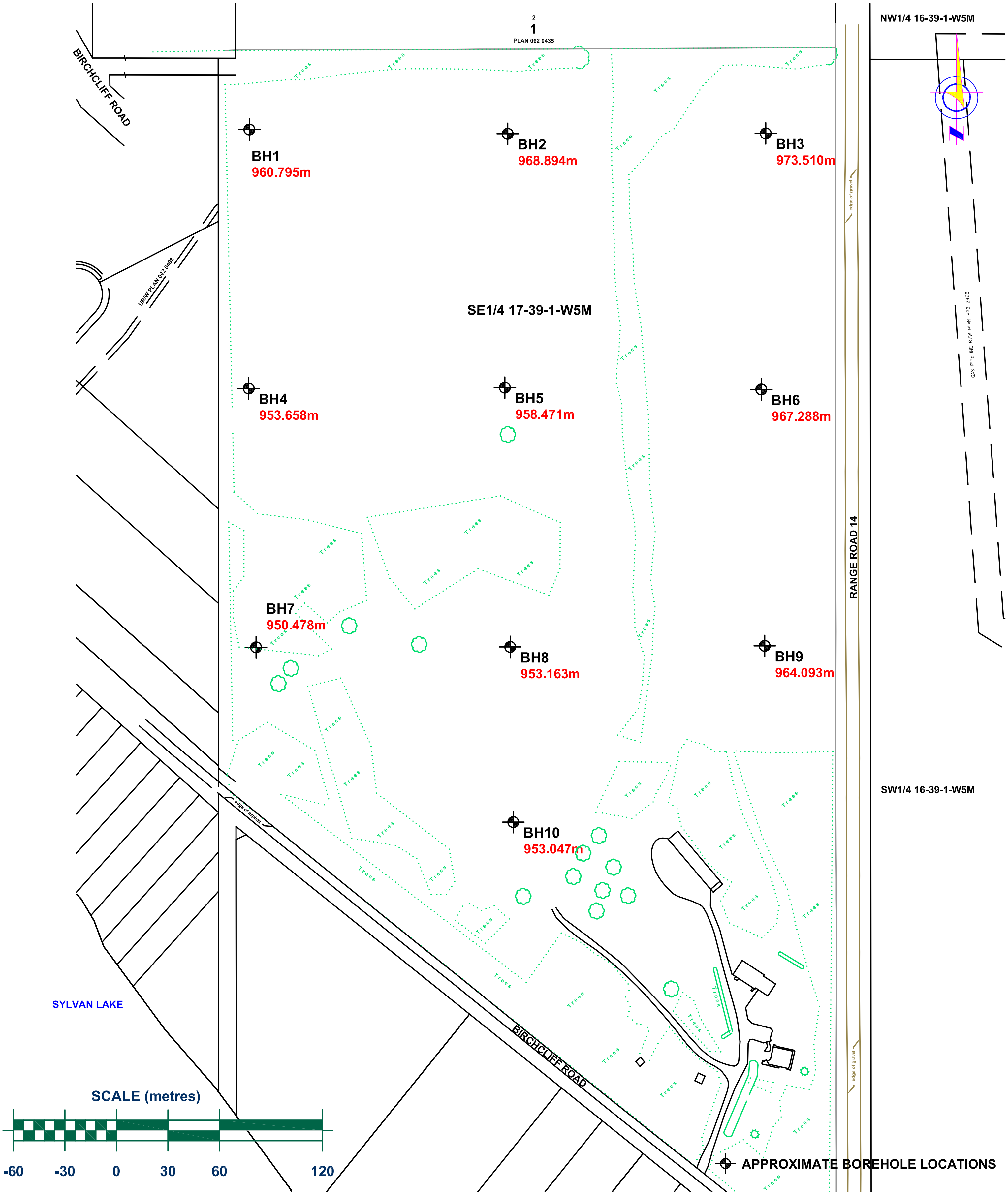
CLIENT:

LONGVIEW Planning + Design

KEY PLAN

BIRCHCLIFF RURAL SUBDIVISION
SE1/4 17-39-1-W5M, LACOMBE COUNTY, ALBERTA

DRAWN: LDL	CHK'D.: MDB	REV #: 1	DATE: AUGUST 2010
SCALE: NTS	JOB NO. RD3452		DRAWING NO. FIGURE 1



ParklandGEO

CLIENT:

LONGVIEW Planning + Design

SITE PLAN

BIRCHCLIFF RURAL SUBDIVISION
SE1/4 17-39-1-W5M, LACOMBE COUNTY, ALBERTA

DRAWN: LDL	CHK'D.: MDB	REV #: 1	DATE: APRIL 2010
SCALE: 1:3000	JOB NO. RD3452		DRAWING NO. FIGURE 2

ParklandGEO

CLIENT:

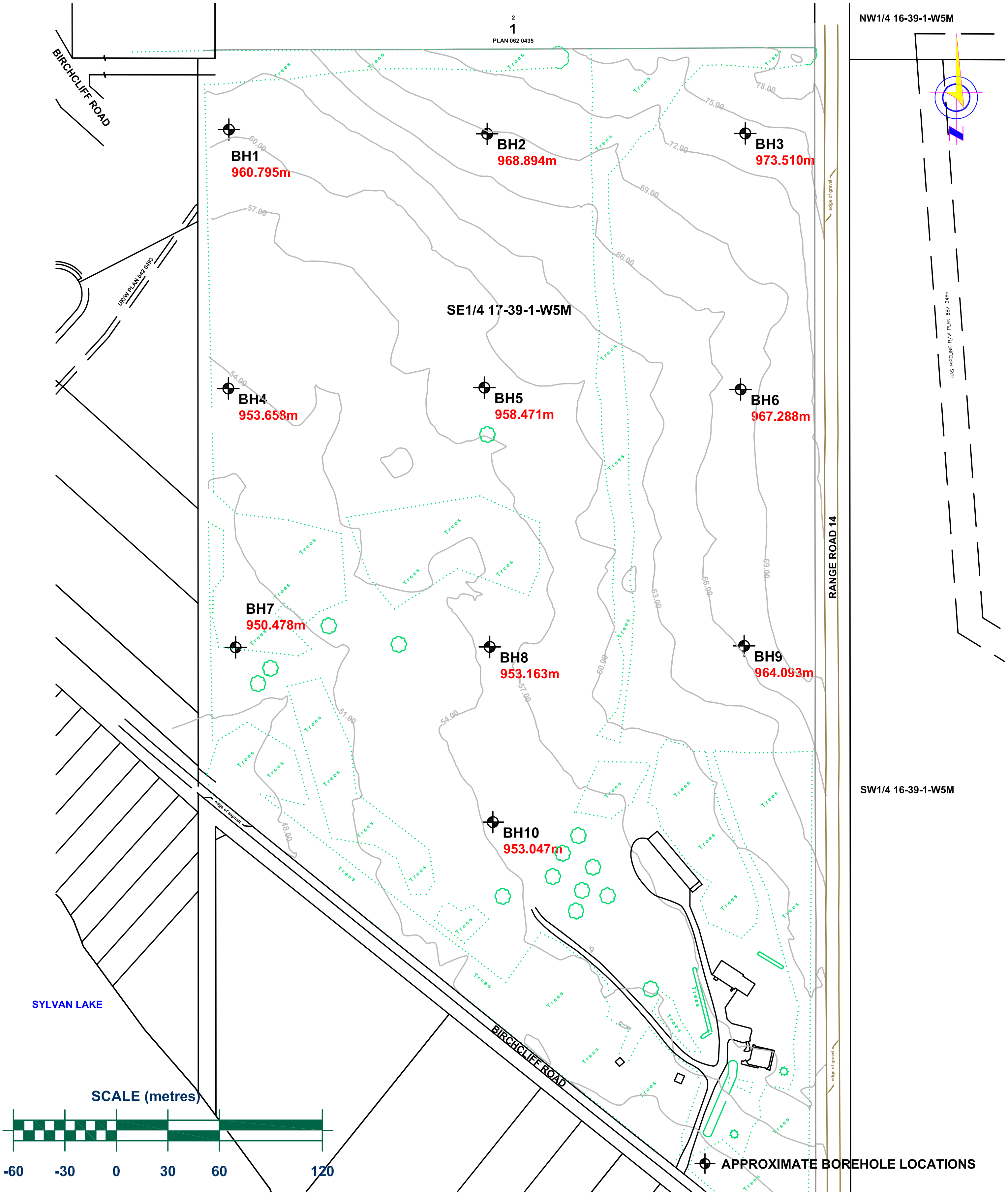
LONGVIEW Planning + Design

2007 AERIAL PHOTOGRAPH

BIRCHCLIFF RURAL SUBDIVISION
SE1/4 17-39-1-W5M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D.:	REV #:	DATE:
LDL	MDB	1	AUGUST 2010

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD3452	FIGURE 3



Parkland GEO

CLIENT:

LONGVIEW
Planning + Design

CONTOUR PLAN

BIRCHCLIFF RURAL SUBDIVISION
SE1/4 17-39-1-W5M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D.:	REV #:	DATE:
LDL	MDB	1	AUGUST 2010

SCALE:	JOB NO.	DRAWING NO.
1:3000	RD3452	FIGURE 4

March 19, 2010: Looking North from Borehole 5.

March 19, 2010: Looking Northeast from Borehole 4.

ParklandGEO

CLIENT:

LONGVIEW Planning + Design

SITE PHOTOGRAPHS

BIRCHCLIFF RURAL SUBDIVISION
SE1/4 17-39-1-W5M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D.:	REV #:	DATE:
LDL	MDB	1	AUGUST 2010

SCALE:	JOB NO.	DRAWING NO.
1:2500	RD3452	FIGURE 5

March 19, 2010: Looking Northwest, from Range Road 14.

March 19, 2010: Treed Section on the Site. Looking Southeast from Borehole 7.

ParklandGEO

CLIENT:

LONGVIEW Planning + Design

SITE PHOTOGRAPHS

BIRCHCLIFF RURAL SUBDIVISION
SE1/4 17-39-1-W5M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D.:	REV #:	DATE:
LDL	MDB	1	AUGUST 2010

SCALE:	JOB NO.	DRAWING NO.
1:2500	RD3452	FIGURE 6

APPENDIX A

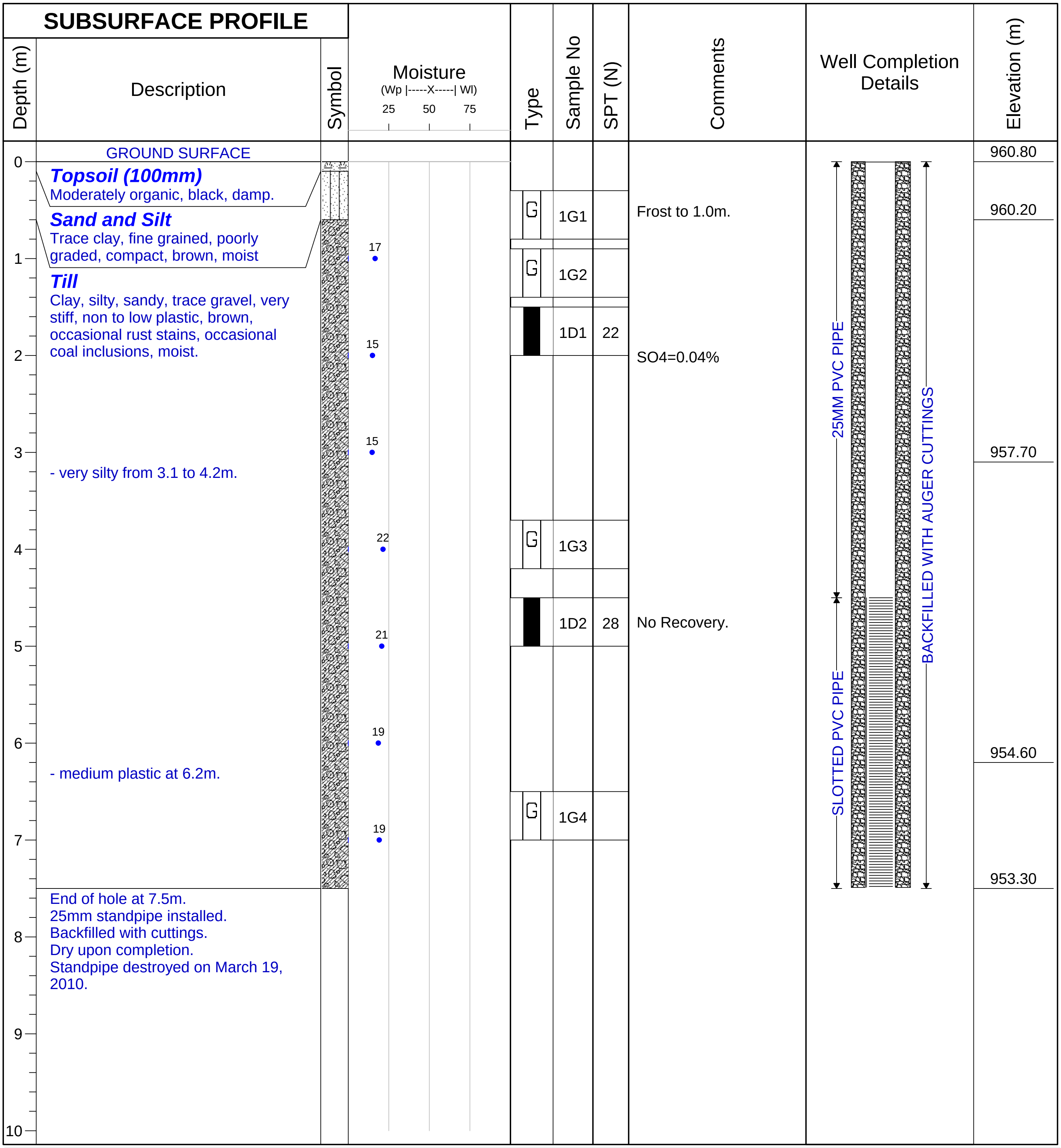
Borehole Logs (BH1 - BH10)
Test Results
Aggregate Specifications
Explanation Sheets

BOREHOLE NO.: 1

CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE



Description

GROUND SURFACE

Topsoil (100mm)
Moderately organic, black, damp.

Sand and Silt
Trace clay, fine grained, poorly graded, compact, brown, moist

Till
Clay, silty, sandy, trace gravel, very stiff, non to low plastic, brown, occasional rust stains, occasional coal inclusions, moist.

- very silty from 3.1 to 4.2m.

- medium plastic at 6.2m.

End of hole at 7.5m.
25mm standpipe installed.
Backfilled with cuttings.
Dry upon completion.
Standpipe destroyed on March 19, 2010.

Type	Sample No	SPT (N)	Comments
G	1G1		Frost to 1.0m.
G	1G2		
■	1D1	22	SO4=0.04%
G	1G3		
■	1D2	28	No Recovery.
G	1G4		

LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

GROUND ELEVATION: 960.80 m
NORTHING:
EASTING:

BOREHOLE NO.: 2

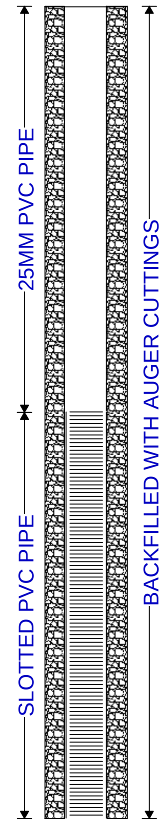
CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Elevation (m)
	GROUND SURFACE						968.89
0	***Topsoil (110mm)*** Moderately organic, black, damp to moist.						
	Sand and Silt Trace clay, fine grained, poorly graded, compact, brown, damp to moist. - dense to very dense at 1.5m.						
1		10	G	2G1		Grain Size Analysis: Gravel=0% Sand=25% Silt and Clay=75%	
							967.39
2		11				SO4=0.04%	
3		13					
4		13	G	2G2			
	Weathered Bedrock Sandstone, very dense, brown, damp.						964.09
5		13					
			G	2G3			
6	End of hole at 6.0m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on March 19, 2010.	12					962.89
7							
8							
9							
10							

Well Completion Details



LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

GROUND ELEVATION: 968.89 m
NORTHING:
EASTING:

Parkland GEO

BOREHOLE NO.: 3

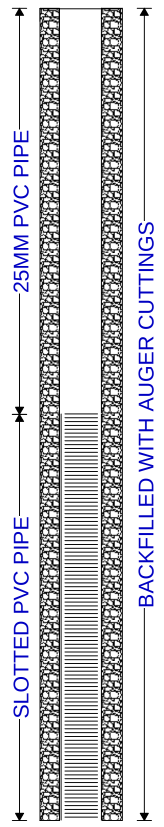
CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Elevation (m)
0	GROUND SURFACE						973.51
0	***Topsoil (100mm)*** Moderately organic, black, moist.						
0.1	***Till*** Clay, sandy, silty, trace gravel, stiff, non to low plastic, brown, occasional rust stains, occasional coal inclusions, damp to moist					Frost to 1.5m.	
1		13	G	3G1			
1.5			■	3D1	13	SO4=0.04%	
2		15					
2.8	- sandy at 2.8m.						970.71
3		17					
3.3	***Sand and Silt*** Trace clay, fine grained, poorly graded, compact to dense, brown, damp to moist.						970.21
4		13	G	3G2		Grain Size Analysis: Gravel=0% Sand=30% Silt and Clay=70%	
4.6	***Weathered Bedrock*** Sandstone, very dense, brown, damp.		■	3D2	50	50 blows for 150mm. Bounce.	968.91
5		13					
6	End of hole at 6.0m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on March 19, 2010.	14					967.51

Well Completion Details



LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

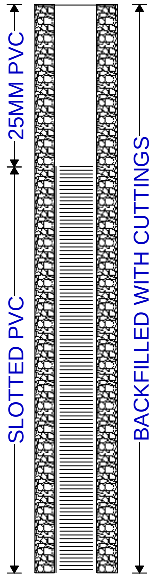
GROUND ELEVATION: 973.51m
NORTHING:
EASTING:

BOREHOLE NO.: 4

CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								953.66
0	***Topsoil (200mm)*** Moderately organic, black, damp.								953.46
	Till Clay, silty, sandy, trace gravel, very stiff, non to low plastic, brown, occasional rust stains, occasional coal inclusions, moist.						Frost to 0.5m.		
1			16	G	4G1				
2	- boulder at 1.9m.		16				SO4=0.04%		951.76
	- boulder at 2.7m.								950.96
3			16	■	4D1	27			
4			15						949.46
	Auger refusal at 4.2m. Possible boulder. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on March 19, 2010.			G	4G2				
5									
6									
7									
8									
9									
10									

LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

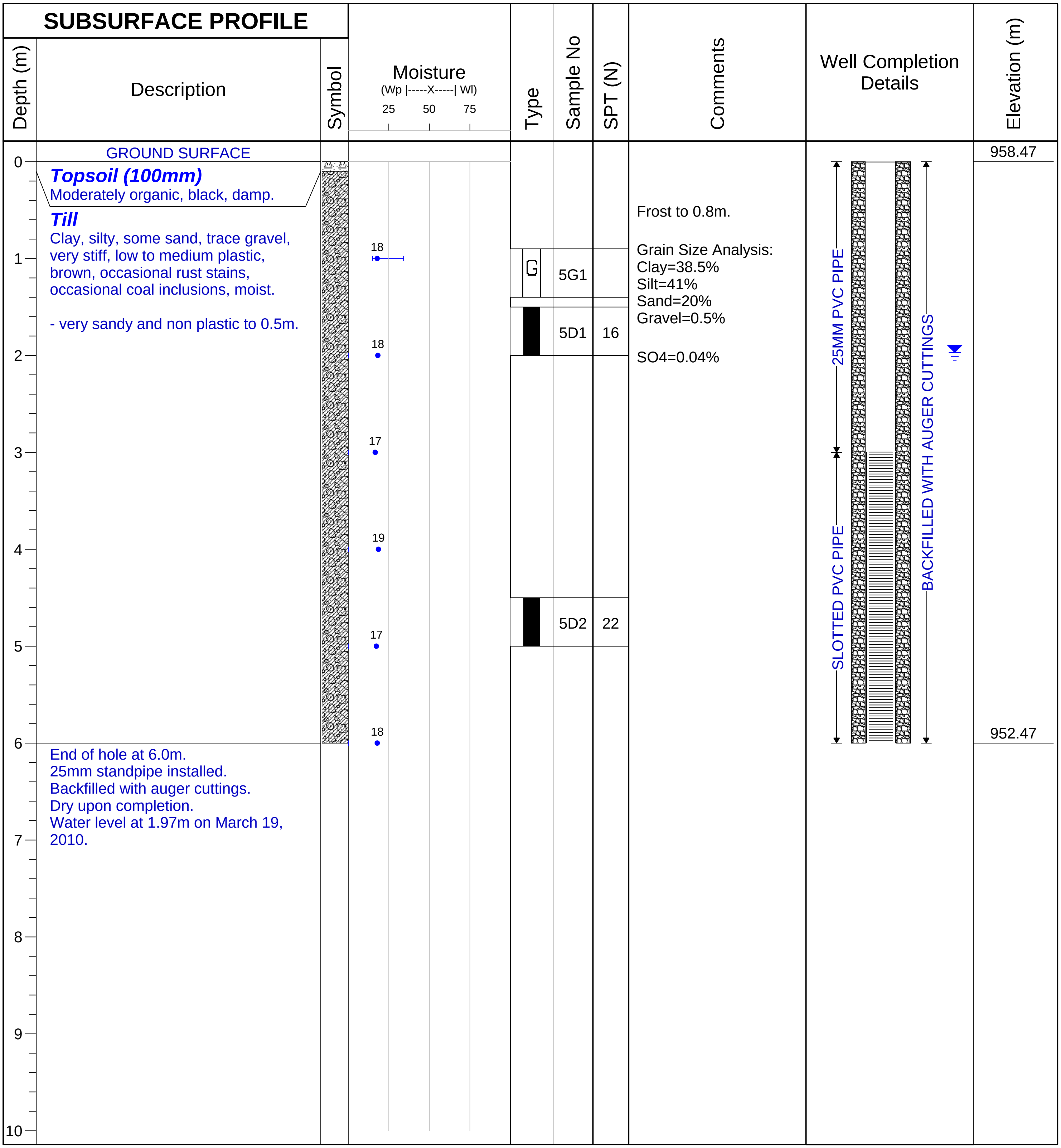
GROUND ELEVATION: 953.66m
NORTHING:
EASTING:

BOREHOLE NO.: 5

CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE



GROUND SURFACE

Topsoil (100mm)
Moderately organic, black, damp.

Till
Clay, silty, some sand, trace gravel, very stiff, low to medium plastic, brown, occasional rust stains, occasional coal inclusions, moist.

- very sandy and non plastic to 0.5m.

End of hole at 6.0m.
25mm standpipe installed.
Backfilled with auger cuttings.
Dry upon completion.
Water level at 1.97m on March 19, 2010.

Type	Sample No	SPT (N)
G	5G1	
■	5D1	16
■	5D2	22

Frost to 0.8m.

Grain Size Analysis:
Clay=38.5%
Silt=41%
Sand=20%
Gravel=0.5%

SO4=0.04%

LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

GROUND ELEVATION: 958.47m
NORTHING:
EASTING:

ParklandGEO

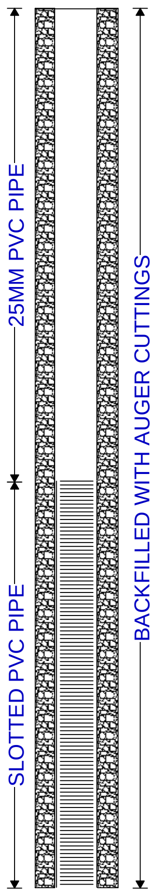
CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

BOREHOLE NO.: 6
PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Elevation (m)
	GROUND SURFACE							967.29
0	***Topsoil (90mm)*** Moderately organic, black, moist.							
	Till Clay, silty, sandy, trace gravel, stiff, non to low plastic, brown, occasional rust stains, occasional coal inclusions, moist.						Frost to 1.2m.	
1			18	G	6G1			
2			15				SO4=0.04%	
3			15	■	6D1	11		
								963.49
4	***Sand and Silt*** Trace clay, trace gravel, fine grained, poorly graded, dense to very dense, brown, moist.		13					
5			15					
	- bedrock nodules at 5.5m.			G	6G2			961.79
6			14	■	6D2	50	50 blows for 150mm. Bounce.	960.79
7	End of hole at 6.5m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on March 19, 2010.							
8								
9								
10								

Well Completion Details



LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

GROUND ELEVATION: 967.29m
NORTHING:
EASTING:

BOREHOLE NO.: 7

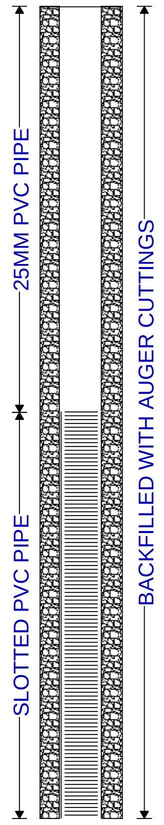
CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Elevation (m)
	GROUND SURFACE							950.48
0	***Topsoil (160mm)*** Moderately organic, black, damp.							950.32
	Till Clay, silty, sandy, trace gravel, very stiff, non to low plastic, brown, occasional rust stains, occasional coal inclusions, moist.						Frost to 1.0m.	
1			15	G	7G1		Grain Size Analysis: Clay=35% Silt=38% Sand=24% Gravel=3%	
2			15				SO4=0.04%	
3			17	■	7D1	28		
4			18					
	- medium plastic at 4.5m.							945.98
5			18					
6	- water at 6.0m.		19	■	7D2	20		944.48
	End of hole at 6.5m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on March 19, 2010.							943.98
7								
8								
9								
10								

Well Completion Details



LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

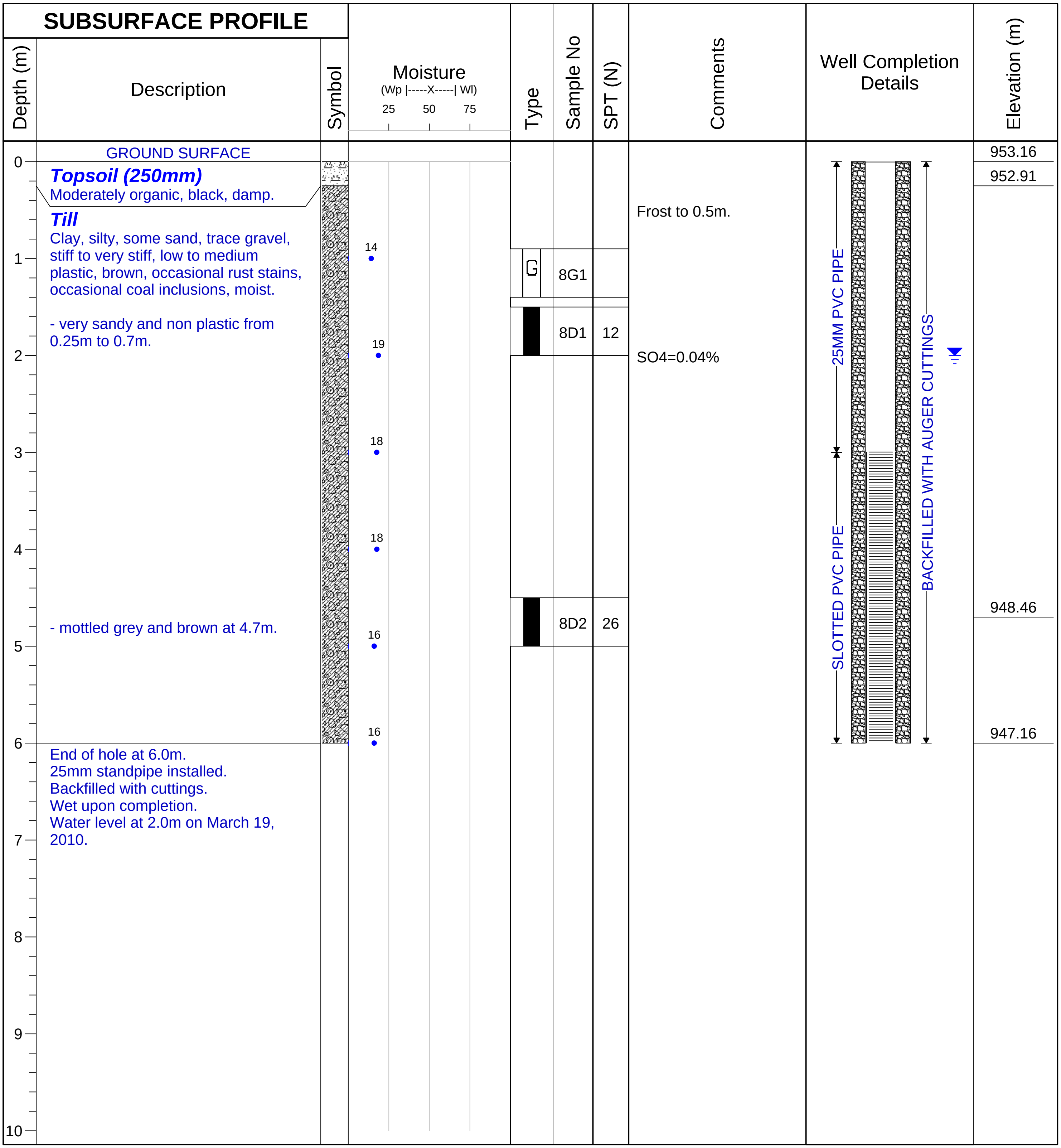
GROUND ELEVATION: 950.48m
NORTHING:
EASTING:

BOREHOLE NO.: 8

CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE



GROUND SURFACE

Topsoil (250mm)
Moderately organic, black, damp.

Till
Clay, silty, some sand, trace gravel, stiff to very stiff, low to medium plastic, brown, occasional rust stains, occasional coal inclusions, moist.

- very sandy and non plastic from 0.25m to 0.7m.

- mottled grey and brown at 4.7m.

End of hole at 6.0m.
25mm standpipe installed.
Backfilled with cuttings.
Wet upon completion.
Water level at 2.0m on March 19, 2010.

Type	Sample No	SPT (N)
G	8G1	
■	8D1	12
■	8D2	26

Comments:
Frost to 0.5m.
SO4=0.04%

LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

GROUND ELEVATION: 953.16m
NORTHING:
EASTING:

ParklandGEO

CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

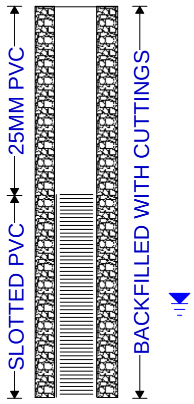
BOREHOLE NO.: 9

PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Elevation (m)
0	GROUND SURFACE						964.09
0	***Topsoil (150mm)*** Moderately organic, black, damp.						
0.15	***Till*** Clay, silty, sandy, trace gravel, very stiff, non to low plastic, brown, occasional rust stains, occasional coal inclusions, bedrock nodules, moist.					Frost to 0.5m.	
1		15	G	9G1			
1.5–2		15		9D1	16	SO4=0.04%	
2.4							961.69
2.5	- very sandy at 2.5m.						
2.7	***Weathered Bedrock*** Sandstone, very dense, brown, damp.						961.39
2.9	End of hole at 2.9m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Water level at 2.2m on March 19, 2010.						961.19

Well Completion Details



LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

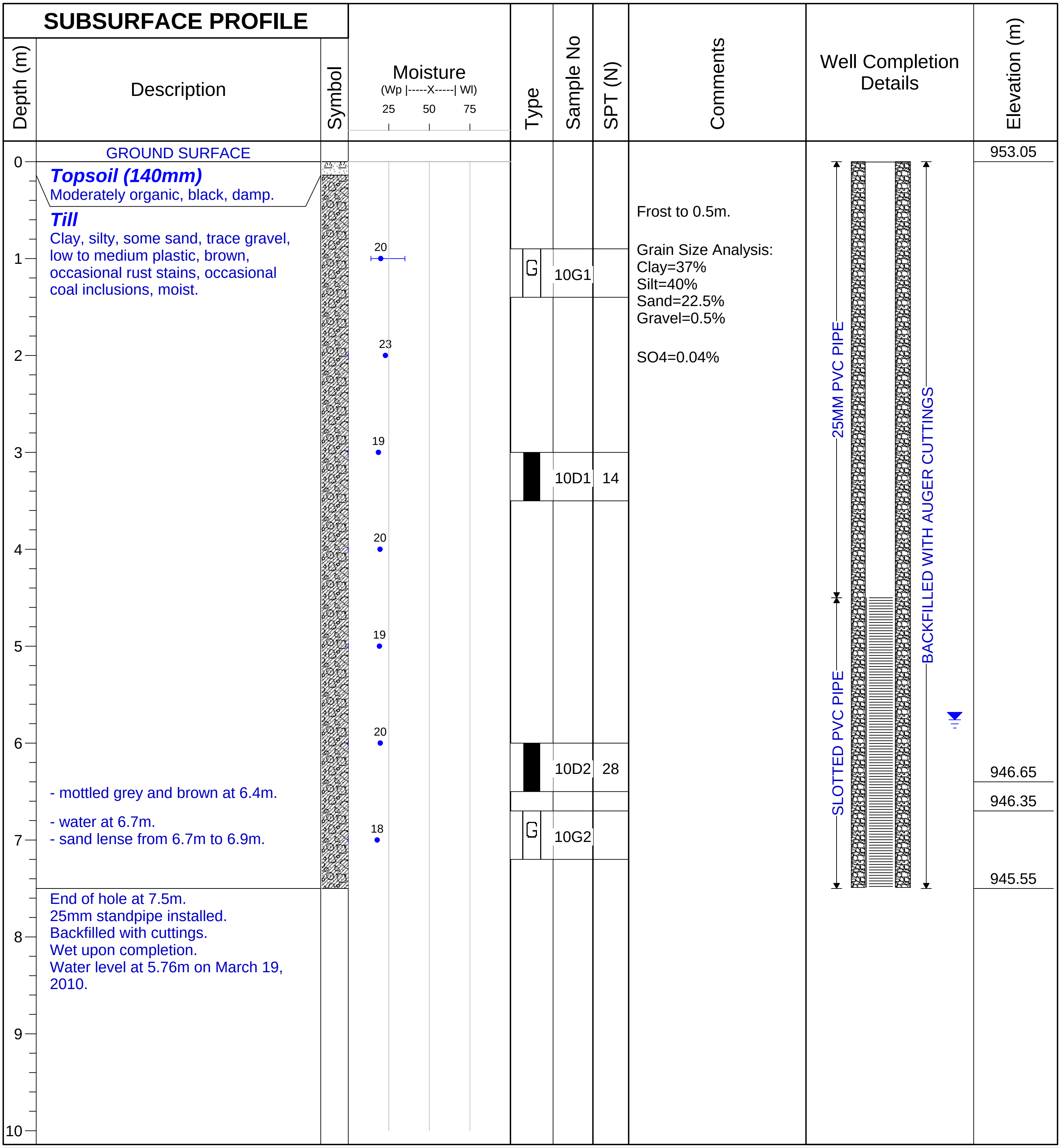
GROUND ELEVATION: 964.09m
NORTHING:
EASTING:

ParklandGEO

CLIENT: Longview Planning & Design
SITE: Birchcliff Rural Subdivision
NOTES:

BOREHOLE NO.: 10
PROJECT NO.: RD3452
BH LOCATION:

SUBSURFACE PROFILE



GROUND SURFACE

Topsoil (140mm)
Moderately organic, black, damp.

Till
Clay, silty, some sand, trace gravel, low to medium plastic, brown, occasional rust stains, occasional coal inclusions, moist.

- mottled grey and brown at 6.4m.
- water at 6.7m.
- sand lense from 6.7m to 6.9m.

End of hole at 7.5m.
25mm standpipe installed.
Backfilled with cuttings.
Wet upon completion.
Water level at 5.76m on March 19, 2010.

Type	Sample No	SPT (N)
G	10G1	
	10D1	14
	10D2	28
G	10G2	

Frost to 0.5m.

Grain Size Analysis:
Clay=37%
Silt=40%
Sand=22.5%
Gravel=0.5%

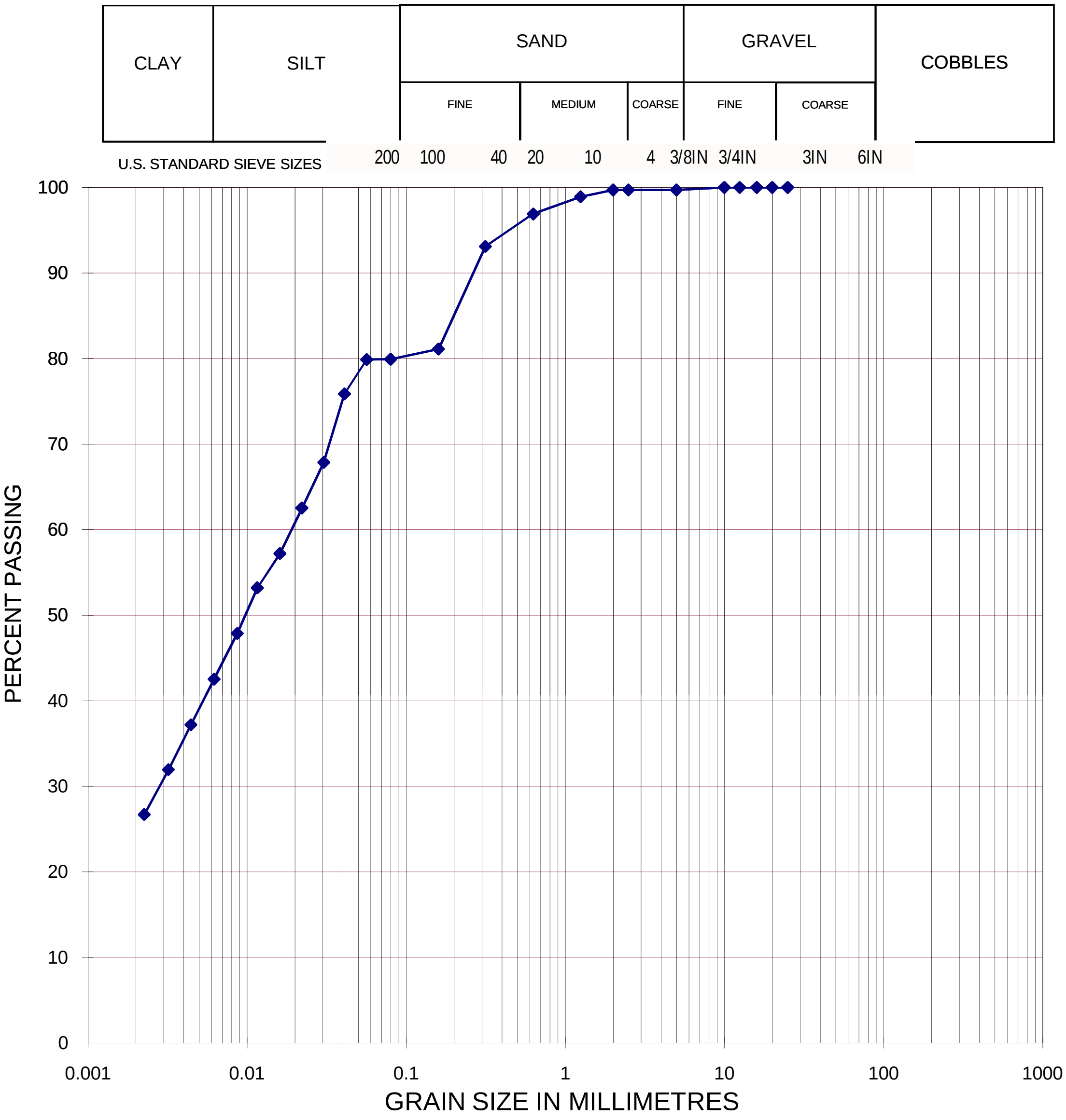
SO4=0.04%

LOGGED BY: BR
CONTRACTOR: J.E.D. Anchors and Environmental Ltd.
RIG/METHOD: Track Mount / Solid Stem Auger
DATE: March 5, 2010
CALIBRATION:

GROUND ELEVATION: 953.05m
NORTHING:
EASTING:

PROJECT Birchcliff Rural Subdivision
PROJECT # RD3452
BOREHOLE 5 **DATE** Mar 10/10
DEPTH 0.9 m **TECH** JB
SAMPLE 5G1
LOCATION

GRAIN SIZE DISTRIBUTION



COMMENTS:

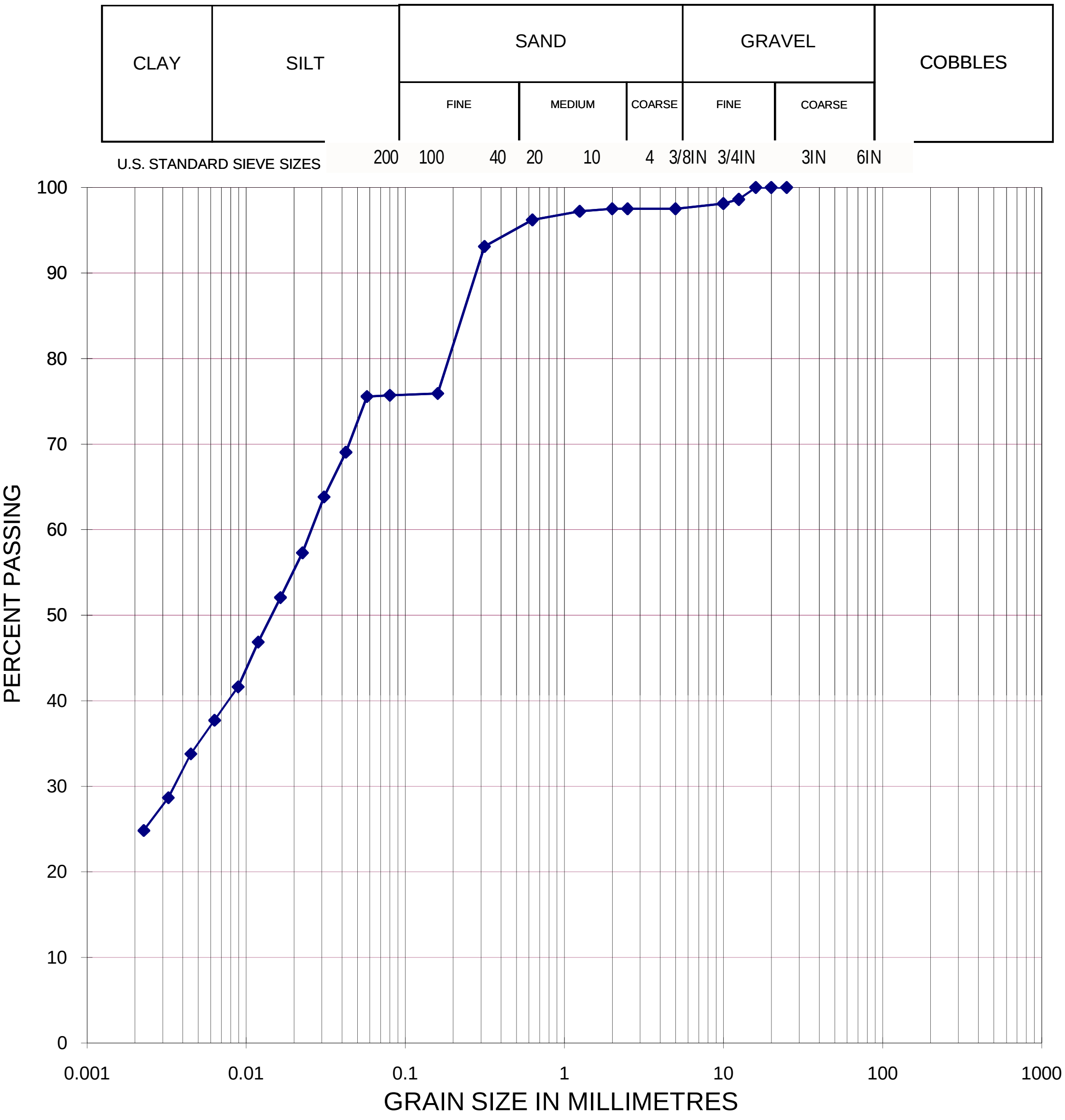
% Retained on 2 mm seive
Soil Type: Silt, and clay, some sand

SUMMARY

D10	=		GRAVEL	0.30%
D30	=		SAND	20.11%
D60	=		SILT	41%
CU	=		CLAY	38.85%
CC	=			

PROJECT Birchcliff Rural Subdivision
PROJECT # RD3452
BOREHOLE 7 **DATE** Mar 10/10
DEPTH 3.0 m **TECH** JB
SAMPLE 7D1
LOCATION

GRAIN SIZE DISTRIBUTION



COMMENTS:

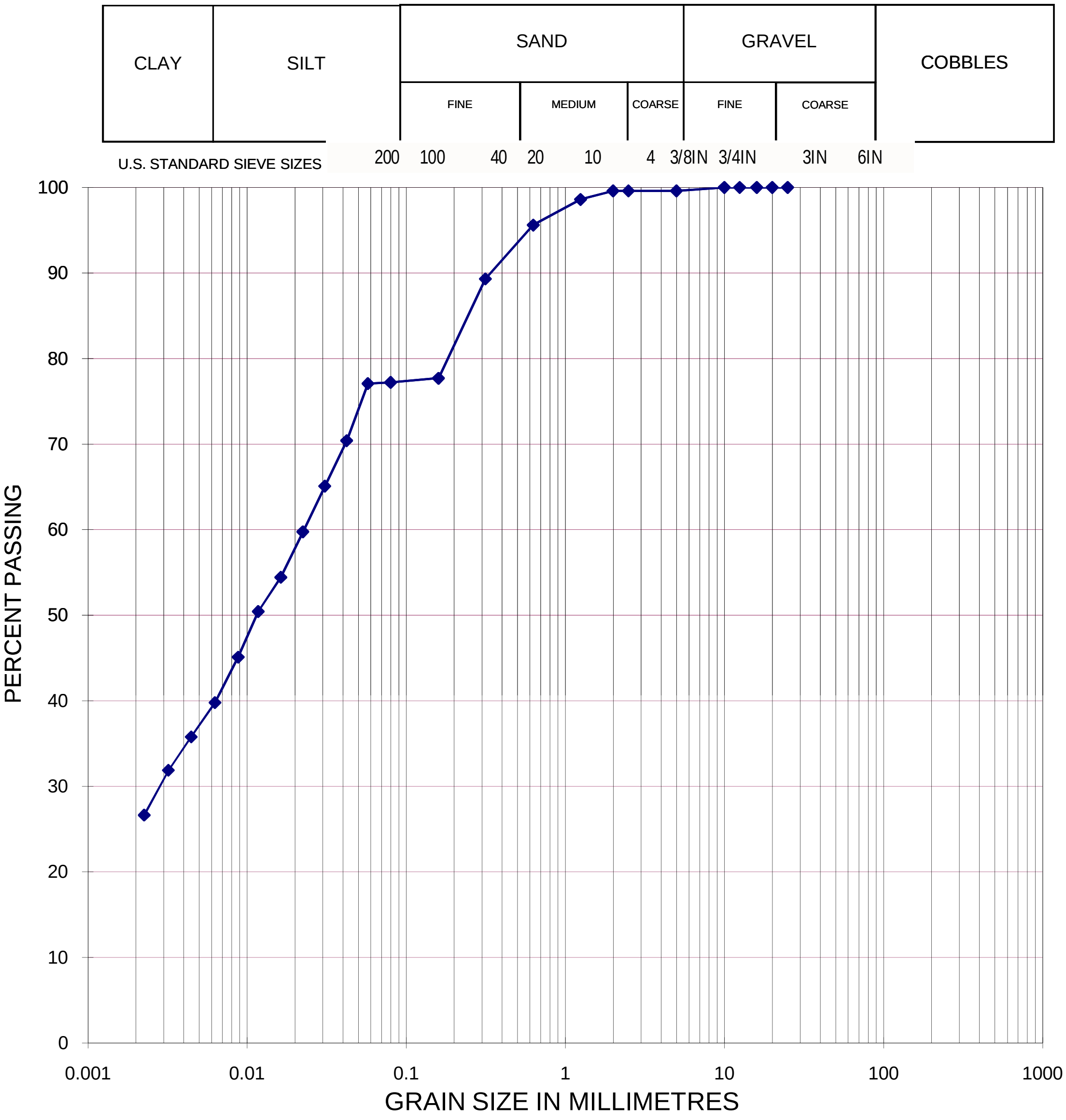
% Retained on 2 mm seive
Soil Type: Silt, some clay, some sand

SUMMARY

D10	=	GRAVEL	2.50%
D30	=	SAND	24.31%
D60	=	SILT	38%
CU	=	CLAY	34.86%
CC	=		

PROJECT	Birchcliff Rural Subdivision		
PROJECT #	RD3452		
BOREHOLE	10	**DATE**	Mar 10/10
DEPTH	0.9 m	**TECH**	JB
SAMPLE	10G1		
LOCATION			

GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Silt, and clay, some sand

SUMMARY

D10 =		GRAVEL	0.40%
D30 =		SAND	22.83%
D60 =		SILT	40%
CU =		CLAY	36.95%
CC =			

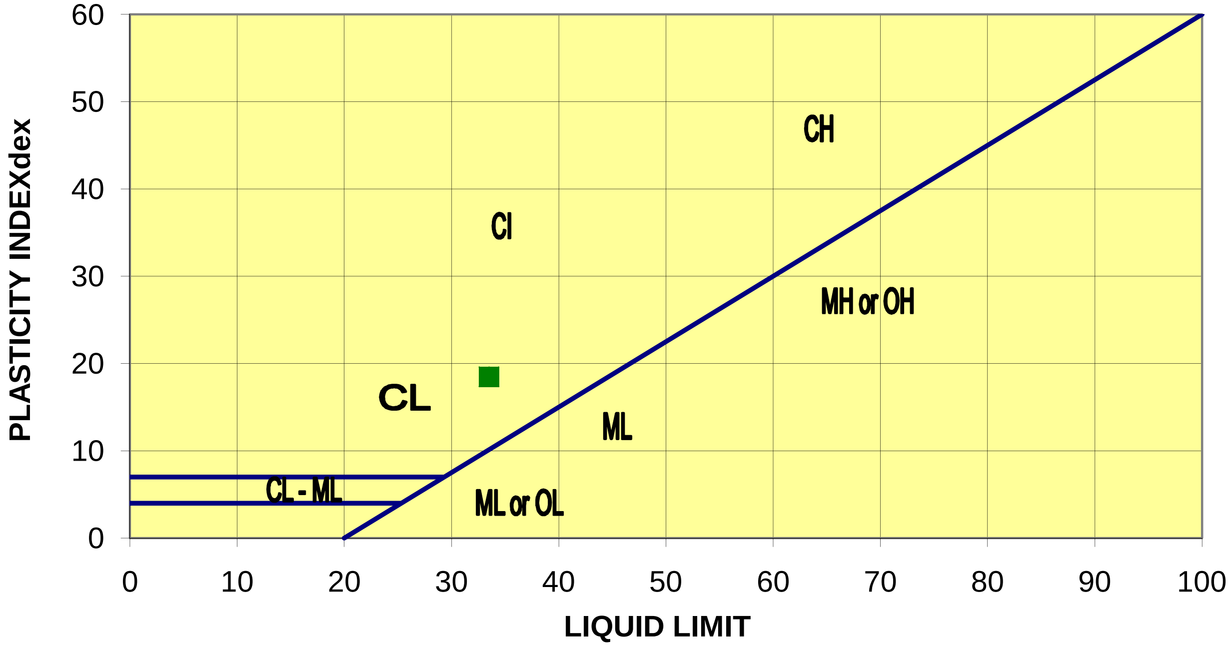
PROJECT#	RD3452
PROJECT	Birchcliff Rural Subdivision
BOREHOLE	5
DEPTH	0.9 m
SAMPLE #	5G1
DATE	Mar 10/10
TECH	JB

SOIL PLASTICITY SUMMARY

LIQUID LIMIT (LL)		
Trial No.	1	2
No. Blows	29	30
Wt. Sample Wet + Tare	39.576	43.074
Wt. Sample Dry + Tare	33.818	36.402
Wt. Water	5.758	6.672
Tare Container	16.232	16.128
Wt. Dry Soil	17.586	20.274
Moisture Content	32.742	32.909
Corrected for Blow Count	33.335	33.643
Liquid Limit Average	**33.5**	

PLASTIC LIMIT (PL)			
Trial No.	1	2	3
Wt. Wet Worm + Tare	8.481	8.724	8.817
Wt. Dry Worm + Tare	8.193	8.412	8.492
Wt. Water	0.288	0.312	0.325
Tare Container	6.298	6.336	6.298
Wt. Dry Worm	1.895	2.076	2.194
Moisture Content	15.198	15.029	14.813
Plastic Limit Average		**15.0**	

PLASTICITY INDEX (PI) = LL-PL **18.5**



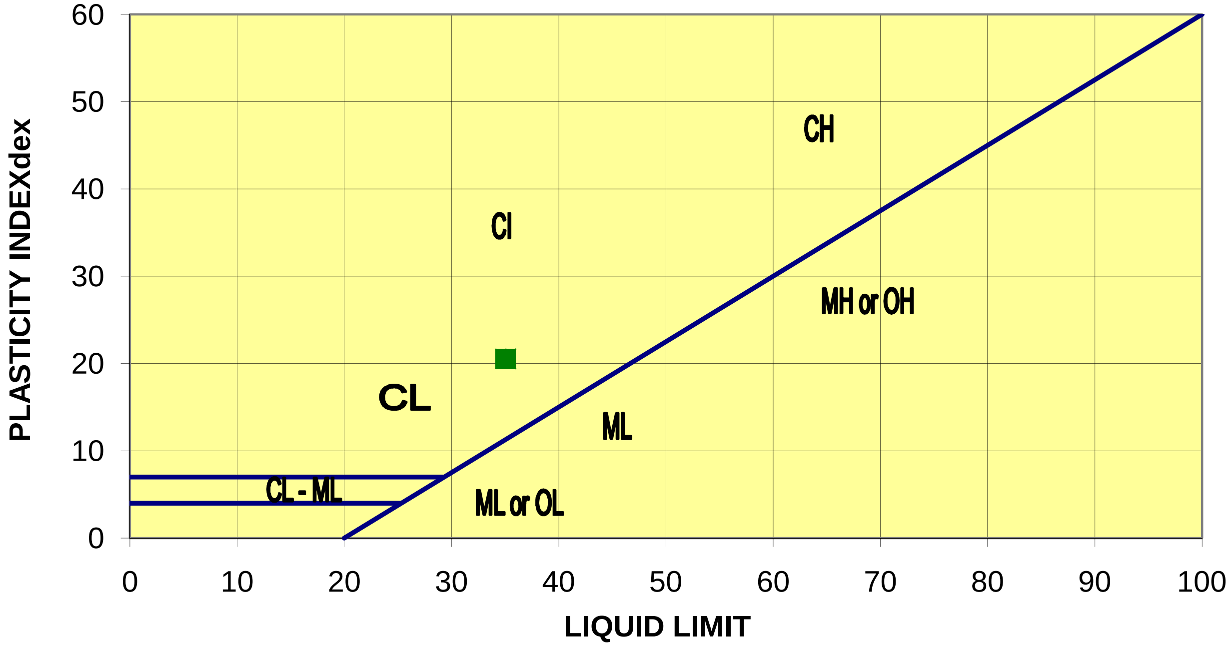
PROJECT#	RD3452
PROJECT	Birchcliff Rural Subdivision
BOREHOLE	10
DEPTH	0.9 m
SAMPLE #	10G1
DATE	Mar 10/10
TECH	JB

SOIL PLASTICITY SUMMARY

LIQUID LIMIT (LL)		
Trial No.	1	2
No. Blows	29	30
Wt. Sample Wet + Tare	40.111	41.320
Wt. Sample Dry + Tare	33.921	34.970
Wt. Water	6.190	6.350
Tare Container	15.989	16.409
Wt. Dry Soil	17.932	18.561
Moisture Content	34.519	34.212
Corrected for Blow Count	35.145	34.975
Liquid Limit Average	**35.1**	

PLASTIC LIMIT (PL)			
Trial No.	1	2	3
Wt. Wet Worm + Tare	8.645	8.416	8.680
Wt. Dry Worm + Tare	8.356	8.139	8.373
Wt. Water	0.289	0.277	0.307
Tare Container	6.322	6.235	6.306
Wt. Dry Worm	2.034	1.904	2.067
Moisture Content	14.208	14.548	14.852
Plastic Limit Average		**14.5**	

PLASTICITY INDEX (PI) = LL-PL **20.5**



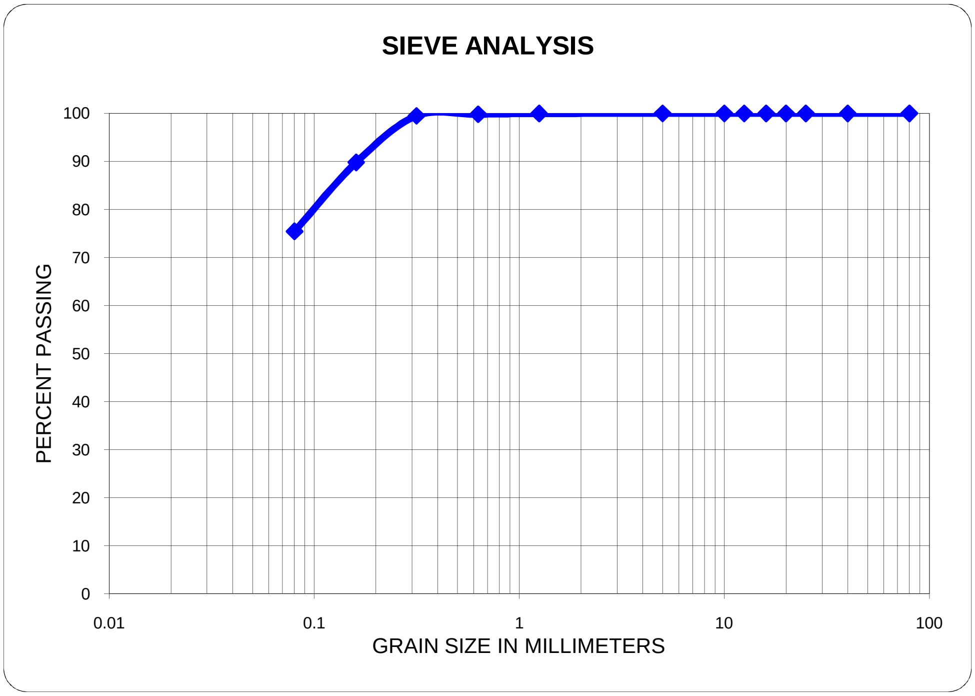
ParklandGEO

PROJECT - Birchcliff Rural Subdivision
PROJECT # RD3452 **DATE -** Mar 12/10
SAMPLE SOURCE -
PIT NAME -
TECHNICIAN - JB **SIEVE #** 2

SIEVE NO.	OPENING SIZE (mm)	WEIGHT RETAINED (g)	TOTAL WT. FINER (gms)	PERCENT PASSING	SPECIFICATION Min.	Max.
80000	80		1041.4	100.0		
40000	40		1041.4	100.0		
25000	25		1041.4	100.0		
20000	20		1041.4	100.0		
16000	16		1041.4	100.0		
12500	12.5		1041.4	100.0		
10000	10		1041.4	100.0		
5000	5		1041.4	100.0		
1250	1.25	0.4	1041	100.0		
630	0.63	1.6	1039.4	99.8		
315	0.315	3.4	1036	99.5		
160	0.16	100.8	935.2	89.8		
80	0.08	149.7	785.5	75.4		
SIEVE PAN		11.1				

MOISTURE CONTENT SAMPLE		SIEVE ANALYSIS SAMPLE		D.W.W.CALCULATIONS
A-WT. WET SAMPLE + PAN	1841.4	G-WT. OF DRY SAMPLE	1041.4	
B-WT. DRY SAMPLE + PAN	1731.3	H- WASHED DRY +PAN	957.3	
C-WT. OF WATER	110.1	I- WT OF WASHED DRY SA	267.4	
D-WT. OF PAN	689.9	J- WT WASHED FINES	774	
E-WT. OF DRY SAMPLE	1041.4			
F-MOISTURE CONTENT	10.6			

DESCRIPTION OF SAMPLE/COMMENTS	METHOD OF PREPARATION	WASHED
BH2	TOTAL WEIGHT	1041
2G1	DRY WT.	1041.4
0.9 m	DIFFERENCE	-0.4
	% DIFFERENCE	-0.0003841



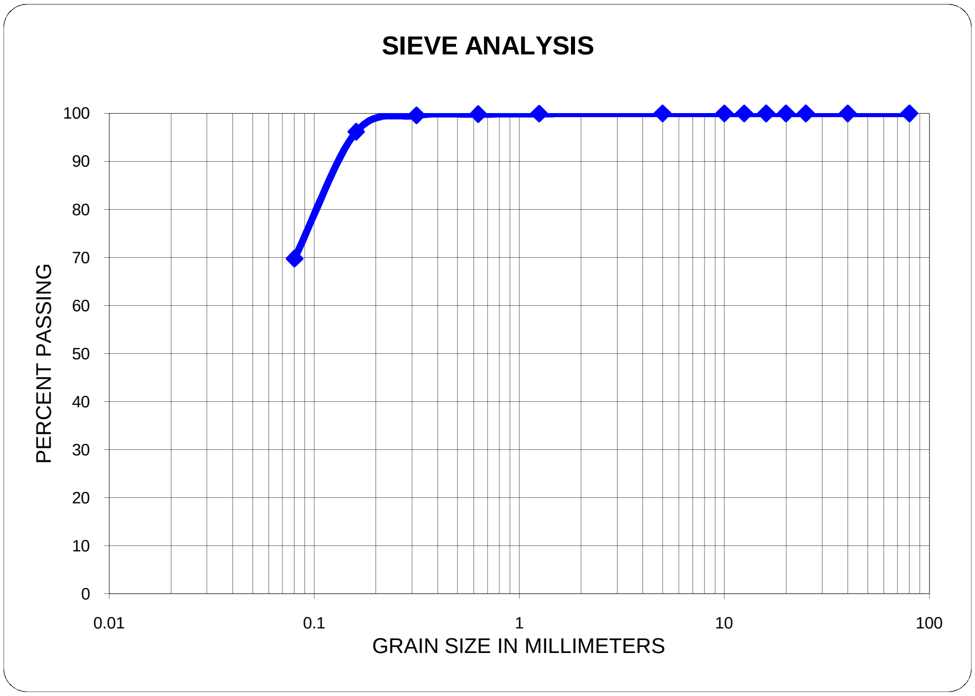
ParklandGEO

PROJECT - Birchcliff Rural Subdivision
PROJECT # RD3452 **DATE -** Mar 12/10
SAMPLE SOURCE -
PIT NAME -
TECHNICIAN - JB **SIEVE #** 1

SIEVE NO.	OPENING SIZE (mm)	WEIGHT RETAINED (g)	TOTAL WT. FINER (gms)	PERCENT PASSING	SPECIFICATION Min.	Max.
80000	80		730.1	100.0		
40000	40		730.1	100.0		
25000	25		730.1	100.0		
20000	20		730.1	100.0		
16000	16		730.1	100.0		
12500	12.5		730.1	100.0		
10000	10		730.1	100.0		
5000	5		730.1	100.0		
1250	1.25	0.4	729.7	99.9		
630	0.63	0.7	729	99.8		
315	0.315	1.8	727.2	99.6		
160	0.16	25.1	702.1	96.2		
80	0.08	192.8	509.3	69.8		
SIEVE PAN		8.5				

MOISTURE CONTENT SAMPLE		SIEVE ANALYSIS SAMPLE		D.W.W.CALCULATIONS
A-WT. WET SAMPLE + PAN	1514.5	G-WT. OF DRY SAMPLE	730.1	
B-WT. DRY SAMPLE + PAN	1421.3	H- WASHED DRY +PAN	920.6	
C-WT. OF WATER	93.2	I- WT OF WASHED DRY SA	229.4	
D-WT. OF PAN	691.2	J- WT WASHED FINES	500.7	
E-WT. OF DRY SAMPLE	730.1			
F-MOISTURE CONTENT	12.8			

DESCRIPTION OF SAMPLE/COMMENTS	METHOD OF PREPARATION	WASHED
BH3	TOTAL WEIGHT	730
3G2	DRY WT.	730.1
4.2 m	DIFFERENCE	-0.1
	% DIFFERENCE	-0.000137



Parkland GEO

Project: Birchcliff Rural Subdivision
Subject: Geotechnical Testing - Soil Sulphate Test Results
Project #: RD3452 **Date:** Mar 12/10

Soil Sulphate Test Results

Laboratory: Parkland Geotechnical

Sample #: MC2 Borehole: 1 Depth: 2.0 m Result (% Sulphate): 0.04	Sample #: MC2 Borehole: 6 Depth: 2.0 m Result (% Sulphate): 0.04
Sample #: MC2 Borehole: 2 Depth: 2.0 m Result (% Sulphate): 0.04	Sample #: MC2 Borehole: 7 Depth: 2.0 m Result (% Sulphate): 0.04
Sample #: MC2 Borehole: 3 Depth: 2.0 m Result (% Sulphate): 0.04	Sample #: MC2 Borehole: 8 Depth: 2.0 m Result (% Sulphate): 0.04
Sample #: MC2 Borehole: 4 Depth: 2.0 m Result (% Sulphate): 0.04	Sample #: MC2 Borehole: 9 Depth: 2.0 m Result (% Sulphate): 0.04
Sample #: MC2 Borehole: 5 Depth: 2.0 m Result (% Sulphate): 0.04	Sample #: MC2 Borehole: 10 Depth: 2.0 m Result (% Sulphate): 0.04

Comments:

REQUIREMENTS FOR CONCRETE SUBJECTED TO SULPHATE ATTACK (CAN/CSA-A231-M04)

EXPOSURE CLASSIFICATION	DEGREE OF EXPOSURE	WATER-SOLUBLE SULPHATE(SO4) IN SOIL SAMPLE, %	SULPHATE(SO4) IN GROUND WATER SAMPLES, mg/L	MINIMUM SPECIFIED 56-DAY COMPRESSIVE STRENGTH, MPa	MAXIMUM WATER/CEMENTING MATERIALS RATIO	PORTLAND CEMENT TO BE USED
S-1	Very Severe	over 2.0	over 10,000	35	0.4	HS
S-2	Severe	0.20 to 2.0	1 500 to 10 000	32	0.45	HS
S-3	Moderate	0.10 to 0.20	150 to 1 500	30	0.5	MS or HS

Tech: JB **Chkd:** BR

DESIGNATION		1			2					3				4			5	6		7	8
CLASS (mm)		10	12.5	16	16	20	25	40	50	12.5A	12.5B	12.5C	16	20	25	40	10	80	125	40	40
PER CENT PASSING METRIC SIEVE (CGSB 8 - GP - 2M) µm	125 000																		100		
	80 000																	100			
	50 000								100									55-100	55-100		
	40 000							100								100				100	100
	25 000						100		63-90						100			38-100	38-100		
	20 000					100								100		55-90					
	16 000			100	100		70-94	55-85	47-79				100					32-85	32-85		
	12 500		100	80-92						100	100	100	72-95								
	10 000	100	83-92	70-84	70-93	63-86	52-79	44-74	38-70	35-65	55-75	70-93	53-85	35-77	30-77	25-72	100			85-100	78-95
	5 000	60-75	55-70	50-65	50-70	40-67	35-64	32-62	28-59	0-15	0-15	30-70	27-64	15-55	15-55	8-55	45-70	20-65	20-65		60-85
	1250	30-45	30-45	30-45	26-45	20-43	18-43	17-43	16-42	0-3	0-3	9-34	9-34	0-30	0-30	0-30	20-45			40-100	27-57
	630	22-38	22-38	22-38	19-38	14-34	12-34	12-34	12-34												
	315	15-30	15-30	15-30	14-30	9-26	8-26	8-26	8-26			0-18	0-18				9-22	6-30	6-30	17-100	5-29
	160	9-20	9-20	9-20	9-20	5-18	5-18	5-18	5-18			0-13	0-13				5-15				0-15
	80	4-10	4-10	4-10	4-10	2-10	2-10	2-10	2-10	0-2	0-2	0-8	0-8	0-12	0-12	0-12	0-10	2-10	2-15	6-30	0-5
% FRACTURE BY WEIGHT (2 FACES)	ALL +5000	60+	60+	60+	60+	60+	60+	50+	40+	75+	75+	60+	60+	40+	40+	25+	N/A	N/A	N/A	N/A	N/A
PLASTICITY INDEX (PI)		0-4	0-4	0-4	0-6	0-6	0-6	0-6	0-6	N/A	N/A	0-4	0-4	0-8	0-8	0-8	0-6	0-8	0-8	0-10	0-5
L.A. ABRASION LOSS PER CENT MAX.		40	40	40	50	50	50	50	50	35	35	35	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
FLAKINESS INDEX		N/A								MAX 15		N/A									
COEFFICIENT OF UNIFORMITY (Cu)		N/A																		3+	N/A

DESIGNATION

1. ASPHALT CONCRETE AGGREGATE (CLASS 10 FOR SURFACE PREPARATION COURSE ONLY)
2. GRANULAR AND ASPHALT STABILIZED BASE COURSES, SUB-BASES AND DUST ABATEMENT AGGREGATES.
3. SEAL COAT AGGREGATE
4. GRAVEL SURFACING AGGREGATE
5. SANDING MATERIAL
6. PIT-RUN GRAVEL FILL
7. CEMENT STABILIZED BASE COURSE AGGREGATE
8. GRANULAR FILTER AGGREGATE

13 MAY 88
417PI169

Alberta
TRANSPORTATION
AND UTILITIES

CHART	3.2 A
	Date
Original	MARCH 1984
Revised	DEC. 1985
Revised	FEB. 1987
Revised	MAR. 1988

SPECIFICATIONS FOR AGGREGATE

EXPLANATION OF TERMS AND SYMBOLS

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

The borehole logs are a graphical representation summarizing the soil profile as determined during site specific field investigation. The borehole logs may include test data from laboratory soil testing, if applicable. The materials, boundaries and conditions have been established only at the borehole locations at the time of drilling. The soil conditions shown on the borehole logs are not necessarily representative of the subsurface conditions elsewhere across the site. The transitions in soil profile usually have gradual rather than distinct unit boundaries as shown on this graphical representation.

1. **PRINCIPAL SOIL TYPE** - The major soil type by weight of material or by behavior.

Material	Grain Size
Boulders	Larger than 300 mm
Cobbles	75 mm to 300 mm
Coarse Gravel	19 mm to 75 mm
Fine Gravel	5 mm to 19 mm
Coarse Sand	2 mm to 5 mm
Medium Sand	0.425 mm to 2 mm
Fine Sand	0.75 mm to 0.425 mm
Silt & Clay	Smaller than 0.075 mm

2. **DESCRIPTION OF MINOR SOIL TYPE** - Minor soil types are identified by weight of minor component.

Percent	Descriptor
35 to 50	and
20 to 35	some
10 to 20	little
1 to 10	trace

3. **RELATIVE STRENGTH OF COARSE GRAINED SOIL** - The following terms are used relative to Standard Penetration Test (SPT), ASTM D1586, N value for blows per 300 mm.

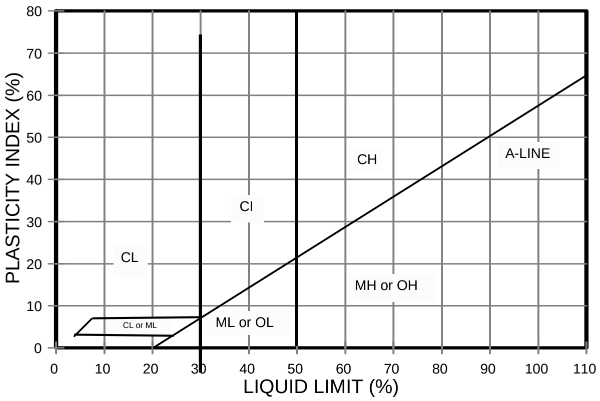
Description	N Value
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Over 50

4. **CONSISTENCY OF FINED GRAINED SOIL** - The following terms are used relative to unconfined strength in kPa and Standard Penetration Test (SPT), ASTM D1586, N value for blows per 300 mm.

Description	Unconfined Compressive Strength (kPa)	N Value
Very Soft	less than 25	Less than 2
Soft	25 to 50	2 to 4
Firm	50 to 100	4 to 8
Stiff	100 to 200	8 to 15
Very Stiff	200 to 380	15 to 30
Hard	Over 380	Over 30

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	▨	WELL GRADED GRAVELS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > C_C = \frac{(D_{30})^2}{D_{10} X D_{60}} = 1 \text{ to } 3$	
			GP	▨	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO	NOT MEETING ALL OF THE ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM	▨	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12 %	ATTERBERG LIMITS BELOW “A” LINE OR P.I. LESS THAN 4
			GC	▨	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE “A” LINE OR P.I. MORE THAN
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW	▨	WELL GRADED SANDS, GRAVELLY SANDS WITH LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > C_C = \frac{(D_{30})^2}{D_{10} X D_{60}} = 1 \text{ to } 3$	
			SP	▨	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ALL OF THE ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM	▨	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12 %	ATTERBERG LIMITS BELOW “A” LINE OR P.I. LESS THAN 4
			SC	▨	CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE “A” LINE OR P.I. MORE THAN
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO. 200 SIEVE)	SILTS BELOW “A” LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML	▨	INORGANIC SILTS & VERY FINE SANDS, ROCK FLUOR, SILTY SANDS OF SLIGHT	CLASSIFICATION IS BASED ON THE PLASTICITY CHART BELOW	
		$W_L > 50\%$	MH	▨	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY		
	CLAYS ABOVE “A” LINE ON PLASTICITY CHART NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL	▨	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR		
		$30\% < W_L < 50\%$	CI	▨	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$W_L > 50\%$	CH	▨	INORGANIC CLAYS OF HIGH PLASTICITY		
	ORGANIC SILTS & CLAYS BELOW “A” LINE ON CHART	$W_L < 50\%$	OL	▨	ORGANIC SILT, AND ORGANIC SILTY CLAYS OF LOW PLASTICITY		
		$W_L > 50\%$	OH	▨	ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt	■	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	



NOTES ON SOIL CLASSIFICATION AND DESCRIPTION:

5. Soils are classified and described according to their engineering properties and behaviour.
6. Boundary classifications for soils with characteristics of two groups are given combined group symbols, eg. GW-GC is a well graded gravel-sand mixture with clay binder between 5 and 12 %.
7. Soil classification is in accordance with the Unified Soil Classification System, with the exception that an inorganic clay of medium plasticity (CI) is recognized.
8. The use of modifying adjectives may be employed to define the estimated percentage range by weight of minor components.

GENERAL TERMS AND CONDITIONS

The use of this attached report is subject to acceptance of the following general terms and conditions.

1. STANDARD OF CARE - In the performance of professional services, ParklandGEO will use that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same or similar localities. No other warranty expressed or implied is made or intended by this agreement or by furnishing oral or written reports of the findings made. ParklandGEO is to be liable only for damage directly caused by the negligence of ParklandGEO.

2. INTERPRETATION OF THE REPORT - The CLIENT recognizes that subsurface conditions will vary from those encountered at the location where borings, surveys, or explorations are made and that the data, interpretations and recommendation of ParklandGEO are based solely on the information available to him. Classification and identification of soils, rocks, geological units, contaminated materials and contaminant quantities will be based on commonly accepted practices in geotechnical consulting practice in this area. ParklandGEO will not be responsible for the interpretation by others of the information developed.

3. SITE INFORMATION - The CLIENT agrees to fully cooperate with ParklandGEO and provide all information with respect to the past, present and proposed conditions and use of the Site whether specifically requested or not. The CLIENT acknowledges that in order for ParklandGEO to properly advise and assist the CLIENT in respect of the investigation of the Site, ParklandGEO is relying upon full disclosure by the CLIENT of all matters pertinent to an investigation of the Site.

   Where specifically stated in the scope of work, ParklandGEO will perform a review of the historical information obtained or provided by the Client to assist in the investigation of the Site unless and except to the extent that such a review is limited or excluded from the scope of work.

4. RIGHT OF ENTRY - The CLIENT is responsible for ensuring that ParklandGEO is provided unencumbered access to the property to the extent necessary for ParklandGEO to complete the scope of work to ParklandGEO's satisfaction. The CLIENT is solely responsible for obtaining permission and permits for ParklandGEO to enter onto the subject site, including informing tenants. The CLIENT shall also provide ParklandGEO with the location of all underground utilities and structures on the subject site, unless otherwise agreed to in writing. While ParklandGEO will take all reasonable precautions to avoid and minimize any damage to any sub-terrain utilities or structures, the CLIENT agrees to hold ParklandGEO harmless for any damage to any sub-terrain utilities or structures or any damage occasioned in gaining access to the subject site.

5. COMPLETE REPORT - The Report is of a summary nature and is not intended to stand alone without reference to the instructions given to ParklandGEO by the CLIENT, communications between ParklandGEO and the CLIENT, and to any other reports, writings or documents prepared by ParklandGEO for the CLIENT relative to the specific Site, all of which constitute the Report. The word "Report" shall refer to any and all of the documents referred to herein. In order to properly understand the suggestions, recommendations and opinions expressed by ParklandGEO, reference must be made to the whole of the Report. ParklandGEO cannot be responsible for use of any part or portions of the report without reference to the whole report. The CLIENT agrees that any and all reports prepared by ParklandGEO shall contain the following statement:

   > "This report has been prepared for the exclusive use of the named CLIENT. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. PARKLAND GEO-ENVIRONMENTAL LTD. 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 CLIENT agrees that in the event that any such report is released to a third party, such disclaimer shall not be obliterated or altered in any manner. The CLIENT further agrees that all such reports shall be used solely for the purposes of the CLIENT and shall not be released or used by others without the prior written permission of ParklandGEO.

6. LIMITATIONS ON SCOPE OF INVESTIGATION AND WARRANTY DISCLAIMER

There is no warranty, expressed or implied, by ParklandGEO that:

a) the investigation shall uncover all potential contaminants or environmental liabilities on the Site; or

b) the Site will be entirely free of all contaminants as a result of any investigation or cleanup work undertaken on the Site, since it is not possible, even with exhaustive sampling, testing and analysis, to document all potential contaminants on the Site.

The CLIENT acknowledges that:

a) the investigation findings are based solely on the information generated as a result of the specific scope of the investigation authorized by the CLIENT;

b) unless specifically stated in the agreed Scope of Work, the investigation will not, nor is it intended to assess or detect potential contaminants or environmental liabilities on the Site;

c) any assessment regarding geological conditions on the Site is based on the interpretation of conditions determined at specific sampling locations and depths and that conditions may vary between sampling locations, hence there can be no assurance that undetected geological conditions, including soils or groundwater are not located on the Site;

d) any assessment is also dependent on and limited by the accuracy of the analytical data generated by the sample analyses;

e) any assessment is also limited by the scientific possibility of determining the presence of unsuitable geological conditions for which scientific analyses have been conducted; and

f) the analytical parameters selected are limited to those outlined in the CLIENT's authorized scope of investigation; and

g) there are risks associated with the discovery of hazardous materials in and upon the lands and premises which may inadvertently discovered as part of this investigation. The CLIENT acknowledges that it may have a responsibility in law to inform the owner of any affected property of the existence or suspected existence of hazardous materials. The CLIENT further acknowledges that any such discovery may result in the fair market value of the lands and premises and of any other lands and premises adjacent thereto to be adversely affected in a material respect.

7. CONTROL OF WORK SITE AND JOBSITE SAFETY - ParklandGEO is only responsible for the activities of its employees on the jobsite. The presence of ParklandGEO personnel on the Site shall not be construed in any way to relieve the CLIENT or any contractors on Site from their responsibilities for Site safety. The CLIENT undertakes to inform ParklandGEO of all hazardous conditions, or possible hazardous conditions which are known to him. The CLIENT also recognizes that the activities of ParklandGEO may uncover previously unknown hazardous materials and that such a discovery may result in the necessity to undertake emergency procedures to protect ParklandGEO employees as well as the public at large and the environment in general. The CLIENT also acknowledges that in some cases the discovery of hazardous conditions and materials will require that certain regulatory bodies be informed and the CLIENT agrees that notification to such bodies by ParklandGEO will not be a cause of action or dispute.