GEOTECHNICAL INVESTIGATION
PROPOSED QUALICO SUBDIVISION
NW & SW 34-39-2-W5M,
LACOMBE COUNTY, ALBERTA

ParklandGEO

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LACOMBE COUNTY, ALBERTA

Prepared for:
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PARKLAND GEOTECHNICAL LTD.
RED DEER, ALBERTA
PROJECT NUMBER: RD2617
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APPENDICES

1.0 INTRODUCTION

EDS Group Inc. is proposing to develop a rural residential subdivision within the NW and SW quarters of 34-39-2 W5M along the north east shore of Sylvan Lake in Lacombe County, Alberta. The site location is shown on the Key Plan, Figure 1 in Appendix A. Parkland Geotechnical Consulting Ltd. (ParklandGEO) conducted a geotechnical investigation at the site. The scope of the work was outlined in ParklandGEO's proposal dated August 16, 2007 (File# PRO1199) Authorization to proceed with the investigation was given by Mr. John Buchko of EDS Group Inc.

This report summarizes results of field and laboratory testing programs and presents geotechnical recommendations for the proposed subdivision. Geotechnical recommendations are provided with respect to design and installation of underground services, residential foundations, roadway subgrades and flexible pavement design for light residential and collector roads. The slope assessment in this report is intended to provide the developer with a reasonable expectation with respect to slope stability and potential for slope movement, and to communicate the technical risks so that the developer can make informed development decisions relating to the slope.

2.0 SITE DESCRIPTION

The general topography of the site is open pasture land with heavy rolling hills on the NW quarter. The south edge of the NW quarter is heavily treed with the lake shore intercepting the south west corner. There is a significant slope in this corner of the NW quarter sloping southwards towards the lake shore with elevation changes from 937.0 m to 951.0 m. The SW quarter is all heavily treed with the lake shore running along the southern and western edge. The topography of the SW quarter is also rolling hills but with smaller slopes than the large slope in the NW quarter. The elevations of the site range from 937.0 m along the shoreline to 971.0 m in the NE corner. The present site development and vegetation at the site is shown on the Aerial Photograph provided in Figure 3, in Appendix A. The contours of this site can be seen in the Contour Plan, Figure 4 in appendix A.

3.0 FIELD AND LABORATORY PROGRAMS

On September 13th, 2007, twelve boreholes were drilled in the accessible areas of the NW quarter with a truck mounted auger drill. The borehole locations were laid out on a 150 m grid (approximate). Boreholes 13 to 20 were drilled at representative locations in the SW quarter on October 29, 2007 using a tracked drill rig. Boreholes 15 and 17 were drilled to a depths of 16.5 and 11m respectively, along the crest of steeper slopes while the rest of the boreholes were drilled to a depth of at least 6m or auger refusal. The locations of the boreholes are shown on the Site Plan, Figure 2 in Appendix A.

The soil encountered was visually examined during excavation and 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. Standard Penetration Tests were taken at selected depth intervals in all boreholes. All soil samples were returned to the Red Deer laboratory for further testing to determine the soil classification and strength properties.

Standpipes were installed in all boreholes at the completion of drilling. Groundwater levels were measured at completion and after groundwater conditions stabilized. The borehole ground surface elevations were surveyed by Pals Survey and Associates Ltd. and referenced to a geodetic datum.

4.0 SOIL CONDITIONS

The general soil profile encountered at the site consisted of, in descending order: topsoil, silty clay, and clay till. A layer of sand was encountered in Boreholes 7, 13, 14. Bedrock was found below the till in Boreholes 7, 10, 15 and 17 had bedrock present. 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 TOPSOIL

Surficial topsoil ranging from 100 to 300 mm thick was encountered in all borehole locations. Based on observations and experience, topsoil thickness is expected to vary and may exist in greater thickness between the borehole locations. The topsoil encountered was black and moderately organic. Local topsoil is considered to be weak and highly compressible when subjected to loads.

4.3 SILTY CLAY

The silty clay soils ranged from low to medium plastic depending on the percentage of clay and silt at the various depths. The silty clay deposits were of a firm to stiff consistency with moisture contents ranging from 13 to 30 percent. The consistency generally increased with depth. The estimated Optimum Moisture Content (OMC) is about 18 to 21 percent, therefore the soil moisture contents of these deposits is considered to be above OMC. The estimated CBR value for these lacustrine silty clay is in the range of 2.5 to 5 in the soaked condition. From local experience these fine grained soils are frost susceptible and sensitive to disturbance when wet.

4.5 SAND DEPOSITS

A layer of silty sand was encountered in Boreholes 7, 13, and 14 at depths of 1.5 to 5.6m below grade. The sand was fine grained and poorly graded with trace clay. The moisture content of the sand ranged from 5 to 24 percent. This is below the estimated OMC of 17 percent.

4.4 CLAY TILL

Clay till was encountered in 13 of 20 boreholes starting from 1.7 to 5.6 m below grade. The exceptions were Boreholes 4, 7, 9, 10, 11, 12, and 14, starting from 1.7 to 5.6 m below grade. The local till had a variable mixture of clay, silt, sand with a trace amount of gravel and occasional inclusions of cobble and coal fragment. In general, the proportions of sand, silt and clay are roughly equal in the clay till and the plasticity of the till was low to medium and the consistency of till was stiff to very stiff. Moisture contents in the till ranged from 11 to 22 percent. The estimated OMC of the till is 14 percent.

4.5 BEDROCK

Bedrock was encountered at 3.0 and 4.7 m in Boreholes 7 and 10 respectively. Boreholes 15 and 17 also had bedrock at 15.2 and 9.3m respectively. The predominant local bedrock is a soft rock composed of weathered clay shale that has the consistency of very hard soil. The bedrock typically becomes stronger and more competent with depth.

4.6 WATER SOLUBLE SULPHATES

Soil samples at a depth of 2.0 m from all boreholes at the site were tested for soluble sulphates. The concentrations of sulphates are expresses as a percent of the dry mass of soil. The concentrations of water soluble sulphate were between 0.04 and 0.08 which indicates a "negligible potential for sulphate attack on buried concrete in direct contact with soil." The soil sulphate concentrations at the borehole locations are shown on Figure 5, in Appendix A.

5.0 GROUNDWATER AND PERCOLATION RATES

For the fist phase of drilling, water levels were measured at completion, on September 26th, 2007 and again on October 26th, 2007. After the second phase of drilling the water levels were measured on November 6th, 2007 and on November 13th, 2007. The Table 1 summarizes the observed groundwater conditions.

TABLE 1
GROUNDWATER LEVELS

BH #	Ground Elevation (m)	Groundwater Levels (mbg)				
		Compl	Sep 26/07	Oct 26/07	Nov 06/07	Nov 13/07
1	965.3	DRY	DRY	5.9	-	-
2	959.38	WET	1.2	1.4	-	-
3	955.49	DRY	1.3	1.5	-	-
4	957.55	DRY	DRY	DRY	-	-
5	952.57	DRY	DRY	DRY	-	-
6	951.15	DRY	DRY	5.4	-	-
7	967.01	DRY	DRY	DRY	-	-
8	962.35	DRY	DRY	DRY	-	-
9	956.21	DRY	DRY	DRY	-	-
10	965.95	DRY	DRY	DRY	-	-
11	962.06	DRY	DRY	DRY	-	-
12	954.95	DRY	5.8	5.6	-	-
13	948.92	DRY	-	-	DRY	DRY
14	939.49	DRY	-	-	1.7	1.9
15	940.29	DRY	-	-	3.3	3.1
16	939.43	DRY	-	-	2.3	1.9
17	951.21	DRY	-	-	9.5	10.2
18	951.14	DRY	-	-	DRY	DRY
19	958.86	DRY	-	-	3.2	3.8
20	943.11	DRY	-	-	0.6	0.6

The elevation the groundwater table at the borehole locations is shown on Figure 6, in Appendix A. The groundwater contours on this figure are inferred between the borehole locations. These groundwater levels are considered to be typical in this area. The observed groundwater level is considered to be near or below the seasonal average. Groundwater elevations are expected to fluctuate higher on a seasonal basis and will be highest after periods of heavy precipitation or snow-melt. The volumes of groundwater encountered will be dependent on seasonal conditions and the size and permeability of clay soil layers.

Field percolation testing could not be done at the site because the ground was frozen at the time of the field investigation. Instead, the soil encountered in select boreholes at various depths was categorized by the SSC soil texture classification system, shown on the Soil Triangle (see Figure 7). The Table 2 summarizes the observed soil conditions.

TABLE 2
SOIL CLASSIFICATION AND SUITABILITY

Borehole #	Depth (m)	Soil Classification		
		Sand Content (%)	Clay Content (%)	SSC Soil Texture Classification
BH1	0.7	13	50.6	Clay
BH5	2.4	13.1	39.4	Silty Clay Loam
BH8	1.5	15.3	27.1	Silty Loam
BH15	3.5	18.1	44.7	Clay
BH17	3.8	36.3	31.8	Clay Loam
BH20	3	11.2	42.2	Silty Clay

Based on visual observations and soil testing, the classifications from each of the boreholes were considered to be representative of the range of soil conditions at the site.

6.0 SLOPE STABILITY ASSESSMENT

The upland area of this subdivision is bordered by a slope overlooking the shoreline of Sylvan Lake. The slope height varies from about 10 to 12 m along the southwest facing slope within NW 34-39-2-W5M to about 4 to 6 m along the westward facing slope. The shoreline within SW 34-39-2-W5M is low lying and has no significant slope (ie.<15%). Lacombe County top-of-slope/escarpment policy sets an arbitrary default set-back of 30 m from all slopes within the county as is a buffer for development near slopes. Relaxation from the default set-back is possible, provided the request for relaxation is supported by a detailed geotechnical assessment. Therefore, a slope stability assessment was conducted to assess the sensitivity of the local escarpment to potential residential development in the upland area at this site.

Slope stability is described in terms of a factor of safety (FS) against slope failure which is the ratio of total forces promoting failure divided by the sum of forces resisting failure. In general, a FS of less than 1 indicates that failure is expected and a FS of more than 1 indicates that the slope is stable. A steepened slope will slump back over time to establish a stable profile for the existing soil and groundwater conditions. The FS of a slope will increase slightly as vegetation is established on the face to protect the subgrade soil from weathering. Given the possibility of soil variation, groundwater fluctuation, erosion and other factors, slopes with FS ranging between 1.0 and 1.3 are considered to be marginally stable and a "long term" stable slope is considered to have a FS of over 1.3.

For top-of-bank development a FS of at least 1.3 is desired for the critical failure surface which failure surface with the lowest calculated FS intersecting the proposed structure or private development. Structures generally represent a higher risk and potential for loss of investment, therefore a FS of at least 1.5 is recommended for the slope or the proposed structure is "set back" a distance from the crest to provide this additional factor of safety. The crest is defined as the line where there is a distinct break in the grade at the top of the slope as determined by the intersection of the slope angle with the extension of upland surface grade. The set-back provides a buffer zone which might be subject to slope movement, but will provide warning to the Owner before the structure is impacted.
For land development above steeper slopes, the recommended practice is to provide two set back lines. The line behind the crest at which the FS>1.5 would provide the recommended set-back for permanent structures (ie. the Building Restriction Line). The line above the crest at which the FS>1.3 would apply to private property lines within the proposed subdivision (ie. the Development Restriction Line). This dual set-back practice recognizes that top of bank movements could result in loss of useable property, but allows less risk sensitive development such as yard landscaping and temporary structures (decks, gazebos, etc.) between the Building and Development Restriction Lines. Under this proposal it must be accepted yard features will be subject to a higher risk of slope movement than the house.

6.1 SITE OBSERVATIONS

The shoreline escarpment within the proposed subdivision is a mature slope with tree cover on the slope face. Geologically, the local slope was considered to be a remnant of glaciation which has been formed by old slope regressions into the local till and bedrock formations followed by subsequent wind and water erosion. The crest area of the slope was generally rounded.

Based on site observations, a review of the survey information, and a review of aerial photographs there was no evidence of significant erosion or slope movement along the shoreline escarpment within the proposed subdivision. A review of aerials indicated no signs of deep movement. During the site visits there was no signs of springs or seeps in the slope. However, although groundwater seepage was not observed in the slope face below the site, the possibility of springs or seeps cannot be totally discounted under all conditions. No tilting trees were observed during the site visits, indicating that the slope has not been subject to any recent movement.

6.2 SLOPE PROFILES

Three escarpment profiles were surveyed as located on the Site Plan, Figure 2. The escarpment profiles considered for the analysis are provided on Figures 8 to 10 in Appendix A. Profiles 2 and 3, Figures 9 and 10 in Appendix A, have been interpolated from the contour drawing.

The soil profile encountered varied along the shore slope. The southwest facing slope (Profile 1) consisted of lacustrine soils in the upper portion of the slope, and stronger till material in the lower portion of the slope. The westward facing slope (Profiles 2 and 3) consisted of only lacustrine soils.

From local experience is lacustrine soils typically regress to stable slopes angles in the order of 3.5H to 4H:1V. Till slopes typically regress to stable slopes angles in the order of 2.5H:1V over time.

From the survey information the observed slope angles in the lacustrine deposits range from 2.0H to 3.1H:1V. The slope angles in the till deposits range from 3.0H to 3.3H:1V. The slope angles in the low-lying area within SW 34-39-2-W5M are 10H:1V or flatter.

6.3 SLOPE SOIL PROFILE

Boreholes 14 to 17 were drilled near the crest of the slope. There were no boreholes drilled on the slope face or at the toe of the slopes due to access issues. Boreholes 15 and 17 were deep boreholes drilled into shale bedrock which was present at elevations of 925.09 m and 941.21 m respectively. Three idealized soil profiles were used for stability analysis.

1. Profile 1 was lacustrine clay to a depth of about 1.5 m below the crest, and till to a depth of about 9.2 m below grade, overlying shale bedrock. The water level in the design cross-section was varied between 10.2 m below grade below the crest location and about 2 m above grade at the toe. The slope face was made up of lacustrine clay and till deposits.

2. Profile 2 was lacustrine clay to a depth of about 7.0 m below the crest, and till to a depth of about 16.9 m below grade, overlying shale bedrock. The water level in the design cross-section was varied between 4.8 m below grade below the crest location and about 2 m above grade at the toe. The slope face was made up of lacustrine clay deposits.

3. Profile 3 was lacustrine clay to a depth of about 6.0 m below the crest, and till to a depth of about 17.8 m below grade, overlying shale bedrock. The water level in the design cross-section was varied between 4.5 m below grade below the crest location and about 2 m above grade at the toe. The slope face was made up of lacustrine clay deposits.

A partially saturated slope face, representative of spring conditions, was also considered in the analysis. The cross section profiles used for the model analysis is provided in Figure 7, Slope Profiles in Appendix A.

6.4 STABILITY ANALYSIS

A stability analysis was carried out using the *Geostudio 2007 Slope/W* computer program to evaluate the slope model composited from the survey sections and observed soil/groundwater conditions. The model parameters and analysis input are provided on the Slope Stability Model Figure, Figure 11 in Appendix A. Based on local experience, the soil parameters outlined in Table 3 were estimated for the clay, clay till and bedrock.

TABLE 3
SOIL PARAMETERS FOR STABILITY ANALYSIS

Soil	Unit Weight (kN/m^3)	Cohesion, c' (kPa)	Phi' (Degrees)
Clay	19	0 - 1	25
Clay Till	19	1 - 2	30
Shale Bedrock	21	5 - 10	38

For long term stability, effective soil parameters and a predicted likely long term pore pressure/groundwater condition were used in the analysis. Pore pressure/groundwater condition conditions were modeled by varying the groundwater table and by using the pore pressure ratio (Ru) where Ru = 0 represents a fully drained slope whereas Ru = 0.5 represents fully saturated slope conditions. A partially saturated slope face, representative of spring conditions, was also considered in the analysis.

The first stage of analysis was to model the slope stability under a saturated case which is considered to be similar to the original formation conditions represented by a pore pressure ratio (Ru) of 0.5. Then the current slope conditions were simulated with a relatively low groundwater level and partially saturated pore pressure conditions in the clay till represented by a Ru < 0.2. For long term stability it was assumed that stability of the slope face would be adversely affected by a saturated slope face simulated by a Ru of 0.4 to 0.5. This saturated condition is typical to possible weather and development impacts such as; heavy snow melt/precipitation, landscape watering and possible service leaks or pipe breaks.

6.5 STABILITY ASSESSMENT

The findings of the slope stability analysis were in general agreement with local experience in the Sylvan Lake area, which suggests that local lacustrine soil slopes regress over the long term to about 3.5H to 4H:1V in the lacustrine clay; and to about 2.5H to 3.0H:1V in the till. The slopes at this site were considered to be natural and free from crest area fills and other development disturbance.

Saturation of the exposed clay and/or till on the slope face, leading to a failure of the saturated mass is considered to be the most likely mode of slope failure at his site, followed by possible regressive slumping of over-steepened sections of the face in localized areas. If a large movement were to occur, the failure in the slope is expected to be slow moving and would provide some warning in the form of tension cracks at the crest or on the slope face prior to failure.

The long term assessment at this site is that the slopes overlooking Sylvan Lake are marginally stable (FS > 1.3) and the potential for a major slope movement is low under present normal conditions with reasonable variation. The FS against a small shallow "slump-type" failure on the slope face is estimated to be about 1, but it would take unusually wet conditions to cause a shallow slump in the slope face. Under reasonably adverse soil moisture and groundwater conditions, the FS for a point about 15 m back from the crest of the slope outlined in Profile 3 (see Figure 10) was estimated to have a FS>1.5 for the assumed representative local slope profile on the escarpment.

7.0 DISCUSSION AND RECOMMENDATIONS

7.1 GEOTECHNICAL EVALUATION

The proposed development will be a rural subdivision with large green areas. Geotechnical conditions at this site are considered to be similar to typical conditions found around Sylvan Lake. The subsurface conditions at this site are considered to be suitable for the proposed residential development. It is understood that some site grading cut/fills may be undertaken to level and raise areas to smooth out grades at the site. Other than slope issues, the main geotechnical issues regarding subdivision development are:

- that the silty and sandy surficial soil 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.

- that relatively loose and sensitive lacustrine soils may be encountered during site development, depending on where the final grade is set. The clay soils are considered to be marginally suitable for use as road base, provided they can be dried to a workable soil moisture content since these soils can be very sensitive to disturbance when wet. Alternatively, wet soils should be mixed or replaced with drier fill or selectively used for general site fill. The till are considered to be better suited for use as an engineered fill.

- the siltier surficial soils will be highly frost susceptible if they are given access to free water or groundwater within the zone of seasonal frost (estimated to an average depth of 2.5 m). In general, the depth to the local water table for some of the site is relatively shallow and within the potential depth of frost.

- 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.

7.2 SLOPE RECOMMENDATIONS

7.2.1 Shoreline Slope Setback

It is expected that the developer will expect to layout residential lots backing onto the shoreline slope area. The minimum recommended set-back distance for the proposed nearest lot property lines to the crest should be equal to the height of the slope with a minimum of 5 m. The minimum recommended set-back distance for the proposed permanent structures on these lots is 15 m. This recommended set-back will provide a buffer between the house and the slope in the event of slope movement along the crest. The crest is defined as the line where there is a distinct break in the grade at the top of the slope as determined by the intersection of the slope angle with the extension of upland surface grade.

The natural slope in the vicinity of the proposed residential area is considered to be relatively stable. The possible removal of soil from the basement excavations near the crest will have a net stabilizing effect on the slope. Regressive slumping of the lacustrine slope is considered to be the most likely mode of slope failure. If a large or deep-seated slope movement were to occur, the failure in this subgrade is expected to be slow moving and would provide some warning in the form of cracks at the crest or tipping of trees on the slope face prior to failure.

7.2.2 Slope Issues

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. The site has several small knolls and slopes with typical slope angels flatter than 25 percent (4.5H:1V). Localized slope areas are expected up to 3H:1V. The proposed site also has many areas of grade flatter than 6.5H:1V, which would support unrestricted development related to slope concerns.

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 slope greater than 15 percent. At this point in the development process, Parkland 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 soil conditions at the site are relatively stable stiff clay and partially overlying very stiff clay till deposits. Under normal dry conditions the local clay 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.

7.2.3 General Slope Development Recommendations

The slope face may be subject to minor surficial failures, especially in localized steepened areas. Slope face stability is influenced by precipitation, surface erosion, groundwater and soil moisture conditions. In order to reduce the possibility of surficial slumping the slope should be kept well vegetated. It is also important that site development does not initiate any detrimental changes to the subsurface conditions and slope geometry. For the slope face areas the following recommendations are provided:

1. Permanent removal of the vegetation from the slope is not recommended and growth of new vegetation on the slope should be encouraged. Any vegetation that has to be removed should be replaced as soon as possible. New vegetation for this site be selected from native types with deep root systems that can grow with a minimum of watering.

2. Erosion control measures should be implemented as necessary. Site grading carried out should be designed to drain surface water due to rainfall and snow-melt away from the slope. If required, features to carry concentrated flows over the crest should be engineered.

3. Permanent underground lawn sprinklers, ponds or swimming pools should not be permitted within 15 m of crest areas without a detailed review by a qualified geotechnical engineer. If these features are proposed they should be properly designed in consultation with qualified engineers; and should be provided with leak detection and control systems.

4. One of the most common mistakes for top of slope residential development is for house contractors to push basement fills onto sloped areas to level out back yard grades. Excess material from basement excavations should be removed from the top of slope lots; and under no circumstances be wasted over the slope face. No new fill should be imported to top-of slope lots. Backyard fills around houses within 30 m of the crest should be placed on native inorganic subgrade and should be kept to less than 1 m in thickness. Significant post development

grading on proposed lots along the crest area should not be undertaken without a detailed engineering review.

7.2.4 General Slope Care

The following general suggestions are intended as a guide to minimize the impact of development on the stability of the slope.

- Thin fills placed on flatter sloped areas should be placed on prepared inorganic soil, not topsoil, because the topsoil layer will provide a weak zone and possible failure slip plane.
- Excessive watering of lawns and trees near the slope should be avoided.
- Fill, grass cuttings and/or construction debris should not be disposed of over the slope crest or on the slope face.
- Discharge from roof leaders and possible weeping tile systems should be directed away from the slope. Water should not be allowed to pond on the ground surface causing increased water infiltration into the slope.
- Unnecessary disturbance to the existing vegetation near the crest, on the slope, or near the toe of the slope should be discouraged. Removal of grass, trees, shrubs and undergrowth on the slope will have a negative impact on the slope stability.

These general recommendations in this section are considered to be "common sense" actions to undertake or avoid in order to minimize potential disturbance to the slope. These recommendations are not considered to be essential to the safety of the proposed development, but it is prudent to follow these recommendations to maintain a low risk to the proposed area. These recommendations and guidelines above are considered to be general and may be subject to site specific modification interpretation based on the review of a qualified geotechnical engineer.

7.3 PRIVATE SEWAGE DISPOSAL

The results of the soil classification system are commonly used to size disposal field systems. The disposal field weeping lateral trench bottom area shall be sized so that the effluent loading rate per day for soil classifications determined in the Soil Triangle, Figure 8, does not exceed the amounts provided in the following table for the four classifications of subgrade soil encountered at this site.

TABLE 4
SSC EFFLUENT LOADING RATES

SSC Guidelines Classification	Maximum Effluent Loading Rate (L/m²)	Boreholes
Clay Loam	10.78	17
Silty Loam	13.72	8
Silty Clay Loam	not suitable without further testing	5
Silty Clay	not suitable without further testing	20
Clay	not suitable without further testing	1, 15

As shown, only two of the six test sites (Boreholes 8 and 17) were classified as suitable for septic field without further testing. It should be noted that soil classified as not suitable without further testing may have an infiltration rate that will accommodate a disposal field. Further testing such as a percolation testing during the spring and summer months may indicate the soil is suitable. However, based on the high clay contents and local experience, further testing is not expected to significantly change the suitability assessment for most of these test locations.

Based on the SSC soil texture classification system, and on the presence of reasonable soils and good groundwater conditions, suitable field sites are expected to be present in some, but not all areas of this property. In areas where subgrade soils do not meet accepted percolation criteria, the most practical option for private sewage disposal will be to modify the existing surface soil by mixing silt, sand and clay soils to achieve an acceptable low to moderate permeability subgrade which would support a normal septic field at proposed field locations. According to the Standard of Practice guidelines, other acceptable options include: the construction of a septic mound, construction of an engineered sewage disposal/treatment systems or installation of a septic tank with a pump out. In areas of shallow groundwater, constructed fields or mounds will need to be built with raised grades to provide sufficient soil cover above the groundwater table.

Septic disposal systems should be constructed in accordance with applicable regulations and should be properly sized and installed by a licensed contractor based on normal testing and verification of actual field conditions.

7.4 SITE PREPARATION

It is understood that the proposed development will try to incorporate the natural vegetation and topography of the site, althogh tree clearing and site grading will occur within the proposed lots and along the proposed roadways. Topsoil could be stockpiled for future use at the site. Stockpiles should be placed no closer to crest of the nearest slope than the height of the slope to a maximum of 30 m.

Ideally, fill used 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 lacustrine silt and clay soils are considered to be marginally suitable fill materials, which will require moisture adjustment to allow compaction to desired density levels.

Engineered fill placed during site grading 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. Granular fill is best compacted with large smooth drum vibratory rollers. Clay fill is best compacted with large vibratory "padfoot" or "sheepsfoot" rollers. In areas which require higher compaction, it is recommended that granular fill be placed at moisture contents zero to 2 percent belowOMC and that clay fill be placed at moisture contents about 0 to 2 percent above OMC. This will help reduce compactive effort and potential risk of subgrade disturbance needed to achieve maximum density.

Special consideration must be given to deep fill areas at proposed residential lots (where fill is greater than 1.0 m below final grade). The engineered fill placed below possible house sites should be uniformly compacted to at least 98 percent of SPMDD at a moisture content within 2 percent of OMC for fills 1.0 to 1.5 m deep. For deeper fill, the compaction standards should be increased to 100 percent of SPMDD. The control of moisture content is considered to be important for the relatively dry, silty fill, because future wetting of these fill soils may cause significant settlement which could occur long after original construction depending on changes in the groundwater regime due to development (ie. lawn watering, servicing, etc.).

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 98 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.

7.5 SERVICE TRENCH INSTALLATION

It is expected that deep buried services will be installed to typical depths within 4.0 m of final ground surface, with some potential for a few deeper trunks. It is expected that the majority of services trenches will be based in lacustrine soils, but some excavation of stiffer till soil will be encountered. Conventional trenched excavations with sloping sides and/or moveable shields are considered to be feasible.

7.5.1 Service Trench Excavation

The side slope of conventional unsupported trench excavations is dependent on the local soil conditions at any given location. Where the deep excavations are proposed, conventional trenched excavations with sloping sides and/or moveable shields are considered to be feasible. For excavations in lacustrine soils greater than 1.5 m deep above the water table side slopes of 1H:1V, or flatter, are recommended. In hard tills, steeper sideslopes could be appropriate subject to site specific review by a qualified Geotechnical Engineer. If saturated zones or perched water are encountered within the cut, flatter side slopes and/or dewatering may be required.

The degree of stability of excavated trench walls directly decreases with time and, therefore, construction should be directed at minimizing the length of time service trenches are left open. Groundwater seepage from the sides of the trenches and from the base of the excavation is not expected, except in seasonal conditions where perched water is encountered after precipitation or snow melt and possibly in low lying areas, if serviced. Base heave and/or boiling of the trench bottom can occur where a significant differential hydrostatic head exists at the bottom of the excavation and soils are not cohesive (eg. sand lenses in the till). Dewatering and other pressure relief measures are available to minimize problems with the stability of the trench bottom.

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.

7.5.2 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.

7.5.3 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 silty clay material which are considered marginally suitable for use as trench backfill. Wetter lacustrine silts and clays are considered less than ideal due to the need to dry backfill for good compaction. Till materials are also considered well suited for use as trench backfill, but the till pieces must be broken down into smaller pieces in order to allow proper compaction and avoid short term bridging of backfill soils, which could result in long term settlement.

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 of the subgrade to help make the subgrade more uniform. This construction procedure is used with success on similar deep trench backfill situations in the City of Red Deer. 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.

7.5.4 Concrete for Underground Structures

General Use Hydraulic (Type GU) cement may be used for all concrete in contact with soil at the site. The recommended minimum 28-day compressive strength for subsurface concrete in underground services is 25 MPA. All concrete exposed to a freezing environment either during or after construction should be air entrained.

7.6 BASEMENT FOUNDATIONS

7.6.1 Footings

Standard house basement foundations using strip and spread footings will generally be acceptable at this site. Footings based on native lacustrine 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 footings placed on undisturbed inorganic soil free from loosened material. 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.

7.6.2 Grade Supported Slabs

Floor slabs should rest on at least 150 mm of well graded, 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.

7.6.3 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 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 moderate to high 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.

7.6.4 Basement Excavations

Basement excavations in the native silty clay 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 the subgrade resulting in a significant weakening of the subgrade. In this case, excavation is best carried out with backhoe or "Gradall" equipment.

7.6.5 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. If possible, the upper 500 mm of backfill should be medium plastic clay, to reduce potential surface water infiltration. 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 subdrainage weeping tile system.

7.6.6 Foundation Concrete

General Use Hydraulic (Type GU) cement should be used for all concrete in contact with soil at the site. The recommended minimum 28-day compressive strength for subsurface concrete in underground services is 25 MPA. All concrete exposed to a freezing environment either during or after construction should be air entrained.

7.7 ROADWAY SUBGRADE CONSTRUCTION

The native surficial soils were estimated to have CBR values in the order of 2.5 to 5 depending on the type of subgrade soil with a typical value of about 4 for the predominant silty clay soil. These estimated CBR values are indicative of a low level of subgrade support.

The exposed roadway subgrade surface should be proof-rolled to identify soft areas. These areas should be subcut and replaced with suitable fill compacted to 95 percent of SPMDD. The depth of excavation should be sufficient to remove the soft material or to bridge over the soft material. When soft subgrade areas are encountered during construction, the typical local practice is to remove and replace the weak soils with a thick layer of coarse granular fill for subgrade improvement. The excavation of sensitive soils should be performed by a tracked backhoe rather than dozer equipment to minimize disturbance to the subgrade.

Fill required to bring the subgrade up to design grade should consist of low to medium plastic clay or well graded granular fill. If coarse granular fill is selected the recommended gravel would have a maximum aggregate size of 150 mm as per the specification provided below.

TABLE 5
150 mm COARSE GRADED GRAVEL

Sieve Size (mm)	Percent Passing By Weight
150	100
75	80 - 100
25	50 - 75
5	25 - 55
0.08	2 - 10

Gravel subgrade improvement material is generally placed at the same time as the granular subbase of the pavement section resulting in a thick lift of coarse granular material below the asphalt and base course gravel layers. Construction procedures should be designed to minimize disturbance to the subgrade. If the subgrade is failed during construction, it can lead to costly replacement of weakened soils. The need for any special construction procedures is best determined based on observations at the time of construction. Therefore, construction of roads will require careful monitoring by an experienced soils technician to avoid costly construction problems.

7.8 FLEXIBLE PAVEMENT DESIGN

Two flexible pavement designs are proposed for this residential subdivision: a moderate traffic section for the local residential collector roads using a Design Traffic of 1 x 10^6 Equivalent Single Axle Loads (ESAL's); and a light traffic section for the local residential streets using an Design Traffic of 1 x 10^5 ESAL's.

These design traffic numbers are based on a design period of 20 years. The proposed pavement designsections for this subdivision are based on the assumption of a stable subgrade which meets the criteria of CBR = 4, or a subgrade which has been improved to an equivalent level as described in Section 6.5. The majority of surficial soils across this quarter section are expected to meet this minimum subgrade support condition and there is the potential for some additional localized soft or sensitive areas. Based on these assumptions the following flexible pavement sections are proposed on Table 6:

TABLE 6
FLEXIBLE PAVEMENT DESIGN

Pavement Sections	Local Residential		Residential Collector	
Design traffic (ESAL's)	1 x 10^5		1 x 10^6	
Asphalt Concrete 20 mm Crushed Base Gravel Subbase Gravel (minimum)	75 mm 300 mm	75 mm 100 mm 300 mm	100 mm 350 mm	100 mm 100 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 for the local residential streets and a 75 blow Marshall test for the collector roads.

Pavement materials should conform to the following recommended pavement specifications.

TABLE 7
ASPHALT CONCRETE

Stability (kN minimum)	5.4
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. Alternate aggregate materials include the following Alberta Transportation specifications.

TABLE 8
RECOMMENDED AGGREGATE SPECIFICATIONS

	ATU Specifications
Asphalt Gravel	Designation 1, Class 16
Crushed Base Gravel	Designation 2, Class 20 or 25
Subbase Gravel	Designation 6, Class 80

Copies of these aggregate specifications are provided in Appendix A. 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.

7.9 FROST ACTION

The potential for frost heave is dependent on grain size, permeability and thermal properties of the soil which govern the ability to draw water from the surrounding subgrade and groundwater table if available. Unsaturated sands gravels are non-frost susceptible since soil moisture water freeze and expand into the air voids between the aggregate particles resulting in no heave. If the granular soil is saturated the frozen soil will heave uniformly 10 percent. Silty soils have a moderate permeability which allows the movement of free-water to ice lenses so silty soils are considered to be highly susceptible to ice lensing.

The potential penetration of frost for a road setting is severe due to the presence of gravel in the profile and lack of snow cover which acts as a insulator to reduce penetration. The effects of frost action in terms of pavement damage may be reduced by providing thick pavement sections which partially remove frost susceptible subgrade. Other general recommendations to minimize frost related problems for road structures, include:

- setting final road grades well above the water table;
- replacing the frost susceptible soils with less frost susceptible fill such as coarser sands and gravels;
- removing or smoothing out sand to silty soil transitions; and
- provision of sub-drainage system and/or capillary cut-off to restrict groundwater migration into the road subgrade in areas of shallow groundwater table.

Although thick gravel layers in these roads minimize damage to the pavement surface, a severely distorted vertical profile in the winter is still undesirable. In these most severe cases, deep replacement of frost susceptible materials and use of insulation materials such as rigid insulation or light weight aggregate (ie. granu-lite) are options to minimize heave or restrict frost penetration into frost susceptible soils. Since these options are very costly it is recommended to try and identify areas which require extraordinary measures prior to subbase construction. It is suggested to closely monitor all service trenches and road beds for signs of sharp sand to clay transitions. It should be understood that texture of local non frost susceptible sand and frost susceptible silty sand is very similar. Therefore, it will be difficult to distinguish all problem situations prior to construction. Some repair of undetected areas of differential heave should be expected after construction.

7.10 STORM WATER DETENTION POND

It is understood that some areas of the site may be developed as a temporary storm water detention pond to impound storm water during peak flows and ease the demand on storm sewers in this area. The present groundwater table is located between 1 and 6 m below grade at most borehole locations. Ponds with bases below the groundwater elevation table are usually designed as wet ponds. However, it is feasible to provide sub-drainage to create a dry pond by slightly lowering the water table. The depth of the pond into the water table governs the feasibility and recommended spacing on the drains so costs increase with depth below the water table. This type of "drained" dry pond would have a tendency to lower the local groundwater table. The storm pond will be drained shortly after major storm events, normally within 24 hours of filling. Other design considerations for detention ponds at this site include, the influence of impounded water on the local groundwater table, shoreline slope stability, shoreline erosion protection and drainage of the pond base.

Impounded water inside a detention pond, above the groundwater table elevation, will have a tendency to raise the local groundwater table through seepage. However, the typical subgrade for the pond base(s) in the area of interest is expected to be a silty clay of relatively low *in-situ* permeability, suggesting that seepage rates will be relatively low. Since the local subgrade is low permeable and the detention periods will be very short, and the potential for long term impact on the groundwater table will be minimal and will be limited to the areas immediately around the pond. The following recommendations are provided:

1. Pond drainage will occur through overland flow to the pond outlet with some seepage through the base if the base is above the water table. The base of the pond should be graded to allow positive drainage towards the pond outlet to minimize seepage. The recommended base slope is at least 1.0 percent. For longer runs, steeper grades may be required or french drains could be provided to direct flow to the outlet.

2. For preliminary design purposes the slope angles on the proposed wet detention pond should be at least 2H:1V below the static water level and 5H:1V for the portion of the slope above the static water level. At these angles, slope below the water surface would be expected to flatten naturally. For stability under normal "dry" conditions the groundwater table at the toe of dry pond slopes should be maintained at least 0.6 m below the final grade. Recommendations for steeper side-slopes may be possible for constructed slope faces upon review of actual soil conditions and groundwater elevations. A review of groundwater levels and slope stability should be performed once the preliminary grades and pond geometry are set.

3. Some restrictions might apply to pond operations, because fast draw-down rates will impact slope stability. For safety reasons, municipal authorities such as the City of Edmonton, design ponds with volumes to limit surface water rises to less than 1.0 m for a 1:25 year rainfall event and 2.5 m for a crisis event.

4. The pond shore line should be protected against erosion from wave action, because shoreline erosion may destabilize the pond slopes. Side slopes should be vegetated as soon as possible after construction.

5. Adjacent development restrictions may be required in relation to design groundwater levels. Seepage from the pond is not expected to significantly impact adjacent structures, however, it is considered prudent to set adjacent foundation elevations above the design high water level in the pond.

8.0 LIMITATIONS

This report is based on local experience and the findings at twenty borehole locations. If different subsoil and groundwater conditions be encountered, this office should be notified and recommendations submitted herein will be reviewed and revised as required. This report has been prepared for the exclusive use of the **EDS Group Inc.**, and their approved agents for specified application to the proposed Qualico Subdivision in SW and NW 34-39-2-W5M, Lacombe County, Alberta. It has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

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

Oct 1/2008

Daniel Yost, E.I.T.
Geotechnical Engineer

Mark Brotherton, P.Eng
Principal Geotechnical Engineer

APPENDIX A

Figure 1 - Key Plan
Figure 2 - Site Plan
Figure 3 - Aerial Photograph
Figure 4 - Contour Plan
Figure 5 - Soil Sulphate Concentrations
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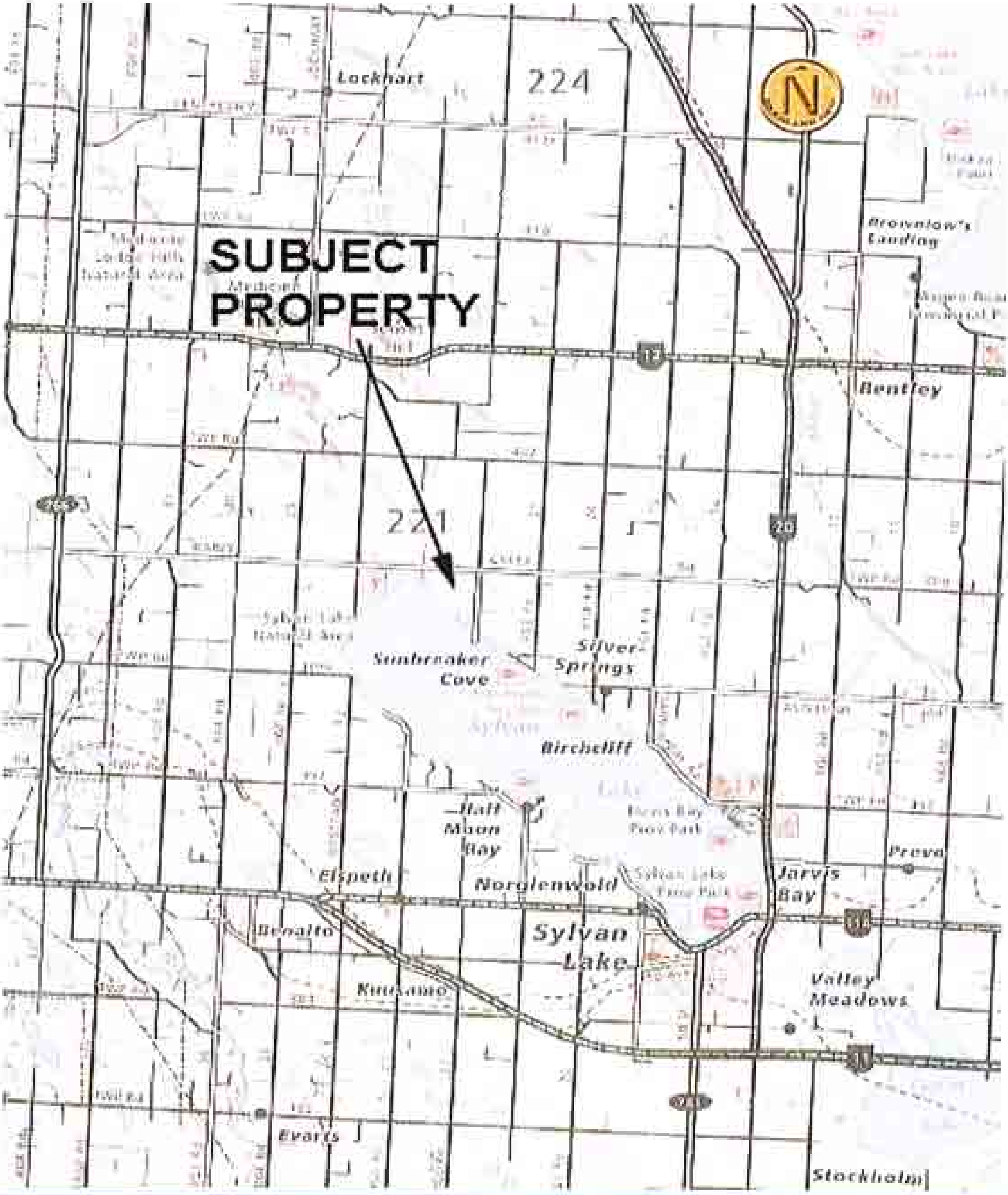
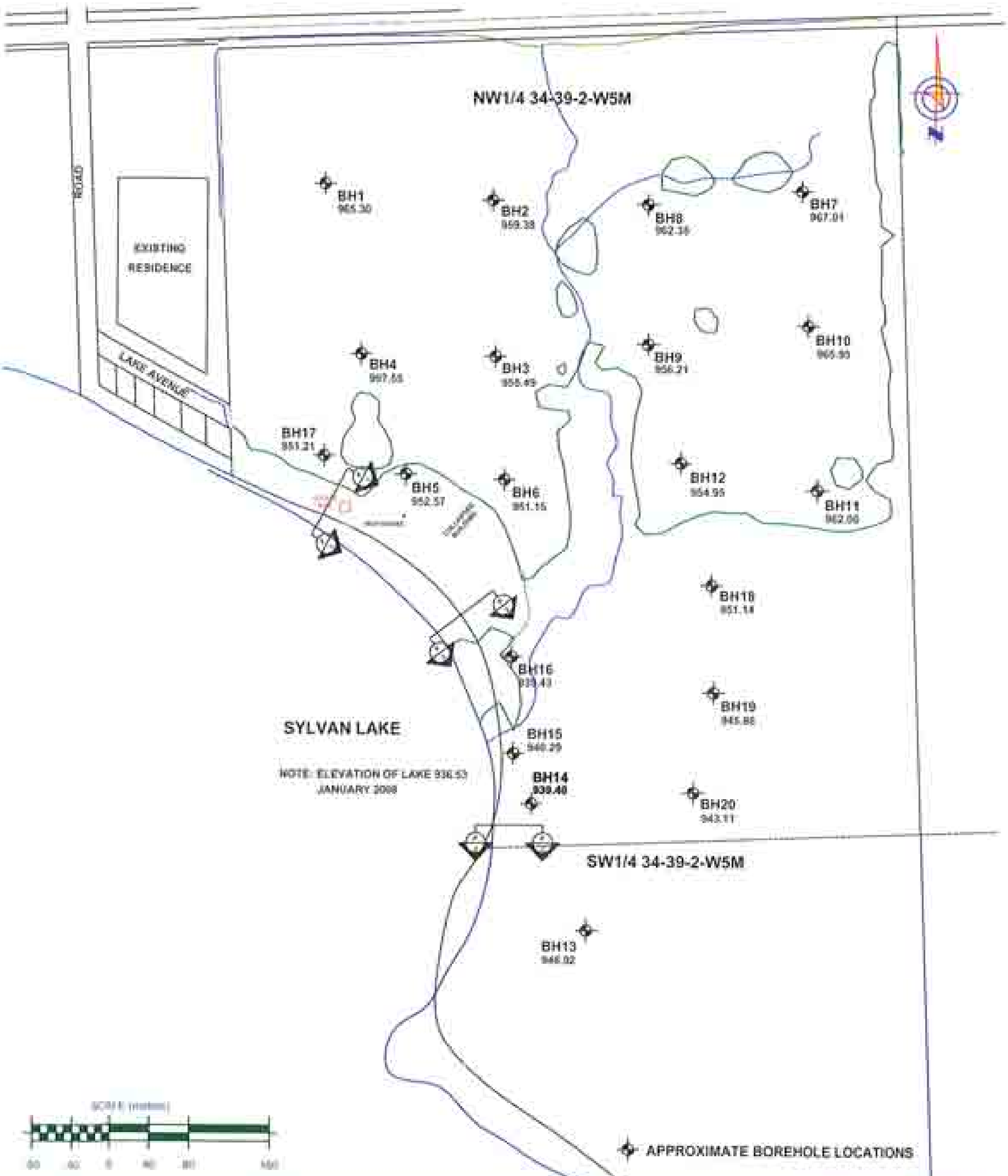
Figure 7 - Soil Texture Classification
Figure 8 - Profile 1 Slope Section
Figure 9 - Profile 2 Slope Section
Figure 10 - Profile 3 Slope Section
Figure 11 - Slope Stability Model Figure

Borehole Logs 1 Through 20
Soil Test Results
Aggregate Specifications
Explanation Sheets



ParklandGEO	EDS GROUP INC.				
	PROPOSED QUALICO SUBDIVISION SW & NW 34-39-2-W5M, LACOMBE COUNTY, ALBERTA **KEY PLAN**				
SCALE: NTS	DATE: OCTOBER 2008	DRAWN: DY	CHK'D: MB	JOB NO.: RD2617	DRAWING NO. FIGURE 1



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EDS GROUP INC.
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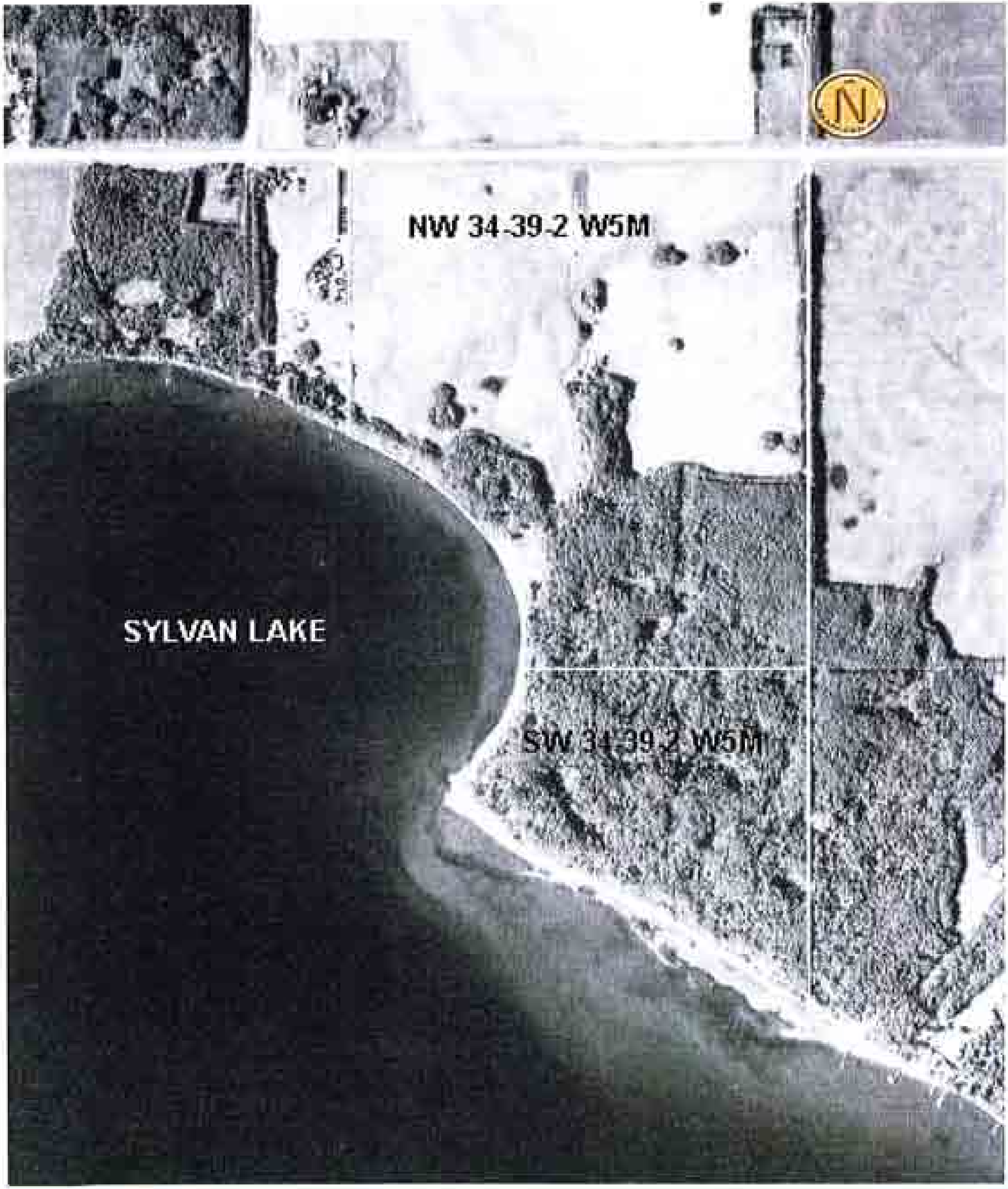
SITE PLAN

PROPOSED QUALICO SUBDIVISION
SW & NW1/4 34-39-2-W5M, LACOMBE COUNTY, ALBERTA

DRAWN	CHKD.	REV #	DATE
LDL	MDB	1	OCTOBER 2008

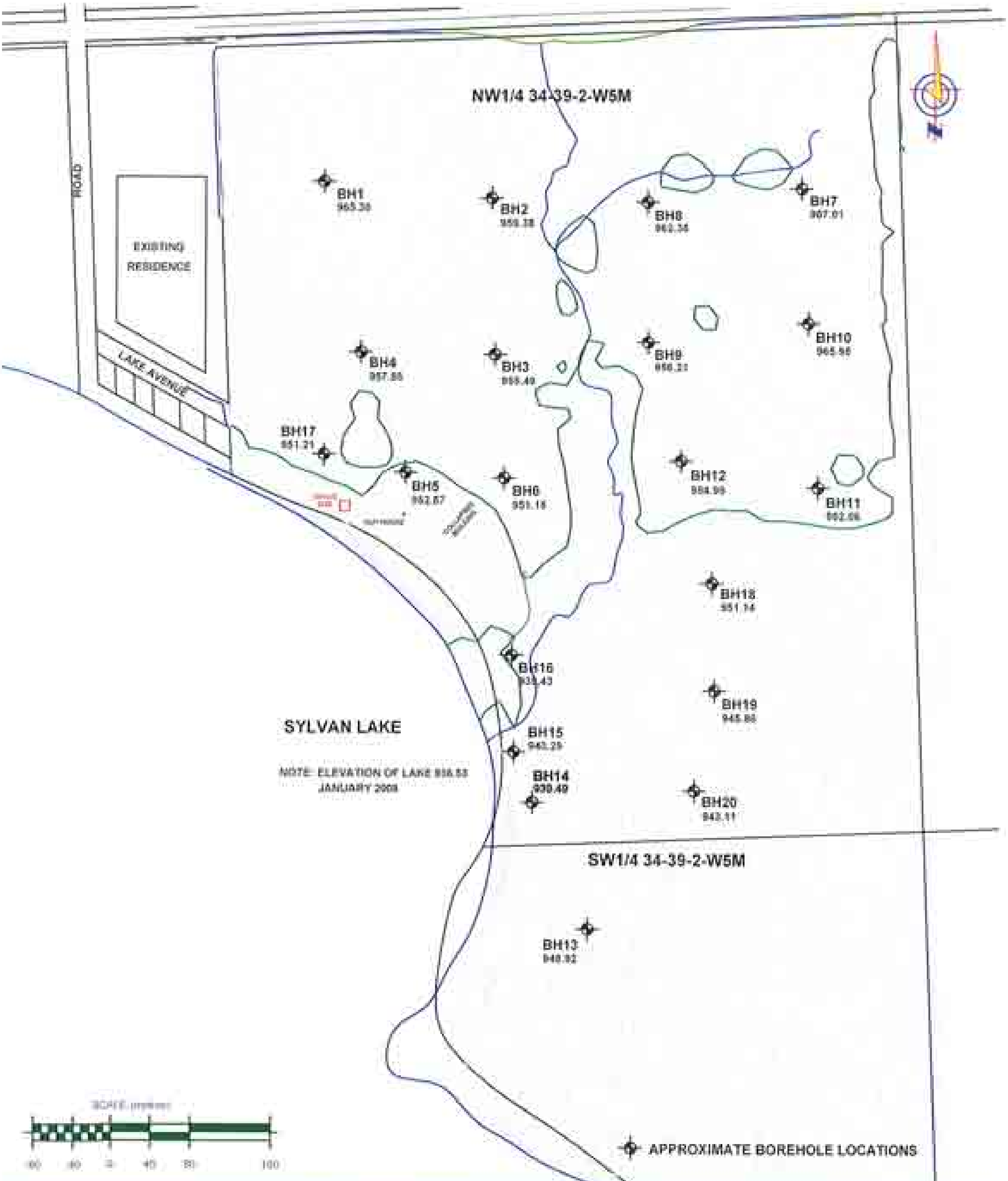
SCALE	JOB NO.	DRAWING NO.
1:5000	RD2617	FIGURE 2



Parkland GEO

EDS GROUP INC.				
PROPOSED QUALICO SUBDIVISION SW & NW 34-39-2-W5M, LACOMBE COUNTY, ALBERTA **AERIAL PHOTO**				

SCALE:	DATE:	DRAWN:	CHK'D:	JOB NO.:	DRAWING NO.
NTS	OCTOBER 2008	DY	MB	RD2617	FIGURE 3



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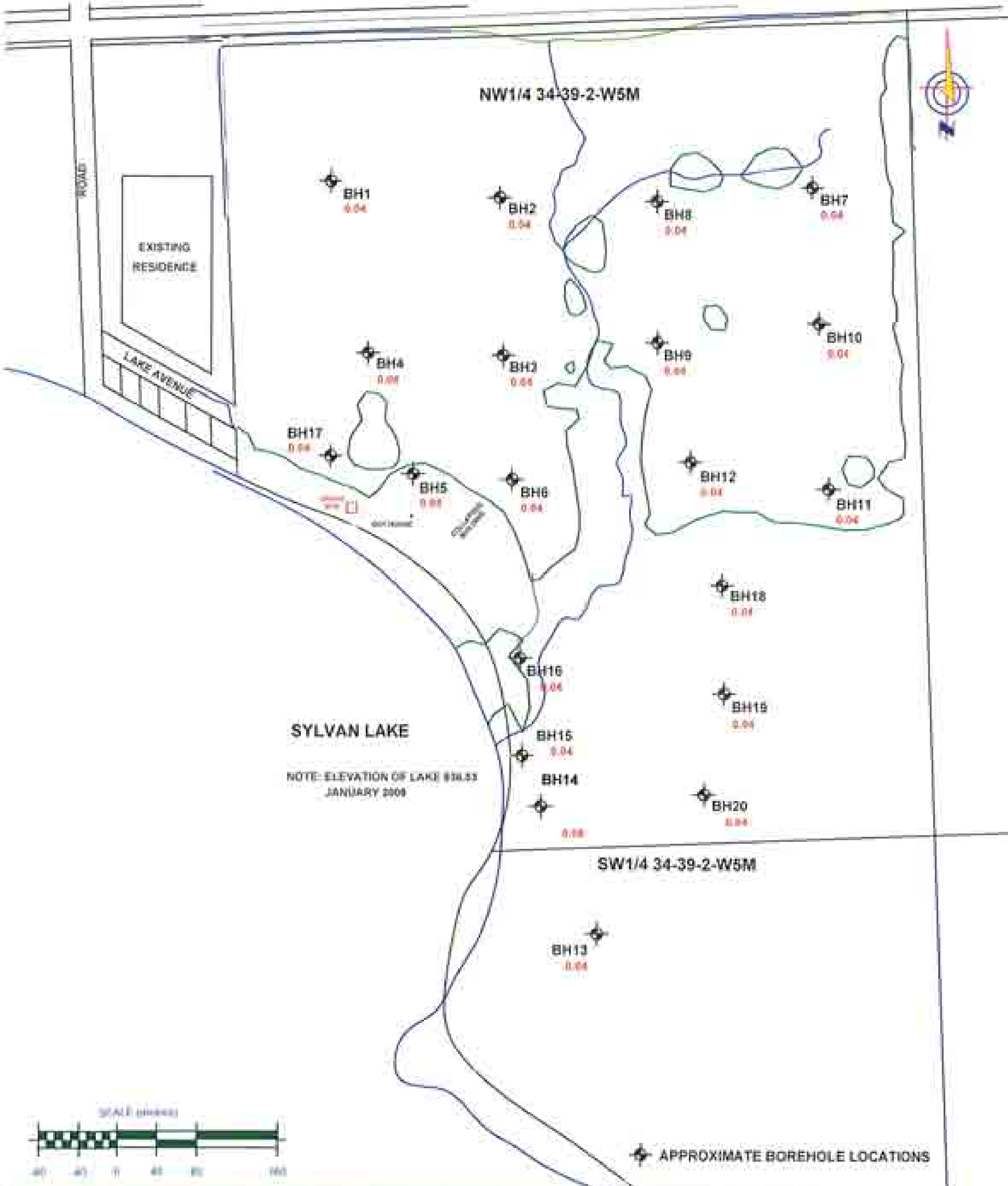
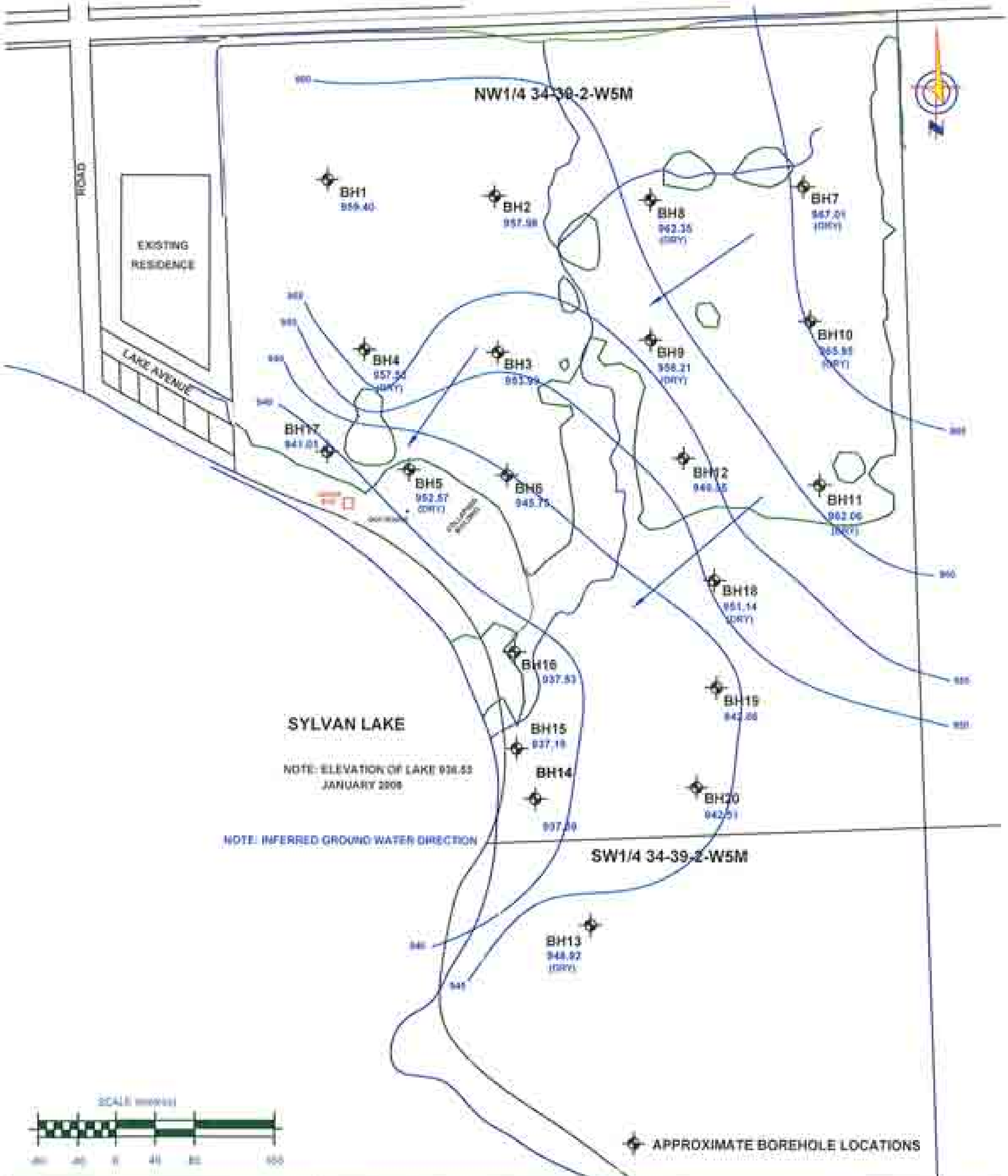
CONTOUR PLAN			
PROPOSED QUALICO SUBDIVISION SW & NW1/4 34-39-2-W5M, LACOMBE COUNTY, ALBERTA			
DRAWN: LDL	CHK'D: MDB	REV #: 1	DATE: OCTOBER 2008
SCALE: 1:5000	JOB NO: RD2817		DRAWING NO: FIGURE 4



ParklandGEO	CLIENT: EDS GROUP INC. EDMONTON, ALBERTA	**SULPHATE CONCENTRATION** PROPOSED QUALICO SUBDIVISION SW & NW1/4 34-39-2-W5M, LACOMBE COUNTY, ALBERTA

DRAWN	CHK'D	REV #	DATE
LDL	MDB	1	OCTOBER 2008

SCALE	JOB NO	DRAWING NO
1:5000	RD2817	FIGURE 5



ParklandGEO	CLIENT: EDS GROUP INC. EDMONTON, ALBERTA	GROUND WATER ELEVATIONS
		PROPOSED QUALICO SUBDIVISION SW & NW1/4 34-39-2-W5M, LACOMBE COUNTY, ALBERTA
		DRAWN: LDL; CHKD: MDB; REV #: 1; DATE: OCTOBER 2008
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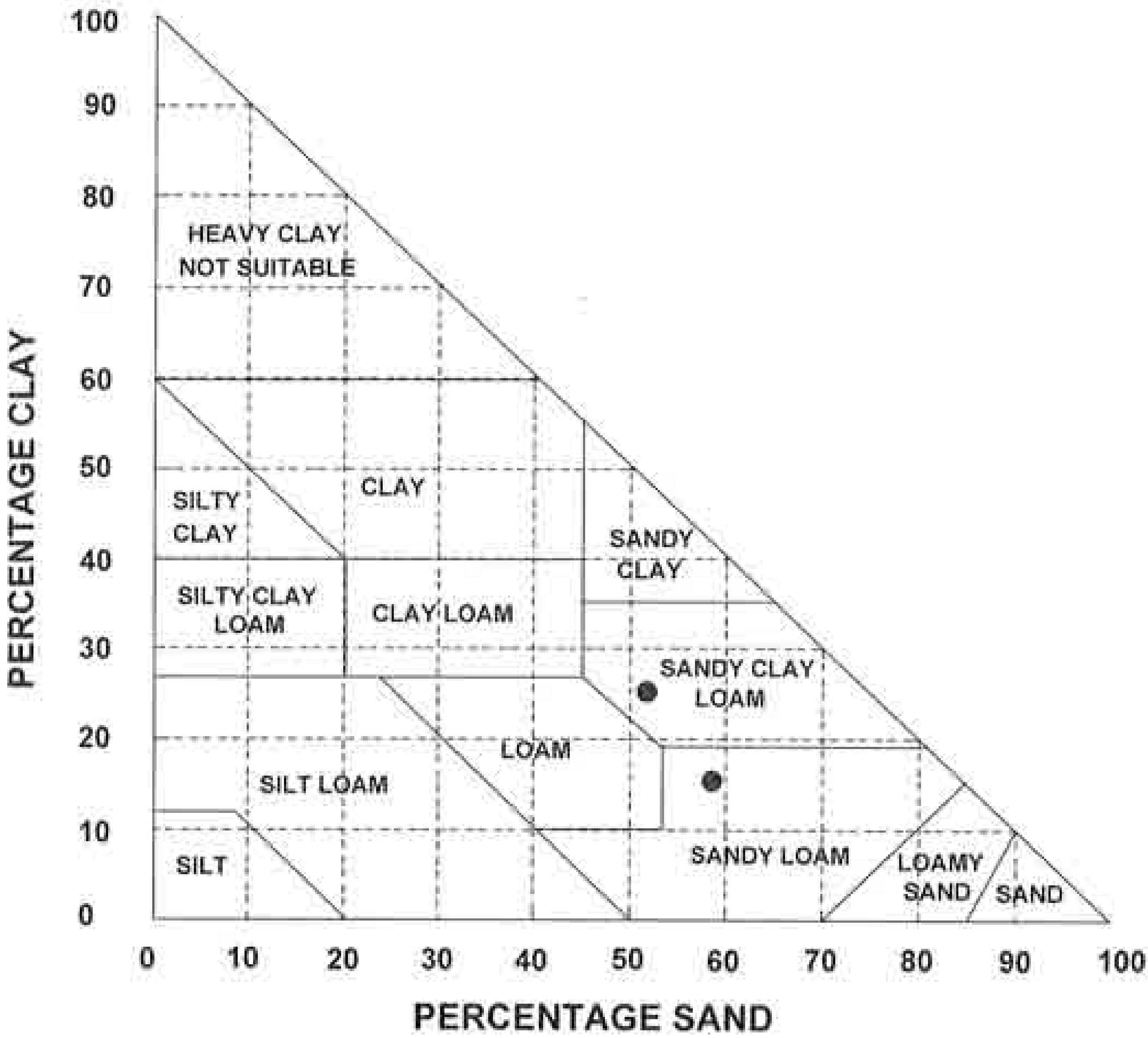

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CLIENT:

EDS GROUP INC.

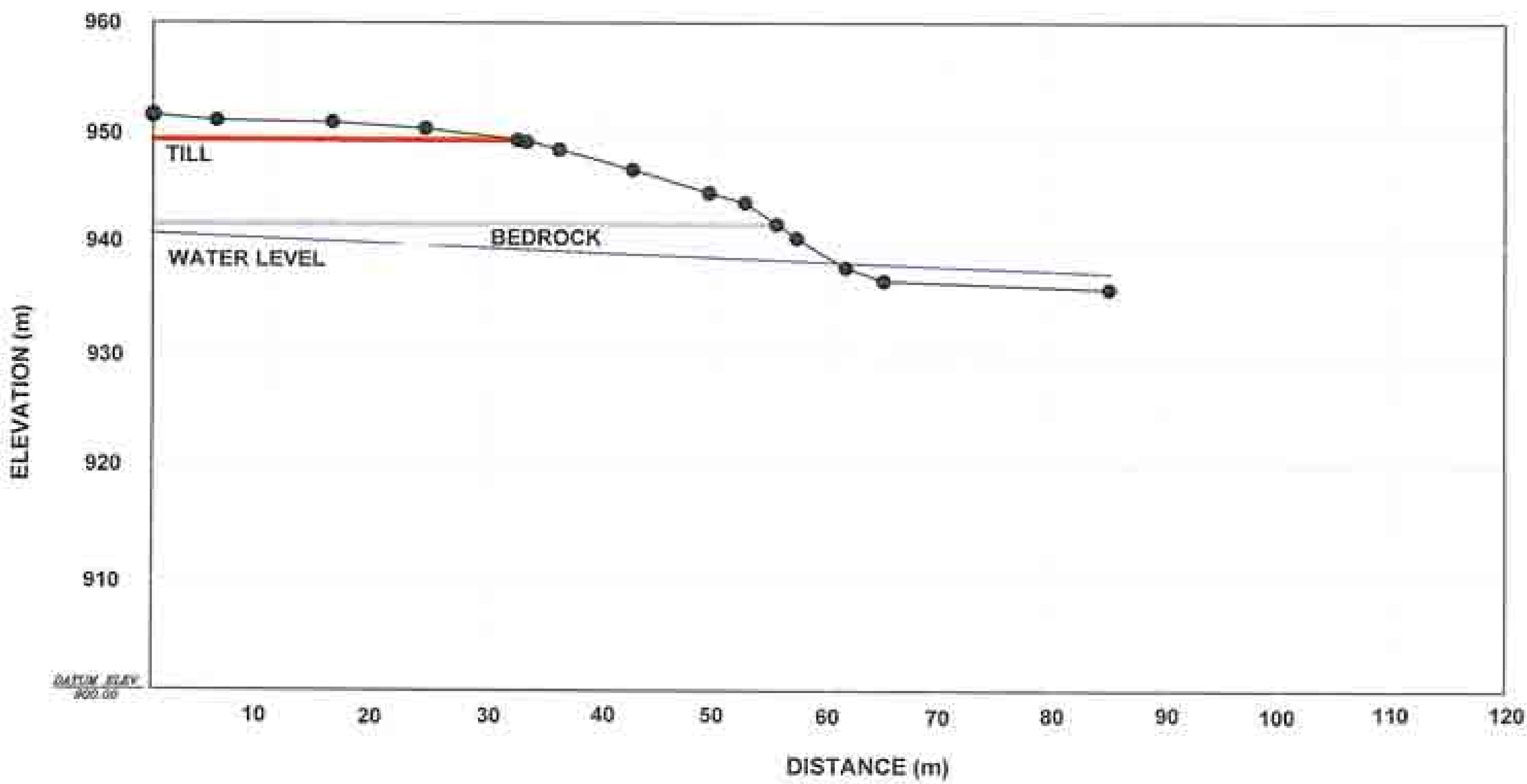
SOIL TEXTURE CLASSIFICATION

PROPOSED QUALICO SUBDIVISION
SW & NW 34-39-2-W5M, LACOMBE COUNTY, ALBERTA

DRAWN:	CHK'D:	REV #:	DATE:
LDL	MDB	1	OCTOBER 2008

SCALE	JOB NO.	DRAWING NO.
NTS	RD2917	FIGURE 7

PROFILE #1

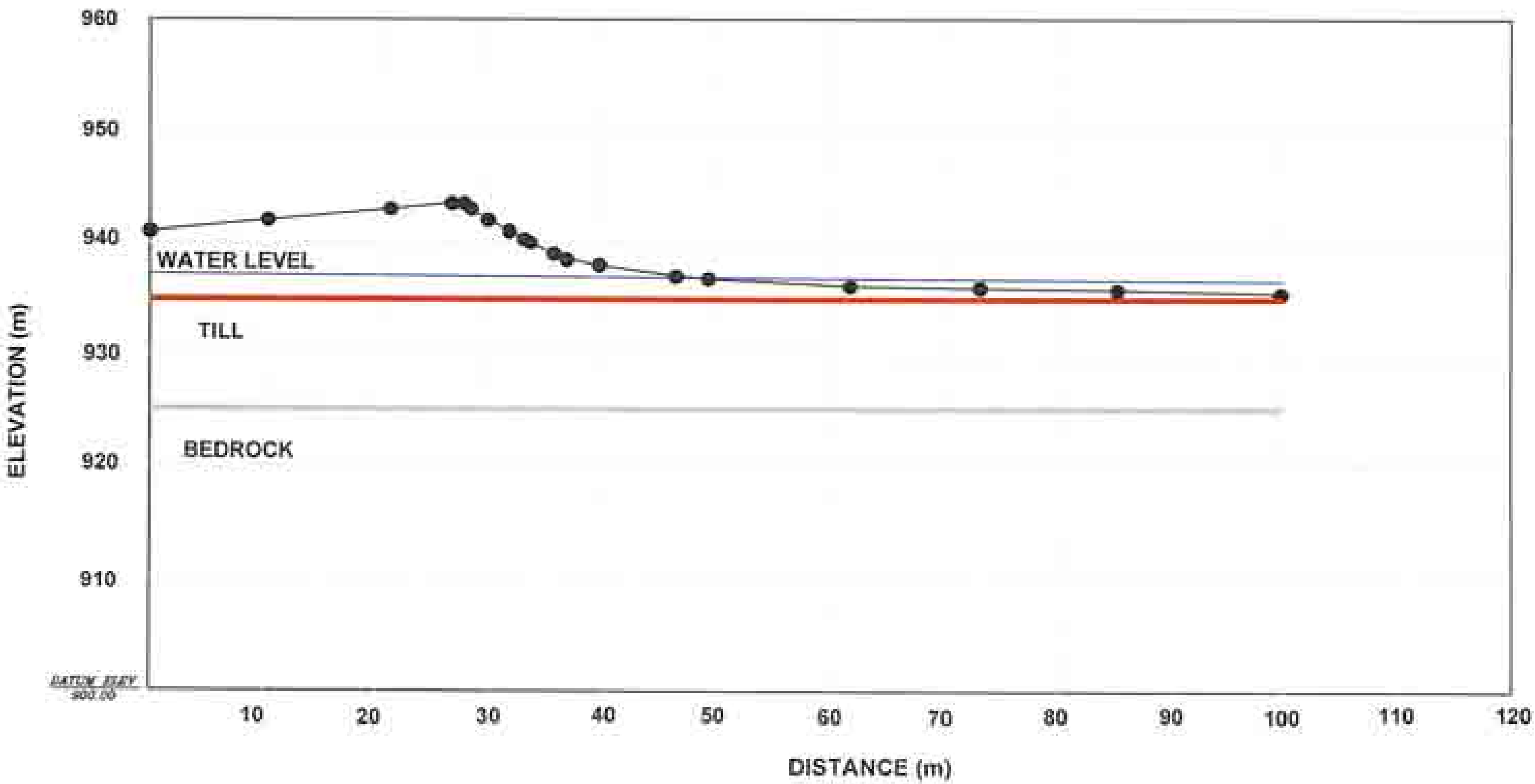


ParklandGEO	CLIENT EDS GROUP INC. EDMONTON, ALBERTA	SLOPE PROFILE #1 PROPOSED QUALICO SUBDIVISION SW & NW 1/4 34-39-2-W5M, LACOMBE COUNTY, ALBERTA

DRAWN	CHK'D	REV #	DATE
LDL	MDB	I	OCTOBER 2008

SCALE	JOB NO	DRAWING NO
NTS	RD2817	FIGURE 8

PROFILE #2



ParklandGEO	CLIENT EDS GROUP INC. EDMONTON, ALBERTA	SLOPE PROFILE #2			
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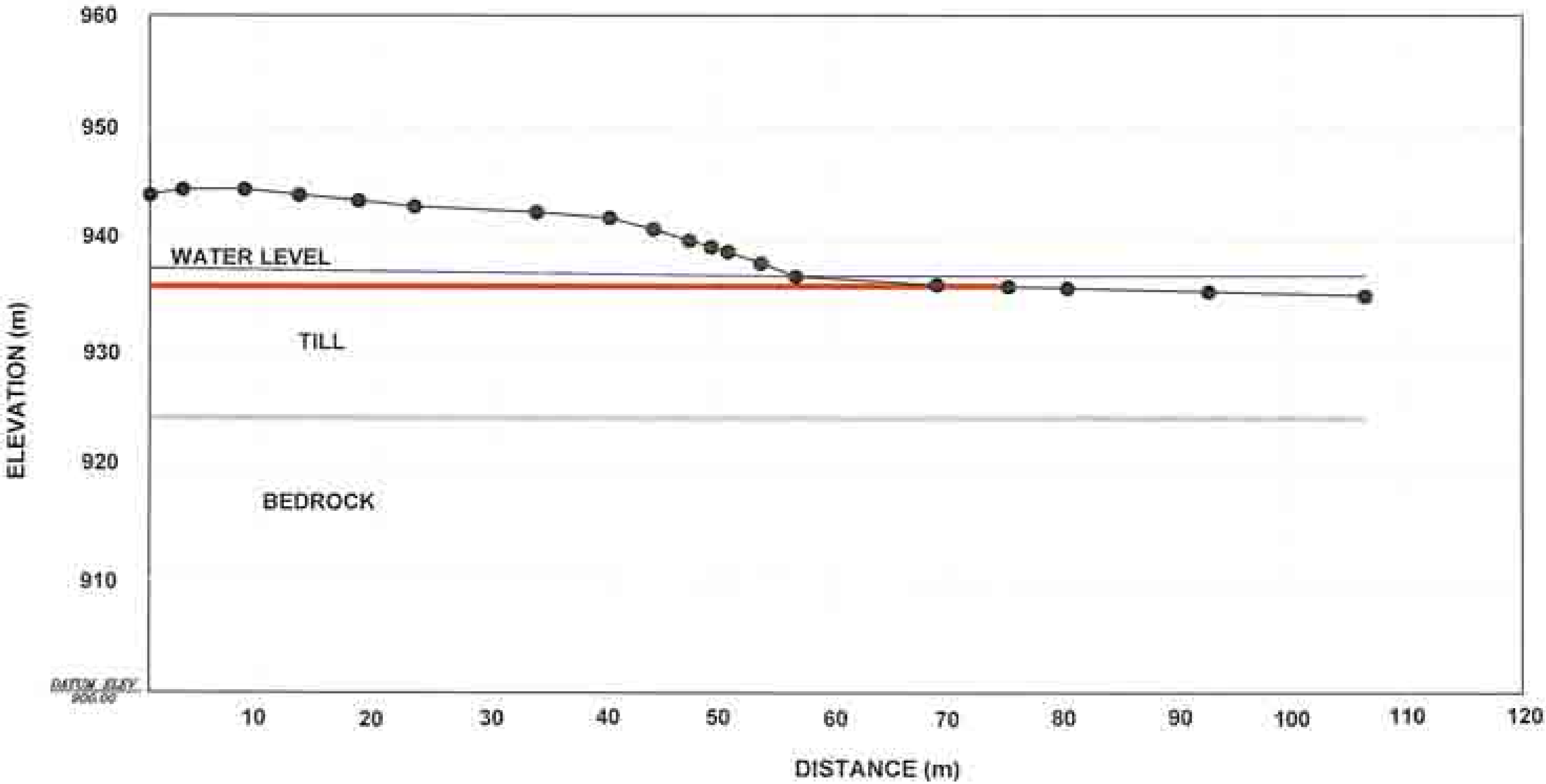
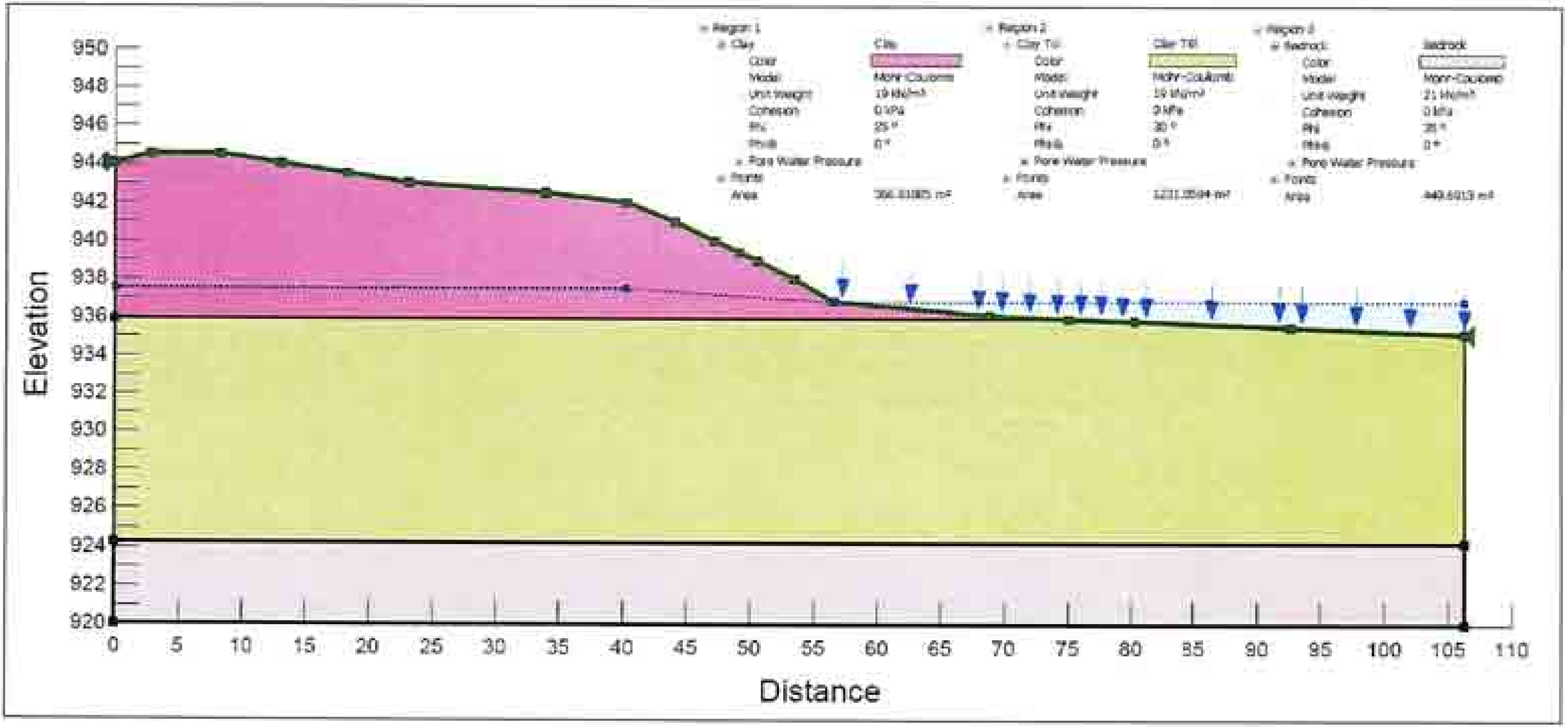
		DRAWN LDL	CHK'D. MDB	REV # 1	DATE OCTOBER 2008
		SCALE NTS	JOB NO RD2617		DRAWING NO FIGURE 9

PROFILE #3



ParklandGEO	CLIENT EDS GROUP INC. EDMONTON, ALBERTA	SLOPE PROFILE #3		
		PROPOSED QUALICO SUBDIVISION SW & NW 1/4 34-39-2-W5M, LACOMBE COUNTY, ALBERTA		
		DRAWN: LDL	CHK'D: MDB	REV #: 1
		DATE: OCTOBER 2008		
		SCALE: NTS	JOB NO: RD2617	DRAWING NO: FIGURE 10



ParklandGEO	CLIENT: **EDS GROUP INC. EDMONTON, ALBERTA**	**SLOPE STABILITY MODEL**
		PROPOSED QUALICO SUBDIVISION SW & NW 1/4 34-39-2-W5M, LACOMBE COUNTY, ALBERTA
		DRAWN: LDL · CHK'D: MDB · REV #: 1 · DATE: OCTOBER 2008
		SCALE: NTS · JOB NO: RD2817 · DRAWING NO: FIGURE 11

ParklandGEO

BOREHOLE NO.: 01

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 | PROJECT NO.: RD2617

NOTES: | BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Type	Sample No	SPT (N)	Comments	Elevation (m)
	GROUND SURFACE					965.30
0	***Topsoil*** moderately organic, black, moist					965.10
	Clay silty, very stiff, low plastic, brown, rust stains, coal inclusions, moist	G	1G1		Grain Size Analysis: Clay = 51% Silt = 36% Sand = 13%	
2					- SO4 = 0.04%	
3	***Till*** clay, silty, trace sand, trace gravel, very stiff, low plastic, brown, rust stains, coal inclusions, moist		1D1	9		962.10
4.5		G	1G2			
6			1D2	14		
6.5	End of hole at 6.5m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on September 26, 2007. Water level at 5.9m on October 26, 2007.					958.80
10						955.30

Well Completion Details: 25mm SOLID PVC PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS

LOGGED BY: DGY | GROUND ELEVATION: 965.3

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL | NORTHING:

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER | EASTING:

DATE: 09/13/07

CALIBRATION:

ParklandGEO

BOREHOLE NO.: 02

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 PROJECT NO.: RD2617

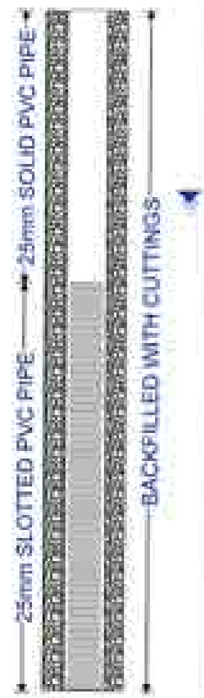
NOTES: BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Moisture	Type	Sample No	SPT (N)	Comments	Elevation (m)
0	GROUND SURFACE						959.38
0.2	***Topsoil*** moderately organic, black, moist						959.18
	Clay silty, stiff, low plastic, brown, rust stains, coal inclusions, moist						
1		21					
1.5–2.0			D	2D1	7		
2		21				SO4 < 0.04%	
3		20					
3.2	***Till*** clay, silty, some sand, trace gravel, very stiff, low plastic, brown, rust stains, coal inclusions, moist						956.18
4		19	G	2G1			
4.5–5.0			D	2D2	12		
5	End of hole at 5.0m. 25mm standpipe installed. Backfilled with cuttings. Wet upon completion. Water level at 1.2m on September 26, 2007. Water level at 1.4m on October 26, 2007.						954.38
10							949.38

Moisture scale: (Wp) —X— (Wl) 25 50 75

Well Completion Details



LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 09/13/07

CALIBRATION:

GROUND ELEVATION: 959.38

NORTHING:

EASTING:

BOREHOLE NO.: 03

ParklandGEO

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5

PROJECT NO.: RD2617

NOTES:

BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Type	Sample No	SPT (N)	Comments	Elevation (m)
	GROUND SURFACE					955.49
0	***Topsoil*** moderately organic, black, moist					955.29
	Clay silty, stiff, medium plastic, brown, rust stains, coal inclusions, moist					
2					SO4 = 0.04%	
	-low plastic at 2.7m					952.79
3	***Till*** clay, silty, trace sand, trace gravel, very stiff, low plastic, brown, rust stains, coal inclusions, moist					952.39
		G	3G1			
4	-grey at 3.8m					
6	End of hole at 6.0m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Water level at 1.3m on September 26, 2007. Water level at 1.5m on October 26, 2007.					949.49
10						945.49

Moisture

Well Completion Details

LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 09/13/07

CALIBRATION:

GROUND ELEVATION: 955.49

NORTHING:

EASTING:

ParklandGEO

BOREHOLE NO.: 04

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 PROJECT NO.: RD2617

NOTES: BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Moisture	Type	Sample No	SPT (N)	Comments	Elevation (m)
	GROUND SURFACE						957.55
0	***Topsoil*** moderately organic, black, moist						957.35
1	***Clay*** silty, trace sand, stiff, low plastic, brown, rust stains, coal inclusions, moist	21					
	-trace gravel at 1.7m						955.85
2		13				- SO4 = 0.04%	
3		16		4D1	11		
4		17					
5		18					
6		20		4D2	13		951.05
7	End of hole at 6.5m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on September 26, 2007. Dry on October 26, 2007.						
10							947.55

Well Completion Details: 25mm SOLID PVC PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS

LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 09/13/07

CALIBRATION:

GROUND ELEVATION: 957.55

NORTHING:

EASTING:

ParklandGEO

BOREHOLE NO.: 05

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC
SITE: SYLVAN LAKE - NW & SW 34-39-2-W5
PROJECT NO.: RD2617
NOTES:
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Type	Sample No	SPT (N)	Comments	Elevation (m)
	GROUND SURFACE					952.57
0	***Topsoil*** moderately organic, black, moist					952.37
	Clay silty, trace sand, stiff, low plastic, brown, rust stains, coal inclusions, moist					
1.5			5D1	17	SO4 = 0.04%	
2.3	-sandy at 2.3m to 2.5m					950.27
2.5		G	5G1		Grain Size Analysis: Clay = 40%, Silt = 47%, Sand = 13%	
3.5	***Till*** clay, silty, sandy, trace gravel, very stiff, low plastic, brown, rust stains, coal inclusions, moist					949.07
4.5			5D2	20		
5	End of hole at 5.0m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on September 26, 2007. Dry on October 26, 2007.					947.57
10						942.57

Well Completion Details: 25mm SOLID PVC PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS

Moisture: 14, 18, 18, 14

LOGGED BY: DGY
CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL
RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER
DATE: 09/13/07
CALIBRATION:
GROUND ELEVATION: 952.57
NORTHING:
EASTING:

ParklandGEO

BOREHOLE NO.: 06

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5

PROJECT NO.: RD2617

NOTES:

BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp — W — WL) 20 50 70	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								951.15
0	***Topsoil*** moderately organic, black, moist							25mm SOLID PVC PIPE; BACKFILLED WITH CUTTINGS	950.95
	Clay silty, stiff, medium plastic, brown, rust stains, coal inclusions, moist								
2							- SO4 = 0.04%		
3								25mm SLOTTED PVC PIPE	
4				G	6G1				
5									945.85
	Till clay, silty, trace sand, trace gravel, very stiff, low plastic, brown, rust stains, coal inclusions, moist								
6									945.15
10									941.15

End of hole at 6.0m.
25mm standpipe installed.
Backfilled with cuttings.
Dry upon completion.
Dry on September 26, 2007.
Water level at 5.4m on October 26, 2007.

LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 09/13/07

CALIBRATION:

GROUND ELEVATION: 951.15

NORTHING:

EASTING:

ParklandGEO

BOREHOLE NO.: 07

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 PROJECT NO.: RD2617

NOTES: 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						967.01
0–0.2	**Topsoil** moderately organic, black, moist						966.81
0.2–3.4	**Clay** silty, trace sand, stiff, low plastic, brown, rust stains, coal inclusions, moist	23 (1.0 m); 20 (2.0 m); 20 (3.0 m)		7G1		- SO4 = 0.04%	
				7D1	17		963.61
3.4–4.7	**Sand** silty, trace gravel, fine grained, poorly graded, compact, brown, moist	16 (4.0 m)		7G2			962.31
4.7–4.9	**Bedrock** Shale, weathered, hard, brown, moist						962.11
10							957.01

Auger refusal at 4.9m.
25mm standpipe installed.
Backfilled with cuttings.
Dry upon completion.
Dry on September 26, 2007.
Dry on October 26, 2007.

Well Completion Details

25mm SOLID PVC PIPE

25mm SLOTTED PVC PIPE

BACKFILLED WITH CUTTINGS

LOGGED BY: DGY
CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL
RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER
DATE: 09/13/07
CALIBRATION:

GROUND ELEVATION: 967.01
NORTHING:
EASTING:

Parkland GEO

BOREHOLE NO.: 08

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 PROJECT NO.: RD2617

NOTES: BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Moisture (Wp — X — Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE							962.35
0–0.2	***Topsoil*** moderately organic, black, moist						25mm SOLID PVC PIPE; BACKFILLED WITH CUTTINGS	962.15
0.2–1.6	***Clay*** silty, trace sand, stiff, low plastic, brown, rust stains, coal inclusions, moist	22						960.75
1.6–2.7	***Clay and Silt*** trace sand, stiff, medium plastic, brown, coal inclusions, moist	28		SD1	11	Grain Size Analysis: Clay = 27%, Silt = 58%, Sand = 15%; - SO4 = 0.04%	25mm SLOTTED PVC PIPE	959.65
2.7–5.0	***Till*** clay, silty, sandy, trace gravel, stiff, low plastic, brown, rust stains, coal inclusions, moist	18; 17		SD2	14			957.35
5.0	End of hole at 5.0m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on September 26, 2007. Dry on October 26, 2007.							
10								952.35

LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 09/13/07

CALIBRATION:

GROUND ELEVATION: 962.35

NORTHING:

EASTING:

BOREHOLE NO.: 09

ParklandGEO

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.
SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 PROJECT NO.: RD2617
NOTES: BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Moisture	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE							956.21
0	***Topsoil*** moderately organic, black, moist							956.01
0–6.0	***Clay*** silty, trace sand, stiff, low plastic, brown, rust stains, coal inclusions, moist						25mm SOLID PVC PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS	
1		21						
2		19				- SO4 = 0.04%		
3		20						
3.8	-trace gravel at 3.8m	18	G	9G1				952.41
5		20						
5.5			BK	9BK1				
6	End of hole at 6.0m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on September 26, 2007. Dry on October 26, 2007.	20						950.21
10								946.21

Moisture scale: 25 50 75

LOGGED BY: DGY
CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL
RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER
DATE: 09/13/07
CALIBRATION:

GROUND ELEVATION: 956.21
NORTHING:
EASTING:

BOREHOLE NO.: 10

ParklandGEO

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.
SITE: SYLVAN LAKE - NW & SW 34-39-2-W5
PROJECT NO.: RD2617
NOTES:
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Type	Sample No	SPT (N)	Comments	Elevation (m)
0	GROUND SURFACE					965.95
0–0.2	***Topsoil*** moderately organic, black, moist					965.75
0.2–3.0	***Clay*** silty, trace sand, stiff, low plastic, brown, rust stains, coal inclusions, moist				- SO4 = 0.04%	962.95
3.0	***Bedrock*** Shale, weathered, hard, brown, moist		10D1	25	-no recovery	
7						958.95

Auger refusal at 3.1m.
25mm standpipe installed.
Backfilled with cuttings.
Dry upon completion.
Dry on September 26, 2007.
Dry on October 26, 2007.

Moisture (Wp — X — Wl): 25 50 75

Well Completion Details: SOLID PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS

LOGGED BY: DGY
CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL
RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER
DATE: 09/13/07
CALIBRATION:

GROUND ELEVATION: 965.95
NORTHING:
EASTING:

BOREHOLE NO.: 11

ParklandGEO

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC
SITE: SYLVAN LAKE - NW & SW 34-39-2-W5
PROJECT NO.: RD2617
NOTES:
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Moisture	Type	Sample No	SPT (N)	Comments	Elevation (m)
	GROUND SURFACE						962.06
0	***Topsoil*** moderately organic, black, moist						961.86
	Clay and Silt trace sand, stiff, medium plastic, brown, coal inclusions, moist	25					960.66
1.4	***Clay*** silty, sandy, trace gravel, stiff, low plastic, brown, rust stains, coal inclusions, moist	19		11D1	11	- SO4 = 0.04%	
		20					
		19		11BK1			
				11D2	14		
5	End of hole at 5.0m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Dry on September 26, 2007. Dry on October 26, 2007.						957.06
10							952.06

Well Completion Details: 25mm SOLID PVC PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS

LOGGED BY: DGY
CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL
RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER
DATE: 09/13/07
CALIBRATION:

GROUND ELEVATION: 962.06
NORTHING:
EASTING:

Parkland GEO

BOREHOLE NO.: 12

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 | PROJECT NO.: RD2617

NOTES: | BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								954.95
0	***Topsoil*** moderately organic, black, moist								954.75
	Clay silty, trace sand, stiff, low to medium plastic, brown, rust stains, coal inclusions, moist							25mm SOLID PVC PIPE; BACKFILLED WITH CUTTINGS	
2							- SO4 = 0.04%		
				G	12G1				
3				G	12G2			25mm SLOTTED PVC PIPE	
5.5					12BK1				
6	End of hole at 6.0m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Water level at 5.8m on September 26, 2007. Water level at 5.6m on October 26, 2007.								948.95
10									944.95

LOGGED BY: DGY | GROUND ELEVATION: 954.95

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL | NORTHING:

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER | EASTING:

DATE: 09/13/07

CALIBRATION:

ParklandGEO

BOREHOLE NO.: 13

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.
SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 PROJECT NO.: RD2617
NOTES: BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Elevation (m)
0	GROUND SURFACE	948.92
0 – 0.2	***Topsoil*** moderately organic, black, moist	948.72
0.2 – 1.5	***Clay*** silty, trace sand, stiff, low plastic, brown, moist	947.42
1.5 – 5.6	***Sand and Silt*** clayey, compact, fine grained, poorly graded, brown, moist	943.32
5.6 – 6.5	***Till*** clay, silty, trace sand, trace gravel, very stiff, low plastic, brown, rust stains, coal inclusions, moist	942.42
10		938.92

End of hole at 6.5m.
25mm standpipe installed.
Backfilled with cuttings.
Dry upon completion.
Dry on Nov 6, 2007.
Dry on Nov 13, 2007.

Type	Sample No	SPT (N)	Comments
G	13G1		- SO4 = 0.04%
G	13G2		
D	13D1	19	
D	13D2	15	

Moisture (Wp — W — Wl): 25 50 75

Well Completion Details: 25mm SOLID PVC PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS

LOGGED BY: DGY
CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL
RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER
DATE: 10/29/07
CALIBRATION:
GROUND ELEVATION: 948.92
NORTHING:
EASTING:

ParklandGEO

BOREHOLE NO.: 14

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5

PROJECT NO.: RD2617

NOTES:

BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE						939.49
0–0.2	***Topsoil*** moderately organic, black, moist						939.29
0.2–1.7	***Clay*** silty, trace sand, stiff, low plastic, brown, trace rust stains, moist; -water at 1.6m						937.99 / 937.79
1.7–3.7	***Sand*** silty, clayey, compact, fine grained, poorly graded, brown, saturated; -blue at 2.8	Sample	14D1	7	- SO4 = 0.08%		935.79
3.7–6.0	***Clay*** silty, trace sand, trace gravel, stiff, low plastic, grey, rust stains, coal inclusions, moist; -very stiff at 4.6m	Sample	14D2	9			933.49
6.0	End of hole at 6.0m. 25mm standpipe installed. Backfilled with cuttings. Slough around pipe to 3.0m. Dry upon completion. Water level at 1.7m on Nov 6, 2007. Water level at 1.9m on Nov 13, 2007						
10							929.49

Moisture: Wp — X — Wl

Well Completion Details: 25mm SOLID PVC PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS

LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 10/29/07

CALIBRATION:

GROUND ELEVATION: 939.49

NORTHING:

EASTING:

Parkland GEO

BOREHOLE NO.: 15

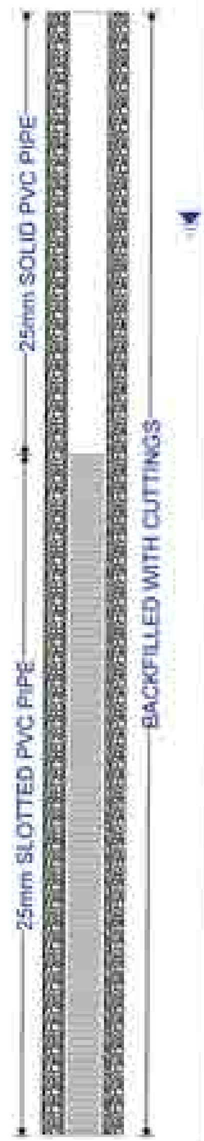
CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.
SITE: SYLVAN LAKE - NW & SW 34-39-2-W5
PROJECT NO.: RD2617
NOTES:
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Sample Type	Sample No	SPT (N)	Comments	Elevation (m)
0	GROUND SURFACE					940.29
0–0.9	**Topsoil** moderately organic, black, moist					
0.9–5.4	**Clay** silty, trace sand, stiff, low plastic, brown, moist				SO4 = 0.04%	
3		Split spoon	15D1	24	Grain Size Analysis Clay = 45% Silt = 37% Sand = 18%	
5.4						934.89
5.4–15.2	**Till** clay, silty, trace sand, trace gravel, very stiff, low plastic, grey, rust stains, coal inclusions, moist					
6		Split spoon	15D2	23		
9		Split spoon	15D3	35		
12		Split spoon	15D4	23	no recovery	
12.5		Grab	15G1			
15.2						925.09
15.2–16.5	**Bedrock** shale, hard, grey, damp	Split spoon	15D5	67		
16.5						923.79
20						920.29

End of hole at 16.5m.
25mm standpipe installed.
Backfilled with cuttings.
Dry upon completion.
Water level at 3.3m on Nov 6, 2007.
Water level at 3.1m on Nov 13, 2007.

Well Completion Details



LOGGED BY: DGY
CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL
RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER
DATE: 10/29/07
CALIBRATION:

GROUND ELEVATION: 940.29
NORTHING:
EASTING:

Parkland**GEO**

BOREHOLE NO.: 16

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 PROJECT NO.: RD2617

NOTES: BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								939.43
0–0.2	***Topsoil*** moderately organic, black, moist								939.23
0.2–3.5	***Clay*** silty, trace sand, trace gravel, stiff, low to medium plastic, brown, moist						- SO4 = 0.04%	25mm SOLID PVC PIPE; BACKFILLED WITH CUTTINGS	
~2.6				G	16G1				
~3.0–3.5				D	16D1	10			935.93
3.5–6.5	***Till*** clay, silty, trace sand, trace gravel, very stiff, medium to high plastic, brown, rust stains, coal inclusions, moist							25mm SLOTTED PVC PIPE	
~5.6				G	16G2				
6.1	-grey at 6.1m								933.33
~6.0–6.5				D	16D2	18			932.93
10									929.43

End of hole at 6.5m.
25mm standpipe installed.
Backfilled with cuttings.
Dry upon completion.
Water level at 2.3m on Nov 6, 2007.
Water level at 1.9m on Nov 13, 2007.

LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 10/29/07

CALIBRATION:

GROUND ELEVATION: 939.43

NORTHING:

EASTING:

Parkland GEO

BOREHOLE NO.: 17

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5 PROJECT NO.: RD2617

NOTES:

BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Elevation (m)
0	GROUND SURFACE	951.21
0	***Topsoil*** moderately organic, black, moist	
	Clay silty, trace sand, stiff, low to medium plastic, brown, moist	
1.8	***Till*** clay, silty, trace sand, trace gravel, very stiff, medium to high plastic, brown, rust stains, coal inclusions, moist	949.41
9.3	***Bedrock*** shale, hard, grey, damp	941.91
11.0	Auger refusal at 11.0m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Water level at 9.5m on Nov 6, 2007. Water level at 10.2m on Nov 13, 2007.	940.21
15		936.21

Sample No	SPT (N)	Comments
17D1	27	SO4 = 0.04%
17G1		Grain Size Analysis Clay = 32% Silt = 23% Sand = 38% Gravel = 0%
17D2	32	
17D3	36	
17G2		
17G3		
17D4	50	no recovery

Well Completion Details: 25mm SOLID PVC PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS

LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 10/29/07

CALIBRATION:

GROUND ELEVATION: 951.21

NORTHING:

EASTING:

ParklandGEO

BOREHOLE NO.: 18

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5

PROJECT NO.: RD2617

NOTES:

BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Type	Sample No	SPT (N)	Comments	Elevation (m)
0	GROUND SURFACE					951.14
	Topsoil moderately organic, black, moist					950.94
	Clay silty, trace sand, stiff, low to medium plastic, brown, rust stains, moist -coal inclusions at 1.3m					
2					- SO4 = 0.04%	948.94
	-low plastic at 2.2	G	18G1			
3			18D1	21		947.74
	Till clay, silty, trace sand, trace gravel, stiff, low plastic, brown, rust stains, coal inclusions, moist					
5	-grey at 5.1m					946.04
		G	18G2			
6			18D2	32		944.64
	End of hole at 6.5m 25mm standpipe installed Backfilled with cuttings Dry upon completion Dry on Nov 6, 2007. Dry on Nov 13, 2007					
10						941.14

Well Completion Details

LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 10/30/07

CALIBRATION:

GROUND ELEVATION: 951.14

NORTHING:

EASTING:

ParklandGEO

BOREHOLE NO.: 19

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.

SITE: SYLVAN LAKE - NW & SW 34-39-2-W5

PROJECT NO.: RD2617

NOTES:

BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								945.86
0	***Topsoil*** moderately organic, black, moist							25mm SOLID PVC PIPE; BACKFILLED WITH CUTTINGS	945.66
	Clay silty, trace sand, stiff, low plastic, brown, rust stains, coal inclusions, moist				19D1	17	- SO4 = 0.04%		
3.7	***Till*** clay, silty, some sand, trace gravel, stiff, low plastic, brown, rust stains, coal inclusions, moist				19D2	26		25mm SLOTTED PVC PIPE	942.16
6	End of hole at 6.0m. 25mm standpipe installed. Backfilled with cuttings. Slough around pipe to 3.0m. Dry upon completion. Water level at 3.2m on Nov 6, 2007. Water level at 3.8m on Nov 13, 2007.								939.86
10									935.86

LOGGED BY: DGY

CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL

RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER

DATE: 10/30/07

CALIBRATION:

GROUND ELEVATION: 945.86

NORTHING:

EASTING:

ParklandGEO

BOREHOLE NO.: 20

CLIENT: QUALICO DEVELOPMENTS C/O EDS GROUP INC.
SITE: SYLVAN LAKE - NW & SW 34-39-2-W5   PROJECT NO.: RD2617
NOTES: BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Type	Sample No	SPT (N)	Comments	Elevation (m)
0	GROUND SURFACE					943.11
	Topsoil moderately organic, black, moist					942.91
	Clay silty, trace sand, stiff, medium plastic, brown, moist					
1.8	-water at 1.8m				- SO4 = 0.04%	941.31
2.4	-rust stains at 2.4m	G	20G1			940.71
3			20D1	16	Grain Size Analysis: Clay = 42% Silt = 47% Sand = 11%	939.71
	Till clay, silty, some sand, trace gravel, stiff, low plastic, brown, grey, rust stains, coal inclusions, moist					
6			20D2	22		936.61
6.5	End of hole at 6.5m. 25mm standpipe installed. Backfilled with cuttings. Dry upon completion. Water level at 0.6m on Nov 6, 2007. Water level at 0.6m on Nov 13, 2007					
10						933.11

Moisture (Wp — W — WL)

Well Completion Details: 25mm SOLID PVC PIPE; 25mm SLOTTED PVC PIPE; BACKFILLED WITH CUTTINGS

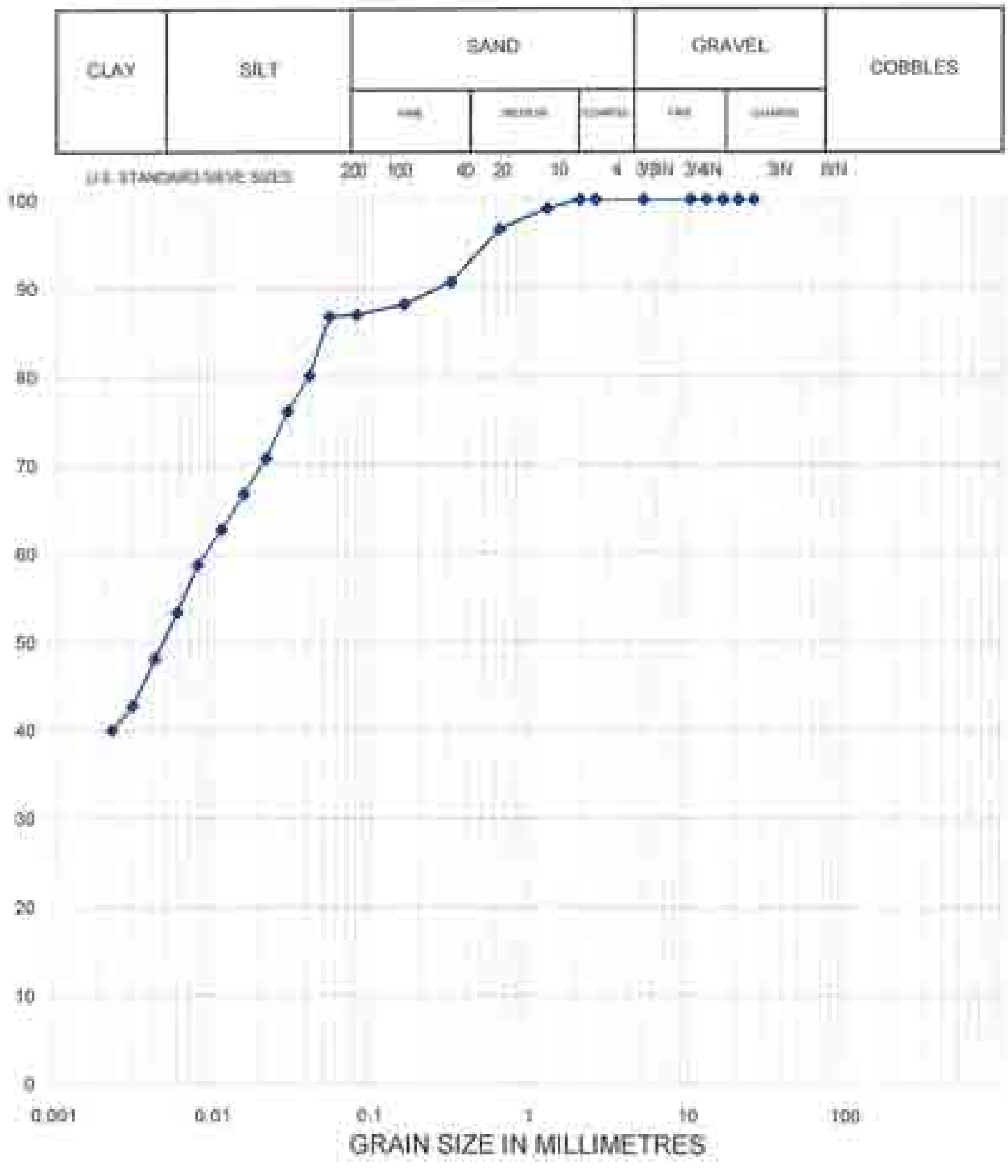
LOGGED BY: DGY   GROUND ELEVATION: 943.11
CONTRACTOR: J.E.D. ANCHORS AND ENVIRONMENTAL   NORTHING:
RIG/METHOD: TRUCK MOUNT SOLID STEM AUGER   EASTING:
DATE: 10/30/07
CALIBRATION:

Parkland GEO

PROJECT	Sylvan Lake Development - NW & SW 34-39-2-W5
PROJECT #	RD2617
BOREHOLE	1
DEPTH	0.7 m
SAMPLE	1G1
LOCATION	

DATE Nov 28/07
TECH JB

GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Clay, and silt, little sand

SUMMARY

D10 =		GRAVEL	0.00%
D30 =		SAND	13.03%
D60 =		SILT	36%
CU =		CLAY	50.55%
CC =			

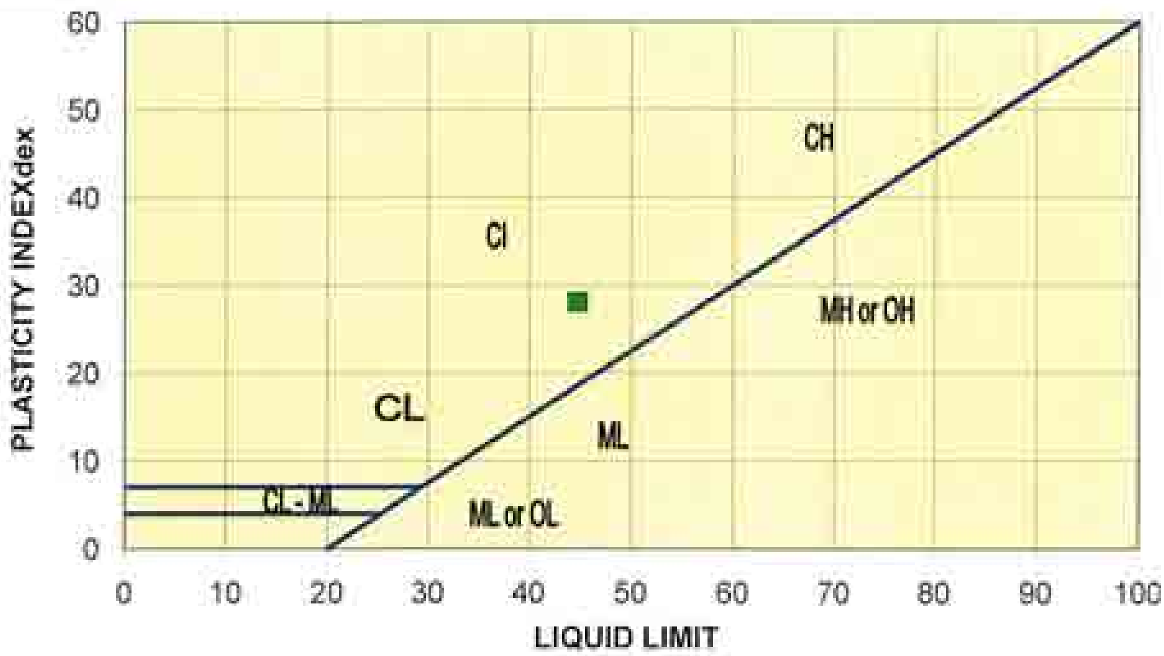
PROJECT# RD2617
PROJECT Sylvan Lake Development - NW&
BOREHOLE 1
DEPTH 0.7 m
SAMPLE # 1G1
DATE Nov 28/07
TECH JB

SOIL PLASTICITY SUMMARY

LIQUID LIMIT (LL)		
Trial No.	1	2
No. Blows	22	23
Wt. Sample Wet + Tare	38.591	43.342
Wt. Sample Dry + Tare	31.584	34.898
Wt. Water	7.007	8.444
Tare Container	16.195	16.191
Wt. Dry Soil	15.389	18.707
Moisture Content	45.533	45.138
Corrected for Blow Count	44.834	44.685
Liquid Limit Average	**44.8**	

PLASTIC LIMIT (PL)			
Trial No.	1	2	3
Wt. Wet Worm + Tare	8.708	8.370	8.377
Wt. Dry Worm + Tare	8.374	8.077	8.073
Wt. Water	0.334	0.293	0.304
Tare Container	6.321	6.324	6.283
Wt. Dry Worm	2.053	1.753	1.790
Moisture Content	16.269	16.714	16.983
Plastic Limit Average		**16.7**	

PLASTICITY INDEX (PI) = LL-PL **28.1**



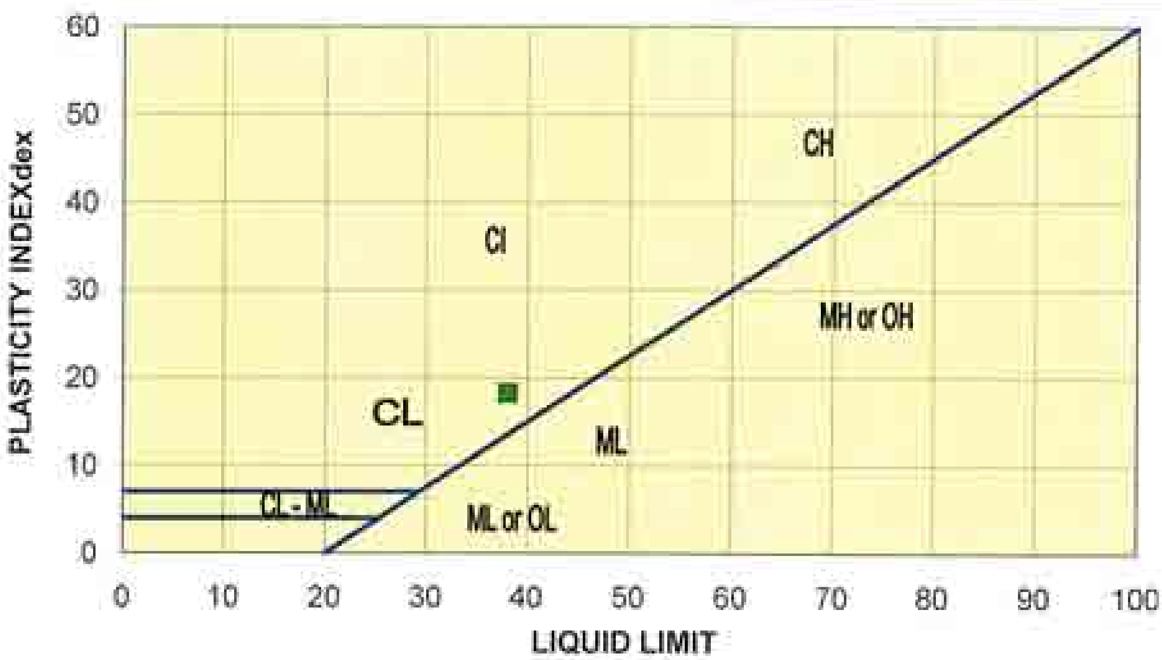
PROJECT# RD2617
PROJECT Sylvan Lake Development - NW&
BOREHOLE 5
DEPTH 2.4 m
SAMPLE # 5G1
DATE Nov 28/07
TECH JB

SOIL PLASTICITY SUMMARY

LIQUID LIMIT (LL)		
Trial No.	1	2
No. Blows	29	30
Wt. Sample Wet + Tare	43.645	45.558
Wt. Sample Dry + Tare	36.180	37.558
Wt. Water	7.465	8.000
Tare Container	16.150	16.156
Wt. Dry Soil	20.030	21.402
Moisture Content	37.269	37.380
Corrected for Blow Count	37.944	38.213
Liquid Limit Average	**38.1**	

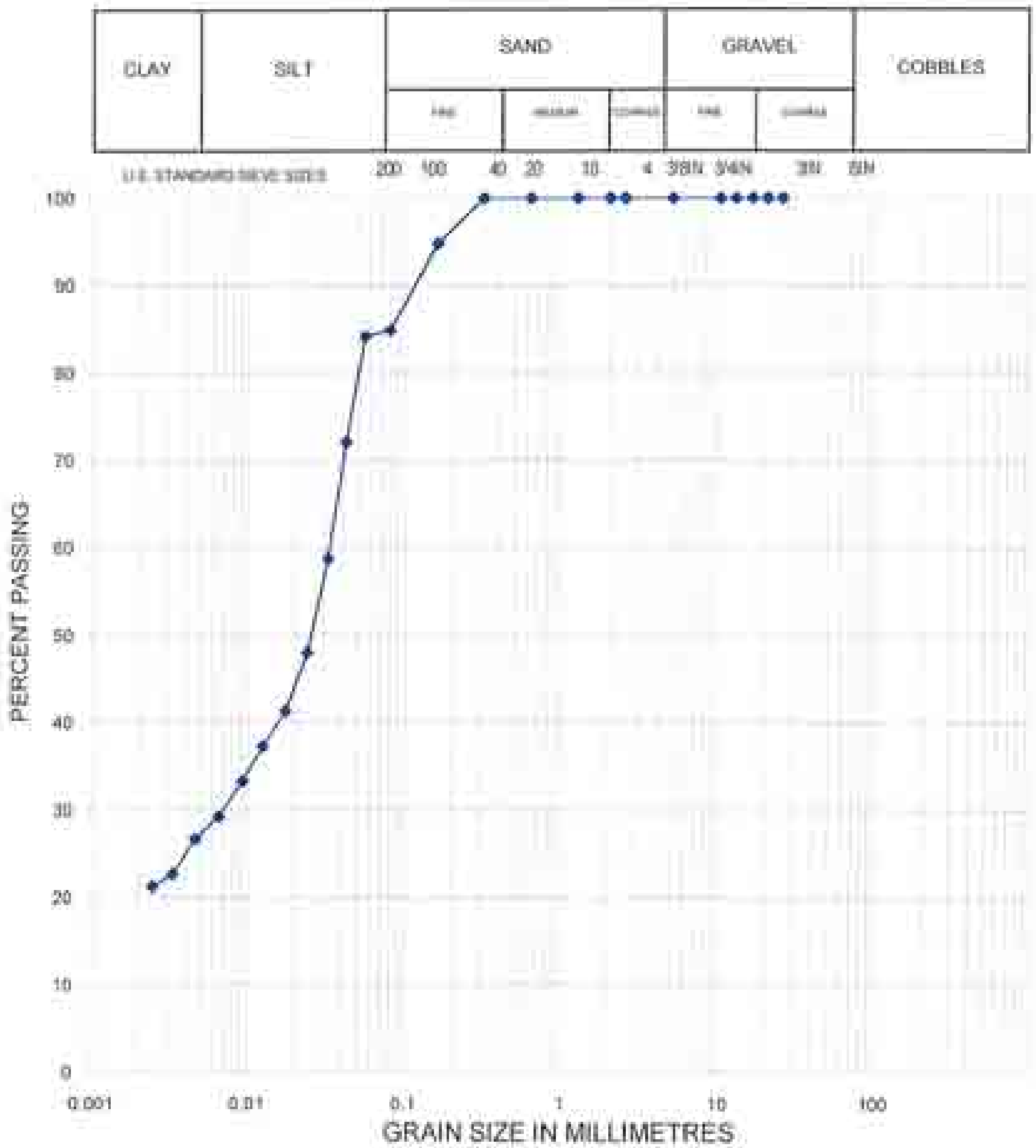
PLASTIC LIMIT (PL)			
Trial No.	1	2	3
Wt. Wet Worm + Tare	8.383	8.790	8.615
Wt. Dry Worm + Tare	8.038	8.378	8.232
Wt. Water	0.345	0.412	0.383
Tare Container	6.296	6.296	6.301
Wt. Dry Worm	1.742	2.082	1.931
Moisture Content	19.805	19.789	19.834
Plastic Limit Average		**19.8**	

PLASTICITY INDEX (PI) = LL-PL **18.3**



PROJECT	Sylvan Lake Development - NW & SW 34-39-2-W5		
PROJECT #	RD2617		
BOREHOLE	8	DATE	Nov 28/07
DEPTH	1.5 m	TECH	JB
SAMPLE	8D1		
LOCATION			

GRAIN SIZE DISTRIBUTION



COMMENTS:

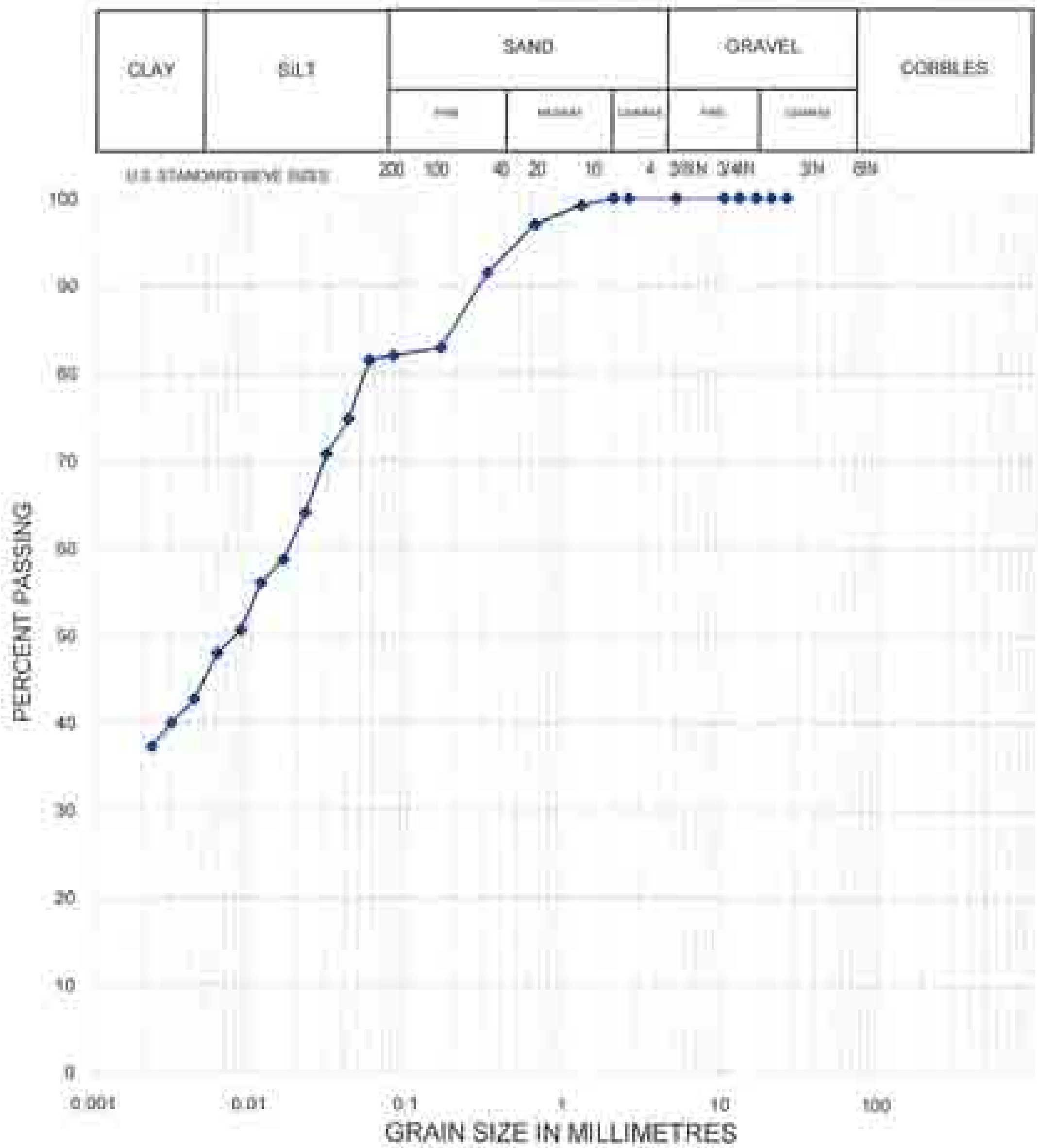
% Retained on 2 mm seive
Soil Type: Silt, some clay, little sand

SUMMARY

D10 =		GRAVEL	0.00%
D30 =		SAND	15.25%
D60 =		SILT	58%
CU =		CLAY	27.16%
CC =			

PROJECT	Sylvan Lake Development - NW & SW 34-39-2-W5		
PROJECT #	RD2617		
BOREHOLE	15	**DATE**	Nov 28/07
DEPTH	3.5 m	**TECH**	JB
SAMPLE	15D1		
LOCATION			

GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Clay, and silt, little sand

SUMMARY

D10 =		GRAVEL	0.00%
D30 =		SAND	18.11%
D60 =		SILT	37%
CU =		CLAY	44.74%
CC =			

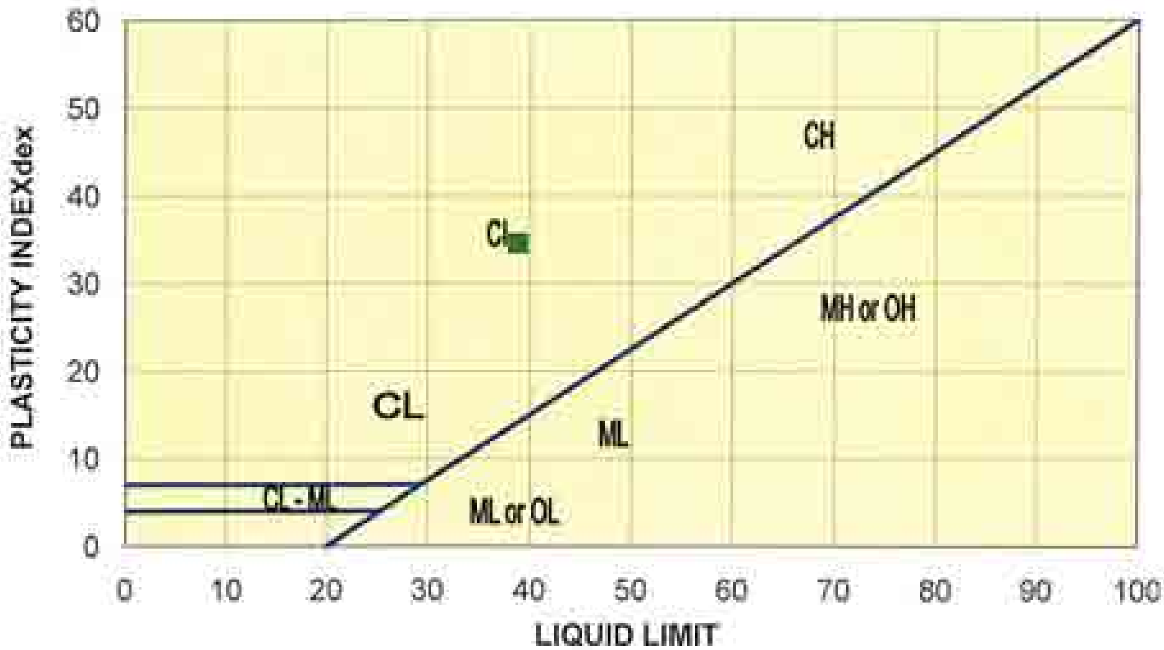
PROJECT#	RD2617
PROJECT	Sylvan Lake Development - NW&:
BOREHOLE	15
DEPTH	3.5 m
SAMPLE #	15D1
DATE	Nov 28/07
TECH	JB

SOIL PLASTICITY SUMMARY

LIQUID LIMIT (LL)		
Trial No.	1	2
No. Blows	29	30
Wt. Sample Wet + Tare	45.064	41.926
Wt. Sample Dry + Tare	37.322	34.817
Wt. Water	7.742	7.109
Tare Container	16.501	16.487
Wt. Dry Soil	20.821	18.330
Moisture Content	37.184	38.783
Corrected for Blow Count	37.857	39.649
Liquid Limit Average	**38.8**	

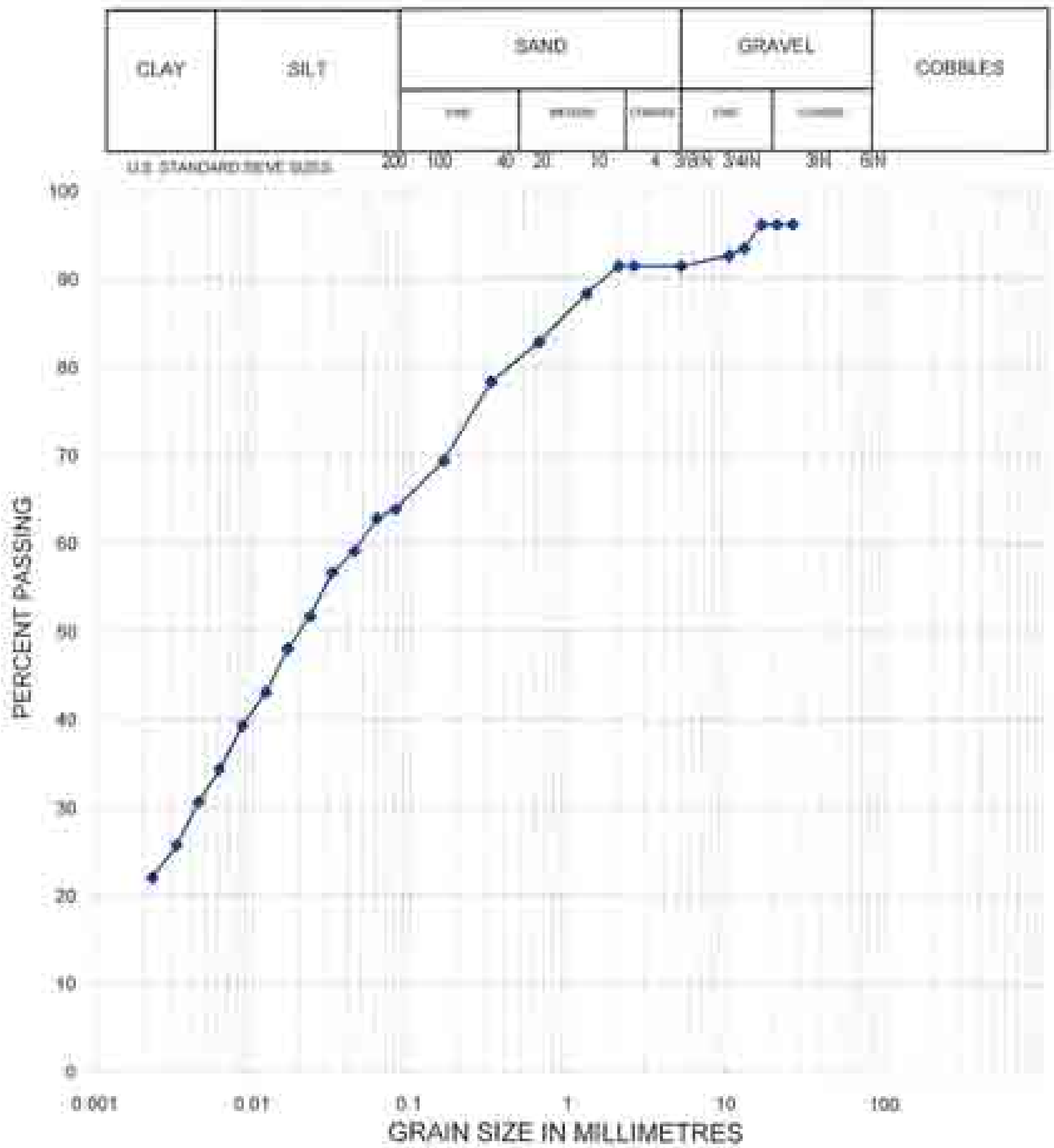
PLASTIC LIMIT (PL)			
Trial No.	1	2	3
Wt. Wet Worm + Tare	8.154	8.197	8.284
Wt. Dry Worm + Tare	8.089	8.115	8.199
Wt. Water	0.065	0.082	0.085
Tare Container	6.335	6.255	6.296
Wt. Dry Worm	1.754	1.860	1.903
Moisture Content	3.706	4.409	4.467
Plastic Limit Average		**4.2**	

PLASTICITY INDEX (PI) = LL-PL	**34.6**



PROJECT	Sylvan Lake Development - SW&NW 34-39-2-W5		
PROJECT #	RD2617		
BOREHOLE	17	**DATE**	Dec 4/07
DEPTH	3.8 m	**TECH**	JB
SAMPLE	17G1		
LOCATION			

GRAIN SIZE DISTRIBUTION



COMMENTS:

% Retained on 2 mm seive
Soil Type: Sand, some clay, some silt

SUMMARY

D10 =		GRAVEL	8.60%
D30 =		SAND	36.29%
D60 =		SILT	23%
CU =		CLAY	31.82%
CC =			

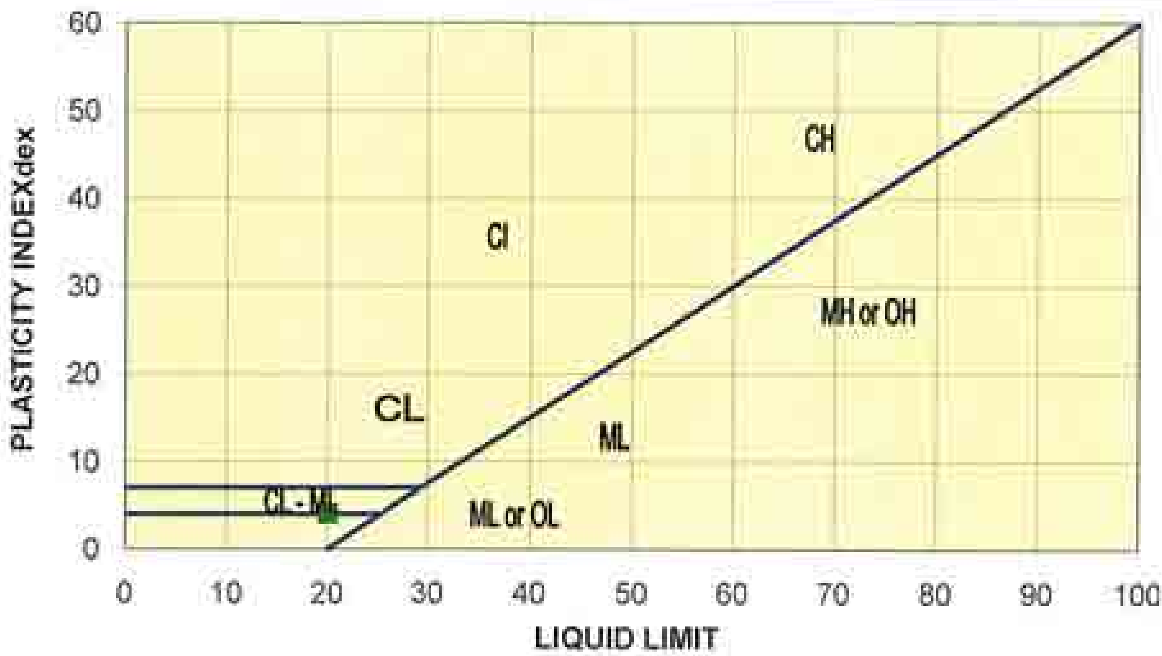
PROJECT# RD2617
PROJECT Sylvan Lake Dev. - SW&NW 34-3
BOREHOLE 17
DEPTH 3.8 m
SAMPLE # 17G1
DATE Dec 4/07
TECH JB

SOIL PLASTICITY SUMMARY

LIQUID LIMIT (LL)		
Trial No.	1	2
No. Blows	20	21
Wt. Sample Wet + Tare	39.565	40.367
Wt. Sample Dry + Tare	35.583	36.269
Wt. Water	3.982	4.098
Tare Container	16.311	16.173
Wt. Dry Soil	19.272	20.096
Moisture Content	20.662	20.392
Corrected for Blow Count	20.112	19.966
Liquid Limit Average	**20.0**	

PLASTIC LIMIT (PL)			
Trial No.	1	2	3
Wt. Wet Worm + Tare	8.820	8.624	8.739
Wt. Dry Worm + Tare	8.479	8.305	8.396
Wt. Water	0.341	0.319	0.343
Tare Container	6.299	6.323	6.279
Wt. Dry Worm	2.180	1.982	2.117
Moisture Content	15.642	16.095	16.202
Plastic Limit Average		**16.0**	

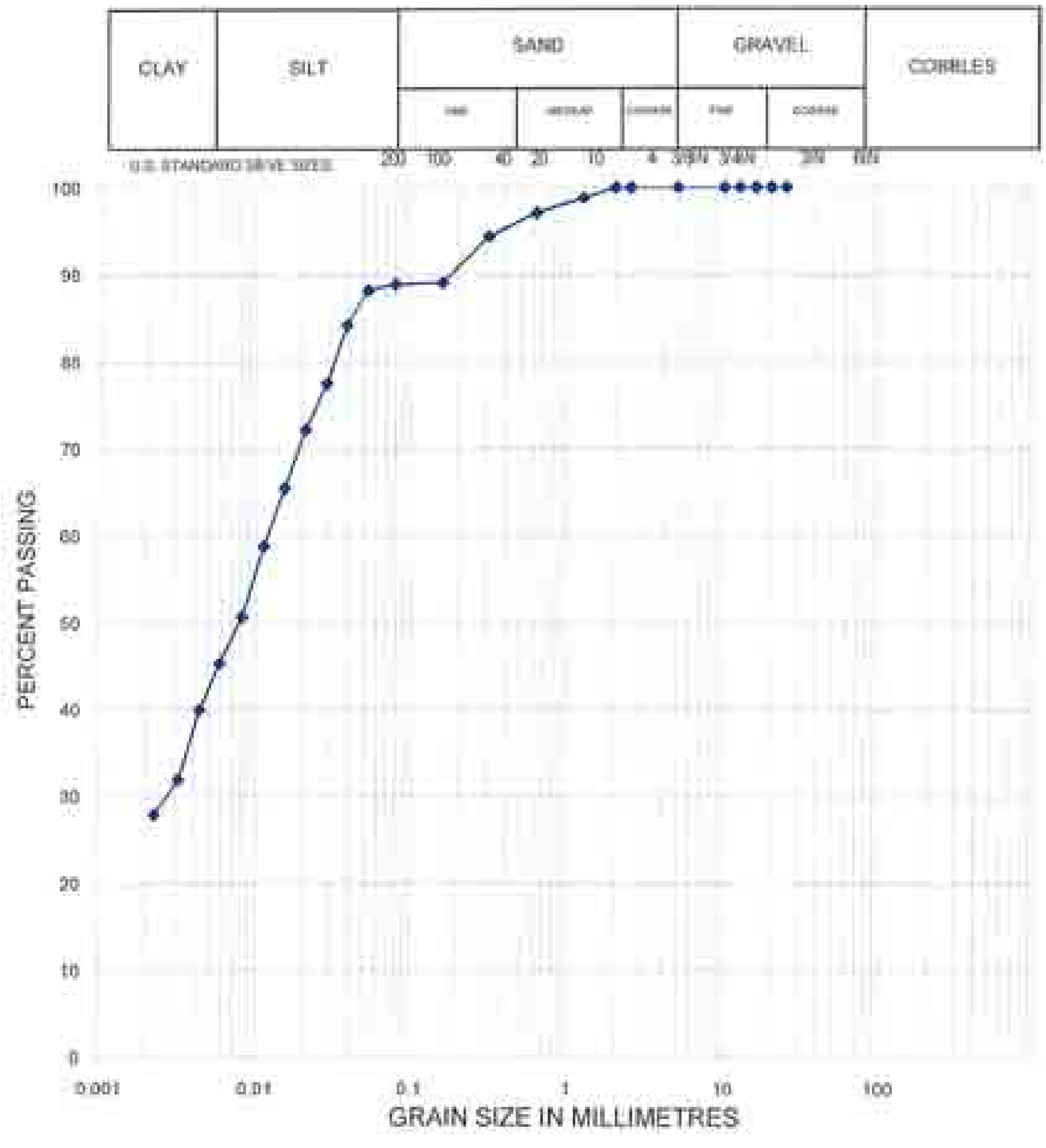
PLASTICITY INDEX (PI) = LL-PL 4.1



Parkland GEO

PROJECT Sylvan Lake Development - SW&NW 34-39-2-W5
PROJECT # RD2617
BOREHOLE 20 DATE Dec 4/07
DEPTH 3.0 m TECH JB
SAMPLE 20D1
LOCATION

GRAIN SIZE DISTRIBUTION



COMMENTS:

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

SUMMARY

D10 =		GRAVEL	0.00%
D30 =		SAND	11.22%
D60 =		SILT	47%
CU =		CLAY	42.16%
CC =			

Parkland GEO

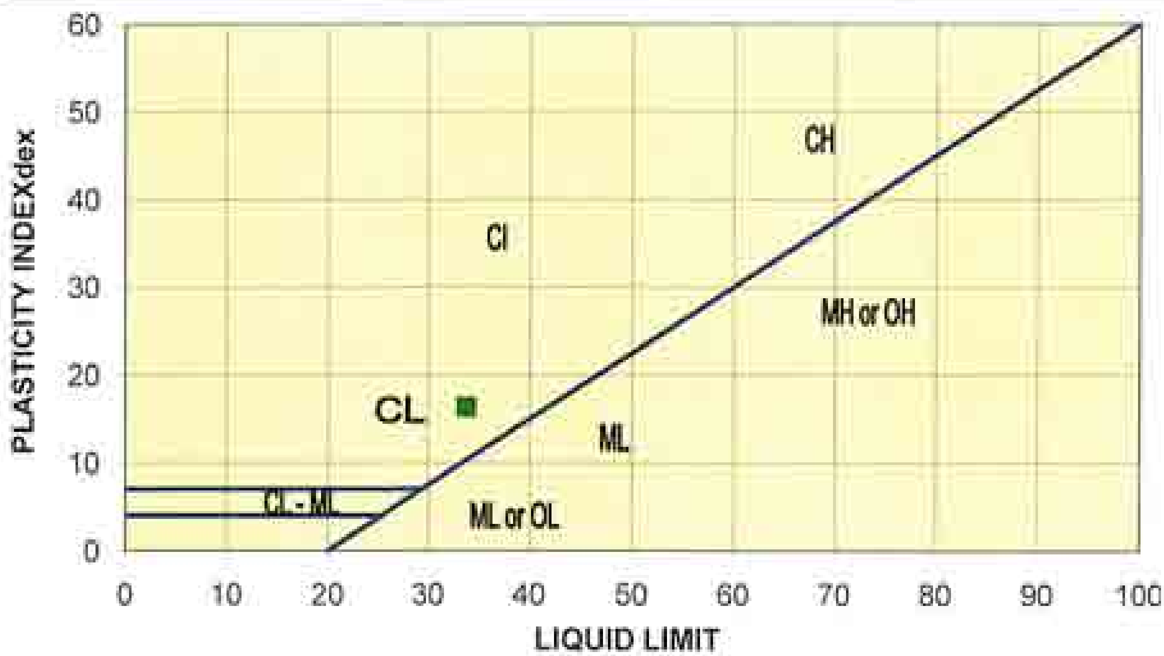
PROJECT#	RD2617
PROJECT	Sylvan Lake Dev. - SW&NW 34-3
BOREHOLE	20
DEPTH	3.0 m
SAMPLE #	20D1
DATE	Dec 4/07
TECH	JB

SOIL PLASTICITY SUMMARY

LIQUID LIMIT (LL)		
Trial No.	1	2
No. Blows	26	27
Wt. Sample Wet + Tare	38.955	43.203
Wt. Sample Dry + Tare	33.272	36.343
Wt. Water	5.683	6.860
Tare Container	16.237	15.949
Wt. Dry Soil	17.035	20.394
Moisture Content	33.361	33.637
Corrected for Blow Count	33.519	33.952
Liquid Limit Average	**33.7**	

PLASTIC LIMIT (PL)			
Trial No.	1	2	3
Wt. Wet Worm + Tare	8.628	8.831	8.402
Wt. Dry Worm + Tare	8.290	8.454	8.079
Wt. Water	0.338	0.377	0.323
Tare Container	6.324	6.288	6.235
Wt. Dry Worm	1.966	2.166	1.844
Moisture Content	17.192	17.405	17.516
Plastic Limit Average		**17.4**	

PLASTICITY INDEX (PI) = LL-PL **16.4**

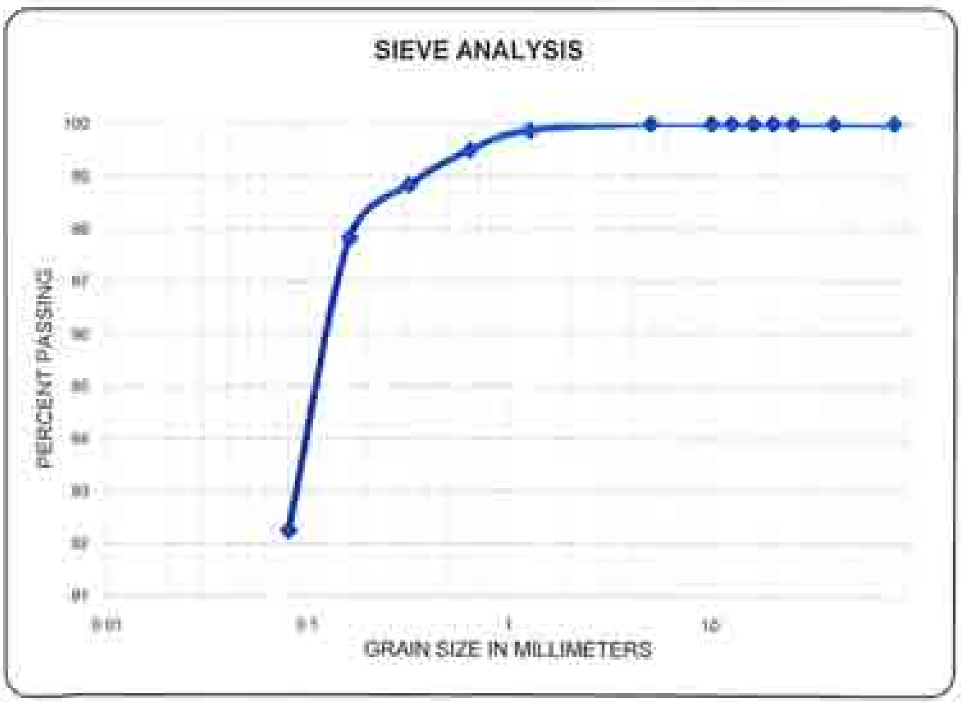


PROJECT -	Sylvan Lake Dev. - SW & NW 34-
PROJECT #	RD2617
DATE -	Nov 22/07
SAMPLE SOURCE -	
SIEVE #	1
PIT NAME -	
TECHNICIAN -	JB

SIEVE NO	OPENING SIZE (mm)	WEIGHT RETAINED (g)	TOTAL WT. FINER (gms)	PERCENT PASSING	SPECIFICATION Min.	SPECIFICATION Max.
80000	80		560.7	100.0		
40000	40		560.7	100.0		
25000	25		560.7	100.0		
20000	20		560.7	100.0		
16000	16		560.7	100.0		
12500	12.5		560.7	100.0		
10000	10		560.7	100.0		
5000	5		560.7	100.0		
1250	1.25	0.7	560	99.9		
630	0.63	2.1	557.9	99.5		
315	0.315	3.7	554.2	98.8		
160	0.16	5.7	548.5	97.8		
80	0.08	31.3	517.2	92.2		
SIEVE PAN		5.5				

MOISTURE CONTENT SAMPLE		SIEVE ANALYSIS SAMPLE		D.W.W.CALCULATIONS
A-WT. WET SAMPLE + PAN	1299.2	G-WT. OF DRY SAMPLE	560.7	
B-WT. DRY SAMPLE + PAN	1251.8	H- WASHED DRY +PAN	740.1	
C-WT. OF WATER	47.4	I- WT OF WASHED DRY SA	49	
D-WT. OF PAN	691.1	J- WT WASHED FINES	511.7	
E-WT. OF DRY SAMPLE	560.7			
F-MOISTURE CONTENT	8.5			

DESCRIPTION OF SAMPLE/COMMENTS	METHOD OF PREPARATION	WASHED
BH13	TOTAL WEIGHT	560.7
12G2	DRY WT	560.7
2.5 m	DIFFERENCE	0
	% DIFFERENCE	0



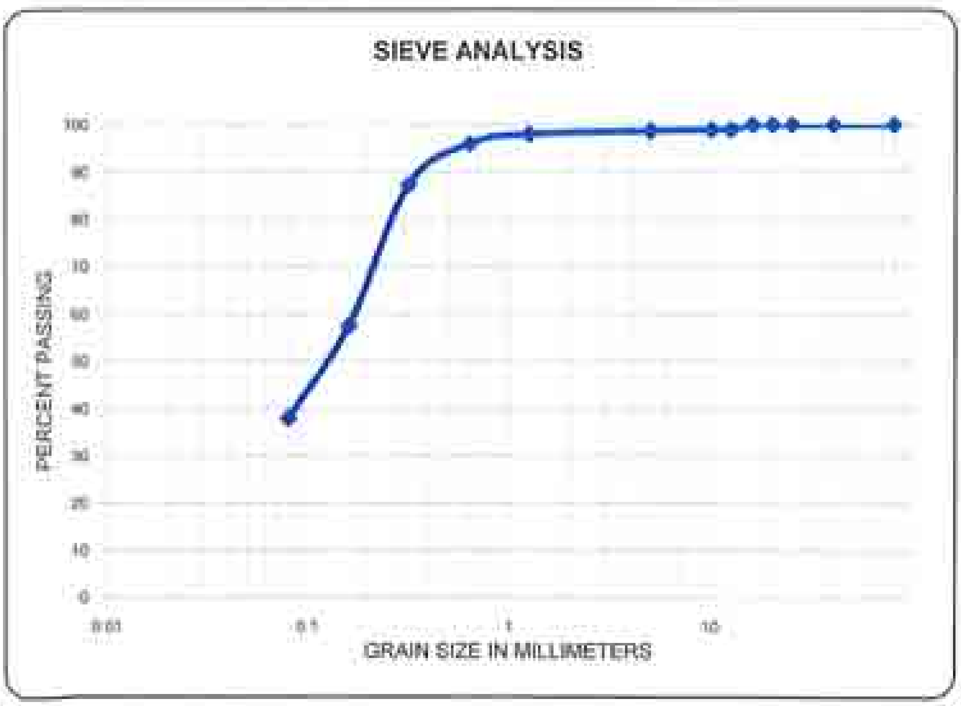
ParklandGEO

PROJECT - Sylvan Lake Dev. - SW & NW 34-
PROJECT # RD2617 **DATE -** Nov 22/07
SAMPLE SOURCE - **SIEVE #** 2
PIT NAME -
TECHNICIAN - JB

SIEVE NO	OPENING SIZE (mm)	WEIGHT RETAINED (g)	TOTAL WT FINER (gms)	PERCENT PASSING	SPECIFICATION Min.	Max.
80000	80		313.4	100.0		
40000	40		313.4	100.0		
25000	25		313.4	100.0		
20000	20		313.4	100.0		
16000	16		313.4	100.0		
12500	12.5	3.3	310.1	98.9		
10000	10		310.1	98.9		
5000	5	0.8	309.3	98.7		
1250	1.25	2.1	307.2	98.0		
630	0.63	6.5	300.7	95.9		
315	0.315	27.3	273.4	87.2		
160	0.16	93.3	180.1	57.5		
80	0.08	61.3	118.8	37.9		
SIEVE PAN		10.5				

MOISTURE CONTENT SAMPLE		SIEVE ANALYSIS SAMPLE		D.W.W.CALCULATIONS
A-WT. WET SAMPLE + PAN	1077.4	G-WT. OF DRY SAMPLE	313.4	
B-WT. DRY SAMPLE + PAN	1003.3	H- WASHED DRY +PAN	895.5	
C-WT. OF WATER	74.1	I- WT OF WASHED DRY SA	205.6	
D-WT. OF PAN	689.9	J- WT WASHED FINES	107.8	
E-WT. OF DRY SAMPLE	313.4			
F-MOISTURE CONTENT	23.6			

DESCRIPTION OF SAMPLE/COMMENTS	METHOD OF PREPARATION	WASHED
BH14	TOTAL WEIGHT	312.9
14D1	DRY WT	313.4
1.5 m	DIFFERENCE	-0.5
	% DIFFERENCE	-0.0015954



Parkland GEO

MOISTURE DENSITY RELATIONSHIP WORKSHEET

PROJECT SYLVAN LAKE DEV PROJECT# RD2617
CLIENT DATE SEPT18/07

	SAMPLE NUMBER	1	2	3	4		
DRY DENSITY	Wt. Sample Wet + Mold	6008	6095	6136	6107		
	Wt. Mold	4174	4174	4174	4174	4174	
	Wt. Sample Wet	1834	1921	1962	1933	-4174	
	Volume Mold	945	945	945	945	945	
	Wet Density kg/m3	1941	2033	2076	2046	-4417	
	Dry Density kg/m3	1719	1779	1786	1726	#DIV/0!	

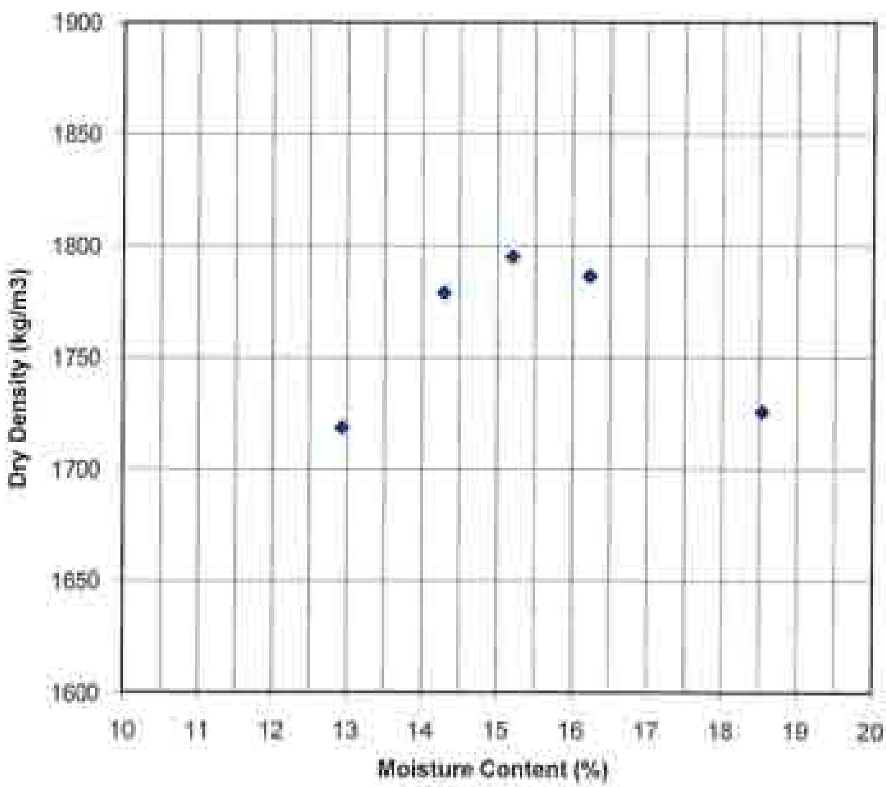
DATE SAMPLED SEPT15/07
CONTRACTOR
SOURCE/LOCAT SYLVAN
SAMPLED BY DANNY

PROCTOR # **P07-0050**

	CONTAINER NUMBER	12	14	16	18		
MOISTURE	Wt. Sample Wet + Tare	315	249	324	325		
	Wt. Sample Dry + Tare	281	220	281	277		
	Wt. Water	34	29	43	48	0	
	Tare Container	18	17	16	18		
	Wt. Dry Soil	263	203	265	259	0	
	Moisture Content	12.9	14.3	16.2	18.5	#DIV/0!	

PREPARATION DRY / MOIST
RAMMER TYPE AUTO /MANUAL

COMPACTION STANDARD ASTM D698 x
ASTM D1557



SOIL TYPE: **SILTY CLAY**

COMMENTS

PERCENT RETAINED
4.75 mm SIEVE 0
19.0 mm SIEVE

MAXIMUM DRY DENSITY 1795 kg/m3 **OPTIMUM MOISTURE CONTENT** 15.2 %

TECHNICIAN JP CHECKED JP

ParklandGEO

Project: Sylvan Lake Dev. - NW & SW 34-39-2-W5
Subject: Geotechnical Testing - Soil Sulphate Test Results
Project #: RD2617 **Date:** Nov 22/07

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(SO_4) IN SOIL SAMPLE, %	SULPHATE(SO_4) 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:**

ParklandGEO

Project: Sylvan Lake Dev. - NW & SW 34-39-2-W5

Subject: Geotechnical Testing - Soil Sulphate Test Results

Project #: RD2617 **Date:** Nov 23/07

Soil Sulphate Test Results

Laboratory: Parkland Geotechnical

Sample #: MC2
Borehole: 11
Depth: 2.0 m
Result (% Sulphate): 0.04

Sample #: MC2
Borehole: 16
Depth: 2.0 m
Result (% Sulphate): 0.04

Sample #: MC2
Borehole: 12
Depth: 2.0 m
Result (% Sulphate): 0.04

Sample #: MC2
Borehole: 17
Depth: 2.0 m
Result (% Sulphate): 0.04

Sample #: MC2
Borehole: 13
Depth: 2.0 m
Result (% Sulphate): 0.04

Sample #: MC2
Borehole: 18
Depth: 2.0 m
Result (% Sulphate): 0.04

Sample #: MC2
Borehole: 14
Depth: 2.0 m
Result (% Sulphate): 0.08

Sample #: MC2
Borehole: 19
Depth: 2.0 m
Result (% Sulphate): 0.04

Sample #: MC2
Borehole: 15
Depth: 2.0 m
Result (% Sulphate): 0.04

Sample #: MC2
Borehole: 20
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(SO_4) IN SOIL SAMPLE, %	SULPHATE(SO_4) 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:**

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

Alberta
TRANSPORTATION AND UTILITIES

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

SPECIFICATIONS FOR AGGREGATE

13 MAY 88
417PI169

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

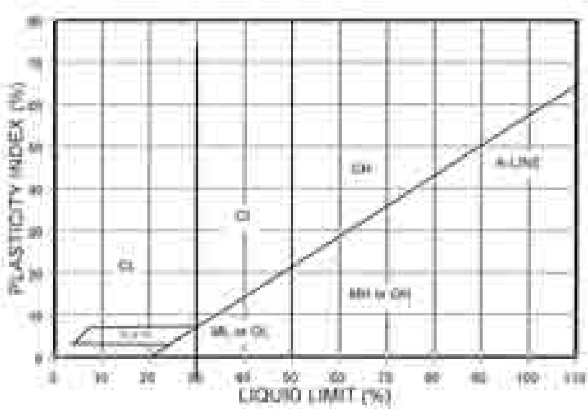
4. **CONSISTENCY OF FINED GRAINED SOIL** - The following terms are used relative to unconfined strength in kPa and Standard Penetration Test (SPT), ASTM D1586, N value for blows per 300 mm.

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

ParklandGEO

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	$C_U = \frac{D_{60}}{D_{10}} > C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ 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 7
	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	$C_U = \frac{D_{60}}{D_{10}} > C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ 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 7
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 FLOUR, 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.