Geotechnical, Environmental and Materials Engineering

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GEOTECHNICAL INVESTIGATION

ASPEN LAKES WEST SUBDIVISION
PORTION OF SW 34-39-27-W4M
BLACKFALDS, ALBERTA

PREPARED FOR

ASPEN LAKES WEST DEVELOPMENT INC.

C/O STANTEC CONSULTING LTD.

1100 – 4900 50TH STREET
RED DEER, ALBERTA

PREPARED BY

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RED DEER, ALBERTA

PROJECT NO. RD5288 REV 1

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1.0 INTRODUCTION

1.1 GENERAL

Aspen Lakes West Development Inc. is proposing to complete the development the Aspen Lakes West Phase 1 residential subdivision in the Town of Blackfalds, Alberta. Parkland Geotechnical Consulting Ltd. (ParklandGEO) was commissioned to conduct a geotechnical assessment and percolation test for the site. The scope was outlined in the ParklandGEO proposal dated March 31, 2015 (File # PRO4113). Authorization to proceed with this assessment was given by Mr. Travis Fillier, P.Eng. of Stantec Consulting Ltd. The site location is shown on Figure 1.

1.2 SCOPE OF WORK

This assessment was based on a review of existing publically available site investigation information. This report summarizes results of historical field and laboratory testing programs for the site and presents geotechnical recommendations for the proposed development. 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.

1.3 PREVIOUS SITE INVESTIGATIONS

Two previous site investigations were performed at this site in 2002. These investigations were documented the following reports which were made available to the developer by the Town of Blackfalds:

1. *"Geotechnical Investigation - Proposed Rutten Subdivision - SE 34-39-27-W4M, Blackfalds, Alberta", submitted to MPE Engineering Ltd. by Parkland Geotechnical Consulting Ltd., December 2002 (File # RD0814).*

2. *"Geotechnical Investigation - Proposed Kuhnen Property – East ½ of SW 34-39-27-W4M, Blackfalds, Alberta", submitted to Watikin Land Development Ltd. by Parkland Geotechnical Consulting Ltd., October 2006 (File # RD2208).*

This assessment is only based on the boreholes and soil test data in the undeveloped portions of the two sites.

2.0 SITE AND PROJECT DESCRIPTION

The Aspen Lakes West Subdivision in Blackfalds, Alberta, covers eastern half of SW 34-39-27-W4M and a portion of the west side of SE 34-39-27-W4M as shown on the Site Plan (Figure 2). The site is located about 400 m east of Queen Elizabeth II Highway and bounded on the south and east side by residential areas and the north and west by farmland. Access to the site is from the east via Aspen Lakes Blvd. The east side of the subdivision property is Aurora Heights subdivision with a two small ponds. The surface coverage and site development is shown on the 2010 Aerial Photograph (Figure 3).

The property has a rolling topography. The overall relief at the site was about 8 m between boreholes with elevations that range from 875 m to 883 m. The average grade slope down to the north.

The proposed developments will be a mix of low to medium density residential developments accessed by an internal road network. The development will be tied into Town of Blackfalds' municipal infrastructure for water supply and sewage. Stormwater management facilities (ie. Storm ponds) are also proposed around the subdivision.

3.0 FIELD AND LABORATORY PROGRAMS

Two field and laboratory programs for the site investigation at this site were performed in 2002 and 2006.

- East ½ of SW 34-39-27-W4M was drilled on September 13, 2006. Four boreholes were drilled with truck mounted power auger drill to depths of 8 to 9 m below grade
  .
- SE 34-39-27-W4M was drilled on November 20 and 22, 2002. Twenty three boreholes were drilled at the site locations laid out by MPE Engineering Ltd. Three of these boreholes were located within the proposed development of Aspen Lakes West Development. Boreholes were drilled with truck mounted power auger drill to depths of 7 m.

The previous site investigations did not comply with the current 150 m borehole spacing required by the Town. Based on the area of the proposed Aspen Lakes West Development, there should be 18 boreholes spaced across the entire site. In addition to the historical geodata, 11 boreholes were drilled at the site on April 30, 2015. The approximate borehole locations from the previous site investigation and the location for new additional boreholes are shown on the Site Plan, Figure 2. Locations of boreholes were selected to provide general coverage of the site. The following sampling and testing procedures were followed during the field program:

- Prior to mobilizing the drilling rig, ParklandGEO completed an Alberta One Call and cleared the proposed borehole locations of underground utilities.

- The boreholes were drilled using a geoprobe owned and operated by Can Drill Solutions Inc. of Lacombe, Alberta, using solid stem augers.

- Drilling operations were monitored by members of ParklandGEO's geotechnical personnel. The soil encountered was visually examined during drilling and logged according to the Modified Unified Soil Classification System.

- Standard Penetration Tests were performed at selected depth intervals in all boreholes.

- At the completion of drilling, 25 mm hand-slotting PVC standpipes were installed in 5 of the boreholes and backfilled with auger cuttings. Groundwater levels were monitored at completion of drilling and measured on May 7, 2015.

- Samples were taken at 1.0 m intervals to determine the soil/moisture profile.

- All soil samples were returned to ParklandGEO's Red Deer laboratory for possible further testing.

- The ground surface elevations and locations of the boreholes were surveyed by ParklandGEO personnel using a Trimble GeoXH 2008 Series GPS receiver and a Trimble Zephyr GPS antenna. UTM coordinates and elevations are provided in the borehole logs in Appendix A.

4.0 SUBSURFACE CONDITIONS

The soil profile encountered at the site was fine sand and sandy silt of variable thickness overlying lacustrine silt and sand. The sand depths vary due to topography. Detailed descriptions of the soil conditions encountered at the borehole locations are provided in the logs in Appendix A. Individual soil test results and definitions of the terminology and symbols used on the borehole logs are provided on the explanation sheets in Appendix A. The following is a brief description of the typical soil types encountered.

4.1 TOPSOIL

The surficial topsoil up to 400 mm thick was found at the borehole locations. Thicker depths of topsoil may be encountered between borehole sites particularly around the slough and pond at the east of the property. This moderately organic, black and moist topsoil layer was considered to be weak and compressible under load.

4.2 LACUSTRINE SILT, SAND AND CLAY

Layers of interbedded silt, sand and clay soils were encountered below the topsoil or surface in all boreholes. These lacustrine materials are considered to typical in this area. The lacustrine deposits were generally non to low plastic, silts and fine sand with interbeds of silty clay at a compact state. These deposits had moisture contents in the order of 2 to 33 percent. The interbedded silty clay in the lacustrine deposits was medium plasticity with stiff consistency. Typical moisture contents for the silty clay were in the order of 15 to 33 percent range. It is estimated the majority of the lacustrine soils were above the OMC. These wet silty deposits were considered to be highly frost susceptible and sensitive to disturbance.

4.3 WATER SOLUBLE SULPHATES

A soil sample was taken at a depth of 2.0 m in all boreholes for water soluble concentration testing. The concentration is expressed as percent of the dry mass of soil. The concentration of water soluble sulphate was below 0.1 percent which is considered to be negligible. However, it is worth noting that this area in Blackfalds is known for very high sulphates as indicated in the previously referenced geotechnical reports which indicates a “severe potential for sulphate attack on burried concrete in direct contact with soil”. The sulphate concentration measured at the hole locations in the undeveloped areas of the site are shown on Figure 5.

5.0 GROUNDWATER LEVELS

Groundwater seepage was observed in the 7 boreholes drilled. Standpipes were installed in all boreholes. The groundwater levels measured on May 7, 2015 are summarized in the following table.

TABLE 1
HISTORICAL GROUNDWATER MEASUREMENTS

Borehole No.	Installation Date	Ground Elevation (m)	Groundwater Level (mbg)		Groundwater Elevations (m)
			Upon Completion	After 7 days	
2002-1	Nov 20/02	869.927	6.1	6.1	836.837
2002-6	Nov 20/02	874.956	Dry	Dry	< 867.956
2002-11	Nov 20/02	876.906	Dry	Dry	< 869.506
2006-1	Sep 13/06	-	Dry	Dry	-
2006-2	Sep 13/06	-	Dry	Well Destroyed	-
2006-3	Sep 13/06	-	Dry	Dry	-
2006-4	Sep 13/06	-	Dry	Dry	-

TABLE 2
GROUNDWATER MEASUREMENT FOR 2015 BOREHOLES

Borehole No.	Installation Date	Ground Elevation (m)	Borehole Depth (m)	Groundwater Level (mbg)		Groundwater Elevations (m)
				Upon Completion	May 7, 2015	
1	Apr 30/15	874.700	6.5	Dry	Dry	< 868.200
2	Apr 30/15	875.363	6.0	Dry	Dry	< 869.363
3	Apr 30/15	875.149	6.5	Dry	Dry	< 868.649
4	Apr 30/15	876.120	6.0	Dry	Dry	< 870.120
5	Apr 30/15	875.495	6.5	Dry	Dry	< 868.995
6	Apr 30/15	875.858	6.0	Dry	Dry	< 869.858
7	Apr 30/15	874.700	6.5	Dry	Dry	< 868.200
8	Apr 30/15	875.553	6.5	Dry	Dry	< 869.053
9	Apr 30/15	876.687	6.0	Dry	Dry	< 870.687
10	Apr 30/15	881.332	6.0	Dry	Dry	< 875.332
11	Apr 30/15	882.775	6.5	Dry	Dry	< 876.275

The groundwater levels measured for all the boreholes were dry except for Borehole 1 which was drilled in 2002. These groundwater conditions are considered to be typical for Blackfalds. Groundwater elevations are expected to fluctuate on a seasonal basis and will be highest after periods of heavy or prolonged precipitation and snow-melt. Groundwater seepage is expected for relatively shallow excavations at this site. The volumes of groundwater encountered will be dependent on seasonal conditions and the permeability of the soils within the profile.

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 GEOTECHNICAL EVALUATION

The subsurface conditions at this site are considered to be suitable for continued residential development. Construction considerations are expected to be similar to those found in north Blackfalds. Based on the existing topography, it is expected that significant cut/fills will be undertaken to pre-grade and level the site including areas of fill over 2 m deep. The main geotechnical concerns regarding soil conditions and foundations at the site include:

1. Final grading will impact the thickness of fills placed at the site and it is anticipated that some of the local depressions will be in-filled in areas proposed for housing. Placement of fill below expected footing elevations will need to be carefully addressed and monitored to minimize the potential for foundation problems due to settlement. Housing developed around the pond area at northeast may subject to some setbacks from steeper slopes.

2. Relatively loose, wet lacustrine soils may be encountered during site development trenching, depending on where the final grade is set. The siltier lacustrine soils are considered to be marginally suitable for use as road base and trench backfill.

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

4. Trench settlement should influence the layout of the underground services in the proposed subdivision to minimize or handle the potential for non-uniform subgrade due to trenching below roadways.

5. Silty clay soils will be moderately to highly frost susceptible if they are present and given access to free water or groundwater within the zone of seasonal frost (estimated to an average depth of 2.5 m). In general, the depth to the local water table for much of the site is relatively deep and will reduce potential heave in these frost susceptible soils.

6. bearing pressures for residential footing foundations will be suitable for the typical lightly loaded residential structures proposed.

6.2 SITE PREPARATION

It is recommended that all vegetation and topsoil be stripped from areas to be developed. Topsoil could be stockpiled for future use at the site. It is understood that the development will be levelled with a cut and fill operation, and for economic reasons, the native soil is expected to be used as general fill to raise lower areas of the site.

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

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

Special consideration must be given to deep fill areas below proposed residential structures (where fill depth are greater than 1.0 m below final grade). The engineered fill placed below structures should be uniformly compacted to at least 98 percent of SPMDD at a moisture content within 2 percent of OMC. The control of moisture content is considered to be important for the relatively dry, silty fill, because future wetting of these fill soils may cause significant settlement. These settlements could occur long after original construction depending on changes in the groundwater regime due to development (ie. lawn watering, servicing, etc.) and on normal seasonal conditions. If these density levels cannot be achieved using common fill during site grading, the footing bearing surfaces should be sub cut and underlain with select granular fills compacted to at least 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 in deep fill areas 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. If adequate density of deep fills is not achievable, other measures may be required to allow house development (ie. Pre-loads, staged development, etc). All residential lot and road development areas with deep fill should be subject to a detailed review to determine suitability and to provide recommendation for the proposed development.

6.3 SERVICE TRENCH INSTALLATION

6.3.1 Service Trench Excavation

It is expected that the majority of buried services will be installed within 4.0 m of ground surface. Therefore, excavations are not expected to extend below the groundwater table. Where excavations are proposed in the local sand, conventional trenched excavations with sloping sides and/or moveable shields are considered to be feasible. Open excavations at this site will require relatively flat side-slopes, particularly if wet conditions are encountered due to rain or runoff. Given the availability of space around the site, an open excavation is expected to be most economical. Side-slopes above the groundwater table should be at least 1H:1V or flatter. The degree of stability of excavated trench walls decreases with time and, therefore, construction should be directed at minimizing the length of time service trenches are left open.

If excavations are required in sands below the water table, very flat side slopes and/or dewatering measures such as sumps or well points may be required. The local sand is relatively permeable and will allow seepage into site excavations. Based on local experience with similar soil profiles in Blackfalds, side-slopes in the order of 3H:1V, or flatter, are expected for deeper excavations into the water table. Steeper cuts may be possible depending on contractor procedures, weather conditions and observed soil conditions in the excavation. The alternative would be to reduce the size of the excavation by many different configurations of braced/slope excavations and dewatering measures. Similarly, trench basing problems may be encountered if construction takes place during high groundwater (wet weather periods).

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. Quality workmanship is essential. Once disturbed, deep saturated cohesionless soils require very expensive measures to rehabilitate.

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

6.3.2 Pipe Bedding

Ideally, 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. Select native materials such as fine sand may be proposed for bedding. However, the use of these materials may require a higher level of compaction in order to satisfy the pipe manufacturer's requirements for adequate pipe support. Native materials consisting of high plastic clay or wet, silty clay that cannot be adequately compacted should not be used for pipe bedding. If granular bedding material is proposed, the following gradation specifications are recommended.

TABLE 3
GRADATION SPECIFICATIONS - GRANULAR BEDDING MATERIAL

Sieve Size (mm)	Percent Passing By Weight		
	Native Sand	Clean Sand	Drain Rock
50	-	-	100
40	-	-	95 - 100
20	-	-	5 -10
10	-	100	0 - 5
5	100	90 -100	0 - 5
2.5	-	80 - 95	-
1.25	66 - 100	55 - 85	-
0.63	52 - 100	30 - 65	-
0.315	35 - 78	10 - 35	-
0.160	18 - 43	2 - 10	-
0.080	2 - 12	0 - 8	-

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

6.3.3 Trench Backfill

It is assumed that trench backfill will consist of excavated sand or silty clay materials. The native sand is considered to be suitable for backfill, but may require removal adjustment of the natural moisture content to achieve proper compaction. Soil used for trench backfill should be free of frozen material, organics, and any other undesirable debris. To minimize fill settlement under self-weight, it is not recommended to allow the use of excavated soil for fill where the water

content exceeds the OMC of the soil by more than 5 percent. If excavated soils are excessively wet, the material should be dried or blended with dry soil prior to use.

Trench backfill in building areas should conform with the recommendations given under the site preparation discussion. In other developed areas, trench backfill should be placed in maximum 150 mm thick lifts compacted to 95 percent of the SPMDD to within 1.5 m of the finished ground surface and to a minimum 98 percent of the SPMDD from 1.5 m below ground surface to grade. The lift thicknesses should be governed by the ability of the selected compaction equipment to uniformly achieve the recommended density. It is recommended to use lifts with a maximum compacted thickness of 150 mm for clay soils.

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. For the compaction recommendations given above it is expected that total settlement in the order of 0.5 to 1.0 percent of the trench depth will occur. For properly moisture conditioned sand backfill the majority of the settlement is expected to occur with 2 to 4 months of backfill. Silty soils will take slightly longer to consolidate. 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 will not provide uniform roadway subgrades for the support of pavement sections. To minimize the effects of potential settlements on completed roadway surfaces, it is recommended that staged asphalt pavement construction be adopted and that placement of final asphalt concrete surfacing materials be delayed as long as possible, subsequent to completion of trench backfilling.

6.4 BASEMENT FOUNDATIONS

6.4.1 Footings

Standard house basement foundations using strip and spread footings will be acceptable at this site. Footings based on native sand or engineered fill 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 sand is expected to be easily disturbed, so it is suggested to finish the final 25 to 50 mm of excavation by hand after footing forms are placed to minimize disturbance to the bearing surface. The design and construction of residential foundations should conform to Alberta Building Code - Section 9. In general, footing excavations should be protected against surface water; footing bases should not be allowed to dry out excessively during construction; and the bearing soil should be protected against freezing during and after construction.

6.4.2 Grade Supported Slabs

Floor slabs should rest on at least 150 mm of free draining, granular base. Suitable materials would include coarse sand or crushed gravel with less than 10 percent passing the 0.080 mm sieve. The drainage layer below the slab should be compacted uniformly to at least 95 percent of SPMDD. Small vertical subgrade movements may be experienced therefore, provisions should be made for movements between partitions and adjoining columns or load bearing walls. In addition, where partitions are placed under structural members a space should be left at the top of the partition to allow vertical movement (at least 25 mm). Columns in basements which support floor joists should be adjustable. Water lines should be installed carefully to minimize the potential for breakage and leaks below slabs. Heating ducts below grade should be insulated to prevent drying of the subgrade soils.

6.4.3 Basement Subdrainage System

A permanent sub-drainage system (weeping tile drain) is recommended around the outside perimeter of basements. Lateral drains below the house are recommended in areas where the average groundwater table is within 1 m of the underside of basement slabs to reduce the hydrostatic pressures against foundation walls and floor slabs. Weeping tile drains should be surrounded with free draining crushed or washed rock. If required, a suitable geotextile wrap should be utilized to prevent the fine grained native soil from being washed into the drain. Groundwater infiltration flows can be significantly increased by poor site drainage around houses, improperly directed roof leaders and poorly graded or compacted backfill.

6.4.4 Basement Excavations

For basement excavations deeper than 1.5 m, side slopes should be cut back to 1H:1V from the base. 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.

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.

6.4.5 Basement Backfill

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

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

6.5 CONCRETE

The water-soluble sulphate concentration from the sample tested indicates negligible potential for chemical attack of subsurface concrete, however the Blackfalds area is known to have areas with very high sulphates. Therefore high sulphate-resistance (Type HS) hydraulic cement is recommended for use in all subsurface concrete in contact with native soil at the site in accordance with CSA Standard CAN3-A23.1-14. The recommended minimum 56 day compressive strength is 32 MPa with a maximum water/cementing materials ratio of 0.45. All concrete exposed to a freezing environment either during or after construction should be air entrained.

6.6 ROADWAY SUBGRADE CONSTRUCTION

The native silty sand soil was found to have CBR value of 5.0. This CBR value is indicative of a moderate level of subgrade support. In general, the subgrade support from the drier sand would be greater than from areas of silty clay. The CBR value for local clay is expected to be 3.0 to 4.0.

The exposed 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. The recommended type of subgrade fill would be a relatively clean coarse graded gravel with a maximum aggregate size of 150 mm. A proposed gradation specification is provided below:

TABLE 4
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

This 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. Based on local experience, the gravel subbase thickness required to establish a stable construction base will be in the order of 200 mm to 500 mm.

Construction procedures should be designed to minimize disturbance to the subgrade and protect the integrity of the granular working mat. 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.

6.7 FLEXIBLE PAVEMENT DESIGN

Two flexible pavement designs are proposed for this residential subdivision, a light traffic section for the local residential streets, and a moderate traffic section for the residential collectors. For design purposes the Design Traffic in equivalent axle loads (80 kN axles) is 9 x 10^4 for local side roads and 1 x 10^6 for the proposed residential collector road in accordance with the Town of Blackfalds Design Guidelines. The flexible pavement sections provided below are based on a minimum design CBR of 4 for the native subgrade in a soaked condition. It is assumed that the subgrade is stable or localized soft areas will be subject to improvement measures as discussed above to provide an equivalent the level of subgrade support. Based on these assumptions the following flexible pavement sections are proposed:

TABLE 5
FLEXIBLE PAVEMENT DESIGN

Pavement Layer	Local	Collector
Design Traffic (ESAL's)	9 x 10^4	1 x 10^6
Asphalt Concrete	75 mm	100 mm
25 mm Crushed Base Gravel	150 mm	150 mm
Granular Sub-Base (minimum)	200 mm	300 mm

The performance of the proposed pavement design sections will be, in part, dependent on achieving an adequate level of compaction in subgrade and pavement materials. The recommended levels of compaction for the granular materials in the pavement section should be a minimum of 98 percent of SPMDD. To include the minimum thickness of granular subbase (as listed above) in the pavement section the upper portion of the layer must meet the 98 percent compaction standard. The asphalt concrete should be compacted to a minimum of 97 percent of Marshall density based on a 50 blow laboratory Marshall test.

Pavement materials should conform to the Town of Blackfalds specifications. Alternatively, it is recommended to use pavement materials conforming to the following specifications:

TABLE 6
ASPHALT CONCRETE

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

Aggregate materials for base and subbase gravel should be composed of sound, hard, durable particles free from organics and other foreign material. Alternate aggregate materials include the following Alberta Transportation specifications.

TABLE 7
RECOMMENDED AGGREGATE SPECIFICATIONS

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

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 2 percent are recommended. Allowing water to a 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. Thickening the pavement section will not significantly reduce the problems of long term fill settlement. 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 over trenches in the road bed should be decided based on the level of support expected from the subgrade based on field observations. The final asphalt surface should be delayed as long as possible after placement of the fill to allow time for fill settlement.

6.8 GRAVELLED LANES

It is understood gravel surfaced back lanes may be proposed for this subdivision. Expected traffic will include light vehicles, regular garbage collection trucks, grading equipment and occasional truck traffic. If gravel lanes are proposed, it should be noted that more vertical movement would be tolerated since annual maintenance of grades would be performed. The proposed lane pavement sections are based on a stable subgrade with design CBR of 4 in a soaked condition or subgrade improvement to an equivalent level of support.

TABLE 8
PROPOSED GRAVEL PAVEMENT SECTIONS FOR LANES

Pavement Sections	Gravel Lanes	
Design Traffic (ESAL's)	5×10^3	
20 mm Crushed Base Gravel Subbase Gravel (minimum)	250 mm -	150 mm 200 mm

The recommended levels of compaction for the granular materials should be a minimum of 98 percent of SPMDD. The gravel specifications in the preceding section may be used. If subbase gravel with a large maximum aggregate size is proposed the thickness of the subbase layer should be at least twice the diameter of the largest particle size. It is recommended to provide surface drainage with cross slope crowns of at least 2 percent on regularly maintained gravel lane surfaces. Allowing water to pond on gravel surfaces will lead to infiltration which could result in subgrade weakening and the associated higher maintenance costs.

6.9 INSPECTION

It is recommended that on-site inspection and testing be performed to verify that actual site conditions are consistent with assumed conditions which meet or exceed design criteria. The recommendations provided within this report are dependent on proper quality control of fill placement. Initial site stripping and excavation activities should be monitored by experienced and qualified geotechnical personnel. The placement of an engineered fill should be monitored and tested by a qualified soils technician to verify adequate levels of compaction and design standards are achieved. Based on the Alberta Building Code, adequate levels of inspection are considered to be: review of all completed bearing surfaces for footings and full time inspection during construction of deep foundations; and monitoring and compaction testing of engineered fill.

7.0 CLOSURE

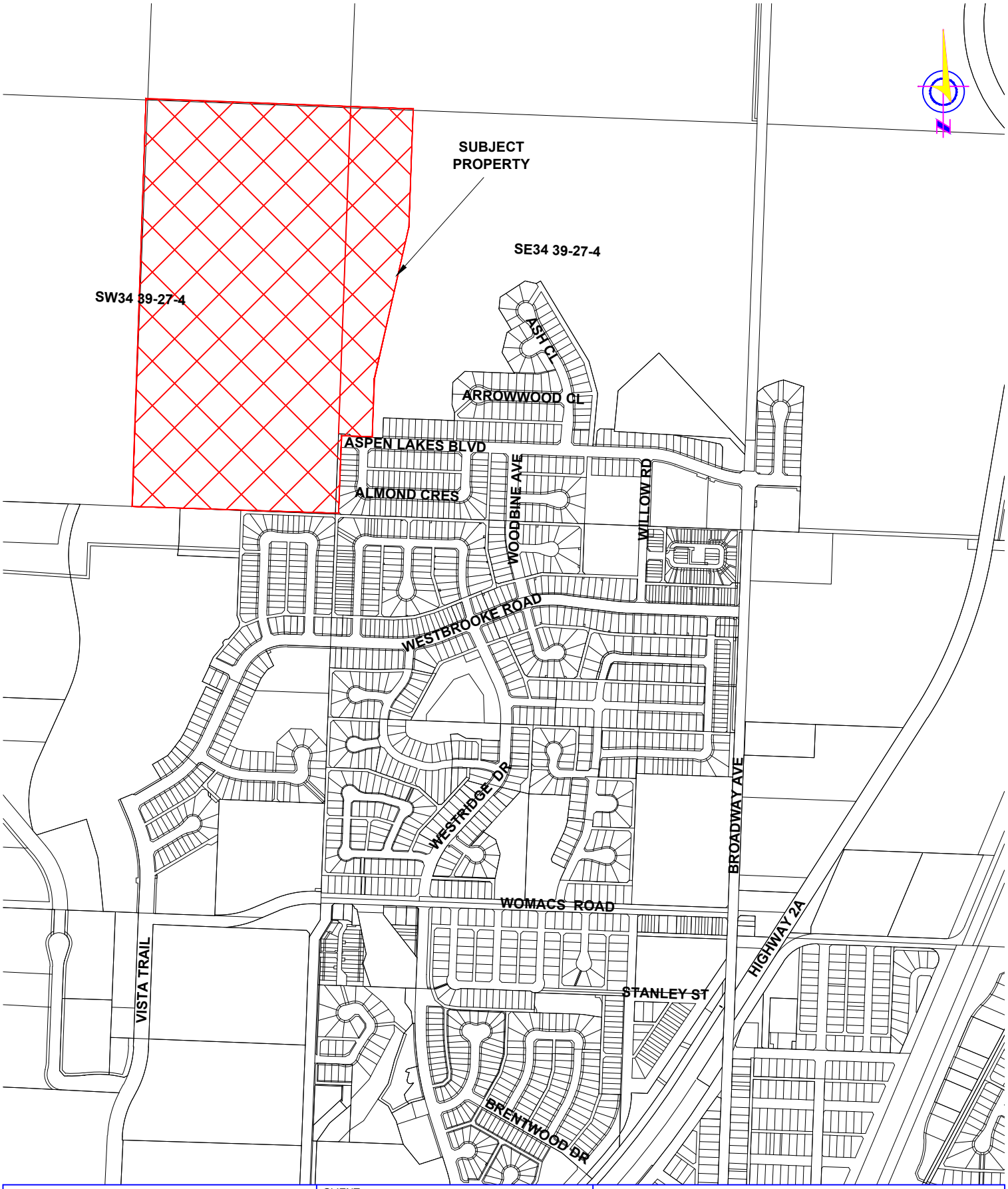
This report is based on the findings at the 18 boreholes at the site. If new information or different subsoil/groundwater conditions are encountered, this office must be notified and recommendations submitted herein will be reviewed and revised as required. This report has been prepared for the exclusive use of **Aspen Lake West Development Inc., Stantec Consulting Ltd.** and their approved agents for the specified application to the proposed residential subdivision within portion of SW and SE 34-39-27-W4M in Blackfalds, Alberta. This report has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made. The limitations of this report are specified in the General Terms and Conditions section and should be considered part of this report.

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

Nick Ng, P.Eng
Geotechnical Engineer

Reviewed By:
Mark Brotherton, P. Eng.

FIGURES



ParklandGEO

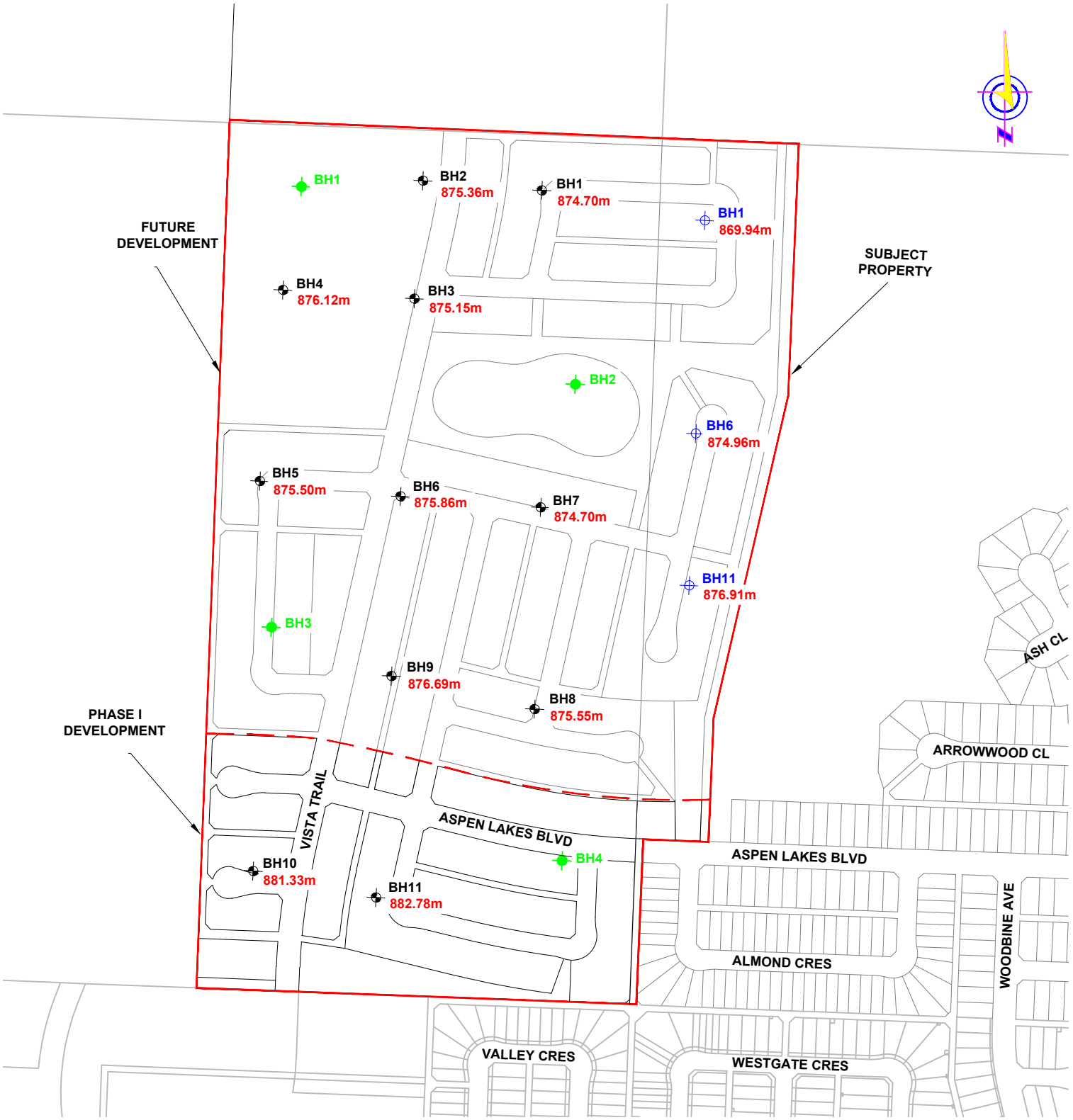
CLIENT: Stantec

KEY PLAN

ASPEN LAKE WEST SUBDIVISION
PORTION OF SW AND SE 34-39-27-W4M, BLACKFALDS, AB

DRAWN:	CHK'D.:	REV #:	DATE:
NC	NN	1	JUNE 2015

SCALE:	JOB NO.	DRAWING NO.
NTS	RD5288	FIGURE 1



ALL BOREHOLE LOCATIONS ARE APPROXIMATE

- BOREHOLES IN 2015 (RD5288)
- BOREHOLES IN 2006 (RD2208)
- BOREHOLES IN 2002 (RD0814)
- 874.70m SURFACE ELEVATION

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

CLIENT: Stantec

SITE PLAN

ASPEN LAKE WEST SUBDIVISION
PORTION OF SW AND SE 34-39-27-W4M, BLACKFALDS, AB

DRAWN:	CHK'D.:	REV #:	DATE:
NC	NN	1	JUNE 2015

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5288	FIGURE 2

NOTE: AERIAL PHOTOGRAPH OBTAINED FROM ABACUS DATAGRAPHICS LIMITED, DATED MAY 9, 2013 TO JULY 3, 2013.

ALL BOREHOLE LOCATIONS ARE APPROXIMATE

- NEW BOREHOLES (2015)
- BOREHOLES IN 2006 (RD2208)
- BOREHOLES IN 2002 (RD0814)

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

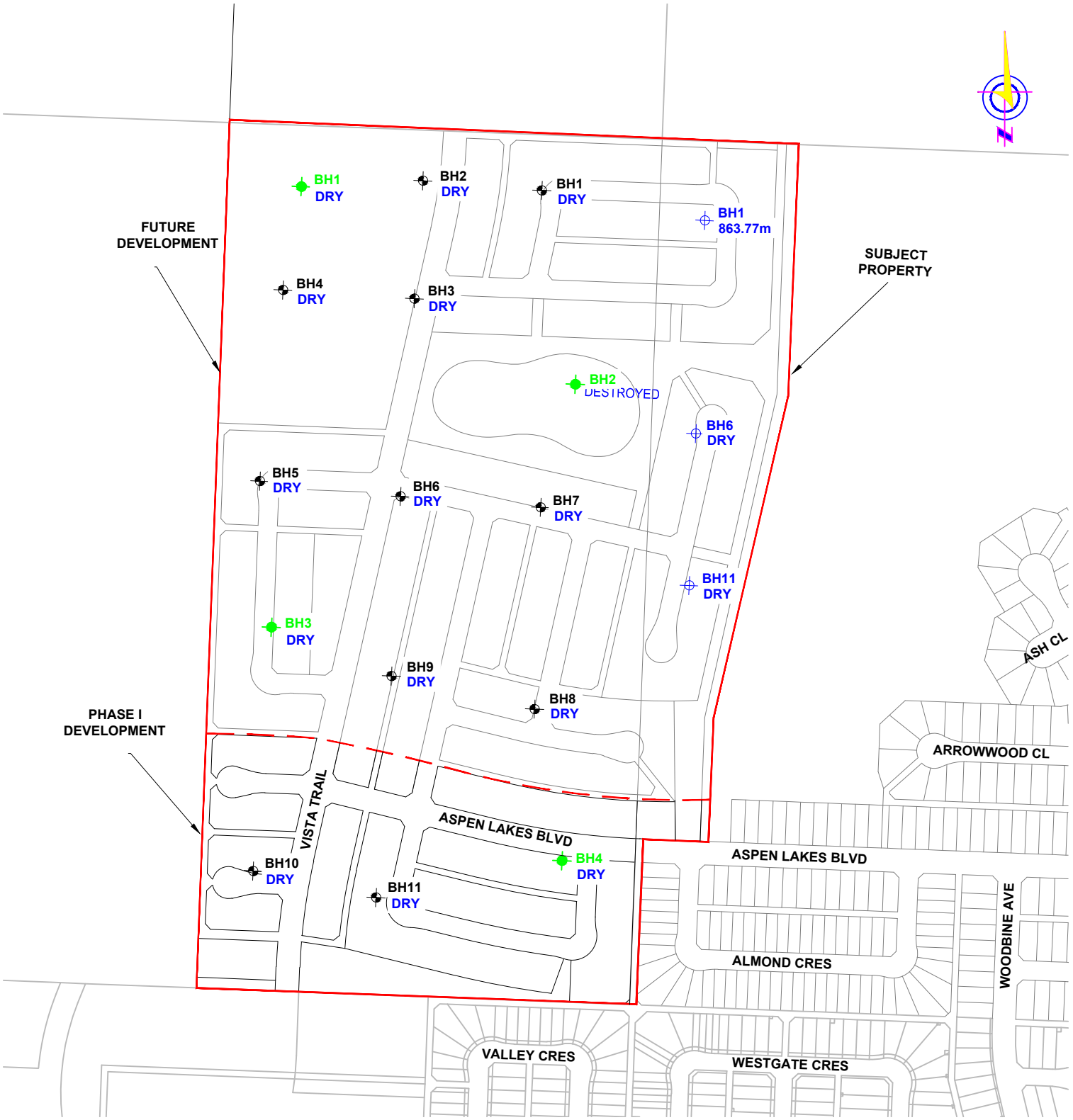
CLIENT: Stantec

AERIAL PLAN

ASPEN LAKE WEST SUBDIVISION
PORTION OF SW AND SE 34-39-27-W4M, BLACKFALDS, AB

DRAWN:	CHK'D.:	REV #:	DATE:
NC	NN	1	JUNE 2015

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5288	FIGURE 3



ALL BOREHOLE LOCATIONS ARE APPROXIMATE

- BOREHOLES IN 2015 (RD5288)
- BOREHOLES IN 2006 (RD2208)
- BOREHOLES IN 2002 (RD0814)
- DRY — GROUNDWATER ELEVATION (MAY 7, 2015)

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

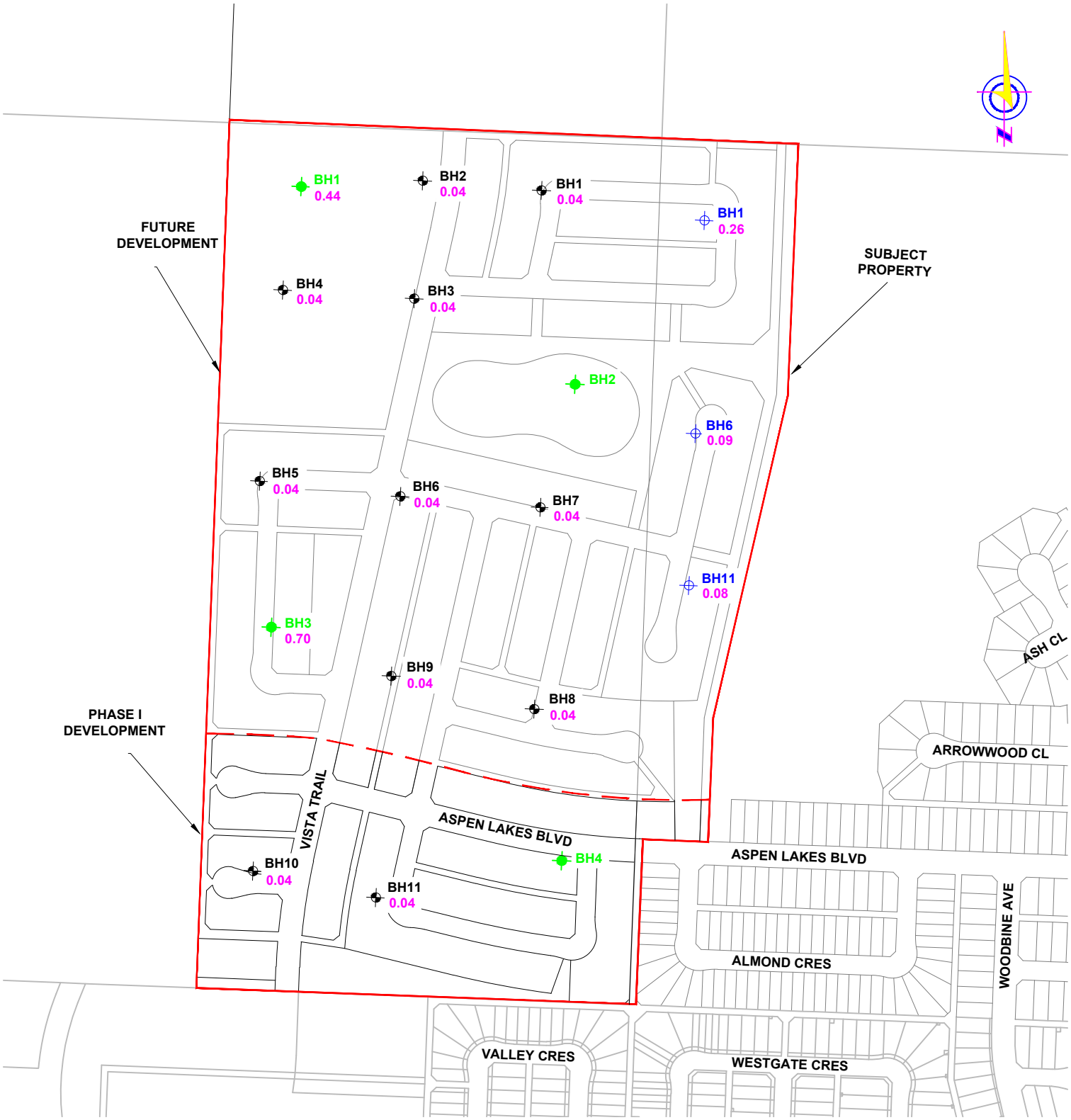
CLIENT: Stantec

GROUNDWATER ELEVATION

ASPEN LAKE WEST SUBDIVISION
PORTION OF SW AND SE 34-39-27-W4M, BLACKFALDS, AB

DRAWN:	CHK'D.:	REV #:	DATE:
NC	NN	1	JUNE 2015

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5288	FIGURE 4



ALL BOREHOLE LOCATIONS ARE APPROXIMATE

- BOREHOLES IN 2015 (RD5288)
- BOREHOLES IN 2006 (RD2208)
- BOREHOLES IN 2002 (RD0814)
- 0.04 SULPHATE CONCENTRATIONS (%)

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

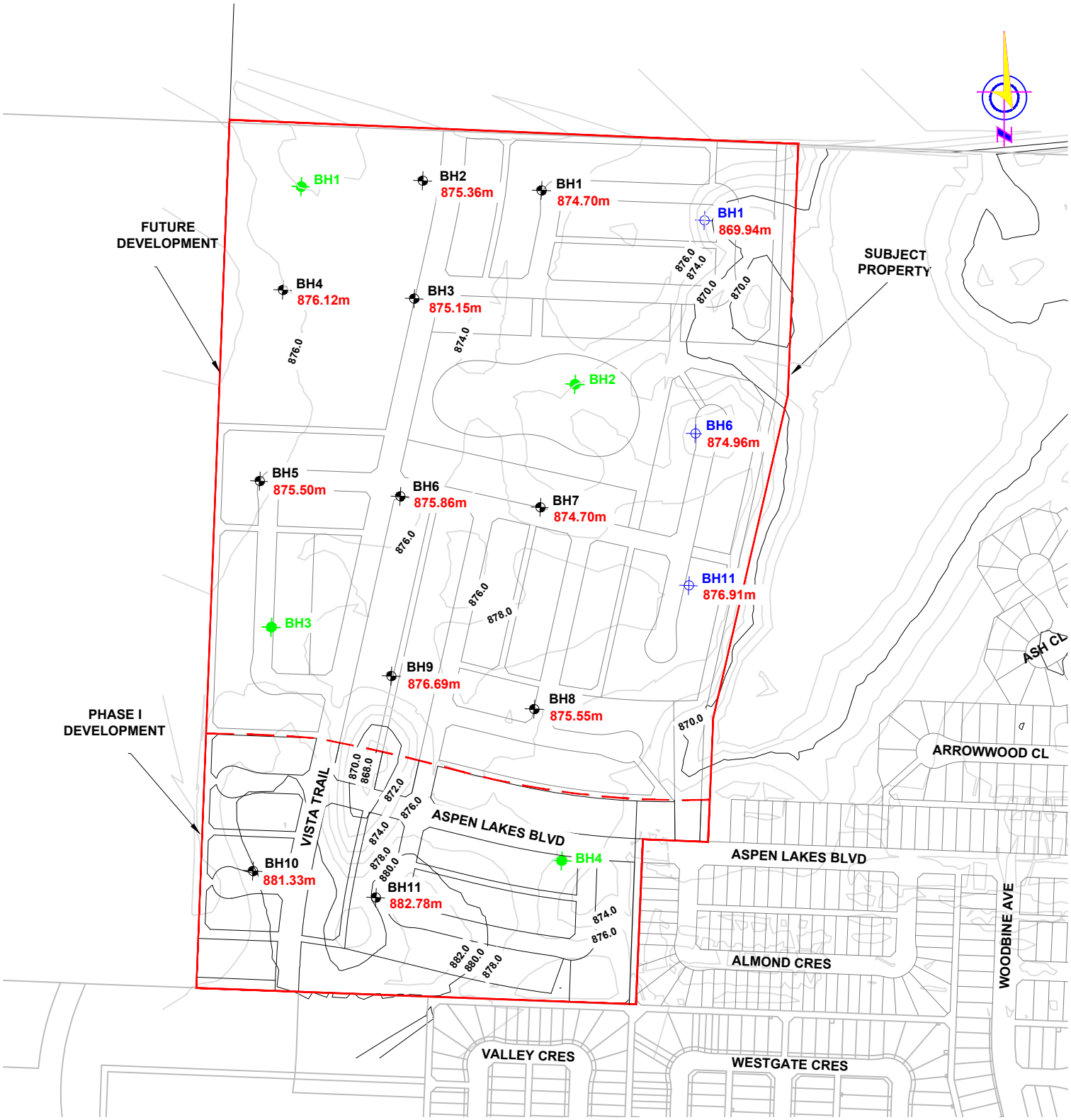
CLIENT: Stantec

SULPHATE CONCENTRATIONS

ASPEN LAKE WEST SUBDIVISION
PORTION OF SW AND SE 34-39-27-W4M, BLACKFALDS, AB

DRAWN:	CHK'D.:	REV #:	DATE:
NC	NN	1	JUNE 2015

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5288	FIGURE 5



NOTE: CONTOUR PLAN OBTAINED FROM CLIENT, ELEVATIONS ARE IN METRES.

ALL BOREHOLE LOCATIONS ARE APPROXIMATE

- BOREHOLES IN 2015 (RD5288)
- BOREHOLES IN 2006 (RD2208)
- BOREHOLES IN 2002 (RD0814)

SCALE (metres)

-100 -50 0 50 100 200

ParklandGEO

CLIENT: Stantec

CONTOUR PLAN

ASPEN LAKE WEST SUBDIVISION
PORTION OF SW AND SE 34-39-27-W4M, BLACKFALDS, AB

DRAWN:	CHK'D.:	REV #:	DATE:
NN	LB	1	JUNE 2015

SCALE:	JOB NO.	DRAWING NO.
1:5000	RD5288	FIGURE 6

APPENDIX A

Borehole Logs
Soil Test Results
AT Specifications
Explanation Sheets

BOREHOLE NO.: 01

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								874.70
	Topsoil Organic, black, moist.								874.40
1	***Clay*** Little silt, trace sand, firm to stiff, low plastic, brown, damp.		24	G	1G1				
	Sand Little silt, compact, fine grained, brown, occcasional black staining, dry.								873.30
2			4				SO_4 = 0.04		
3			4		1D1	18			
4			5	G	1G2				
5			4						
6	- Black staining, wet at 5.9 m.		13		1D2	14			
	End of hole at 6.5 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015.								868.20
7									867.20

SOLID PVC PIPE
SLOTTED PVC PIPE
BACKFILLED WITH AUGER CUTTINGS

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 874.700 m
NORTHING: 5808902.012
EASTING: 308887.517

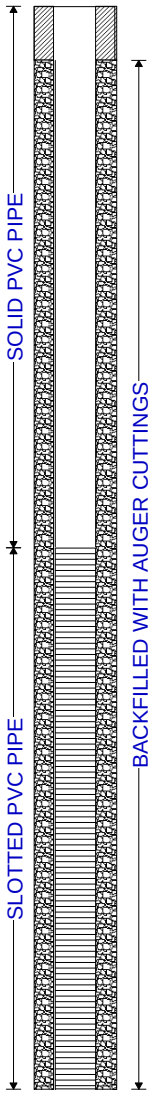
BOREHOLE NO.: 02

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								875.36
0	***Topsoil*** Organic, black, moist.								
	Clay Little silt, trace sand, stiff, low to medium plastic, brown, occasional black staining, damp.		17	G	2G1				
1									873.76
	Sand Little silt, compact, fine grained, brown, damp. - little gravel at 1.9 m.		9		2D1	14	SO_4 = 0.04		
2									873.26
	Silt Little clay, little sand, stiff, non plastic, brown, occasional rust staining, damp.		12						
3									872.26
	Clay Little to some silt, trace sand, stiff, medium plastic, brown, damp.		18	G	2G2				
4									870.76
	Sand Little silt, compact, fine grained, brown, occasional black staining, damp.		5		2D2	13			
5									
	- Wet at 6.0 m.		13						
6	End of hole at 6.0 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion.								869.36
7									867.86



LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 875.363 m
NORTHING: 5808906.279
EASTING: 308776.307

BOREHOLE NO.: 03

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								875.15
0	***Topsoil*** Organic, black, moist.								
	Silt Little clay, little sand, firm, non plastic, brown, damp.		9						
1									874.05
	Sand Little silt, trace gravel, compact, fine grained, brown, occcasional black staining, dry.		2				SO_4 = 0.04		
2				G	3G1		Grain Size Analysis: Gravel - 4.4% Sand - 84.3% Silt and Clay - 11.3%		
			3						
3					3D1	14			
			4						
4									
			2						
5				G	3G2				
			2						
6					3D2	9			
	End of hole at 6.5 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015								868.65
7									867.65

SOLID PVC PIPE
BACKFILLED WITH AUGER CUTTINGS
SLOTTED PVC PIPE

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 875.149 m
NORTHING: 5808796.002
EASTING: 308773.148

BOREHOLE NO.: 04

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								846.12
0	***Topsoil*** Organic, black, moist.								
	Silt Little clay, little sand, stiff, non plastic, brown, occasional rust staining, damp.		8						
1									845.02
	Sand Little silt, trace gravel, compact, fine grained, brown, damp.		7		4D1	18			
2							SO_4 = 0.04		
			11	G	4G1				
3	- Dry at 3. 4 m.								
			4						
4									
			4		4D2	13			
5									
			5						
6	End of hole at 6.0 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015.								840.12
7									838.62

SOLID PVC PIPE
SLOTTED PVC PIPE
BACKFILLED WITH AUGER CUTTINGS

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 876.120 m
NORTHING: 5808798.829
EASTING: 308650.323

BOREHOLE NO.: 05

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								875.50
0	***Topsoil*** Organic, black, moist.								875.29
	Sand Little silt, trace gravel, compact, fine grained, brown, damp.		6	G	5G1		SO_4 = 0.03		
1									
									873.89
	Silt Little clay, little sand, stiff, non plastic, brown, occasional rust staining, damp.		6				SO_4 = 0.04		873.70
2	***Sand*** Little silt, loose to compact, coarse grained, brown, dry to damp.								
			5		5D1	5			
3									
			4						
4									
	- Fine grained at 4.7 m.		4	G	5G2				
5									
			5		5D2	16			
6									869.00
	End of hole at 6.5 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015.								
7									868.00

SOLID PVC PIPE
SLOTTED PVC PIPE
BACKFILLED WITH AUGER CUTTINGS

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 875.495 m
NORTHING: 5808619.696
EASTING: 308636.283

BOREHOLE NO.: 06

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								875.86
0	***Topsoil*** Organic, black, moist.								875.66
	Sand Little silt, compact, fine grained, brown, damp.		5						
1									
			6		6D1	7			
2							SO_4 = 0.04		
			7	G	6G1				
3									
			9						
4									
					6D2	14			
5			6						
			7						
6	End of hole at 6.0 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015.								869.86
7									868.36

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

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 875.858 m
NORTHING: 5808610.984
EASTING: 308767.947

BOREHOLE NO.: 07

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								874.70
0	***Topsoil*** Organic, black, moist.								874.50
	Sand Little silt, compact, coarse grained, brown, damp.								873.90
1	***Silt*** Little clay, little sand, firm, non plastic, brown, occasional rust staining, damp.		17						873.70
	Sand Little silt, compact, coarse grained, brown, damp.		7				SO_4 = 0.04		
2									
3			5		7D1	11			
4			5	G	7G1		Grain Size Analysis: Sand - 86.0% Silt and Clay - 14.0%		
5			6						
6			6		7D2	11			868.20
7	End of hole at 6.5 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015.							SOLID PVC PIPE; SLOTTED PVC PIPE; BACKFILLED WITH AUGER CUTTINGS	867.20

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 874.700 m
NORTHING: 5808606.385
EASTING: 308899.106

BOREHOLE NO.: 08

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								875.55
	Topsoil Organic, black, moist.								875.15
	Sand Little silt, compact, coarse grained, brown, damp.								874.65
1	***Clay*** Some silt, trace sand, stiff, medium plastic, brown, occasional black and rust staining, moist.		20	G	8G1				
2			29				SO_4 = 0.04		
3			33		8D1	12	Grain Size Analysis: Sand - 1.8% Silt - 32.3% Clay - 65.8%		
4			32						
5			24	G	8G2				869.75
6	***Silt*** Little clay, little sand, stiff, non plastic, brown, occasional rust staining, damp.		14		8D2	17			869.05
7	End of hole at 6.5 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015.							SOLID PVC PIPE; SLOTTED PVC PIPE; BACKFILLED WITH AUGER CUTTINGS	868.05

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 875.553 m
NORTHING: 5808417.961
EASTING: 308901.476

BOREHOLE NO.: 09

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
0	GROUND SURFACE								876.69
	Topsoil Organic, black, moist.								876.39
	Sand Little silt, trace gravel, compact, fine grained, brown, damp.								875.89
1	***Silt*** Little clay, little sand, stiff, non plastic, brown, occasional rust staining, wet.		6						875.69
	Sand Little silt, loose to compact, coarse grained, brown, dry to damp.				9D1	7			
2			12				SO_4 = 0.04		
	- Fine grained at 2.1 m.								
3			5	G	9G1		SO_4 = 0.03		
4			6						
	- Little to trace gravel, coarse grained at 4.6 m.				9D2	10			
5			4						
6	End of hole at 6.0 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015.		3						870.69
7									869.19

SOLID PVC PIPE
SLOTTED PVC PIPE
BACKFILLED WITH AUGER CUTTINGS

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 876.687
NORTHING: 5808443.116
EASTING: 308766.735

BOREHOLE NO.: 10

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								881.33
0	***Topsoil*** Organic, black, moist.								881.03
	Sand Little silt, trace gravel, compact, fine grained, brown, damp.		6						
1									
			11		10D1	7			
2	***Silt and Clay*** Little sand, stiff, non plastic, brown, occasional rust staining, damp.						SO_4 = 0.04		879.33
				G	10G1		Grain Size Analysis: Sand - 17.9% Silt - 44.1% Clay - 38.0%		
			12						
3	***Sand*** Little silt, loose to compact, coarse grained, brown, dry to damp.								878.33
			6						
4									
					10D2	7			
5			4						
	- Wet 5.8 m.								
			15						
6	End of hole at 6.0 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015.								875.33
7									873.83

SOLID PVC PIPE
SLOTTED PVC PIPE
BACKFILLED WITH AUGER CUTTINGS

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 881.332 m
NORTHING: 5808255.705
EASTING: 308645.583

BOREHOLE NO.: 11

CLIENT: Stantec Consulting Ltd.
SITE: Aspen Lakes West
NOTES:

PROJECT NO.: RD5288
BH LOCATION:

SUBSURFACE PROFILE

Depth (m)	Description	Symbol	Moisture (Wp |-----X-----| Wl) 25 50 75	Type	Sample No	SPT (N)	Comments	Well Completion Details	Elevation (m)
	GROUND SURFACE								882.77
0	***Topsoil*** Organic, black, moist.								
	Silt Little clay, little sand, firm, non plastic, brown, occasional rust staining, damp.		11						
1									881.48
	Clay Some silt, trace sand, firm, medium plastic, brown, occasional black and rust staining, moist.		21	G	11G1		SO_4 = 0.04		880.77
2	***Sand*** Little silt, loose, fine grained, brown, damp.								
			5		11D1	4			
3									
			3						
4	- Black staining from 4.4 to 4.6 m.			G	11G2				
			6						
5									
			3		11D2	9			
6									876.27
	End of hole at 6.5 m. 25 mm PVC standpipe installed. Backfilled with auger cuttings. Dry upon completion. Dry on May 7, 2015.								
7									875.27

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

LOGGED BY: AZ
CONTRACTOR: Darkhorse Drilling Ltd.
RIG/METHOD: Geoprobe/ Solid Stem
DATE: April 30, 2015
CALIBRATION:

GROUND ELEVATION: 882.775 m
NORTHING: 5808235.918
EASTING: 308761.141

WATKINS LAND DEVELOPMENT LTD.	EVER GREEN DRILLING LTD.	TEST HOLE NO: 1
KUHNEN PROPERTY	TRUCK MOUNT	PROJECT NO: RD2208
SW1/4 34-39-27-W5M, LACOMBE COUNTY, AB	SOLID STEM AUGER	ELEVATION:

SAMPLE TYPE: TUBE | BULK | SPT | Grab | Split Pen | Core Sample

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

YDepth(m)	Soil Description	SAMPLE NO	SPT(N)	Comments/Other Data
0.0	TOPSOIL: organics, black, moist.			
	SILT: some clay trace sand, very stiff, low plastic, brown, occasional coal inclusions, dry.	1G1		
1.0				
		1D1	35	
2.0		1G2		SO4=0.44%
3.0		1G3		
4.0	SILT AND SAND: fine grained, poorly graded, some clay, comapct, brown, dry.			
		1D2	15	
5.0				
		1G4		GRAIN SIZE ANALYSIS: CLAY=27% SILT=38% SAND=35% GRAVEL=0%
6.0		1G5		
7.0				
		1D3		NO RECOVERY.
8.0	End of hole at 8.0m. Backfilled with cuttings. 25mm pipe installed to 4.9m. Sloughed to 4.9m. Dry upon completion. Dry on Sep20,2006.			
9.0				
10.0				
11.0				

PLASTIC — M.C. — LIQUID; 20 40 60 80

WELL INSTALLATION

ELEVATION(m): 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0

Parkland Geotechnical Consulting Ltd. Red Deer, Alberta	LOGGED BY: JC	COMPLETION DEPTH: 8 m
	REVIEWED BY: MDB	COMPLETE: 09/13/06
		Page 1 of 1

06/10/06 01:03PM (PARKLAND)

WATKINS LAND DEVELOPMENT LTD.	EVER GREEN DRILLING LTD.	TEST HOLE NO: 2
KUHNEN PROPERTY	TRUCK MOUNT	PROJECT NO: R02208
SW1/4 34-39-27-W5M, LACOMBE COUNTY, AB	SOLID STEM AUGER	ELEVATION:

SAMPLE TYPE: TUBE | BULK | SPT | Grab | Split Pen | Core Sample

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

YDepth(m)	Soil Description	SOIL SYMBOL	PLASTIC / M.C. / LIQUID (20 40 60 80)	SAMPLE TYPE	SAMPLE NO	SPT(N)	Comments/Other Data	WELL INSTALLATION	ELEVATION(m)
0.0	SAND AND SILT: trace organics, fine grained, poorly graded, loose, non plastic, brown, moist.				2G1				0.0
1.0									-1.0
2.0	SILT AND CLAY: trace sand, stiff, low plastic, brown, moist.				2G2				-2.0
	SAND AND SILT: fine grained, poorly graded, loose to compact, brown, occasional coal inclusions, moist.								
3.0					2D1	8			-3.0
4.0									-4.0
	SILT: some sand, some clay, stiff, low plastic, brown, moist.								
5.0									-5.0
6.0					2D2	13			-6.0
7.0									-7.0
8.0									-8.0
9.0									-9.0
	End of hole at 9.2m. Backfilled with cuttings. 25mm pipe installed to 8.0m. Sloughed to 8.0m. Dry upon completion. Well Destroyed on Sep20,2006.								
10.0									-10.0
11.0									-11.0

Parkland Geotechnical Consulting Ltd.
Red Deer, Alberta

LOGGED BY: JC	COMPLETION DEPTH: 9.2 m
REVIEWED BY: MDB	COMPLETE: 09/13/06
	Page 1 of 1

06/10/06 01:03PM (PARKLAND)

WATKINS LAND DEVELOPMENT LTD.	EVER GREEN DRILLING LTD.	TEST HOLE NO: 3
KUHNEN PROPERTY	TRUCK MOUNT	PROJECT NO: RD2208
SW1/4 34-39-27-W5M,LACOMBE COUNTY,AB	SOLID STEM AUGER	ELEVATION:

SAMPLE TYPE: TUBE | BULK | SPT | Grab | Split Pen | Core Sample

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

YDepth(m)	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	Comments/Other Data
0.0	SILT AND SAND: little clay, trace organics, fine grained, poorly graded, loose, non plastic, brown, moist.				
			3G1		
			3D1	7	GRAIN SIZE ANALYSIS: CLAY=13% SILT=32% SAND=35% GRAVEL=0% SO4=0.7%
2.0	SILT: some clay, trace sand, stiff, low plastic, brown, trace sulpher inlcusions, moist.				
			3G2		
			3D2	13	
5.0	SILT AND SAND: little clay, compact, non plastic, brown, coal inclusions, moist.		3BLK1		
6.0	SILT: sandy, clayey, stiff, non plastic, brown, moist.				
			3D3	17	
8.0	End of hole at 8.0m. Backfilled with cuttings. 25mm pipe installed to 8.0m. Dry upon completion. Dry on Sep20,2006.				
11.0					

PLASTIC M.C. LIQUID

20 40 60 80

WELL INSTALLATION

ELEVATION(m): 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0

Parkland Geotechnical Consulting Ltd.

Red Deer, Alberta

LOGGED BY: JC

REVIEWED BY: MDB

COMPLETION DEPTH: 8 m

COMPLETE: 09/13/06

06/10/06 01:03PM (PARKLAND)

WATKINS LAND DEVELOPMENT LTD.	EVER GREEN DRILLING LTD.	TEST HOLE NO: 4
KUHNEN PROPERTY	TRUCK MOUNT	PROJECT NO: RD2208
SW1/4 34-39-27-W5M, LACOMBE COUNTY, AB	SOLID STEM AUGER	ELEVATION:

SAMPLE TYPE: TUBE | BULK | SPT | Grab | Split Pen | Core Sample

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

YDepth(m)	Soil Description	SOIL SYMBOL	PLASTIC / M.C. / LIQUID (20 40 60 80)	SAMPLE TYPE	SAMPLE NO	SPT(N)	Comments/Other Data	WELL INSTALLATION	ELEVATION(m)
0.0	TOPSOIL: organics, black, moist.								0.0
	SILT: some clay, trace sand, trace organics, stiff, non plastic, brown, moist.				4G1				
1.0									-1.0
	SAND: fine grained, poorly graded, compact, brown, occassional coal inclusions, moist.								
2.0	CLAY: silty, trace sand, trace gravel, firm to stiff, medium plastic, brown, occasional coal inclusions, occasional rust stains, moist.								-2.0
3.0					4D1	12			-3.0
					4G2				
4.0	SILT AND SAND: trace clay, fine grained, poorly graded, compact, non plastic, brown, occasional coal, moist.								-4.0
5.0									-5.0
6.0					4D2	13			-6.0
7.0									-7.0
8.0									-8.0
9.0									-9.0
	End of hole at 9.2m. Backfilled with cuttings. Dry upon completion. Dry on Sep20,2006.								
10.0									-10.0
11.0									-11.0

Parkland Geotechnical Consulting Ltd.
Red Deer, Alberta

LOGGED BY: JC
REVIEWED BY: MDB

COMPLETION DEPTH: 9.2 m
COMPLETE: 09/13/06

06/10/06 01:03PM (PARKLAND)

MPE ENGINEERING LTD.	DRILLED WITH SOLID STEM AUGER	BOREHOLE NO: 1
RUTTEN SUBDIVISION		PROJECT NO: RD0814
SE34-39-27-W4M, BLACKFALDS, AB		ELEVATION: 869.937 m

SAMPLE TYPE: TUBE | BULK | SPT | Grab | Split Pen | Core Sample

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth(m)	Soil Description	Comments/Other Data
0.0	TOPSOIL: silty, black, damp (275mm).	Frost to 0.1 m.
	SAND: fine grained, some silt, compact, light brown, rootlets to 0.8 m, dry to damp.	
1.0	– medium coarse to coarse, dk. brown.	
2.0		SO4 = 0.26%
3.0	–silty.	Grain Size Analysis: Sand = 62 % Silt = 38 %
	SILT: some fine grained sand, little clay, trace pebbles, brown, interbedded, occ. coal, moist.	
4.0		
5.0		
6.0	– free water.	
7.0	End of Hole at 7.0 m. 25mm standpipe installed to 7.0m. Water at 6.1 m upon completion. Water at 6.1 m on November 22, 2002. Water at 6.1 m on December 2, 2002.	
8.0		

SOIL SYMBOL | PLASTIC M.C. LIQUID (20 40 60 80) | SAMPLE TYPE | SAMPLE NO | SPT(N) | WELL INSTALLATION | ELEVATION(m)

SAMPLE NO: 1G1

ELEVATION(m): 869.0, 868.0, 867.0, 866.0, 865.0, 864.0, 863.0, 862.0

Parkland Geotechnical Consulting Ltd.
Red Deer, Alberta

LOGGED BY: ART
REVIEWED BY: MDB

COMPLETION DEPTH: 7 m
COMPLETE: 20/11/02

02/12/05 12:20PM (PARKLAND)

MPE ENGINEERING LTD.	DRILLED WITH SOLID STEM AUGER	BOREHOLE NO: 6
RUTTEN SUBDIVISION		PROJECT NO: RD0814
SE34-39-27-W4M, BLACKFALDS, AB		ELEVATION: 874.956 m

SAMPLE TYPE: TUBE | BULK | SPT | Grab | Split Pen | Core Sample

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth(m)	Soil Description	SOIL SYMBOL	PLASTIC M.C. LIQUID (20 40 60 80)	SAMPLE TYPE	SAMPLE NO	SPT(N)	Comments/Other Data	WELL INSTALLATION	ELEVATION(m)
0.0	TOPSOIL: silty, black, damp (175mm).						Frost to 0.02m.		874.0
	SAND: medium grained, little silt, compact, light brown, rootlets to 0.6m, damp.								
1.0	-some silt.								873.0
	-trace fine sand, compact to dense, dry.						SO4 = 0.09%		
2.0									872.0
	-trace clay.								
3.0									871.0
	-little silt, dense.								
	-interbedded clay laminates.								
4.0	-coarse sand.								870.0
5.0									869.0
6.0									868.0
7.0	End of hole at 7.0m. 25mm standpipe installed to 7.0m. No water at completion. No water on November 22, 2002. No water on December 2, 2002.								867.0
8.0									

Parkland Geotechnical Consulting Ltd.
Red Deer, Alberta

LOGGED BY: ART
REVIEWED BY: MDB

COMPLETION DEPTH: 7 m
COMPLETE: 20/11/02

02/12/05 12:24PM (PARKLAND)

MPE ENGINEERING LTD.	DRILLED WITH SOLID STEM AUGER	BOREHOLE NO: 11
RUTTEN SUBDIVISION		PROJECT NO: RD0814
SE34-39-27-W4M, BLACKFALDS, AB		ELEVATION: 876.906 m

SAMPLE TYPE: TUBE | BULK | SPT | Grab | Split Pen | Core Sample

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth(m)	Soil Description	SOIL SYMBOL	PLASTIC M.C. LIQUID (20 40 60 80)	SAMPLE TYPE	SAMPLE NO	SPT(N)	Comments/Other Data	WELL INSTALLATION	ELEVATION(m)
0.0	TOPSOIL: silt, sand, black, damp. (200mm)								876.0
	SILT AND CLAY: some sand, firm, medium plastic, light brown, rootlets to 0.55m, dry to damp.								
1.0	-rootlets to 0.55m.						Grain Size Analysis: Sand = 7 % Silt = 53 % Clay = 40 %		875.0
	-trace clay.								
2.0							SO4 = 0.08%		
	-some clay.				11D1	15			874.0
	CLAY: silty, stiff, low to medium plastic, brown grey, damp.								
3.0									
	-sand/silt partings.				11D2	14			873.0
4.0									
	SILT: some clay, trace sand, stiff, low plastic, dry to damp.								872.0
5.0					11D3	15			
									871.0
6.0	-fine sand lense.								
7.0					11D4	22			870.0
	End of hole at 7.4m. 25mm standpipe installed to 6.8m. No water at completion. No water on November 22, 2002. No water on December 2, 2002.								869.0
8.0									

Parkland Geotechnical Consulting Ltd. Red Deer, Alberta	LOGGED BY: ART REVIEWED BY: MDB	COMPLETION DEPTH: *.* COMPLETE: 22/11/02
		Page 1 of 1

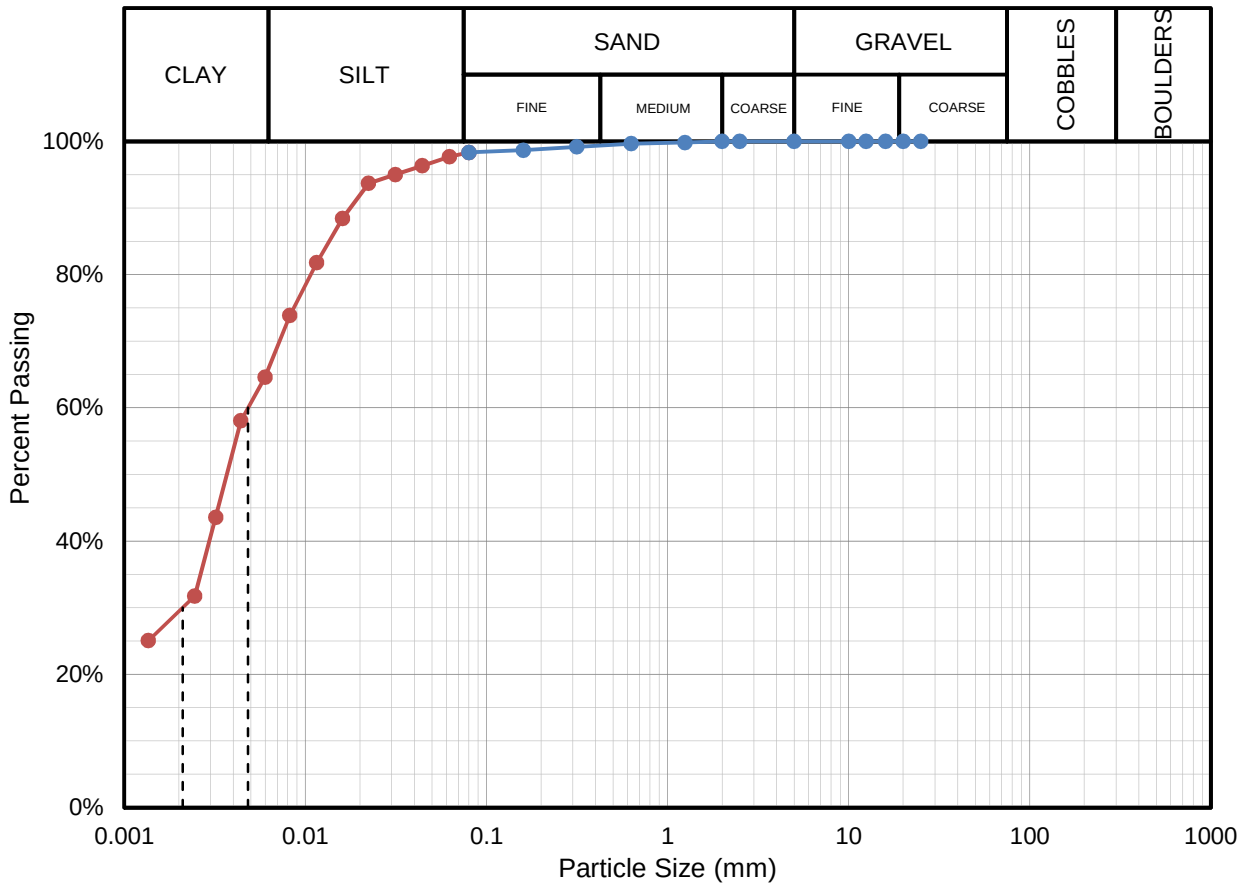
02/12/05 12:36PM (PARKLAND)

PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

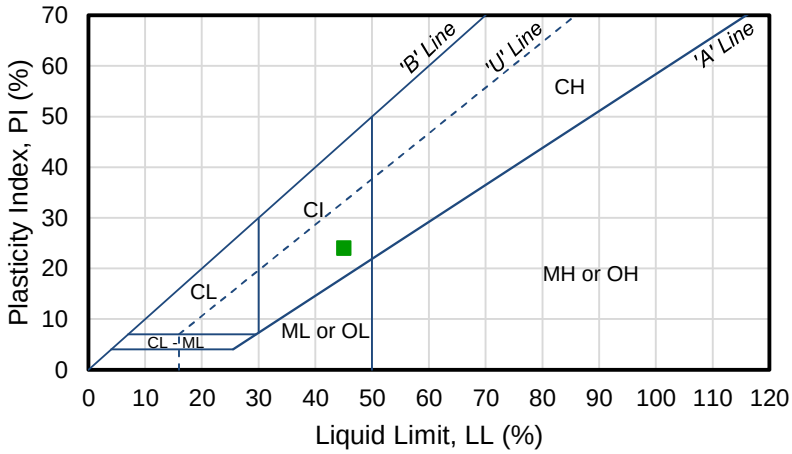
ASTM D422 & ASTM D4318

PROJECT: Aspen Lakes West
PROJECT#: RD5288
CLIENT: Stantec Consulting Ltd..
SOIL DESCRIPTION: clay, some silt, trace sand

SAMPLE DATE: May 7, 2015
TEST DATE: May 20/15
SAMPLE ID: 8D1
DEPTH: 3.0m



PARTICLE-SIZE ANALYSIS	Gravel	0.0%
	Sand	1.8%
	Silt	32.3%
	Clay	65.8%
	D_{10}	---
	D_{30}	0.0021 mm
	D_{60}	0.0048 mm
	C_U	---
	C_C	---
LIMITS	PL	21
	LL	45
	PI	24



Modified Unified Soil Classification	Group Symbol
Lean clay	CI

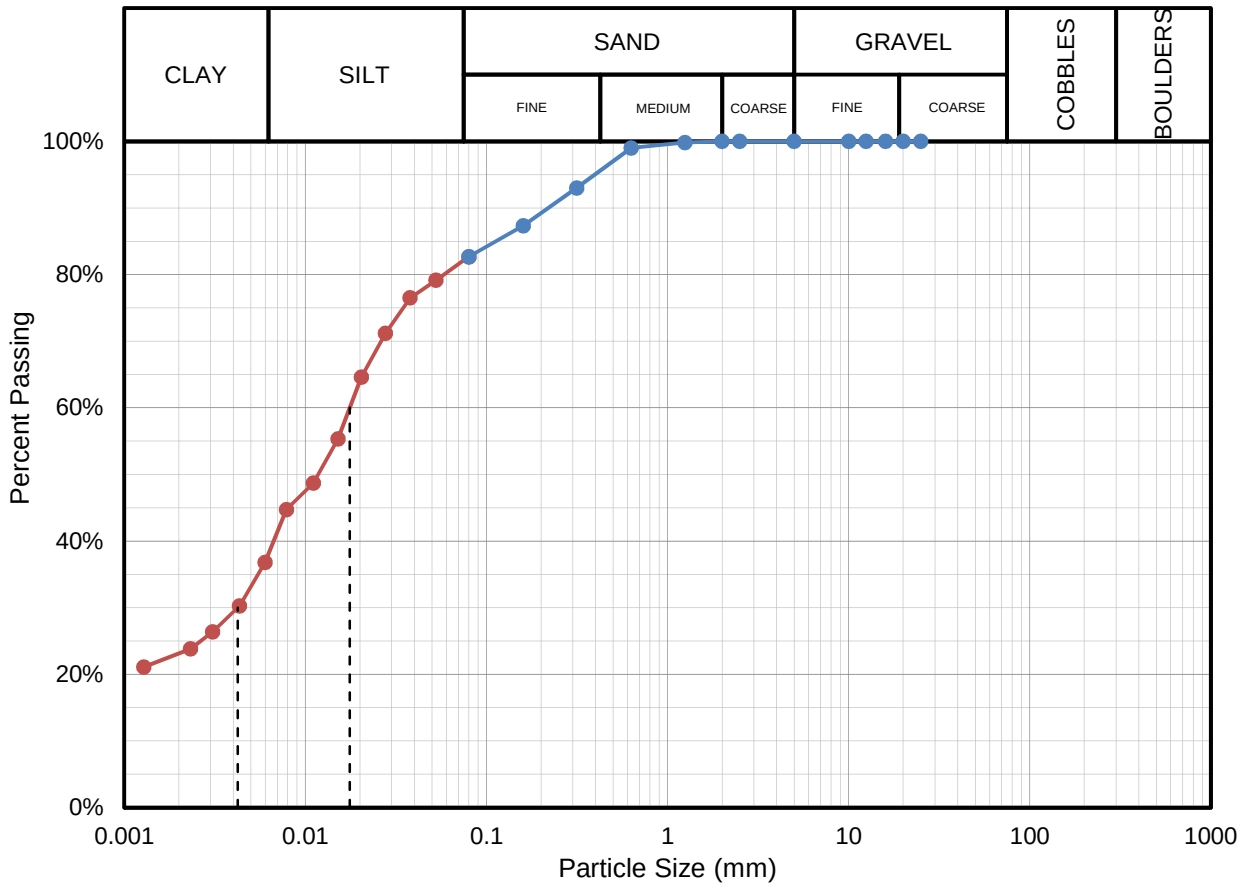
TECH: AB
CHECKED: ##
1 of 1

PARTICLE-SIZE ANALYSIS, LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY

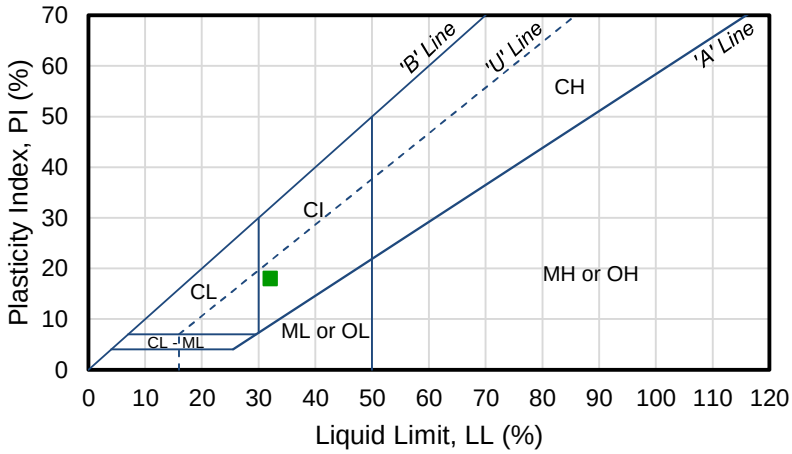
ASTM D422 & ASTM D4318

PROJECT: Aspen Lakes West
PROJECT#: RD5288
CLIENT: Stantec Consulting Ltd..
SOIL DESCRIPTION: silt, and clay, little sand

SAMPLE DATE: May 7, 2015
TEST DATE: May 20/15
SAMPLE ID: 10G1
DEPTH: 2.5m



PARTICLE-SIZE ANALYSIS	Gravel	0.0%
	Sand	17.9%
	Silt	44.1%
	Clay	38.0%
	D_{10}	---
	D_{30}	0.0042 mm
	D_{60}	0.0176 mm
	C_U	---
	C_C	---
LIMITS	PL	14
	LL	32
	PI	18



Modified Unified Soil Classification	Group Symbol
Lean clay with sand	CI

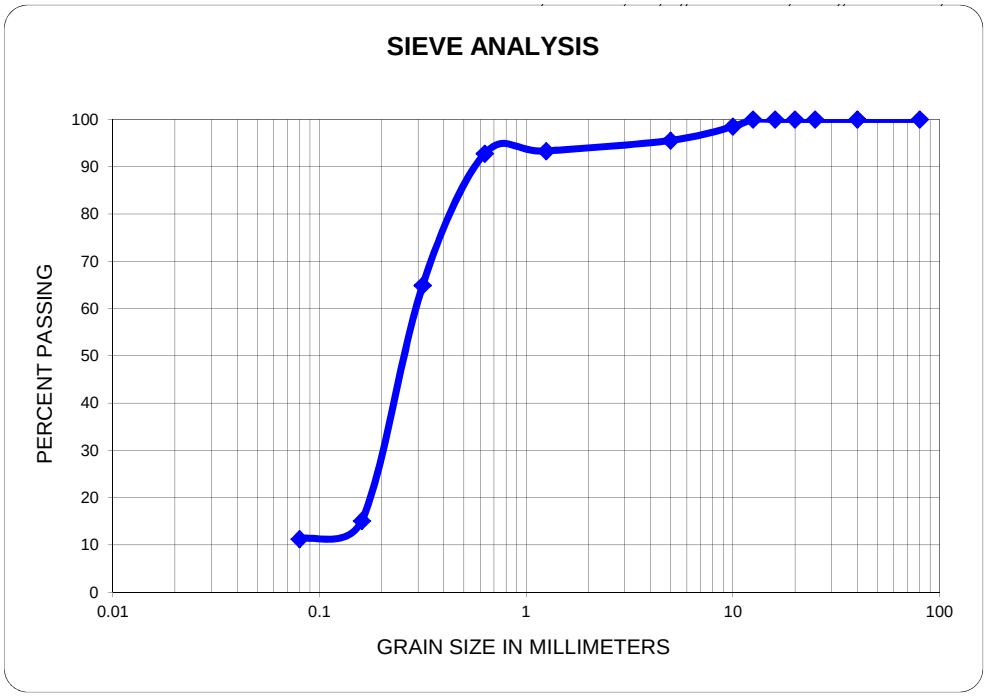
TECH: AB
CHECKED: ##
1 of 1

PROJECT - Aspen Lakes West
PROJECT # RD5288 **DATE -** May 11/15
SAMPLE SOURCE -
PIT NAME -
TECHNICIAN - AB **SIEVE #** 1

SIEVE NO.	OPENING SIZE (mm)	WEIGHT RETAINED (g)	TOTAL WT. FINER (gms)	PERCENT PASSING	SPECIFICATION Min.	SPECIFICATION Max.
80000	80		520	100.0		
40000	40		520	100.0		
25000	25		520	100.0		
20000	20		520	100.0		
16000	16		520	100.0		
12500	12.5		520	100.0		
10000	10	7.7	512.3	98.5		
5000	5	15.3	497	95.6		
1250	1.25	11.6	485.4	93.3		
630	0.63	2.8	482.6	92.8		
315	0.315	145.1	337.5	64.9		
160	0.16	258.7	78.8	15.2		
80	0.08	20	58.8	11.3		
SIEVE PAN		0.5				

MOISTURE CONTENT SAMPLE		SIEVE ANALYSIS SAMPLE		D.W.W.CALCULATIONS
A-WT. WET SAMPLE + PAN	1239	G-WT. OF DRY SAMPLE	520	
B-WT. DRY SAMPLE + PAN	1227.7	H- WASHED DRY +PAN	1169.7	
C-WT. OF WATER	11.3	I- WT OF WASHED DRY SAI	462	
D-WT. OF PAN	707.7	J- WT WASHED FINES	58	
E-WT. OF DRY SAMPLE	520			
F-MOISTURE CONTENT	2.2			

DESCRIPTION OF SAMPLE/COMMENTS	METHOD OF PREPARATION	WASHED
BH3	TOTAL WEIGHT	519.7
3G1	DRY WT.	520
2.5m	DIFFERENCE	-0.3
	% DIFFERENCE	-0.00057692

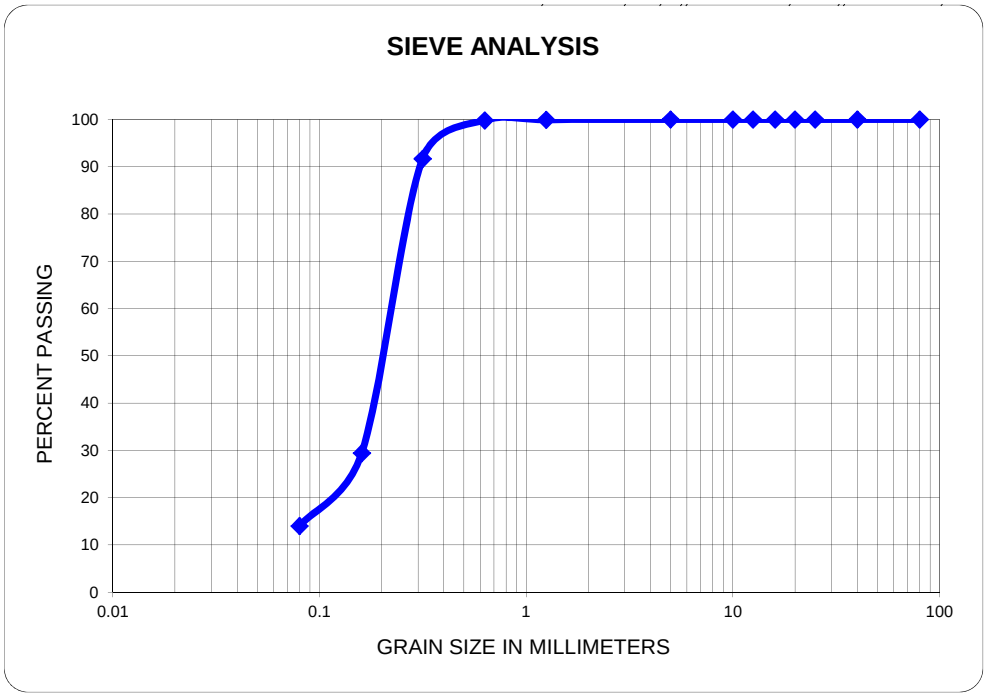


PROJECT - Aspen Lakes West
PROJECT # RD5288 **DATE -** May 11/15
SAMPLE SOURCE -
PIT NAME -
TECHNICIAN - AB **SIEVE #** 1

SIEVE NO.	OPENING SIZE (mm)	WEIGHT RETAINED (g)	TOTAL WT. FINER (gms)	PERCENT PASSING	SPECIFICATION Min.	SPECIFICATION Max.
80000	80		729.4	100.0		
40000	40		729.4	100.0		
25000	25		729.4	100.0		
20000	20		729.4	100.0		
16000	16		729.4	100.0		
12500	12.5		729.4	100.0		
10000	10		729.4	100.0		
5000	5		729.4	100.0		
1250	1.25	0.2	729.2	100.0		
630	0.63	1	728.2	99.8		
315	0.315	59.1	669.1	91.7		
160	0.16	454.1	215	29.5		
80	0.08	112.7	102.3	14.0		
SIEVE PAN		5.7				

MOISTURE CONTENT SAMPLE		SIEVE ANALYSIS SAMPLE		D.W.W.CALCULATIONS
A-WT. WET SAMPLE + PAN	1476	G-WT. OF DRY SAMPLE	729.4	
B-WT. DRY SAMPLE + PAN	1433.4	H- WASHED DRY +PAN	1336.8	
C-WT. OF WATER	42.6	I- WT OF WASHED DRY SAI	632.8	
D-WT. OF PAN	704	J- WT WASHED FINES	96.6	
E-WT. OF DRY SAMPLE	729.4			
F-MOISTURE CONTENT	5.8			

DESCRIPTION OF SAMPLE/COMMENTS	METHOD OF PREPARATION	WASHED
BH7	TOTAL WEIGHT	729.4
7G1	DRY WT.	729.4
4.1m	DIFFERENCE	0
	% DIFFERENCE	0



CALIFORNIA BEARING RATIO

ASTM D1883

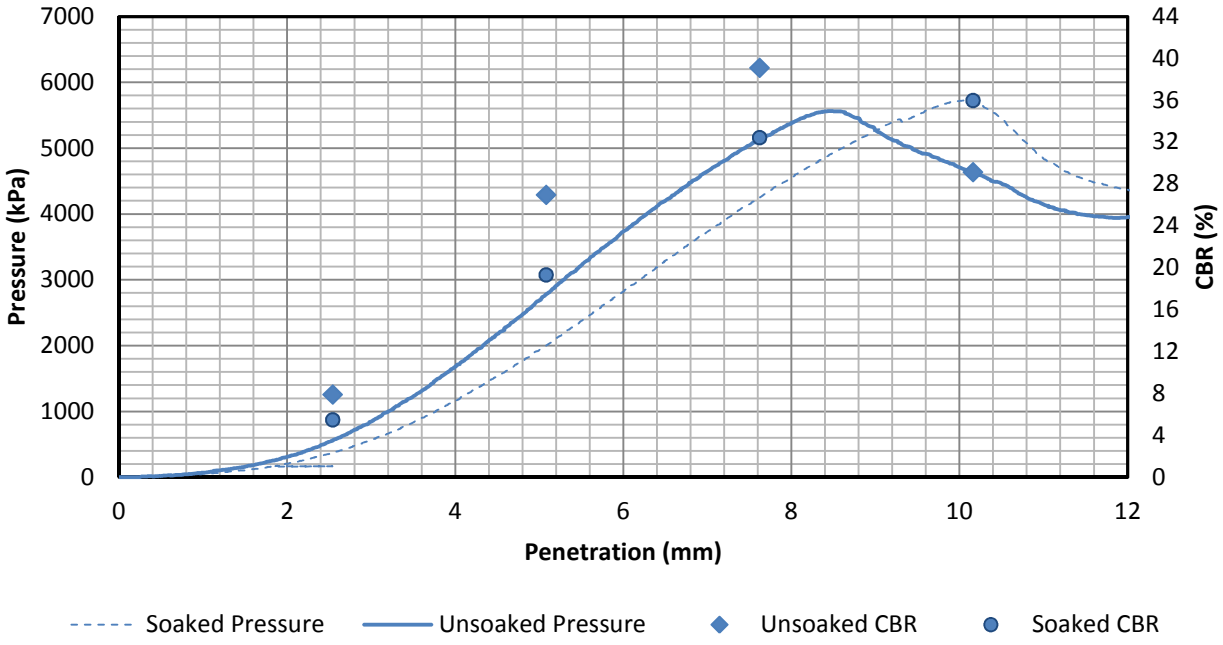
PROJECT: Aspen Lakes West
PROJECT#: RD5288
CLIENT: Stantec

SOIL DESCRIPTION: Silty Sand

SAMPLE ID: BH9
SAMPLE DATE: April 30, 2015
TEST DATE: May 15, 2015

PROCTOR NUMBER: P15-079
MAXIMUM DRY DENSITY: 1796 kg/m³
OPTIMUM MOISTURE CONTENT: 12.3%

		Unsoaked	Soaked
DRY DENSITY	Wet Sample + Mold (g)	11504.6	11523.7
	Mold (g)	7178.2	7130.3
	Wet Sample (g)	4326.4	4393.4
	Volume Mold (cm^3)	2128.7	2128.7
	Wet Density (kg/m^3)	2032.5	2063.9
	Dry Density (kg/m^3)	1810.4	1831.6
MOISTURE CONTENT	Sample Wet + Tare (g)	171.1	223.9
	Sample Dry + Tare (g)	154.3	200.6
	Water (g)	16.8	23.3
	Tare Container (g)	17.3	16.9
	Dry Soil (g)	137.0	183.7
	Moisture Content (%)	12.3%	12.7%
TEST RESULTS	Relative Compaction (%)	-	102.0%
	Relative Moisture Content (%)	0.0%	0.4%
	Surcharge Weight (kg)	-	4.54
	Initial Swell Reading (mm)	-	0.0920
	Final Swell Reading (mm)	-	0.0900
	Swell (%)	-	98%
	CBR at 2.54 mm (%)	7.9	5.5
	CBR at 5.08 mm (%)	27.0	19.3



TECH:TH
CHECKED:BL

MOISTURE DENSITY RELATIONSHIP WORKSHEET

V2.31 U20150316

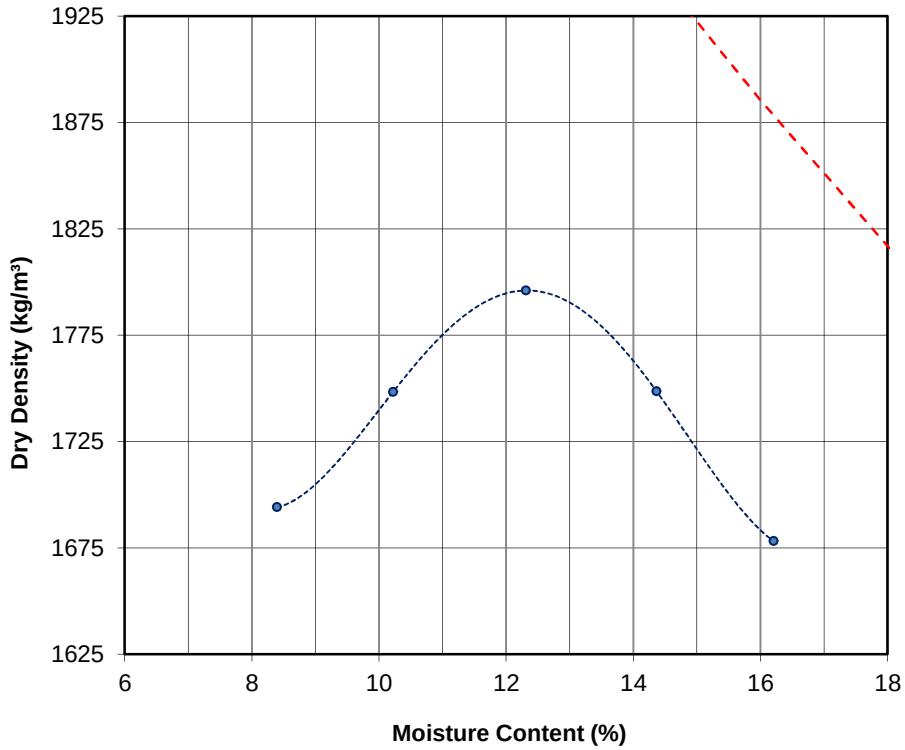
PROJECT: Aspen Lakes West | PROJECT #: RD5288
CLIENT: Stantec | DATE: 5-May-15

DRY DENSITY	SAMPLE NUMBER	1	2	3	4	5	
	Wt. Sample Wet + Mold	6502.2	6587.3	6671.8	6655.5	6608.9	
	Wt. Small Mold	4779.7	4779.7	4779.7	4779.7	4779.7	
	Wt. Sample Wet	1722.5	1807.6	1892.1	1875.8	1829.2	
	Volume Mold, cm³	938	938	938	938	938	
	Wet Density, kg/m³	1836	1927	2017	2000	1950	
	Dry Density, kg/m³	1694	1748	1796	1749	1678	
	Corr. Density, kg/m³						

MOISTURE	CONTAINER NUMBER	A	B	C	D	E	
	Wt. Sample Wet + Tare	226.2	250.0	309.8	262.2	253.0	
	Wt. Sample Dry + Tare	210.0	228.4	277.7	231.4	220.1	
	Wt. Water	16.2	21.6	32.1	30.8	32.9	
	Tare Container	17.1	17.1	17.0	17.0	17.1	
	Wt. Dry Soil	192.9	211.3	260.7	214.4	203.0	
	Moisture Content	8.4	10.2	12.3	14.4	16.2	
	Corr. Moisture Content						

DATE SAMPLED: 1-May-15
CONTRACTOR: N/A
SOURCE: BH 09
SAMPLED BY: A.Z.
PROCTOR #: P15-079

PREPARATION:
RAMMER TYPE:
COMPACTION STANDARD: ASTM D698



SOIL TYPE: Silty Sand

COMMENTS:

ROCK CORRECTION
% Rock Retained
4.75 mm Sieve
19.0 mm Sieve
% Moisture Content
Tare wt. :
Wet wt.+ Tare :
Dry wt. + Tare :
Wt. of Water :
Moisture Content:

MAXIMUM DRY DENSITY (Corrected)

MAXIMUM DRY DENSITY (Uncorrected): 1796 kg/m³

OPTIMUM MOISTURE CONTENT (Corrected)

OPTIMUM MOISTURE CONTENT (Uncorrected): 12.3 %

TECHNICIAN: C.H.
CHECKED: S.N-K.

Results are valid for <40 percent retained on 4.75 mm sieve, and <30 percent retained on 19 mm sieve as per ASTM D4718.

Project: Aspen Lakes West
Subject: Geotechnical Testing - Soil Sulphate Test Results
Project #: RD5288 **Date:** May 29, 2015

Soil Sulphate Test Results

Laboratory: Parkland Geotechnical

Sample #: 1M2 Borehole: 1 Depth: 2.0m Result (% Sulphate): 0.04	Sample #: 7M2 Borehole: 7 Depth: 2.0m Result (% Sulphate): 0.04
Sample #: 2M2 Borehole: 2 Depth: 2.0m Result (% Sulphate): 0.04	Sample #: 8M2 Borehole: 8 Depth: 2.0m Result (% Sulphate): 0.04
Sample #: 3M2 Borehole: 3 Depth: 2.0m Result (% Sulphate): 0.04	Sample #: 9M2 Borehole: 9 Depth: 2.0m Result (% Sulphate): 0.04
Sample #: 4M2 Borehole: 4 Depth: 2.0m Result (% Sulphate): 0.04	Sample #: 10M2 Borehole: 10 Depth: 2.0m Result (% Sulphate): 0.04
Sample #: 5M2 Borehole: 5 Depth: 2.0m Result (% Sulphate): 0.04	Sample #: 11M2 Borehole: 11 Depth: 2.0m Result (% Sulphate): 0.04
Sample #: 6M2 Borehole: 6 Depth: 2.0m Result (% Sulphate): 0.04	Sample #: Borehole: Depth: Result (% Sulphate):

REQUIREMENTS FOR CONCRETE SUBJECTED TO SULPHATE ATTACK (CAN/CSA-A231-M14)

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

Tech: AB **Chkd:** NN

AGAT Laboratories

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 15R980125

PROJECT: RD5288

CLIENT NAME: PARKLAND GEOTECHNICAL CONSULTING

ATTENTION TO: Nick Ng

SAMPLING SITE:

SAMPLED BY:

Soil Analysis - Soluble Sulfate

DATE RECEIVED: 2015-06-01

DATE REPORTED: 2015-06-03

		SAMPLE DESCRIPTION:		MC 5-1	MC 9-3
		SAMPLE TYPE:		Soil	Soil
		DATE SAMPLED:		4/30/2015	4/30/2015
Parameter	Unit	G / S	RDL	6608872	6608873
Sulfate, Soluble	mg/L		2	10	7
Sulfur (as Sulfate), Soluble (mg/kg)	mg/kg		2	3	3
Sulfur(as Sulfate), Soluble	% w/w		0.0002	0.0003	0.0003

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By:

ALBERTA TRANSPORTATION - SPECIFICATIONS FOR AGGREGATE (TABLE 3.2.3.1, DECEMBER 2010)

DESIGNATION		1				2				3				4			5		6		7	8	9
Class (mm)		10	12.5	16	25	*16(N2)	20	25	40	12.5AW	12.5BW	12.5C	16	20	25	40	10A	10B	80	125	40	25	8
Percent Passing Metric Sieve (CGSB 8-GP-2M) µm	125 000																			100			
	80 000																		100				
	50 000																		55-100	55-100			
	40 000								100							100					100		
	25 000				100			100	70-94						100				38-100	38-100		100	
	20 000				85-95		100	82-97						100		55-90							
	16 000			100	75-87	100	84-94	70-94	55-85				100						32-85	32-85		90-100	
	12 500		100	80-92	65-80	89-100				100	100	100	72-95										
	10 000	100	83-92	70-84	58-72	78-94	63-86	52-79	44-74	35-65	55-75	70-93	53-82	35-77	30-77	25-72	100	100			85-100	45-75	
	8 000																						100
	5 000	60-75	55-70	50-65	40-58	55-70	40-67	35-64	33-62	0-15	0-15	30-60	27-54	15-55	15-55	8-55	70-90	45-70	20-65	20-65		0-15	85-100
	1250	26-45	26-45	26-45	25-44	26-45	20-43	18-43	17-43	0-3	0-3	9-28	9-28	0-30	0-30	0-30	20-45	20-45			40-100	0-5	45-75
	630	18-38	18-38	18-38	16-36	18-38	14-34	12-34	12-34														30-50
	315	12-30	12-30	12-30	10-28	12-30	9-26	8-26	8-26			0-15	0-15				9-22	9-22	6-30	6-30	17-100		18-30
	160	8-20	8-20	8-20	6-18	8-20	5-18	5-18	5-18			0-11	0-11				5-15	5-15					10-21
	80	4-10	4-10	4-10	4-10	4-10	2-10	2-10	2-10	0-0.3	0-0.3	0-8	0-8	0-12	0-12	0-12	0-10	0-10	2-10	2-15	6-30		5-15
%FRACTURE BY WEIGHT (2 FACES)	ALL +5000	* SEE NOTE (N1)				60+	60+	60+	50+	75+ (100% 1 face)	75+ (100% 1 face)	60+	60+	40+	40+	25+	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PLASTICITY INDEX (PI)		NP	NP	NP	NP	NP	NP-6	NP-6	NP-6	N/A	N/A	NP-4	NP-4	NP-8	NP-8	NP-8	NP-6	NP-6	NP-8	NP-8	NP-5	NP-5	NP
L.A. ABRASION LOSS PERCENT MAX.		40	40	40	40	50	50	50	50	35	35	35	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35
FLAKINESS INDEX		N/A								MAX 15		N/A											
COEFFICIENT OF UNIFORMITY (C_U)		N/A																			3+	N/A	

Designations:

Designation 1 - Asphalt Concrete Pavement

Designation 2 - Base Course Aggregate

Designation 3 - Seal Coat Aggregate

Designation 4 - Gravel Surfacing Aggregate

Designation 5 - Sanding Material

Designation 6 - Gravel Fill

Designation 7 - Cement Stabilized Base Course Aggregate

Designation 8 - Granular Filter Aggregate

Designation 9 - Slurry Seal Aggregate

* Notes:

N1. According to Specification 3.50, Asphalt Concrete Pavement - EPS or 3.53, Apshalt Concrete Pavement - Superpave and Mix Type Specified.

N2. Designation 2 Class 16 Material is ASBC

N3. For crushed aggregates other than all Designation 5 and Designation 9 materials, a tolerance of three percent in the amount passing the maximum size sieve will be permitted provided all oversize material passes the next larger standard sieve size.

N4. Unless otherwise specified, Pit-Run Aggregate will be defined as unprocessed granular material, with no specified gradation requirement, that is extracted from an aggregate deposit.

THE PARKLANDGEO CONSULTING GROUP
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 materials, boundaries, and conditions have been established only at the borehole location 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 the borehole logs.

1. PRINCIPAL SOIL TYPE – The major soil type by weight of material or by behaviour.

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	0.075 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

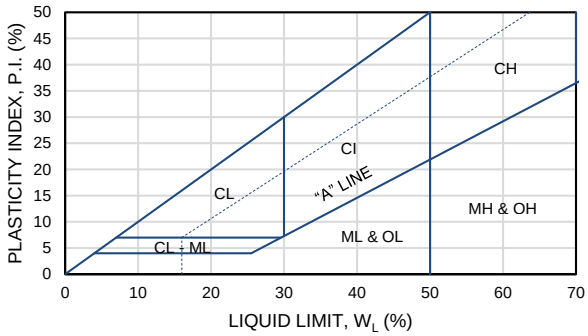
4. CONSISTENCY OF FINE GRAINED SOILS – The following terms are used relative to undrained shear strength and Standard Penetration Test (SPT), ASTM D1586, N value for blows per 300 mm. It is noted that this correlation needs to be used with caution as the correlation is only very approximate.

Description	Undrained Shear Strength, C_u (kPa)	N Value
Very Soft	Less than 12	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 150	15 to 30
Hard	Over 150	Over 30

THE PARKLANDGEO CONSULTING GROUP
EXPLANATION OF TERMS AND SYMBOLS

MODIFIED UNIFIED CLASSIFCATION 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, GRAVEL-SAND MIXTURE, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP		POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING 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. LESS 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	$C_U = \frac{D_{60}}{D_{10}} > Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP		POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING 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. LESS 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 OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)	
		$W_L > 50\%$	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY SOILS		
		$30\% < W_L < 50\%$	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS		
		$W_L > 50\%$	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$W_L < 50\%$	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW AND MEDIUM PLASTICITY		
		$W_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY, ORGANIC SILTS		
HIGHLY ORGANIC SOILS			Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	



NOTES ON SOIL CLASSIFICATION AND DESCRIPTION:

1. Soil are classified and described according to their engineering properties and behaviour.
2. Boundary classification for soil with characteristics of two groups are given combined group symbols (e.g. GW-GC is a well graded gravel sand mixture with clay binder between 5 and 12%).
3. Soil classification is in accordance with the Unified Soil Classification System (ASTM D2487) with the exception that an inorganic clay of medium plasticity (CI) is recognized.
4. The use of modifying adjectives may be employed to define the estimated percentage range by eight of minor components.

LIMITATION

General Terms and Conditions

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

1. STANDARD OF CARE - In the performance of professional services, ParklandGEO used the degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same or similar localities. No other warranty expressed or implied is made in any manner.

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

3. SITE INFORMATION - The CLIENT has agreed to provide all information with respect to the past, present and proposed conditions and use of the Site, whether specifically requested or not. The CLIENT acknowledged that in order for ParklandGEO to properly advise and assist the CLIENT, ParklandGEO has relied on full disclosure by the CLIENT of all matters pertinent to the Site investigation.

4. COMPLETE REPORT - The Report is of a summary nature and is not intended to stand alone without reference to the instructions given to ParklandGEO by the CLIENT, communications between ParklandGEO and the CLIENT, and to any other reports, writings or documents prepared by ParklandGEO for the CLIENT relative to the specific Site, all of which constitute the Report. The word "Report" shall refer to any and all of the documents referred to herein. In order to properly understand the suggestions, recommendations and opinions expressed by ParklandGEO, reference must be made to the whole of the Report. ParklandGEO cannot be responsible for use of any part or portions of the report without reference to the whole report. The CLIENT has agreed that "This report has been prepared for the exclusive use of the named CLIENT. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. ParklandGEO accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report."

   The CLIENT has agreed that in the event that any such report is released to a third party, the above disclaimer shall not be obliterated or altered in any manner. The CLIENT further agrees that all such reports shall be used solely for the purposes of the CLIENT and shall not be released or used by others without the prior written permission of ParklandGEO.

5. LIMITATIONS ON SCOPE OF INVESTIGATION AND WARRANTY DISCLAIMER
   There is no warranty, expressed or implied, by ParklandGEO that:
   a) the investigation uncovered all potential geo-hazards, contaminants or environmental liabilities on the Site; or
   b) the Site is entirely free of all geo-hazards or contaminants as a result of any investigation or cleanup work undertaken on the Site, since it is not possible, even with exhaustive sampling, testing and analysis, to document all potential geo-hazards or contaminants on the Site.

   The CLIENT acknowledged that:
   a) the investigation findings are based solely on the information generated as a result of the specific scope of the investigation authorized by the CLIENT;
   b) unless specifically stated in the agreed Scope of Work, the investigation will not, nor is it intended to assess or detect potential contaminants or environmental liabilities on the Site;
   c) any assessment regarding geological conditions on the Site is based on the interpretation of conditions determined at specific sampling locations and depths and that conditions may vary between sampling locations, hence there can be no assurance that undetected geological conditions, including soils or groundwater are not located on the Site;
   d) any assessment is also dependent on and limited by the accuracy of the analytical data generated by the sample analyses;
   e) any assessment is also limited by the scientific possibility of determining the presence of unsuitable geological conditions for which scientific analyses have been conducted; and
   f) the laboratory testing program and analytical parameters selected are limited to those outlined in the CLIENT's authorized scope of investigation; and
   g) there are risks associated with the discovery of hazardous materials in and upon the lands and premises which may inadvertently discovered as part of the investigation. The CLIENT acknowledges that it may have a responsibility in law to inform the owner of any affected property of the existence or suspected existence of hazardous materials and in some cases the discovery of hazardous conditions and materials will require that certain regulatory bodies be informed. The CLIENT further acknowledges that any such discovery may result in the fair market value of the lands and premises and of any other lands and premises adjacent thereto to be adversely affected in a material respect.

6. COST ESTIMATES - Estimates of remediation or construction costs can only be based on the specific information generated and the technical limitations of the investigation authorized by the CLIENT. Accordingly, estimated costs for construction or remediation are based on the known site conditions, which can vary as new information is discovered during construction. As some construction activities are an iterative exercise, ParklandGEO shall therefore not be liable for the accuracy of any estimates of remediation or construction costs provided.

7. LIMITATION OF LIABILITY - The CLIENT has agreed that to the fullest extent permitted by the law ParklandGEO's total liability to CLIENT for any and all injuries, claims, losses, expenses or damages whatsoever arising out of or in anyway relating to the Project is contractually limited, as outlined in ParklandGEO's standard Consulting Services Agreement. Further, the CLIENT has agreed that to the fullest extent permitted by law ParklandGEO is not liable to the CLIENT for any special, indirect or consequential damages whatsoever, regardless of cause.

8. INDEMNIFICATION - To the fullest extent permitted by law, the CLIENT has agreed to defend, indemnify and hold ParklandGEO, its directors, officers, employees, agents and subcontractors, harmless from and against any and all claims, defence costs, including legal fees on a full indemnity basis, damages, and other liabilities arising out of or in any way related to ParklandGEO's work, reports or recommendations.