APPENDIX A:

Geotechnical Report
December 4, 2015

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REPORT

GEOTECHNICAL REPORT

IBI Group Architects Engineers Waterton Lakes Staff Housing, Waterton Lakes National Parks, AB

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by IBI Group (IBI) to provide consulting services in support of the Waterton Lakes National Parks Staff Housing Design Project which includes geotechnical investigation, environmental assessment and hazardous building materials assessment services.

The following report documents the results of Golder's geotechnical investigation of the property. The environmental assessment and hazardous building materials assessment reports are provided under separate cover.

This report is prepared for the exclusive use of IBI and Parks Canada, who are the only approved users of this report. Use of this report is subject to the conditions outlined in the "*Important Information and Limitations of this Report*" that follow the main text of this report and form an integral part of the report.

2.0 SCOPE OF WORK

The scope of the geotechnical services generally included the following tasks:

- Desktop study and review of available background information, including surficial geology information and groundwater conditions at the property.
- Ground disturbance protocol, including Alberta One-Call notification and locating underground utilities by a private utility location sub-contractor prior to drilling to confirm the absence of buried utilities and/or obstructions at borehole locations.
- Geotechnical field drilling program to assess the subsurface conditions, including drilling eight Becker Hammer boreholes to depths ranging from approximately 4.6 to 9.3 m below ground surface (mbgs).
- Laboratory testing of selected soil samples obtained during the geotechnical drilling investigation.
- Preparation of this geotechnical report summarizing the desk study and factual results of the geotechnical investigation, and providing geotechnical comments and recommendations for the proposed development of the project sites.

3.0 SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Based on the information and site plans provided by IBI, the proposed new staff housing will be located in Waterton town site within Waterton Lakes National Parks. The new staffing housing developments will comprise four sites, as follows:

- Site 1: Block 42 – Lots 3 and 4 (site addresses: 104 and 106 Clematis Avenue, respectively) with approximate land area of 1,761 square metres (sq.m.) for development of 22-unit staff housing building with 622 sq.m. footprint and 12 parking lot stalls;
- Site 2: Block 42 – Lots 20 and 21 (site addresses: 102 and 104 Windflower Avenue, respectively) with approximate land area of 2,054 sq.m. for development of 24-unit staff housing building with 750 sq.m. footprint and 10 parking lot stalls;
- Site 3: Block 2 – Lots 41 and 42 (site addresses: 101 Fountain Avenue and 105 Windflower Avenue, respectively) with approximate land area of 2,000 sq.m., development details unknown; and

- Site 4: Block 2 – Lot 39 (site addresses: 105 Windflower Avenue) with approximate land area of 1,045 sq.m for 22 parking lot stalls.

It is understood that the proposed development for new staff housing will include two storey and one and half storey residential buildings with full basements at Sites 1 and 2, and Site 3 respectively. There will be concrete side walks around the buildings, with gravel surfaced parking. A paved parking area with 26 stalls will be developed over Site 4.

The sites are currently developed with existing structures, except Site 4, which is relatively open. It is understood that the existing structures, utilities, etc. will be demolished and removed for re-development of the new staff housing structures and associated parking areas. Figures for each site and site location sketch, provided by IBI are presented in Appendix A.

4.0 REVIEW OF AVAILABLE BACKGROUND INFORMATION

Golder reviewed the available background information, including surficial geology maps and geotechnical subsurface test pit records for nearby sites. A summary of this information is provided in the following sub-sections.

4.1 Published Geological Information

Based on published geological information for Waterton Lakes National Park, the natural surficial soils at the sites generally consist of medium textured alluvial till and gravelly coarse textured outwash. The bedrock underlying the sites is classified as moderately hard limestones, dolomites, argillites, and lawn flows of the Precambrian formation (Harrison 1976).

4.2 Test Pit Investigation

A test pit investigation was conducted by Amec Foster Wheeler at nearby sites within the town in 2015. The test pit logs and location plan was provided to Golder by IBI. Based on a review of this information, the nearest test pit location, TP15-01 was approximately 100 m southwest of Site 2. Based on the test pit log the soil comprised compact gravel with trace boulders and cobbles becoming moist to very moist at depth of 1.5 mbgs.

5.0 GEOTECHNICAL INVESTIGATION

5.1 Pre-Drilling Activities

Prior to the commencement of the site investigation, Golder developed a Health and Safety Plan to address the potential on-site hazards. Alberta One-Call and DigShaw were notified and underground utility clearance was carried out at borehole locations prior to the site drilling investigation. In addition, private utility locates were conducted by The Utility Locators of Calgary, Alberta, for utility clearance at borehole locations on October 13, 2015.

5.2 Drilling and Sampling Program

Based on the surficial geology and subsurface conditions encountered in the test pit investigation, referenced above, the use of a Becker Hammer drill rig was considered suitable to complete the boreholes for the field investigation. The boreholes were advanced with a truck mounted drill rig using 168 mm diameter continuous casing. The drilling contractor, Earth Drilling Co. Ltd., Calgary, Alberta, was subcontracted by Golder for this work.

A total of eight boreholes (designated as Boreholes BH15-01 through BH15-08) were completed on October 14 and 15, 2015 at the locations selected by Golder, as shown in the Borehole Location Plan, Figure 1, provided in Appendix B, as follows:

- Boreholes BH15-01 and BH15-02 were advanced within the proposed building footprint at Site 3.
- Boreholes BH15-03 and BH15-04 were advanced within the proposed building footprint at Site 2.
- Boreholes BH15-05 and BH15-06 were advanced within the proposed building footprint at Site 1.
- Boreholes BH15-07 and BH15-08 were advanced within the proposed parking lot area at Site 4.

The boreholes were generally located around existing structures and physical constraints within the sites, where a drill rig could easily access.

The field work was carried out under full-time supervision of a Golder field supervisor, who visually observed and logged the subsurface soil and groundwater conditions encountered during drilling. Golder's Soil Classification System, which is based on a modified Unified Soil Classification System (USCS), was used for soil descriptions and classification purposes, and is presented along with a list of abbreviations and symbols and the Record of Borehole Sheets in Appendix B of this report.

The Becker open-casing penetration resistance (blows per 300 mm of casing advance) was recorded during drilling at each borehole location, from which the relative density or consistency of the subgrade soils was inferred for geotechnical description. Buckets placed beneath the drill rig cyclone soil return were used to retrieve disturbed soil samples (denoted as grab samples on the Record of Borehole Sheets) for visual description, classification and testing.

Standard Penetration Tests (SPT) and split spoon samples were completed at selected depths within each borehole, and were performed in the field in general accordance with ASTM D1586. Disturbed soil samples were obtained from a standard split-spoon sampler that was driven with blows of a 63.5 kg (140 lbs.) hammer, falling 76.2 cm using an automatic hammer.

All collected soil samples were stored in moisture-proof bags and delivered to Golder's geotechnical laboratory in Calgary, Alberta for index and classification testing. Soil corrosivity tests were carried out by ALS Laboratory Group (ALS) in Calgary, Alberta.

The subsurface conditions encountered at the test hole locations during the geotechnical investigation are provided in the Record of Borehole Sheets included in Appendix B. A summary of the completed borehole locations and drilling depths are provided in Table 1.

Table 1: Borehole Location and Depth Summary

Borehole ID	Approximate Coordinates[1]		Final Drilled Depth (mbgs)[2]
	Northing (m)	Easting (m)	
BH15-01	5437475	287320	9.3
BH15-02	5437460	287351	9.3
BH15-03	5437430	287328	9.0
BH15-04	5437417	287355	9.3
BH15-05	5437360	287360	9.3
BH15-06	5437351	287341	9.3
BH15-07	5437437	287371	4.7
BH15-08	5437454	287383	4.6

[1] Coordinates are Universal Transverse Mercator (UTM), Zone 12, NAD 83 datum. Borehole coordinates were measured using a hand-held GPS and should be considered approximate.

[2] Drill depths measured from top of ground surface at time of investigation.

5.3 Laboratory Testing

The laboratory testing of select soil samples was carried out in accordance with relevant ASTM or CSA standards, and included the determination of the natural water content (ASTM D2216, 2010), Atterberg limits (ASTM D4318, 2010), particle size analyses by sieve and hydrometer methods (ASTM D422-63, 2007 and ASTM C136, 2006), water soluble sulphate content, and testing for corrosion potential (ALS 2012). The results of laboratory tests are included on the Record of Borehole Sheets in Appendix B and are presented in Appendix C. The water soluble sulphate and corrosivity test results are summarized in Section 8.9 and presented in Appendix C.

6.0 SUBSURFACE CONDITIONS

Descriptions of the subsurface conditions are presented in the Record of Borehole Sheets in Appendix B. The stratigraphic boundaries shown in the Record of Borehole Sheets are based on visual observation of the soil at the time of drilling, and thus represent transitions between soil types at these specific locations rather than exact planes of geological change in the area. Subsurface conditions may vary both with depth and laterally between individual test hole locations.

The subsurface conditions are generally considered to be relatively consistent for Sites 1 to 4. Therefore, a general summary of the summary of the subsurface conditions encountered at all the sites is presented, and conditions for each site are not provided.

6.1 Subsurface Soils

6.1.1 Topsoil

All the boreholes were advanced on the lawn grass areas. This soil unit comprised dark brown to black topsoil layer with grass, rootlets and trace organics, and is approximately 100 mm thick.

6.1.2 Fill

Fill was encountered in all boreholes beneath the topsoil unit. The fill generally comprises brown to dark brown, loose to compact silty sand with some gravel to gravelly sand, trace rootlets and trace organics. The fill material extended to approximately between 0.5 to 1.4 m in depth.

6.1.3 Sand and Gravel

A mixture of sand and gravel with cobbles and boulders was encountered underlying the fill zone to depth of termination of all the boreholes.

The material is generally well-graded and has angular to sub-rounded shapes. Cobbles were observed within this stratum, and boulder and cobble fragments, broken by the Becker Hammer drill technique were observed.

Becker Hammer blow counts ranged from 11 to 226 per 300 mm penetration. The relatively high becker hammer blow counts and practical refusal of several SPT tests likely indicate cobble and boulder size material.

Presence of a higher percentage of silt within the sand and gravel was observed in the drill cuttings with depth at boreholes BH15-01, BH15-02 and BH15-05 indicating the likely presence of pockets or layers of silty sand interbedded in the sand and gravel.

6.2 Groundwater Conditions

Groundwater seepage was noted during drilling in boreholes BH15-01 to BH15-06. Table 2 summarises the depth of the observed seepage in all borehole locations.

Table 2: Observed Seepage Depths

Borehole	Total Depth of the Borehole (mbgs)	Observed Seepage Depth (mbgs)
BH15-01	9.3	5.2
BH15-02	9.3	7.6
BH15-03	9	8.2
BH15-04	9.3	7.3
BH15-05	9.3	8.5
BH15-06	9.3	8.8
BH15-07	4.6	Not observed
BH15-08	4.6	Not observed

Grab samples and SPT samples, were generally observed to be slightly moist to moist, and no free water was observed within the soil cuttings or cyclone return during drilling.

A 50 mm diameter, PVC standpipe was installed in boreholes BH15-02 and BH15-05 to permit future measurement of water levels. Water level measurements were recorded after completion of the drilling and are summarized in Table 3.

Table 3: Summary of Water Level Measurements

Standpipe	Total Depth of Installed Standpipe, mbgs	Water Level Reading taken on October 14, 2015, mbgs	Water Level Reading taken on October 21, 2015, mbgs
BH15-02	8.8	6.6	6.6
BH15-05	8.8	8.2	8.2

These water level measurements are considered preliminary and may not represent stabilized conditions. Seasonal fluctuations in groundwater levels should be expected in response to snow melt, rainfall, flooding or other weather events. Future water level monitoring is recommended to assess the groundwater levels and seasonal fluctuations.

7.0 GEOTECHNICAL ENGINEERING CONSIDERATIONS

Based on the findings of the geotechnical investigation, the following geotechnical engineering considerations fare provided.

- In general, the Site is considered to be suitable for the development of the proposed low-rise residential building structures and parking lot.
- The sites are underlain by a limited thickness of surficial fill materials, which are underlain by sand and gravel with varying amounts of cobble and boulders. The undisturbed sand and gravel strata is considered to be suitable for shallow foundations (spread and strip footings) and slab-on-grade for the proposed low-rise residential development, following suitable site and subgrade preparation.
- Fill material consisting of silty sand and occasionally gravely sand materials (likely associated with previous site development and use), is inferred to underlie each site to a depth up to approximately 1.4 mbgs at the test hole locations, and may extend deeper at/adjoining the existing basement areas of the existing structures on the sites, or within existing utility trenches.
- The native sand and gravel are potentially suitable for use as engineered (i.e. structural) fill, however this material does contain variable amounts of cobbles and boulders and would be subject to separation and removal of over-size materials for re-use. The quantity of over-size may vary, requiring varying degrees of effort and handling to make the native soils suitable for structural backfill.
- Seepage and measured groundwater levels at the sites were encountered at depths of approximately 5 to 9 mbgs. Groundwater levels are inferred to be variable and likely fluctuate seasonally with varying precipitation, and varying water levels in the Upper Waterton Lake. Based on field observation of seepage and measured groundwater levels, groundwater seepage is not anticipated to be an issue for the proposed development utilizing shallow foundations.
- The borehole locations completed for the drilling investigation at Sites 1 to 3 were located within readily accessible areas to avoid existing structures and utilities. Subsurface conditions may vary over the sites, and some existing fill conditions adjacent to structures and for utilities may exist that can impact the design of the development. Subsurface conditions within areas with pre-existing structures and utilities should be reviewed upon removal to confirm conditions are as assumed for the recommendations below.
- Demolition and removal of existing structures and underground development (i.e. basements, utilities, etc.) may impact proposed building footprints. Backfilling of excavations may be required to facilitate new construction. The support of construction equipment and new foundations within fill, disturbed soils or bridging between fill and undisturbed soils should be avoided and considered for design and construction.

8.0 GEOTECHNICAL RECOMMENDATIONS

This section of the report provides our interpretation of existing data obtained during the geotechnical drilling investigation carried out at Sites 1 to 4, together with geotechnical engineering considerations for foundation design and potential geotechnical issues for the proposed development.

Where comments are provided on the general site conditions and on construction considerations, they are provided to highlight aspects that could affect the design of the project. Parties requiring information on aspects of the sites beyond the scope of this report must make their own interpretation of the subsurface information provided herein, particularly as it affects their proposed construction methods, costs, equipment selection, scheduling and other aspects of their work.

It should be noted that the maximum depth of exploration at the building sites is 9.3 mbgs. It is possible that subsurface conditions below this depth may vary from those provided above. Confirmation of deeper subsurface soil conditions should be verified if required.

8.1 Seismic Site Response Classification

The National Building Code of Canada (NBCC) (2010) categorizes the seismic response of sites into seven types (A through F), based on the average soil/bedrock properties within the upper 30 m of the soil profile. This classification is mainly based on the average undrained shear strength, standard penetration resistance (N_{60}) and shear wave velocity of the soil profile. Based on the standard penetration resistance of the encountered material, the sites are defined as Site Class C.

Based on the 2010 NBCC hazard calculation, the estimated ground motions with a 2% probability of being exceeded in 50 years at the Site for the NBCC hazard reference site (Site Class C) is Sa(0.2) = 0.251, Sa(1.0) = 0.076, and peak ground acceleration (PGA) = 0.129 g (where g is the acceleration due to gravity). The acceleration and velocity-based site coefficients are determined as described in Section 4.1.8.4 of the NBCC.

8.2 Frost Penetration Depth

The major soil unit encountered at the test hole locations is generally mixed sand and gravel with cobbles. The qualitative frost susceptibility of a soil is typically assessed using guidelines developed by Casagrande (1932) on the basis of the percentage by weight of the soil finer than 0.02 mm and its plasticity index. This classification system has been adapted by the U.S. Army Corps of Engineers and the Canadian Foundation Engineering Manual (CFEM, 2006). Soils are classed as F1 through F4 in order of increasing frost susceptibility. The sandy gravel to gravely sand encountered at the Site is classified as a non-frost susceptible soil, F1, based on the weight of soil finer than 0.02 mm. The seasonal frost penetration depth for the native surficial sandy gravel to gravely sand soil unit is generally estimated by following the procedure described in CFEM (2006). A mean freezing index of 1,250°C-days was used for the Site area. The seasonal frost penetration depth is estimated to be approximately 1.8 m for open, unprotected and unheated areas. Estimated frost depth assumes that there is no significant snow cover, peat or vegetation on the surface. The presence of significant snow and/or vegetation may reduce the seasonal frost penetration depth.

It is understood the depth of building foundations will be established below frost penetration level, however, considerations should be given to maintain portions of the structure that are on grade, such as shallow foundations that may be located at depths exposed to frost penetration.

8.2.1 Frost Protection for Shallow Foundations

Design frost penetration depths of about 1.2 m and 1.8 m should be used for shallow foundations for heated and unheated structures, respectively. If footings are not provided with this amount of soil cover, consideration of the use of insulation will be required to provide protection equivalent to the soil cover.

8.3 Geotechnical Design Parameters

Based on the results of the field investigations, laboratory testing and Golder's experience with similar soils, estimated soil parameters are provided in Table 4 below:

Table 4: Estimated Material Parameters

Soil Unit	Consistency	Parameter[(1)]			
		Unit Weight (kN/m^3)	Undrained Shear Strength (kPa)	Effective Friction Angle (º)	Effective Cohesion (kPa)
Sand and Gravel with Cobbles	Compact to Very Dense	21	-	33	0

[(1)] The total unit weight, undrained shear strength and effective friction angle have been based on SPT 'N' values, visual observations of soil conditions encountered during geotechnical investigation and Golder's experience and previous testing of similar soils.

The above parameters are estimates made based on observation of the soil, drilling progress, and Golder's experience with similar sites. In situ soil strength testing was not completed during the investigation, and only minimum identification laboratory testing is completed.

No geotechnical parameters are assigned to the fill, since fill composition and associated behaviour may change across the sites and differ from the soil encountered at the borehole locations.

8.4 Foundations

Proposed new development is understood to comprise residential two-story buildings with a full basement.

8.4.1 Shallow Foundations

Based on the subsurface conditions encountered, the undisturbed native sand and gravel soils are considered suitable for shallow foundations, comprising spread and strip footings for the proposed new residential buildings. Based on information provided, it is understood the staff housing structures will be developed with full basements that will likely extend at least 2 m below grade (ground surface to top of floor elevation), and shallow building foundations will correspond to an elevation near this depth. Further it is understood that the basement levels and foundations will extend below existing structures (to be demolished) and are assumed to be bearing within native soils. The Ultimate Limit Sate ULS and Serviceability Limit State (SLS) bearing pressures for shallow foundations are provided.

Table 5 provides Golder's recommended factored geotechnical bearing resistance at ULS for square and strip footings with an embedment depth of at least 2 m (for non-heated structures) and widths ranging from 0.5 to 2.5 m for shallow foundations placed on native undisturbed Sand and Gravel. The factored geotechnical bearing resistance at ULS for foundation design uses a geotechnical resistance factor (ϕ) of 0.5.

Table 5: Factored ULS Bearing Pressure (kPa) for Square and Strip Footings Placed on Native Undisturbed Sand and Gravel

Footing Width	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m
Square Footing	550	600	675	725	775
Strip Footing	575	650	-[1]	-[1]	-[1]

[1] Not expected to have such footing sizes.

The bearing pressure at SLS is dependent on footing width, shape, embedment depth and the base material. The estimated bearing pressure for strip and spread footing foundations bearing on the native undisturbed sand and gravel, based on SLS are provided in Table 6. These values are based on settlements not exceeding 25 mm for foundations placed at a depth of at least 2 m below grade, for strip and spread footings, respectively with widths ranging from about 0.5 to 2.5 m wide.

Table 6: SLS Bearing Pressure (kPa) for Square and Strip Footings Placed on Native Undisturbed Sand and Gravel

Footing Width	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m
Square Footing	1000	600	400	300	300
Strip Footing	600	425	-[1]	-[1]	-[1]

[1] Not expected to have such footing sizes.

It is recommended that independent structures be founded within the same stratum to minimize potential differential settlement. Strip and spread footings should have minimum widths as outlined in the National Building Code of Canada.

Should shallow footings be designed, it is recommended that Golder be retained to review footing designs, subgrade conditions and preparation prior to placing concrete to confirm that the actual ground conditions are as described in this report.

The values presented above are for vertical, concentric loading as described in the Canadian Foundation Engineering Manual (CFEM). If footings would be subjected to eccentric and/or inclined loads, the bearing pressures would need to be adjusted as outlined in CFEM.

8.4.2 Concrete Slabs-on-Grade

Non-structural concrete slabs-on-grade expected should be supported on a levelling course comprising of at least 150 mm thickness of compacted, well-graded, 25 mm minus crushed gravel placed over properly prepared, competent native subgrade soils or approved engineered fill. Local soft, loose areas or unsuitable soil should be sub-excavated and replaced with well-compacted and approved granular soil. The crushed gravel levelling course soil should be compacted uniformly to 98% of the Standard Proctor Maximum Dry Density (SPMDD) within an optimum water content of +/- 3%.

Design of the levelling course may be governed by the drainage requirements.

8.5 Temporary Excavation

It is expected that the overburden soils encountered within drilled depths can be excavated using conventional equipment. It is understood that the existing structures will be demolished and/or removed from the sites and provision should be made for the removal of the all foundations, abandoned underground utilities and other debris or deleterious materials that may exist from previous site use.

Temporary excavations for demolition or development within the sand and gravel soils above the groundwater table can be undertaken at slopes up to 1.5 horizontal to 1 vertical (1.5H:1V) or flatter. Where excavations extend within fill soils, below the groundwater table or where seepage is encountered, the temporary excavation slopes of 2H:1V or flatter will likely be required, depending on the quality of fill material, and/or rate of groundwater seepage inflow. Stockpiling of materials should not take place within 3 m of the crest of excavations so that excavation stability is not compromised. All trenching and excavations should be carried out according to the latest version of Alberta Occupational Health and Safety Regulations (OH&S). Specifically, Part 32 of the OH&S regulations deals with excavations.

Based on our understanding of the locations of the existing structures, demolition requirements and locations of new structures, it is assumed that excavation will be undertaken within suitable proximity to adjacent structures to allow unsupported cuts. If excavations are required to be steeper and are in close proximity to existing structures, a review of the conditions and recommendation for excavation and possible temporary structural support should be provided.

8.5.1 Lateral Earth Pressures on Foundation Walls

Earth pressures on foundations walls may be designed using “at rest” or “active” earth pressure coefficients (K_0 and K_a), dependent on the allowable deformation/movement of the structure. The lateral soil pressure distribution (σ_h) may be assumed to increase linearly with depth according to:

$$\sigma_h = K(\sigma'_v + q)$$

$$\sigma'_v = gz - g_w h_w$$

Where:

- σ_h = Lateral earth pressure (kPa)
- K = Coefficient of lateral earth pressure
- q = Surcharge loading (kPa)
- σ'_v = Vertical effective stress at depth z (kPa)
- g = Bulk unit weight of soil (kN/m^3)
- g_w = Unit weight of water (kN/m^3)
- h_w = Height of water (m)
- z = Depth below grade (m)

Table 7 summarises the recommended coefficient of lateral earth pressure for both native and engineered fill materials. Design should take into consideration hydrostatic pressures, as required.

Table 7: Coefficients of Lateral Earth Pressure

Soil Unit	Consistency/Compactness	K_a	K_p	K_o
Engineered Fill [(1)]	Compact	0.33	3.00	0.50
Sand and Gravel with Cobbles	Compact to very dense	0.29	3.39	0.46

[(1)] A friction angle of 30° is assumed for engineered fill.

8.5.2 Temporary Groundwater Control during Construction

Based on observation and results of measured ground water levels (from stand pipes), the groundwater elevation and seepage is expected to vary between about 5 to 9 mbgs. Seepage and groundwater flow into shallow excavations (i.e. less than 2.5 m below ground) at the sites is not considered likely. However pockets of seepage or seepage within deeper excavations may occur. The amount of the seepage could vary significantly depending on the actual conditions encountered and on the depth of the excavation.

8.6 Subgrade Preparation

Site preparation should include clearing and stripping of all vegetation and topsoil, fill, existing abandoned foundations and utilities, and other deleterious fill materials.

If soft, disturbed, deleterious or otherwise unsuitable soils are encountered during preparation for side pedestrian walk components, foundations or other structural components, these materials should be sub-excavated and replaced with suitable, well-compacted fill. The exposed native subgrade soil should be inspected by Golder prior to placement of fill, foundation forms or concrete. Provision should be made for proof-rolling using a loaded heavy vehicle (such as a loaded dump truck or equivalent) to confirm the suitability of the subgrade within parking areas, at the time of the inspection. Care should be taken during construction to minimize the degree of disturbance to the exposed native soils.

8.7 Backfill

Backfill beneath the floor slab, as required for permanent groundwater control, should consist of free-draining crushed gravel with a maximum particle size of 25 mm and meeting the design specifications. The gravel backfill should be compacted to a minimum of 98% SPMDD within an optimum water content of +/- 3%. Where spatial limitations exist, compaction equipment may be limited to small rollers and hand-operated equipment where lift thicknesses should not exceed 150 mm (loose measure), otherwise lift thicknesses of 200 mm (loose measure) may be used when utilizing suitable large, heavy compaction equipment.

The available native sand and gravel soils may be suitable as engineered granular fill provided all cobbles or boulders over 150 mm (largest dimension) in size and all soft and otherwise deleterious materials are removed. The use and purpose of this material should be reviewed. Removal of oversized material (cobbles in excess of 150 mm diameter and boulders), organics, debris, frozen soils or other deleterious materials will be required. The suitability of this material should be further evaluated for use as fill at the time of construction. Water content conditioning (drying or wetting) may be required, depending on the natural water content relative to the optimum water content for compaction purposes. Based on our observation of the rock within the sand and gravel matrix, it has been noted that the rock can be platy. Reuse of the native material with platy rock will be difficult.

Fill materials should not be placed in a frozen state, nor placed on frozen subgrade.

If not otherwise specified, material for roadway and sidewalk base courses and other base materials (such as utility bedding) should comply with the City of Calgary standards.

8.8 General Grading and Site Drainage

Final grades should be developed and sloped so that surface water is directed away from the building structures footprint and towards existing site drainage pathways.

Suitable drainage of foundations is good practice and drains should be provided for all below-grade walls, and should consist of a 150 mm diameter continuous, perforated PVC drain pipe, placed in a minimum 300 mm by 300 mm cross-sectional area of 20 mm minus drain rock. The permanent foundation drainage system should be provided with clean-outs to allow for future maintenance and inspection.

It is understood that a French drain will be considered for the development of some sites. For this purpose, the typical porosity for the native sand gravel strata is in the range of 30% to 40%.

8.9 Cement Type and Corrosion Potential

Corrosivity testing was conducted by ALS Laboratory Group in Calgary, Alberta, on soil samples from two boreholes (BH15-01 and BH15-04) for water soluble sulphate contents, resistivity, chlorides and pH. A summary of the corrosivity test results are provided in Table 8 and shown in the Record of Borehole Sheets in Appendix B, and the Laboratory Testing Results (ALS Environmental Analytical Report) in Appendix C.

Table 8: Summary of Soil Corrosion Test Results

Borehole	Sample No.	Depth Below Ground Surface (m)	Resistivity (ohm-cm)	pH	Chloride (mg/L)	Sulphate Content (%)	Cement Type[(1)]
BH15-01	GS-3, GS-4 and GS-5 combined	1.8-4.6	19000	8.27	22	0.00217	GU[(2)]
BH15-04	GS-5, GS-6 and GS-7 combined	3.7-6.4	18500	8.22	<20	0.00205	GU[(2)]

[(1)] Cement type based on Table CSA A23.1 – Table 3 (Canadian Standards Association, Concrete Materials and Methods of Concrete Construction).
[(2)] Cement Type GU: General Use.

The soluble sulphate content test results ranged between 21.7 mg/L and 20.5 mg/L (0.00217% and 0.00205%), indicating negligible potential for sulphate attack. Based on the degree of exposure to sulphate attack following the Canadian Standards Association's Concrete Materials and Methods of Concrete Construction Recommendations, General Use (GU) Portland cement may be considered.

Imported soils should be tested for compatibility with recommended cement types. These recommendations are based on limited laboratory testing and limited review of available literature. A detailed analysis of concrete durability or performance properties or concrete material evaluation was beyond the scope of work of this project.

The test data provided in Table 8 should be reviewed by material manufacturers, supplier/installers and designers to provide suitable recommendations for corrosion protection, if required. Imported fill that will be in contact with structures should also be tested.

8.10 Pavement Design

The pavement materials should be placed on approved subgrade, upon suitable site preparation, grading and proof-rolling. A reasonably conservative CBR value of 7 for the native sand and gravel subgrade has been considered for design of pavement structures provided that the upper 300 mm of the subgrade will be compacted to 98% of SPMDD.

It is understood that Site 4 will be developed as parking lot for light vehicles. Asphaltic concrete pavement is typically used in Alberta to construct parking lots. The recommended pavement structure for light and limited heavy duty traffic loading and assumed equivalent single axle loads (ESAL's) are provided in Table 9. A design life of 20 years has been assumed for well drained native sand and gravel or suitably prepared granular subgrade fill soils for the design recommendation of the pavement structure.

Table 9: Flexible Pavement Recommendation

Unit	Light Duty Traffic[(1)] (Maximum 2.5x10^4 ESAL's) (mm)	Limited Heavy Duty Traffic (Maximum 1x10^5 ESAL's) (mm)
Asphalt Concrete Pavement (ACP)	80	100
Crushed Base Course	100	100
Sub-base Course	200	300

[(1)] Light traffic design structure based on City of Calgary minimum design standards for residential road.

All crushed gravel base course and surface layer materials should be placed and compacted to 98% of SPMDD. Asphaltic concrete pavement should be compacted to at least 93% of the recommended Marshall Maximum Relative Density of the mix design being utilized. Materials should meet City of Calgary Specifications for Road Construction.

9.0 CLOSURE

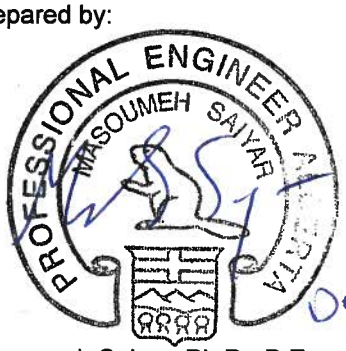
We trust that the above information meets your current requirements. Please do not hesitate to contact the undersigned if you have any questions or require further information.

Yours truly,

GOLDER ASSOCIATES LTD.

APEGA PERMIT TO PRACTICE #05122

Prepared by:



Masoumeh Saiyar, Ph.D., P.Eng.
Geotechnical Engineer

Reviewed by:

Cory Smith, P.Eng.
Principal, Senior Geotechnical Engineer

MS/HM/CS/sb

\\golder.gds\calgary\active_2015\3 proj\1534393 ibi group_staff house design_waterton\2000_geotechnical inv\5. reporting\final\1534393 ibi - waterton lakes staff housing - final geotech report.docx

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Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

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Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

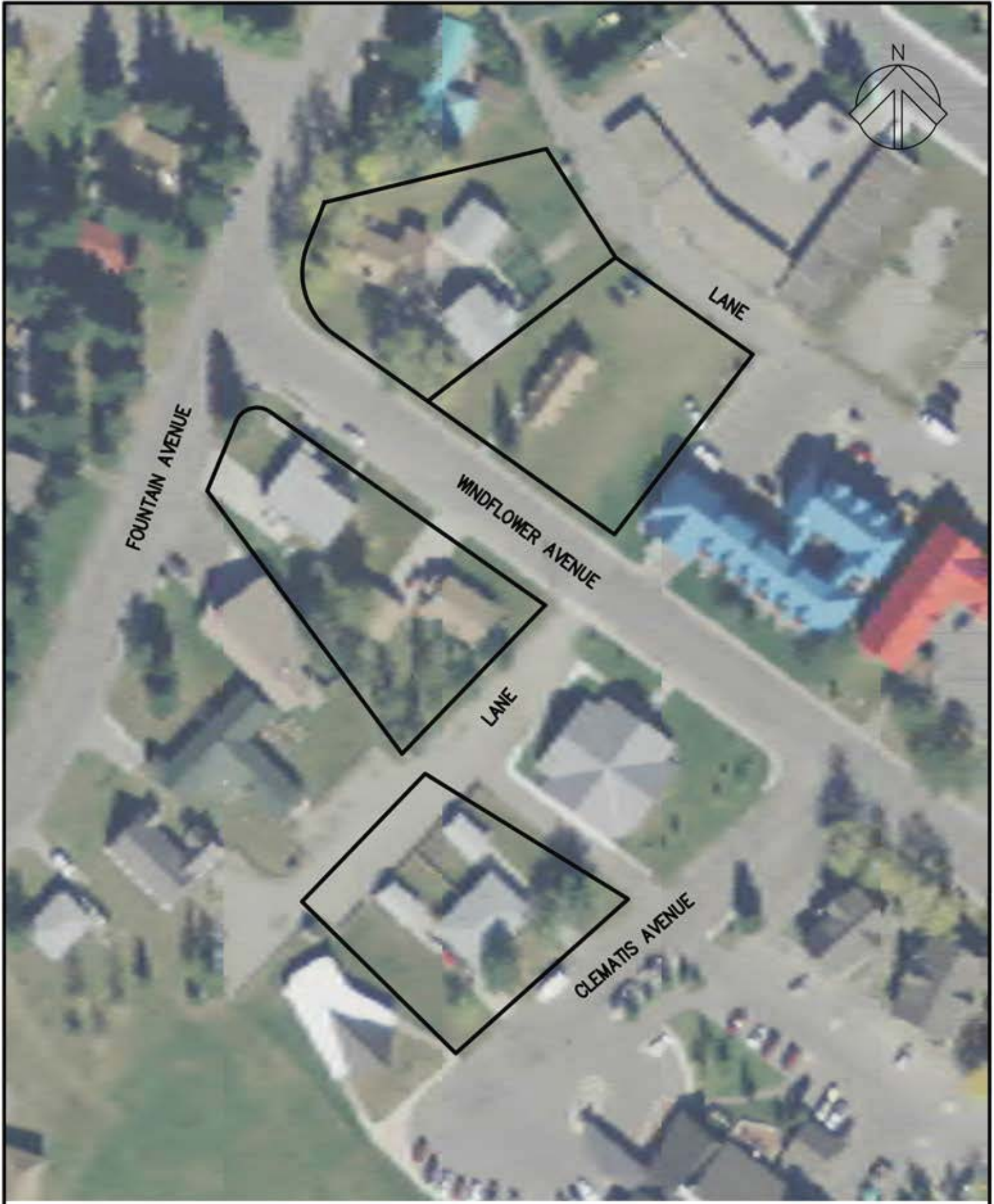
During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

APPENDIX A

Development Concept



IBI

IBI GEOMATICS INC.
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1167 Kensington Cres NW
Calgary AB T2N 1X7 Canada
tel 403 270 5600 fax 403 270 5610

SKETCH SHOWING
WATERTON SITE LOCATIONS

1:1000
September 17, 2015
DRAWN: BM
PS: SKETCH
39000A900.dwg

SITE PLAN - LOTS 3 & 4

SCALE 1:200

SITE 1 (Lots 3 & 4)

22 Unit Option

Waterton Key Plan

Site Information: Lots 3 & 4 Block 42

Approximate Area: 1761 m² (18,955 ft²)

Required		Provided
Zoning: Institutional		✓
Front Setback: 6m		✓
Rear Setback: 6m		✓
Side Setbacks: 1.8m		✓
Max. FAR: 1.4		0.53
Building Max. Coverage: 40%		35.3%
Landscape Min. Coverage: 20%		Approx. 52.2%
Parking Count: 22 Units = 15 Stalls (2 Stalls Per 3 Beds)		12 Stalls
Building Footprint Area:	Total -	622.0 Sq. M.
Building Floor Area:	Main -	622.0 Sq. M.
	Second -	307.0 Sq. M.
	Total -	929.0 Sq. M.

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Parks Canada Parcs Canada

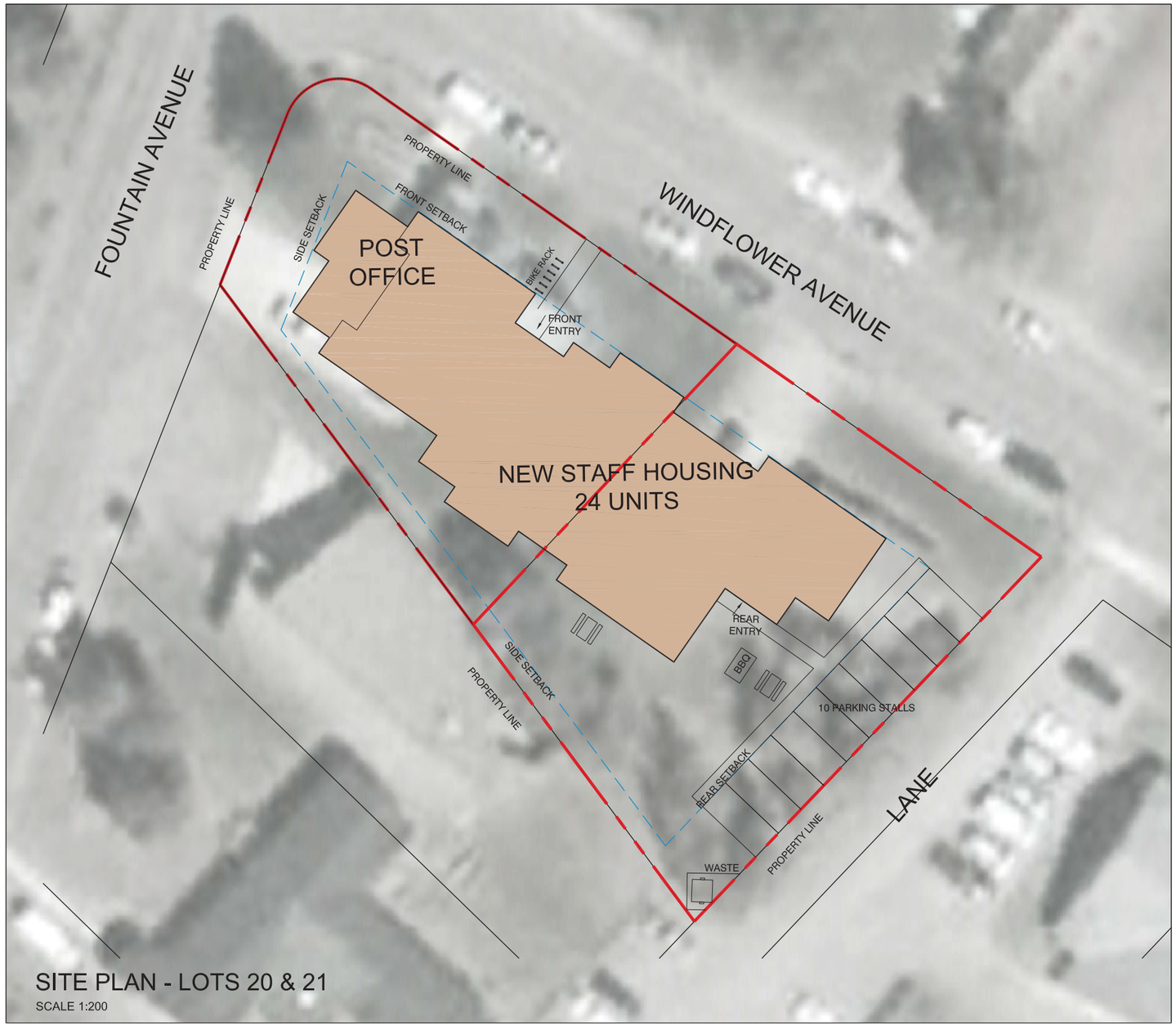
WATERTON LAKES STAFF HOUSING

Parks Canada Agency

Waterton Lakes National Park, AB

ISSUED FOR: Review
DATE: October 8, 2015
PROJECT NO: 39000
SCALE: As Indicated

SD-1.4



SITE PLAN - LOTS 20 & 21

SCALE 1:200

Site 2 (Lots 20 & 21)

24 Unit Option

Waterton Key Plan

Site Information: Lots 20 & 21 Block 42

Approximate Area: 2054 m² (22,109 ft²)

Required	Provided
Zoning: Institutional	✓
Front Setback: 6m	✓
Rear Setback: 6m	✓
Side Setbacks: 1.8m	✓
Max. FAR: 1.4	0.90 (incl. basement)
Building Max. Coverage: 40%	36%
Landscape Min. Coverage: 20%	Approx. 56%
Parking Req'd: 18 stalls 24 Units = 16 Stalls (2 Stalls Per 3 Beds) 16 Stalls (2 Post Office = 2 stalls (1 stall/50 SM)	10 Stalls
Building Footprint Area: Total -	750 Sq. M.
Building Floor Area: Main -	690 Sq. M. + 60 Sq. M. Post Office
Second -	345 Sq. M.
Total -	1095 Sq. M.

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WATERTON LAKES STAFF HOUSING

Parks Canada Agency

Waterton Lakes National Park, AB

N

ISSUED FOR: Review
DATE: October 8, 2015
PROJECT NO: 39000
SCALE: As Indicated

SD-2.4

SITE PLAN - LOTS 41 & 42

SCALE 1:200

Site 3, Lots 41 & 42

Future Development

Waterton Key Plan

Site Information: Lots 41 & 42 Block 2

Approximate Area: 2000 m² (21,528 ft²)

Required	Provided
Zoning: Institutional	REZONING REQUIRED
Front Setback: 6m	✓
Rear Setback: 6m	✓
Side Setbacks: 1.8m	✓

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Waterton Lakes National Park, AB

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DATE: October 8, 2015
PROJECT NO: 39000
SCALE: As Indicated

SD-3.2

Site 4 (Lot 39)

Parking Lot

Waterton Key Plan

Site Information: Lot 39 Block 2

Approximate Area: 1045 m² (11248 ft²)

Required	Provided
Zoning: Institutional	✓
Front Setback: 6m	✓
Rear Setback: 6m	✓
Side Setbacks: 1.8m	✓
Max. FAR: 1.4	
Building Max. Coverage: 40%	
Landscape Min. Coverage: 20%	
Parking Count: 26 Stalls Provided	

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WATERTON LAKES STAFF HOUSING
Parks Canada Agency
Waterton Lakes National Park, AB

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ISSUED FOR: Review
DATE: October 8, 2015
PROJECT NO: 39000
SCALE: As Indicated

SD-4.1

APPENDIX B

Figure 1: Borehole Location Plan
Golder Soil Classification System
List of Symbols
Record of Borehole Sheets

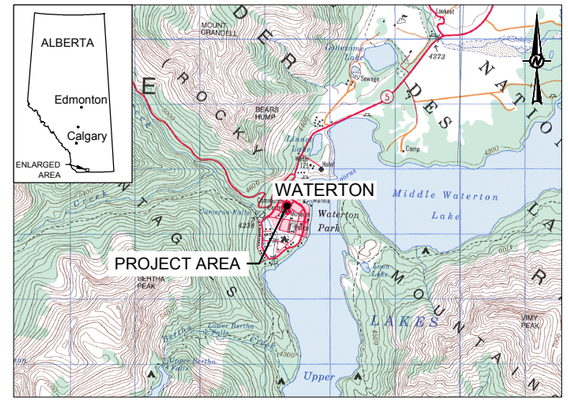
LEGEND

BOREHOLE LOCATION

SITE BOUNDARY

NOTES

THE COORDINATES OF BH15-01 TO BH15-08 ARE BASED ON HAND-HELD GPS TAKEN ON OCTOBER 15, 2015.



KEY MAP

NOT TO SCALE

REFERENCE(S)

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DATUM: NAD83, PROJECTION: UTM ZONE 12.

0 25 50
1:1,000 (APPROX.) METRES

CLIENT
IBI GROUP

PROJECT
GEOTECHNICAL INVESTIGATION FOR STAFF HOUSING
AT WATERTON PARK, ALBERTA

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-12-02
PREPARED	YW
DESIGN	HM
REVIEW	MS
APPROVED	CS

PROJECT No.	CONTROL	Rev.	FIGURE
1534393	2000-HS-0001	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

0

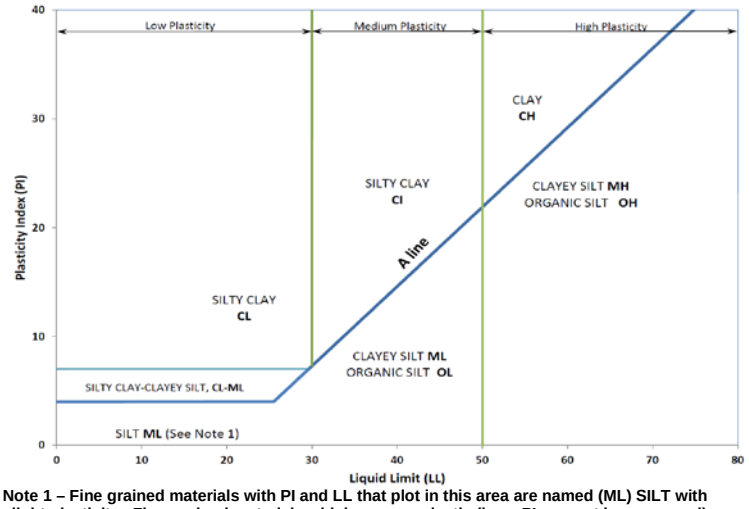
Path: ---- | File Name: 1534393-2000-HS-0001.dwg

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil		Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
					Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)		Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
					Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
					Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
				Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
					None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)		Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% (see Note 2)	CL	SILTY CLAY
				Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
				Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures								30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat								75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to ~~or~~ indicate~~s~~ a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL, SAND and CLAY)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.).

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 - 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1] (blows/0.3m)
Very Soft	<12	0 to 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 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

DATA ENTRY: KD

PROJECT No.: 1534393.2000

RECORD OF BOREHOLE: BH15-01

SHEET 1 OF 1

LOCATION: Lot 42 (See Location Plan)
N:5437475 E:287320
(NAD UTM Zone 12 - Coordinates obtained using hand-held GPS)

BORING DATE: October 14, 2015

PROJECT: Waterton Lakes Staff Housing

DATUM: -

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	Becker Hammer Counts, Blows/0.3m (⊕ 40 80 120 160; □ 100 200 300 400)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Becker Hammer R34, Earth Drilling Co. Ltd.	TOPSOIL- grass, rootlets, dark brown		0.06							
		(SM) SILTY SAND, some gravel, trace rootlets, trace organics; dark brown (FILL); non-cohesive, moist, loose to compact			1	GRAB					
1											
		(SP-GP) SAND and GRAVEL with cobbles, trace to some fines; brown; non-cohesive, moist, compact to dense, boulders inferred		1.22	2	GRAB					
2					3	GRAB				CL=22 mg/L Resistivity = 19000 ohm cm SO4=21.7 mg/L pH=8.27	
		(GP) Sandy GRAVEL with cobbles, trace to some fines; grey; non-cohesive, moist, dense, boulders inferred		2.74							
3					4	GRAB					
4					5	GRAB					
		(SP-GP) SAND and GRAVEL with cobbles, some fines; grey; non-cohesive, moist to wet, dense, boulders inferred		4.57							
5		--- groundwater seepage at 5.2 mbgs			6	GRAB					
					7A	SS	50 for 75 mm				
6					7	GRAB					
		(GP) Sandy GRAVEL with cobbles, trace to some fines; grey; non-cohesive, moist, dense		6.71	8	GRAB					
7		(SM) Gravelly SILTY SAND; brown; non-cohesive, moist, compact		7.32							
					9	GRAB					
8					10	GRAB					
9					11	SS	13				
		End of BOREHOLE.		9.30							
10		NOTES: 1. Borehole terminated at 9.3 mbgs. 2. Groundwater seepage observed at 5.2 mbgs during drilling. 3. Borehole backfilled with drill cuttings, 2 bags of bentonite chips and 2 bags of sand at the surface.									

DEPTH SCALE
1 : 54

Golder Associates

LOGGED: HM

CHECKED: MS

BOREHOLE - EXPANDED ADD. LAB TESTING 1534393-WATERTON PARK STAFF HOUSING.GPJ CALGARY.GDT 12/4/15

DATA ENTRY: KD

PROJECT No.: 1534393.2000

RECORD OF BOREHOLE: BH15-02

SHEET 1 OF 1

LOCATION: Lot 41 (See Location Plan)
N:5437460 E:287351
(NAD UTM Zone 12 - Coordinates obtained using hand-held GPS)

BORING DATE: October 14, 2015

PROJECT: Waterton Lakes Staff Housing

DATUM: -

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	Becker Hammer Counts, Blows/0.3m (40 80 120 160 / 100 200 300 400)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Becker Hammer R34 Earth Drilling Co. Ltd.	TOPSOIL- grass, rootlets, dark brown		0.06							Flushmount Concrete
		(SM) SILTY SAND, some gravel, trace rootlets, trace organics; brown (FILL); non-cohesive, moist, loose		0.46	1	GRAB					Bentonite
1		(GP) Sandy GRAVEL, with cobbles, trace to some fines; grey; non-cohesive, moist, compact to dense, boulders inferred			2	GRAB					
2					3	GRAB					
					4A	SS	50 for 75 mm				
3											
		(SP-GP) SAND and GRAVEL, with cobbles, some fines; brown; non-cohesive, moist, dense to very dense, boulders inferred		3.20	4	GRAB					
4					5	GRAB					Cuttings
5					6	GRAB					
6					7	SS	53			Gravel = 71% Sand = 23% Fines = 6%	
		(GP) Sandy GRAVEL, with cobbles, trace to some fines; grey; non-cohesive, moist, dense, boulders inferred		6.10							21/10/2015 14/10/2015
					8	GRAB					
7		(SM) Gravelly SILTY SAND; brown; non-cohesive, moist to wet, compact		7.01							Bentonite
		--- groundwater seepage at 7.6 mbgs			9	GRAB					
8											Sand
					10	GRAB					
9					11	SS	22				Slough
		End of BOREHOLE.		9.30							
10		NOTES: 1. Borehole terminated at 9.3 mbgs. 2. Standpipe installed at 8.8 mbgs. 3. Groundwater seepage observed at 7.6 mbgs during drilling. 4. Groundwater was measured at 6.6 mbgs on October 14, 2015. 5. Groundwater was measured at 6.6 mbgs on October 21, 2015.									

DEPTH SCALE
1 : 54

Golder Associates

LOGGED: HM

CHECKED: MS

BOREHOLE - EXPANDED ADD. LAB TESTING 1534393-WATERTON PARK STAFF HOUSING.GPJ CALGARY.GDT 12/4/15

DATA ENTRY: KD

PROJECT No.: 1534393.2000

RECORD OF BOREHOLE: BH15-03

SHEET 1 OF 1

LOCATION: Lot 20 (See Location Plan)
N:5437430 E:287328
(NAD UTM Zone 12 - Coordinates obtained using hand-held GPS)

BORING DATE: October 14, 2015

PROJECT: Waterton Lakes Staff Housing

DATUM: -

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	Becker Hammer Counts, Blows/0.3m (40 80 120 160 / 100 200 300 400)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Becker Hammer R34 Earth Drilling Co. Ltd.	TOPSOIL- grass, rootlets, black		0.06							
		(SM) SILTY SAND, some gravel, trace rootlets, trace organics; black (FILL); non-cohesive, moist, loose to compact			1	GRAB					
		(SP) Gravelly SAND, with cobbles; brown; non-cohesive, moist, dense, boulders inferred		0.61							
1					2	GRAB					
2		--- becoming light brown at 1.8 mbgs			3	GRAB					
3		--- cobbles/boulders at 3.2 mbgs			4	GRAB			226		
		(SP-GP) SAND and GRAVEL, with cobbles, some fines; light brown; non-cohesive, moist, dense, boulders inferred		3.51							
4					5	GRAB					
5					6	GRAB					
		(GP) Sandy GRAVEL, with cobbles, some fines; brown; non-cohesive, moist to wet, dense, boulders inferred		5.49							
6					7	GRAB					
7					8	GRAB					
8		--- groundwater seepage at 8.2 mbgs			9	GRAB					
					10	GRAB					
					11	SS	50 for 125 mm				
9		End of BOREHOLE.		8.96							
10		NOTES: 1. Borehole terminated at 9.0 mbgs. 2. Groundwater seepage observed at 8.2 mbgs during drilling. 3. Borehole backfilled with drill cuttings, 2 bags of bentonite chips and 6 bags of sand at the surface.									

BOREHOLE - EXPANDED ADD. LAB TESTING 1534393-WATERTON PARK STAFF HOUSING.GPJ CALGARY.GDT 12/4/15

DEPTH SCALE
1 : 54

Golder Associates

LOGGED: HM

CHECKED: MS

DATA ENTRY: KD

PROJECT No.: 1534393.2000

RECORD OF BOREHOLE: BH15-04

SHEET 1 OF 1

LOCATION: Lot 21 (See Location Plan)
N:5437417 E:287355
(NAD UTM Zone 12 - Coordinates obtained using hand-held GPS)

BORING DATE: October 14, 2015

PROJECT: Waterton Lakes Staff Housing

DATUM: -

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	Becker Hammer Counts, Blows/0.3m (⊕ 40 80 120 160; □ 100 200 300 400)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0		TOPSOIL- grass, rootlets, black		0.06							
		(SM) SILTY SAND, some gravel, trace rootlets, trace organics; black (FILL); non-cohesive, moist, loose			1	GRAB					
		(SP) Gravelly SAND, trace rootlets, trace to some fines; dark brown (FILL); non-cohesive, moist, compact		0.61							
1					2	GS					
		(SP-GP) SAND and GRAVEL, with cobbles, trace to some fines; brown; non-cohesive, moist, compact to dense, boulders inferred		1.37							
2					3	GRAB					
3					4	GRAB					
		(GP) Sandy GRAVEL, with cobbles, some fines; grey; non-cohesive, moist, dense, boulders inferred		3.51							
4					5	GRAB				CL<20 mg/L Resistivity = 18500 ohm cm SO4=20.5 mg/L pH=8.22	
5	Becker Hammer R34 Earth Drilling Co. Ltd.				6	GRAB					
		(SP-GP) SAND and GRAVEL, with cobbles, some fines; brown; non-cohesive, moist to wet, compact to dense, boulders inferred		5.49							
6					7	GRAB					
7					8	GRAB					
		--- groundwater seepage at 7.3 mbgs, becoming compact			9	SS	25			Gravel = 38% Sand = 56% Fines = 6%	
8					10	GRAB					
					11	GRAB					
9					12	SS	18				
		End of BOREHOLE.		9.30							
10		NOTES: 1. Borehole terminated at 9.3 mbgs. 2. Groundwater seepage observed at 7.3 mbgs during drilling. 3. Borehole backfilled with drill cuttings, 2 bags of bentonite chips and 2 bags of sand at the surface.									

DEPTH SCALE
1 : 54

Golder Associates

LOGGED: HM

CHECKED: MS

BOREHOLE - EXPANDED ADD. LAB TESTING 1534393-WATERTON PARK STAFF HOUSING.GPJ CALGARY.GDT 12/4/15

PROJECT No.: 1534393.2000

RECORD OF BOREHOLE: BH15-05

SHEET 1 OF 1

LOCATION: Lot 3 (See Location Plan)
N:5437360 E:287360
(NAD UTM Zone 12 - Coordinates obtained using hand-held GPS)

BORING DATE: October 14, 2015

PROJECT: Waterton Lakes Staff Housing

DATUM: -

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	Becker Hammer Counts, Blows/0.3m (40 80 120 160 / 100 200 300 400)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Becker Hammer R34, Earth Drilling Co. Ltd.	TOPSOIL- grass, rootlets, black		0.09							Flushmount Concrete
		(SP) Gravelly SAND, trace rootlets, trace to some fines; dark brown (FILL); non-cohesive, moist, loose to compact			1	GRAB					Bentonite
		(SP-GP) SAND and GRAVEL, with cobbles, trace to some fines; light brown; non-cohesive, moist, dense, boulders inferred		0.61							
1					2	GRAB					
2					3	GRAB					
3		(GP) Sandy GRAVEL, with cobbles, some fines; light brown; non-cohesive, moist, dense, boulders inferred		2.74	4	GRAB					Cuttings
4					5	GRAB					
5					6	GRAB					
6		(SP-GP) SAND and GRAVEL, with cobbles, trace to some fines; brown; non-cohesive, moist, dense, boulders inferred		5.49	7	GRAB					Bentonite
7					8	GRAB					
		(SM) Gravelly SILTY SAND; brown; non-cohesive, moist, very dense		7.32	9	SS	85 for 275 mm			Gravel = 16%, Sand = 65%, Fines = 19%	Sand
8		(SP-GP) SAND and GRAVEL, with cobbles, trace to some fines; brown; non-cohesive, moist to wet, dense to very dense, boulders inferred		7.92	10	GRAB					14/10/2015
		--- groundwater seepage at 8.5 mbgs			11	GRAB					21/10/2015
9					12	SS	54				Slough
		End of BOREHOLE.		9.30							
10		NOTES: 1. Borehole terminated at 9.3 mbgs. 2. Standpipe installed at 8.8 mbgs. 3. Groundwater seepage observed at 8.5 mbgs during drilling. 4. Groundwater was measured at 8.2 mbgs on October 14, 2015. 5. Groundwater was measured at 8.3 mbgs on October 21, 2015.									

DEPTH SCALE
1 : 54

Golder Associates

LOGGED: HM

CHECKED: MS

DATA ENTRY: KD

BOREHOLE - EXPANDED ADD. LAB TESTING 1534393-WATERTON PARK STAFF HOUSING.GPJ CALGARY.GDT 12/4/15

DATA ENTRY: KD

PROJECT No.: 1534393.2000

RECORD OF BOREHOLE: BH15-06

SHEET 1 OF 1

LOCATION: Lot 4 (See Location Plan)
N:5437351 E:287341
(NAD UTM Zone 12 - Coordinates obtained using hand-held GPS)

BORING DATE: October 14, 2015

PROJECT: Waterton Lakes Staff Housing

DATUM: -

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	Becker Hammer Counts, Blows/0.3m (⊕ 40 80 120 160; □ 100 200 300 400)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Becker Hammer R34, Earth Drilling Co. Ltd.	TOPSOIL- grass, rootlets, black		0.08							
		(SM) SILTY SAND, some gravel, trace rootlets, trace organics; black (FILL); non-cohesive, moist, loose to compact			1	GRAB					
		(SP-GP) SAND and GRAVEL, with cobbles, trace to some fines; light brown; non-cohesive, moist, dense, boulders inferred		0.61							
1					2	GRAB					
2					3	GRAB					
3					4	GRAB					
4		(GP) Sandy GRAVEL,with cobbles, some fines; brown; non-cohesive, moist, dense, boulders inferred		3.96	5	GRAB					
		(SP-GP) SAND and GRAVEL, with cobbles, trace to some fines; brown; non-cohesive, moist, dense, boulders inferred		4.57							
5					6	GRAB					
6					7	GRAB					
7					8	GRAB					
		(GP) Sandy GRAVEL, with cobbles, some fines; brown; non-cohesive, moist to wet, dense to very dense, boulders inferred		7.32	9	GRAB					
8					10	GRAB					
		--- seepage at 8.8 mbgs			11	SS	60				
9		End of BOREHOLE.		9.30							
10		NOTES: 1. Borehole terminated at 9.3 mbgs. 2. Groundwater seepage observed at 8.8 mbgs during drilling. 3. Borehole backfilled with drill cuttings, 2 bags of bentonite chips and 2 bags of sand at the surface.									

BOREHOLE - EXPANDED ADD. LAB TESTING 1534393-WATERTON PARK STAFF HOUSING.GPJ CALGARY.GDT 12/4/15

DEPTH SCALE
1 : 54

Golder Associates

LOGGED: HM

CHECKED: MS

DATA ENTRY: KD

PROJECT No.: 1534393.2000

RECORD OF BOREHOLE: BH15-07

SHEET 1 OF 1

LOCATION: Lot 39 (See Location Plan)
N:5437437 E:287371
(NAD UTM Zone 12 - Coordinates obtained using hand-held GPS)

BORING DATE: October 15, 2015

PROJECT: Waterton Lakes Staff Housing

DATUM: -

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	Becker Hammer Counts, Blows/0.3m (⊕ 40 80 120 160; □ 100 200 300 400)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Becker Hammer R34, Earth Drilling Co. Ltd.	TOPSOIL- grass, rootlets, dark brown		0.06							
		(SM) SILTY SAND, some gravel, trace rootlets; dark brown (FILL); non-cohesive, moist, loose			1	GRAB					
1		(SP-GP) SAND and GRAVEL, with cobbles, trace to some fines; brown; non-cohesive, moist, dense to very dense, boulders inferred		0.61							
2					2	GRAB					
3					3	GRAB					
4		(GP) Sandy GRAVEL, with cobbles, some fines; brown; non-cohesive, moist, dense to very dense, boulders inferred		3.66	4	GRAB					
					5	SS	50 for 75 mm				
		End of BOREHOLE.		4.65							
5		NOTES: 1. Borehole terminated at 4.7 mbgs. 2. No groundwater seepage observed during drilling. 3. Borehole backfilled with drill cuttings, 2 bags of bentonite chips and 2 bags of sand at the surface.									
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 54

Golder Associates

LOGGED: HM
CHECKED: MS

BOREHOLE - EXPANDED ADD. LAB TESTING 1534393-WATERTON PARK STAFF HOUSING.GPJ CALGARY.GDT 12/4/15

DATA ENTRY: KD

PROJECT No.: 1534393.2000

RECORD OF BOREHOLE: BH15-08

SHEET 1 OF 1

LOCATION: Lot 39 (See Location Plan)
N:5437454 E:287383
(NAD UTM Zone 12 - Coordinates obtained using hand-held GPS)

BORING DATE: October 15, 2015

PROJECT: Waterton Lakes Staff Housing

DATUM: -

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	Becker Hammer Counts, Blows/0.3m (⊕ 40 80 120 160; □ 100 200 300 400)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Becker Hammer R34, Earth Drilling Co. Ltd.	TOPSOIL- grass, rootlets, dark brown		0.06							
		(SM) SILTY SAND, some gravel, trace rootlets, trace organics; dark brown (FILL); non-cohesive, moist, loose to compact			1	GRAB					
		(SP-GP) SAND and GRAVEL, with cobbles, trace to some fines; brown; non-cohesive, moist, dense, boulders inferred		0.61							
1					2	GRAB					
2		(GP) Sandy GRAVEL, with cobbles, trace to some fines; brown to grey; non-cohesive, moist, dense, boulders inferred		1.83	3	GRAB					
3					4	GRAB					
4					5	GRAB					
		End of BOREHOLE.		4.57							
5		NOTES: 1. Borehole terminated at 4.6 mbgs. 2. No groundwater seepage observed during drilling. 3. Borehole backfilled with drill cuttings, 2 bags of bentonite chips and 2 bags of sand at the surface.									
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 54

Golder Associates

LOGGED: HM
CHECKED: MS

BOREHOLE - EXPANDED ADD. LAB TESTING 1534393-WATERTON PARK STAFF HOUSING.GPJ CALGARY.GDT 12/4/15

APPENDIX C

Laboratory Testing Results

Golder Associates

General Lab Testing Summary

Project No.: 1534393
Short Title: Waterton Park Staff Housing
Tested By: DS

Phase: 2000
Sched: B662
Date: 19-Oct-15

Sample Identification					Laboratory Test Results					
Source	Sample Type	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-01	GS1	0.0	0.9	B662-01	-					
	GS2	0.9	1.8	B662-02	-					
	GS3	1.8	2.7	B662-03	1.3					
	GS4	2.7	3.7	B662-04	2.1					
	GS5	3.7	4.6	B662-05	-					
	GS6	4.6	5.8	B662-06	2.8					
	SS7A	5.8	5.9	B662-07	-					
	GS7	5.9	6.4	B662-08	3.2					
	GS8	6.4	7.3	B662-09	-					
	GS9	7.3	8.2	B662-10	2.3					
	GS10	8.2	8.8	B662-11	-					
	SS11	8.8	9.3	B662-12	-					

Reviewed By:

Bay 7, 820 - 28th Street NE
Calgary, AB

Golder Associates

General Lab Testing Summary

Project No.: 1534393
Short Title: Waterton Park Staff Housing
Tested By: DS

Phase: 2000
Sched: B662
Date: 19-Oct-15

Sample Identification					Laboratory Test Results					
Source	Sample Type	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-02	GS1	0.0	0.9	B662-13	-					
	GS2	0.9	1.8	B662-14	0.8					
	GS3	1.8	2.7	B662-15	0.6					
	SS4A	2.7	3.1	B662-16	-					
	GS4	3.1	3.7	B662-17	-					
	GS5	3.7	4.6	B662-18	1.3					
	GS6	4.6	5.8	B662-19	-					
	SS7	5.8	6.2	B662-20	-					
	GS8	6.2	7.3	B662-21	1.5					
	GS9	7.3	8.2	B662-22	6.3					
	GS10	8.2	8.8	B662-23	2.9					
	SS11	8.8	9.3	B662-24	-					

Reviewed By:

Golder Associates

General Lab Testing Summary

Project No.: 1534393
Short Title: Waterton Park Staff Housing
Tested By: DS

Phase: 2000
Sched: B662
Date: 19-Oct-15

Sample Identification					Laboratory Test Results					
Source	Sample Type	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-03	GS1	0.0	0.9	B662-25	-					
	GS2	0.9	1.8	B662-26	-					
	GS3	1.8	2.7	B662-27	2.9					
	GS4	2.7	3.7	B662-28	1.7					
	GS5	3.7	4.6	B662-29	-					
	GS6	4.6	5.5	B662-30	1.5					
	GS7	5.5	6.4	B662-31	-					
	GS8	6.4	7.3	B662-32	1.6					
	GS9	7.3	8.2	B662-33	4.1					
	GS10	8.2	8.8	B662-34	3.8					
	SS11	8.8	9.3	B662-35	-					

Reviewed By:

Bay 7, 820 - 28th Street NE
Calgary, AB

Golder Associates

General Lab Testing Summary

Project No.: 1534393
Short Title: Waterton Park Staff Housing
Tested By: DS

Phase: 2000
Sched: B662
Date: 19-Oct-15

Sample Identification					Laboratory Test Results					
Source	Sample Type	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-04	GS1	0.0	0.9	B662-36	-					
	GS2	0.9	1.8	B662-37	4.5					
	GS3	1.8	2.7	B662-38	2.6					
	GS4	2.7	3.7	B662-39	-					
	GS5	3.7	4.6	B662-40	1.7					
	GS6	4.6	5.8	B662-41	-					
	GS7	5.8	6.4	B662-42	3.5					
	GS8	6.4	7.6	B662-43	2.7					
	SS9	7.6	8.1	B662-44	-					
	GS10	8.1	8.2	B662-45	3.3					
	GS11	8.2	8.8	B662-46	4.3					
	SS12	8.8	9.3	B662-47	-					

Reviewed By:

Bay 7, 820 - 28th Street NE
Calgary, AB

Golder Associates

General Lab Testing Summary

Project No.: 1534393
Short Title: Waterton Park Staff Housing
Tested By: DS

Phase: 2000
Sched: B662
Date: 19-Oct-15

Sample Identification					Laboratory Test Results					
Source	Sample Type	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-05	GS1	0.0	0.9	B662-48	-					
	GS2	0.9	1.8	B662-49	-					
	GS3	1.8	2.7	B662-50	1.9					
	GS4	2.7	3.7	B662-51	1.4					
	GS5	3.7	4.6	B662-52	-					
	GS6	4.6	5.5	B662-53	1.9					
	GS7	5.5	6.4	B662-54	-					
	GS8	6.4	7.6	B662-55	4.2					
	SS9	7.6	8.1	B662-56	-					
	GS10	8.1	8.2	B662-57	-					
	GS11	8.2	8.8	B662-58	4.5					
	SS12	8.8	9.3	B662-59	-					

Reviewed By: _____

Golder Associates

General Lab Testing Summary

Project No.: 1534393
Short Title: Waterton Park Staff Housing
Tested By: DS

Phase: 2000
Sched: B662
Date: 19-Oct-15

Sample Identification					Laboratory Test Results					
Source	Sample Type	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-06	GS1	0.0	0.9	B662-60	-					
	GS2	0.9	1.8	B662-61	-					
	GS3	1.8	2.7	B662-62	3.3					
	GS4	2.7	3.7	B662-63	1.4					
	GS5	3.7	4.6	B662-64	1.8					
	GS6	4.6	5.5	B662-65	-					
	GS7	5.5	6.4	B662-66	3.1					
	GS8	6.4	7.3	B662-67	-					
	GS9	7.3	8.2	B662-68	1.2					
	GS10	8.2	8.8	B662-69	-					
	GS11	8.8	9.3	B662-70	-					
	SS12	9.3	9.8	B662-71	-					

Reviewed By: GM

Golder Associates

General Lab Testing Summary

Project No.: 1534393
Short Title: Waterton Park Staff Housing
Tested By: DS

Phase: 2000
Sched: B662
Date: 19-Oct-15

Sample Identification					Laboratory Test Results					
Source	Sample Type	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-07	GS1	0.0	0.9	B662-72	10.2					
	GS2	0.9	2.7	B662-73	-					
	GS3	2.7	3.7	B662-74	-					
	GS4	3.7	4.6	B662-75	1.0					
	GS5	4.6	4.6	B662-76	-					

Reviewed By:

Golder Associates

General Lab Testing Summary

Project No.: 1534393
Short Title: Waterton Park Staff Housing
Tested By: DS

Phase: 2000
Sched: B662
Date: 19-Oct-15

Sample Identification					Laboratory Test Results					
Source	Sample Type	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-08	GS1	0.0	0.9	B662-77	-					
	GS2	0.9	1.8	B662-78	3.1					
	GS3	1.8	2.7	B662-79	2.1					
	GS4	2.7	3.7	B662-80	0.7					
	GS5	3.7	4.6	B662-81	-					

Reviewed By:

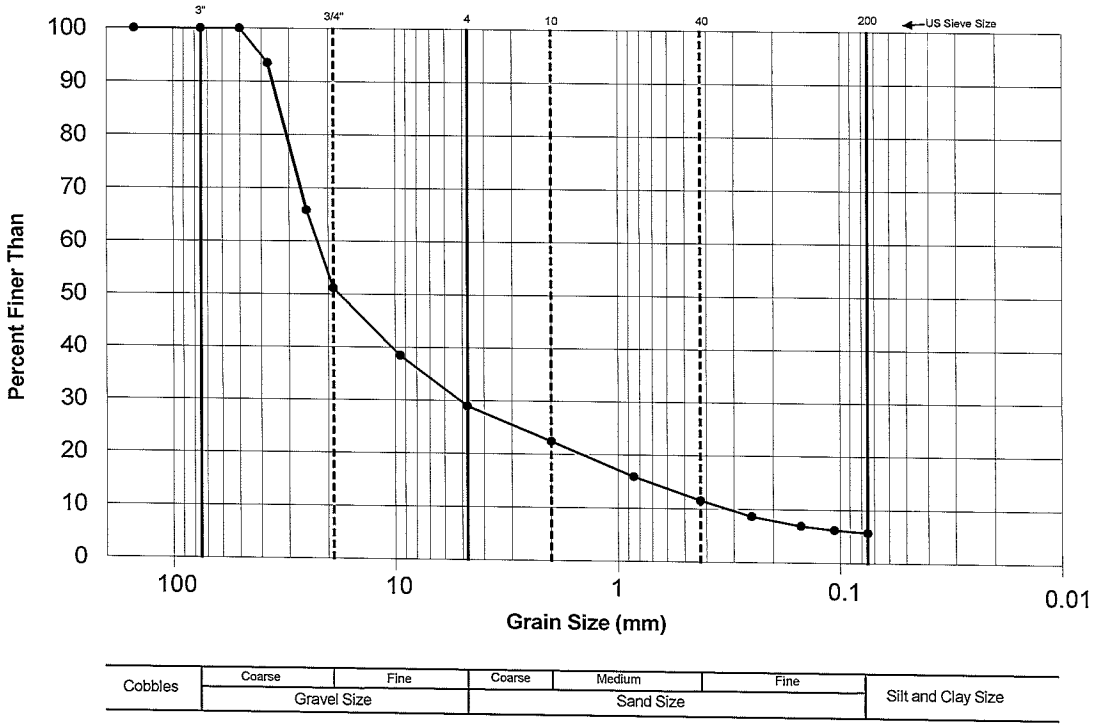
Bay 7, 820 - 28th Street NE
Calgary, AB

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1534393	Phase:	2000		Date:	19-Oct-15
Short Title:	Waterton Park Staff Housing					
Sub Sampled By:	DS	Washed By:	DS		Sieved By:	DS
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-02
Lab No.:	B662-20	Northing:	-	m	Sample No.:	SS7+GS8
Sampled By:	H.Marwasi	Easting:	-	m	Depth From:	5.79 m
Sample Date:	14-Oct-15	Elevation:	-	m	Depth To:	7.32 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	94
25	66
19	51
9.5	38
4.75	29
2	22
0.85	16
0.425	12
0.25	9
0.15	7
0.106	6
0.075	6

Received Water Content (%)
1.8

Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)
0	71	23	6

D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
22.6	5.2	0.3	68.5	3.7

Sample Description: (GP-GM) sandy fine to coarse sub-angular GRAVEL, fine to coarse sand; brown; non-cohesive, dry

USCS Classification: GP-GM

Remarks:

Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

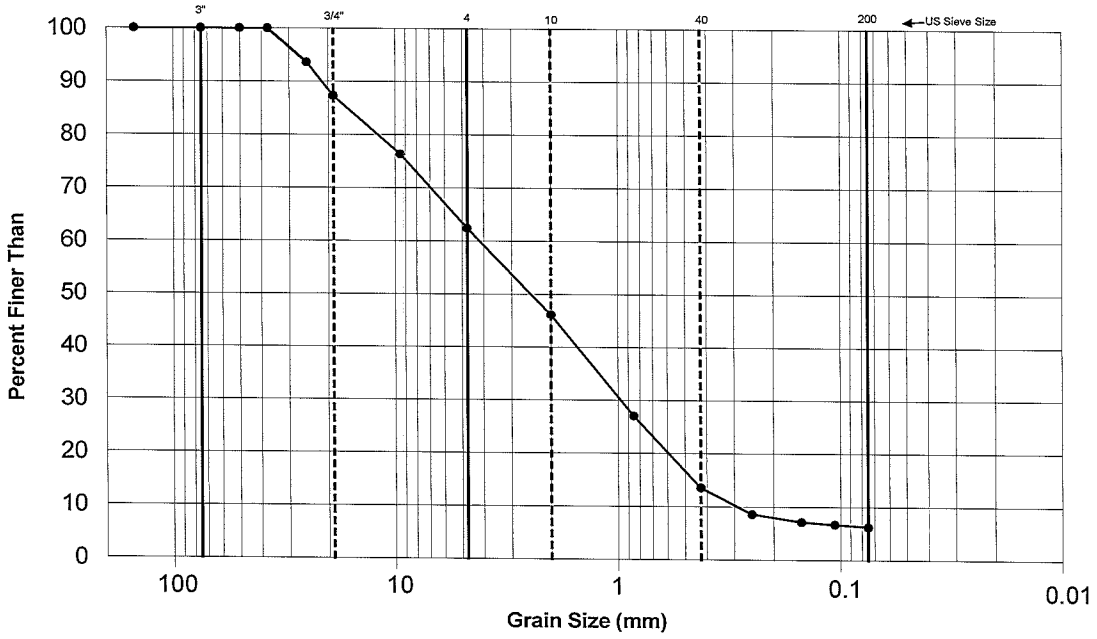
Reviewed by:

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1534393	Phase:	2000		Date:	19-Oct-15
Short Title:	Waterton Park Staff Housing					
Sub Sampled By:	DS	Washed By:	DS		Sieved By:	DS
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-04
Lab No.:	B662-44	Northing:	-	m	Sample No.:	SS9+GS10
Sampled By:	H.Marwasi	Easting:	-	m	Depth From:	7.62 m
Sample Date:	14-Oct-15	Elevation:	-	m	Depth To:	8.23 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	94
19	87
9.5	76
4.75	62
2	46
0.85	27
0.425	14
0.25	9
0.15	7
0.106	7
0.075	6

Received Water Content (%)
3.7

Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)
0	38	56	6

D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
4.3	1.0	0.3	14.5	0.8

Sample Description: (SP-SM) fine to coarse SAND and fine to coarse sub-angular GRAVEL, some non-plastic fines; brown;

USCS Classification: SP-SM

Remarks:

Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by: _____

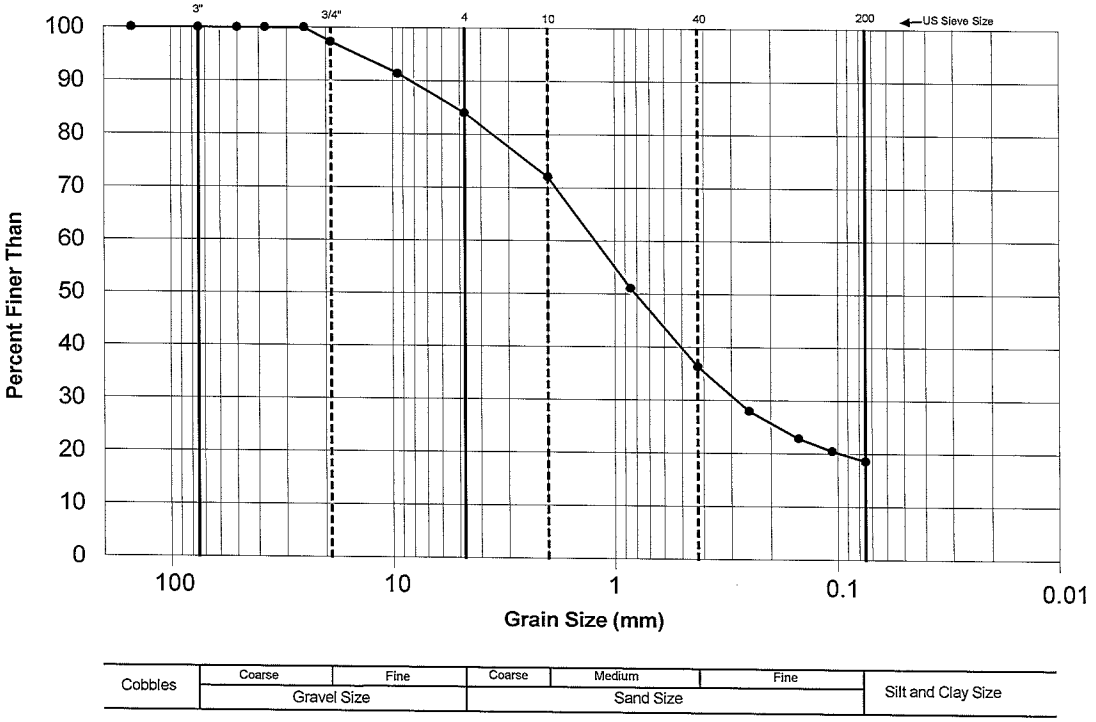
Golder Associates

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1534393	Phase:	2000		Date:	19-Oct-15
Short Title:	Waterton Park Staff Housing					
Sub Sampled By:	DS	Washed By:	DS		Sieved By:	DS
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-05
Lab No.:	B662-56	Northing:	-	m	Sample No.:	SS9+GS10
Sampled By:	H.Marwasi	Easting:	-	m	Depth From:	7.62 m
Sample Date:	14-Oct-15	Elevation:	-	m	Depth To:	8.23 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	97
9.5	91
4.75	84
2	72
0.85	51
0.425	36
0.25	28
0.15	23
0.106	21
0.075	19

Received Water Content (%)
5.9

Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)
0	16	65	19

D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
1.3	0.3	N/A	N/A	N/A

Sample Description: (SM) gravelly SILTY SAND, fine to coarse sub-angular gravel, fine to coarse sand; brown; non-cohesiv

USCS Classification: SM

Remarks:

Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by:

Golder Associates Ltd.
ATTN: DEREK HUDSON
8, 820-28th Street NE
Calgary AB T2A 6K1

Date Received: 21-OCT-15
Report Date: 28-OCT-15 17:33 (MT)
Version: FINAL

Client Phone: 403-248-6386

Certificate of Analysis

Lab Work Order #: L1691575

Project P.O. #:	NOT SUBMITTED
Job Reference:	1534393.2000
C of C Numbers:	10-254693
Legal Site Desc:	WATERTON PARK STAFF HOUSING

Jessica Spira, Env. Tech. DIPL
Senior Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1691575-1 BH15-01 GS3,GS4&GS5 COMBINED (1.83-4.57M)							
Sampled By: DS							
Matrix: SOIL							
Miscellaneous Parameters							
% Saturation	20.0		1.0	%		28-OCT-15	R3298467
Chloride (Cl)	22		20	mg/L		28-OCT-15	R3298484
Resistivity	19000		1.0	ohm cm		28-OCT-15	R3298197
Sulfur (as SO4)	21.7		6.0	mg/L		28-OCT-15	R3298331
pH in Saturated Paste	8.27		0.10	pH		28-OCT-15	R3298467
Salinity in mg/kg							
Chloride (Cl)	4.3		4.0	mg/kg		28-OCT-15	
Sulfur (as SO4)	4.3		1.2	mg/kg		28-OCT-15	
L1691575-2 BH15-04 GS5,GS6&GS7 COMBINED (3.66-6.40M)							
Sampled By: DS							
Matrix: SOIL							
Miscellaneous Parameters							
% Saturation	20.3		1.0	%		28-OCT-15	R3298467
Chloride (Cl)	<20		20	mg/L		28-OCT-15	R3298484
Resistivity	18500		1.0	ohm cm		28-OCT-15	R3298197
Sulfur (as SO4)	20.5		6.0	mg/L		28-OCT-15	R3298331
pH in Saturated Paste	8.22		0.10	pH		28-OCT-15	R3298467
Salinity in mg/kg							
Chloride (Cl)	<4.1		4.1	mg/kg		28-OCT-15	
Sulfur (as SO4)	4.2		1.2	mg/kg		28-OCT-15	

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

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
EXTEMP10	14C - Samples Received with temperature >10 Degrees C

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-PASTE-COL-CL	Soil	Chloride in Soil (Paste) by Colorimetry	CSSS, APHA 4500-Cl E
A soil extract produced by the saturated paste extraction procedure is analyzed for Chloride by Colourimetry.			
PH-PASTE-CL	Soil	pH in Saturated Paste	CSSS 16.2
A soil extract produced by the saturated paste extraction procedure is analyzed by pH meter.			
RESISTIVITY-PASTE-CL	Soil	PASTE RESISTIVITY	ASTM G57-95A
This analysis is carried out using procedures adapted from ASTM G57-95a (2001) "Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method". In summary, 200 to 500 grams of sample is mixed with deionized water as required to create a saturated paste. The sample is then placed directly into a four electrode resistivity soil box and measured for resistivity using a resistivity meter.			
SAL-MG/KG-CALC-CL	Soil	Salinity in mg/kg	Manual Calculation
SAT-PCNT-CL	Soil	% Saturation	CSSS 18.2-Calculation
SO4-PASTE-ICP-CL	Soil	Sulphate (SO4)	CSSS CH15/EPA 6010B
A soil extract produced by the saturated extraction procedure is analyzed for sulfate by ICPOES.			

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

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

Laboratory Definition Code	Laboratory Location

Chain of Custody Numbers:

10-254693

GLOSSARY OF REPORT TERMS

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

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

Quality Control Report

Workorder: L1691575 Report Date: 28-OCT-15

Client: Golder Associates Ltd.
8, 820-28th Street NE
Calgary AB T2A 6K1
Contact: DEREK HUDSON

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
CL-PASTE-COL-CL	**Soil**							
Batch R3298484								
WG2202892-4 DUP		**L1691575-1**						
Chloride (Cl)		22	21		mg/L	1.0	30	28-OCT-15
WG2202937-4 DUP		**L1691575-1**						
Chloride (Cl)		22	21		mg/L	1.0	30	28-OCT-15
WG2202937-3 IRM		**SAL-STD8**						
Chloride (Cl)			86.4		%		70-130	28-OCT-15
WG2202937-1 MB								
Chloride (Cl)			<20		mg/L		20	28-OCT-15
WG2202937-5 MS		**L1691575-1**						
Chloride (Cl)			88.2		%		60-140	28-OCT-15
PH-PASTE-CL	**Soil**							
Batch R3298467								
WG2202892-4 DUP		**L1691575-1**						
pH in Saturated Paste		8.27	8.29	J	pH	0.02	0.3	28-OCT-15
WG2202892-3 IRM		**SAL-STD8**						
pH in Saturated Paste			7.30		pH		6.9-7.5	28-OCT-15
RESISTIVITY-PASTE-CL	**Soil**							
Batch R3298197								
WG2202582-2 DUP		**L1691575-1**						
Resistivity		19000	18000		ohm cm	5.4	10	28-OCT-15
WG2202582-1 IRM		**SAL-STD8**						
Resistivity			91.7		%		80-120	28-OCT-15
SAT-PCNT-CL	**Soil**							
Batch R3298467								
WG2202892-4 DUP		**L1691575-1**						
% Saturation		20.0	19.0		%	5.1	20	28-OCT-15
WG2202892-3 IRM		**SAL-STD8**						
% Saturation			100.8		%		80-120	28-OCT-15
SO4-PASTE-ICP-CL	**Soil**							
Batch R3298331								
WG2202892-4 DUP		**L1691575-1**						
Sulfur (as SO4)		21.7	21.9		mg/L	0.9	30	28-OCT-15
WG2202892-3 IRM		**SAL-STD8**						
Sulfur (as SO4)			87.8		%		70-130	28-OCT-15
WG2202892-1 MB								
Sulfur (as SO4)			<6.0		mg/L		6	28-OCT-15

Quality Control Report

Legend:

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

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.

Hold Time Exceedances:

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

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

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

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

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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