DISTRICT OF SUMMERLAND

SUMMERLAND SOLAR ARRAY

GEOTECHNICAL ENGINEERING ASSESSMENT REPORT

MARCH 13, 2020

wsp

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DISTRICT OF SUMMERLAND

DRAFT REPORT (REVISION 1)

PROJECT NO.: 191-15279-00
DATE: MARCH 13, 2020

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March 13, 2020

DISTRICT OF SUMMERLAND
13211 Henry Avenue
Summerland, BC V0H 1Z0

Attention: Ms. Tami Rothery, Sustainability/Alternative Energy Coordinator

Dear Madam:

Subject: Geotechnical Engineering Assessment Report

13500 Prairie Valley Road, 12591 Morrow Avenue, and Ottley Avenue Future Road Right-of-Way

As requested, WSP Canada Inc. (WSP) has prepared this geotechnical engineering assessment report for the above-referenced project in Summerland, BC. Our geotechnical scope of services for this project did not include assessment of the site soil or groundwater with respect to environmental considerations, or assessment/recommendations for any off-site works required as part of the proposed development. An environmental report is being provided under separate cover.

This report has been prepared in general accordance with our proposal number P19-11042-61 dated November 1, 2019. Authorization to proceed with the scope of work discussed in the proposal was received from District of Summerland (the Client) on November 25, 2019.

Yours truly,

WSP Canada Inc.

Per: Andrew Van Dyk, P.Eng., PMP
Senior Geotechnical Engineer, Environment

ML/AVD/PRE

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Andrew Van Dyk, P.Eng., PMP	Paul R Ell., P.Eng.	

SIGNATURES

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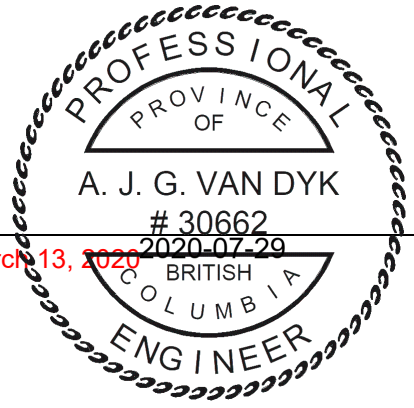

Per: Andrew Van Dyk, P.Eng., PMP
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March 13, 2020

REVIEWED AND APPROVED[1] BY *(must be reviewed for technical accuracy prior to approval)*

Per: Paul R. Ell, P.Eng.
Senior Geotechnical Engineer

March 13, 2020

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This project was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are provided solely by the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

CONTRIBUTORS

CLIENT

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WSP

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Project Geotechnical Engineer	Andrew Van Dyk, P.Eng.
Review Geotechnical Engineer	Paul R. Ell, P.Eng.

SUBCONSULTANTS

Utility Locating Contractor	Quadra Utility Locating Ltd.
Drilling Contractor	Mud Bay Drilling (2015) Ltd.

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TABLES

APPENDICES

1 SITE AND PROJECT DESCRIPTION

The site is located at 13500 Prairie Valley Road, 12591 Morrow Avenue, and a future right-of-way at Ottley Avenue in Summerland, BC. The subject portion of the site is an approximately 5-acre area of an overall 25.7-acre property that was formerly a District of Summerland public works yard and storage area. The overall site slopes gently down from north to south and is generally covered with low vegetation and sparse trees. The subject site area is centered around a relatively flat portion of the site that has previously been partially cleared of vegetation where the ground surface generally consists of exposed soils. There is an asphalt-surfaced access road that runs from the south-west corner of the site toward the north, then east into the flat clearing area.

The site is shown on **Figure 1**, attached to this report.

We understand that a 1 megawatt (MW) solar array and battery storage facility is proposed to be constructed on the site. The proposed foundation systems are not known at this time, but based on past experience on similar projects, we anticipate that driven piles could be used to support the solar panels while shallow foundations would likely be used to support other structures associated with the facility. The anticipated design of the project will likely include 12 m or 6 m long shipping containers, small electrical substations, concrete pads for electrical equipment, oil containment for transformers, and perimeter fencing. The panel mounting system will be either directly anchored to the ground or ballasted on the ground surface. The project is also expected to include an at grade driveway and parking. No further information has been provided to us at this time.

Once the design concept has been finalized, the structural drawings should be forwarded to a professional engineering firm such as WSP for review. Based on the nature of the proposed development and anticipated foundation preparation and construction, interaction between a professional engineering firm such as WSP and the Structural Engineer will be required.

2 SUBSURFACE EXPLORATIONS

To assess the soil and groundwater conditions at the site, on December 2 to 4, 2019, WSP advanced a total of 10 boreholes (BH19-01 to BH19-10), using a track-mounted sonic drill rig. The boreholes were advanced to depths of about 4.6 to 9.8 m below existing grade, Standard Penetration Tests (SPTs) were conducted at all of boreholes to assess the *in-situ* relative density/consistency of the soils. The approximate locations of the boreholes are shown on the attached site plan, **Figure 1**.

Groundwater monitoring wells were installed in three of the boreholes (BH19-01 to BH19-03).

The soil and groundwater conditions encountered at the boreholes were logged in the field by members of our environmental and geotechnical staff. Disturbed soil samples were collected from the boreholes for visual classification and laboratory index testing purposes. The boreholes were closed in conformance with provincial groundwater protection requirements immediately upon completion of logging of the soils.

Detailed descriptions of the soil and groundwater conditions encountered at the boreholes are provided on the soil logs in **Appendix B**. The soil logs also graphically illustrate the SPT blow counts, the moisture content of disturbed soil samples collected from the sonic core sampled, and the percent fines (material passing the 0.075 mm sieve) of the samples on which grain size analyses were conducted. The results of the grain size analyses can be found in **Appendix C**. The Universal Transverse Mercator (UTM) Northing and Easting coordinates and geodetic surface elevations of the borehole locations, as determined on site by survey, are recorded at the top of each soil log, and summarized in **Table 2-1**.

Table 2-1 Borehole Locations and Elevations

BOREHOLE	NORTHING	EASTING	SURFACE ELEVATION
BH19-01	5497055.746	304885.847	571.663
BH19-02	5497146.489	304886.399	568.453
BH19-03	5497134.719	304809.278	568.631
BH19-04	5497118.291	304917.082	572.397
BH19-05 / BH19-05B	5497167.232	304883.369	567.350
BH19-06	5497215.703	304827.987	568.510
BH19-07 / BH19-07B	5497233.696	304745.860	569.856
BH19-08	5497179.180	304792.285	569.166
BH19-09	5497119.538	304863.606	570.168
BH19-10	5497075.312	304847.611	572.500

A summary discussion of the soil and groundwater conditions at the boreholes is provided in the following section of this report. The attached soil logs should be used in preference to the general summary of soil conditions provided below.

3 SOIL AND GROUNDWATER CONDITIONS

3.1 SURFICIAL GEOLOGY

The surficial geology map titled "Surficial Deposits of Late Glacial and Recent Age, Southern Okanagan Valley" prepared by Hugh Nasmith to accompany BC Department of Mines and Petroleum Resources Bulletin 46, 1962, and online map "Surficial geology of Canada" prepared by the Geological Survey of Canada, Canadian Geoscience Map 195, (ed. Prelim., Surficial Data Model v.2.0 conversion of Map 1880A), 2014, describe the soils at the site as deposits consisting of glaciolacustrine / glacial lake sediments in the form of kame terraces and meltwater channels.

3.2 SUBSURFACE SOIL & GROUNDWATER CONDITIONS

The deposits encountered at the WSP boreholes were generally consistent with the description provided on the surficial geology maps.

The general soil deposits encountered at the boreholes at the site were as follows:

- Asphalt (only encountered at BH19-03);
- Topsoil (only encountered at BH19-08);
- Fills (not encountered at BH19-01 and BH19-08);
- Native, mixed and interlayered granular and non-plastic fine-grained deposits;
- Till (only encountered in BH19-05B and BH19-10); and
- Possible bedrock or boulder (only encountered at BH19-10).

Asphalt measuring about 75 mm in thickness was encountered at the surface of BH19-03.

Topsoil consisting of sandy silt measuring about 75 mm in thickness was encountered at the surface of BH19-08.

Fills consisting of sand with varying amounts of gravel and silt ("and" gravel to trace gravel / trace silt to silty) or sandy silt, some gravel were encountered at the surface or beneath the asphalt at all of the boreholes except BH19-01 and BH19-08 and extended to a depth of about 0.2 to 1.5 m below existing grade. The fills were judged to range from compact to very dense based on the SPT blow counts and drilling effort.

Beneath the surficial asphalt, topsoil, and/or fills (or at the surface of BH19-01), native mixed and interlayered granular and non-cohesive fine-grained deposits were encountered to a depth of about 3.0 to 9.8 m below existing grade (bottom of the boreholes, except BH19-05B and BH19-10). These deposits consisted of sand with varying amounts of silt and gravel ("and" silt to trace silt / no gravel to "and" gravel), gravel, trace to some sand, trace silt or silt with varying sand and gravel contents (some sand to "and" sand / no gravel to some gravel). These granular deposits were judged to vary from loose to compact within the planned drilling depths (i.e., about 6 m) based on the SPT blow counts and drilling effort. Boreholes BH19-01, BH19-03 and BH19-06, began to transition to a dense compactness conditions around depths of about 5 m to 6 m below ground surface. Boreholes BH19-05B and BH19-07B were extended to about 9.8 m below ground surface and found that the compactness condition of the soil became dense to very dense around 7 m to 8 m.

Underlying the interlayered granular and non-cohesive fine-grained deposits, till consisting of sandy silt, some gravel to silty sand and gravel was encountered at BH19-05B and BH19-10. The till was encountered at about 9.1 m below ground surface of BH19-05B and extended to the bottom of the borehole at a depth of about 9.8 m below existing grade. In BH19-03, the till was inferred to be a thin seam at a depth of about 3.0 m below existing grade. The till was judged to be very dense based on the SPT blow counts and drilling effort.

Possible bedrock or boulder was encountered at about 3.1 m below existing grade in BH19-10, and extended to the bottom of the hole at about 4.5 m below existing grade.

Groundwater was not encountered in any of the boreholes at the site during the time they remained open. Observations of the site topography and anecdotal evidence suggests that seasonal seepage areas occur around the northern boundary of the development area. We expect that presence of groundwater will vary depending on prevailing weather conditions as well as on a seasonal basis.

3.3 LABORATORY TESTS

Grain size analyses were conducted according ASTM C136/C136M-19 on five samples collected from the boreholes. The grain size analysis results are attached to this report in **Appendix C**, and are summarized in **Table 3-1**:

Table 3-1 Grain Size Analyses

SAMPLE	GRAVEL CONTENT	SAND CONTENT	*FINES CONTENT
BH19-01, G6 (3.0 m)	0.0%	22.7%	77.3%
BH19-03, SPT4 (2.3 m)	0.0%	65.5%	34.5%
BH19-05B, G10 (6.7 m)	0.0%	86.8%	13.2%
BH19-07, SPT4 (1.4 m)	0.0%	52.3%	47.7%
BH19-09, SPT5 (3.0 m)	0.0%	73.7%	26.3%

*Fines is material passing the 0.075 mm sieve.

Corrosivity testing for metal piles was conducted on selected samples collected from the boreholes. The test method was based on the American Water Works Association method for assessment of corrosion of ductile iron pipe (AWWA C105). The results of the AWWA C105 tests that were conducted on four samples are attached to this report in **Appendix D**, and are summarized in **Table 3-2**:

Table 3-2 AWWA C105 Testing

SAMPLE	RESISTIVITY	PH	REDOX	SULFIDES
BH19-07 – 1.1-1.5 m	322050 Ohm-cm	7.1	244 mV	None
BH19-08 – 1.1-1.4 m	305375 Ohm-cm	6.9	257 mV	None
BH19-09 – 1.1-1.4 m	129375 Ohm-cm	7.7	273 mV	None
BH19-10 – 0.8-1.1 m	131625 Ohm-cm	6.6	283 mV	None

Tests to assess the potential for sulfate attack on concrete testing were conducted on three selected samples collected from the boreholes. Likewise, the potential for degradation of concrete from chlorides in the soil was tested on seven samples. These soil chemistry tests were conducted by a subcontracted analytical laboratory. The results are attached to this report in **Appendix E**, and are summarized in **Tables 3-3 and 3-4**:

Table 3-3 Water-Soluble Sulfates

SAMPLE	WATER-SOLUBLE SULFATES
BH19-04, SPT7 (4.6-5.2 m)	<0.050%
BH19-05, SPT2 (0.6-1.2 m)	<0.050%
BH19-06, SPT4 (2.3-2.9 m)	<0.050%

Table 3-4 Chloride Content

SAMPLE	CHLORIDES
BH19-01, SPT3 (1.2-1.8 m)	0.00026%
BH19-02, SPT3 (1.5-1.8 m)	<0.00020%
BH19-03, SPT3 (1.5-1.8 m)	0.00026%
BH19-04, SPT3 (1.5-1.8 m)	<0.00020%
BH19-05, SPT3 (1.5-1.8 m)	<0.00020%
BH19-05, SPT4 (2.4-2.7 m)	<0.00020%
BH19-06, SPT3 (1.5-1.8 m)	<0.00020%

4 GEOTECHNICAL ASSESSMENT

4.1 GENERAL

The following sections of this report provides geotechnical design considerations based on WSP's interpretation of the field and laboratory test results. The discussion provided below is intended as preliminary guidance for planning and design by qualified engineers.

Sections of this report may present comments that pertain to aspects of construction methodology that could affect the project design. Contractors bidding on or undertaking any work at the site should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing, etc.

The geotechnical assessment provided in this section of the report are preliminary. WSP was not provided with details regarding the proposed solar array layout or foundation design. Where required WSP has made assumptions. At detail design, a qualified professional such as WSP should be retained to review the design and modify the recommendations in the report as may be required to remain consistent with the design.

4.2 SITE SUITABILITY

Slopes around the proposed development area were generally inclined between about 20 and 30 degrees from horizontal. Evidence of large-scale landslides were not observed. Assuming the soil conditions on the slopes are generally comprised of compact granular soils with elevated fines content, typical of the area, these slopes are likely to remain adequately stable throughout the life of the proposed solar array.

Two areas with over-steepened cut slopes exist along the access road and cleared portion of the site. Their locations are shown on the attached **Figure 1**. These areas may be subject to localized sloughing and/or surface ravelling.

Bedrock outcrops occurred at some in localized areas outside of the cleared portion of the site area but were generally less than 1 m high. Fractured rock and cobbles and/or boulders are present at the ground surface in localized areas. Evidence of rockfall was not observed at the site, however loose rocks on the ground surface of the slopes could roll into the development area. Upon confirming the site layout, the slopes above should be inspected for potential rolling rock, and the necessity of rockfall catchment fencing evaluated.

Fine-grained soils encountered in the boreholes were judged to have a low susceptibility for shrinking, swelling or collapse. Sinkholes or subsurface voids were not evident at the site.

Based on available climate data for the Summerland area, the anticipated depth of frost penetration for the site is 0.6 m below grade.

In our opinion, based on the soil and groundwater conditions encountered in our boreholes as well as the ground conditions of the slopes around the proposed development area, the subject site is suitable to support the proposed solar array from a geotechnical perspective.

These subjective comments are intended to identify potential concerns with the objective of providing an opinion regarding site suitability. Detailed qualitative or quantitative analyses were not part of our scope of work. More detailed assessment may be required if a landslide assessment assurance statement is required.

4.3 SEISMIC CONSIDERATIONS

The soils encountered at the boreholes generally consist of surficial fills overlying native deposits of interlayered granular and fine-grained soils. The relative density/consistency of the underlying native soils ranged from loose to very dense, and generally became denser with increasing depth. Groundwater levels were not encountered in any of the boreholes to a maximum depth of about 9.8 m below grade at the time of our investigation. It is our preliminary opinion that the overall site soils would be adequately resistant to liquefaction during a design seismic event defined by the 2018 British Columbia Building Code.

For preliminary design purposes, Site Class "D" is assigned to the site due to the presence of loose soil conditions within the upper 3 m of the site, however, reassigning a Site Class "C" to this site could be possible if in-situ seismic shear wave measurements become available.

Based on Natural Resources Canada 2015 National Building Code seismic hazard calculation for the site coordinates, the seismic hazard values for use in determining F(T) values are attached to this report in **Appendix F**. The values provided in the appendix pertain Site Class "C" and must be adjusted to Site Class "D" using the Tables 4.1.8.4-B to 4.1.8.4-H of the 2018 BC Building Code and considering Site Class "D", the PGA should be factored by 1.29 to obtain the design PGA for this site.

It should be noted that the Site Class provided above should be reviewed at the time of detailed design and may need to be revised if the Building Code has been updated at that time.

4.4 SOIL CORROSIVITY ON STEEL

The average laboratory resistivity of the soil is summarized in Section 3.3 (Laboratory Tests), and ranges from 129,375 to 322,050 Ohm-cm. Soil resistivity is often used in practice as a measure of the corrosion potential of a soil. Roberge (2000)[2] developed a corrosivity rating based on soil resistivity alone. The classification is summarized in **Table 4-1**. Based on the Roberge criteria, laboratory electrical resistivity testing results suggest the site soil is "essentially non-corrosive".

Table 4-1 Corrosivity Severity Rating

SOIL RESISTIVITY (Ω.CM)	CORROSIVITY RATING
>20,000	Essentially non-corrosive
10,000-20,000	Mildly corrosive
5,000-10,000	Moderately corrosive
3,000-5,000	Corrosive
1,000-3,000	Highly corrosive
<1,000	Extremely corrosive

By comparison AWWA C105 uses a 25-point scale based on five parameters to assess the potential of the soil to corrode ductile iron, where 10 points or more is considered potentially corrosive. In this case, the samples tested per the AWWA C105 method scored 1, suggesting that the soils at this site are unlikely to cause corrosion of iron-based elements in the ground.

[2] Roberge, P.R. (2000). *Handbook of Corrosion Engineering*, McGraw-Hill Companies Inc., New York, New York.

Australia/New Zealand Standard 2041.1[3] has guidance for expected metal loss rates based on resistivity and pH for galvanized steel. For soils with resistivity near 10 and 50 Ohm-m and pH near 4 to 9 respectively the select soil may be aggressive and the sulfate and chloride ion concentration shall be considered.

The results from the water-soluble sulfate content and chloride content laboratory tests are summarized in Section 3.3 (Laboratory Tests). Water-soluble sulfate concentrations in the selected soil samples collected from the boreholes were all less than 0.05 percent (500 ppm). Chloride concentrations in the selected soil samples collected from the boreholes were all less than 0.0025 percent (25 ppm).

Soils meeting the above resistivity and pH criteria, with a chloride ion content greater than 200 ppm or sulfate ion content greater than1000 ppm, or both, loss rates are specified in Standard 2041.1. However, based on the resistivity, sulfate ion content, and chloride ion content, the loss rates provided in the Standard are not applicable for the site soils tested.

The lost rate shall be calculated from the worst-case loss based on the pH, chlorides, and resistivity.

4.5 CONCRETE EXPOSURE CLASS

The results from the water-soluble sulfate content laboratory tests are summarized in Section 3.3 (Laboratory Tests). Water-soluble sulphate concentrations in the selected soil samples collected from the boreholes were all less than 0.05 percent. Table 3 of the CSA Group Standard Practices[4] "Additional Requirements for Concrete Subjected to Sulphate Attack" indicates that the degree of exposure is considered "moderate" for sulphate concentrations of 0.1 to 0.2 percent, and "severe" for concentrations of 0.2 to 2.0 percent. The test results indicate a negligible degree of exposure to sulfate attack on concrete in contact with the soils. Any imported soils should be tested for water-soluble sulfate concentration and associated sulfate exposure classification.

Concrete properties should be specified by the structural engineer to meet structural requirements and exposure to freeze and thawing and/or chlorides.

4.6 DEEP FOUNDATIONS (PILES)

4.6.1 GEOTECHNICAL FEASIBILITY OF DEEP FOUNDATIONS

Generalized stratigraphy at the site for the purpose of designing deep foundations includes loose silt/sand mixtures to a depth of about 4 m, underlain by compact silt/sand mixtures to a depth of about 7.5 m, underlain in turn by dense silt/sand/gravel mixtures to about 10 m below ground surface. At depths greater than about 10 m, very dense glacial till is assumed to persist until bedrock is encountered.

Granular soils are generally poor for developing large frictional resistances along the pile shaft but generally can provide adequate end-bearing resistance. In addition, driven piles can develop higher resistances than bored piles. At this site, we suggest that low to moderate end-bearing resistances can be achieved with driven piles founded between about 4.0 and 7.5 m below existing ground surface, while significantly higher end-bearing resistances are available below about 7.5 m.

Bored piles could be considered, however ground sloughing along the annulus of the bore shaft would be prevalent in the loose silt/sand mixtures making it necessary to case the holes until concrete is in place.

[3] Standards Australia Limited/Standards New Zealand (2011). Buried Corrugated Metal Structures, SAI Global Limited, Sydney, Australia.
[4] CSA Group (2014). "Concrete materials and methods of concrete construction / Test methods and standard practices for concrete – A23.1-14 / A23.2-14." CSA Group.

Helical piles would be difficult to install to the depths generally required to develop higher end-bearing resistances, due to the presence of coarse gravels and cobbles, particularly at greater depths. Further, the loose soils at shallow depths are unlikely to develop adequate lateral resistance against the slender shafts common to this pile type. For this reason, we suspect that use of helical piles should be limited to lightly loaded structures not subjected to lateral loading, or for structures that require uplift resistance. Nonetheless, helical piles are economical so we suggest their feasibility be reviewed once loading details become available.

Based on the foregoing discussion, we expect that driven piles, (e.g., open or close-end steel pipes, and H-piles) are most suitable for the site, from a geotechnical perspective. Deeper piles bearing in the dense to very dense strata encountered at depths below about 7.5 to 10 m are better suited for steel H-piles with hardened bearing points as these are less likely to become hung on cobbles or boulders. Minimum pile sizes will depend on the axial and lateral loading that they will be required to carry and should be determined during detailed design.

Construction considerations for pile driving at this site are discussed in Section 5.2 below.

4.6.2 BEARING RESISTANCE OF DEEP FOUNDATIONS AT ULS

Based on our interpretation of the subsurface soil and groundwater conditions at the site, we estimate the factored shaft and end-bearing tip resistances at Ultimate Limit States (ULS) listed in **Table 4-2** will be adequate for preliminary design purposes. We recommend neglecting shaft resistance when calculating the end-bearing resistance of piles loaded in compression. End-bearing tip resitances should be reduced by a resistance factor of 0.4 and uplift shaft resistances should be reduced by a resistance factor of 0.3; these factors are already considered in the table below. Higher resistance factors can be used if in-situ pile load testing is conducted prior to construction.

Pile spacing should be at least three times the shaft diameter otherwise group efficiency reductions will be required.

Adfreeze stresses are anticipated to be negligible for piles installed at the site due to the shallow frost penetration depth. However, the soil strength in the upper 0.6 m (the adfreeze stress zone) of the subgrade soils should be ignored due to potential effects of frost action.

Table 4-2 Preliminary Factored Design Parameters for Driven Piles

PILE TIP DEPTH	ANTICIPATED SOIL TYPE	FACTORED ULS UPLIFT RESISTANCE Φ=0.3	FACTORED ULS END-BEARING RESISTANCE Φ=0.4
4.0 m	Fill or loose silt/sand mixtures	4 kPa	100 kPa
7.5 m	Compact silt/sand mixtures	10 kPa	3,000 kPa
10.0 m	Dense silt/sand/gravel mixtures	18 kPa	10,000 kPa

A preliminary estimate for the end-bearing and uplift capacity of a single helical pile is provided in **Table 4-3**. Our preliminary estimate considers a 355 mm diameter helical pile installed to a depths of 4 m and 7.5 m. The soil bearing capacity is applied to each individual helical plate. Provided that helical plates are spaced greater than three times the diameter of the largest helix, the end-bearing capacity may be given as the summation of the capacity of each plate. Estimates of uplift capacity is based on a single helical plate. Uplift capacity cannot be summed in the same manner as end-bearing capacity. As is the case with driven piles, we recommend neglecting shaft resistance. The same end bearing and uplift resistance factors used for driven piles are applicable to helical piles.

Table 4-3 Preliminary Factored Design Parameters for Helical Piles

	ANTICIPATED SOIL TYPE	FACTORED ULS UPLIFT RESISTANCE Φ=0.3	FACTORED ULS END-BEARING RESISTANCE Φ=0.4
4.0 m	Fill or loose silt/sand mixtures	50 kN	100 kN
7.5 m	Compact silt/sand mixtures	150 kN	300 kN
10.0 m	Dense silt/sand/gravel mixtures	N/A	N/A

4.6.3 SERVICEABILITY OF DEEP FOUNDATIONS

4.6.3.1 SETTLEMENT OF DEEP FOUNDATIONS

The Serviceability Limit State (SLS) of end-bearing piles was assumed to correspond to a maximum settlement of 20 mm. The applied load required to achieve that magnitude of settlement was calculated. The results indicate that an unfactored axial compressive load of 700 kN yielded maximum settlement less than the assumed SLS settlement limit.

4.6.3.2 LATERAL PILE RESISTANCE

Soil resistance lateral loading on a pile is dependent on the magnitude of loading, the stiffness of the pile and the stiffness of the soil. One method for calculating the performance of a pile under lateral loading is by applying empirical load-deflection formulae, known as p-y curves, and using those to calculate the soil-pile interaction at a series of nodes along the pile length. These calculations are commonly performed using commercial software such as Lpile by Ensoft, Inc.

Two soil models are available in Lpile that are considered applicable to the granular soils at the proposed development site: the Reese model and the API RP 2A model. In either case, the absences of a groundwater level in the boreholes indicates that the variants of these two models for sand above the water table are applicable. We expect that either Reese or API models would be appropriate or both can be applied and used for verification of results. Cyclic loading from sustained wind loading should be considered by the pile designers.

Soil parameters recommended for analysis of serviceability limits of a laterally loaded pile using the Reese and API models are provided in **Table 4-4**. The lateral pile capacity should be confirmed by a lateral load test.

Table 4-4 Soil Parameters for Lateral Pile Capacity Analysis

SOIL TYPE	UNIT WEIGHT, γ (kN/m^3)	ANGLE OF INTERNAL FRICTION, (°)	COEFFICIENT OF HORIZONTAL SUBGRADE REACTION, K_S (MN/m^3)	COEFFICIENTS C_1, C_2, AND C_3 FOR API SAND
Loose Silt/sand Mixtures	17	30	10	35, 55, 25
Compact Silt/Sand Mixtures	18	34	30	55, 65, 45
Dense Silt/Sand/Gravel Mixtures	21	38	55	75, 80, 80

4.7 SHALLOW FOUNDATIONS

4.7.1 BEARING RESISTANCE AT ULS

Bearing resistance estimates at Ultimate Limit States (ULS) that can be used to design auxiliary buildings associated with the solar arrays are as listed in **Table 4-4**. Assumptions affecting the foundation design parameters are stated below. Where the listed assumptions are inconsistent with the final design, the SLS and ULS bearing resistances provided below should be revised.

- The footings will consist of shallow strip and spread footings.
- Strip footings are assumed to be at least 0.5 m wide.
- Spread footings are assumed to be at least 1.0 m square.
- The footings will bear on loose silt/sand mixtures after they have been compacted or on an engineered fill bearing pad (see Section 5.9).
- The minimum foundation elevation will be at least 0.6 m below surrounding grade for confinement purposes and frost protection.
- The foundations will be concentrically and vertically loaded.
- Footings will be stepped at no steeper than 2H:1V
- Footings will be located below a 2H:1V influence line taken up from the base of the adjacent excavations for other footings, utilities, etc.

Table 4-5: ULS factored bearing resistance for shallow foundations.

SUBGRADE SOIL TYPE	STRIP FOOTINGS (Φ=0.5) (1)	SPREAD FOOTINGS (Φ=0.5) (1)
Loose Silt/sand Mixtures (after compacting) or Engineered Fill	150 kPa	200 kPa

(1) Geotechnical reduction factor, per the Building Code.

The bearing resistances provided will be heavily influenced by the quality of the subgrade preparation. Comments on construction considerations as they may affect the design and/or performance of the as-constructed structure are provided in Sections 5.3 and 5.9. Recommendations for geotechnical review are provided in Section 5.11.

4.7.2 SERVICEABILITY OF SHALLOW FOUNDATIONS

The Serviceability Limit State (SLS) of shallow strip and spread footings was assumed to correspond to a maximum total settlement of 25 mm or less and maximum differential settlement of 20 mm over a 10 m length or less.

Bearing resistance estimates at SLS that can be used to design auxiliary buildings associated with the solar arrays are as listed in **Table 4-5**. Assumptions affecting the foundation design parameters are stated in the previous section of this report.

Table 4-6: SLS unfactored factored bearing resistance for shallow foundations.

SUBGRADE SOIL TYPE	STRIP FOOTINGS (Φ=1.0) (1)	SPREAD FOOTINGS (Φ=1.0) (1)
Loose Silt/sand Mixtures (after compacting) or Engineered Fill	150 kPa	200 kPa

(2) Geotechnical reduction factor, per the Building Code.

4.8 RAFT FOUNDATIONS

Raft foundations may be required for some aspects of the proposed solar array development. These types of foundations are not typically governed by overall bearing capacity, but by the stiffness and settlement characteristics of the slab or raft. In designing slab or raft foundations for deflection, the vertical modulus of subgrade reaction, kv, is commonly used to represent the vertical stiffness of the soil below the foundation and is defined as follows:

$$k_v = \frac{q}{\delta}$$

Where k_v = Modulus of vertical subgrade reaction (MPa/m)
q = Applied pressure acting on the footing (MPa)
δ = Settlement of the footing by the applied pressure (m)

The modulus value changes with footing size; therefore, a 1 ft^2 (300 mm by 300 mm) plate has been adopted as the standard reference. The vertical modulus of subgrade reaction for a standard 1 ft^2 (300 mm by 300 mm) plate is denoted by k_{v1}. A typical value of k_{v1} for the loose silt and sand mixtures is about 10 MPa/m. For foundations with dimensions larger than the 1 ft^2 (300 mm by 300 mm) reference area, the calculation is performed as follows.

$$k_{vb} = k_{v1} \cdot \left(\frac{3.28b + 1}{6.56b}\right)$$

Where k_{vb} = Modulus of vertical subgrade reaction for actual foundation dimension, b (MPa/m)
k_{v1} = Modulus of vertical subgrade reaction for a 1 ft^2 plate (MPa/m)
b = Width of loaded area

Modulus of vertical subgrade reaction is not an intrinsic material property but is dependent on the size and shape of the raft or footing, as well as the load distribution throughout the raft. The values for modulus of vertical subgrade reaction provided herein represents estimated empirical correlations based on interpretations of the available geotechnical data collected during our geotechnical investigation at the Site.

4.9 DRAINAGE

4.9.1 FOUNDATION DRAINAGE

At this preliminary stage, we expect that lightly loaded structures founded at or slightly below grade will not require perimeter foundation drainage, provided any building interior graded supported slabs are above surrounding grade and grade slopes away from the building(s).

4.9.2 SITE DRAINAGE

Groundwater was not encountered in the test holes however seepage is expected to occur seasonally and following periods of sustained precipitation. Exterior grades adjacent to proposed foundations should direct surface water away from foundations, accounting for potential long-term settlement of foundation wall backfill, if any. Any grading design that introduces water into engineered fills that are placed on the site to support structures could result in unexpected settlements and should therefore be avoided.

The soil encountered in the boreholes within about 2 m of the ground surface was generally comprised of granular soil with highly variable fines content, loose and dry. On-site stormwater disposal could be considered at this site provided disposal areas are at least 5 m downgradient of foundation elements. The permeability of the soils will be variable, with relatively low discontinuous layers of lower permeability soils. We recommend assessing the viability of potential stormwater disposal areas once the site layout has been confirmed.

4.10 SLAB-ON-GRADE

The interior slab-on-grade of proposed buildings should be constructed on an under-slab drainage layer consisting of a minimum of 150 mm of 25 mm minus crushed sand and gravel which contains less than 8 percent fines by weight. The drainage layer should be compacted to at least 98 percent of the material's SPMDD.

We recommend that polyethylene sheeting be provided below the interior slab-on-grade to inhibit moisture migration through the concrete.

For areas that are not sensitive to settlement, a slab-on-grade system could be used for foundations of un-heated structures. The subgrade should be prepared in accordance with our recommendations in Section 5.3 (Subgrade Preparation). It is important that the subgrade surface be protected from moisture changes and freezing temperatures both during and after construction to minimize the potential of frost heave/thaw and softening of the subgrade soils.

If a slab-on-grade system is used for foundations, the concrete slab should float independently of any load-bearing walls and columns to minimize the potential damage from small differential settlement between these elements.

4.11 ACCESS ROAD PAVEMENT STRUCTURE

Where subgrade fill is required to establish the desired pavement grades, it should consist of engineered fill as described in Section 5.9 (Engineered Fill / Foundation Backfill) and placed and compacted as described in that section as well.

For asphalt-surfaced on-site access roadway and parking areas constructed as part of the proposed development, we recommend the following:

- 65 mm of hot-mix asphaltic concrete, underlain by
- A minimum of 75 mm of 25 mm minus crushed gravel base course, underlain by
- A minimum of 300 mm of 75 mm minus pit run sand and gravel sub-base course, underlain by
- Inorganic subgrade or compacted subgrade fill placed over the inorganic subgrade.

For gravel-surfaced on-site roadway and parking areas, we recommend the following:

- A minimum of 200 mm of 25 mm minus crushed gravel base course, underlain by
- A minimum of 300 mm of 75 mm minus pit run sand and gravel sub-base course, underlain by
- Inorganic subgrade or compacted subgrade fill placed over the inorganic subgrade.

The subgrade should be compacted and proof-rolled under the review of the Geotechnical Engineer prior to placement of subgrade and/or subbase fill or base course fill, areas that rut or deflect excessively would require excavation to competent subgrade and replacement with compacted engineered fill. Subbase and base course fills should be compacted to not less than 100 percent of their SPMDD, as confirmed by in-place soil density testing.

Comments on construction considerations as they may affect the design and/or performance of the as-constructed structure are provided in Sections 5.4 and 5.9. Recommendations for geotechnical review are provided in Section 5.11.

5 CONSTRUCTION CONSIDERATIONS

5.1 GENERAL

This section of the report provides geotechnical considerations that pertain to aspects of construction methodology that could affect the project design. The recommendations below should be incorporated into the project design as they may affect assumptions used to develop recommendations provided in the previous section.

This section is not intended to provide instructions to contractors tasked with construction the proposed solar farm. Contractors bidding on or undertaking any work at the site should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing, etc.

5.2 PILE DRIVING

Set criteria for pile driving are based on empirical formulae and depend on the pile driving equipment, pile compressibility and the ground resistance. These formulae are well known to have low reliability and should only be used as a tool to assist with confirming that the pile is seated in an adequate bearing stratum. Using these formuale to determine the bearing capacity of the pile is discouraged.

As an initial guideine set criteria given below are based on a 2250 kg diesel hammer dropped about 1.5 m, onto a driving cap with a dolly of sufficient thickness made of greenheart timber. Where these assumptions differ from the actual equipment used during construction, the set criterion should be revised. Based on the above, practical refusal for the driven piles may be taken as about 2 blows per 25 mm of pile penetration. Piles should not be driven beyond practical refusal unless proven by a pile load test in the field that higher hammer energy will not result in the damage of the piles. Upon selection to the pile type and section, the structural capacity of the section should be confirmed reative to the expected driving stresses associated with the above.

Ground conditions below about 7.5 m are expected to be dense to very dense, with presence of coarse gravel, cobbles, bounders and possible bedrock. Piles should be fitted with a hardened cutting shoe to mitigate potential damage to the pile tip when driving through these materials.

5.3 FOUNDATION SUBGRADE PREPARATION

Uncontrolled, unsuitable or otherwise deleterious materials (e.g. organic materials, topsoil, tree roots, random fill, and frozen soils) should be stripped from proposed foundation footprints, interior slab-on-grade footprints, or Engineered Fill areas. Based on the boreholes, stripping depth of about 0.5 to 1.5 m are expected to remove asphalt, topsoil, and existing fills and expose native subgrade soils, but actual stripping depths may vary across the site. These materials can be stockpiled separately for use as landscaping fill but may not necessarily be suitable for use as engineered fill.

Where excavation deeper than the proposed footing depth is required to remove existing fills, buried structures, or other subsurface obstructions, the grade should be reinstated using engineered fill as described in Section 5.9 (Engineered Fill / Foundation Backfill).

To reduce subgrade disturbance, excavation should be conducted with a smooth-mouth clean-out bucket as the excavator retreats from the excavated area. The subgrade should be compacted with a large, smooth-drum vibratory roller, and proof-rolled under the review of the geotechnical engineer prior to placing foundations or engineered fill. Areas that rut or deflect excessively would require further excavation and replacement with compacted engineered fill. Construction traffic should not travel directly on the exposed subgrade.

Construction traffic should not travel directly on the unprotected subgrade and should generally avoid travelling across proposed building footprints.

The geotechnical engineer should review the prepared subgrade under foundations, and slabs-on-grade areas prior to placing engineered fill or foundations.

5.4 ROADWAY SUBGRADE PREPARATION

Uncontrolled, unsuitable or otherwise deleterious materials (e.g. organic materials, topsoil, tree roots, random fill, and frozen soils) should be stripped from proposed access roads and on-site driving areas. Existing fill at the site is likely suitable to remain in place, pending confirmation of the subgrade conditions at the time of construction, and some settlement and/or heave can be tolerated. In this case, stripping depths on the order of about 0.5 m in local areas could suffice to remove asphalt and organic soils and expose a subgrade consisting of native soils or existing fills.

To reduce subgrade disturbance, excavation should be conducted with a smooth-mouth clean-out bucket as the excavator retreats from the excavated area. The subgrade should be compacted with a large, smooth-drum vibratory roller, and proof-rolled under the review of the geotechnical engineer prior to placing pavement structure fills. Areas that rut or deflect excessively would require further excavation and replacement with compacted engineered fill. Construction traffic should not travel directly on the exposed subgrade.

Construction traffic should not travel directly on the unprotected subgrade and should generally avoid travelling across the proposed building footprint. Depending on the contractor's equipment and construction methods, thickened haul roads may be required to preserve the subgrade integrity.

The geotechnical engineer should review the prepared subgrade under driving surface or exterior hard-surfaced areas prior to placing pavement structure fill.

5.5 TEMPORARY EXCAVATIONS

Temporary excavations that are more than 1.2 m deep and require worker access should be conducted in accordance with WorkSafe BC regulations. An allowable inclination of 1.5 Horizontal:1 Vertical (1.5H:1V) is considered appropriate for unsupported temporary excavations in the site soils. Recommendations to reduce the inclination of temporary excavations could be given by the geotechnical engineer at the time of construction if loose/soft soils and/or groundwater seepage is encountered. All temporary excavations steeper than recommended above should be approved in writing by a Geotechnical Engineer prior to workers entering the excavation or approaching the edge the excavation in such areas.

Cobbles, boulders or other large debris that may be exposed at the face of temporary excavation slopes could become dislodged and strike workers in the excavation. Such objects should be removed prior to worker entry. In addition, stockpiles of material or machinery should be set back from the crest of the temporary slope a horizontal distance equal to or greater than the depth of excavation.

Temporary excavations that are not sensitive to ground movement but require excavation slopes steeper than described above can use temporary protection systems that permit lateral earth movement, or locally steeper temporary cut slopes that have been approved in advance by the Geotechnical Engineer. Such options may not be feasible where the foundations of adjacent structures are within about 2.5 times the depth of the excavation.

Temporary excavations adjacent to areas that are sensitive to ground movement, should use a shoring system capable of limiting lateral soil movements. Additional design recommendations may be required to design temporary protection or shoring systems.

5.6 WATER MANAGEMENT DURING CONSTRUCTION

Surface and groundwater management is advised during construction to allow excavation and construction to be carried out in dry conditions.

Depending on seasonal conditions or precipitation events at the time of construction, shallow surface water infiltration and run-off could enter open excavations. We anticipate that surface water ingress into open excavations can be managed by implementing effective surface water management measures such as temporary grading, swales, and interceptor ditches to direct surface water away from excavations and material stockpiles.

Groundwater was not encountered in the test holes. Depending on actual groundwater conditions the time of construction, seasonal changes, and prevailing weather conditions, we expect that potential groundwater seepage could be encountered in open excavations. We anticipate groundwater seepage can be adequately managed by pumping from properly filtered sumps located at the base of excavations, if required.

All water discharged from water management activities during construction should be directed to a suitable discharge point selected in consultation with the geotechnical engineer. Sediment controls should be incorporated into the temporary water management plan to reduce the effects of sediment laden water at off-site locations. Furthermore, potential contaminants at the site may require additional disposal requirements; these will not be addressed in this report.

5.7 PERMANENT CUT AND FILL SLOPES

As an initial guideline, permanent cut and fill slopes may be developed at 2 Horizontal to 1 Vertical (2H:1V) or flatter in the native deposits or imported fill that is consistent with the recommendations provided in this report. Due to the variability of the existing fills on the site, we recommend permanent cut slopes in existing fills be developed at 2.5H:1V or flatter. Where constructing a lateral extension to an existing slope, the fill should be placed in horizontal lifts, regardless of the pre-existing site topography. The fill should be stepped into adjoining existing slope areas. The steps should be not more than 0.6 m in height and have a horizontal length of not less than 2 times the height of the adjacent step. The recommended stepping will create a staggered transition between the pre-existing slope and the new fill that will provide the necessary stability at the interface between the existing slope face and the new fill slope extension. The constructed fill slope should be over-built at least 500 mm beyond its final position and then trimmed back to the final position after compaction.

Completed permanent cut and fill slopes should be protected from erosion by surface water runoff with suitable plantings, erosion control mats, or by hydroseeding, immediately after they are constructed.

5.8 SETBACKS AND FORESETS NEAR SLOPES

Foundations should be located behind or below a set-back line when situated above the crest of a slopes. We recommend a minimum set-back of at least 3 m from the crest of slopes on the site and a minimum of 2H:1V set-back from the toe of the slope.

Structures should also be located beyond a fore-set line when below the toe of slopes. We also recommend a minimum fore-set of at least 3 m from the toe of slopes inclined at 2H:1V or flatter, or for steeper slopes, beyond a line projected from the crest of the slope at an incline of 2H:1V.

Where reduced setbacks or fore-sets are preferred, a case-specific assessment should be conducted.

5.9 ENGINEERED FILL / FOUNDATION BACKFILL

Engineered fill is defined in this report as fill soils and aggregates required to support foundations, slabs, pavements, and, if required, sidewalks. Imported engineered fill should consist of 75 mm minus pit run or crushed aggregate sand and gravel containing less than 8 percent fines by weight. It should be placed in discrete lifts a maximum of 300 mm in thickness and be compacted to not less than 100 percent of the material's Standard Proctor Maximum Dry Density (SPMDD).

In-place soil density testing and visual review should be conducted on the engineered fill by the Geotechnical Engineer, as it is being placed and compacted, to confirm that adequate compaction is achieved.

Engineered fill below foundations should extend horizontally beyond the foundations a distance at least equal to its thickness below the foundations.

Existing fills and native interlayered granular and non-cohesive fine-grained soils encountered in the boreholes could be considered for use as structural fill however, we expect that these soils will require more effort to moisture conditions and compact. Where soil is borrowed from on-site source, it should be moisture conditions to within 2% of the optimum water content for construction purposes prior to placement. Lifts should be limited to 200 mm in loose thickness and then compacted to 100% of the SPMDD. Full-time geotechnical review may be required during placement of these soils in engineered fill pads.

5.10 WINTER AND WET WEATHER CONSTRUCTION

Construction that occurs during periods of cold or wet weather may encounter difficulties when preparing the foundation subgrades or compacting fill where long-term settlement control is expected. Frozen soils, fill containing snow, or subgrade surfaces that are snow-covered or frozen could experience excessive post-construction settlements when the frozen soil thaws or the snow melts. Likewise, excessively wet subgrade or fill surfaces could experience excessive post-construction settlements upon draining. Considerations for managing winter construction and wet weather are provided below:

- Keep subgrade surfaces free of frost before, during, and after construction by using sacrificial lifts of fill or other means to reduce exposure.
- Keep fill free of snow, ice, and other deleterious materials and avoid placing fill on frozen or snow-covered surfaces.
- Cover fill stockpiles with tarpaulins to protect them from precipitation and to manage the soil water content.
- Place fill on surfaces that are free of standing water and that are not excessively wet (relative to the optimum water content for compaction purposes).
- Reduce standing water on exposed surfaces where fill or foundation elements will be placed by using an appropriate water management plan during construction, and/or by using sacrificial lifts of fill or other means to reduce exposure.
- Pour concrete on ground that is not frozen. Protect the concrete and the subgrade from freezing until permanent frost protection is in place.

5.11 ADDITIONAL WORK & GEOTECHNICAL REVIEW

When available, final site grading and structural design drawings should be provided to a qualified professional such as WSP for review so that we can confirm that they incorporate the recommendations provided in this report, or so that we can provide additional recommendations as necessary to meet the actual project requirements.

The Geotechnical Engineer should be retained to review the following during the design development and construction stages of the project:

1 Preparation of the detailed specifications for pile foundations;
2 Review of pre-design pile load testing;
3 Review of contractor's work plan including construction methodology and quality control practices;
4 Review of pile installation on full-time basis, as required by the Building Code;
5 Subgrade preparation for the footings and slab-on-grade;
6 All sources of engineered fill, slab-on-grade fill, and foundation backfill;
7 Compaction of engineered fill, slab-on-grade fill, and foundation backfill; and
8 Subgrade preparation and pavement structure fill selection and compaction for exterior slabs, on-site parking areas, and on-site driveways.

6 CLOSURE

This geotechnical engineering assessment report has been prepared by WSP Canada Inc. for the account of District of Summerland in accordance with the professional services agreement. The disclosure of any information contained in this report is the sole responsibility of the intended recipient. The material in it reflects WSP's judgement considering the information available at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. WSP accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. The limitations statement is considered part of this report.

The soil logs attached to this report provide description of the soil and groundwater conditions encountered at discrete test hole locations. Actual soil conditions in areas remote from the test holes may vary across the site. Contractors should make their own interpretation of the soil logs and the site conditions for the purposes of bidding and performing work at the site.

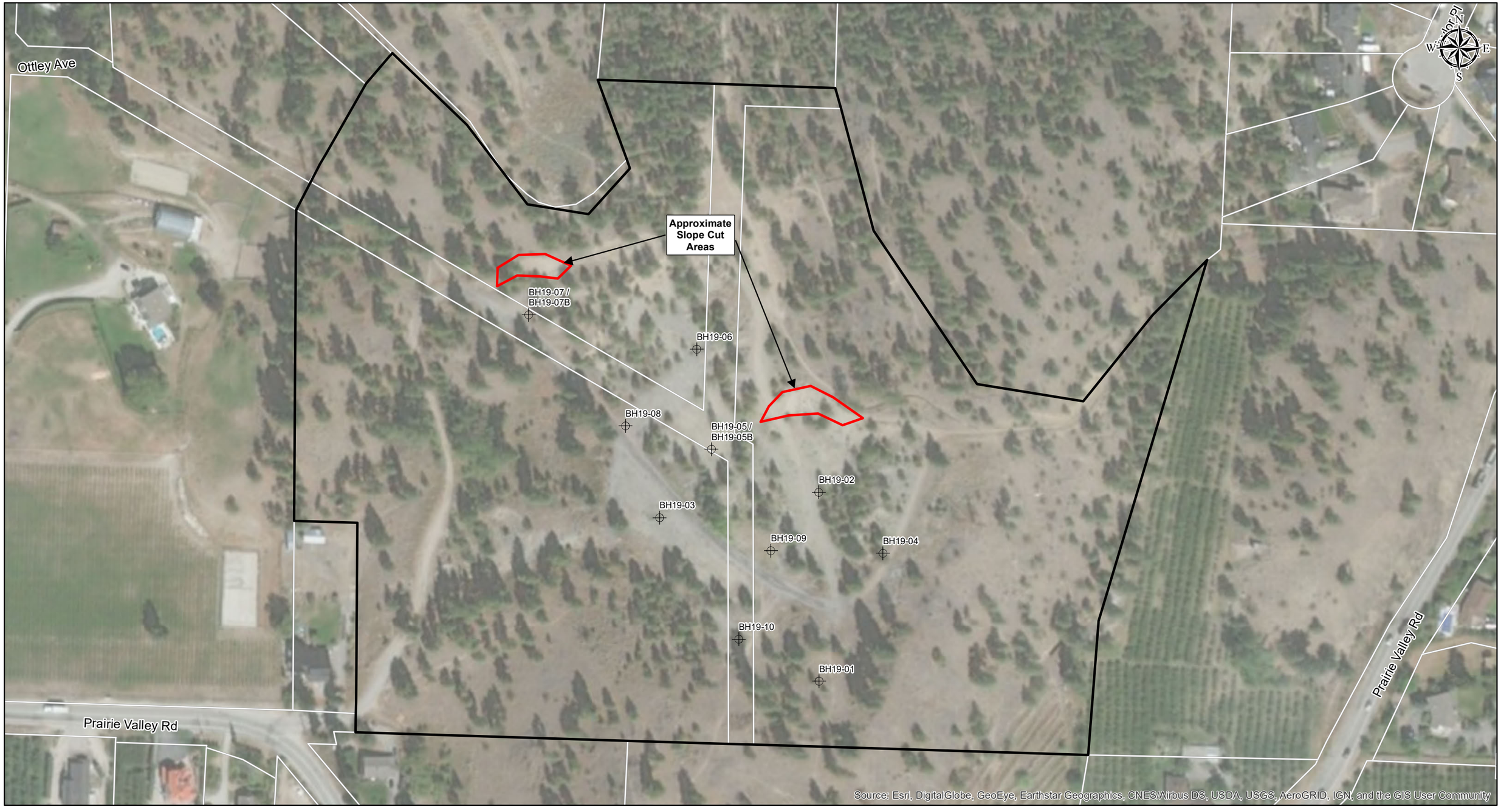
The original of the technology-based document sent herewith has been authenticated and will be retained by WSP for a minimum of ten years. Since the file transmitted is now out of WSP's control and its integrity can no longer be ensured, no guarantee may be given to any modifications made to this document.

The Terms of Reference included in **Appendix G** form an integral part of this geotechnical report.

We trust this meets your immediate requirement. If you have any questions or require further information, please contact our office.

APPENDIX

A FIGURE 1



Legend

- Borehole
- Parcel
- Project Area
- Approximate Slope Cut Areas

0 10 20 30 40 50 Meters

Scale: 1:1,750

References:
Data BC - BC Catalogue
Open Government License
(http://www.data.gov.bc.ca/)
NRCAN Geogratis
Open Government License
(http://geogratis.cgdi.gc.ca/)

PROJECT:
Geotechnical Investigation
Solar Array and Battery Storage Facility

TITLE:
Site Location

CLIENT:
District of Summerland

DATE:	ANALYST:	REVIEWED:	
February 11, 2020	MY	SR	**Figure 1**

GIS FILE:
01-01-004_Geotech_Site_Location_v2.mxd

PROJECT NO:
191-15279-00

COORDINATE SYSTEM:
NAD 1983 UTM Zone 11N

wsp

Y:\GIS\Projects\2019\191-15279-00 _Summerland_Solar_Array\Mapping\01_general\01_overview\01-01-004_Geotech_Site_Location_v2.mxd

APPENDIX

B SOIL LOGS

WSP Canada Inc.
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Fax: +1 250-491-9729
www.wspgroup.com

Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-01

Project No: 191-15279-00
Northing: 5497056 Easting: 304886

Depth (m)	Depth (ft)	Description	Well 1	C	N	Type/ Sample #	Water Level
Elev. 571.7m							
0	0	Compact to loose, brown, SAND, silty to trace silt, trace gravel, with rootlets, moist.			27	SPT1	
	2						
1	4	- Trace to some silt, loose below 0.6 m.			7	SPT2	
					7	SPT3	
	6						
2		Compact, brown, silty SAND, moist.			15	SPT4	
	8						
		Compact to dense, brown, SILT, some sand to sandy, moist.			29	SPT5	
3	10						
						G6	
	12						
4						G7	
	14	- Trace gravel, occasional cobbles below 4.3 m.					
		Dense, brown, SILT, some sand, trace gravel, moist.			36	SPT8	
5	16						
	18	Dense, brown, sandy SILT, some gravel, occasional cobbles, moist.				G9	
6					24 blows over 150 mm	SPT10	
	20	- No groundwater encountered.					
	22						
7							
	24						
	26						
8							
	28						
9							
	30						
	32						

10 20 30 40 50 60 70 80 90

Elevation (m) (ft)
Elev. 571.7m
571 1874
1872
570 1870
1868
569 1866
1864
568 1862
567 1860
1858
566 1856
1854
565 1852
564 1850
1848
563 1846
562 1844

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

STANDARD PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Bentonite/Grout Plug
Solid Pipe
Cuttings
Slotted Pipe
Sand/Pea-Gravel

Drill Method: Sonic
Date Drilled: 2019-12-02
Logged by: SR/KM
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

1 LOG PER PAGE 20-7-24

WSP Canada Inc.
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Fax: +1 250-491-9729
www.wspgroup.com

Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-02

Project No: 191-15279-00
Northing: 5497146 Easting: 304886

Depth (m)	Depth (ft)	Description	Well 1	C	N	Type/ Sample #	Water Level
Elev. 568.5m							
		Very dense, brown, gravelly SAND FILL, trace silt, with rootlets, moist.			68	SPT1	
	2	Compact, brown, SAND, trace silt, moist.					
1					13	SPT2	
	4	Compact, brown, sandy SILT, moist.					
	6	Compact, brown, SAND, some silt to silty, moist.			12	SPT3	
2		- Silty below 2.1 m.					
	8				11	SPT4	
3	10				15	SPT5	
	12						
4						G6	
	14						
	16	Compact, brown, sandy SILT, moist.			21	SPT7	
5							
	18	Compact, brown, silty SAND, contains cobbles, moist.				G8	
6	20				25	SPT9	
	22						
7	24	- No groundwater encountered.					
	26						
8	28						
	30						
9	32						

10 20 30 40 50 60 70 80 90

Elevation (m)	Elevation (ft)
Elev. 568.5m	
568	1864
	1862
567	1860
	1858
566	1856
	1854
565	1852
	1850
564	1848
	1846
563	1844
	1842
562	1840
	1838
561	1836
	1834
560	
559	

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

STANDARD PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Bentonite/Grout Plug
Solid Pipe
Cuttings
Slotted Pipe
Sand/Pea-Gravel

Drill Method: Sonic
Date Drilled: 2019-12-02
Logged by: SR/KM
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

1 LOG PER PAGE 20-7-24

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Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-03

Project No: 191-15279-00
Northing: 5497135 Easting: 304809.3

Depth (m)	Depth (ft)	Description	Well 1	C	N	Type/ Sample #	Water Level
Elev. 568.6m							
		ASPHALT (75 mm thick).					
		Dense, brown to black, sandy SILT FILL, some gravel, moist.				G1	
	2	Loose, brown, silty SAND, trace gravel, moist.					
1	4	- Black below 1.1 m.			8	SPT2	
		Loose to compact, brown, silty SAND, moist.					
	6				5	SPT3	
2	8				6	SPT4	
3	10					G5	
	12						
4	14	- Becomes compact				G6	
	16				41	SPT7	
5		Dense, brown, sandy SILT, some gravel, occasional cobbles, moist, non-cohesive.					
	18					G8	
6	20				50 blows over 75 mm	SPT9	
	22	- No groundwater encountered.					
7	24						
	26						
8	28						
	30						
9	32						

10 20 30 40 50 60 70 80 90

Elevation (m) (ft)
Elev. 568.6m
568 1864
1862
567 1860
1858
566 1856
565 1854
1852
564 1850
1848
563 1846
562 1844
1842
561 1840
1838
560 1836
559 1834

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

STANDARD PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Bentonite/Grout Plug
Solid Pipe
Cuttings
Slotted Pipe
Sand/Pea-Gravel

Drill Method: Sonic
Date Drilled: 2019-12-02
Logged by: SR/KM
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

1 LOG PER PAGE 20-7-24

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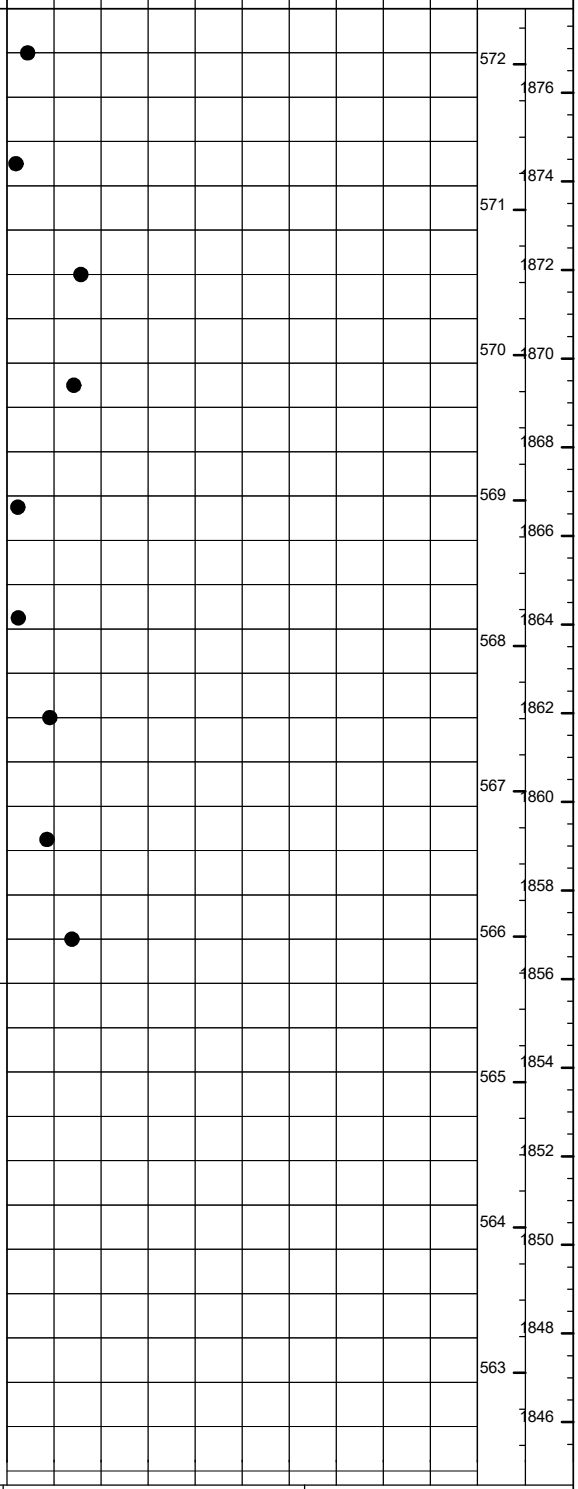
Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-04

Pg 1 of 1
Project No: 191-15279-00
Northing: 5497118 Easting: 304917

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
Elev. 572.4m						
		Compact, brown, silty SAND FILL, trace gravel, moist.		27	SPT1	
	2					
		Compact, brown, gravelly SAND, some silt, dry to moist.		13	SPT2	
1	4					
		Compact, brown, silty sandy GRAVEL, moist.				
	6	Compact, brown, SAND, trace silt, moist.		12	SPT3	
2						
	8	- Some gravel below 2.3 m.		15	SPT4	
3	10					
		Compact, brown, SAND, gravelly to some gravel, trace silt, moist.			G5	
	12					
4						
	14				G6	
	16			21	SPT7	
5		Compact, brown, silty SAND, moist.				
	18	Compact, brown, sandy SILT, moist.				
					G8	
6	20					
				20	SPT9	
	22					
7		- No groundwater encountered.				
	24					
8	26					
	28					
9						
	30					
	32					



Elevation (m)	Elevation (ft)
572	1876
	1874
571	
	1872
570	1870
	1868
569	
	1866
	1864
568	
	1862
567	1860
	1858
566	
	1856
	1854
565	
	1852
564	
	1850
	1848
563	
	1846

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

STANDARD PENETRATION TEST

Plastic Limit (%) — Liquid Limit (%)
Moisture Content (%)

- Ground Water Level
- Shear strength in kPa (Torvane)
- PP Pocket Penetrometer (compressive strength in kPa)
- Shear strength in kPa (Unconfined)
- Shear strength in kPa (Field vane)
- Remolded strength in kPa
- Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 2019-12-03
Logged by: SR/KM
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

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Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-05

Pg 1 of 1
Project No: 191-15279-00
Northing: 5497167 Easting: 304883

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
Elev. 567.4m						
		Dense, brown, SAND FILL, some gravel, some silt, moist.		39	SPT1	
1	2					
	4	Compact, brown, silty SAND, trace gravel, moist.		10	SPT2	
	6			9	SPT3	
2		Compact to loose, brown, SAND and SILT, trace gravel, moist.				
	8			11	SPT4	
3	10					
	12				G5	
4		Compact, brown, SAND, some silt to silty, moist.				
	14				G6	
		- Silty below 4.6 m.				
5	16			22	SPT7	
	18				G8	
6	20					
	22			25	SPT9	
7	24	- No groundwater encountered.				
8	26					
	28					
9	30					
	32					

Elevation (m) (ft) Elev. 567.4m

(m)	(ft)
567	1860
	1858
566	1856
	1854
565	1852
564	1850
	1848
563	1846
	1844
562	1842
561	1840
	1838
560	1836
559	1834
	1832
558	1830

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

STANDARD PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 2019-12-03
Logged by: SR/KM
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

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Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-05B

Project No: 191-15279-00
Northing: 5497167 Easting: 304883

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
Elev. 568.3m						
		Drilled out.				
6	20	Compact, brown, SAND, some silt, moist.			G10	
8	26	Dense, light brown, SAND, some gravel, trace sand, moist.		38	SPT11A	
		Dense, light brown, SAND, some silt, moist.			SPT11B	
					G12	
9	28	Very dense, brown, SILT and SAND, trace gravel, moist. - Cobble at 8.7 m.			G13	
	30	Very dense, brown to grey, sandy SILT TILL, some gravel, moist.		89	SPT14	
	32	- No groundwater encountered.				

Elevation (m) (ft) Elev. 568.3m

568 1864
1862
567 1860
1858
566 1856
1854
565 1852
564 1850
1848
563 1846
562 1844
1842
561 1840
1838
560 1836
559 1834
1832

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 2019-12-04
Logged by: SR
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

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Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-06

Project No: 191-15279-00
Northing: 5497216 Easting: 304828

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
Elev. 568.5m						
		Very dense, brown, SAND and GRAVEL FILL, trace silt, moist.		59	SPT1	
1	2					
	4	Compact, light brown, SAND, silty to some silt, trace gravel, moist.		11	SPT2	
	6	- Some silt below 1.5 m.		11	SPT3	
2	8	Compact, brown, SAND, some gravel, trace silt, moist.		21	SPT4	
3	10	Compact, brown, silty SAND, moist.			G5	
	12					
4	14	Compact, brown, SAND, some gravel, some silt, moist.			G6	
	16			32	SPT7	
5	18	Dense, brown, SAND, silty to some silt, some gravel to gravelly, moist. - Gravelly, some silt below 5.3 m.			G8	
6	20			44	SPT9	
	22					
7	24	- No groundwater encountered.				
	26					
8	28					
	30					
9	32					

Elevation (m) / (ft) — Elev. 568.5m

(m)	(ft)
568	1864
	1862
567	1860
	1858
566	1856
	1854
565	1852
	1850
564	1848
	1846
563	1844
	1842
562	1840
	1838
561	1836
	1834
560	
559	

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

STANDARD PENETRATION TEST

Plastic Limit (%) — Liquid Limit (%)
Moisture Content (%)

- Ground Water Level
- Shear strength in kPa (Torvane)
- PP Pocket Penetrometer (compressive strength in kPa)
- Shear strength in kPa (Unconfined)
- Shear strength in kPa (Field vane)
- Remolded strength in kPa
- Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 2019-12-03
Logged by: SR/KM
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

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Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-07
Pg 1 of 1
Project No: 191-15279-00
Northing: 5497234 Easting: 304746

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		Dense, brown, SAND and GRAVEL FILL some silt, moist.			SPT1A	
				41	SPT1B	
	2	Compact, brown, SAND some silt, trace gravel, moist.				
1	4	Loose, brown SAND, trace silt, moist.		9	SPT2	
	6	- Fine to medium sand from 1.5 to 2.0 m.		7	SPT3A	
2		- Medium to coarse sand below 2.0 m.			SPT3B	
	8	Loose, brown, SAND and SILT, moist.		10	SPT4	
3	10				SPT5A	
				7	SPT5B	
	12	Loose, light brown, SAND, trace to some gravel, trace silt, moist.				
4	14					
	16			17	SPT6A	
5		Compact, brown, GRAVEL, some sand, trace silt, moist.			SPT6B	
	18					
6	20			20	SPT7	
	22					
7	24	- No groundwater encountered.				
	26					
8	28					
9	30					
	32					

Elevation (m) / (ft) Elev. 569.9m

Elevation (m)	Elevation (ft)
569	1868
	1866
568	1864
	1862
567	1860
	1858
566	1856
	1854
565	1852
	1850
564	1848
	1846
563	1844
	1842
562	1840
	1838
561	
560	

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

Plastic Limit (%) ◄—● Liquid Limit (%)
Moisture Content (%)

- Ground Water Level
- Shear strength in kPa (Torvane)
- PP Pocket Penetrometer (compressive strength in kPa)
- Shear strength in kPa (Unconfined)
- Shear strength in kPa (Field vane)
- Remolded strength in kPa
- Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 2019-12-03
Logged by: SR
Checked by: AVD

1 LOG PER PAGE 20-7-24

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Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-07B

Pg 1 of 1
Project No: 191-15279-00
Northing: 5497234 Easting: 304746

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		Drilled out.				
6	20	Compact, brown, GRAVEL, some sand, trace silt, occasional cobbles, moist.				
7	22	Compact, grey and brown, SAND and GRAVEL, trace silt, moist.			G8	
8	24	Compact, brown, GRAVEL, trace sand, trace silt, occasional cobbles, moist				
	26	Dense, grey and brown, SAND and GRAVEL, trace silt, moist.		45	SPT9	
	28	Compact, brown, SAND, some silt, moist.			G10	
9	30	Very dense, brown to grey, silty, sandy GRAVEL, moist.			G11	
	32			58	SPT12	
		- No groundwater encountered.				

Elevation (m) (ft) Elev. 569.9m

10 20 30 40 50 60 70 80 90

569 1868
568 1866
567 1864
566 1862
565 1860
564 1858
563 1856
562 1854
561 1852
560 1850
559 1848
558 1846
557 1844
556 1842
555 1840
554 1838
553 1836

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 2019-12-04
Logged by: SR
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

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Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-08

Project No: 191-15279-00
Northing: 5497179 Easting: 304792

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
	Elev. 569.2m					
		Compact, dark brown to black, sandy SILT TOPSOIL, moist.		26	SPT1	
	2	Compact to loose, brown, SAND, trace to some gravel, trace silt, moist.				
1		- Loose below 0.8 m.		7	SPT2	
	4					
		- Sandy GRAVEL below about 1.45 m				
	6	Compact to loose, brown, SAND, trace to some gravel, trace silt, moist.		18	SPT3	
2						
	8			9	SPT4A	
					SPT4B	
3		Loose, brown, SAND, trace to some silt, occasional cobbles, moist.				
	10	Compact, brown, SAND, some silt, moist.		19	SPT5A	
	12				SPT5B	
		Compact, brown, silty SAND, moist.				
4					G6	
	14					
	16			17	SPT7	
5						
	18				G8	
6						
	20	- Interlayed fine and medium sand below 6.1 m.		24	SPT9A	
	22				SPT9B	
7		- No groundwater encountered.				
	24					
	26					
8						
	28					
9						
	30					
	32					

Elevation (m)	Elevation (ft)
569	1866
	1864
568	
	1862
567	1860
	1858
566	
	1856
	1854
565	
	1852
564	1850
	1848
563	
	1846
	1844
562	
	1842
561	
	1840
	1838
560	
	1836

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

STANDARD PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 2019-12-04
Logged by: SR
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

1 LOG PER PAGE 20-7-24

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Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-09

Pg 1 of 1
Project No: 191-15279-00
Northing: 5497120 Easting: 304864

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		Dense, brown, SAND AND GRAVEL FILL, some silt, moist.		49	SPT1	
1	2	Compact, brown, SAND FILL, some gravel, trace to some silt, moist.		25	SPT2	
	4	- Some silt below 1.2 m.				
2	6	Compact, brown, SAND, trace silt, moist.		14	SPT3	
	8	Compact, light brown, SAND, trace silt to silty, dry to moist		11	SPT4	
3	10			17	SPT5	
	12	- Silty below 3.3 m.				
4	14				G6	
		- Interlayered silty sand and sand, some silt below 4.6 m.		17	SPT7	
5	16					
	18					
6	20	Compact, brown, SAND and SILT, moist.			G8	
				25	SPT9A	
	22	Compact, brown, SAND, some silt, moist.			SPT9B	
7	24	- No groundwater encountered.				
	26					
8	28					
9	30					
	32					

10 20 30 40 50 60 70 80 90

Elevation (m) (ft)
Elev. 570.2m

570 1870
1868
569 1866
1864
568 1862
567 1860
1858
566 1856
1854
565 1852
564 1850
1848
563 1846
1844
562 1842
561 1840
1838

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

STANDARD PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 2019-12-04
Logged by: SR
Checked by: AVD

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

1 LOG PER PAGE 20-7-24

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Summerland Solar Array
The District of Summerland
Summerland, BC

BH19-10

Project No: 191-15279-00
Northing: 5497075 Easting: 304848

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		Dense, dark brown, silty SAND FILL, trace organics, moist.		41	SPT1A SPT1B SPT1C	
	2	Compact, brown, silty SAND, moist.				
		Compact, brown, SAND, some silt, moist.				
1	4	Loose to compact, brown, SAND, trace to some silt, dry to moist.		6	SPT2	
	6			14	SPT3	
2					G4	
	8			55	SPT5	
		Very dense, brown, silty, gravelly, SAND, dry to moist. - Boulder from 2.6 to 3.0 m.				
3	10					
		Very dense, brown, silty SAND and GRAVEL TILL, moist.		50	SPT6	
	12	Possible BEDROCK or BOULDER.				
4						
	14					
	16	- No groundwater encountered.				
5						
	18					
6						
	20					
	22					
7						
	24					
	26					
8						
	28					
9						
	30					
	32					

10 20 30 40 50 60 70 80 90

Elevation (m) (ft)
Elev. 572.5m

572 1878
1876
571 1874
1872
570 1870
1868
569 1866
1864
568 1862
567 1860
1858
566 1856
565 1854
1852
564 1850
1848
563 1846

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

SOIL CLASSIFICATION IN ACCORDANCE WITH THE CANADIAN FOUNDATION ENGINEERING MANUAL 4TH EDITION 2006.

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type: Safety Hammer

Plastic Limit (%) ▶ Moisture Content (%) ◀ Liquid Limit (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 2019-12-04
Logged by: SR
Checked by: AVD

1 LOG PER PAGE 20-7-24

APPENDIX

C GRAIN SIZE ANALYSES ASTM C136/C136M-19

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Richmond, BC V6V 2H9
Tel: (604) 278-1411
Fax: (604) 278-1412

Client: The District of Summerland
Project: Summerland Solar Array
Site Address: Summerland, BC

File No.: 191-15279-00
Phase:

Report of Grain Size Analysis

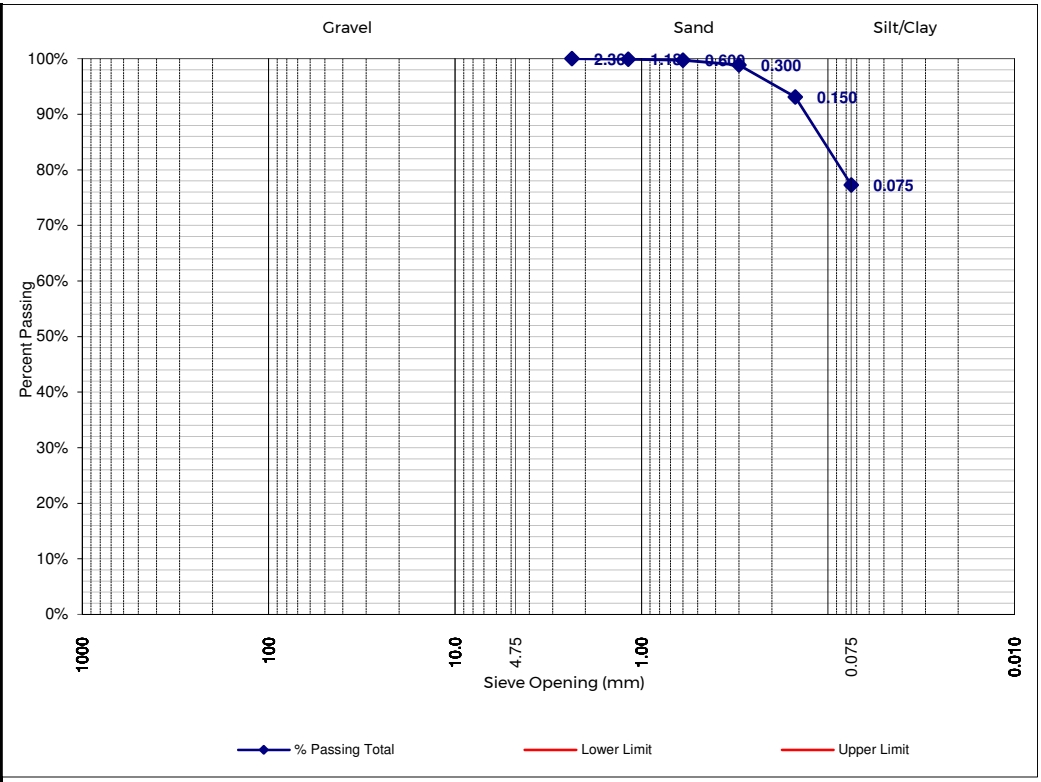
Sample Location: BH19-01, G6 - 3.0 m
Supplier:
Material Type: sandy SILT
Usage:
Specification:

Sampled By: SAR
Tested By: SF
Date Sampled: December 2, 2019
Date Tested: January 17, 2020
Sieve No. 1

Moisture Content (as received): 5%

Washed Sieve

Screen Opening (mm):	% Passing Total:	Specification Upper Limit	Specification Lower Limit
150.0			
100.0			
75.0			
50.0			
37.5			
25.0			
19.0			
12.5			
9.51			
4.75			
2.36	100.0%		
1.18	99.9%		
0.600	99.7%		
0.425			
0.300	98.9%		
0.150	93.1%		
0.075	77.3%		



Remarks:

Reporting of these results constitutes a testing service only.
No engineering interpretation of the results is expressed or implied.
Engineering review and interpretation of these results can be provided upon written request.

WSP Canada Inc.

Per: Stephen Renner

Stephen Renner, EIT

#108, 3677 Hwy 97N
Kelowna, BC V1X 5C3
Tel: (250) 491-9778
Fax: (250) 491-9729

#100, 20339 96 Ave.
Langley, BC V1M 0E4
Tel: (604) 533-2992
Fax: (604) 533-0768

12791 Clarke Pl.
Richmond, BC V6V 2H9
Tel: (604) 278-1411
Fax: (604) 278-1412

Client: The District of Summerland
Project: Summerland Solar Array
Site Address: Summerland, BC

File No.: 191-15279-00
Phase:

Report of Grain Size Analysis

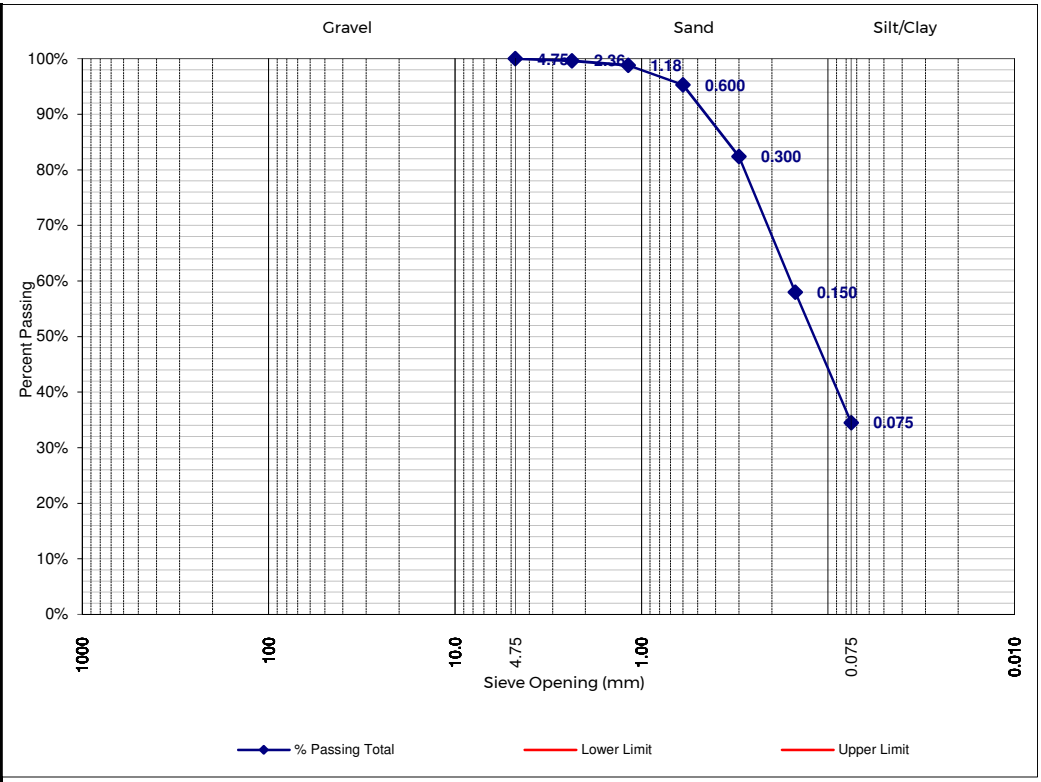
Sample Location: BH19-03, SPT4 - 2.3 m
Supplier:
Material Type: silty SAND
Usage:
Specification:

Sampled By: SAR
Tested By: SF
Date Sampled: December 2, 2019
Date Tested: January 17, 2020
Sieve No. 2

Moisture Content (as received): 4%

Washed Sieve

Screen Opening (mm):	% Passing Total:	Specification Upper Limit	Specification Lower Limit
150.0			
100.0			
75.0			
50.0			
37.5			
25.0			
19.0			
12.5			
9.51			
4.75	100.0%		
2.36	99.6%		
1.18	98.8%		
0.600	95.3%		
0.425			
0.300	82.4%		
0.150	58.0%		
0.075	34.5%		



Remarks:

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WSP Canada Inc.

Per: Stephen Renner

Stephen Renner, EIT

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Fax: (604) 533-0768

12791 Clarke Pl.
Richmond, BC V6V 2H9
Tel: (604) 278-1411
Fax: (604) 278-1412

Client: The District of Summerland
Project: Summerland Solar Array
Site Address: Summerland, BC

File No.: 191-15279-00
Phase:

Report of Grain Size Analysis

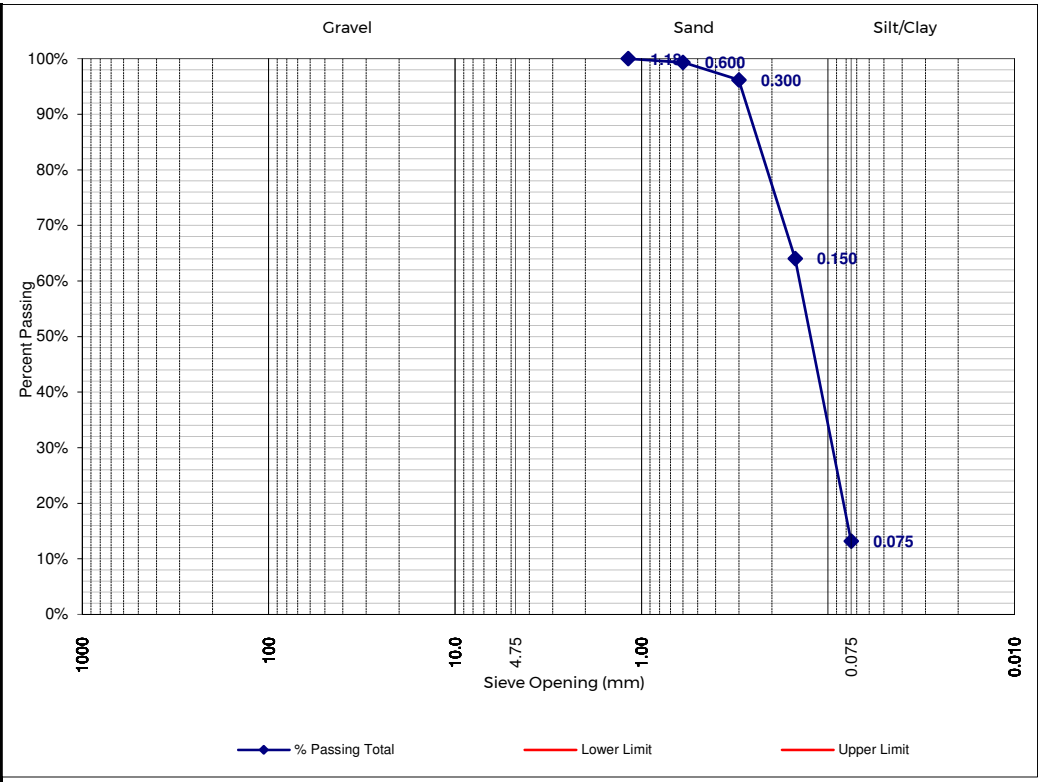
Sample Location: BH19-05B, G10 - 6.7 m
Supplier:
Material Type: SAND, some silt
Usage:
Specification:

Sampled By: SLR
Tested By: SF
Date Sampled: December 4, 2019
Date Tested: January 17, 2020
Sieve No. 3

Moisture Content (as received): 6%

Washed Sieve

Screen Opening (mm):	% Passing Total:	Specification Upper Limit	Specification Lower Limit
150.0			
100.0			
75.0			
50.0			
37.5			
25.0			
19.0			
12.5			
9.51			
4.75			
2.36			
1.18	100.0%		
0.600	99.3%		
0.425			
0.300	96.1%		
0.150	64.0%		
0.075	13.2%		



Remarks:

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No engineering interpretation of the results is expressed or implied.
Engineering review and interpretation of these results can be provided upon written request.

WSP Canada Inc.

Per: Stephen Renner

Stephen Renner, EIT

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Fax: (604) 533-0768

12791 Clarke Pl.
Richmond, BC V6V 2H9
Tel: (604) 278-1411
Fax: (604) 278-1412

Client: The District of Summerland
Project: Summerland Solar Array
Site Address: Summerland, BC

File No.: 191-15279-00
Phase:

Report of Grain Size Analysis

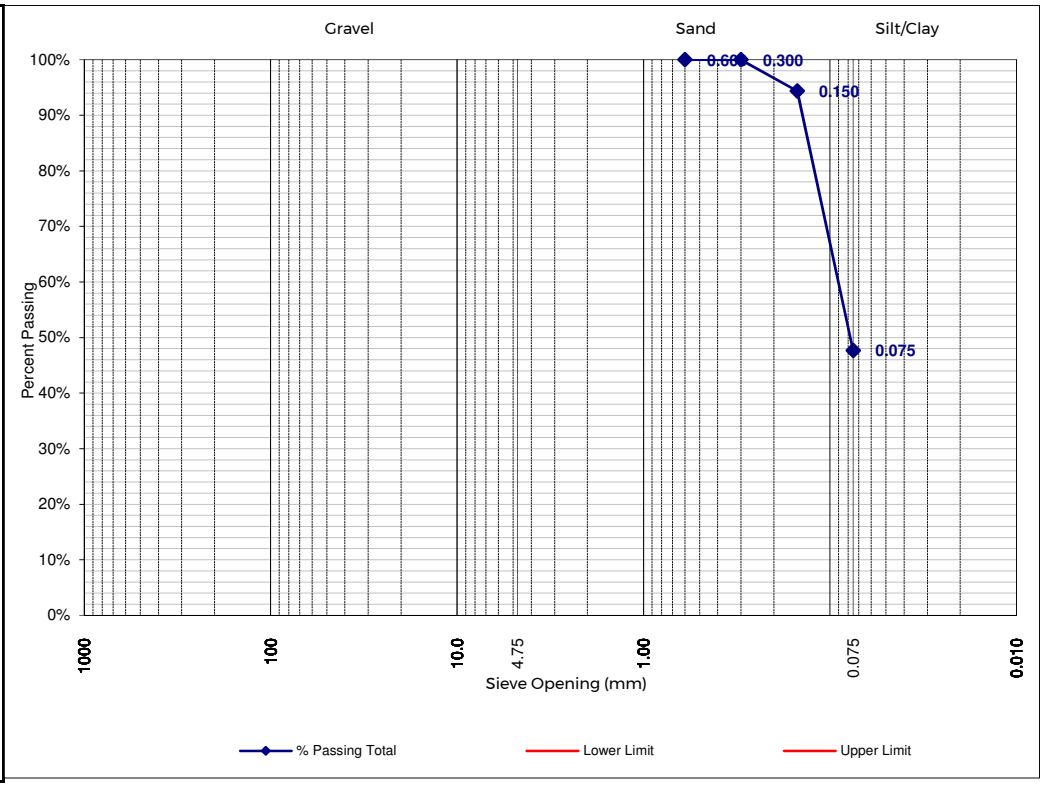
Sample Location: BH19-07, SPT4 - 1.4 m
Supplier:
Material Type: SAND and SILT
Usage:
Specification:

Sampled By: SLR
Tested By: SF
Date Sampled: December 3, 2019
Date Tested: January 17, 2020
Sieve No. 4

Moisture Content (as received): 8%

Washed Sieve

Screen Opening (mm):	% Passing Total:	Specification Upper Limit	Specification Lower Limit
150.0			
100.0			
75.0			
50.0			
37.5			
25.0			
19.0			
12.5			
9.51			
4.75			
2.36			
1.18			
0.600	100.0%		
0.425			
0.300	100.0%		
0.150	94.4%		
0.075	47.7%		



Remarks:

Reporting of these results constitutes a testing service only.
No engineering interpretation of the results is expressed or implied.
Engineering review and interpretation of these results can be provided upon written request.

WSP Canada Inc.

Per: Stephen Renner

Stephen Renner, EIT

#108, 3677 Hwy 97N
Kelowna, BC V1X 5C3
Tel: (250) 491-9778
Fax: (250) 491-9729

#100, 20339 96 Ave.
Langley, BC V1M 0E4
Tel: (604) 533-2992
Fax: (604) 533-0768

12791 Clarke Pl.
Richmond, BC V6V 2H9
Tel: (604) 278-1411
Fax: (604) 278-1412

Client: The District of Summerland
Project: Summerland Solar Array
Site Address: Summerland, BC

File No.: 191-15279-00
Phase:

Report of Grain Size Analysis

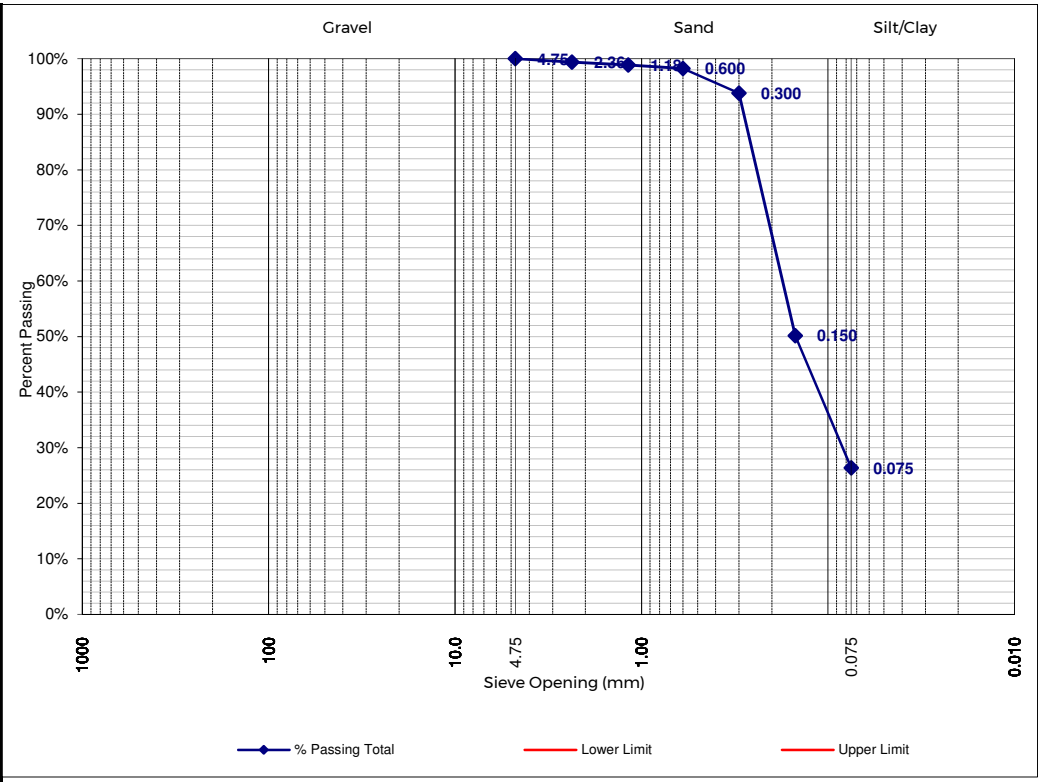
Sample Location: BH19-09, SPT5 - 3.0 m
Supplier:
Material Type: silty SAND
Usage:
Specification:

Sampled By: SLR
Tested By: SF
Date Sampled: December 4, 2019
Date Tested: January 17, 2020
Sieve No. 5

Moisture Content (as received): 5%

Washed Sieve

Screen Opening (mm):	% Passing Total:	Specification Upper Limit	Specification Lower Limit
150.0			
100.0			
75.0			
50.0			
37.5			
25.0			
19.0			
12.5			
9.51			
4.75	100.0%		
2.36	99.4%		
1.18	98.8%		
0.600	98.2%		
0.425			
0.300	93.8%		
0.150	50.2%		
0.075	26.3%		



Remarks:

Reporting of these results constitutes a testing service only.
No engineering interpretation of the results is expressed or implied.
Engineering review and interpretation of these results can be provided upon written request.

WSP Canada Inc.

Per: Stephen Renner

Stephen Renner, EIT

APPENDIX

D SOIL RESISTIVITY TESTS

WSP CANADA INC.
100-20339 96 Avenue
Langley, BC V1M 0E4
T: 604.533.2992

Client: District of Summerland
Project: Summerland Solar Array
Site Address: Summerland, BC

File No.: 191-15279-00
Task: 03

Report of AWWA C105 Electrochemical Soil Corrosion

Sampled By: SLR
Tested By: ARP
Date Sampled: 3/4-Dec-2019
Date Tested: 24-Dec-2019

Sample ID	Sample Description	Resistivity (ohm-cm)	pH	Redox (mV)	Sulfides	Moisture	AWWA C105 Appendix A Score
BH19-07 (1.1-1.5 m)	brown Sand	322050	7.1	244	None	Moist	1
BH19-08 (1.1-1.4 m)	brown Sand	305375	6.9	257	None	Moist	1
BH19-09 (1.1-1.4 m)	brown Sand	129375	7.7	273	None	Moist	1
BH19-10 (0.8 - 1.1 m)	brown Sand	131625	6.6	283	None	Moist	1

Remarks: Samples tested in as received condition.

Reporting of these results constitutes a testing service only.
No engineering interpretation of the results is expressed or implied.
Engineering review and interpretation of these results can be provided upon written request.

WSP Canada Inc.

Per: 

Anton Parsons, A.Sc.T.

APPENDIX

E SOIL ANALYTICAL TESTS

WSP Canada Inc.
ATTN: Stephen Renner
Unit 108 - 3677 Highway 97N
Kelowna BC V1X 5C3

Date Received: 10- DEC- 19
Report Date: 06- JAN- 20 17:02 (MT)
Version: FINAL

Client Phone: 250- 491- 9778

Certificate of Analysis

Lab Work Order #: L2394204
Project P.O. #: NOT SUBMITTED
Job Reference: 191- 15277- 00
C of C Numbers: 17- 786899
Legal Site Desc:

Comments: Please find sublet data attached at the back of this report.

Carla Fuginski
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID					
Grouping Analyte					

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

** 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:

17-786899

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
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 of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
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.

CERTIFICATE OF ANALYSIS

REPORTED TO	ALS Environmental (Burnaby) Suite 100 8081 Lougheed Highway Burnaby, BC V5A 1W9		
ATTENTION	Carla Fuginski	**WORK ORDER**	9121653
PO NUMBER	L2394204	**RECEIVED / TEMP**	2019-12-18 10:15 / 10°C
PROJECT	Soil Testing	**REPORTED**	2020-01-06 14:45
PROJECT INFO		**COC NUMBER**	L2394204

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO 17025:2005 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

If you have any questions or concerns, please contact me at acrump@caro.ca

Authorized By:

Alana Crump
Junior Account Manager

TEST RESULTS

REPORTED TO	ALS Environmental (Burnaby)	**WORK ORDER**	9121653
PROJECT	Soil Testing	**REPORTED**	2020-01-06 14:45

Analyte	Result	RL	Units	Analyzed	Qualifier
L2394204-1 (9121653-01) | Matrix: Soil | Sampled: 2019-12-03 08:40					
General Parameters					
Sulfate, Water-Soluble	< 0.050	0.050	%	2020-01-05	
Moisture	**11.1**	1.0	% wet	2019-12-20	HT1
L2394204-2 (9121653-02) | Matrix: Soil | Sampled: 2019-12-03 09:55					
General Parameters					
Sulfate, Water-Soluble	< 0.050	0.050	%	2020-01-05	
Moisture	**3.8**	1.0	% wet	2019-12-20	HT1
L2394204-3 (9121653-03) | Matrix: Soil | Sampled: 2019-12-03 10:50					
General Parameters					
Sulfate, Water-Soluble	< 0.050	0.050	%	2020-01-05	
Moisture	**2.9**	1.0	% wet	2019-12-20	HT1

Sample Qualifiers:

HT1 The sample was prepared and/or analyzed past the recommended holding time.

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	ALS Environmental (Burnaby)	**WORK ORDER**	9121653
PROJECT	Soil Testing	**REPORTED**	2020-01-06 14:45

Analysis Description	Method Ref.	Technique	Location
Moisture in Soil	ASTM D2974-87*	Gravimetry (Dried at 105C)	N/A
Sulfate, Water-Soluble in Soil	CSA A23.2-3B / CSA A23.2-2B	Extraction (HCl) / Gravimetry (Barium Sulfate Precipitation)	Richmond

Note: An asterisk in the Method Reference indicates that the CARO method has been modified from the reference method

Glossary of Terms:

RL	Reporting Limit (default)
%	Percent
% wet	Percent (as received basis)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
ASTM	ASTM International Test Methods
CSA	Canadian Standards Association Chemical Test Methods

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued unless otherwise agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:acrump@caro.ca

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	ALS Environmental (Burnaby)	**WORK ORDER**	9121653
PROJECT	Soil Testing	**REPORTED**	2020-01-06 14:45

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B9L2178										
Blank (B9L2178-BLK1)				Prepared: 2019-12-30, Analyzed: 2020-01-05						
Sulfate, Water-Soluble	< 0.050	0.050	%							
Duplicate (B9L2178-DUP1)				**Source: 9121653-01**	Prepared: 2019-12-30, Analyzed: 2020-01-05					
Sulfate, Water-Soluble	< 0.050	0.050	%		< 0.050				19	

L2394204-COFC

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

Affix ALS barcode label here (lab use only)

COC Number: 17 - 786899

Page 1 of 1

Report To	Contact and company name below will appear on the final report
Company:	WSP
Contact:	Stephen Renner
Phone:	(778) 392-5029
	Company address below will appear on the final report
Street:	700-1631 Dickson Ave.
City/Province:	Kelowna, BC
Postal Code:	V1Y 0B5
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☐ NO
Company:	
Contact:	

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL | EDD (DIGITAL)

Quality Control (QC) Report with Report ☐ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL | MAIL ☐ FAX

Email 1 or Fax: Stephen.Renner@WSP.com

Email 2:

Email 3:

Invoice Distribution

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax:

Email 2:

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] ☐ | 3 day [P3-25%] ☐ | 2 day [P2-50%] ☐

EMERGENCY: 1 Business day [E - 100%] ☐ | Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:	19-15279-00	Major/Minor Code:	Routing Code:
PO / AFE:		Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only):		ALS Contact:	Sampler: S. Rusnak

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	CSA 23.2 water soluble sulphate	Moisture Content	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	BH19-04-07	3-Dec-19	8:40	Soil	1	X	X		
	BH19-05-02	↓	9:55	↓	1	X	X		
	BH19-06-04	3-Dec-19	10:30	Soil	1	X	X		

Sublet to Caro per Selam.

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☒ NO

Are samples for human consumption/ use? ☐ YES ☒ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

Small Cooler

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ | SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ | Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
				5	5	6.6	°C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:
S. Renner	9/12/19					JG	10 Dec 19	8:27AM

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

APPENDIX

F 2015 NATIONAL BUILDING CODE SEISMIC HAZARD VALUES

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 49.595N 119.701W **User File Reference:** Summerland Solar Array 2020-02-02 05:51 UT

Requested by: Marisa Loude, WSP Canada Inc.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.086	0.053	0.035	0.012
Sa (0.1)	0.127	0.078	0.050	0.018
Sa (0.2)	0.162	0.104	0.070	0.028
Sa (0.3)	0.159	0.107	0.075	0.032
Sa (0.5)	0.141	0.097	0.069	0.030
Sa (1.0)	0.104	0.070	0.049	0.021
Sa (2.0)	0.072	0.046	0.031	0.013
Sa (5.0)	0.032	0.018	0.011	0.004
Sa (10.0)	0.010	0.006	0.004	0.002
PGA (g)	0.075	0.048	0.031	0.011
PGV (m/s)	0.133	0.083	0.055	0.021

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

APPENDIX

G TERMS OF REFERENCE FOR GEOTECHNICAL REPORT

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY WSP CANADA INC.

1 STANDARD OF CARE

WSP Canada Inc. ("WSP") prepared and issued this geotechnical report (the "Report") for its client (the "Client") in accordance with generally-accepted engineering consulting practices for the geotechnical discipline. No other warranty, expressed or implied, is made. Unless specifically stated in the Report, the Report does not address environmental issues.

The terms of reference for geotechnical reports issued by WSP (the "Terms of Reference") contained in the present document provide additional information and caution related to standard of care and the use of the Report. The Client should read and familiarize itself with these Terms of Reference.

2 COMPLETENESS OF THE REPORT

All documents, records, drawings, correspondence, data, files and deliverables, whether hard copy, electronic or otherwise, generated as part of the services for the Client are inherent components of the Report and, collectively, form the instruments of professional services (the "Instruments of Professional Services"). The Report is of a summary nature and is not intended to stand alone without reference to the instructions given to WSP by the Client, the communications between WSP and the Client, and to any other reports, writings, proposals or documents prepared by WSP for the Client relative to the specific site described in the Report, all of which constitute the Report.

TO PROPERLY UNDERSTAND THE INFORMATION, OBSERVATIONS, FINDINGS, SUGGESTIONS, RECOMMENDATIONS AND OPINIONS CONTAINED IN THE REPORT, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WSP CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT AND ITS VARIOUS COMPONENTS.

3 BASIS OF THE REPORT

WSP prepared the Report for the Client for the specific site, development, building, design or building assessment objectives and purpose that the Client described to WSP. The applicability and reliability of any of the information, observations, findings, suggestions, recommendations and opinions contained in the Report are only valid to the extent that there was no material alteration to or variation from any of the said descriptions provided by the Client to WSP unless the Client specifically requested WSP to review and revise the Report in light of such alteration or variation.

4 USE OF THE REPORT

The information, observations, findings, suggestions, recommendations and opinions contained in the Report, or any component forming the Report, are for the sole use and benefit of the Client and the team of consultants selected by the Client for the specific project that the Report was provided. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION OR COMPONENT WITHOUT THE WRITTEN CONSENT OF WSP. WSP will consent to any reasonable request by the Client to approve the use of this Report by other parties designated by the Client as the "Approved Users". As a condition for the consent of WSP to approve the use of the Report by an Approved User, the Client must provide a copy of these Terms of Reference to that Approved User and the Client must obtain written confirmation from that Approved User that the Approved User will comply with these Terms of Reference, such written confirmation to be provided separately by each Approved User prior to beginning use of the Report. The Client will provide WSP with a copy of the written confirmation from an Approved User when it becomes available to the Client, and in any case, within two weeks of the Client receiving such written confirmation.

The Report and all its components remain the copyright property of WSP and WSP authorises only the Client and the Approved Users to make copies of the Report, but only in such quantities as are reasonably necessary for the use of the Report by the Client and the Approved Users. The Client and the Approved Users may not give, lend, sell or otherwise disseminate or make the Report, or any portion thereof, available to any party without the written permission of WSP. Any use which a third party makes of the Report, or any portion of the Report, is the sole responsibility of such third parties. WSP accepts no responsibility for damages suffered by any third party resulting from the use of the Report. The Client and the Approved Users acknowledge and agree to indemnify and hold harmless WSP, its officers, directors, employees, agents, representatives or sub-consultants, or any or all of them, against any claim of any nature whatsoever brought against WSP by any third parties, whether in contract or in tort, arising or related to the use of contents of the Report.

5 INTERPRETATION OF THE REPORT

a. **Nature and Exactness of Descriptions:** The classification and identification of soils, rocks and geological units, as well as engineering assessments and estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1 above. The classification and identification of these items are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel,

may fail to locate some conditions. All investigations or assessments utilizing the standards of Paragraph 1 involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to changes over time and the parties making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or when the Client has special considerations or requirements, the Client must disclose them to WSP so that additional or special investigations may be undertaken, which would not otherwise be within the scope of investigations made by WSP or the purposes of the Report.

b. **Reliance on information**: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site investigation and field review and on the basis of information provided to WSP. WSP has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, WSP cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons providing information.

c. **Additional Involvement by WSP**: To avoid misunderstandings, WSP should be retained to assist other professionals to explain relevant engineering findings and to review the geotechnical aspects of the plans, drawings and specifications of other professionals relative to the engineering issues pertaining to the geotechnical consulting services provided by WSP. To ensure compliance and consistency with the applicable building codes, legislation, regulations, guidelines and generally-accepted practices, WSP should also be retained to provide field review services during the performance of any related work. Where applicable, it is understood that such field review services must meet or exceed the minimum necessary requirements to ascertain that the work being carried out is in general conformity with the recommendations made by WSP. Any reduction from the level of services recommended by WSP will result in WSP providing qualified opinions regarding adequacy of the work.

6 ALTERNATE REPORT FORMAT

When WSP submits both electronic and hard copy versions of the Instruments of Professional Services, the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding upon WSP. The hard copy versions submitted by WSP shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancy, the hard copy versions shall govern over the electronic versions; furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed and sealed versions of the Instruments of Professional Services maintained or retained, or both, by WSP shall be deemed to be the overall originals for the Project.

The Client agrees that the electronic file and hard copy versions of Instruments of Professional Services shall not, under any circumstances, no matter who owns or uses them, be altered by any party except WSP. The Client warrants that the Instruments of Professional Services will be used only and exactly as submitted by WSP.

The Client recognizes and agrees that WSP prepared and submitted electronic files using specific software or hardware systems, or both. WSP makes no representation about the compatibility of these files with the current or future software and hardware systems of the Client, the Approved Users or any other party. The Client further agrees that WSP is under no obligation, unless otherwise expressly specified, to provide the Client, the Approved Users and any other party, or any or all of them, with specific software and hardware systems that are compatible with any electronic submitted by WSP. The Client further agrees that should the Client, an Approved User or a third party require WSP to provide specific software or hardware systems, or both, compatible with the electronic files prepared and submitted by WSP, for any reason whatsoever included but not restricted to an order from a court, then the Client will pay WSP for all reasonable costs related to the provision of the specific software or hardware systems, or both. The Client further agrees to indemnify and hold harmless WSP, its officers, directors, employees, agents, representative or sub-consultant, or any or all of them, against any claim or any nature whatsoever brought against WSP, whether in contract or in tort, arising or related to the provision or use or any specific software or hardware provided by WSP.