Geotechnical Assessment Report for Proposed Development at 1750 Highway 3, Osoyoos, BC

Presented To: **Steinar Johnsen**

Dated: November 2020

Ecora File No.: 201589

ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA

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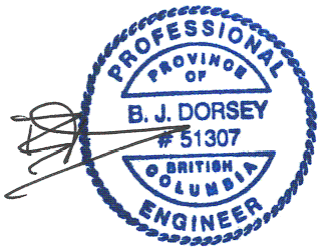

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Ecora's General Conditions are provided in Appendix A of this report.

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1. Introduction

1.1 General

Mr. Steinar Johnsen retained Ecora Engineering & Resource Group Ltd. (Ecora) to undertake a geotechnical assessment of the property located at 1750 Highway 3, Osoyoos, BC (the site). Ecora understands that Mr. Johnsen is currently proposing a 6 lot bare land strata and conservation area, as shown in Figure 1.0. Ecora has reviewed the letter addressed to Mr. and Mrs. Johnsen from the Regional District of Okanagan-Similkameen (RDOS) (File No. A2018.207-ZONE), regarding an amendment to a land use application submitted to the RDOS. Mr. Johnsen proposes to amend the official community plan designation for the subject property, from large holdings to part small holdings and part conservation area, as well as amend the zoning of the property from large holdings one zone (LH1) to part small holdings three zone (SH3) and part conservation area zone (CA).

The purpose of this geotechnical assessment is to address the requirements of the aforementioned letter from the RDOS, including the placement of uncontrolled fill on the site, evaluate the suitability of the site for the future lots, and identify the presence and extent of any geotechnical constraints associated with this project.

The geotechnical assessment has been undertaken in accordance with the Association of the Professional Engineers and Geoscientists of BC's (APEGBC) Guidelines for Legislated Landslide Assessments for Proposed Residential Development (updated 2010).

This report summarizes our findings and provides geotechnical recommendations with respect to the development of the proposed subdivision.

1.2 Scope of Work

The proposed scope of work as outlined in Ecora's proposal dated September 4, 2020 adopted a phased approach to the geotechnical assessment as outlined below.

- Task 1 – Geotechnical Site Investigation & Reconnaissance
- Task 2 – Geotechnical Analysis, Design & Reporting

2. Site Description

The property comprises an irregularly shaped parcel of land of approximately 125 000 m². Existing site topography generally descends from the southeast towards Highway 3 at between 30 to 50%. The property is bounded by Highway 3 to the southeast, and by private property on all other sides. The site is intersected by a Telus right-of-way (ROW) which runs along the southwest boundary and crosses the access road just north of the entrance. The property's legal description is:

- Lot 15, Plan KAP217589, Sublot 2, District Lot 2709, SDYD, Except Plan KAP90322.

In 2016, Ecora conducted a preliminary geotechnical assessment relating to the establishment of residential lots, the construction of a strata access road to the lots, and the installation of utilities. Ecora's preliminary geotechnical assessment (attached in Appendix E) indicates the site consists of exposed bedrock outcrops to Lake Oliver Sediments, including terraced and benched silt, varved clay, and sand, overlain by flood deposits including outwash sand and gravel, or locally by till, diamicton, boulders, or wind-blown (aeolian) sand.

3. Project Description

The proposed development involves the construction of five strata lots, stormwater infrastructure, road access, and utility services. Additionally, the property will include one strata lot as a conservation area in the northwest portion of the site. Currently, the official community plan is zoned Large Holdings One Zone (LH1). A land use bylaw amendment application has been submitted to amend the zoning to part Small Holdings Three Zone (SH3) and part Conservation Area Zone (CA).

Current development of the property is restricted to the common property access road and Strata Lot (SL) 5. The development of the access road to-date has consisted of establishing access from Highway 3 to SL 5, developing the entrance and safely sloping the cut banks, and the site grading of SL 5.

4. Background Review

4.1 Published Surficial Geology

Reference to the publication "Okanagan Geology South" (Roed et al. 2011) indicates that the site is underlain by Lake Oliver sediments, including terraced and benched silt, varved clay, and sand, overlain by flood deposits including outwash sand and gravel, or locally by till, diamicton, boulders, or wind-blown (aeolian) sand.

4.2 Published Bedrock Geology

Reference to the Geological Survey of Canada 1:100,000 bedrock geology map "Okanagan Watershed" indicates that the area is underlain by Osoyoos Lake Gneiss, consisting of hornblende and biotite rich, gneissic, granodiorite.

4.3 Historical Imagery Review

Aerial photographs and satellite imagery for the area between 1982 and 2020 were reviewed to understand the history of development at and around 1750 Highway 3 in Osoyoos. The following was observed from a combination of historical aerial photographs (1982-1995) and Google Earth™ (2004-2020):

- 1982 – The subject property is undeveloped. An access road to 1826 Highway 3 can be seen.
- 1985 – The property remains undeveloped with no signs of use or activity. The residence at 1826 Highway 3 has been constructed.
- 1995 – 1750 Highway 3 remains undeveloped. An access road to the future location of a residence at 1806 Highway 3 has been established.
- 2004 – The subject site is undeveloped. Residences at 1806 and 1826 to the north of the proposed subdivision have been constructed, and land surrounding the dwellings is being used for agricultural activities. What appears to be a game trail running north-south is the only indication of activity on the subject site.
- 2008 – Some activity at the north end of the site, approximately SL 2 and SL 3, is apparent. It appears that the vegetation has been removed in two locations, likely for groundwater wells drilled between 2004 and 2008 (Section 4.4).

- 2009 – There appears to be activity at the current entrance location to the property. The disturbed footprint is relatively confined to the entrance area and appears to only access the Bourguiba Creek gully.
- 2015 – The entrance to site has been widened to allow for the beginning of access road construction.
- 2016 – An access road from the site entrance to present SL 5 has been roughed in. SL 5 has been stripped of vegetation and topsoil. A pad to the west of the access road in the SL 3 area has been established, likely for Ecora's subsurface soil investigation in 2015 (Section 5.1). Excavation of slopes above (to the northeast of) the entrance and blasting of bedrock along the access road is apparent. About midway between the entrance and SL 5, an access route to the gully of an unnamed creek has been established. It appears that some fill has been placed in the unnamed creek gully at SL 3 by this time. On the west side of Highway 3, opposite the site entrance, some fill has been placed to the north of Bourguiba Creek. The driveway to 1806 Highway 3 has been surfaced with asphalt, it appeared to be gravel until this time.
- 2018 – Work along the access road has continued. The area just north of the blasted rock face has been widened, and a second access path to the south end of the uncontrolled fill area has been established. The area of uncontrolled fill has been stripped and appears to be used as a site laydown and fill dump site. Most of the access road north of the uncontrolled fill to SL 5 remains unchanged. SL 5 development has not substantially changed.

Multiple bedrock outrcrop areas were identified from the aerial imagery review. The outcrop locations varied across site and included outcrops on shallow slopes as well as outcrops near the top of steep slopes. These outcrops are expected to be potential source zones for rock fall.

Indications of slope instability, land mass movements, or erosion due to surface water runoff were not apparent over the period of photos reviewed during this desktop exercise.

4.4 Water Wells

Reference to the Provincial Water Well Database, iMapBC, indicates that four water wells (Tag #57089, #84786, #69157, and #105407) were installed at various locations within the subject site, and groundwater levels were recorded at a minimum depth of 21.9 m below surrounding site grade (m bgl). The water wells are summarized in Table 1 below and the reports are included in Appendix B.

Table 1 Water Well Summary

Water Well No.	Approx. Location On Site	Drillers Description	Depth (m bgl)	Static Groundwater (m bgl)
57089	NW corner of SL 6 (CA), 5 m north of SL 5	"Weathered granite"	0 – 3.7	42.7
		"Dolomitic granite"	3.7 – 57.0	
		"Dioritic granite"	57.0 – 88.4	
		"Varied dioritic granite with some fractures"	88.4 – 149.4	
84786	NE corner of SL 3	"Sandy brown clay w/ gravel and cobbles"	0 - 1.2	Not Recorded
		"Broken and shattered rock w/ some sandy brown clay"	1.2 - 1.8	

		“Solid black and white granite bedrock”	1.8 - 40.8	
		“Black and white w/ some brown granite bedrock”	40.8 - 44.2	
		“Hard black and white granite bedrock”	44.2 - 50.6	
		“Softer black, white, and brown granite bedrock”	50.6 - 51.2	
		“Soft brown and tan granite bedrock”	51.2 - 53.9	
		“Very soft brown and tan granite bedrock”	53.9 - 59.1	
		“Hard black and white granite bedrock”	59.1 - 139.6	
		“Dark green and white granite bedrock”	139.6 - 142.6	
		“Very hard black and white granite bedrock”	142.6 - 158.5	
69157	SW corner of SL 6 (CA)	“Fine sand and silt”	0 – 1.5	Not Recorded
		“Boulders”	1.5 – 2.4	
		“Bedrock”	2.4 – 155.4	
105407	Site Entrance	“Sand, fine-med; boulders and cobbles”	0 – 9.1	21.9
		“Crystalline”	9.1 – 44.2	
		“Crystalline”	44.2 – 47.2	
		“Crystalline”	47.2 – 54.9	

5. Geotechnical Site Investigations

Ecora has conducted three separate geotechnical site investigations, two as part of the preliminary geotechnical assessment conducted in 2015 and 2016 and a third, in 2020, to assess the uncontrolled fill on the subject site.

5.1 2016 Preliminary Geotechnical Assessment Soil Investigation

The preliminary assessment investigation, performed in 2015, consisted of four test pits to depths of up to 3.7 m below existing ground, one auger borehole with Standard Penetration Tests (SPT) to a depth of 3.3 m below existing ground, and discontinuity mapping of rock outcrops along the driveway route.

The locations of the test pits and borehole are shown below in Table 2.

Table 2 Summary of 2015 Test Hole Locations

Test Hole No.	Easting (m)	Northing (m)	Test Hole Depth (m)	Location
TP15-01	323744	5433012	3.0	SL 5

TP15-02	323728	5432890	2.5	SL 4
TP15-03	323674	5432864	2.5	SL 3
TP15-04	323676	5432732	3.7	SL 1
BH15-01	323801	5432495	3.3	Strata Access Road Entrance

A site plan showing the test hole locations can be found on Figure 1.0. The laboratory test results are summarized in Section 5.6 and further details, including test hole logs, are found in the appended 2016 Preliminary Geotechnical Assessment.

5.2 2016 Preliminary Geotechnical Assessment Depth to Bedrock Investigation

In addition to the 2015 soil investigation, 48 probe holes were drilled in 2016 to determine the depth to bedrock northeast of the site entrance from Highway 3. The results of the probe investigation are consistent with overburden depths encountered across the site during the previous site investigation and site reconnaissance observations. The probe hole locations can be seen on Figure 1.0.

5.3 2020 Uncontrolled Fill Drilling Investigation

In order to assess the uncontrolled fill placed on the west side of the site (further discussed in Sections 8-9) near the intersection of SL 3, 2, and 1, a drilling investigation was undertaken by Ecora that consisted of three boreholes. The purpose of the investigation was to determine fill characteristics, such as the composition and relative density of the placed material, obtain representative samples, and determine the depth of the placed fill.

The locations of the boreholes are shown below in Table 3.

Table 3 Summary of 2020 Borehole Locations

Borehole No.	Easting (m)	Northing (m)	Borehole Depth (m)	Location
BH20-01	323669	5432745	4.9	SL 1
BH20-02	323671	5432736	3.1	
BH20-03	323674	5432726	1.5	

The borehole locations can be found on Figure 1.0, with the laboratory test results and borehole logs , located in Appendix C and D, respectively.

5.4 Encountered Soil Conditions

From the 2015 subsurface investigation, the in-situ soil types encountered on site consist of:

- Topsoil, loose to compact sandy topsoil to a depth of 0.1 m, which is underlain by;
- Aeolian Deposits, loose to compact fine silty sand and fine sand and silt with some roots to a depth of 0.4 to 2.3 m which in turn overlies;

- Glaciofluvial Deposits, compact gravelly sand with some cobbles and trace silt, to depths of 2.5 to 3.0 m, which in turn overlies; and
- Crystalline metamorphic bedrock within TP15-01, TP15-02, and TP15-03 at a maximum depth of 3.0 m. Bedrock consisted of metamorphic gneiss rock, cross cut by dikes of orthoclase feldspar rich igneous rocks up to 100 mm thick.

The 2020 uncontrolled fill drilling investigation encountered material types consisting of the following:

- Fill, compact to dense sandy silt, trace gravel and blast rock to depths of 0.6 to 4.3 m.
- Aeolian Deposits, compact sandy silt, some cobbles, to depths of 0.6 to 4.9 m.
- Bedrock at a maximum depth of 4.9 m. Bedrock inferred to be hornblende and biotite rich granodiorite, gneissic.

5.5 Groundwater Conditions

At the time of the 2015 and 2020 investigations, no groundwater or seepage was encountered or visible within excavated test pits or at ground surface (i.e. slope surface with shallow bedrock). Based on the elevation, topography, and the well data obtained from Provincial Well Database, iMapBC, we anticipate that the permanent groundwater table is well below existing site grades, however, a temporary perched groundwater table may be encountered near the surface of the till and bedrock, during periods of heavy rainfall and snow-melt.

5.6 Laboratory Testing

Laboratory testing was conducted on selected soil samples to confirm the field observations and their physical characteristics. Grain size analysis distribution tests (ASTM C136 and D422) were conducted on SPT samples from the test holes. Results of the laboratory tests are summarized in Table 4 and presented in detail in Appendix C. Laboratory test results from the 2015 investigation can be found in the appended 2016 Preliminary Geotechnical Assessment in Appendix E of this report.

Table 4 Summary of Laboratory Testing Results

Borehole No.	Sample Depth (m)	Particle Size Distribution (%)		
		Gravel	Sand	Fines
BH-15-01	3.0 – 3.3	24.0	57.5	18.5
TP-15-02	1.6 – 1.8	23.4	68.3	8.3
TP-15-03	1.3 – 1.6	0.9	54.9	44.2
BH20-01	1.8 – 2.4	17.8	31.9	50.3
BH20-02	1.2 – 1.5	5.4	49.5	45.1
BH20-03	0.6 – 1.2	4.3	46.3	49.4

6. 2016 Preliminary Geotechnical Assessment

6.1 General

Ecora performed a preliminary geotechnical assessment for the proposed development using a phased approach and included the following:

- A field investigation that comprised excavating four test pits, and advancing one solid stem auger borehole;
- An air track drilling investigation to determine the depth to bedrock at the proposed entrance of the strata access road;
- Field discontinuity mapping of exposed rock outcrops along the road alignment; and
- Preparation a report summarizing the geotechnical investigation and providing recommendations for site preparation and construction of the access road.

6.2 Results

Ecora identified the following potential geohazards in the 2016 Preliminary Geotechnical Assessment:

- Aeolian Deposits which are susceptible to collapse and erosion;
- Glaciofluvial Silts which are susceptible to collapse; and
- Slope stability of cut and fill slopes due to highly sensitive aeolian sands and silts and the possible introduction of water.

6.3 Geotechnical Characteristics of Glaciofluvial Silts and Aeolian Sands

The glaciofluvial silts as well as aeolian Sand encountered in the South Okanagan area can present significant geotechnical challenges and have historically performed poorly when their unique behaviour has not been taken into consideration in site development. Known issues and causes of failures in these soil types include:

- Susceptible to erosion when subject to concentrated surface water runoff.
- Piping and the formation of sinkholes, through the introduction of water creating steep hydraulic gradients and development of internal erosion along preferential paths of seepage.
- Toppling failure of bluffs, through presence of perpendicular stress release joints near the top of a near vertical bluff and the introduction of water into a vertical and/or horizontal joint result in the softening or erosion of a supporting layer.
- Rotational and planer landslides, through the introduction of water forming elevated hydrostatic pressures and steeper hydraulic gradients, internal erosion along preferential paths of seepage, softening and reduction in strength, and removal of toe support.
- Collapse, rapid consolidation when subjected to increased surcharge loading and increased saturation.

The majority of the overburden soils within the property consist of aeolian sand and glaciofluvial silts. Due to the above mentioned geotechnical challenges associated with aeolian sand and glaciofluvial silts coupled with shallow bedrock and the placement of fill on the site, storm water management and site drainage of the property is of vital importance. The recommendations for site development related to these challenges are provided in Section 9.

7. Geohazard Assessment

7.1 Method of Assessment

Considering the lack of long-term records of geotechnical hazards at the subject property, the potential for the occurrence of geohazards cannot be assessed by a review of historical events. Therefore, a subjective assessment of the geohazards present on the subject property was undertaken based on the guidelines presented in the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) Guidelines for Legislated Landslide Assessments and "Hazard Acceptability Thresholds for Development Approvals by Local Government" by Dr. Peter Cave (Cave 1993). In this assessment, Ecora has reviewed the hazards that could potentially affect the subject properties and provide recommendations for the safe use of the site.

The Cave paper also identified seven types of development based on their intensity of land use. They range from minor repair to major rezoning and community planning. Based on the nature of the proposed construction, this development falls under the category of a “subdivision”.

Ecora assessed the subject area and immediate surroundings to determine its' susceptibility to the following potential geohazards:

- Inundation by flood waters;
- Mountain stream erosion and avulsion;
- Debris flows and debris torrents;
- Debris floods;
- Small to largescale landslides within the native glaciofluvial silts and/or aeolian sands;
- Snow avalanche;
- Rock fall; and
- Uncontrolled fill.

7.2 Terrain Classification

Terrain classification was undertaken for the study area and the distribution of soils in the subject property is presented on Figure 2.0. The analysis was conducted by the interpretation of satellite imagery, air photos, and field confirmation.

Terrain classification within the subject property is summarized in Table 5. The terrain interpretation confirms that the majority of the study area are overlain by silty glaciofluvial deposits. However, the site investigations revealed

that in areas aeolian sand sediments overlay the mapped glaciofluvial deposits. Aeolian deposits are sedimentary deposits of grains transported by wind that typically infill topography and can by difficult to different when deposited adjacent and/or over other sedimentary deposits of similar particle sizes that they likely originated from. Subsequently the referenced surficial deposit mapping has not differentiated these aeolian deposits from the glaciofluvial deposits, and the inclusion of these deposits is of importance primarily due to the incurred land management implications of these areas. These silty glaciofluvial and aeolian sand deposits represent approximately 7.9 ha (63%) of the site.

Small upland portions on the eastern side of the study area are classified as bedrock outcrops which generally consist of steep rocky cliffs. This remaining terrain type represents approximately 4.6 ha (37%).

Table 5 Terrain Classification within Subject Property

Terrain Description	Area (ha) (% of subject property)
Silty Glaciofluvial / Aeolian Sand Deposits	7.9 ha (63%)
Bedrock Outcrops	4.6 ha (37%)
Total	12.5 ha (100%)

7.3 Geohazard Type Risk Classes

The criteria in Section 7.1 and the terrain classifications from Section 7.2 were used to classify the geohazard areas identified during the site reconnaissance, which is summarized in Table 6 below.

Table 6 Geohazard Risk Classes Description for the Proposed Development

Risk Class	Probability of Occurrence	Description and Examples
Low (Safe Building Areas)	Less than 1 in 10,000 year catastrophic events. Less than 1 in 475 years for property-damaging events.	Low likelihood of landslide/rock fall initiation following development (i.e., Slopes gentler than 50% - 60% with no signs of instability)
Moderate	Less than 1 in 10,000 year catastrophic events. Greater than 1 in 475 years for property-damaging events.	Expected to contain areas with a moderate likelihood of landslide/rock fall initiation following development (i.e., Slopes steeper than about 50% - 60% with visible signs of instability, polygons mapped with aeolian and/or glaciofluvial sediments)
High (No-Build Areas)	Greater than 1 in 10,000 year catastrophic events. Greater than 1 in 475 years for property-damaging events.	Natural instability present. Expected to contain areas with a high likelihood of landslide/rock fall initiation following development (i.e., Steep rocky cliffs from which rock fall has occurred, all material and landforms that are unstable)

7.4 Site Reconnaissance

The site reconnaissance was planned and undertaken using the preliminary information collected during the desktop study and in accordance with the EGBC Guidelines for Legislated Landslide Assessments for Proposed Residential Developments. The purpose of the site reconnaissance was to observe the surface and near surface conditions, and to verify both hazardous and stable slope conditions identified during the desktop study.

The information collected during the site reconnaissance was used to produce a geohazard map (Figure 3.0) to guide the subdivision planning process. Key observations from the site reconnaissance are as follows:

- Approximately 75% of the site is classified as having natural slopes of 15-30°. The slopes across the majority of site sloped east to west, with some areas having greater than 30° slopes. The slope surfaces generally contained tall grasses and shrubs. Bedrock outcrops were observed throughout the site (Photo 1).
- Two unnamed, ephemeral streams were identified, one crossing midway through the property running northeast to southwest (Photo 2), and one across the north tip of the property from east to west (Photo 3). These streams were noted to be dry at the time of the site reconnaissance.
- The southern portion of the site was noted to have slopes exceeding 30° to the east of the access road. This area has rock fall mitigation in place consisting of catchment fences, and blasting to remove the highest risk areas has been undertaken (Photo 4).
- Potential rock fall source locations, identified during the desktop study and confirmed during the site reconnaissance, are shown on Figures 2.0 and 3.0. Smooth, fractured bedrock outcrops with subangular boulders were noted to the west of the access road (Photo 5). Smooth bedrock outcrops with indications of planar failure were observed to the east of the access road, head scarps were also observed (Photo 6). Both areas where rock fall runout was noted were observed to be on slopes of approximately 20°.
- Uncontrolled fill was placed across an unnamed, ephemeral stream. The slope of the fill from crest to toe along the west side is approximately 30°. The width of the uncontrolled fill platform is approximately 12 m. The fill is approximately 5.0 m thick (Photos 7-9, 11). A 450 mm corrugated HDPE culvert runs below the uncontrolled fill along the unnamed creek path (Photos 10 and 12). The length of the culvert is estimated to be 25 m.

7.5 Geohazard Areas

7.5.1 General

The probability of occurrence for geohazards are estimated based on our engineering judgment, proposed development and site conditions at the time of preparation of this report. The estimated geohazard frequencies are subject to change, and can be impacted by ground modifications such as site regrading or drainage profiles and does not account for human activities which may affect geohazards.

Ecora has divided the subject property into hazard areas based on the potential risk of geohazards. The majority of the constructable area of the subject property is considered to be a ‘moderate’ hazard corresponding to return periods of greater than 1 in 475 years for property damaging events and less than 1 in 10,000 for catastrophic events. ‘Low’ hazard areas were identified along the western side of the subject site (SL 2) and in SL 5, while the steep slopes located along the ephemeral stream gullies and the bedrock outcrops to the east of the access road are considered to be within a ‘high’ hazard risk class.

It is important to note that additional rock fall and slope stability geohazards may be present on site. However, as the final site grading plan detailing all proposed building locations is not available, the risk cannot currently be quantified. Upon the establishment of final site grading and building locations, an additional geohazard assessment performed by a qualified professional engineer is required to ensure that the hazard areas discussed in this report are not infringed upon without adequate mitigation.

It is Ecora's opinion that inundation by flood waters, debris flows, debris torrents, debris floods, snow avalanche, and large-scale landslides will not impact the proposed building locations as they are located away from any watercourses, or other significantly steep slopes.

The identified hazard areas are presented on the attached Figure 3.0 and further discussed in the following sections.

7.5.2 Rock Fall Hazard

A rock fall hazard source zone with a moderate to very high return period and potentially property damaging events is located along the east side of the property, primarily through the middle of SL 6 (Conservation Area). The rock fall shadow from this source zone extends to the proposed SL 1, 3, and LCP access driveway for SL 1 and 2. Mitigation measures for this area are expected to be possible through a combination of site grading and protection measures (i.e. ditched berms) during development of the strata.

7.5.3 Uncontrolled Fill Hazard

The infilled gully identified during the site reconnaissance and current site investigations, could pose a potential hazard in the form of instability, unacceptable settlement and/or development of sinkholes within that specific area. The approximate extent of the infill material is shown in Figure 3.0. Mitigation measures for this hazard consists of the removal of all uncontrolled fill. These areas may require the placement of engineered fill following the removal of uncontrolled fill to facilitate site development. The engineered fill would need to be placed under the supervision and direction of a qualified professional engineer.

7.6 Geohazard Mitigation Measures

The Cave 1993 paper lists avoidance and protection as two possible actions for hazard mitigation. Avoidance is defined as exposure reduction and is the more desirable of the two. It can be achieved by measures such as elevating the proposed construction above flood levels and introducing setback or set-forward distances from slopes and watercourses. Protective measures are typically easier to implement but they usually involve maintenance and additional cost.

An additional measure in dealing with geohazards is the transfer of liability with the 'save harmless' clause as a form of indemnity to protect the approving authority from a lawsuit. Save harmless clauses can be registered as legal incumbrancers against the title of the property.

In Ecora's opinion, given the terrain of the proposed development, avoidance in the form of a safe building set-forward distance from the shadow of any potential rock fall source zones would be the preferred mitigation measure for the rock fall hazard identified on the subject site. The rock fall shadow area is denoted by a line dipping 27.5° from horizontal measured from the crest of the talus slope at the base of a cliff (Wyllie, 2015) (see Figure 6.0). The extent of this rock fall shadow area is incorporated within the 'high' risk class area shown on Figure 3.0. If this is deemed to be not practical, a catchment ditch, berm, or rock fill barrier should be constructed. Ecora can provide a design of such structure if required.

Further details on the recommended geohazard mitigation measures to be implemented in the design and construction of the development are presented in Section 9.

8. Slope Stability Assessment –Uncontrolled Fill

8.1 General

Sometime between the site reconnaissance for Ecora's 2016 preliminary geotechnical assessment and prior to Mr. Johnsen's re-zoning application in 2020, a significant volume of fill was placed on a slope and in a natural draw on the area proposed as limited common property (LCP) access driveway for SL 1 and 2, and in the SL 1 area. The natural slope is approximately 21°, sloping northeast to southwest towards Highway 3. The placement of this fill was not observed or documented by Ecora, or to the knowledge of Ecora, any other qualified professional geotechnical engineer. A topographic survey of the area revealed that a footprint of approximately 1310 m^2 was covered, and a volume of approximately 4,000 m^3 of fill was placed. The slope of the fill embankment from crest to toe is about 30°.

In order to assess the suitability of this fill for loading such as roadways or structures, a slope stability assessment was undertaken based on the soil conditions encountered during the 2020 geotechnical site investigation.

8.2 Design Criteria

There is no nationally adopted level of slope stability safety for Canada, however EGBC Professional Practice Guidelines for Retaining Wall Design (2020) recommends minimum static factors of safety between 1.3 and 2.0 for the design of earthworks and retaining walls. EGBC recommends a minimum factor of safety of 1.1 for pseudo-static seismic conditions and this is generally considered to be the industry norm.

8.3 Model Parameters

Computer modelling of the stability of a typical slope cross section of the uncontrolled fill area based on field measurement's and a topographic survey has been performed using the commercial computer program Slide2 Modeler™ v9.003 by Rocscience. Circular (global) factors of safety for the analysed slopes were calculated using the two-dimensional Limit State Equilibrium analysis utilizing the Morgenstern-Price method with a half sine interslice force adopted. The analysis was carried out to evaluate the long-term global stability of the uncontrolled fill located on the LCP and SL 1 under static and pseudo-static conditions.

The geotechnical design parameters summarized below in Table 7 have been derived based on Ecora's previously completed site investigation, lab testing, as well as published geotechnical literature. A surcharge load of 30 kPa was used to simulate a permanent structure and loading such as a roadway with vehicles .

Typically, both static and earthquake induced slope stability is analysed. In the pseudo-static slope stability analysis, the 2% in 50-year seismic event corresponding to a return period of 2,475 years and peak ground acceleration (PGA) of 0.078g, based on the British Columbia Building Code (BCBC 2018), was used.

Table 7 Numerical Model Material Properties

Material Name	Unit Weight (kN/m^3)	Strength Type	Cohesion (kPa)	Friction Angle (degrees)	UCS (MPa)

Native Silty Sand (Aeolian)	19	Mohr-Coulomb	1	33	-
Fill (Aeolian Sand & Silt, trace to some gravel)	20	Mohr-Coulomb	0.5	35	-
Bedrock (Granodiorite)	26	Generalized Hoek-Brown	-	-	100

8.4 Results

A summary of the numerical analyses results is outlined in Table 8. The factors of safety obtained from the numerical modelling within the uncontrolled fill area fail to meet the required static and, seismic conditions. The numerical model results for static and pseudo-static analyses are shown in Figure 5.0 and Figure 5.1, respectively. Further discussion and recommendations regarding the uncontrolled fill can be found in Section 9.

Table 8 Summary of Global Stability Analyses Results

Section	Minimum Required Factor of Safety		Calculated Values (Within the Uncontrolled Fill Area)	
	Static	*Pseudo-Static*	*Static*	*Pseudo-Static*
A-A’	1.50	1.10	1.15	1.03

9. Discussion and Recommendations for Site Development

9.1 Discussion

Based on our understanding of the project and the ground conditions observed during our geotechnical assessments, we are of the opinion that, from a geotechnical perspective, the subject site is suitable for the proposed development, provided that our recommendations and mitigation measures are followed during the design and construction of the project.

Geotechnical recommendations for proposed subdivision development are provided in the following sections.

Ecora will reassess the potential geohazards across the site once the final site grading plan is available. Figure 3.0 shows the approximate range of site slope angles. Slopes steeper than 30° are considered to be potentially unstable, and Ecora expects these areas will be classified as ‘high’ risk class (no-build areas) as noted in Table 6 above.

9.2 LCP Driveway and Strata Lot 1

Based on the site reconnaissance, current geotechnical site investigation, and review of the 2016 geotechnical assessment, Ecora has identified a potential geotechnical hazard in the LCP and SL 1 area, as shown on Figure 3.0.

As noted in Section 8, placement of the uncontrolled fill on the LCP and SL 1 does not meet static or pseudo-static stability requirements.

In addition to the instability of the uncontrolled fill, the fill was placed across an unnamed, ephemeral stream. iMapBC indicates the unnamed stream originates on the subject property and runs for a distance of approximately 587 m from it's source to the point where it joins Haynes Creek to the southwest of Highway 3. A corrugated 600 mm diameter HDPE storm culvert can be seen extending approximately 3 m above the fill and appears to lie along the base of the unnamed stream underneath the fill, until it daylights a few meters southwest of the downslope toe of the fill. It should be noted that the design and installation details of this culvert are unknown, and factors such as it's adequacy to pass design flows, pipe bedding, backfill compaction, and joint installation were not monitored.

Since Ecora's initial site visit for this 2020 geotechnical assessment in August of 2020, no water has been noted in this stream area. However, due to the shallow bedrock it would not be unreasonable to expect the possibility for some flows during high runoff events such as freshet or large precipitation events.

The geotechnical characteristics of aeolian sandy silt outlined in Section 6.3 are of additional concern relating to the stability of placed fill. The placement of the fill over the stream path and undocumented installation of the stormwater culvert raises concerns regarding the introduction of surface water runoff under and into the fill area. This increases the risk of the potential for surface erosion, piping and sinkhole formation, rotational and planar landslides due to elevated hydrostatic pressures, internal erosion, and collapse due to rapid consolidation with increased surcharge loading and increased saturation.

Based on the site conditions and analysis performed in this assessment, Ecora is of the opinion that no infrastructure or buildings be placed in this area of uncontrolled fill. Due to the increased possibility of surface erosion, piping and sinkholes in the area caused by the direction of surface water beneath the fill, usage of the area as a yard or green space is also not recommended.

In order to facilitate the use of the area for an LCP access driveway to Lots 1 and 2, and potential building footprint or yard area, Ecora recommends the removal of all uncontrolled fill as well as the culvert in the stream path. A building or road platform and culvert in this location is possible and can be achieved, however, additional engineering design and construction monitoring by a qualified professional engineer is required.

9.3 Recommendations for Site Development

9.3.1 Set Back and Set Forward Distances

The required setback from the crest of slopes will depend on the size of the building and the composition of the subgrade.

Ecora recommends that a set-forward distance based on the rock fall shadow area be adopted, as described in Section 7.5.2.

Set back and set forward requirements should be reviewed on a lot by lot basis by the geotechnical engineer prior to construction of structures. Final set back and set forward recommendations shall be incorporated into a geotechnical covenant to be registered on the title of any lots affected.

9.3.2 Site Preparation

The footprint of proposed structures and fill slopes shall be thoroughly cleared of all rubbish, debris, uncontrolled fill soil, and vegetation which shall be disposed of away from the site. All topsoil shall be stripped from earthworks areas and stockpiled separately clear of the earthworks.

Based on the results of our site reconnaissance and investigations, it is possible that minimal site preparation will be required to expose a suitable subgrade of competent bedrock. However, excavation to the proposed footing elevations may be require significant effort depending on the number and spacing of pre-existing fractures within the bedrock.

9.3.3 Foundation Options

Footings founded on both bedrock and native soil may experience differential settlement which may cause cracking of foundations and/or interior walls footings. There are therefore two options for footing foundations:

- **Option 1**: Blasting or excavating to bottom of footing elevation, and casting footings directly on clean, bedrock surface. In this case, the footings may be "pinned" directly to bedrock using rock dowels depending on the grade of the proposed footings. The rock dowels shall be designed by qualified professional structural and/or geotechnical engineers; or;
- **Option 2**: Sub-excavate or blast a minimum of 0.3 m below the proposed footing elevation (ensuring a clean, horizontal, bedrock surface) and replace with compacted structural fill as described in Section 9.3.4 below. In this case frost protection requirements as described in Section 9.3.7 below shall apply.

Under no circumstances shall footings be placed on a combination of soil and bedrock.

9.3.4 Structural Fill

Upon site preparation and subgrade approval from the geotechnical engineer, structural fill may be placed (if required) and shall be moisture conditioned and placed in one horizontal lift of 300 mm in loose thickness and uniformly compacted to a minimum 100% Standard Proctor Maximum Dry Density (SPMDD) (ASTM D698).

Structural fill shall consist of an approved well graded, free draining (free from excess fines, organics and deleterious matter) material with a maximum particle size of 150 mm. All structural fill is subject to approval by a geotechnical engineer prior to placement and compaction.

Care should be taken during winter construction to ensure that fill materials are not placed in a frozen or excessively wet state.

9.3.5 Foundation Design

- **Option 1:** If rock anchored foundations are designed, Ecora shall be contacted to provide pull out capacity recommendations. In general accordance with Part 9 of BCBC (2018), foundations directly on sound bedrock shall be designed for an allowable bearing pressure of 500 kPa.
- **Option 2:** Shallow foundations placed directly on approved prepared subgrade or structural fill as discussed in Section 9.3.2 and 9.3.4, in general accordance with Part 9 of BCBC (2018), shall be designed for an allowable bearing pressure of 75 kPa.

9.3.6 Re-Use of On-Site Material

Based on the observations from the site reconnaissance, it is our opinion that the native on-site soils are not suitable for re-use as structural fill. Re-use of any excavated material shall be approved by the geotechnical engineer prior to placement.

The suitability of any soil proposed for use as structural fill should be verified by a geotechnical engineer prior to its use onsite.

9.3.7 Frost Protection

Frost susceptibility of soils refers to the propensity of the soil to grow ice lenses and heave during freeze and thaw cycles. Based on the frost design soil classification (US Corps of Engineers, 1981) the frost group for the native material in the upper 3.0 m is F2 to F3, which classified the soils as low to high in the degree of frost susceptibility.

Based on the Regional District of Okanagan-Similkameen (RDOS) Bylaw No. 2805, the frost penetration depth for the region where the proposed building site falls into is estimated (from normal freezing index) at 0.6 m below ground surface (RDOS). Therefore, the underside of shallow footings shall be placed at least 0.6 m below final site grades to conform to the minimum frost protection requirement. It should be noted that granular backfill, approved by the geotechnical engineer, would need to be placed around and above the foundation wall underside.

Where the underside of a footing cannot be designed with the minimum cover depth of 0.6 m, thermal insulation shall be incorporated according to design guidelines such as ASCE 32-01 (published by American Society of Civil Engineers) into the foundation design.

9.3.8 Slab On-Grade Floors

Interior slabs on grade should be supported on a minimum 150 mm thick layer of under-slab fill consisting of 19 mm clear crushed gravel, overlying approved native material or structural fill prepared in accordance with the recommendations in this report. The under-slab fill shall be moisture conditioned and compacted to a minimum 100% SPMDD.

Slab-on-grade floors should be designed in accordance with Section 9.13 of BCBC (2018) with regards to damp proofing, waterproofing and soil gas control.

9.3.9 Foundation Drainage

Section 9.14.2 of the BCBC (2018) specifies that unless it can be shown to be unnecessary, the base of every exterior foundation wall shall be drained by a drainage tile or pipe laid around the exterior of the foundation or by a layer of gravel or crushed rock.

Ecora recommends a conventional perimeter drainage system be installed along the new exterior building foundations. The perimeter drainage system should be constructed with rigid perforated PVC piping with a minimum diameter of 150 mm covered with not less than 150 mm of crushed stone or other coarse, clean granular material. The invert of the perimeter drain-pipes should be located at least 300 mm below the top of the floor slab. The collected water should drain to the storm water disposal system as discussed in Section 9.3.10 below.

9.3.10 Storm Water Management and Site Storm Disposal

The field investigation results indicate that the aeolian sand and glaciofluvial silts encountered at the site are in compact to dense states. However, it is important to note that introduction of water can cause surface erosion and potentially create steep hydraulic gradients that can cause internal erosion of the sand and silt along preferred zones of seepage (see Section 6.3). Therefore, it is important to divert all the surface water away from the proposed structures on the property.

Site grading of the lots should be designed in such a manner so as to prevent the ponding of surface water near building foundation areas or not to discharge over sloping ground. Sidewalks, paved or landscaped areas within a

zone of approximately 2 m of building should be sloped to drain water away from the structure at a minimum gradient of 2%.

All foundation drainage systems shall be drained directly to a storm water infiltration pit (rock pit) via rigid PVC piping. The rock pit should be sized and designed by a qualified professional engineer prior to construction. Storm water and roof downspouts should be tied directly to the subdivision storm water system and conveyed off site. Irrigation systems shall only include low pressure systems (i.e., drip irrigation system) and the pressure reducer shall be internally within the dwelling. Pools shall only be allowed to be drained to the storm water system and shall not be disposed over slopes.

Drainage considerations established during design and construction should be maintained for the life of the development. Property owners should be made aware that altering drainage patterns can be detrimental to slope stability and foundation performance.

9.3.11 Temporary Excavation and Utility Trenching

Temporary excavation work should be carried out in accordance with requirements specified by the WorkSafeBC Occupational Health & Safety Regulations, Part 20 presented in Figure 7.0. Soil sloughing, development of tension cracks atop the excavation, groundwater seepage or loose/soft soil conditions encountered during excavation may require flatter excavation slopes than those specified in the WorkSafeBC Occupational Health & Safety Regulations, Part 20. A qualified Professional geotechnical engineer shall review all proposed temporary excavation works during construction, when required by WorkSafeBC.

Excavated material from trenches should either be removed from the site or placed a minimum distance away from the excavation, equal to the depth of the excavation. Where buildings or other structures are near the excavation, additional review of the proposed excavation work should be undertaken by a qualified professional geotechnical engineer.

All utilities should be bedded as per the RDOS development by-laws. General trench backfill above the bedding should be placed in loose lifts not exceeding 300 mm thickness, and each lift should be compacted to a minimum of 95% of Modified Proctor Maximum Dry Density (MPMDD) (ASTM D1557).

9.3.12 Permanent Cut and Fill

Permanent cut and fill slopes in the native soils and/or structural fill shall not be graded steeper than 2H:1V. Permanent fill slopes shall be over-built and then trimmed back to the recommended inclination.

Permanent cut and fill slopes shall be vegetated immediately after construction to prevent surface erosion. Vegetation growing on slopes assists in stabilization by root-binding, preventing erosion and lowering soil moisture content. The establishment of additional vegetation comprising of native grasses and perennial mix with pocket planted shrubs is recommended. Large trees should be kept well away from shallow surface foundations to prevent root interaction effects.

9.3.13 Retaining Walls

Should it not be possible to achieve site grading requirements, construction of permanent retaining walls may be required. Retaining walls shall comply with the RDOS zoning regulations, with all walls over 1.2 m in height to be designed by a professional engineer in accordance with the requirements of the EGBC retaining wall design professional practice guidelines. All tiered slopes consisting of two or more retaining walls less than 1.2 m in height shall be designed as an engineered slope where averaged grading exceeds the above recommended

grading requirements. An assessment of global stability shall be undertaken in the design of all engineered retaining walls and/or slopes.

Any retaining walls at or below a 1H:1V line projected from the outside leading edge of a foundation supporting a structure is considered to be a structural element as specified in Appendix A-9.3.2.9.(4) of the BCBC 2018 and therefore shall be designed by a professional engineer. Retaining walls above the 1H:1V projected line may be considered a structural element. A typical drawing showing this requirement is presented in Figure 8.0.

10. Design and Construction Review

Ecora should be given the opportunity to review the details of the design and construction specifications related to all geotechnical aspects of this project, prior to construction. Past experience has shown that this action may prevent inconsistencies that may lead to disputes.

Ecora shall be given a chance to review any design drawings prior to construction and provide updated recommendations, if required.

All design recommendations presented in this report are based on the assumption that an adequate level of geotechnical field review will be provided during construction, and that construction will be carried out by a suitably qualified contractor, experienced in earthworks construction. One of the purposes of providing an adequate level of field review is to check that recommendations based on data obtained at discrete test locations are relevant to other areas of the site. It is recommended that reviews are carried out by Ecora geotechnical personnel during construction of the residential structure for the following:

- Building set back distances from sloping ground;
- Confirmation of rock fall shadow zones;
- Sub-excavation/replacement works;
- For shallow foundations, observation of all bearing surfaces prior to placement of structural fill and prior to concrete placement;
- Observation of footing drain installation and tie-in to the storm sewer system; and,
- For earthworks and structural fill, full-time monitoring and compaction testing.

Suitably qualified persons, independent of the contractor, should carry out all such monitoring. It should be noted that failure to provide an adequate level of foundation monitoring might be in contravention of the BCBC (2018). Ecora can provide quality control of the above-mentioned tasks.

11. Closure

We trust this report meets your requirements. Please contact the authors above if you have any questions or comments concerning this report.

References

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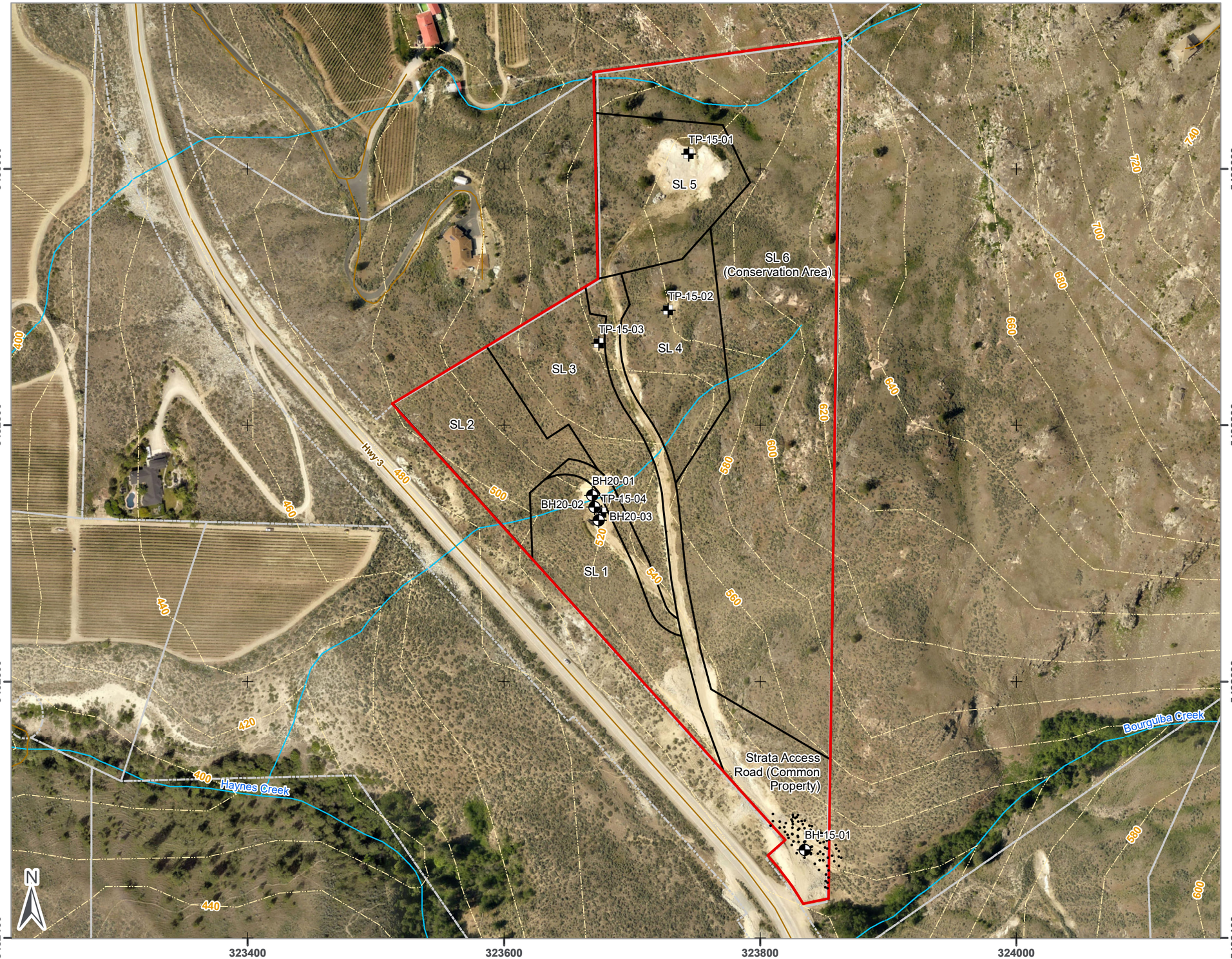
Figures

SITE PLAN



GEOTECHNICAL ASSESSMENT
STEINAR JOHNSEN DEVELOPMENT
OSOYOOS, BC

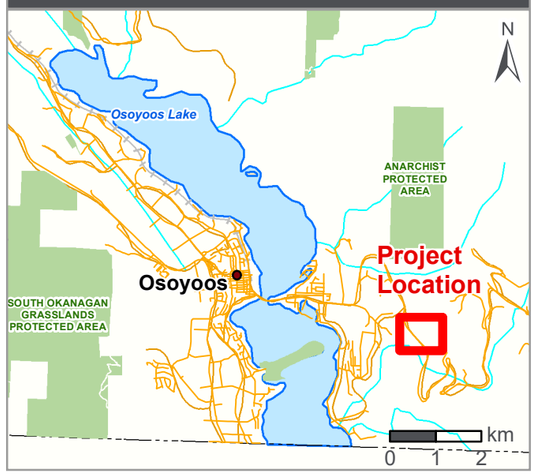
Legend

- Borehole Locations
- Test Pit Locations
- 2016 Depth to Bedrock Investigation
- Digital Road Atlas Roads
- 20m TRIM Contour Lines
- Fresh Water Atlas Streams
- Legal Lot Lines
- RDOS Legal Parcels
- Property Boundary

References

Aerial Imagery: RDOS GIS. Imagery Date: January 15, 2016

LOCATION MAP



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0 50 100 150 200 Meters

Project No.: 201589
Client: Steinar Johnsen

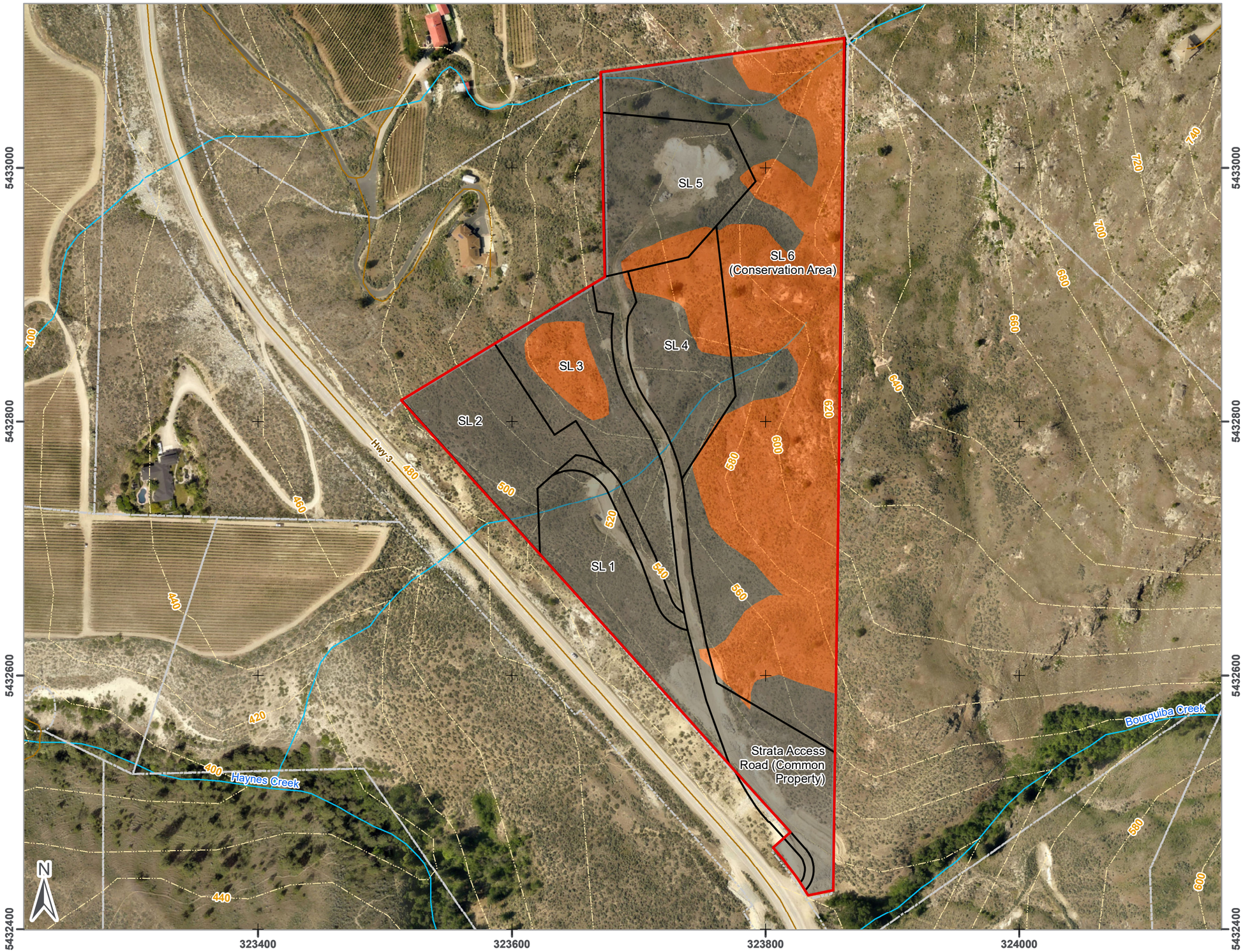
Date: 2020/11/18
Drawn: MT Check: BD

NAD 1983 UTM Zone 11N

Figure 1.0

TERRAIN CLASSIFICATION

ecora™



GEOTECHNICAL ASSESSMENT
STEINAR JOHNSEN DEVELOPMENT
OSOYOOS, BC

Legend

- Digital Road Atlas Roads
- 20m TRIM Contour Lines
- Fresh Water Atlas Streams
- Legal Lot Lines
- RDOS Legal Parcels
- Property Boundary

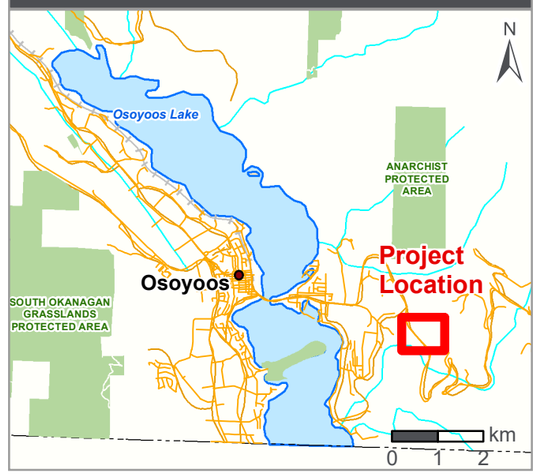
Terrain Class

- Bedrock Outcrops / Shallow Soil
- Glaciofluvial / Aeolian Deposits

References

Aerial Imagery: RDOS GIS. Imagery Date: January 15, 2016

LOCATION MAP



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Project No.: 201589
Client: Steinar Johnsen

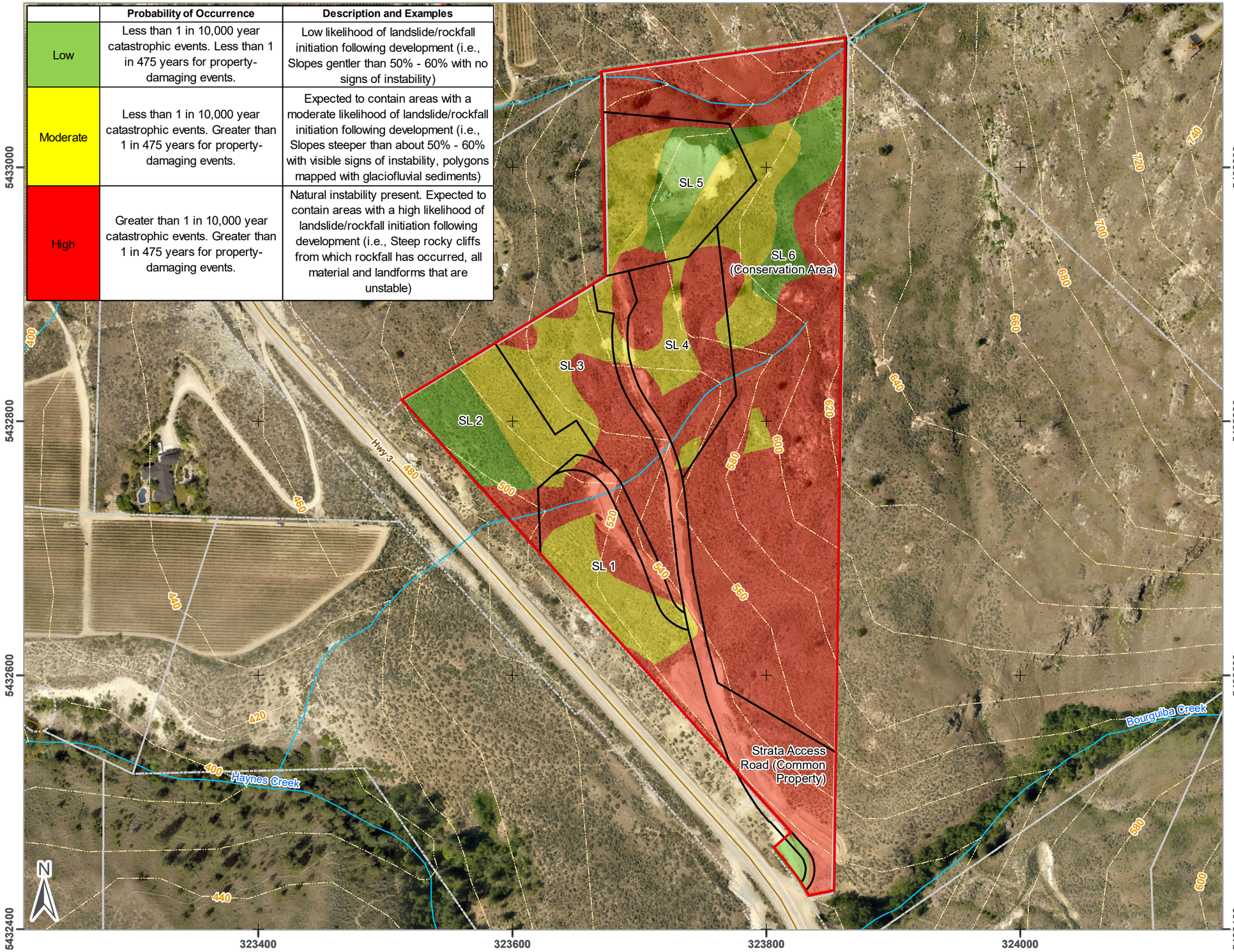
Date: 2020/11/24
Drawn: MT Check: BD

NAD 1983 UTM Zone 11N

Figure 2.0

RISK CLASS ANALYSIS

	Probability of Occurrence	Description and Examples
Low	Less than 1 in 10,000 year catastrophic events. Less than 1 in 475 years for property-damaging events.	Low likelihood of landslide/rockfall initiation following development (i.e., Slopes gentler than 50% - 60% with no signs of instability)
Moderate	Less than 1 in 10,000 year catastrophic events. Greater than 1 in 475 years for property-damaging events.	Expected to contain areas with a moderate likelihood of landslide/rockfall initiation following development (i.e., Slopes steeper than about 50% - 60% with visible signs of instability, polygons mapped with glaciofluvial sediments)
High	Greater than 1 in 10,000 year catastrophic events. Greater than 1 in 475 years for property-damaging events.	Natural instability present. Expected to contain areas with a high likelihood of landslide/rockfall initiation following development (i.e., Steep rocky cliffs from which rockfall has occurred, all material and landforms that are unstable)



GEOTECHNICAL ASSESSMENT
STEINAR JOHNSEN DEVELOPMENT
OSOYOOS, BC

Legend

- Digital Road Atlas Roads
- 20m TRIM Contour Lines
- Fresh Water Atlas Streams
- Legal Lot Lines
- RDOS Legal Parcels
- Property Boundary

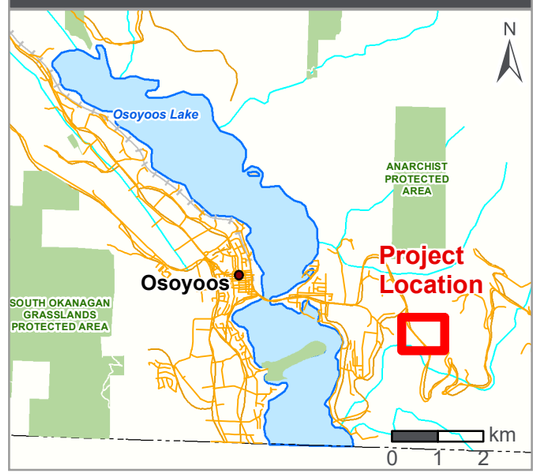
Risk Class

- Low
- Moderate
- High

References

Aerial Imagery: RDOS GIS. Imagery Date: January 15, 2016

LOCATION MAP



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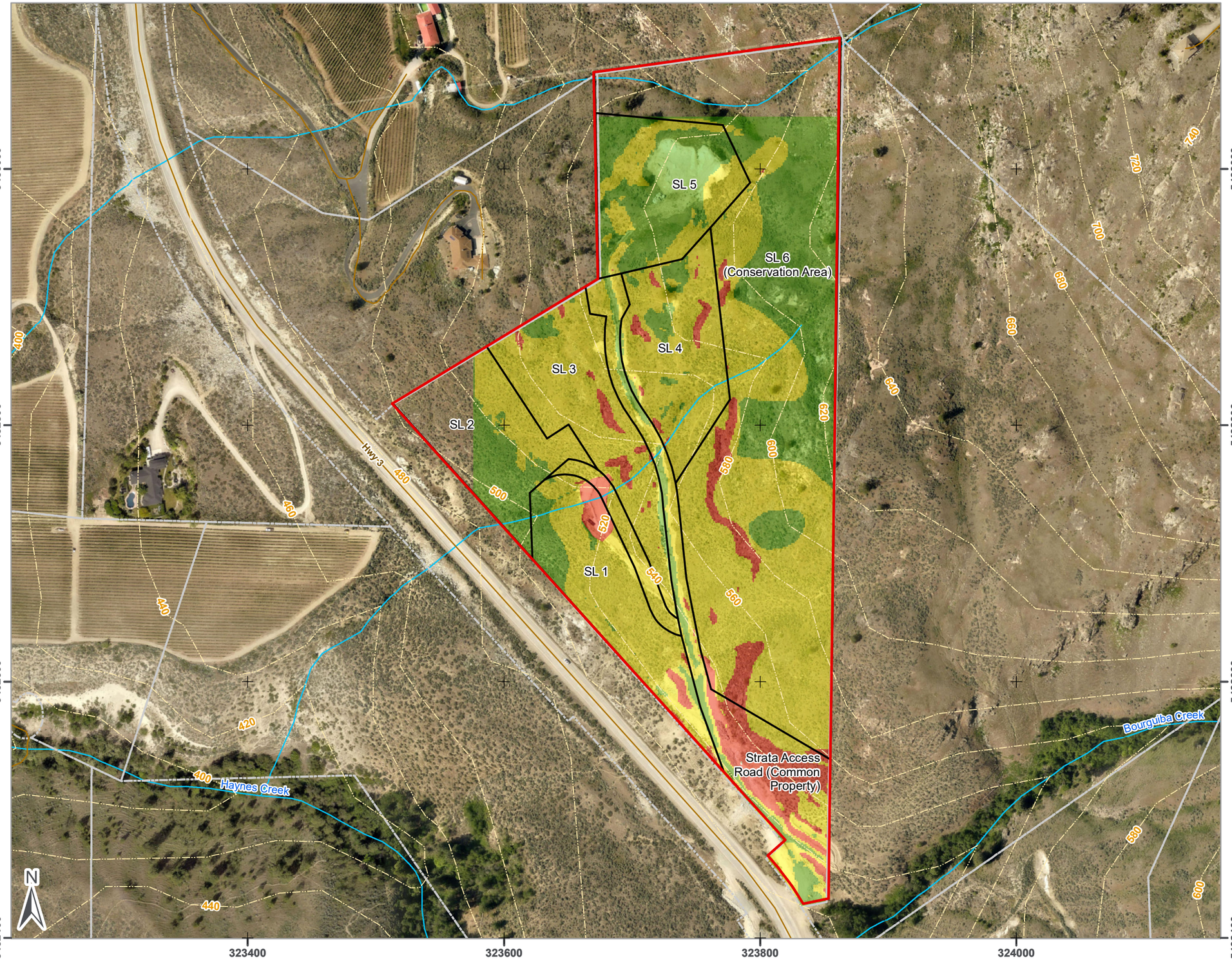
Project No.: 201589
Client: Steinar Johnsen
Date: 2020/11/23
Drawn: MT Check: BD

NAD 1983 UTM Zone 11N

Figure 3.0

SLOPE ANALYSIS



GEOTECHNICAL ASSESSMENT
STEINAR JOHNSEN DEVELOPMENT
OSOYOOS, BC

Legend

- Digital Road Atlas Roads
- 20m TRIM Contour Lines
- Fresh Water Atlas Streams
- Legal Lot Lines
- RDOS Legal Parcels
- Property Boundary

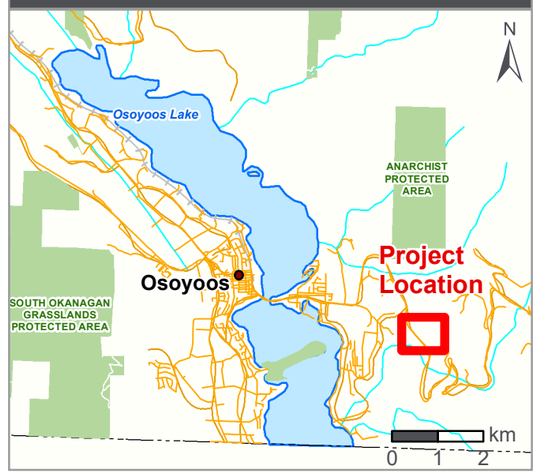
Slope Class

- 0 - 15 degrees
- 15 - 30 degrees
- 30 + degrees

References

Aerial Imagery: RDOS GIS. Imagery Date: January 15, 2016

LOCATION MAP



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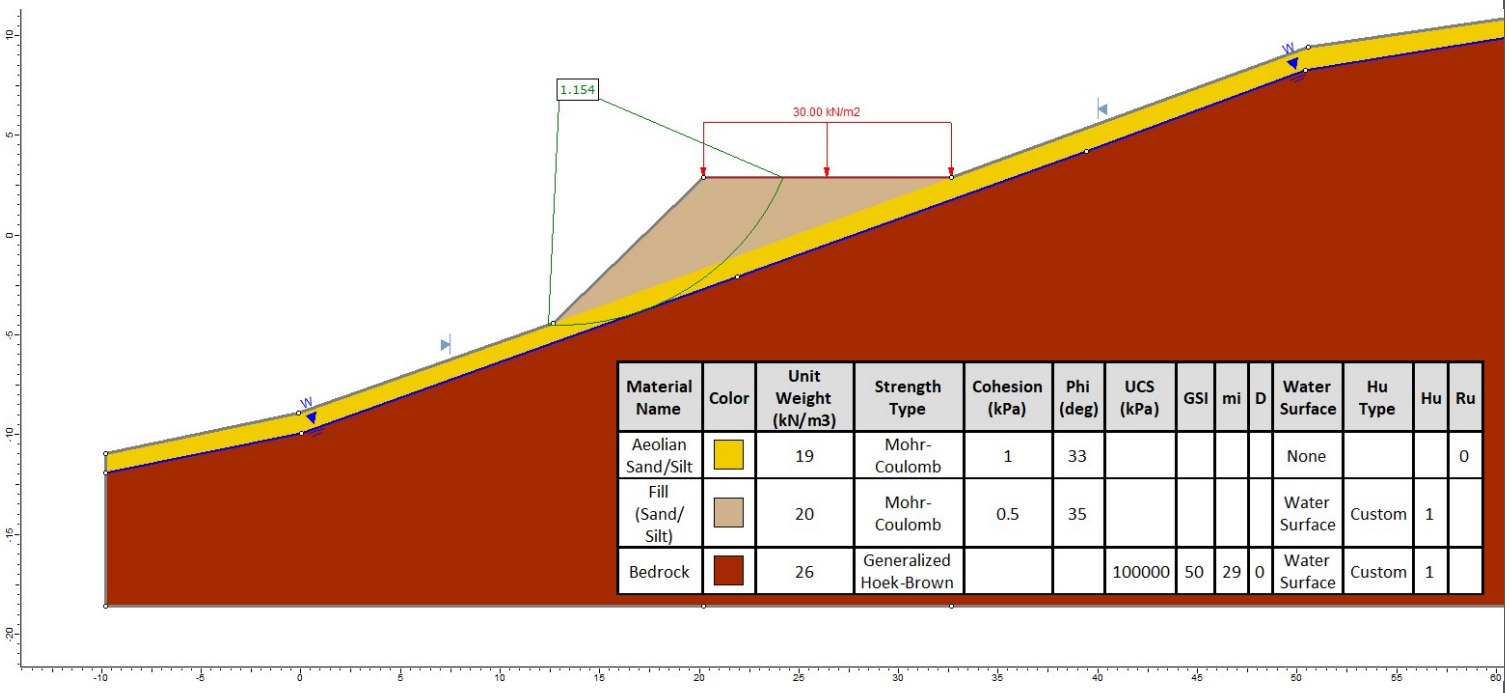
Project No.: 201589
Client: Steinar Johnsen

Date: 2020/11/18
Drawn: MT Check: BD

NAD 1983 UTM Zone 11N

Figure 3.0



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Hu	Ru
Aeolian Sand/Silt		19	Mohr-Coulomb	1	33					None			0
Fill (Sand/ Silt)		20	Mohr-Coulomb	0.5	35					Water Surface	Custom	1	
Bedrock		26	Generalized Hoek-Brown			100000	50	29	0	Water Surface	Custom	1	

Notes:

Slide2 Modeler v9.003, 2D Limit Equilibrium Slope Stability Analysis Software, Rocscience, 2020.

GEOTECHNICAL ASSESSMENT
1750 Hwy 3, Osoyoos, BC

Uncontrolled Fill – Static Stability Analysis Results

Project No. 201589
Client: Steinar Johnsen
Office: Penticton
Scale: NTS
Date: 2020-11-13
DWN: BD CHK: JR

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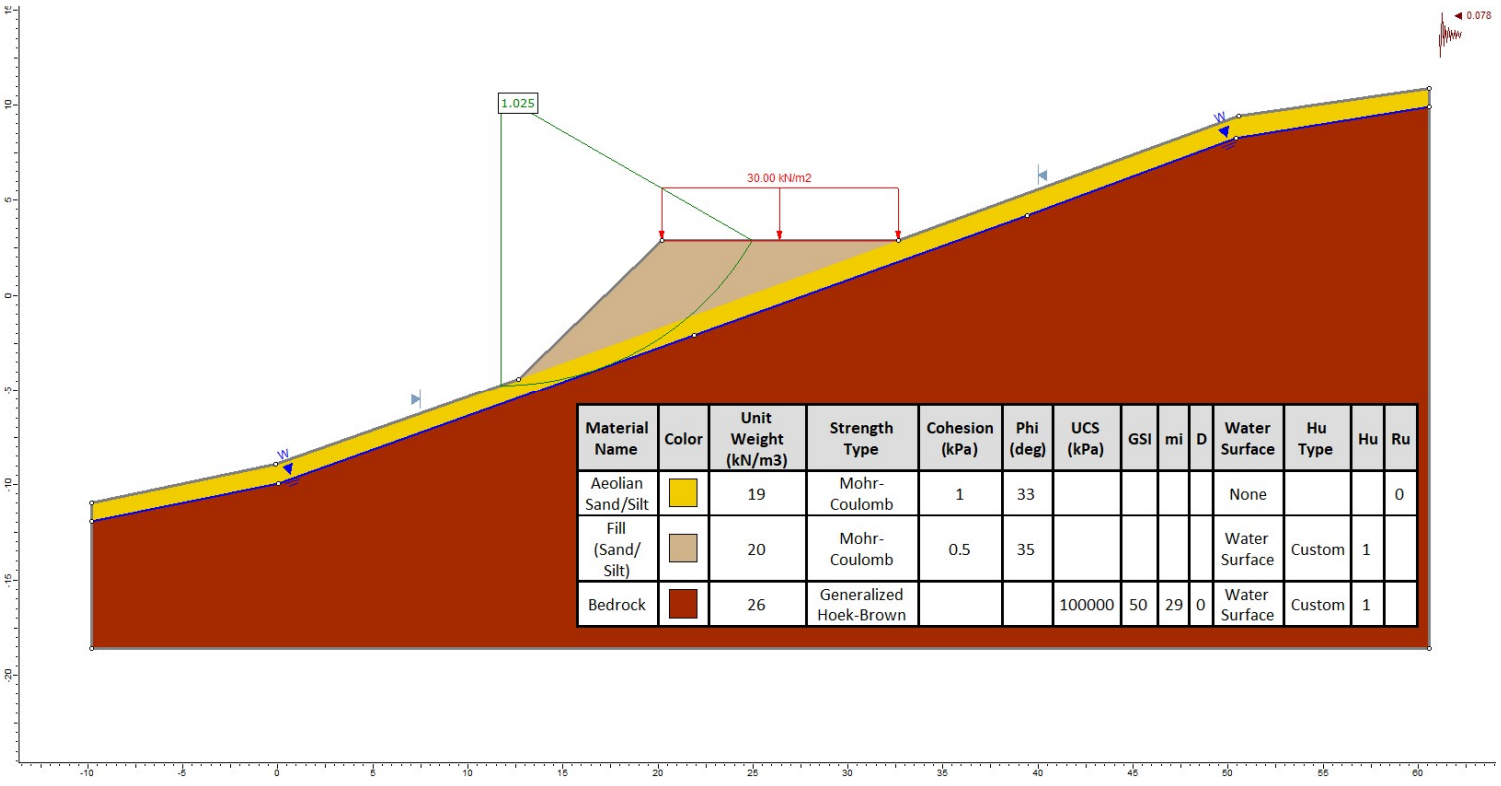
Figure 5.0



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Hu	Ru
Aeolian Sand/Silt		19	Mohr-Coulomb	1	33					None			0
Fill (Sand/ Silt)		20	Mohr-Coulomb	0.5	35					Water Surface	Custom	1	
Bedrock		26	Generalized Hoek-Brown			100000	50	29	0	Water Surface	Custom	1	

Notes:

Slide2 Modeler v9.003, 2D Limit Equilibrium Slope Stability Analysis Software, Rocscience, 2020.

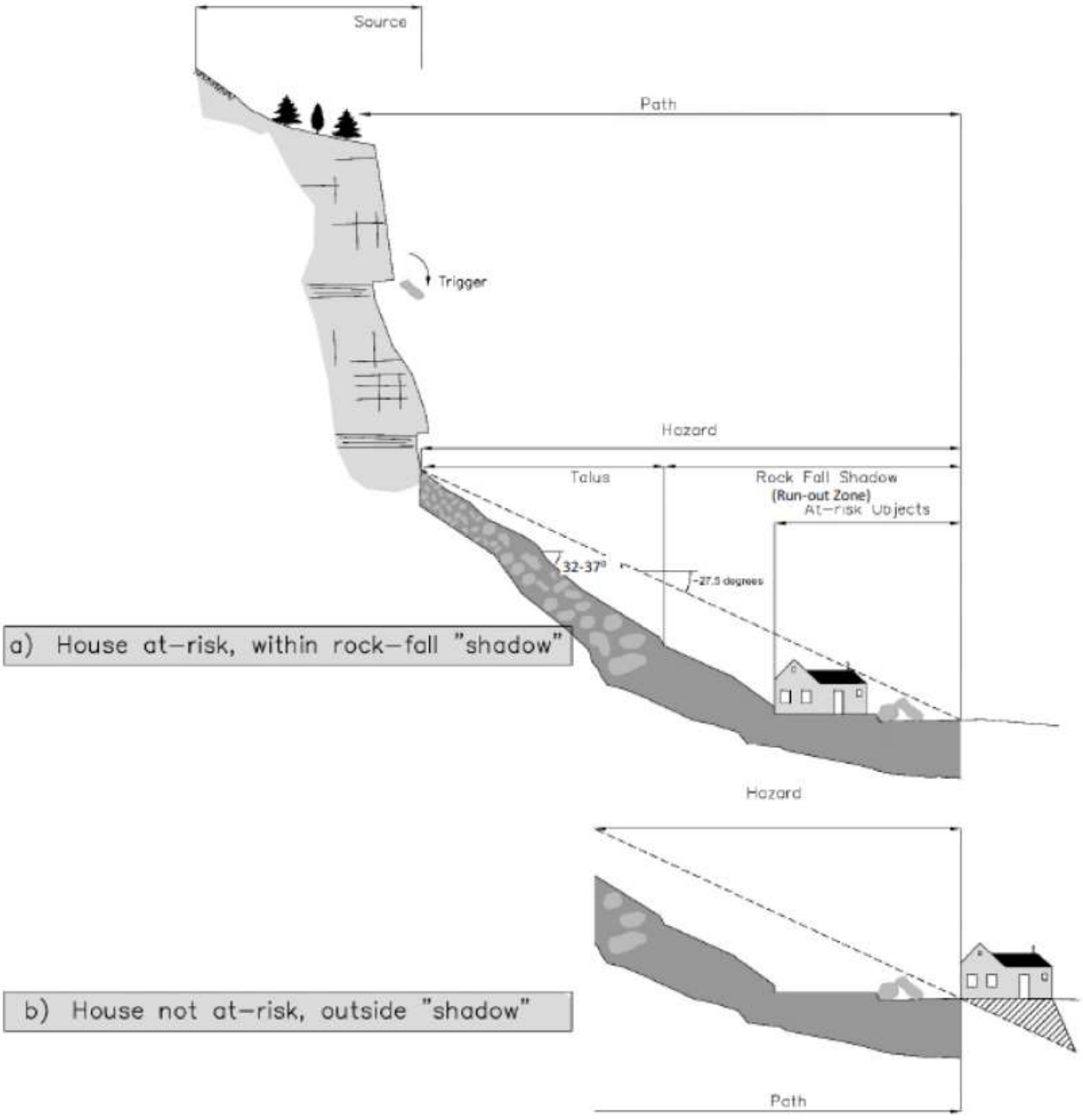
GEOTECHNICAL ASSESSMENT
1750 Hwy 3, Osoyoos, BC

Uncontrolled Fill – Pseudo-Static Stability Analysis Results

Project No. 201589
Client: Steinar Johnsen
Office: Penticton
Scale: NTS
Date: 2020-11-13
DWN: BD CHK: JR

ecora

Figure 5.1



Notes:

Wyllie, Duncan C., 2015. Rock Fall Engineering. CRC Press, Taylor and Francis Group.

GEOTECHNICAL ASSESSMENT
1750 Hwy 3, Osoyoos, BC

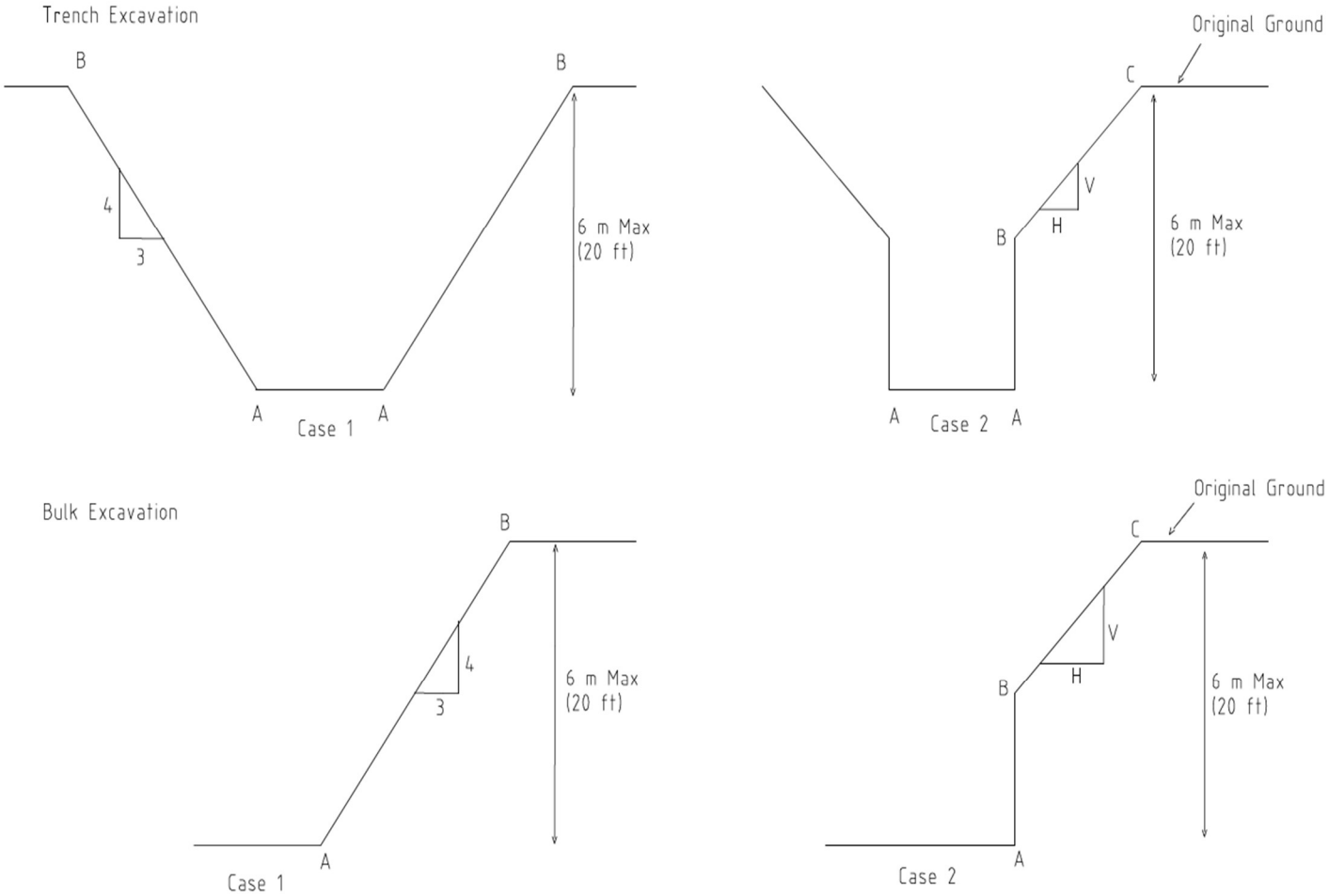
Rockfall Shadow Angles

Project No.	201589
Client:	Steinar Johnsen
Office:	Penticton
Scale:	NTS
Date:	2020-11-13
DWN:	BD CHK: MJL

ecora

Figure 6.0

Sloping



Requirements for Case 2 Slopes

Height of Line AB		Maximum Slope of Line BC (in hard and solid soil)
Centimeters	Feet	
Up to 30	Up to 1	1 horizontal (H) to 1 vertical (V)
30 to 60	1 to 2	3H to 2V
60 to 90	2 to 3	2H to 1V
90 to 120	3 to 4	3H to 1V

Notes:

Work Safe BC, Occupational Health and Safety Regulation Part 20 Construction, Excavation and Demolition. October 2003.

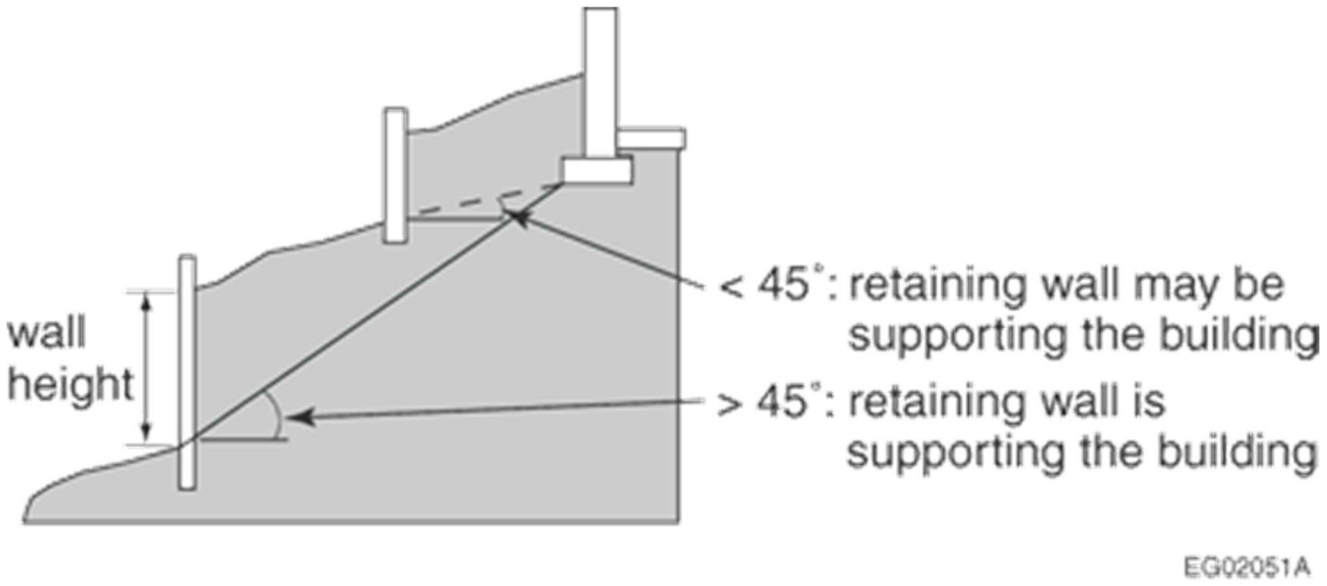
GEOTECHNICAL ASSESSMENT
1750 Hwy 3, Osoyoos, BC

WorkSafe BC Temporary Excavation Sloping Requirements

Project No. 201589
Client: Steinar Johnsen
Office: Penticton
Scale: NTS
Date: 2020-11-13
DWN: BD CHK: MJL

ecora

Figure 7.0



Notes:

BCBC 2018 Appendix A-9.3.2.9.(4)

GEOTECHNICAL ASSESSMENT
1750 Hwy 3, Osoyoos, BC

Influence Zone of Retaining Walls as per BCBC 2018 Appendix A-9.3.2.9.(4)

Project No.	201589
Client:	Steinar Johnsen
Office:	Penticton
Scale:	NTS
Date:	2020-11-13
DWN:	BD CHK: MJL

ecora™

Figure 8.0

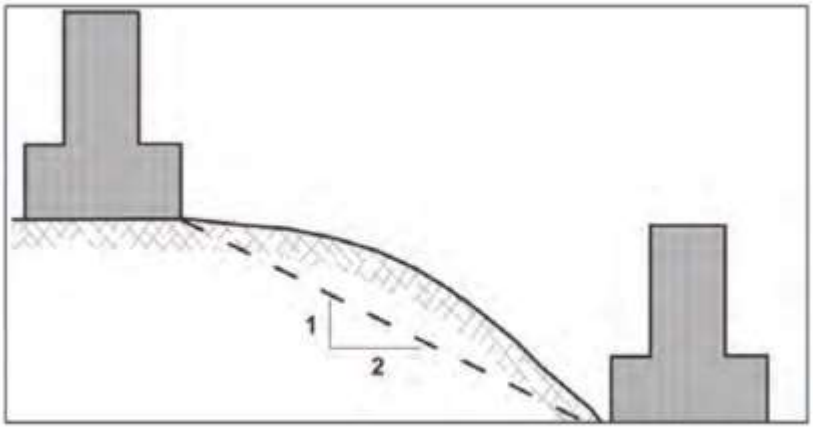


Figure 5: **Footings should step at no more than 1 vertical to 2 horizontal**

Notes:

Homeowner Protection Office, 2015. "Housing Foundations and Geotechnical Challenges: Best Practices for Residential Builders in British Columbia"

GEOTECHNICAL ASSESSMENT
1750 Hwy 3, Osoyoos, BC

Influence Zone of Footings

Project No.	201589
Client:	Steinar Johnsen
Office:	Penticton
Scale:	NTS
Date:	2020-11-13
DWN:	BD CHK: MJL

ecora

Figure 9.0

Photographs

Photo 1.0	View of Northwestern portion of the site slope, looking south.
Photo 2.0	View of Southern ephemeral stream looking east.
Photo 3.0	View of Northern ephemeral stream looking east.
Photo 4.0	View of scaled and blasted bedrock east of the access road looking east. Rock fall mitigation can be seen at the top of the photo.
Photo 5.0	View smooth bedrock outcrop with sub-angular boulders, west of access road. Photo looking southwest.
Photo 6.0	View of smooth bedrock outcrop east of access road with planar failures visible. Photo looking east.
Photo 7.0	View of the uncontrolled fill, looking south. Blast rock is currently being stored in the area. The access road to the south portion of the fill can be seen in the top left corner of the photo.
Photo 8.0	Downslope view from northwest crest of the uncontrolled fill, looking southwest. A berm to stop material from rolling towards Highway 3 is located at various points around the area, but not around the complete area of uncontrolled fill.
Photo 9.0	View of the north side and slope of the uncontrolled fill prior to the stockpiling of blast rock, looking north.
Photo 10.0	Inlet of the 450 mm corrugated HDPE culvert running along the unnamed stream bed, below the uncontrolled fill. Photo looking east.
Photo 11.0	View of the uncontrolled fill area looking north prior to the stockpiling of blast rock in this area, photo looking north.
Photo 12.0	Approximate outlet location downslope of the toe, of the 450 mm corrugated HDPE culvert running below the uncontrolled fill. Highway 3 can be seen running northwest-southeast in the background, photo looking west.

Photo 1 **View of Northwestern portion of the site slope, looking south.**

Photo 2 **View of Southern ephemeral stream looking east.**

Photo 3 View of Northern ephemeral stream looking east.

Photo 4 **View of scaled and blasted bedrock east of the access road looking east. Rockfall mitigation can be seen at the top of the photo.**

Photo 5 **View smooth bedrock outcrop with sub-angular boulders, west of access road. Photo looking southwest.**

Photo 6 **View of smooth bedrock outcrop east of access road with planar failures visible. Photo looking east.**

Photo 7 **View of the uncontrolled fill, looking south. Blast rock is currently being stored in the area. The access road to the south portion of the fill can be seen in the top left corner of the photo.**

Photo 8 **Downslope view from northwest crest of the uncontrolled fill, looking southwest. A berm to stop material from rolling towards Highway 3 is located at various points around the area, but not around the complete area of uncontrolled fill.**

Photo 9 **View of the north side and slope of the uncontrolled fill prior to the stockpiling of blast rock, looking north.**

Photo 10 **Inlet of the 450 mm corrugated HDPE culvert running along the unnamed stream bed, below the uncontrolled fill. Photo looking east.**

Photo 11 **View of the uncontrolled fill area looking north prior to the stockpiling of blast rock in this area, photo looking north.**

Photo 12 **Approximate outlet location downslope of the toe, of the 450 mm corrugated HDPE culvert running below the uncontrolled fill. Highway 3 can be seen running northwest-southeast in the background, photo looking west.**

Appendix A

General Conditions

Standard of Care

Ecora Engineering and Resource Group Ltd. (Ecora) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report

This report and the recommendations contained in it are intended for the sole use of Ecora's Client. Ecora does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Ecora's Client unless otherwise authorized in writing by Ecora. Any unauthorized use of the report is at the sole risk of the user. In order to properly understand the suggestions, recommendations and opinions expressed herein, reference must be made to the whole of the report. We cannot be responsible for use by any party of portions of the report without reference to the whole report.

Alternate Report Format

Where Ecora submits both electronic file and hard copy versions of reports, drawings and other project-related documents, only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Ecora shall be deemed to be the original for the Project. Both electronic file and hard copy versions of Ecora's deliverables shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Ecora.

Soil, Rock and Groundwater Conditions

Classification and identification of soils, rocks and geological units have been based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Ecora does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities such as traffic, excavation, groundwater level lowering, pile driving, blasting on the site or on adjacent sites. Excavation may expose the soils to climatic elements such as freeze/thaw and wet /dry cycles and/or mechanical disturbance which can cause severe deterioration. Unless otherwise indicated the soil must be protected from these changes during construction.

Environmental and Regulatory Issues

The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Sample Disposal

Ecora will dispose all soil and rock samples for 30 days following issue of this report. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

Construction Services

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

Job Site Safety

Ecora is responsible only for the activities of our employees on the jobsite. The presence of Ecora's personnel on the site shall not be construed in any way to relieve the Client or any contractors on site from their responsibilities for site safety. The Client acknowledges that he, his representatives, contractors or others retain control of the site and that Ecora never occupy a position of control of the site. The Client undertakes to inform Ecora of all hazardous conditions, or other relevant conditions of which the Client is aware. The Client also recognizes that our activities may uncover previously unknown hazardous conditions or materials and that such a discovery may result in the necessity to undertake emergency procedures to protect our employees as well as the public at large and the environment in general.

Changed Conditions and Drainage

Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Ecora be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Ecora be employed to visit the site with sufficient frequency to detect if conditions have changed significantly. Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Ecora takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

Services of Sub consultants and Contractors

The conduct of engineering and environmental studies frequently requires hiring the services of individuals and companies with special expertise and/or services which we do not provide. Ecora may arrange the hiring of these services as a convenience to our Clients. As these services are for the Client's benefit, the Client agrees to hold the Company harmless and to indemnify and defend Ecora from and against all claims arising through such hiring's to the extent that the Client would incur had he hired those services directly. This includes responsibility for payment for services rendered and pursuit of damages for errors, omissions or negligence by those parties in carrying out their work. In particular, these conditions apply to the use of drilling, excavation and laboratory testing services.

Appendix B

Water Well Logs

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 57089
Well Identification Plate Number:
Owner Name: ANTON DEKLEUA
Intended Water Use: Private Domestic

Well Status: New
Well Class: Water Supply
Well Subclass: Domestic
Aquifer Number: 808

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

Location Information

Street Address: ANARCHIST MTN HWY 3
Town/City: OSOYOOS

Legal Description:

Lot	15
Plan	21789S
District Lot	41
Block	
Section	
Township	
Range	
Land District	54
Property Identification Description (PID)	

Description of Well Location:

Geographic Coordinates - North American Datum of 1983 (NAD 83)
Latitude: 49.025087
Longitude: -119.411386
UTM Easting: 323721
UTM Northing: 5433046
Zone: 11
Coordinate Acquisition Code: (100 m accuracy) Digitized from old Dept. of Lands, Forests and Water Resources maps

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	1987-05-21		Aqua-Terra Drilling	August 13th 2003 at 8:01 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
1987-05-21					

Well Completion Data

Total Depth Drilled:
Finished Well Depth: 490.00 feet
Final Casing Stick Up:
Depth to Bedrock: 0.00 feet
Ground elevation:

Static Water Level (BTOC): 140.00 feet
Estimated Well Yield: 30.000 USGPM
Artesian Flow:
Artesian Pressure:
Method of determining elevation: Unknown

Well Cap:
Well Disinfected Status: Not Disinfected
Drilling Method: Other
Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0.00	12.00	weathered granite						
12.00	187.00	dolomitic granite						
187.00	290.00	dioritic granite						
290.00	490.00	varied dioritic granite with some fract.						

Casing Details

From (ft)	To (ft)	Casing Type	Casing Material	Diameter	Wall Thickness	Drive Shoe
There are no records to show						

Surface Seal and Backfill Details

Surface Seal Material:
Surface Seal Installation Method:
Surface Seal Thickness:
Surface Seal Depth:

Backfill Material Above Surface Seal:
Backfill Depth:

Liner Details

Liner Material:
Liner Diameter:
Liner from:

Liner Thickness:
Liner to:

Liner perforations

From	To
There are no records to show	

Screen Details

Intake Method:
Type:
Material:
Opening:
Bottom:

Installed Screens

From	To	Diameter	Assembly Type	Slot Size
There are no records to show				

Well Development

Developed by:

Development Total Duration:

Well Yield

Estimation Method:
Static Water Level Before Test:
Hydrofracturing Performed: No

Estimation Rate:
Drawdown:
Increase in Yield Due to Hydrofracturing:

Estimation Duration:

Well Decommission Information

Reason for Decommission:
Sealant Material:
Decommission Details:

Method of Decommission:
Backfill Material:

Comments

METHOD OF DRILLING = DRILLED

Alternative Specs Submitted: No

Documents

- WTN 57089_Well Record.pdf

Disclaimer

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 69157
Well Identification Plate Number:
Owner Name: MAUZ ALBERT
Intended Water Use: Private Domestic

Well Status: New
Well Class: Water Supply
Well Subclass: Domestic
Aquifer Number: 808

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

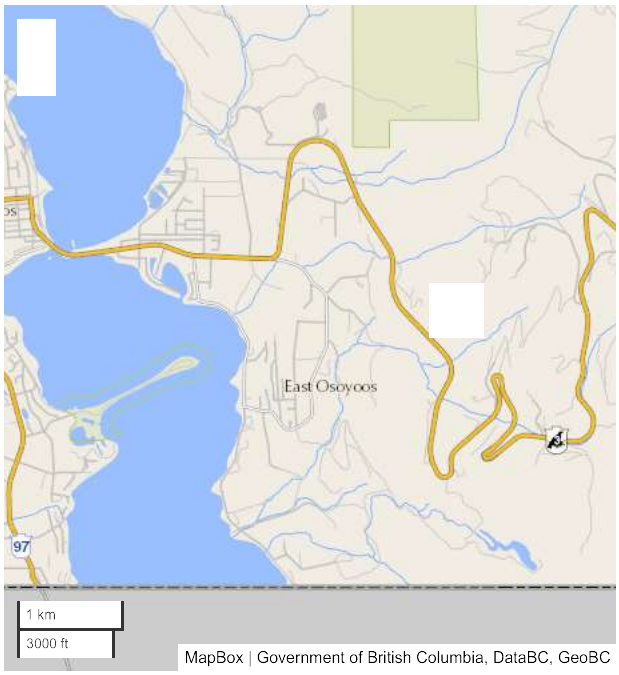
Location Information

Street Address: HWY 3
Town/City: EAST OF OSOYOOS

Legal Description:

Lot	15
Plan	21789
District Lot	2709
Block	
Section	
Township	
Range	
Land District	54
Property Identification Description (PID)	002165481

Description of Well Location: SUBLOT 2



Geographic Coordinates - North American Datum of 1983 (NAD 83)
Latitude: 49.021055
Longitude: -119.410178
UTM Easting: 323795
UTM Northing: 5432595
Zone: 11
Coordinate Acquisition Code: (20 m accuracy) Digitized from 1:5,000 mapping

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	1995-05-18	1995-05-27	Quality Well Drilling	August 13th 2003 at 9:15 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
1995-05-18	1995-05-27				

Well Completion Data

Total Depth Drilled:
Finished Well Depth: 510.00 feet
Final Casing Stick Up:
Depth to Bedrock: 8.00 feet
Ground elevation:
Static Water Level (BTOC):
Estimated Well Yield: 2.500 USGPM
Artesian Flow:
Artesian Pressure:
Method of determining elevation: Unknown
Well Cap:
Well Disinfected Status: Not Disinfected
Drilling Method: Air Rotary
Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0.00	5.00	FINE SAND & SILT	0 nothing entered		0 nothing entered			
5.00	8.00	BOULDERS						
8.00	510.00	BEDROCK						

Casing Details

From (ft)	To (ft)	Casing Type	Casing Material	Diameter	Wall Thickness	Drive Shoe
0.00	11.00			6.000		Installed

Surface Seal and Backfill Details

Surface Seal Material:
Surface Seal Installation Method:
Surface Seal Thickness:
Surface Seal Depth:
Backfill Material Above Surface Seal:
Backfill Depth:

Liner Details

Liner Material:
Liner Diameter:
Liner from:
Liner Thickness:
Liner to:

Liner perforations

From	To
There are no records to show	

Screen Details

Intake Method:
Type:
Material:
Opening:
Bottom:

Installed Screens

From	To	Diameter	Assembly Type	Slot Size
There are no records to show				

Well Development

Developed by:
Development Total Duration:

Well Yield

Estimation Method: Air Lifting
Static Water Level Before Test:
Hydrofracturing Performed: No
Estimation Rate: 2.00
Drawdown:
Increase in Yield Due to Hydrofracturing:
Estimation Duration: 2.00

Well Decommission Information

Reason for Decommission:
Sealant Material:
Decommission Details:
Method of Decommission:
Backfill Material:

Comments

2 FT STICK UP. APPROX 40 FT SE OF HOME.

Alternative Specs Submitted: No

Documents

- WTN 69157_Well Record.pdf

Disclaimer

The information provided should not be used as a basis for making financial or any other commitments. The Government of British Columbia accepts no liability for the accuracy, availability, suitability, reliability, usability, completeness or timeliness of the data or graphical depictions rendered from the data.

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 84786
Well Identification Plate Number:
Owner Name: REGINE C MAUZ
Intended Water Use: Private Domestic

Well Status: New
Well Class: Water Supply
Well Subclass:
Aquifer Number: 808

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

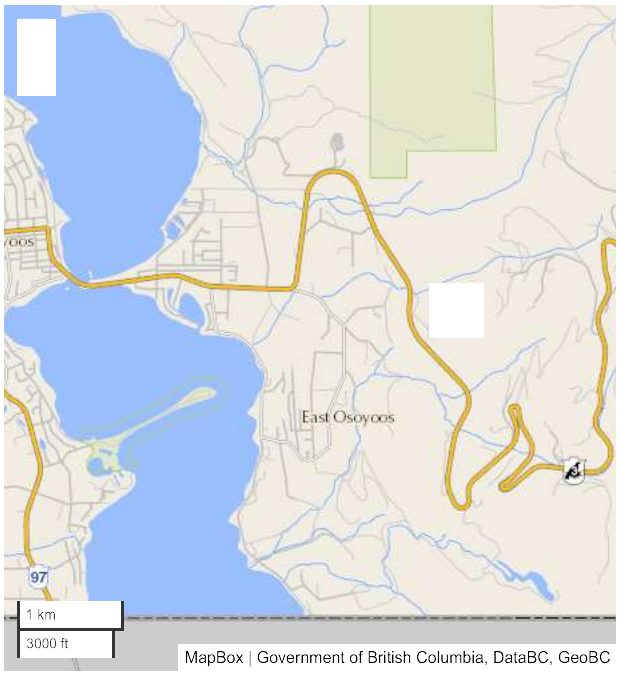
Location Information

Street Address: 1806 HIGHWAY 3E
Town/City:

Legal Description:

Lot	15
Plan	21789
District Lot	2709
Block	
Section	
Township	
Range	
Land District	54
Property Identification Description (PID)	

Description of Well Location: 5 KMS FROM CITY CENTRE; SUBSIDY LOT 2



Geographic Coordinates - North American Datum of 1983 (NAD 83)
Latitude: 49.023646
Longitude: -119.412315
UTM Easting: 323648
UTM Northing: 5432888
Zone: 11
Coordinate Acquisition Code: unknown, accuracy based on parcel size) ICF cadastre, poor or no location sketch, arbitrarily located in center of parcel

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	2005-03-30	2005-03-30	Cyclone Drilling Ltd.	January 13th 2006 at 6:31 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
2005-03-30	2005-03-30				

Well Completion Data

Total Depth Drilled: 520.00 feet
Finished Well Depth: 520.00 feet
Final Casing Stick Up:
Depth to Bedrock: 6.00 feet
Ground elevation:

Static Water Level (BTOC):
Estimated Well Yield: 2.000 USGPM
Artesian Flow:
Artesian Pressure:
Method of determining elevation: Unknown

Well Cap: STEEL CAP WELDED TO CASING
Well Disinfected Status: Not Disinfected
Drilling Method: Air Rotary
Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0.00	4.00	SANDY BROWN CLAY W GRAVEL & COBBLES						
4.00	6.00	BROKEN & SHATTERED ROCK W SOME SANDY BROWN CLAY						
6.00	134.00	SOLID BLACK & WHITE GRANITE BEDROCK						
18.00		6 STEEL CASING STOPPED. CEMENTED INTO 8 X17' SURFACE HOLE						
134.00	145.00	BLACK & WHITE W SOME BROWN GRANITE BEDROCK						
145.00	166.00	HARD BLACK & WHITE GRANITE BEDROCK						
166.00	168.00	SOFTER BLACK, WHITE & BROWN GRANITE BEDROCK						
168.00	177.00	SOFT BROWN & TAN GRANITE BEDROCK						
177.00	194.00	VERY SOFT BROWN & TAN GRANITE BEDROCK						
194.00	458.00	HARD BLACK & WHITE GRANITE BEDROCK						
458.00	468.00	DARK GREEN & WHITE GRANITE BEDROCK						
468.00	520.00	VERY HARD BLACK & WHITE GRANITE BEDROCK						
520.00		STOPPED DRILLING						
		SOFT SPOTS & FRACTURES @ 151,168,177,194,242,246,275,285,296,387,436 & 478'						
		WATER BEARING FRACTURES @ 296 & 436'						

Casing Details

From (ft)	To (ft)	Casing Type	Casing Material	Diameter	Wall Thickness	Drive Shoe
0.00	17.50		Steel	6.620		Installed
6.00	520.00		Plastic	4.500		Installed

Surface Seal and Backfill Details

Surface Seal Material:
Surface Seal Installation Method:
Surface Seal Thickness:
Surface Seal Depth:

Backfill Material Above Surface Seal:
Backfill Depth:

Liner Details

Liner Material:
Liner Diameter:
Liner from:

Liner Thickness:
Liner to:

Liner perforations

From	To
There are no records to show	

Screen Details

Intake Method:
Type:
Material:
Opening:
Bottom:

Installed Screens

From	To	Diameter	Assembly Type	Slot Size
There are no records to show				

Well Development

Developed by:

Development Total Duration:

Well Yield

Estimation Method: Air Lifting
Static Water Level Before Test: 180.00
Hydrofracturing Performed: No

Estimation Rate: 2.00
Drawdown:
Increase in Yield Due to Hydrofracturing:

Estimation Duration:

Well Decommission Information

Reason for Decommission:
Sealant Material:
Decommission Details:

Method of Decommission:
Backfill Material:

Comments

MEASUREMENTS TAKEN AT GROUND LEVEL

Alternative Specs Submitted: No

Documents

- WTN 84786_Well Record.pdf

Disclaimer

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 105407
Well Identification Plate Number: 27891
Owner Name: ALBERT & KARIN MAUZ
Intended Water Use: Private Domestic

Well Status: New
Well Class: Water Supply
Well Subclass: Domestic
Aquifer Number:

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

Location Information

Street Address: 1806 HIGHWAY 3 EAST
Town/City: OSOYOOS

Legal Description:

Lot	15
Plan	21789
District Lot	2709
Block	
Section	
Township	
Range	
Land District	54
Property Identification Description (PID)	

Description of Well Location: 1/2 KM PAST 1806 HEADING EAST ON LEFT SIDE OF HWY.

Geographic Coordinates - North American Datum of 1983 (NAD 83)
Latitude: 49.019639
Longitude: -119.409481
UTM Easting: 323841
UTM Northing: 5432436
Zone: 11
Coordinate Acquisition Code: (10 m accuracy) Handheld GPS with accuracy of +/- 10 metres

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	2009-06-26	2009-06-30	Cyclone Drilling Ltd.	February 1st 2012 at 5:20 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
2009-06-26	2009-06-30				

Well Completion Data

Total Depth Drilled: 180.00 feet
Finished Well Depth: 180.00 feet
Final Casing Stick Up: 24.000 inches
Depth to Bedrock: 33.00 feet
Ground elevation: 1657.00

Static Water Level (BTOC): 72.00 feet
Estimated Well Yield: 10.000 USGPM
Artesian Flow:
Artesian Pressure:
Method of determining elevation: Unknown

Well Cap: WELDED
Well Disinfected Status: Disinfected
Drilling Method: Air Rotary
Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0.00	30.00	SAND FINE-MED & BOULDERS & COBBLES			tan	Dense	DRY	
30.00	145.00	CRYSTALLINE	dark-coloured		grey	Hard	WET, 1.5 GPM @ 85'	
145.00	155.00	CRYSTALLINE			green	Hard	DRY	
155.00	180.00	CRYSTALLINE	dark-coloured		grey	Hard	HIGH PRODUCTION, 10 GPM @ 155'	

Casing Details

From (ft)	To (ft)	Casing Type	Casing Material	Diameter	Wall Thickness	Drive Shoe
0.00	15.00	Steel Removed		8.000	0.250	Not Installed
0.00	33.00		Steel	6.630	0.250	Installed

Surface Seal and Backfill Details

Surface Seal Material: Bentonite clay
Surface Seal Installation Method: Poured
Surface Seal Thickness: 1.00
Surface Seal Depth:

Backfill Material Above Surface Seal:
Backfill Depth: 3.00

Liner Details

Liner Material: PVC
Liner Diameter:
Liner from:

Liner Thickness:
Liner to:

Liner perforations

From	To
60.00 ft	170.00 ft

Screen Details

Intake Method:
Type:
Material:
Opening:
Bottom:

Installed Screens

From	To	Diameter	Assembly Type	Slot Size
There are no records to show				

Well Development

Developed by: Air lifting

Development Total Duration: 2.00 hours

Well Yield

Estimation Method: Air Lifting
Static Water Level Before Test: 72.00
Hydrofracturing Performed: No

Estimation Rate: 10.00
Drawdown:
Increase in Yield Due to Hydrofracturing:

Estimation Duration: 20.00

Well Decommission Information

Reason for Decommission:
Sealant Material:
Decommission Details:

Method of Decommission:
Backfill Material:

Comments

GREAT WATER WELL. DRILLER REG #: GWDT 2008-146.

Alternative Specs Submitted: No

Documents

- WTN 105407_Well Construction.pdf

Disclaimer

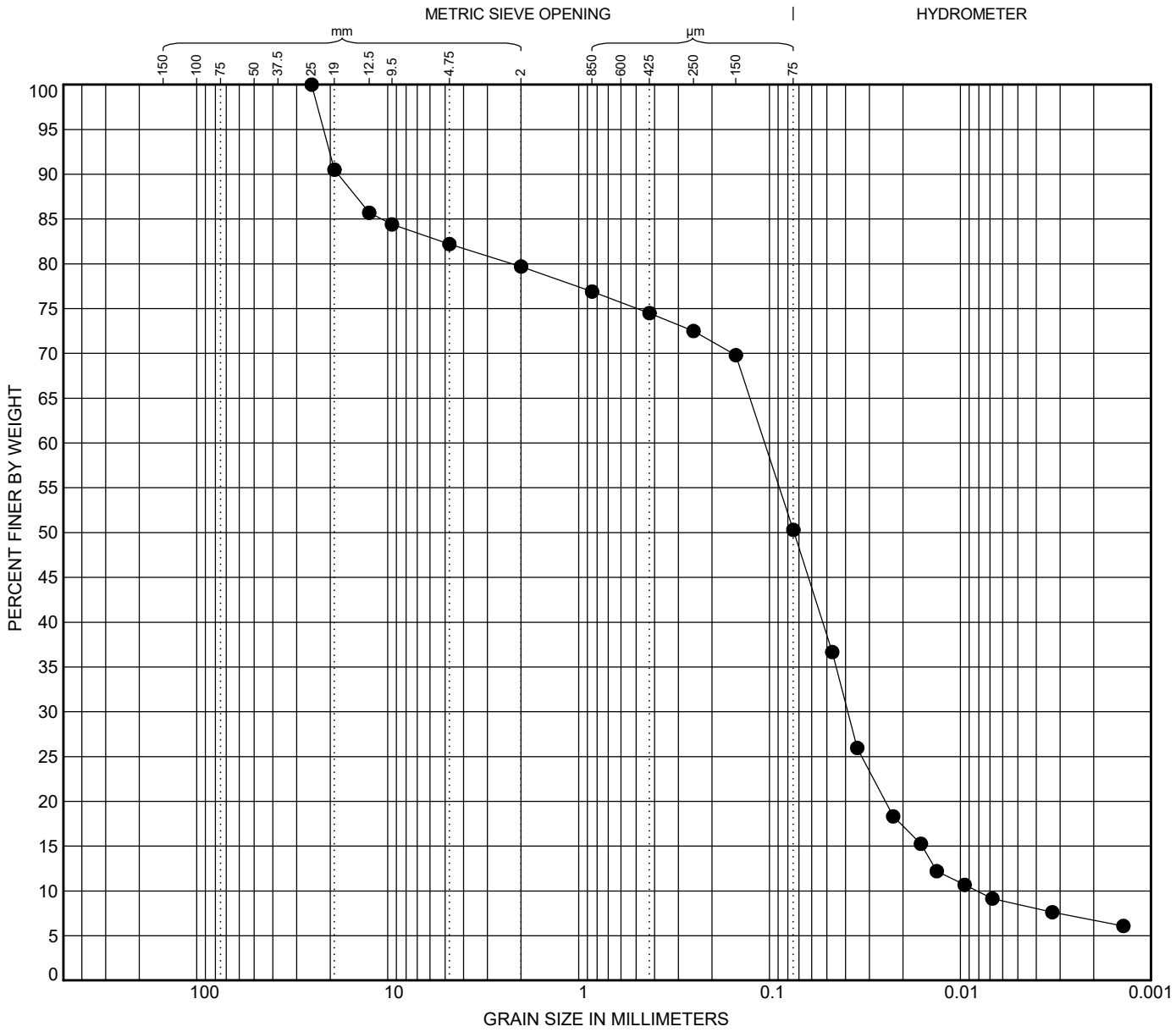
Appendix C

Laboratory Test Results

GRAIN SIZE DISTRIBUTION ASTM D422

Project: Steinar Johnsen Development
Location: 1750 Highway 3, Osoyoos, BC
Sample Location/Source: BH20-01

Project No: 201589
Client: Steinar Johnsen
Depth: 1.83 m to 2.44 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**10.783**	**0.106**	**0.039**	**0.016**	**0.008**	**1.74**	**12.93**	**17.8**	**31.9**	**43.6**	**6.7**

Description: Sandy SILT, some gravel, trace clay
Natural Moisture Content: 8 %
Material Specification: N/A
Intended Use: N/A
Comments:

Sample Number: 20-466
Date Tested: 2020-09-15
Tested By: KRB

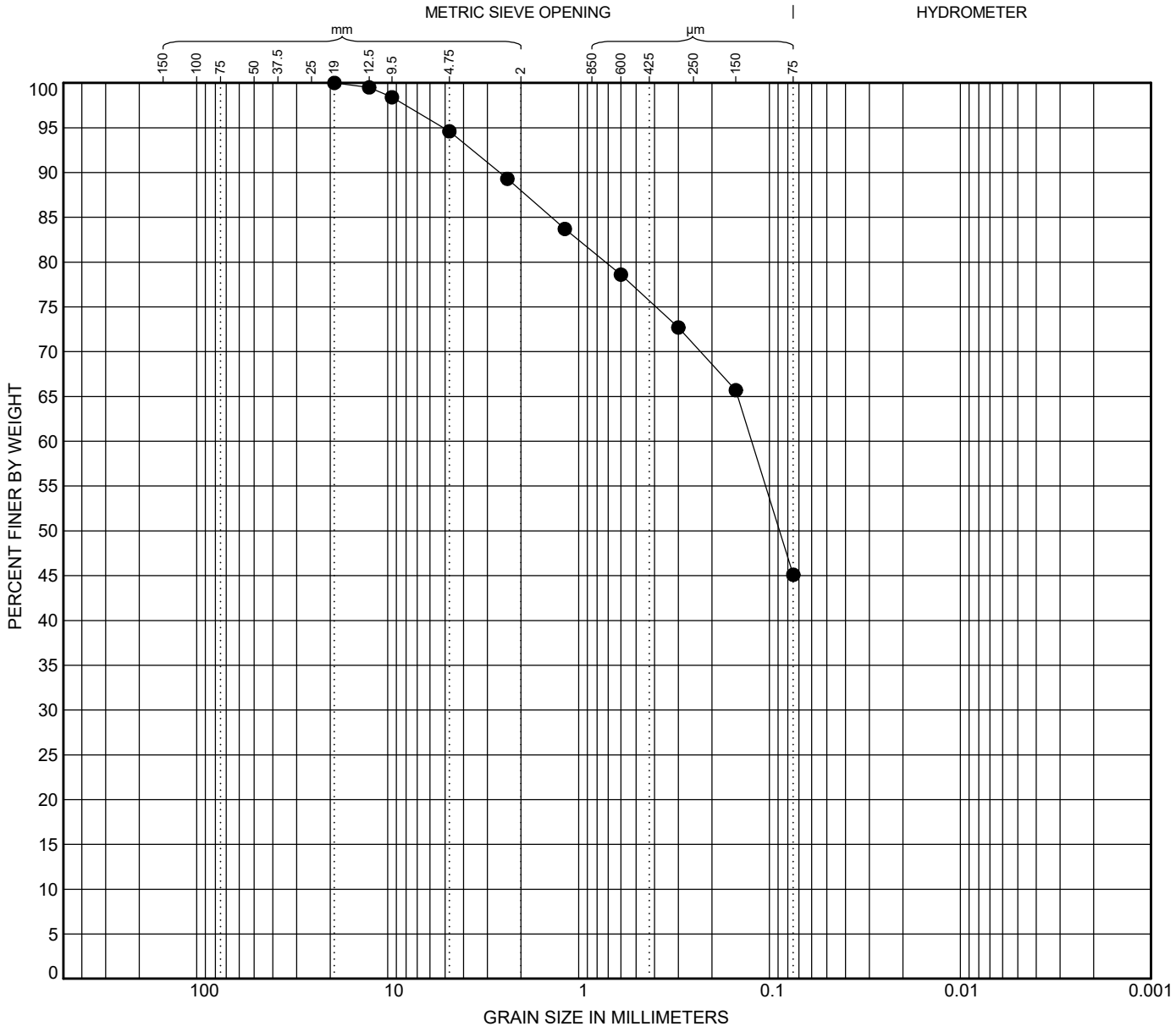
Checked By: _____

GRAIN SIZE DISTRIBUTION 201589.GPJ DATAECORA2018.GDT 20/9/25

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Steinar Johnsen Development
Location: 1750 Highway 3, Osoyoos, BC
Sample Location/Source: BH20-02

Project No: 201589
Client: Steinar Johnsen
Depth: 1.22 m to 1.53 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
19	**1.386**	**0.124**						**5.4**	**49.5**	**45.1**	

Description: SAND and FINES, trace gravel
Natural Moisture Content: 7 %
Material Specification: N/A
Intended Use: N/A
Comments:

Sample Number: 20-467
Date Tested: 2020-09-11
Tested By: KRB

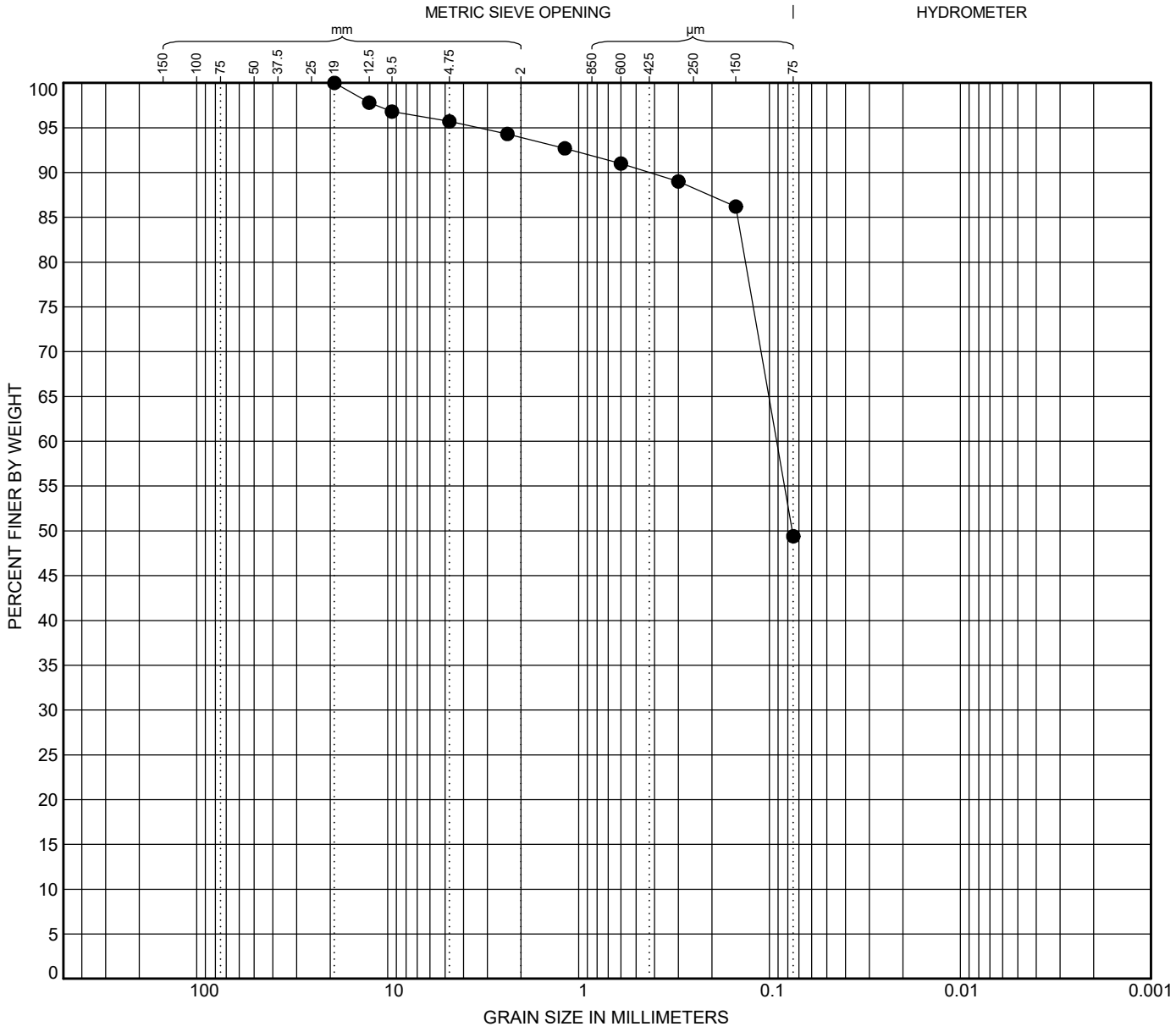
Checked By: _____

GRAIN SIZE DISTRIBUTION 201589.GPJ DATAECORA2018.GDT 20/9/25

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Steinar Johnsen Development
Location: 1750 Highway 3, Osoyoos, BC
Sample Location/Source: BH20-03

Project No: 201589
Client: Steinar Johnsen
Depth: 0.61 m to 1.22 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
19	**0.147**	**0.092**						**4.3**	**46.3**	**49.4**	

Description: Fines and SAND, trace gravel
Natural Moisture Content: 7.2 %
Material Specification: N/A
Intended Use: N/A
Comments:

Sample Number: 20-468
Date Tested: 2020-09-11
Tested By: KRB

Checked By: _____

GRAIN SIZE DISTRIBUTION 201589.GPJ DATAECORA2018.GDT 20/9/25

Appendix D

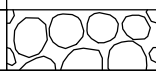
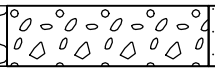
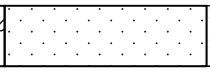
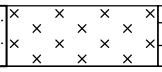
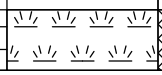
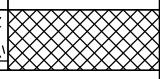
Borehole Logs

TERMS, SYMBOLS AND ABBREVIATIONS USED ON BOREHOLE & TEST PIT LOGS

SOIL DESCRIPTION SEQUENCE OF TERMS - consistency - fraction - grading - moisture - plasticity - additional

The visual field description and classification of soils is made in accordance with the Canadian Foundation Engineering Manual 4th Edition (Canadian Geotechnical Society, 2006) and the International Association of Engineering Bulletin, Rock and Soil Description and Classification for Engineering Geological Mapping (1981) with the exception of particle size criteria which is made on the basis of ASTM D2487-06 Standard Practice for Classification of Soils for Engineering Purposes.

PARTICLE SIZE CRITERIA & GRAPHIC SYMBOL

TYPE	COARSE							FINE		ORGANIC	FILL
	Boulders	Cobbles	Gravel		Sand			Silt	Clay	Organic Soil	Fill
			coarse	fine	coarse	medium	fine				
Size Range (mm)	200	75	19		4.75	2	0.475	0.075	0.002		
Graphic Symbol											

Notes: 1.) Graphic symbols are combined for mixed soil types.
2.) The upper particle size for clay is as per the Canadian Foundation Engineering Manual.

PROPORTIONAL TERMS

FRACTION	TERM	% OF SOIL MASS	EXAMPLE
Major	(....) and (.....) (UPPER CASE)	35 to 50	GRAVEL
Subordinate	(....) y (lower case)	20 to 35	sandy
Minor	some (....) (lower case)	10 to 20	some clay
	trace (....) (lower case)	less than 10	trace silt

CONSISTENCY TERMS FOR COHESIVE SOILS

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	FIELD DIAGNOSTIC CHARACTERISTICS
very soft	< 12	Easily exudes between fingers when squeezed.
soft	12 to 25	Easily indented by fingers.
firm	25 to 50	Can be indented by strong finger or thumb pressure.
stiff	50 to 100	Cannot be indented by thumb pressure.
very stiff	100 to 200	Can be indented by thumb nail.
hard	200 to 500	Difficult to indent by thumb nail.

CONSISTENCY TERMS FOR GRANULAR SOILS

DESCRIPTIVE TERM	SPT 'N' VALUE (BLOWS / 300 mm)	DYNAMIC CONE (SCALA) (BLOWS / 100 mm)
very loose	< 4	0 to 2
loose	4 to 10	1 to 3
compact	10 to 30	3 to 7
dense	30 to 50	7 to 17
very dense	> 50	> 17

Notes: 1.) No correlation implied between the SPT and Scala Penetrometer.
2.) SPT 'N' values are uncorrected.

MOISTURE CONDITION

DESCRIPTIVE TERM	CONDITION	FIELD DIAGNOSTIC CHARACTERISTICS	
		COHESIVE SOILS	GRANULAR SOILS
dry	Looks and feels dry.	Hard, powdery or friable.	Runs freely through hands.
moist	Feels cool, darkened in colour.	Weakened by moisture, but no free water on hands when remoulding.	Tend to cohere.
wet		Weakened by moisture, free forms water on hands when handling.	
saturated	Feels cool, darkened in colour and free water is present on the sample.		

PLASTICITY TERMS FOR COHESIVE SOILS

TERM	DESCRIPTION
high plasticity	Can be moulded or deformed over a wide range of moisture contents without cracking or showing any tendancy to change volume.
medium plasticity	Can be moulded over a wide range of moisture contents however will crack at low moisture contents.
low plasticity	Can be moulded in fingers when moist however crumbles.
non plastic	Has no ability to be moulded at any moisture content, may show quick or dilatant behavior.

GRADING TERMS FOR GRANULAR SOILS

TERM	DESCRIPTION	
well graded	Good representation of all particle sizes from largest to smallest.	
poorly graded	Limited representation of grain sizes - further divided into:	
	uniformly graded	Most particles about the same size.
	gap graded	Absence of one or more intermediate sizes.

SENSITIVITY TERMS FOR COHESIVE SOILS

TERM	S_t RATIO OF PEAK/REMOULDED UNDRAINED SHEAR STRENGTH
quick clay	$S_t > 16$
extra sensitive	$8 < S_t < 16$
sensitive	$4 < S_t < 8$
medium sensitivity	$2 < S_t < 4$
low sensitivity	$S_t < 2$

SAMPLE TYPE

TERM	DESCRIPTION
B	Bulk disturbed sample.
C	Core sample obtained with the use of standard size coring bits.
D	Small disturbed sample.
P	Piston sampler
S	Split spoon sample (obtained by performing the Standard Penetration Test)
T	Shelby tube or thin wall tube.

WATER LEVEL

SYMBOL	DESCRIPTION
▼	Measured in a standpipe, piezometer, or well.
▽	Inferred.

BOREHOLE: BH20-01

Project: Steinar Johnsen Development
Location: 1750 Highway 3, Osoyoos, BC
Zone: 11 Northing: 5432745.25 Easting: 323668.97

Project No: 201589
Client: Steinar Johnsen
Elevation: 520 m

DEPTH (m)	DRILLING METHOD	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	SAMPLE NUMBER	PARTICLE SIZE DISTRIBUTION GRAVEL (%)	SAND (%)	FINES (%)	STANDARD PENETRATION TEST (N)	DYNAMIC CONE PENETRATION TEST (Blows/150mm) / SCALA PENETRATION TEST (Blows/50mm) / STANDARD PENETRATION TEST (N) (Blows/300mm)	POCKET PEN. (kPa) / FIELD VANE (kPa) REMOULDED PEAK / PLASTIC M.C. LIQUID	ELEVATION (m)
0	Solid Stem		**FILL (FILL)** (0 m to 0.61 m) Drill Out									
1			**SILT (FILL)** (0.61 m to 1.22 m) Sandy, gravelly SILT, dry, brown. Rock is fractured, appears to be blastrock.	S	SA01				15 26 30 N=56			
			SILT (FILL) (1.22 m to 1.83 m) Sandy SILT, moist, fine grained sand with blastrock.	S	SA02				19 17 20 N=37			
2			**SILT (FILL)** (1.83 m to 4.27 m) Sandy SILT, moist, brown-grey. Rock is fractured. Minerals reflecting light in sample.	S	SA03	17.8	31.9	50.3	17 23 24 N=47			
3			Fine grained sand content increases slightly at 3 m.						15 18 23 N=41			
			Fine grained sand content increases slightly at 3.7 m.									
4				S	SA05				11 9 99 N=108			
			SAND (AEOLIAN) (4.27 m to 4.88 m) Silty SAND, trace gravel, moist, non plastic, brown, fine grained sand, angular.	S	SA06				4 8 16 N=24			
			Encountered refusal at 4.9 m, bedrock inferred, borehole terminated.									

Contractor: Van Mars
Drilling Rig Type: Track Rig

Logged By: BD
Reviewed By: CC

Started: 2020-09-09
Completed: 2020-09-09

Hole Inclination: -90°
Hole Orientation: °

Completion Depth: 4.88m

BOREHOLE: BH20-02

Project: Steinar Johnsen Development
Location: 1750 Highway 3, Osoyoos, BC
Zone: 11 Northing: 5432736.07 Easting: 323670.73

Project No: 201589
Client: Steinar Johnsen
Elevation: 519 m

DEPTH (m)	DRILLING METHOD	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	SAMPLE NUMBER	PARTICLE SIZE DISTRIBUTION GRAVEL (%)	SAND (%)	FINES (%)	STANDARD PENETRATION TEST (N)	ELEVATION (m)
0	Solid Stem		**FILL (FILL)** (0 m to 0.61 m) Drill out							
1			**SAND (FILL)** (0.61 m to 2.44 m) Silty SAND, trace fractured rock, moist, brown, fine grained sand.	S	SA07				7 9 10 N=19	
				S	SA08	5.4	49.5	45.1	9 15 30 N=45	
			Rock at 1.5 m.							
2				S	SA09				40 28 19 N=47	
			Crushed rock at 2.4 m.							
			SAND (AEOLIAN) (2.44 m to 3.05 m) Silty SAND, trace organics, damp, light brown, fine grained sand.	S	SA10				13 14 16 N=30	
3			Bedrock encountered at 3.05 m, borehole terminated.							

○ DYNAMIC CONE PENETRATION TEST (Blows/150mm) 20 40 60 80
■ SCALA PENETRATION TEST (Blows/50mm) 3 6 9 12
■ STANDARD PENETRATION TEST (N) (Blows/300mm) 10 20 30 40

▲ POCKET PEN. (kPa) ▲ 100 200 300 400
FIELD VANE (kPa) REMOULDED PEAK 40 80 120 160
PLASTIC M.C. LIQUID 10 20 30 40

Contractor: Van Mars
Drilling Rig Type: Track Rig

Logged By: BD
Reviewed By: CC

Started: 2020-09-09
Completed: 2020-09-09

Hole Inclination: -90°
Hole Orientation: °

Completion Depth: 3.05m
Page 1 of 1

BOREHOLE: BH20-03

Project: Steinar Johnsen Development
Location: 1750 Highway 3, Osoyoos, BC
Zone: 11 Northing: 5432826.01 Easting: 323473.88

Project No: 201589
Client: Steinar Johnsen
Elevation: 519 m

DEPTH (m)	DRILLING METHOD	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	SAMPLE NUMBER	PARTICLE SIZE DISTRIBUTION GRAVEL (%)	SAND (%)	FINES (%)	STANDARD PENETRATION TEST (N)	ELEVATION (m)
	Solid Stem		**FILL (FILL)** (0 m to 0.61 m) Drill out							
1			**SAND (AEOLIAN)** (0.61 m to 1.53 m) Silty SAND, fractured rock, moist, brown, grey rock, fine grained sand.	S	SA11	4.3	46.3	49.4	6 8 13 N=21	
			Bedrock encountered at 1.5 m, borehole terminated.							

DYNAMIC CONE PENETRATION TEST (Blows/150mm): 20 40 60 80
SCALA PENETRATION TEST (Blows/50mm): 3 6 9 12
STANDARD PENETRATION TEST (N) (Blows/300mm): 10 20 30 40

POCKET PEN. (kPa): 100 200 300 400
FIELD VANE (kPa): REMOULDED PEAK 40 80 120 160
PLASTIC M.C. LIQUID 10 20 30 40

Contractor: Van Mars
Drilling Rig Type: Track Rig

Logged By: BD
Reviewed By: CC

Started: 2020-09-09
Completed: 2020-09-09

Hole Inclination: -90°
Hole Orientation: °

Completion Depth: 1.53m
Page 1 of 1

Appendix E

Preliminary Geotechnical Assessment

December 12, 2016 Ecora File No.: PE-13-177-JOH

Mr. Steinar Johnsen
Hwy 3, Osoyoos, BC

Dear Mr. Johnsen

Reference: **Preliminary Geotechnical Assessment Relating to Construction of the Proposed Development at Lot 15, Plan 21789, Highway 3, Osoyoos, BC**

1. Introduction

1.1 General

Ecora Engineering & Resource Group Ltd. (Ecora) was engaged by Mr. Steinar Johnsen to undertake a geotechnical assessment in support of the development of a new strata subdivision located on Lot 15, Hwy 3, Osoyoos, BC. The proposed development is to comprise;

- The establishment of residential lots;
- The construction of a strata access road to the lots; and
- Installation of utilities.

The scope of the work, as described in our proposal dated September 29, 2016, included:

- A field investigation that comprises excavating four test pits, and one solid stem auger borehole;
- Field discontinuity mapping of exposed rock outcrops along the road alignment; and
- Preparation a report summarizing the geotechnical investigation and providing recommendations for site preparation, and construction of the access road.

In May of 2016, Ecora's scope of work was expanded to included an additional air track drilling investigation, which took place on May 13, 2016 to determine the depth to bedrock at the southern edge of the proposed strata road.

1.2 Site Description

The property comprises an irregularly shaped parcel of land of approximately 110 000 m². Existing site topography generally slopes toward the southeast towards Hwy 3 at between 30 to 50%. The property is bounded by Hwy 3 on the southeast, and by private property on all other sides. The property is currently undeveloped.

2. Geology

2.1 Surficial Geology

Reference to the publication "Okanagan Geology South" (Roed et al. 2011) indicates that the site is underlain by Lake Oliver sediments, including terraced and benched silt, varved clay, and sand, overlain by flood deposits including outwash sand and gravel, or locally by till, diamicton, boulders, or wind-blown (Aeolian) sand.

2.2 Bedrock Geology

Reference to the Geological Survey of Canada 1:100,000 bedrock geology map "Okanagan Watershed" indicates that the area is underlain by Osoyoos Lake Gneiss, consisting of hornblende and biotite rich granodiorite.

3. Site Investigation

3.1 Soil Investigation

In addition to a review of published geological data, several reconnaissance sessions of the property were undertaken by Mr. Michael J. Laws, P.Eng, Mr. Cevat Catana, P.Eng, and Mr. Peter Wittstock, EIT, from Ecora in the fall of 2015. The field investigations consisted of four test pits to depths of up to 2.7 m below existing ground, one auger borehole with Standard Penetration Tests (SPT) to a depth of 3.3 m below existing ground, and discontinuity mapping of rock outcrops along the driveway route.

The locations of the test pits and borehole are shown in Table 3.1 below.

Table 3.1 Summary of Test Pits

Test Pit No.	Northing (m)	Easting (m)	Termination Depth (m)
TP16-01	5433012	323744	3.00
TP16-02	5432890	323728	2.50
TP16-03	5432864	323674	2.50
TP16-04	5432732	323676	3.65
BH16-01	5432495	323801	3.30

At the completion of the geotechnical field program the test pit and borehole locations were determined utilizing a hand help GPS. A site plan that shows the location of test pits and boreholes is provided as Figure 1.0. The borehole and test pit logs are presented in Appendix B. Laboratory test results are presented as Appendix C.

3.2 Depth to Bedrock Investigation

Ecora carried out a supplemental investigation to determine the depth to bedrock in the vicinity of a proposed cut slope at the southern end of the proposed access road. This investigation was undertaken by Tyler Rowe, AScT, from Ecora on May 13, 2016. A total of 48 probe holes were drilled to depths of up to 10 m. The locations of probe holes are shown on Figure 3.0. Cross sections showing the slope profile and depth to bedrock are attached as Figure 3.1. Depths to bedrock ranged from 3.0 to over 10 m in the investigated area.

4. Encountered Soil Conditions

4.1 Materials

The following material types were encountered in the zone investigated by the four test pits and one borehole in the following sequence:

- Topsoil, loose to compact sandy topsoil to a depth of 0.1 m, which is underlain by;
- Aeolian Deposits, loose to compact fine sandy silt with some roots to a depth of 0.4 to 2.3 m which in turn overlies;
- Glaciofluvial Deposits, compact gravelly sand with some cobbles and trace silt, to depths of 2.5 to 3.0 m, which in turn overlies; and
- Crystalline metamorphic bedrock within TP15-01, TP15-02, and TP15-03 at a maximum depth of 3.0 m. Bedrock consisted of metamorphic gneiss rock, cross cut by dikes of orthoclase feldspar rich igneous rocks up to 100 mm thick.

4.2 Groundwater

At the time of the investigation, no groundwater was observed in the test pits or borehole.

Moist soil was present in the upper 0.3 to 0.4 m of the Test Pits due to rain and snow melt.

The BC well Database lists four wells within the subject property. The wells are tagged 105407, 69157, 84786, and 57089. The wells indicate groundwater is at a minimum depth of 21.9 m below surrounding site grade. The locations of these wells are shown on Figure 1.0.

5. Bedrock Structural Field Mapping

To assess the structural characteristics of the encountered rock mass field mapping of the existing rock excavation was undertaken by a Michael J. Laws, P. Eng, a Senior Geotechnical Engineer from Ecora on October 2, 2015 who conducted a traverse along a rock face exposed by blasting on the access road.

The existing rock cut comprised slightly weathered strong granular gneiss and it was noted that existing rock excavation has been undertaken using a normal bulk blasting pattern for surface excavation resulting in some overblast and significant blasting damage to the existing excavation face.

A summary of mapped discontinuity orientations is attached as Appendix D.

6. Geohazards

6.1 Level of Geohazard Risk

There is no established national level of geohazard risk in Canada. Therefore, the standard acceptable safety levels defined by the BC Ministry of Transportation and Infrastructure (BC MoTI) are generally utilized in these type of applications:

- For a building site, unless otherwise specified, an annual probability of occurrence of a damaging landslide/rock fall of 1/475 (10% probability in 50 years);
- For a building site or a large scale development an annual probability of occurrence of a life-threatening or catastrophic landslide/rock fall of 1/10,000 (0.5% probability in 50 years); and
- Large scale developments must also consider total risk and refer to international standards.

The risk level for potential building areas are outlined in Table 6.1. Risk class zones for the development area are shown on Figure 6.1.

Table 6.1 Geohazard Risk Class Description for the Proposed Development

Risk Level	Probability of Occurrence	Description and Examples
Safe Building Areas	Less than 1 in 10,000 year catastrophic events. Less than 1 in 475 years for property-damaging events.	Low likelihood of landslide/rockfall initiation following development (i.e., Slopes gentler than 50% - 60% with no signs of instability)
Moderate	Less than 1 in 10,000 year catastrophic events. Greater than 1 in 475 years for property-damaging events.	Expected to contain areas with a moderate likelihood of landslide/rockfall initiation following development (i.e., Slopes steeper than about 50% - 60% with visible signs of instability, polygons mapped with glaciolacustrine sediments)
No-Build Areas	Greater than 1 in 10,000 year catastrophic events. Greater than 1 in 475 years for property-damaging events.	Natural instability present. Expected to contain areas with a high likelihood of landslide/rockfall initiation following development (i.e., Steep rocky cliffs from which rockfall has occurred, all material and landforms that are unstable)

6.2 Potential Geohazards Identified

Based on the review of the background information and Ecora's experience within the area, the following potential geohazards were identified:

- Aeolian Deposits which are susceptible to collapse and erosion; and
- Southern Interior Glaciolacustrine Silts which are susceptible to collapse; and
- Slope stability of cut and fill slopes.

These potential geohazards are discussed and reviewed in detail in the following sections.

It is important to note that other geohazards may be present on site, including rock fall, and slope stability of natural slopes. However these geohazards have not been assessed at this time, as the final site grading plan is not available, and the risk cannot be quantified.

7. Geotechnical Characteristics of Southern Interior Glaciolacustrine/Glaciofluvial Silt

The Glaciolacustrine/Glaciofluvial silts encountered in the South Okanagan area can present significant geotechnical challenges and have historically performed poorly when their unique behaviour has not been taken into consideration in site development. The performance of these soils have been the subject of several studies, including, Lum (1975), Nyland and Miller (1977), BC Ministry of Transportation and Highways (1991), and Iravani (1999). Known issues and causes of failures in these soil types include:

- Piping and the formation of sinkholes, through the introduction of water creating steep hydraulic gradients and development of internal erosion along preferential paths of seepage.
- Toppling failure of bluffs, through presence of perpendicular stress release joints near the top of a near vertical bluff and the introduction of water into a vertical and/or horizontal joint result in the softening or erosion of a supporting layer.
- Rotational and planer landslides, through the introduction of water forming elevated hydrostatic pressures and steeper hydraulic gradients, internal erosion along preferential paths of seepage, softening and reduction in strength, and removal of toe support.
- Collapse, rapid consolidation when subjected to increased surcharge loading and increased saturation. Collapse potential curves of southern interior glaciolacustrine silt from the four studies above are presented on the attached Figure 7.1.

The majority of the overburden soils within the property consist of Glaciolacustrine silts. Due to the above mentioned geotechnical challenges associated with Glaciolacustrine silts coupled with shallow bedrock across the site, the storm water management and site drainage of the property is of vital importance. The recommendations related to the storm water management are provided in Section 8.3.

8. Discussion and Recommendations

8.1 Driveway Design and Construction

Ecora recommends that the proposed strata road shall be designed and constructed by cutting into the existing native soil and rock slope on site. The use of sidling fill construction on the Aeolian deposits is not permitted in road way design and construction. Ecora's recommendations for the construction of the proposed strata road way are provided in the sections below.

8.1.1 Rock Excavation

It is recommended that rock excavation be carried out using rock hammer or controlled blasting techniques in general accordance with Section 204 of the BC MoTI Standard Specifications for Highway Construction Volume 1. Blasting needs to be carefully designed to minimize damage to the final rock faces, limit over-break and prevent flyrock. Pre-splitting should also be used to form the final cut face in order to minimize the potential for blast damage.

8.1.2 Blasting Recommendations

For developing a pioneer access bench across the crest of the cut, the backline holes will necessarily be drilled sub-horizontal. Due to limitations with most drilling equipment, there will be a tendency for these holes to fan out, providing uneven spacing between holes. To counter this tendency, the length of pioneer advance rounds should be limited to not more than 5 m. In addition, the backline holes should be spaced not more than 0.6 m apart and be loaded/delayed as a cushion blast rather than as a pre-shear.

8.1.3 Recommended Cut Slope Angles

Based on the site reconnaissance and Ecora's experience within the project area, we recommend a maximum design cut slope angle of 0.25H:1V to be used for unsupported rock excavation slopes. However, during construction, rock cut slopes should be inspected by Ecora to determine whether localized stabilization such as trim blasting or bolting may be recommended during construction. Soil Cut Slopes

8.1.4 Soil Cut Slopes

Ecora encountered both Aeolian silt and sands, and glaciofluvial sands during the geotechnical investigation. Cut slopes within the glaciolacustrine and glaciofluvial material may be sloped at a maximum angle of 1.5:1 (H:V). Cut slopes within the Aeolian material may be sloped at a maximum angle of 2:1 (H:V).

8.1.5 Vibration Monitoring

Due to the close proximity of the proposed development to existing underground utilities, structures and roadways we recommend that a pre-construction and post-construction survey be completed on the adjacent roadways, concrete walkways, and any other structures that may be impacted during the proposed ground improvement works. These surveys typically include detailed video or photographic recording, a level survey, and crack monitoring (i.e. of existing cracks). Periodic surveys of underground utilities during blasting could identify potential problems prior to damage to these utilities.

The US Bureau of Mines (USBM) report RI 8507 "Structure Response and Damage Produced by Ground Vibration from Surface Mining Blasting" (1980) is commonly utilised in North America for developing monitoring criteria for ground induced vibrations. However, the USBM study focused on unreinforced, low-rise residential dwellings situated adjacent to mining sites. The main limitations of the USBM study is that it provides no guidance with respect to other types of structures, and specifies no limits on structural damage levels or limits for continuous vibrations.

Therefore, given the nature and proximity of existing structures to the development site we recommend that the criteria provided German Standard DIN 4150-3: 1999-02 "Structural Vibration – Part 2: Effects of Vibration on

Structures" as summarized in Table 8.1 and Table 8.2 below be utilized as the vibration criteria for this project to ensure vibrations induced on adjacent structures and utilities are kept within tolerable limits.

Table 8.1 Guideline values for maximum permissible vibration velocity to be used when evaluating the effects of short-term vibration on structures (DIN 4150-3)

Type of Structure	Guideline values for maximum permissible velocity, vi (mm/s)			
	Vibration at the foundation at a frequency of			Vibration at horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz*	
Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or occupancy.	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration cannot be classified	3	3 to 8	8 to 10	8

(*) At frequencies above 100 Hz the values given in this column shall be used as the maximum permissible velocity.

Table 8.2 Guideline values for maximum permissible vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework (DIN 4150-3)

Pipe Material	Guideline values for maximum permissible velocity on the pipe, vi (mm/s)
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
Masonry, plastic	50

8.1.6 Blast Rock Fill Slopes

Blast rock may be used as structural fill for the construction of slopes during site grading. Rock fill may be placed at a maximum slope angle of 1.5:1 (H:V). The geotechnical engineer should review the design of all slopes prior to construction. A set back from the crest of the slope should be determined by the geotechnical engineer during their review.

If it is desired to use the rock as rock fill for embankment construction, it may be necessary to use a tighter blast pattern than might normally be required to improve fragmentation and minimize the amount of oversized material.

8.1.7 Retaining Walls

If sloping or rock cuts are not possible at in section of the proposed access road, retaining walls may be used. Retaining walls over 1.2 m high shall be designed by an engineer. Ecora expects segmental retaining walls such as lock block, or allan block walls will be suitable for this application.

8.2 Lot Development

8.2.1 General

Based on our understanding of the project and on the results of our investigation, we are of the opinion that, from a geotechnical perspective, the site is suited for the proposed development provided that our recommendations are followed during design and construction of the project.

Detailed recommendations regarding site preparation, design of foundations, blasting, storm water management and site grading are provided below.

Ecora will reassess the potential geohazards across the site once the final site grading plan is available. Figure 6.0 shows site slope angles. Slopes steeper than 30° are considered to be potentially unstable, and Ecora expects these areas will be classified as No-Build Areas as noted in Table 6.1 above.

8.2.2 Set Back and Set Forward Distances

The required setback from the crest of slopes will depend on the size of the building, and whether the composition of the subgrade.

As a general rule, buildings shall not be located no closer than 5.0 m horizontally from the crest of slopes. Foundations shall be situated below a 2H:1V line projected from the toe of any adjacent slope and/or retaining wall(s).

Ecora recommends that a set-forward distance based on the rockfall shadow area be adopted. The rockfall shadow area is denoted by a line dipping 27.5° from horizontal measured from the crest of the talus slope at the base of a cliff (Wyllie, 2015) (See Figure 8.0). The extend of this rockfall shadow area is incorporated within the "High" risk class area shown on Figure 6.1. If this is deemed to be not practical, a catchment ditch, berm, or rock fill barrier should be constructed. Ecora can provide a design of such structure if required.

Set back and set forward requirements should be reviewed on a lot by lot basis by the geotechnical engineer prior to construction of structures. Final set back and set forward recommendations shall be incorporated into a geotechnical covenant to be registered on the title of any lots affected.

8.2.3 Site Preparation

The footprint of proposed structures and fill slopes shall be thoroughly cleared of all rubbish, debris, uncontrolled fill soil, and vegetation which shall be disposed of away from the site. All topsoil shall be stripped from earthworks areas and stockpiled separately clear of the earthworks.

Excavated material which is intended to be reused at the site as fill shall be stockpiled in a suitable area away from the earthworks. Excavated material which is unsuitable for reuse as fill shall be removed from the site.

8.2.4 Design of Shallow Foundations

Base on the soil conditions observed during Ecora's investigation, and the expected building loads, Ecora expects conventional shallow footings will be sufficient. Footings shall be founded on compact glaciofluvial deposits, bedrock, or structural fill placed on a subgrade approved by the geotechnical engineer. Structures built in

accordance with Part 9, Table 9.4.4.1. of the British Columbia Building Code (BCBC) may be designed with an allowable bearding capacity of 75 kPa.

Structures built in accordance with part 4 of the BCBC will require a site specific geotechnical assessment.

8.2.5 Frost Penetration

Frost susceptibility of soils refers to the propensity of the soil to grow ice lenses and heave during freezing. Based on the US Corps of Engineers Frost Design Soil Classification the Frost Group for the soil type encountered in the upper 3.0 metres is F2 to F3, which classified the soils as low to high in the degree of frost susceptibility. According to National Research Council of Canada (Canadian Building Digest 182) the frost penetration depth for the region where the proposed site falls into is estimated (from normal freezing index) at 0.6 m below ground surface. Therefore the underside of footings and utilities should be placed at least 0.6 m below the site grade to conform to the frost protection requirement.

It should be noted that granular backfill, approved by the geotechnical engineer, would be needed to be placed around and above the foundation underside. Site grading fill should be placed in approximately horizontal layers not to exceed 300 mm in loose thickness. Cobbles larger than 100 mm should not be placed in the top layer of the fill. Site grading fill should be compacted to a minimum 95% Standard Proctor Maximum Dry Density (SPMDD).

Where the underside of footing cannot be designed at the minimum depth (0.6 m below site grade) thermal insulation shall be incorporated according to design guidelines such as ASCE 32-01 (published by American Society of Civil Engineers) into the foundation design.

8.2.6 Foundation Drainage

The foundation depth is expected to be above the static groundwater table. Therefore we recommend a conventional perimeter drainage system be designed around the proposed dwelling, and located at the foundation grade. The perimeter drainage system should be constructed with rigid PVC piping with a minimum diameter of 150 mm, and tied into infiltration pits.

8.3 Slab On-Grade Floors

Slab on grade floors should be brought up to the bottom of slab elevations with structural fill compacted to a minimum 98% SPMDD. Ecora recommends that a 150 mm thick layer of 19 mm crushed gravel levelling course, compacted to a minimum of 98% of SPMDD, be placed directly below slab on grade floors.

If impermeable floor coverings are planned for slab-on-grade floors, then a 12 mil minimum thick PVC membrane should be placed, and floor covering only be placed when moisture diffusion through the concrete had reduced to acceptable levels.

8.3.1 Site Drainage

The field investigation results indicate that the Glaciolacustrine silts encountered at the site are in compact state. However, it is important to note that introduction of water can potentially create steep hydraulic gradient and can cause internal erosion of silt along preferred zones of seepage (See Section 7). Therefore, it is important to divert all the surface water away from the proposed structures on the property.

Any additional site grading of the lots should be designed in such a manner so as to prevent the ponding of surface water near building foundation areas or not to discharge over sloping ground. Sidewalks, paved or landscaped areas within a zone of approximately 2 m of building should be sloped to drain water away from the structure at a minimum gradient of 2%.

All foundation drainage systems, storm water and roof downspouts shall be drained directly to the storm sewer system. Irrigation systems shall only include low pressure systems (i.e., drip irrigation system) and the pressure reducer shall be internally within the dwelling. Pools shall only be allowed be drained to the sanitary sewer system and shall not be disposed over slopes.

Drainage considerations established during design and construction should be maintained for the life of the development. Property owners should be made aware that altering drainage patterns can be detrimental to slope stability and foundation performance.

8.3.2 Site Storm Disposal

Storm water shall be directed away from all structures within the proposed development, and away from the silty sand noted in the test pit and borehole logs.

8.3.3 Temporary Excavations

All work conducted in and around excavations should be carried out in accordance with requirements specified by the WorkSafe BC Occupational Health & Safety Regulations, Part 20.

Temporary trenches for underground utilities should be excavated at a slope no steeper than 2.0(H):1(V) (See Figure 8.1)

Unsupported excavations greater than 1.2 m depth should be reviewed by a professional engineer in accordance with WorkSafe BC. Alternatively, service line trenches or excavations deeper than 1.2 m must be shored.

All utilities should be bedded as per the Regional District of Okanagan-Similkameen (RDOS) development by-laws. General trench backfill above the bedding should be placed in loose lifts not exceeding 300 mm thickness, and each lift should be compacted to a minimum of 95% of Modified Proctor Maximum Dry Density (MPMDD).

9. Design and Construction Review

Ecora should be given the opportunity to review details of the design and construction specifications related to all geotechnical aspects of this project, prior to construction. Past experience has shown that this action may prevent inconsistencies that may lead to project delays. Details which should be reviewed and confirmed during lot development include:

- Building set back distances from sloping ground;
- Confirmation of rock fall shadow zones;
- Appropriate storm water disposal; and
- Lot grading and building plans.

All foundation design recommendations presented in this report are based on the assumption that an adequate level of monitoring will be provided during construction, and that construction will be carried out by a suitably qualified contractor, experienced in foundation and earthworks construction. An adequate level of monitoring is considered to be:

- For shallow foundations observation of all bearing surfaces prior to placement of structural fill and prior to concrete placement; and
- For earthworks full-time monitoring and compaction testing.

Suitably qualified persons, independent of the contractor, should carry out all such monitoring. It should be noted that failure to provide an adequate level of foundation monitoring may be in contravention of the Building Code.

One of the purposes of providing an adequate level of monitoring is to confirm that recommendations based on data obtained at discrete borehole locations, are relevant to other areas of the site.

Site subgrades following stripping, structural fill placement and compaction, bearing surfaces, foundation installation, and subgrade and base course preparation for slabs-on-grade and pavement areas should be inspected by qualified geotechnical personnel during construction. Ecora will provide these services, if requested.

10. Limitations of Report

This report and its contents are intended for the sole use of Mr. Steinar Johnsen, his agents and the applicable regulatory agencies. Ecora Engineering and Resource Group Ltd. (Ecora Engineering) does not accept any responsibility for the accuracy of any data, analyses, or recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Mr. Johnsen, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user.

Where Ecora submits both electronic file and hard copy versions of reports, drawings and other project-related documents, only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Ecora shall be deemed to be the original for the Project. Both electronic file and hard copy versions of Ecora's deliverables shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Ecora.

Ecora Engineering's General Conditions are provided in Appendix A of this report.

11. Closure

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Sincerely

Ecora Engineering & Resource Group Ltd.

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Issued for Review

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OQM | Organizational Quality Management Program

Version Control and Revision History

Version	Date	Prepared By	Reviewed By	Notes/Revisions
A	2016-12-13	PW	CC/MJL	Issued for Review

Attachments:

Figure 1.0	Site plan
Figure 3.0	Locations of Bedrock Probe Holes and Cross Section Lines
Figure 3.1	Cross Sections Showing Depth to Bedrock Between Stations 0+040 and 0+070
Figure 6.0	Site Plan - Slope Analysis
Figure 6.1	Site Plan - Risk Classification
Figure 7.1	Collapse Potential of Southern Interior Glaciolacustrine Silts
Figure 8.0	Site Plan - Slope Angles
Figure 8.1	Worksafe BC Excavation Sloping Requirements
Photo 1	Rock slope exposed by blasting along the access road, November 20, 2015
Photo 2	Discontinuity mapping of rock outcrops during mapping
Photo 3	Test pitting investigation
Appendix A	Statement of General Conditions — Geotechnical
Appendix B	Borehole and Testpit Logs
Appendix C	Laboratory Test Results
Appendix D	Mapped Discontinuities

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Figures

SITE PLAN

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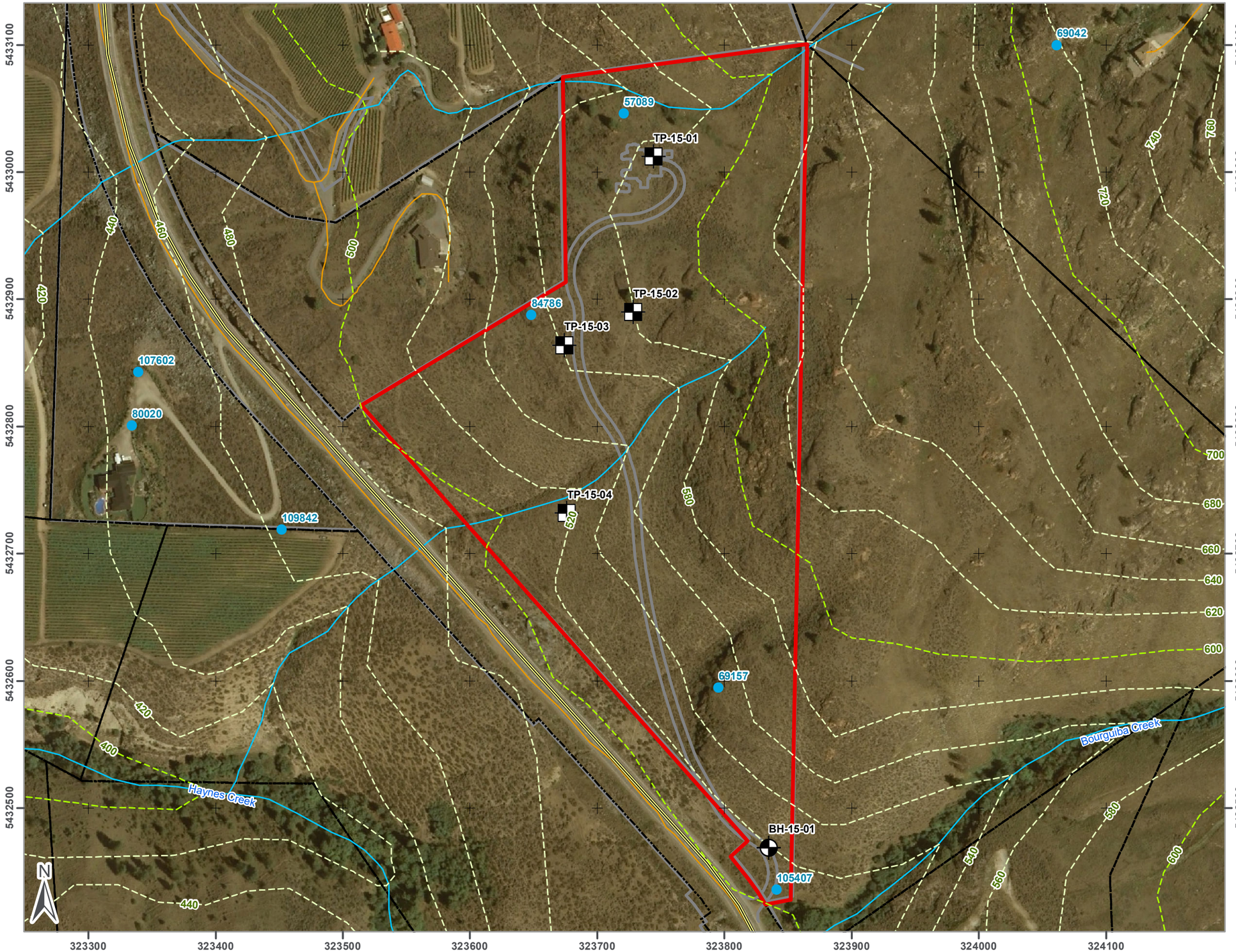
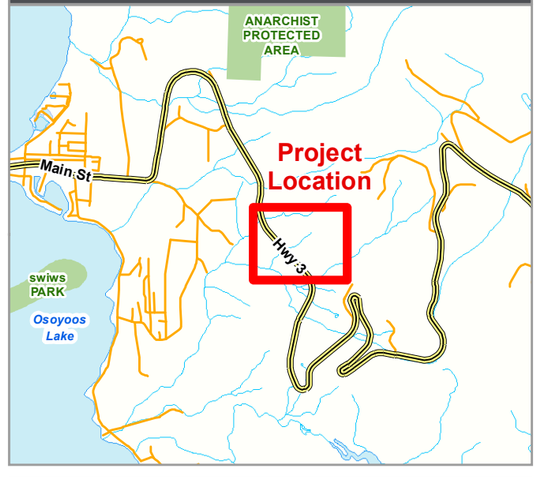


GEOTECHINICAL ASSESSMENT PROPOSED 5 LOT STRATA SUBDIVISION - REM LOT 15, HWY 3 OSOYOOS, BC

Legend

- Borehole Location
- Test Pit Locations
- Ground Water/Water Well Locations
- 20m TRIM Contours
- 100m TRIM Contours
- TRIM Roads
- Highways
- Streams
- Site Plan Lines from Ecora Engineering
- Existing Cadastral Fabric
- Subject Property

LOCATION MAP



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0 100 200 Meters

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Client: Steinar Johnsen
NAD 1983 UTM Zone 11N

Date: 2016/12/13
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Figure 1.0

SLOPE ANALYSIS

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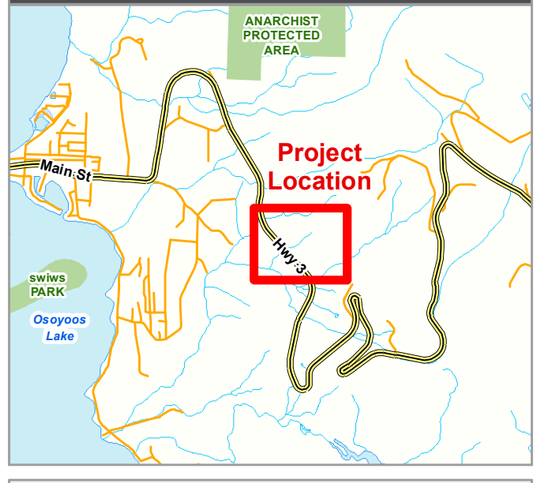
GEOTECHINICAL ASSESSMENT PROPOSED 5 LOT STRATA SUBDIVISION - REM LOT 15, HWY 3 OSOYOOS, BC

Legend

- 0 - 15 degrees
- 15 - 30 degrees
- 30+ degrees
- 20m TRIM Contours
- 100m TRIM Contours
- TRIM Roads
- Highways
- Streams
- Site Plan Lines from Ecora Engineering
- Existing Cadastral Fabric
- Subject Property

LOCATION MAP



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0 100 200 Meters

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NAD 1983 UTM Zone 11N

Date: 2016/12/13
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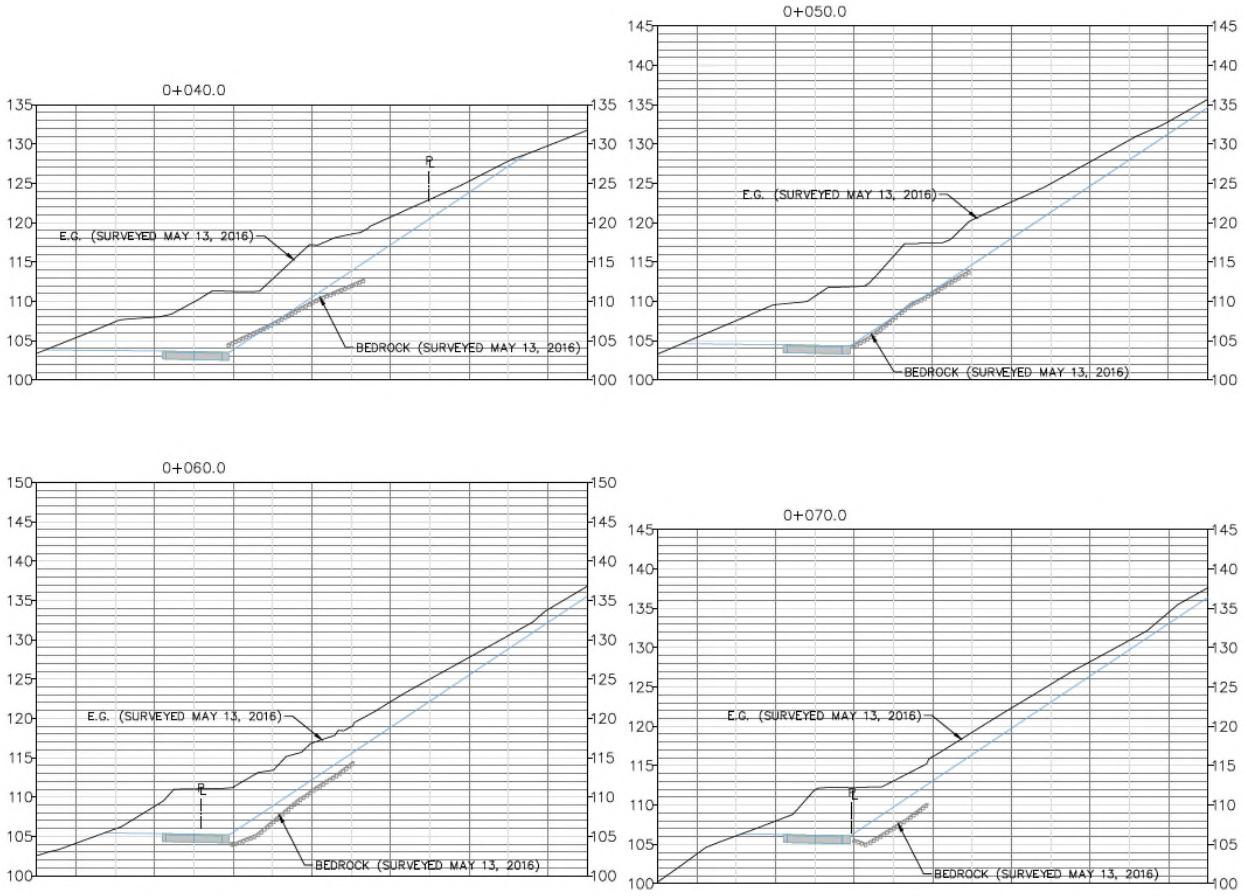
Figure 7.0



Notes:

Preliminary Geotechnical Assessment: Proposed Development, Lot 15, Plan 21789, Hwy 3, Osoyoos, BC.

Cross Sections Showing Depth to Bedrock Between Stations 0+040 and 0+070

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Paper Size: 8½ x 11
Date: 2016-12-13

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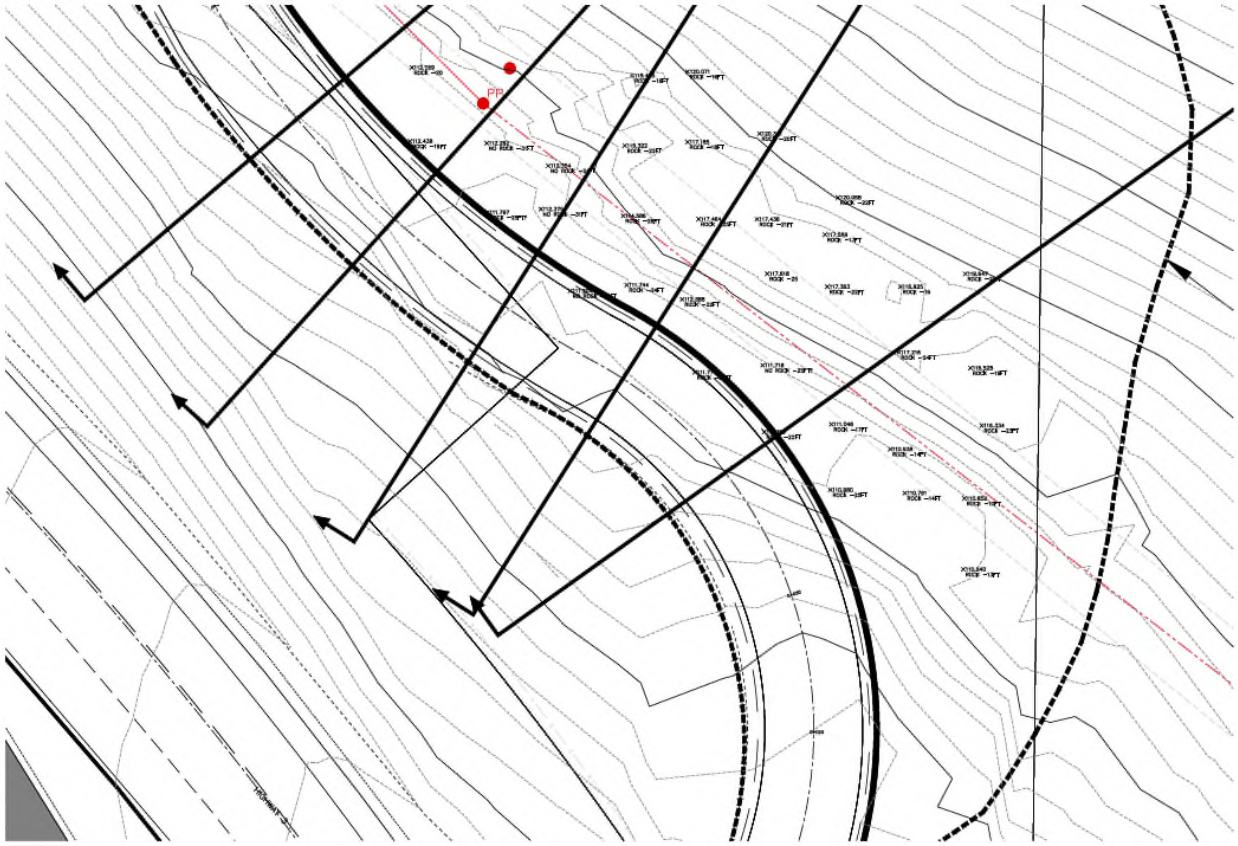
Figure 3.1



Notes:

Preliminary Geotechnical Assessment: Proposed Development, Lot 15, Plan 21789, Hwy 3, Osoyoos, BC.

Location of Bedrock Probe Holes and Cross Sections

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Figure 3.0

SLOPE ANALYSIS

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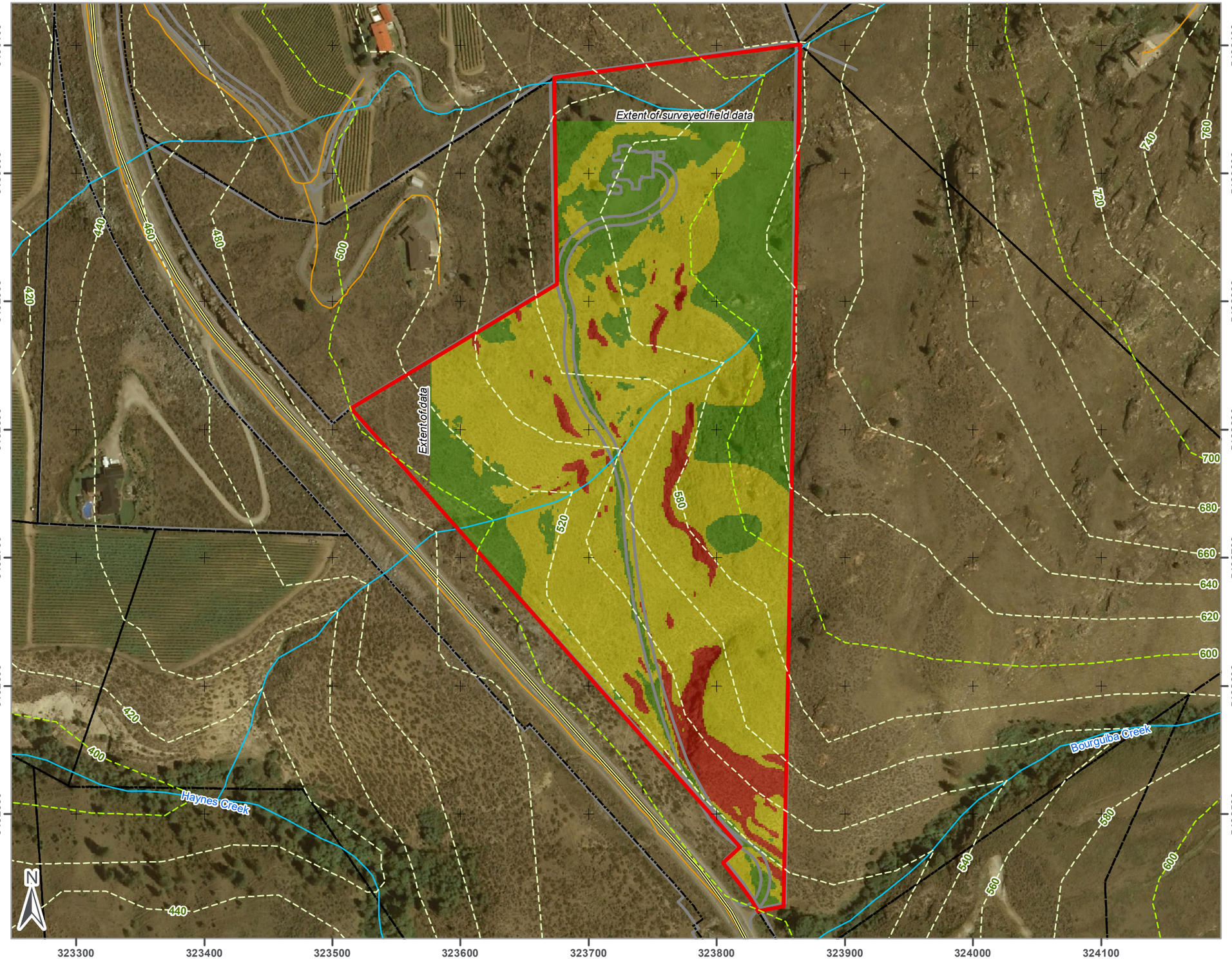

GEOTECHINICAL ASSESSMENT PROPOSED 5 LOT STRATA SUBDIVISION - REM LOT 15, HWY 3 OSOYOOS, BC

Legend

- 0 - 15 degrees
- 15 - 30 degrees
- 30 + degrees
- 20m TRIM Contours
- 100m TRIM Contours
- TRIM Roads
- Highways
- Streams
- Site Plan Lines from Ecora Engineering
- Existing Cadastral Fabric
- Subject Property

LOCATION MAP

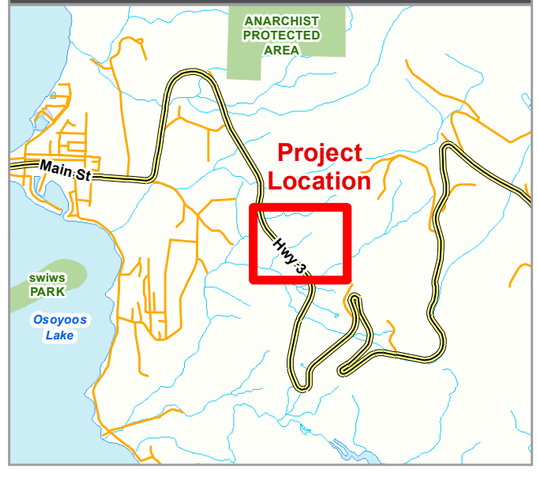

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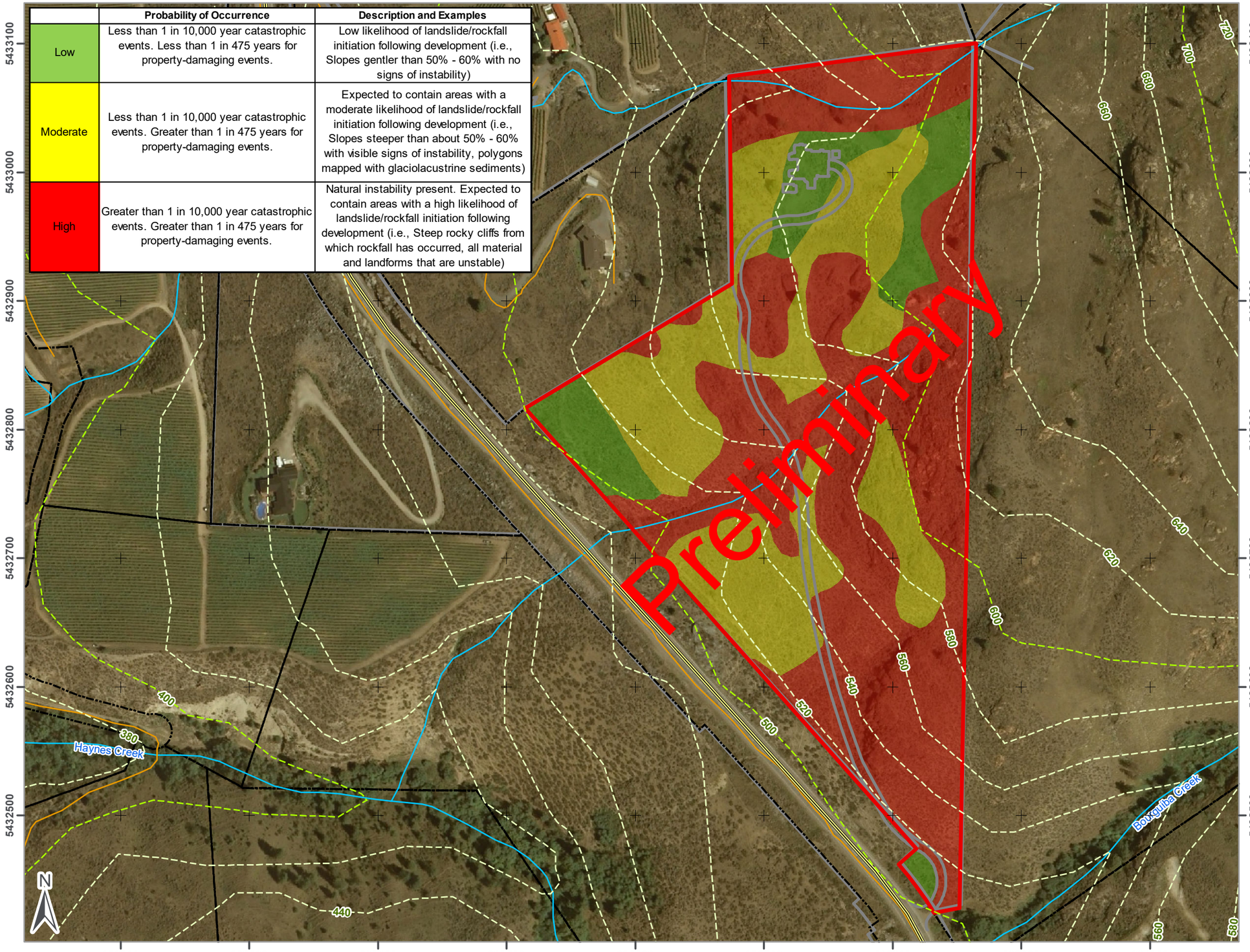
Figure 6.0

RISK CLASS ANALYSIS

	Probability of Occurrence	Description and Examples
Low	Less than 1 in 10,000 year catastrophic events. Less than 1 in 475 years for property-damaging events.	Low likelihood of landslide/rockfall initiation following development (i.e., Slopes gentler than 50% - 60% with no signs of instability)
Moderate	Less than 1 in 10,000 year catastrophic events. Greater than 1 in 475 years for property-damaging events.	Expected to contain areas with a moderate likelihood of landslide/rockfall initiation following development (i.e., Slopes steeper than about 50% - 60% with visible signs of instability, polygons mapped with glaciolacustrine sediments)
High	Greater than 1 in 10,000 year catastrophic events. Greater than 1 in 475 years for property-damaging events.	Natural instability present. Expected to contain areas with a high likelihood of landslide/rockfall initiation following development (i.e., Steep rocky cliffs from which rockfall has occurred, all material and landforms that are unstable)

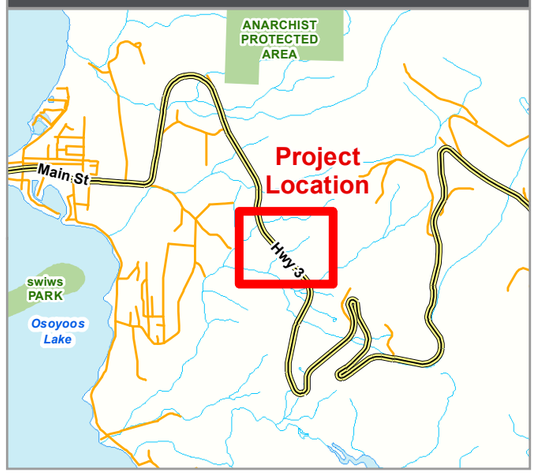


GEOTECHINICAL ASSESSMENT PROPOSED 5 LOT STRATA SUBDIVISION - REM LOT 15, HWY 3 OSOYOOS, BC

Legend

- Low
- Moderate
- High
- 20m TRIM Contours
- 100m TRIM Contours
- TRIM Roads
- Highways
- Streams
- Site Plan Lines from Ecora Engineering
- Existing Cadastral Fabric
- Subject Property

LOCATION MAP



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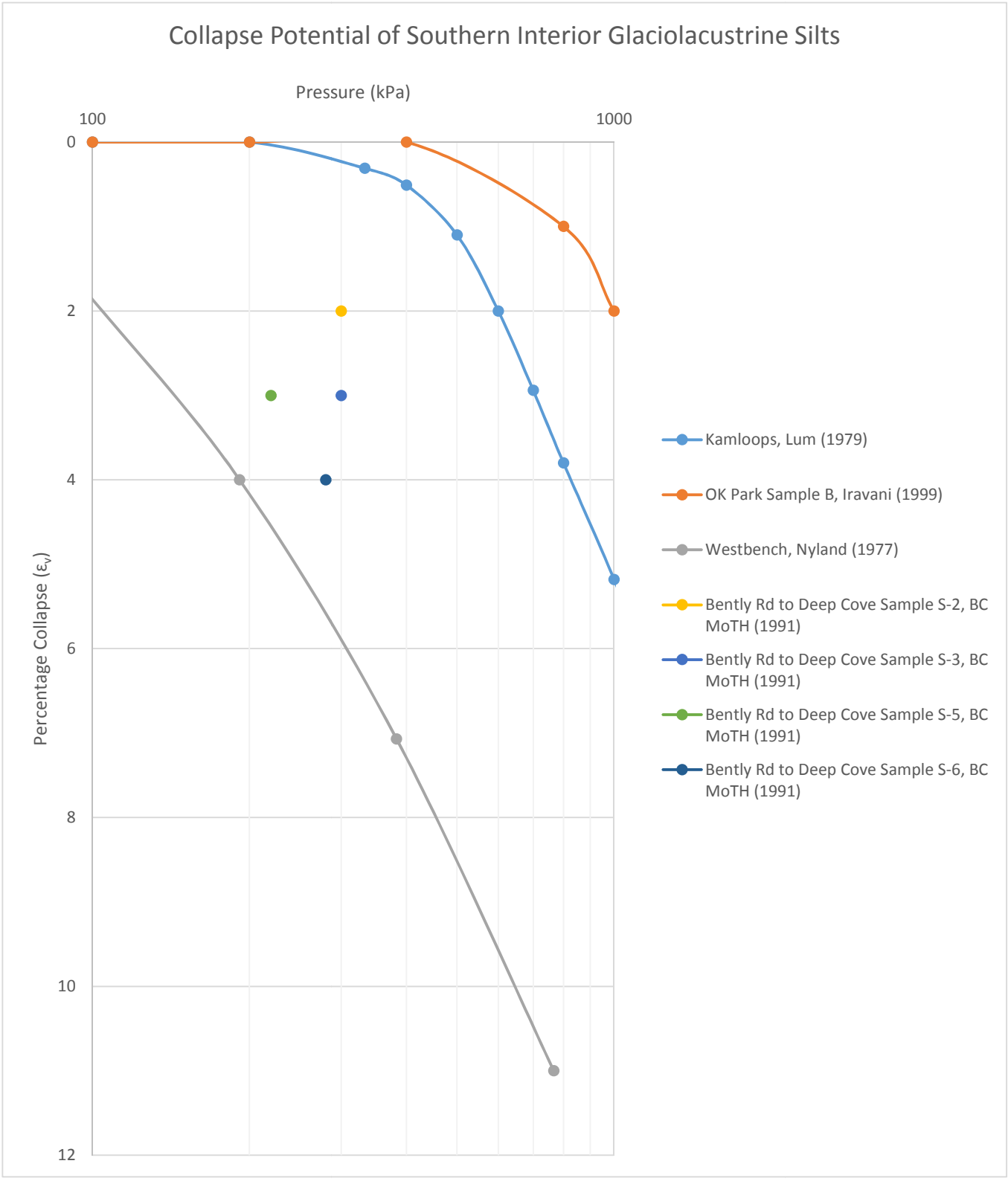
Project No.: PE-13-177-JOH
Date: 2016/12/14
Client: Steinar Johnsen
Drawn: DET Check: PW
NAD 1983 UTM Zone 11N

Figure 6.1



Notes:

Preliminary Geotechnical Assessment: Proposed Development, Lot 15, Plan 21789, Hwy 3, Osoyoos, BC.

Collapse Potential of Southern Interior Glaciolacustrine Silts

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Office: Penticton
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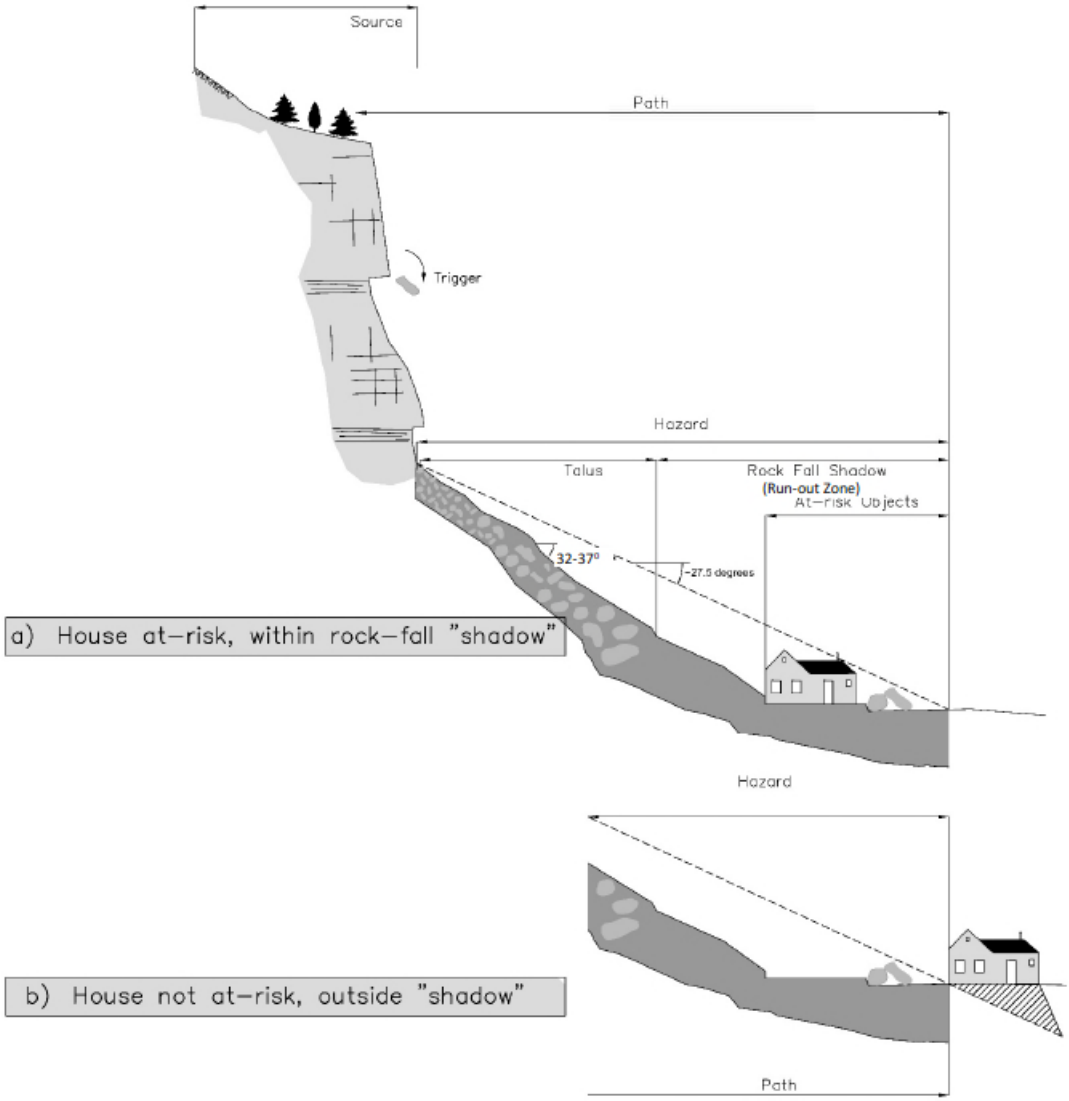
Figure 7.1



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Preliminary Geotechnical Assessment: Proposed Development, Lot 15, Plan 21789, Hwy 3, Osoyoos, BC.

Rockfall Shadow Angles

Project No.: PE-13-177-JOH
Office: Kelowna
Scale: NTS
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Figure 8.0

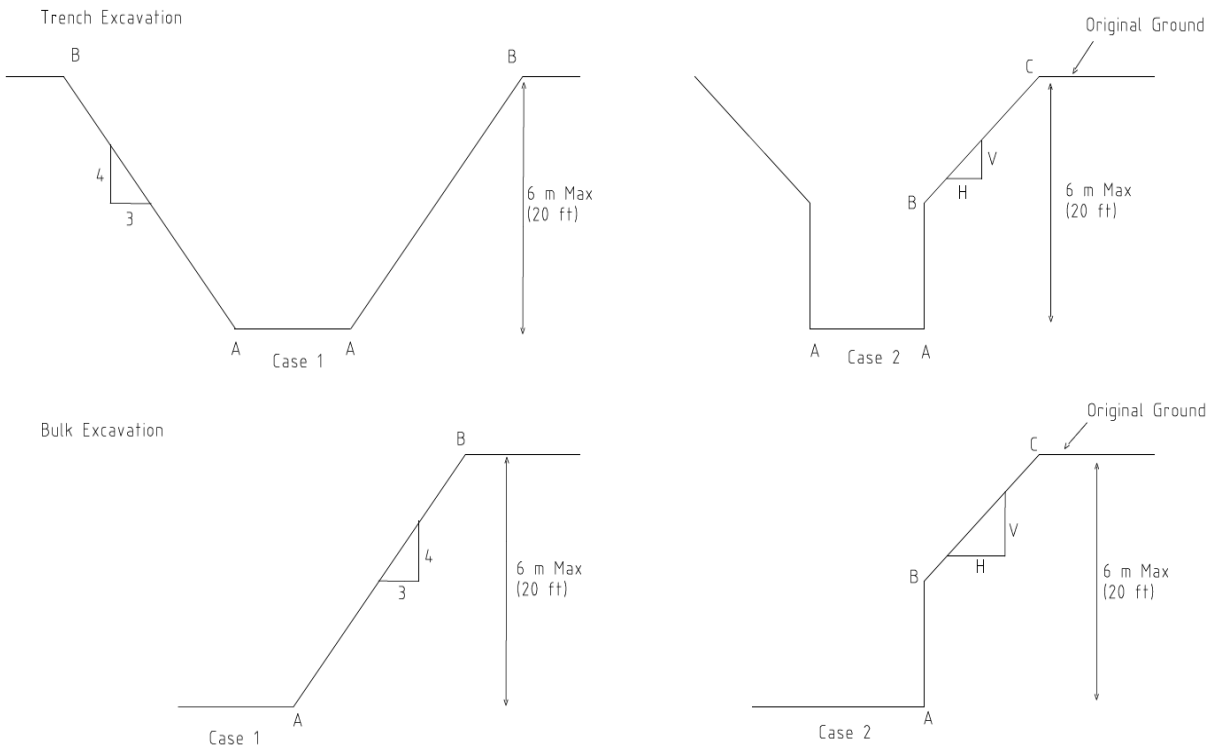

Table 6.0: Sloping Requirements for Case 2 Slopes

Height of Line AB		**Maximum Slope of Line BC (in hard and solid soil)**
Centimeters	Feet	
Up to 30	Up to 1	1 horizontal (H) to 1 vertical (V)
30 to 60	1 to 2	3H to 2V
60 to 90	2 to 3	2H to 1V
90 to 120	3 to 4	3H to 1V

Notes: Modified from WorkSafe BC Guidelines, Section 20.

Figure 20.1, Retrieved 2016-12-12

Preliminary Geotechnical Assessment: Proposed Development, Lot 15, Plan 21789, Hwy 3, Osoyoos, BC.

WorkSafe BC Temporary Excavation Sloping Requirements

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Scale: NTS
Paper Size: 8½ x 11
Date: 2016-12-12

Rev: 0
Dwn: PW
Chk: MJL

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Figure 7.1

Photographs

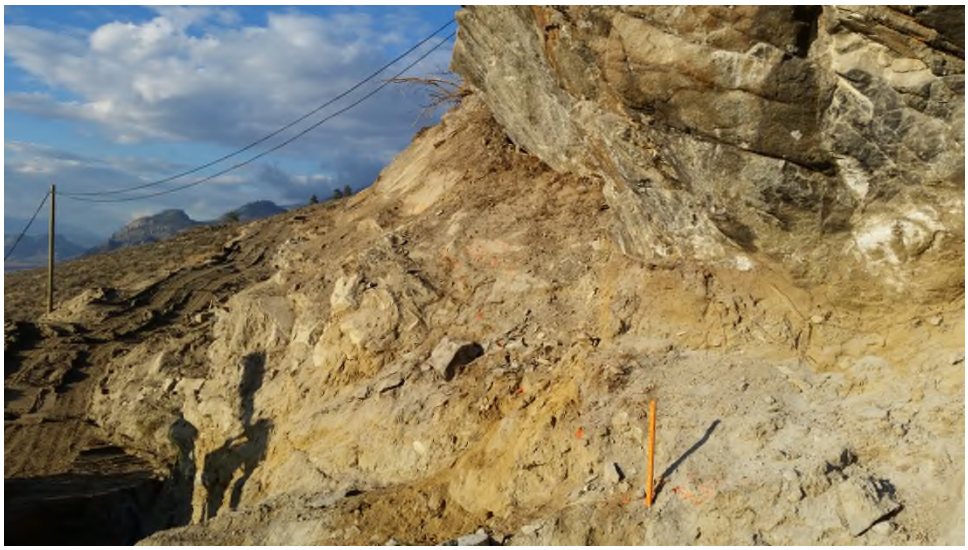


Photo 1 **Rock slope exposed by blasting along the access road, November 20, 2015.**

Photo 2 **Discontinuity mapping of rock outcrops during mapping.**

Photo 3 Test pitting investigation.

Appendix A

Statement of General Conditions — Geotechnical

Standard of Care

Ecora Engineering and Resource Group Ltd. (Ecora) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report

This report and the recommendations contained in it are intended for the sole use of Ecora's Client. Ecora does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Ecora's Client unless otherwise authorized in writing by Ecora. Any unauthorized use of the report is at the sole risk of the user. In order to properly understand the suggestions, recommendations and opinions expressed herein, reference must be made to the whole of the report. We cannot be responsible for use by any party of portions of the report without reference to the whole report.

Alternate Report Format

Where Ecora submits both electronic file and hard copy versions of reports, drawings and other project-related documents, only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Ecora shall be deemed to be the original for the Project. Both electronic file and hard copy versions of Ecora's deliverables shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Ecora.

Soil, Rock and Groundwater Conditions

Classification and identification of soils, rocks and geological units have been based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Ecora does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities such as traffic, excavation, groundwater level lowering, pile driving, blasting on the site or on adjacent sites. Excavation may expose the soils to climatic elements such as freeze/thaw and wet /dry cycles and/or mechanical disturbance which can cause severe deterioration. Unless otherwise indicated the soil must be protected from these changes during construction.

Environmental and Regulatory Issues

The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Sample Disposal

Ecora will dispose all soil and rock samples for 30 days following issue of this report. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

Construction Services

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

Job Site Safety

Ecora is responsible only for the activities of our employees on the jobsite. The presence of Ecora's personnel on the site shall not be construed in any way to relieve the Client or any contractors on site from their responsibilities for site safety. The Client acknowledges that he, his representatives, contractors or others retain control of the site and that Ecora never occupy a position of control of the site. The Client undertakes to inform Ecora of all hazardous conditions, or other relevant conditions of which the Client is aware. The Client also recognizes that our activities may uncover previously unknown hazardous conditions or materials and that such a discovery may result in the necessity to undertake emergency procedures to protect our employees as well as the public at large and the environment in general.

Changed Conditions and Drainage

Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Ecora be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Ecora be employed to visit the site with sufficient frequency to detect if conditions have changed significantly. Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Ecora takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

Services of Sub consultants and Contractors

The conduct of engineering and environmental studies frequently requires hiring the services of individuals and companies with special expertise and/or services which we do not provide. Ecora may arrange the hiring of these services as a convenience to our Clients. As these services are for the Client's benefit, the Client agrees to hold the Company harmless and to indemnify and defend Ecora from and against all claims arising through such hiring's to the extent that the Client would incur had he hired those services directly. This includes responsibility for payment for services rendered and pursuit of damages for errors, omissions or negligence by those parties in carrying out their work. In particular, these conditions apply to the use of drilling, excavation and laboratory testing services.

Appendix B

Borehole and Test Pit Logs

BOREHOLE: BH-15-01

Project: Steinar's Drive
Location: Lot 15, PL 21789, DL 2709, Highway 3
Zone: 11 Northing: Easting:

Project No: PE-13-177-JOH
Client: Steinar Johnsen
Elevation: 110 m

DEPTH (m)	DRILLING METHOD	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	SAMPLE NUMBER	PARTICLE SIZE DISTRIBUTION: GRAVEL (%)	SAND (%)	FINES (%)	STANDARD PENETRATION TEST (N)	ELEVATION (m)
0			**SAND (AEOLIAN)** (0 m to 1.5 m) Very loose to loose, fine SAND some silt, poorly graded, light brown, dry to moist.							
1										109
2			**SAND (GLACIOFLUVIAL DEPOSITS)** (1.5 m to 3.3 m) Compact, gravelly SAND some cobbles, trace silt, occasional boulders, light grey, moist.	S	1				5 5 5 N=10	108
3				S	2	24.0	57.5	18.5	30 20 for 140 mm N=50+	107
			End of Borehole at 3.3 m. Refusal.						N=	

DYNAMIC CONE PENETRATION TEST (Blows/300mm): 10 20 30 40
SCALA PENETRATION TEST (Blows/50mm): 1 2 3 4
STANDARD PENETRATION TEST (N) (Blows/300mm): 10 20 30 40

POCKET PEN. (kPa): 100 200 300 400
FIELD VANE (kPa): REMOULDED ◇ PEAK ◆ 40 80 120 160
PLASTIC M.C. LIQUID: 10 20 30 40

Contractor: On The Mark
Drilling Rig Type: Auger
Logged By: CC
Reviewed By: MJL
Started: 2015-12-03
Completed: 2015-12-03
Completion Depth: 3.3m
Page 1 of 1

TEST PIT: TP-15-01

Project: Steinar's Drive
Location: Lot 15, PL 21789, DL 2709, Highway 3
Zone: 11 Northing: 5433012 Easting: 323744

Project No: PE-13-177-JOH
Client: Steinar Johnsen
Elevation: 584 m

DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION GRAVEL (%)	SAND (%)	FINES (%)	CLASSIFICATION TESTS PLASTIC M.C. LIQUID 10 20 30 40	IN-SITU SHEAR VANE TEST REMOULDED (kPa) PEAK (kPa) 40 80 120 160 / SCALA PENETROMETER Blows Per 50mm Penetration 3 6 9 12	ELEVATION (m)
0		**TOPSOIL (TOPSOIL)** (0 m to 0.1 m) Loose, Organic topsoil with roots, black, wet.						
		SILT and SAND (AEOLIAN DEPOSITS) (0.1 m to 0.4 m) Loose to compact, fine SAND and SILT with some roots, brown, wet.						
1		**SILT (GLACIOFLUVIAL DEPOSITS)** (0.4 m to 3 m) Compact, silty, gravelly SAND with some cobbles, light grey, moist.						583
2								582
3		Test pit terminated on bedrock at 3.0 m.						581

PHOTOGRAPH

Contractor:	Logged By: PW	Started: 2015-12-03	Completion Depth: 3m
Excavator Type: Exavator	Reviewed By: CC	Completed: 2015-12-03	Page 1 of 1

TEST PIT: TP-15-02

Project: Steinar's Drive
Location: Lot 15, PL 21789, DL 2709, Highway 3
Zone: 11 Northing: 5432890 Easting: 323728

Project No: PE-13-177-JOH
Client: Steinar Johnsen
Elevation: 582 m

DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	SAMPLE NUMBER	PARTICLE SIZE DISTRIBUTION GRAVEL (%)	SAND (%)	FINES (%)	CLASSIFICATION TESTS PLASTIC M.C. LIQUID (10 20 30 40)	IN-SITU SHEAR VANE TEST REMOULDED (kPa) PEAK (kPa) (40 80 120 160) SCALA PENETROMETER Blows Per 50mm Penetration (3 6 9 12)	ELEVATION (m)
		SILT (AEOLIAN DEPOSITS) (0 m to 0.4 m) Loose to compact, fine sandy SILT with some roots, brown, wet.								
1		**SILT and SAND (AEOLIAN DEPOSITS)** (0.4 m to 1.2 m) Loose to compact, fine SAND and SILT with some roots to 0.8 m, light brown, slightly moist.								581
		Cobbles (GLACIOLACUSTRINE DEPOSITS) (1.2 m to 1.4 m) Compact, COBBLES some silt and fine sand, light brown to light grey, slightly moist.								
2		**SAND (GLACIOFLUVIAL DEPOSITS)** (1.4 m to 2.7 m) Compact, gravelly SAND some cobbles, trace silt, light grey, moist.	D	141-15	23.4	68.3	8.3			580
		Test pit terminated on bedrock at 2.7 m.								

PHOTOGRAPH

Contractor:
Excavator Type: Exavator

Logged By: PW
Reviewed By: CC

Started: 2015-12-03
Completed: 2015-12-03

Completion Depth: 2.7m

TEST PIT: TP-15-03

Project: Steinar's Drive
Location: Lot 15, PL 21789, DL 2709, Highway 3
Zone: 11 Northing: 5432864 Easting: 323674

Project No: PE-13-177-JOH
Client: Steinar Johnsen
Elevation: 562 m

DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	SAMPLE NUMBER	PARTICLE SIZE DISTRIBUTION GRAVEL (%)	SAND (%)	FINES (%)	CLASSIFICATION TESTS PLASTIC M.C. LIQUID (10 20 30 40)	IN-SITU SHEAR VANE TEST REMOULDED (kPa) PEAK (kPa) (40 80 120 160) SCALA PENETROMETER Blows Per 50mm Penetration (3 6 9 12)	ELEVATION (m)
		SILT (AEOLIAN DEPOSITS) (0 m to 0.4 m) Loose to compact, fine sandy SILT with some roots, brown, wet.								
1		**SILT and SAND (AEOLIAN DEPOSITS)** (0.4 m to 2.3 m) Loose to compact, fine SAND and SILT with some roots to 0.8 m, light brown, slightly moist.	D	143-15	0.9	54.9	44.2			561
2		**SILT (GLACIOFLUVIAL DEPOSITS)** (2.3 m to 2.5 m) Loose to compact, fine sandy SILT some gravel and cobbles, light brown to light grey, slightly moist. Test pit terminated on bedrock at 2.5 m.								560

PHOTOGRAPH

Contractor:
Excavator Type: Exavator

Logged By: PW
Reviewed By: CC

Started: 2015-12-03
Completed: 2015-12-03

Completion Depth: 2.6m

TEST PIT: TP-15-04

Project: Steinar's Drive
Location: Lot 15, PL 21789, DL 2709, Highway 3
Zone: 11 Northing: 5432732 Easting: 323676

Project No: PE-13-177-JOH
Client: Steinar Johnsen
Elevation: 521 m

DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	PARTICLE SIZE DISTRIBUTION GRAVEL (%)	SAND (%)	FINES (%)	CLASSIFICATION TESTS PLASTIC M.C. LIQUID (10 20 30 40)	IN-SITU SHEAR VANE TEST REMOULDED (kPa) PEAK (kPa) (40 80 120 160) SCALA PENETROMETER Blows Per 50mm Penetration (3 6 9 12)	ELEVATION (m)
0		**SILT and SAND (AEOLIAN DEPOSITS)** (0 m to 3.65 m) Loose to compact, fine SAND and SILT with some roots to 0.8 m, light brown, slightly moist.							521
1			D						520
2									519
		End of Test Pit at 3.65 m.							

PHOTOGRAPH

Contractor:
Excavator Type: Exavator

Logged By: PW
Reviewed By: CC

Started: 2015-12-03
Completed: 2015-12-03

Completion Depth: 2.4m

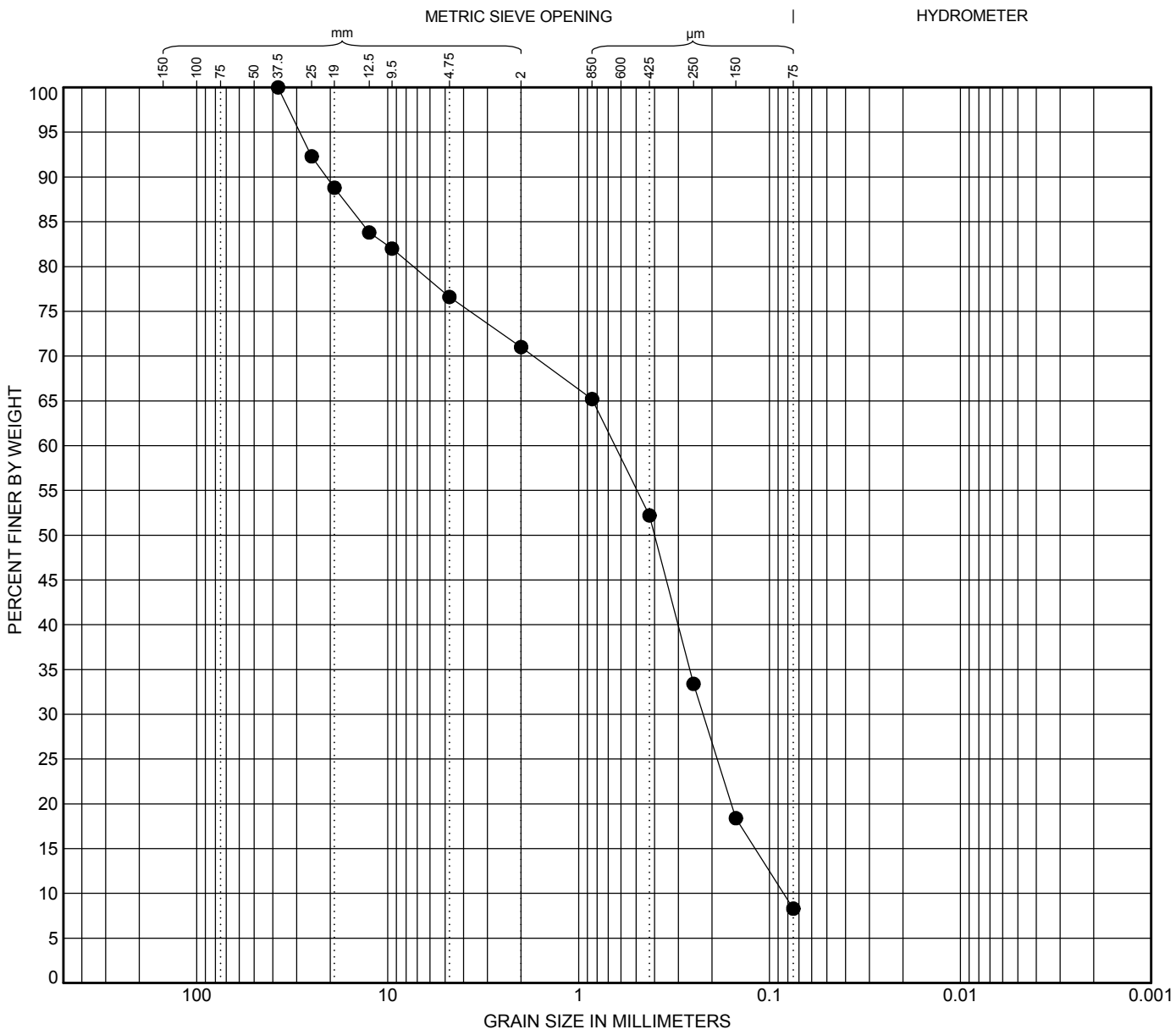
Appendix C

Laboratory Test Results

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Steinar's Drive
Location: Lot 15, PL 21789, DL 2709, Highway 3
Sample Location: TP-15-02

Project No: PE-13-177-JOH
Client: Steinar Johnsen
Depth: 1.6 m to 1.9 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
37.5	**13.821**	**0.644**	**0.223**	**0.119**	**0.084**	**0.91**	**7.64**	**23.4**	**68.3**	**8.3**	

Description: Gravelly SAND, trace fines
Natural Moisture Content: 0.8 %
Material Specification:
Intended Use:
Comments:

Sample Number: 141-15
Date Tested: 2015-12-07
Tested By: BW

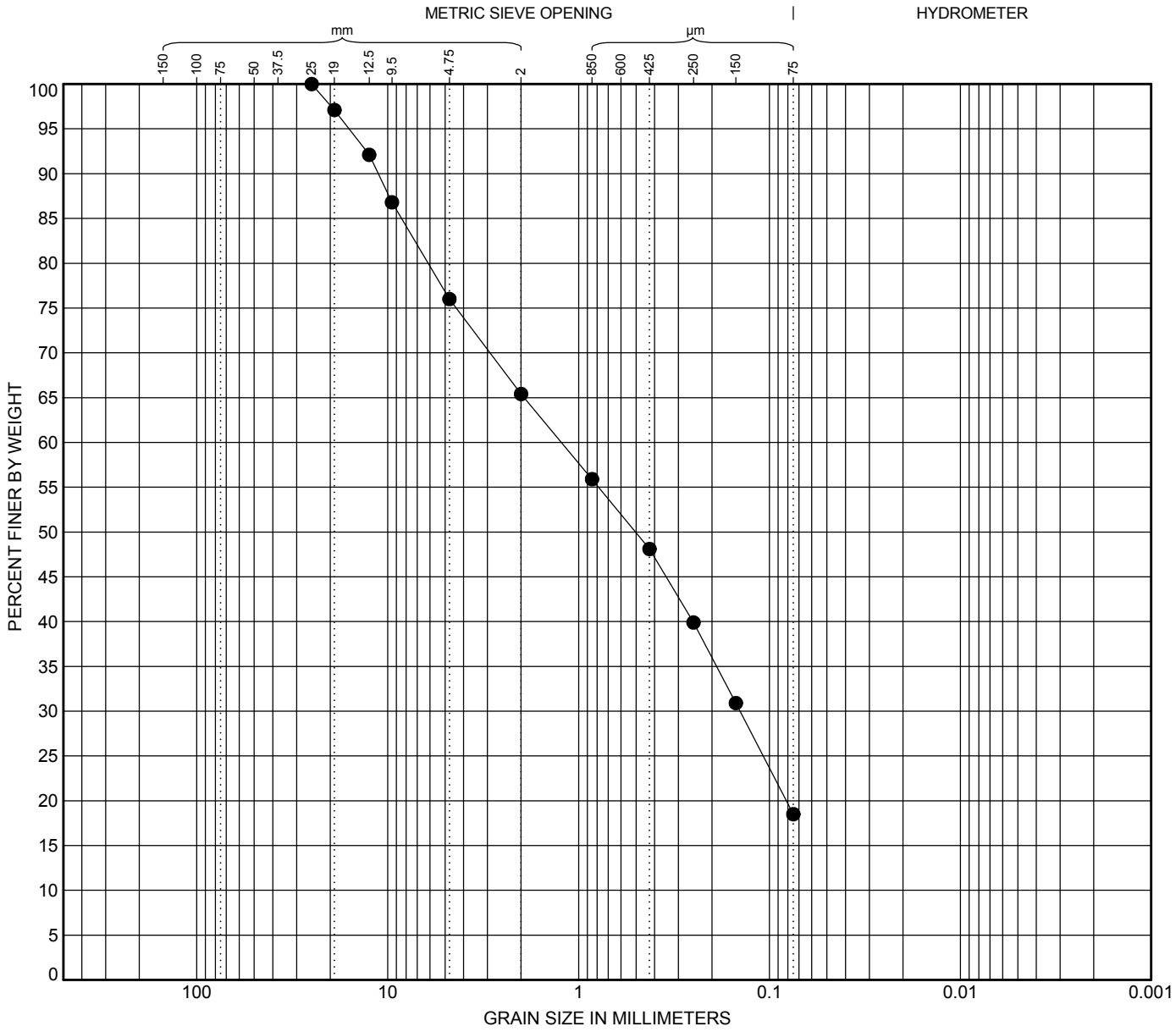
Checked By: _____

GRAIN SIZE DISTRIBUTION PE-13-177-JOH.GPJ DATAECORA2015.GDT 1/8/16

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Steinar's Drive
Location: Lot 15, PL 21789, DL 2709, Highway 3
Sample Location: BH-15-01

Project No: PE-13-177-JOH
Client: Steinar Johnsen
Depth: 3 m to 3.3 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**8.464**	**1.23**	**0.143**					**24.0**	**57.5**	**18.5**	

Description: Gravelly SAND, some silt
Natural Moisture Content: 0.7 %
Material Specification:
Intended Use:
Comments:

Sample Number: 144-15
Date Tested: 2015-12-07
Tested By: BW

Checked By: _____

Appendix D

Mapped Discontinuities

Dip	Dip Direction
67	143
45	339
57	246
76	266
79	136
45	340
86	248
32	346
71	109
34	340
27	172
44	345
38	101
37	275
34	177
39	290
45	325