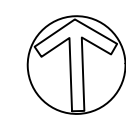
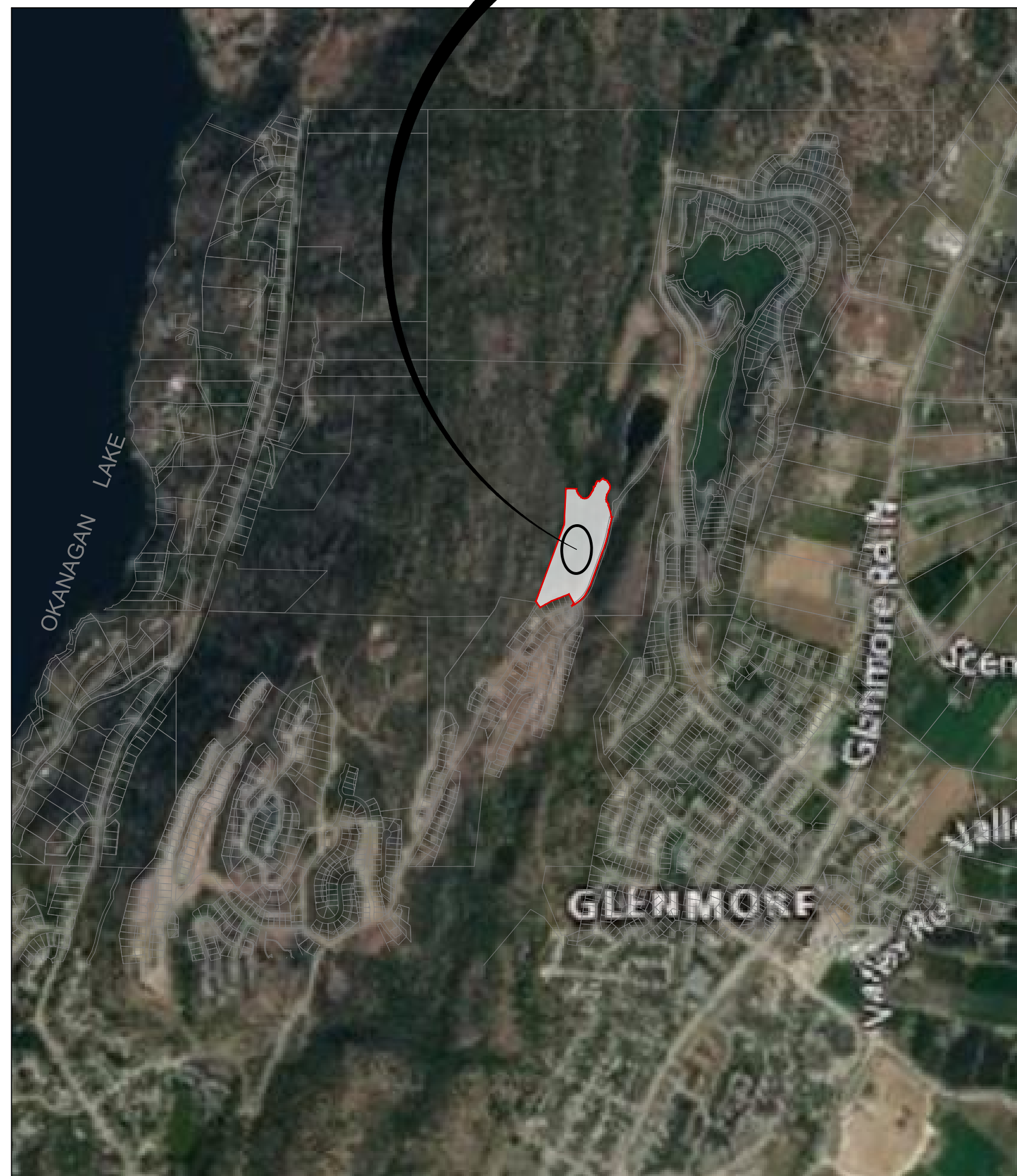


# WILDEN CONSTRUCTION CORP. CATTAIL POND MULTI-FAMILY DEVELOPMENT UPPER CANYON DRIVE ISSUED FOR DEVELOPMENT PERMIT OCTOBER 3, 2022



PROJECT LOCATION



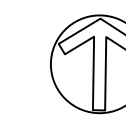
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**CITY OF KELOWNA**

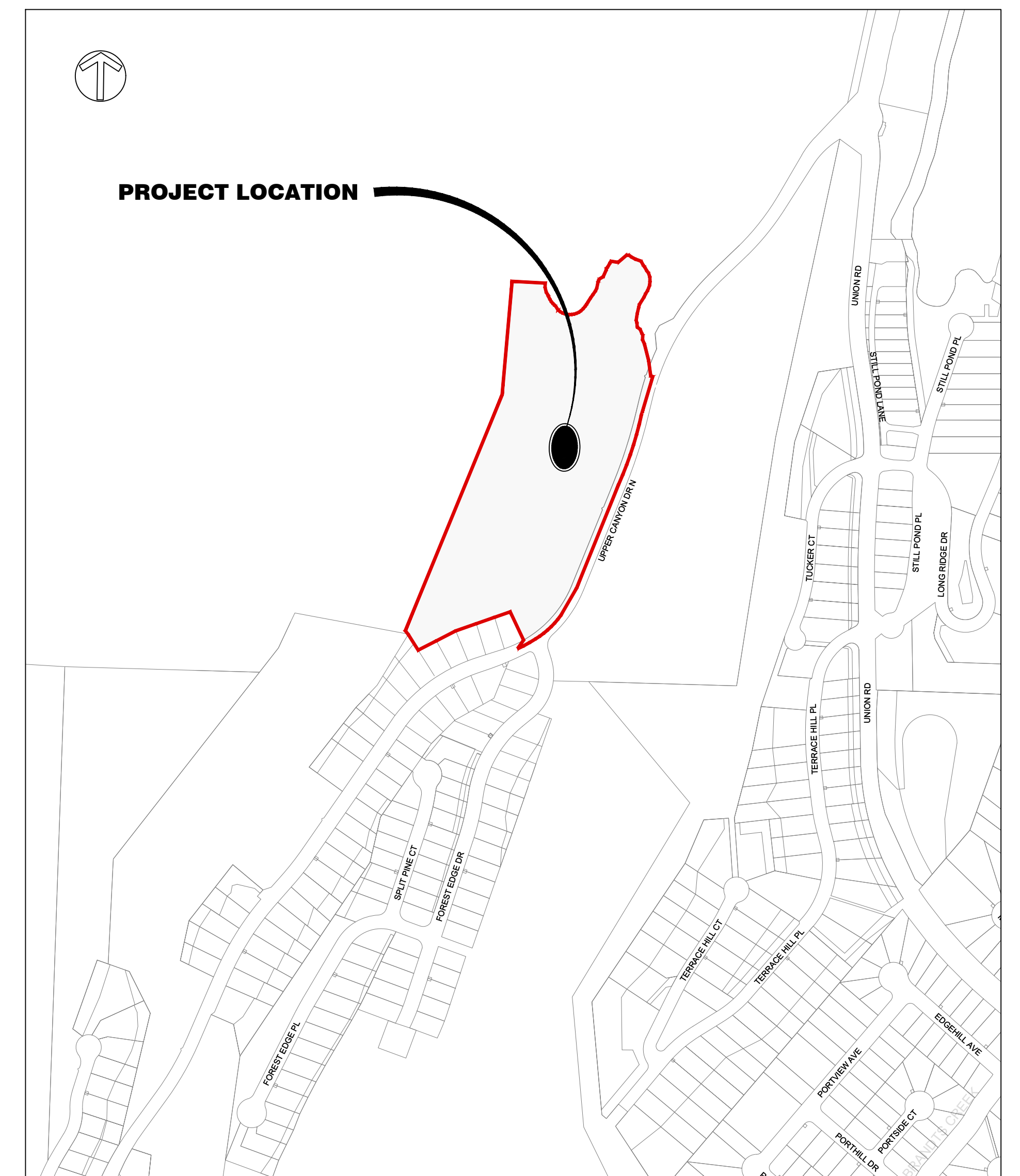
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## INDEX OF DRAWING SHEETS

DRAWINGS SHEET TITLE	DRAWING SHEET NO.
COVER SHEET	201827-C0.0
SITE LAYOUT	201827-C1.0
SITE GRADING PLAN	201827-C2.0
SITE SECTIONS	201827-C2.1
ROAD A PROFILE AND CROSS SECTIONS	201827-C3.0
ROAD B PROFILE AND CROSS SECTIONS	201827-C4.0
ROAD B CROSS SECTIONS	201827-C4.1XS
ROAD C PROFILE AND CROSS SECTIONS	201827-C5.0
ROAD D PROFILE	201827-C6.0
ROAD D CROSS SECTIONS	201827-C6.1XS
LANES 1 AND 2 PROFILES AND CROSS SECTIONS	201827-C7.0
LANE 3 PROFILE AND CROSS SECTIONS	201827-C8.0
CUT AND FILL MAP	201827-C9.0
EROSION AND SEDIMENT CONTROL PLAN	201827-C10.0



PROJECT LOCATION

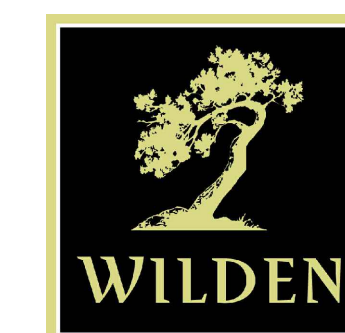


**INDEX MAP**

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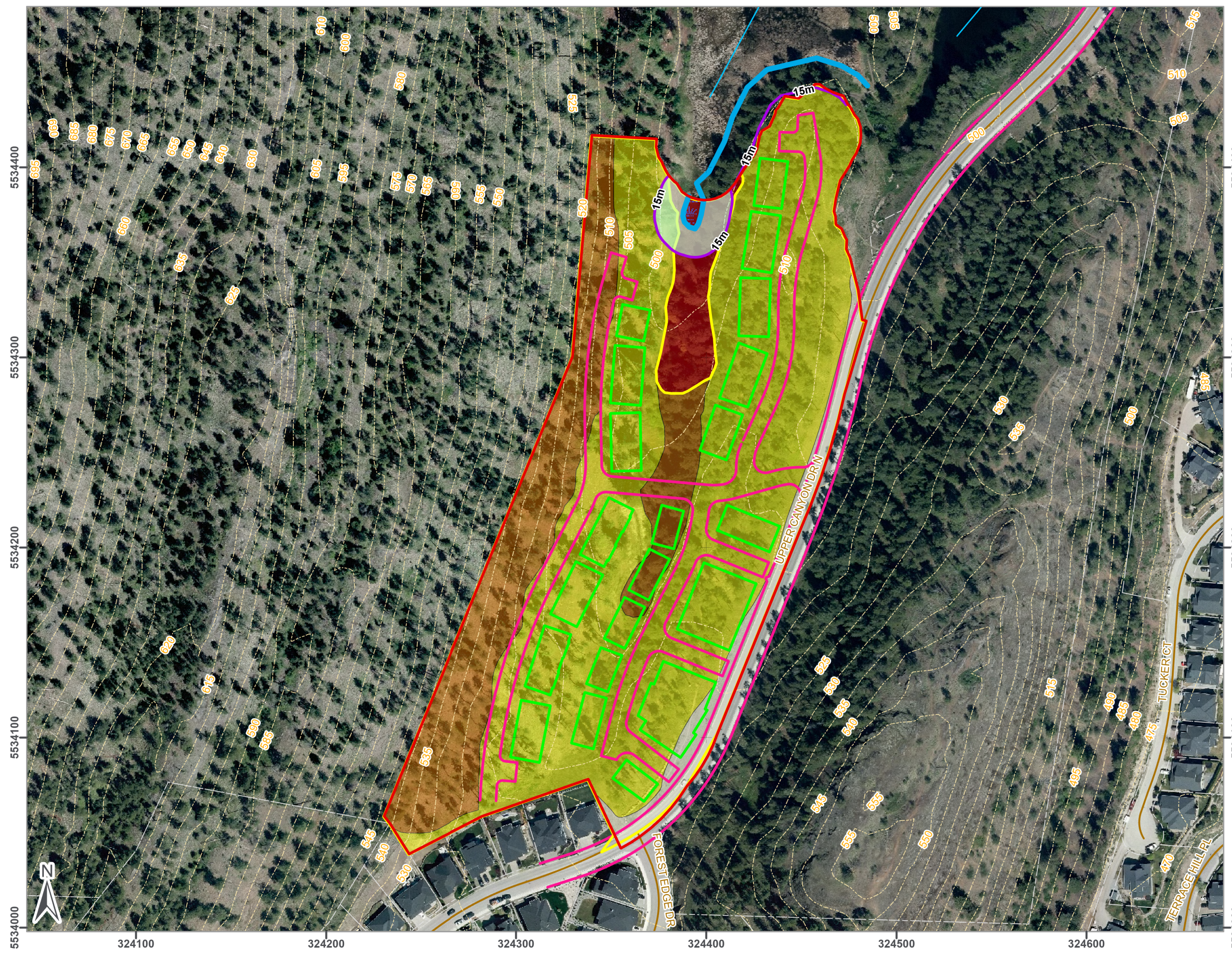
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**LEGAL DESCRIPTION:  
KAP75116, LOT D, 8-23, ODYD, EXCEPT  
FOR EPP24895 AND EPP24897**



**201827-C0.0**

## ENVIRONMENTAL ASSESSMENT 225 CLIFTON RD KELOWNA, BC

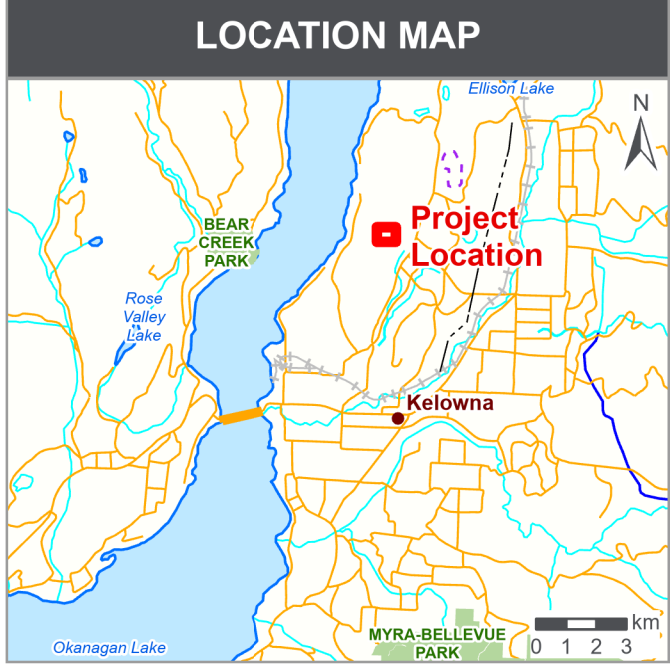


### Legend

Development Boundary	ESA 1 - High
Proposed Roads	ESA 2 - Moderate
Riparian Management Area (15m)	ESA 3 - Low
High Water Mark	ESA 4 - Not Sensitive
Fresh Water Atlas Streams	
City of Kelowna 5m Contours	
City of Kelowna Roads	
Riparian Area	
Riparian Management Area	
Proposed Buildings	
Property Boundary	
City of Kelowna Legal Parcels	

### References

Aerial Imagery: City of Kelowna GIS. Imagery Date: 2020

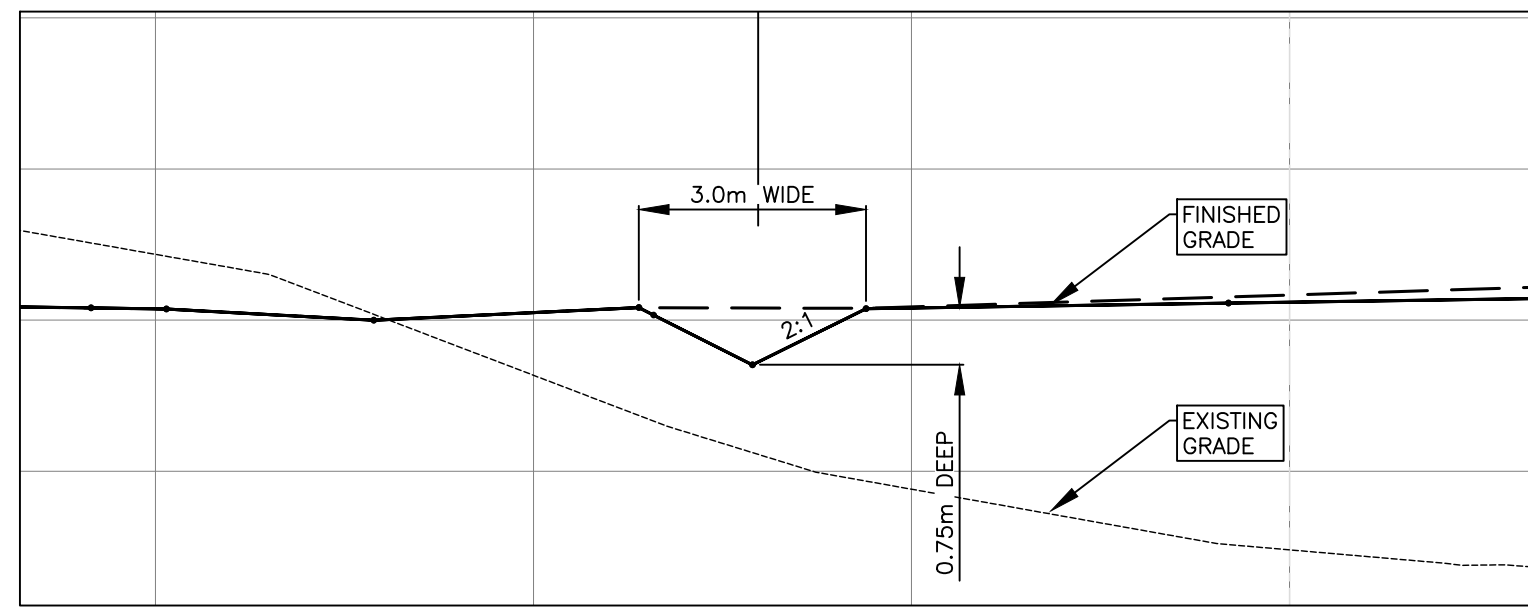


Project No.: 201827 Date: 2022/09/20  
 Client: Wilden Construction Corp. Drawn: SC Check: AP

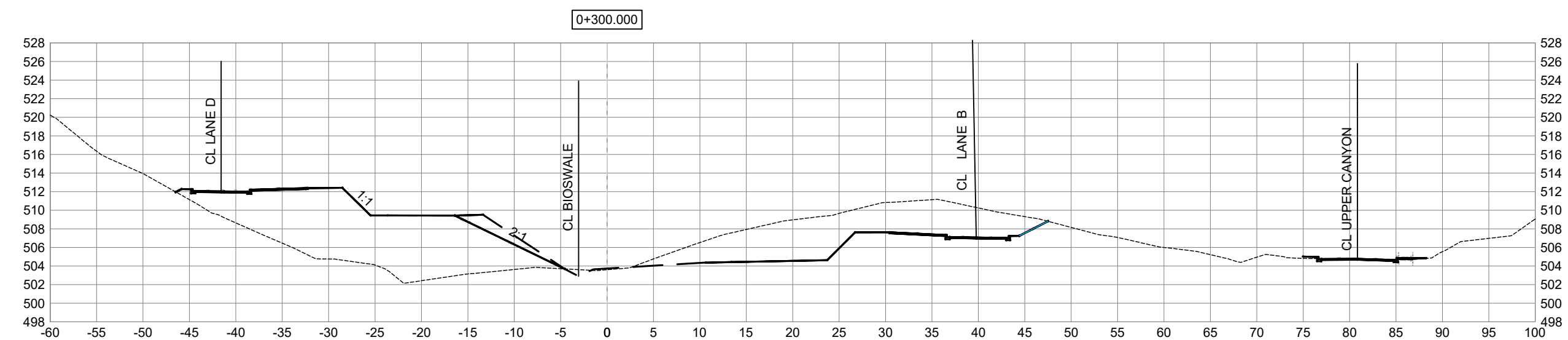
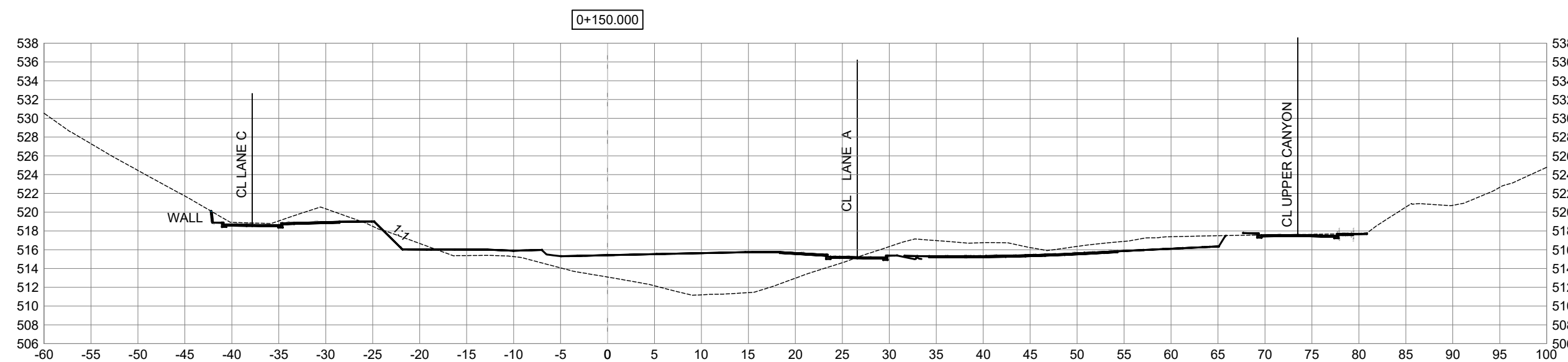
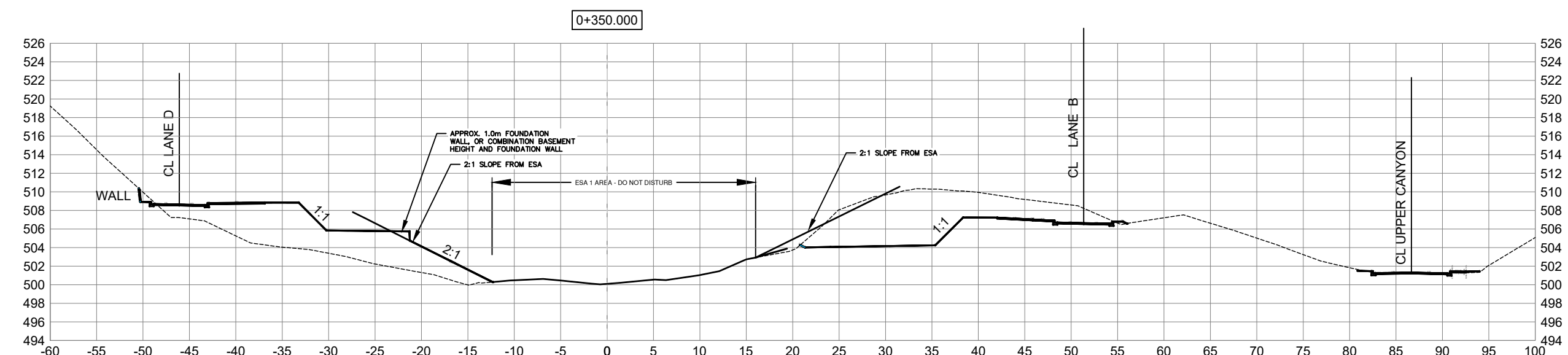
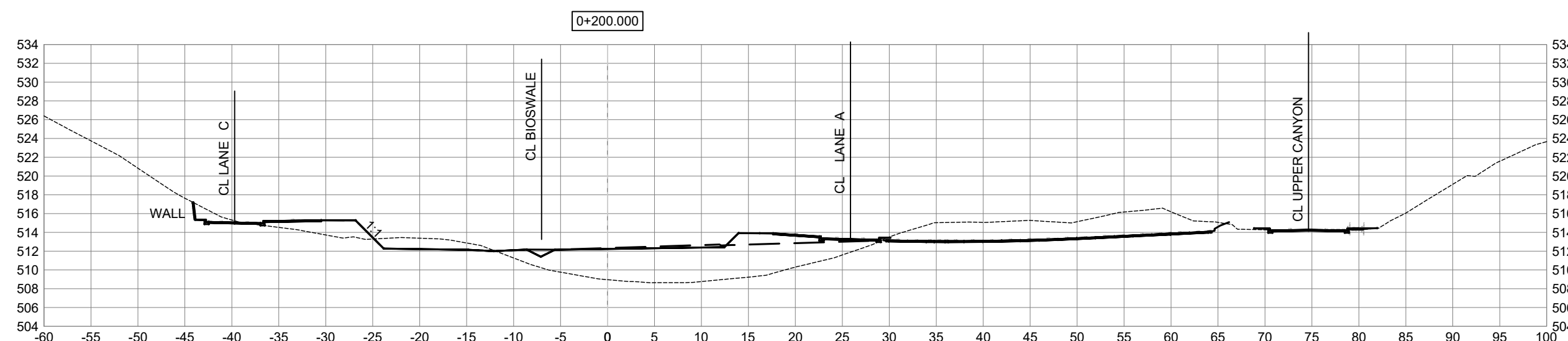
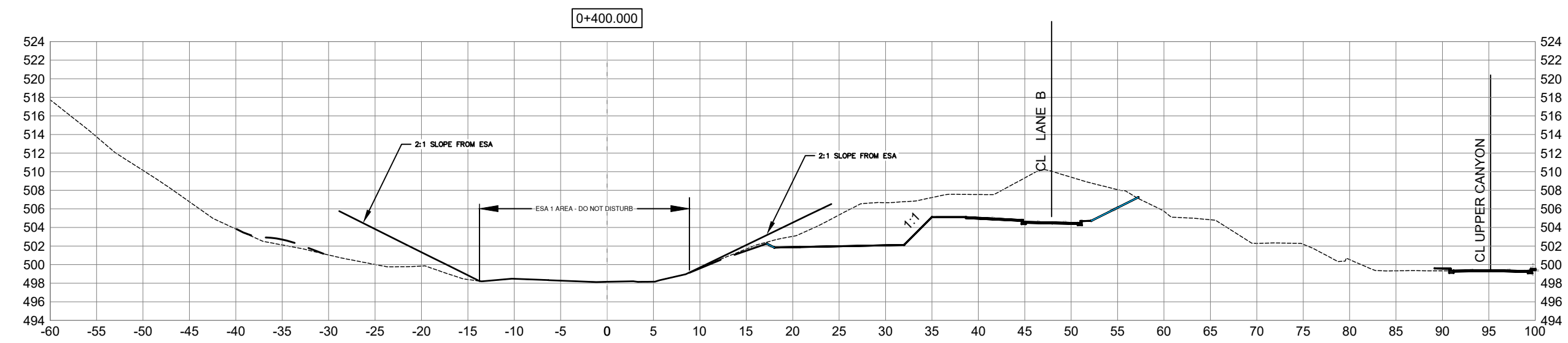
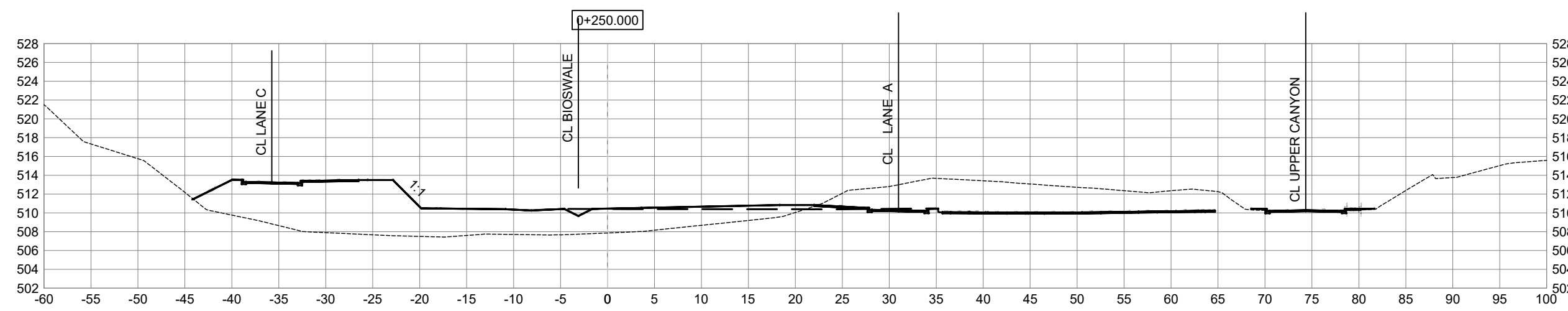




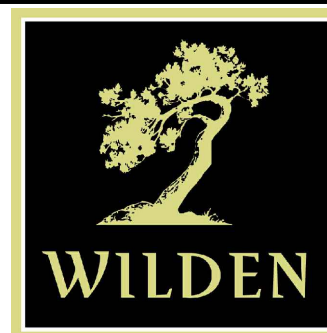




**TYPICAL BIOSWALE**  
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PARKS DIVISION Super.	
CITY ENGINEER	
AS-BUILT APPROVAL	

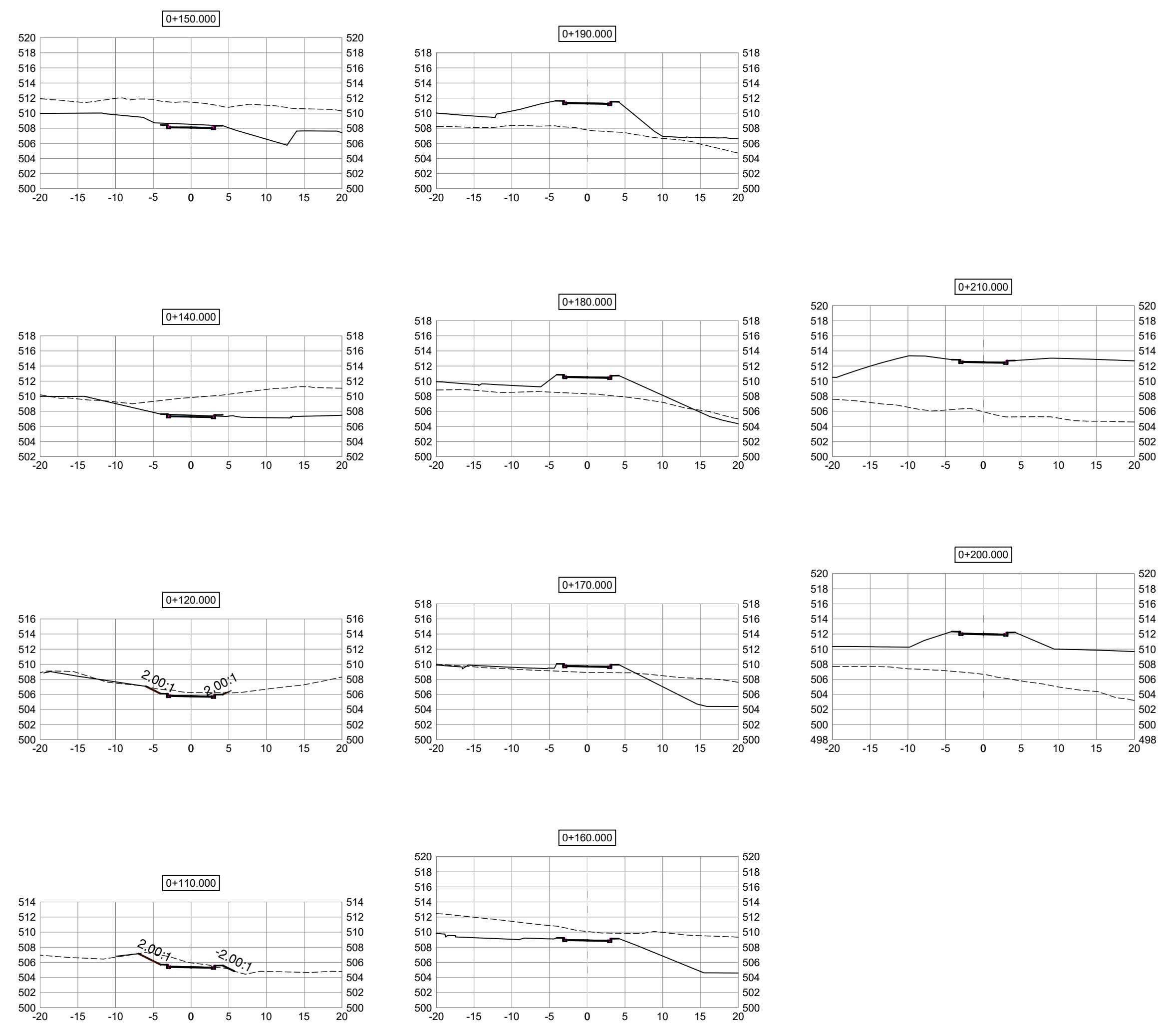
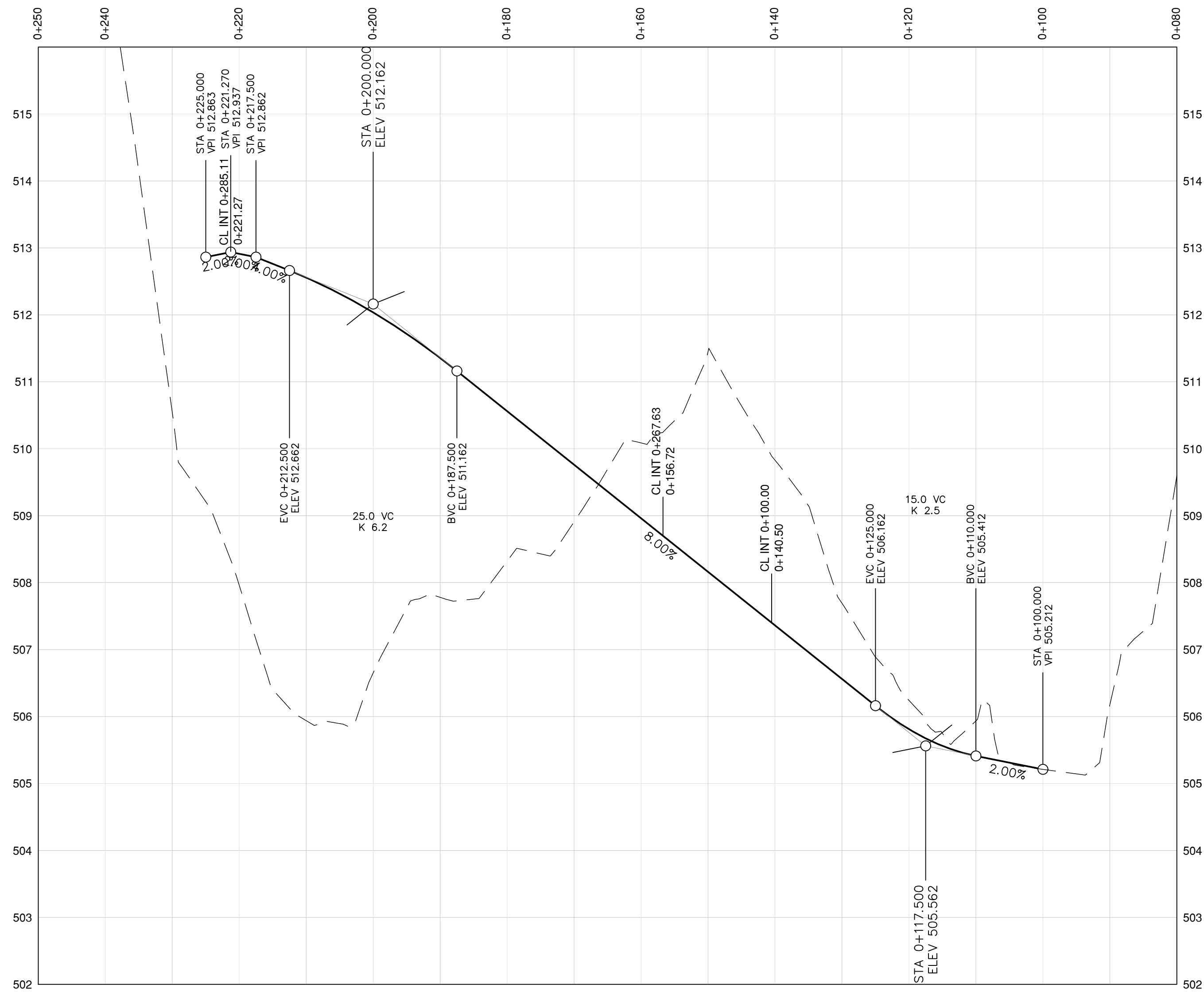
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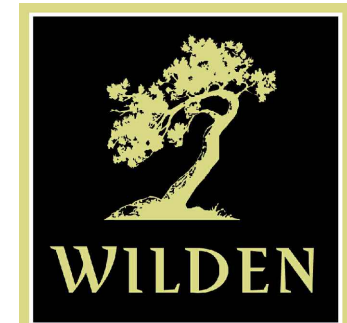
**CITY OF KELOWNA**  
**WILDEN CONSTRUCTION CORP.**  
**CATTAIL POND**  
**SITE SECTIONS**

Drawing No. 201827 - C2.1	Rev.No A

ALIGNMENT: ROAD A



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CITY OF KELOWNA  
 WILDEN CONSTRUCTION CORP.  
 CATTAIL POND  
 ROAD A PROFILE & CROSS SECTIONS

  
 Drawing No. 201827 - C3.0  
 Rev.No A

SEAL















**EROSION AND SEDIMENT CONTROL PLAN**

**GENERAL NOTES:**

1. EROSION AND SEDIMENT CONTROL DRAWINGS ARE PROVIDED FOR REFERENCE ONLY AND WERE PREPARED SPECIFICALLY FOR APPROVALS FROM THE CITY OF KELOWNA. THEY MAY NOT INCLUDE ALL THE MEASURES REQUIRED. THE CONTRACTOR(S) SHALL COMPLY WITH ALL REGULATORY AUTHORITIES AND SHALL BE RESPONSIBLE FOR ALL COSTS IN COMPLYING WITH THESE MEASURES.
2. PRIOR TO, AND DURING CONSTRUCTION, THE CONTRACTOR SHALL TAKE ADEQUATE STEPS, INCLUDING BUT NOT LIMITED TO: DIVERTING FLOWS FROM EXPOSED AREAS, PROVIDING CHECK DAMS AND CHANNEL PROTECTION IN TEMPORARY AND PERMANENT ON-SITE DRAINAGE COURSES, INSTALLATION OF SEDIMENT FENCES AROUND THE DEVELOPMENT PERIMETER AS SHOWN AND SOIL STOCKPILES, INSTALLATION OF FILTER OR COMPOST TUBES AROUND THE PERIMETER OF ALL CATCH BASINS, STABILIZED CONSTRUCTION ENTRANCES, POLY SHEETING, HYDRO SEEDING, STRAWING, DITCHING AND ANY OTHER MEASURES AS MAY BE NECESSARY TO PREVENT SEDIMENT AND OTHER BELTERIOUS MATERIALS FROM THE WORKS ENTERING THE STORM SEWER SYSTEM AND RECEIVING WATER COURSE.
3. ALL WORK TO BE UNDERTAKEN AND COMPLETED BY THE CONTRACTOR IN SUCH A MANNER AS TO PREVENT THE RELEASE OF TURBID AND SEDIMENT LADEN WATER INTO ANY WATER COURSE AND STORM SEWER. THE QUALITY CRITERIA FOR THE SITE IS THAT ALL RUNOFF GENERATED FROM THE SITE IS TO CONTAIN LESS THAN 75mg/L TSS AFTER SIGNIFICANT RAINFALL EVENTS, TURBIDITY TO BE 25 NTU'S OR LESS DURING NORMAL WEATHER CONDITIONS (LESS THAN 25mm OF RAIN IN A 24 HOUR PERIOD).
4. ALL SEDIMENT CONTROLS FACILITIES TO REMAIN IN PLACE UNTIL 90% OF ON-SITE CONSTRUCTION IS COMPLETE.
5. WHILE CIVIL SITE CONSTRUCTION IS ONGOING, THE SITE SERVICING CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING SEDIMENT CONTROL FACILITIES ARE INSTALLED, MAINTAINED AND WORKING ADEQUATELY TO CONTROL ALL DISCHARGES FROM THE SITE. ALL FACILITIES SHALL BE INSPECTED BY ECORA ENGINEERING CONSULTANTS ON A WEEKLY BASIS AND AFTER EVERY RAINFALL EVENT TO ENSURE PROPER OPERATION UNTIL REMOVAL.
6. DURING HOME CONSTRUCTION AND ONCE ALL CIVIL SITE WORKS ARE COMPLETE, THE DEVELOPER IS RESPONSIBLE FOR ENSURING THAT SEDIMENT CONTROL FACILITIES ARE MAINTAINED AND WORKING ADEQUATELY TO CONTROL ALL DISCHARGES FROM THE SITE.
7. ANY IRREGULARITIES BE SHALL BE REPORTED TO THE ENGINEER OF RECORD IMMEDIATELY.
8. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING PAVED ROAD SURFACES ARE KEPT CLEAN OF ANY ACCUMULATIONS OF SOIL UNTIL COMPLETION OF ALL CIVIL WORKS FOLLOWING WHICH IT WILL BECOME THE DEVELOPER'S RESPONSIBILITY. FLUSHING IS PROHIBITED. CONTRACTOR SHALL ALSO BE RESPONSIBLE FOR DUST CONTROL.
9. ALL STOCKPILED MATERIAL SHALL BE COVERED WITH POLY AND SURROUNDED WITH SILT FENCE.
10. DURING CONSTRUCTION THE CONTRACTOR MAY NEED TO EMPLOY ADDITIONAL MEASURES INCLUDING BUT NOT LIMITED TO INTERCEPT DITCHES, SILT FENCES, ROCK CHECK DAMS, ETC TO PREVENT THE RELEASE OF SEDIMENT LADEN WATER TO THE EXISTING WATERCOURSES. THE CONTRACTOR SHALL HAVE AN EMERGENCY SUPPLY OF EROSION CONTROL MEASURES ON SITE AT ALL TIMES.

**STAGE 1 - CLEARING, GRUBBING, STRIPPING & GRADING**

1. CONTRACTOR TO INSTALL SILT FENCE AT LOCATIONS AS SHOWN ON THIS DRAWING.
2. CONTRACTOR TO INSTALL GRAVEL SITE ACCESS PAD OFF UPPER CANYON DRIVE. ALL VEHICLES TO ENTER AND EXIT THE SITE VIA THE GRAVEL ACCESS PAD. THE ACCESS PAD SHALL BE CONSTRUCTED WITH 150mm, CLEAN, WELL GRADED RIPRAP 300mm THICK ON NON WOVEN FILTER FABRIC. SINCE THE PAD IS LOCATED WITHIN THE ROAD ALIGNMENT, THE PAD SHALL BE REMOVED PRIOR TO PLACEMENT OF PIT RUN GRAVEL.
3. CONTRACTOR TO BE RESPONSIBLE FOR SUPPLYING, INSTALLING, AND REMOVING ANY TEMPORARY CULVERTS AT WATERCOURSE CROSSING LOCATIONS TO ENSURE FREE FLOW OF WATER THROUGH THE WATERCOURSES AT ALL TIMES.
4. CONTRACTOR TO PROVIDE MECHANICAL SWEEPING OF ON-SITE ROADS TO REMOVE ANY ACCUMULATIONS OF SEDIMENT ANY ACCUMULATIONS OF SEDIMENT AS A RESULT OF CONSTRUCTION ACTIVITIES, SUCH OPERATIONS TO BE CARRIED OUT ON A WEEKLY BASIS (MIN) OR AS DIRECTED BY THE ENGINEER OF RECORD OR HIS REPRESENTATIVE, PARTICULARLY IN ADVANCE OF INCLEMENT WEATHER CONDITIONS. NO FLUSHING ALLOWED.
5. ALL DISTURBED AREAS TO BE RESTORED AND HYDROSEED AS SOON AS POSSIBLE FOLLOWING SITE SERVICING CONSTRUCTION. HYDROSEED TO BE DRAUGHT TOLERANT TO DOLC STANDARDS.
6. CONTRACTOR SHALL INSTALL CATCH BASIN SEDIMENT TRAPS BY LAYFIELD (OR APPROVED EQUAL) IN EXISTING CATCH BASINS ON THE OFFSITE ROADS PRIOR TO COMMENCING CONSTRUCTION.

**STAGE 2-CONSTRUCTION OF ROADS AND UNDERGROUND UTILITIES**

- 1) STOCKPILES OF EXCAVATED MATERIALS ARE TO BE PROTECTED WITH 6mm THICK POLYETHYLENE SHEETING (OR SIMILAR) AND SURROUNDED BY SILT FENCE TO MINIMIZE SOIL EROSION DUE TO RAINFALL EVENTS.
- 2) FOLLOWING INSTALLATION OF THE CB'S AND DITCH INLET, INSTALL "FILTERSOXX", "TERRATUBE" OR APPROVED EQUAL CB SURROUNDS AROUND THE CB AND DITCH INLET TO PREVENT SEDIMENT FROM ENTERING THE NEW STORM SEWER SYSTEM.
- 3) DURING THE CONSTRUCTION PERIOD, PROVIDE MECHANICAL STREET SWEEPING ALONG OFFSITE ROADS TO REMOVE ANY ACCUMULATION OF SEDIMENT AS A RESULT OF CONSTRUCTION ACTIVITIES, AS DIRECTED BY THE ENGINEER OF RECORD.

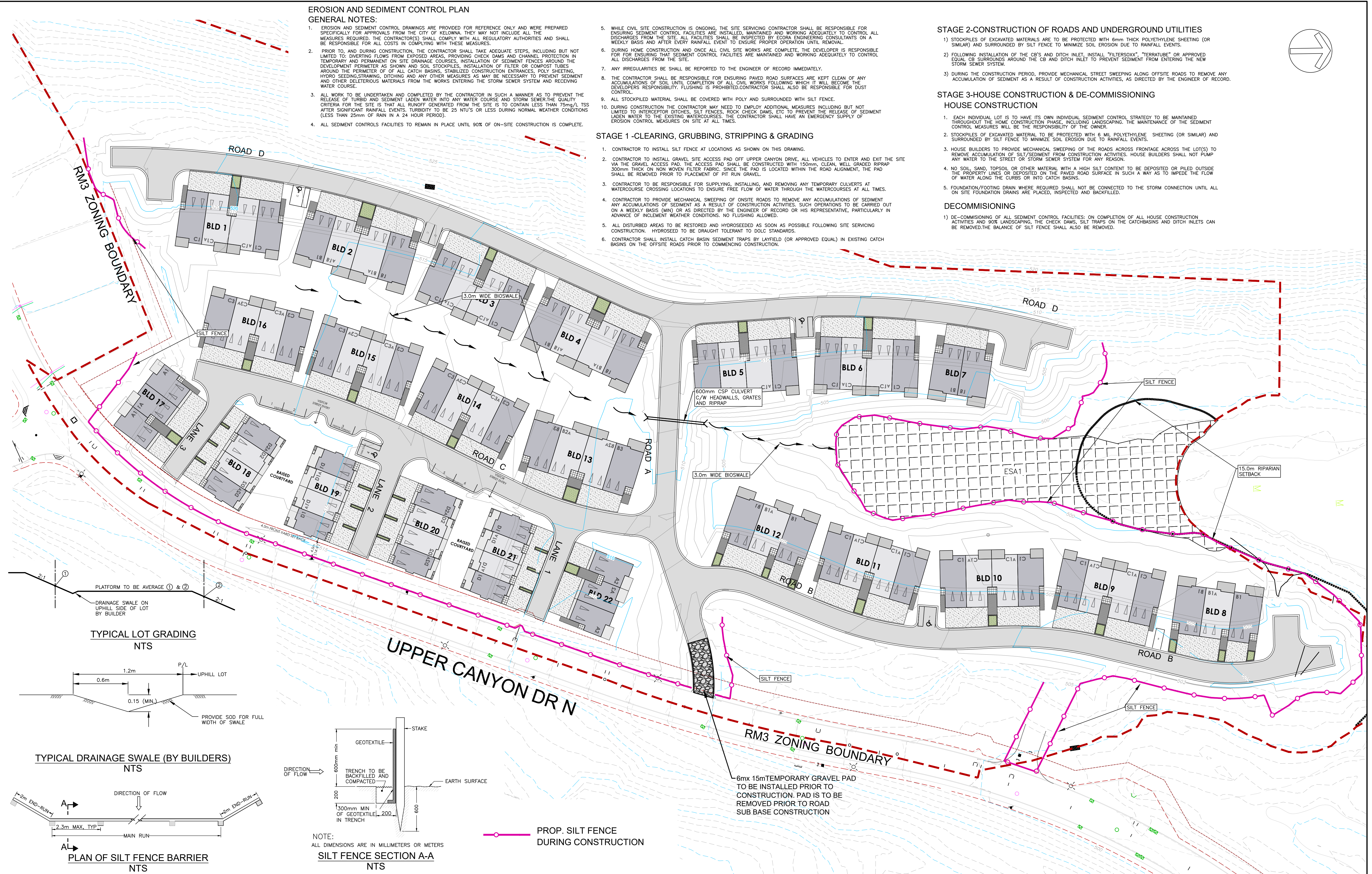
**STAGE 3-HOUSE CONSTRUCTION & DE-COMMISSIONING**

**HOUSE CONSTRUCTION**

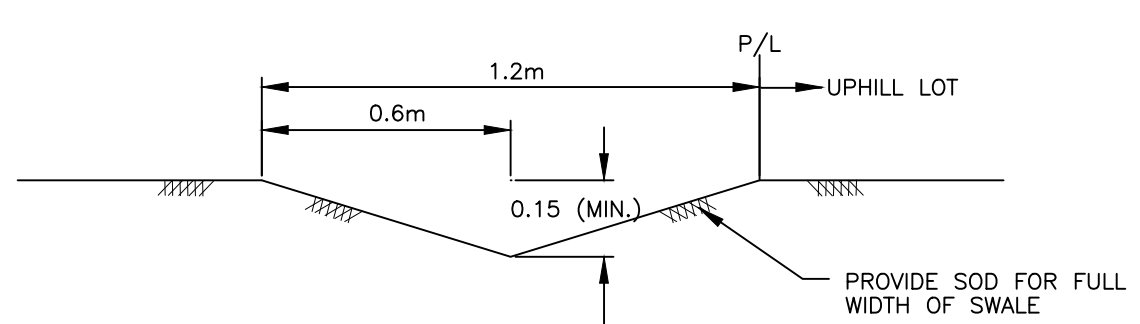
1. EACH INDIVIDUAL LOT IS TO HAVE ITS OWN INDIVIDUAL SEDIMENT CONTROL STRATEGY TO BE MAINTAINED THROUGHOUT THE HOME CONSTRUCTION PHASE, INCLUDING LANDSCAPING. THE MAINTENANCE OF THE SEDIMENT CONTROL MEASURES WILL BE THE RESPONSIBILITY OF THE OWNER.
2. STOCKPILES OF EXCAVATED MATERIAL TO BE PROTECTED WITH 6 MIL POLYETHYLENE SHEETING (OR SIMILAR) AND SURROUNDED BY SILT FENCE TO MINIMIZE SOIL EROSION DUE TO RAINFALL EVENTS.
3. HOUSE BUILDERS TO PROVIDE MECHANICAL SWEEPING OF THE ROADS ACROSS FRONTAGE ACROSS THE LOT(S) TO REMOVE ACCUMULATION OF SILT/SEDIMENT FROM CONSTRUCTION ACTIVITIES. HOUSE BUILDERS SHALL NOT PUMP ANY WATER TO THE STREET OR STORM SEWER SYSTEM FOR ANY REASON.
4. NO SOIL, SAND, TOPSOIL OR OTHER MATERIAL WITH A HIGH SILT CONTENT TO BE DEPOSITED OR PILED OUTSIDE THE PROPERTY LINES OR DEPOSITED ON THE PAVED ROAD SURFACE IN SUCH A WAY AS TO IMPEDE THE FLOW OF WATER ALONG THE CURBS OR INTO CATCH BASINS.
5. FOUNDATION/FOOTING DRAIN WHERE REQUIRED SHALL NOT BE CONNECTED TO THE STORM CONNECTION UNTIL ALL ON SITE FOUNDATION DRAINS ARE PLACED, INSPECTED AND BACKFILLED.

**DECOMMISSIONING**

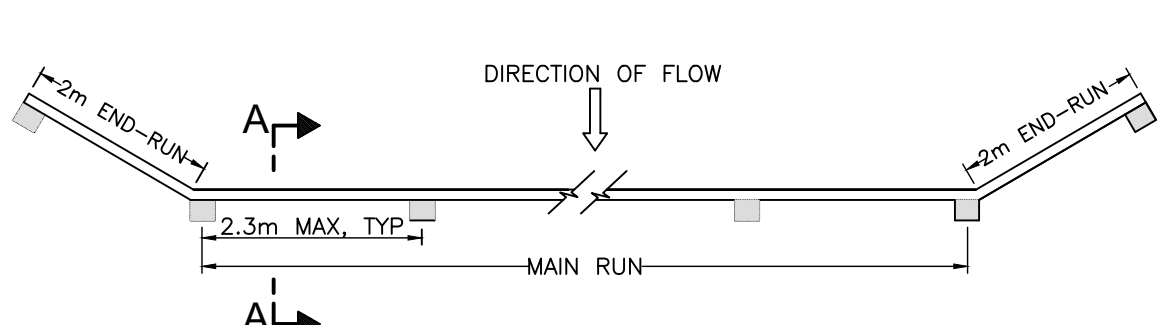
- 1) DE-COMMISSIONING OF ALL SEDIMENT CONTROL FACILITIES: ON COMPLETION OF ALL HOUSE CONSTRUCTION ACTIVITIES AND 80% LANDSCAPING, THE CHECK DAMS, SILT TRAPS ON THE CATCHBASINS AND DITCH INLETS CAN BE REMOVED. THE BALANCE OF SILT FENCE SHALL ALSO BE REMOVED.



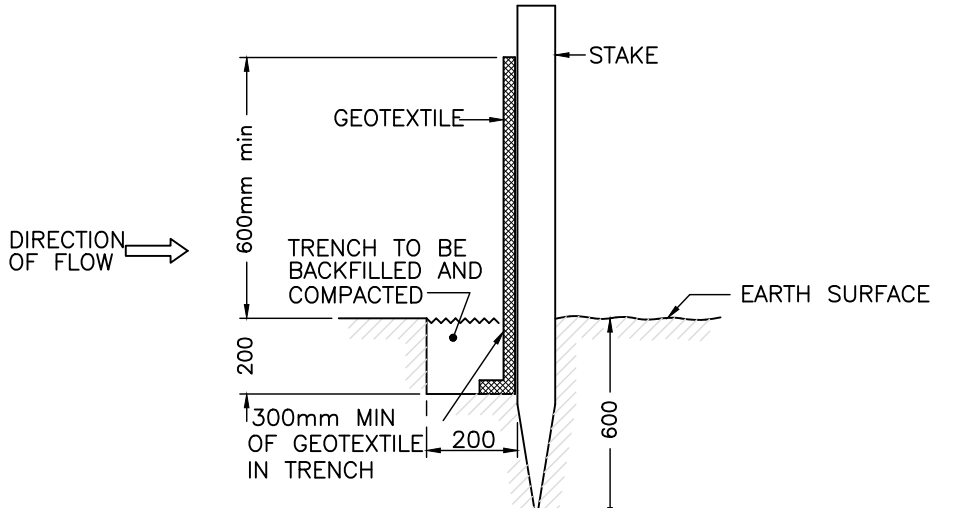
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**TYPICAL DRAINAGE SWALE (BY BUILDERS)**  
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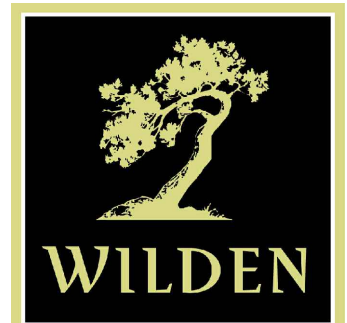
**PLAN OF SILT FENCE BARRIER**  
NTS



**SILT FENCE SECTION A-A**  
NTS

NOTE: ALL DIMENSIONS ARE IN MILLIMETERS OR METERS

PROP. SILT FENCE DURING CONSTRUCTION



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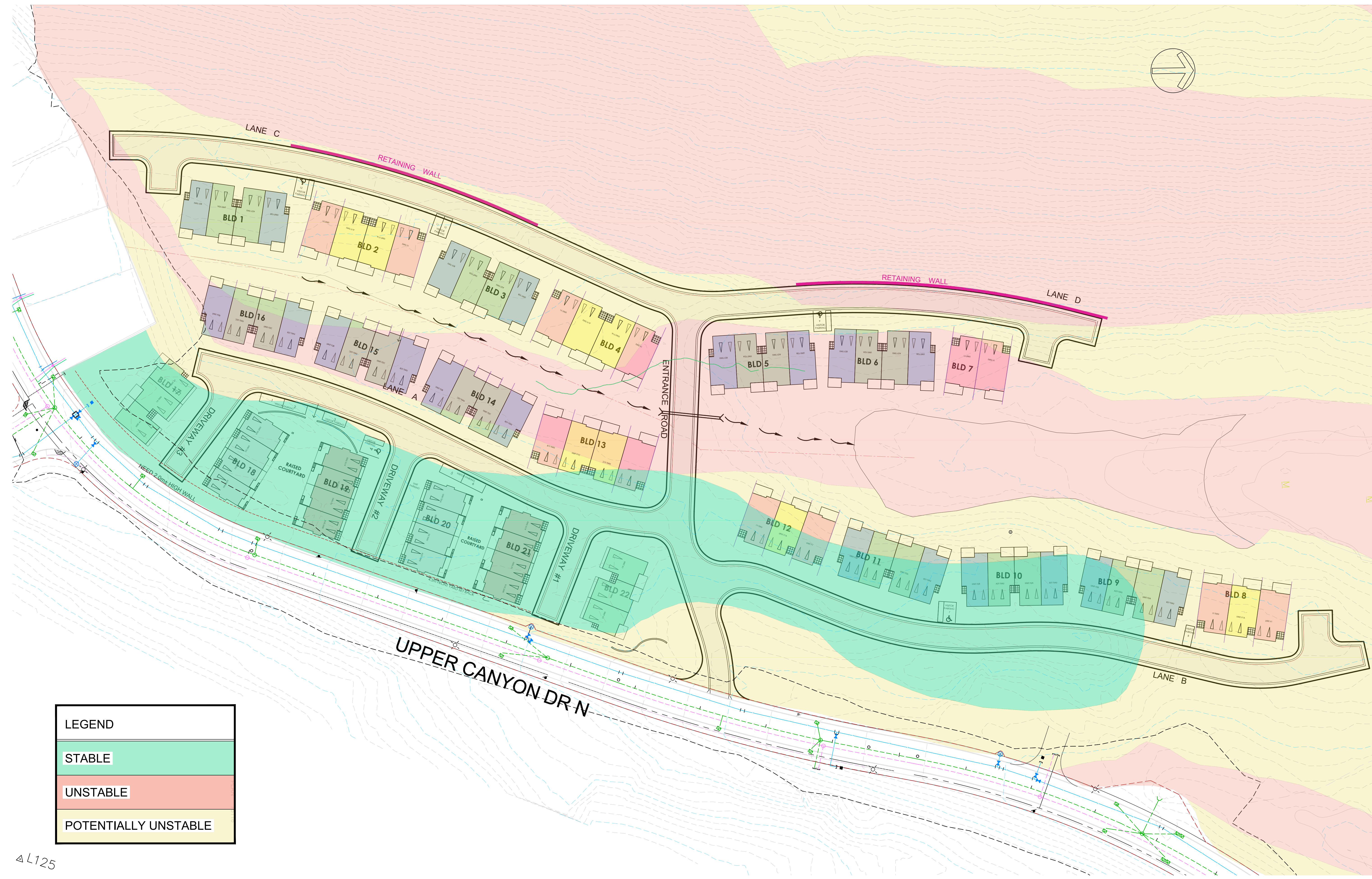
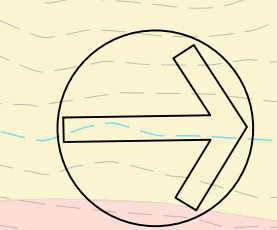
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WILDEN CONSTRUCTION CORP.  
CATTAIL POND  
EROSION/SEDIMENT CONTROL PLAN

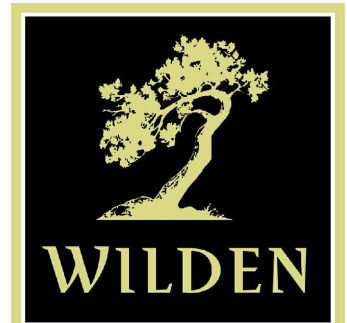
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LEGEND	
	STABLE
	UNSTABLE
	POTENTIALLY UNSTABLE

4L125



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**CITY OF KELOWNA**  
 WILDEN - CATTAIL POND  
 BLENK DEVELOPMENT CORP  
 PRELIMINARY LAYOUT w GEO AREAS

**City of Kelowna**  
 Drawing No. 201827 - C9.0  
 Rev.No A

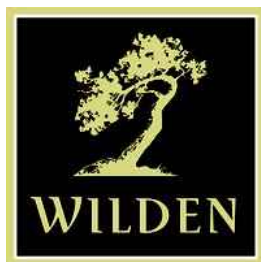
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# Geohazard Assessment Report

## 225 Upper Canyon Drive North, Kelowna, BC

Presented To:



Dated: December 2021

Ecora File No.: 201827

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## Presented To:

Wilden Construction Corp.  
1454 Rocky Point Drive  
Kelowna, BC, V1V 3E3

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2021-12-23

Date

### Version Control and Revision History

Version	Date	Prepared By	Reviewed By	Notes/Revisions
0	2021-12-23	DT/NM-H	MJL	Issued For Use

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

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## Acronyms and Abbreviations

ASP	Area Structure Plan
BC	(Province of) British Columbia
BCBC	British Columbia Building Code (2018)
BC MoTI	British Columbia Ministry of Transportation and Infrastructure
DP	Development Permit
EGBC	Engineers and Geoscientists of British Columbia (formerly APEGBC)
E.I.T	Engineer in Training (registered with EGBC)
ESA	Environmentally Sensitive Area
ESCP	Erosion Sediment Control Plan
FCL	Flood Construction Level
FLNRORD	(British Columbia Ministry of) Forests, Lands, Natural Resource Operations and Rural Development
GSC	Geological Survey of Canada
GIC	Geographic Information Centre
G.I.T	Geoscientist in Training (registered with EGBC)
m asl	meter(s) above sea level
OCP	Official Community Plan
P.Eng.	Professional Engineer (registered with EGBC)
P.Geo.	Professional Geoscientist (registered with EGBC)
RIC	Resource Inventory Committee
SWMP	Storm water management plan
UBC	University of British Columbia

# 1. Introduction

## 1.1 General

Ecora Engineering & Resource Group Ltd. (Ecora) was retained by Wilden Construction Corp. to provide Consulting Engineering Services (civil, geotechnical, and environmental) in support of a proposed multi-family development at 225 Upper Canyon Drive North, Kelowna, BC (the Site).

The purpose of this Geohazard Assessment Report is to provide a high-level evaluation of the suitability of the Site for the proposed development, and to satisfy the City of Kelowna's Development Permit (DP) requirements (Development Bylaw No. 7900, 2020).

Ecora understands that the proposed development is to comprise 118 units consisting of 4-plex and 6-plex townhomes, including new roadways, and associated infrastructure. It is anticipated that the proposed development will fall within the design requirements of Part 9 of the British Columbia Building Code (BCBC, 2018). Should the structures fall under Part 4 of the BCBC (2018), further geotechnical investigation, assessment, and analysis may be required.

This geohazard assessment was completed in accordance with the professional association for Engineers and Geoscientists of British Columbia (EGBC) "Guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia" (2010).

This report summarizes our desktop review, site reconnaissance observations, and a high level geohazard assessment based on our current understanding of the proposed site development. The findings of our Environmental and Preliminary Geotechnical Assessments are summarized in separate reports, however, should be read in conjunction with this report.

## 1.2 Scope of Work

The geotechnical scope of work for this project is outlined in Ecora's proposal, dated December 17, 2020, and included a phased approach, as outlined below:

- Phase 1: Preliminary Geotechnical Assessment
  - Task 1: Desktop Assessment and Site Reconnaissance
  - Task 2: Preliminary Geotechnical Site Investigation
  - Task 3: Laboratory Testing
  - Task 4: Slope Stability Analysis and Reporting
- Phase 2: Detailed Geotechnical Design and Analysis
- Phase 3: Construction Geotechnical Services

Authorization to proceed with the geotechnical scope of work was received from Mr. Cameron Dodd, Development Manager at Wilden Construction Corporation, on June 4, 2021. This report addresses Phase 1, Task 1 of the above work scope.

## 1.3 Site Description

The subject property is located at 225 Upper Canyon Drive North (the Site), Kelowna, BC (see Figure 1.3). The legal description of the property is Plan KAP75116 Lot D, Section 8, Township 23, Except Plan EPP24895, EPP24897, and is currently zoned as RM3 (low density multiple housing). According to the City of Kelowna (the City) property report, the lot is approximately 54,000 m<sup>2</sup> (13.34 acres).

The Site is situated on an undeveloped greenfield site, bounded by Upper Canyon Drive to the east, residential lots to the south, and undeveloped property to the north and west. The property generally slopes down towards the west with relatively steeper gradients along the western boundary, with elevations ranging from approximately 545 m above sea level (m asl) at the southeast corner of the property, to 500 m asl at the northeast corner of the property.

## 1.4 Proposed Development

The proposed development is to comprise 118 units consisting of 4-plex and 6-plex townhouses, as well as new roadways, and associated infrastructure (see Appendix B). Based on the conceptual design, the townhouse structures will be situated along the toe of the slope along the eastern property boundary; a short row of townhouses to the south of the wetland/marsh area, adjacent to existing residential structures; a row of townhouses along Upper Canyon Drive North, situated perpendicular to the road, neighbouring existing residential structures within the southwest portion of the Site; and a row of townhouses setback from the road, behind a natural bedrock ridge, overlooking the wetland/marsh at the northwest section of the Site. The specific details of site grading, and whether units will have basements, partial basements, fills, etc. is not finalized.

# 2. Geology and Topography

## 2.1 Surficial Geology

The Geological Survey of Canada (GSC) 1:50,000 “Surficial Geology Map, Kelowna” (Paradis, 2009), indicates the Site is underlain by a continuous till blanket comprising “...*lodgement and ablation facies*...”, overlying bedrock. The Site is located between bedrock ridges located to the east and west. A small area of Quaternary age organic sediments comprising “*muck, mucky peat, marl and peat*...” is shown immediately north of the property boundary, along the base of the western bedrock ridge.

## 2.2 Bedrock Geology

The GSC 1:100,000 scale “Geology, Okanagan Watershed, British Columbia” (Okulitch, 2013), indicates the underlying bedrock is from the Nimpit Lake Member of the Marron Formation, and is comprised of “*lava, trachyte, trachyandesite; minor breccia*”.

## 2.3 Topography

The Site is located on the eastern side of a bedrock-controlled ridge that is aligned parallel to the eastern side of Lake Okanagan, extending from Knox Mountain Park to the south, terminating at McKinley Landing to the north.

The subject property is located on the lower slopes of the bedrock-controlled ridge, between the base of a moderately steep to steep slope (27°->35°), which rises up to >700 m elevation, and a moderate to moderately steep (16°-35°) ridge (up to 50 m high). The elevation within the subject site ranges between 518 m and 543 m

elevation along the western boundary of the site, and 500 m to 519 m elevation along Upper Canyon Drive North. The lowest elevation point is 498 m at the northern end of the property at the interface between the wetland and Rush Pond.

Glacial fluting lineaments shown on the GSC “Surficial Geology Map, Kelowna” (Paradis, 2009) generally trend north/south (N-S) to north-north-east/south-south-west (NNE-SSW). The glacial fluting has resulted in a natural switchback ramp configuration for the watershed to drain from Rush Pond, east into Wilden Pond, north into Walroy Lake, and south into Still Pond before draining further south into the Glenmore Valley.

A small watercourse flows from south to north through the middle of the Site to Rush Pond. A mound at the southwestern corner of the subject site appears to have impacted the natural drainage channel and blocked it in the past.

### 3. Desktop Study

#### 3.1 Background Review

**Glenmore Highlands, Area Structure Plan (Ekistics Town Planning Inc., 2000)**

An Area Structure Plan (ASP), coordinated by Glenwest Properties Ltd., was developed to provide a framework for development of the Glenmore Highlands through ‘community design, public consultation, agency input, and municipal review’. The Glenmore Highlands area is approximately 720 hectares, with the boundary extending north to Stephen’s Coyote Ridge Regional Park, Clifton Road to the west, Glenmore Valley to the east, and Knox Mountain Park to the south. The ASP was developed to conform within the City of Kelowna’s development policies and guidelines, and conceptually assist with future rezoning and subdivision applications.

#### 3.2 Historic Aerial Photographs

Available historic aerial photography obtained from the Geographic Information Centre (GIC) at the University of British Columbia (UBC) for the area between 1938 and 2006 was reviewed using a stereoscope to assist with understanding the history of development around the Site, and to help identify large scale geomorphological features that would be difficult to identify in the field. Identification of features is limited to the resolution and the elevation at which the aerial photography was taken. **Error! Reference source not found.** summarizes the aerial photographs (year, scale, and type) used.

**Table 3.2 Summary of Historic Aerial Photos Reviewed for 225 Upper Canyon Drive North, Kelowna, BC.**

Year	Aerial Photo No.	Scale	Type
1938	BC132: 52-54	Not available	Black and White
1959	BC1247: 42-43 A16658: 25-26	Not available	Black and White
1963	BC4181: 167-169	1:16,000	Black and White
1969	BC5329: 128-129	1:32,000	Black and White
1975	BC7590: 220-222	1:16,000	Black and White
1980	15BC80070: 215-217	1:20,000	Black and White
1985	30BCC352: 172-173 30BCC362: 167-169	1:15,000	Black and White
1992	30BCC92041: 194-196	1:15,000	Black and White

Year	Aerial Photo No.	Scale	Type
1998	30BCB98004: 120-122; 164-166	1:10,000	Black and White
2001	15BCC01030: 221-222	1:30,000	Colour
2006	2006031/1: 160-162	Not available	Colour

The review of the aerial photographs noted the following:

- In 1938, no development or infrastructure on the mountainside above the existing Glenmore neighbourhood had been established. An unpaved local road was observed along the general position of the existing Union Road alignment. Local trails were also observed around the subject site. Glenmore Road North had been established and the main land use type in the Glenmore Valley, east of the subject site was agricultural activity (orchards). An orchard has been established on the northern boundary of Walroy Lake.

Two lineament sets were observed within the bedrock-controlled topography (shown to be ‘Glacial Fluting’ on the GSC “Surficial Geology Map, Kelowna” (Paradis, 2009)).

There is evidence of at least one large rock fall event, which has deposited debris on the terrace above the subject site. Smaller localized rock fall/landslide failures were also observed on both the eastern and western slopes flanking the Site. The western slope immediately above the project site was moderately to densely vegetated with trees.

- By 1975, no change was observed at the project site. The general alignment of Union Road had been established further as an apparent trail. Residential development was being established in the Glenmore Valley, along North Glenmore Road.
- By 1985, localized rock failures were observed on the western slopes above Rush Pond. The frequency of local, unpaved road networks around the subject site had been expanded. Residential development was observed to the north of Walroy Lake.
- By 1992, Walroy Lake and Wilden Pond were observed to have significantly reduced in size. Two possible rockslide features were noted along the southern portion of Site however, the resolution was such that they could not be confirmed. Significant residential development had occurred in the Glenmore Valley, along the southern portion of North Glenmore Road. Further development of local roads had occurred, including the current Begbie Road.
- By 1998, Walroy Lake had changed shape along the northern margin due to construction of a berm and laydown site. Vegetation had also been cleared between Wilden Pond and Walroy Lake. Significant development had occurred in the Glenmore Valley, around Millard Glenn Park and Snowsell Street. Local road development was occurring along the current Union Road.
- By 2001, a notable reduction in the Wilden Pond surface area was observed due to vegetation clearance at the northern end of the pond.
- By 2006, significant construction had occurred at Longridge Drive, north of Walroy Lake, and at Glenmore Highlands. Partial residential development was observed along Hidden Lake Place. Begbie Road had been realigned. Union Road and was under constructed to intersect with Begbie Road.

Historic Google Earth™ images were used to supplement the aerial photography of the Site between 2006 and 2020. The following additional observations were made:

- By 2002, Union Road had been established as an unpaved, local road.

- By 2004, the wetland area on Site, leading to Rush Pond appears to be in the process of being 'managed' and has been reduced in area size. An earth berm is observed along the northern margin of Rush Pond. Vegetation clearance and site laydown area preparation was expanding between Wilden Pond, Still Pond, and Walroy Lake, in preparation for construction of Union Road. Residential development had occurred along parts of Longridge Drive, Trucker Court, and the current Union Road.
- By 2005, Union Road had been paved above Still Pond, north of Longridge Drive and Trucker Court.
- By 2009, further residential construction had occurred along the western edge of Still Pond and Union Road, and development of the Hidden Lake Park neighbourhood had been completed. Union Road paving had been completed. Paving of Upper Canyon Drive from the Clifton Road access of the Wilden development had commenced, as well as side roads, and some lot development.
- By 2012, both ends of Upper Canyon Drive (from Clifton Road and from Glenmore) have been connected however the Clifton side was more developed. The connection was completed by mid-2012. Grading and site preparation for Upper Canyon Drive, the Glenmore Road bypass in the Glenmore Valley had been completed.
- By 2015, residential construction along Upper Canyon Drive North had commenced. Site preparation was underway for the Forest Edge Drive area.
- By 2017, significant development of the Wilden residential area was observed. Construction of the Hidden Lake Park area, north of Walroy Lake, had been completed.
- By 2018, construction of the Forest Edge Drive area had been completed.

No significant changes were observed between 2018 and 2020.

### 3.3 Water Well Database

The Provincial Water Well Database, iMapBC, indicates that there is no water well records within a reasonable distance or elevation to be considered relevant to the study area.

The nearest waterways are Rush Pond to the north, and Wilden Pond to the northwest of the subject property.

## 4. Site Reconnaissance

### 4.1 General

Ecora representatives Ms. Naomi Mason-Herrtage, P.Geo., Mr. Daniel Tamas, G.I.T., Mr. Devon Adamson, E.I.T., completed a site reconnaissance on June 8, 2021. Weather conditions at the time of the site visit were sunny to overcast, with temperatures of approximately 14°C to 22°C. Prior to the site reconnaissance, light rain had occurred on June 6, 2021. Select photos are provided at the end of the report. Select placemark reference numbers are shown on Figure 1.3.

Key observations from the site reconnaissance are summarized below:

- A high pressure fortis gas pipeline was observed along the road frontage of the Site (Placemarks 1 and 39), with several manholes also observed.

- A very low flow to stagnant stream traverses through the middle of the Site, draining to the north, through a wetland area towards Rush Pond. Deposition of possible colluvial and/or fluvial soils at the southern end of the Site has impacted the natural water course, partially blocked the flow, and shifted it east towards the bedrock ridge. Standing water was observed at Placemark 26 being the furthest upstream location where water was observed within the stream bed.
- Within the subject site upstream, to the southwest (Placemark 4), the stream channel was approximately 5 m wide, with an upstream angle of 10° and downstream angle of 5°. No flow was observed; however, the soils were saturated at surface. At Placemark 21 the stream measured 0.94 m wide and 0.38 m deep; 2.5 m wide and 0.66 m deep at Placemark 24; and 2.5 m wide and 1.6 m deep at Placemark 25.
- The slope angles along the western boundary of the Site measured between 30° to 35°. Outcrops were exposed at the edge of upslope benches and were observed to be strong to very strong, generally massive with irregular fractures, moderately weathered, granitic bedrock.
- Irregularly formed benches were observed upslope of the Site. The lowest elevation bench above the southern portion of Site (Placemark 10) was approximately 15 m wide, with a ridge approximately 2.5 m high along the downslope edge. The rockfall reach angle ranges between 31°-45°, while the rock fall shadow angle is 22°-25°. Examples of these rockfall angles is shown in Figure 4.1. The talus appeared well graded, up to 250 mm x 180 mm x 50 mm in size.
- The lowest elevation bench above the northern portion of Site (Placemark 12) contained a rockfall reach angle of approximately 34°, and a rock fall shadow angle of about 32°. A historic rockfall zone was observed containing younger trees upslope, flanked by talus slopes, and cobbles with occasional boulders scattered along the bench below the assumed rockfall zone.
- A bedrock ridge is situated parallel to Upper Canyon Drive North, on the eastern side of the Site. Bedrock exposures observed were weak, moderately to highly weathered, moderately to highly fractured, and was estimated to be easily to moderately rippable. The bedrock fractured into angular, blocky, cobble sized fragments. A veneer of soil overlay the bedrock exposures.
- Slope angles along the ridge ranged from 11° to 18° down the eastern side, 13° to 27° down the western side, and a single measurement of 17° was measured down the northern slope.
- Bedrock at Placemark 29 was observed to be very weak, highly weathered, highly fractured, and chemically altered. The parent material appeared sedimentary in origin with visibly large grain size.

## 5. Geohazard Assessment

### 5.1 Regulatory Framework

The Land Title Act, Section 88, includes a statement that reads *“the land may be used safely for the use intended”*. The City’s ‘Hazardous Condition DP Guidelines’ (Chapter 13) provides conditions for Development Permits (DP) in hazard condition development areas. The City’s general guidelines include *“all developments have a level of safety for geotechnical failures with no more than a 2% probability of failure occurring in a 50-year period (a return period of 1:2,500 years) or adhere to the prevailing standard as set by the BC Building Code, whichever is greater”*.

## 5.2 Method of Assessment

Considering the insufficient detailed 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 qualitative assessment of the geohazards presented in the EGBC “Guidelines for Legislated Landslide Assessments” (2010), British Columbia Resources Inventory Committee (1996), and “Hazard acceptability Thresholds for Development Approvals by Local Government” by Dr. Peter Cave (1993). In this assessment, Ecora has reviewed the hazards that could potentially impact the subject property and provides recommendations for the safe use of the Site. Appendix D of the EGBC “Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC” is attached.

The Cave (1993) paper identified several 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 ‘subdivision’.

Eight types of geotechnical hazards were identified by Cave (1993). 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-scale landslides within the native soils and or uncontrolled fill;
- Snow avalanches;
- Rock falls; and,
- Large scale landslides within the native soils and/or uncontrolled fill.

It is important to note that designing a level of acceptable or tolerable risk is the role of the policy makers, whereas determining the hazard at a site, their magnitude and frequency, and appropriate mitigative measures / strategies necessary to render them acceptable at established hazard levels is the role of the qualified professionals (2010).

## 5.3 Potential Hazard Type and Estimated Frequencies

Table 5.3 below outlines the qualitative rating of hazard frequencies developed by the British Columbia Resource Inventory Committee (RIC) (1996) utilized in this study to rank the identified geohazards above.

The geohazard frequencies provided in Table 5.3 are estimated based on our engineering judgement, proposed development and site conditions at the time of preparation of this report. The estimated geohazard frequencies are subject to change, by ground modifications such as site regrading or drainage profiles and does not account for human activities which may affect geohazards.

**Table 5.3 Relative Terms and Ranges of Annual Probability of Hazard Occurrence**

Relative Terms of Probability	Range of Annual Probability of Exceedance (Pa)	Comments
Very High	>1/20	Indicates the hazard is imminent and well within the lifetime of a person or typical structure. Events occurring with a return interval of 1/20 or less generally have clear and relatively fresh signs of disturbance.
High	1/100 to 1/20	Indicates that the hazard can happen within the appropriate lifetime of a person or typical structure. Events are clearly identifiable from deposits and vegetation but may not appear fresh.
Moderate	1/475 to 1/100	Indicates the hazard within a given lifetime is not likely, but possible. Signs of previous events, such as vegetation damage may not be easily noted.
Low	1/2,475 to 1/475	Indicates the hazard is of uncertain significance.
Very Low	>1/2475	-

Based on RIC (1996)

## 5.4 Geohazards

### 5.4.1 Terrain Classification

Ecora developed terrain and terrain stability classification maps (see Figures 5.4.a and 5.4.b) based on the field reconnaissance, historical aerial photography, preliminary results from the limited geotechnical site investigation, and additional background information reviewed. The terrain classification was undertaken in accordance with the BC Terrain Classification System (Howes & Kenk, 1997), and following the BC Province methods for terrain mapping (RIC, 1996). These methods represent current standards of practice for terrain mapping in BC and provide a consistent and standardized approach.

Interpretation of the terrain indicates that the Site is bedrock controlled with a thin veneer of Till-like soil on the ridges and benches, deposited during the Fraser Glaciation, and colluvial soils on the steep slopes. The glacial flutes observed on the slopes to the west of the subject site indicate the direction of glacial movement. Sediments deposited within the stream and wetland are predominantly derived from modern fluvial processes.

**Table 5.4.a Terrain Classification within the Project Area**

Terrain Unit	Description
X	Man-made fill and/or reworked material.
zsFp	Unconsolidated silt and sand fluvial plain sediments.
zsF <sup>A</sup> p	Unconsolidated silt and sand from an active fluvial plain.
zsFt/C-R	Unconsolidated silt and sand fluvial terrace sediments.
Mw/R	Mantle of Till of unknown, variable thickness, overlying bedrock.
zsCv/R	Unconsolidated colluvial soils intermixed with fluvial silts and sands, overlying bedrock.
rCv/Rs	Veneer of colluvium/talus overlying moderately steeply sloped (27°-35°) to steeply sloped (>35°) bedrock.

**Table 5.4.b Terrain Stability Criteria within the Project Area**

Terrain Stability Class	Description
Stable	No obvious signs of historic instability or erosion. Soils generally have a low susceptibility to slope instability.
Potentially Unstable	Some signs of slope instability or erosion. Generally, over steepened slopes and/or soils with moderate susceptibility or slope instability. Evidence of significant earthworks and/or unconsolidated, reworked material.
Unstable	Obvious signs of historic instability or erosion. Generally, over steepened slopes and/or soils with high susceptibility or slope instability

## 5.4.2 Inundation by Flood Waters

Reference to the City’s Official Community Plan (OCP) Bylaw No. 10500 (Revised 2021), Chapter 13, “*Flood hazard is limited to Okanagan Lake and the Mill Creek floodplain, until detailed work identifying floodplain limits on other water courses is completed*”. The Site is not located within the Okanagan Lake or Mill Creek floodplain, however reference to the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) ‘Flood Hazard Area Land Use Management Guidelines’, Section 3.2 (Amended 2018), guidelines for building setbacks and flood construction levels (FCLs) have been provided.

Where a flood construction level (FCL) for streams has not been designated, such is the case for the subject site, the following criteria is required:

- FCL should be no lower than 3 m above the natural boundary of any nearby watercourse, except:
  - For some smaller streams (see guidelines for specific exemption criteria) the setback requirement may be reduced to 15 m from the natural boundary of the water course, provided the floodway is not obstructed, and the FCL should be established greater than 1.5 m above the natural boundary of the water course.

Where a FCL for small lakes, ponds, swamps and marsh areas has not been designated, such is the case for the subject site, the following criteria is required:

- Where a lake is <15 km, and for ponds, swamps or marsh areas, buildings should be set back at least 7.5 m from the natural boundary of the water body, with an elevation greater than 1.5 m above the natural boundary of the water body.

Based on the available information and site reconnaissance observations, the stream and water bodies on site may be subject to seasonal fluctuations, therefore it is estimated the likelihood of inundation of the site by flood waters is low to moderate for proposed structures shown as A-6, A-4, and B-6 (middle row) in Appendix B.

## 5.4.3 Mountain Stream Erosion and Avulsion

Mountain stream erosion and avulsion, and snow avalanches **will not** impact the proposed development as they are not at an elevation that would result in significant snow accumulation.

## 5.4.4 Debris Flows, Debris Torrents, and Debris Floods

Evidence for historic debris flows, debris torrents, and debris floods were not observed during the site reconnaissance or during the review of historic aerial photographs; however, it is not to say they have not occurred in the past. There are no major gullies or waterways that flow directly downslope through the Site, instead the water courses appear to be ramped due to the glacial flutes and appear to be confined by bedrock ridges. It is estimated

that the occurrence of debris flows, debris torrents, and debris floods impacting the Site is considered very low to low.

## 5.4.5 Small-Scale Landslides

Landslides are defined as a “*downslope movement of soil, rock and organic materials under the effects of gravity*” Highland and Bobrowsky (2008). Classification of landslides are based on the type of movement and material i.e., soil or rock (or both) and can occur at both small- and large-scales. For the purpose of this report, small-scale landslides will refer to localized events impacting an immediate area, whereas large-scale landslides (discussed in Section 5.4.7) will be considered to impact areas in the order of hundreds of square kilometres.

The historic aerial photos indicate that localized, small-scale landslides have occurred since 1938 but are predominantly confined to areas upslope of the Site. Colluvial and talus deposits were found to be contained by the benches created by glaciofluvial fluting along the bedrock. At the southern portion of the Site, there is a ‘mound’ at the base of the western slope that was not captured within the available historic air photo record; however, was observed during the site reconnaissance impacting the natural stream alignment. **Based on the observation of small-scale landslide events between 1938 and 2006 in the historical imagery review, the probability for future events to occur is considered high for the general Wilden area. The probability for events impacting development at the site is variable depending on the location and scope of construction. Risks associated with small scale landslide events must be assessed during the detailed design phase for each proposed construction lot within the site.**



**Photo 5.1a: Facing West from the southeast corner of the site to the ‘mound’ identified during field reconnaissance. The mound pre-dates the historical photo review (1938-2020). (Placemark 3, 2021-06-09)**

## 5.4.6 Rock Fall Hazards

Ecora identified several rock fall source zones during the site reconnaissance. Identified rock fall source zones typically consisted of rock outcrops with signs of instability. These signs included but were not limited to:

- Jointing;
- Detached boulders; and,
- Presence of rock fall debris downslope of the source zones.

Rock fall debris was observed during the site reconnaissance scattered along the western slope and talus slopes were observed within the rock fall shadow zone (see Figure 4.1) below inferred bedrock crests and bedrock outcrops. The talus deposition observed across the site is variable in age inferred by the relative overgrowth of vegetation and moss. Areas lacking vegetation and moss are indications of more recent movement events than areas overgrown, and moss covered. **Based on the observations on site and the historical imagery review, the estimated overall probability of rock fall hazard events vary, ranging from negligible to high risk of occurrence depending on the location. Rockfall protection measures must be assessed and implemented**

on a site-specific basis for each proposed development structure. Mitigation designs must be developed based on the local risk and scope of the construction during the detailed design phase of the project.



Photo 5.1b: Detached boulders and jointing were identified on bedrock exposures on the west slope above the 'mound' identified on the south end of the site. (Placemark 9, 2021-06-09)



**Photo 5.1c: Talus was identified along the west slope above the site as well as at the toe of the slope along the west perimeter of the site. (Placemark 12, 2021-06-09)**

## 5.4.7 Large-Scale Landslides

As discussed in Section 5.4.5, large-scale landslides are considered to impact areas in the order of hundreds of square kilometers.

Evidence of large-scale landslides were not observed during the site reconnaissance; however, it is not to say they have not occurred in the past. Based on the historic aerial photos and the site reconnaissance, the likelihood of a large-scale landslide is considered very low.

## 5.4.8 Development of a Geohazard Map

Upon completion of the assessment of potential geohazards, identified geohazards were classed into three zones (green, yellow, and red); depending on range of annual probability of occurrence. The zones are shown on the geohazard map in Figure 5.4.c, as defined below. .

- Zone 1 – Very Low to Low return period, low likelihood the initiation of a geohazard occurs following development;
- Zone 2 – Moderate return period, moderate likelihood that a geohazard occurs with potentially property damaging events; and,
- Zone 3 – High to Very High return period, with potentially catastrophic or life threatening events.

#### 5.4.8.1 Green – Very Low to Low Risk

The green area is designated to areas with a low to very low geohazard risk. This low risk rating encompasses the areas that include:

- Gentle to moderately inclined (5-15%) sand and/or gravel slopes with no signs of historic instability;

With respect to development decisions, areas classed as very low to low risk are not free from influencing hazards elsewhere, such as surface water runoff and or groundwater movement may impact the creek running within the centre of the site.

#### 5.4.8.2 Yellow – Moderate Risk

The yellow area is designated to areas that are potentially subject to geologic hazard and where further assessment may be required to further define the hazard. Development within this Zone may require remedial measures, such as slope stabilization works, rock fall protection works and/or specially designed on-site water management. Zone 2 may include the following:

- Moderate to steep (10-30%) sand/or gravel slopes;

#### 5.4.8.3 Red – High to Very High Risk

The red area is designated to areas that are subject to a high level of geologic hazard. This zone contains evidence of historical slope failures and fall within a rockfall shadow. Development within this zone will require a more detailed site-specific investigation and require special remedial measures to safely use the land. Zone 3 may include the following:

- Steep to very steep (>60%) slopes that show signs of historic instability;
- Development areas that fall within a rockfall shadow;
- Presence of colluvium material at the base of slopes; and,
- Areas that are in close proximity to water vessels (ie water streams, ponds).

### 5.4.9 Geohazard Mitigation Measures

The Cave (1993) paper lists avoidance and protection as two possible actions for hazard mitigation. Avoidance is defined as exposure to reduction and is the more desirable of the two. It can be achieved by measures such as introducing set-back/set-forward distances from slopes and water courses or constructing rock fall berms. Protective measures are typically easier to implement but they usually involve maintenance and additional cost.

Recommendations for geohazard mitigation measures to be implementing in the design and construction of the proposed development are presented in Section 7 below.

## 6. Summary of Findings

The following summarizes our geohazard findings:

- To the west of the subject site, the topography is bedrock controlled, rising up to >700 m elevation, with a moderately steep to steep slope (27°->35°). A moderate to moderately steep (16°-35°) bedrock ridge (up to 50 m high) lies to the east of Upper Canyon Drive North. Within the site, a smaller bedrock ridge parallels Upper Canyon Drive North to the west. An ephemeral stream flows through approximately the middle of the Site towards the Rush Pond wetland.
- The GSC surficial geology map (Paradis, 2009) shows glacial fluting along the slope to the west of the Site, seen as offset lineaments in the historic aerial photos.
- The Site is not located within the City of Kelowna's main floodplains of concern (Okanagan Lake or Mill Creek); however, due to the presence of the stream through the Site, building setbacks and FCL's provided by FLNRORD guidelines (Amended 2018) will need to be considered.
- Evidence for historic debris flows, debris torrents, and debris floods were not observed during the site reconnaissance or during the review of historic aerial photographs; however, it is not to say they have not occurred in the past. It is estimated that the occurrence of these events is considered very low to low.
- Smaller localized rock fall/landslide failures were evident in the historic aerial photographs and are considered a high hazard in some areas and low or negligible in others.
- At least one large rock fall event was observed to have occurred on the slope above the site prior to the 1938 historic aerial photographs; however, large-scale rock fall/landslide failures are considered a very low hazard.
- The historic aerial photographs showed earthworks within the project area has significantly impacted the surrounding natural waterways and wetland areas and changed their extents.
- Ecora considers it possible that small-scale, localized landslides and/or rockfalls have occurred more frequently than observed during the historic aerial photograph review, however the quality, resolution, seasonal variability etc. were such that these observations could not be confirmed with certainty. Our site reconnaissance observations included evidence for talus slopes and sporadic rock fall across the western slope; however, **did not** find evidence of recent movement.
- At the base of the western slope, to the south of the Site, a terrace is present that was anticipated to comprise colluvial and fluvial sediments. The terrace was observed to impact the natural alignment of the stream that flows through the Site.

## 7. Discussion and Recommendations

### 7.1 General

Based on Ecora's understanding of the project, our background review, and site reconnaissance observations, we are of the opinion that, from a high-level geohazard perspective, portions of the property can be developed in accordance with the safety levels defined by EGBC (2010), and the Land Title Act (Section 88) provided that certain geohazards are accounted for and mitigated during the detailed design and construction of the proposed development. For areas of the site where geohazards are not mitigated during detailed design through site

regrading, slope stabilization and/or the implementation of rock fall protection works a legal covenant shall be established for remaining high and moderate hazard areas.

The following sections provide potential mitigation measures to address the geohazards identified in this assessment. Geotechnical recommendations for site development will be outlined in Ecora's Geotechnical Assessment Report, which is currently awaiting completion of the geotechnical site investigation. The hazards identified are variable across the site and as such mitigation designs must be specific to each construction area. Specific hazard mitigation designs must be assessed and developed during the detailed design phase of the project to evaluate the risk of the proposed design in the proposed footprint.

## 7.2 Stripping and Site Preparation

Site preparation for the proposed structures and supporting infrastructure (i.e., roads), shall be thoroughly cleared of all rubbish, debris, vegetation, organic material, topsoil, and uncontrolled fill to expose competent native soil or bedrock. Based on the site reconnaissance, we anticipate that removal depths of fill and other deleterious material will be variable across the Site.

Further site preparation recommendations i.e., subgrade preparation, structural fill, re-use of on-site material etc. will be provided in the Geotechnical Assessment Report upon completion of the geotechnical site investigation.

## 7.3 Erosion and Sediment Control

The topography above the Site, to the west, comprises steep slopes, therefore large amounts of potential high energy overland flows may impact the subject property. Additionally, a waterway flowing from south to north, through the centre of the Site, appears to be seasonally influenced and flows towards a highly sensitive wetland area. Further details on erosion and sediment control measures are provided in the Environmental Assessment Report (2021) and should be read in conjunction with this report.

### 7.3.1 Erosion Mechanisms

Erosion is the wearing away of material by naturally occurring agents through the detachment and transport of soil material from one location to another, usually at a lower elevation. Natural agents are mostly responsible for this phenomenon but the extent to which erosion occurs can be considerably accelerated through human activities.

Water is typically the predominant agent of erosion on development sites. In general, soils containing high proportion of silt and very fine sand are usually the most erodible. Water erosion can be divided into several mechanisms:

- **Raindrop erosion** – the effect of dislodging soil particles by the impact of raindrops;
- **Sheet erosion** – resulting from surface runoff of water;
- **Rill erosion** – occurs when small variations in topography cause surface runoff to concentrate in defined channels, causing rills;
- **Gully erosion** – occurs when rills join to form larger, deeper channels; and,
- **Channel erosion** – water in a stream channel removing material from the banks and bed.

Increasing rainfall intensity results in higher raindrop energy and the potential for raindrop erosion. Increased rainfall duration results in higher volumes of surface water runoff and increases the moisture content of a soil, which causes decreased stability of soil slopes and reduces the soil's ability to infiltrate surface water.

Vegetation cover controls erosion by reducing the impact of raindrops, slowing runoff velocity, increasing the infiltration potential of the soil mass, and increasing the soil shear strength through root reinforcement. A large reduction in erosion can be achieved by the vegetation of slopes, with erosion potentially significantly decreased as vegetation becomes established.

## 7.3.2 Erosion Control Measures

Erosion control is the most successful when measures are implemented to prevent the dislodgement of soil particles. The following is a list of potential temporary and permanent erosion control measures.

- **Diversions Ditches** – A channel upslope of the crest, usually with a ridge on the lower side, constructed to intercept and divert stormwater runoff away from the slope to a stabilized outlet at non-erosive velocities.
- **Granular / Rock Blankets** – A permanent, erosion-resistant ground cover of large, loose, angular stone installed on the slope face wherever soil conditions, water turbulence and velocity, expected vegetation cover, etc., are in a condition that may allow the soil to erode.
- **Vegetation Covers** – Vegetation covers such as hydro-seeding remains one of the most effective and economical methods for large-scale applications of surface erosion control. Hydro-seeding consists of spraying a slurry of seed and mulch upon the slope face. Where hydro-seeding is utilized to re-vegetate cut slopes, a product must be selected that adheres to the manufacturer's specifications regarding the maximum slope angle for which the product is to be utilized for.
- **Slope Roughening** – Consisting of grooving slopes or leaving slopes in a roughened state by not finishing the slope with a smooth grade. The roughened slopes will reduce runoff velocities, provide sediment trapping, increases infiltration, and facilitates the establishment of vegetation on the exposed slope.

An Erosion Sediment Control Plan (ESCP) should be followed during construction activities to protect identified water courses and other environmentally sensitive habitats.

During construction of temporary excavations and prior to hydroseeding of permanent soil slopes, it is recommended that soil slope excavations are protected from rainfall and surface water runoff by the implementation of temporary berms and ditches.

## 7.4 Rock Fall Protection Options

As discussed in Section 5.4.6, the probability of rockfall hazards is variable across the site with both high and low risk areas. Rockfall hazard mitigation will be necessary in some areas of the site depending on the exact location and scope of development proposed. As such, rockfall mitigation options must be assessed and designed during the detailed design phase of the project for each specific development structure area. Rockfall protection measures will be required to be implemented to mitigate the hazards to low or negligible as a risk factor of moderate or higher would not permit new development within the proposed building sites. Depending on the site location and building design the following options can be implemented:

- **Ditches and Berms** (earthen embankments) - are usually constructed at the base of slopes, or along benches on the slope where space permits, and are generally the most cost-effective option to mitigate rock fall hazards. They can be designed for a range of impact energies based on their size and construction material.
- **Barriers** – are wall structures constructed at the base of slopes, typically when geometric constraints do not permit the use of ditches and berms. They typically comprise precast concrete

barriers such as a Lock-Block™ wall, cast-in-place concrete barriers (walls), gabion baskets, flexible fence structures constructed of high tensile strength wire mesh supported by steel posts, or a high tensile wire mesh draping system.

If mitigation measures are insufficient to decrease the hazard rating to a low risk the building location must be moved, or the design must be changed. Further details will be discussed with the Client once the location of the proposed structures have been confirmed and during detailed design.

## 7.5 Localized Rock Cut Slope Stabilization

If required, rock stabilization work should be reviewed in the field by the Geotechnical Engineer with the Contractor, to identify areas that require rock support and to confirm the requirements of localized rock support.

Mitigation measures to enhance stability include the following:

- **Scaling** – consisting of the removal of loose rock off the cut face and overburden from the crest of a slope. Scaling is expected to be done by hand or by a machine.
- **Rock Removal** – consisting of re-sloping and unloading the rock mass by rock scaling, trimming, or other excavation techniques. Rock trimming can be done with hydraulic splitters, chemical expanders, or pneumatic hammers.
- **Structural Reinforcement** – may be provided by spot rock bolts and dowels. Tensioned rock bolts are used to increase the normal stress along the discontinuity where sliding is possible, thus increasing the shear resistance of the discontinuity. They may also be used to anchor potentially unstable rock blocks in place. Dowels are un-tensioned rock bolts or shear pins used to resist lateral movement of rock blocks by their shear capacity. Bolts and dowels should be galvanized and fully encapsulated in grout with the use of centralizers.
- **Dentition** – can be used to backfill slots resulting from trimming of bands of soft material or to support overhand formed in the rock face.
- **Drainage** – dewateres the rock slope to reduce the impact of groundwater pressures and improves slope stability. Reduced groundwater pressures within a discontinuity increases the shear strength. Proper drainage of rock slopes can be achieved by installing drain holes (wee holes, horizontal drains).

## 7.6 Localized Soil Slope Stabilization

During the site reconnaissance, unstable sections were identified within the proposed development area from shallow localized instabilities and unconsolidated fluvial sediments deposited from the creek, as shown in Figure 5.4.a. Mitigation measures for further instabilities from development can include regrading of slopes using structural fill and/or reuse of onsite material with adequate compaction. Specifications for regrading and reuse of material will be specified in the Geotechnical Assessment Report.

## 7.7 Development Set Back/Forward

A minimum safe building set forward / set back distance is recommended between the proposed structures and the toe of the natural slope identified as 'unstable' or 'potentially unstable'. Bedrock outcrops and talus slopes along the western portion of the subject property have been mapped as 'unstable', and the slopes along the eastern portion of the Site have been mapped as 'potentially unstable'. The recommended set forward / set back distance is determined by projecting an imaginary line from the crest of the talus slope (at the base of the rock outcrop) down

slope towards where rockfall was observed in the field. This is called the rock fall shadow area (Copons, Vilaplana, & Linares, 2009), see Figure 4.1. Shadow angles were observed during the site reconnaissance, the south section ranged from 22-25° and the north section was approximately 30-32°. Alternatively permanent rock fall protection works such as catchment fences or berms could be considered to mitigate the rock fall hazard within the rock fall shadow area. The geohazard map outlines the boundary of the high to very high risk of rockfall hazard, determined in part by the site specific rockfall shadows on Figure 5.4.c.

Ecora recommends a *No Build Zone*, for High Hazard Areas, in the form of a legal covenant to be registered on the title of any buildings affected. This zone includes the slope plus a safe building set back from the crest.

Development set forward and/or set back distances may also be recommended for identified Environmentally Sensitive Area (ESA) 1 and 2. Further details are presented in Ecora's Environmental Assessment Report (2021) and should be read in conjunction with this report.

## 7.8 Permanent Water Management Plan

The management of surface and subsurface water is an integral part of the site preparation works, particularly where there is evidence for preferential flow. Stormwater drainage features are required to discharge into existing stormwater systems or natural watercourses (i.e., Mill Creek) as per the City's Bylaw No. 7900 (Schedule 4, Section 3, (2020)). There are several different types of drainage features including ditches, swales, interceptor drains, relief drains, French drains, and blanket drains. The following provides a brief description of potential drainage options:

- **Interceptor Drains** – a gravel trench that is excavated into a relatively impermeable soil layer and installed to collect and remove groundwater as it flows across the impermeable layer. Generally, trenches are constructed 0.6 m to 1.0 m wide and are lined with a non-woven geotextile. There is a 0.3 m to 0.6 m overlap of the geotextile above the gravel and below the backfill in the trench. Water carried by the trench pipe should be conveyed to a tightline (solid pipe) which transfers water down the slope to an approximate discharge point. Trenches can be excavated with curves and bends to prevent cutting tree roots and hitting underground utilities. Trenches can be covered with topsoil and replanted to conform to the existing ground conditions. Trenches over 1.2 m deep (on level ground) should be protected against collapse. A flush port for cleaning purposes should also be included. If not properly backfilled and compacted, surface water can flow into the trench and cause additional problems for the slope and drainage system.
- **Relief Drains** – installed similarly to interceptor drains, except in a designed patten arranged to artificially lower the groundwater elevation in the slope to a specific elevation. Relief drains can also be constructed to intercept surface water drainage if placed at the surface. Typically, they are shallower trenches sloped to drain to a collection tightline pipe. Groundwater continues to flow below the relief drains because these drains are not typically excavated into the impermeable soil. Relief drains can be used in conjunction with geotextile wrap (sock) around the pipe instead of gravel. Trenches open at surface can accumulate fine grained soil, reducing the system capacity to capture surface water over time. A flush port for cleaning purposes should also be included.
- **French Drains** – sometimes confused with interceptor drains, French drains generally use large gravel without a pipe and the trench itself conveys the water across and down the slope. Consequently, the trench must be sloped. These drains must still convert trench flow to pipe flow in order to get drainage down the slope. French drains are not generally the system of choice for slope applications.
- **Blanket Drains** – a layer of free draining granular material which can be used to remove water from beneath foundations or pavement structures as a permeable base. In slope stability applications, drainage blankets improve slope stability by preventing a seepage surface

developing on the slope and by providing a buttressing effect. Drainage blankets are also used as an interface between embankment and soft foundations to provide drainage during foundation consolidation. These drains often require a collection system and transverse pipe underdrains that may be required to outlet the blanket.

Unlined ditches should be maintained and cleared of debris and vegetation to prevent blockages and stagnant water pooling. Mitigation measures such as a surface armour blanket should also be considered to reduce erosion and increase slope stability where surface slumping or groundwater seepage is encountered.

Any man-made water courses may be adjusted subject to a hydrotechnical assessment and civil design. However, any changes to the natural water courses should be consulted with an environmental professional first, prior to having a permanent storm water management plan (SWMP) developed with adjustments to them.

Any permanent water management should be designed in such a manner to prevent any negative impacts to the adjacent properties and nearby water courses. Drainage considerations established during design and construction should be maintained for the life of the development.

Recommendations for stormwater management pertaining to structure foundation drainage will be provided in the Geotechnical Assessment Report, to be issued at a later date.

## 8. Study Limits

This geohazard assessment relied upon information that was available at the time of the assessment, and the existing site conditions observed during the site reconnaissance. A Preliminary Geotechnical Assessment and Environmental Assessment are provided as separate reports. The Preliminary Geotechnical Assessment includes the results of the test pits, and laboratory testing results of select samples collected during the site investigation. Should the site investigation reveal significantly different subsurface information than outlined above, the terrain classifications and geotechnical constraints should be reviewed as this may impact geotechnical recommendations, analysis, and design.

## 9. Closure

We trust this report meets your requirements. Please contact our office if you have any questions or comments concerning this report.

# References

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# Figures

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Figure 1.3	Site Plan
Figure 4.1	Rockfall Reach and Shadow Angles
Figure 5.4.a	Terrain Map
Figure 5.4.b	Terrain Stability Classification Map
Figure 5.4.c	Geohazard Map

## GEOHAZARD ASSESSMENT 225 UPPER CANYON DRIVE NORTH KELOWNA, BC

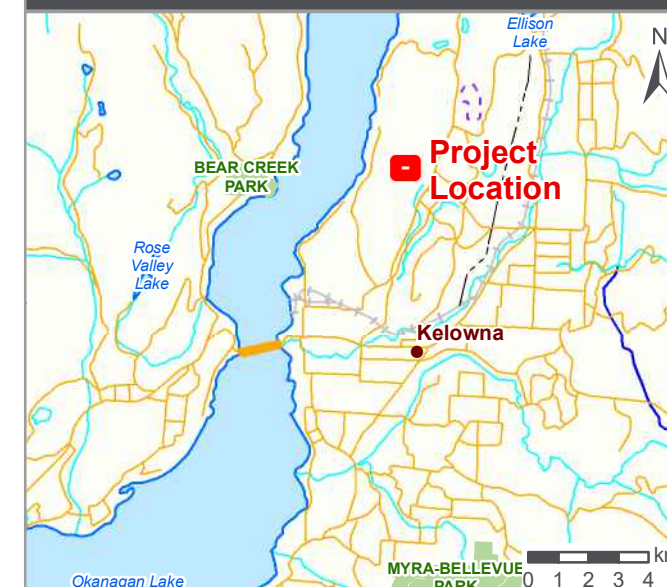
### Legend

- Field Points
- City of Kelowna Roads
- City of Kelowna 1m Contours
- Approximate Fortis Gas Line
- City of Kelowna Legal Parcels
- Property Boundary

### References

Aerial Imagery: City of Kelowna GIS. Imagery Date: 2020

### LOCATION MAP



1:2,000



Project No.: 201827

Date: 2021/09/16

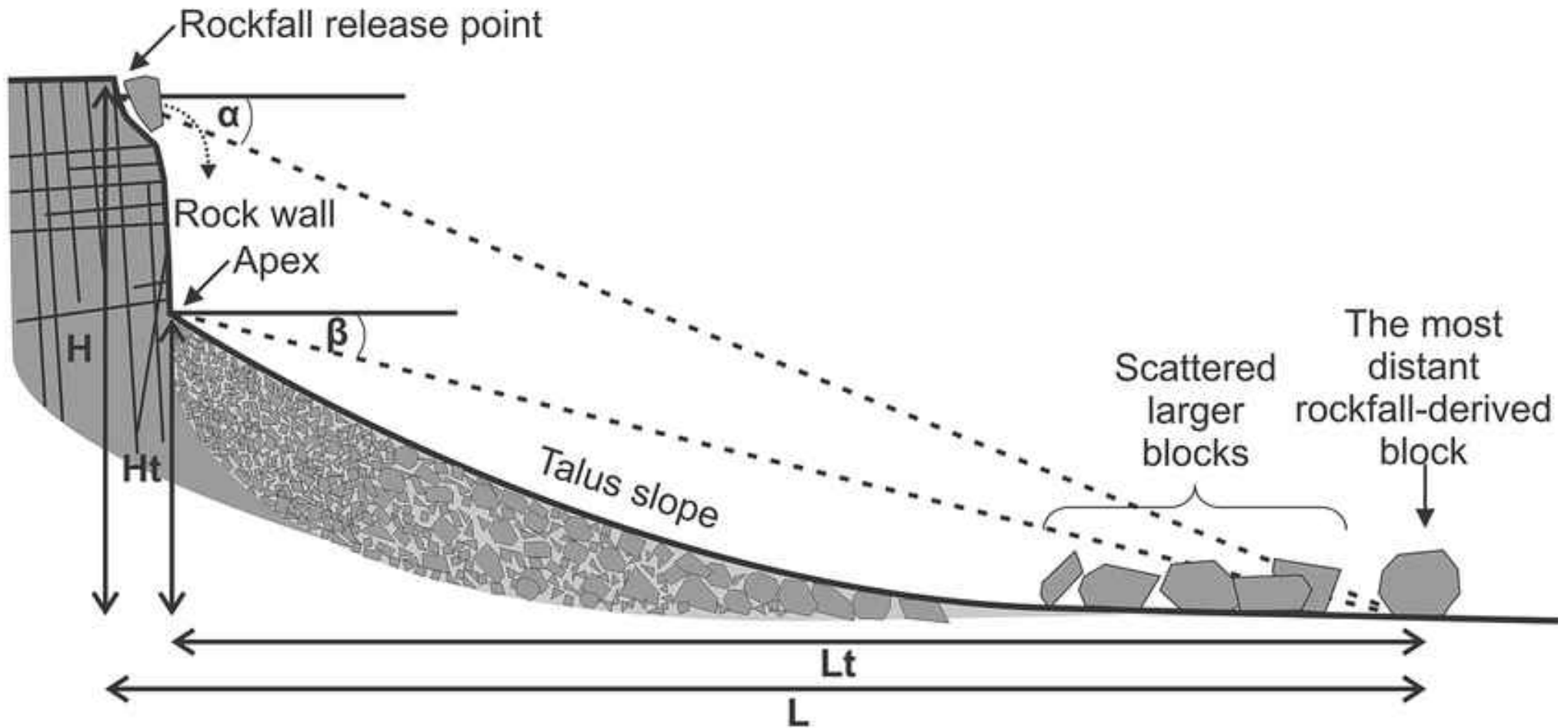
Client: Wilden Construction Corp.

Drawn: MT Check:

NAD 1983 UTM Zone 11N

**Figure 1.3**





Notes:

Figure taken from Copon et al. (2009)

$\alpha$  corresponds to Rockfall Reach Angle,  $\beta$  corresponds to Rockfall Shadow Angle

## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

### Rockfall Reach and Shadow Angles

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 16, 2021  
 DWN: DA CHK: JC

**ecora**<sup>™</sup>

Figure 4.1

Material Type	Terrain Symbol	Symbol Interpretation	Description
Fill	X	Man-made fill and/or reworked material	Man-made fill related to development
Fluvial Sediments	zsFp	Silt and sand fluvial plain sediments	Unconsolidated silt and sand with trace to some gravels. Grain size is variable.
	zsF <sup>a</sup> p	Silt and sand active fluvial plain sediments	Unconsolidated silt and sand with trace to some gravels actively deposited by stream and channel processes. Grain size is variable. May contain pockets of organic material.
	zsFt/C-R	Silt and sand fluvial terrace sediments	Unconsolidated silt and sand with trace to some gravels deposited during higher energy stream and channel processes, overlying colluvium and/or bedrock. Grain size is variable. May contain pockets of organic material.
Glacial Sediments (Till/Moraine)	Mw/R	Till of unknown variable thickness overlying bedrock	Mantle of Till (likely sands and gravels) of unknown variable thickness overlying bedrock.
Colluvium overlying Bedrock	zsCv/R	Colluvium intermixed with fluvial deposits overlying bedrock	Unconsolidated colluvial soils (less than 1 m thick) intermixed with fluvial silts and sands. May contain pockets of organic material.
	rCv/Rs	Veneer of Colluvium/Talus overlying steep bedrock	Colluvial soils (less than 1 m thick) and blocky, angular talus deposits overlying moderately steeply sloped (27°-35°) to steeply sloped (>35°) bedrock.

Terrain symbology and interpretation based on the BC Terrain Classification System (Howes and Kenk, 1997).

## GEOHAZARD ASSESSMENT 225 UPPER CANYON DRIVE NORTH KELOWNA, BC

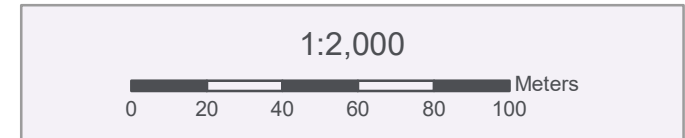
### Legend

- City of Kelowna Roads
- Stream
- Approximate Fortis Gas Line
- City of Kelowna Legal Parcels
- Property Boundary

### References

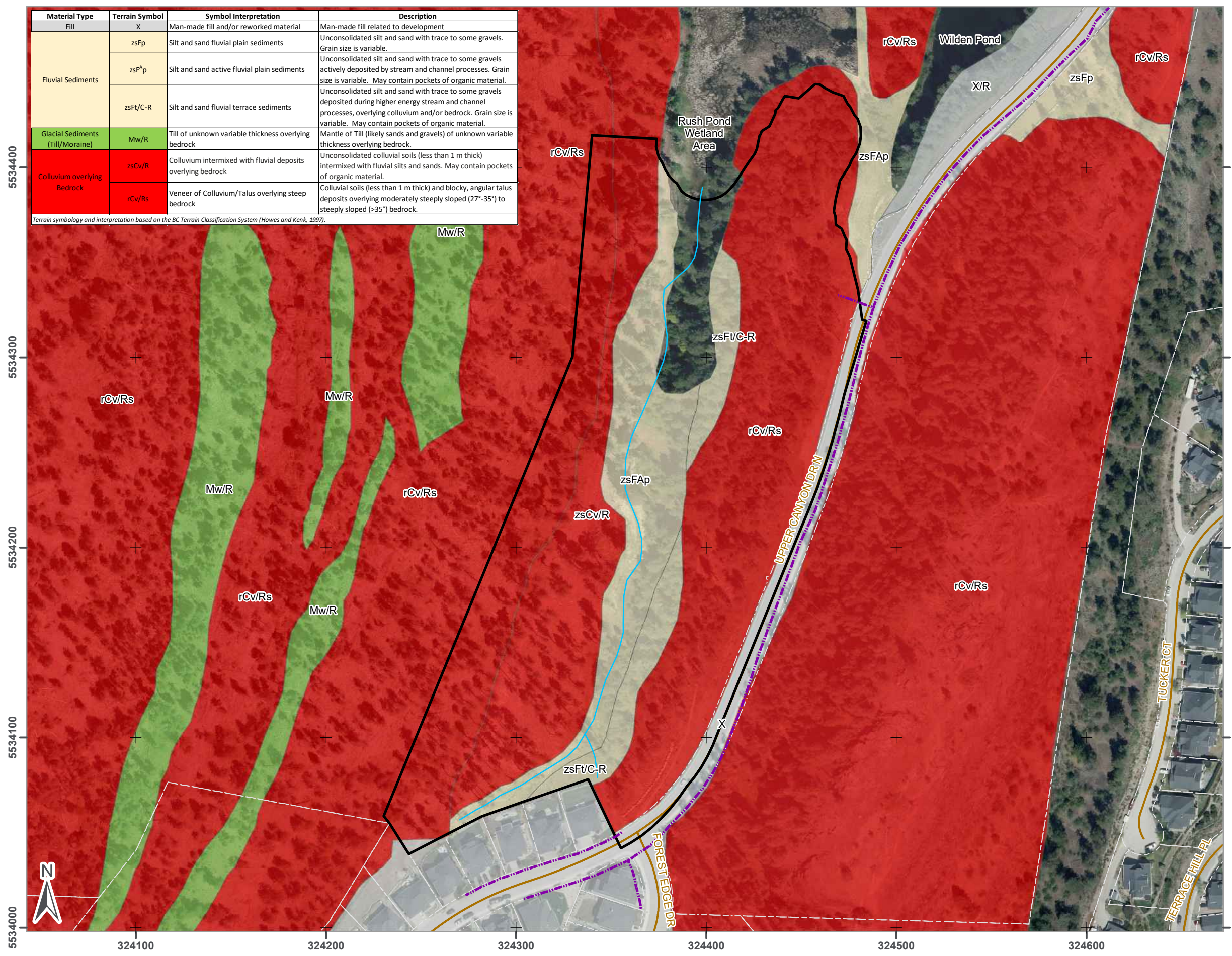
Aerial Imagery: City of Kelowna GIS. Imagery Date: 2020

### LOCATION MAP

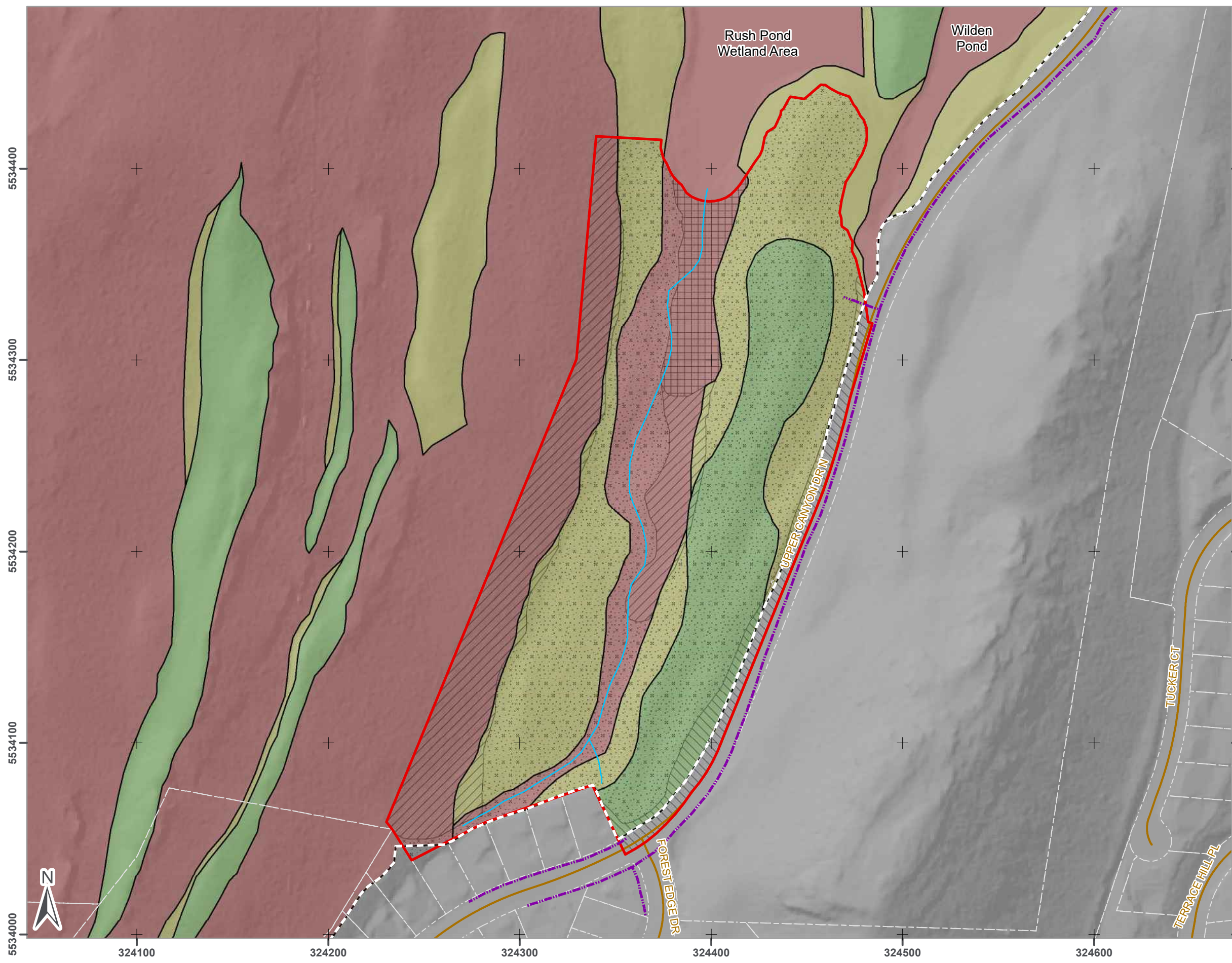


Project No.: 201827 Date: 2021/09/16  
 Client: Wilden Construction Corp. Drawn: MT Check:

NAD 1983 UTM Zone 11N **Figure 5.4.a**



# TERRAIN STABILITY CLASSIFICATION MAP



## GEOHAZARD ASSESSMENT 225 UPPER CANYON DRIVE NORTH KELOWNA, BC

**Legend**

- City of Kelowna Roads
- Stream
- Approximate Fortis Gas Line
- City of Kelowna Legal Parcels
- Property Boundary
- Assessment Boundary

**Terrain Stability Class**

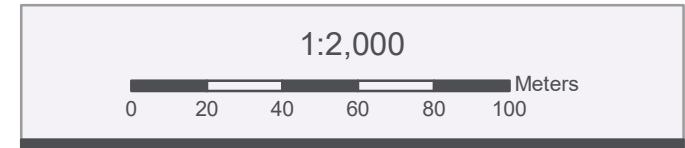
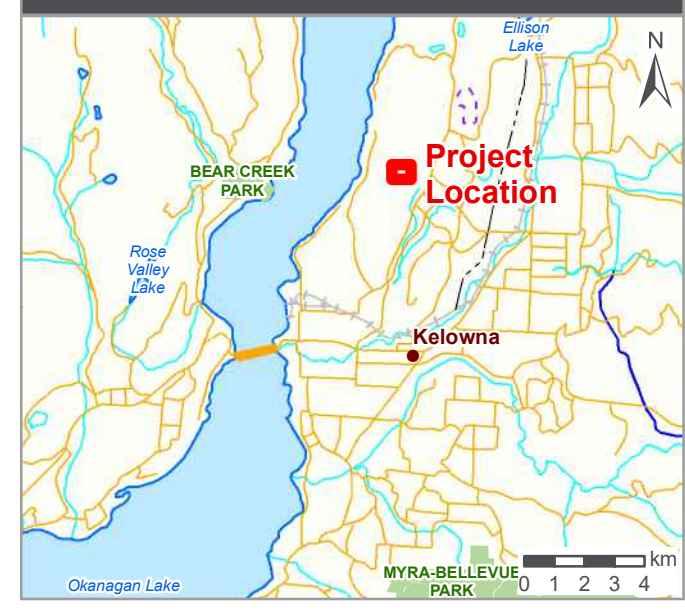
- Stable
- Potentially Unstable
- Unstable

**ESA Ranking**

- ESA 1 - High
- ESA 2 - Moderate
- ESA 3 - Low
- ESA 4 - Not Sensitive

**References**  
Aerial Imagery: City of Kelowna GIS. Imagery Date: 2020

### LOCATION MAP



Project No.: 201827 Date: 2021/09/16  
Client: Wilden Construction Corp. Drawn: MT Check:

NAD 1983 UTM Zone 11N **Figure 5.4.b**

# GEOHAZARD MAP

	Range of Annual Probability of Occurrence (Pa)	Description and Examples
Very Low to Low	Less than 1 in 475 years.	Low likelihood of landslide/rockfall initiation following development (i.e., Slopes gentler than 50% - 60% with no signs of instability)
Moderate	Greater than 1 in 475 years. Less than 1 in 100 years.	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 to Very High	Greater than 1 in 100 years.	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)

Based on Rif, 1996

## GEOHAZARD ASSESSMENT 225 UPPER CANYON DRIVE NORTH KELOWNA, BC

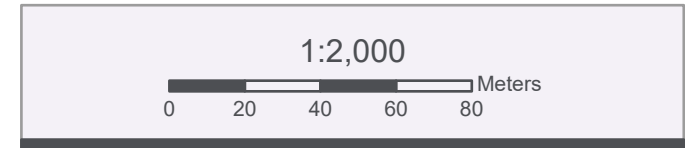
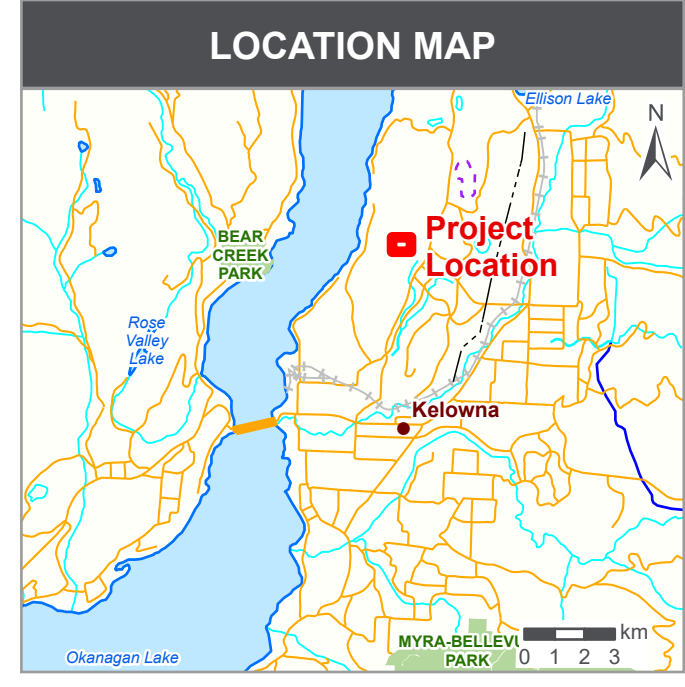
**Legend**

- City of Kelowna Roads
- Stream
- Approximate Fortis Gas Line
- City of Kelowna Legal Parcels
- Property Boundary
- Assessment Boundary

**Geohazard Risk**

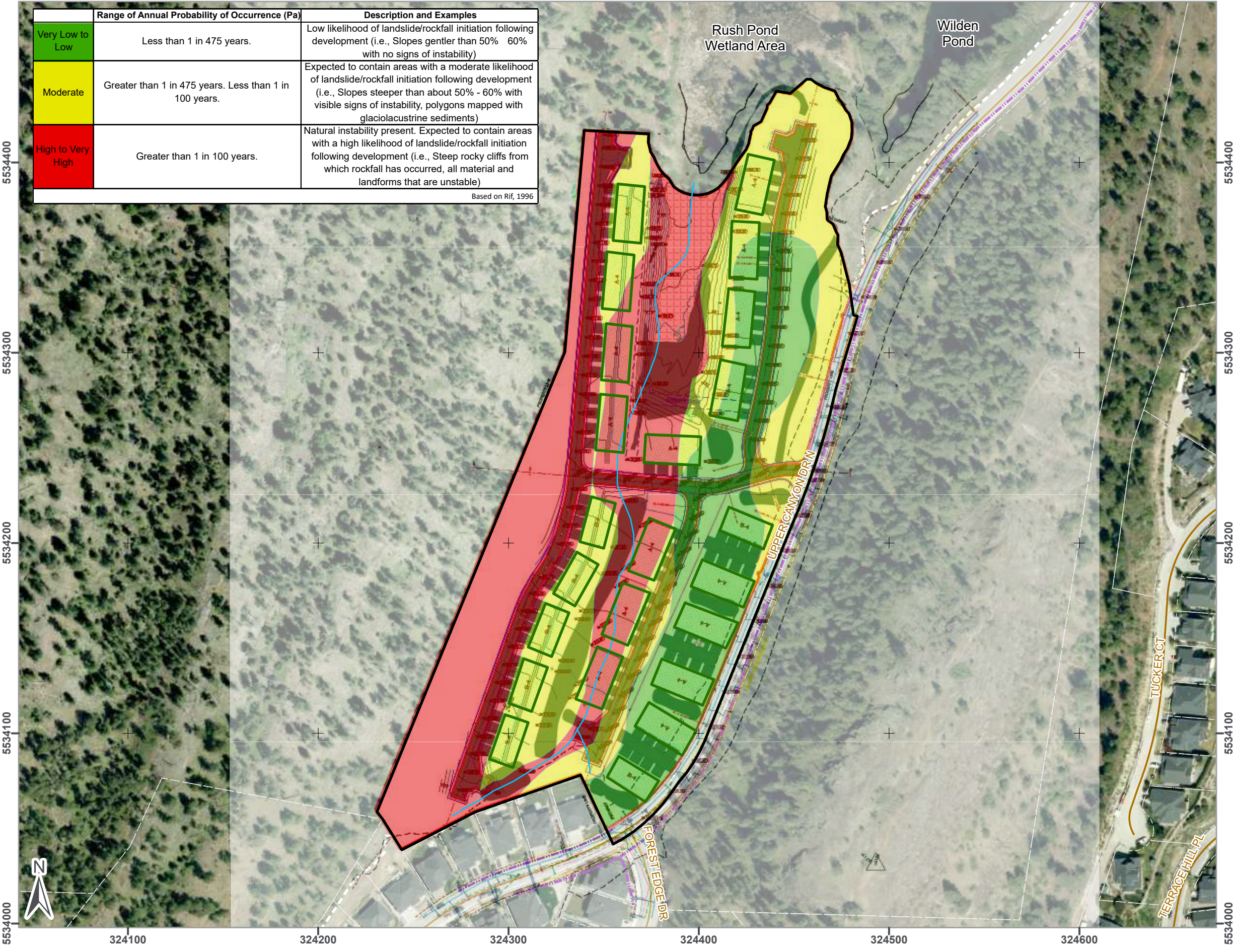
- Very Low to Low
- Moderate
- High to Very High

**References**  
Aerial Imagery: City of Kelowna GIS. Imagery Date: 2020



Project No.: 201827 Date: 2021/12/23  
Client: Wilden Construction Corp. Drawn: MB Check: DA

NAD 1983 UTM Zone 11N **Figure 5.4.c**



# Photographs

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Photo 5.1a      Placemark 3

Photo 5.1b      Placemark 9

Photo 5.1c      Placemark 12

# Appendix A

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## General Conditions

## 1. 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.

## 2. Basis and Use of the Report

This report and the recommendations contained in it are intended for the sole use of Ecora's Client, their agents and the applicable regulatory authorities. 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, their agents and the applicable regulatory authorities 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.

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## 3. 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.

## 4. 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.

## 5. 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.

## 6. 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.

### **7. 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.

### **8. 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.

### **9. 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.

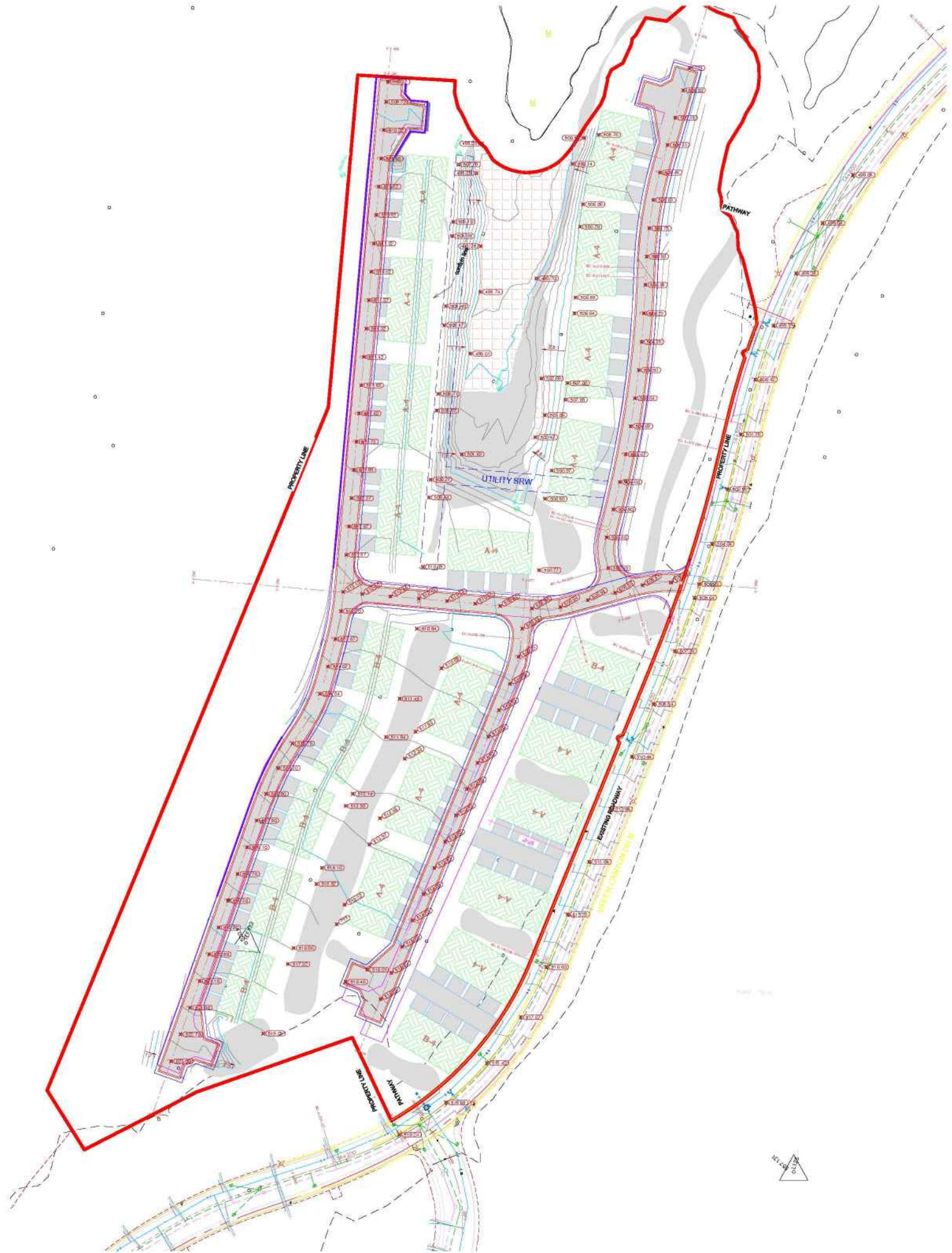
### **10. Services of Sub consultants and Contractors**

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

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## Preliminary Site Layout Drawing



# Appendix D

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## Appendix D Landslide Assessment Assurance

# APPENDIX D: LANDSLIDE ASSESSMENT ASSURANCE STATEMENT

Note: This Statement is to be read and completed in conjunction with the "APEGBC Guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia", March 2006/Revised September 2008 ("APEGBC Guidelines") and the "2006 BC Building Code (BCBC 2006)" and is to be provided for *landslide assessments* (not floods or flood controls) for the purposes of the Land Title Act, Community Charter or the Local Government Act. Italicized words are defined in the APEGBC Guidelines.

To: The Approving Authority

Date: December 23, 2021

City of Kelowna

Jurisdiction and address

With reference to (check one):

- Land Title Act (Section 86) – Subdivision Approval
- Local Government Act (Sections 919.1 and 920) – Development Permit
- Community Charter (Section 56) – Building Permit
- Local Government Act (Section 910) – Flood Plain Bylaw Variance
- Local Government Act (Section 910) – Flood Plain Bylaw Exemption
- British Columbia Building Code 2006 sentences 4.1.8.16 (8) and 9.4 4.4.(2) (Refer to BC Building and Safety Policy Branch Information Bulletin B10-01 issued January 18, 2010)

For the Property:

225 Upper Canyon Drive North, PLAN KAP75116, Block D, section 8  
Legal description and civic address of the Property Township 23

The undersigned hereby gives assurance that he/she is a *Qualified Professional* and is a *Professional Engineer* or *Professional Geoscientist*.

I have signed, sealed and dated, and thereby certified, the attached *landslide assessment* report on the Property in accordance with the *APEGBC Guidelines*. That report must be read in conjunction with this Statement. In preparing that report I have:

Check to the left of applicable items

- 1. Collected and reviewed appropriate background information
- 2. Reviewed the proposed *residential development* on the Property
- 3. Conducted field work on and, if required, beyond the Property
- 4. Reported on the results of the field work on and, if required, beyond the Property
- 5. Considered any changed conditions on and, if required, beyond the Property
- 6. For a *landslide hazard analysis* or *landslide risk analysis* I have:
  - 6.1 reviewed and characterized, if appropriate, any *landslide* that may affect the Property
  - 6.2 estimated the *landslide hazard*
  - 6.3 identified existing and anticipated future *elements at risk* on and, if required, beyond the Property
  - 6.4 estimated the potential *consequences* to those *elements at risk*
- 7. Where the *Approving Authority* has adopted a *level of landslide safety* I have:
  - 7.1 compared the *level of landslide safety* adopted by the *Approving Authority* with the findings of my investigation
  - 7.2 made a finding on the *level of landslide safety* on the Property based on the comparison
  - 7.3 made recommendations to reduce *landslide hazards* and/or *landslide risks*
- 8. Where the *Approving Authority* has **not** adopted a *level of landslide safety* I have:

- 8.1 described the method of *landslide hazard analysis* or *landslide risk analysis* used
- 8.2 referred to an appropriate and identified provincial, national or international guideline for *level of landslide safety*
- 8.3 compared this guideline with the findings of my investigation
- 8.4 made a finding on the *level of landslide safety* on the Property based on the comparison
- 8.5 made recommendations to reduce *landslide hazards* and/or *landslide risks*
- 9. Reported on the requirements for future inspections of the Property and recommended who should conduct those inspections.

Based on my comparison between

Check one

- the findings from the investigation and the adopted *level of landslide safety* (item 7.2 above)
- the appropriate and identified provincial, national or international guideline for *level of landslide safety* (item 8.4 above)

I hereby give my assurance that, based on the conditions<sup>[1]</sup> contained in the attached *landslide assessment* report,

Check one

- for subdivision approval, as required by the Land Title Act (Section 86), "that the land may be used safely for the use intended"

Check one

- with one or more recommended registered covenants.
- without any registered covenant.

- for a development permit, as required by the Local Government Act (Sections 919.1 and 920), my report will "assist the local government in determining what conditions or requirements under [Section 920] subsection (7.1) it will impose in the permit".

- for a building permit, as required by the Community Charter (Section 56), "the land may be used safely for the use intended"

Check one

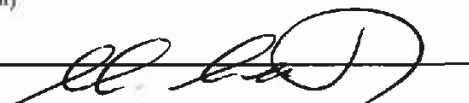
- with one or more recommended registered covenants.
- without any registered covenant.

- for flood plain bylaw variance, as required by the "Flood Hazard Area Land Use Management Guidelines" associated with the Local Government Act (Section 910), "the development may occur safely".

- for flood plain bylaw exemption, as required by the Local Government Act (Section 910), "the land may be used safely for the use intended".

Cevat Catana, P.ENG  
Name (print)

DEC 24, 2021  
Date

  
Signature

<sup>[1]</sup> When seismic slope stability assessments are involved, *level of landslide safety* is considered to be a "life safety" criteria as described in the National Building Code of Canada (NBCC 2005), Commentary on Design for Seismic Effects in the User's Guide, Structural Commentaries, Part 4 of Division B. This states:

*"The primary objective of seismic design is to provide an acceptable level of safety for building occupants and the general public as the building responds to strong ground motion; in other words, to minimize loss of life. This implies that, although there will likely be extensive structural and non-structural damage, during the DGM (design ground motion), there is a reasonable degree of confidence that the building will not collapse nor will its attachments break off and fall on people near the building. This performance level is termed 'extensive damage' because, although the structure may be heavily damaged and may have lost a substantial amount of its initial strength and stiffness, it retains some margin of resistance against collapse".*

200-2045 ENTERPRISE WAY  
Address

KELOWNA, BC, V1Y 9T5

250-469-9757  
Telephone



If the *Qualified Professional* is a member of a firm, complete the following.

I am a member of the firm FLORA ENGINEERING & RESOURCE GROUP  
and I sign this letter on behalf of the firm. (Print name of firm)



# Preliminary Geotechnical Assessment

## 225 Upper Canyon Drive North, Kelowna, BC

Presented To:



Dated: December 2021

Ecora File No.: 201827

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## Presented To:

Wilden Construction Corp.  
1454 Rocky Point Drive  
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### Version Control and Revision History

Version	Date	Prepared By	Reviewed By	Approved by	Notes/Revisions
0	2021-12-23	DA/NM-H	JMC/MJL	MJL	Issued for Use

## Limitations of Report

This report and its contents are intended for the sole use of Wilden Construction Corp., their agents, and the applicable regulatory authorities. Ecora Engineering & Resource Group Ltd. (Ecora) 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 Wilden Construction Corp., their agents, the applicable regulatory authorities or for any Project other than that described in this report. 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's General Conditions are provided in Appendix A of this report.

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- Appendix B Site Development Drawings
- Appendix C Test Pit Logs
- Appendix D Laboratory Testing Results
- Appendix E Slope Stability Analysis Results

## Acronyms and Abbreviations

ASCE	American Society of Civil Engineers
ASTM	ASTM International (formerly American Society for Testing and Materials)
BC	British Columbia
BCBC	British Columbia Building Code (2018)
BC MoTI	British Columbia Ministry of Transportation and Infrastructure
CCIL	Canadian Council of Independent Laboratories
CFEM	Canadian Foundation Engineering Manual
CPT	Cone Penetration Testing
DCPT	Dynamic Cone Penetration Testing
DP	Development Permit
FHWA	Federal Highway Administration
FoS	Factor of Safety
GIC	Geographic Information Centre
GPS	Global Positioning System
GSC	Geological Survey of Canada
GSI	Geological Strength Index
H:V	Horizontal: Vertical
LE	Limit Equilibrium
m asl	meter(s) above sea level
m bgl	meter(s) below ground level
MPMDD	Modified Proctor Maximum Dry Density
NAD	North American Datum
NBCC	National Building Code of Canada (2015)
ODYD	Osoyoos Division Yale Land District
OH&S	Occupational Health & Safety
P.Eng.	Professional Engineer (registered with EGBC)
PGA	Peak Ground Acceleration
P.Geo.	Professional Geoscientist (registered with EGBC)
PVC	Polyvinyl Chloride
RDCO	Regional District of Central Okanagan

Sa(T)	Spectral Acceleration
SLS	Serviceability Limit State
SPT	Standard Penetration Test
UBC	University of British Columbia
UCS	Unconfined Compressive Strength
ULS	Ultimate Limit State
UTM	Universal Transverse Mercator
WSDoT	Washington State Department of Transportation

# 1. Introduction

## 1.1 General

Ecora Engineering & Resource Group Ltd. (Ecora) was retained by Wilden Construction Corp. to provide Consulting Engineering Services (civil, geotechnical, and environmental) to support a proposed multi-family development at 225 Upper Canyon Drive North, Kelowna, BC.

The purpose of this preliminary geotechnical assessment is to evaluate the suitability of the Site for the proposed development, to determine the extent of any geotechnical constraints associated with this project identified in the companion geohazard report, provide recommendations for any geohazard mitigation works and general site development, and to satisfy the City of Kelowna's Development Permit (DP) requirements (Development Bylaw No. 7900, 2020).

Ecora understands that the proposed development comprises 118 units consisting of 4-plex and 6-plex townhomes. It is anticipated that the proposed development will follow the design requirements of Part 9 of the British Columbia Building Code (BCBC) (2018). Should the structures fall under Part 4 of the BCBC (2018), further geotechnical investigation, assessment, and analysis may be required.

This report summarizes Ecora's preliminary geotechnical assessment, including the results of the geotechnical site investigation, subsequent laboratory testing, preliminary analysis, and provides general geotechnical recommendations with respect to the design and construction of the proposed development. The findings of our environmental and geohazard assessments are summarized in separate reports, however, should be read in conjunction with this report.

## 1.2 Scope of Work

The geotechnical scope of work for this project was outlined in Ecora's proposal (2020) and included a phased approach, as outlined below:

- Phase 1: Preliminary Geotechnical Assessment
  - Task 1: Desktop Review and Site Reconnaissance
  - Task 2: Preliminary Geotechnical Site Investigation
  - Task 3: Laboratory Testing
  - Task 4: Slope Stability Analysis and Reporting
- Phase 2: Detailed Geotechnical Design and Analysis
- Phase 3: Construction Geotechnical Services

Authorization to proceed with the geotechnical scope of work was received from Mr. Cameron Dodd, Development Manager at Wilden Construction Corporation, on June 4, 2021.

This report fulfills the tasks associated with Phase 1, as outlined above.

## 1.3 Site Description

The subject property is located at 225 Upper Canyon Drive North (the Site), Kelowna, BC. The legal description of the property is Plan KAP75116 Lot D, Section 8, Township 23, Except Plan EPP24895, EPP24897, and is currently zoned as RM3 (low density multiple housing). According to the City of Kelowna (the City) property report, the lot is approximately 54,000 m<sup>2</sup> (13.34 acres).

The Site is situated on an undeveloped greenfield site, bounded by Upper Canyon Drive to the east, residential lots to the south, undeveloped property to the west, and the Rush Pond Wetland Area and Wilden Pond to the north. The property generally slopes down towards the west with steeper gradients along the western boundary, with elevations ranging from approximately 543 m above sea level (m asl) at the southwest corner of the property, to 500 m asl at the northeast corner of the property. The site topography is generally a populous treed area with bedrock outcrops along the eastern portion of the site with a creek running south-north into the wetland area.

The site plan is shown on the attached Figure 1.3.

## 1.4 Proposed Development

The proposed development comprises 118 units consisting of 4-plex and 6-plex townhouses, as well as residential roads and associated infrastructure (see Appendix B). Based on the conceptual design, the townhouse structures are situated in three different rows: along the western boundary of the property lot at the toe of the slope, a short row underneath the wetland/marsh area, and along the eastern boundary of the property lot parallel with Upper Canyon Drive North. It is understood that the proposed development will be strata property.

# 2. Geology and Topography

## 2.1 Surficial Geology

The Geological Survey of Canada (GSC) 1:50,000 “Surficial Geology Map, Kelowna” (Paradis, 2009), indicates the Site is underlain by a continuous till blanket comprising “...*lodgement and ablation facies*...”, overlying bedrock. The Site is located between bedrock ridges located to the east and west. A small area of Quaternary age organic sediments comprising “*muck, mucky peat, marl and peat*...” is shown immediately north of the property boundary, along the base of the western bedrock ridge.

## 2.2 Bedrock Geology

The GSC 1:100,000 scale “Geology, Okanagan Watershed, British Columbia” (Okulitch, 2013), indicates the underlying bedrock is from the Nimpit Lake Member of the Marron Formation, and is comprised of “*lava, trachyte, trachyandesite; minor breccia*”.

## 2.3 Topography

The Site is located on the eastern side of a bedrock-controlled ridge that is aligned parallel to the eastern side of Lake Okanagan, extending from Knox Mountain Park to the south, terminating at McKinley Landing to the north.

The subject property is located on the lower slopes of the bedrock-controlled ridge, between the base of a moderately steep to steep slope (27°->35°), which rises up to >700 m elevation, and a moderate to moderately steep (16°-35°) ridge (up to 50 m high). The elevation within the subject site ranges between 518 m and 543 m

elevation along the western boundary of the site, and 500 m to 519 m elevation along Upper Canyon Drive North. The lowest elevation point is 498 m at the north end of the property, at the interface between the wetland and Rush Pond.

Glacial fluting lineaments shown on the GSC “Surficial Geology Map, Kelowna” (Paradis, 2009) generally trend north/south (N-S) to north-north-east/south-south-west (NNE-SSW). The glacial fluting has resulted in a natural switchback ramp configuration for the watershed to drain from Rush Pond, east into Wilden Pond, north into Walroy Lake, and south into Still Pond before draining further south into the Glenmore Valley.

A small watercourse flows from south to north through the middle of the Site to Rush Pond. A mound at the southwestern corner of the subject site appears to have impacted the natural drainage channel and blocked it in the past.

A terrain stability map was completed and is shown on the attached Figure 2.3.

## 3. Background Information

### 3.1 Geohazard Assessment Key Findings

A geohazard assessment has been carried out and is presented in a separate companion report. The following points summarize the key findings from the assessment:

- Evidence for historic debris flows, debris torrents, and debris floods were not observed during the site reconnaissance or during the review of historic aerial photographs; however, it is not to say they have not occurred in the past. It is estimated that the occurrence of these events is considered very low to low.
- Smaller localized rock fall/landslide failures were evident in the historic aerial photographs and are considered a low to moderate hazard.
- At least one large rock fall event was observed to have occurred on the slope above the site prior to the 1938 historic aerial photographs; however, large-scale rock fall/landslide failures are considered a very low hazard.
- The historic aerial photographs showed earthworks within the project area have significantly impacted the surrounding natural waterways and wetland areas and changed their extents.
- Ecora considers it possible that small-scale, localized landslides and/or rockfalls have occurred more frequently than observed during the historic aerial photograph review, however the quality, resolution, seasonal variability etc. were such that these observations could not be confirmed with certainty. Our site reconnaissance observations included evidence for talus slopes and sporadic rock fall across the western slope; however, **did not** find evidence of recent movement.
- At the base of the western slope, to the south of the Site, a terrace is present that was anticipated to comprise colluvial and fluvial sediments. The terrace was observed to impact the natural alignment of the stream that flows through the Site.
- A *No Build Zone* shall be included for High Hazard Areas.

## 3.2 Historical Aerial Photograph Review

Available historic aerial photography obtained from the Geographic Information Centre (GIC) at the University of British Columbia (UBC) for the area between 1938 and 2006 was reviewed using a stereoscope to assist with understanding the history of development around the Site, and to help identify large scale geomorphological features that would be difficult to identify in the field. Identification of features is limited to the resolution and the elevation at which the aerial photography was taken.

The historical aerial photograph review was completed during the geohazard assessment and is included in the geohazard report.

## 3.3 Water Well Database

The Provincial Water Well Database, iMapBC, indicates that there are no water well records within a reasonable distance or elevation to be considered relevant to the study area.

The nearest waterway is Wilden pond, which is man-made and immediately north of the property. Still Pond lies approximately 275 m northeast of the Site with the water level surface at approximately 498 m.

## 3.4 Site Reconnaissance

A site reconnaissance was completed on June 8, 2021. This site recon was included in the geohazard assessment report and key findings are highlighted for this geotechnical assessment report are included in Section 3.1.

# 4. Geotechnical Site Investigation

## 4.1 General

Ecora conducted an intrusive geotechnical site investigation on August 31, 2021, comprising the excavation of 13 test pits.

The test pits were advanced using an excavator, operated by Copcan Civil LP of Rossland, BC. The geotechnical site investigation was supervised by Ecora field personnel from the Kelowna office, who logged the encountered material and collected representative samples for laboratory testing.

A summary of the geotechnical site investigation is provided in Table 4.1. A site plan showing the test pit locations is shown as Figure 1.3. The detailed logs are presented in Appendix C.

**Table 4.1 Geotechnical Site Investigation Summary**

Test Pit No.	Northing (m)	Easting (m)	Termination Depth (m bgl)	Comments
TP21-01	5534356.08	324373.13	3.0	Encountered Bedrock
TP21-02	5534263.76	324359.44	2.5	Encountered Bedrock
TP21-03	5534201.33	324338.75	4.3	Encountered Bedrock
TP21-04	5534164.22	324337.48	4.3	Encountered Bedrock
TP21-05	5534150.88	324309.91	2.4	Refusal
TP21-06	5534121.12	324317.76	5.1	Reached Target Depth

Test Pit No.	Northing (m)	Easting (m)	Termination Depth (m bgl)	Comments
TP21-07	5534093.79	324299.16	5.0	Reached Target Depth
TP21-08	5534133.25	324371.43	1.3	Encountered Bedrock
TP21-09	5534194.92	324406.96	1.0	Refusal
TP21-10	5534289.02	324422.38	0.8	Refusal
TP21-11	5534343.71	324442.51	0.7	Refusal
TP21-12	5534237.94	324438.04	3.2	Encountered Bedrock
TP21-13	5534145.94	324354.10	1.5	Observations for Groundwater Table

Note: Coordinates are reported in NAD 1983 UTM Zone 11 and were recorded on site using a handheld GPS receiver.

The test pits were backfilled immediately upon completion.

## 5. Encountered Subsurface Conditions

### 5.1 Soil and Bedrock Conditions

The following subsurface conditions were encountered during the geotechnical site investigation:

- **Topsoil** – topsoil was encountered at most test pit locations and generally consisted of roots and rootlets at ground surface ranging in thickness from 0.1 to 0.2 m.
- **Colluvial deposits** – generally consisted of loose sand, silty to and silt, some gravel to gravelly, poorly to well graded, fine to coarse grained sand, and fine to coarse grained gravel. The deposits were typically dry, beige to light grey in colour, low to no plasticity, and contained trace rootlets. The layer depth generally was found to terminate between 0.4 m to 2.0 m bgl.
- **Alluvial deposits** – generally consisted of loose to dense sands and gravels, trace silt to silty, with angular cobbles, well graded, fine to coarse grained sand, fine to coarse grained gravel, and sub rounded to angular gravel. The deposits were typically dry, light grey to dark brown in colour, and trace rootlets. TP21-02 observed soft clay, trace medium grained sand, and high plasticity. A dense gravel layer was also found within the eastern section of the property lot at shallow depths, typically reaching refusal from 0.7m to 1.0 mbgl.
- **Bedrock** – Assumed breccia white to grey in colour, encountered refusal at depths varying between 1.3 m to 4.3 m bgl.

### 5.2 Groundwater Conditions

At the time of the geotechnical site investigation, groundwater was encountered between 2.9 m and 1.5 m bgl in TP21-12 and TP21-13, respectively. It should be noted that groundwater levels fluctuate depending on the time of year, such as spring freshet or after heavy rainfall.

### 5.3 Laboratory Testing

Laboratory testing was conducted on select representative soil samples at our Canadian Council of Independent Laboratories (CCIL) certified laboratory in Penticton, BC, to confirm the field observations and geotechnical

properties. Testing was carried out in general conformance with the relevant ASTMs. Table 5.3 provides a summary of the laboratory testing results, with more detailed test results provided in Appendix D, and are included on the test pit logs in Appendix C.

**Table 5.3 Summary of Laboratory Testing Results**

Test Pit No.	Top of Sample Depth (m bgl)	Moisture Content (%)	Atterberg Limits (%)			Particle Size Distribution (% finer than)			
			Liquid Limit	Plastic Limit	Plasticity Index	Gravel	Sand	Fines Silt Clay	
TP21-01	1.3 – 2.0	20.1	-	-	-	0.2	55.5	44.3	
TP21-03	2.5 – 3.5	28.1	72	25	47	0.1	37.9	38.8	23.2
TP21-04	3.0 – 4.0	11.4	-	-	-	27.5	65.8	6.7	
TP21-12	1.9 – 3.2	11.2	-	-	-	29.8	53.7	16.5	

## 6. Seismic Considerations

### 6.1 General

The BCBC (2018) recommends a performance criterion where the threat to “life safety” for seismic hazards is less than a 2% chance in 50 years. This performance criterion assumes that there is a high probability that once every 2,475 years, a seismic event will occur resulting in extensive structural damage. There is a reasonable degree of confidence that a well-constructed and maintained building will not collapse despite experiencing extensive structural and non-structural damage as a consequence of such an extreme event. This life safety criteria does not consider the extent of soil movement that might occur (i.e., slope instability, lateral spreading etc. that may extend to under, or beyond the structure).

### 6.2 Seismicity

The GSC has developed a probabilistic (5<sup>th</sup> Generation) seismic hazard model (Halchuk, Adams, & Allen, 2015) that forms the basis of the seismic design provisions of the National Building Code of Canada (2015).

Peak Ground Accelerations (PGA) and Spectral Accelerations (Sa(T)) for a reference “Class C” (very dense soil and soft rock) can be obtained from the Earthquakes Canada website (Earthquakes Canada, 2021) for various return periods. The values for the project area are summarized in Table 6.2 below.

**Table 6.2 Reference (Class C) Design PGA and Sa(T) for 225 Upper Canyon North Drive, Kelowna, BC.**

Return Period	PGA (g)	Sa(0.2) (g)	Sa(0.5) (g)	Sa(1.0) (g)	Sa(2.0) (g)
475 years	0.026	0.058	0.058	0.043	0.028
975 years	0.040	0.087	0.082	0.061	0.041
2,475 years	0.065	0.141	0.120	0.090	0.063

## 6.3 Site Classification for Seismic Response

Based on Table 6.3 below (reproduction of Table 4.1.8.4.A, BCBC) (2018), along with the results of our site observations, the geotechnical site investigation, and our experience with similar sites in the area, a seismic site classification of Class C “Very Dense Soil” is anticipated for the site.

**Table 6.3 Site Classification for Seismic Site Response based on Soil Compactness/Consistency (BCBC 2018)**

Average Properties in Top 30 m as per BCBC (2018), (Division B- Part 4)				
Site Class	Soil Profile Name	Soil Shear Wave Average Velocity $\bar{V}_{s30}$ (m/s)	Standard Penetration Resistance, $\bar{N}_{60}$	Soil Undrained Shear Strength $s_u$ (kPa)
A	Hard Rock	$\bar{V}_{s30} > 1500$	Not Applicable	Not Applicable
B	Rock	$760 < \bar{V}_{s30} < 1500$	Not Applicable	Not Applicable
C	Very Dense Soil and Soft Rock	$360 < \bar{V}_{s30} < 760$	$50 < \bar{N}_{60}$	$100 < s_u$
D	Stiff Soil	$180 < \bar{V}_{s30} < 360$	$15 \leq \bar{N}_{60} \leq 50$	$50 < s_u < 100$
E	Soft Soil	$\bar{V}_{s30} < 180$	$\bar{N}_{60} < 15$	$s_u < 50$
		Any profile with more than 3 m of soil with the following characteristics: Plasticity Index, $I_p > 20$ ; Moisture Content, $w \geq 40\%$ ; and Undrained Shear Strength, $s_u < 25$ kPa		
F	Other Soils	Site specific evaluation required		

- (1) Site Classes A and B, hard rock and rock, are not to be used if there is more than 3m of softer materials between the rock and the underside of footing or mat foundations. The appropriate Site Class for such cases is determined on the basis of the average properties of the total thickness of the softer materials (see Note A-4.1.8.4.(3) and Table 4.1.8.4 -A).
- (2) Where  $\bar{V}_{s30}$  has been measured in-situ, F(T) values for Site Class A derived from Tables 4.1.8.4-B to 4.1.8.4-G are permitted to be multiplied by the factor  $0.04 + (1500 / \bar{V}_{s30})^{1/2}$
- (3) Other soils include:
  - a) liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils, and other soils susceptible to failure or collapse under seismic loading;
  - b) peat and/or highly organic clays greater than 3 m in thickness;
  - c) highly plastic clays ( $PI > 75$ ) more than 8 m thick, and
  - d) soft to medium stiff clays more than 30 m thick.

## 6.4 Liquefaction Assessment

Based on the encountered subsurface conditions and considering the relatively low seismic hazard values for the Site, the encountered soils are considered to have a low susceptibility to liquefaction.

# 7. Slope Stability Analysis

## 7.1 General

The stability of a slope is controlled by the ratio between available shear resistance and the acting shear stresses along a potential sliding plane or slip surface, which can be expressed in terms of a Factor of Safety (FoS). A slope with a FoS of 1.0 is at equilibrium and is considered marginally stable.

The purpose of the analysis was to evaluate the long-term static and pseudo-static global stability of the slopes in vicinity of the proposed development in order to establish safe set back/set forward distances and for the provision of recommendations.

## 7.2 Methodology

Limit Equilibrium (LE) stability analyses were performed using the commercial computer program Slide2 v9.016 by RocScience, based on the existing ground conditions, as described in Section 5. The analysis was undertaken using topography from the City contours for the four cross-sections Sections A-A', B-B', C-C', and D-D' (as indicated on Figure 1.3). There is no slope analysis for Section D-D' as the only slope represented for development is at the location of the proposed walk-out basement.

Global FoS were calculated using the two-dimensional Morgenstern-Price method with a half sine interslice force adopted. Surcharge loads of 20 kPa and 12 kPa have been applied for proposed structures and roadways, respectively.

## 7.3 Geotechnical Design Criteria

As the City of Kelowna has not established minimum design criteria for slope stability, reference has been made to the BC Ministry of Transportation and Infrastructure (MoTI), who are the subdivision approval authority for the Regional District of Central Okanagan (RDCO), for which is the region the City falls in. The Technical Circular T-04/17 Geotechnical Design Criteria (2017) stipulates (for slopes less than 70°) “*Soil slope and embankment global stability shall be designed to meet the values in Table 6.2b (Resistance Factors, Consequence Factors, and FoS for Global Stability of Embankments) in the MoTI Supplement to CHBDC S6-14 (MoTI Supplement)*” which states a minimum FoS for long-term global stability of 1.54 assuming typical degree of stie understanding and typical consequence).

Technical Circular T04-17 Geotechnical Design Criteria (2017) also stipulates “*Seismic performance criteria are provided for slopes and embankments in the MoTI Supplement*”, which states a minimum FoS of 1.1 for pseudo-static conditions.

## 7.4 Geotechnical Design Parameters

Geotechnical design parameters used in the analysis are given in Table 7.4.a and have been derived based on the geotechnical site investigation, laboratory testing results, existing site conditions, published correlations, and Ecora’s previous local experience.

Several publications provide typical values for a range of different soil types encountered, such as Bowles (1997), which provides representative values of angle of internal friction as well as the Washington State Department of Transportation (WSDoT), Geotechnical Design Manual (2015), which outlines typical material properties for materials similar to those found in the Interior of BC.

The analysis generally assumes that the soil shear strength is governed by the Mohr-Coulomb criteria given by:

$$\tau = c' + \sigma' \tan \phi'$$

$\tau$  = Soil Shear Strength.

$\sigma'$  = Normal Effective Stress.

$c'$  = Effective Cohesion.

$\phi'$  = Effective Angle of Internal Friction.

**Table 7.4.a Summary of Geotechnical Design Parameters**

Material Name	Strength Type	Unit Weight, $\gamma$ (kN/m <sup>3</sup> )	Effective Cohesion, $c'$ (kPa)	Effective Friction Angle, $\phi'$ (°)
Structural Fill	Mohr Coulomb	21	0	37
Sandy Silt (Colluvium)	Mohr Coulomb	19	0	32
Sandy Silt (Alluvium)	Mohr Coulomb	20	1	34
Dense Gravel (Alluvium)	Mohr Coulomb	20	1	38
Bedrock <sup>1</sup>	Generalized Hoek-Brown	26	-	-

<sup>1</sup> The rock mass strength was modelled utilizing the Generalized Hoek-Brown (2002) criterion discussed in the following sections.

## 7.4.1 Hoek-Brown Criterion

The Generalized Hoek-Brown (2002) criterion is an empirical failure criterion which establishes the strength of rock in terms of major and minor principal stresses. It predicts strength envelopes that agree well with values determined from laboratory tri-axial tests of intact rock, and from observed failures in jointed rock masses and can be used to model the stability of rock slopes.

The input parameters used are summarized in Table 7.4.b below. A disturbance factor, D, of 0 was used for the undisturbed rock mass forming the existing slope.

**Table 7.4.b Hoek Brown Criterion Calculation Input Parameters**

Unconfined Compressive Strength (UCS) (MPa)	Geological Strength Index (GSI)	mi curve fitting parameter
15	69	19

The Generalized Hoek-Brown material constants were calculated using the program RocLab™ by RocScience and are presented in Table 7.4.c below.

**Table 7.4.c Hoek-Brown Material Constants**

mb	s	a
6.280	0.0319	0.501

## 7.4.2 Results

The results of the stability analysis for Sections A-A', B-B' and C-C' are summarized in Table 7.4.d below and presented in Appendix E. Both east and west slopes were analyzed for each of the sections and the minimum factor of safety of the critical slip surfaces is shown below. Results of the analysis indicate that under existing conditions, the slopes in Sections A-A' and B-B' **do not** meet the minimum design criteria for global stability.

The reported calculated FoS values are for slip surfaces that impact the Site only and do not include the stability of cut slopes along the roads.

**Table 7.4.d Calculated Global Stability Factors of Safety**

Section	Minimum Required FoS		Calculated Minimum FoS	
	Static	Pseudo-Static	Static	Pseudo-Static
Section A-A'	1.54	1.1	1.00	0.87

Section	Minimum Required FoS		Calculated Minimum FoS	
	Static	Pseudo-Static	Static	Pseudo-Static
Section B-B'	1.54	1.1	1.00	0.88
Section C-C'	1.54	1.1	1.54	1.34
Section D-D'	1.54	1.1	-	-

The steep slopes along the western boundary of the property lot consisted of existing colluvium and as shown in the terrain stability map in Figure 5.2.b, they were considered unstable. A supplementary subsurface investigation can be completed in detailed design to determine the depth of soil to bedrock and confirm cut slopes required for the proposed roadway being developed to the west of the site.

From the results, the west slopes for Sections A-A' and B-B' **do not** meet the required minimum static and pseudo-static FoS as outlined in Table 6.2b of the Supplement to the CHBDC S6-14 (2016). The slope stabilities do not meet the minimum FoS due to 1.2H:1V and 1H:1V slopes at Sections A-A' and B-B'. Unless flatter slopes can be achieved, stabilization measures will need to be considered to meet slope stability requirements. It is understood that the ESA located at the toe of the slope presents geometric constraints.

## 8. Discussion and Preliminary Recommendations

### 8.1 General

In Ecora's opinion, from a geotechnical engineering perspective, the Site is suitable for the proposed development provided the geotechnical constraints identified below are addressed during the detailed design and construction phases of the project. Ecora has provided preliminary recommendations for site preparation, shallow foundation design, and site drainage in the following sections.

### 8.2 Geotechnical Design Constraints

Based on the site reconnaissance, encountered soil conditions, and the results of our analysis, Ecora has identified the following geotechnical constraints:

- There is currently limited design information of the proposed structures, however it is anticipated the structures will fall under Part 4 of the BCBC (2018), which is expected to govern the design of the structures.
- Sections A-A' and B-B' do not meet the minimum required Global FoS for static and pseudo-static conditions. If more gradual slopes cannot be achieved due to geometric constraints, slope stabilization measures such as retaining walls and/or geogrid reinforced slopes should be considered during detailed design.
- Proposed structure positioned within the rockfall shadow will require either rockfall mitigation measures to the adjacent rock slope or moving the proposed development outside of the rockfall shadow.
- If structures are proposed at locations within the Site where bedrock is present, detailed assessment of the bedrock is required and may include kinematic analysis and laboratory testing to assist with rock slope design and stabilization recommendations.

- An Acid Rock Drainage (ARD) and Metal Leaching (ML) assessment will be required during the detailed design phase to identify potential areas of concern with respect to rock excavation and disposal.
- Localized rock cut slope stabilization i.e., scaling, rock removal, structural reinforcement, dentition, and/or drainage, may be required at locations within the Site where bedrock is exposed.
- For shallow foundations at locations within the Site where bedrock is present, rock dwelling may be required to resist lateral loads imposed on structures by excavations.
- Shoring and/or retaining wall(s) may be required during excavation and construction in areas identified as moderate and high to very high geohazard risk.
- Shoring may also be required during excavation for new foundations if conditions do not allow for a safe excavation slope.
- Areas of low and moderate environmentally sensitive areas have been identified in an environmental assessment of the site, submitted under a separate report.

Recommendations will be refined and updated during the detailed geotechnical design phase, where architectural drawings are anticipated to be provided.

## 8.3 Development Set Back

As discussed in the companion geohazard report, Ecora recommends a *No Build Zone* for High Hazard Areas. This zone includes the slope plus a safe building set back from the crest, as shown in Figure 8.3. This zone is restricted by the following conditions:

- Buildings, deck posts, and structures are permitted to encroach into this zone providing their foundations are located a minimum of 0.6 m below the projected 2H:1V line;
- No surface discharge of water from irrigation systems or swimming pools;
- No rock pits or other drainage discharge (i.e. septic fields);
- No excavation greater than 0.5 m;
- No removal or disturbance of vegetation (with the exception of the removal of weeds by hand) or trees, except for wildfire mitigation and forest health maintenance;
- No utilities or pipe-ways, unless approved by a Qualified Geotechnical Engineer; and,
- Any pools located in this area shall incorporate a leak detection system.

During construction, the above-mentioned *No Build Zone* shall also be followed for stockpiling material, construction traffic, and any other soil disturbances. Adequate silt fence installation will be required to provide effective sediment control. All silt fence locations and installation shall be in accordance with the Erosion Control Plan, prepared as per the control measures in Section 7.3 of the Geohazard Assessment Report, and confirmed by the on-site civil site representative.

The geotechnical *No Build Zone* shall be permanently surveyed and pinned in the field for the building department and homeowner reference and confirmed by a Qualified Geotechnical Engineer on-site.

Revisions to the geotechnical *No Build Zone* is subject to a site-specific geotechnical assessment and design by a Qualified Professional Geotechnical Engineer.

Development within the stable to potentially unstable areas will have site prepped according to recommendations specified in Sections 8.5.

## 8.4 Development Set Forward

As described in the companion geohazard report, it was found that all cross-sections selected through the proposed development location downslope is within the rockfall shadow, which is determined by projecting a line from the crest of the slope down to the ground surface. As identified in the geohazard report, the rockfall shadow angles varied from 22-25° within the south section, and 30-32° in the north section.

Any proposed structure positioned within the rockfall shadow will require either rockfall mitigation measures to the adjacent rock slope or moving the proposed development outside of the rockfall shadow. However, it should be noted that the locations of the proposed development have not been finalized at the time of this report and thus, further analysis will be required to ensure the location is outside of the rockfall shadow or incorporate the design of a selected rockfall mitigation measure. In the case where rock stabilization mitigation measures are required, long term maintenance will be required by the owner as the development is considered to be strata.

## 8.5 Site Preparation

### 8.5.1 Stripping

The site preparation for the proposed residential structures shall be thoroughly cleared of all rubbish, debris, vegetation, organic material, topsoil, uncontrolled fill, and other deleterious material to expose native soil or bedrock. Based on the soil conditions encountered in the test holes/pits, we anticipate that stripping and sub-excavation depths required to expose competent subgrade will be approximately 1.0 mbgl. Greater excavation depths may be required in localized areas.

All site preparation should allow for the foundations to be constructed below the minimum depth of freezing, as described in Section 8.6.3. The subgrade elevation should be free of oversized material (i.e., cobbles, boulders etc.) to allow for uniform compaction of the subgrade soils.

### 8.5.2 Subgrade Preparation

The stripped subgrade shall be reviewed by a Qualified Geotechnical Engineer prior to any fill or concrete placement (including formwork). Any cobbles and boulders present at the subgrade elevation should be removed to allow for uniform compaction of the subgrade soils. Areas that contain fill, organic matter or unsuitable soil shall be over-excavated and replaced with structural fill in accordance with the recommendations provided in Section 8.5.3.

Prior to placement of structural fill, the exposed native subgrade shall be moisture conditioned to +/- 2% of the optimum moisture content and compacted using self propelled vibratory equipment to a minimum 95% of the Modified Proctor Maximum Dry Density (MPMDD) (ASTM D1557-12e1, 2012) under the supervision of the Qualified Geotechnical Engineer. Areas that break up, show evidence of movement or visible deformation shall be undercut by a minimum of 0.3 m and re-compacted then replaced with structural fill.

### 8.5.3 Structural Fill

Structural fill in this report refers to permanent fill that will be located below foundations, slabs, and other settlement-sensitive features. The structural fill material shall comprise clean (free draining, less than 8% fines), well-graded granular material such as 75 mm minus pit run sand and gravel or an approved alternative. A Qualified Geotechnical

Engineer should be provided with the opportunity to review and approve alternative materials prior to their use at the site.

Upon subgrade approval from a Qualified Geotechnical Engineer, the structural fill material shall be moisture conditioned to  $\pm 2\%$  of the optimum moisture content, placed in horizontal lifts typically not exceeding 300 mm in loose thickness and uniformly compacted to a minimum 95% of the material's MPMDD in accordance with ASTM D1557 (2012). In-place soil density testing on all structural fill shall be completed to confirm that adequate compaction is achieved.

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

Care should be taken during winter construction to make sure that the structural fill material is not placed in a frozen or excessively wet state. Structural fill soils shall also not be placed on frozen subgrade.

## 8.5.4 Re-use of On-Site Material

Excavated native sand and gravel material may be re-used as structural fill provided that it is free of organics, any deleterious material, the silt content is less than 8%, and that the specified 95% of MPMDD compaction can be achieved (ASTM D1557-12e1, 2012). It should be noted that the surficial granular soils have fines content greater than 8%. The suitability of any on-site or imported material proposed for use as structural fill should be confirmed by a Qualified Geotechnical Engineer prior to its use on site.

Excavated on-site materials may also be re-used as utility trench backfill provided it is free of organics, any deleterious material and that the specified 95% MPMDD compaction can be achieved.

Excavated material which is intended to be re-used at the site shall be stockpiled in a suitable area away from the earthworks and excavations. Excavated material which is unsuitable for re-use as fill shall be removed from site.

## 8.6 Preliminary Foundation Recommendations

### 8.6.1 Shallow Foundations

Given the general layout of the structures and that the topography of the cut and fill sections are not finalized at the time of writing of this report, proposing dimensions and ultimate bearing capacities for the shallow foundation cannot be completed at this time. However, a preliminary allowable bearing capacity of 75 kPa in accordance with Table 9.4.4.1 in the BCBC (2018) can be issued at this time based on the soil conditions encountered during the site investigation and Part 9 structure foundation requirements.

### 8.6.2 Slab-on-Grade Floors

Interior slab-on-grade floors should be supported on a minimum 150 mm thick layer of under-slab fill consisting of clean drain rock in accordance with the City's Development Bylaws (City of Kelowna, 2020), overlying approved native material or structural fill prepared in accordance with the recommendations in this report. The under-slab fill shall be placed to ensure good hydraulic connectivity to the perimeter drain discussed in Section 8.7.3 below.

If impermeable floor coverings are to be used for slab-on-grade floors, a 12 mm minimum thick PVC membrane shall be placed, with floor covering only to be placed once moisture diffusion through the concrete has reduced to acceptable levels.

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

## 8.6.3 Frost Penetration

Based on the US Corps of Engineers Frost Design Soil Classification from the CFEM, the Frost Group for the surficial soil encountered are considered to have a high frost susceptibility.

The CFEM (Canadian Geotechnical Society, 2006) states that frost penetration is proportional to the square root of time for a step-change in ground surface temperature. The most useful relationship, that is used in standard industry practice, to determine the frost penetration depth neglecting the frost heave is the modified Berggren equation as stated in Equation 13.8.1.

$$X = \lambda \sqrt{\frac{2(k_f)I_s}{L_s}} \quad (\text{Berggren, Equation 13.8.1})$$

Where:  $X$  = Depth of frost penetration

$I_s$  = Surface freezing index which can be estimated from the air freezing index times a ground surface interface factor “ $n$ ” (Equation 13.3 in CFEM, (2006)).

$k_f$  = Thermal conductivity of the frozen soil (Figure 13.6 “For coarse-grained soil” and Figure 13.7 “For fine-grained soil” in CFEM (2006)).

$L_s$  = Volumetric latent heat of the soil (Equation 13.6 in CFEM (2006)).

$\lambda$  = A dimensionless coefficient that is a function of the temperature gradient, the volumetric latent heat of the soil and the volumetric heat capacity of the soil. (Figure 13.8 in CFEM (2006)).

According to Environment Canada climatic data ([https://climat.meteo.gc.ca/climate\\_normals](https://climat.meteo.gc.ca/climate_normals)), the freezing index for the subject site is approximately 309-degree days below 0°C. Table 13.2 in CFEM (2006) recommends a ground surface interface factor ( $n$ ) of 1.0 for snow, which typically covers the project site throughout winter.

Based on the frost depth calculation and subsurface soil conditions, the anticipated maximum frost depth penetration is estimated at 0.6 m bgl.

It is important to note that the construction schedule plays an important role in the short- and long-term performance of proposed foundations and slabs. Should construction of the proposed structures be planned to take place over winter, Ecora shall be contacted to review and confirm that the winter related design concerns (i.e., frost heave of the subgrade) are addressed.

## 8.7 Drainage Considerations

### 8.7.1 Construction Dewatering

Depending on the final design and foundation elevations of the proposed structures, dewatering may be required.

Construction dewatering can generally be performed by pumping the water from inside and/or outside of the excavation.

The temporary construction method for this project would likely be a system of ditches leading to sumps equipped with pumps. Typically, the design and operation of the dewatering system would be the responsibility of the construction Contractor, with review and approvals from a Qualified Geotechnical Engineer.

Temporary dewatering will lower the surrounding groundwater table and may result in some additional deformation of the surrounding soils. The specific requirements of any temporary dewatering systems will need to be assessed during the detailed design.

## 8.7.2 Foundation Drainage

Section 9.14.2 of the BCBC (2018) specifies that unless it can be shown to be unnecessary, the bottom 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 exterior building foundations. The perimeter drainage system should be constructed with rigid perforated PVC piping with a minimum diameter of 100 mm covered with not less than 150 mm of clean drain rock in accordance with the City's Development Bylaws (2021). The invert of the perimeter drain-pipes should be located at least 300 mm below the top of the floor slab or at the bottom of the footing, whichever is deeper. The collected water should drain to the storm water disposal system as discussed in Section 8.7.3 below.

## 8.7.3 Storm Water Management and Site Storm Disposal

The use of on-site stormwater disposal systems (i.e., infiltration pits) are not considered to be suitable for this development due to the silty soils onsite and close vicinity to the creek, and would likely act as more of a stormwater retention rather than detention system. The City's map viewer indicates a 375 mm diameter AC stormwater main flows along Upper Canyon North Drive. It is recommended that roof leader and perimeter drainage is connected to the nearest City stormwater system if site grading allows. Should the City's stormwater system not have sufficient capacity to dispose of peak stormwater generated from the Site, it may be necessary to tank the stormwater and slow release it into the City system.

Sidewalks, paved, or landscaped areas within a zone of approximately 2.0 m of the exterior perimeter of any buildings should be sloped to drain water away from the structure at a minimum gradient of 2%. Site grading should be designed in such a manner so as to prevent the ponding of surface water near foundation walls and paved areas. Roof rainwater leaders should be connected to a separate drainage system comprised of non-perforated rigid PVC drainpipes.

Drainage considerations established during design and construction should be maintained for the life of the development. Altering drainage patterns can be detrimental to the performance of the building's floor slab and foundation.

## 8.8 Temporary Excavation and Utility Trenching

Temporary excavation work should be carried out in accordance with requirements specified by the WorkSafe BC Occupational Health & Safety (OH&S) Regulations, Part 20 presented in Figure 8.8 (2014). 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 WorkSafe BC OH&S Regulations, Part 20. A Qualified Geotechnical Engineer shall review all proposed temporary excavation works during construction, when required by WorkSafe BC.

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 Geotechnical Engineer.

All utilities should be bedded as per the City's Development Bylaws (2020). 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 MPMD, in accordance with ASTM D1557 (2012).

## 8.9 Permanent Cut and Fill Slopes

As reported in Section 7.4.2, Sections A-A' and B-B' do not meet the minimum required Global FoS for static and pseudo-static conditions. Ideally, permanent cut and fill slopes formed in the native soils shall be graded no steeper than 2H:1V (horizontal:vertical). Permanent fill slopes shall be over-built and then trimmed back to the recommended inclination. If this cannot be achieved due to geometric constraints, slope stabilization measures such as retaining walls and/or geogrid reinforced slopes can be considered during detailed design, as outlined below.

Retaining walls are proposed by the client to stabilize sections along the western boundary to allow for roadway ROW. The design of the retaining walls can be determined during detailed design with the addition of the supplementary subsurface investigation as mentioned in Section 7.4.2.

The establishment of vegetation on slopes assist with stabilization by root-binding, preventing erosion, and lowering soil moisture content. Permanent cut and fill slopes shall be vegetated immediately after construction to minimize the potential for erosion. Large trees should be kept away from shallow surface foundations to prevent root interaction effects.

### 8.9.1 Soil Reinforced Wall

A soil reinforced wall is an option that can be considered to stabilize permanent slopes. Reinforcement within the soil can comprise of geosynthetic or steel material and the anchorage to the wall can be segmental facing blocks or wrapped-facing panels. Then the slope above or below the wall can be flattened to a more favourable slope angle, such as 2H:1V. Placing the wall at the crest as opposed to the toe of the slope is recommended as placement at the toe would require the wall to retain both the slope and structure, instead of just the structure requiring less reinforcement for the wall construction.

### 8.9.2 Reinforced Slopes

Reinforced soil slopes can be reinforced with geogrid or other similar products to enable the construction of steeper slopes that otherwise do not meet design criteria. They stabilize the soil by restraining lateral deformations through soil compaction and confinement along the length of the geogrid reinforcement strips/sheets. This confinement mechanism acts to bond the soil with the reinforcement, creating a solid soil mass block reducing the likelihood of shallow soil slides at steeper slope grades. Slopes are easy to install, have a low cost, and are effective in slope stabilization.

## 8.10 Localized Rock Cut Slope Stabilization

If required, rock stabilization work should be reviewed in the field by the Geotechnical Engineer with the Contractor, to identify areas that require rock support and to confirm the requirements of localized rock support.

Mitigation measures to enhance stability include the following:

- **Scaling** – consisting of the removal of loose rock off the cut face and overburden from the crest of a slope. Scaling is expected to be done by hand or by a machine.
- **Rock Removal** – consisting of re-sloping and unloading the rock mass by rock scaling, trimming, or other excavation techniques. Rock trimming can be done with hydraulic splitters, chemical expanders, or pneumatic hammers.

- **Structural Reinforcement** – may be provided by spot rock bolts and dowels. Tensioned rock bolts are used to increase the normal stress along the discontinuity where sliding is possible, thus increasing the shear resistance of the discontinuity. They may also be used to anchor potentially unstable rock blocks in place. Dowels are un-tensioned rock bolts or shear pins used to resist lateral movement of rock blocks by their shear capacity. Bolts and dowels should be galvanized and fully encapsulated in grout with the use of centralizers.
- **Dentition** – can be used to backfill slots resulting from trimming of bands of soft material or to support overhand formed in the rock face.
- **Drainage** – dewateres the rock slope to reduce the impact of groundwater pressures and improves slope stability. Reduced groundwater pressures within a discontinuity increases the shear strength. Proper drainage of rock slopes can be achieved by installing drain holes (wee holes, horizontal drains).

## 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 disputes.

**Once the details of the proposed development have been confirmed, Ecora shall review the stability of proposed site regrading and potential for rock fall hazards to impact the proposed development.**

All preliminary 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;
- Engineering review of temporary excavation works (including construction of temporary shoring) and slope monitoring during excavation to maintain stability of the slope bordering the site; 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 might be in contravention of the BCBC (2018).

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

## 10. Closure

We trust that this report satisfies your present requirements. Please contact our office if you have any questions or comments.

# References

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# Figures

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Figure 1.3	Site Overview
Figure 8.3	No-Build Zone
Figure 8.8	WorkSafe BC Temporary Excavation Sloping

## GEOTECHNICAL ASSESSMENT 225 CANYON DRIVE NORTH KELOWNA, BC

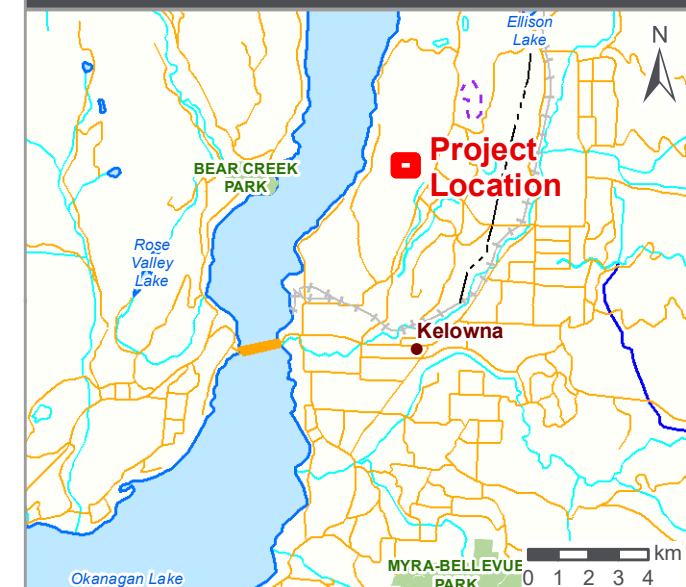
### Legend

- Test Pit Locations
- Section Lines
- 20m TRIM Contour Lines
- City of Kelowna Roads
- Approximate Fortis Gas Line
- City of Kelowna Legal Parcels
- Property Boundary

### References

Aerial Imagery: City of Kelowna GIS. Imagery Date: 2020

### LOCATION MAP



1:2,000



Project No.: 201827

Date: 2021/11/10

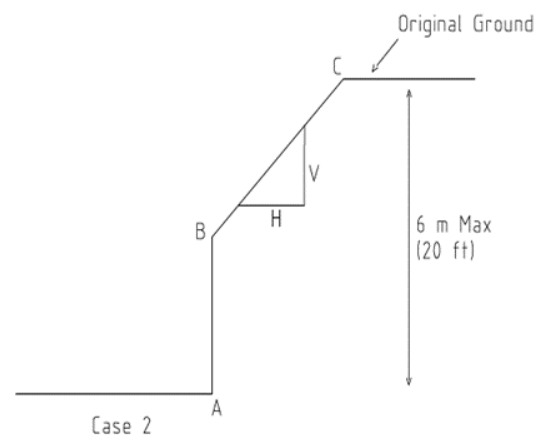
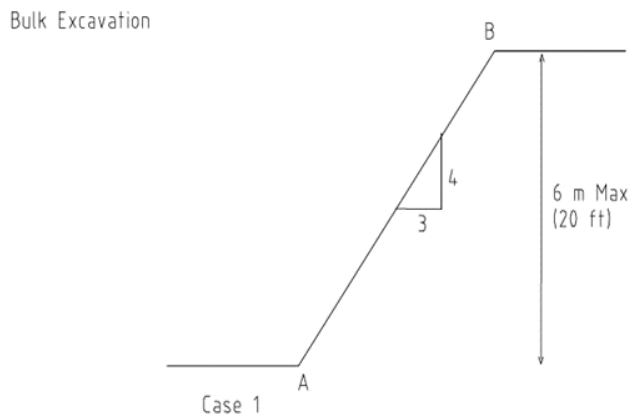
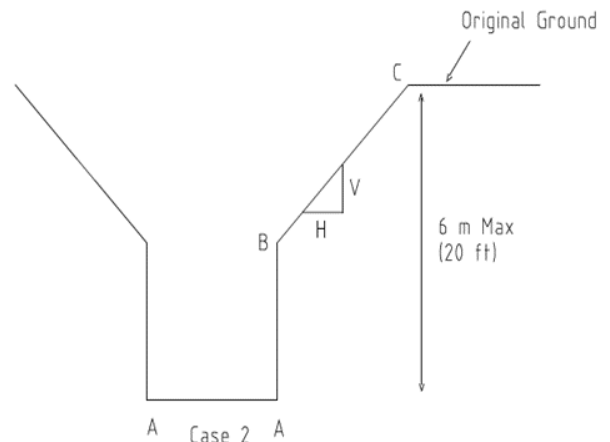
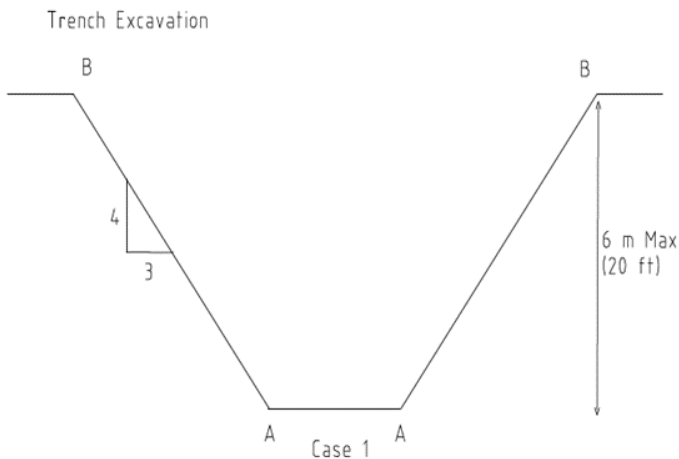
Client: Wilden Construction Corp.

Drawn: DT Check: DA

NAD 1983 UTM Zone 11N

**Figure 1.3**





**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

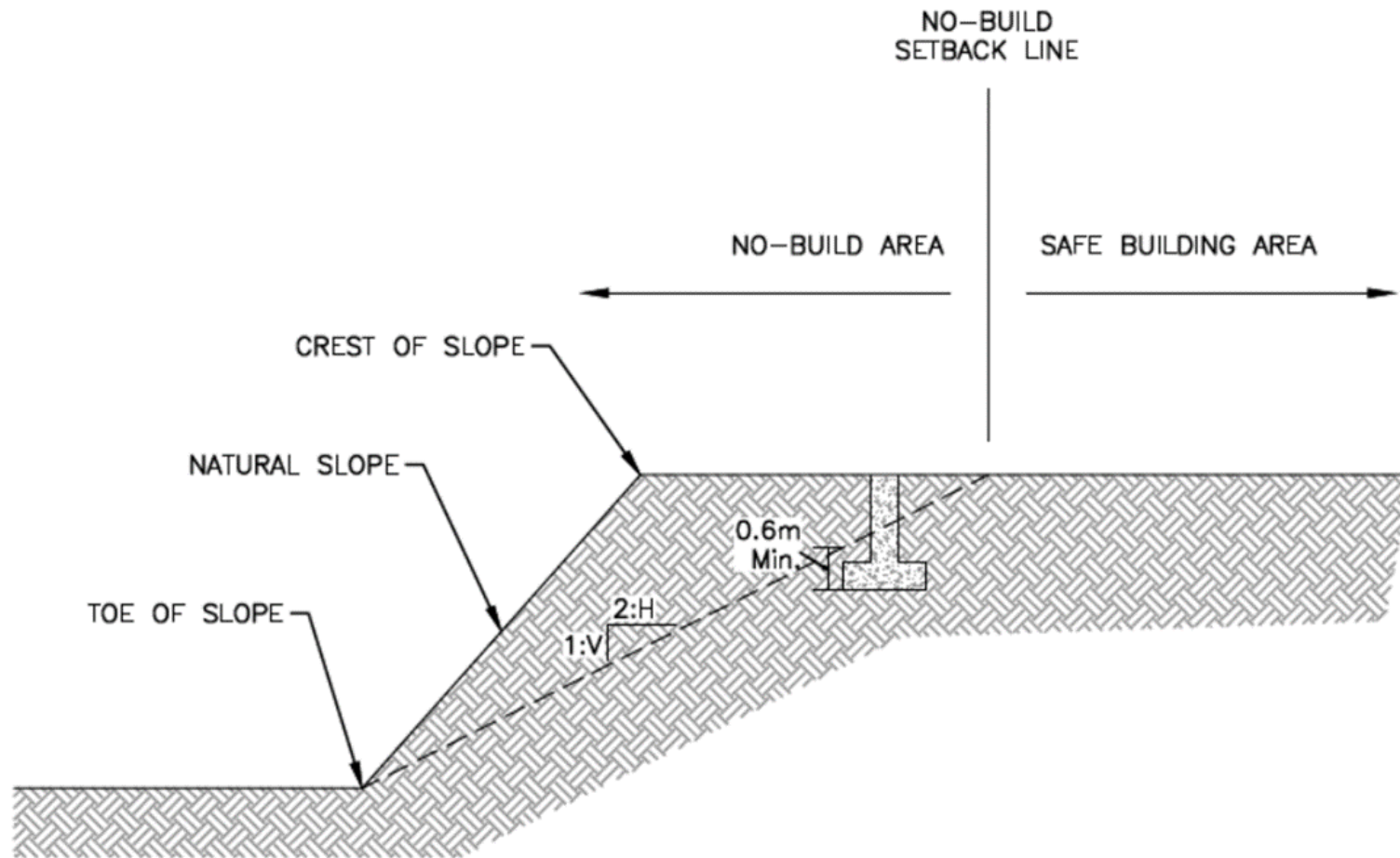
**GEOTECHNICAL ASSESSMENT**  
**225 Upper Canyon Drive North, Kelowna, BC**

**WorkSafe BC Temporary Excavation Sloping Requirements**

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 16, 2021  
 DWN: DA CHK: JC



**Figure 8.8**



**NO-BUILD AREA – TYPICAL SECTION FOR NATURAL SLOPES GREATER THAN 2H:1V**

NTS

Notes:

**GEOTECHNICAL ASSESSMENT  
225 Upper Canyon Drive North, Kelowna, BC**

**No-Build Area – Typical Section**

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 16, 2021  
 DWN: DA CHK: JC



**Figure 8.3**

# Appendix A

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## 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.

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### **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.

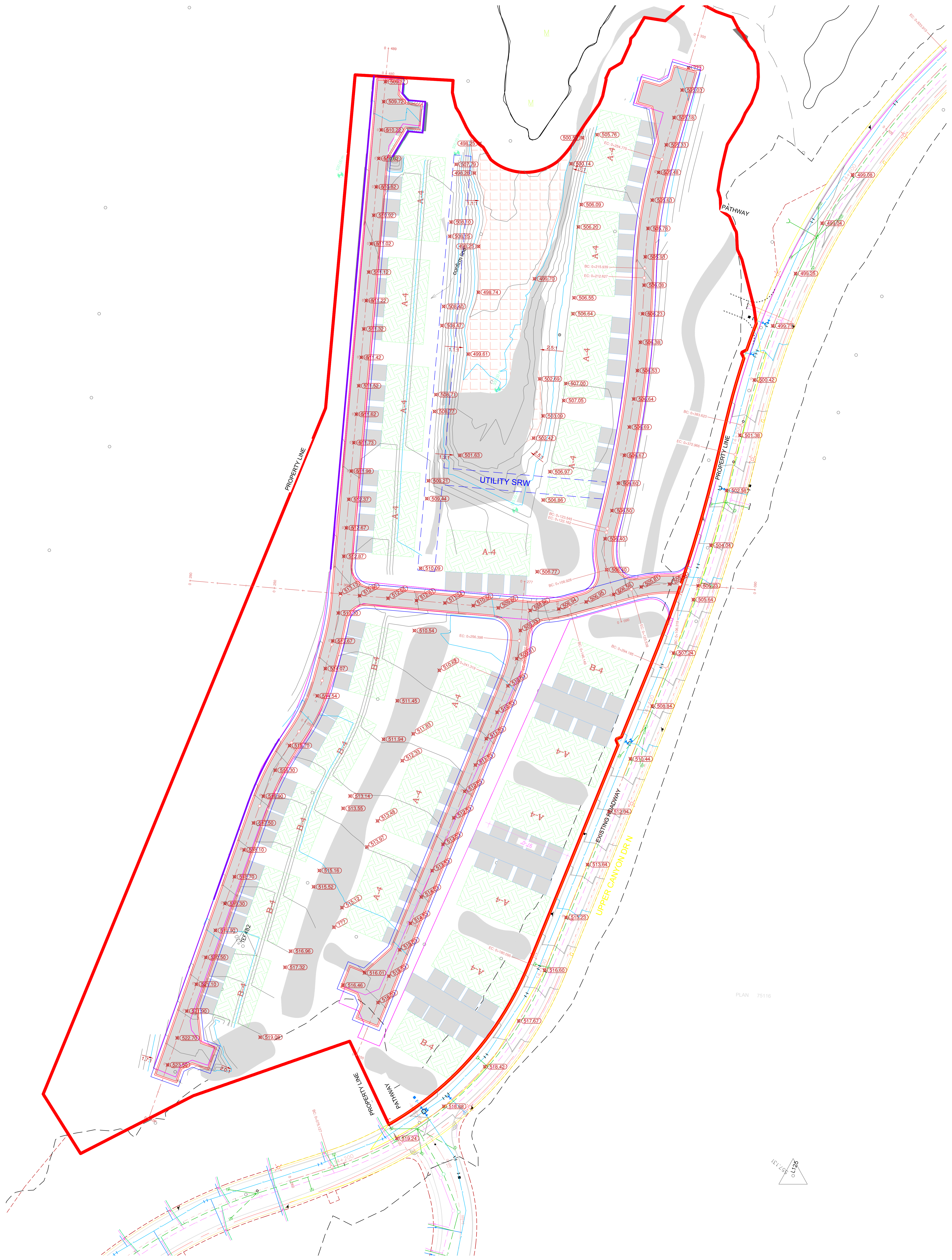
### **Services of Sub consultants and Contractors**

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.

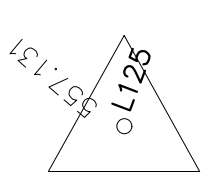
# Appendix B

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## Site Development Drawings



PLAN 75116



# Appendix C

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## Test Pit Logs

# TEST PIT: TP21-01

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534356 Easting: 324373

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 500 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS  PLASTIC      M.C.      LIQUID 	IN-SITU SHEAR VANE TEST REMOULDED (kPa)    PEAK (kPa)		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		SCALA PENETROMETER Blows Per 50mm Penetration		
0		<b>ORGANICS (TOPSOIL)</b> (0 m to 0.1 m) Compact ORGANICS.							
0.1		<b>SAND and SILT (COLLUVIUM)</b> (0.1 m to 1.1 m) Compact to loose, gravelly SAND and SILT, trace to some clay, with cobbles, well graded, moist, light grey to beige, fine to coarse grained sand.							
1.1		<b>SAND (ALLUVIAL DEPOSITS)</b> (1.1 m to 1.3 m) Gravelly SAND, some silt and clay, well graded, wet to saturated, fine to coarse grained sand, fine to coarse subangular to subrounded gravel. At 1.1 m: water seeping.	0.2	55.5	44.3				499
1.3		<b>SAND (ALLUVIAL DEPOSITS)</b> (1.3 m to 3 m) Loose, SAND and SILT, some compact "chunks" of clay, brown with dark brown "chunks", fine to coarse grained sand. From 2.0 m: poorly graded, dry, brown.							498
3.0		End of testpit at 3.0 m, encountered refusal on bedrock.							497

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT.ECORA2018.GDT 21-12-10

# TEST PIT: TP21-02

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534263 Easting: 324359

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 503 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS  PLASTIC M.C. LIQUID 10 20 30 40	IN-SITU SHEAR VANE TEST REMOULDED (kPa) PEAK (kPa) 40 80 120 160		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		SCALA PENETROMETER Blows Per 50mm Penetration 3 6 9 12		
0	x	<b>SAND (ALLUVIAL DEPOSITS)</b> (0 m to 0.6 m) Loose, silty SAND, some clay, with cobbles, poorly graded, dry, low plasticity, brown, fine to coarse grained sand, trace rootlets.							
0.6	x	<b>SAND and SILT (ALLUVIAL DEPOSITS)</b> (0.6 m to 1.2 m) Gravelly SAND and SILT, trace clay, well graded, low plasticity, light grey, fine to coarse grained sand, fine to coarse gravel.							502
1.2	x	<b>CLAY (ALLUVIAL DEPOSITS)</b> (1.2 m to 1.7 m) Soft CLAY, trace sand, trace silt, wet, high plasticity, beige, medium grained sand, oxidation.							
1.7	x	<b>SAND and CLAY (ALLUVIAL DEPOSITS)</b> (1.7 m to 2 m) SAND and CLAY, trace gravel, dry to moist, medium plasticity, dark brown, coarse grained sand.							501
2.0	x	<b>SAND (ALLUVIAL DEPOSITS)</b> (2 m to 2.5 m) SAND, some silt, trace clay, poorly graded, low plasticity, dark brown, coarse to fine grained sand, trace woody debris.							
2.5		End of testpit at 2.5 m. Encountered bedrock at west side of hole.							

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT.AECORA2018.GDT 21-12-10

# TEST PIT: TP21-03

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534201 Easting: 324338

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 510 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS		IN-SITU SHEAR VANE TEST REMOULDED (kPa) PEAK (kPa)		ELEVATION (m)								
			GRAVEL (%)	SAND (%)	FINES (%)	PLASTIC	M.C.	LIQUID	SCALA PENETROMETER Blows Per 50mm Penetration									
0 to 4.1	x	<b>SAND and SILT (ALLUVIAL DEPOSITS)</b> (0 m to 4.1 m) SAND and SILT, trace to some clay, trace gravel, low plasticity, beige with brown sand, fine grained sand.  - Below 0.7 m, becomes fine grained sand.  - Below 1.8 m, becomes fine to medium grained sand.  - Below 2.5 m, becomes brown with teal-blue inclusions, becoming sandier with depth.  - Below 3.5 m, found some compact, subrounded, brown-red chunks of fine grained sand.	0.1	37.9	62.0	10	20	30	40	40	80	120	160	3	6	9	12	509
4.1 to 4.3	x	<b>SAND (ALLUVIAL DEPOSITS)</b> (4.1 m to 4.3 m) SAND, trace to some silt, well graded, dark grey, fine to coarse grained sand, fine to coarse angular gravel.																506

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT.ECORA2018.GDT 21-12-10



# TEST PIT: TP21-04

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534164 Easting: 324337

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 511 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS  PLASTIC    M.C.    LIQUID  ----- -----  10    20    30    40	IN-SITU SHEAR VANE TEST REMOULDED (kPa)    PEAK (kPa)		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		40    80    120    160	SCALA PENETROMETER Blows Per 50mm Penetration	
0		<b>ORGANICS (TOPSOIL)</b> (0 m to 0.2 m) Organics.							511
0.2		<b>SAND (ALLUVIAL DEPOSITS)</b> (0.2 m to 4.3 m) Loose SAND, some silt, poorly graded, dry, grey-brown, fine to coarse grained sand.							510
1									509
2		- Below 2.0 m, becomes dark brown							508
3		- Below 2.4 m, becomes some angular gravel, gravel compacted together.							507
4									507
		End of testpit at 4.3 m. Encountered refusal on bedrock.							

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT.ECOR.A2018.GDT.21-12-10

# TEST PIT: TP21-05

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534164 Easting: 324337

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 517 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS  PLASTIC    M.C.    LIQUID  ----- -----  10    20    30    40	IN-SITU SHEAR VANE TEST		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		REMOULDED (kPa)	PEAK (kPa)	
		<b>ORGANICS (TOPSOIL)</b> (0 m to 0.2 m) Organics.							
		<b>SAND (ALLUVIAL DEPOSITS)</b> (0.2 m to 2.3 m) Compact to dense, silty SAND, with cobbles, trace gravel, poorly graded, dry, grey-brown, fine to coarse grained sand, fine to coarse subrounded gravel, with angular to subrounded cobbles.  - Below 0.8 m, found ~30% blocky, compacted sand and silt.							516
		<b>(TILL)</b> (2.3 m to 2.4 m) Very hard layer, bedrock or compacted dry till. End of testpit at 2.4 m. Encountered refusal.							515

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT.AECORA2018.GDT 21-12-10

# TEST PIT: TP21-06

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534121 Easting: 324317

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 516 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS	IN-SITU SHEAR VANE TEST REMOULDED (kPa) PEAK (kPa)		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		PLASTIC	M.C.	
0		<b>ORGANICS (TOPSOIL)</b> (0 m to 0.2 m) Roots, rootlets.							
0.2		<b>SILT and SAND (COLLUVIUM)</b> (0.2 m to 2 m) SILT and SAND, some gravel, trace cobbles, well graded, dry, grey, fine grained sand, trace to some medium to coarse grained sand, fine to coarse subangular to subrounded gravel, subangular to subrounded cobbles, trace rootlets. - Below 1.6 m, no rootlets.							
2		<b>SAND (ALLUVIAL DEPOSITS)</b> (2 m to 5.1 m) Gravelly SAND, trace silt, with cobbles, well graded, dry, dark black-brown, coarse grained sand, some fine to medium grained sand, fine to coarse angular gravel, angular cobbles.							
3									
4			27.5	65.8	6.7				
5		End of testpit at 5.1 m.							

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT/ECORA2018.GDT 21-12-10

# TEST PIT: TP21-07

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534093 Easting: 324299

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 518 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS	IN-SITU SHEAR VANE TEST		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		REMOULDED (kPa)	PEAK (kPa)	
0	x	<b>ORGANICS (TOPSOIL)</b> (0 m to 0.1 m) Roots, rootlets.							518
0.1	x	<b>SILT (COLLUVIUM)</b> (0.1 m to 0.7 m) Firm SILT, trace to some sand, trace gravel, poorly graded, non plastic, fine to coarse grained sand, fine to coarse subrounded gravel, trace to some rootlets.							517
0.7	x	<b>SAND (ALLUVIAL DEPOSITS)</b> (0.7 m to 2.5 m) Loose, silty SAND, some gravel, with cobbles, well graded, dry, brown, fine to coarse grained sand, fine to coarse subrounded gravel, subrounded cobbles.							516
2.5	o	<b>SAND (ALLUVIAL DEPOSITS)</b> (2.5 m to 5 m) Loose, gravelly SAND, some silt, with cobbles, well graded, dry, reddish brown, fine to coarse grained sand, fine angular gravel, some coarse gravel, angular cobbles.							515
4.0	o	- Below 4.0 m, becomes fine to coarse subangular gravel, angular cobbles.							514
5.0		End of testpit at 5.0 m.							513

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT.AECORA2018.GDT 21-12-10

# TEST PIT: TP21-08

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534133 Easting: 324371

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 518 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS	IN-SITU SHEAR VANE TEST		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		REMOULDED (kPa)	PEAK (kPa)	
		<b>ORGANICS (TOPSOIL)</b> (0 m to 0.1 m) Organics.							
		<b>SILT (COLLUVIUM)</b> (0.1 m to 1.2 m) SILT, some sand, some gravel, poorly graded, dry, brown/beige, fine to coarse grained sand, fine to coarse angular gravel, low plasticity, trace to some roots and rootlets.  - Below 0.4 m, becomes trace gravel, fine to medium grained sand, fine to coarse angular to subangular gravel.				PLASTIC      M.C.      LIQUID  -----●-----  10    20    30    40	40    80    120    160 ○-----● SCALA PENETROMETER _____ Blows Per 50mm Penetration		
1		<b>BRECCIA (BEDROCK)</b> (1.2 m to 1.3 m) Fractured surface of bedrock.  End of testpit at 1.3 m. Encountered refusal on bedrock.							517

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT.AECORA2018.GDT 21-12-10

# TEST PIT: TP21-09

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534194 Easting: 324406

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 513 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS  PLASTIC    M.C.    LIQUID  ----- -----  10    20    30    40	IN-SITU SHEAR VANE TEST REMOULDED (kPa)    PEAK (kPa) ○-----● 40    80    120    160		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		SCALA PENETROMETER Blows Per 50mm Penetration 3    6    9    12		
		<b>TOPSOIL (TOPSOIL)</b> (0 m to 0.2 m) Organics, roots and rootlets.							
		<b>SAND (ALLUVIAL DEPOSITS)</b> (0.2 m to 0.6 m) Loose, silty, gravelly SAND, with cobbles, well graded, dry, brown, fine to coarse grained sand, fine to coarse subangular gravel, trace roots.							
		<b>GRAVEL (ALLUVIAL DEPOSITS)</b> (0.6 m to 1 m) Compact, sandy GRAVEL, some sand, trace silt, with cobbles, well graded, dry, beige, fine to coarse grained sand, fine to coarse angular gravel, angular cobbles, trace rootlets.							
1		End of testpit at 1.0 m. Encountered refusal on compact material.							512

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT.ECORA2018.GDT 21-12-10

# TEST PIT: TP21-10

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11      Northing: 5534289      Easting: 324422

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 510 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS  PLASTIC      M.C.      LIQUID  M.C. is marked at approximately 28%	IN-SITU SHEAR VANE TEST		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		REMOULDED (kPa)	PEAK (kPa)	
		<b>ORGANICS (TOPSOIL)</b> (0 m to 0.1 m) Roots, rootlets.							
		<b>SAND (ALLUVIAL DEPOSITS)</b> (0.1 m to 0.6 m) Loose, silty SAND, some gravel, well graded, brown, fine to coarse grained sand, fine to coarse subangular gravel, trace to some roots and large woody debris.							
		<b>GRAVEL (ALLUVIAL DEPOSITS)</b> (0.6 m to 0.8 m) Dense, sandy GRAVEL, some silt, with cobbles, dry, brown, fine to coarse grained sand, fine to coarse angular gravel, angular cobbles, trace roots and rootlets.							
		End of testpit at 0.8 m. Encountered refusal on compact, beige/light grey material..							

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT/ECORA2018.GDT 21-12-10

# TEST PIT: TP21-11

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11      Northing: 5534343      Easting: 324442

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 510 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS	IN-SITU SHEAR VANE TEST		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		REMOULDED (kPa)	PEAK (kPa)	
		<b>ORGANICS (TOPSOIL)</b> (0 m to 0.1 m) Roots, organic litter.							
		<b>SAND (ALLUVIAL DEPOSITS)</b> (0.1 m to 0.4 m) Loose, silty SAND, some gravel, well graded, dry, dark brown, fine to coarse grained sand, fine to coarse subangular gravel, trace to some roots and rootlets.							
		<b>GRAVEL (ALLUVIAL DEPOSITS)</b> (0.4 m to 0.7 m) Dense, sandy GRAVEL, some sand, some silt, medium grey-brown, fine to coarse grained sand, fine to coarse angular gravel.							
		End of testpit at 0.7 m. Encountered refusal on compact material.							

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ DATA ECORA 2018.GDT 21-12-10

# TEST PIT: TP21-12

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534237 Easting: 324438

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 507 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS		IN-SITU SHEAR VANE TEST		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)	PLASTIC	M.C.	LIQUID	REMOULDED (kPa)	
0		<b>ORGANICS (TOPSOIL)</b> (0 m to 0.1 m) Leaf litter, roots and rootlets.								507
0.1		<b>SAND (ALLUVIAL DEPOSITS)</b> (0.1 m to 0.3 m) Loose, silty SAND, trace gravel, poorly graded, dark brown, fine to coarse grained sand, fine to coarse subangular gravel, some roots and rootlets..								506
0.3		<b>SILT (ALLUVIAL DEPOSITS)</b> (0.3 m to 1.2 m) Loose, gravelly SAND, some silt, non plastic, medium beige, fine grained sand, trace medium to coarse grained sand, trace rootlets.								506
1.2		<b>SAND (ALLUVIAL DEPOSITS)</b> (1.2 m to 3.2 m) Loose, gravelly SAND, some silt, poorly graded, fine to coarse grained sand, moist.								505
1.9		- Below 1.9 m, becomes trace to some gravel, trace silt, with cobbles, fine to coarse subrounded gravel, subangular cobbles. Heavy slumping.								505
3.2		End of testpit at 3.2 m. Encountered refusal on bedrock. Becoming saturated.	29.8	53.7	16.5					504

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ.DAT.ECOR.A2018.GDT.21-12-10

# TEST PIT: TP21-13

Project: Wilden Upper Canyon RM3 MF Site  
 Location: 225 Upper Canyon Drive North, Kelowna, BC  
 Zone: 11 Northing: 5534145 Easting: 324354

Project No: 201827  
 Client: Wilden Construction Corp.  
 Elevation: 510 m



DEPTH (m)	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	PARTICLE SIZE DISTRIBUTION			CLASSIFICATION TESTS  PLASTIC      M.C.      LIQUID  ----- -----  10    20    30    40	IN-SITU SHEAR VANE TEST		ELEVATION (m)
			GRAVEL (%)	SAND (%)	FINES (%)		REMOULDED (kPa)	PEAK (kPa)	
		Testpit excavated to observe water infiltration.							
1									509
		At 1.5 m: water coming from east side.							

## PHOTOGRAPH



2018 - TEST PIT LOG 201827.GPJ DATA ECORA 2018.GDT 21-12-10

# Appendix D

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## Laboratory Testing Results

# GRAIN SIZE DISTRIBUTION ASTM C136

Project: Wilden Upper Canyon RM3 MF Site

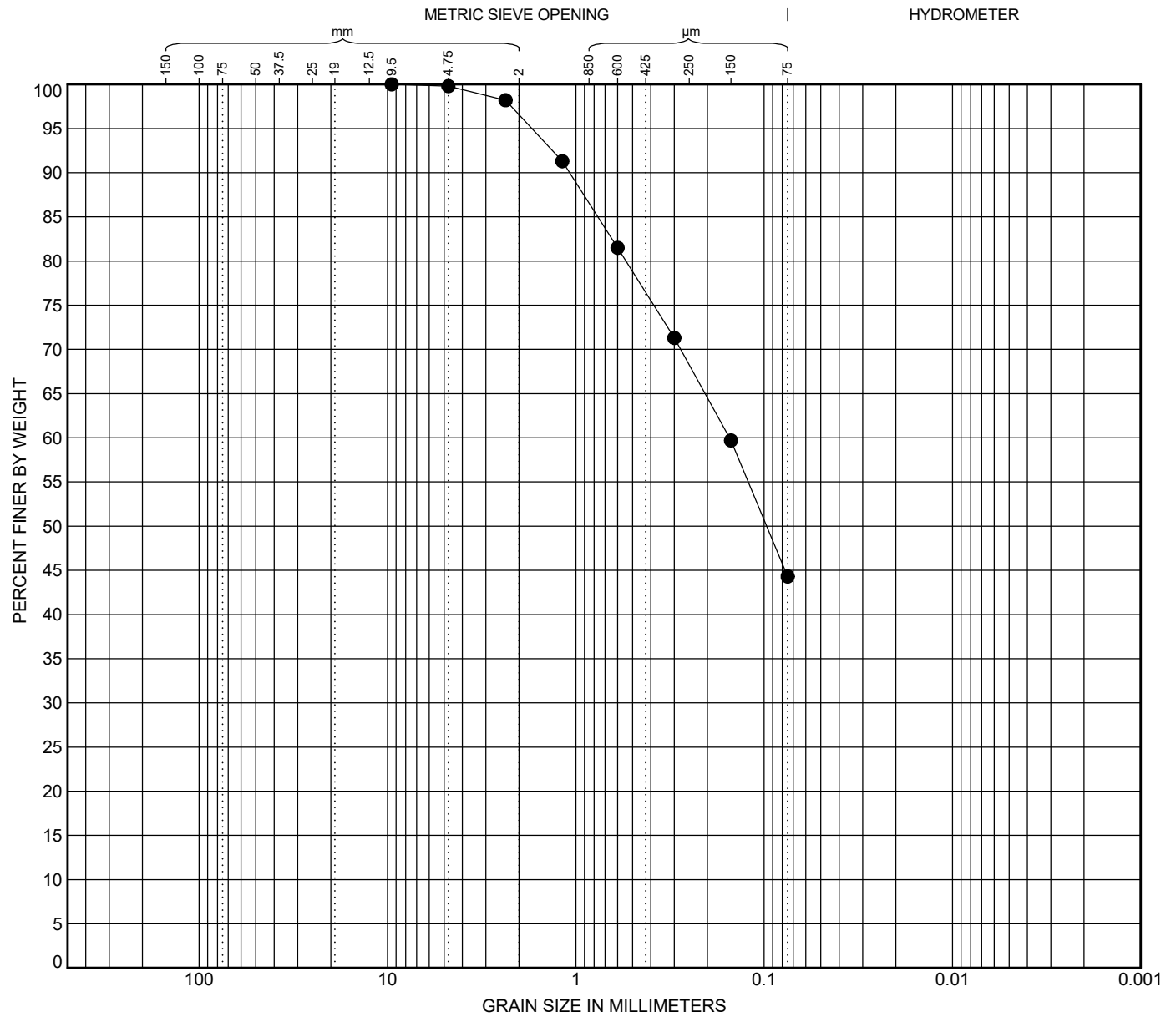
Project No: 201827

Location:

Client: Wilden Construction Corp.

Sample Location/Source: TH21-01

Depth: 1.3 m to 2 m




COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D <sub>100</sub>	D <sub>85</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>15</sub>	D <sub>10</sub>	C <sub>c</sub>	C <sub>u</sub>	%Gravel	%Sand	%Silt	%Clay
9.5	0.764	0.153						0.2	55.5		44.3

GRAIN SIZE DISTRIBUTION 201827.GPJ DATAECORA2018.GDT 21-11-18

Description: SAND and FINES, trace gravel  
 Natural Moisture Content: 20.1 %  
 Material Specification: N/A  
 Intended Use: N/A  
 Comments: N/A

Sample Number: 21-448  
 Date Tested: 2021-10-15  
 Tested By: SQ

Checked By: 

# GRAIN SIZE DISTRIBUTION ASTM D422

Project: Wilden Upper Canyon RM3 MF Site

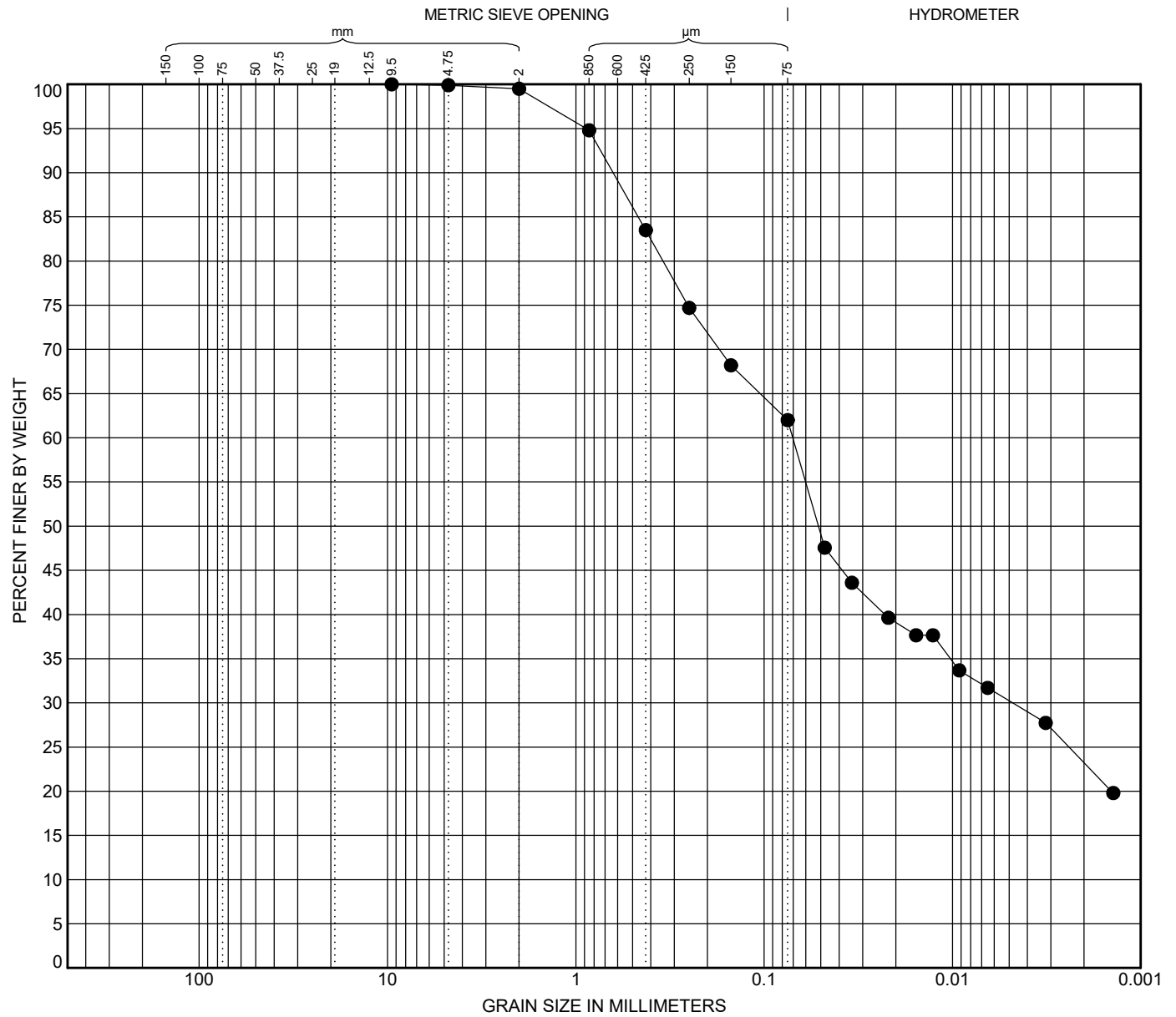
Project No: 201827

Location:

Client: Wilden Construction Corp.

Sample Location/Source: TH21-03

Depth: 2.5 m to 3.5 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D <sub>100</sub>	D <sub>85</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>15</sub>	D <sub>10</sub>	C <sub>c</sub>	C <sub>u</sub>	%Gravel	%Sand	%Silt	%Clay
9.5	0.466	0.07	0.005					0.1	37.9	38.8	23.2

GRAIN SIZE DISTRIBUTION 201827.GPJ DATAECORA2018.GDT 21-11-18

Description: Clayey SILT and SAND, trace gravel  
 Natural Moisture Content: 28.1 %  
 Material Specification: N/A  
 Intended Use: N/A  
 Comments: N/A

Sample Number: 21-449  
 Date Tested: 2021-10-19  
 Tested By: SQ

Checked By: 

# GRAIN SIZE DISTRIBUTION ASTM C136

Project: Wilden Upper Canyon RM3 MF Site

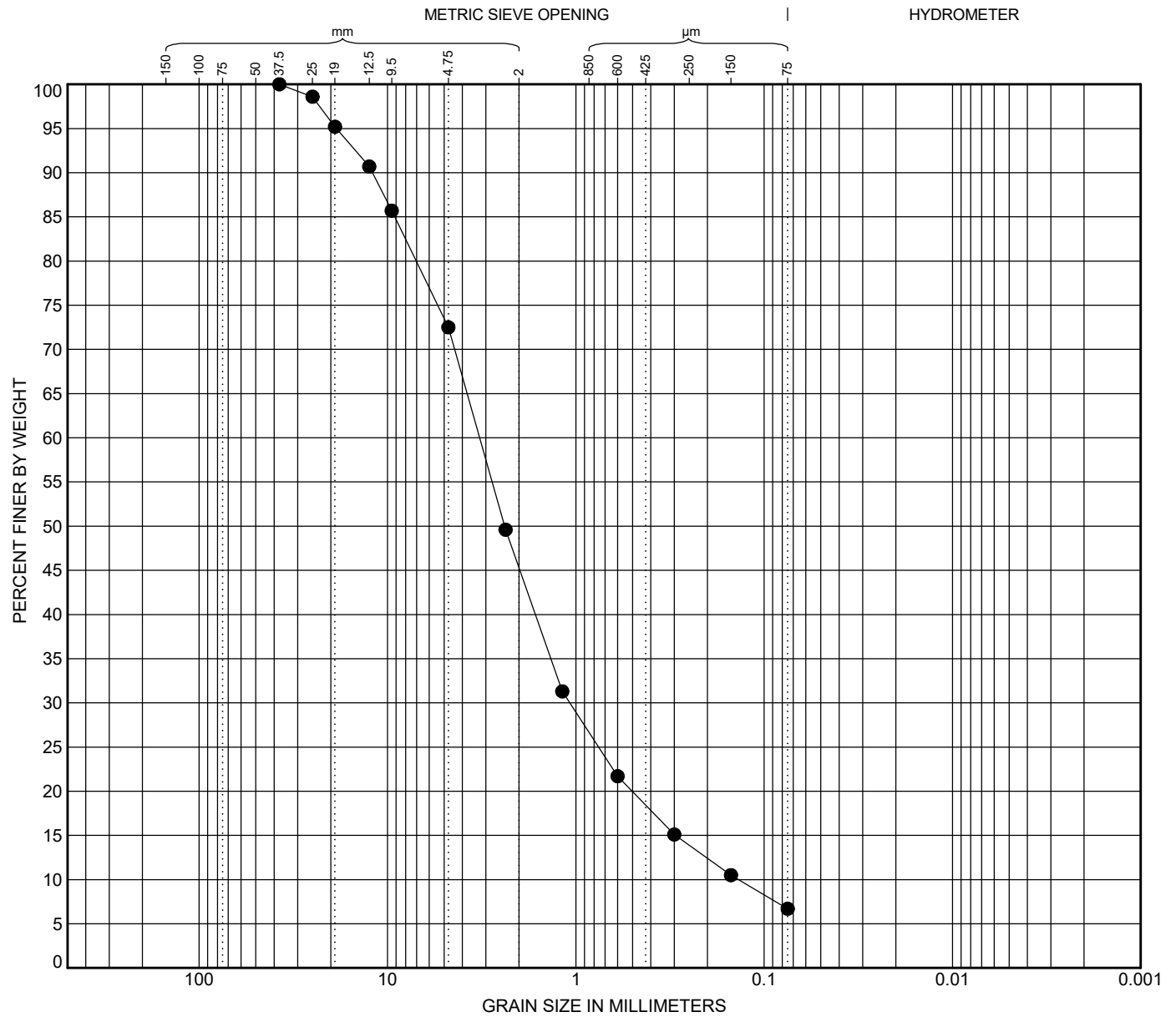
Project No: 201827

Location:

Client: Wilden Construction Corp.

Sample Location/Source: TH21-04

Depth: 3 m to 4 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D <sub>100</sub>	D <sub>85</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>15</sub>	D <sub>10</sub>	C <sub>c</sub>	C <sub>u</sub>	%Gravel	%Sand	%Silt	%Clay
37.5	9.157	3.242	1.077	0.296	0.137	2.61	23.68	27.5	65.8	6.7	

GRAIN SIZE DISTRIBUTION 201827.GPJ DATAECORA2018.GDT 21-11-18

Description: Gravelly SAND, trace fines  
 Natural Moisture Content: 11.4 %  
 Material Specification: N/A  
 Intended Use: N/A  
 Comments: N/A

Sample Number: 21-450  
 Date Tested: 2021-10-15  
 Tested By: SQ

Checked By: 

# GRAIN SIZE DISTRIBUTION ASTM C136

Project: Wilden Upper Canyon RM3 MF Site

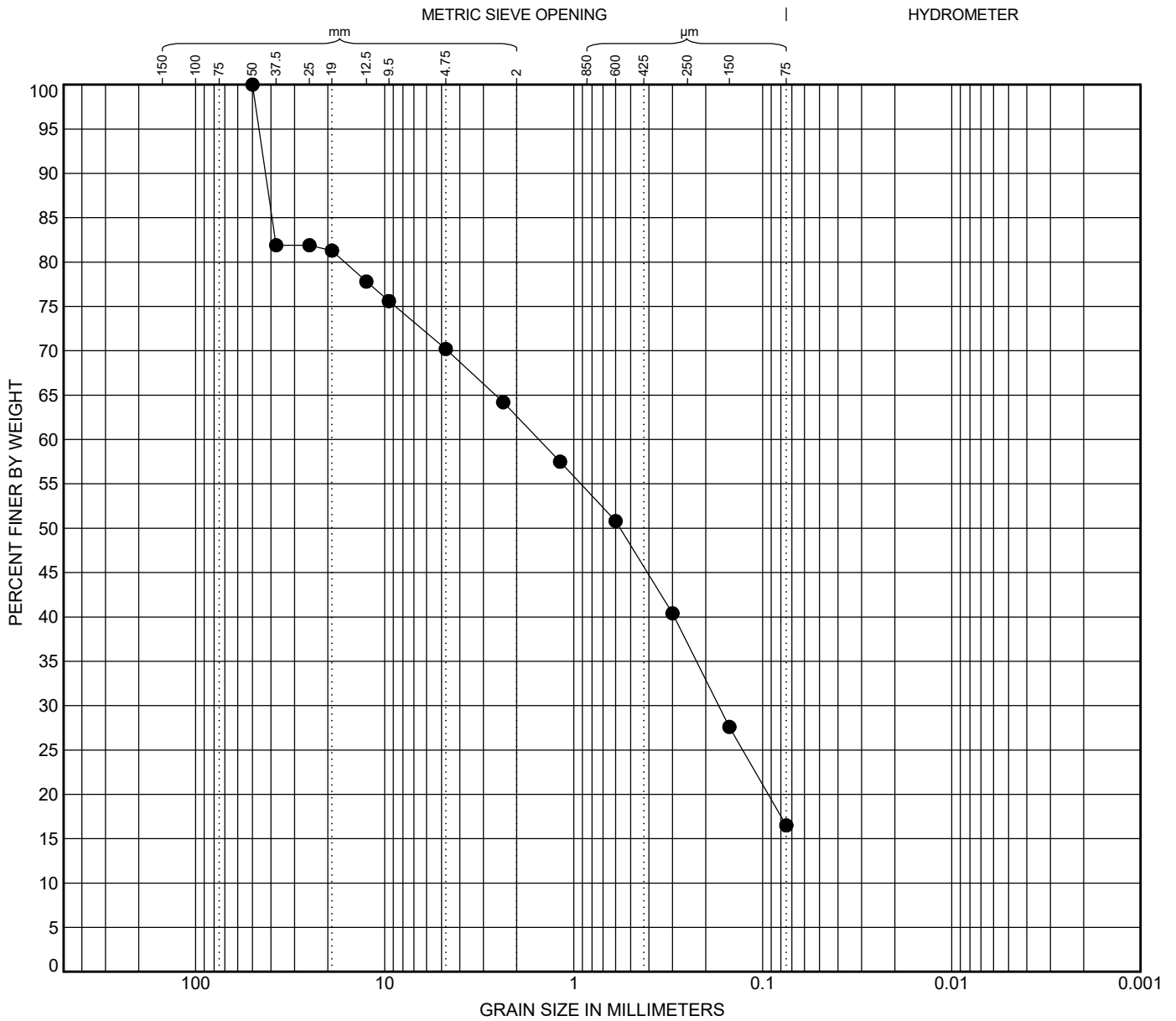
Project No: 201827

Location:

Client: Wilden Construction Corp.

Sample Location/Source: TH21-12

Depth: 1.9 m to 3.2 m




COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D <sub>100</sub>	D <sub>85</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>15</sub>	D <sub>10</sub>	C <sub>c</sub>	C <sub>u</sub>	%Gravel	%Sand	%Silt	%Clay
50	39.394	1.528	0.171					29.8	53.7		16.5

GRAIN SIZE DISTRIBUTION 201827.GPJ DATAECORA2018.GDT 21-11-18

Description: Gravelly SAND, some fines  
 Natural Moisture Content: 11.2 %  
 Material Specification: N/A  
 Intended Use: N/A  
 Comments: N/A

Sample Number: 21-451  
 Date Tested: 2021-10-15  
 Tested By: SQ

Checked By: 

# ATTERBERG LIMITS ASTM D4318



**Project:** 225 Upper Canyon Drive North  
**Location:** Kelowna, BC  
**Sample Location/Source:** TH21-03 @ 2.5 - 3.5 m

**Project No.:** 201827  
**Client:** Wilden Construction Corp.

## LIQUID LIMIT (ASTM Designation D 423)

Trial Number	1	2	3
Tare Number	L1	L2	L3
Number of Blows	44	23	13
Mass of Wet Soil and Tare (g)	31.61	32.51	35.46
Mass of Dry Soil and Tare (g)	25.15	25.39	26.90
Mass of Tare (g)	15.60	15.78	16.09
Mass of Moisture (g)	6.46	7.12	8.56
Mass of Dry Soil (g)	9.55	9.61	10.81
Moisture Content(%)	67.6	74.1	79.2

## PLASTIC LIMIT (ASTM Designation D 424)

Trial Number	1	2
Tare Number	P1	P2
Mass of Wet Soil and Tare (g)	21.93	21.90
Mass of Dry Soil and Tare (g)	20.64	20.70
Mass of Tare (g)	15.64	15.84
Mass of Moisture (g)	1.29	1.20
Mass of Dry Soil (g)	5.00	4.86
Moisture Content (%)	25.8	24.7

### Test Results

Liquid Limit: **72**  
 Plastic Limit: **25**  
 Plasticity Index: **47**

### Plasticity Classification (based on Liquid Limit $W_L$ )

0 to 30 Low Plasticity  
 30 to 50 Medium Plasticity  
 > 50 High Plasticity

**Sample Description:** CH - High Plastic Clay  
**Natural Moisture Content:** 28.1%

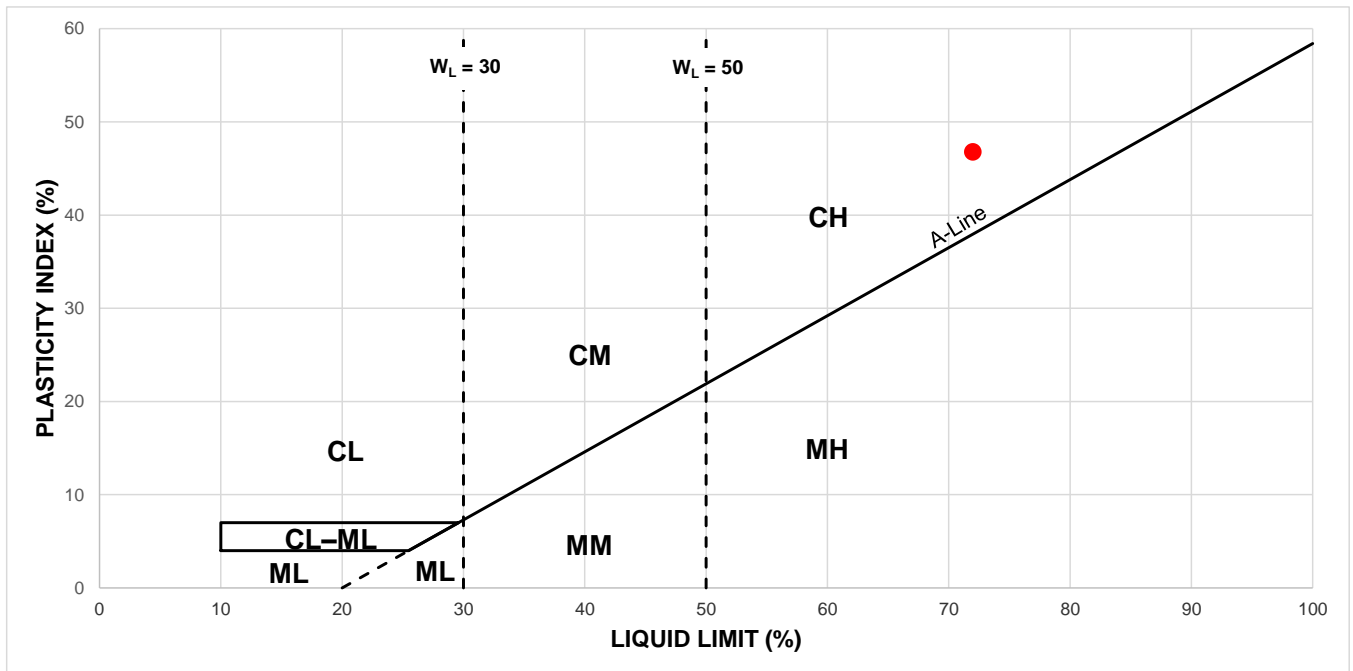
**Sample Number:** 21.449

**Date Tested:** 15-Oct-2021

**Tested by:** SQ

**Checked by:** SK

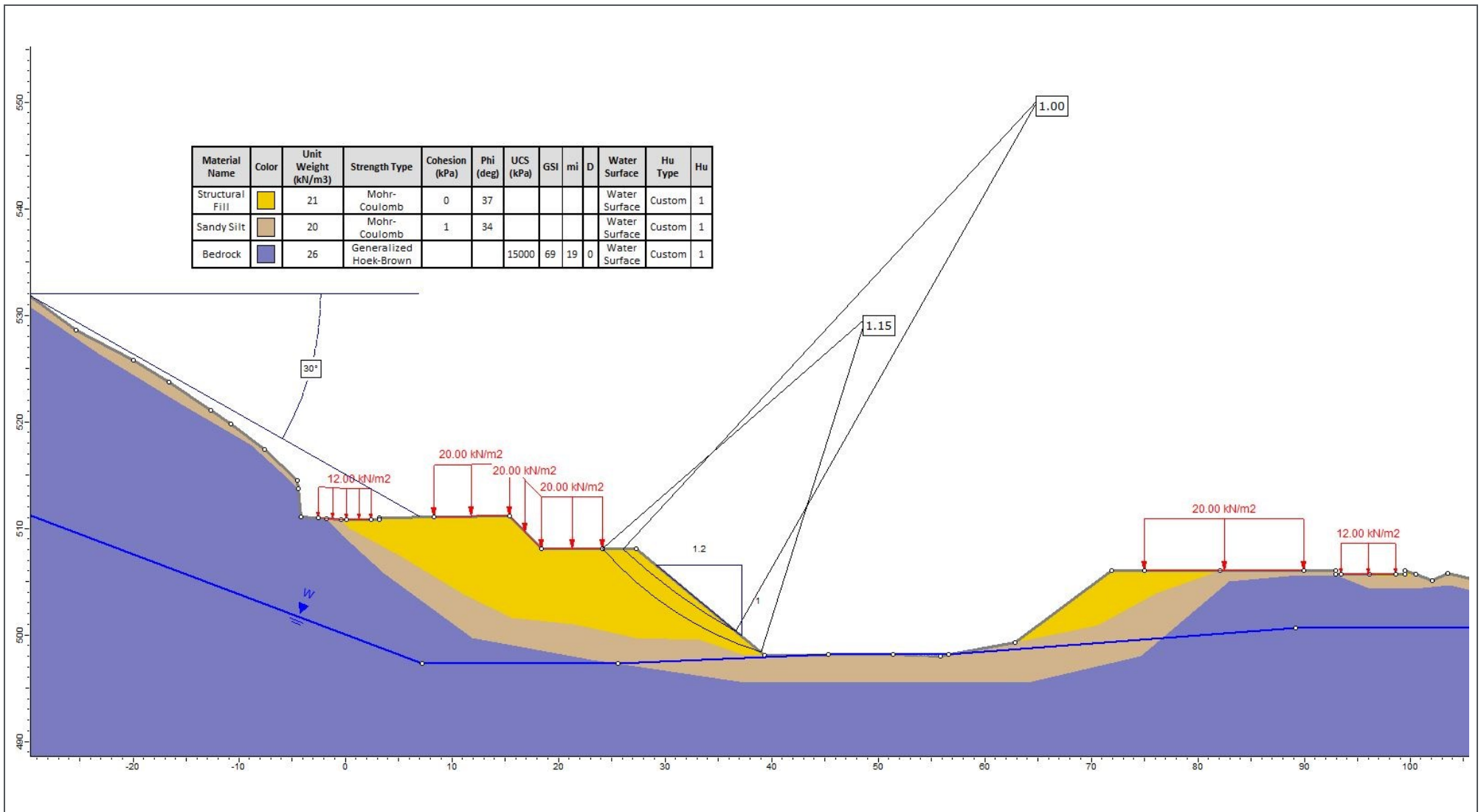
**Comments:**



# Appendix E

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## Slope Stability Analysis Results



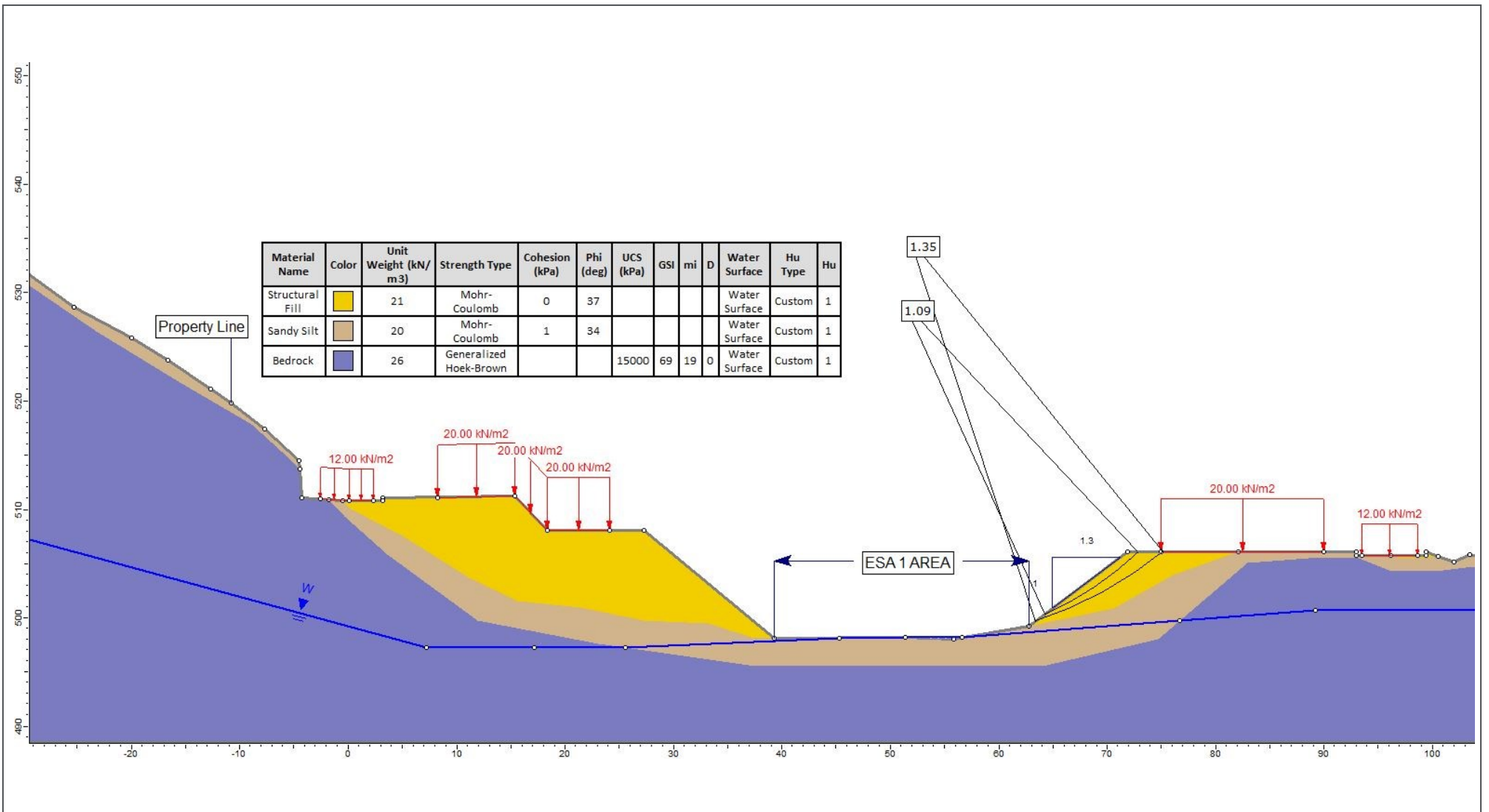
## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

### Static Analysis – Global Stability (Section A-A')

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL



Appendix D1



**Notes:**  
Right Slopes

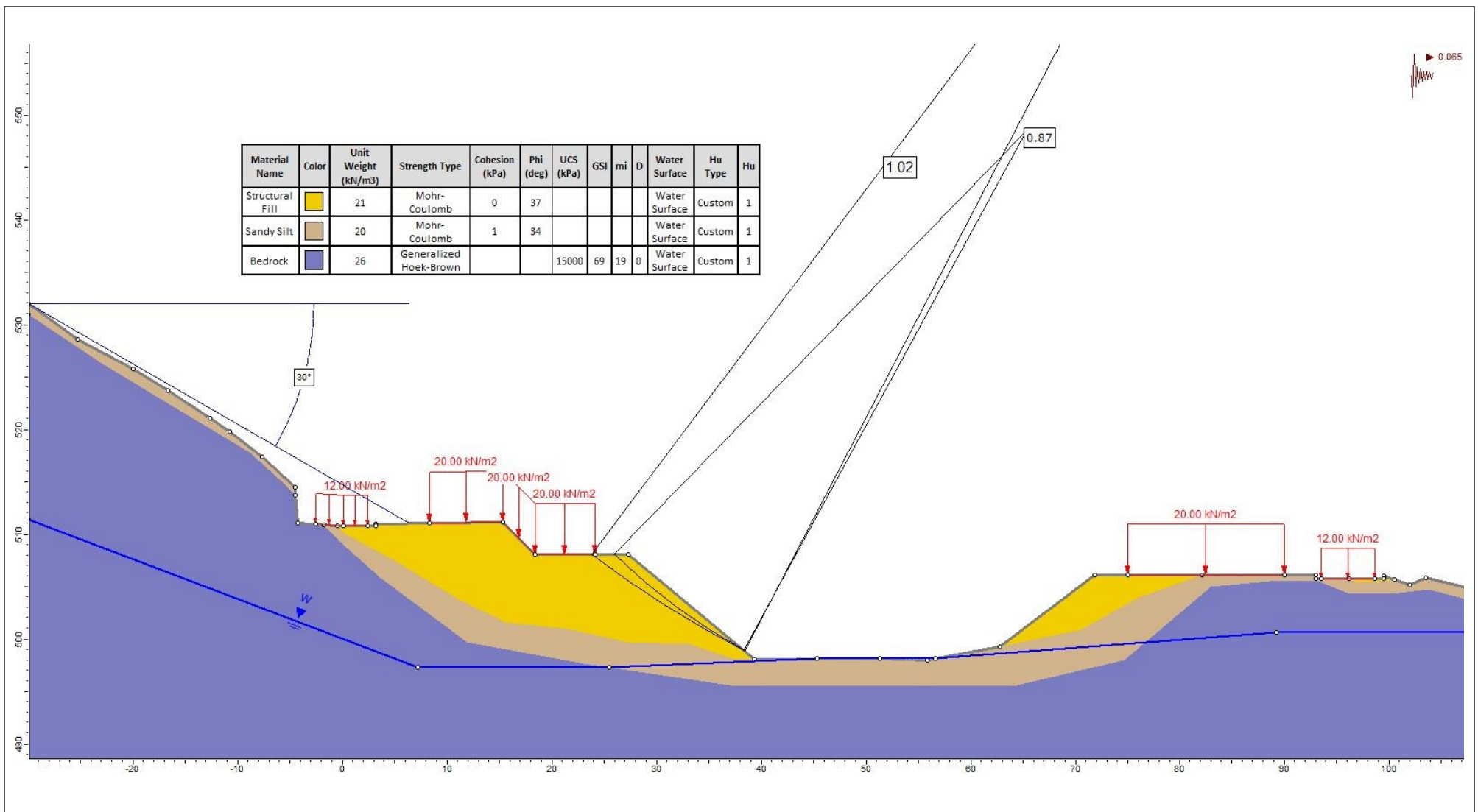
## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

### Static Analysis – Global Stability (Section A-A')

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL



Appendix D2



**Notes:**  
Right Slopes

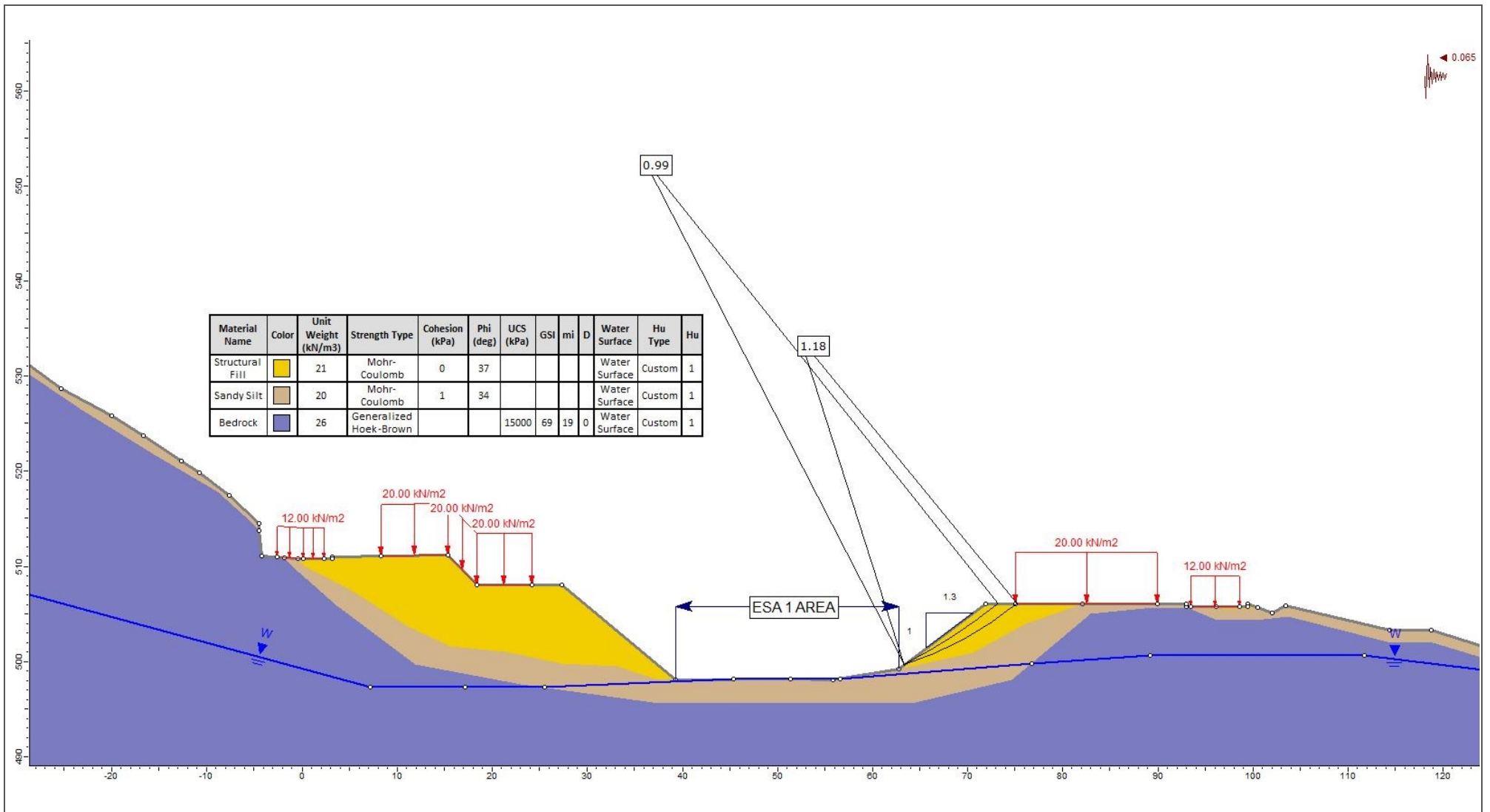
## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

### Pseudo-Static Analysis – Global Stability (Section A-A')

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL



Appendix D3



**Notes:**  
Right Slopes

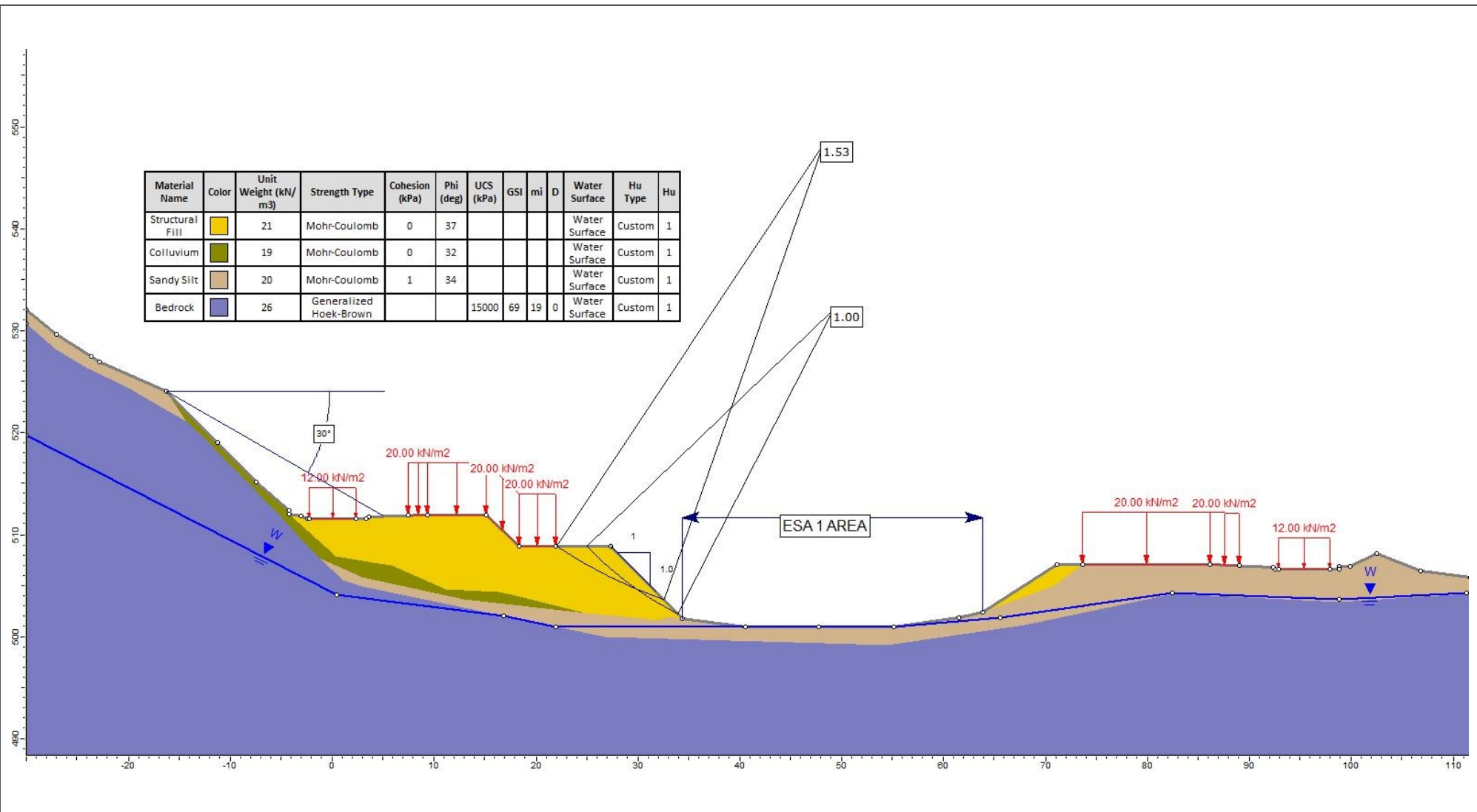
## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

Pseudo-Static Analysis – Global Stability (Section A-A')

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL



Appendix D4



**Notes:**  
Left Slopes

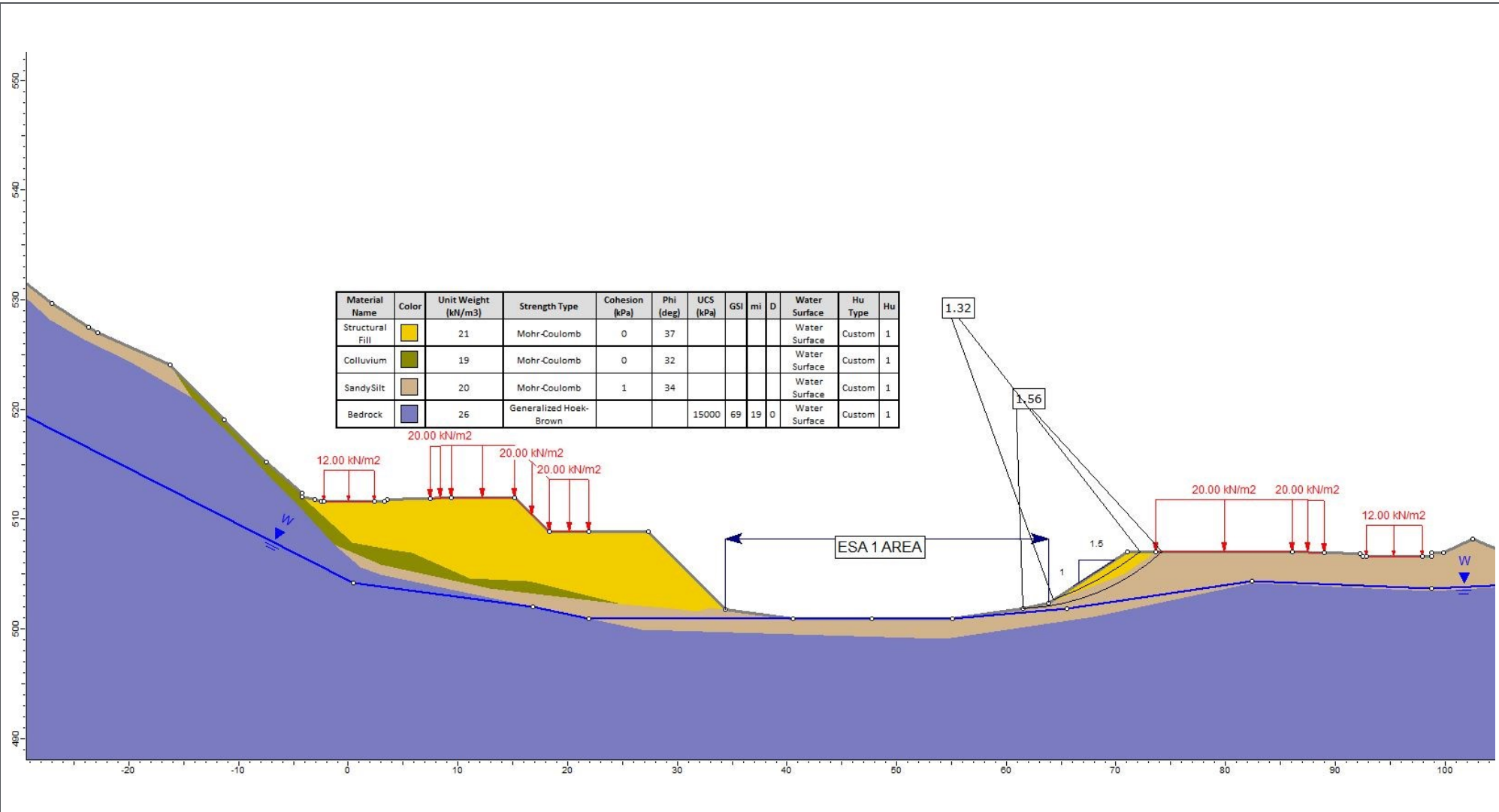
## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

### Static Analysis – Global Stability (Section B-B')

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL



Appendix D5



**Notes:**  
Right Slopes

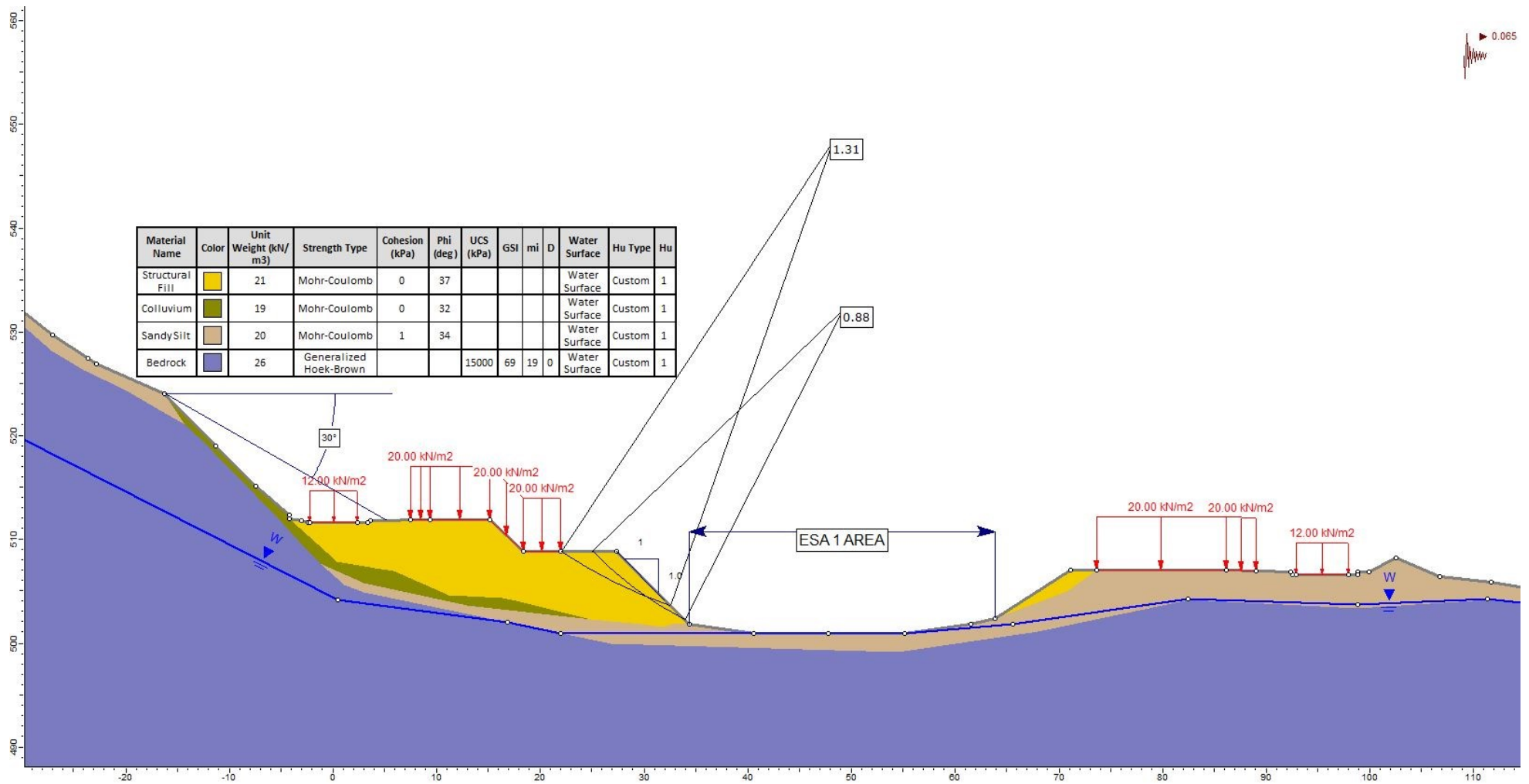
## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

### Static Analysis – Global Stability (Section B-B')

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL



Appendix D6



**Notes:**  
Left Slopes

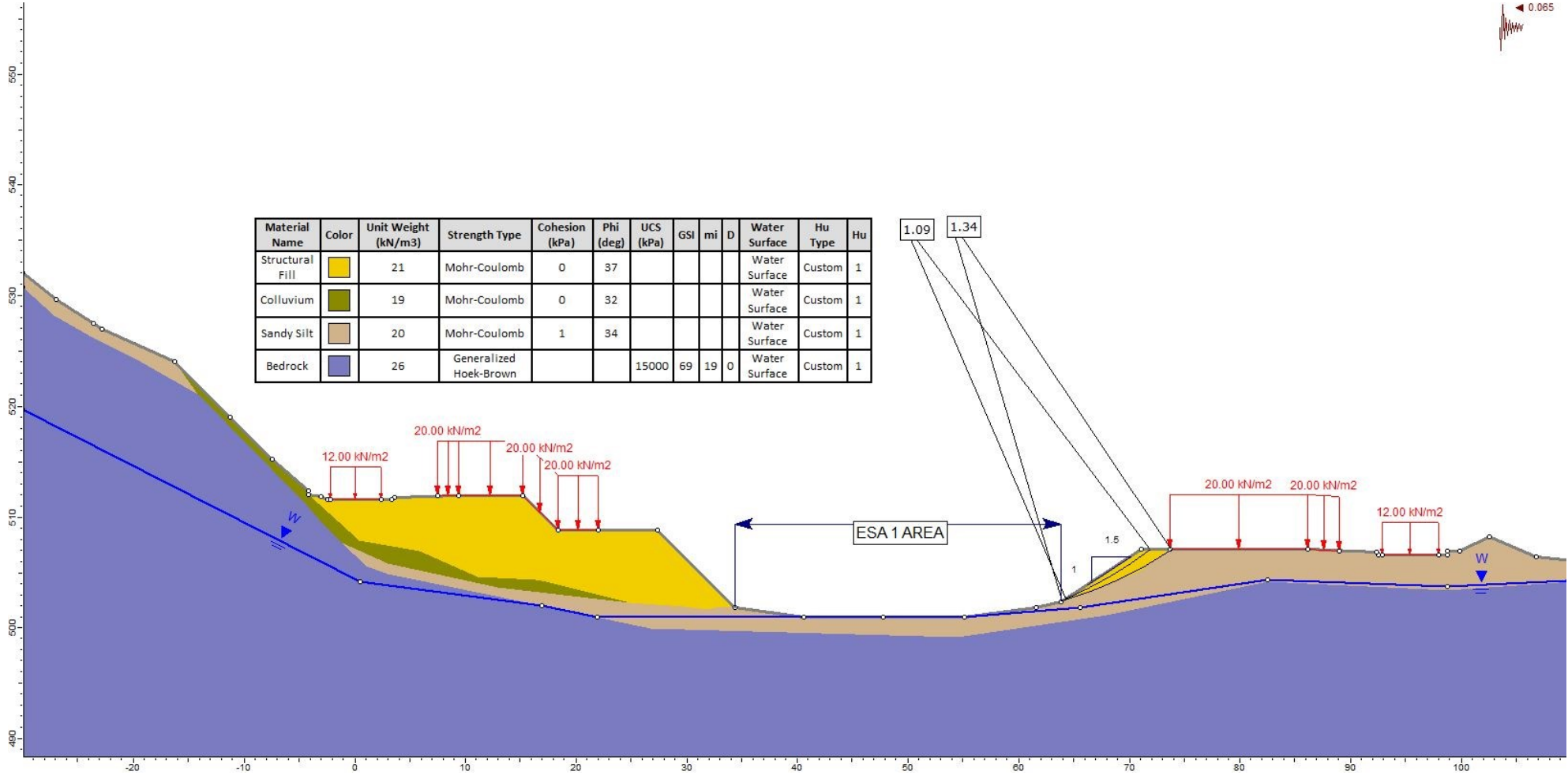
## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Dr., Kelowna, BC

**Pseudo-Static Analysis – Global Stability (Section B-B')**

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL



Appendix D7



Material Name	Color	Unit Weight (kN/m <sup>3</sup> )	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Hu
Structural Fill	Yellow	21	Mohr-Coulomb	0	37					Water Surface	Custom	1
Colluvium	Green	19	Mohr-Coulomb	0	32					Water Surface	Custom	1
Sandy Silt	Brown	20	Mohr-Coulomb	1	34					Water Surface	Custom	1
Bedrock	Blue	26	Generalized Hoek-Brown			15000	69	19	0	Water Surface	Custom	1

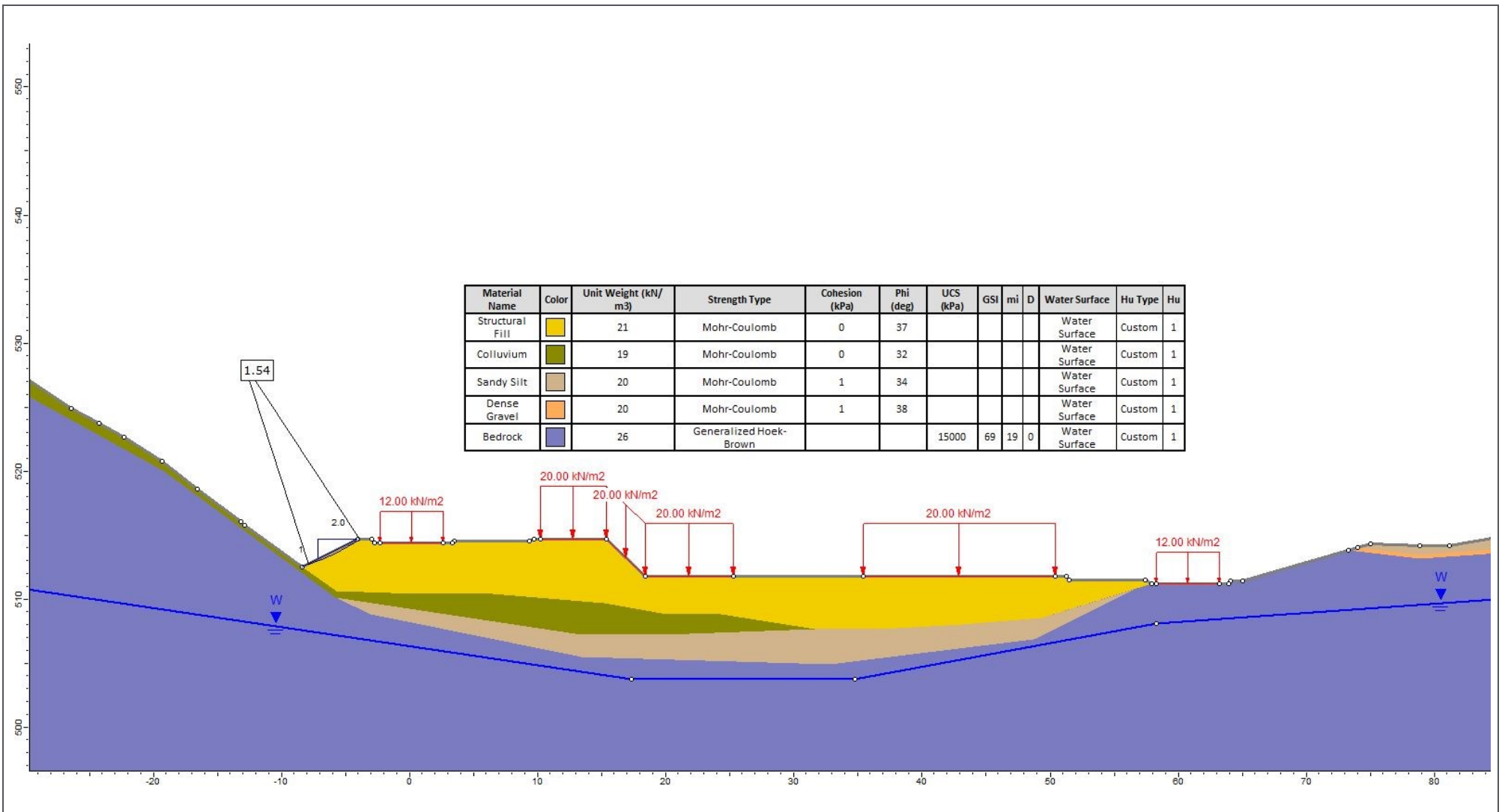
**Notes:**  
Right Slopes

## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

### Pseudo-Static Analysis – Global Stability (Section B-B')

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL





**Notes:**  
Right Slope

## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

### Static Analysis – Global Stability (Section C-C')

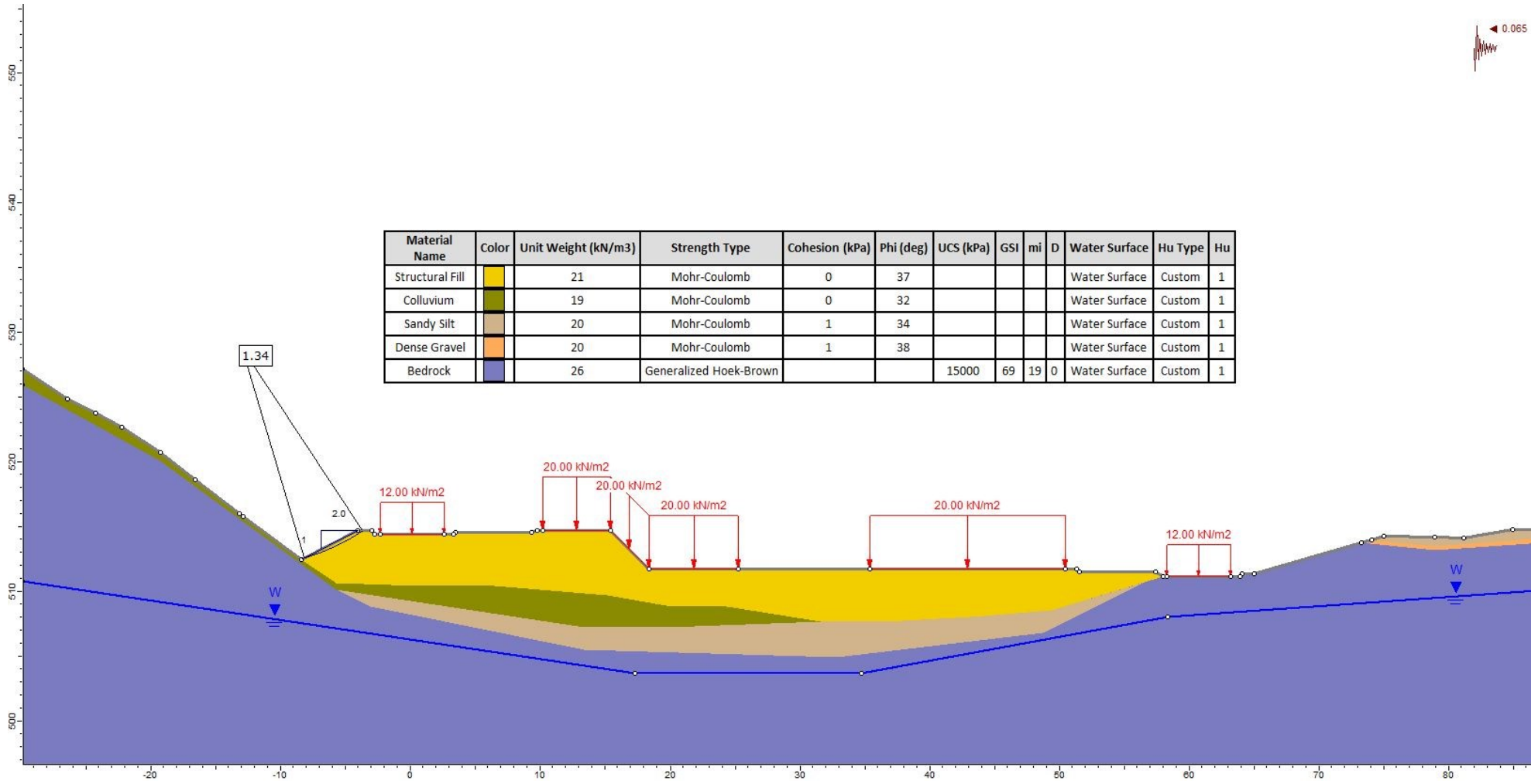
Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL



Appendix D9



Material Name	Color	Unit Weight (kN/m <sup>3</sup> )	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Hu
Structural Fill	Yellow	21	Mohr-Coulomb	0	37					Water Surface	Custom	1
Colluvium	Green	19	Mohr-Coulomb	0	32					Water Surface	Custom	1
Sandy Silt	Brown	20	Mohr-Coulomb	1	34					Water Surface	Custom	1
Dense Gravel	Orange	20	Mohr-Coulomb	1	38					Water Surface	Custom	1
Bedrock	Blue	26	Generalized Hoek-Brown			15000	69	19	0	Water Surface	Custom	1



**Notes:**  
Right Slope

## GEOTECHNICAL ASSESSMENT 225 Upper Canyon Drive North, Kelowna, BC

**Pseudo-Static Analysis – Global Stability (Section C-C')**

Project No. 201827  
 Client: Wilden Construction Corp.  
 Office: Kelowna  
 Scale: NTS  
 Date: November 15, 2021  
 DWN: DA CHK: MJL



**Appendix D10**