PATERSON GROUP
Consulting Engineers
9 Auriga Drive
Ottawa, Ontario
K2E 7T9
Tel: (613) 226-7381

Geotechnical Engineering
Environmental Engineering
Hydrogeology
Materials Testing
Building Science
Rural Development Design
Retaining Wall Design
Noise and Vibration Studies

patersongroup.ca

July 5, 2022
PG5828-LET.01 Rev. 1

Uniform Developments
300-117 Centrepoint Drive
Ottawa, Ontario
K2G 5Y6

Attention: **Mr. Ryan MacDougall**

Subject: **Slope Stability Assessment**
Proposed River Park
4386 Rideau Valley Drive - Ottawa, Ontario

Dear Sir,

Paterson Group (Paterson) was commissioned by Uniform Developments to conduct a slope review for the proposed river park to be located across 4386 Rideau Valley Drive in the City of Ottawa, Ontario.

1.0 Field Observation

The field program for the proposed river park was completed on June 16, 2022. At that time, a total of two boreholes were advanced down to a maximum depth of 5.9 m below existing ground surface. The test hole locations were distributed in a manner to provide general coverage of the subject site and taking into consideration underground utilities and site features. The borehole locations are shown on Drawing PG5828-2 – Limit of Hazard Lands Plan attached to this letter.

Surface Conditions

The subject site is currently vacant and covered with grass and trees. It is bound to the east by Rideau River, to the west by Rideau Valley Drive followed by a future development, to the south by a single-family dwelling, and to the north by a similar vacant lot. The ground surface across the subject site is generally flat and gently sloping upwards towards the south and west from an approximate geodetic elevation of 80 m at the north to 88 m at the south. The site is approximately 1.5 to 2.0m lower than Rideau Valley Drive. The southern portion of the site is generally covered with mature trees.

The slope conditions were reviewed by Paterson on May 17, 2022. The existing slopes were generally observed to be covered with well rooted vegetation across the surface. The western slopes were observed to be approximately 2 to 3 m high and appeared to have a relatively steep profile of less than 1H:1V. On the other hand, the eastern slopes were observed to be 4 to 5m high and appeared to have a slope profile ranging between 2H:1V to 3H:1V.

The width of the Rideau River was noted to be between 26 m wide to the south and 80 m wide to the north along the site length The majority of the riverbed appeared to be covered by an in-situ stiff brown silty clay. The majority of the riverbanks were observed to be affected by active erosion and were exposed directly to stream flow. Additional signs of erosion consisted of exposed tree roots.

Subsurface Conditions

Generally, the subsurface soil profile at the test hole locations consists of topsoil underlain by a deposit of very stiff to stiff brown silty clay underlain by glacial till. The brown silty clay was observed to be underlain by a stiff grey silty clay at BH 1-22. Glacial till was encountered below the clay deposit at all boreholes. The glacial till deposit was generally observed to consist of compact to dense brown silty sand with gravel, cobbles and boulders. Practical refusal to augering was encountered at an approximate depth of 5.9m and 2.7m at the locations of BH 1-22 and 2A-22, respectively. Practical refusal to DCPT was encountered at an approximate depth of 4.24m at BH 2-22. Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for the details of the soil profile encountered at each test hole location.

Based on available geological mapping, the bedrock in the subject area consists of Dolomite of the Oxford formation, with an overburden drift thickness of 10 to 25 m depth.

2.0 Slope Stability Assessment

The existing slope conditions were reviewed by Paterson to define a conceptual limit of hazard lands setback, which is to be respected for any permanent structures, such as gazebos. It should be noted that stone dust paths with minor grading adjustments and park benches are acceptable to be placed within the limit of hazard lands line from a geotechnical perspective. The proposed limit of hazard lands designation line consists of the following:

- a stable slope with a minimum factor of safety of 1.5 under static conditions and 1.1 under seismic loading
- a toe erosion allowance
- a 6 m access allowance and top of slope

Three slope cross sections were studied as the worst-case scenario. The cross-section locations are presented on Drawing PG5828-2 – Limit of Hazard Lands Plan attached to this report.

Stable Slope Setback

The analyses of the stability of the slopes were carried out using SLIDE, a computer program which permits a two-dimensional slope stability analysis using several methods including the Bishop's method, which is a widely used and accepted analysis method. The program calculates a factor of safety, which represents the ratio of the forces resisting failure to those favouring failure. Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and the variability of the subsoil and groundwater conditions, a factor of safety greater than one is usually required to ascertain that the risks of failure are acceptable. Minimum factors of safety of 1.5 and 1.1 are generally recommended for static and seismic conditions, respectively, where the failure of the slope would endanger permanent structures.

The cross-sections were analysed using the existing slope geometry from the topographical site survey provided by the client and information collected during our site visit. The slope stability analysis was completed at the slope cross-sections under worst-case-scenario by assigning cohesive soil layers as being fully saturated. Subsoil conditions at the cross-sections were inferred based on the general knowledge of the area's geology.

Static Loading Analysis

The results are shown in Figures 1, 3, and 5. The results indicate a slope with a factor of safety of 1.16, 1.66, and 0.4 at Sections 1, 2, and 3, respectively. Based on these results, a stable slope setback varying between 7 and 9 m from the top of the slope are required for sections 1-1 and 3-3 to achieve a factor of safety of 1.5 for the limit of the hazard lands in the park area. Section 2-2 will not require a stable slope allowance.

Seismic Loading Analysis

An analysis considering seismic loading and the groundwater at ground surface was also completed. A horizontal acceleration of 0.16g was considered for all slopes. A factor of safety of 1.1 is considered to be satisfactory for stability analyses including seismic loading. The results of the analyses including seismic loading are shown in Figures 2, 4, and 6. The results indicate a slope with a factor of safety greater than 1.1 at all sections. However, it should be noted that the stable slope setback associated with our static loading analysis governs the required stable slope setback required for static conditions.

Toe Erosion and Access Allowances

Based on the soil profiles encountered at the borehole locations and the soil encountered throughout the river, a stiff grey silty clay is anticipated to be subject to erosion activity by the river flow. Based on the encountered soils and the observed active erosion, a toe erosion allowance of 5 m should be applied for the subject slope. Furthermore, a minimum 6 m access allowance should be considered.

Limit of Hazard Lands

Based on the above, a setback taken from the top of the current slope has been provided as based on the above-noted observations and analysis. Reference should be made to Drawing PG5828-2 – Limit of Hazard Lands Plan for the proposed River Park at the subject site.

3.0 Conclusions

The recommendations provided in this letter report are in accordance with Paterson's present understanding of the project. Should any conditions at the site be encountered which differ from our site observations, Paterson requests immediate notification to permit reassessment of the recommendations.

The present letter report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Uniform Developments, or her agents, is not authorized without review by Paterson Group Inc. for the applicability of our recommendations to the altered use of the report.

We trust this report meets your present requirements.

Best Regards,

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
July 5, 2022
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

Maha Saleh, M.A.Sc., P.Eng

David J. Gilbert, P.Eng

Attachments

- ❑ Soil Profile and Test Data Sheets
- ❑ Symbols
- ❑ Figures 1 to 6 - Sections for Slope Stability Analysis
- ❑ Drawing PG5828-2 – Limit of Hazard Lands Plan

Report Distribution

- ❑ Uniform Developments (e-mail copy)
- ❑ Paterson Group (1 copy)

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed River Park - 4386 Rideau Valley Drive
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY Track-Mount Power Auger

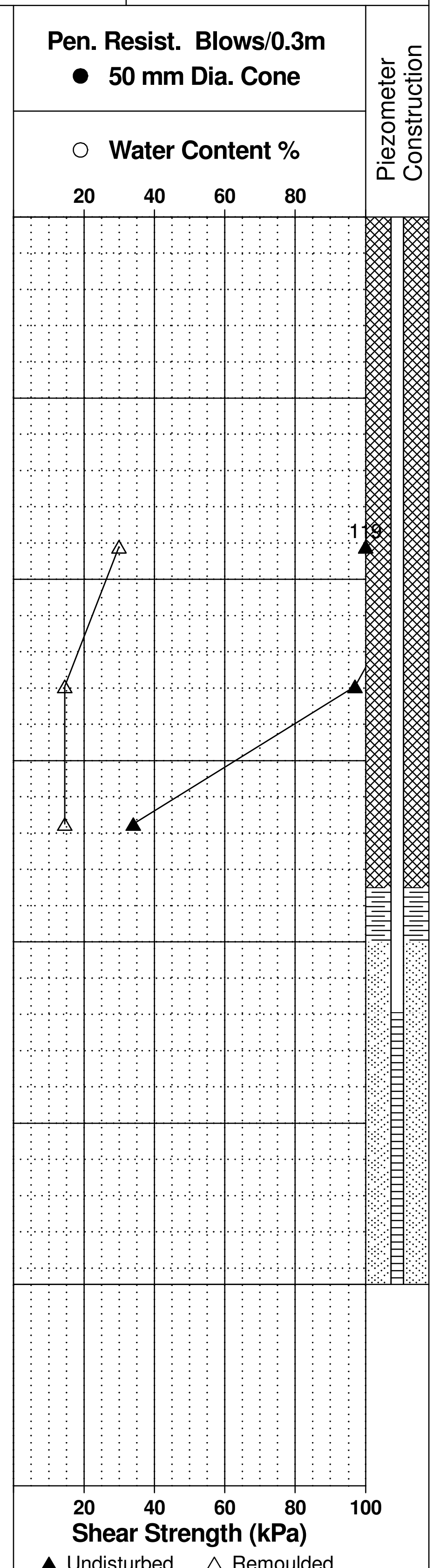
DATE June 16, 2022

FILE NO. PG5828

HOLE NO. BH 1-22

SOIL DESCRIPTION	Strata depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.25				
Very stiff to stiff, brown **SILTY CLAY,** trace sand and gravel	0.69	AU	1		
Very stiff to stiff, brown **SILTY CLAY**		SS	2	100	7
		SS	3	100	P
		SS	4		P
- firm and grey by 3.0m depth	3.50	SS	5	25	P
GLACIAL TILL: Compact, grey silty sand with gravel, cobbles and boulders, trace clay		SS	6	17	15
		SS	7	8	10
	5.89	SS	8	38	50+
End of Borehole Practical refusal to augering at 5.89m depth					

DEPTH (m)	ELEV. (m)
0	83.47
1	82.47
2	81.47
3	80.47
4	79.47
5	78.47



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed River Park - 4386 Rideau Valley Drive
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY Track-Mount Power Auger

DATE June 16, 2022

FILE NO. PG5828

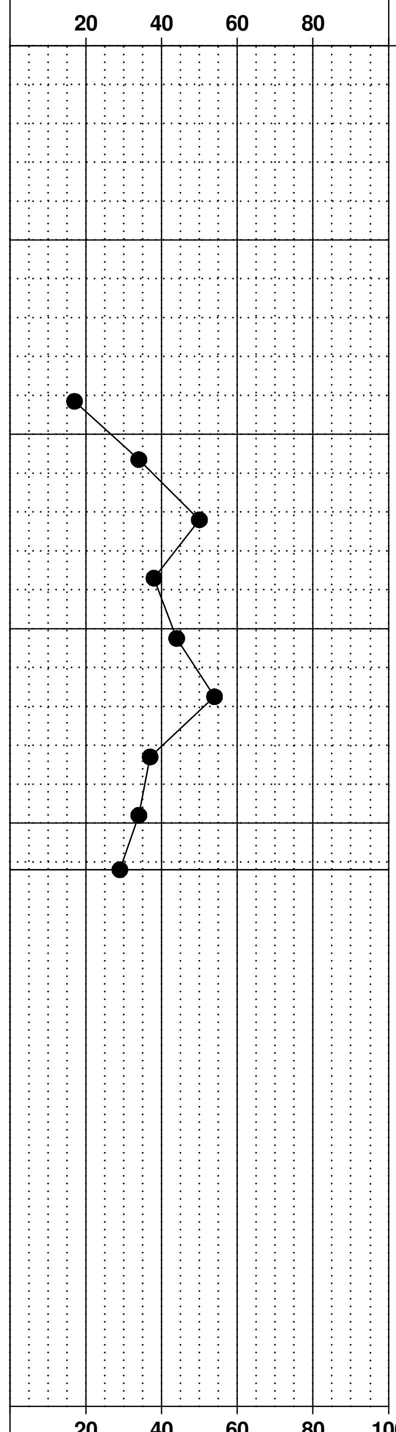
HOLE NO. BH 2-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	85.56
TOPSOIL							
0.33		AU	1				
Very stiff to stiff, brown **SILTY CLAY,** some sand		SS	2	75	9	1	84.56
1.45							
GLACIAL TILL: Compact to dense, brown silty sand with gravel, cobbles and boulders		SS	3	100	50+		
1.65							
Dynamic Cone Penetration Test commenced at 1.65m depth.						2	83.56
						3	82.56
						4	81.56
4.24							
End of Borehole							
Practical DCPT refusal at 4.24m depth							
(BH dry upon completion)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

Piezometer Construction



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed River Park - 4386 Rideau Valley Drive
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY Track-Mount Power Auger

DATE June 16, 2022

FILE NO. PG5828

HOLE NO. BH 2A-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20, 40, 60, 80)	Piezometer Construction
GROUND SURFACE						0	85.74		
OVERBURDEN						1	84.74		
1.52									
GLACIAL TILL: Dense, brown silty sand with gravel, cobbles and boulders		SS	1	67	42	2	83.74		
2.67									
End of Borehole Practical DCPT refusal at 2.67m depth (BH dry upon completion)									

Shear Strength (kPa): 20, 40, 60, 80, 100

▲ Undisturbed △ Remoulded

SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) 'N' value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	'N' Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

Consistency	Undrained Shear Strength (kPa)	'N' Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called “mechanical breaks”) are easily distinguishable from the normal in situ fractures.

RQD %	ROCK QUALITY
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube
PS	-	Piston sample
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC% - Natural moisture content or water content of sample, %
LL - Liquid Limit, % (water content above which soil behaves as a liquid)
PL - Plastic limit, % (water content above which soil behaves plastically)
PI - Plasticity index, % (difference between LL and PL)

Dxx - Grain size which xx% of the soil, by weight, is of finer grain sizes
These grain size descriptions are not used below 0.075 mm grain size
D10 - Grain size at which 10% of the soil is finer (effective grain size)
D60 - Grain size at which 60% of the soil is finer

Cc - Concavity coefficient = $(D30)^2 / (D10 \times D60)$
Cu - Uniformity coefficient = D60 / D10

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: 1 < Cc < 3 and Cu > 4
Well-graded sands have: 1 < Cc < 3 and Cu > 6
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay (more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

p'_o - Present effective overburden pressure at sample depth
p'_c - Preconsolidation pressure of (maximum past pressure on) sample
Ccr - Recompression index (in effect at pressures below p'_c)
Cc - Compression index (in effect at pressures above p'_c)

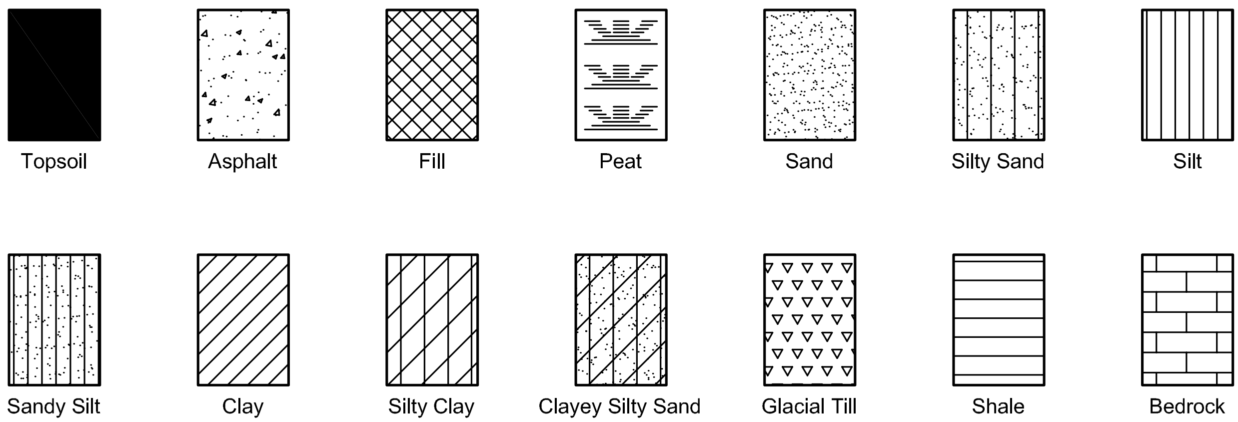
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

PERMEABILITY TEST

k - Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

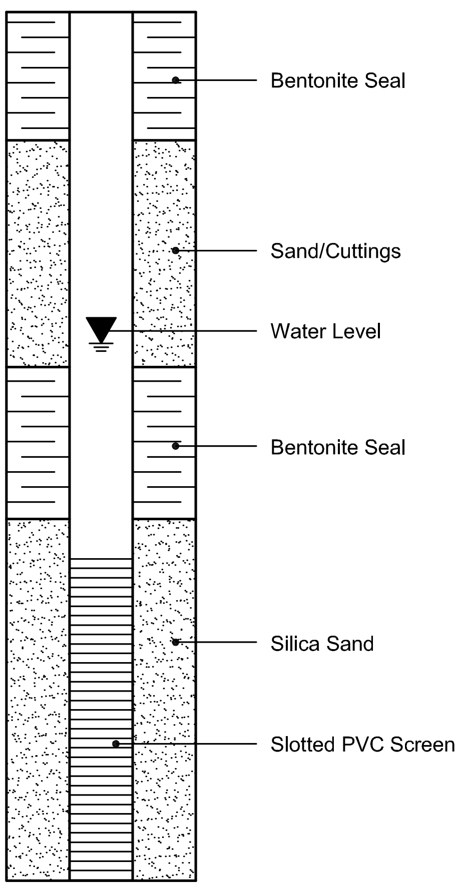
SYMBOLS AND TERMS (continued)

STRATA PLOT

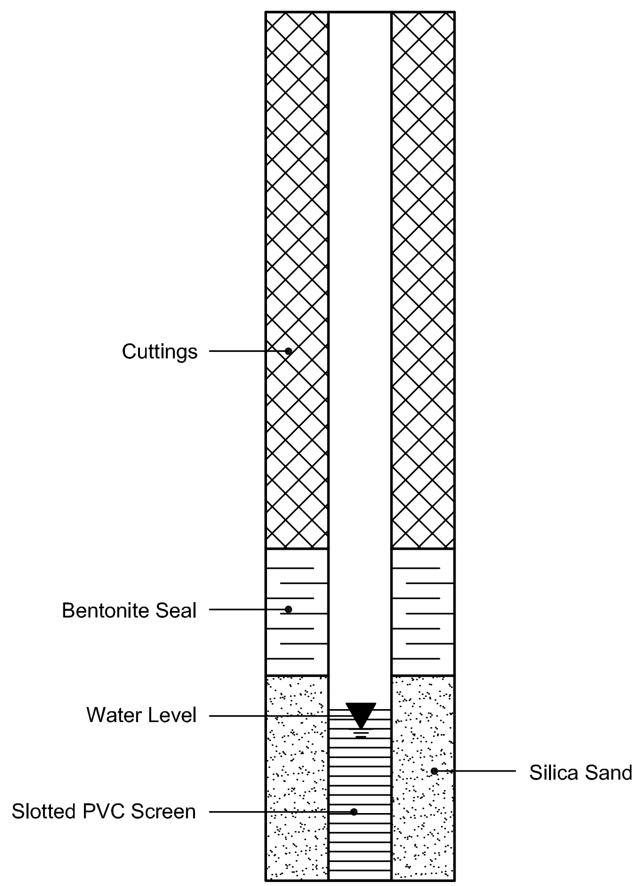


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



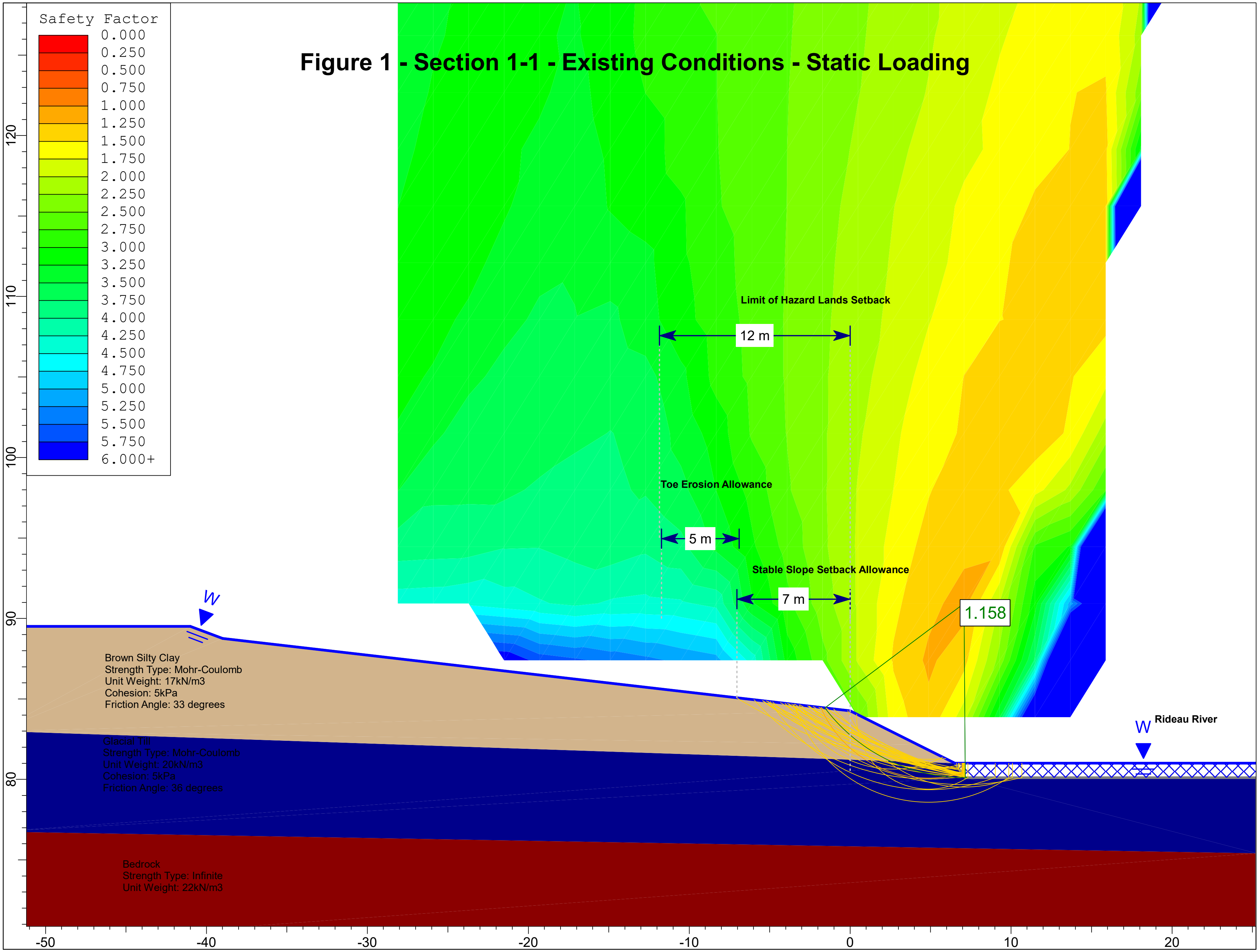


Figure 1 - Section 1-1 - Existing Conditions - Static Loading

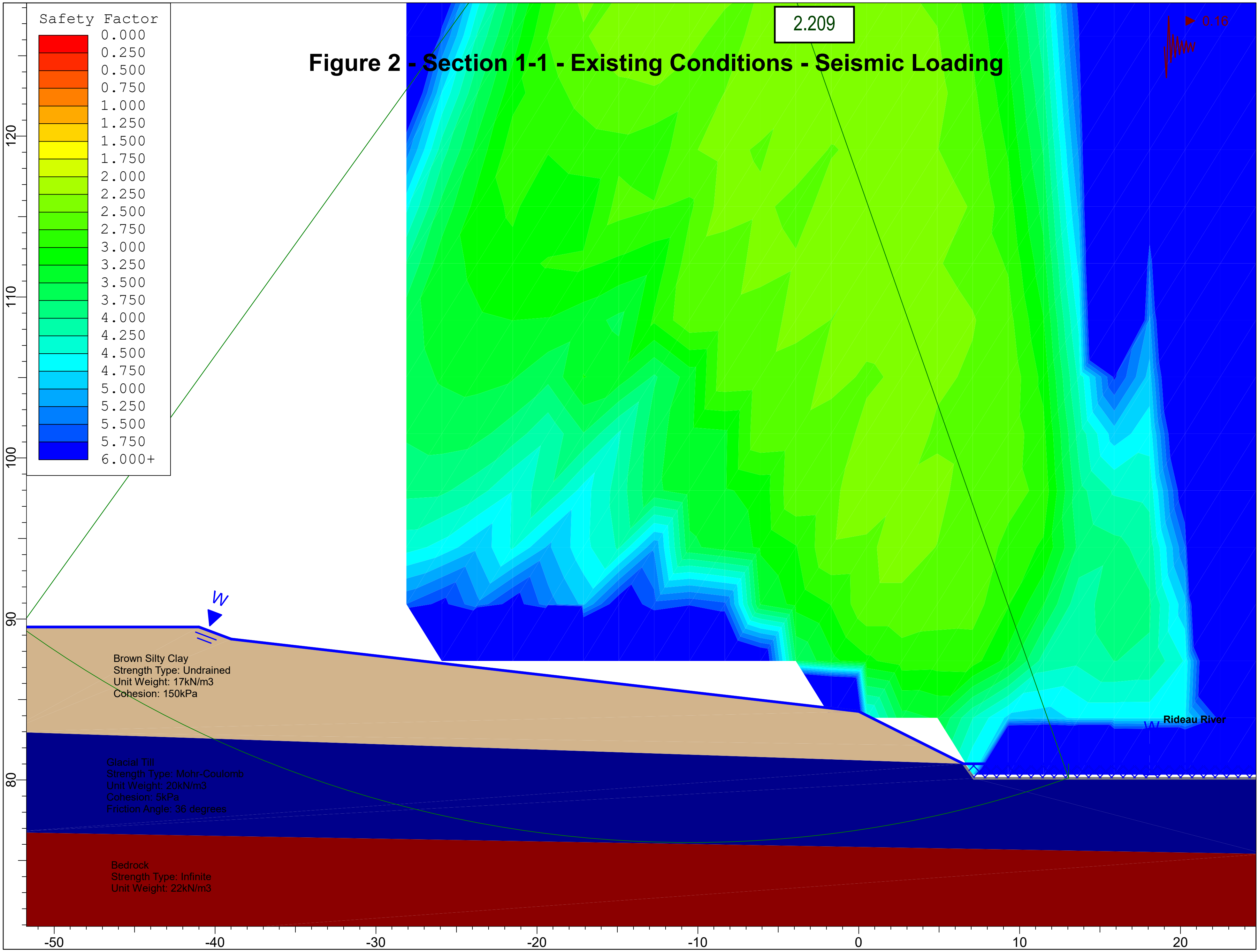


Figure 2 - Section 1-1 - Existing Conditions - Seismic Loading

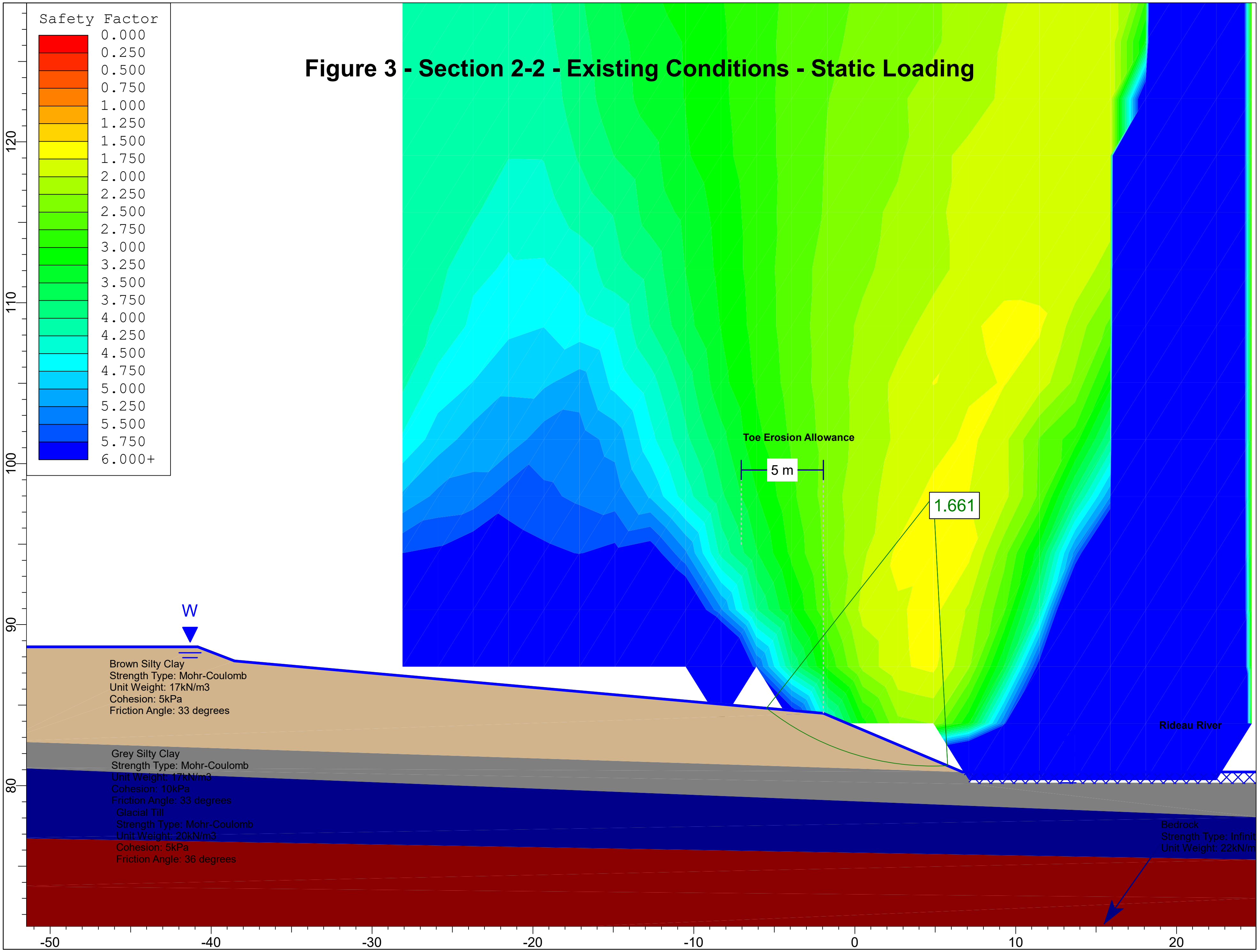


Figure 3 - Section 2-2 - Existing Conditions - Static Loading

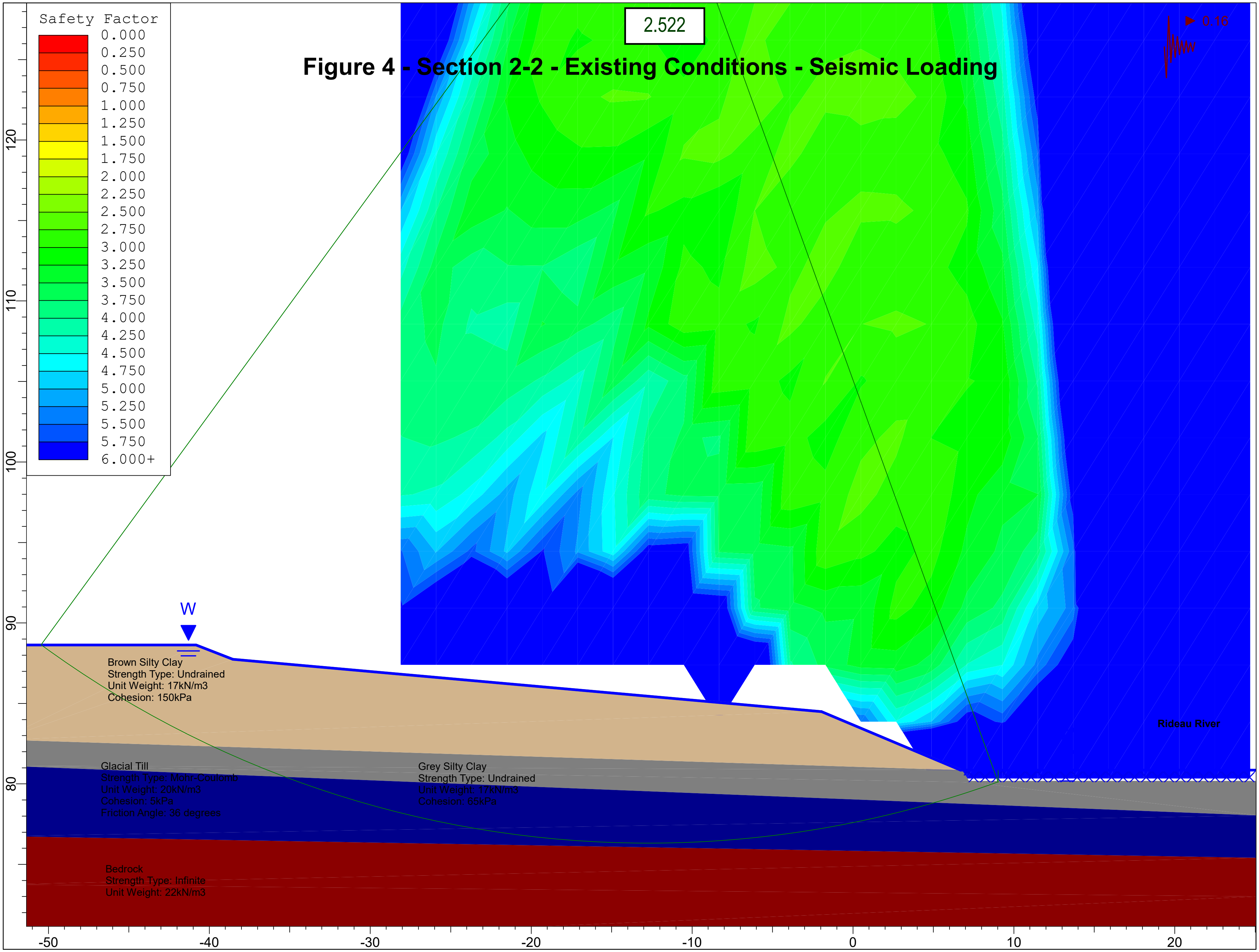
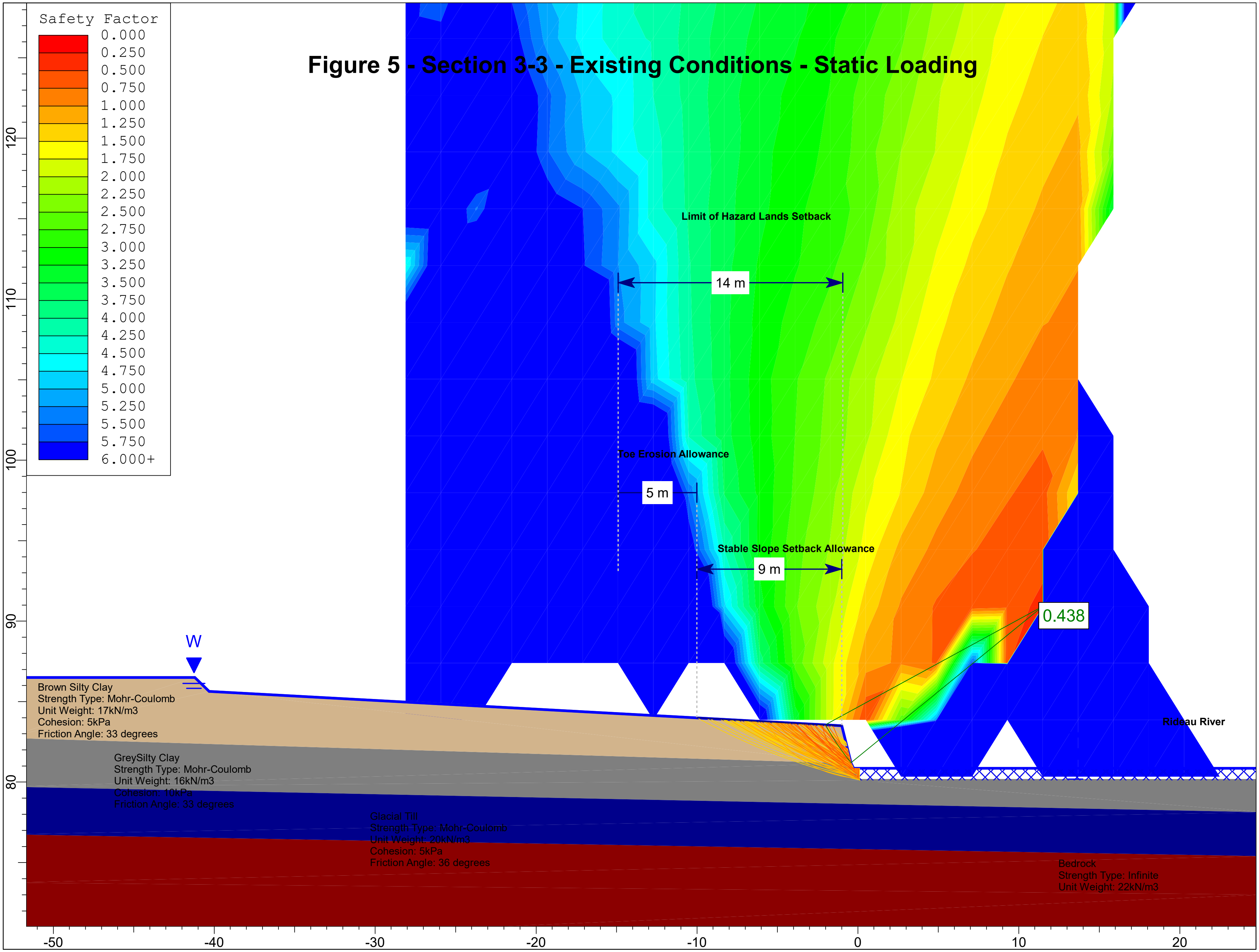
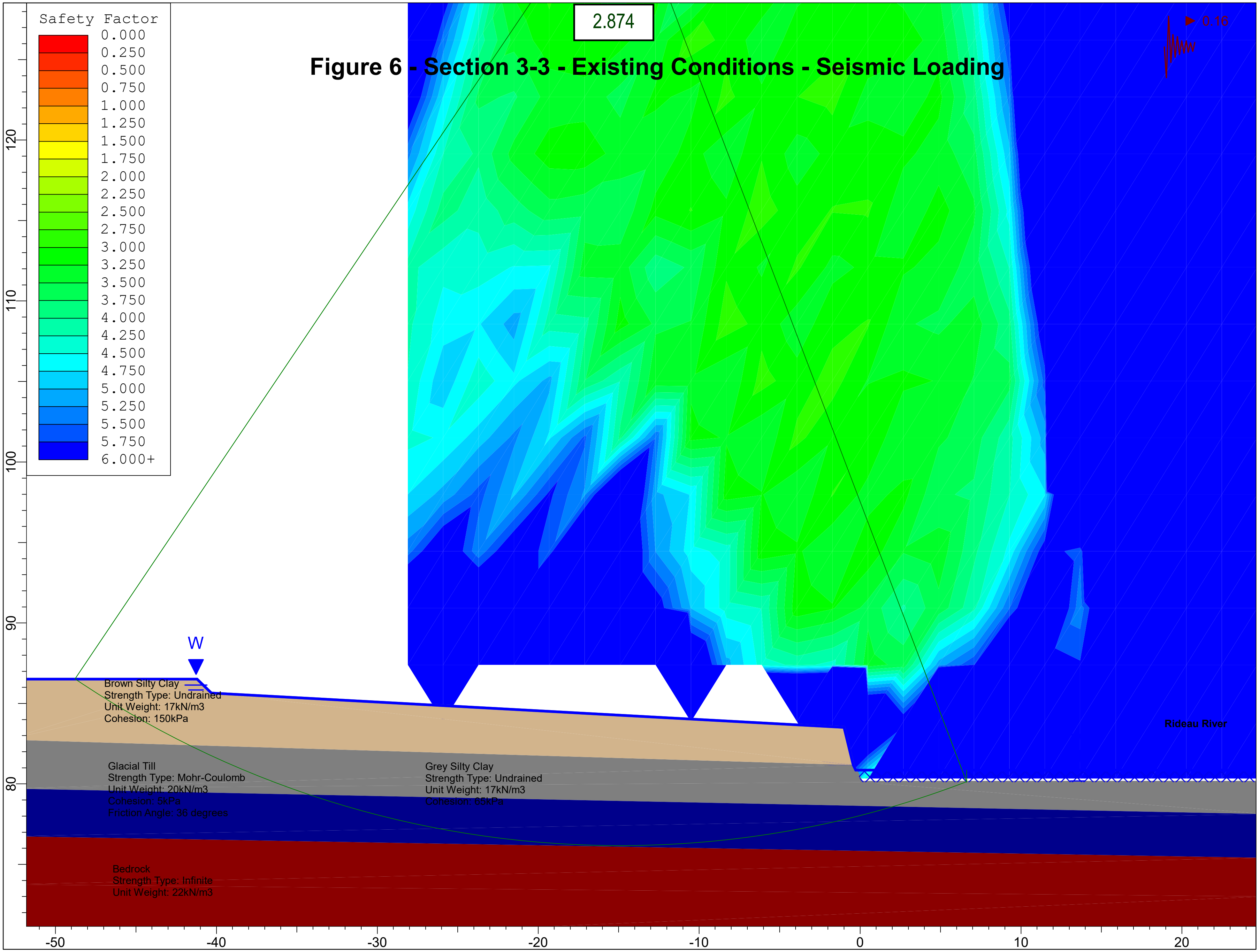


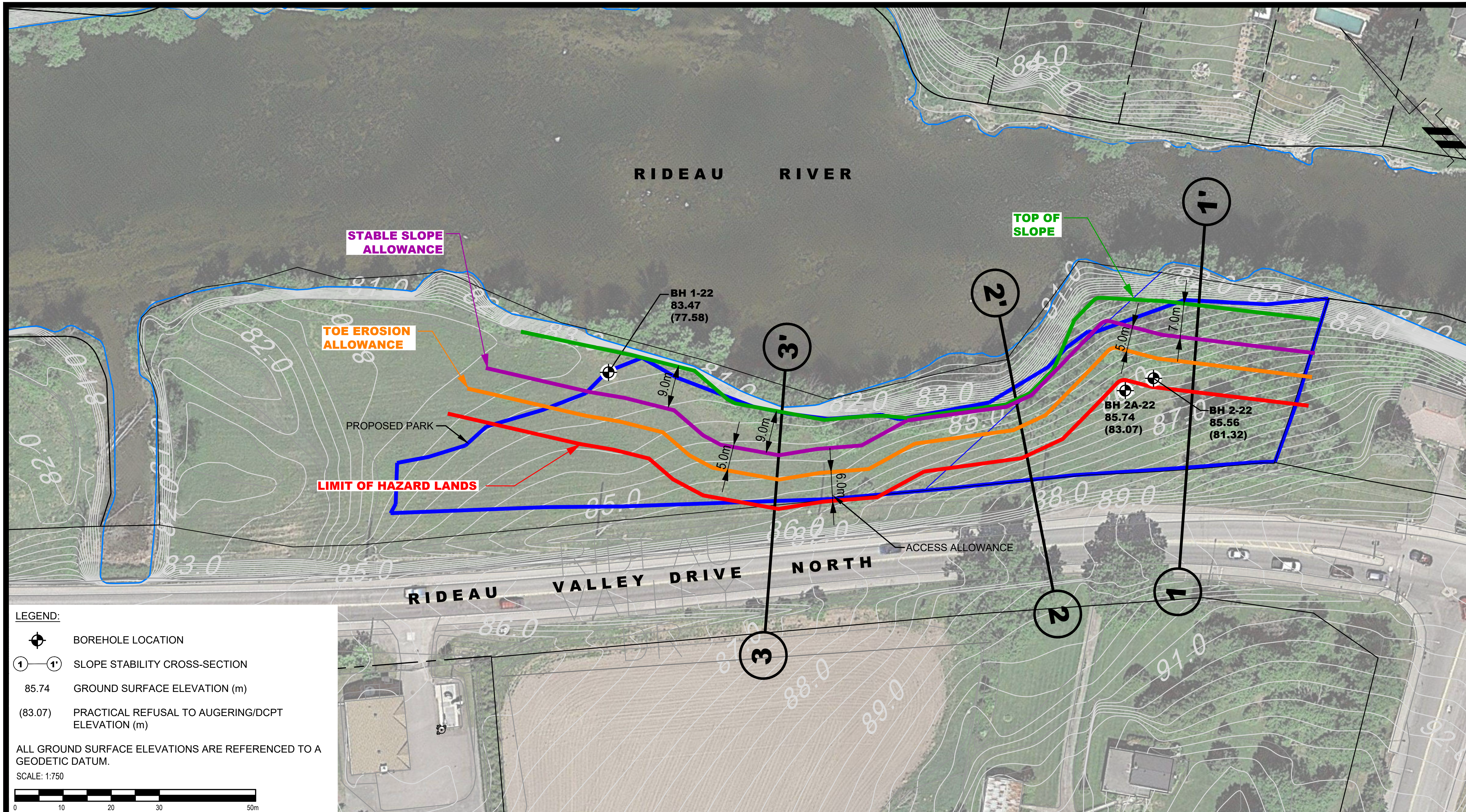
Figure 4 - Section 2-2 - Existing Conditions - Seismic Loading

Figure 5 - Section 3-3 - Existing Conditions - Static Loading





Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
2.874
Figure 6 - Section 3-3 - Existing Conditions - Seismic Loading
0.16
W
Brown Silty Clay
Strength Type: Undrained
Unit Weight: 17kN/m3
Cohesion: 150kPa
Glacial Till
Strength Type: Mohr-Coulomb
Unit Weight: 20kN/m3
Cohesion: 5kPa
Friction Angle: 36 degrees
Grey Silty Clay
Strength Type: Undrained
Unit Weight: 17kN/m3
Cohesion: 65kPa
Bedrock
Strength Type: Infinite
Unit Weight: 22kN/m3
Rideau River
120
110
100
90
80
-50
-40
-30
-20
-10
0
10
20



LEGEND:

- BOREHOLE LOCATION
- 1 —— 1' SLOPE STABILITY CROSS-SECTION
- 85.74 GROUND SURFACE ELEVATION (m)
- (83.07) PRACTICAL REFUSAL TO AUGERING/DCPT ELEVATION (m)

ALL GROUND SURFACE ELEVATIONS ARE REFERENCED TO A GEODETIC DATUM.

SCALE: 1:750

0 10 20 30 50m

patersongroup
consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL

UNIFORM DEVELOPMENTS

SLOPE STABILITY ANALYSIS
PROPOSED PARK
RIDEAU VALLEY DRIVE

MANOTICK, ONTARIO

Title:

LIMIT OF HAZARD LANDS PLAN

Scale: 1:750	Date: 06/2022
Drawn by: NFRV	Report No.: PG5828-LET.01
Checked by: MS	Dwg. No.: PG5828-2
Approved by: DJG	Revision No.:

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