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Slope Stability Assessment and Delineation of the Erosion Hazard Limit

Proposed Residential Subdivision
819 County Road 23
Merrickville-Wolford, Ontario

Prepared For:
2873633 Ontario Inc.
210 Prescott Street
Kemptville, Ontario
K0G 1J0

PROJECT #: 210816

Revision 0 – Determination of Limit of Hazard Lands April 8, 2024

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Kollaard File # 210816

2873633 Ontario Inc.
210 Prescott Street
Kemptville, Ontario
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Re: Slope Stability Assessment and Delineation of the Erosion Hazard Limit
Proposed Residential Development
819 County Road 23, Merrickville, Ontario.

1. Introduction and Background

1.1. Introduction

Kollaard Associates Inc has been retained by 2873633 Ontario Inc. to complete an assessment of the stability of the existing slopes at the site of the proposed development. The purpose of the assessment is to verify the stability of the slope and to determine the limit of development or safe setback line along the top of the slope.

For slopes along a river or stream, the distance from the top of slope to the closest location to the top of slope that would permit safe development is referred to as the 'Erosion Hazard Limit'. The Erosion Hazard limit is also known as the limit of development or the safe setback line.

For the purposes of this report, project north lies in a direction perpendicular to County Road 23, located at the southern limit of the site. The site is located along the north side of County Road 23 and along the east side of the Rideau River.

The proposed residential development site consists of a 24.0 hectare irregular shaped parcel of land located on the north side of County Road 23 and is bound on the north and west sides by the Rideau River. The site is bordered by agricultural land to the east. The site is currently occupied by a single family dwelling with detached garage, which are to remain and be undisturbed as part of the proposed development. The existing detached garage is on the eastern limit of the site. The existing single family dwelling is between the existing detached garage and the top of the slope. The existing single family dwelling is outside of the scope of this letter. As previously mentioned, the site is irregular in shape. The depth of the site varies from about 350m to 450m between the eastern property line and the Rideau River adjacent to the existing single family dwelling, narrowing at the northern portion of the site to an average depth of about 147 metres between the eastern property line and the Rideau River. The site has a length along the eastern property line of about 905 metre.

It is understood that the client is considering a residential development consisting of single family dwellings, which are to be on private services.

1.2. Background

This letter summarizes the results of various site visits to the above noted site carried out by the undersigned and other staff of Kollaard Associates. On March 31, 2022 Kollaard Associates was on site to supervise the installation of three test wells on the site in addition to the two existing wells servicing the existing single family dwelling on the site. On March 3, 2023, ten test holes were advanced on the site using a track mounted excavator. Eight auger holes were advanced on the site; four of which were logged and are included in Appendix A of this letter, and the other four were advanced in order to install stand pipes for groundwater modeling. In addition to the field investigation, topographic surveys were completed by staff of Kollaard Associates on November 12, 2021, November 18, 2021, July 19 to 21, 2022 and May 1 to 3, 2023. The locations of the test wells, test pits, and auger holes advanced on the site are shown on the drawing 210816-SLP attached in Appendix E.

The purpose of the site visits completed by Kollaard Associates was to observe the condition, height and inclination of the slope at the site, subsurface conditions along the toe, face and top of the slope, as well as the subsurface and topographic features throughout the remainder of the site.

The purpose of the topographic survey was to obtain factual information with respect to the existing riverbank and development area at the site. The purpose of the test pits and auger holes was to obtain factual information with respect to the subsurface conditions at the site, near the top of slope, in general throughout site and at the toe of the riverbank.

An updated legal survey of the site was completed by H.A. Ken Shipman Surveying Ltd. and was provided to Kollaard Associates by the client in PDF and CAD format. The survey provided up to date property line information regarding the existing lot lines of the site (i.e. not the proposed subdivided lots) and the water's edge at the upper navigation level of 88.73m.

As previously stated, the slope stability assessment is intended to provide site specific guidance on the extent of the limit of hazard lands at the site from a geotechnical perspective. The limit of hazard lands is defined by the Ministry of Natural Resources and Forestry as the sum of the safe slope allowance, toe erosion allowance and erosion access allowance, documented in the Ontario Ministry of Natural Resources Water Resource Section Technical Guide *River & Stream Systems: Erosion Hazard Limit*.

1.3. General Existing Conditions

The site is currently occupied by an existing single family dwelling with detached garage located adjacent the top of the riverbank slope about 315m to 325 metres north of County Road 23. The existing dwelling has occupied the site for more than 20 years. This existing dwelling together with the portion of the property occupied by the dwelling will be severed from the remainder of the site at time of development. The area immediately adjacent the dwelling consists of mowed lawn with mature trees.

The development area has an average depth ranging from 122m to 415 m between the east property line and the top of the riverbank. The main portion of the riverbank has a height ranging from about 2.7 to 7.5 metres and is inclined downward toward the Rideau River at an angle of between 12 and 61 degrees from horizontal. Portions of the riverbank slope are lightly vegetated with a mixture of grasses with some young to mature trees and shrubs throughout. It is noted that the toe of the slope is subject to active erosion, and is causing the slope to become over steepened in some areas. Some vegetation has fallen due to this erosion. The development area is well vegetated with a mixture of mature trees and undergrowth with the exception of an about 1.5 hectare area in the vicinity of the existing single family dwelling and detached garage which is maintained grass with several mature trees. A walking trail is maintained around the perimeter of the site.

The results of the topographic survey are provided on Kollaard Associates drawing 210816-SLP. This drawing indicates the location of the existing dwelling as well as the locations where test holes were put down at the site. The drawing also indicates where the various sections used in the slope stability analysis were obtained. The locations where the slope sections were obtained were visually selected during the site visits as being representative of the various slope conditions (in terms of height and slope angle) encountered at the site.

Drawing 210816-SLP also provides an overly lay of the cross sections used in the analysis. The sections indicate that the height and inclination of the slope increase from south to north along the site.

2. Subsurface Conditions

2.1. Review of Geological Mapping

A review of available surficial geological maps of the area indicates that the subsurface conditions at the site consist of fine textured glaciomarine deposits (silty clay) and modern alluvial deposits (sand and gravel). Bedrock geology maps indicate that the bedrock underlying the site consists of limestone and dolomite of Beekmantown Formation.

2.2. Site Investigation

A total of total of 8 test holes and three auger holes were put down at the site to verify the subsurface conditions on the slope on the table land above the slope. The test holes were advanced by a track mount excavator. The auger holes were advanced by hand.

The test hole logs are included following the text of this letter in Appendix A. The locations of the test holes are indicated on drawing 210816-SLP included in Appendix E.

The soil descriptions in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification was in general completed by visual-manual procedures in accordance with ASTM 2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

Classification and identification of soil involves judgement and Kollaard Associates Inc. does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

The groundwater conditions described in this report refer only to those observed at the location and on the date the observations were noted in the report and on the test hole logs. Groundwater conditions may vary seasonally, or may be affected by construction activities on or in the vicinity of the site. The groundwater was encountered in test pits TP1, TP5, and TP7 at the time of excavation on March 2, 2023 at depths of between 3.3m and 3.6m below existing ground surface. The groundwater level in the stand pipes installed on the site encountered water at between 0.58m and 1.70 below existing ground surface when measured on February 20, 2024. It is noted that the highest groundwater measured within the stand pipes was encountered in stand pipes at AH01 and AH02, which are on the table land above the slope at depths of 0.58 and 0.67 metres below ground surface respectively. The closest stand pipe to the top of slope was AH05, which encountered groundwater at 1.70m below ground surface at the time of measurement on February 20, 2024.

The following is a brief overview of the subsurface conditions encountered at the test pits.

2.3. Table Land

2.3.1. Topsoil

A thin layer of topsoil was encountered from the ground surface at all of the test hole locations. The topsoil layer ranged in thickness from about 0.3 metres to 0.4 metres. The identification of the topsoil layer is for geotechnical purposes only and does not constitute a statement as to the suitability of this layer for cultivation and sustainable plant growth. The topsoil was fully penetrated at the test locations.

2.3.2. Silty Clay

Silty clay was encountered beneath the topsoil in all of the test pits. The silt clay ranged from red brown to grey brown in colour. In situ shear vane tests were carried out in the silty clay deposit in the test pits, which gave undrained shear strength values of greater than 120 kilopascals within the test pits. The results of in situ shear vane testing and tactile examination carried out for silty clay material indicates that the clay is very stiff in consistency. Test pits TP1 to TP8 were terminated within the silty clay deposit at at depths of between 3.1m to 3.6m below existing ground surface.

2.3.3. Bedrock

Bedrock was not encountered in any of the test pits. Bedrock was encountered at the time of the test well drilling on March 21, 2022. The bedrock was encountered in the test wells at depths ranging from 10.4m to 11.3m below existing ground surface. A review of available well logs in the area indicates bedrock at depths of between 1.8m and 13.7m below existing ground surface. The well logs from the test wells on the site are included in appendix B of this report.

2.4. Slope

In general, the subsurface conditions on the slope consisted of a thin layer of topsoil underlain by silty clay. The hand auger holes were advanced to depths of around 3.0 to 4.0m and were terminated within the silty clay.

2.5. Groundwater

As mentioned above, groundwater was encountered in the test pits at depths ranging from 3.4m to 3.6m below existing ground surface at the time of the site visit on March 2, 2023. Groundwater was measured within the standpipes at a depth of 0.58m and 1.70m below existing ground surface on February 20, 2024. The slope stability sections modelled include a ground water level at a depth of about 3.0 metres below existing ground surface at the top of the slope to the navigable water level of the Rideau River at the toe of the slope. A second scenario was considered for elevated groundwater conditions on the slope. The second scenario assumed a ground water level at a depth of about 1.0 metres below existing ground surface at the top of the slope to the navigable water level of the Rideau River at the toe of the slope. This was done to model seasonal fluctuations in ground water, and increased loading on the slope from on-site septic systems to service the proposed dwellings.

3. Existing Slope Conditions

3.1. Observations and Measurements

The slope at the site can be subdivided into two zones, Zone 1 and Zone 2. Zone 1 has been determined to be western portion of the site, where the Rideau River runs on a north-south axis. Zone 2 is considered to be the portion of the site where the river turns to the east along the north portion of the site. The slope in Zone 2 is flatter than Zone 1, and is on the deposition side of the river. The border separating Zone 1 from Zone 2 is located along the lot-line between the proposed sub-lot 1 & sub-lot 2. Zone 1 encompasses the lots along the western portion of the site (proposed sub-lots 2-9). Zone two encompasses the lots along the north portion of the site (proposed sub-lot 1, and the proposed park land). Zone 1 is represented by the analysis of slope sections 1 through 5, and Zone 2 is represented by the analysis in slope section 6.

The majority of the site is currently vacant and has a relatively level area between the front of the site and the top of the river bank slope. Mapping obtained from the Rideau Valley Conservation Authority website indicates that the regulation limit at the site is located approximately 17.5 metres east of the west property line and between 15.6m to 22.6m south of the north property line. It is understood that the regulation limit is imposed because of the floodplain, but given the characteristics of the site, that the riverbank slope at the site is also to be considered to be a potential hazard to be assessed. It is further understood that the extent of the regulation limit shown on the RVCA website has not been defined by a site specific geotechnical investigation.

At the time of the site visits by Kollaard Associates, the height and inclination of the slope extending downward from the table land was measured using topographic survey equipment. The locations at which the sections were obtained are indicated on Kollaard Associates drawing 210816-SLP. The cross sections were also overlain for comparative purposes.

In general, the slope measurements obtained indicate that the ground surface naturally slopes downward from the relatively level development area above the top of the riverbank of the Rideau River at the west and north portions of the site. The slope is highest and steepest along the southern portion of the site adjacent to the existing single family dwelling becoming less extreme along the northern portion of the site. Portions of the slope have become over steepened due to erosion from wave action at the toe of the slope. The slope along the north portion of the site is flatter and was not observed to be subject to the same over steepening. The steeper sections of the slope are inclined downward from horizontal at between 17 and 61 degrees. The flatter sections along the north portion of the site are inclined from horizontal at between 12 and 30 degrees. The toe of the slope is directly connected to the Rideau River.

The shoreline at the bottom of the riverbank consists of a mixture of silty clay with some sand and gravel on the surface. Soundings of the river were taken at intervals to a distance of between 6m to 18m from the shoreline. The slope of the riverbed from the bottom of the slope at the water's edge is inclined at between 5 to 15 degrees from horizontal with an average horizontal inclination of about 7.5 degrees. The following was also observed at the time of the site visit:

- No seepage was observed on the slope;
- There is noted active erosion along the slope, which has led to undermining and over steepening of portions of the slope;
- Root mass from vegetation growing along portions of the toe of the slope are exposed in locations, and trees have fallen in the river from shallow slope failures due to erosion.
- The face of the slope is lightly vegetated with mostly grasses with trees and shrubs throughout.
- The development area above the slope is well vegetated with mature trees and undergrowth;

3.2. Location of Top of Slope

It is considered that the transition from the development area to the face of the riverbank slope is abrupt resulting in a clearly defined location of the top of slope. For the purposes of this site, the top of slope was identified as the location at which there was a significant change in slope angle from relatively horizontal to significantly sloped. The relatively horizontal development area was considered to be areas that once developed, could be comfortably and easily accessed and maintained with regular equipment such as lawnmowers or normal equipment and road vehicles (not off road or all terrain vehicles).

4. Erosion Hazard Limit – Safe Setback Requirements

In accordance with the Ontario Ministry of Natural Resources Technical Guide - River & Stream Systems: Erosion Hazard Limit 2002 [MNR Technical Guide], the Erosion Hazard Limit consists of three components: (1) Stable Slope Allowance, (2) Toe Erosion Allowance, and (3) Erosion Access Allowance. Each of these components are discussed separately in the following Sections 5 to 7 and are combined to define the safe slope setback or erosion hazard limit in Section 8.

The intent of defining the Erosion Hazard Limit is to ensure that proposed development occurs at a location where it is protected from any potential erosion and slope stability hazard associated with the slope along a river or stream.

As shown in the guidance provided for the slope stability assessment in the MNR Technical Guide, the degree of risk or setback requirement is associated with the intended use or nature of development. Development resulting in no permanent or habitable structures will require less setback than would public infrastructure or buildings.

5. Component 1) Stable Slope Allowance – Slope Assessment

The details of the required investigation have been defined based on Table 4.2 (slope stability rating chart) of the MNR's "Technical Guide River & Stream Systems: Erosion Hazard Limit"

Table 1 – Excerpt From Table 4-2: Zone 1

Category	Criteria	Rating
1. Slope Inclination	more than 26	16
2. Soil Stratigraphy	Clay, Silt	12
3. Seepage from Slope Face	None	0
4. Slope Height	5.1 to 10 metres (4.40m to 7.45m)	4
5. Vegetation	Light vegetation; mostly grass, weeds, occasional trees, shrubs	4
6. Table Land Drainage	Minor Drainage over slope no active erosion from table land drainage	2
7. Proximity to Watercourse	Less than 15 m	6
8. Previous Landslide Activity	Yes	6
Total		50
50 – Moderate Potential = Boreholes, piezometers, lab tests, detailed report		

Table 2 – Excerpt From Table 4-2: Zone 2

Category	Criteria	Rating
1. Slope Inclination	more than 26	16
2. Soil Stratigraphy	Clay, Silt	12
3. Seepage from Slope Face	None	0
4. Slope Height	2.1 to 5 metres (2.70m)	2
5. Vegetation	Light vegetation; mostly grass, weeds, occasional trees, shrubs	4
6. Table Land Drainage	Minor Drainage over slope no active erosion from table land drainage	2
7. Proximity to Watercourse	Less than 15 m	6
8. Previous Landslide Activity	Yes	6
Total		48
48 – Moderate Potential = Boreholes, piezometers, lab tests, detailed report		

5.1. Soil Strength Parameters

The soil conditions used in the stability analyses were based, in part, on the results of the test holes advanced across the site. The stability analyses were carried out using silty clay and bedrock strength parameters based on the results of the geotechnical investigation as well as our experience in the vicinity of the subject site and geology maps of the area. The soil parameters selected were obtained from the City of Ottawa Slope Stability Guidelines for Weathered Silty Clay Crust, and Grey Silty Clay. The values fall within the range of the Silty Clay parameters. The soil parameters fit, due to their observed visual characteristics at the time of the site visit and high clay content based on the results of the hydrometer testing completed on samples obtained from TP4 and TP8. This is represents a reasonable assumption and is appropriate given the site conditions. A screenshot of the table from the City of Ottawa Slope Stability Guidelines can be seen below:

Soil Type	Bulk Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Effective Internal Friction Angle (kPa)
Sand	17 – 21	0	28 – 40
Weathered Silty Clay Crust	15.5 – 19	0 – 12	25 – 38
Grey Silty Clay	15.5 – 19	0 - 12	25 – 38
Glacial Till	19 - 22	0 - 3	30 – 35

The following Table 2 summarizes the parameters used in the analysis

Table 2 - Soil Parameters

Soil Type	Effective Angle of Internal Friction (degrees)	Effective Cohesion (kPa)	Unit Weight kN/m^3
Silty Clay	32	9	16
Silty Clay (undrained conditions)	--	50*	16
Bedrock	n/a	n/a	n/a

* The effective cohesion in undrained conditions was set to 50 kPa, which is lower than typical of silty clay in the Ottawa area such as those encountered at the site. Shear vane testing completed within the test pits indicated that the shear strength of the silty clay on the site was between 100 kPa to in excess of 120 kPa. The lower cohesion value represents a conservative estimate for undrained shear strength analysis.

The results of the stability analysis are dependent on the assumed groundwater conditions. As previously indicated, the depth at which groundwater was encountered was between 3.4m to 3.6m below existing ground surface at the time of the site work and was observed in the stand pipes at between 0.58m and 2.52m on February 20, 2024. One slope scenario was run assuming a groundwater table of about 3.0 metres below ground surface on the table land near the top of the slope to the navigable level of the Rideau River at the toe of the slope. This represents a reasonable approach for realistic groundwater table elevations expected on the site. A second scenario was introduced with elevated groundwater table elevations. As a conservative approach, the second scenario for the slope stability analysis was completed using a ground water level which

ranged from about 1.0 metre below the ground surface on the table land near the top of slope to above the navigable water level of the Rideau River at the toe of the slope. The elevated ground water table elevations will take into account seasonal fluctuations in ground water level and additional loading from septic systems.

5.2. Design Factors of Safety

The slope stability analyses were completed using soils parameters, groundwater conditions and a slope profile that attempt to model the slopes in question. The cross sections selected are considered to be representative of the various conditions across the site. The models, however, do not exactly represent the actual conditions at the site.

For the purposes of this slope stability assessment the MNR Technical Guide provides the design minimum factors of Safety for static conditions in Table 4.3 copied below:

Table 4.3

	LAND-USES	DESIGN MINIMUM FACTOR OF SAFETY
A	**PASSIVE**; no buildings near slope; farm field, bush, forest, timberland, woods, wasteland, badlands, tundra	1.10
B	**LIGHT**; no habitable structures near slope; recreational parks, golf courses, buried small utilities, tile beds, barns, garages, swimming pools, sheds, satellite dishes, dog houses	1.20 to 1.30
C	**ACTIVE**; habitable or occupied structures near slope; residential, commercial, and industrial buildings, retaining walls, storage/warehousing of non-hazardous substances	1.30 to 1.50
D	**INFRASTRUCTURE and PUBLIC USE**; public use structures or buildings (i.e., hospitals, schools, stadiums), cemeteries, bridges, high voltage power transmission lines, towers, storage/warehousing of hazardous materials, waste management areas	1.40 to 1.50

This would indicate that a minimum factor of safety of 1.3 to 1.5 is suitable for habitable structures to be occupied near the slope. It is noted that the City of Ottawa Slope Stability Guidelines indicate a minimum factor of safety of 1.5 is required for the construction of a dwelling or structure. The guideline indicates that development of lands within the slope stability hazard zone should be restricted. They should not be developed with permanent structures, parking or roadway areas, amenity areas (i.e., the landscaped area around a house, typically in the rear yard, that could be developed with pools or decks), septic beds, or any other valuable infrastructure. It is noted that the slope stability hazard zone is only one component of the Erosion Hazard limit and is not the same as the Erosion Hazard limit.

The minimum design factor of safety for seismic conditions is obtained from the City of Ottawa slope stability design guidelines. The City of Ottawa design guidelines indicate that slopes with a minimum factor of safety of 1.1 are considered to be stable during seismic conditions.

5.3. Slope Stability Modelling

The slopes at the site were modelled using the sections considered to be representative of the site in GeoStudio 2019 (Slope/W).

Seismic Stability was also modelled using GeoStudio 2019 (Slope/W) and a seismic coefficient of k = 0.102 where k is equal to one half of the Peak (horizontal) Ground Acceleration at 2% probability of exceedance in 50 years. A PGA of 0.203 was obtained for the site from the 2015 National Building Code Seismic Hazard Calculation. A copy of the Seismic Hazard Calculation is included in Appendix A.

The slope stability modelling was completed to consider two different potential failure surface scenarios during both static and seismic conditions in order to ensure potential unforeseen scenarios have been addressed. These potential failure surface scenarios consist of normal and elevated groundwater table elevations.

5.3.1. Slope Stability – Normal Groundwater Conditions

The results of the slope stability assessment for the overall slope for each section with in-situ ground water conditions under both static and seismic conditions using normal strength parameters and under static conditions using undrained conditions are provided in Appendix C.

The following Table 3 also summarizes the minimum factor of safety for each section.

Table 3 - Minimum Factor of Safety – Entire Slope

Section	Minimum FS			Minimum Setback for Origin of Slip Surface with FS≥ 1.5 [1]
	Normal Strength		Undrained	
	Static	Seismic	Static	
Section 1	1.56	1.15	2.22	none encountered [2]
Section 2	2.04	1.63	3.42	none encountered [2]
Section 3	1.61	1.38	3.00	none encountered [2]
Section 4	1.59	1.33	2.70	none encountered [2]
Section 5	1.55	1.35	3.07	none encountered [2]
Section 6	3.44	2.36	5.32	none encountered [2]

1) The location of the origin of the slip surface with an FS ≥ 1.5 defines the point on the slope above which all of the factors of safety originating beyond that point will be greater than 1.5 in normal static conditions.
2) There were no slip surfaces encountered during the modelling of this section where the factor of safety was less than 1.5 during static conditions.

The minimum safe slope setback distance is defined as the distance from the top of slope at which the slope will be "Safe" From the MNRF guidelines section 4.3.3.1 the design minimum factor of safety is 1.4 to 1.5 for infrastructure and public use. Using the City of Ottawa Slope stability guidelines, a minimum FS of 1.5 is required for a stable slope. Using the City of Ottawa criteria, the minimum setback distance then is the distance from the top of slope to a point at which all of the factors of safety originating beyond that point will be greater than 1.5. Since there were no factors of

safety calculated below 1.5 in static conditions or 1.1 in seismic conditions, there is no slope setback in this scenario.

5.3.2. Slope Stability – Elevated Groundwater Conditions

The sections were re-modeled assuming groundwater table elevations of 1.0m below existing ground surface overall slope for each section under both static and seismic conditions using normal strength parameters and under static conditions using undrained conditions are provided in Appendix D. The assumed groundwater elevation of 1.0m below the existing ground surface was completed as a conservative estimate as the monitored groundwater elevation measured was 1.58m below the existing ground surface at the highest point.

The following Table 4 also summarizes the minimum factor of safety for each section.

Table 4 - Minimum Factor of Safety – Entire Slope With Elevated Ground Water Conditions

Section	Minimum FS			Minimum Setback for Origin of Slip Surface with FS≥ 1.5 [1]
	Normal Strength		Undrained	
	Static	Seismic	Static	
Section 1	1.42	1.30	2.21	8.3m
Section 2	1.70	1.37	3.45	none encountered [2]
Section 3	1.56	1.32	2.99	none encountered [2]
Section 4	1.22	1.22	2.70	8.1m
Section 5	1.38	1.23	3.06	3.9m
Section 6	3.00	2.12	5.32	none encountered [2]

1) The location of the origin of the slip surface with an FS ≥ 1.5 defines the point on the slope above which all of the factors of safety originating beyond that point will be greater than 1.5 in normal static conditions.
2) There were no slip surfaces encountered during the modelling of this section where the factor of safety was less than 1.5 during static conditions.

5.4. Summary of Component 1 - Stable Slope Allowance

The stable slope allowance corresponds to the minimum set back distance from the top of the slope such that the minimum factor of safety originating for any slip surface originating at or beyond the setback distance is greater than 1.5 in static conditions and 1.1m in seismic conditions.

The slope stability analysis completed on each of the sections indicated that under normal ground water conditions, that the slope meets the minimum slope stability criteria in static and seismic conditions for residential development. However, when the model was reanalyzed with elevated groundwater conditions, the slope sections the stability of portions of sections 1, section 4, and section 5 were deemed marginally stable, having factors of safety of less than 1.5 in static conditions.

In Zone 1, the maximum distance from the top of the slope, in which a minimum factor of safety was found to be 1.5 in static conditions and 1.1 in seismic conditions was found in section 1 during elevated water conditions as 8.3m from the top of the slope. Therefore, a stable slope allowance, resulting in a setback from the top of slope, as described in the MNR Technical Guide is to be 8.3m.

In Zone 2, the slope was determined to be stable in static and seismic conditions for both normal and elevated groundwater conditions.

6. Component 2) Toe Erosion Allowance

The minimum toe erosion allowance for a slope adjacent a river is defined by Table 3: Determination of Toe Erosion Allowance in the MNR Technical Guide copied below.

Table 3: Determination of Toe Erosion Allowance

MINIMUM TOE EROSION ALLOWANCE - River Within 15 m of Slope Toe*

Type of Material Native Soil Structure	**Evidence** of Active Erosion** OR Bankfull Flow Velocity > Competent Flow Velocity***	**No evidence** of Active Erosion** OR Bankfull Flow Velocity <Competent Flow Velocity***		
	RANGE OF SUGGESTED TOE **EROSION ALLOWANCES**	Bankfull Width		
		< 5m	5-30m	> 30m
1.Hard Rock (granite) *	0 - 2 m	0 m	0 m	1 m
2.Soft Rock (shale, limestone) Cobbles, Boulders *	2 - 5 m	0 m	1 m	2 m
3.Stiff/Hard Cohesive Soil (clays, clay silt), Coarse Granular (gravels) Tills *	5 - 8 m	1 m	2 m	4 m
4.Soft/Firm Cohesive Soil, loose granular, (sand, silt) Fill *	8 - 15 m	1-2 m	5 m	7 m

As previously indicated, the subsurface conditions along the shoreline at the site consisted of a silty clay (condition 3). As discussed above, the slope on the site has been subdivided into two zones. The first zone is the western portion of the site and the east bank of the Rideau River. The second zone is the gentle sloping north portion of the site on the south bank of the Rideau River. It is noted that the water level of the Rideau River at the site is controlled by the Locks at Burritts Rapids, which are located about 2.6km downstream of the north end of the site. During normal flow conditions (navigable water level), there is noted active erosion. However, since the water level is controlled, the water level is lowered for the winter months, reducing the time that erosion takes place on the site.

The bank full width is greater than 30 metres. Based on the shore line conditions, the range of suggested toe erosion allowance is 5 to 8 metres. Zone one is noted as being on the erosion side of the river. There is noted active erosion on the east bank of the Rideau River at the site. It is suggested that the toe erosion allowance in Zone 1 be 8m, which corresponds to the highest suggested setback from the MNR technical guide. Zone 2 is located on the deposition side of the creek as the river turns to the east, and changes orientation from north-south to east-west. Since the soil conditions are consistent across the entire site, and there is still active erosion in close proximity, it is recommended that a toe erosion allowance of 5m be selected for Zone 2. The lower

toe erosion allowance is due to this portion of the site being located on the deposition side of the river so erosion of the shoreline is anticipated to be at a slower rate than in Zone 1, where the riverbank is on the erosion side of the Rideau River.

As shown in Figure 115b copied below from the MNR Technical Guide the toe erosion allowance is applied below the bottom of the slope beginning at the edge of the river bank or edge of watercourse. The stable slope is then measured from the extent of the toe erosion allowance.

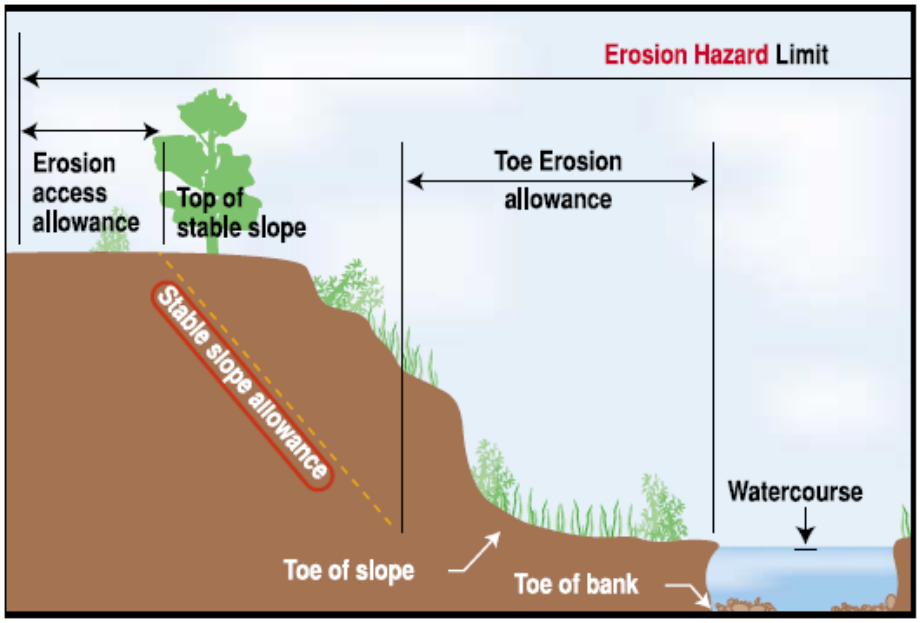


Figure 115 b - Stable Slope Allowance
(toe of valley slope ≤15m from watercourse)

Typically as indicated in Figure 115b, in circumstances where the 8m toe erosion allowance cannot be provided at the toe of the slope, the deficiency in setback would be applied at the top of the slope. Since there is no distinct bank beyond the toe of the slope, the toe erosion allowance has been applied to the top of the slope.

7. Component 3) Erosion Access Allowance

The erosion access allowance is discussed in Section 3.4 of the MNR Technical Guideline.

The MNR Technical Guide provides the following information:

- In the absence of a site specific study, the erosion access allowance for river and stream systems be 6 metres.
- The erosion access allowance is applied following the stable slope allowance.

The application of the erosion access allowance for confined systems is illustrated in the figures copied below.

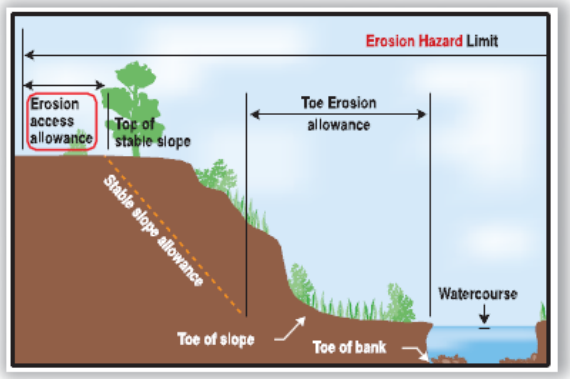


Figure 123 - Erosion Access Allowance:

Figure 124 - Erosion Access Allowance

The wording and illustrations in the Technical Guide state that the erosion access allowance be added to the stable slope allowance after the stable slope allowance is added to the toe erosion allowance.

From the MNR Technical Guide, three main principles support the inclusion of the erosion access allowance:

1. Providing for emergency access to erosion prone areas;
2. Providing for construction access for regular maintenance and access to the site in the event of an erosion event or failure of a structure;
3. Providing protection against unforeseen or predicted external conditions which could have an adverse effect on the natural conditions or processes acting on or within an erosion prone area of provincial interest.

Since the site is subject to all three of the above criteria, a erosion access allowance of 6m is to be applied beyond the stable slope setback.

8. Minimum Setback Distance - Erosion Hazard Limit

As previously discussed, the minimum setback distance or Erosion Hazard Limit is defined as the sum of Stable Slope or Slope Setback Allowance + Toe Erosion Allowance + Erosion Access Allowance.

As discussed in Section 5 above, the stable slope setback allowance required from the top of the slope has been subdivided into two zones. Zone 1 is the western limit of the site on the east bank of the Rideau River. The stable slope setback in zone 1 is equal to 8.3m. The second zone is the north portion of the site, and the south bank of the Rideau River. The stable slope setback in zone 2 is equal to zero.

As discussed in Section 6 above, it is proposed that the toe erosion allowance for Zone 1 to be 8m and for Zone 2 to be 5m. Since there is no defined are between the toe of the slope and the top of the riverbank, the toe erosion allowance has been added to the top of the slope.

As discussed in Section 7 above, an erosion access allowance of 6m was determined to be appropriate for the site.

As discussed in Section 3 above, the site was divided into two zones based on the physical characteristics of the riverbank and the location of the bank. The limit of hazard land in Zone 1 is defined as being equal to = 8.3 m + 8m + 6 m = 22.3 metres. The limit of hazard land in Zone 2 is defined as being equal to = 0 m + 5 m + 6 m = 11 metres.

The Erosion Hazard Limit setbacks in Zone 1 and Zone 2 of 22.3 metres and 11 metres from the top of the slope respectively are illustrated on drawing 210816-SLP. This setback represents a limit for the proposed development at the site.

9. Conclusions

Based on the results of this slope stability assessment and delineation of the Erosion Hazard Limit for the proposed development, it is considered that an Erosion Hazard Lands Setback in Zone 1 and Zone 2 of 22.6 metres and 11 metres respectively, is appropriate for the site. The Erosion Hazard Limit has been illustrated on drawing 210816-SLP

The slope at the site is considered to be adequately stable to allow the construction and development of the proposed residential building lots at a setback distances defined for their zones as discussed above.

The top of slope at each lot line is indicated on the attached drawing 210816-SLP. The top of the slope should be verified between the lot lines during site specific grading of each individual lot as required by the geotechnical engineer and/or an Ontario Land Surveyor taking into account the change in slope inclination and topographic conditions.

We trust this letter provides sufficient information for your present purposes. If you have any questions concerning this letter please do not hesitate to contact our office.

Sincerely,
Kollaard Associates Inc.

Prepared by:

Nicholas Recoskie, P.Eng.

Reviewed by:

Steve deWit, P.Eng.

APPENDIX A – RECORD OF TEST HOLES

BOREHOLE TP01

PROJECT: Proposed Subdivision
CLIENT: 2873633 Ontario Inc
LOCATION: 819 Burritts Rapids Road
PENETRATION TEST HAMMER: N/A

PROJECT NUMBER: 210816
DATE OF BORING: 2023-03-02
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o (0 20 40 60 80 100)	DYNAMIC CONE PENETRATION TEST blows/300 mm (0 20 40 60 80 100)	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	TOPSOIL	0.00		95.30							
0.5	Red brown SILTY CLAY	0.40		94.90							
	Grey brown SILTY CLAY	0.70		94.60							
1.0											Some groundwater observed at about 3.6 metres below the existing ground surface, March 2, 2023. Groundwater measured in standpipe at about XX metres, DATE.
1.5											
2.0										36	
2.5											
3.0											
3.5											
	End of test pit in SILTY CLAY	3.60		91.70							

DEPTH SCALE: 1 to 25
LOGGED: CI

BORING METHOD: Track-Mounted Excavator
AUGER TYPE: N/A
CHECKED: SD

BOREHOLE TP02

PROJECT: Proposed Subdivision
CLIENT: 2873633 Ontario Inc
LOCATION: 819 Burritts Rapids Road
PENETRATION TEST HAMMER: N/A

PROJECT NUMBER: 210816
DATE OF BORING: 2023-03-02
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE: DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o (0 20 40 60 80 100)	DYNAMIC CONE PENETRATION TEST blows/300 mm (0 20 40 60 80 100)	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	TOPSOIL	0.00		95.99							
0.5	Red brown SILTY CLAY	0.30		95.69							
1.0											Test pit dry, March 2, 2023. Groundwater measured in standpipe at about XX metres, DATE.
	Grey brown SILTY CLAY	1.20		94.79							
1.5											
2.0										35	
2.5											
3.0											
	End of test pit in SILTY CLAY	3.30		92.69							

DEPTH SCALE: 1 to 25
LOGGED: CI

BORING METHOD: Track-Mounted Excavator
AUGER TYPE: N/A
CHECKED: SD

BOREHOLE TP03

PROJECT: Proposed Subdivision
CLIENT: 2873633 Ontario Inc
LOCATION: 819 Burritts Rapids Road
PENETRATION TEST HAMMER: N/A

PROJECT NUMBER: 210816
DATE OF BORING: 2023-03-02
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE: DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o (0 20 40 60 80 100)	DYNAMIC CONE PENETRATION TEST blows/300 mm (0 20 40 60 80 100)	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	TOPSOIL	0.00		95.11							
0.5	Red brown SILTY CLAY	0.30		94.81							
1.0	Grey brown SILTY CLAY	0.90		94.21							Test pit dry, March 2, 2023.
1.5										26	
2.0											
2.5											
3.0											
	End of test pit in SILTY CLAY	3.30		91.81							

DEPTH SCALE: 1 to 25
LOGGED: CI

BORING METHOD: Track-Mounted Excavator
AUGER TYPE: N/A
CHECKED: SD

BOREHOLE TP04

PROJECT: Proposed Subdivision
CLIENT: 2873633 Ontario Inc
LOCATION: 819 Burritts Rapids Road
PENETRATION TEST HAMMER: N/A

PROJECT NUMBER: 210816
DATE OF BORING: 2023-03-02
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE: DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	UNDIST SHEAR STRENGTH (x Cu. kPa x) / REM SHEAR STRENGTH (o Cu. kPa o) 0 20 40 60 80 100	DYNAMIC CONE PENETRATION TEST blows/300 mm 0 20 40 60 80 100	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	TOPSOIL	0.00		94.28							
0.5	Red brown SILTY CLAY	0.30		93.98							
1.0	Grey brown SILTY CLAY	1.00		93.28						37	Test pit dry, March 2, 2023.
1.5											
2.0											
2.5											
3.0											
	End of test pit in SILTY CLAY	3.30		90.98							

DEPTH SCALE: 1 to 25
LOGGED: CI

BORING METHOD: Track-Mounted Excavator
AUGER TYPE: N/A
CHECKED: SD

BOREHOLE TP05

PROJECT: Proposed Subdivision
CLIENT: 2873633 Ontario Inc
LOCATION: 819 Burritts Rapids Road
PENETRATION TEST HAMMER: N/A

PROJECT NUMBER: 210816
DATE OF BORING: 2023-03-02
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE: DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o (0 20 40 60 80 100)	DYNAMIC CONE PENETRATION TEST blows/300 mm (0 20 40 60 80 100)	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	TOPSOIL	0.00		91.63							
0.5	Red brown SILTY CLAY	0.30		91.33							
	Grey brown SILTY CLAY	0.80		90.83							
1.0											Some groundwater observed at about 3.3 metres below the existing ground surface, March 2, 2023. Groundwater measured in standpipe at about XX metres, DATE.
1.5									x		
										26	
2.0									x		
2.5											
3.0											
	End of test pit in SILTY CLAY	3.30		88.33							▽

DEPTH SCALE: 1 to 25
LOGGED: CI

BORING METHOD: Track-Mounted Excavator
AUGER TYPE: N/A
CHECKED: SD

BOREHOLE TP06

PROJECT: Proposed Subdivision
CLIENT: 2873633 Ontario Inc
LOCATION: 819 Burritts Rapids Road
PENETRATION TEST HAMMER: N/A

PROJECT NUMBER: 210816
DATE OF BORING: 2023-03-02
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE: DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o (0 20 40 60 80 100)	DYNAMIC CONE PENETRATION TEST blows/300 mm (0 20 40 60 80 100)	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	TOPSOIL	0.00		93.41							
0.5	Red brown SILTY CLAY	0.30		93.11							
	Grey brown SILTY CLAY	0.70		92.71							
1.0											Test pit dry, March 2, 2023.
1.5										28	
2.0											
2.5											
3.0											
	End of test pit in SILTY CLAY	3.30		90.11							

DEPTH SCALE: 1 to 25
LOGGED: CI

BORING METHOD: Track-Mounted Excavator
AUGER TYPE: N/A
CHECKED: SD

BOREHOLE TP07

PROJECT: Proposed Subdivision
CLIENT: 2873633 Ontario Inc
LOCATION: 819 Burritts Rapids Road
PENETRATION TEST HAMMER: N/A

PROJECT NUMBER: 210816
DATE OF BORING: 2023-03-02
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE: DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o (0 20 40 60 80 100)	DYNAMIC CONE PENETRATION TEST blows/300 mm (0 20 40 60 80 100)	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	TOPSOIL	0.00		94.34							
0.5	Red brown SILTY CLAY	0.30		94.04							
	Grey brown SILTY CLAY	0.60		93.74							
1.0											Some groundwater observed at about 3.3 metres below the existing ground surface, March 2, 2023.
1.5										38	
2.0											
2.5											
3.0											
	End of test pit in SILTY CLAY	3.30		91.04							

DEPTH SCALE: 1 to 25
LOGGED: CI

BORING METHOD: Track-Mounted Excavator
AUGER TYPE: N/A
CHECKED: SD

BOREHOLE TP08

PROJECT: Proposed Subdivision
CLIENT: 2873633 Ontario Inc
LOCATION: 819 Burritts Rapids Road
PENETRATION TEST HAMMER: N/A

PROJECT NUMBER: 210816
DATE OF BORING: 2023-03-02
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE: DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o (0 20 40 60 80 100)	DYNAMIC CONE PENETRATION TEST blows/300 mm (0 20 40 60 80 100)	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	TOPSOIL	0.00		96.02							
0.5	Red brown SILTY CLAY	0.30		95.72							
1.0											Test pit dry, March 2, 2023.
	Grey brown SILTY CLAY	1.20		94.82					x		
1.5										39	
2.0									x		
2.5											
3.0											
	End of test pit in SILTY CLAY	3.10		92.92							

DEPTH SCALE: 1 to 25
LOGGED: CI

BORING METHOD: Track-Mounted Excavator
AUGER TYPE: N/A
CHECKED: SD

TABLE I

RECORD OF HAND AUGER HOLES
SLOPE STABILITY ASSESSMENT
PROPOSED RESIDENTIAL SUBDIVISION
819 COUNTY ROAD 23
MERRICKVILLE-WOLFORD, ONTARIO

TEST PIT NUMBER	DEPTH (METRES)	DESCRIPTION
AH01	0.00 – 0.40	TOPSOIL
	0.40 – 3.00	Grey brown SILTY CLAY
	3.00	End of Auger Hole in SILTY CLAY

Auger hole DRY At time of installation on March 28, 2023
Water was measured at an elevation of about 0.58m below ground surface on February 20, 2024.

AH02	0.00 – 0.30	TOPSOIL
	0.30 – 3.00	Red Brown to Grey brown SILTY CLAY
	3.00	End of test pit in SILTY CLAY

Auger hole DRY At time of installation on March 28, 2023
Water was measured at an elevation of about 0.67m below ground surface on February 20, 2024.

AH05	0.00 – 0.30	TOPSOIL
	0.30 – 3.00	Red brown to Grey brown SILTY CLAY
	3.00	End of auger hole in SILTY CLAY

Auger hole DRY At time of installation on March 28, 2023
Water was measured at an elevation of about 1.70m below ground surface on February 20, 2024.
.

APPENDIX B – WELL LOGS

Ontario — Ministry of the Environment, Conservation and Parks

Tag#:A342163

(Print Below) A342163

Well Record

Regulation 903 Ontario Water Resources Act

Measurements recorded in: ☐ Metric ☒ Imperial

Page ____ of ____

Well Owner's Information

First Name	Last Name/Organization	E-mail Address	☐ Well Constructed by Well Owner
	2873633 Ontario Inc		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
Unit 1- 210 Prescott Street, Box 189	Kemptville	ON	K0G 1J0	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
819 County Road 23	Wolford	P/L 1A	B

County/District/Municipality	City/Town/Village	Province	Postal Code
Leeds Grenville	Merrickville	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 8 3	18	435583	4979206	15R-6660 Part 1-7 / 15R-9295 Part 1	

Overburden and Bedrock Materials/Abandonment Sealing Record (see instructions on the back of this form)

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
	Clay	& Boulders		0'	37'
Black	Limestone			37'	98'
Black	Limestone			98'	102'
Black	Limestone			102'	104'
Black	Limestone			104'	110'

* Test Well # 1 of 3

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
~~43~~	~~33~~	~~Neat cement~~	~~12.48~~
~~33~~	~~0~~	~~Bentonite slurry~~	~~12.6~~
43	33	Neat Cement Slurry	12.48
33	0	Bentonite Slurry	12.6

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☒ Air percussion ☐ Other, specify ____

Well Use

☐ Public ☒ Domestic ☐ Livestock ☐ Irrigation ☐ Industrial ☐ Other, specify ____ ☐ Commercial ☐ Municipal ☐ Test Hole ☐ Cooling & Air Conditioning ☐ Not used ☐ Dewatering ☐ Monitoring

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
6 1/4"	Steel	.188"	+2'	43'
6 1/8"	Open Hole		43'	110'

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Status of Well

☒ Water Supply ☐ Replacement Well ☐ Test Hole ☐ Recharge Well ☐ Dewatering Well ☐ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☐ Abandoned, other, specify ____ ☐ Other, specify ____

Water Details

Water found at Depth (m/ft)	Gas	Kind of Water: Fresh	Untested	Other, specify
98	☐	☒	☐	
102	☐	☐	☒	
104	☐	☐	☒	

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0'	43'	9 3/4"
43'	110'	6 1/8"

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify **Not tested**

If pumping discontinued, give reason: X

Pump intake set at (m/ft): 100

Pumping rate (l/min / GPM): 20

Duration of pumping: ____ hrs + 1 hr ____ min

Final water level end of pumping (m/ft): 14'8"

If flowing give rate (l/min/GPM): X

Recommended pump depth (m/ft): 80'

Recommended pump rate (l/min/GPM): 10

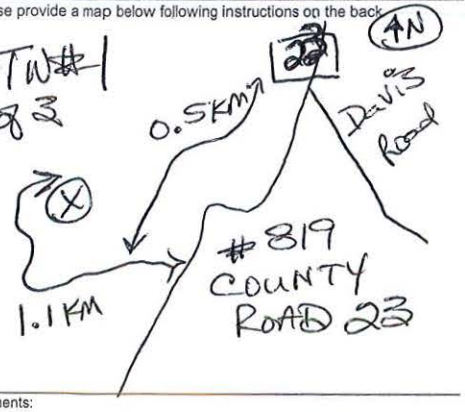
Well production (l/min/GPM): 20

Disinfected? ☒ Yes ☐ No

Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	14'2"		14'8"
1	14.5	1	14.2
2	14.5	2	14.2
3	14.5	3	14.2
4	14.5	4	14.2
5	14.6	5	14.2
10	14.6	10	14.2
15	14.6	15	14.2
20	14.7	20	14.2
25	14.7	25	14.2
30	14.7	30	14.2
40	14.8	40	14.2
50	14.8"	50	14.2"
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments: 1/2HR-10GPM Sand @ 80 Ft

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Air Rock Drilling Co. Ltd.	7881

Business Address (Street Number/Name)	Municipality	Province	Postal Code	Business E-mail Address
6659 Franktown Road	Richmond	ON	K0A 2Z0	air-rock@sympatico.ca

Business Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)	Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
6135382170	Hanna, Jeremy	T3632		2022 03 31

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☒ Yes ☐ No	2022 03 03	2022 03 28

Ministry Use Only

Audit No. Z379214

Received

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Ministry's Copy

Ontario — Ministry of the Environment, Conservation and Parks

Well Tag#: A342162 (nt Below)

A342162

Well Record

Regulation 903 Ontario Water Resources Act

Measurements recorded in: ☐ Metric ☒ Imperial

Page ____ of ____

Well Owner's Information

First Name	Last Name/Organization	E-mail Address	☐ Well Constructed by Well Owner
	2873633 Ontario Inc		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
Unit 1 210 Prescott Street Box 189	Kemptville	ON	K0G 1J0	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
819 County Road 23	Wolford	P/L 1A	B

County/District/Municipality	City/Town/Village	Province	Postal Code
Leeds Grenville	Merrickville	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 8 3	18	435514	4979446	15R-6660 Part 1-7 / 15R-9295 Part 1	

Overburden and Bedrock Materials/Abandonment Sealing Record (see instructions on the back of this form)

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
	(Hard) Clay	* Boulders		0'	34'
Grey & Black	Limestone			34'	134'
Grey & Black	Limestone			134'	140'

* Test well #2 of 2

Annular Space

Depth Set at (m/ft) From	Depth Set at (m/ft) To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
40'	30'	Neat cement	12.48
30'	0'	Bentonite slurry	8.4

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☒ Air percussion
☐ Other, specify SURGED

Well Use

☐ Public ☐ Commercial ☐ Not used
☒ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, specify

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
6 1/4"	Steel	.188"	+2'	40'
6 1/8"	Open Hole		40'	140'

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Status of Well

☒ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, specify
☐ Other, specify

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, specify Not tested

If pumping discontinued, give reason: X

Pump intake set at (m/ft): 120

Pumping rate (l/min/GPM): 15

Duration of pumping: 1 hrs + 0 min

Final water level end of pumping (m/ft): 36.3'

If flowing give rate (l/min/GPM): X

Recommended pump depth (m/ft): 100'

Recommended pump rate (l/min/GPM): 10

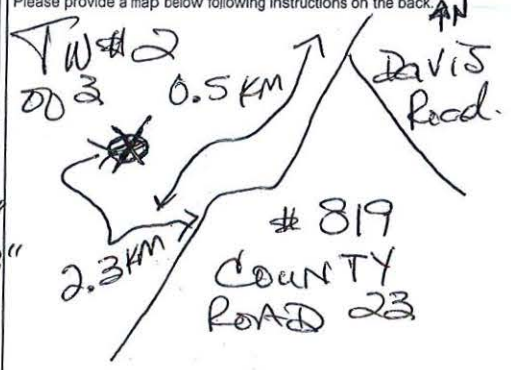
Well production (l/min/GPM): 15

Disinfected? ☒ Yes ☐ No

Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	63"		36.3"
1	15	1	24.8
2	20.7	2	18.5
3	24.7	3	15.1
4	27.6	4	12.5
5	29.6	5	10.9
10	34.1	10	7.2
15	35.5	15	6.3
20	35.9	20	6.3
25	36.1	25	6.3
30	36.1	30	6.3
40	36.2	40	6.3
50	36.2	50	6.3
60	36.3"	60	6.3"

Map of Well Location

Please provide a map below following instructions on the back.



Water Details

Water found at Depth (m/ft)	Kind of Water	Gas	Other, specify
134 (m/ft)	☐ Fresh ☒ Untested	☐ Gas	
(m/ft)	☐ Fresh ☐ Untested	☐ Gas	
(m/ft)	☐ Fresh ☐ Untested	☐ Gas	

Hole Diameter

Depth (m/ft) From	Depth (m/ft) To	Diameter (cm/in)
0'	40'	9 3/4"
40'	140'	6 1/8"

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Air Rock Drilling Co. Ltd.	7681

Business Address (Street Number/Name)	Municipality	Province	Postal Code	Business E-mail Address
6859 Franktown Road	Richmond	ON	K0A 2Z0	air-rock@sympatico.ca

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)	Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted (Y Y Y Y M M D D)
6138382170	Hanna, Jeremy	13632		2022 03 31

Comments: 1/2HP - 10GPM Set @ 100 FT

Well owner's information package delivered	Date Package Delivered (Y Y Y Y M M D D)
☒ Yes ☐ No	2022 03 01

Ministry Use Only

Audit No. Z379215

Received

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Ministry's Copy

Ontario — Ministry of the Environment, Conservation and Parks

Measurements recorded in: ☐ Metric ☒ Imperial

We Tag#: A342161 (Print Below)

A342161

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name/Organization	E-mail Address	☐ Well Constructed by Well Owner
	2873633 Ontario Inc		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
Unit 1 210 Prescott Street, Box 189	Kemptville	ON	K0G 1J0	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
819 County Road 23	Wolford	P/L 1A	B

County/District/Municipality	City/Town/Village	Province	Postal Code
Leeds Grenville	Merrickville	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 8 3	18	435868	4978811	15R-6660 Part 1-7 / 15R-9295 Part 1	

Overburden and Bedrock Materials/Abandonment Sealing Record (see instructions on the back of this form)

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
	Clay	& Boulders		0'	36'
Grey & Black	Limestone			36'	75'
Grey & Black	Limestone			75'	82'

* Test well 3 of 3

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
42'	32'	Neat cement	10.92
32'	0'	Bentonite slurry	8.4

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☒ Air percussion
☐ Other, specify

Well Use

☐ Public ☐ Commercial ☐ Not used
☒ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, specify

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
6 1/4"	Steel	.188"	+2'	42'
6 1/8"	Open Hole		42'	82'

Status of Well

☒ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, specify
☐ Other, specify

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Water Details

Water found at Depth (m/ft)	Gas	Kind of Water	Other, specify
75	☐	☐ Fresh ☒ Untested	
	☐	☐ Fresh ☐ Untested	
	☐	☐ Fresh ☐ Untested	

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0'	42'	9 3/4"
42'	82'	6 1/8"

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, specify **Not tested**

If pumping discontinued, give reason: X

Pump intake set at (m/ft): 70

Pumping rate (l/min / GPM): 10

Duration of pumping: 1 hrs + 0 min

Final water level end of pumping (m/ft): 24.3'

If flowing give rate (l/min/GPM): X

Recommended pump depth (m/ft): 70'

Recommended pump rate (l/min / GPM): 10

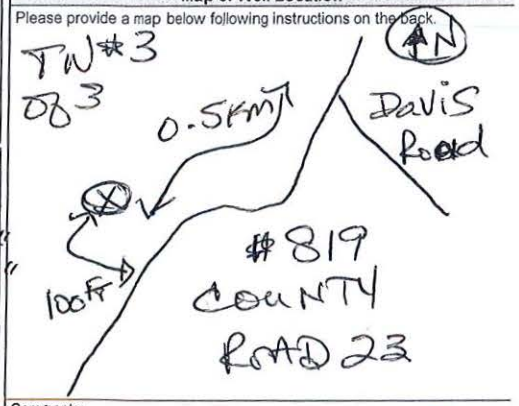
Well production (l/min / GPM): 10

Disinfected? ☒ Yes ☐ No

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	22'			24.3'
1	23.8		1	23.5
2	23.8		2	23
3	23.9		3	22.8
4	23.9		4	22.6
5	24		5	22.5
10	24.1		10	22.1
15	24.1		15	22
20	24.2		20	22
25	24.2		25	22
30	24.2		30	22
40	24.2		40	22
50	24.3		50	22
60	24.3'		60	22'

Map of Well Location

Please provide a map below following instructions on the back.



Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Air Rock Drilling Co. Ltd.	7681

Business Address (Street Number/Name)	Municipality
6650 Franktown Road	Richmond

Province	Postal Code	Business E-mail Address
ON	K0A 2Z0	air-rock@sympatico.ca

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
6138382170	Hanna, Jeremy

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted (Y Y Y Y M M D D)
13652		2022 03 31

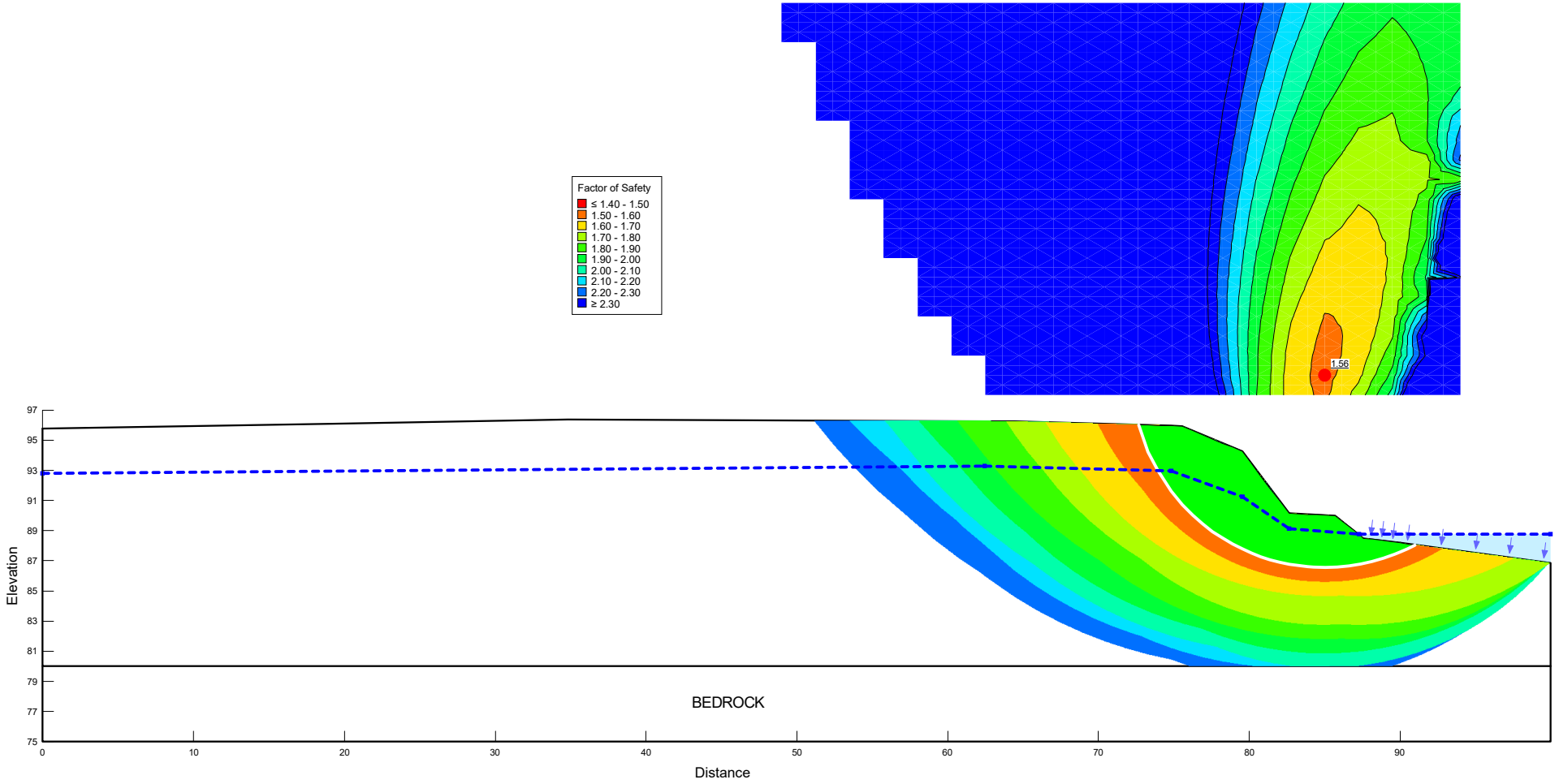
Comments: 1/2HP 10GPM Set@70 ft

Well owner's information package delivered	Date Package Delivered (Y Y Y Y M M D D)	Ministry Use Only
☒ Yes ☐ No	2022 03 03	Audit No. Z379216

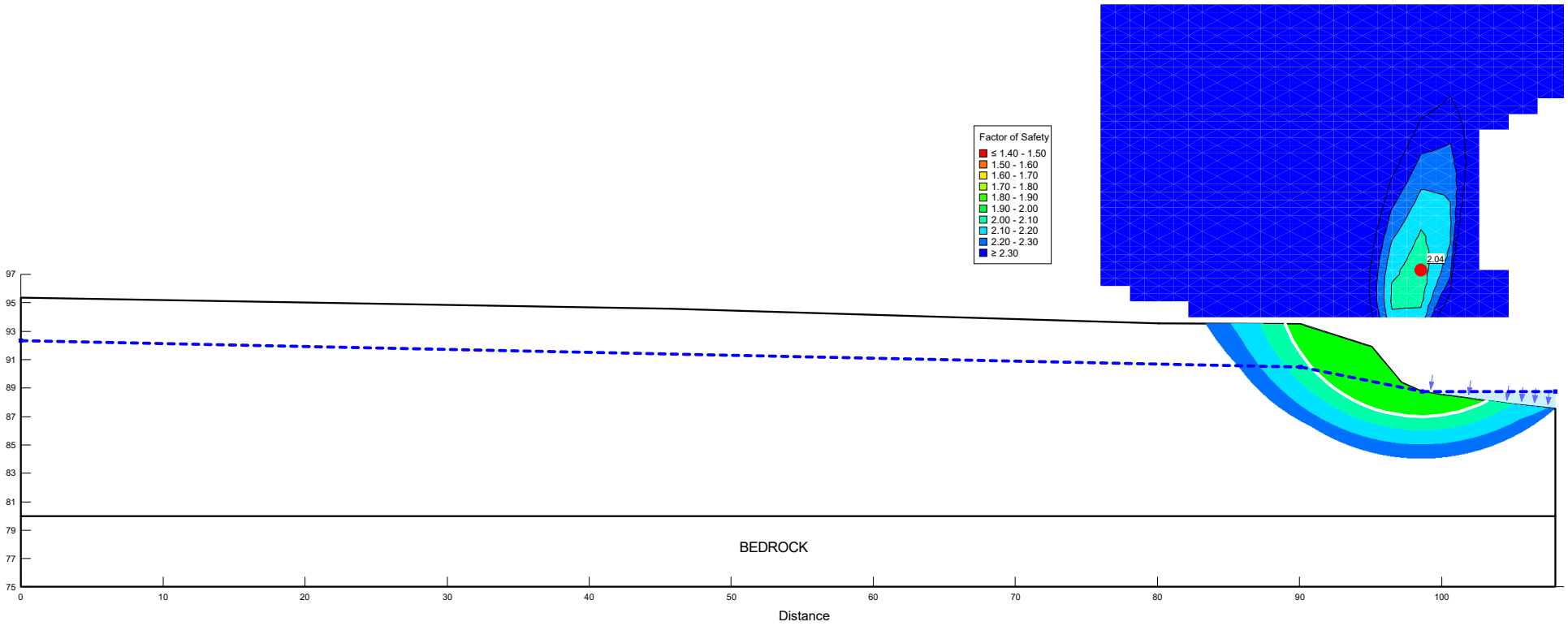
Received

APPENDIX C – SLOPE STABILITY ANALYSIS RESULTS – IN-SITU GROUND WATER TABLE

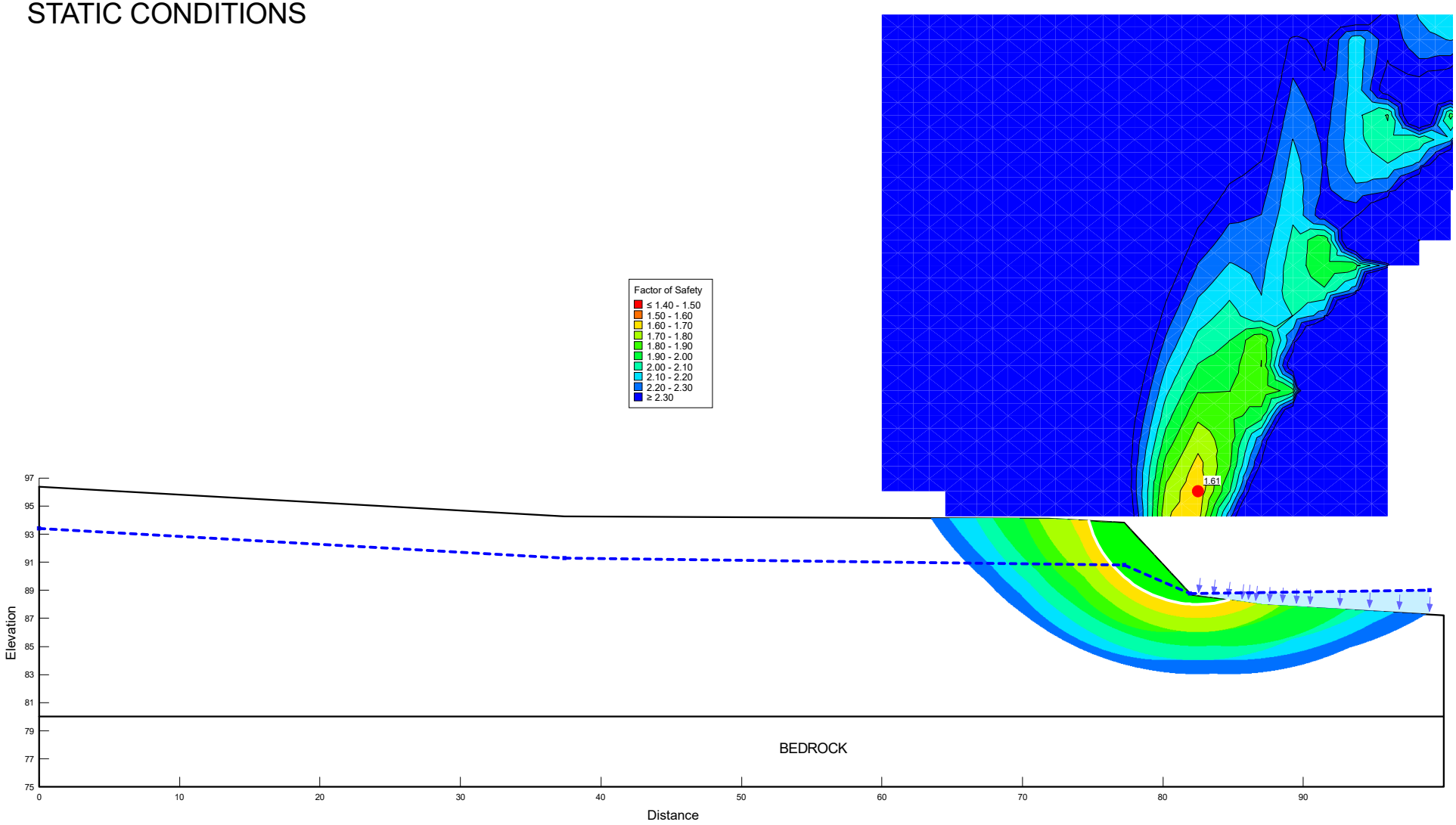
SLOPE SECTION 1
STATIC CONDITIONS



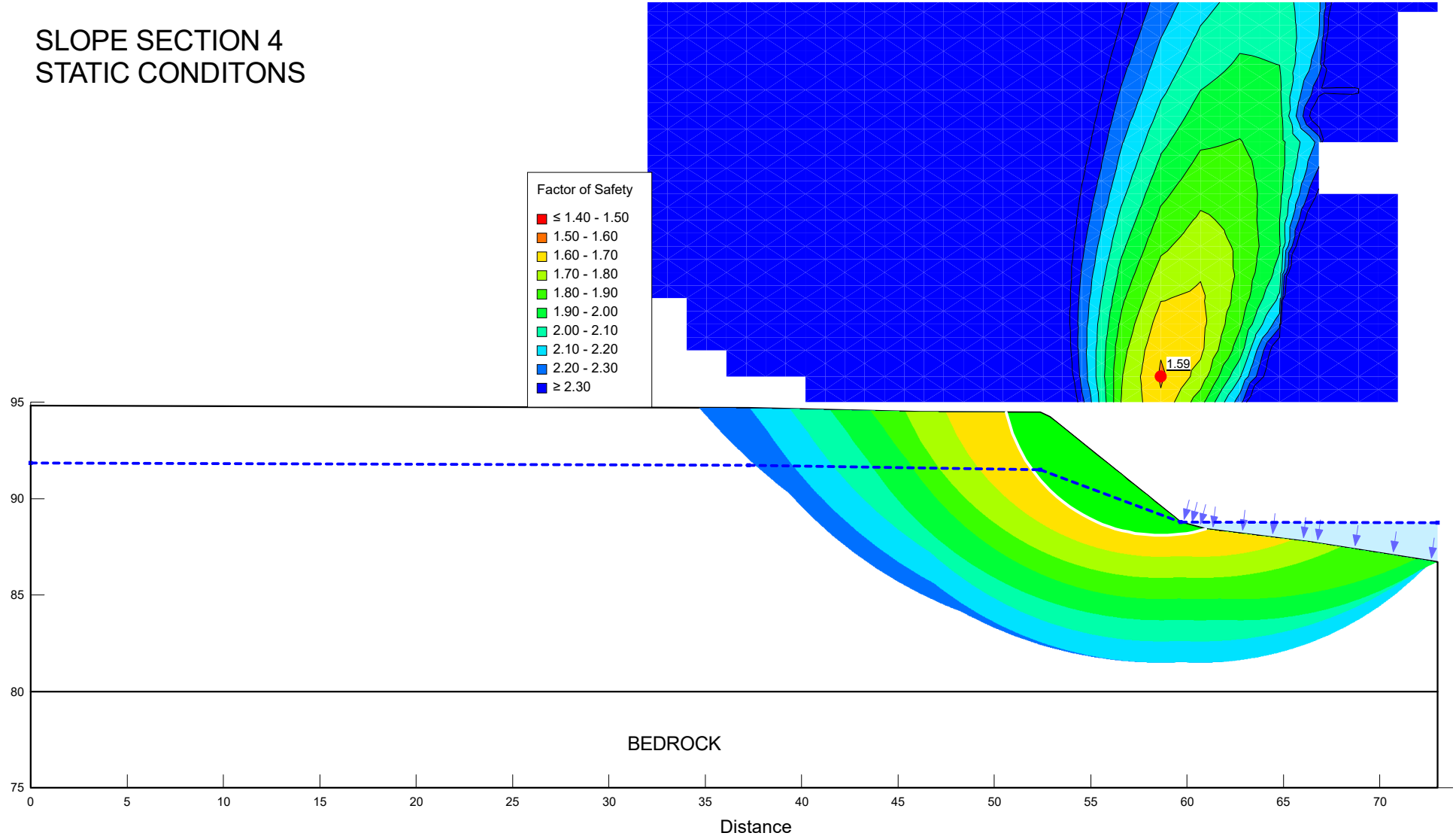
SLOPE SECTION 2
STATIC CONDITIONS



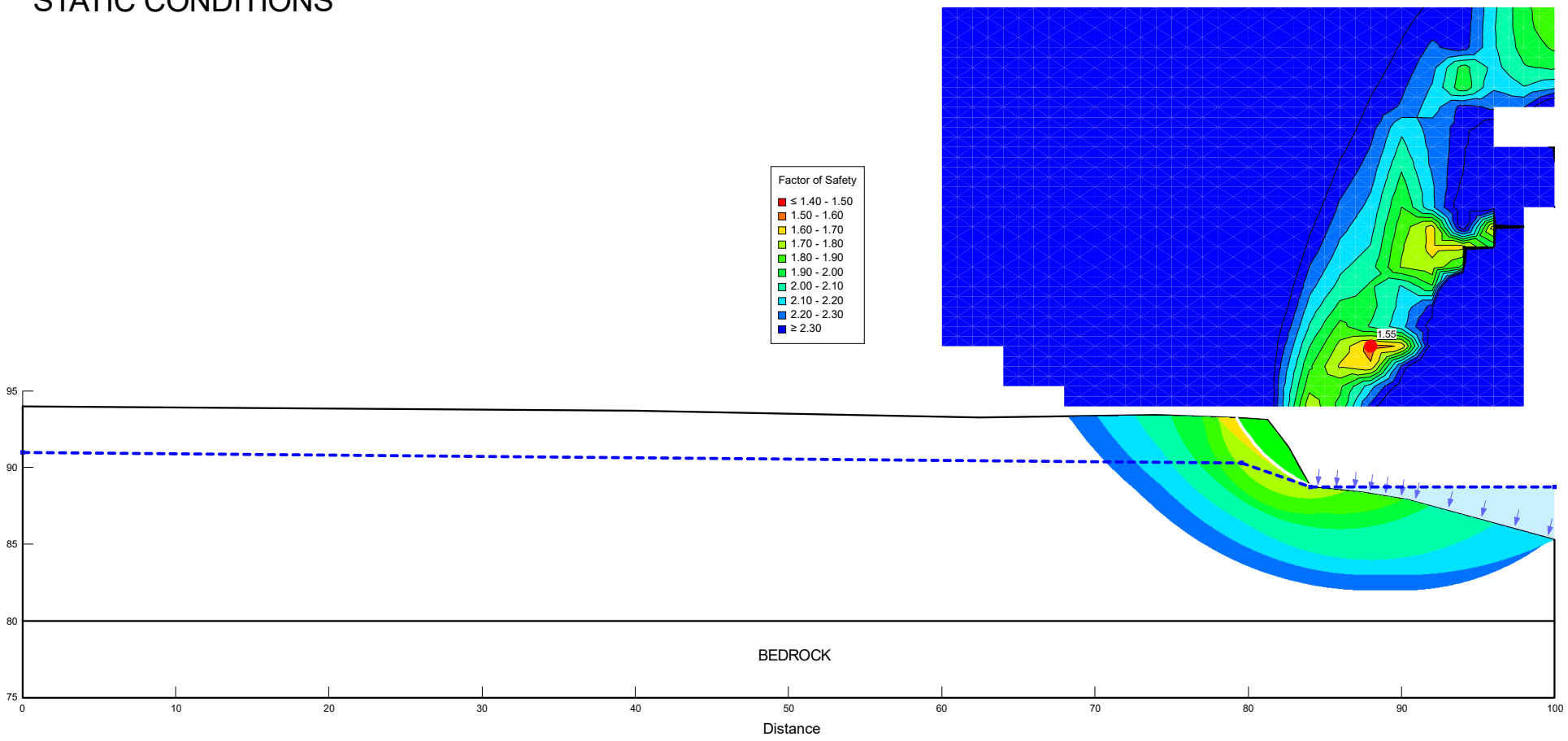
SLOPE SECTION 3
STATIC CONDITIONS



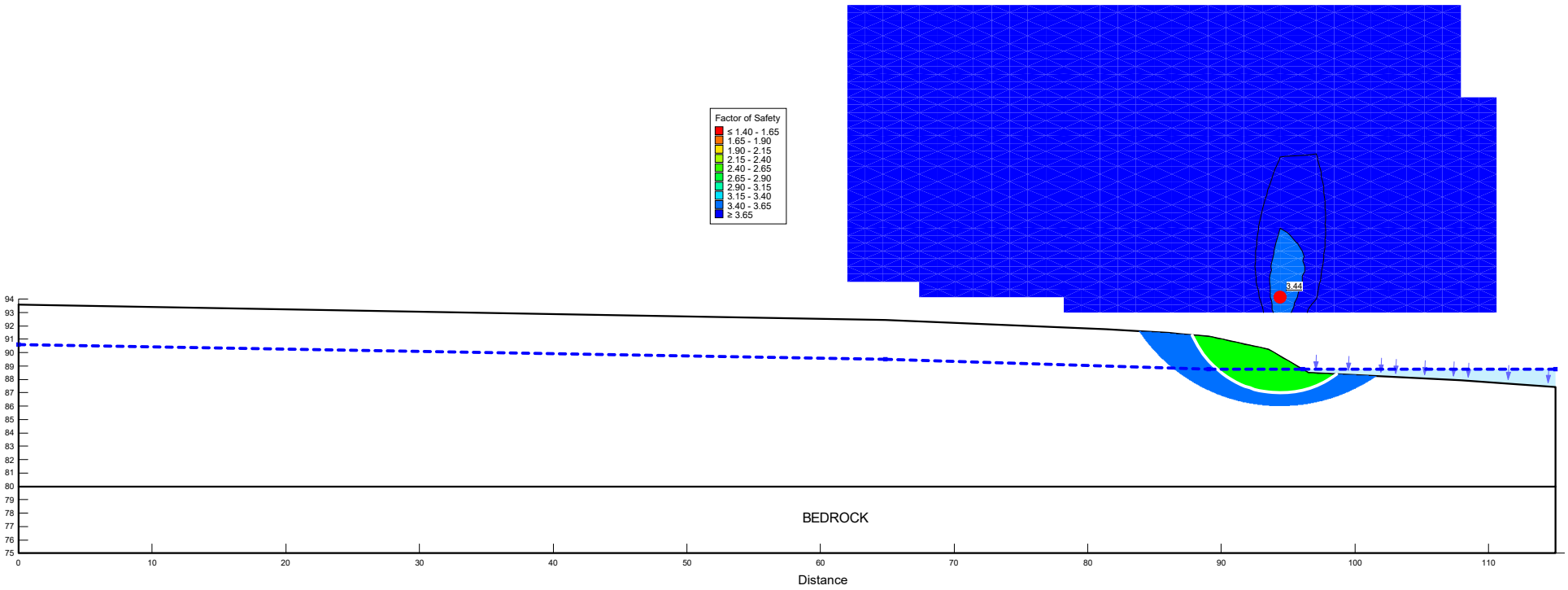
SLOPE SECTION 4
STATIC CONDITONS



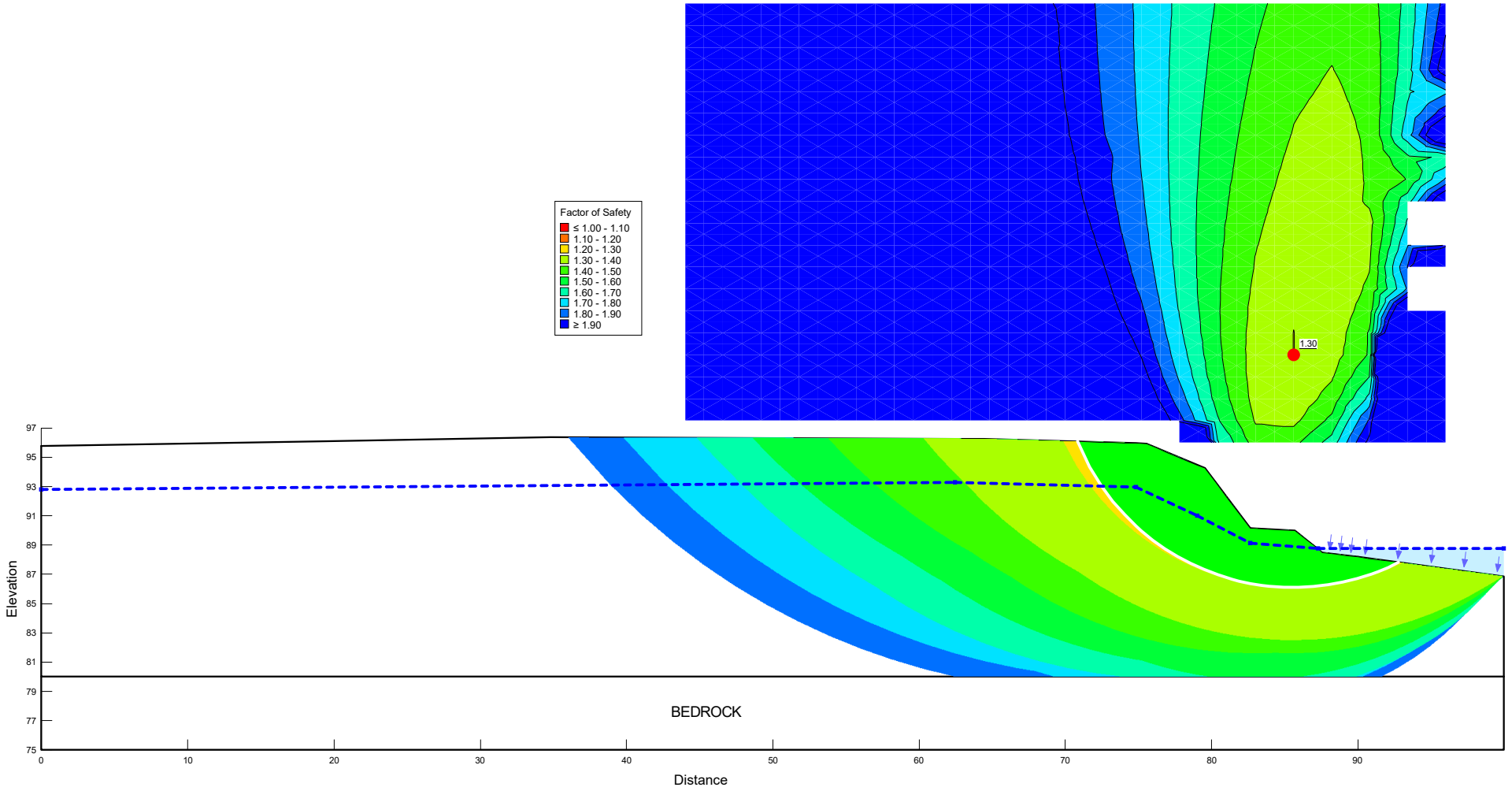
SLOPE SECTION 5
STATIC CONDITIONS



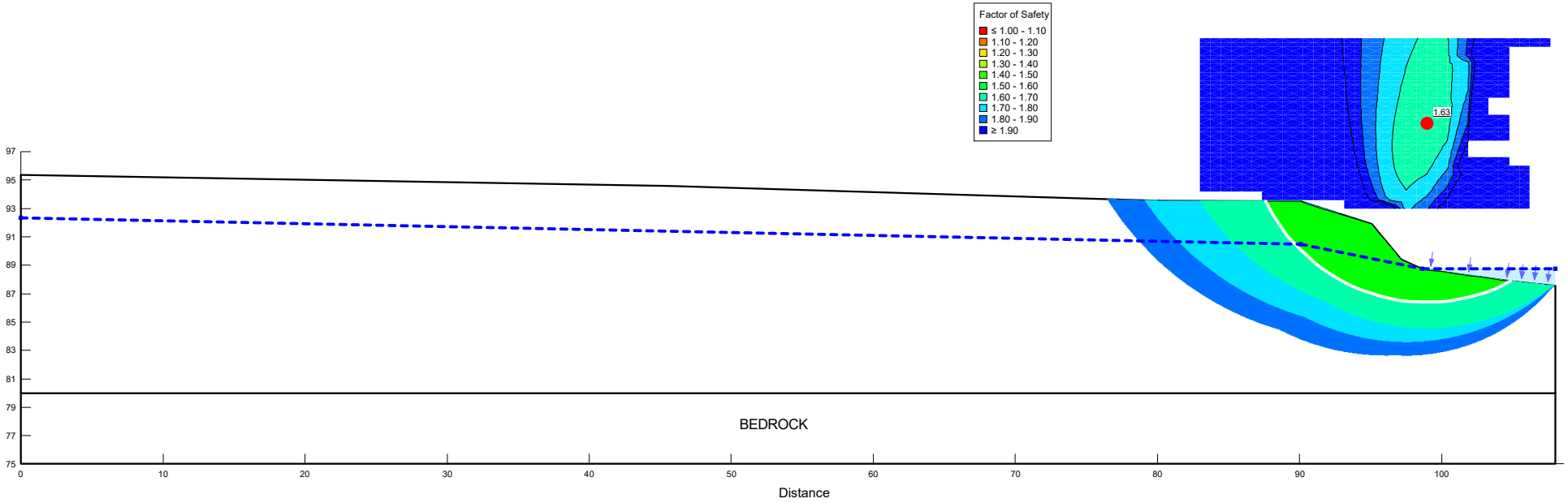
SLOPE SECTION 6
STATIC CONDITONS



SLOPE SECTION 1
SEISMIC CONDITIONS



SLOPE SECTION 2
SEISMIC CONDITIONS



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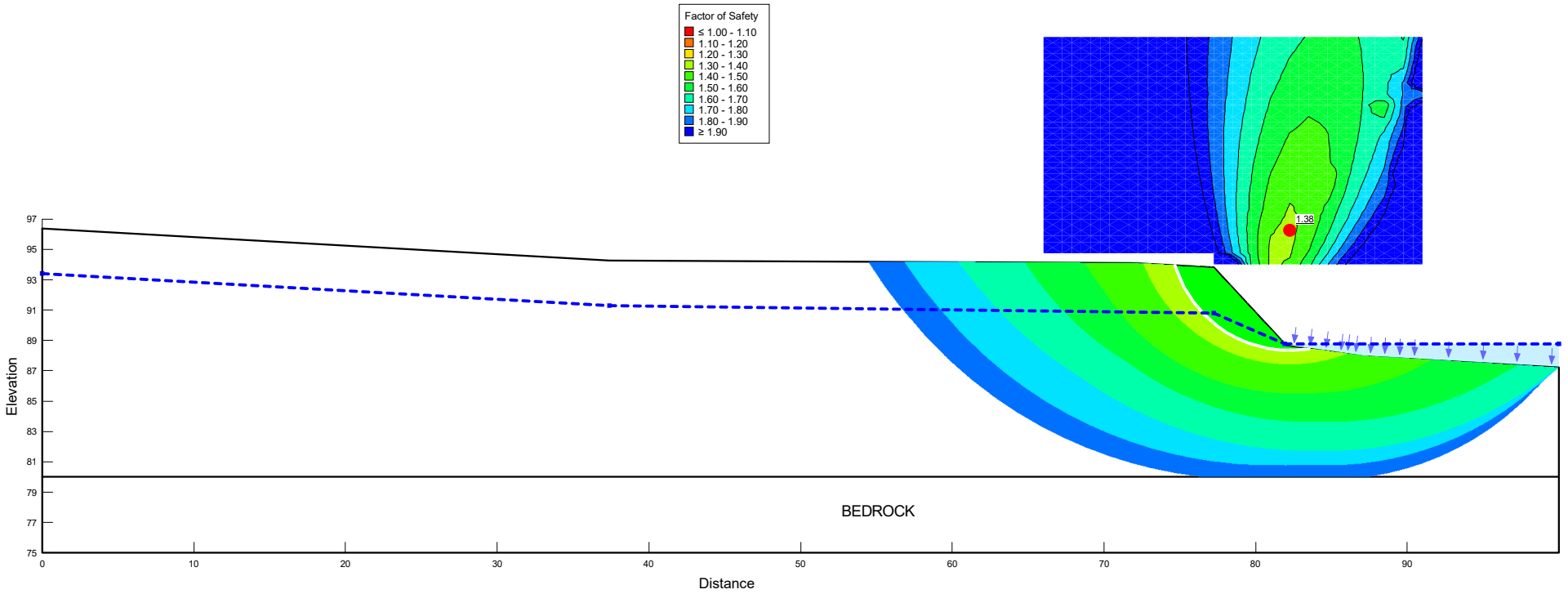
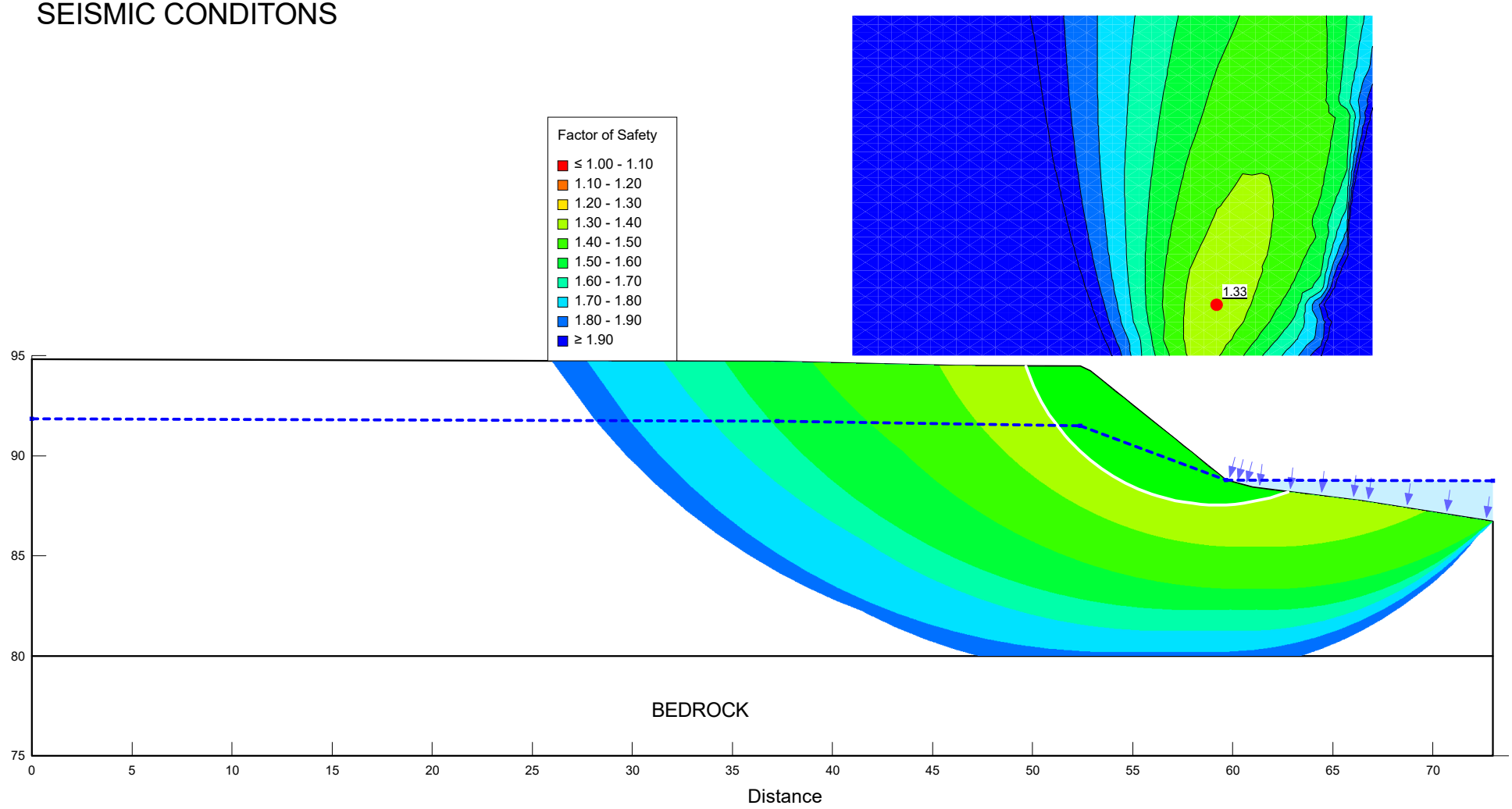
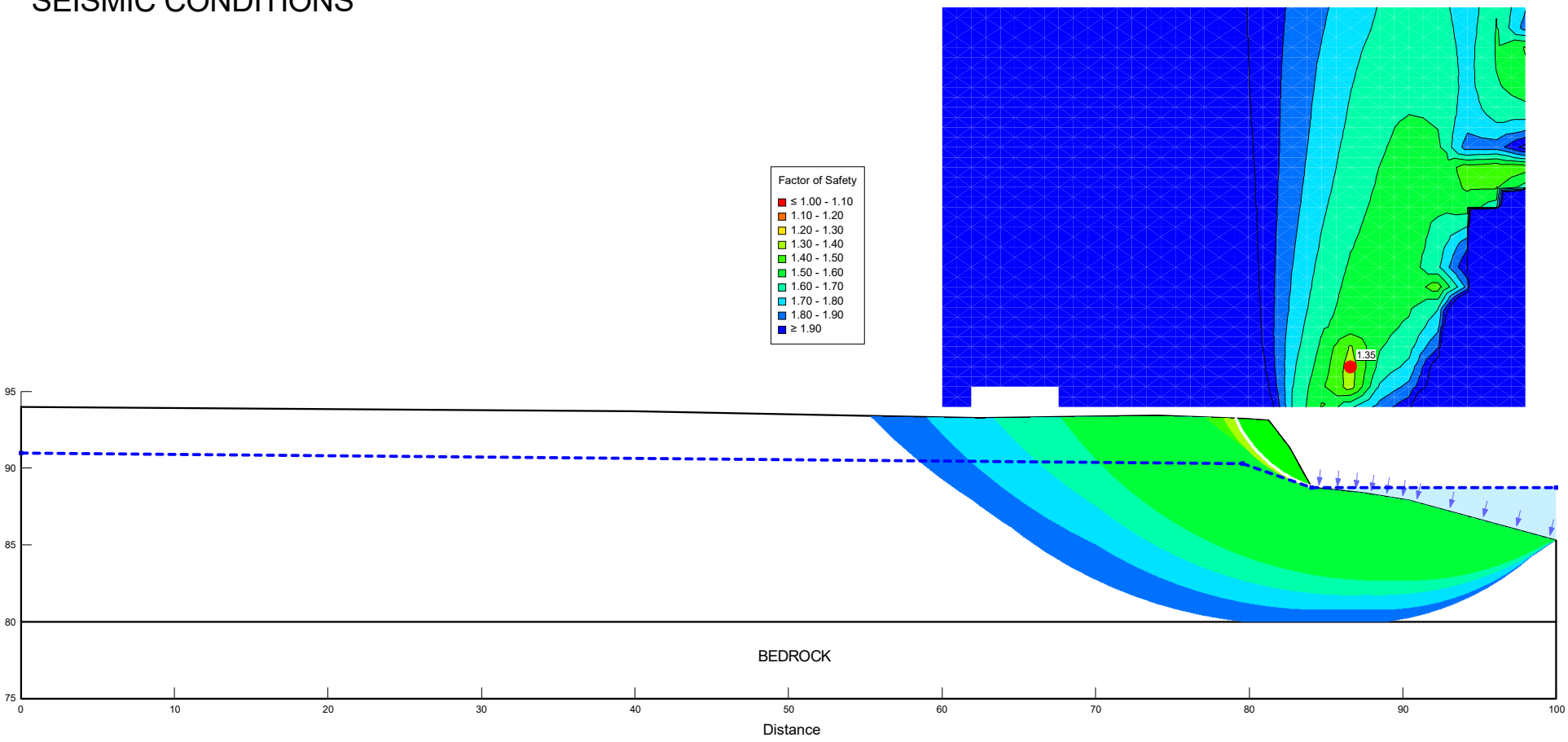
SEISMIC CONDITIONS



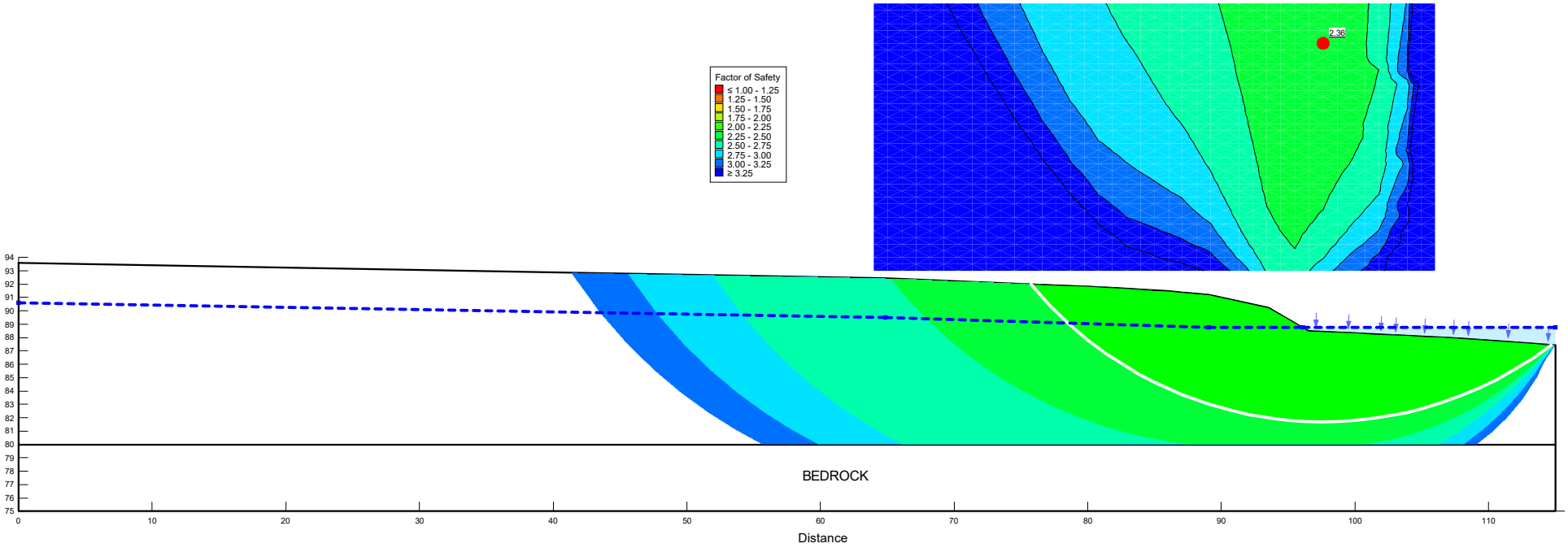
SLOPE SECTION 4
SEISMIC CONDITONS



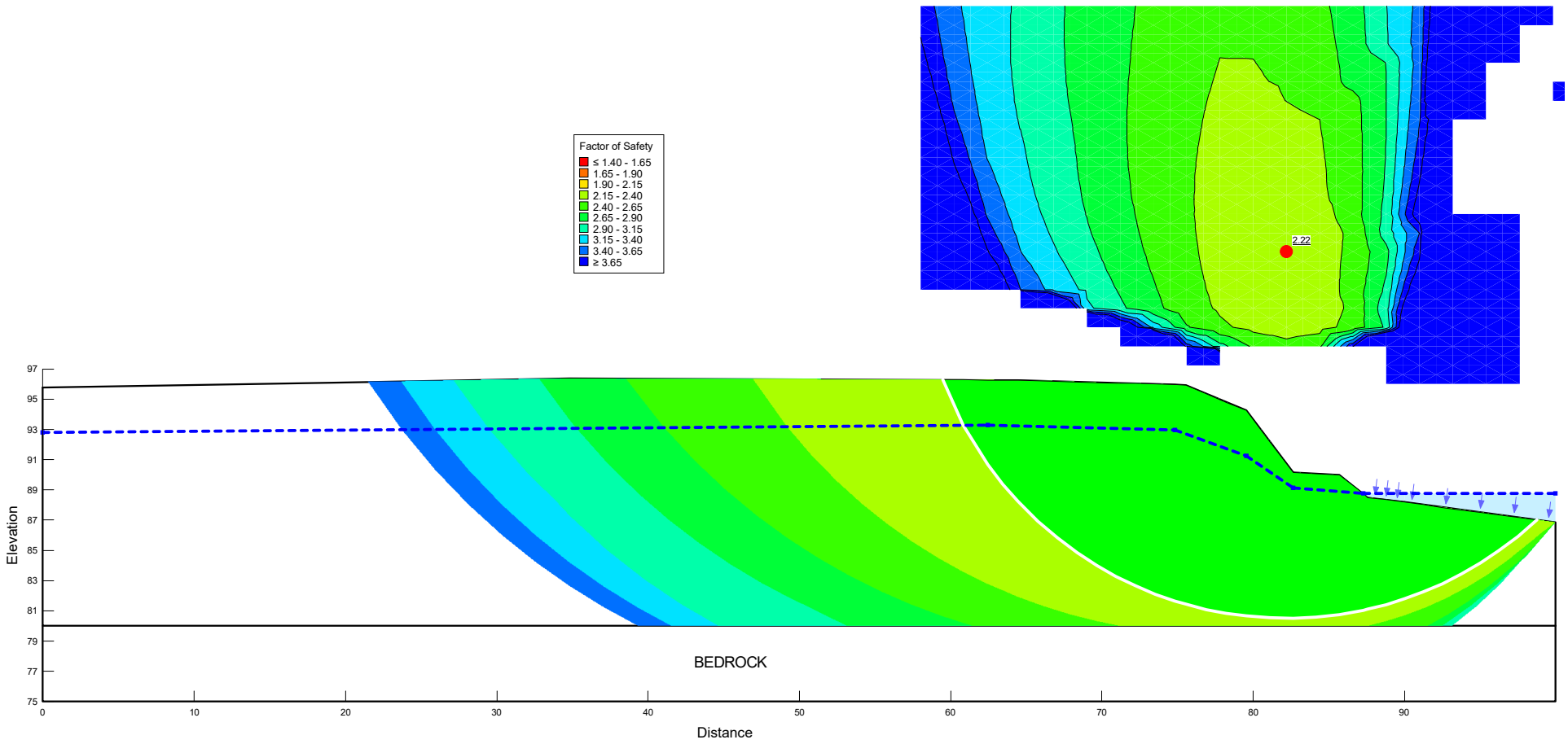
SLOPE SECTION 5
SEISMIC CONDITIONS



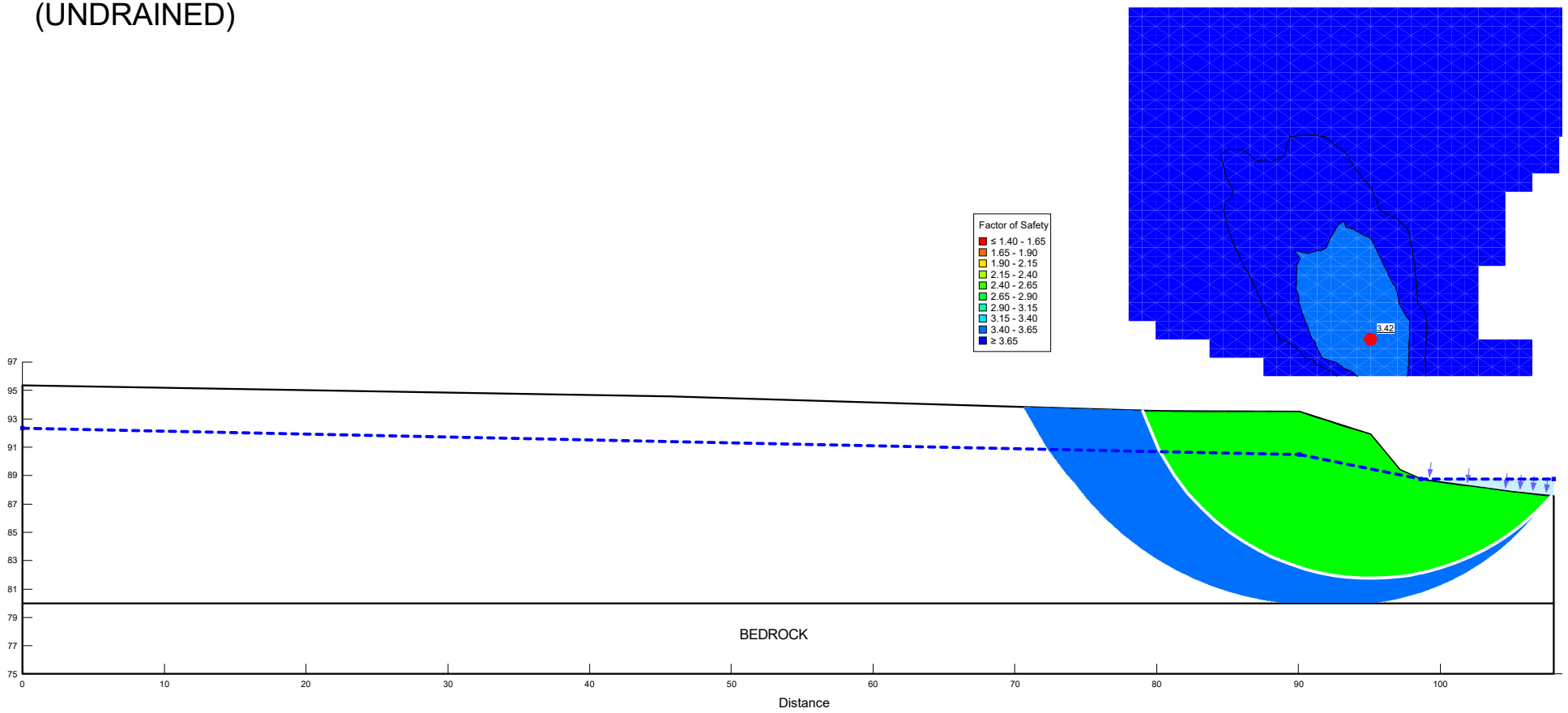
SLOPE SECTION 6
SEISMIC CONDITONS



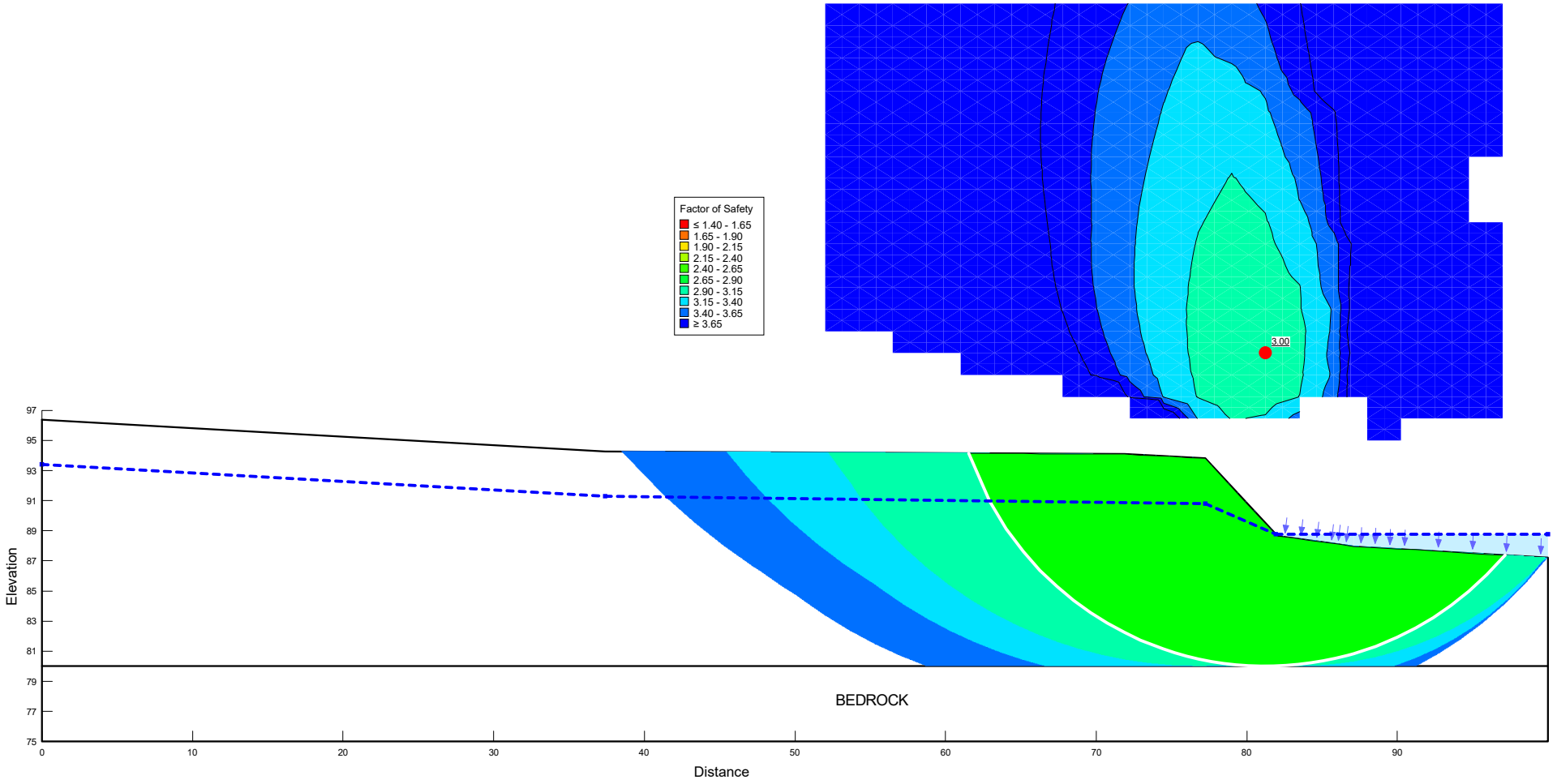
SLOPE SECTION 1
STATIC CONDITIONS
(UNDRAINED)



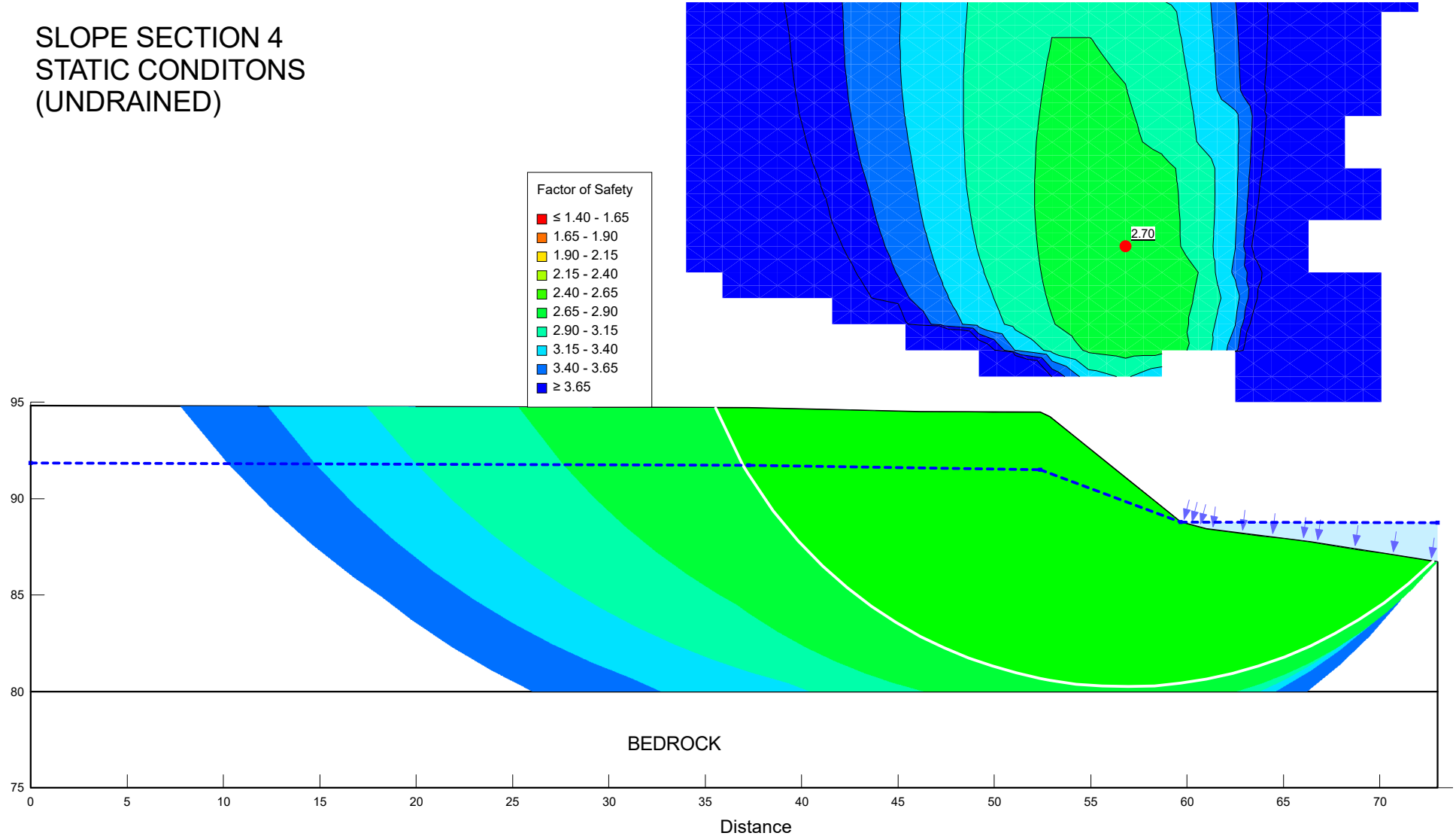
SLOPE SECTION 2
STATIC CONDITIONS
(UNDRAINED)



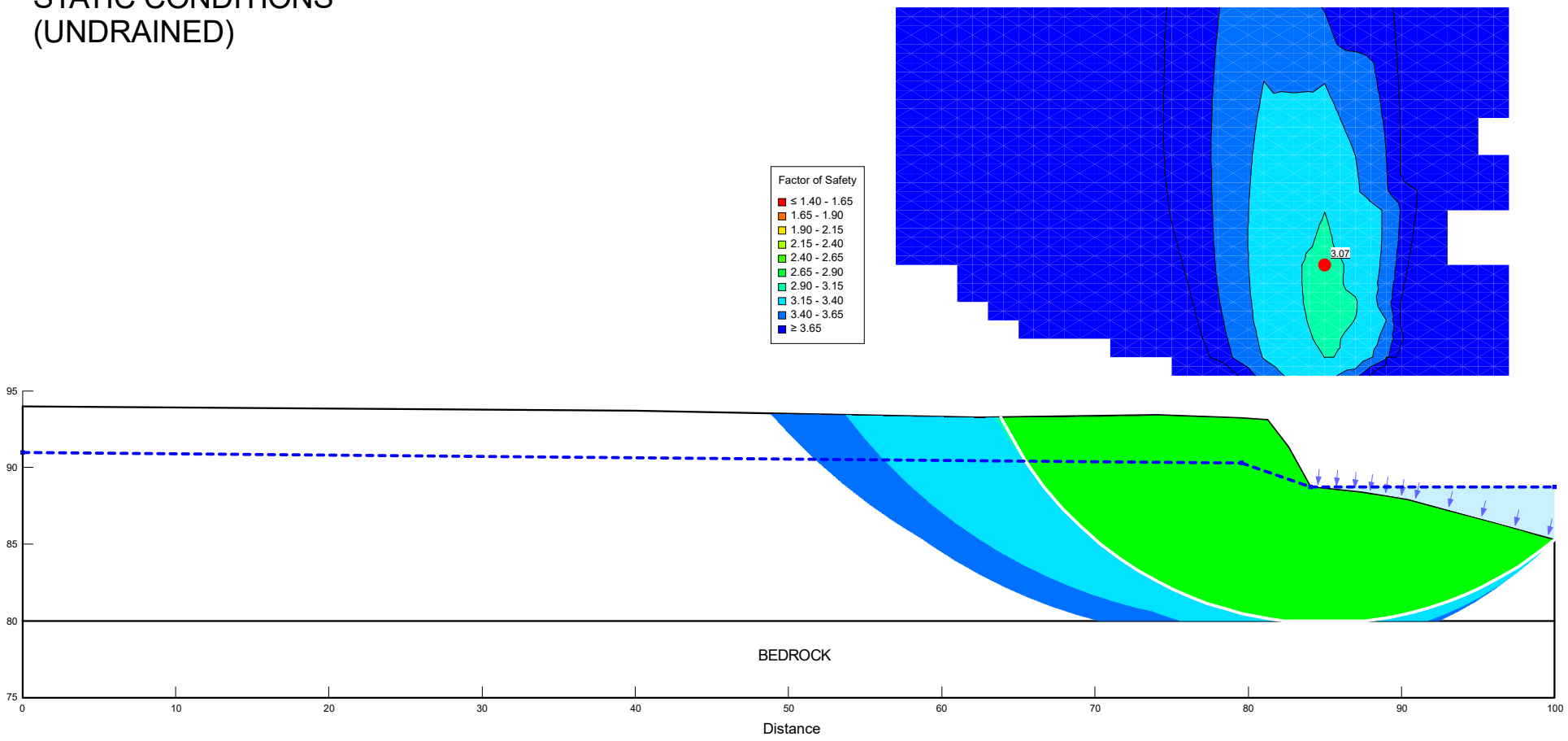
SLOPE SECTION 3
STATIC CONDITIONS
(UNDRAINED)



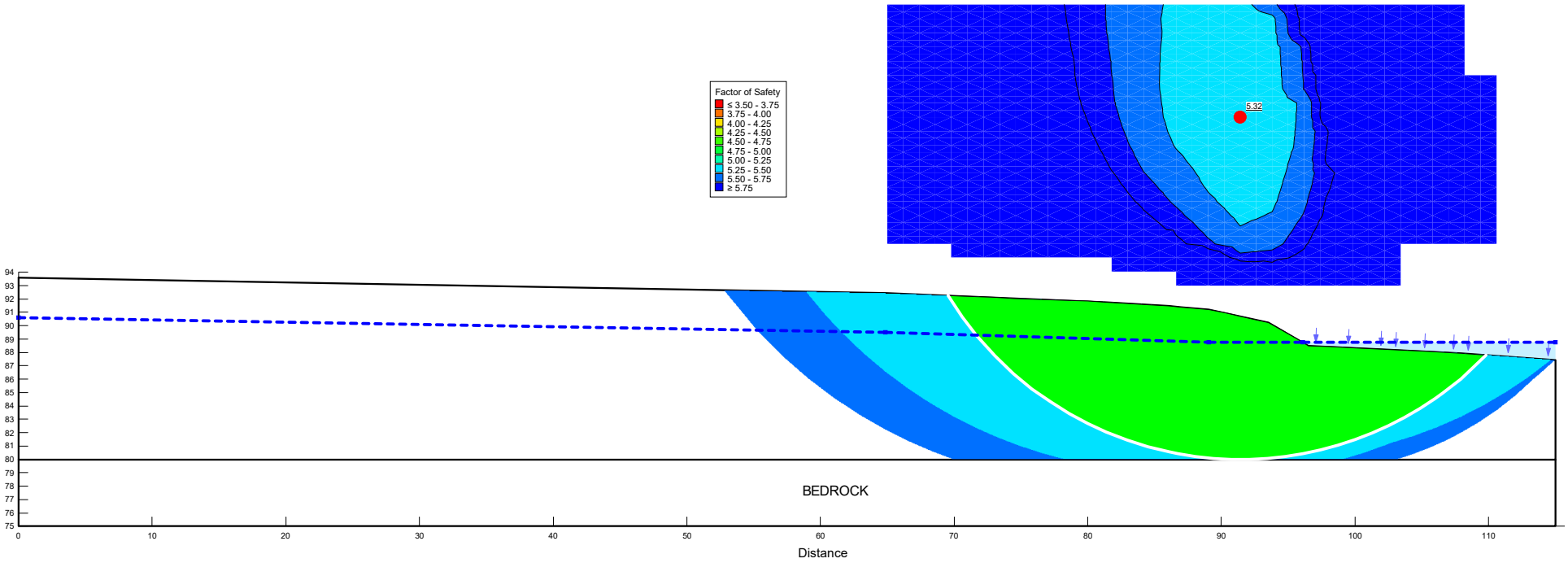
SLOPE SECTION 4
STATIC CONDITONS
(UNDRAINED)



SLOPE SECTION 5
STATIC CONDITIONS
(UNDRAINED)

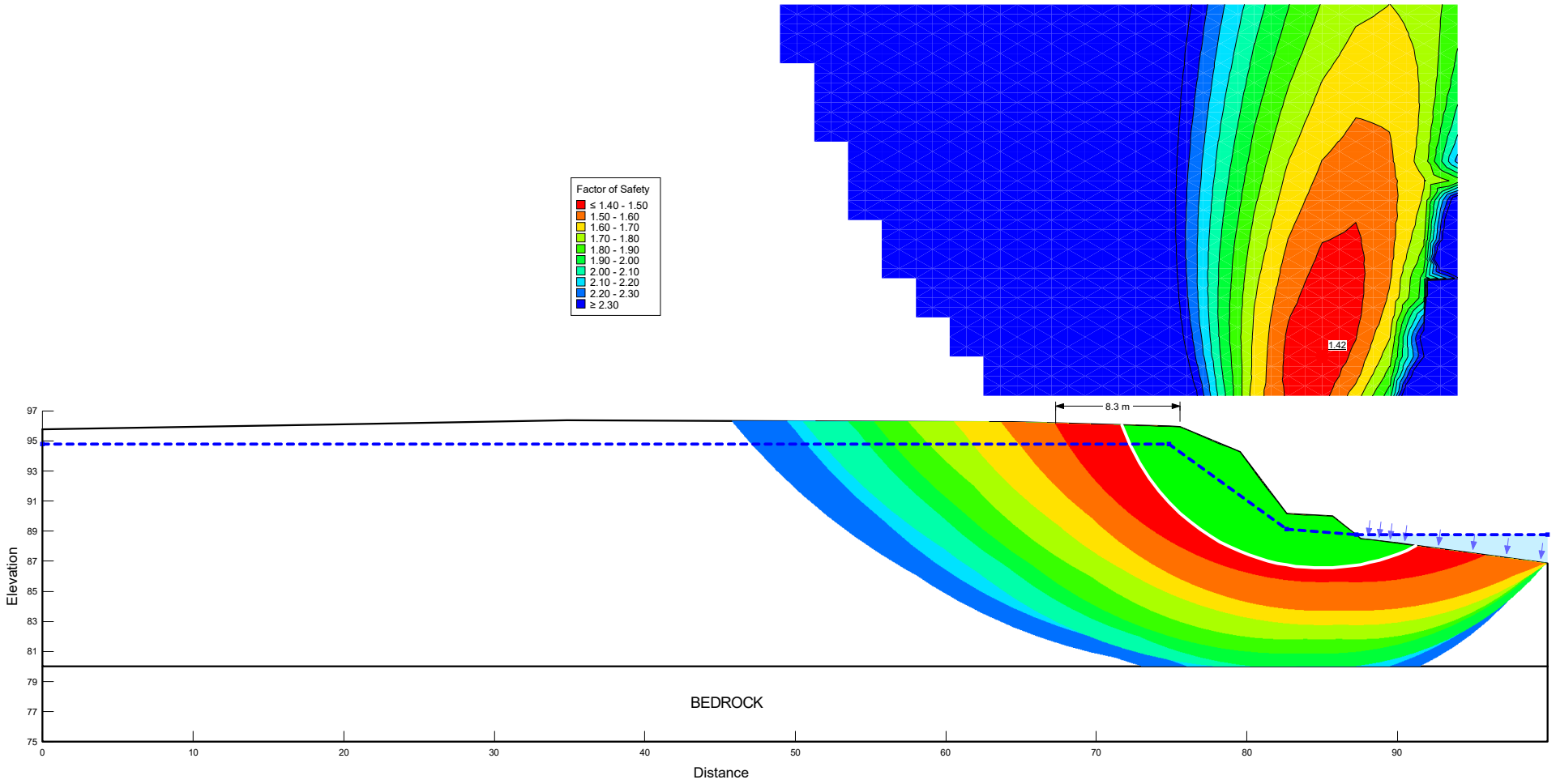


SLOPE SECTION 6
STATIC CONDITONS
(UNDRAINED)

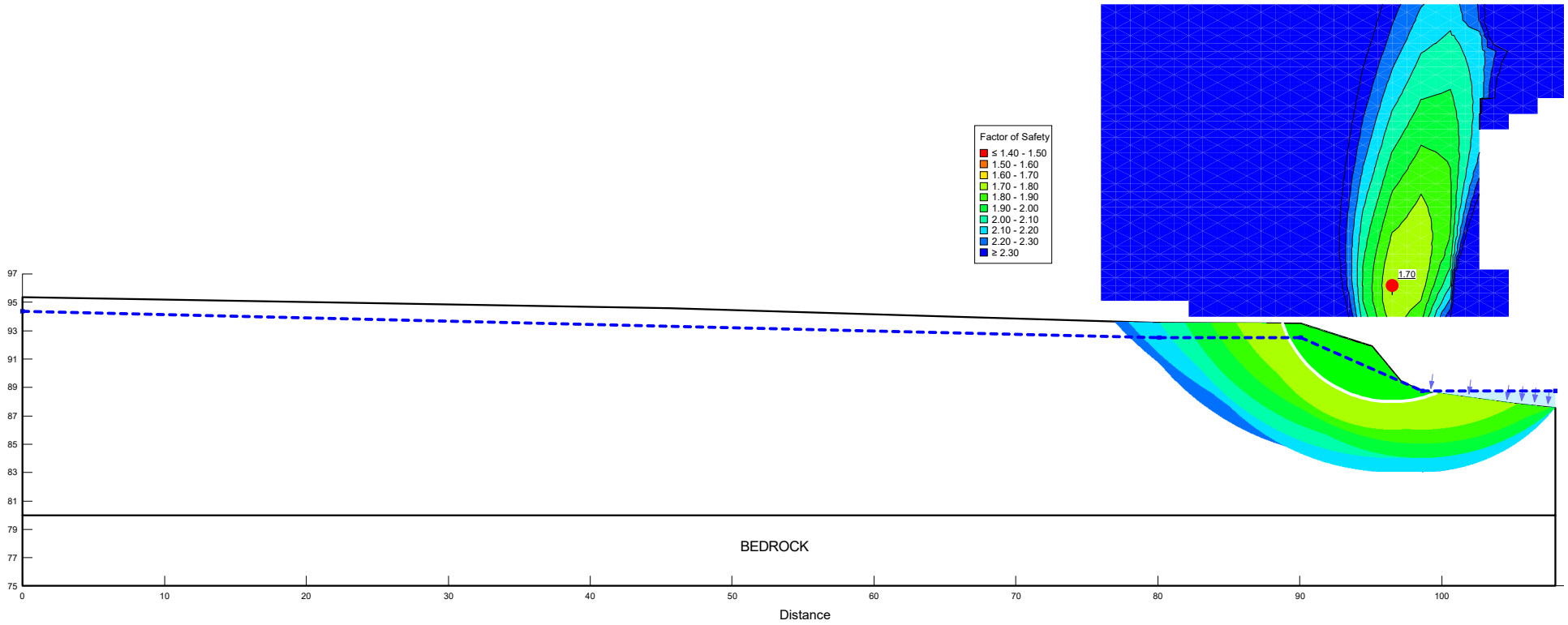


APPENDIX D – SLOPE STABILITY ANALYSIS RESULTS – ELEVATED GROUND WATER TABLE

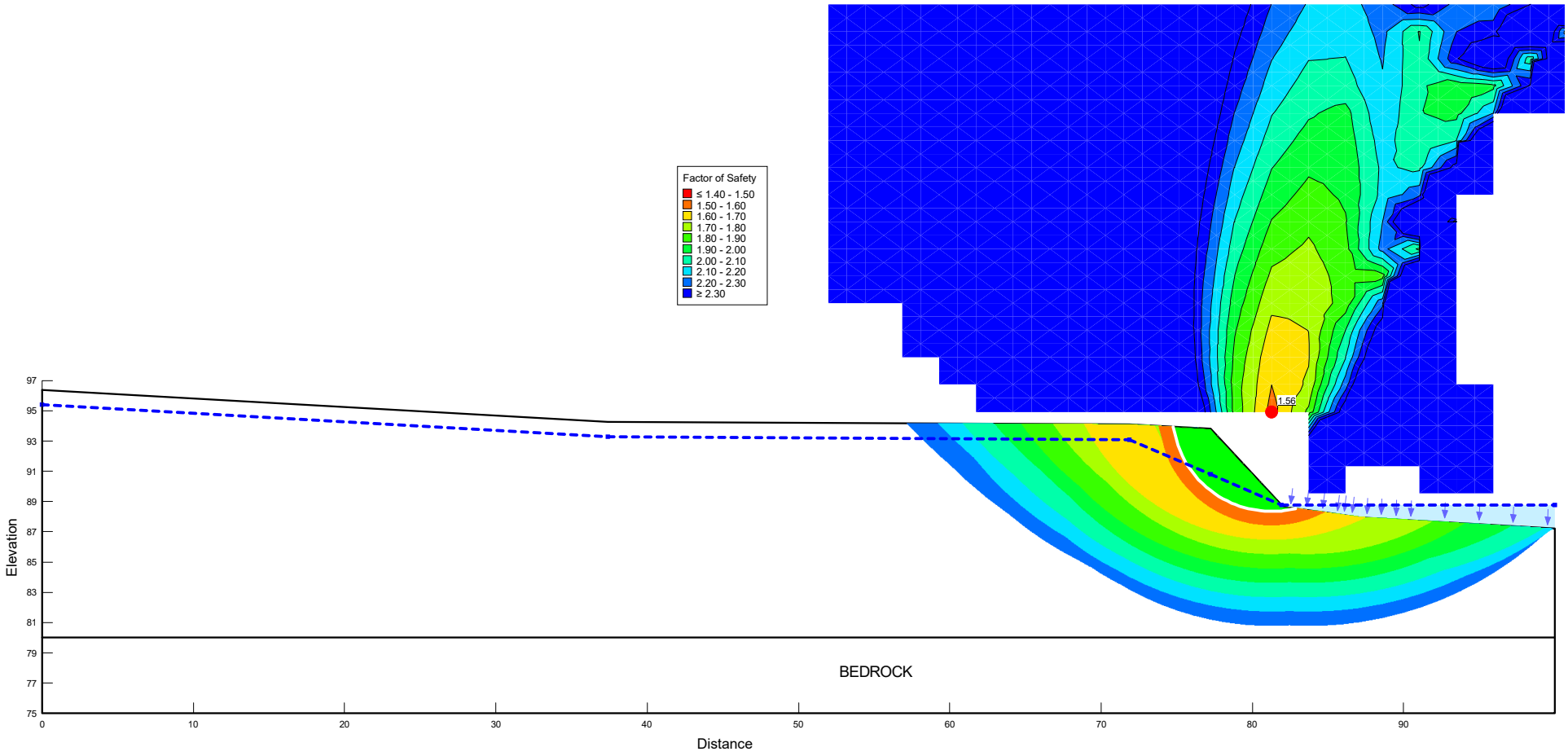
SLOPE SECTION 1
STATIC CONDITIONS
ELEVATED GROUNDWATER TABLE



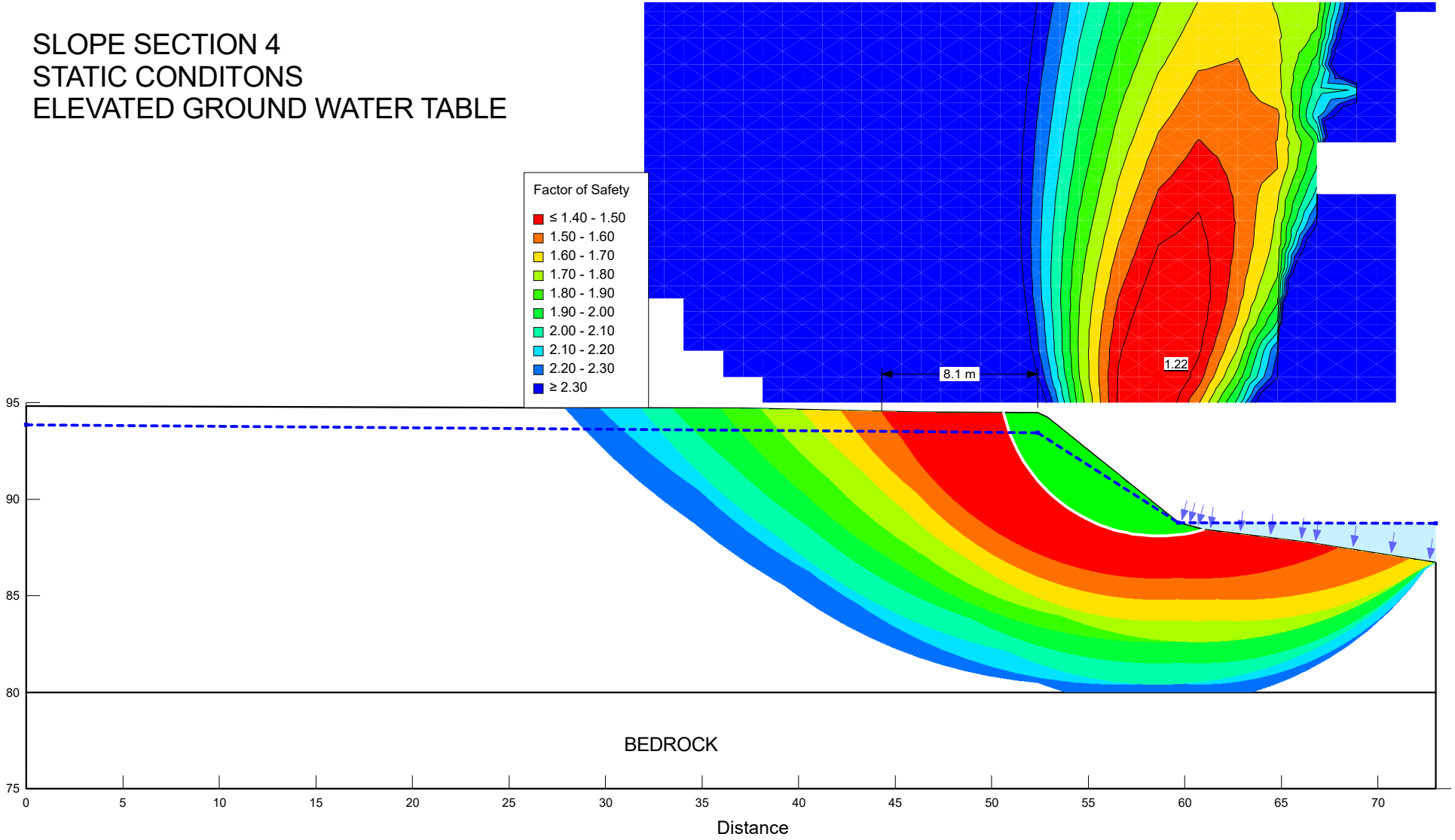
SLOPE SECTION 2
STATIC CONDITIONS
ELEVATED GROUNDWATER TABLE



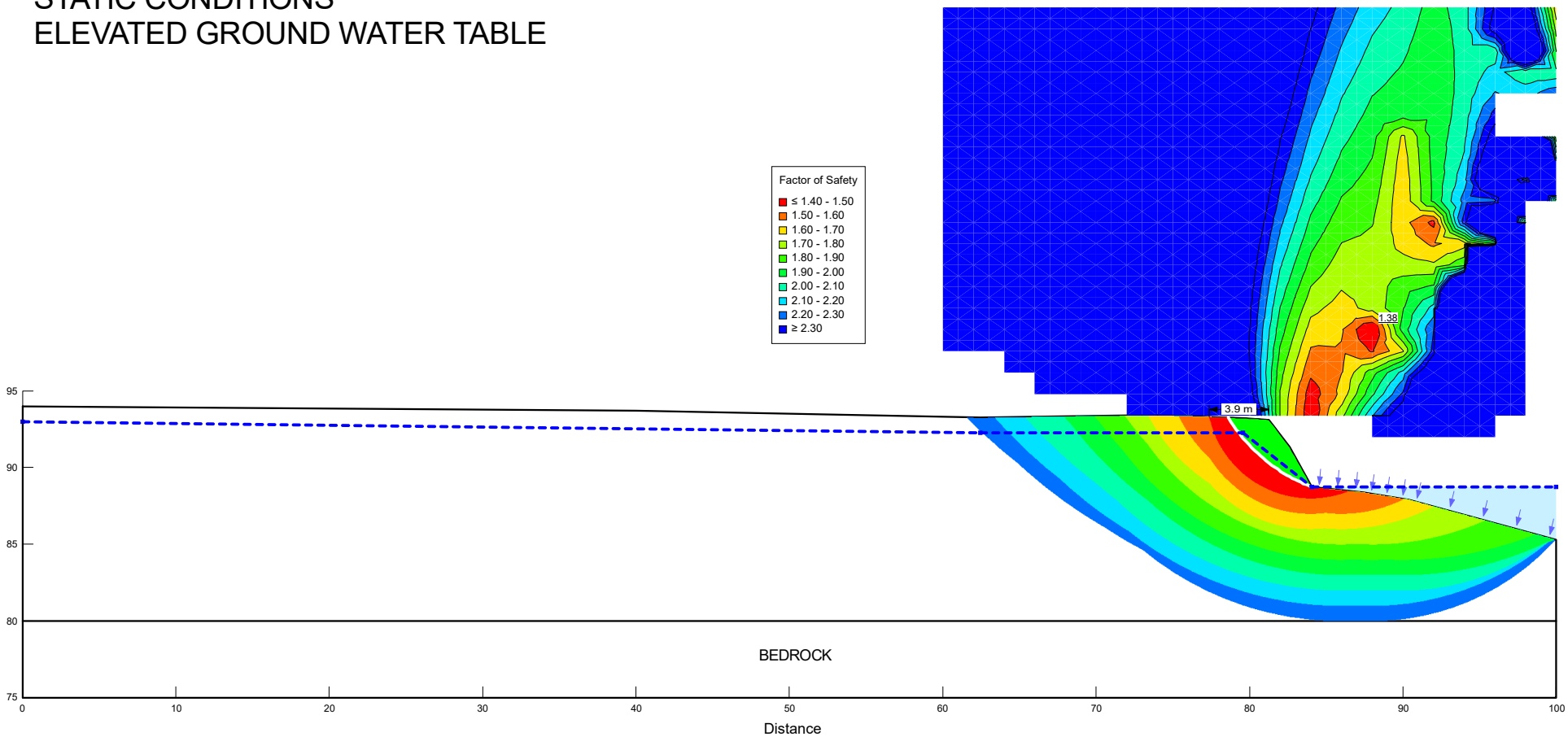
SLOPE SECTION 3
STATIC CONDITIONS
ELEVATED GROUNDWATER TABLE



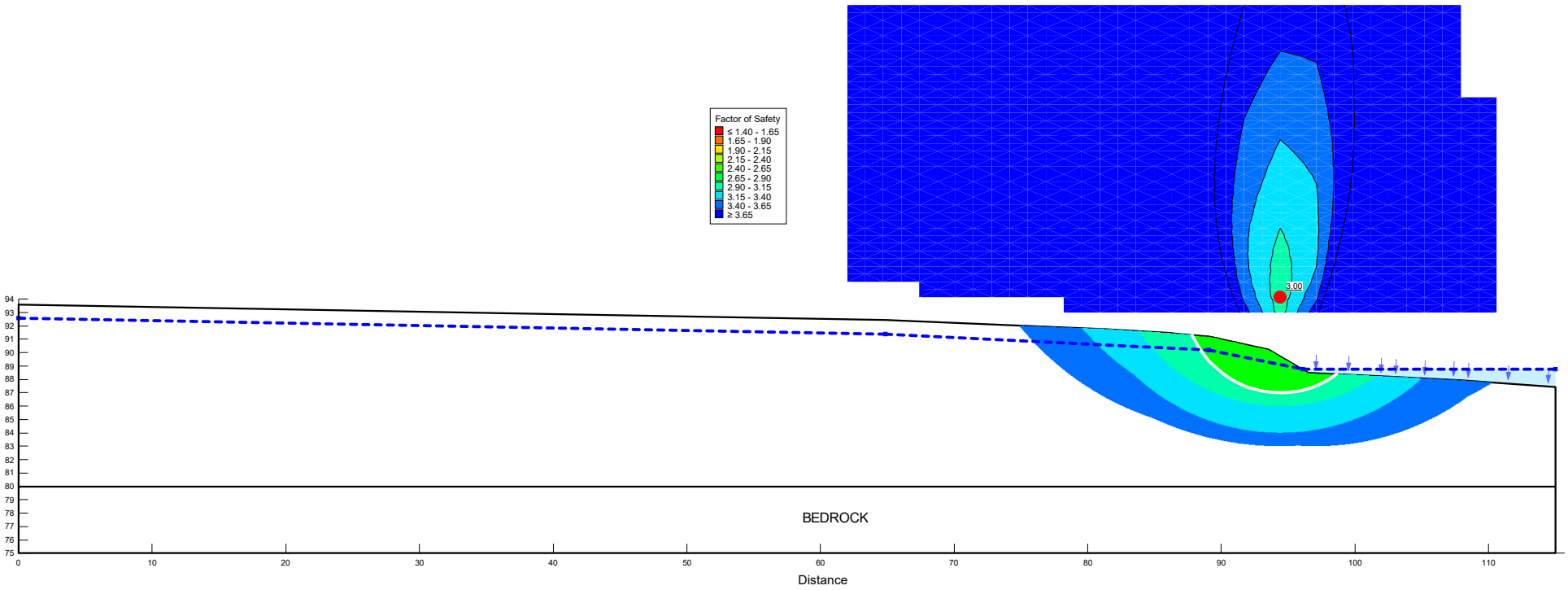
SLOPE SECTION 4
STATIC CONDITONS
ELEVATED GROUND WATER TABLE



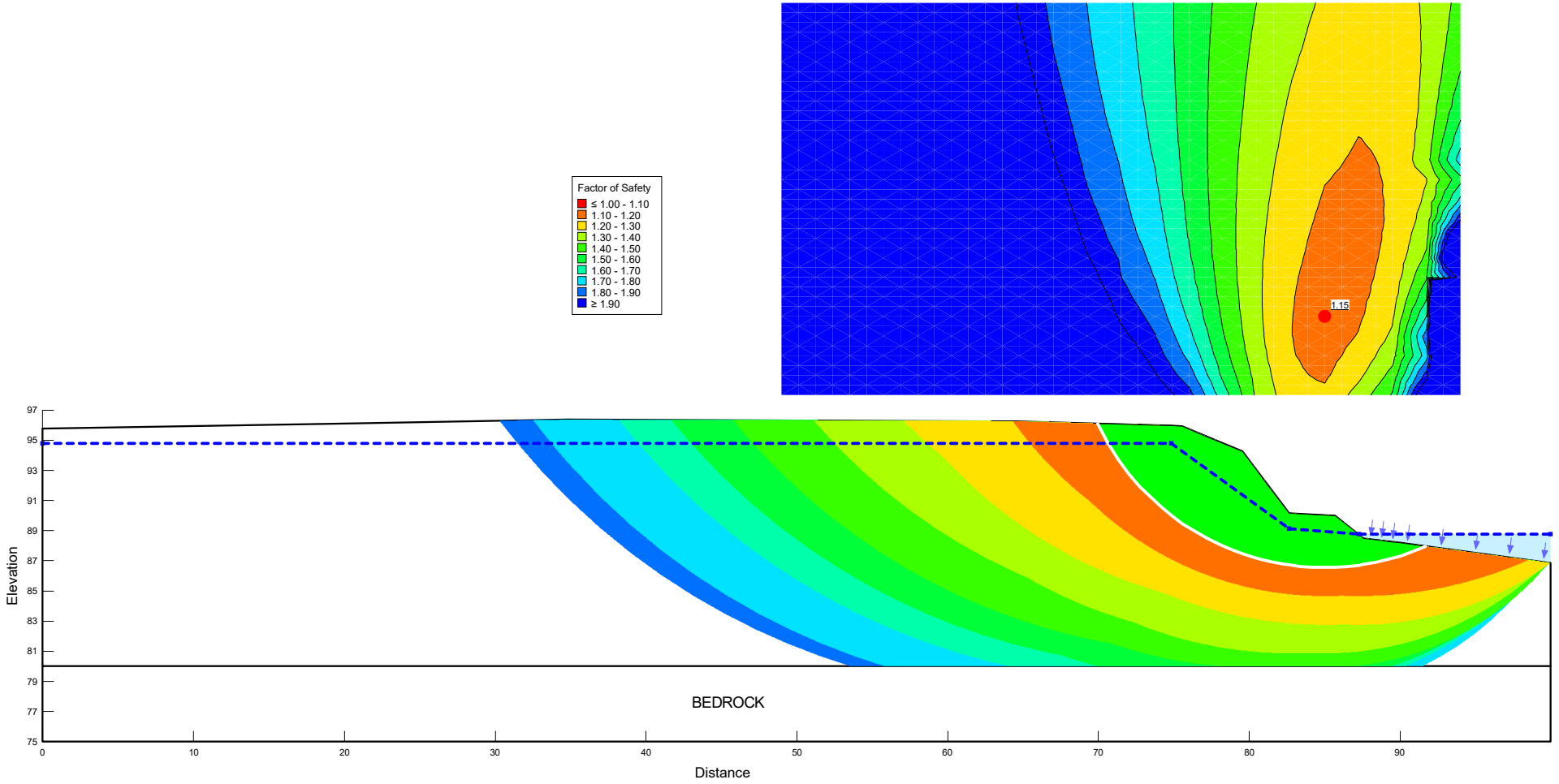
SLOPE SECTION 5
STATIC CONDITIONS
ELEVATED GROUND WATER TABLE



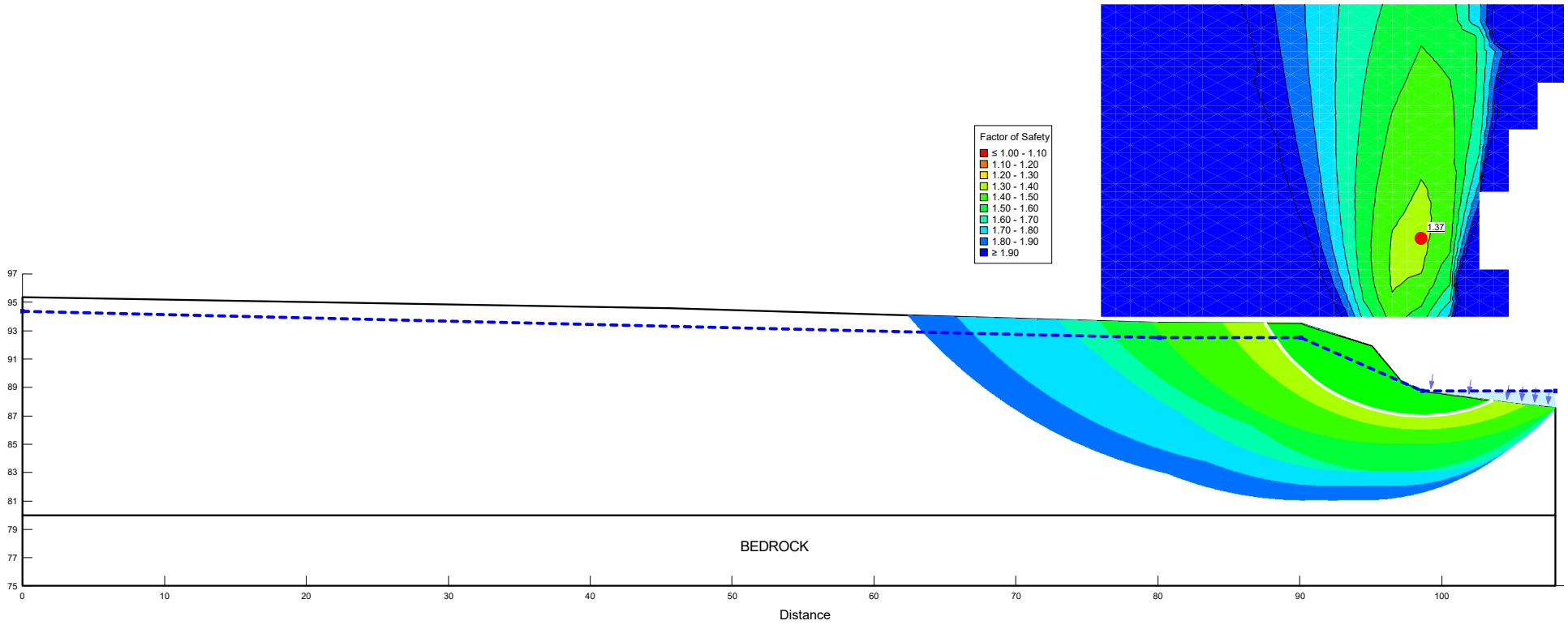
SLOPE SECTION 6
STATIC CONDITONS
ELEVATED GROUNDWATER TABLE



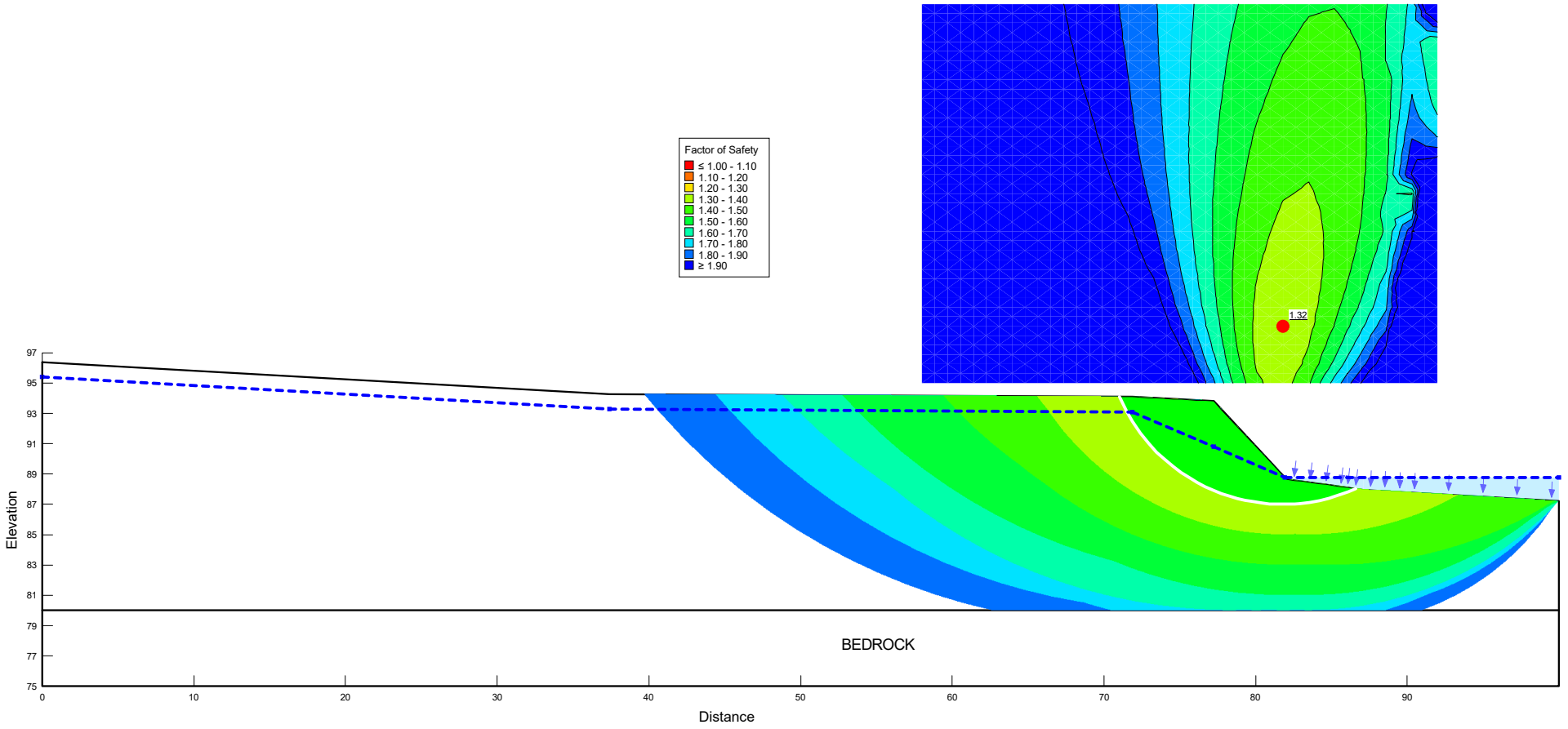
SLOPE SECTION 1
SEISMIC CONDITIONS
ELEVATED GROUNDWATER TABLE



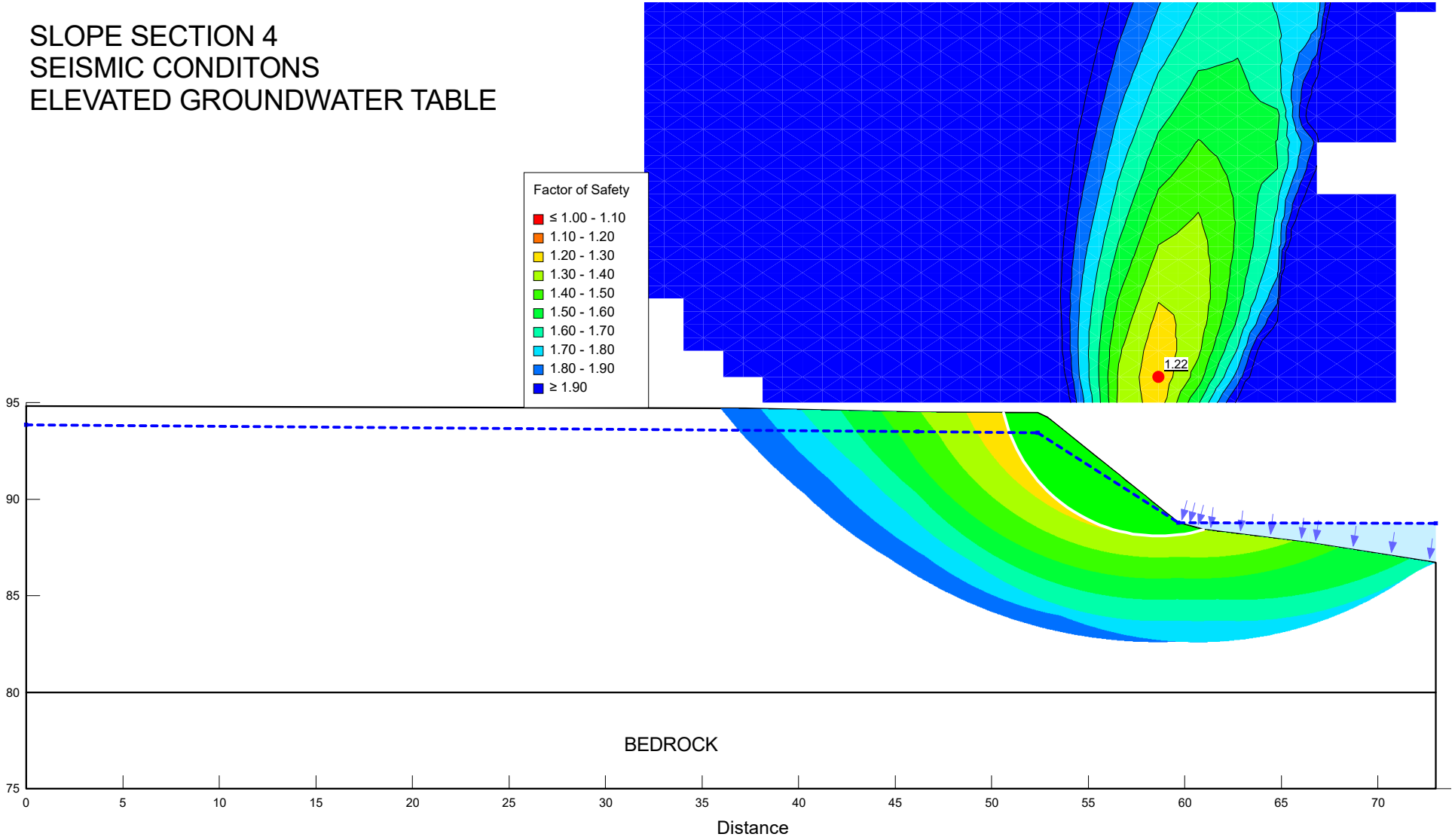
SLOPE SECTION 2
SEISMIC CONDITIONS
ELEVATED GROUNDWATER TABLE



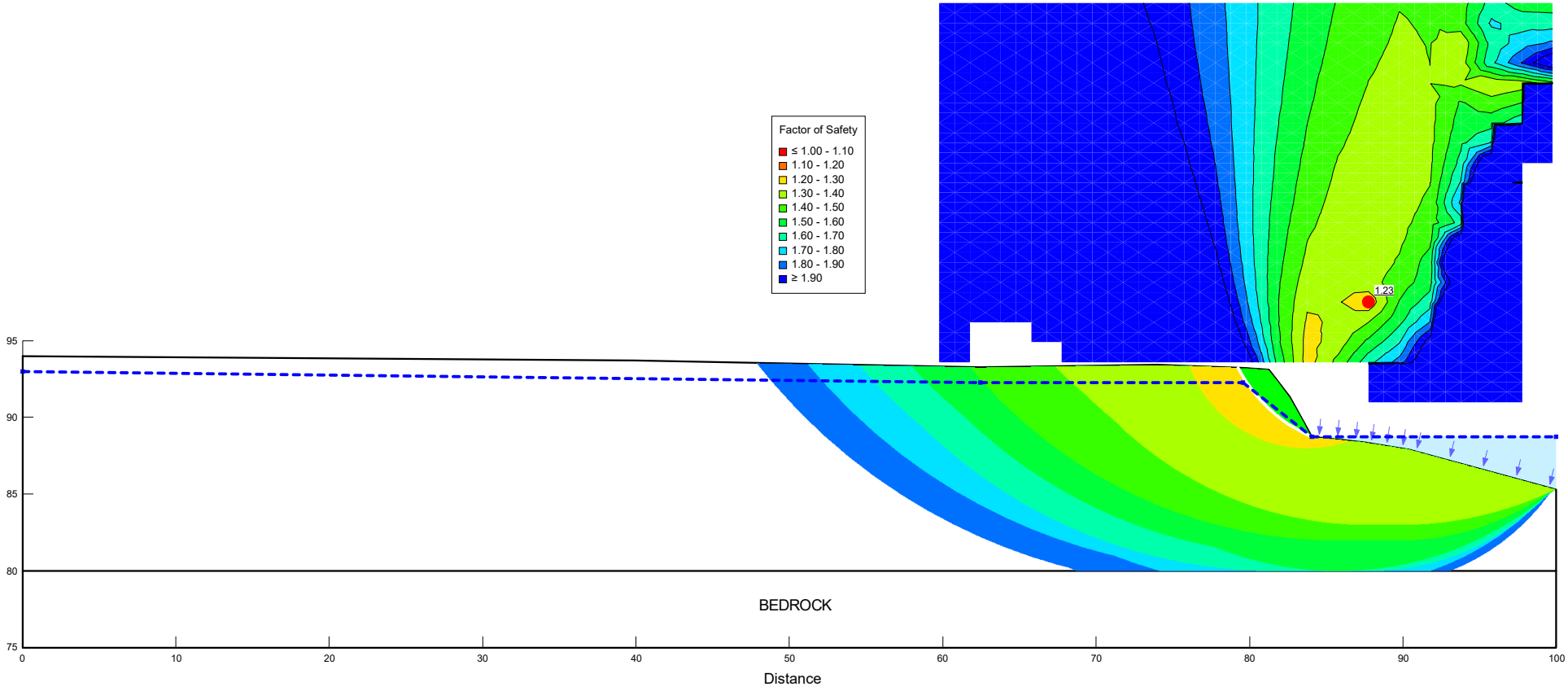
SLOPE SECTION 3
SEISMIC CONDITIONS
ELEVATED GROUND WATER TABLE



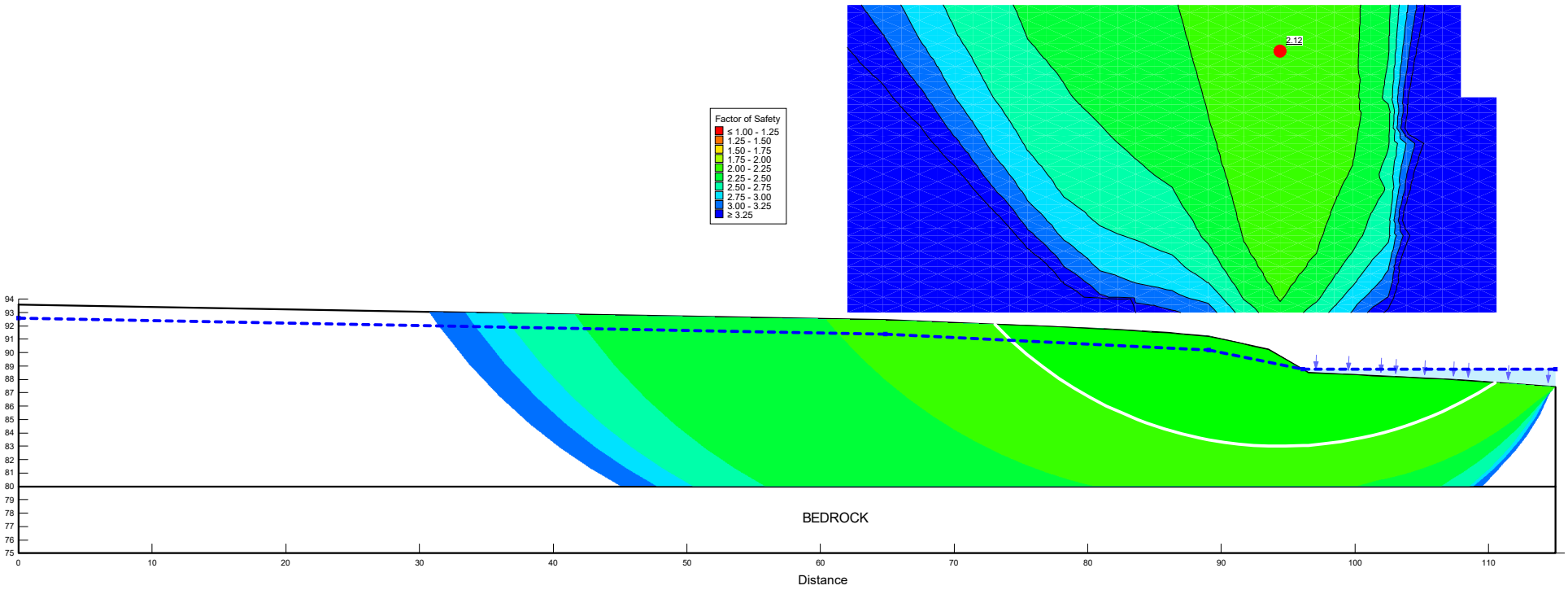
SLOPE SECTION 4
SEISMIC CONDITONS
ELEVATED GROUNDWATER TABLE



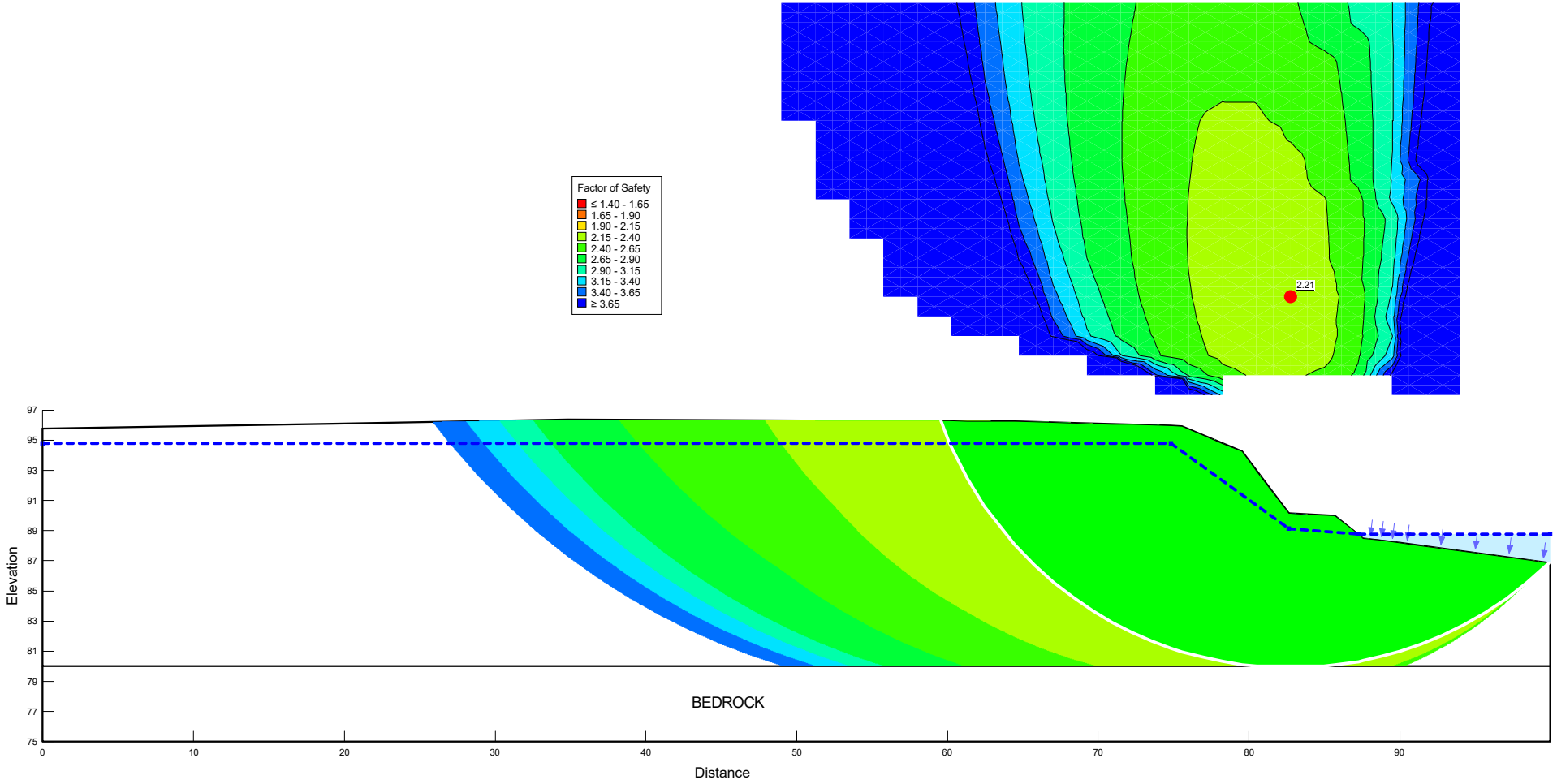
SLOPE SECTION 5
SEISMIC CONDITIONS
ELEVATED GROUNDWATER TABLE



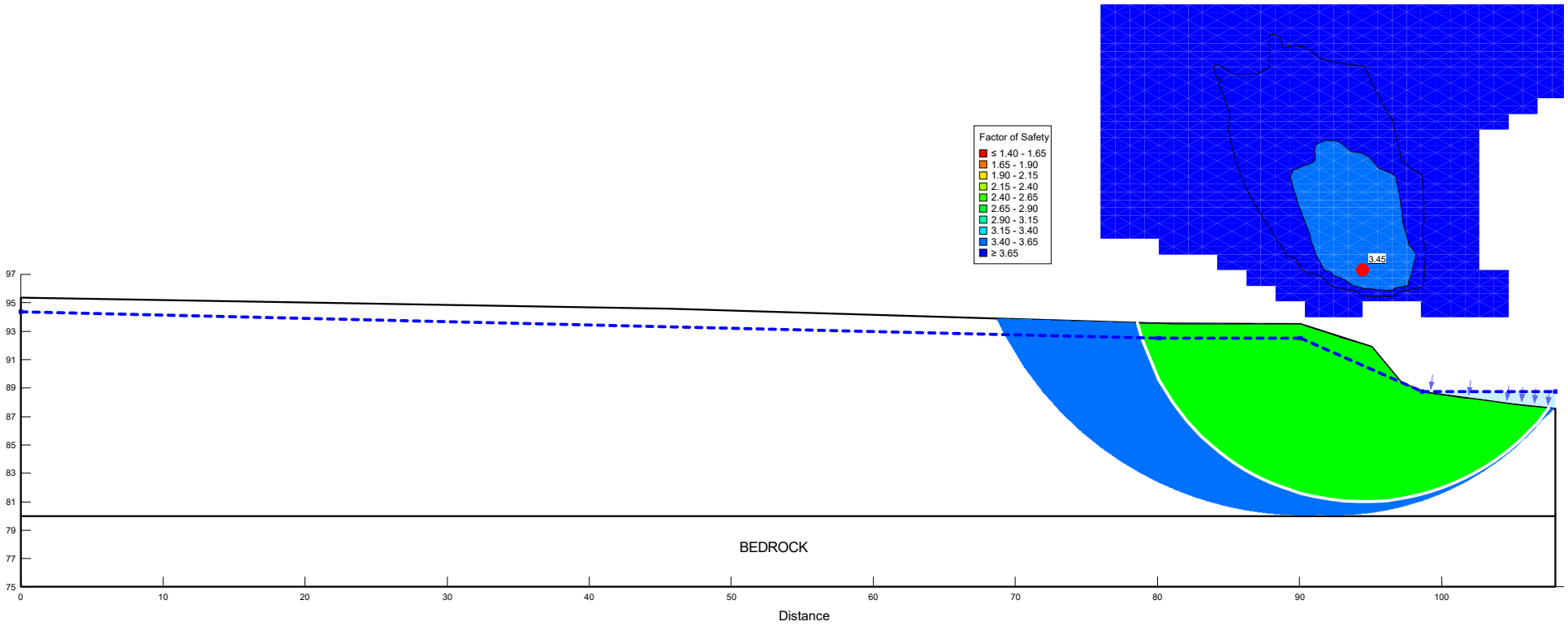
SLOPE SECTION 6
SEISMIC CONDITONS
ELEVATED GROUND WATER TABLE



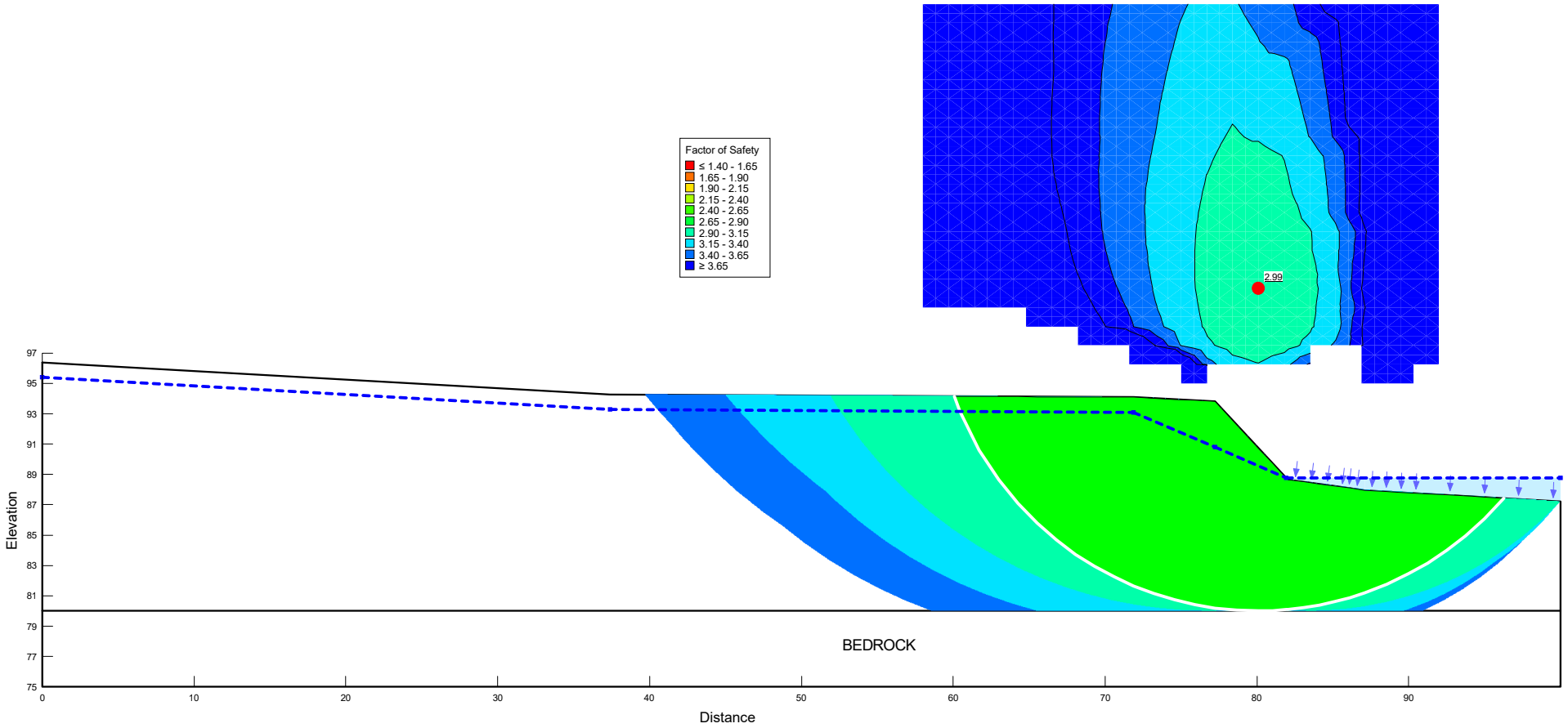
SLOPE SECTION 1
STATIC CONDITIONS
(UNDRAINED)
ELEVATED GROUNDWATER TABLE



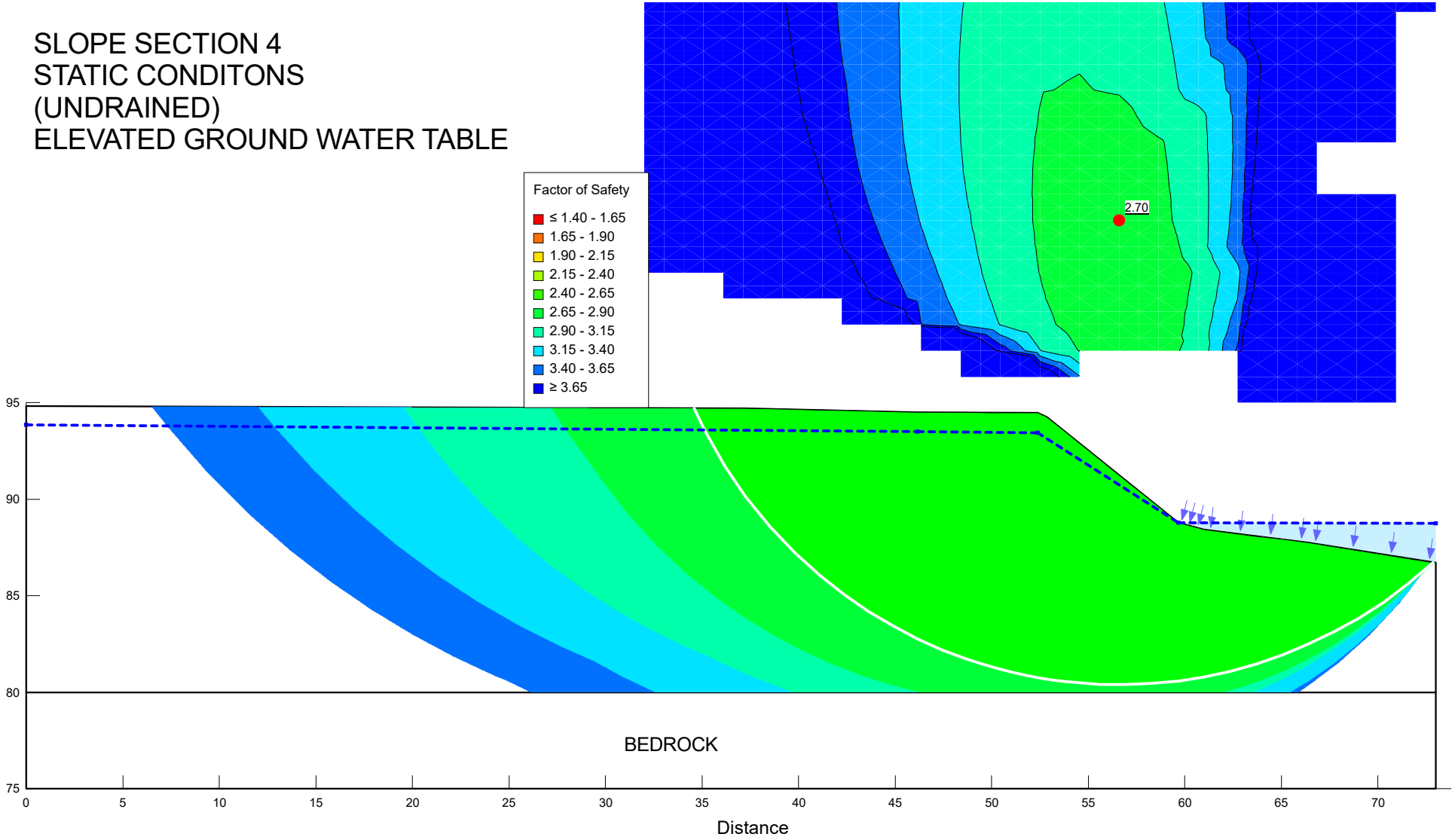
SLOPE SECTION 2
STATIC CONDITIONS
(UNDRAINED)
ELEVATED GROUNDWATER TABLE



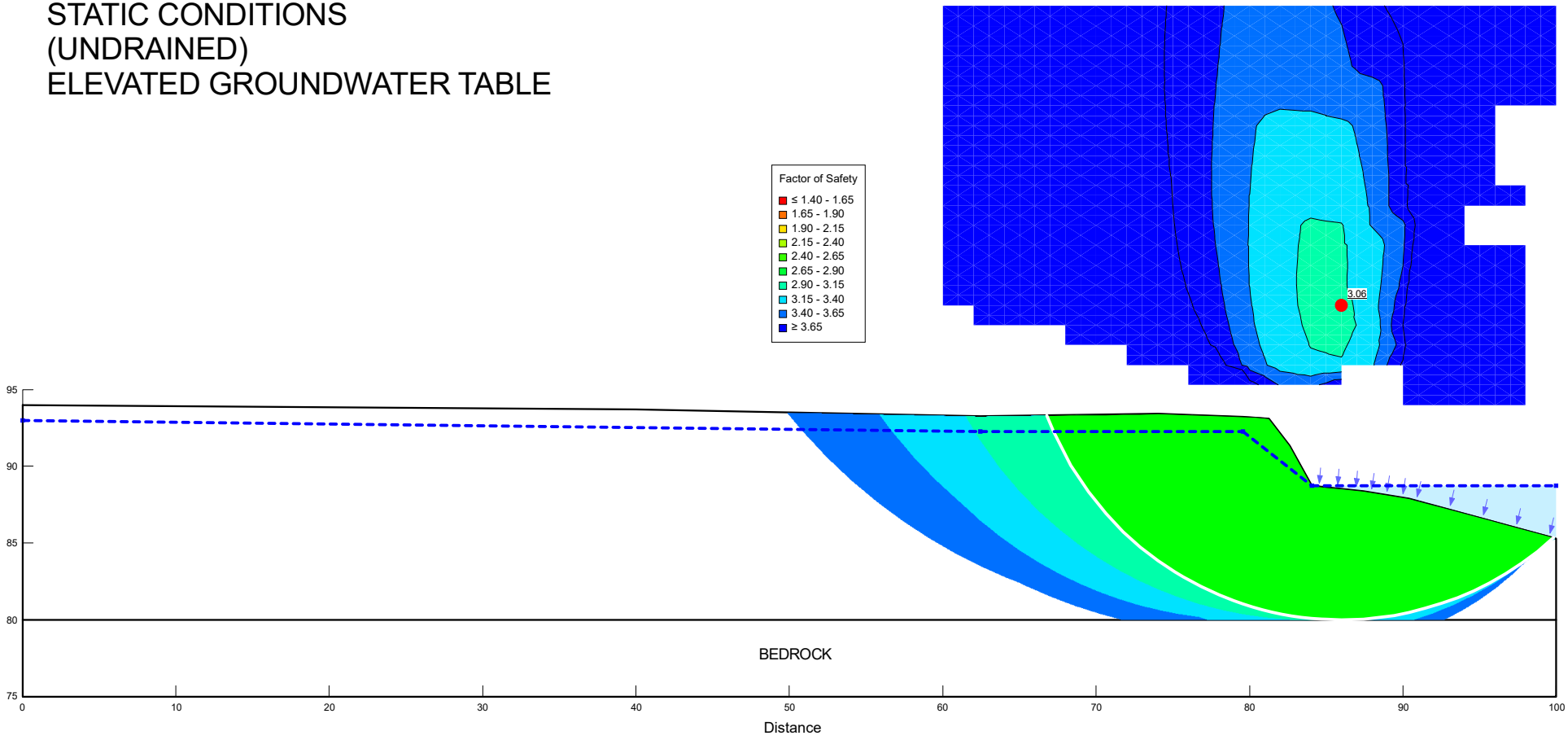
SLOPE SECTION 3
STATIC CONDITIONS
(UNDRAINED)
ELEVATED GROUND WATER TABLE



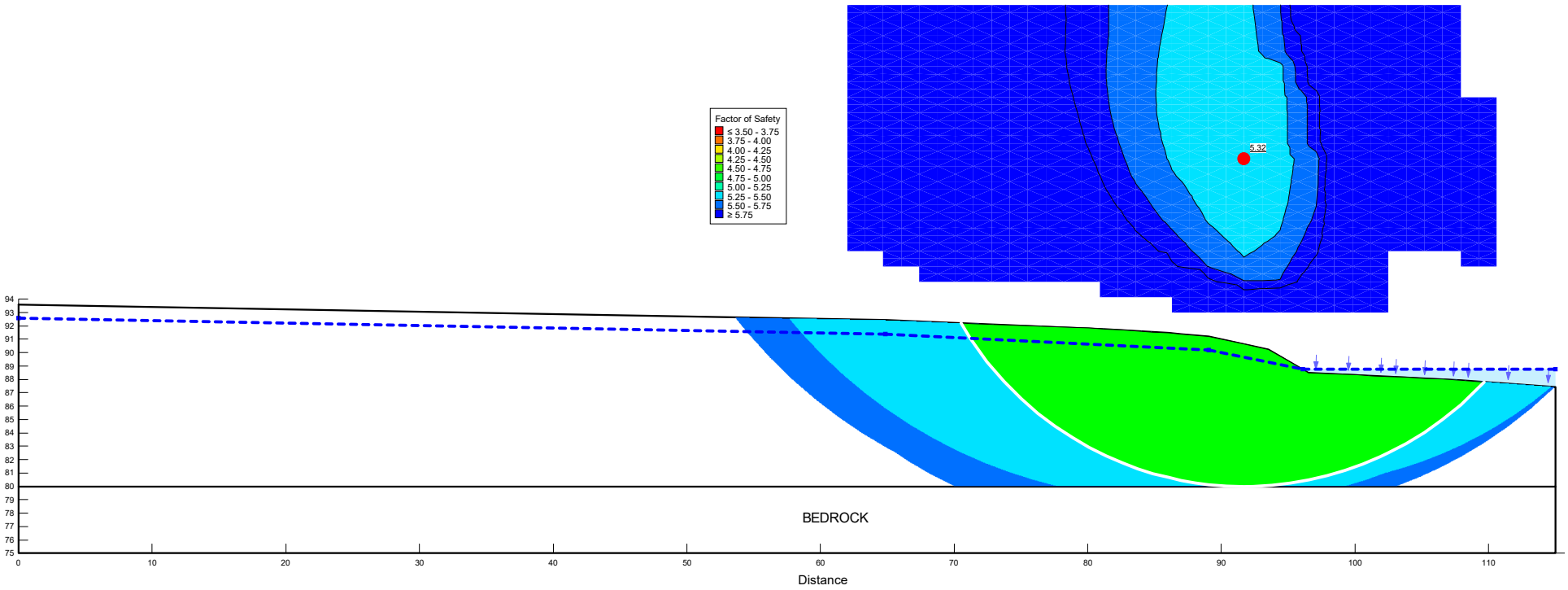
SLOPE SECTION 4
STATIC CONDITONS
(UNDRAINED)
ELEVATED GROUND WATER TABLE



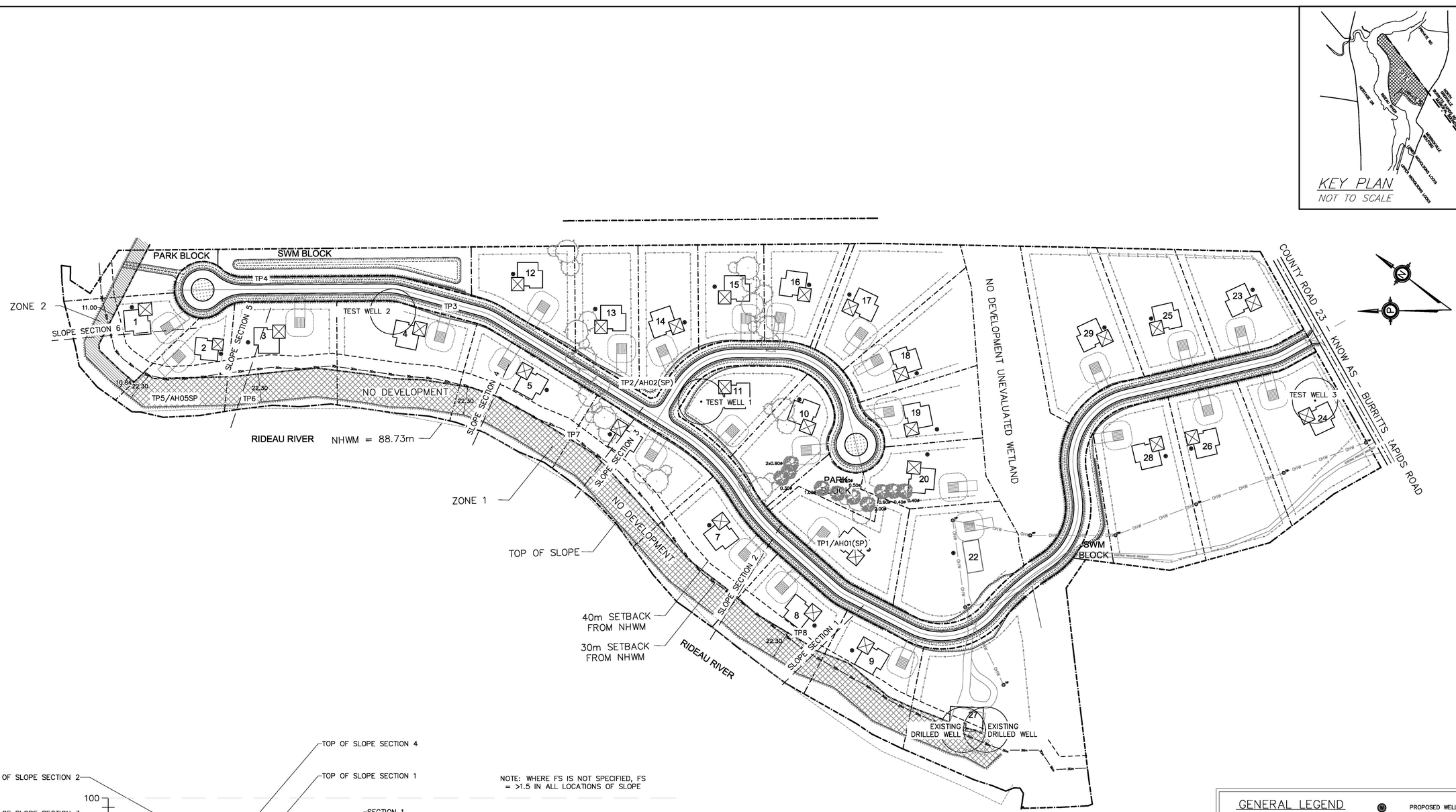
SLOPE SECTION 5
STATIC CONDITIONS
(UNDRAINED)
ELEVATED GROUNDWATER TABLE

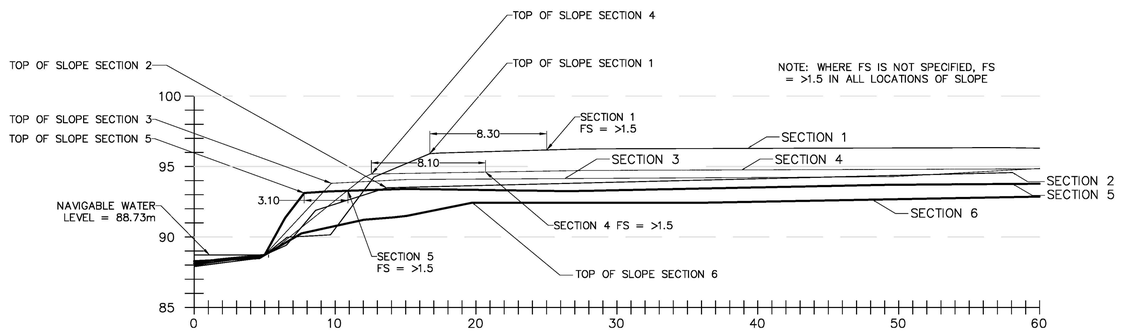


SLOPE SECTION 6
STATIC CONDITONS
(UNDRAINED)
ELEVATED GROUND WATER TABLE



APPENDIX E – SLOPE STABILITY DRAWINGS





COMPARISON OF SECTIONS

SCALE = 1:200

SLOPE SECTIONS AND LIMIT OF HAZARD LANDS SETBACK

SCALE = 1:1500

GENERAL LEGEND

- EXISTING ELEVATION
- PROPOSED/EXISTING ELEVATIONS
- PROPOSED DITCH ELEVATION
- 0.0% DRAINAGE ARROW
- DIRECTION OF FLOW
- PROPOSED SEPTIC BED LOCATION
- PROPOSED WELL LOCATION
- EXISTING WATER WELL
- NO-DEVELOPMENT AREA (LIMIT OF HAZARD LANDS)
- FENCELINE
- PROPERTY LINES
- EDGE OF ASPHALT
- TOP OF SLOPE
- PROPOSED DWELLING LOCATION

NOTE:

1. ALL DIMENSIONS ARE IN METRES, UNLESS OTHERWISE SPECIFIED; ALL ELEVATIONS ARE IN METRES AND ARE GEODETIC.
2. THIS IS NOT A SITE PLAN OR A LEGAL SURVEY AND IS TO BE USED FOR SLOPE STABILITY PURPOSES ONLY.
3. Any CHANGES MADE TO THIS DRAWING MUST BE VERIFIED AND APPROVED BY KOLLAARD ASSOCIATES INC.
4. CLIENT IS RESPONSIBLE FOR ACQUIRING ALL NECESSARY PERMITS.
5. THIS DRAWING IS NOT FOR CONSTRUCTION UNTIL ALL APPROVALS HAVE BEEN GRANTED.
6. CONTRACTOR TO VERIFY THAT APPROPRIATE PERMITS HAVE BEEN ACQUIRED PRIOR TO ANY CONSTRUCTION.
7. THIS DRAWING IS INTENDED TO INDICATE THE LOCATION OF THE PROPOSED CONSTRUCTION RELATIVE TO THE EXISTING SLOPE AS WELL AS THE SECTION LOCATIONS FOR THE SLOPE STABILITY ASSESSMENT.
8. THIS DRAWING IS PART OF KOLLAARD ASSOCIATES SLOPE STABILITY ASSESSMENT REPORT # 210816.

No.	REVISION	DATE	BY
0.	DETERMINATION OF LIMIT OF HAZARD LANDS SETBACK	08.APR.2024	NJR

Kollaard Associates
Engineers
BOX 189
210 PRESCOTT STREET
KEMPTVILLE, ONTARIO
K0G 1J0
FACSIMILE (613) 258-0475
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LICENSED PROFESSIONAL ENGINEER
APR 08, 2024
S.E. deWit
100079612
PROVINCE OF ONTARIO

DESIGN	---
CHECKED	---
DRAWN	JR/NJR
CHECKED	SD
APPROVED	SD

SCALE: AS SHOWN

PROJECT LOCATION	819 COUNTY ROAD 23, MERRICKVILLE, ON
CLIENT NAME	2873633 Ontatio Inc.
PROJECT NAME	PROPOSED RESIDENTIAL SUBDIVISION
DRAWING	SLOPE STABILITY SECTIONS
PROJECT No.	210816
DRAWING No.	210816-SLP
DATE	APR 08, 2024
SHEET SET	1 OF 1