**PROJECT NO.: SM 230430-G** July 12, 2023

DIANE LEON
3637 Firelane 12
Port Colborne, Ontario
L3K 5V3

**SLOPE STABILITY ASSESSMENT**
**PROPOSED SINGLE FAMILY DWELLING**
**3637 FIRELANE 12**
**PORT COLBORNE, ONTARIO**

Dear Mrs. Leon,

Further to your authorisation, SOIL-MAT ENGINEERS & CONSULTANTS has completed our assessment of the slope at the above noted property. Our comments and recommendations, based on our observations and assessment are presented herein.

We understand that it is proposed to construct a new single-family dwelling, upon demolition of the existing structure at 3637 Firelane 12, Port Colborne, Ontario. It is also understood that the proposed development will include a garage near the northern end of the property. As the property falls under the jurisdiction of Niagara Peninsula Conservation Authority [NPCA], permit approval will be required from NPCA for any construction near the slope. In order for permit approval, it was necessary to conduct a slope stability assessment in order to establish the stability of the existing slope, and the effect of the proposed development near the existing slope.

This work has been conducted in general accordance with the guideline policies of NPCA, including the Natural Hazards Technical Guide by MNR and the supporting document "Geotechnical Principles for Stable Slopes".

## PROCEDURE

The site was visited initially on June 8, 2023, by a representative of SOIL-MAT ENGINEERS & CONSULTANTS LTD. During our site visit representative slope profiles of the subject slopes were measured from the south east and south west corners of the existing dwelling down to the shore of Lake Erie. A third slope profile was measured from the existing gravel driveway north towards Firelane 12. These profile locations are indicated on the attached Drawing No. 1 and 1A, Slope Profile Location Plans, while the slope profiles are illustrated on the attached Drawing Nos. 2 to 4, Slope Profile A-A to C-C. It is noted that these slope profiles were measured in the field roughly perpendicular to the slope, at locations considered to be representative of the worst case, or steepest, inclination.

A Slope Stability Rating Chart, as per the Ontario Ministry of Natural Resources publication “Geotechnical Principles for Stable Slopes” [Geotechnical Principles publication] was completed for the southern slope indicated a Rating Value of 32, respectively, corresponding to a slight potential for slope instability. A copy of the Slope Stability Rating Chart has been appended to the end of this report.

## SLOPE CONDITIONS AND STABILITY ASSESSMENT

The southern slope was measured to be approximately 10 to 11 metres in height with overall inclinations of 1.9 to 2.0 horizontal to 1 vertical. The slope was noted to be vegetated with occasional shrubs and covered with scrub vegetation. An armour stone revetment was noted at the toe. The northern slope was measured to be approximately 6 to 7 metres in height with overall inclinations of 2.4 horizontal to 1 vertical. The slope was noted to be well vegetated with young trees and scrub vegetation. No significant evidence of failure scars tension cracks, or other signs of slope instability were noted on either slope at the time of our visit.

A review of available published information [Quaternary Geology of Ontario, Southern Sheet Map 2556] indicate the subsurface soils to consist of coarse-textured lacustrine deposits of sand and gravel with minor silt and clay, and Eolian deposits of fine sand and silt. This is consistent with our observations on site within a series of hand dug test pits, and experience in the area.

As with all slopes, there is a reduction in shearing resistance attributed to the effects of freezing and thawing, wetting and drying, burrowing animals, etc. With time, the surface of the slope will degenerate and tend to reach equilibrium within its stress and ambient environment, including vegetative cover. However, this degeneration of the slope angle is a very slow process as is evident by the present condition of the existing slope.

A stability analysis of the ‘worst case’ Slope Profiles B-B and C-C were performed with a computerized modelling program [SLOPE/W 2023] utilising multiple methods of analysis [Bishop, Janbu, Morgenstern-Price] and considering different slip planes and centres of rotation, as well as normal and elevated groundwater conditions, to determine the minimum factor of safety for a series of potential trial slip surfaces.

Soil properties for the subsurface soils have been conservatively attributed based on our experience in the area and the soil strata encountered in the hand dug test pits. In this case the subsurface soils have been modelled as silt sand, and assigned a unit weight of $\gamma$ = 18 kN/m$^3$, an angle of internal friction of $\phi$ = 32 degrees, and cohesion of c = 0 kPa for the purpose of this analysis.

Based on our analyses using the conservative assumptions noted above, the south subject slope was found to have minimum factors of safety, with respect to the ground surface at the top of stable slope location in the area of profile B-B on the order of 1.48 for normal and 1.38 for elevated groundwater conditions. With respect to the existing structure footprint, or at any depth below the surface at the top of stable slope location, as shown in the attached factor of safety 'heat maps', the factors of safety for normal groundwater conditions are greater than 1.5. The calculated factor of safety for Slope Profile C-C at the top of stable slope location is noted to be on the order of 1.42 and 1.38 for normal and elevated groundwater conditions, respectively.

The Ministry of Natural Resources "Geotechnical Principles for Stable Slopes" publication, Table 7.2 lists a minimum Factor of Safety of 1.3 to 1.5 for Active Land Use properties [habitable or occupied structures near the slope] and 1.2 to 1.3 for Light Land Use [non habitable structures near the slope]. As the calculated factors of safety for the proposed structures fall within the range of minimum factors for Active and Light Land Use, the proposed development may be considered stable in the long and short term with respect to the top of stable slope locations, discussed further below.

## TOP OF STABLE SLOPE

The top of stable slope location is determined by the application of an erosion allowance at the toe and stable slope inclinations through the slope. Given the distance between the shore of Lake Erie and the toe of the slope, as well as the presence of shoreline protection at the toe of the southern slope, the focus of this assessment was on the slope stability, and an erosion allowance of zero has been assumed. For the northern slope, no watercourse was noted to be present, so similarly, an erosion allowance of zero has been applied. Table 4.3 of the Ministry of Natural Resources publication "Geotechnical Principles for Stable Slopes" indicates stable slope inclinations through sands and gravels in the range of 1.5 to 2.0 horizontal to 1.0 vertical. A conservative stable slope inclination of 2.3 horizontal to 1 vertical has been applied for the fine-grained silty sand soils. Applying these conservative stable slope inclinations results in a conservative long-term top of stable slope location approximately 1.8 to 2.8 meters "uphill" of the existing dwelling for the southern slope at Profiles B-B and A-A, respectively, and approximately 12 metres north of the existing driveway, as illustrated in Drawing No. 1A.

## CONSTRUCTION CONSIDERATIONS

Based on the above discussions, the existing southern and northern slopes are considered to be stable in both the short and long-term with respect to the top of stable slope locations. As such, it is our opinion that construction of the proposed residential development and associated garage, uphill of the top of stable slope locations, would have no negative impact on the stability of the subject slope, from a geotechnical point of view, and no further setback from the top of stable slope location would be necessary. This is further supported from access to the toe of the slope being readily available from the beach, and the depth of the proposed residence footings relative to the top of the slope.

While the proposed septic bed technically 'encroaches' beyond where the top of stable slope line meets the ground surface, the septic bed would also be installed at a depth below the surface. As such, any septic bed constructed below the stable slope inclination, taken as 2.3 horizontal to 1 vertical from the toe of the slope, would be considered stable from a geotechnical point of view, given the above noted factors of safety being above the requirements for light land use. Where the leaching bed is installed at an inclination, the inclination must not be any steeper than 4 horizontal to 1 vertical, in accordance with the Ontario Building Code. Where re-grading of the northern slope is required to allow for the installation of the septic bed, the overall slope should not be steepened beyond present inclinations without incorporating engineered systems such as retaining walls, geogrids or fabrics, etc. Alternatively, any flattened slope only further increases the overall stability of the slope.

The following recommendations should be considered in the proposed construction:

- With respect to the southern and northern slope, excavated soil and/or heavy construction equipment should not be placed or travel near the top of stable slope location. In this regard it is recommended that a silt fence be placed along, or slightly 'uphill' from, the top of stable slope for the duration of construction. This will act as a barrier for construction activity and also prevent sediment runoff during construction.
- Any drainage towards the slope should be in a controlled fashion, such as sheet flow through well-established grass or vegetation, so as to not alter the natural drainage over the slope or create concentrated flows onto the slope.
- Vegetation on the slope should be protected during construction and all existing trees on the slope maintained where feasible. Uphill of the crest of the slope the vegetation should be repaired/improved with the establishment of new deep-rooted vegetation post construction, where required, in accordance with the site landscape plan.

We trust that this geotechnical investigation and slope stability assessment report is sufficient for your present requirements. Should there be any questions regarding the content or comments within this report please do not hesitate to contact our office.

Yours very truly,
SOIL-MAT ENGINEERS & CONSULTANTS LTD.

Kevin Reid, B.Eng., EIT
Junior Engineer

Adam Roemmele, P. Eng.
Project Engineer

LICENSED PROFESSIONAL ENGINEER
July 12, 2023
A. D. ROEMMELE
100212893
PROVINCE OF ONTARIO

Enclosures: Drawing Nos. 1 and 1A, Slope Profile Location Plans
Drawing No. 2, 3, and 4, Profile A-A to C-C
Slope Stability Rating Chart
Slope Stability Analyses

Distribution: Diane Leon


LEGEND

Slope Profile Location

NOTES

1. This drawing should be read in conjunction with Soil-Mat Engineers & Consultants Ltd. Report No. SM 230430-G.

2. Slope profile locations are approximate.

# Soil-Mat

Engineers & Consultants Ltd.

Slope Stability Assessment
3637 Firelane 12
Port Colborne, Ontario

Slope Profile Location Plan

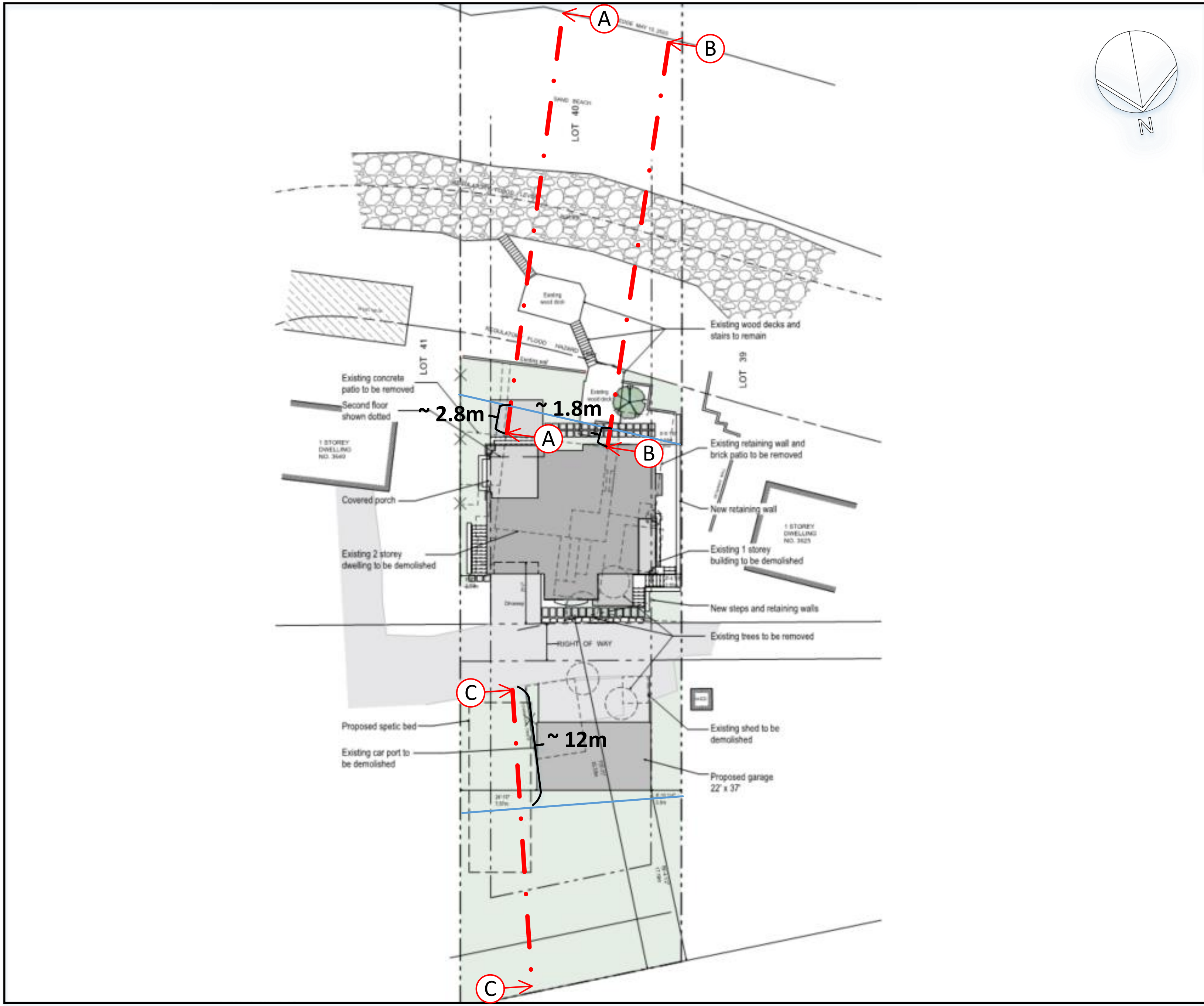
Project No. SM 230430-G

Date: June 2023

| Drawn: KJR | Checked: AR |
|---|---|

SM 230430-G Slope Profile Location Plan

Drawing No. 1




LEGEND

Slope Profile Location

Top of Stable Slope Location

NOTES

1. This drawing should be read in conjunction with Soil-Mat Engineers & Consultants Ltd. Report No. SM 230430-G.

2. Slope profile and top of stable slope locations are approximate.

3. Base Drawing from John Willmott Architect Inc., dated July 6, 2013

# SOIL-MAT

ENGINEERS & CONSULTANTS LTD.

Slope Stability Assessment
3637 Firelane 12
Port Colborne, Ontario

Slope Profile Location Plan

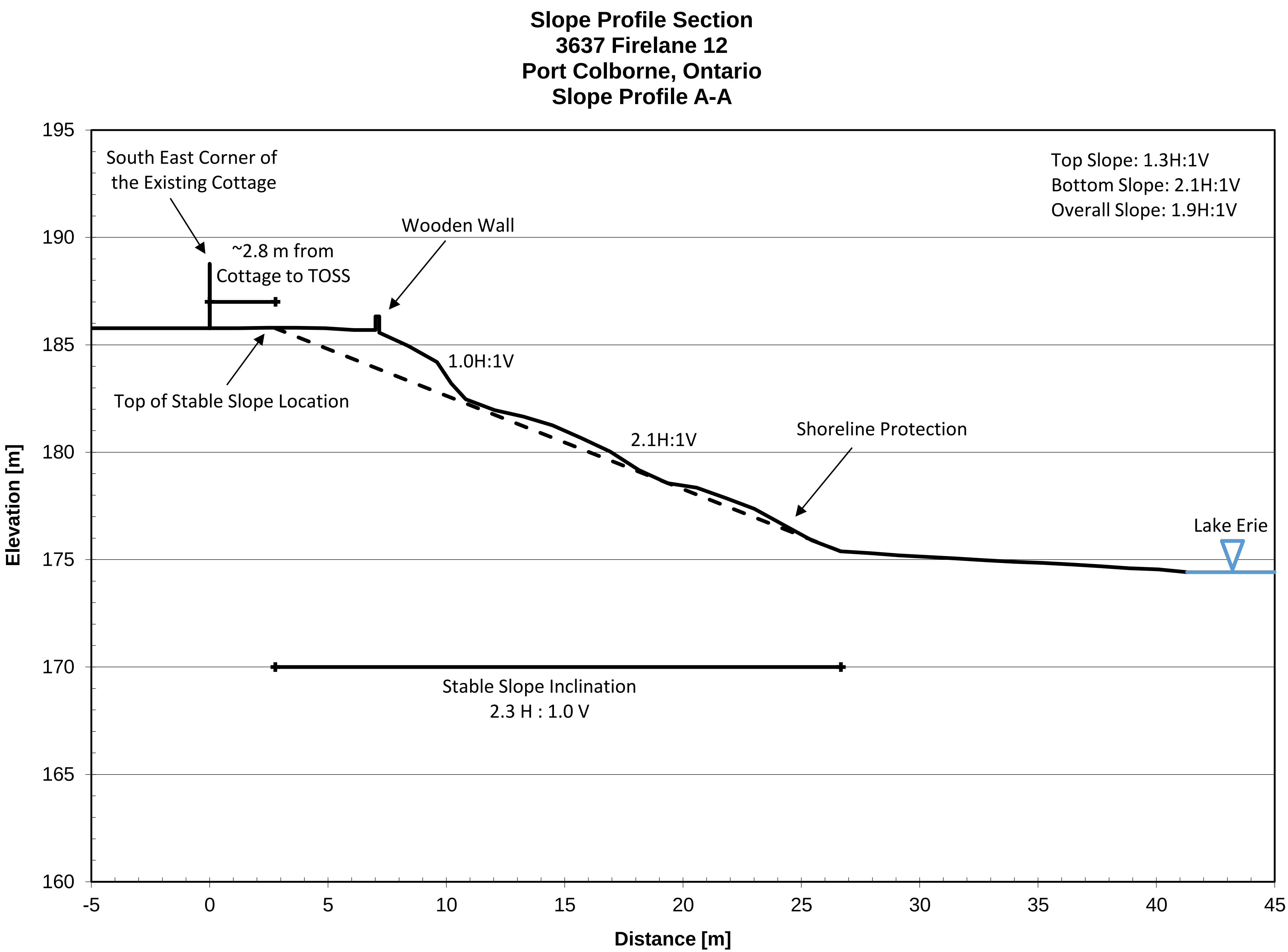
Project No. SM 230430-G

Date: July 2023

Drawn: KJR | Checked: AR

SM 230430-G Slope Profile Location Plan

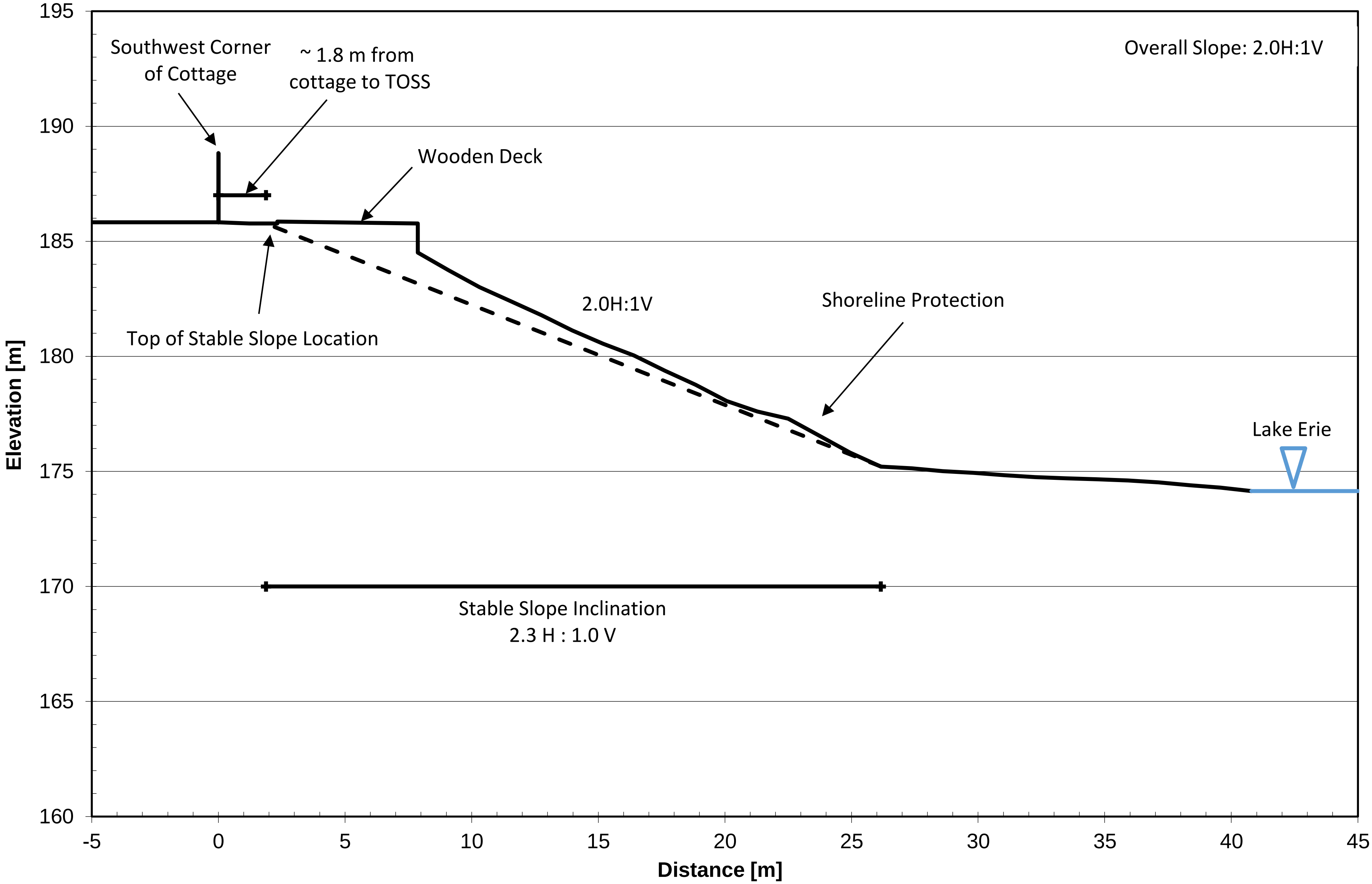
Drawing No. 1A




Project No.: SM 230430G

DRAWING No. 2

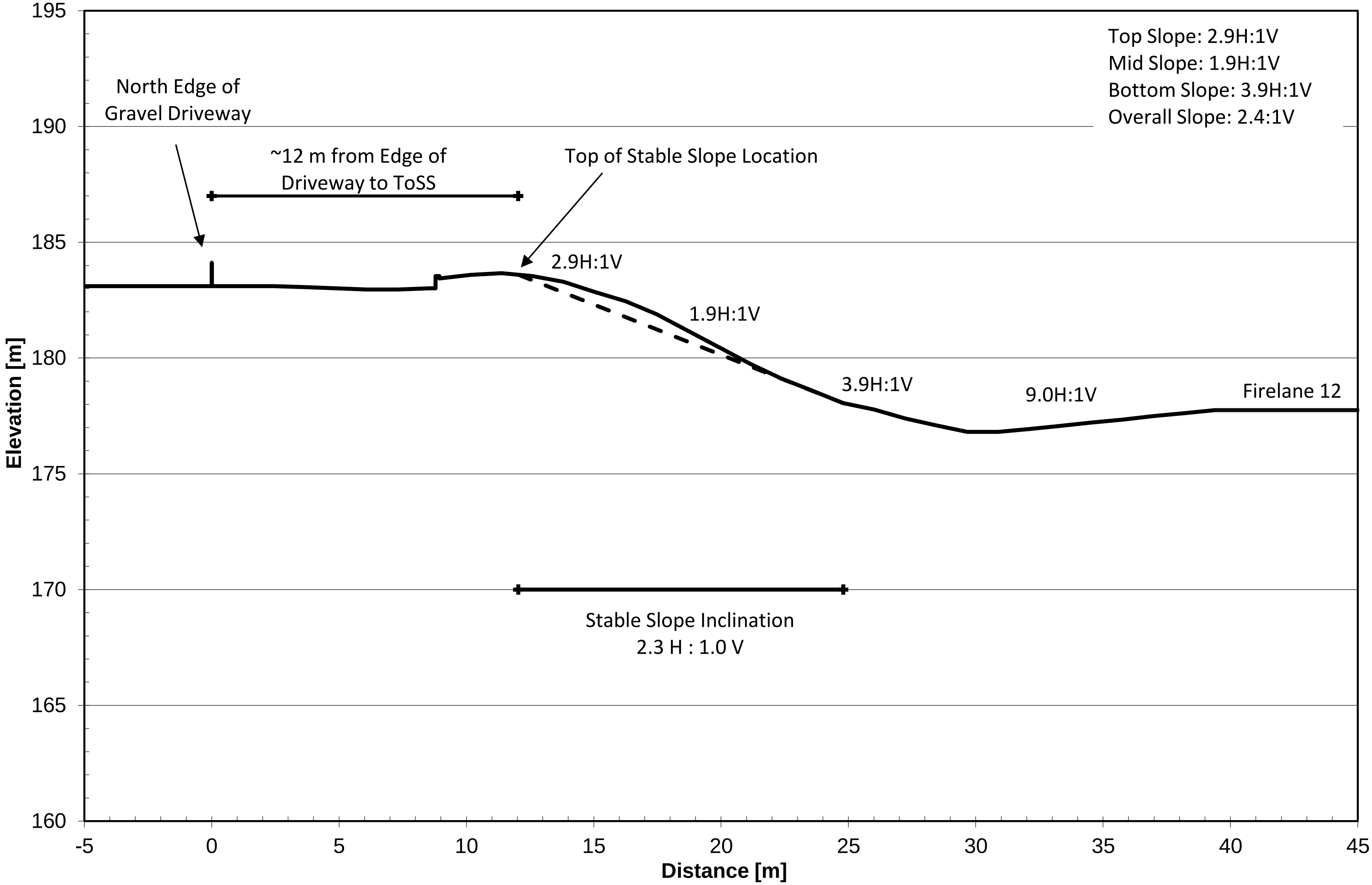
# Slope Profile Section
# 3637 Firelane 12
# Port Colborne, Ontario
# Slope Profile B-B




Project No.: SM 230430-G

DRAWING No. 3

# Slope Profile Section
# 3637 Firelane 12
# Port Colborne, Ontario
# Slope Profile C-C




Project No.: SM 230430-G

DRAWING No. 4

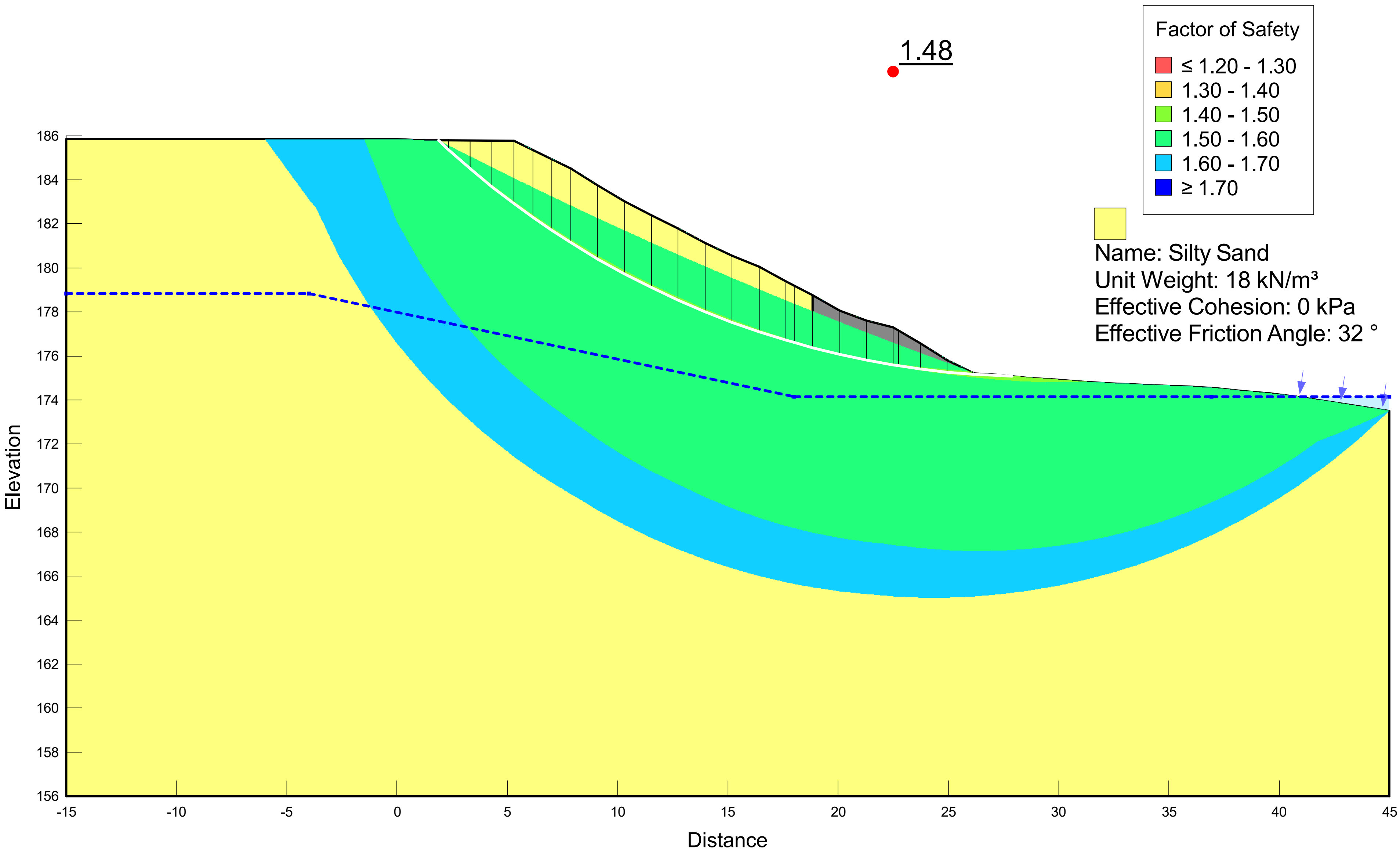
**TABLE 8.1 - SLOPE STABILITY RATING CHART**

Site Location: 3637 Firelane 12, Port Colborne | File No. SM 230430-G
Property Owner: | Inspection Date: June 8, 2023
Inspected By: Kevin Reid | Weather:

| | | | | Rating Value | |
|---|---|---|---|---|---|
| **1.** | **SLOPE INCLINATION** | | | | |
| | | **degrees** | **horiz. : vert.** | | |
| | a) | 18 or less | 3 : 1 or flatter | 0 | 6 |
| | b) | 18 - 26 | 2 : 1 to more than 3 : 1 | 6 | |
| | c) | more than 26 | steeper than 2 : 1 | 16 | |
| **2.** | **SOIL STRATIGRAPHY** | | | | |
| | a) | Shale, Limestone, Granite (Bedrock) | | 0 | |
| | b) | Sand, Gravel | | 6 | |
| | c) | Glacial Till | | 9 | 6 |
| | d) | Clay, Silt | | 12 | |
| | e) | Fill | | 16 | |
| | f) | Leda Clay | | 24 | |
| **3.** | **SEEPAGE FROM SLOPE FACE** | | | | |
| | a) | None or Near bottom only | | 0 | 0 |
| | b) | Near mid-slope only | | 6 | |
| | c) | Near crest only or, From several levels | | 12 | |
| **4.** | **SLOPE HEIGHT** | | | | |
| | a) | 2 m or less | | 0 | |
| | b) | 2.1 to 5 m | | 2 | 8 |
| | c) | 5.1 to 10 m | | 4 | |
| | d) | more than 10 m | | 8 | |
| **5.** | **VEGETATION COVER ON SLOPE FACE** | | | | |
| | a) | Well vegetated; heavy shrubs or forested with mature trees | | 0 | 4 |
| | b) | Light vegetation; Mostly grass, weeds, occasional trees, shrubs | | 4 | |
| | c) | No vegetation, bare | | 8 | |
| **6.** | **TABLE LAND DRAINAGE** | | | | |
| | a) | Table land flat, no apparent drainage over slope | | 0 | 2 |
| | b) | Minor drainage over slope, no active erosion | | 2 | |
| | c) | Drainage over slope, active erosion, gullies | | 4 | |
| **7.** | **PROXIMITY OF WATERCOURSE TO SLOPE TOE** | | | | |
| | a) | 15 metres or more from slope toe | | 0 | 6 |
| | b) | Less than 15 metres from slope toe | | 6 | |
| **8.** | **PREVIOUS LANDSLIDE ACTIVITY** | | | | |
| | a) | No | | 0 | 0 |
| | b) | Yes | | 6 | |

| | SLOPE INSTABILITY RATING | RATING VALUES TOTAL | INVESTIGATION REQUIREMENTS | TOTAL 32 |
|---|---|---|---|---|
| 1. | Low potential | < 24 | Site inspection only, confirmation, report letter. | |
| 2. | Slight potential | 25-35 | Site inspection and surveying, preliminary study, detailed report. | |
| 3. | Moderate potential | > 35 | Boreholes, piezometers, lab tests, surveying, detailed report. | |

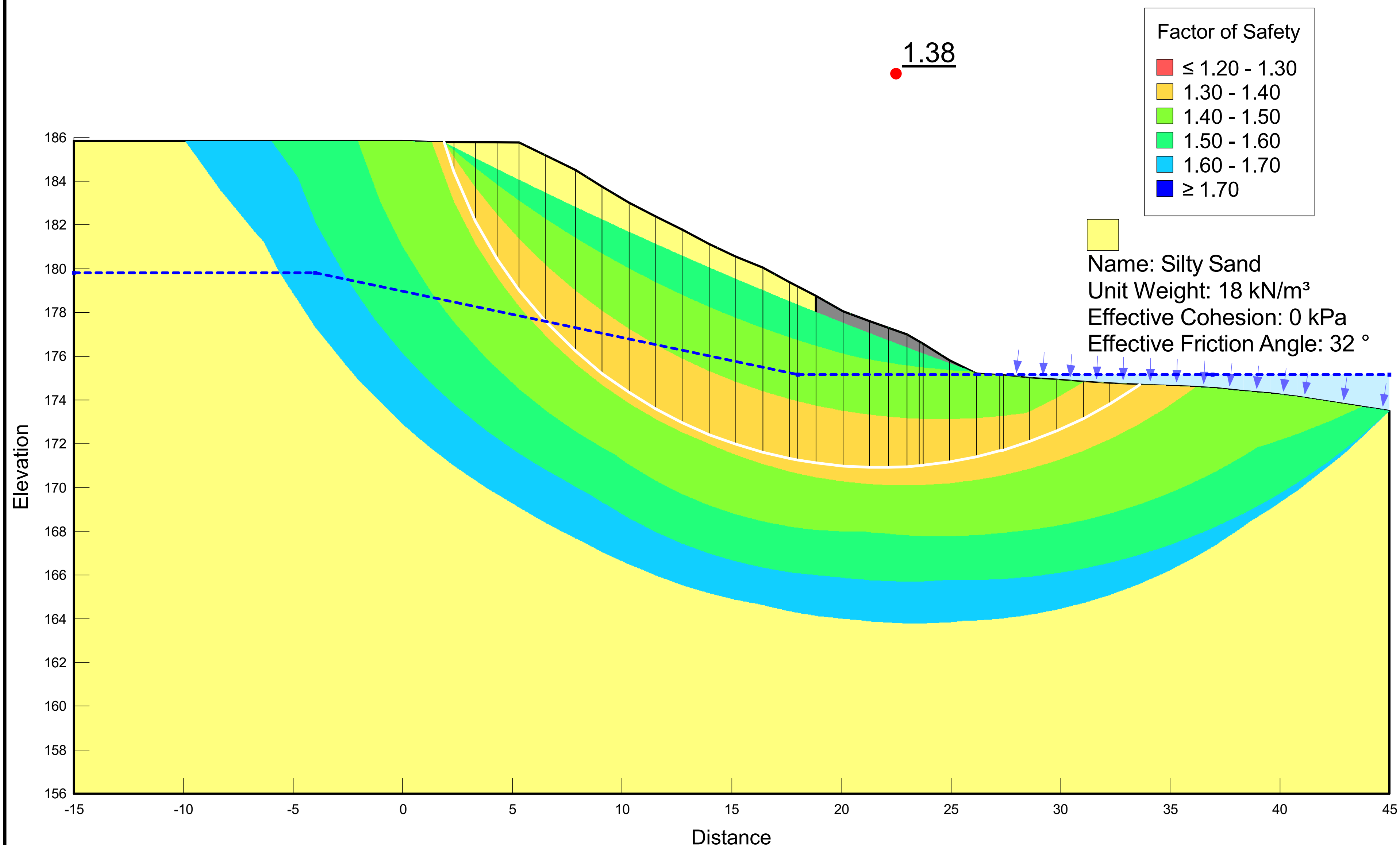
**NOTES:**
a) Choose only one from each category; compare total rating value with above requirements.
b) If there is a water body (stream, creek, river, pond, bay, lake) at the slope toe; the potential for toe erosion and undercutting should be evaluated in detail and, protection provided if required.




Slope Stability Analysis - 3637 Firelane 12, Port Colborne

Slope Profile B-B (Normal Groundwater)

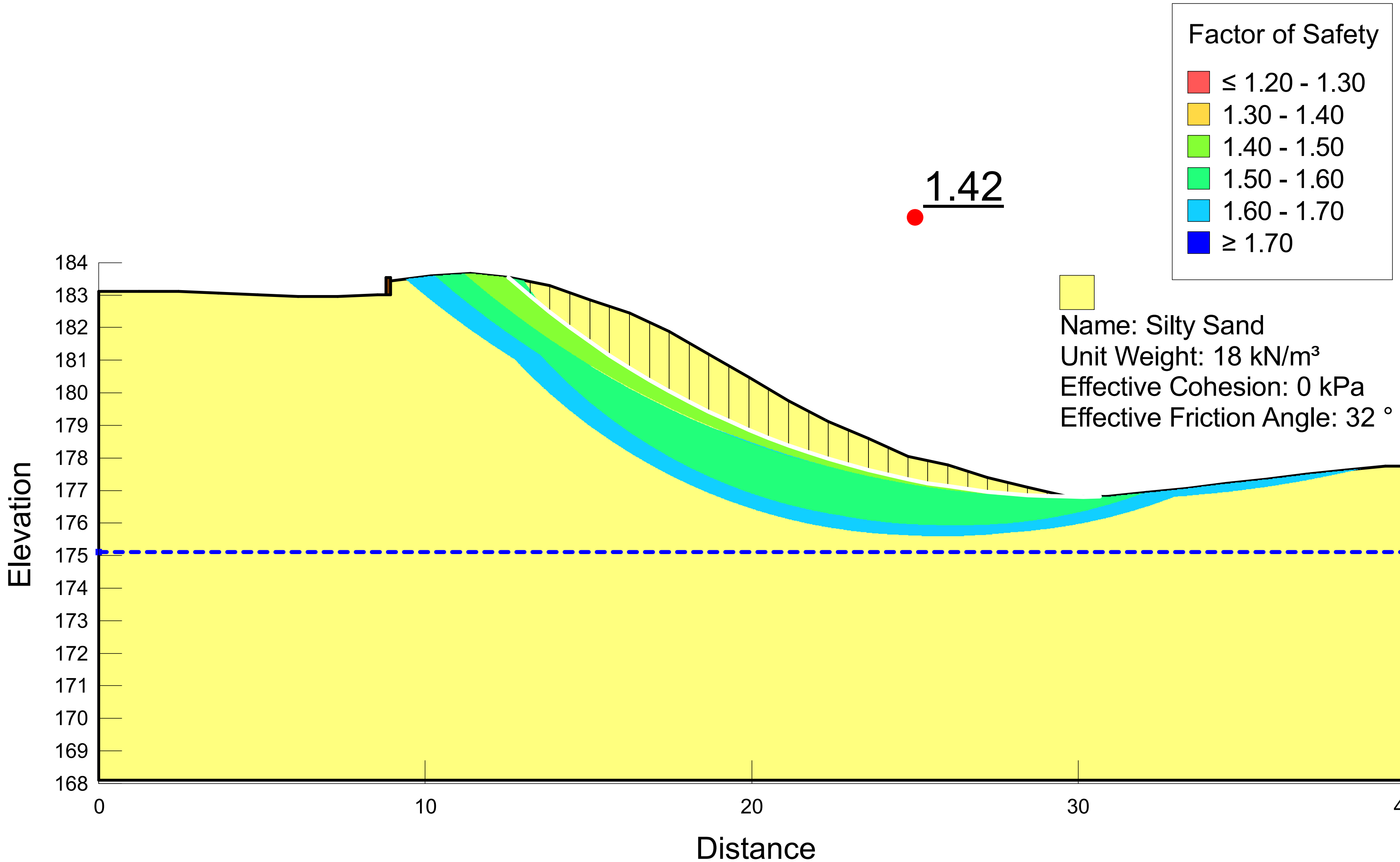
July, 2023




Slope Stability Analysis - 3637 Firelane 12, Port Colborne

Slope Profile B-B (Elevated Groundwater)

July, 2023

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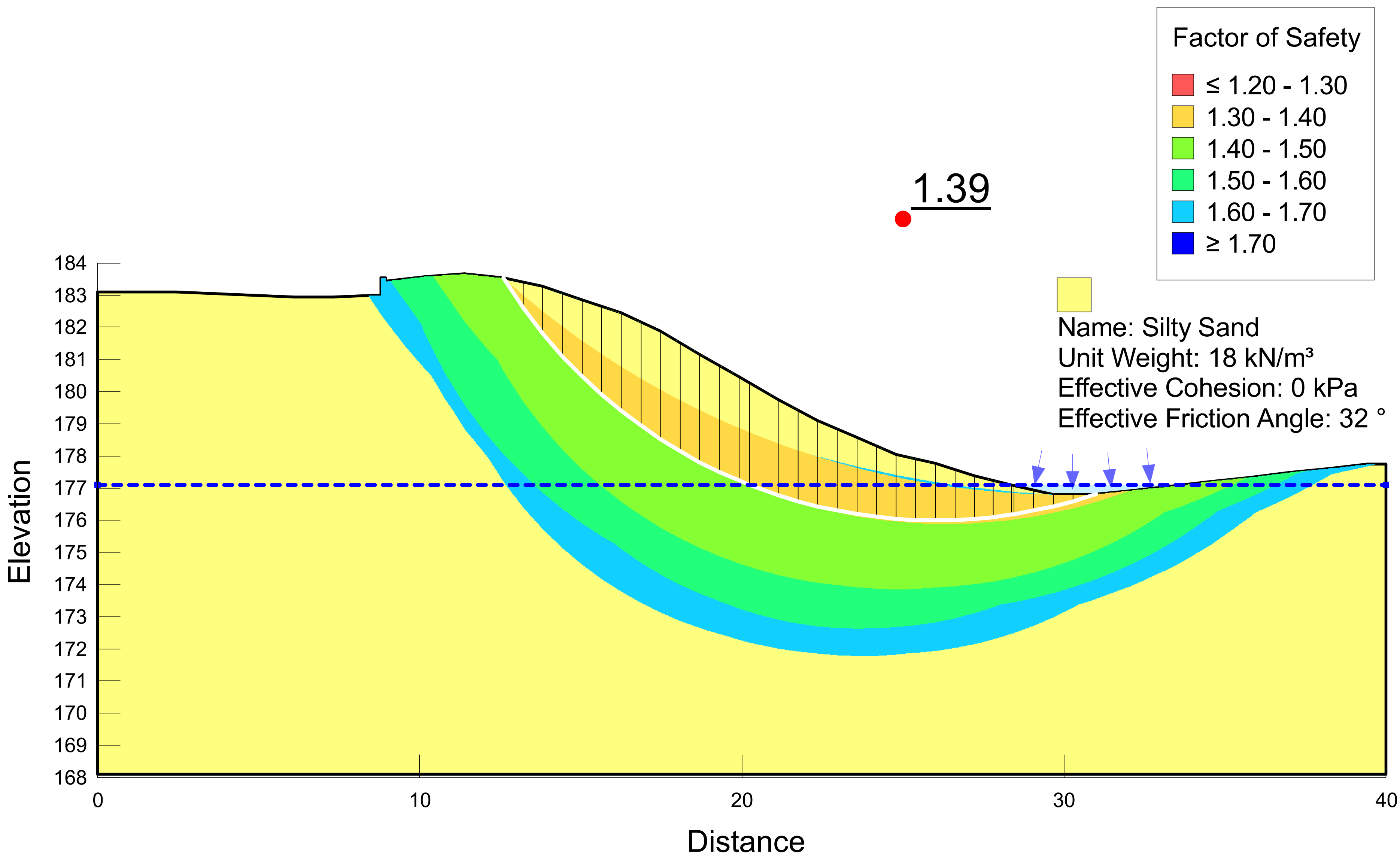
| Slope Stability Analysis - 3637 Firelane 12, Port Colborne |
| Slope Profile C-C (Normal Groundwater) |
| July, 2023 |

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| Slope Stability Analysis - 3637 Firelane 12, Port Colborne |
| Slope Profile C-C (Elevated Groundwater) |
| July, 2023 |