Erosion Hazard Limit Study Report

Heritage Line Residential Development

Lot 14, Concession 6, Otonabee-South Monaghan, ON

D.M. Wills Project Number 21-10985

D.M. Wills Associates Limited
Partners in Engineering, Planning and Environmental Services
Peterborough

August 2021

Prepared for:
Alina Stewart & Shawn Elmhirst

Submissions Summary

Submission No.	Submission Title	Date of Release	Submissions Summary
1	Draft Erosion Hazard Limit Study Report	August 5, 2021	Draft Submission for Client Review and Comment
2	Final Erosion Hazard Limit Study Report	September 8, 2021	Final Submission to Client

This report has been formatted considering the requirements of the Accessibility for Ontarians with Disabilities Act.

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1.0 Introduction

D.M. Wills Associates Limited (Wills) was retained by Alina Stewart and Shawn Elmhirst (Client) to complete an Erosion Hazard Limit Study (Study) for the property located on Lot 14, Concession 6 in the municipality of Otonabee-South Monaghan (Subject Property). A Subject Property Plan showing the approximate property boundary is included as **Figure 1**.

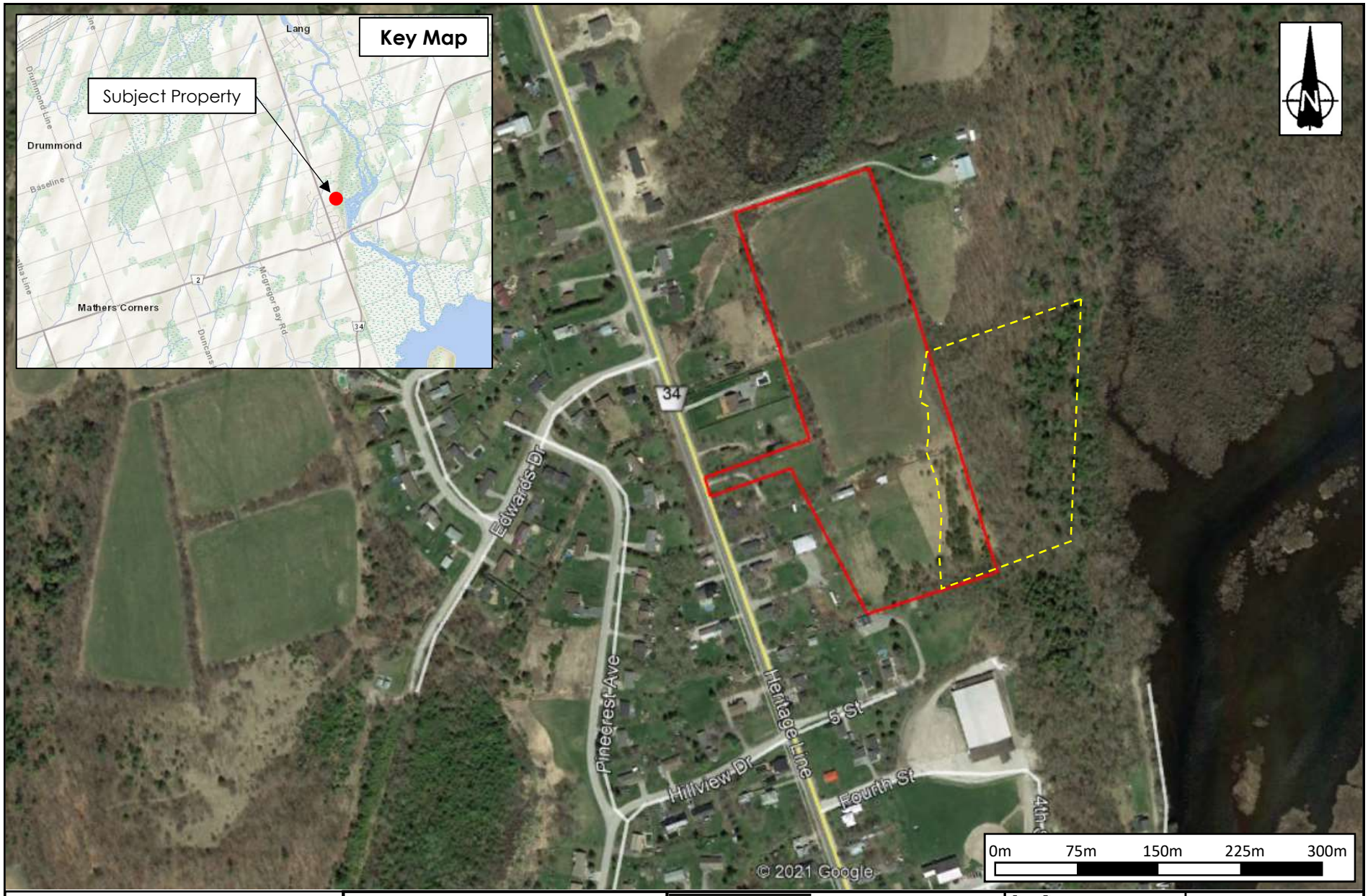
Wills understands that the Subject Property is proposed to be developed as a residential subdivision (Proposed Development), and residential structures are expected to be constructed adjacent to an on-site slope (Subject Slope), located on the southeast side of the Subject Property. The approximate footprint of the Subject Slope is shown on **Figure 1.**

The natural features area surrounding Indian River is within the jurisdiction of the Otonabee Region Conservation Authority (ORCA), and therefore development within and adjacent to this area and associated slopes is regulated by ORCA. Wills' Study is required to confirm the stable top of slope, and associated development setbacks limits in context of the Proposed Development, and was conducted on the basis of the Ministry of Northern Development, Mines, Natural Resources and Forestry (NDMNRF) *Technical Guide for River and Stream Systems: Erosion Hazard Limit (*Technical Guideline).

2.0 Scope of Work

Wills' approved Scope of Work to complete the Study included the following:

- Inspection of the Subject Slope to confirm existing conditions, including:
  - Shallow hand dug test pits to confirm shallow subsurface soils on and adjacent to the Subject Slope.
  - Confirmation of soil exposure over the slope face, toe, and crest.
  - Evidence of slope failures or slumping, scour, or irregularities in encountered soil surfaces; including toe of slope erosion.
  - Observations of vegetation / stabilization of soils.
  - Evidence of groundwater or surface water flows over or through the Subject Slope face.
- Measurement of worst case slope profiles for consideration of overall slope stability.
- Preparation of this Erosion Hazard Limit Study Report, including determination of the stable top of slope and development setback limits in context of the encountered Subject Slope conditions and Proposed Development.



Legend

Subject Property

Subject Slope

Subject Property Plan

Erosion Hazard limit Study
Heritage Line Residential
Development

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Project No. 21-10985	Drawing File No. Figure 1

3.0 Site Reconnaissance

3.1 Subsurface Profile

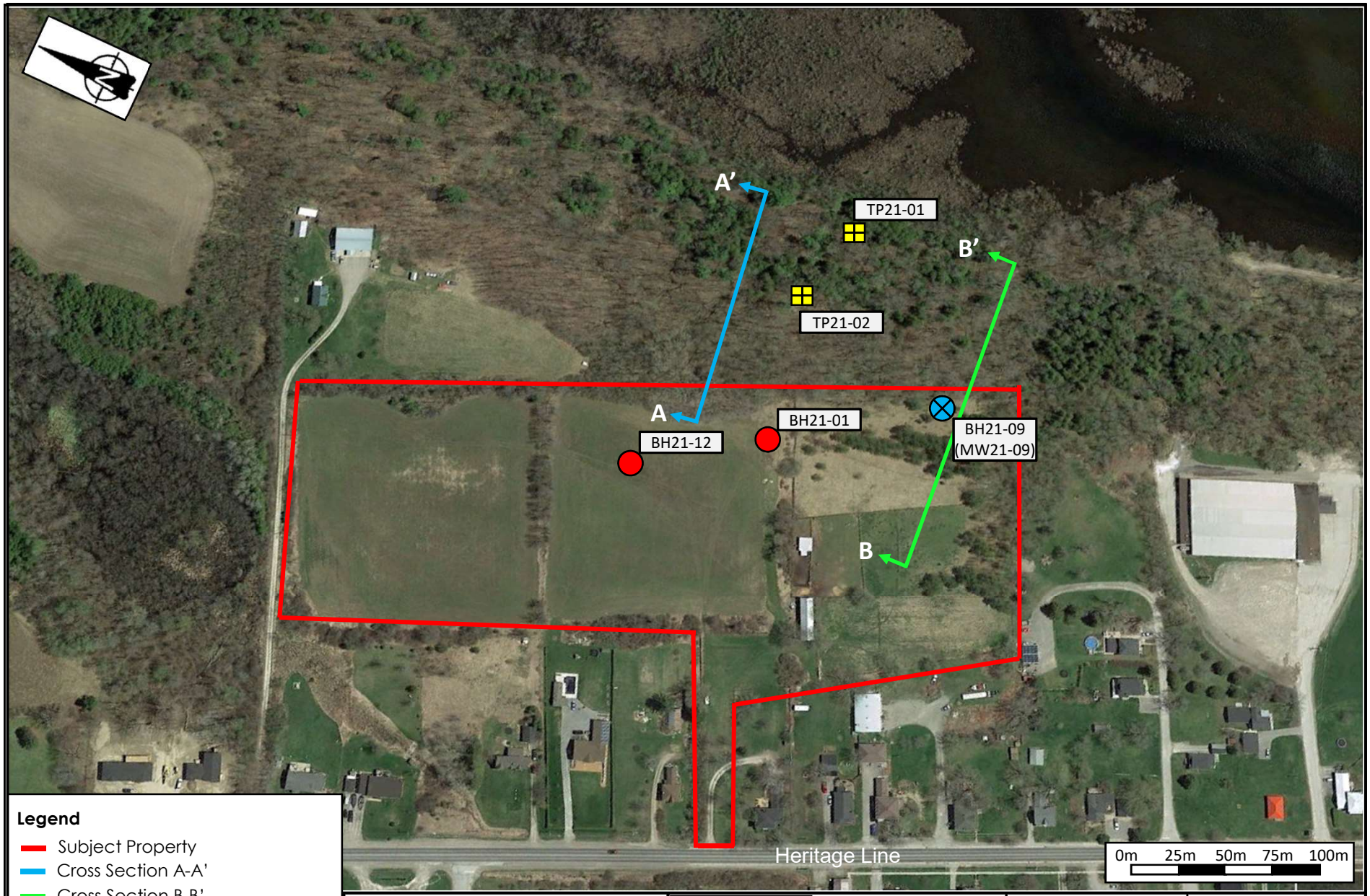
Two (2) hand dug test pits were excavated on the Subject Slope face and toe of slope area by Wills staff on June 30, 2021. The test pits were designated as TP21-01 and TP21-02, and were both terminated at an approximate depth of 0.70 metres below grade (mbg). Test pit locations are shown on **Figure 2.**

Subsurface soil samples, collected from the test pits, were classified in the field based on grain size and stratigraphy. The subsurface profile included a thin layer of sandy silt to silty sand topsoil, underlain by sand at TP21-01 and sandy silt with underlying silty sand till material at TP21-02. **Table 1** summarizes the subsurface conditions encountered at the two (2) test pit locations.

Table 1 – Test Pit Stratigraphy

Test Pit ID/UTM Coordinates	Soil Unit	Depth (mbg)	Material Description
TP21-01	Topsoil	0.00 - 0.4	Dark brown silty sand topsoil, trace clay, rootlets and organics, moist.
17T 0726697 4903228	Sand	0.4 – 0.7	Light brown coarse sand, some silt, trace gravel, occasional cobbles wet to saturated.
TP21-02	Topsoil	0.0 - 0.3	Dark brown sandy silt topsoil, trace clay, rootlets and organics, moist.
17T 0726648 4903241	Sandy silt	0.3 – 0.4	Medium brown silty sand, trace clay, moist.
	Till	0.4 – 0.7	Light brown silty sand, trace clay, trace gravel, occasional cobble, moist.

Wills' oversaw a drilling investigation on the Subject Property between May 3 and May 5, 2021, which was conducted in support of a Hydrogeological Investigation and Geotechnical Investigation for the Proposed Development. Boreholes were advanced using a CME-55 LC track-mounted drill rig and soil samples were obtained using split-spoon samplers. Split-spoon samples were retained for stratigraphic logging and laboratory testing. Three (3) boreholes identified as BH21-01, BH21-09, and BH21-12 were advanced on the Subject Slope crest and face, and are included in this report to corroborate the shallow test pit findings.



Subsurface Investigation Plan

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Project No.	21-10985	Drawing File No.	Figure 2

Borehole locations are shown on **Figure 2,** and the encountered subsurface conditions are summarized in **Table 2.**

Table 2 – Borehole Stratigraphy

Borehole ID/UTM Coordinates	Soil Unit	Depth (mbg)	Material Description
BH21-01	Topsoil	0.0 - 0.7	Dark brown silty sand topsoil, trace gravel, moist, very loose.
17T 0726565 4903233	Silty Gravelly Sand	0.7 – 2.3	Light brown silty gravelly sand, some clay, occasional cobble, moist, compact.
	Till	2.3 – 6.6	Light brown silty gravelly sand till, some clay, occasional cobble, moist to wet, compact to very dense.
BH21-09 (MW21-09)	Topsoil	0.0 - 0.7	Dark brown silty sand topsoil, trace gravel, moist, very loose.
17T 0726615 4903148	Sandy silt	0.7 – 2.3	Light brown sandy silt, some clay, trace to some gravel, moist to wet, compact.
	Till	2.3 – 6.6	Light brown sandy silt till, some clay, trace to some gravel, moist to wet, compact to very dense.
BH21-12	Topsoil	0.0 - 0.7	Dark brown silty sand topsoil, moist, very loose.
17T 0726526 4903296	Sandy silt	0.7 – 2.3	Light brown silty sand, some clay, trace gravel, occasional cobble, wet, loose.
	Till	2.3 – 6.6	Light brown silty sand till, some clay, trace gravel, occasional cobble, wet, compact to very dense.

Based on Wills' subsurface investigations, the inferred subsurface profile on the Subject Slope includes a surficial layer of silty sand topsoil, underlain by silty sand (with varying amounts of gravel), and a basal layer of silty sand till. Bedrock was not encountered in any of the borehole locations during the subsurface investigation.

In view of the encountered subsurface conditions, Wills' expects that the overall stability of the Subject Slope will be governed by the compact to very dense glacial till material that is generally encountered below a depth of approximately 2.3 mbg.

3.2 Slope Inspection

An inspection of the Subject Slope was conducted on June 30, 2021, and included a visual inspection of the toe of slope, slope face, and crest, as well as a survey of two (2) 'worse-case' (steepest) sections of the Subject Slope using a clinometer and tape measure. The survey was used to corroborate a topographic survey completed by Elliot and Parr (Peterborough) Ltd. (Reference No.: 21-19-079-00) for the Subject Property, and to measure slope gradients outside (east) of the Subject Property boundary towards Indian River.

The slope sections surveyed by Wills are shown on **Figure 2** and were designated as section A-A' and section B-B'**.** In general, the Subject Slope ranges in height from approximately 30 to 35 meters, and maintains slope gradients from 3H:1V (horizontal:vertical) to shallower than 4H:1V. Isolated areas on the Subject Slope maintain gradients approaching 2H:1V, although these areas represent a small percentage of the slope profile and are not expected to affect the overall slope stability. Cross sections A-A' and B-B' are included in **Appendix A**, and are discussed in further detail in **Section 3.3.**

The following visual observations of the Subject Slope and surrounding area are provided on the basis of Wills' inspection:

- Existing features on the Subject Slope include a meandering trail that is located along the slope face, as well as a raised trail that runs generally north-south along the toe of slope area.
- The Subject Slope face is well vegetated with mixed mature tree species (including poplar and pine species) with an understory of grasses that transitions into both mature deciduous tree species (Including maple species) with an understory of juvenile trees (including cedar, birch, and elm) and shrubs at the toe of slope area.
- The area to the east of the toe of slope includes mixed tree species that transition into wetland species at the edge of Indian River, which is located in excess of 45 m from the toe of slope.
- Evidence of preferential surface water flows over Subject Slope face were not observed during the inspection. Drainage along the Subject Slope is anticipated to follow natural topographic lows, however, evidence of overland flows or erosion (e.g. scour, gullies, or bare areas) were not observed.
- The Subject Slope face was free of groundwater seepage.
- No major disturbance in the form of slumping or tension cracking was observed.
- A photographic log showing the Subject Slope and surrounding features is included in **Appendix B**.

On the basis of Wills' site reconnaissance findings, the Subject Slope was evaluated using *Table 4.2 – Slope Stability Rating Chart* in the Technical Guideline. Wills determined a slope instability rating of 19 for the Subject Slope on the basis of the provided criteria, as summarized in **Table 3**. In view of this rating, the Subject Slope is considered to have low potential for instability (rating of less than 24), and therefore, a site inspection only, with confirmation and a report letter are considered to be sufficient investigative requirements on the basis of the Technical Guideline.

Table 3 – Slope Stability Investigation Rating

Feature	Field Observations	Slope Stability Rating Value
1. Slope Inclination	3H:1V or Flatter	0
2. Soil Stratigraphy	Glacial Till	9
3. Seepage from Slope Face	None	0
4. Slope Height	30 to 34 m	8
5. Vegetation Cover on Slope Face	Well vegetated	0
6. Table Land Drainage	Minor drainage over slope, no active erosion	2
7. Proximity of Watercourse to Slope Toe	More than 15 m from slope toe	0
8. Previous Landslide Activity	No	0
Slope Instability Rating Values Investigation Rating Summary		**Total: 19**

Note: Slope stability rating values informed by Table 4.2 (Page 57) Slope Stability Rating Chart in the Technical Guideline.

The completed *Table 4.2 – Slope Stability Rating Chart* and summary of rating values and resulting investigation requirements from the Technical Guideline is included in **Appendix C.**

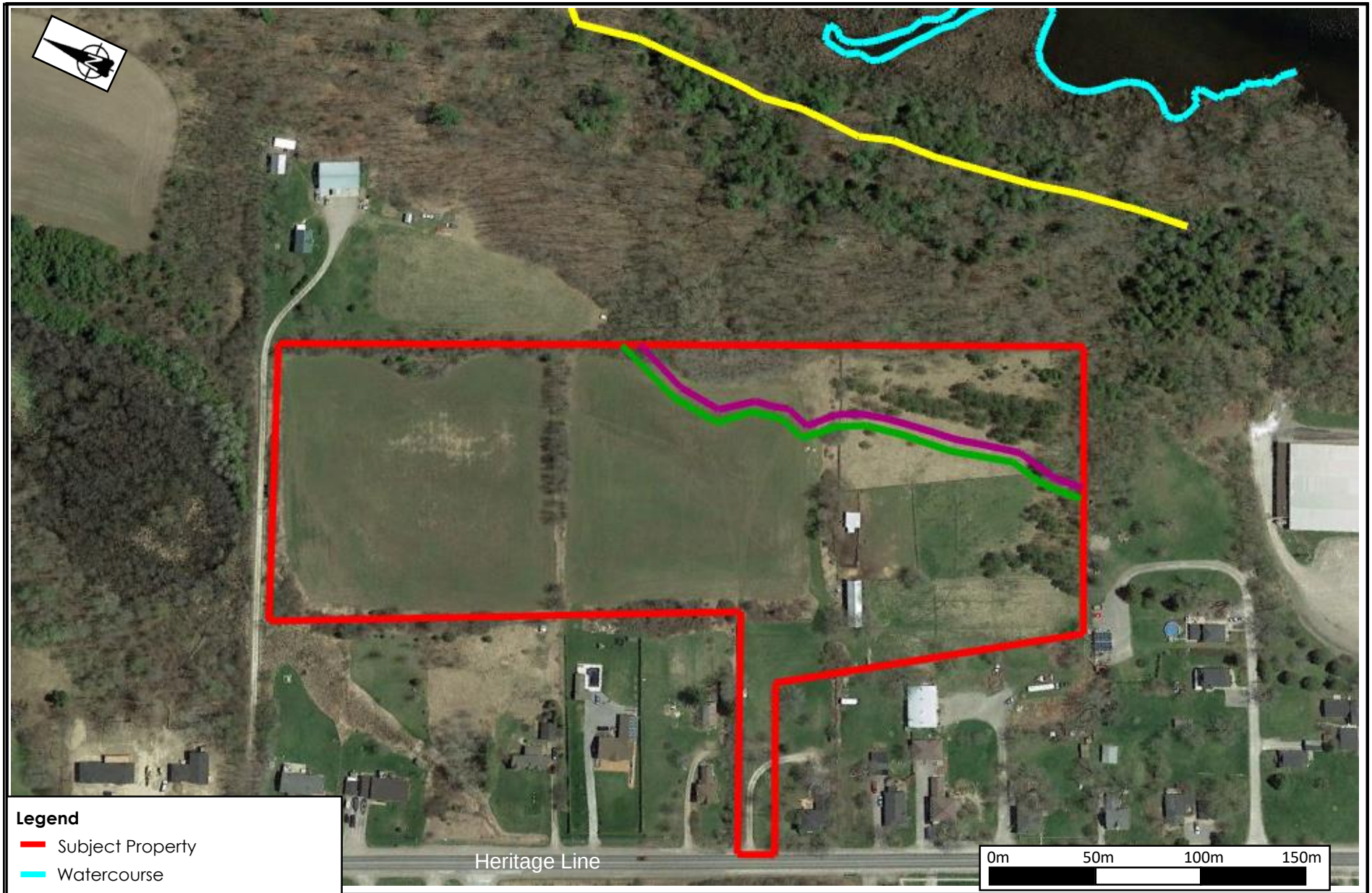
3.3 Slope Stability Setbacks

The results of Wills' site reconnaissance were used to determine the appropriate development slope stability setbacks on the basis of the Technical Guideline

requirements. Slope stability setbacks are illustrated on Slope Sections AA' and BB' in **Appendix A,** as well as on the Slope Stability Setback Plan included as **Figure 3.**

Wills provides the following with respect to the slope stability setbacks determined for the Subject Slope:

- Existing topographic survey for the Subject Slope, and Wills' confirmatory slope measurements indicate the Subject Slope has an overall gradient that is shallower than 3H:1V (as projected from the toe of slope), and is considered stable on the basis of the Technical Guideline.
- A toe erosion allowance was not applied in view of the Indian River (watercourse) being in excess of 15 m away from the toe of slope.
- The long term stable top of slope (LTSTOS) was determined to be the existing top of slope, as determined by Wills staff during the site reconnaissance.
- Based on the Technical Guideline, a 6 m erosion access allowance was applied beyond the LTSTOS. Although this allowance will likely not be required to permit slope stabilization activities, the 6 m allowance also coincides with the 6 m development setback limit provided in ORCA's *Watershed Planning & Regulation Policy Manual* (updated December 4, 2015) for subdivisions, condominiums, and consents in the vicinity of a confined/apparent valley system.



Legend

- Subject Property
- Watercourse
- Toe of Slope
- Long Term Stable Top of Slope (LTSTOS)
- LTSTOS with 6m Erosion Access Allowance

Slope Stability Setback Plan

Erosion Hazard Limit Study
Heritage Line Residential Development

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Checked IA	Date July, 2021
Project No. 21-10985	Drawing File No. Figure 3

4.0 Conclusions and Recommendations

Based on Wills' Assessment, the following conclusions and recommendations are provided.

- A Site reconnaissance including a slope inspection and subsurface investigation was completed by Wills on June 30, 2021. Subsurface information was corroborated using borehole data collected by Wills on the Subject Property in May 2021 (under a separate assignment).
- The Subject Slope is located on the south-east side of the Subject Property, is approximately 30 to 34 m in height, and maintains slope gradients that generally range from 3H:1V to 4H:1V or shallower. The Subject Slope is considered stable on the basis of the Technical Guideline.
- Isolated areas on the Subject Slope maintain gradients that approach 2H:1V, however, these steeper sections are considered insignificant and are not expected to influence the overall slope stability.
- The inferred subsurface profile on the Subject Slope includes a surficial layer of silty sand topsoil, underlain by silty sand, and a basal layer of silty sand till. Bedrock was not encountered in any of the borehole locations during the subsurface investigation.
- Wills' expects that that overall stability of the Subject Slope will be governed by the compact to very dense glacial till material that is generally encountered below a depth of approximately 2.3 mbg.
- The Subject Slope is well vegetated with mature trees and understory growth, and shows no visible signs of groundwater seepage, surface water scour/erosion, tension cracking or slumping.
- The Indian River shoreline is in excess of 45 m away from the toe of slope. A toe erosion allowance was not applied to the slope stability setbacks.
- In view of the stable slope gradients measured by Wills, the LTSTOS was determined to be the existing physical top of slope.
- A 6 m erosion access allowance was applied beyond the LTSTOS, which aligns with the 6 m development setback limit provided in ORCA's *Watershed Planning & Regulation Policy Manual* (updated December 4, 2015) for subdivisions, condominiums, and consents in the vicinity of a confined/apparent valley system.

We trust that the information contained in and attached to this report meets your needs at this time. The following Statement of Limitations should be read carefully and is an integral part of this report. Do not hesitate to contact the undersigned if you have any questions or concerns.

Respectfully submitted,

Prepared by: _____
Ian Ames, M.Sc., P.Geo.
Environmental Monitoring and
Management Lead

Reviewed by: _____
Michael J. Lord, B.A., Dipl. ET
Manager, Environmental Services

HW/IA/avg

Statement of Limitations

This report is intended solely for Alina Stewart and Shawn Elmhirst (Client) for the Proposed Development located on Lot 14, Concession 6 in the municipality of Otonabee-South Monaghan, ON, and is prohibited for use by others without D.M. Wills Associates Limited's (Wills) prior written consent. This report is considered Wills' professional work product and shall remain the sole property of Wills. Any unauthorized reuse, redistribution of or reliance on this report shall be at the Client and recipient's sole risk, without liability to Wills. The Client shall defend, indemnify and hold Wills harmless from any liability arising from or related to the Client's unauthorized distribution of the report. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include supporting drawings and appendices.

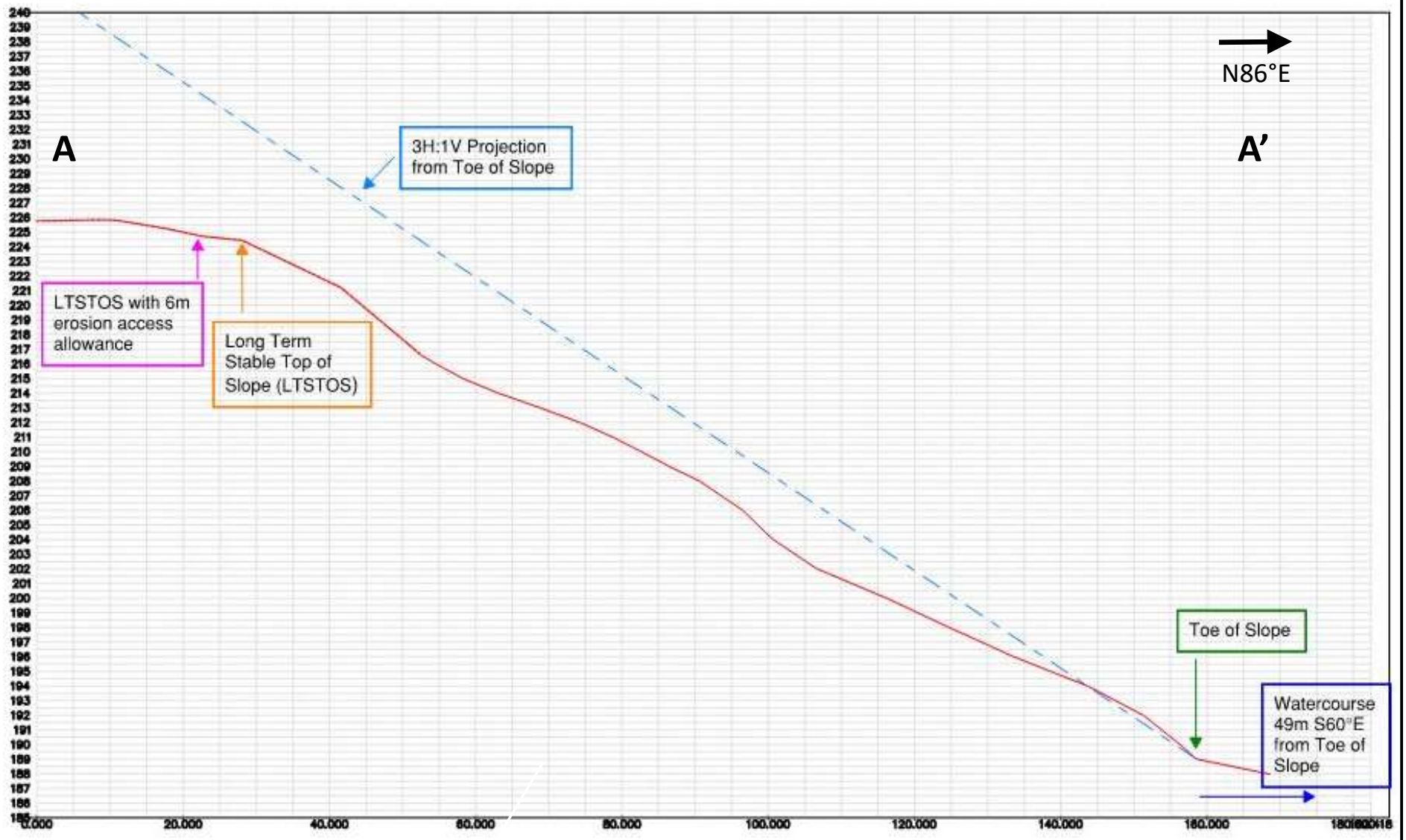
The recommendations made in this report are based on Wills' present understanding of the project, the current and proposed site use, ground and subsurface conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with the level of care and skill ordinarily exercised by members of geoscience or engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the sole responsibility of such third parties.

The recommendations and comments made in this report are based on Wills' investigations and resulting understanding of the project, as defined at the time of the assignment. Wills should be retained to review our recommendations when the final or any modified design drawings and specifications are complete. Without this review, Wills shall not be liable for any misunderstanding of our recommendations or their application and adaptation.

Soil, bedrock, and groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations. Should any conditions at the Subject Property be encountered which differ from those found at the test locations, Wills must be notified immediately in order to permit a reassessment of our recommendations. If different conditions are identified, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by Wills is completed.

Appendix A

Subject Slope Cross Sections



Vertical Exaggeration: 2X
Units: meters

Legend

- Surveyed Ground Surface (Wills)
- Stable 3H:1V Projection

Slope Section AA'

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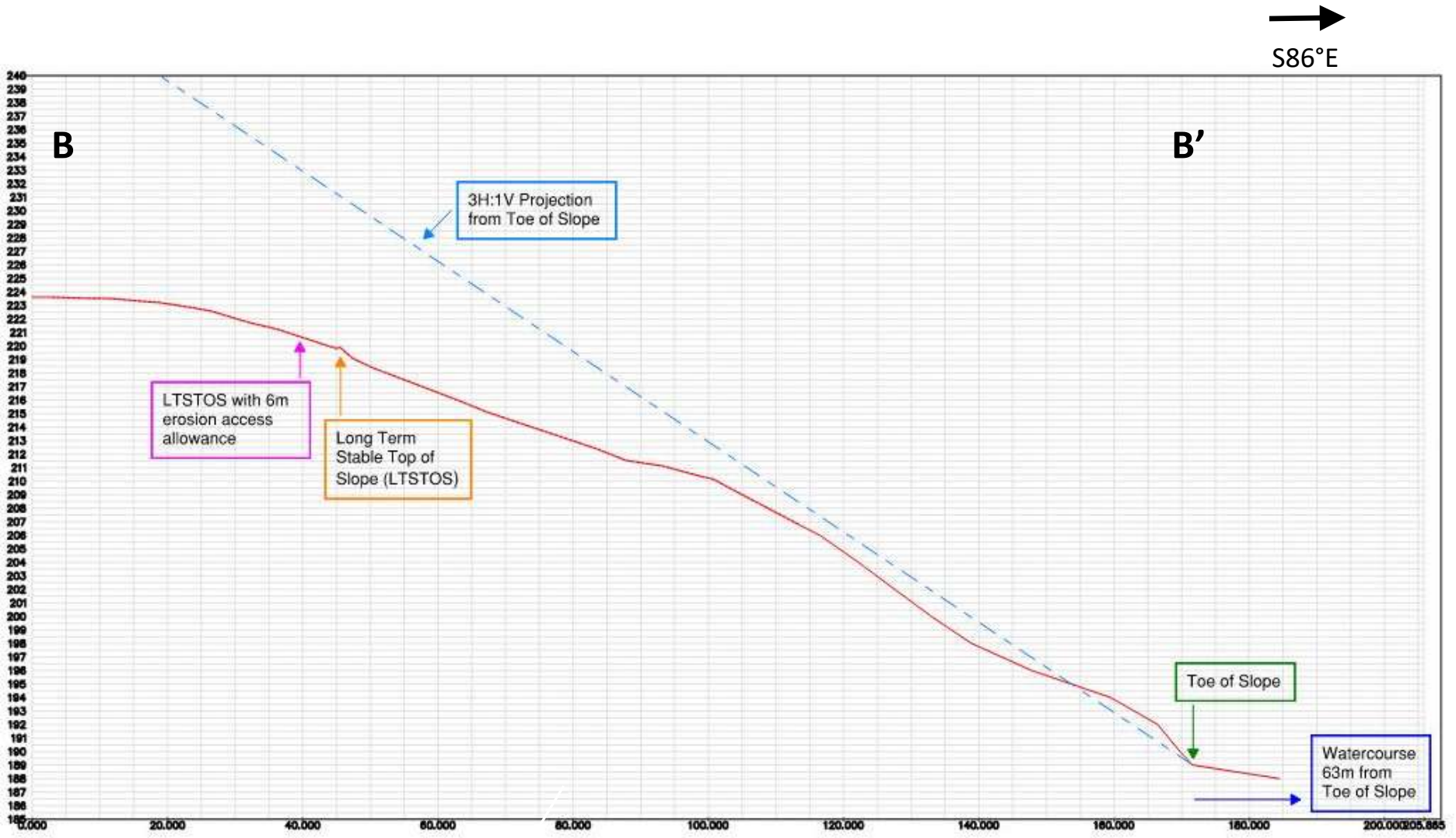

Vertical Exaggeration: 2X
Units: meters

Legend

Surveyed Ground Surface (Wills)
Stable 3H:1V Projection

Slope Section BB'

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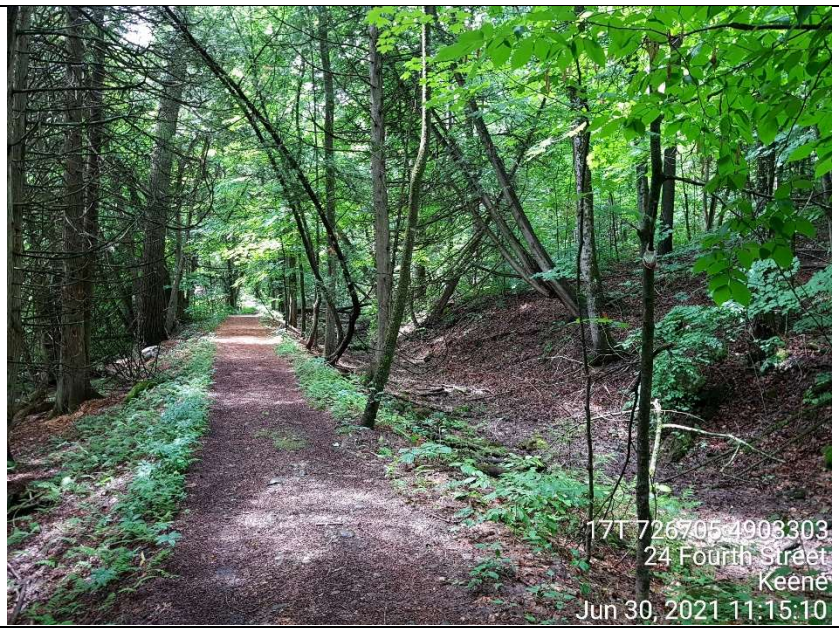
Appendix B

Photographic Log

Client Name:	**Site Location:**
Alina Stewart & Shawn Elmhirst	Lot 14, Concession 6, Otonabee-South Monaghan, ON

Photograph No.: 1
Date: June 30, 2021
Direction: South
Description: Trail adjacent to toe of slope.



Photograph No.: 2
Date: June 30, 2021
Direction: West
Description: TP21-01 at toe of slope. Dark brown sandy silt topsoil overlying light brown sand material. Groundwater pooling in test pit.

Photograph No.: 3
Date: June 30, 2021
Direction: West
Description: TP21-02 on slope face. Dark brown sandy silt topsoil overlying medium to light brown silty sand till. No groundwater encountered.

Photograph No.: 4
Date: June 30, 2021
Direction: North
Description: View of mid-section of slope. Ground cover, mixed forest and deadfall.

Photograph No.: 5
Date: June 30, 2021
Direction: North
Description: Mid-section of slope. Ground cover and hardwood growthq.

Photograph No.: 6
Date: June 30, 2021
Direction: Northwest
Description: Photo taken west of tree line, slope crest visible in background.

Photograph No.: 7
Date: June 30, 2021
Direction: South
Description: Southern end of Subject Property. Slope crest visible on left adjacent to tree line.

Appendix C

MNRF Table 4.2 – Slope Stability Rating Chart

TABLE 4.2 - SLOPE STABILITY RATING CHART

Site Location: File No.
Property Owner: Inspection Date:
Inspected By: Weather:

1.	**SLOPE INCLINATION**		
	degrees	**horiz. : vert.**	
a)	18 or less	3 : 1 or flatter	(0)
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)
d)	Clay, Silt		12
e)	Fill		16
f)	Leda Clay		24
3.	**SEEPAGE FROM SLOPE FACE**		
a)	None or Near bottom only		(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
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)
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
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)
b)	Less than 15 metres from slope toe		6
8.	**PREVIOUS LANDSLIDE ACTIVITY**		
a)	No		(0)
b)	Yes		6

SLOPE INSTABILITY RATING VALUES INVESTIGATION RATING SUMMARY **TOTAL 19**

SUMMARY OF RATING VALUES AND RESULTING INVESTIGATION REQUIREMENTS

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.

The Rating Chart identifies 3 levels of stability and associated investigation requirements. The three levels are:

1. Stable / Site Inspection Only
A rating of 24 or less, suggests stable slope conditions,

- no toe erosion,
- good vegetation cover
- no evidence of past instability
- no structures within (slope height) of the crest

and that no further investigation (beyond visual inspection) is needed. This should be simply confirmed through a visual site inspection and estimate of the slope configuration and slope stratigraphy and drainage (i.e. no measurements). Confirmation of the slope stability should be provided in the form of a letter (signed and sealed with A.P.E.O. stamp) from an experienced and qualified geotechnical engineer. The letter should include a summary of the site inspection observations which could be recorded on a Slope Inspection Form (see enclosed) and should clearly identify;

- slope height and inclination,
- vegetation cover on slope face,
- toe erosion, or surface erosion on slope,
- structures near slope crest or on slope,
- drainage features near slope crest, on slope face, or near slope toe.

2. Slight Potential / Site Inspection, Preliminary Study
A rating between 25-35 suggests the presence of several surface features that could create an unstable slope situation. The stability of the slope should be confirmed through a visual site inspection only, without boreholes. In addition to recording the visual observations outlined in the section above, some direct measurements of site features are required.

The slope height and inclination should be determined either with a hand inclinometer, or by 'breaking slope', or from mapping, or by surveying. As well, more information about the soil stratigraphy of the slope, should be obtained (without drilling boreholes) based on either previous or nearby subsurface investigations, or geologic mapping, or hand augering or test pits to determine shallow depth soil type(s). Measurements should be taken (by hand tape or surveying) of the locations of structures relative to the crest, and other features such as vegetation, past slide features (tension cracks, scarps, slumps, bulges, ridges), and erosion features. If available, historical air photographs should be examined for evidence of any past instability over the long-term. Confirmation of the slope stability should be provided in the form of a detailed report (signed and sealed with A.P.E.O. stamp) from an experienced and qualified geotechnical engineer.

This report will include:

- Slope Inspection Record (Appendix)
- a Site Plan and a Slope Profile indicating the positions of the various measurements taken on site (slope crest, slope toe, location of structures relative to crest, drainage features, erosion features, vegetation cover, indicators of past instability or movements)
- photographs of the site and slope conditions
- a discussion of the site inspection and measurements taken, review of previous information
- preliminary engineering analysis of slope stability (i.e., calculation of Factor of Safety) based on the above information and measurements, but utilizing conservative soil strength parameters and groundwater conditions since boreholes were not carried out.

3. Moderate Potential / Borehole Investigation
A rating of more than 35 suggests a moderate potential for instability. This may result if the slope is either steep, high and/or has several features that could create an unstable slope situation. The stability of the slope should be assessed more precisely through topographic survey of slope configuration and boreholes for slope stratigraphy and penetration resistance tests. Piezometers must be installed in the boreholes and measurements must be taken for groundwater levels. Laboratory testing on the borehole samples must be conducted to measure Basic Index Properties (water contents, unit weights, grain size distribution, Atterberg Limits) described in Appendix D, or other properties as required.

A detailed engineering stability analysis must be conducted to determine if the Factor of Safety for the original slope conditions equals or exceeds a design minimum Factor of Safety. The analysis should be based on the information obtained from the site survey and the borehole information. Historical data such as air photographs should also be reviewed. Confirmation of the slope stability or instability (and the stable slope inclination) should be provided in the form of a detailed report (signed and sealed with A.P.E.O. stamp) from an experienced and qualified geotechnical engineer. This