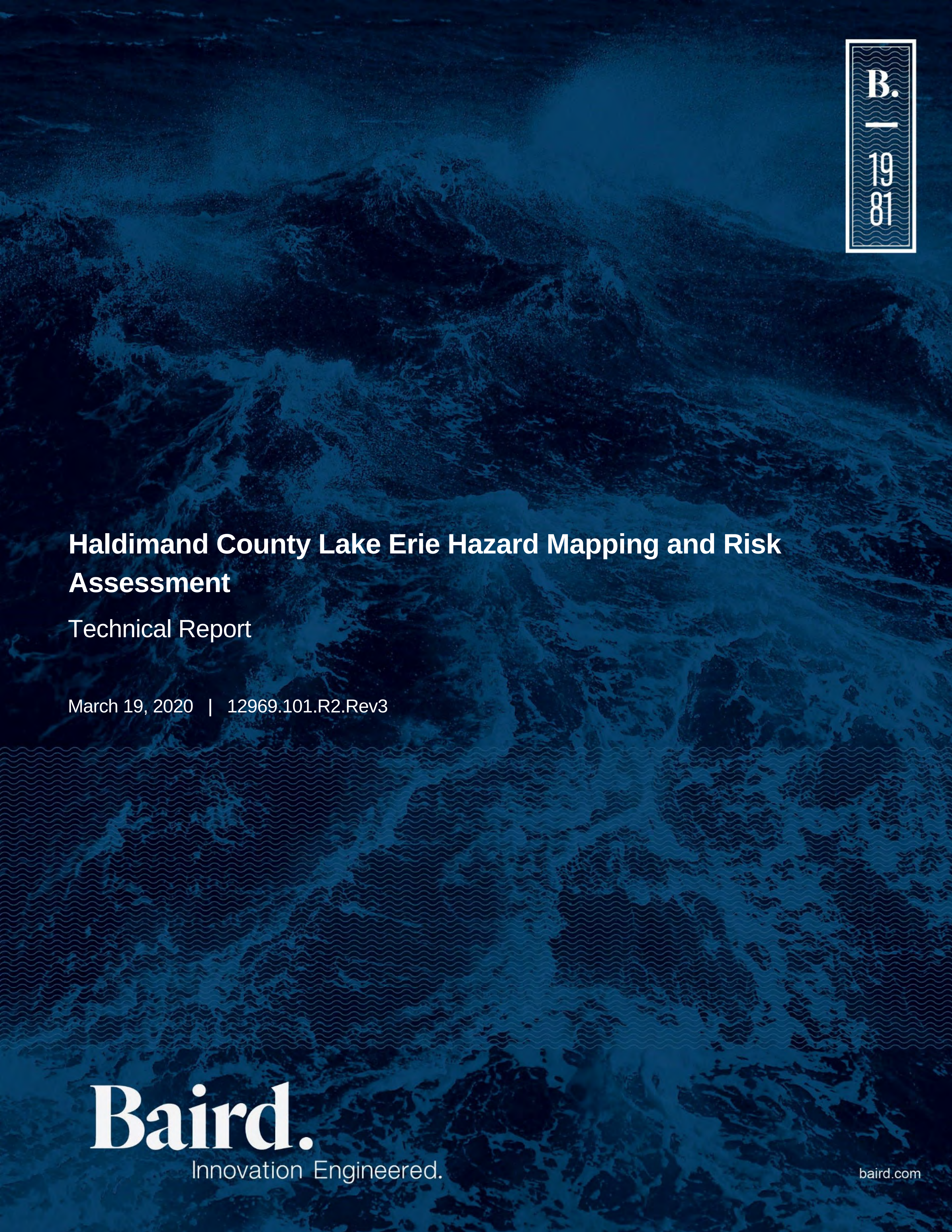

Haldimand County Lake Erie Hazard Mapping and Risk Assessment

Technical Report

March 19, 2020 | 12969.101.R2.Rev3

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Haldimand County Lake Erie Hazard Mapping and Risk Assessment

Technical Report

Prepared for:

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On behalf of Haldimand County, Long Point Region Conservation Authority and Niagara Peninsula Conservation Authority

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12969.101.R2.Rev3

Haldimand County Lake Erie Hazard Mapping and Risk Assessment

Technical Report

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Rev A	2019 08 12	Draft	Preliminary – not for review	SKL/JDW	FJLD	FJLD
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Rev 3	2020 03 19	Final		JDW/FJLD	FJLD	FJLD

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Figures

1. Introduction

The Grand River Conservation Authority (GRCA), on behalf of Haldimand County and neighbouring Niagara Peninsula Conservation Authority (NPCA) and Long Point Region Conservation Authority (LPRCA) retained Baird & Associates with geotechnical sub-consultant Terraprobe Inc. to undertake the Haldimand County Lake Erie Hazard Mapping project. This report describes the technical studies undertaken to update the Lake Erie hazard mapping for Haldimand County.

Haldimand County has 87 km of Lake Erie shoreline, spanning parts of the jurisdictions of three Conservation Authorities (GRCA, LPRCA and NPCA) as shown in Figure 1.1. The lakeshore area is comprised predominantly of agricultural lands with strip residential developments bisected by the Lakeshore Road. There are designated tourist residential nodes that consist of a mix of seasonal and year-round developments. Some of these major nodes include Peacock Point, Featherstone Point, Hoover Point, Evans Point and Mohawk Point. There are also many seasonal trailer parks and campgrounds within the lakeshore area. In addition to these privately owned facilities, there are several Provincial Parks, Conservation Areas and other public facilities such as Port Maitland where the Grand River spills into Lake Erie. Dunnville is a town of 12,000 located on the Grand River about 7 km upstream from Lake Erie. Portions of Dunnville are at sufficiently low elevations where they are subject to lake related flood impacts in addition to riverine flooding. The Lake Erie flood hazard extends about 9 km upstream of the Dunnville Dam.

Previous shoreline hazard mapping for the County within LPRCA and GRCA jurisdictions was prepared in the late 1980s to early 1990s, while the mapping within the NPCA jurisdiction was updated in 2010. Since completion of some of this work, the provincial technical guidance has been updated (2001), and there have been legislative changes, including an updated Provincial Policy Statement (2014) under the Planning Act, and new regulations under the Conservation Authorities Act.

This report summarizes the technical analyses undertaken to update the Lake Erie shoreline flooding, erosion, and dynamic beach hazard mapping within Haldimand County. The mapping, provided under separate cover, supports land use planning and permitting decisions in at-risk communities such as Dunnville and Port Maitland and the numerous shoreline areas within the County. Updates to conservation authority shoreline management plans and Haldimand County official plan policies were outside the scope of the project.

The technical information for this project may also support flood and erosion-related response and mitigation planning. Updates to a risk assessment for shoreline flooding, including estimates of damage potential, are provided under separate cover.

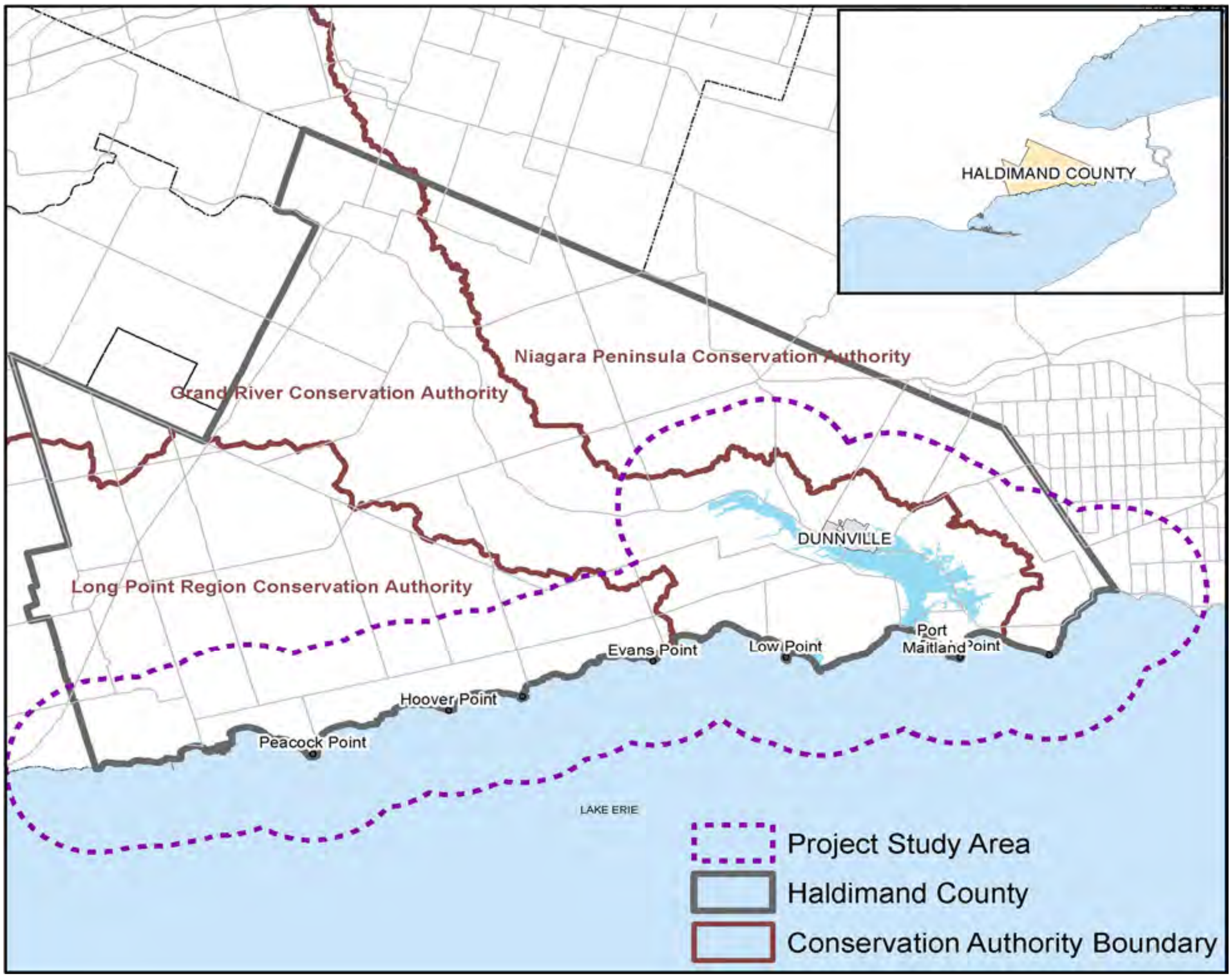

Figure 1.1: Map showing study area, Haldimand County, and Conservation Authority boundaries

2. Previous Technical Studies

Key technical studies and data, relevant to the development of the Haldimand County Lake Erie hazard mapping are summarized in this section.

2.1 Policies for the Administration of Ontario Regulations 178/06, 150/06 and 155/06

Ontario Regulation 97/04 stipulates the criteria by which each Conservation Authority must establish its updated regulated area or ‘Regulation Limit’. The Province of Ontario subsequently enacted the regulations listed in Table 2.1, requiring each Conservation Authority (CA) to regulate areas that are river or stream valleys, wetlands and other areas where development could interfere with the hydrologic function of a wetland, adjacent or close to the shoreline of Great Lakes-St. Lawrence System and inland lakes that may be affected by flooding, erosion or dynamic beach hazards. The Regulated Area represents the greatest extent of the combined hazards plus a prescribed allowance as set out in the Regulation.

Each CA has developed a policy for making decisions regarding the outcome of applications made under the Regulations, to ensure a consistent, timely and fair approach to the review of applications, staff recommendations and CA decisions, and to achieve efficient and effective use and allocation of available resources. The regulations and policies reviewed for this study are listed in Table 2.1.

Table 2.1: Ontario regulations for the individual Conservation Authorities

Conservation Authority	Ontario Regulation	CA Policy
Long Point Region	178/06	*Policies for the Administration of the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation (received by Board of Directors Oct. 4, 2017)*
Grand River	150/06	*Policies for the Administration of the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation (approved Oct. 23, 2015)*
Niagara Peninsula	155/06	*Policies for the Administration of the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation (approved Sept.19, 2018)*

2.2 Shoreline Management Plans

2.2.1 Grand River Conservation Authority (1994)

Shoreline Management Plan (Technical Components), Grand River Conservation Authority (Shoreplan Engineering Ltd., 1994) is the current shoreline management plan for the Grand River CA. It presents the methodologies used in 1994 to delineate the flood, erosion and dynamic beach hazards. This document predates the *Technical Guide for the Great Lakes – St. Lawrence River System and Large Inland Lakes (MNR, 2001a)*, which provides technical direction on the methodologies to be used when delineating the natural hazard limits. The Average Annual Recession Rate (AARR) were based on limited data presented in the Great Lakes Shore Damage Survey Coastal Zone Atlas (MNR, EC, 1975). Since that time, additional data has become available and approaches to delineating the hazards have advanced.

2.2.2 Long Point Region Conservation Authority (1989)

Shoreline Management Plan. Long Point Region Conservation Authority (Philpott Associates, 1989) is the current shoreline management plan for the Long Point Region CA. It presents the methodologies used in 1989 to delineate the flood, erosion and dynamic beach hazards. This document predates MNR (2001a), which provides technical direction on the methodologies to be used when delineating the natural hazard limits. Philpott (1989) describes the flood hazard as the "100-year uprush limit"; the erosion hazard as 100 times the AARR plus a stable slope allowance; and the dynamic beach as the landward limit of the cohesionless beach deposit. Limited detail on mapping methodologies is provided. Since that time, additional data has become available and approaches to delineating the hazards have advanced.

2.2.3 Niagara Peninsula Conservation Authority (2010)

Lake Erie Shoreline Management Plan Update, Niagara Peninsula Conservation Authority (Shoreplan Engineering Limited, 2010) is the current shoreline management plan for Niagara Peninsula CA's Lake Erie shoreline. It presents the methodologies used to delineate the flood, erosion and dynamic beach hazards in 2010, and was an update to the Niagara Peninsula CA's previous Lake Erie shoreline management plan from 1992.

A review of Shoreplan (2010) indicates that the Average Annual Recession Rate (AARR) used to delineate the erosion hazard, was not updated for the 2010 mapping. Instead, AARR developed for the previous shoreline management plan based on the following data were used: the Coastal Zone Atlas (MNR and EC, 1975); the Great Lakes Erosion Monitoring Program (Boyd, 1981); and Erosion Monitoring Station profiles surveyed by NPCA between 1983 and 1990 to estimate the AARR. For some reaches, recession rates were based on limited data that did not meet the definition of an acceptable level of data as defined in MNR (2001a). A default stable slope allowance of 3 horizontal to 1 vertical (3H:1V) was used.

2.3 Haldimand County Official Plan

The Haldimand County Official Plan (2006) was approved by Haldimand County on June 26, 2006, and by the Ministry of Municipal Affairs and Housing in 2009. The document provides a 20-year strategic vision for managing growth and future land use decisions in the County. It also provides the link through which the Provincial Policy is implemented into the local context.

The Official Plan recognizes the natural hazards and identifies Haldimand County's commitment to the protection of life and property by respecting natural and man-made hazards. It states that development shall be directed away from Hazard Lands, while recognizing that there are certain areas of the County where extensive development has taken place within Hazard Lands. The hazard mapping that was updated during this project is referenced in the Official Plan.

2.4 Technical Direction

2.4.1 Technical Guide for Great Lakes - St. Lawrence River System

In 2001, the Ministry of Natural Resources (now the Ontario Ministry of Natural Resources and Forestry (MNRF)) released the Technical Guide for the Great Lakes – St. Lawrence River System and Large Inland Lakes (MNR, 2001a). This guide provides the technical basis and procedures for establishing the hazard limits for flooding, erosion, and dynamic beaches in Ontario as well as options for addressing the hazards.

2.4.2 Understanding Natural Hazards

The Ontario Ministry of Natural Resources (now the Ontario Ministry of Natural Resources and Forestry) also prepared Understanding Natural Hazards (MNR, 2001b) to assist the public and planning authorities with an explanation of the Natural Hazard Policies (3.1) of the Provincial Policy Statement of the Planning Act. This publication updates and replaces the older Natural Hazards Training Manual (from 1997). This document is also referenced when addressing natural hazard concerns.

2.4.3 Great Lakes System Flood Levels and Water Related Hazards

This document was developed by the Ontario Ministry of Natural Resources (1989) to assist Conservation Authorities in delineating shoreline hazard areas. It includes a combined probability analysis of Great Lakes water levels, considering monthly mean water levels and surge. Water levels are presented for the 100-year return period event, as well as other return periods. While this document is referenced in the Technical Guide (MNR, 2001a), for use in calculating hazard limits, it does not consider the 30 years of water level data collected since 1989. Section 6.1 provides an analysis of the most recent water level data.

3. Data

3.1 Aerial Imagery

The 2015 Southwestern Ontario Orthophotography Project (SWOOP) acquired aerial imagery at 20 cm resolution through the Government of Ontario's Imagery Acquisition Strategy that provides Land Information Ontario (LIO) with a mandate to collect and refresh imagery for southern Ontario on a five-year cycle. Data was collected between 12 April and 23 May 2015. This dataset is consistent across the entire study area of Haldimand County. The imagery provides a visual reference for ground features such as the delineation of shore protection structures, indications of shoreline substrate, and was used as a base layer for the 1:2,000-scale mapping developed for this study.

3.2 Elevation

Two elevation datasets were used to develop the Hazard Mapping, 2017 Lake Erie Watershed LiDAR and 2015 SWOOP. These data sets provide elevation surfaces for calculations of flooding and erosion hazards, and they were used to extract profiles for the slope stability analysis. The data also provide contours as cartographic elements, that are included in the 1:2,000-scale series of maps.

The 2017 Lake Erie Watershed LiDAR data were collected as part of the Ontario Government's LiDAR Digital Terrain Model (2016-2018) LIO Dataset. The Airborne Topographic LiDAR (ATL) was acquired through a collaborative partnership between the Ministry of Natural Resources and Forestry (MNRF), the Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and a private contractor. It was collected in March to May 2017 and October to December 2017. The LiDAR Digital Terrain Model (DTM) is a 50 cm resolution raster representing the bare-earth terrain derived from a classified LiDAR point cloud, which has been hydro-flattened using water body breaklines. This dataset provides coverage of the Grand River and most of the Haldimand County Lake Erie shoreline, except for about 7.5 km of shoreline at the eastern limit.

The 2015 Southwestern Ontario Orthophotography Project (SWOOP) DSM and DTM are 2 metre raster elevation data products that were generated from a classified LAS (data format for storing airborne LiDAR data), acquired through the Government of Ontario's Imagery Acquisition Strategy that provides LIO with a mandate to collect and refresh imagery for southern Ontario on a five year cycle. Data was collected between 12 April and 23 May 2015. As part of this data collection a 2 metre DTM was generated. For this project, GRCA processed this DTM to create products in the new vertical datum of CGVD2013. GRCA converted the 2 m DTM to points and converted from CGVD28 to CGVD2013 using the Natural Resources Canada GPS-H desktop tool, then converted back to a raster with a 2 m cell size, then generated contours at a 1 m interval. This dataset does not have the same level of detail as the 2017 LiDAR but has sufficient detail to match the 1:2,000-scale mapping requirements of the project. This dataset was only used for the eastern end of Haldimand County, approximately 7.5 km of shoreline, where the 2017 LiDAR product does not provide coverage. Baird further processed this dataset by removing noise that occurred in Lake Erie.

3.3 Bathymetry

The Government of Canada Department of Fisheries and Oceans (DFO) bathymetry was collected by an airborne bathymetry sensor and was surveyed between 19 April and 19 June 2018. For this project, GRCA processed the original gridded point data, adjusting the vertical datum to CGVD2013 and generating gridded raster products at 5 m and 10 m resolutions. As a result of water clarity issues during the acquisition flights, this dataset has some gaps. In Figure 3.1, these gaps can be seen on the right side of the figure (areas without coloured data points). The gaps were filled with the Lake Erie 1 m depth contours, a dataset compiled by the

US National Oceanographic and Atmospheric Administration (NOAA) National Geophysical Data Center Marine Geology and Geophysics Division (NGDC/MGG), the NOAA Great Lakes Environmental Research Laboratory (GLERL) and the Canadian Hydrographic Service (CHS). This product includes data from various data sets, collected over different years. The bathymetry is primarily used for calculating wave runup at select locations.

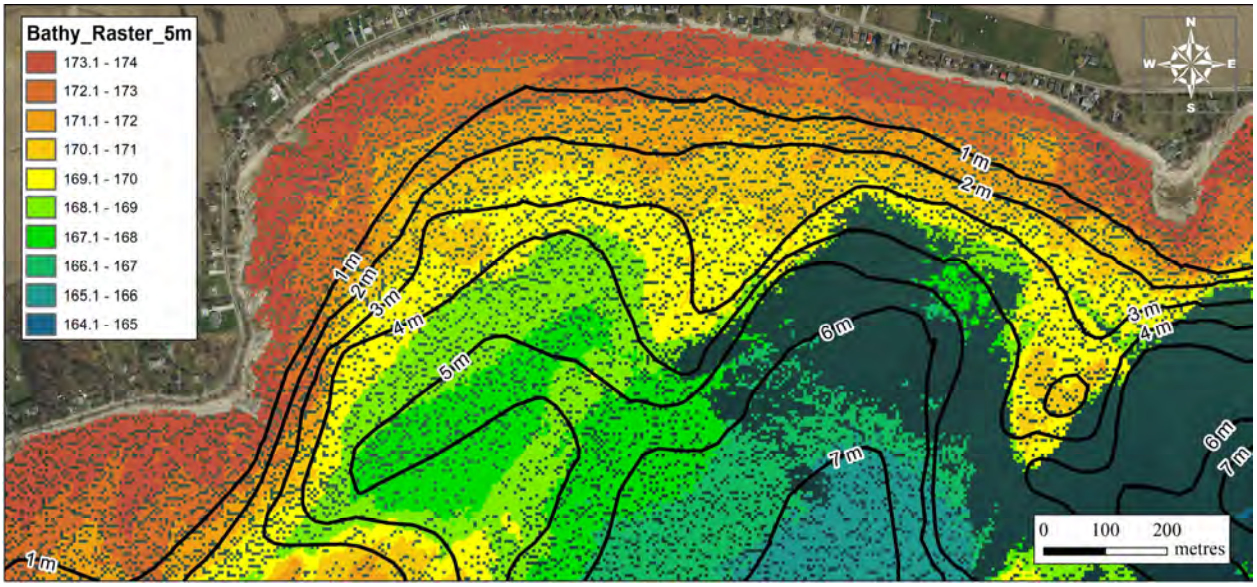

Figure 3.1: DFO aerial bathymetry data and NOAA contours

3.4 Water Levels

Lake Erie water levels were obtained from the Department of Fisheries and Oceans (DFO) Marine Environmental Data Service (MEDS). Permanent gauging stations are maintained at Port Dover (to the west) and Port Colborne (to the east) of Haldimand County. Approximately two months of measured water levels are available at Dunnville. A summary of the available hourly water level data is provided in Table 3.1.

Table 3.1: Summary of Lake Erie water level gauges near Haldimand County

Station Name	Station Number	Date Range of Hourly Data	Status
Port Colborne	12865	January 1,1962 to present	Permanent
Port Dover	12710	November 1, 1961 to present	Permanent
Dunnville	12805	July 4 to August 28, 1986	Temporary

It is noted that Port Colborne daily water level and annual peak instantaneous water level data extend back to 1911, however, the hourly dataset is only available from 1962.

3.5 Waves

Wave hindcast data were obtained from the US Army Corps of Engineers Wave Information Study (WIS). The wave hindcast consists of an hourly time series of modelled wave height, period, and direction at offshore locations where the waves are unaffected by the water depth. Approximately 20 output points are located offshore of the Haldimand County shoreline (see Figure 3.2). The hindcast extends from January 1, 1979 to December 31, 2014.

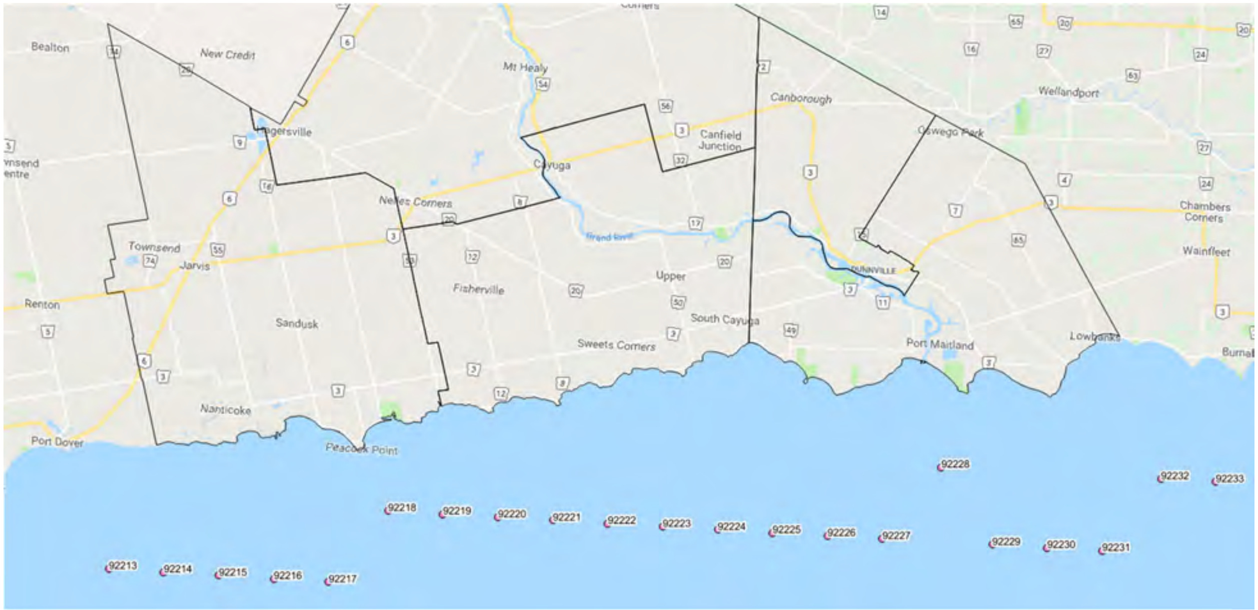

Figure 3.2: Wave hindcast output points from the US Army Corps of Engineers Wave Information Study

The offshore wave conditions were transformed to the Haldimand County nearshore region to assess wave uprush as discussed in Section 6.2.

3.6 Geotechnical

The geotechnical background data used for the slope stability analysis was reviewed by Terraprobe:

- Visual observations from site visits undertaken in August 2018 and April 2019
- Terraprobe reports from the areas Nanticoke, and Rainham. Burnaby and Wainfleet, Ontario
- Locally available geotechnical boreholes from the Ministry of Energy, Northern Development and Mines
- Locally available quaternary geology from the Ministry of Energy, Northern Development and Mines
- Locally available well records from the Government of Ontario
- LiDAR data of the shoreline described in Section 3.2

These data sets are discussed in further detail in Appendix A.

4. Defining the Natural Hazards

4.1 Overview of Shoreline Hazards

The Provincial Policy Statement (PPS) provides policy direction on matters of provincial interest related to land use planning and development. Hazardous lands are defined in the PPS, (MMAH, 2014) as “property or lands that could be unsafe for development due to naturally occurring processes.” Along shorelines of the Great Lakes – St. Lawrence River System, this means the land, including that covered by water between the international boundary where applicable, and the furthest landward extent of the flooding hazard, erosion hazard, or dynamic beach hazard limits.

The technical basis and methodologies for defining and applying the hazard limits for flooding, erosion, and dynamic beaches are provided by the Technical Guide for Flooding, Erosion and Dynamic Beaches, Great Lakes – St. Lawrence River System and Large Inland Lakes (MNR, 2001a). The basic procedures outlined in the Technical Guide (MNR, 2001a) with some modifications have been included in subsequent documents, such as Ontario Regulation 97/04 (“Generic Regulation”) and Guidelines for Developing Schedules of Regulated Areas (Conservation Ontario, 2005). The methodologies outlined in MNR (2001a) have been used on this project.

It is important to note, as outlined in the Technical Guide (MNR, 2001a), that the regulated hazard limits are generally to be mapped based on the assumption of no shoreline protection works in place. The clearly stated intent is that the mapped flooding, erosion, and dynamic beach hazard limits are to represent the underlying ambient nature of the natural shoreline hazard and should not be modified by the presence of existing or proposed shoreline protection. The most landward limit of the Flooding, Erosion and Dynamic Beach hazards is utilized in determining the regulated area along the Haldimand County shoreline.

4.2 Flooding Hazard

The flooding hazard limit is defined as the 100-year flood level plus an allowance for wave uprush and other water-related hazards, as depicted graphically in Figure 4.1.

The 100-year flood level is the sum of the static water level plus storm surge with a combined 1% probability of being equalled or exceeded in a given year. This means that on average it has a one percent probability of occurring in any given year. The 100-year flood levels as defined by MNR (1989) and listed in Section 6.1 were used to map the flooding hazard for this project.

When shorelines are exposed to wave action, wave uprush and overtopping occur driving water above the 100-year water level. Other water-related hazards may include ship generated waves and ice. Site specific studies may be used to assess the allowance for wave uprush and water related hazards. The Technical Guide (MNR, 2001a) requires a flooding allowance of 15 m, measured horizontally from the location of the 100-year flood level, as shown in Figure 4.1, if a study using accepted engineering, and scientific principles is not undertaken. Wave uprush was calculated on a reach basis for this study, as presented in Section 6.2.

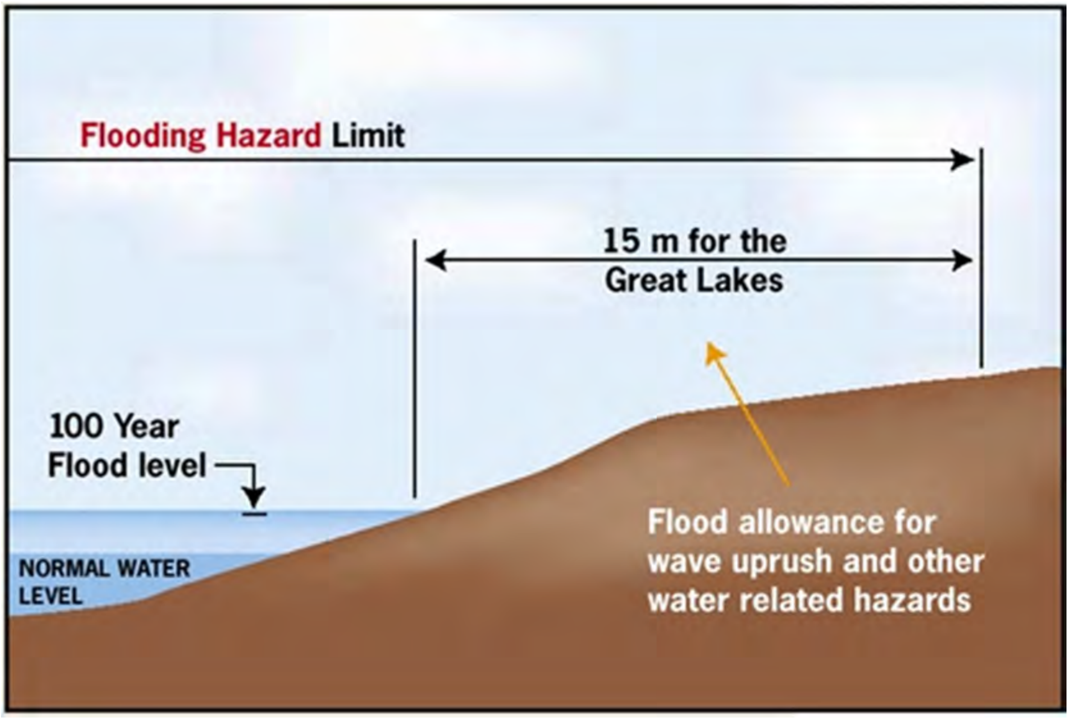

Figure 4.1: Flooding hazard limit for the Great Lakes (from MNR, 2001a)

4.3 Erosion Hazard

The erosion hazard limit is calculated as the sum of the stable slope allowance, plus the 100-year erosion allowance. Figure 4.2 shows the erosion hazard limit as defined in the Technical Guide (MNR, 2001a) and Understanding Natural Hazards (MNR, 2001b).

The approach used in Ontario Regulation 97/04 is similar, but the recession allowance is applied first and then the stable slope allowance is applied. The stable slope allowance was applied first for this study, because the stable slope line is used to identify lands and infrastructure in an imminent high risk zone.

The stable slope allowance is a horizontal allowance measured landward from the toe of the bluff or bank. It is dependent on soil characteristics and groundwater conditions. In the absence of a site-specific study, a stable slope allowance of three times the bluff height may be used. The bluff heights are calculated as the vertical change in elevation from the toe of bluff to the top of bluff. For this study, the stable slope allowance was determined on a reach basis, for representative profiles, and a geotechnical analysis of slope stability was undertaken as described in Section 6.4.

The erosion allowance is the distance the shoreline would erode in 100 years from present. It is calculated as 100 times the average annual recession rate (AARR) as shown in Figure 4.2. For this study, the AARR was calculated based on a comparison of historical aerial imagery where sufficient data existed (see Section 6.5). In the absence of a minimum 35 years of reliable data, a 30-metre erosion allowance is used (as shown in Figure 4.3). This is also applied in areas where the shoreline has been protected and an erosion allowance cannot be determined.

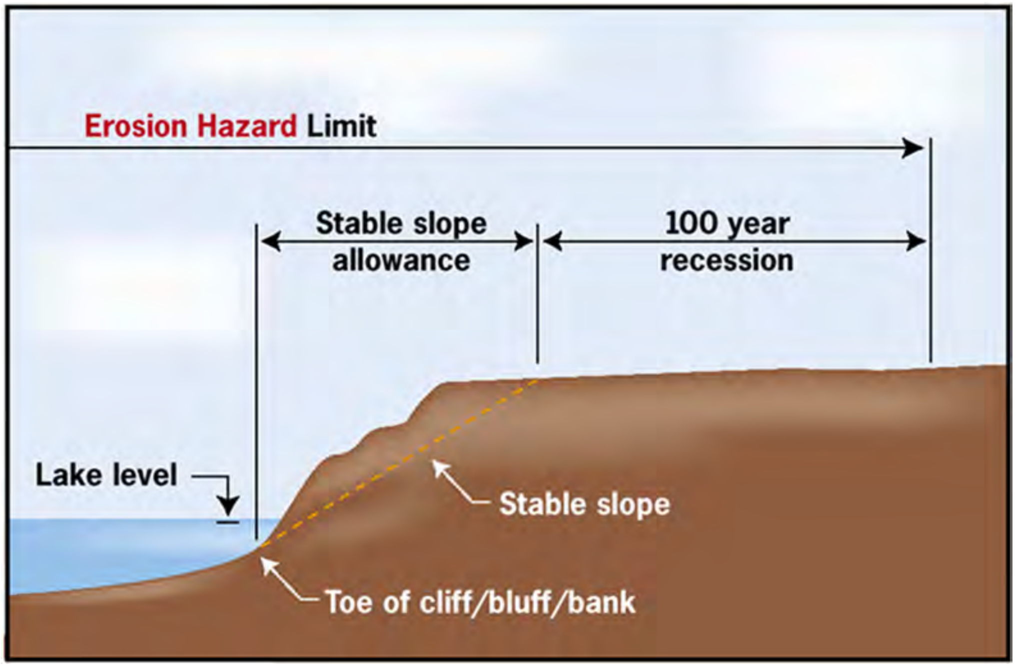

Figure 4.2: Erosion hazard limit defined with reliable recession data (from MNR, 2001a)

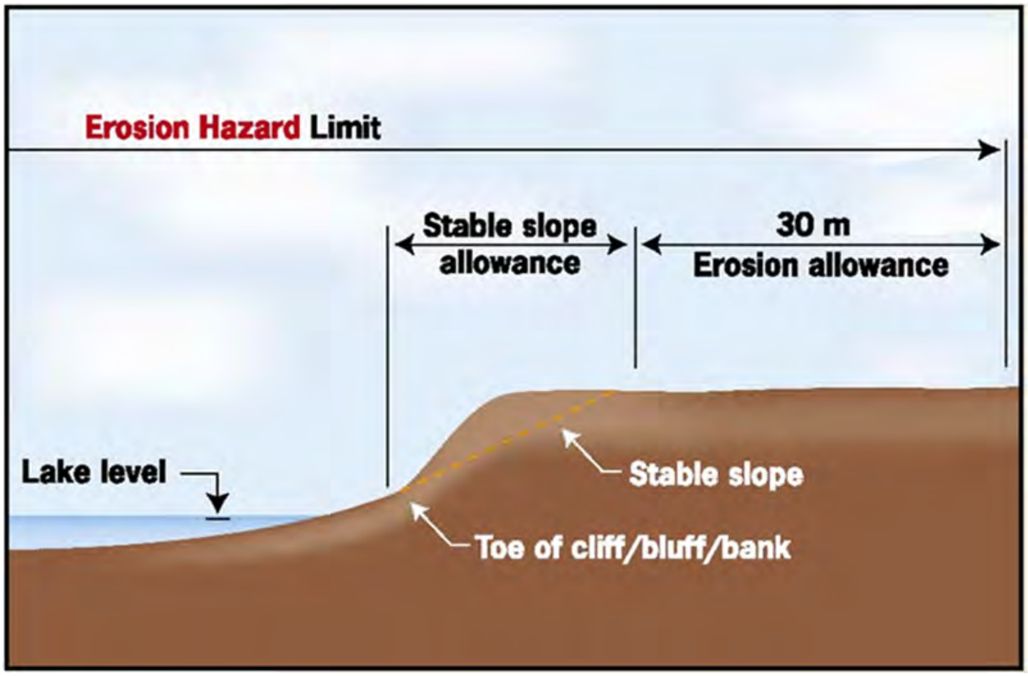

Figure 4.3: Erosion hazard limit defined where reliable recession data not available (from MNR, 2001a)

4.4 Dynamic Beach Hazard

Assessment of the dynamic beach hazard involves the calculation of the cumulative impacts of the flooding hazard, an erosion allowance, and a dynamic beach allowance.

The dynamic beach hazard is only applied where: a beach or dune deposit exists landward of the water line; the beach or dune deposits overlying bedrock or cohesive material are equal to or greater than 0.3 m in thickness, 10 m in width, and 100 m in length along shoreline; and the fetch is more than 5 km (MNR, 2001a).

The dynamic beach hazard limit is defined as the landward limit of the flooding hazard (100-year flood level plus a flood allowance for wave uprush and other water related hazards), plus a 30 m dynamic beach allowance or a distance determined by an accepted coastal study (see Figure 4.4). If the dynamic beach is backed by an eroding bluff, the definition of the erosion hazard is applied to the bluff feature.

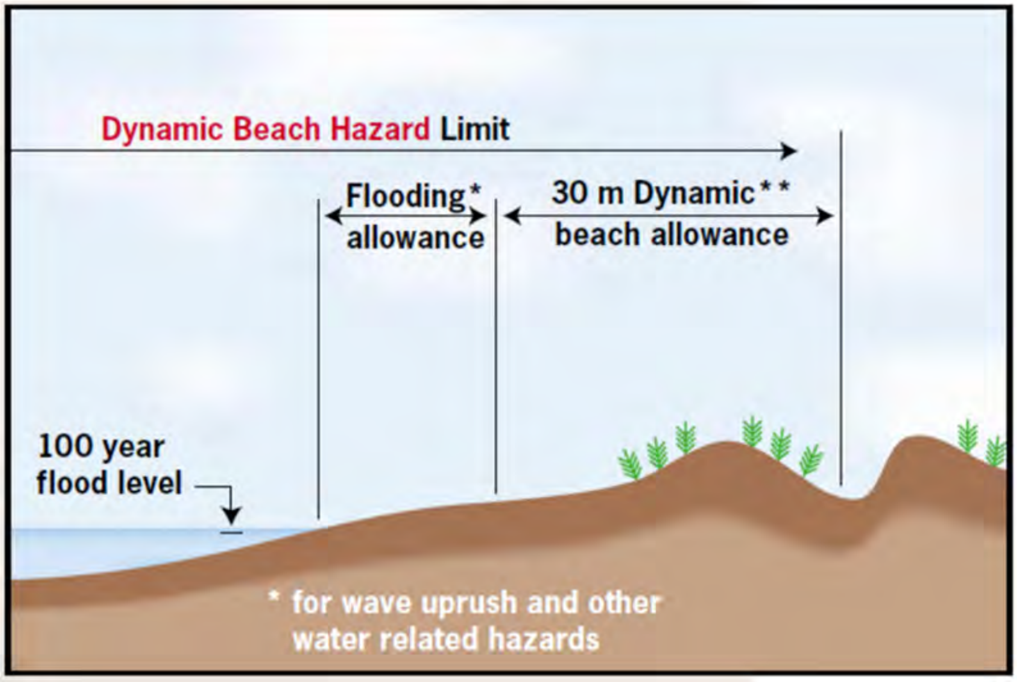

Figure 4.4: Dynamic beach hazard limit (from MNR, 2001a)

5. Shoreline Reaches

The shoreline was divided into reaches to support the mapping of the natural hazards (flood, erosion, and dynamic beach). Shoreline reaches are segments of shoreline having relatively uniform physical characteristics (MNR, 2001a). In establishing the reaches, the following factors were considered: shoreline type, controlling nearshore substrate, surficial nearshore substrate, and shoreline exposure and planform. Reaches defined by the Conservation Authority (CA) for previous mapping were used as a starting point and then refined. The reaches used for the mapping are shown in Figure 5.1and Figure 5.2 and summarized in Table 5.1 including: the CA the reach is located in, reach number, general location, brief description of the shoreline, and approximate reach length. The hazard mapping, provided under separate cover, shows reach boundaries at higher resolution (1:2000).

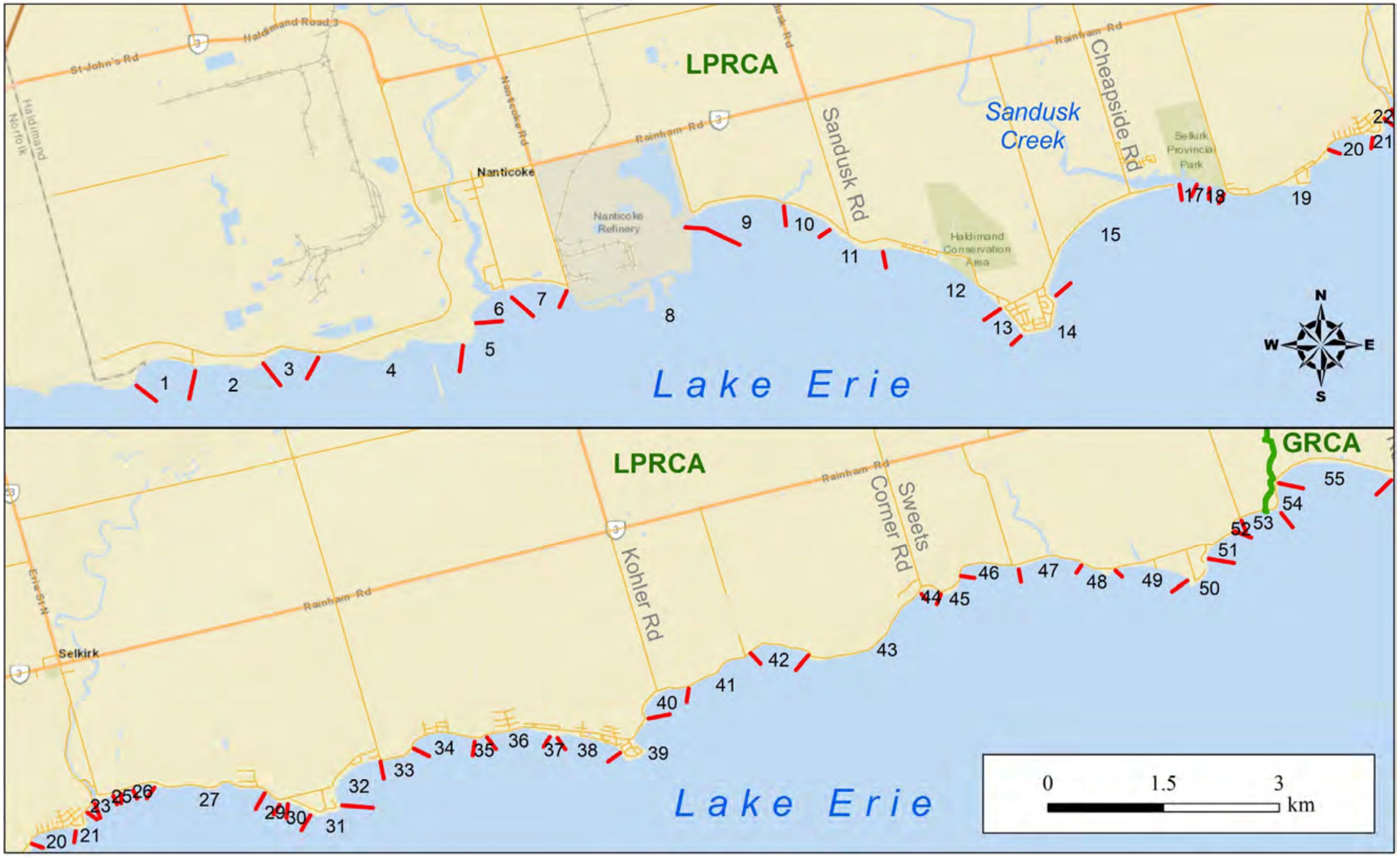

Figure 5.1: Reaches used for natural hazard delineation on Lake Erie, Haldimand County (west end)

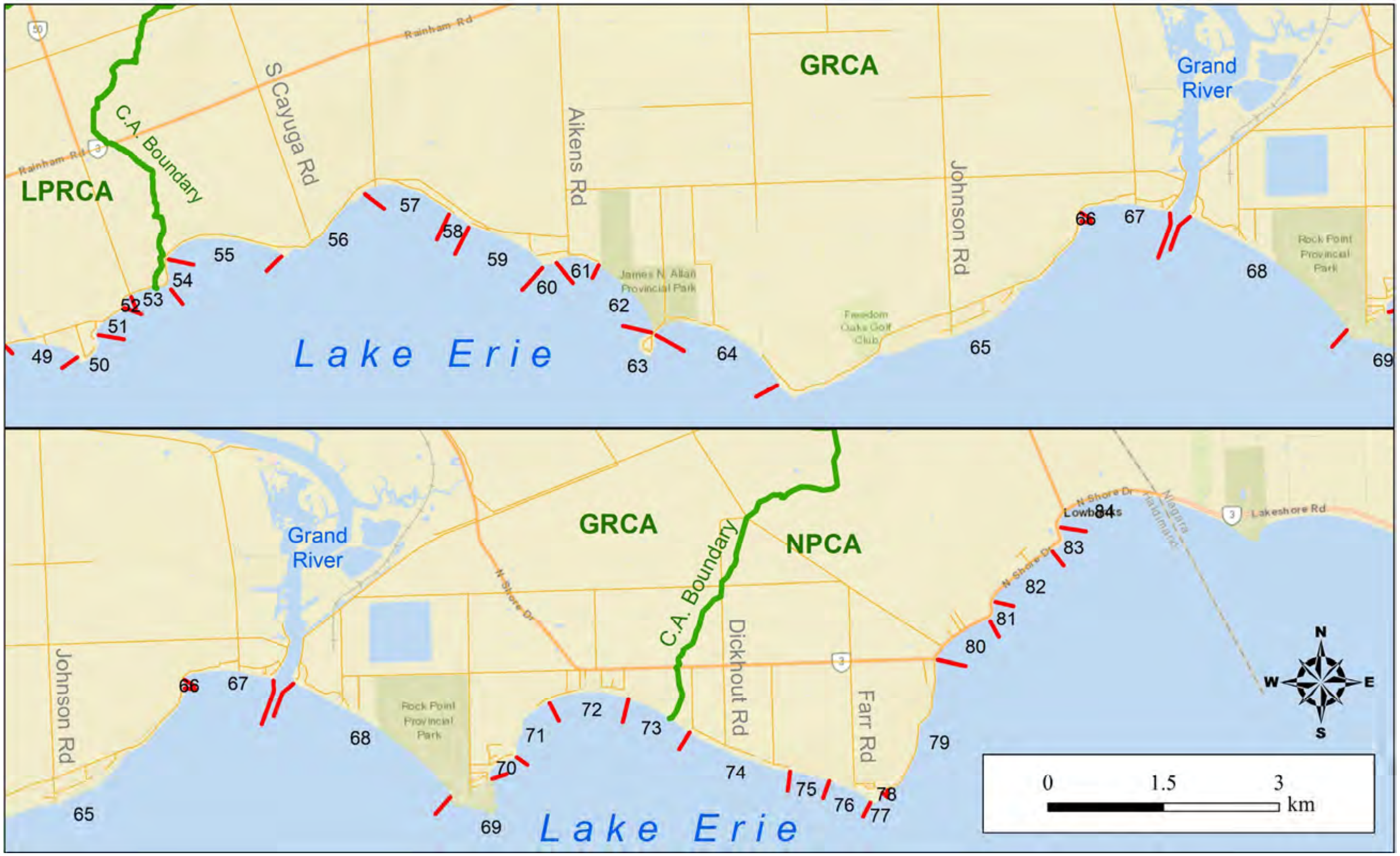

Figure 5.2: Reaches used for natural hazard delineation on Lake Erie, Haldimand County (east end)

Table 5.1: Reaches with location, description, and length

CA	Reach #	Location	Description	Length (m)
LPRCA	1	County limit to 144 Old Lakeshore Rd.	Embayment	950
	2	Woodhouse CON 1 PT LOTS 22 TO 24	Low bank with sand/cobble deposit	870
	3	Woodhouse CON 1 PT LOTS 24 and Walpole CON 1 PT LOTS 1	Low bank embayment with sand/cobble deposit, partially protected with armourstone	750
	4	1156 New Lakeshore Rd, Elmcrest Ln., 1 Riverside Dr., includes the US Steel Canada Nanticoke Works wharf consisting of causeway and pier to Part Lot 4	Low bank with sand/cobble deposit	2040
	5	1 Riverside Dr.	Rocky outcrop	450
	6	West of Nanticoke Creek	Embayment with sand/cobble deposit	530
	7	East of Nanticoke Creek, Hickory Beach Lane	Embayment with sand/cobble deposit	760
	8	Former Nanticoke Power Generating Station	Engineered fill and shoreline	3700
	9	East of former Nanticoke Power Generating Station to Hickory Creek	Embayment, remnant shoreline protection including armourstone and rock groynes, with sand/cobble deposit	1400
	10	Hickory Creek to 400 South Coast Dr.	Embayment with sand/cobble deposit	690
	11	402-488 South Coast Dr.	Sand/cobble deposit	800
	12	392 South Coast Dr. and West, Haldimand Cons. Area to 755 South Coast Dr.	Low bank with sand/cobble deposit	1760
	13	Peacock Point West shore	Fully protected shoreline	440
	14	Peacock Point	Rocky headland	910
	15	West of Sandusk Creek	Low bank with sand/cobble deposit	2370
	16	Selkirk Prov. Park	Sandy river mouth, cobble bar feature and small sand/cobble deposit	100
	17	Selkirk Prov. Park	Rocky	180
	18	Selkirk Prov. Park	Small sand/cobble deposit	240
	19	0-186 Blue Water Pkwy.	Rocky outcrop headland	1800
	20	195 Blue Water Pkwy. to 20 Summerhaven Cres.	Embayment, small sand/cobble deposit	640
	21	26-76 Summerhaven Cres.	Rocky headland	400
	22	West of Stoney Creek	Embayment, fill since 1973	150
	23	East of Stoney Creek, 6-15 Lakeshore Rd.	Rocky shoreline & nearshore	220
	24	25 Lakeshore Rd.	Sand/cobble deposit	110
	25	48-56 Lakeshore Rd.	Rocky headland	170
	26	65-98 Lakeshore Rd.	Sandy/cobble deposit	300
	27	104-299 Lakeshore Rd.	Rocky shoreline & nearshore	1500

CA	Reach #	Location	Description	Length (m)
	28	Rainham Conc. 1 Part Lot 4	Cobble shore, heavily protected	250
	29	358-370 Lakeshore Rd.	Rocky outcrop headland	100
	30	Hoover Point west	Rocky headland	340
	31	Hoover Point central	Rocky headland	550
	32	East of Hoover Point, 76 Hoover Point Lane to 1 Anchor Lane, Hoover Cemetery	Embayment, sand/cobble deposit	940
	33	594-669 Lakeshore Rd.	Rocky outcrop	570
	34	699-789 Lakeshore Rd.	Embayment, sand/cobble deposit	880
	35	791-811 Lakeshore Rd.	Rocky outcrop	160
	36	817-934 Lakeshore Rd.	Embayment, sand/cobble deposit	850
	37	936-946 Lakeshore Rd.	Rocky outcrop	120
	38	948 Lakeshore to 6 Lake Rd.	Embayment (all protected), pockets of sand/cobble deposits	870
	39	Featherstone Point	Rocky headland	1120
	40	1126-1219 Lakeshore Rd.	Embayment (all protected)	790
	41	1238-1371 Lakeshore Rd.	Rock shelf	970
	42	1373-1495 Lakeshore Rd.	Embayment with creek outlet, pockets of sand/cobble deposits	815
	43	1497-1750 Lakeshore Rd.	Rocky nearshore shelf	1950
	44	East of Sweets Corners Rd.	Embayment, sand/cobble deposit	280
	45	1806-1847 Lakeshore Rd.	Rocky headland	450
	46	1847 Lakeshore Rd. to Bookers Rd.	Embayment, sand/cobble deposit, with nearshore rock shelf	840
	47	Bookers Bay, Wardells Creek, 1982-2057 Lakeshore Rd.	Embayment, sand/cobble deposit	850
	48	2066-2079 Lakeshore Rd.	Rocky headland, pocket sand/cobble deposit	540
	49	2086-2190 Lakeshore Rd.	Embayment, sand/cobble deposit	980
	50	Evans Point	Rocky headland	660
	51	15 Paradise Lane to 2301 Lakeshore Rd.	Rock shelf	530
	52	Austins Trailer Park	Rock shelf, small sand/cobble deposit	200
GRCA	53	LPRCA-GRCA boundary	Rocky nearshore shelf, sand/cobble deposit	510
	54	2455-2489 Lakeshore Rd.	Rocky nearshore shelf	370
	55	2503-2742 Lakeshore Rd.	Embayment, sand/cobble deposit	1600
	56	2742-2894 Lakeshore Rd.	Rocky headland nearshore shelf	1560

CA	Reach #	Location	Description	Length (m)
	57	2896 Lakeshore Rd. South Cayuga to 217 Lakeshore Rd. Dunnville, Hald-Dunn Townline	Low bank with sand/cobble deposit	1200
	58	East end of Edgewater Place to 3100 Lakeshore Rd. Former Lakeshore Rd lost	Low bank with sand/cobble deposit	310
	59	3102 Lakeshore Rd. to 53 Horseshoe Bay Rd.	Low bank with sand/cobble deposit	1100
	60	Blott Point, 53-31 Horseshoe Bay Rd.	Rocky headland with pocket sand/cobble deposit reshaping but not bluff eroding	220
	61	25 Horseshoe Bay Rd. to 50 Lakeview Line	Embayment, sand/cobble deposit	600
	62	James N. Allan Provincial Park	Dynamic Beach (low plain, partial headland, sand and cobble)	1160
	63	Low Point	Rocky headland	830
	64	Between Low and Grant Points, Paradise Lane, Baygrove Line, 835-783 Sandy Bay Rd.	Dynamic Beach (low plain, partial headland, sand and cobble)	1960
	65	Grant Point and East 771-445 Sandy Bay Rd., Dearden Lane, Stonehaven Rd., Weatherburn Line, Greens Line, 297-135 Lighthouse Dr.	Rocky nearshore shelf	4950
	66	105-135 Lighthouse Dr.	Transition zone; lakefill	120
	67	West of Grand River, Port Maitland West Beach; Splatt Bay, 105-1 Lighthouse Dr., Dover St.	Dynamic Beach (low plain, partial headland, sand and cobble)	1190
	68	East of Grand River, Beckley Beach and Rock Point Provincial Park	Dynamic Beach (low plain, partial headland, sand and cobble)	2550
	69	Rock Point	Rocky headland	1200
	70	Mohawk Bay West, Rock Point B Line	Embayment, sand/cobble deposit	500
	71	Mohawk Bay West	Eroding bluff, sand/cobble deposit	930
NPCA	72	Mohawk Bay Central, 43-1 Gull Line, Warnick Rd., Lakeridge Blvd.	Eroding bluff, sand/cobble deposit	1060
	73	Mohawk Bay Central, 1930-1958 North Shore Dr., 1980 Regional Rd 3 E., 63 Pyle Rd.	Eroding high bluff	920
	74	Mohawk Bay East; Villella-Derner-Erie Heights	Eroding bluff	1400
	75	Transition zone	Forested bluff	520

CA	Reach #	Location	Description	Length (m)
	76	Mohawk Point West face	Rocky headland	600
	77	Mohawk Point East face	Rocky headland	250
	78	End of Mohawk Point Rd.	Pocket sand/cobble deposit	70
	79	Mohawk Point Rd.	Fill and armoured since 1955	1950
	80	2441-2543 North Shore Blvd.	Sand/cobble deposit	880
	81	2558-2587 North Shore Blvd.	Headland, fill since 1955	270
	82	2605-2718 North Shore Blvd.	Sand/cobble deposit, Fill since 1955	1000
	83	Lowbanks Cemetery East to 2758 North Shore Blvd.	Headland, fill since 1955, fully armoured shoreline; rocky nearshore substrate	400
	84	2762 North Shore Blvd. to County Limit	Fully armoured shoreline, fill since 1955	1450

6. Technical Analyses

6.1 100-Year Flood Level

Return period water levels for locations on the Great Lakes were developed by the Ontario Ministry of Natural Resources (MNR, 1989). The return period water level estimates in MNR (1989) were developed for static lake levels (i.e. monthly mean levels), storm surge, and all combinations of static lake levels and storm surge. The statistical analyses were conducted using the HYDSTAT software package developed by MNR (1982). The report defines the 100-year flood level, which is the still-water level (or peak instantaneous water level) having a 1% annual chance of being equalled or exceeded. The still-water level is equivalent to the hourly water level.

Unless otherwise noted, all water levels are reported in IGLD85. Datum conversions are listed in Table 6.1. The conversion from IGLD85 to CGVD2013 is based on the NRCan Benchmark Station Reports.

Table 6.1: Datum conversions for Port Dover and Port Colborne

Datum	Port Dover NRCAN Benchmark MMDCCXXX	Port Colborne NRCAN Benchmark 71U032
IGLD1955	175.627	175.731
IGLD1985	175.797	175.921
CGVD28	175.793	175.904
CGVD2013	175.341	175.456

6.1.1 Static Water Levels

In MNR (1989), the historical monthly mean lake levels from 1900 to 1988 were adjusted to the constant set of conditions existing after about 1960 (regulation conditions, diversions, etc.) to form a consistent basis of comparison. The “Basis of Comparison” Lake Erie water levels are shown in Figure 6.1 with the measured water levels (1918-2018).

Considering that an additional 30 years of data has been measured since 1988, and recognizing the 1970s to 1990s were a period of higher water levels in the Great Lakes, Baird updated the static water level return periods for Port Dover and Port Colborne using only the measured data corresponding to the period of hourly water level measurements (1962-2018). This is a conservative approach (i.e. errs on the side of higher extreme lake levels). The data set includes 57 years of water level measurements under conditions (flow regulation, diversions, dredging, etc.) similar to the present.

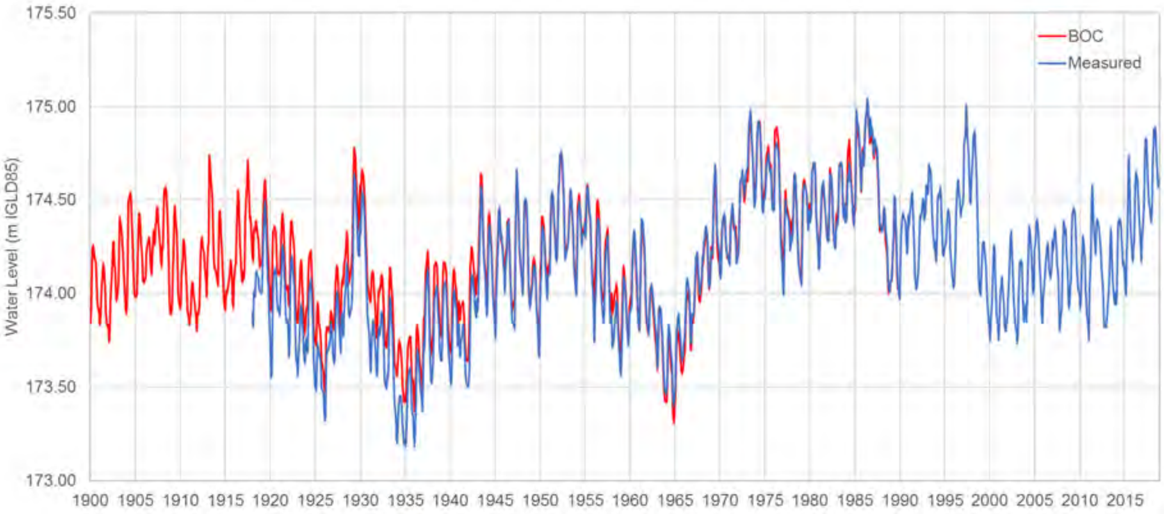

Figure 6.1: Lake Erie measured and “Basis of Comparison (BOC)” monthly water levels

6.1.2 Surge Levels

Storm surge (or wind setup) was calculated in MNR (1989) by subtracting the mean monthly water level from the hourly water level measurements. A computer model was used to estimate storm surges for locations between gauge stations.

Baird updated the storm surge analysis using the 57 years of hourly water level data (1962-2018). In the analysis, static water levels were calculated using a Gaussian-weighted 30-day moving average filter to eliminate the stairstep effect between months. Surge was calculated by subtracting the hourly water level measurements from the “smoothed” static water level. Hourly water levels, calculated static levels, and calculated surges for Port Colborne are shown in Figure 6.2.

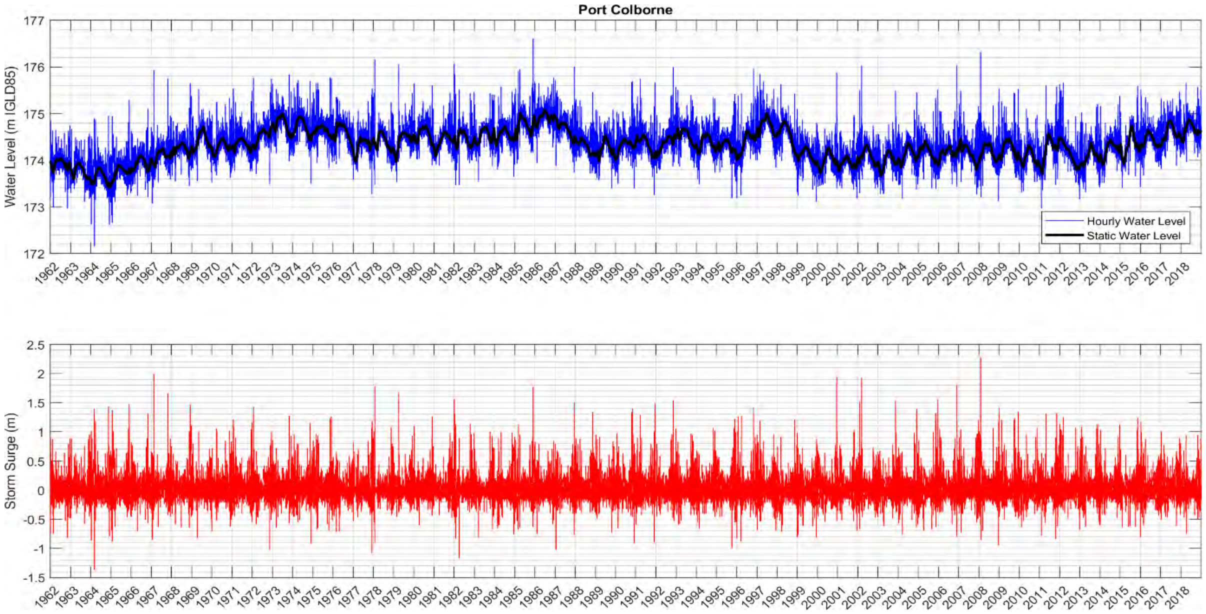

Figure 6.2: Hourly and static water level and calculated surge at Port Colborne 1962 to 2018

A listing of the largest surge events at Port Colborne and Port Dover is provided in Table 6.2. The largest surge on record occurred on January 30, 2008.

Table 6.2: Listing of the largest surge events at Port Colborne and Port Dover 1962 to 2018

Rank	Port Colborne			Port Dover		
	Date	Surge (m)	Water level (m IGLD85)	Date	Surge (m)	Water level (m IGLD85)
1	2008-01-30 07:00	2.27	176.31	2008-01-30 08:00	1.63	175.63
2	1967-02-16 06:00	1.99	175.93	2006-12-01 19:00	1.50	175.69
3	2000-12-12 06:00	1.94	175.87	2002-03-10 00:00	1.44	175.50
4	2002-03-10 00:00	1.92	176.02	1967-02-16 07:00	1.31	175.24
5	2006-12-01 18:00	1.80	176.03	1967-10-27 20:00	1.31	175.37

6.1.3 Return Period Water Levels

The HYDSTAT software package was used to estimate the return period static water levels, surge levels, and joint probability of static water levels and storm surge (still-water levels). The input data consisted of the annual maximum monthly water levels for 1962 to 2018 and the 57 largest surges over this period. The Log-Pearson Type 3 distribution, which was the best fitting distribution, was selected in the analyses.

The existing (MNR, 1989) and updated return period water levels for Port Colborne and Port Dover are summarized in Table 6.3 and Table 6.4, respectively. The updated 100-year still-water levels are within 1 cm of the levels in MNR (1989). Following review and discussion with the Project Team, it was decided that no update to the existing 100-year flood levels for Haldimand County's Lake Erie shoreline would be made. The 100-year Flood Level used in the Hazard Mapping is therefore as defined in MNR (1989).

Table 6.3: Port Colborne return period water levels

Study	Water Level	Return Period Water Level (m and m IGLD85)						
		2 year	5 year	10 year	25 year	50 year	100 year	200 year
MNR (1989)	Static	174.37	174.61	174.74	174.86	174.95	175.02	175.08
	Surge	1.32	1.61	1.80	2.01	2.17	2.32	2.46
	Stillwater	175.70	176.07	176.28	176.51	176.66	**176.80**	176.93
Baird (2019)	Static	174.53	174.75	174.86	174.98	175.04	175.10	175.16
	Surge	1.35	1.55	1.71	1.93	2.11	2.30	2.51
	Stillwater	175.91	176.22	176.39	176.57	176.69	**176.80**	176.90
Difference	Stillwater	0.21	0.15	0.11	0.06	0.03	**0.00**	-0.03

Table 6.4: Port Dover return period water levels

Study	Water Level	Return Period Water Level (m and m IGLD85)						
		2 year	5 year	10 year	25 year	50 year	100 year	200 year
MNR (1989)	Static	174.35	174.59	174.72	174.84	174.93	175.00	175.06
	Surge	1.15	1.32	1.42	1.52	1.59	1.66	1.72
	Stillwater	175.50	175.79	175.94	176.10	176.20	**176.30**	176.38
Baird (2019)	Static	174.53	174.75	174.86	174.98	175.04	175.10	175.16
	Surge	1.01	1.17	1.28	1.43	1.55	1.68	1.81
	Stillwater	175.55	175.82	175.96	176.11	176.21	**176.29**	176.37
Difference	Stillwater	0.05	0.03	0.02	0.01	0.01	**-0.01**	-0.01

The 100-year flood levels for Port Colborne and Port Dover used to define the stillwater levels in the Haldimand County hazard mapping are summarized in Table 6.5. The 100-year flood levels were defined for each reach using a linear interpolation between the 100-year flood levels at Port Colborne and Port Dover adjusted to CGVD2013 datum. The values used in the mapping are discussed further in Section 7.1.

Table 6.5: 100-year flood levels at Port Colborne and Port Dover used for flood hazard mapping

Gauge Location	100-year Flood Level (m IGLD85)	100-year Flood Level (m CGVD2013)
Port Colborne	176.80	176.34
Port Dover	176.30	175.84

6.2 Wave Uprush

Wave uprush (runup), wave overtopping, and the inland extent of overtopping waves were calculated for each of the 84 shoreline reaches using a representative shoreline profile for each reach. The analysis used the 100-year flood level with the 20-year wave condition as per MNR (2001a). The definition sketch for wave uprush is shown in Figure 6.3. In this figure, “R” is the wave runup height for threshold extension of slope, “F” is the freeboard height; and “Ls” is the maximum distance that an overtopping wave is predicted to travel inland. The distance “Ls” is proportional to the excess runup (R minus F) and the wave period. The wave uprush allowance is equal to the horizontal extent of the wave runup on the slope measured from the 100-year flood level plus the distance “Ls”.

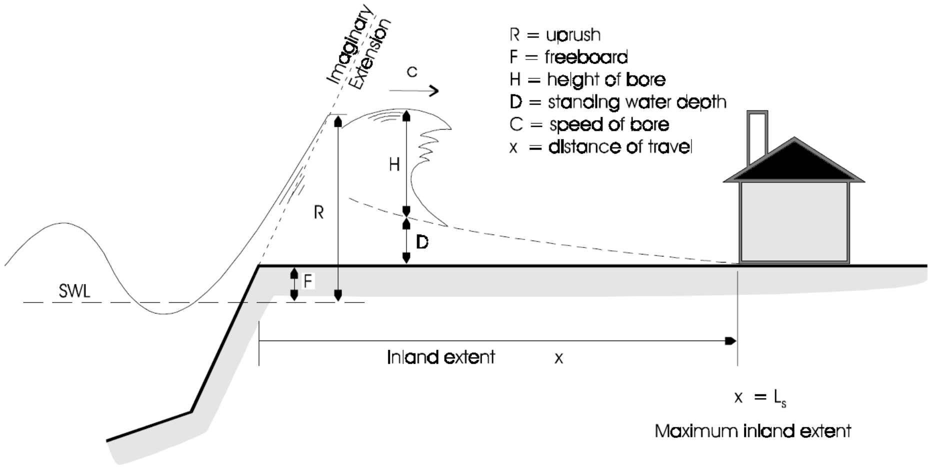

Figure 6.3: Definition sketch of wave uprush over low bluff (from MNR, 2001a)

6.2.1 Nearshore Wave Modelling

The two-dimensional spectral wave model MIKE21 SW was used to transform the offshore “deep water” wave conditions from the US Army Corps of Engineers (USACE) Wave Information Study (WIS) to the Haldimand County shoreline. The WIS hindcast consists of hourly wave data for 1979-2014. The nearshore wave model bathymetry was developed using a gridded bathymetric dataset of Lake Erie from NOAA and Canadian Hydrographic Service (CHS). The model domain extends approximately 10 km east and 5 km west of Haldimand County and the offshore boundary was selected to coincide with the WIS output points. The model mesh is composed of approximately 83,000 triangular elements which vary in size from 250 m at the offshore boundary to 50 m at the nearshore. The model mesh, bathymetry, and WIS output points are shown in Figure 6.4.

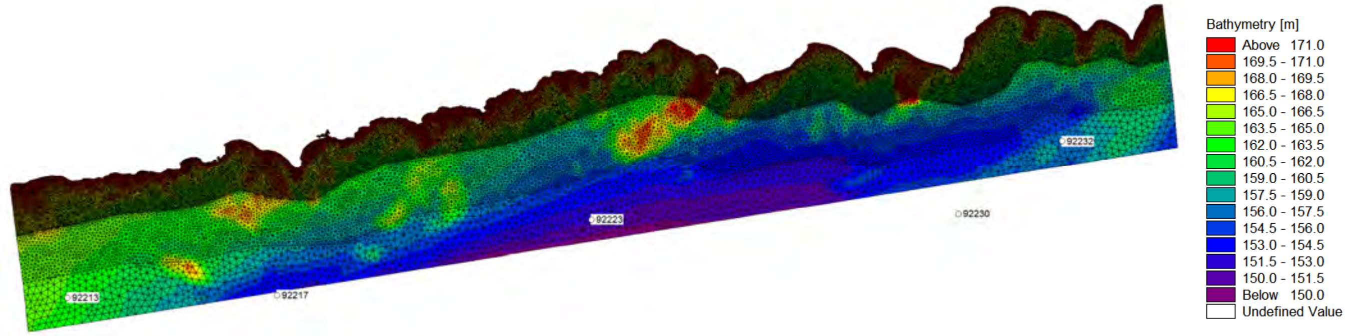

Figure 6.4: MIKE21 Spectral Wave model of the Haldimand County shoreline

The nearshore wave model was run using spatially varying water levels corresponding to the 100-year flood levels at Port Colborne and Port Dover (interpolated over the model domain) and the 20-year offshore wave conditions at the WIS output points. The 20-year offshore wave heights varied between 3.4 m at the westernmost WIS point and 5.7 m at the easternmost WIS point. A series of model runs were carried out using the range of wave heights, periods, and directions that corresponded to the 20-year wave condition at the five WIS output points. Wind conditions were examined for the selected storm events, and a constant onshore wind of 22.5 m/s was applied in the model runs.

An output point was defined at each of the 84 shoreline profiles (reaches), approximately 200 m from the shoreline. The wave direction vectors were examined for each of the model runs to determine the envelope of nearshore output points influenced by the particular model run (combination of wave height, period, and direction for a particular WIS output point). For example, Profiles 39-56 are influenced by the two WIS output points shown in Figure 6.5. The top panel shows the zone of influence based on a model run with Hm0=4.3 m; Tp=7 s; Dir =250 deg. The bottom panel shows the zone of influence based on a model run with Hm0=5.5 m; Tp=8.5 s; Dir =200 deg. The 20-year wave condition at each of the profile locations was selected as the maximum wave condition from the series of corresponding model runs.

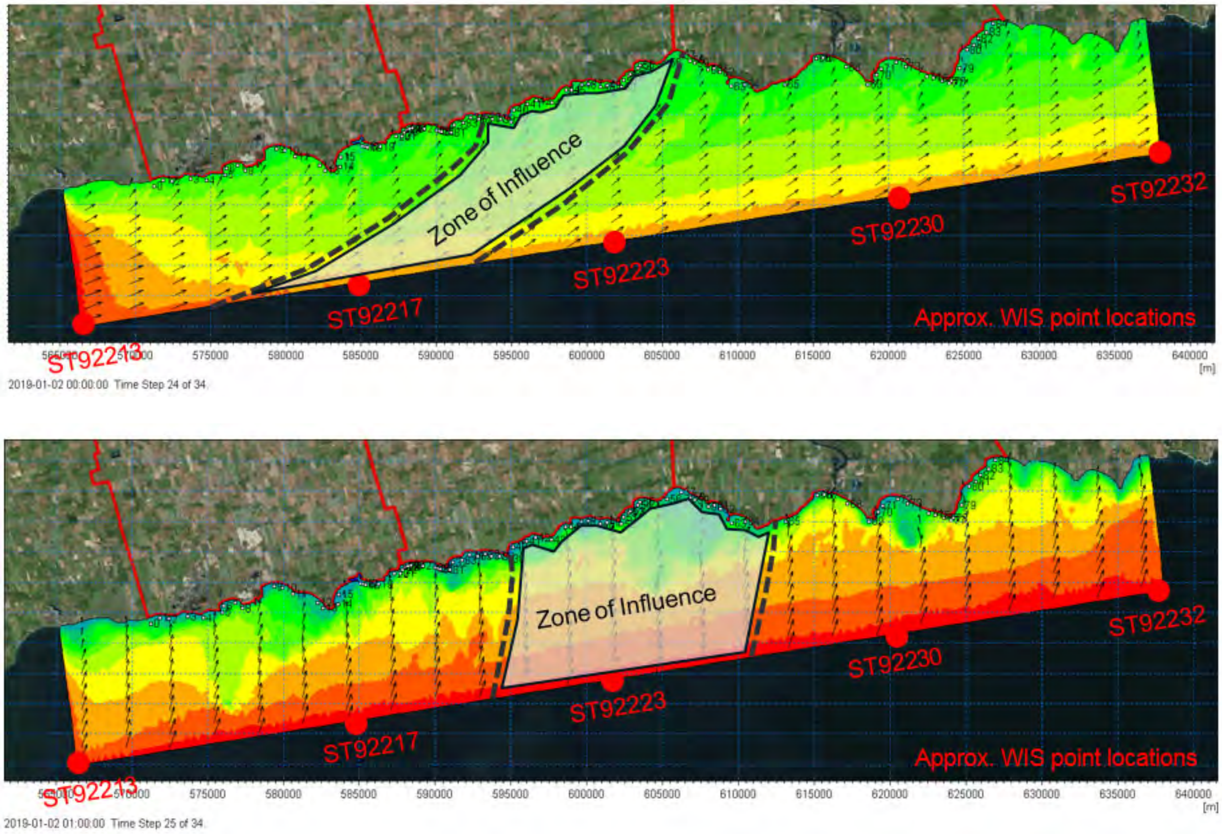

Figure 6.5: Example of nearshore wave modelling and selection of model runs for reach locations

6.2.2 Wave Uprush Analysis

Wave uprush (runup) elevations and horizontal distances were calculated for each reach using a representative shoreline profile. The shoreline profiles were extracted from a high-resolution merged dataset (listed in order of priority for use in developing) of the 2017 SWOOP LiDAR, 2015 SWOOP LiDAR, 2018 DFO bathymetric LiDAR and the NOAA/CHS Lake Erie bathymetry. The profiles were schematized to define the nearshore lakebed slope, water depth at the toe of slope, lower slope, beach berm (if applicable), upper slope, and crest height. Wave runup elevations were calculated for each profile using the empirical equations in the EurOtop overtopping manual (Van der Meer et al., 2018) for the 100-year flood level, 20-year wave conditions (from the nearshore wave modelling), and schematized shoreline profile.

An example of the wave runup elevation and corresponding horizontal runup distance on a high bluff is shown in Figure 6.6. In this example, the wave runup is 4.5 m above the 100-year flood level, and the corresponding horizontal runup distance is 11 m. In this figure, the "spike" at x=200 m is an artifact of the merging of the different LiDAR datasets at the shoreline and, as such, the "spike" is ignored.

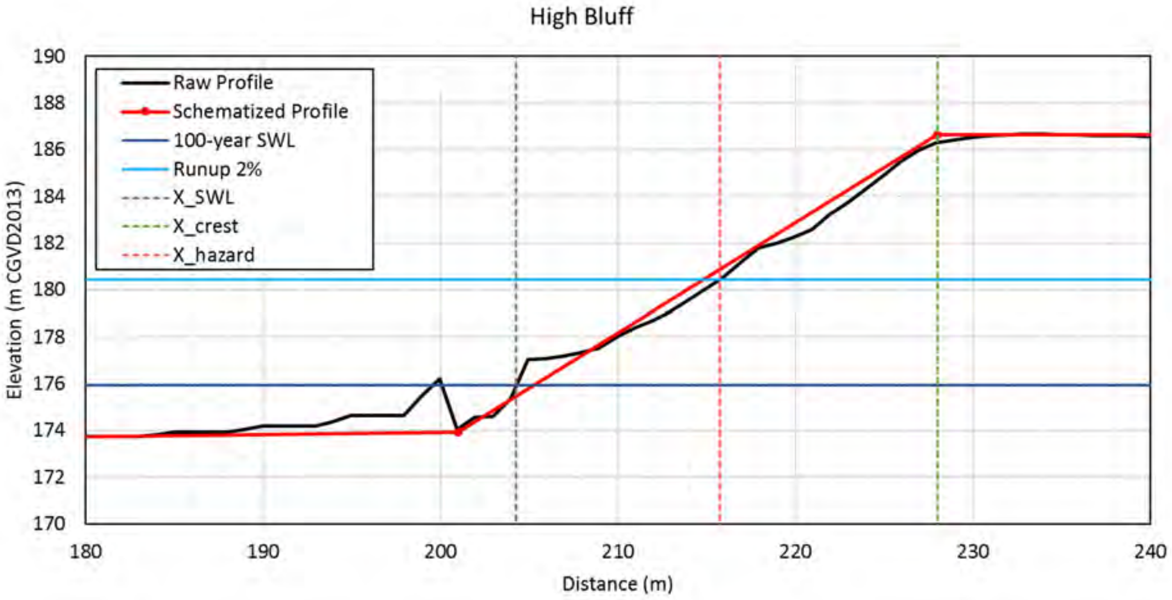

Figure 6.6: Example of wave uprush on a high bluff

An example of wave runup on a low bluff is shown in Figure 6.7. In this example, the wave runup is 4.6 m above the 100-year flood level, which exceeds the height of the bluff by 1.4 m.

When the wave runup exceeds the height of the bluff, the inland extent of the overtopping wave is then calculated according to the Cox-Machemehl equation (Eq. 1), as presented in MNR (2001a) and shown in Figure 6.3.

$$L_s = \frac{T\sqrt{g}}{5}(R-F)^{1/2}$$

where:

Ls = horizontal extent of wave uprush measured from the slope crest
T = wave period
g = acceleration due to gravity
R = wave runup
F = freeboard

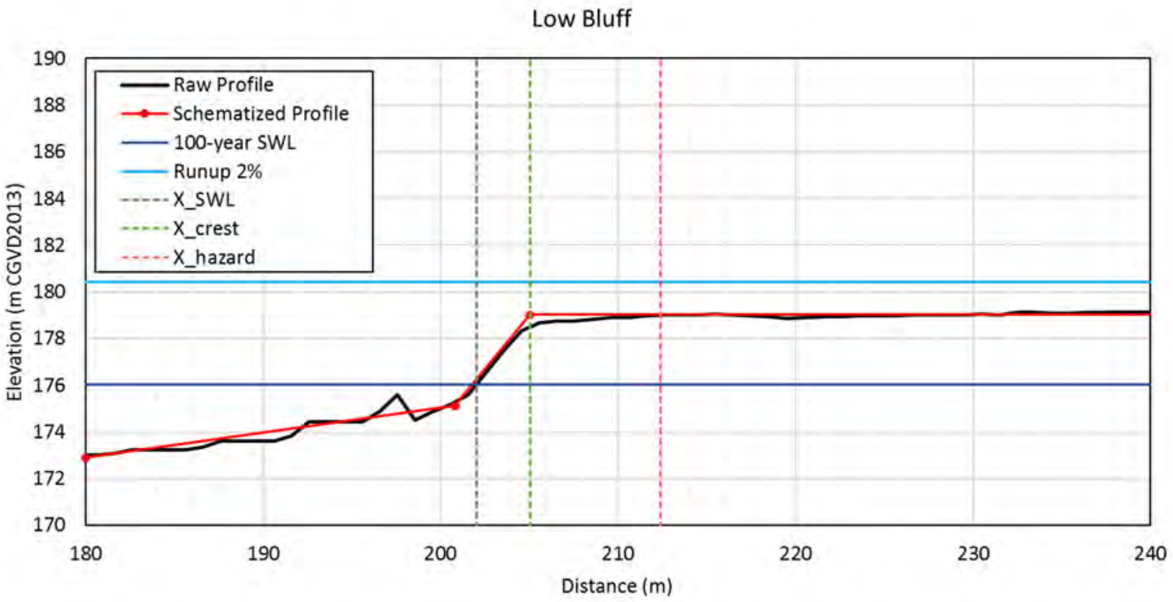

Figure 6.7: Example of wave uprush on a low bluff

In the example shown in Figure 6.7, the horizontal extent of wave uprush is 10 m (3 m horizontally on the slope and 7 m from the slope crest to the distance Ls).

6.3 Ice Impacts

A risk assessment of ice ride-up/piling was conducted for the Haldimand County Lake Erie shoreline. This phenomenon is also sometimes called an ice shove, ice surge, or ice tsunami in newspapers and local media.

MNR (2001a) describes the process as being caused by onshore winds and waves. The wind and wave action help to break up the ice into smaller floes, providing the conditions needed for ice piling (MNR, 2001a). Onshore winds drive the ice floes into the shoreline, which then pile-up under their own momentum. Generally, ice piling does not cause serious damage to beaches, bulkheads, and riprap revetments (MNR, 2001a). However, shore perpendicular structures (e.g. groynes, dock walls, piers, etc.), buildings, and other infrastructure may be significantly damaged by ice piling. MNR (2001a) notes that local experience with the impacts of ice piling is the best guide to help define the extent of the ice hazard.

A photograph of the February 25, 2019 ice pile-up event at Fort Erie, Ontario (east of Haldimand County) is shown in Figure 6.8. No historical ice pile-up events of this magnitude were identified by the project team for Haldimand County.

Figure 6.8: Ice pile-up along Lake Erie shoreline in Fort Erie, Ontario during Feb 25, 2019 (Mazza, 2019)

This section of the report includes a review of historical ice pile-up events in Haldimand County, shoreline conditions vulnerable to ride-up/pile-up processes, and evaluation of the risk of ice pile-up for the 84 shoreline reaches in Haldimand County.

6.3.1 Historical Ice Pile-up Events

A literature review was conducted to understand the historical risk of ice damage along the Haldimand County shoreline, and to obtain information or reports of past occurrences. From the literature review, and consultation with representatives of GRCA, NPCA, LPRCA and Haldimand County, it appears Haldimand County has historically had minimal impact due to ice pile-up. Ice piling is more common along the Niagara County shore of Lake Erie, where ice pile-up events have occurred in 2014, 2018, and 2019 (see Figure 6.9).

Figure 6.9: January 31, 2008 ice pile-up event in Niagara County (from NPCA)

In addition to Fort Erie (located east of Haldimand County), Erieau and Wheatley (located west of Haldimand County) have also experienced significant ice piling in the past and are indicated as areas prone to ice piling in Figure 6.10 (from MNR, 2001a).

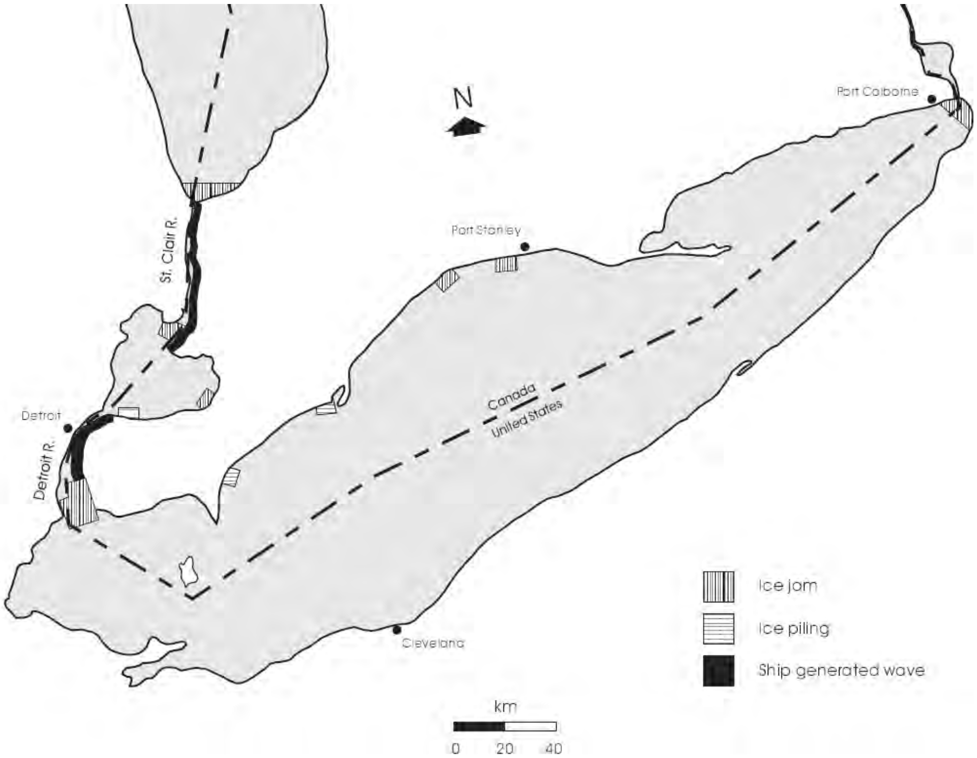

Figure 6.10: Ontario locations on Lake Erie vulnerable to ice piling (MNR, 2001a)

In Haldimand County, ice jams near the mouth of the Grand River are the primary ice and flooding concern. In January 2008, the combination of storm surge and wind, pushed a large amount of ice upstream into the Grand River, resulting in flooding near Dunnville. The Canadian Coast Guard often carries out ice breaking operations at the river mouth in the late winter to reduce the potential for upstream flooding (see Figure 6.11).

Figure 6.11: Canadian Coast Guard ice breaking operations in the Grand River, February 2009 (GRCA)

In terms of less severe ice effects along the Haldimand County shoreline, anecdotal reports were obtained from the GRCA and various residents. From the information obtained, it is evident that ice spray can occur during winter months when the lake is not completely frozen, or ice has been broken up by wave action. This combined with winds, results in the spray of waves icing structures along the shoreline. Specifically, this was noted to have occurred in December 1985 and February 2019 but may occur more frequently.

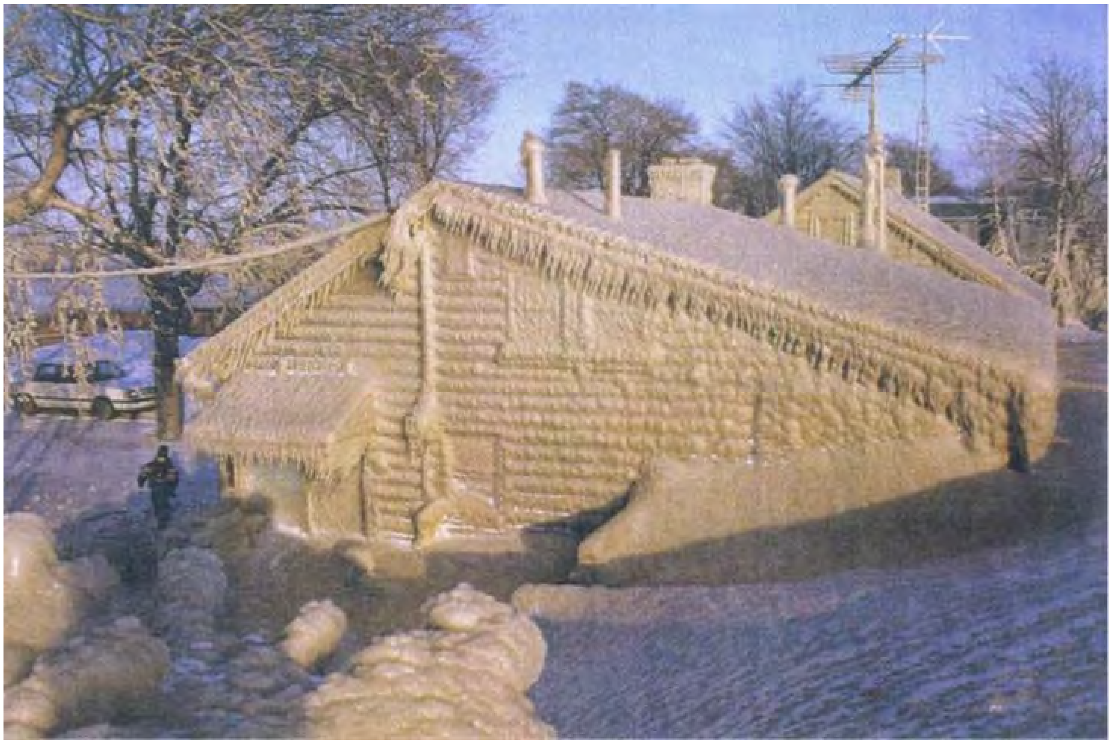

Figure 6.12: Example of Lake Erie ice spray on Erie Shore Drive (from LTVCA, date unknown)

6.3.2 Shoreline Conditions Vulnerable to Ice Ride-up/Pile-up

Ice ride-up tends to occur in places where the water is relatively deep, and the shore is relatively low and flat. Canadian experience on the Great Lakes and St. Lawrence River indicate that slopes of 2H:1V or steeper above the water line and about 4H:1V or flatter below the water line tend to limit ice pileup and damage (MacIntosh et al., 1995; Danys, 1979). The steeper slopes above the water line tend to contain the amount of ice ride-up/pile-up, and flatter slopes below the water line, or berms, will cause the ice to ground on the lakebed rather than pileup on the shoreline (MNR, 2001a).

6.3.3 Shoreline Risk Assessment

The risk of ice ride-up/pile-up was evaluated for the 84 shoreline reaches in Haldimand County based on the height of the shoreline bluff, shoreline orientation, above water slope, and below water slope. The open-water fetch distance for all reaches is sufficient for ice piling to occur.

The risk of ice ride-up/pile-up was estimated for each reach using the following criteria:

1. Freeboard Risk Factor:
    - 100% risk of ice ride-up when the bluff is at the same elevation as the 100-year flood level,
    - 0% risk of ice ride-up when the bluff is 3 m above the 100-year flood level.

2. Azimuth Risk Factor:
    - 100% risk of ice ride-up when the wind is perpendicular to the shoreline and onshore,
    - 0% risk of ice ride-up when the wind is parallel to the shoreline or offshore.
3. Lower Slope Risk Factor:
    - 100% risk of ice ride-up when the below water slope is 2H:1V or steeper,
    - 0% risk of ice ride-up when the below water slope is 4H:1V or flatter.
4. Upper Slope Risk Factor:
    - 100% risk of ice ride-up when the above water slope is 4H:1V or flatter,
    - 0% risk of ice ride-up when the above water slope is 2H:1V or steeper.

The risk factors were assessed using the reach profiles developed for the wave uprush estimates. The 100-year flood level was used for the freeboard risk factor estimates and is representative of a high-water condition that could occur during an ice pile-up event. Three metres was selected as a reasonable bluff height that would contain/limit the landward progression of an ice pile-up event (e.g. see Figure 6.8).

The azimuth (shoreline orientation) risk factor was calculated using the 40-year wind/wave hindcast for all wind occurrences over 10 m/s.

Based on information obtained from the literature review in relatively similar conditions to what is experienced along Haldimand County's shoreline (MacIntosh et al., 1995), both the lower and upper slopes of each reach profile were considered independently. For the lower slope, 2H:1V or steeper tends to promote the ice ride-up process, while slopes 4H:1V or milder will tend to promote grounding of the ice sheet and prevent ice ride-up. If the ice sheet is able to reach the upper slope, an upper slope of 2H:1V or steeper tends to prevent the ice from riding up the beach, while 4H:1V or milder will not. The slopes were considered with the associated bounds, and risk factors were calculated for each.

Given the limited information available on the quantification of different parameters and their influence on the overall ice ride-up process, minimum and maximum bounds were chosen for each parameter based on information obtained from the literature review, and a linear interpolation was done in between these bounds (see Figure 6.13).

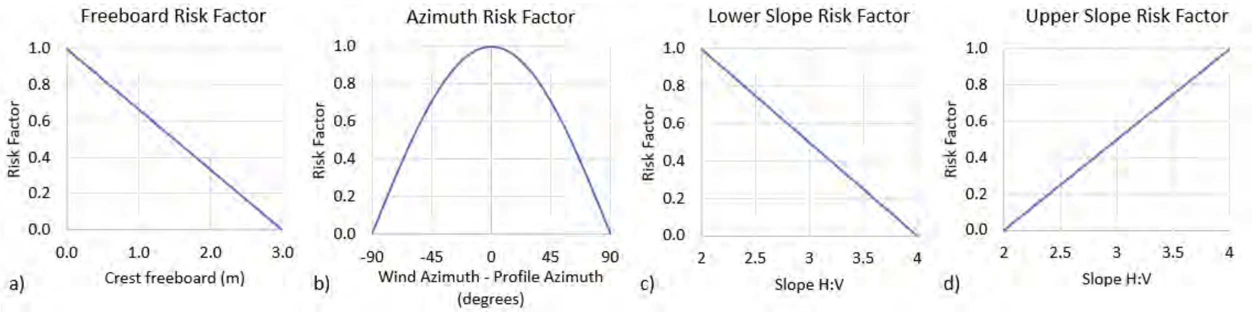

Figure 6.13: Functions used to estimate ice ride-up/pile-up risk factors

A combined Risk Factor (CRF) was calculated based on a weighted average using the equation below.

CRF = (Freeboard RF + Azimuth RF + 0.5* Lower RF + 0.5* Upper RF) / 3

Each reach was then classified as low, medium or high risk for ice ride-up/pile-up as follows: low (CRF<0.33); medium (0.33<CRF<0.66); or high (>0.66). Irrespective of the calculated CRF value, the combined risk of ice ride-up/pile-up was set to "low" for reaches when either of the following conditions were met:

- Height of the shoreline bluff greater than 3 m above the 100-year flood level, or
- Above water slope 2H:1V or steeper and below water slope 4H:1V or flatter.

Table 6.6 summarizes the resulting classifications for each reach along the Haldimand County Shoreline.

Table 6.6: Ice risk classification by reach

Risk of Ice Ride-up	Reaches
Low	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 24, 26, 27, 28, 29, 30, 31, 35, 37, 46, 48, 55, 56, 57, 58, 59, 65, 66, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 82
Medium	16, 17, 18, 19, 20, 21, 22, 23, 25, 32, 33, 34, 36, 38, 39, 40, 41, 42, 43, 44, 45, 47, 49, 50, 51, 52, 53, 54, 60, 61, 62, 63, 64, 67, 68, 80, 81, 83, 84
High	none

6.4 Geotechnical Analysis of Stable Slope

The Stable Slope Allowance used to determine the Erosion Hazard Limit (as defined in Section 4.3) is a horizontal allowance measured landward from the toe of the bluff, equivalent to three times the bluff height, or as determined through a study using accepted geotechnical principles (MNR, 2001a). For this project, a study was undertaken by Terraprobe Inc. to determine the stable slope allowance. The complete geotechnical report is provided in Appendix A, and the findings are summarized in this section.

The shoreline generally comprises sand beaches, visible limestone bedrock, or native slopes comprising glaciolacustrine silt and clay or glacial till. Stretches of shoreline are protected with armourstone, concrete retaining walls, steel sheet pile, and ad hoc protection.

The stable slope analysis was based on a review of publicly available subsurface information, existing Terraprobe reports for the area, and a detailed visual slope inspection. Cross-sections were developed from the 2017 LiDAR data at 52 representative locations in the reaches with a focus on the reaches where the Erosion Hazard governs (see Figure 6.14 and Figure 6.15). The subsurface conditions including general stratigraphy were assessed based on publicly available information, Terraprobe reports, and visual observations during the site visits. The water table was estimated from well records and site observations of seepage from the slope face.

An engineering analysis of slope stability was completed for each of the 52 locations. The analysis was conducted utilizing computer software (Slide 8.016, released July 23, 2018, developed by Rocscience Inc.) and several standard methods of limit equilibrium analysis (Bishop, Janbu, Morgenstern/Price, and Spencer). These methods of analysis allow the calculation of Factors of Safety for hypothetical or assumed slip surfaces through the slope. The analysis method is used to assess potential for movements of large masses of soil over a specific slip surface which can be curved or circular, or noncircular.

For a specific slip surface, the Factor of Safety is defined as the ratio of the available soil strength resisting movement, divided by the gravitational forces tending to cause movement. A Factor of Safety of 1.0 represents a “limiting equilibrium” condition where the slope is at a point of pending failure since the soil resistance is equal to forces tending to cause movement. It is usual to require a Factor of Safety greater than one (1) to ensure stability of the slope. The typical Factor of Safety used for engineering design of slopes for stability ranges from about 1.3 to 1.5 for developments situated close to the slope crest. For active land use, the MNR Policy Guidelines allow a minimum Factor of Safety of 1.4 to 1.5 for slope stability and a Factor of Safety of 1.5 was used for this study.

The computed minimum Factors of Safety for the sections analyzed was as low as 1.0 and the minimum Factors of Safety obtained for existing conditions in 10 of 52 section locations are considered inadequate and unacceptable for long-term planning purposes.

The stable slope was determined for each section considering soil type and available data. The soil type of each section is composed of assumed earth fill, surficial sand, silt and clay, and/or glacial till. For the slopes with a composition of native silt and clay or glacial till, a number of representative trial stabilized slope profiles were analysed to obtain the required factor of safety. The stable slope inclinations for each of the reaches analyzed are listed in Table 6.7, along with the primary soil type. Where the slope is earth fill and/or surficial sand, a value of 3H:1V was used. Additional information on slope height, inclination and existing Factor of Safety (FS) are provided in Appendix A.

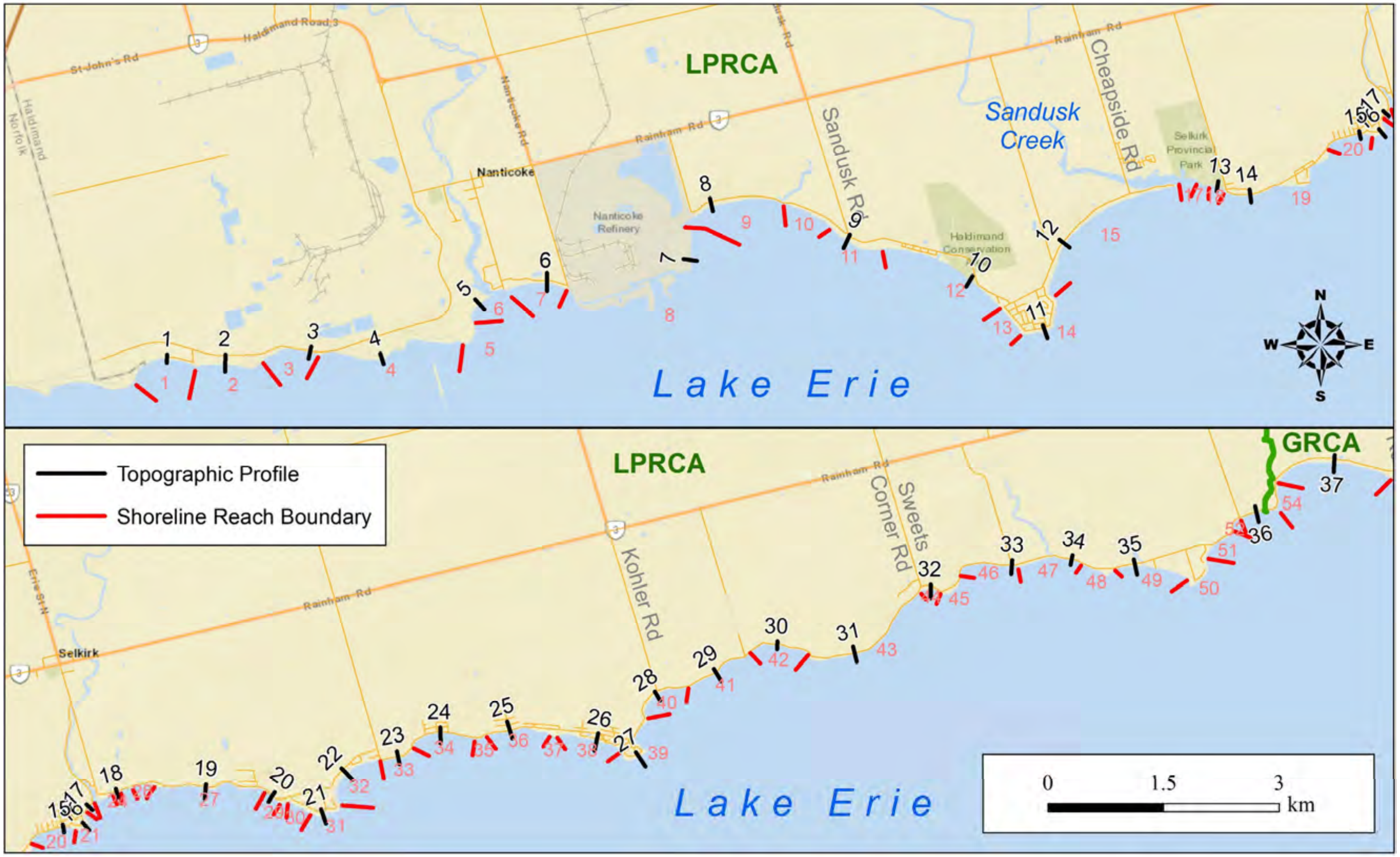

Figure 6.14: Map showing reaches and locations where a stable slope analysis was completed (west end of Haldimand County)

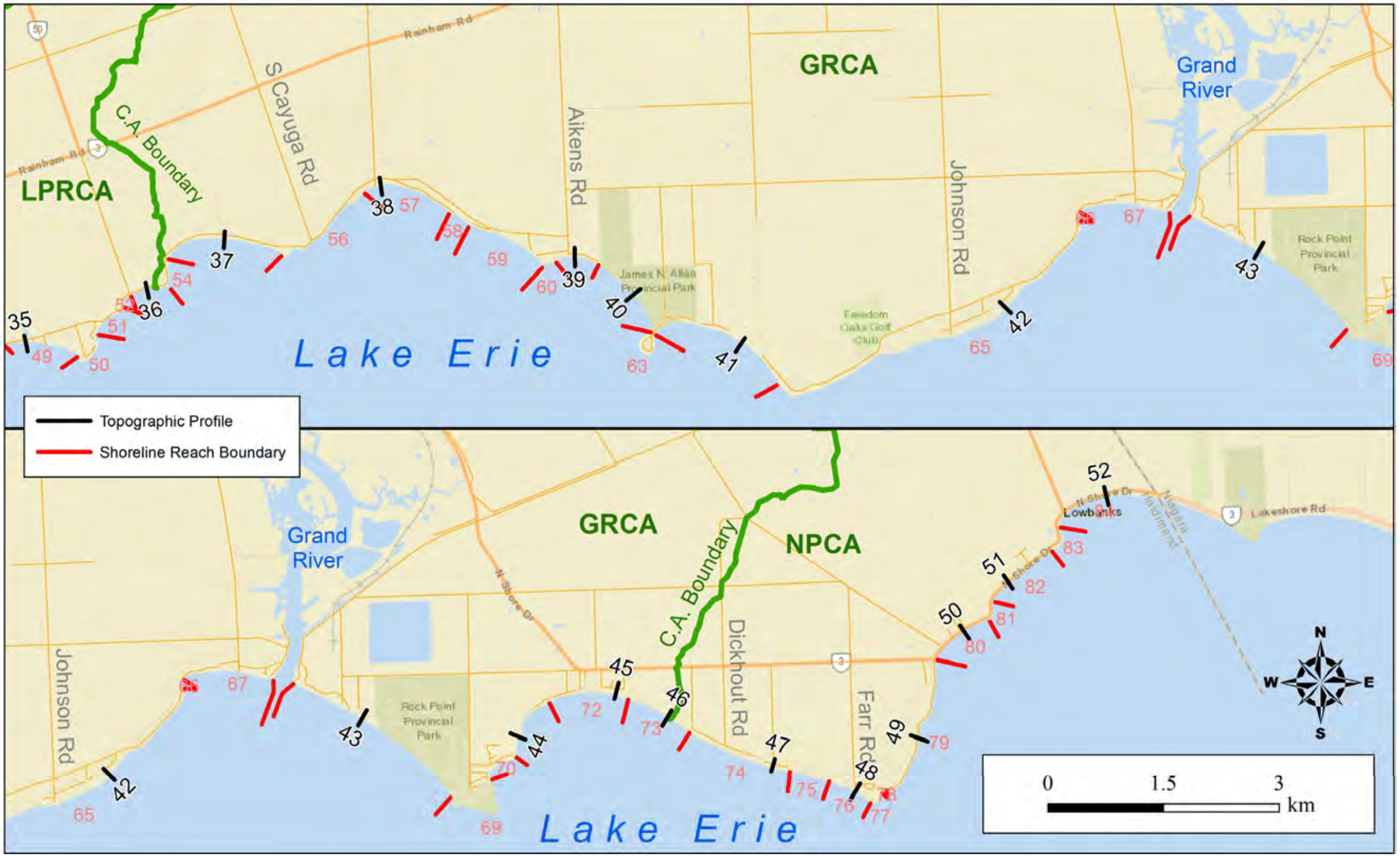

Figure 6.15: Map showing reaches and locations where a stable slope analysis was completed (east end of Haldimand County)

Table 6.7: Stable slope inclinations for each of the cross sections based on the primary soil type

Reach	Section #	Primary Soil Type	Stable Inclination
1	1	glaciolacustrine silt and clay	2.3H:1V
2	2	glaciolacustrine silt and clay	2.3H:1V
3	3	glaciolacustrine silt and clay	2.3H:1V
4	4	glaciolacustrine silt and clay	2.3H:1V
6	5	glaciolacustrine silt and clay	2.3H:1V
7	6	glaciolacustrine silt and clay	2.3H:1V
8	7	earth fill	3.0H:1V
9	8	glaciolacustrine silt and clay	2.3H:1V
11	9	glaciolacustrine silt and clay	2.3H:1V
12	10	glaciolacustrine silt and clay	2.3H:1V
14	11	glaciolacustrine silt and clay	2.3H:1V
15	12	glaciolacustrine silt and clay	2.3H:1V
18	13	glaciolacustrine silt and clay	2.3H:1V
19	14	glaciolacustrine silt and clay	2.3H:1V
20	15	glaciolacustrine silt and clay	2.3H:1V
21	16	glaciolacustrine silt and clay	2.3H:1V
22	17	glaciolacustrine silt and clay	2.3H:1V
24	18	glaciolacustrine silt and clay	2.3H:1V
27	19	sand	3.0H:1V
		glaciolacustrine silt and clay	2.3H:1V
28	20	glaciolacustrine silt and clay	2.3H:1V
31	21	glaciolacustrine silt and clay	2.3H:1V
32	22	glaciolacustrine silt and clay	2.3H:1V
33	23	glaciolacustrine silt and clay	2.3H:1V
34	24	glaciolacustrine silt and clay	2.3H:1V
36	25	glaciolacustrine silt and clay	2.3H:1V
38	26	glaciolacustrine silt and clay	2.3H:1V
39	27	sand	3.0H:1V
		glaciolacustrine silt and clay	2.3H:1V
40	28	glaciolacustrine silt and clay	2.3H:1V
41	29	glaciolacustrine silt and clay	2.3H:1V
42	30	glaciolacustrine silt and clay	2.3H:1V
43	31	glaciolacustrine silt and clay	2.3H:1V
44	32	glaciolacustrine silt and clay	2.3H:1V

Reach	Section #	Primary Soil Type	Stable Inclination
46	33	glaciolacustrine silt and clay	2.3H:1V
47	34	glaciolacustrine silt and clay	2.3H:1V
49	35	sand	3.0H:1V
53	36	glaciolacustrine silt and clay	2.3H:1V
55	37	glaciolacustrine silt and clay	2.3H:1V
57	38	glacial till	1.8H:1V
61	39	glacial till	1.8H:1V
62	40	sand	3.0H:1V
		glacial till	1.8H:1V
64	41	sand	3.0H:1V
		glaciolacustrine silt and clay	2.3H:1V
65	42	earth fill / unknown	3.0H:1V
		bedrock	1.4H:1V
68	43	sand	3.0H:1V
		glaciolacustrine silt and clay	2.3H:1V
71	44	glacial till	1.8H:1V
72	45	glacial till	1.8H:1V
73	46	glacial till	1.8H:1V
74	47	glacial till	1.8H:1V
76	48	glacial till	1.8H:1V
79	49	sand	3.0H:1V
		glacial till	1.8H:1V
80	50	sand	3.0H:1V
82	51	sand	3.0H:1V
84	52	sand	3.0H:1V

6.5 Average Annual Recession Rate (AARR)

The Average Annual Recession Rate (AARR) is used to delineate the Erosion Hazard, as defined in Section 4.3. The Technical Guide (MNR, 2001a) identifies the use of historic aerial photographs extending over long periods of time as a good indicator of future recession/erosion rates. Specifically, it is recommended that at least 35 years of sound recession information for the unprotected shoreline should exist to calculate an AARR.

The 2017 LiDAR data and the 2015 aerial imagery (described in Section 3.2) were used as a basis of comparison with historical imagery to estimate the AARR. The bank toe and crest lines were manually digitized in GIS, providing a good estimate of the existing bluff conditions upon which to estimate the future erosion setback. The elevation difference between the toe and crest was calculated at the representative profile in each reach to establish the bluff height.

Historic aerial imagery for Haldimand County was obtained from sources including the National Air Photo Library, internal collections of the member Conservation Authorities, and various other government and university collections. These collections provided aerial photographs from dates including 1945, 1955, 1964, and 1973. When compared to the current 2015 aerial imagery, these aerial photos provide temporal change over periods ranging from 42 to 70 years.

The oldest historic aerial photographs would provide the longest temporal period to measure a more accurate long-term recession rate, but there are other factors to consider when selecting aerial photographs for shoreline change analysis including: photographic scale, lake water level, quality of the prints, time of year such that vegetation cover does not obscure ground features, type of photographic film (black and white, colour, near infrared), and other factors. Figure 6.16 is a map showing the selected historic aerial photographs reviewed for estimating the AARR. The oldest available photographs are from 1945 but were limited to the lands that became the Nanticoke Power Generation Station and the broader Lake Erie Industrial Park lands as far east as Peacock Point. The 1955 photographs were acquired in the summer months, so the tree canopy cover limited their use to the east end of the County where erosion was still observable on bluff faces. The 1964 photographs at the west end of the County provide a high resolution and high contrast capture, but this photo set was limited to the west end of the County. The 1973 photographs were acquired on May 19 and are infrared photographs providing a leaf-off view of the central shoreline where there is not a distinctive eroding high bluff.

For both the historic aerial photographs and the 2015/2017 dataset, a reference top of bank feature was digitized where the shoreline was unprotected and a change in top of bank location could be identified. The change in top of bank location was measured using a series of parallel transects at 10 metre spacing. Figure 6.17 is a map showing an example of these transects at unprotected shoreline stretches in Mohawk Bay. The transects used to estimate shoreline change are shown on the maps provided in Appendix B. The recession rate was determined based on the mean of the transect recessions in each reach plus one standard deviation (S.D.). The historic imagery date, temporal period of comparison, number of transects measured, average recession, standard deviation and AARR plus 1 S.D. are tabulated in Table 6.8, for the reaches where an AARR could be established. These values were used for mapping the Erosion Allowance as described in Section 7.1.2.

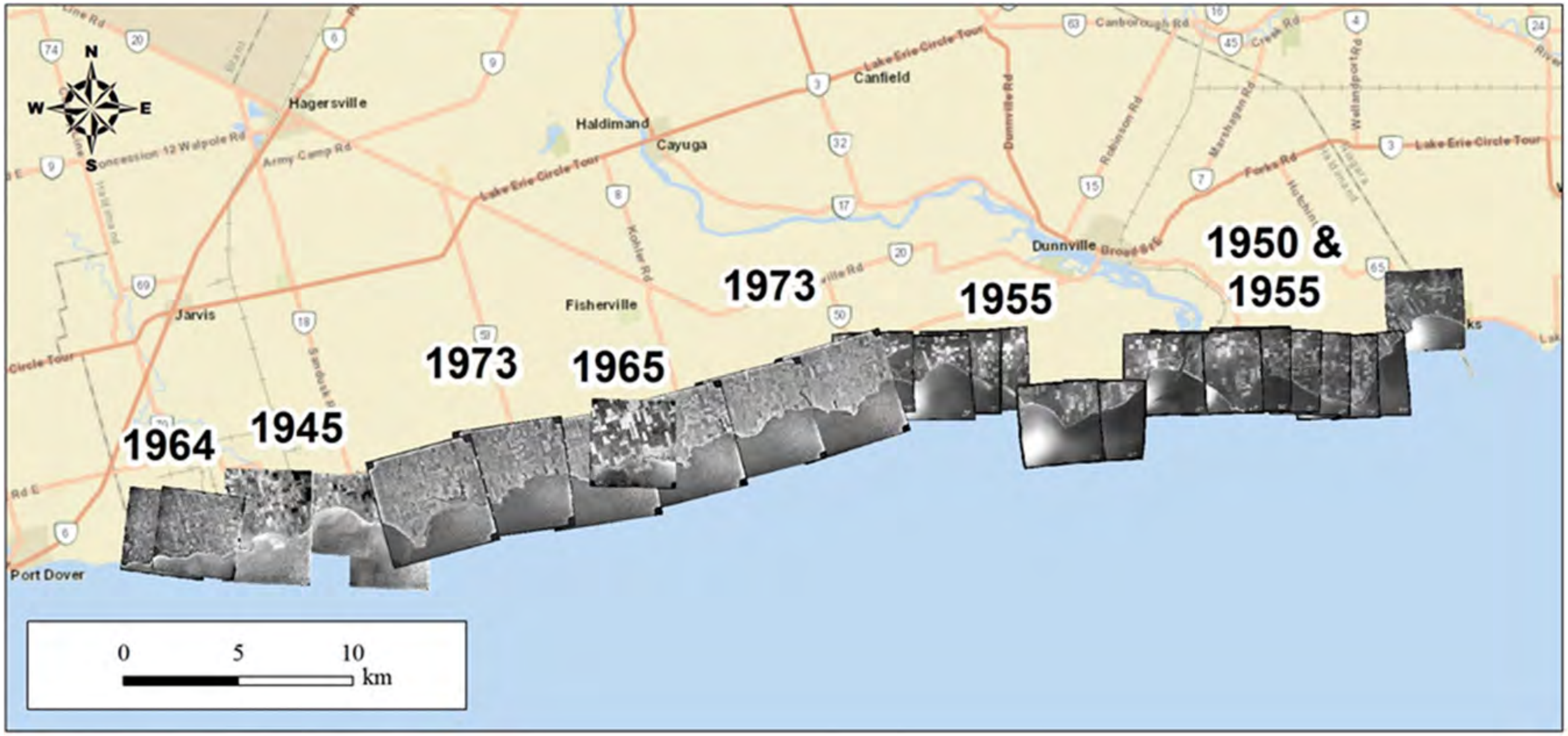

Figure 6.16: Map of selected historic aerial photographs used to estimate the AARR

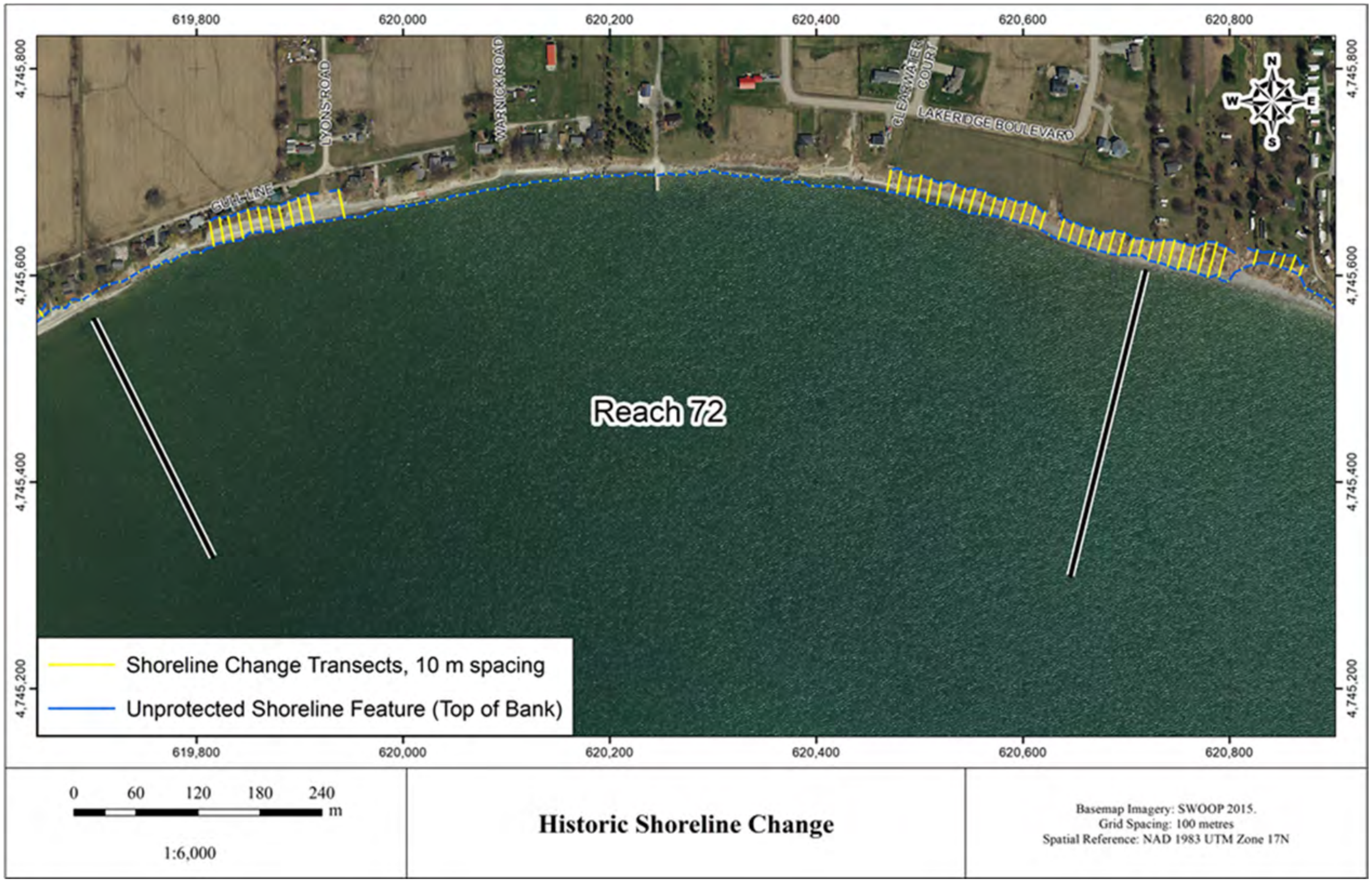

Figure 6.17: Example map of transects where change in top of bank location was measured at unprotected shoreline, to estimate the AARR

Table 6.8: Summary of calculated shoreline change and AARR for reaches where AARR was measured

Reach	Historic Year	Temporal Period	Transect Count	Average Recession (metres)	1 S.D. (metres)	Avgerage + 1 S.D. (metres)	AARR + 1 S.D. (metres/year)
2	1964	51	85	7.56	5.11	12.67	0.25
6	1945	70	35	17.32	12.44	29.76	0.43
7	1945	70	17	11.83	4.14	15.96	0.23
9	1945	70	55	4.28	1.82	6.10	0.09
10	1945	70	22	11.24	3.91	15.14	0.22
11	1945	70	22	4.33	1.33	5.66	0.08
12	1945	70	52	25.68	5.19	30.87	0.44
15	1973	42	32	17.35	11.80	29.15	0.69
18	1973	42	11	10.76	1.18	11.94	0.28
32	1973	42	18	7.21	3.57	10.79	0.26
36	1973	42	8	2.37	1.11	3.48	0.08
57	1955	60	34	11.37	1.21	12.59	0.21
58	1955	60	8	21.30	1.87	23.17	0.39
59	1955	60	20	15.74	2.56	18.30	0.30
61	1955	60	4	18.92	1.25	20.17	0.34
62	1955	60	40	3.06	1.80	4.85	0.08
64	1955	60	32	19.40	3.25	22.65	0.38
70	1955	60	27	5.48	2.81	8.28	0.14
71	1955	60	72	14.96	4.74	19.71	0.33
72	1955	60	38	21.28	2.92	24.21	0.40
73	1955	60	71	24.14	6.41	30.54	0.51
74	1955	60	86	15.23	5.44	20.66	0.34
75	1955	60	14	10.85	1.41	12.26	0.20

6.6 Climate Change

The Ontario Climate Consortium and Ontario Ministry of Natural Resources and Forestry published a climate change synthesis report for the Great Lakes basin in 2015 (McDermid et al., 2015). The report draws on over 70 scientific studies published since 2010 for the Great Lakes basin. The report outlines the anticipated climate change impacts, evidence, uncertainty, and agreement between studies in language that this accessible to the general public. Findings from the synthesis report will be referred to throughout this section as it reflects the current state of climate change science for the Great Lakes basin.

6.6.1 Projected Climate Change Impacts

The impacts of climate change in the Great Lakes are uncertain and are likely to remain uncertain even as climate change science advances. The uncertainty is related to the complexity of the hydrological conditions in the Great Lakes basin including their long-term cyclic nature (precipitation, evapotranspiration, runoff, etc.), the difficulties in modelling the conditions, and predicting future green house gas levels which will depend on human actions and behaviours.

Future water levels will be most affected by changes in air temperature and precipitation. Over the past 60 years, average annual air temperatures have increased and are predicted to continue increasing. The increase in air temperature is expected to result in lower water levels due to increased evapotranspiration. The past 60 years have also been slightly wetter than the historical average and annual precipitation is predicted to increase over the next century. However, the increase in air temperature is predicted to be more significant than the increase in precipitation, resulting in overall drier conditions and lower lake levels (McDermid et al., 2015).

The natural variability in water supplies is likely more significant than the anticipated climate change impacts on water levels in the Great Lakes. Long-term (decadal) fluctuations in water supplies have been measured since 1860 and are believed to be driven by large-scale atmospheric and oceanic circulation patterns such as the Atlantic Multidecadal Oscillation (Hanrahan et al., 2014; Watras et al., 2014). These large-scale anomalies affect air temperature, moisture availability, and precipitation. The natural variation in monthly mean water levels is approximately 2 m for Lake Erie.

The terms, “confidence” and “uncertainty” are used extensively in climate change literature. In general, confidence relates to the amount, quality, and agreement of the evidence, and uncertainty relates to the magnitude of the unknowns. In McDermid et al. (2015) the various studies were reviewed by a cross-section of climate change researchers and information on each topic was evaluated and ranked as low, medium or high confidence based on the agreement among available studies; type, amount, and quality of the evidence; and limitations of the research.

Uncertainty in future projections is also related to the challenges of predicting future human behaviour related to future green house gas levels (scenario uncertainty), and model imperfection. Climate models use mathematical equations to represent complex processes between the atmosphere, earth surface, and human and natural systems. Model uncertainty is related to our understanding of those systems and the accuracy of the model results.

A summary of projected climate change impacts on factors affecting Lake Erie water levels are provided in Table 6.9. The various factors are discussed in detail in the following sections.

Table 6.9: Projected impacts of climate change in the Great Lakes Basin (adapted from McDermid et al., 2015)

Theme	General Projections	Trend	Confidence
Air Temperature	• 1.5 to 7 °C increase by the 2080s depending on climate scenario model used. • Greater increases in the winter.	Increase	High evidence High agreement
Precipitation	• 20% increase in annual precipitation across the Great Lakes Basin by 2080s under the highest emission scenario. • Increases in rainfall, decreases in snowfall.	Increase	High evidence Medium agreement

Theme	General Projections	Trend	Confidence
	• Increased spring precipitation, decreased summer precipitation. • More frequent extreme rain events.		
Drought	• Increases in frequency and extent of drought.	Increase	Low evidence High agreement
Wind	• Increased wind gust events.	Increase	Low evidence Low agreement
Water Temperature	• 0.9 to 6.7 °C increase in surface water temperature by the 2080s. • 42-90 day increase in ice free season.	Increase	High evidence Low agreement
Water Levels	• Water levels in the Great Lakes naturally fluctuate by up to 1.5m. • Long-term water levels in the Great Lakes peaked in the 1980s and have been decreasing since. • Projections of future lake water levels vary; however, they generally suggest fluctuations around lower mean water levels. • Lower water levels are due to several factors including warmer air temperatures, increased evaporation and evapotranspiration, drought, and changes in precipitation patterns.	Decrease	High evidence Low agreement
Ice	• Projected decreases in ice cover duration, ice thickness, and ice extent. • Increased mid-winter thaws, changing river ice dynamics.	Decrease	Medium evidence High agreement
Flood	• Increases in flood severity and frequency.	Increase	Medium evidence Medium agreement

Air Temperature

There is high confidence that air temperatures in the Great Lakes basin have risen in the past 60 years and will continue to rise in the future. Average annual air temperatures have risen by up to 2°C and are predicted to continue to rise regardless of the emissions scenario (Lofgren et al., 2002; Hayhoe et al., 2010; McKenney et al., 2011). The largest temperature increases have occurred and are projected to occur in the winter and spring (McKenney et al. 2011), resulting in more winter rainfall (less snowfall), less ice cover (more evaporation), and also affecting the timing of the spring freshet. Higher air temperatures in the summer and fall are projected to result in increased evaporation and plant transpiration (collectively evapotranspiration).

Precipitation

There is medium to high confidence that the Great Lakes basin is in a period of slightly wetter weather. Future projections indicate that annual precipitation will increase by up to 20% across the Great Lakes basin (Lofgren et al., 2002; McKenney et al., 2011).

Rising air temperatures are expected to result in a higher percentage of precipitation falling as rain, and less as snow. Snowfall losses of up to 48% are projected for the Great Lakes basin by the end of the century (Notaro et al., 2014). The projected increase in winter rainfall and decline in snowpack is expected to affect the timing and magnitude of the spring freshet.

Rainfall amounts are projected to increase in the spring and decline in the summer (Kling et al., 2003; Hayhoe et al., 2010). The resulting shifts in the timing of precipitation and snowmelt could present challenges for lake regulation, though this is less relevant for Lake Erie.

Heavy rainfalls are twice as frequent as a century ago and are projected to become more frequent in the future (Changnon and Kunkel, 2006; Kling et al., 2003). Heavy rainfalls are more of a concern for flood-prone urban and riverine areas.

Drought

There is moderate confidence that the Great Lakes basin has been and will become more vulnerable to drought (Bonsal et al., 2011). Air temperature and evapotranspiration are projected to increase in the summer while precipitation is predicted to decline.

Wind/Storminess

There is low confidence in projections of future wind speeds and wind patterns. It is believed that warmer air and water temperatures in the Great Lakes may increase atmospheric turbulence, resulting in higher wind speeds in the lower atmosphere (Austin and Colman, 2007; Desai et al., 2009; Huff et al., 2014). However, other studies such as Yao et al. (2012), project a decrease in wind speeds in the Great Lakes Basin by the year 2100. Cheng et al. (2012) projected that wind gusts will become at least 10% more frequent by the end of the century.

Water Temperature

There is moderate confidence that surface water temperatures in the Great Lakes basin have risen in the past century and will continue to rise in the future. The high evidence and low agreement for this topic indicates that there is considerable variability between studies. The increase in water temperature is projected to result in less ice cover (duration and extent), resulting in increased evaporation from the lake surface.

Water Levels

McDermid et al. (2015) reports moderate confidence that water levels in the Great Lakes peaked in the 1980s, declined, and will continue to decline in the future. This seems to ignore longer term variations in water levels prior to 1980, and water levels reached record highs on Lake Erie in 2019. Masking climate change impacts are the much larger natural (decadal) cycles of high and low water supplies.

Projections indicate that future mean water levels will be similar or slightly lower due to higher evapotranspiration rates, and changes in precipitation patterns (Mortsch et al., 2003; Hayhoe et al., 2010; Lofgren et al., 2002; McKenney et al., 2011; Angel and Kunkel, 2010; MacKay and Seglenieks, 2013). Some earlier studies, which predicted more severe water level declines, are believed to have overestimated evapotranspiration rates (Lofgren et al., 2011). Emerging research using an energy balance approach to evapotranspiration suggest that declines, and possibly increases, in water levels will be modest.

Ice

There is moderate to high confidence that ice cover in the Great Lakes is decreasing and that mid-winter thaws are becoming more frequent. A decrease in the duration and extent of the ice cover will result in increased evaporation from the lake surface. The greatest evaporation losses on the Great Lakes occur in the fall and winter when cold, dry air blows over the warmer lakes (Mortsch et al., 2003). Mid-winter thaws may pose challenges for river ice management.

The extent of ice cover on the Great Lakes decreased 71% between 1973 and 2010 (Wang et al., 2012) and the ice cover period decreased by 1 to 2 months over the past century (McDermid et al., 2015). Ice protects the shoreline and prevents erosion during winter storms. Therefore, a reduction in the ice-in period will render shorelines more susceptible to extreme storm events (Mortsch et al. 2003). Baird (2019) describes wave modeling undertaken on Lake Erie to examine the impact of future ice regimes on wave climatology. It was found that wave energy along the Chatham-Kent shoreline at the west end of Lake Erie would increase by 150% to 200% if lake ice disappears in the future.

Flood

There is medium confidence that summer floods will become more frequent and more severe and that spring floods will become less severe in the Great Lakes basin. Spring runoff is projected to decline due to the predicted decrease in snowfall (Notaro et al., 2014; Shaw and Riha, 2011). However, extreme rainfall events are projected to become more frequent in the future. These changes are likely to result in less frequent riverine flooding (smaller freshets), and more frequent urban (pluvial) flooding.

6.6.2 Summary

The latest climate change research related to precipitation, evaporation, snow and ice cover, and storminess in the Great Lakes basin was reviewed to assess potential future changes to static water levels, storm surge, waves and sediment processes in the study area.

Over the past 60 years, the Great Lakes basin has become warmer and has been slightly wetter (than the long-term average). Air temperature and precipitation are projected to increase in the future, with water levels in the Great Lakes remaining similar or slightly decreasing (McDermid et al., 2015). The uncertainty in water level projections is related to the relative roles of evapotranspiration and precipitation. It is likely that the impacts of climate change on static water levels will be less than the natural variability of Lake Erie.

Snowfall and ice cover in the Great Lakes-St. Lawrence River basin are projected to decrease resulting in an earlier and smaller spring freshet (Kling et al., 2003) and increased evaporation from the lake surface in the winter. In addition, predicted reduced ice cover will result in increased wave energy, which in turn would result in higher erosion rates and sediment transport rates. Increased exposure to surge could also be expected as a result on reduced ice cover.

Wind gusts, although expected to increase slightly over the next century, are anticipated to have a lesser impact on storm surge and waves.

7. Mapping

7.1 Hazard Mapping

The 2015 SWOOP imagery was used to prepare the base maps for the hazard mapping. The flood, erosion and dynamic beach hazard limits were mapped as described below.

7.1.1 Flooding Hazard Mapping

The Flood Hazard Limit is the 100-year flood level plus an allowance for wave uprush as defined in MNR (2001a) and described in Section 4.2.

The 100-year flood level was established based on analyses described in Section 6.1. The 100-year flood levels were defined for each reach using a linear interpolation between the 100-year flood levels at Port Dover and Port Colborne adjusted to CGVD2013 datum. The flood levels were rounded to the nearest 0.1 m increment, with breaks occasionally adjusted to coincide with headland features. For example, the 100-year flood level transitions from 176.0 m to 176.1 m CGVD2013 at Hoover Point (Reaches 28/29) rather than at Reaches 34/35 (where the 100-year flood level transitions from 176.04 to 176.05 m). Shifting the 100-year flood level breaks to the headlands is supported by the understanding of the natural storm surge processes. The location of the 100-year flood level was mapped using the 2015 and 2017 elevation datasets, which are of sufficient scale and accuracy to locate the flood elevation.

The horizontal wave uprush allowance includes both the wave runup on the shoreline slope and the inland extent of overtopping waves. Wave uprush was established based on the analyses described in Section 6.2. The mapped wave uprush is based on the calculated horizontal extent of wave uprush measured from the 100-year flood level, except in cases where it was clear that wave uprush would not exceed the top of bluff elevation. In these cases, the wave uprush allowance was plotted at the calculated uprush elevation, on the bluff slope.

The average calculated horizontal wave uprush was 14.6 m for the 84 profiles, with a minimum value of 5 m and maximum value of 33 m. All values less than 15 m were mapped as 15 m due to possible variability in wave exposure, nearshore slope, water depth at the toe, and bluff height within a reach. Approximately 40% of the reaches have a wave uprush allowance greater than 15 m.

The 100-year flood level and allowance for wave uprush values used to map the Flooding Hazard are listed on a reach basis in Appendix C. While the vertical uprush elevation is listed in the table, this value should not be used to establish floodproofing elevations. Floodproofing is discussed further in Section 8.1 and in MNR (2001a, Appendix A7.1).

7.1.2 Erosion Hazard Mapping

The Erosion Hazard Limit is the stable slope allowance plus the erosion allowance as defined in MNR (2001a) and described in Section 4.3.

The stable slope allowance was defined on a reach basis, using a geotechnical study, as summarized in Section 6.4 and described in detail in Appendix A. For those reaches where a stable slope was not defined by a geotechnical study, a stable slope of 3H:1V was assumed, consistent with MNR (2001a). The stable slope allowance was calculated by multiplying the stable slope inclination by a representative bluff height within the reach. The stable slope allowance was measured inland from the delineated toe of bluff and mapped. Where the stable slope allowance plotted lakeward of the existing top of bluff, an adjustment was made, and the stable slope allowance was moved inland to the top of bluff. The stable slope allowance values used in the mapping are listed in Appendix C.

Where erosion could be measured using the historical shoreline comparison, the erosion allowance was calculated from the values presented in Section 6.5. The AARR + 1 S.D. was multiplied by 100, representing the 100-year planning horizon as specified in MNR (2001a). The erosion allowance was measured inshore from the stable slope allowance and mapped. Where erosion was not measured, due to the presence of shore protection along the reach or difficulty in delineating a bluff crest, an erosion allowance of 30 m was assumed, consistent with MNR (2001a). An erosion allowance of 40 m was applied at Reaches 78 and 79, located towards the east end of Haldimand County, because this value was reported in the Shoreline Management Plan update (Shoreplan, 2010), and there was no justification for reducing it to a less conservative value of 30 m.

There are a number of bedrock headlands along the Haldimand shoreline, where no measurable change in shoreline position was identified. At these locations, there is not a well defined top of bluff, however shoreline recession rates are low due to the geological characteristics. A 10 m erosion allowance was used at bedrock headlands. An abrupt change in recession rates can be expected where the shoreline changes from a bedrock headland to a cohesive bluff. An example of this occurs at Peacock Point; erosion rates increase east of Peacock Point. There are limited stretches of shoreline where erosion rates could be measured east of Peacock Point because the shoreline is largely protected. Shore protection is generally indicative of an eroding shoreline.

The erosion allowance was measured inland from the stable slope allowance and mapped. The erosion allowance values used in the mapping are listed in Appendix C.

At reach boundaries, the Erosion Hazard Limit changes from one reach to the next and no transition was applied. This may result in a discontinuity at reach boundaries.

7.1.3 Dynamic Beach Hazard Mapping

The Dynamic Beach Hazard Limit is the landward limit of the flooding hazard (100-year flood level plus a flood allowance for wave uprush and other water related hazards), plus a 30 m dynamic beach allowance or a distance determined by an accepted coastal study as defined in MNR (2001a) and described in Section 4.4.

The dynamic beach was mapped as described above.

7.1.4 Establishing Hazard Limits Onsite

It is understood that the hazard limits will be measured onsite, in response to site specific development applications. While the mapping provides a visual representation of the hazard limits on a reach basis, a more accurate assessment should be determined onsite using information provided in this report. For example, a representative bluff height was used to establish the stable slope allowance within a given reach, however bluff height can vary to some degree along the reach and adjustments may be required. In addition, where shorelines are eroding, the hazard limit will need to be adjusted inland in response to erosion occurring after the date of the data used for mapping.

7.2 Flood Depth Mapping for Flood Preparedness

Mapping was developed to identify areas that would be rendered inaccessible to people and vehicles due to water depth and wave uprush conditions during the 100-year flood. Roads located within the Flooding Hazard (100-year flood level plus an allowance for wave uprush) were identified. Water depths on the roads were then mapped at 0.3 m intervals for the 100-year flood level. Roads located in the wave uprush zone are also indicated on the maps. Roads in the wave uprush zone will be exposed to moving water. Velocities within the wave uprush zone vary temporally and spatially and cannot be readily defined as is typically done for river flooding.

The mapping is presented in Appendix D. The mapping informs the National Disaster Mitigation Program, Risk Assessment Information Template (NDMP-RAIT) that was updated for this study and is provided under separate cover.

7.2.1 Vehicular Access/Egress

Ingress and egress from an area by the most "typical" automobiles will be halted by flood depths above 0.3 to 0.4 m (MNR, 2002). This is generally consistent with MNR (2001a), which references a depth limit of 0.3 - 0.5 m. This is the typical depth of key electrical components, which fail when submerged, preventing vehicle egress. A maximum flood velocity of 4.5 m/s would be permissible providing that flood depths are less than 0.3 m.

In Haldimand County, emergency responders make decisions about vehicle access on a case by case basis. In general, emergency vehicles will not access a road where flooding exceeds 0.3 m, the lines on the road are not visible, or the road is exposed to wave uprush.

7.2.2 Pedestrian Access/Egress

MNR (2002) provides technical considerations for pedestrian access/egress during flooding. This document pertains to river and stream systems flooding but it is also relevant for Lake Erie flooding. Hazard to life is linked to the depth of the flood waters and the velocity of flow. A product of depth and velocity less than or equal to 0.4 m^2/s defines a low risk hazard, providing that the depth does not exceed 0.8 m and velocity does not exceed 1.7 m/s (MNR, 2001a).

For stagnant backwater areas (i.e., zero flow velocity), depths in excess of about 1 m are sufficient to float young children, and depths above 1.4 m are sufficient to float teenage children and many adults. Even shallower depths can pose a risk. In shallow areas, velocities in excess of about 1.8 m/s pose a threat to the stability of many individuals (MNR, 2001a). In areas exposed to wave uprush, the combination of flood depth and velocities may be sufficient to pose danger to pedestrians. In areas subject to direct wave action, the maximum depth of flooding to define a low risk hazard is 0.25 m.

8. Recommendations for Flooding and Erosion Prevention and Protection

This section provides general recommendations for flooding and erosion prevention and protection. Consultation with a coastal engineer is recommended as conditions will vary from reach to reach, and within a shoreline reach. The reader is referred to the Technical Guide for Great Lakes – St. Lawrence River System (MNR, 2001a) for further information. A permit from the Conservation Authority is required for any work undertaken within the Regulation Limit and other permits may also be required.

Shoreline management approaches can be classified as prevention or protection. Prevention is normally achieved through planning of land use and the regulation of development within the hazard limits. Prevention approaches are generally considered the most environmentally sound and cost-effective means of ensuring that buildings and structures are not susceptible to hazards. Protection approaches involve engineered methods for protecting development located within hazard susceptible shoreline areas. Where protection works are constructed, they are to be combined with an appropriate hazard allowance.

Prevention is generally considered to be the preferred approach. However, it is recognized that prevention is not always practicable, particularly for existing development. This section provides an overview of the floodproofing and protection works standards as they can be applied along the Lake Erie shoreline of Haldimand County.

8.1 Floodproofing Standard

Floodproofing is generally defined as a combination of structural changes and/or adjustments incorporated into the basic design and/or construction or alteration of individual buildings, structures or properties subject to flooding hazards so as to reduce the risk of flood damages, including wave uprush and other water related hazards. Floodproofing and flood protection works can only reduce the risk and/or lessen the damage to properties. No measure will prevent all damages due to flooding. Where it has been determined that development and site alteration could possibly be located within the less hazardous portion of the flooding hazard, the floodproofing standard should be applied. The minimum floodproofing standard is as follows: development and site alteration is to be protected from flooding, as a minimum, to an elevation equal to the sum of the 100-year static water level plus the 100-year surge plus a vertical flood allowance for wave uprush and other water related hazards. The 100-year static water level plus the 100-year surge is listed by reach in Appendix C. It is recommended that a minimum freeboard of 0.3 m be added to these elevations as a factor of safety to compensate for factors that may increase flood heights and uncertainties inherent in determining flood frequencies and flood elevations (ASCE/SEI, 2014). The vertical flood allowance for wave uprush varies with shoreline conditions and is determined on a site specific basis. Some example wave uprush values for selected shoreline conditions are listed in Appendix C. The flood proofing elevation should be determined by a Professional Engineer with experience in flood proofing.

Floodproofing measures that could be incorporated into the design of new buildings and retrofit of existing buildings is described in Part 7 of the Technical Guide (OMNR, 2001). Examples include elevating buildings on posts, piers, walls, pilings or engineered fill; elevating electrical equipment and utilities above the expected flood levels; using watertight closures for doors and windows; and using flood resistant materials. The guide describes “dry floodproofing” as measures that prevent the entry of floodwater into a building, and “wet floodproofing” as measures that minimize the impact of flooding. Dry floodproofing is usually accomplished by elevating the building above the floodproofing standard elevation, and is the most desirable measure for residential buildings. It may not be feasible or desirable to elevate certain non-residential buildings (e.g. garages, boathouses, sheds, warehouses, etc.) above the floodproofing standard elevation. Wet floodproofing measures such as the use of flood resistant building materials and elevating contents and utilities can lessen the impact of flooding and improve the clean up and recovery time for non-residential buildings.

Table 8.1 identifies the buildings that are most vulnerable to flooding from Lake Erie. The building location and other information can be obtained from the building inventory geodatabase using the unique Building ID (provided under separate cover in the RAIT deliverable). The minimum ground elevation along the perimeter of the building and the estimated first floor elevation is provided in the table. The first floor elevation is estimated to be 0.2 m above ground for commercial and institutional buildings, and 0.7 m above ground for residential buildings.

Table 8.1: List of buildings most vulnerable to flooding

Building ID	Building Use	Reach	Minimum Ground Elevation (m CGVD2013)	Estimated First Floor Elevation (m CGVD2013)
541	residential	21	173.16	173.86
1116	commercial	8	173.33	173.53
623	commercial	8	173.50	173.70
1114	commercial	8	173.51	173.71
2064	commercial	Dunnville	173.73	173.93
517	commercial	6	173.74	173.94
993	residential	6	173.74	174.44
425	residential	Dunnville	174.01	174.71
514	residential	6	174.05	174.75
463	commercial	Dunnville	174.07	174.27
496	residential	16	174.29	174.99
498	residential	Dunnville	174.32	175.02
453	residential	Dunnville	174.33	175.03
499	residential	Dunnville	174.35	175.05
973	residential	39	174.35	175.05
1189	residential	41	174.42	175.12
2598	residential	Dunnville	174.45	175.15
525	commercial	6	174.48	174.68
129	residential	16	174.50	175.20
136	residential	16	174.50	175.20
444	residential	Dunnville	174.53	175.23
2503	residential	Dunnville	174.57	175.27
422	residential	Dunnville	174.58	175.28
1026	residential	Dunnville	174.59	175.29
1039	residential	42	174.59	175.29
1025	residential	Dunnville	174.63	175.33
1283	residential	64	174.63	175.33
429	residential	Dunnville	174.65	175.35
519	residential	6	174.67	175.37
2736	residential	Dunnville	174.67	175.37
1281	residential	64	174.69	175.39
1289	residential	64	174.69	175.39
415	residential	Dunnville	174.71	175.41
447	residential	Dunnville	174.71	175.41

Building ID	Building Use	Reach	Minimum Ground Elevation (m CGVD2013)	Estimated First Floor Elevation (m CGVD2013)
524	commercial	6	174.72	174.92
1280	residential	64	174.73	175.43
2499	residential	Dunnville	174.73	175.43
984	residential	57	174.73	175.43
2730	residential	Dunnville	174.74	175.44
1198	residential	42	174.76	175.46
991	residential	30	174.76	175.46
2585	residential	Dunnville	174.77	175.47
1500	residential	64	174.79	175.49

8.2 Protection Works Standard

By definition (PPS, Section 6.0 Definitions), protection works standards “means the combination of non-structural or structural works and allowances for slope stability and flooding/erosion to reduce the damages caused by flooding hazards, erosion hazards and other water-related hazards, and to allow access for their maintenance and repair” (PPS 2014). The Technical Guide (MNR 2001a), developed in support of the PPS, outlines specific guidelines for the protection works standard including protection works, the stable slope allowance and the erosion hazard allowance.

The three key elements of the protection works standard are described in the Technical Guide (MNR 2001a) as follows:

- Protection works should be of sound, durable construction and be designed by a qualified coastal engineer according to accepted practice;
- Protection works should be used in conjunction with appropriate stable slope and hazard allowances; and
- There must be access to the protection works for suitable equipment for future rehabilitation, replacement or repairs.

8.3 Shore Protection

This section describes some alternative shore protection measures that may be considered along the Haldimand County shoreline. Shore protection should be designed on a site specific basis by a coastal engineer. Permits are required for the construction of shore protection including an assessment to confirm there will be no negative impacts on adjacent properties.

8.3.1 Armourstone Revetment

Armourstone revetments are sloped shore parallel structures with a protective layer of large "armour" stones that are built to prevent the direct attack of waves on the toe of a bluff (see Figure 8.1). These structures rely on the mass of the armour stones to withstand the forces of the waves. As waves impact the structure, energy is dissipated as the water moves over the rough, permeable sloped face of the structure, and through the voids between the armour stones. The land behind the structure is thus protected from the erosional stress that results from wave attack.

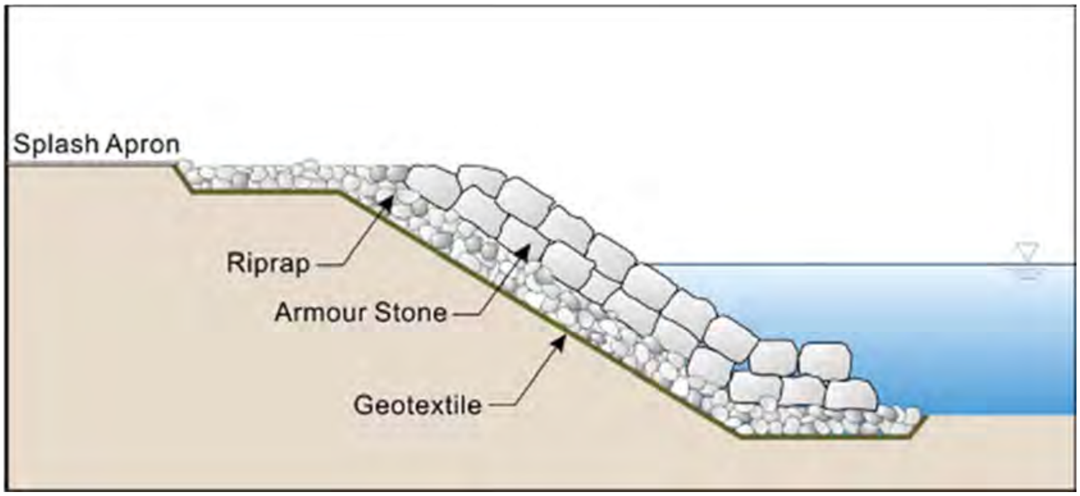

Figure 8.1: Schematic showing typical armourstone revetment section

Armour stone revetments have advantages over many other forms of shore protection, because they are flexible, can accommodate some settlement and do not generally fail catastrophically. The use of larger armour stones and/or a higher crest elevation will provide a stable structure which protects the backshore under more severe conditions. This type of structure can be designed to accommodate the ongoing erosion of the lakebed, thus providing long term protection to the backshore.

Revetments, like any other shore protection structure, have a number of disadvantages that make them inappropriate for some conditions. Revetments may severely limit access to the beach and water, and do not increase the amount of recreational space. Beach or water access must often be provided by staircases or ramps located intermittently along the shoreline. Access along the beach may also be obstructed. Another disadvantage of revetments is that the structure does not encourage beach development, and may in fact increase scour in front of the structure as a result of wave reflection at the structure. If the lakebed erodes, higher waves may be able to reach the structure, further eroding the bottom and possibly undermining the structure. Flanking can be an issue at the termination of the structure, particularly if the adjacent property is not protected and is eroding at a high rate.

Key design features for the armour stone revetment include: sound, good quality, durable armour stone with sufficient size to resist wave action and ice; sufficient crest elevation to protect against wave overtopping; riprap underlayer; and geotextile filter to prevent loss of backfill. The armour stone size is dependent on the wave height, the inclination of the revetment slope and placement (i.e., degree of “interlocking”). Typically, the individual armour stones in an armour stone have a mass of 3 to 5 tonnes for a single layer of armour; slightly smaller stones could be used with flatter slopes or double layers. A qualified coastal engineer should design the revetment. A double layer of armour provides more “reserve capacity” (i.e., damage to a double layer armour revetment is more progressive than damage to a single layer).

8.3.2 Seawalls

Seawalls are vertical, sloped, curved or stepped shore parallel walls that function in a very similar manner to a revetment (see Figure 8.2). They are typically made of steel sheet piles or concrete (pre-cast or cast-in-place) and are placed to protect the toe of a bluff from wave attack.

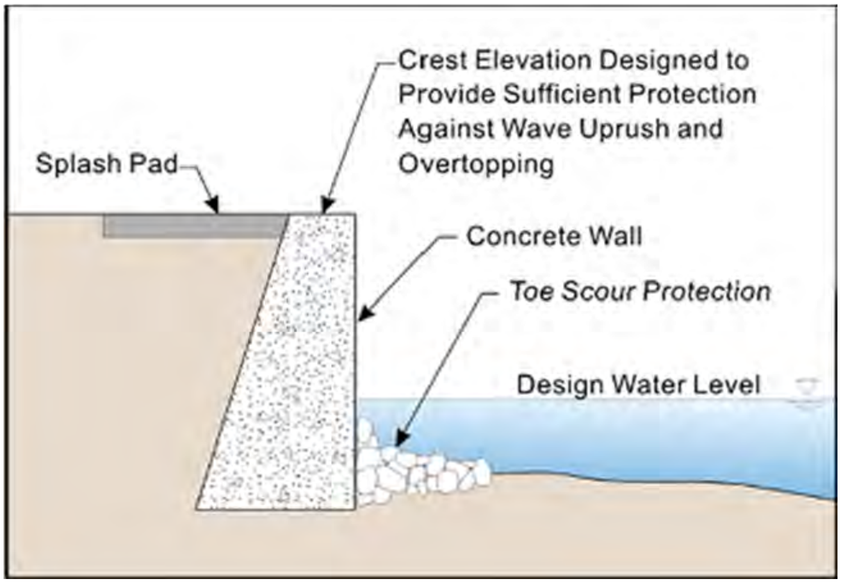

Figure 8.2: Schematic showing concrete seawall section

Some property owners consider seawalls to be more aesthetically pleasing than revetments for a number of reasons. Seawalls allow people to be closer to the water and/or beach than an armour stone revetment. It is also easier to incorporate stairs or ramps for access to the water. Seawalls also require less width than a revetment, possibly making construction feasible in some areas with a steep backshore where a sloped structure might require large amounts of earth moving.

However, seawalls are rigid structures and do not accommodate settlement. In addition, seawalls, due to their steep (often vertical), impermeable and generally smooth face, cause more wave reflection, resulting in increased scour and the risk of undermining at the toe of the structure. Because of this, seawalls may fail catastrophically if not designed correctly. Seawalls also require higher crest elevations than revetments to provide a similar level of protection against wave overtopping.

8.4 Critical Warning Levels

Being aware of risks is an important part of flood preparedness. Haldimand County and the Conservation Authorities provide information to the public, including critical warning levels for flooding. Communities along Lake Erie are susceptible to flooding due to storm surge, which can be exacerbated by high water levels. Water levels along the shoreline can change in a matter of hours and areas can become flooded. The situation can be further exacerbated by wave action. During flooding events, there is a heightened risk of shoreline flooding, beach submersion, crawl space and septic system inundation and wave-driven erosion along some reaches of Lake Erie.

The Conservation Authorities monitor water levels and flood warnings posted on the Ontario Ministry of Natural Resources and Forestry (OMNRF) Surface water Monitoring Centre's web site https://www.ontario.ca/law-and-safety/flood-forecasting-and-warning-program#section-3. Data published on this site is based on the Great Lakes Storm Surge Operational System (GLSSOS) developed for OMNRF. The system uses real time water level and meteorological data and the Danish Hydraulics Institute MIKE21 model to provide 48 hour forecasts with time series plots of water level, wave height, mean wave direction and peak wave period at selected locations on the Great Lakes. The locations nearest to Haldimand County are Port Colborne and Long Point.

LPRCA, GRCA and NPCA issue flood warnings based on the five stages shown in Figure 8.3. The figure also shows the probability of the water levels associated with the stages. Flood levels at the east end of the County are higher than at the west end of the County. For example, the 100-year return period flood level corresponds to a Stage 4 flood level at the west end of Haldimand County (Port Dover) and a Stage 5 flood level at the east end (Port Colborne).

A meeting was held with emergency responders from the County on January 21, 2020 to discuss issues related to emergency response and updates the National Disaster Mitigation Program Risk Assessment Information Template (NDMP RAIT) completed for this project. Based on that meeting, it is our recommendation that the current flood warning stages be maintained. The flood warnings are well understood by emergency responders and the correlation with probabilities of exceedance shown in Figure 8.3 provides additional context.

The CAs issue flood warning messages based on the data provided by the MNRF. Haldimand County issues flood messages on Twitter and Facebook. Emergency information is also broadcast on 92.9 the Grand FM, Haldimand County's official emergency information broadcast partner.

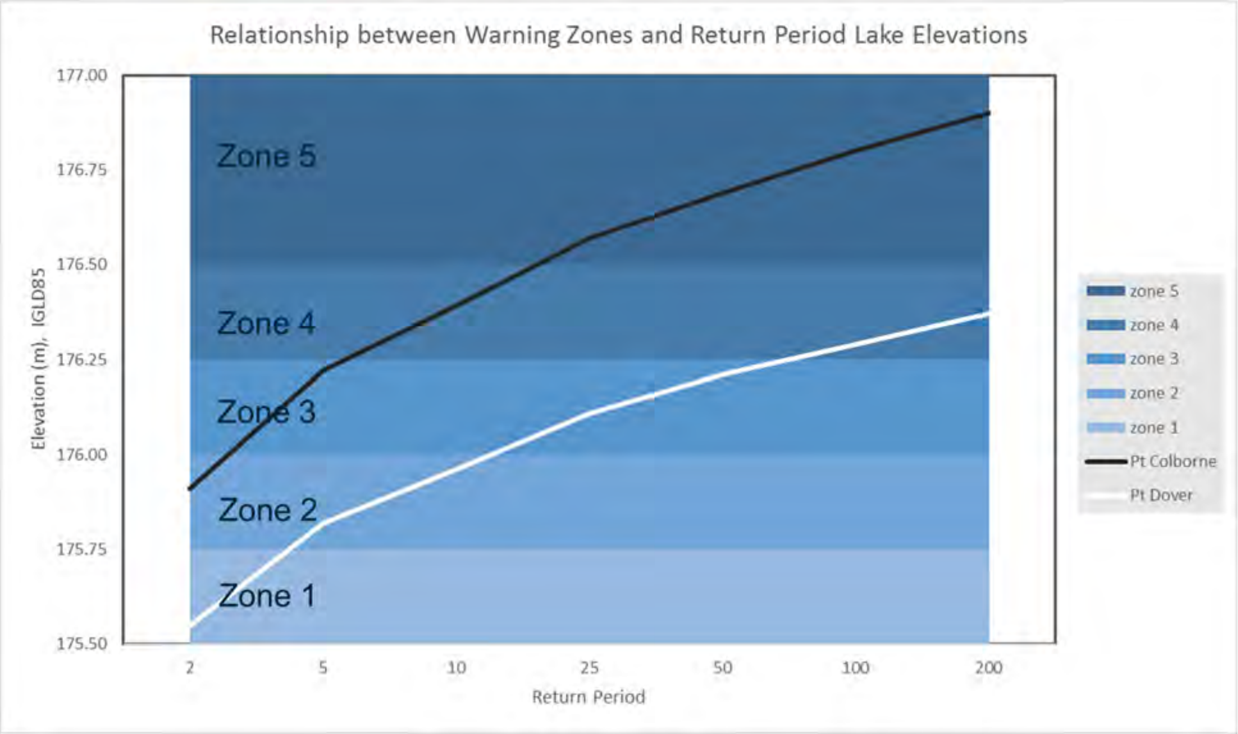

Figure 8.3: Relationship between Haldimand County Lake Erie flood warning stages and return period

8.5 Emergency Access/Egress

The Technical Guide (MNR, 2001a) discusses access/egress with respect to development located within the flooding hazard and development that may be isolated from access/egress during flooding events. It is not desirable to have development isolated during the flood conditions because roads and escape routes are not passable. Flooding characteristics that must be considered when evaluating ingress/egress include:

- Depth of expected flooding and, in shoreline areas, height of wave crests.
- Velocity of flood waters and waves.
- Frequency of flooding, which is the amount of time between occurrences of damaging floods.
- Duration of flooding, which affects the length of time access/egress may be impacted.

- Rate of rise, which indicates how rapidly water depth increases during flooding. This determines warning time before a flood, which will influence the need for access routes (ingress/egress) to be elevated above floodwaters.
- Ice and debris, which can block access/egress, and may damage roads and bridges.

Mapping for flood preparedness is discussed in Section 7.2 and specific locations are identified, where access/egress may be disrupted during flooding events. Additional information on access/egress and emergency access planning is provided in the National Disaster Mitigation Plan, Risk Assessment Information Template (NDMP RAIT), prepared for Haldimand County for this project, and provided under separate cover. Mapping developed for the NDMP RAIT, showing flood depths during the 100-year return period event is provided in Appendix E for those reaches where roads and buildings are flooded. The mapping shows that 31 km of road is flooded during this event, including roads in the wave uprush zone. Table 8.2 identifies roads that are vulnerable to flooding from Lake Erie, the lowest elevation along the centreline of the road, and the corresponding Warning Zone used by the County and Conservation Authorities.

Table 8.2: List of roads most vulnerable to flooding

Road Name	Reach	Elevation (m CGVD2013)	Elevation (m IGLD1985)	Warning Zone
East Lakeshore Road	22	174.1	174.6	0
White Cap Lane	48	174.5	175.0	0
The Esplanade	67	174.6	175.0	0
Seagull Lane	38	174.6	175.1	0
Sandy Bay Road	64	174.8	175.2	0
Erie Street	7	174.9	175.4	0
Erie Avenue	7	174.9	175.4	0
Port Maitland Road	67	174.9	175.4	0
Paradise Line	64	174.9	175.4	0
Myrnam Beach Road	64	174.9	175.4	0
Feeder Canal Road	67	175.0	175.4	0
Briar Line	64	175.0	175.5	1
Baygrove Line	64	175.0	175.5	1
Beckly Line	67	175.0	175.5	1
Lakeshore Road	48	175.1	175.6	1
Reicheld Road	42	175.1	175.6	1
Baygrove Line	64	175.2	175.7	1
Hydro Street	Dunnville	175.2	175.7	1
Lakeshore Road	48	175.3	175.7	1
Siddall Line	67	175.3	175.8	2
Central Lane	Dunnville	175.3	175.8	2
Blue Water Pkwy	22	175.3	175.8	2
Swallow Lane	38	175.3	175.8	2
Winger Bay Lane	38	175.4	175.8	2
Birch Lane	38	175.4	175.9	2
Lakeshore Road	38	175.5	175.9	2
Siddall Road	67	175.5	176.0	3
Heather Lane	38	175.5	176.0	3
Lakeshore Road (at Kohler Road)	38	175.6	176.0	3

Road Name	Reach	Elevation (m CGVD2013)	Elevation (m IGLD1985)	Warning Zone
Evan's Point Lane	48	175.6	176.0	3
Brant Street	Dunnville	175.6	176.1	3
Brace Street	Dunnville	175.6	176.1	3
Niagara Street	Dunnville	175.6	176.1	3
Broad Street East	Dunnville	175.7	176.1	3
Lakeshore Road	42	175.7	176.2	3
Haldimand Road 53	22	175.7	176.2	3
Pike Lane	38	175.8	176.2	3
Tamarac Street	Dunnville	175.8	176.2	3
Front Street	Dunnville	175.8	176.2	3
Dover Street	67	175.8	176.3	4
Connor Bay Line	67	175.8	176.3	4
Videoway Lane	38	175.8	176.3	4
Queen Street	Dunnville	175.8	176.3	4
Auld Lane	38	176.0	176.4	4
Taylor Road	Dunnville	176.0	176.5	5

8.6 Protection of Municipal Infrastructure

When municipal structures are located within the hazard limits, a more detailed assessment of the risks may be warranted. A number of these structures, by their very nature are located within the hazard limits (e.g. water intake, bridges, drains, culverts, treatment and conveyance structures) and protection works are often required. Public parks are often located along the waterfront and some investment may be warranted to protect these public spaces, if the impacts can be mitigated.

Where municipal infrastructure is concerned, public safety, minimizing risks to life, property damage, adverse environmental impacts and social disruption are paramount. Ecological, geomorphological and socioeconomic elements must be considered. In addition, public access, recreation and aesthetics may be considerations.

There are areas where protection works may be inappropriate and unacceptable as they would not meet all of the requirements defined in the Technical Guide (MNR, 2001a). These areas may include, but are not limited to: locations where the active erosion of the site provides an essential sediment source for downdrift beaches; sites where the proposed protection works would result in unacceptable environmental impacts (i.e., adjacent wetland or fish habitat is significantly impacted); areas where the protection works create or aggravate hazards at updrift/downdrift properties (i.e., groynes trapping or deflecting alongshore sediment transport resulting in a significantly reduced quantity of sediment on beaches at adjacent properties thus increasing hazards).

Special consideration is required for roads located within the hazard limits. These roads may be used for access/egress and may become unusable during flooding events, or as a result of erosion. Examples in Haldimand County are discussed in Section 7.2. For roads at risk due to erosion, the recommendations for shore protection provided in Section 8.3 are applicable. As an alternative, it may be necessary to relocate roads.

For roads at risk due to flooding, mitigation measures include raising the road elevation, emergency access such as constructing temporary gravel roads and permanently relocating roads. As a planning tool, the County may wish to identify priority road segments where it may be possible to secure easements along the rear property lines for future road alignments.

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Appendix A

Terraprobe Slope Stability Analysis Report

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLOPE STABILITY STUDY
LAKE ERIE NORTH SLOPE
EAST OF LOWBANKS TO EAST OF PORT DOVER

Prepared For:	W.F. Baird & Associates Coastal Engineers Ltd. 1267 Cornwall Road, Suite 100 Oakville, Ontario L6J 7T5
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File No. 1-18-0402-01
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1.0 THE PROJECT

Terraprobe was retained by W.F. Baird & Associates Coastal Engineers Ltd. to conduct a detailed slope stability and erosion risk assessment for the Lake Erie North Slope, which covers a total of 87 kms of the north shoreline of Lake Erie from east of Lowbanks to east of Port Dover. The subject slope along the shoreline is up to 21.5 m in height. The tableland is generally occupied by agricultural land, residential properties, conservation land, or municipal roadways. Lake Erie is present approximately at the toe of slope. A site location plan is provided as Figure 1.

This slope stability study and erosion risk assessment has been prepared for the purposes of establishing the Stable Slope Inclinations at a county scale. Site specific studies are recommended. The stable slope allowance is used for mapping the Erosion Hazard.

This report encompasses a review of publicly available subsurface information, existing Terraprobe reports in the area, and a detailed visual slope inspection to establish existing conditions. The scope of work also includes a detailed slope stability analysis. Based on these studies, this report provides geotechnical engineering recommendations pertaining to the site including the stable slope allowance for the slope along the north shoreline of Lake Erie.

2.0 SITE & PROJECT DESCRIPTION

The study area includes approximately 87 km of shoreline along Lake Erie’s north shore, from east of Lowbanks to east of Port Dover. The tableland is generally flat, and is occupied by agricultural land, residential properties, conservation land, or municipal roadways. The shoreline generally comprises sand beaches, armourstone or concrete retaining walls, visible limestone bedrock, or native slopes comprising glaciolacustrine silt and clay or glacial till. The study area has been divided by Terraprobe into six areas (Area A to F). The areas are described in the table below.

Area Label	Sections in Area	Limits - Towns
A	1 to 7	Crescent Bay to Nanticoke
B	8 to 12	Nanticoke to Peacock Point
C	13 to 27	Peacock Point to Featherstone
D	28 to 43	Featherstone to Rock Point
E	44 to 49	Rock Point to Townline Road
F	50 to 52	Townline Road to Lowbanks

The stratigraphy and recommendations can be interpolated between sections by transitioning approximately halfway between adjacent sections.

At the west end of the study area (Area A and B, Crescent Bay to Peacock Point) the slope is up to 12.6 m in height with a composition of glaciolacustrine silt and clay. At the east end of the study area (Area E, Rock Point to Townline Road), there are glacial till bluffs up to 21.5 m in height. Relevant site features and photograph locations are provided in Appendix A.

Terraprobe was provided with cross sections created from LiDAR data of the entire study area in .xlsx format from Baird by email that included 0.50 m contours for Section 1 to 47 and 2.0 m contours for Section 48 to 52. The LiDAR data provided was used and relied on as factual in preparation of this report. The cross-section locations are shown on Appendix A and the detailed sections are provided in Appendix G.

Jory Hunter, EIT, of Terraprobe carried out a site and detailed slope inspection on August 10th, 2018. Jason Crowder, P.Eng., also inspected the slope in April 2019. The MNR Slope Stability Rating Chart was completed during the inspection (included in Appendix E). Area A and B (glaciolacustrine silt and clay slopes) obtained a value of 28, indicating a slight potential for instability. Area E (glacial till bluffs) obtained a value of 59, indicating a moderate potential for instability. Areas C, D, and F of the study area obtained a value of 26, indicating a slight potential for instability.

3.0 SUBSURFACE INFORMATION

3.1 Stratigraphy

Boreholes were not advanced as part of this scope of work. Terraprobe determined the subsurface conditions based on a review of publicly available subsurface information, existing Terraprobe reports in the area, and a detailed visual slope inspection. A flow chart depicting the steps to determining the soil type and subsequent analysis is included as Figure 2.

The Ministry of Northern Development and Mines (MNDM) has publicly available subsurface information including geotechnical boreholes (Appendix A), and quaternary geology (Figure 3) and surficial geology (Figure 4) of the study area. The government of Ontario has publicly available well records for wells drilled in the study area. The locations of the well records used for the study are included in Appendix A, and the well records are included in Appendix C. This information was used to determine the general stratigraphy encountered in the study area.

Terraprobe completed subsurface investigations in the study area, including the regions of Nanticoke (1974 and 2015), Rainham (2004), Burnaby (2016), and Wainfleet (2017), Ontario. The borehole logs are included in Appendix B.

Terraprobe relied on visual observation during the detailed visual slope inspection to confirm the subsurface conditions within the study area. Visual observations are included in Appendix A.

A summary of the stratigraphy at each of the cross sections can be seen in the table below.

Area	Section #	Geotechnical Borehole ID from MNDM	Geotechnical Borehole Description from MNDM	Quaternary Geology from MNDM	Surficial Geology from MNDM	Well Record ID	Well Record Soil Description	Soil Type at shoreline through visual observation
A	1	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	7123004	silty clay over limestone	clayey silt
	2	700002	clay, silt	glaciolacustrine silt and clay	glaciolacustrine silt and clay	4401956	clay over rock	clayey silt
	3	700003	clay, silt	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600917	clay over rock	earth fill
	4	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600919	clay over rock	earth fill
	5	700004	clay, silt, pebbles	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600922	clay over rock	clayey silt
	6	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600927	clay over rock	clayey silt
	7	n/a	n/a	glaciolacustrine silt and clay	n/a	n/a	n/a	earth fill
B	8	700005	clay, silt, pebbles	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600928	silty clay over rock	clayey silt
	9	700024	clay, silt	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2602646	clay over rock	earth fill
	10	700026	clay, silt, pebbles	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2601326	clay over rock	clayey silt
	11	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600932	clay over rock	earth fill
	12	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	n/a	n/a	earth fill
C	13	n/a	n/a	bedrock	glaciolacustrine silt and clay	2600939	clay over rock	sand
	14	n/a	n/a	bedrock	glaciolacustrine silt and clay	n/a	n/a	earth fill
	15	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600982	clay over rock	earth fill
	16	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2601309	brown clay over rock	earth fill
	17	n/a	n/a	glaciolacustrine silt and clay	bedrock	2601001	clay over rock	earth fill
	18	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	n/a	n/a	earth fill
	19	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600471	red and grey clay	sand
	20	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600474	clay over rock	earth fill
	21	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2601283	blue clay over rock	earth fill
	22	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	n/a	n/a	earth fill
	23	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2601511	clay over rock	sand
	24	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2601275	clay over rock	earth fill
	25	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2601721	clay over rock	earth fill
	26	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600517	clay over rock	earth fill

Area	Section #	Geotechnical Borehole ID from MNDM	Geotechnical Borehole Description from MNDM	Quaternary Geology from MNDM	Surficial Geology from MNDM	Well Record ID	Well Record Soil Description	Soil Type at shoreline through visual observation
C	27	n/a	n/a	glaciolacustrine silt and clay	eolian sand	2600525	clay over rock	earth fill
D	28	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600534	clay over rock	earth fill
	29	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600536	clay over rock	sand
	30	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2601421	clay over rock	sand
	31	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600559	clay over rock	sand
	32	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600566	brown clay over rock	sand
	33	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	n/a	n/a	sand
	34	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600570	clay over rock	sand
	35	856345	clay, silt, sand, very stiff	glaciolacustrine silt and clay	eolian sand	2600574	sand, clay and gravel over rock	earth fill
	36	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600579	clay over rock	sand
	37	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine silt and clay	2600895	clay over rock	sand
	38	n/a	n/a	glaciolacustrine silt and clay	till	2600884	clay over rock	sand
	39	n/a	n/a	halton till	till	2600094	brown and blue clay	earth fill
	40	n/a	n/a	halton till	glaciolacustrine silt and clay	n/a	n/a	sand
	41	n/a	n/a	glaciolacustrine silt and clay	lacustrine sand	2600101	sand over clay	sand
	42	n/a	n/a	halton till	till	7144407	clay over rock	limestone bedrock
	43	n/a	n/a	fluvial deposits, gravel and sand	lacustrine sand	2602506	sand	sand
E	44	n/a	n/a	glaciolacustrine silt and clay	n/a	2600833	clay over rock	glacial till
	45	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine sand (moraine)	7049015	clay and boulders over rock	glacial till
	46	n/a	n/a	glaciolacustrine silt and clay	glaciolacustrine sand (moraine)	2602105	clay and sand	glacial till
	47	700802	till, grey-brown	glaciolacustrine silt and clay	till	2601412	clay and gravel, over	glacial till
	48	700804	till, grey-brown	glaciolacustrine silt and clay	till	2601678	clay with stones over	glacial till
	49	700805	till, brown	glaciolacustrine silt and clay	till	2600840	large gravel over rock	sand
F	50	n/a	n/a	glaciolacustrine silt and clay	lacustrine sand	n/a	n/a	sand
	51	700801	gravel, sand	glaciolacustrine silt and clay	lacustrine sand	7290178	sand over rock	sand
	52	n/a	n/a	glaciolacustrine silt and clay	lacustrine sand	2600251	sand	sand

A summary of the subsurface information provided in Terraprobe's reports in the surrounding area is included in the table below.

Report	**Label**	**Soil Descriptions**	
		Silty Clay	**Bedrock**
Publicly available borehole information – no report attached	Nanticoke (1974)	**Silty Clay**, hard, brown with grey mottling, to very stiff, greyish brown, with faint indication of thin stratifications N = 19 to 39 (Elev. 190.3 to 181.3 m)	**Limestone**, sound, occasional cherty patches Percent Core Recovery = 72% to 100% RQD = 72% to 91% (Elev. 181.3 to 175.5 m)
Publicly available borehole information – no report attached	Nanticoke (2015)	**Silty Clay trace sand and gravel**, stiff to hard, brown with iron staining to grey, grey fissures and occasional to numerous silt lenses and shale fragments N = 12 to 33 (Elev. 188.7 to 183.6 m)	**Inferred Bedrock** (Elev. 183.6 m)
"Geotechnical Investigation, Proposed Culvert Replacement", Terraprobe, Project No. 7-04-0006-6, dated March 7, 2004	Rainham (2004)	**Silty Clay trace sand and gravel**, brown, very stiff to hard, with silt seams and layers N = 15 to 30 Elev. (97.2 to 95 ±m)	**Inferred Bedrock**
"232 South Lakeshore Road, Port Dover, Ontario", Terraprobe, Project No. 1-18-0624, dated October 15, 2018 Boreholes by Englobe, Project No. 160-P-0016606-0-01-100-GE-R-0001-00, dated August 2018	South Cayuga (2018)	**Silt some clay, trace to some sand, trace gravel** brown, stiff to very stiff, moist N = 10 to 23 (Elev. 188.8 to 185.0 m) **Silty Clay** grey, firm to stiff N = 4 to 13 (Elev. 185.0 to 169.0 m)	**Not observed in borehole**
"Geotechnical Investigation, 11603 Lakeshore Road, Burnaby Ontario", Terraprobe, Project No. 7-16-0133-01, dated February 20, 2018	Burnaby (2016)	**Clayey Silt (Glacial Till)**, very stiff, brownish black N = 19 (Elev. 180.4 to 179.9 m)	**Inferred Bedrock** (Elev. 179.9 m)
"Preliminary Geotechnical Investigation, 11705 Lakeshore Road, Wainfleet Ontario", Terraprobe, Project No. 7-16-0082-01, dated April 19, 2017	Wainfleet (2017)	**Silty Clay,** brown, very stiff to firm, occasional seams and layers of silt N = 8 to 21 Field Vane = 90 kPa (Elev. 175.9 to 172.8 m)	**Inferred Bedrock** (Elev. 172.8 m)

3.2 Ground Water

Installing ground water monitoring wells was not part of the scope of work. Static water levels recorded on the well records are included in the table below. Due to the proximity of Lake Erie, the water table along the shoreline is hydraulically connected to the lake. The water table was estimated with this information and from observations of seepage at the slope face.

Area	Section #	Well Record ID	Well Record Static Water Level (ft) (depth below grade)	Well Record Static Water Level (m) (depth below grade)
A	1	7123004	n/a	n/a
	2	4401956	21	6.4
	3	2600917	25	7.6
	4	2600919	n/a	n/a
	5	2600922	n/a	n/a

Area	Section #	Well Record ID	Well Record Static Water Level (ft) (depth below grade)	Well Record Static Water Level (m) (depth below grade)
A	6	2600927	25	7.6
	7	n/a	n/a	n/a
B	8	2600928	n/a	n/a
	9	2602646	23	7.0
	10	2601326	30	9.1
	11	2600932	25	7.6
	12	n/a	n/a	n/a
C	13	2600939	12	3.7
	14	n/a	n/a	n/a
	15	2600982	6	1.8
	16	2601309	12	3.7
	17	2601001	13	4.0
	18	n/a	n/a	n/a
	19	2600471	n/a	n/a
	20	2600474	18	5.5
	21	2601283	17	5.2
	22	n/a	n/a	n/a
	23	2601511	17	5.2
	24	2601275	13	4.0
	25	2601721	10	3.0
	26	2600517	8	2.4
	27	2600525	12	3.7
D	28	2600534	41	12.5
	29	2600536	14	4.3
	30	2601421	8.5	2.6
	31	2600559	6	1.8
	32	2600566	n/a	n/a
	33	n/a	n/a	n/a
	34	2600570	9	2.7
	35	2600574	14	4.3
	36	2600579	10	3.0
	37	2600895	25	7.6
	38	2600884	18	5.5
	39	2600094	15	4.6
	40	n/a	n/a	n/a
	41	2600101	60	18.3

Area	Section #	Well Record ID	Well Record Static Water Level (ft) (depth below grade)	Well Record Static Water Level (m) (depth below grade)
D	42	7144407	18	5.5
	43	2602506	17	5.2
E	44	2600833	26	7.9
	45	7049015	40	12.2
	46	2602105	n/a	n/a
	47	2601412	42	12.8
	48	2601678	12	3.7
	49	2600840	19	5.8
F	50	n/a	n/a	n/a
	51	7290178	20	6.1
	52	2600251	17	5.2

3.3 Visual Slope Inspections

A detailed visual slope inspection of the slope area from the crest to the toe was conducted by Jory Hunter of Terraprobe on August 10th, 2018. Jason Crowder of Terraprobe also inspected the slope in April 2019. General information pertaining to the existing slope features such as slope profile, slope drainage, water course features, vegetation cover, buildings in the vicinity of the slope, erosion features, and slope slide features were obtained during the inspection. A summary of the visual slope inspection is presented below. Photographs taken during the inspections are included as Appendix D. The locations of the features discussed below are shown on the Cross-sections, Photographs, and Site Features plan in Appendix A.

The study area includes approximately 87 km of shoreline running approximately west to east along Lake Erie's north shore, from east of Lowbanks to east of Port Dover. The tableland is generally flat, and is occupied by agricultural land, residential properties, conservation land, or municipal roadways. At the west end of the study area (Area A and B), there are native slopes up to 12.6 m in height with a composition of glaciolacustrine silt and clay. At the east end of the study area (Area E), there are glacial till bluffs up to 21.5 m in height. Otherwise, the shoreline generally comprises sand beaches, armourstone or concrete retaining walls, or visible limestone bedrock.

A large drainage pipe was observed in Area E at the end of Dickout Road, with the outlet at the toe of slope. Other drainage pipes were not observed, although there may be more drainage pipes over the slope in areas where there are dwellings in the tableland.

The tableland is generally vegetated with grass, shrubs, young to mature trees, or is occupied by agricultural land. At the west end of the study area (Areas A and B) the slope face is generally forested. The face of the glacial till bluffs (Area E) is bare. Majority of the shoreline (Areas C, D, and F), the slope face is either vegetated with grass, shrubs, and young trees, or covered by armourstone walls, concrete walls, or an unvegetated sand veneer.

The glacial till bluffs at the east end of the study area (Area E) are near vertical to sub-vertical. There is talus accumulation at the toe of the slope. Ground water seepage was observed through the talus. There are staircases and informal walking paths down the glacial till bluffs to the sand and gravel beach below. Toe erosion protection was observed along the east end of the bluff formation, including concrete blocks and retaining walls. There are some dwellings in close proximity to the slope crest at Area E (from Pyle Road to Farr Road), where there was limited access to the slope. These dwellings are potentially within the erosion hazard, and therefore, a more detailed and site-specific analysis is recommended.

A summary of the visual observations across the study area is shown below.

Area	Sections	General Slope Height (±m)	General Slope Inclination	Exposed Soil	Features
A	1 to 7	3 to 13	steeper than 1.0H:1V to 3.0H:1V	cohesionless **sand and silt** overburden	• Agricultural land, dwellings, municipal roadways, and industrial facilities in the tableland • Forested with shrubs and trees, landscaped with grass, or agricultural land • At the toe, sand and gravel beaches, limestone shelf, or armourstone and concrete retaining walls (1-2 m height)
B	8 to 12	7 to 11	steeper than 1.0H:1V to 2.0H:1V	cohesionless **sand and silt** overlying **silt and clay**, trace sand, layered, grey, moist, very stiff to hard	• Agricultural land, dwellings, and municipal roadways in the tableland • Forested with shrubs and trees, landscaped with grass, or agricultural land • At the toe, sand and gravel beaches or armourstone and concrete retaining walls (1-2 m height) • Section 8: 1 m toe erosion scarp and tension cracks in upper slope
C	13 to 27	2 to 6	steeper than 1.0H:1V to flatter than 3.0H:1V	surficial **sand or earth fill**	• Agricultural land, dwellings, and municipal roadways in the tableland • Forested with shrubs and trees, landscaped with grass, or agricultural land • At the toe, sand and gravel beaches, limestone shelf, or armourstone and concrete retaining walls (1-4 m height)
D	28 to 43	1.5 to 8	steeper than 1.0H:1V to flatter than 3.0H:1V	surficial **sand or earth fill**	• Agricultural land, dwellings, and municipal roadways in the tableland • Forested with shrubs and trees, landscaped with grass, or agricultural land • At the toe, sand and gravel beaches, limestone shelf, or armourstone and concrete retaining walls (1-2 m height)
E	44 to 49	8 to 22	steeper than 1.0H:1V to 2.5H:1V	**Silt**, some sand, some clay, trace gravel, trace cobbles and boulders, reddish brown, moist to wet, compact/stiff (Glacial Till)	• Agricultural land, dwellings, and municipal roadways in the tableland • Tableland forested with shrubs and trees, landscaped with grass, or agricultural land • Slope face is bare and unvegetated • At the toe, sand and gravel beaches or armourstone, concrete, and gabion retaining walls (1-7 m height) • Active erosion at the toe of slope • Drainage pipe observed, extended to the toe of slope • Seepage through talus at toe

Area	**Sections**	**General Slope Height (±m)**	**General Slope Inclination**	**Exposed Soil**	**Features**
F	50 to 52	3 to 4	2.0H:1V to flatter than 3.0H:1V	surficial **sand**	• Agricultural land, dwellings, and municipal roadways in the tableland • Forested with shrubs and trees, landscaped with grass, or agricultural land • At the toe, sand and gravel beaches or armourstone and concrete retaining walls (1-2 m height)

4.0 SLOPE STABILITY ANALYSIS

4.1 Existing Conditions

A detailed engineering analysis of slope stability was carried out on the subject slope as shown in plan as Appendix A, and in profile in Appendix G. The analysis was completed using the LiDAR data provided by Baird. Terraprobe has assumed for the present purposes that this factual data represents the existing slope conditions. A flow chart depicting the steps to the analysis is included as Figure 2.

The analysis was conducted utilizing computer software (Slide 8.016, released July 23, 2018, developed by Rocscience Inc.) and several standard methods of limit equilibrium analysis (Bishop, Janbu, Morgenstern/Price, and Spencer). These methods of analysis allow the calculation of Factors of Safety for hypothetical or assumed slip surfaces through the slope. The analysis method is used to assess potential for movements of large masses of soil over a specific slip surface which can be curved or circular, or non-circular. The analysis involves dividing the sliding mass into many thin slices and calculating the forces on each slice. The normal and shear forces acting on the sides and base of each slice are calculated. It is an iterative process that converges on a solution. An example analysis is provided as Appendix F, which shows the critical slip surface, the slices, and the inter-slice forces, as well as pertinent aspects of the slope stability output.

For a specific slip surface, the Factor of Safety is defined as the ratio of the available soil strength resisting movement, divided by the gravitational forces tending to cause movement. The Factor of Safety of 1.0 represents a “limiting equilibrium” condition where the slope is at a point of pending failure since the soil resistance is equal to forces tending to cause movement. It is usual to require a Factor of Safety greater than one (1) to ensure stability of the slope. The typical Factor of Safety used for engineering design of slopes for stability ranges from about 1.3 to 1.5 for developments situated close to the slope crest. The most common design guidelines are based on a 1.5 minimum Factor of Safety.

Each analysis was carried out by preparing a model of the slope geometry and subsurface conditions, and analyzing numerous different slip surfaces through the slope in search of the minimum or critical Factor of Safety for specific conditions. The pertinent data obtained from topographic plan, slope profiles, slope mapping, and the borehole information, were input for the slope stability analysis. Many calculations were carried out to examine the Factor of Safety for varying depths of potential slip surfaces. Circular and non-circular surfaces were both analyzed and circular surfaces were found to govern.

The average soil properties utilized for the soil strata in the slope stability analysis were assessed from information secured from the boreholes, publicly available information, and visual inspection. The average soil properties are based on effective stress analysis for long-term slope stability, and are summarized in the table below. These soil properties are considered conservative; the soils on site are actually stronger. Short-term effects such as negative pore water pressures within unsaturated soils can increase the stability of a slope, and have been conservatively omitted. The presence of limestone at the shoreline has been conservatively omitted (except at Section 42).

Material	Unit Weight (kN/m^3)	Cohesion (kPa)	Internal Friction Angle (deg.)
Earth Fill	19	0	28
Glaciolacustrine Silt and Clay	21	6	30
Sand	20	0	30
Glacial Till	20	2	36
Limestone Bedrock	22	impenetrable	impenetrable

The Lake Erie water level was Elev. 173.2 m CGVD2013 on the date the LiDAR was collected in 2017.

The results of the slope stability analysis of the existing conditions are provided in Appendix G, and are summarized in the table below.

Sector	Section #	Height from section (m)	Existing Inclination from section	Existing FS	Critical (circular) Slip Surface Description
A	1	12.6	1.6 to 2.4H:1V	1.6	Surfaces pass through the lower slope profile
	2	9.0	1.9H:1V	1.6	Surfaces pass through the lower slope profile
	3	8.1	0.5 to 2.9H:1V	1.3	Surfaces pass through the lower slope profile
	4	5.7	1.1H:1V	1.5	Surfaces pass through the mid-slope profile
	5	2.8	2.0H:1V	2.6	Surfaces pass through the mid-slope profile
	6	6.7	3.6H:1V	2.1	Surfaces pass through the lower slope profile
	7	8.0	3.0H:1V	1.5	Surfaces pass through the lower slope profile
B	8	10.3	0.6H:1V	1.0	Surfaces pass through the lower slope profile
	9	10.7	1.5H:1V	1.5	Surfaces pass through the lower slope profile

Sector	Section #	Height from section (m)	Existing Inclination from section	Existing FS	Critical (circular) Slip Surface Description
B	10	7.7	2.0H:1V	1.5	Surfaces pass through the lower slope profile
	11	8.0	1.3H:1V	1.5	Surfaces pass through the lower slope profile
	12	7.5	1.9H:1V	2.0	Surfaces pass through the lower slope profile
C	13	2.3	0.9H:1V	1.8	Surfaces pass through the mid-slope profile
	14	5.1	0.8H:1V	1.3	Surfaces pass through the lower slope profile
	15	3.7	0.9H:1V	2.2	Surfaces pass through the lower slope profile
	16	3.7	1.1H:1V	2.4	Surfaces pass through the lower slope profile
	17	2.8	1.0H:1V	<1.0	Surfaces pass through the lower slope profile
	18	5.6	1.5H:1V	1.7	Surfaces pass through the lower slope profile
	19	2.4	1.3H:1V	2.1	Surfaces pass through the mid-slope profile
	20	5.9	1.7H:1V	1.8	Surfaces pass through the lower slope profile
	21	4.0	1.5H:1V	2.2	Surfaces pass through the lower slope profile
	22	3.2	1.5H:1V	3.0	Surfaces pass through the lower slope profile
	23	2.1	1.5H:1V	2.1	Surfaces pass through the lower slope profile
	24	3.1	3.7H:1V	2.7	Surfaces pass through the lower slope profile
	25	3.8	2.7H:1V	3.0	Surfaces pass through the lower slope profile
	26	2.6	0.5H:1V	<1.0	Surfaces pass through the lower slope profile
	27	3.4	1.0H:1V	1.9	Surfaces pass through the lower slope profile
D	28	2.6	1.6H:1V	1.9	Surfaces pass through the lower slope profile
	29	1.8	0.8H:1V	2.7	Surfaces pass through the lower slope profile
	30	3.6	1.2H:1V	2.2	Surfaces pass through the mid-slope profile
	31	4.8	2.2H:1V	2.4	Surfaces pass through the lower slope profile
	32	2.7	1.2H:1V	3.0	Surfaces pass through the mid-slope profile
	33	2.0	1.0H:1V	2.3	Surfaces pass through the lower slope profile
	34	2.6	1.5H:1V	2.4	Surfaces pass through the lower slope profile
	35	4.0	1.7H:1V	1.4	Surfaces pass through the lower slope profile
	36	2.6	1.6H:1V	2.2	Surfaces pass through the lower slope profile
	37	2.2	0.8H:1V	1.8	Surfaces pass through the lower slope profile

Sector	Section #	Height from section (m)	Existing Inclination from section	Existing FS	Critical (circular) Slip Surface Description
D	38	7.1	3.7H:1V	1.2	Surfaces pass through the mid-slope profile
	39	4.1	1.6H:1V	1.8	Surfaces pass through the lower slope profile
	40	3.4	4.4H:1V	3.7	Surfaces pass through the mid-slope profile
	41	4.0	4.4H:1V	3.2	Surfaces pass through the lower slope profile
	42	7.5	2.8H:1V	impenetrable*	n/a*
	43	1.6	1.1H:1V	1.9	Surfaces pass through the lower slope profile
E	44	8.2	1.3H:1V	1.5	Surfaces pass through the lower slope profile
	45	10.2	0.5H:1V	<1.0	Surfaces pass through the lower slope profile
	46	21.5	0.3H:1V to 1.2H:1V	1.1	Surfaces pass through the lower slope profile
	47	9.4	1.5H:1V	1.4	Surfaces pass through the lower slope profile
	48	8.8	2.3H:1V	2.0	Surfaces pass through the lower slope profile
	49	11.0	2.4H:1V	1.6	Surfaces pass through the lower slope profile
F	50	3.0	10H:1V to 4.3H:1V	2.6	Surfaces pass through the lower slope profile
	51	3.7	2.3H:1V	1.6	Surfaces pass through the lower slope profile
	52	3.8	3.4H:1V	2.9	Surfaces pass through the lower slope profile

*stratigraphy at this section is primarily bedrock, which is modelled as an infinite strength/impenetrable material.

Circular surfaces were found to govern for the existing conditions, with critical slip surfaces generally passing through the lower slope profile. The results indicate that the majority of the site (42 out of 52 sections) have adequate factors of safety of 1.5 or higher. Ten of the cross sections have factors of safety less than 1.5.

At Sections 3, 14, 17, 26, and 38 the slope appears to be oversteepened. Armourstone or concrete retaining walls were observed at the face of the slope. The slope at these sections is unstable to moderately stable with critical factors of safety of less than 1.0 to 1.3.

At Section 35, the critical factor of safety is 1.4, indicating the slope at this section is moderately stable.

At the west end of the study area (Section 8), the slope is unstable with a critical factor of safety of 1.0. There is active toe erosion that is undermining the toe of slope. Tension cracks were observed in the upper slope face. The slope is therefore considered unstable at this section.

At the east end of the study area (Sections 45 to 47), the slope is unstable to moderately stable with critical factors of safety of less than 1.0 to 1.4. There is active toe erosion which has caused glacial till bluffs to become oversteepened. Talus accumulation was observed at the toe of slope. The slope is progressively self-stabilizing by eroding back (i.e. crest migration) to a more stable inclination. Future toe erosion and crest migration is anticipated.

4.2 Stable Inclination Setback

For active land use, the MNR Policy Guidelines allow a minimum Factor of Safety of 1.3 to 1.5 for slope stability, as follows.

TYPE	LAND-USES	DESIGN MINIMUM FACTOR OF SAFETY
A	PASSIVE: no buildings near slope; farm field, bush, forest, timberland, woods, wasteland, badlands, tundra	1.1
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 slopes; 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 and 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

Based on the MNR policy guidelines, the LTSSC analysis was conducted using a Factor of Safety of 1.5 (“$\text{LTSSC}_{1.5}$”, for habitable or occupied structures near slopes). The computed minimum factors of safety is as low as less than 1.0, with critical (circular) slip surfaces generally passing through the lower slope profile. Therefore, the minimum factors of safety obtained under existing conditions in 10 of the 52 section locations are considered inadequate and unacceptable for long-term planning purposes. An additional setback from the existing top of slope will be required to achieve a long-term stable inclination.

4.2.1 Stable Slope Inclination

The stable slope analysis was determined following the flow chart included as Figure 2, which depicts the steps to the analysis. Based on the soil type of the subject section (as described in Section 3.0 and shown in Appendix G), the subject slope is either composed of assumed earth fill, surficial sand, silt and clay and/or glacial till. Due to the variability or the earth fill and surficial sand, the Grand River Conservation Authority (GRCA), Long Point Region Conservation Authority (LPRCA), and Niagara Peninsula Conservation Authority (NPCA) guidelines were followed to determine the stable slope inclination for these soil types. For the slopes with a composition of native silt and clay or glacial till, a number of representative trial stabilized slope profiles were analysed to obtain the required factor of safety.

Terraprobe referred to the following documents for the policies in the study area:

- Grand River Conservation Authority, "Policies for the Administration of the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation, Ontario Regulation 150/06", dated October 23, 2015.
- Long Point Region Conservation Authority, "Policies for the Administration of the Development, Interference with Wetlands, and Alterations to Shorelines and Watercourses Regulation, Ontario Regulation 178/06", dated October 4, 2017.
- Niagara Peninsula Conservation Authority, "NPCA Policy Document: Policies for the Administration of Ontario Regulation 155/06 and The Planning Act", dated September 2018.

The GRCA indicates that the stable slope angle is determined from a geotechnical study or engineering assessment. The LPRCA indicates that the stable slope inclination should be taken as 3.0H:1V unless a site-specific geotechnical investigation determines a different value. Due to the variable nature of earth fill and surficial sand across the study area, stable slope inclination of 3.0H:1V should apply to these soil types where encountered. The NPCA indicates that the stable slope allowance along the Great Lakes shoreline is 3:1 (horizontal to vertical) in the absence of a site specific geotechnical study.

For the slopes comprising the native glaciolacustrine silt and clay or glacial till, a number of representative trial stabilized slope profiles were analyzed to obtain a minimum factor of safety for global stability of 1.5 (shown in Appendix H) for normal ground water conditions and temporary and infrequent high water table conditions.

The stable slope inclinations are shown in profile in Appendix H, and summarized in the table below.

Soil Type	**Stable Slope Inclinations for:** **Normal Ground Water Table (FS = 1.5)** **Temporary and Infrequent High Ground Water Table (FS = 1.3)**
Earth Fill	3.0H:1V[1]
Sand	3.0H:1V[1]
Glaciolacustrine Silt and Clay	2.3H:1V[2]
Glacial Till	1.8H:1V[2]
Bedrock	1.4H:1V[3]

1. Based on GRCA, LRPCA, and NPCA guidelines.
2. Based on Terraprobe analysis.
3. Based on other conservation guidelines in Ontario.

In addition to a stable slope inclination setback, an erosion allowance (to be provided by Baird) should be applied to determine the long-term stable slope crest position.

The following table provides the stable slope inclinations for each of the cross sections based on the primary soil type.

Section #	Primary Soil Type	Stable Inclination
1	glaciolacustrine silt and clay	2.3H:1V
2	glaciolacustrine silt and clay	2.3H:1V
3	glaciolacustrine silt and clay	2.3H:1V
4	glaciolacustrine silt and clay	2.3H:1V
5	glaciolacustrine silt and clay	2.3H:1V
6	glaciolacustrine silt and clay	2.3H:1V
7	earth fill	3.0H:1V
8	glaciolacustrine silt and clay	2.3H:1V
9	glaciolacustrine silt and clay	2.3H:1V
10	glaciolacustrine silt and clay	2.3H:1V
11	glaciolacustrine silt and clay	2.3H:1V
12	glaciolacustrine silt and clay	2.3H:1V
13	glaciolacustrine silt and clay	2.3H:1V
14	glaciolacustrine silt and clay	2.3H:1V
15	glaciolacustrine silt and clay	2.3H:1V
16	glaciolacustrine silt and clay	2.3H:1V
17	glaciolacustrine silt and clay	2.3H:1V
18	glaciolacustrine silt and clay	2.3H:1V
19	sand	3.0H:1V
	glaciolacustrine silt and clay	2.3H:1V
20	glaciolacustrine silt and clay	2.3H:1V
21	glaciolacustrine silt and clay	2.3H:1V
22	glaciolacustrine silt and clay	2.3H:1V
23	glaciolacustrine silt and clay	2.3H:1V
24	glaciolacustrine silt and clay	2.3H:1V
25	glaciolacustrine silt and clay	2.3H:1V
26	glaciolacustrine silt and clay	2.3H:1V
27	sand	3.0H:1V
	glaciolacustrine silt and clay	2.3H:1V
28	glaciolacustrine silt and clay	2.3H:1V
29	glaciolacustrine silt and clay	2.3H:1V
30	glaciolacustrine silt and clay	2.3H:1V
31	glaciolacustrine silt and clay	2.3H:1V

Section #	Primary Soil Type	Stable Inclination
32	glaciolacustrine silt and clay	2.3H:1V
33	glaciolacustrine silt and clay	2.3H:1V
34	glaciolacustrine silt and clay	2.3H:1V
35	sand	3.0H:1V
36	glaciolacustrine silt and clay	2.3H:1V
37	glaciolacustrine silt and clay	2.3H:1V
38	glaciolacustrine silt and clay	2.3H:1V
39	glaciolacustrine silt and clay	2.3H:1V
40	sand	3.0H:1V
	glaciolacustrine silt and clay	2.3H:1V
41	sand	3.0H:1V
	glaciolacustrine silt and clay	2.3H:1V
42	earth fill / unknown	3.0H:1V
	bedrock	1.4H:1V
43	sand	3.0H:1V
	glaciolacustrine silt and clay	2.3H:1V
44	glacial till	1.8H:1V
45	glacial till	1.8H:1V
46	glacial till	1.8H:1V
47	glacial till	1.8H:1V
48	glacial till	1.8H:1V
49	sand	3.0H:1V
	glacial till	1.8H:1V
50	sand	3.0H:1V
51	sand	3.0H:1V
52	sand	3.0H:1V

5.0 SUMMARY AND CLOSURE

This report encompasses slope stability and erosion risk assessment for the purpose of establishing the Stable Slope Inclinations at a county scale. Site specific studies are recommended. The stable slope allowance is used for mapping the Erosion Hazard.

The study area is along the Lake Erie North Slope, from east of Lowbanks to east of Port Dover. The subject slope along the shoreline is up to 21.5 m in height. The tableland is generally occupied by agricultural land, residential properties, conservation land, or municipal roadways. Lake Erie is present approximately at the toe of slope. The scope of work includes a detailed visual slope inspection to review the existing slope conditions and a detailed slope stability analysis.

Based on the detailed slope stability analysis, the existing slope generally has a minimum Factor of Safety of greater than 1.5. In some areas, the minimum Factor of Safety of the slope is less than 1.5, and is not considered stable for long-term planning purposes. Minimum Factors of Safety of 1.5 for normal ground water and temporary elevated ground water conditions are achieved with a stable slope inclination of 3.0H:1V in the earth fill and sand, 2.3H:1V in the glaciolacustrine silt and clay, and 1.8H:1V in the glacial till. To determine the Long Term Stable Slope Crest, an erosion allowance must be applied. MNR guidelines require that developments, dwellings, buildings, or other structures have an additional setback for planning purposes.

There are some dwellings in close proximity to the slope crest at Area E (from Pyle Road to Farr Road), where there was limited access to the slope. These dwellings are potentially within the erosion hazard, and therefore, a more detailed and site-specific analysis is recommended.

In general, any site development and construction activities should be conducted in a manner which does not result in surface erosion of the slope. In particular, site grading and drainage should be designed to prevent direct concentrated or channelized surface runoff from flowing directly over the slope. Water drainage from down-spouts, sumps, road drainage, and the like should not be permitted to flow over the slope.

This report is prepared for the express use of W.F. Baird & Associates Coastal Engineers Ltd. and the client, Grand River Conservation Authority, Long Point Region Conservation Authority and Niagara Peninsula Conservation Authority. It is not for use by others.

W.F. Baird & Associates Coastal Engineers Ltd. and the client, Grand River Conservation Authority, Long Point Region Conservation Authority and Niagara Peninsula Conservation Authority, are authorized users.

We trust that this report meets your present requirements. Should you have any questions regarding the information presented, please do not hesitate to contact our office.

Terraprobe Inc.

J. J. CROWDER
100077148
15/10/2019

Jory Hunter, B.Sc.(Eng.), E.I.T.
Geotechnical Engineering Division

Jason Crowder, Ph.D., P.Eng.
Principal

FIGURES

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Reference
Google Earth Pro ©2019

Scale 1: 526,000

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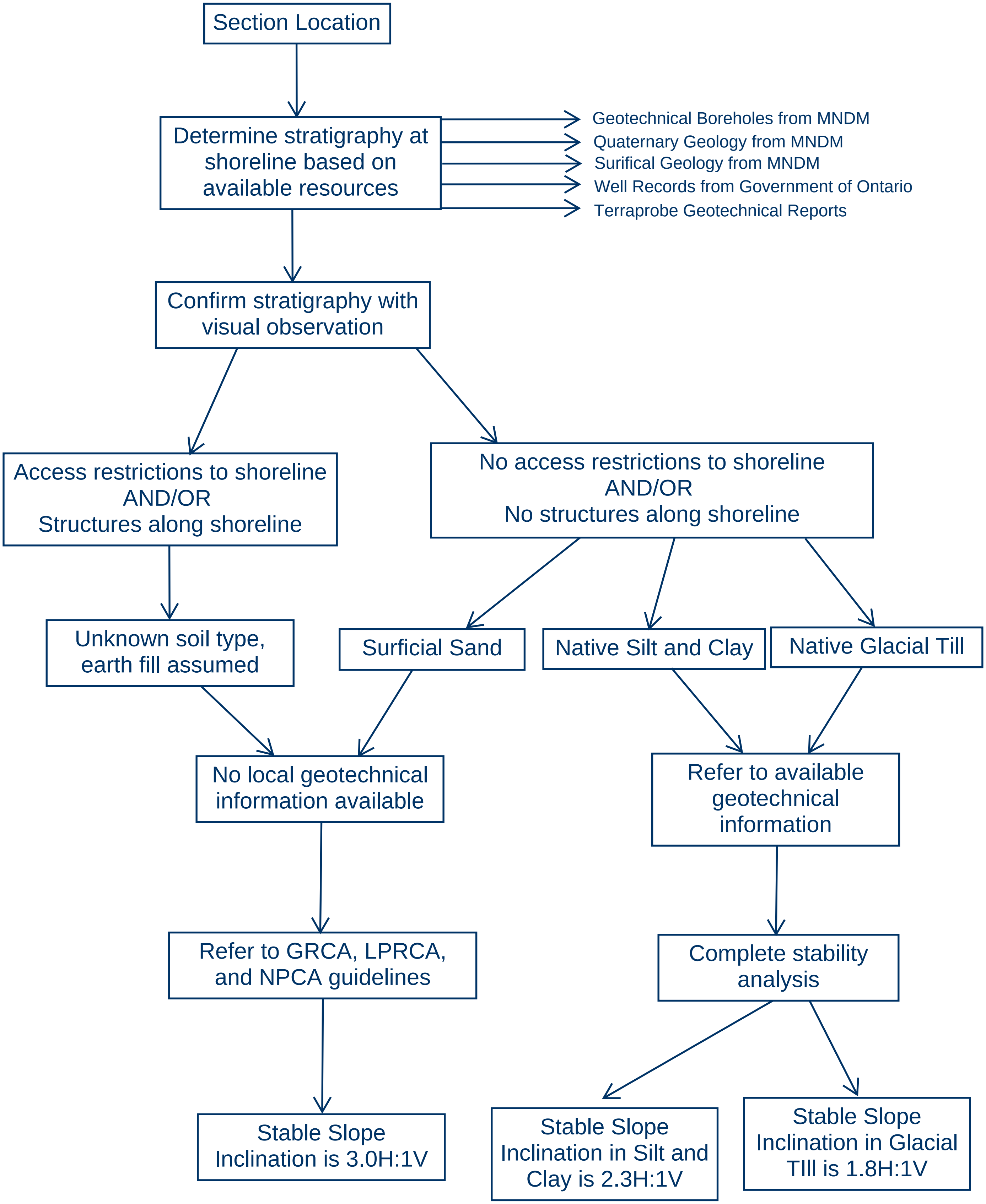
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

Site Location Plan

File. No.: 1-18-0402-01

FIGURE : 1



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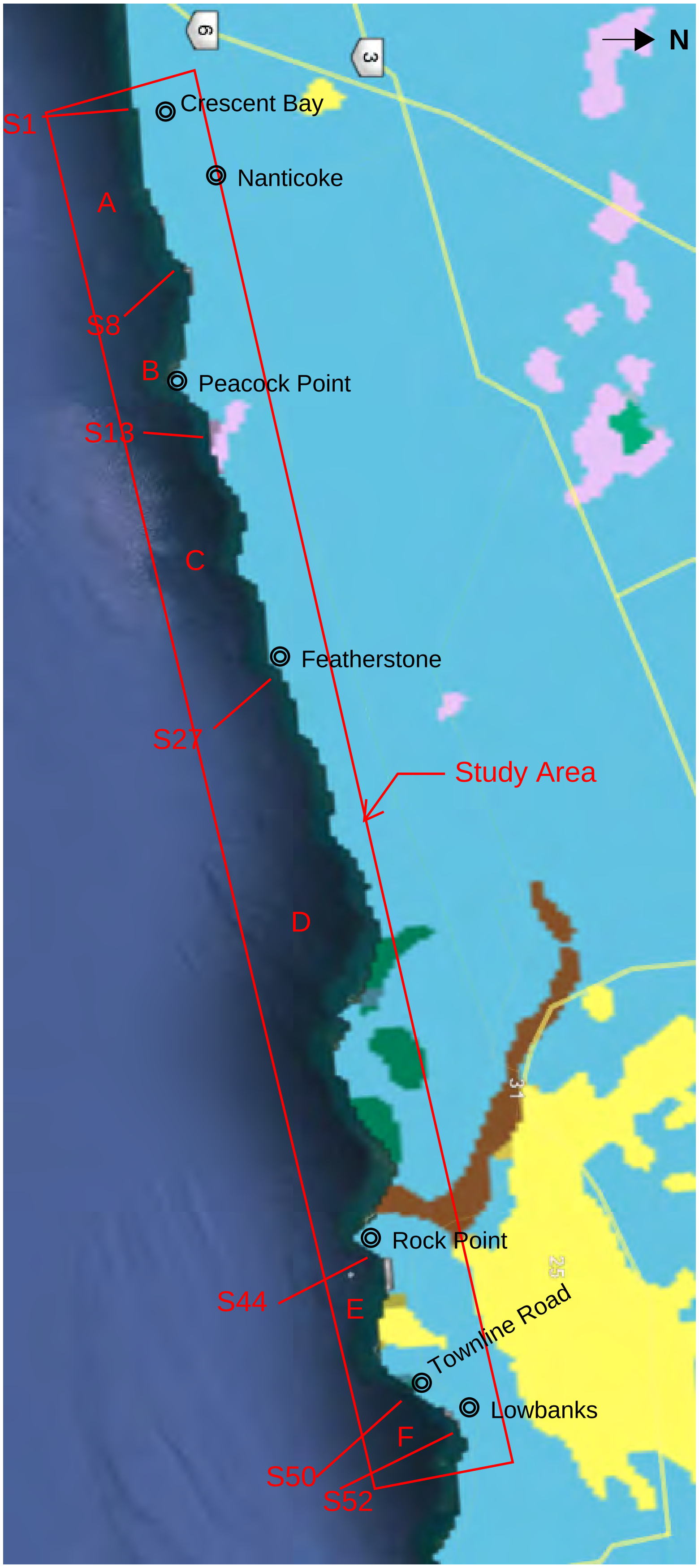
Title:

SSI Determination Flow Chart

File. No.: 1-18-0402-01

FIGURE : 2



Legend

🟦	**Glaciolacustrine Deposits** silt and clay, minor sand, basin and quiet water deposits Pleistocene
🟪	**Bedrock, post-Precambrian** undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift Paleozoic
🟩	**Halton Till** predominantly silt to silty clay matrix, high in matrix carbonate content and clast poor Pleistocene
🟫	**Fluvial Deposits** gravel, sand, silt and clay, deposited on modern flood plains Recent
🟨	**Glaciolacustrine Deposits** sand, gravelly sand and gravel, nearshore and beach deposits Pleistocene
▨	**Lacustrine Deposits** sand, gravelly sand and gravel, neashore and beach deposits Recent

Reference
Ontario Geological Survey 2000. *Quaternary geology, seamless coverage of the Province of Ontario; Ontario Geological Survey, Data Set 14---Revised.*

Terraprobe
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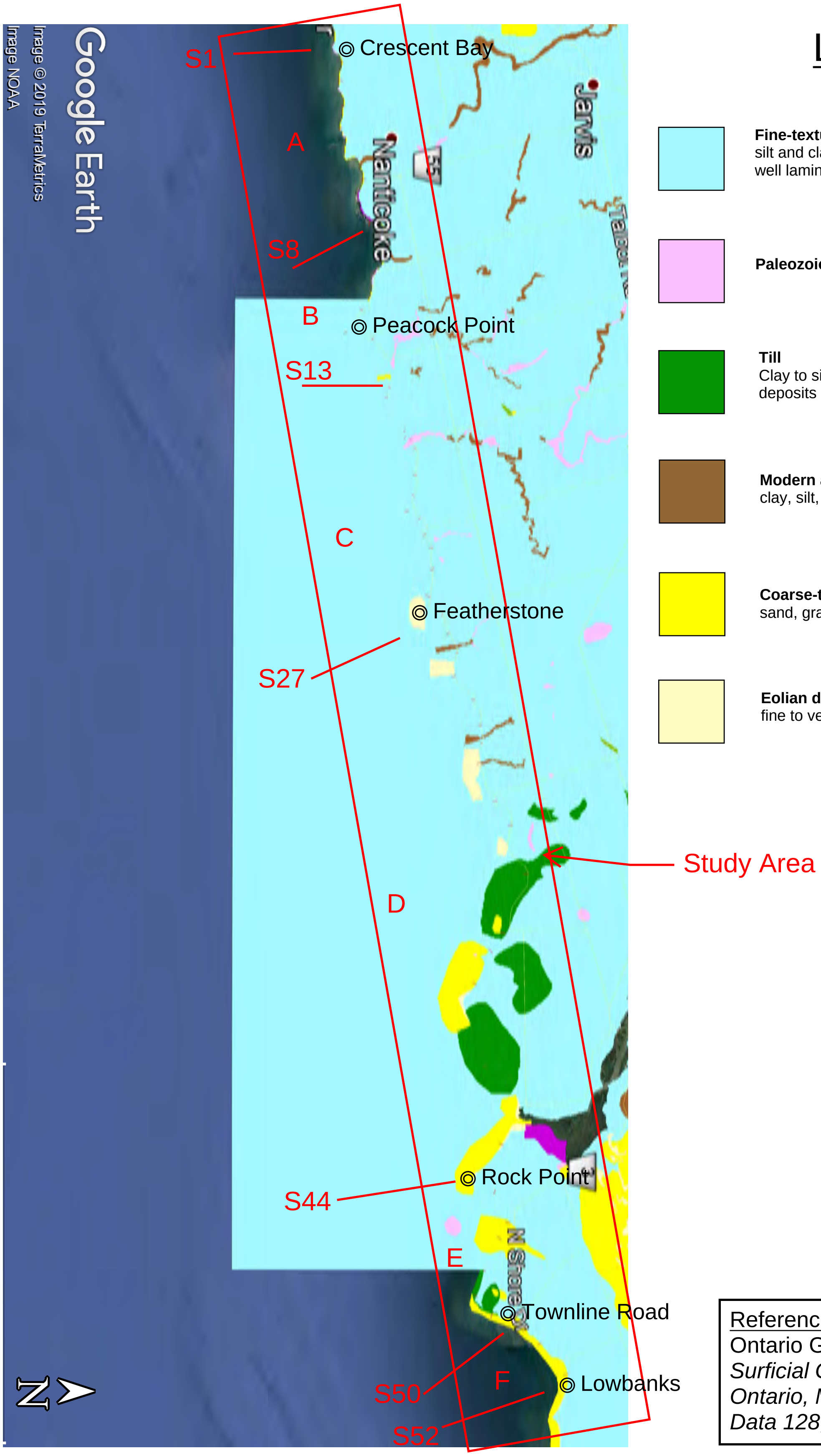
Title:
MNDM Quaternary Geology

File. No.:
1-18-0402-01

FIGURE :
3



Legend

🟦	**Fine-textured glaciolacustrine deposits** silt and clay, minor sand and gravel, massive to well laminated
🟪	**Paleozoic Bedrock**
🟩	**Till** Clay to silt-textured till (derived from glaciolacustrine deposits or shale)
🟫	**Modern alluvial deposits** clay, silt, sand, gravel, may contain organic remains
🟨	**Coarse-textured lacustrine deposits** sand, gravel, minor silt and clay, littoral deposits
⬜	**Eolian deposits** fine to very fine sand and silt

Reference
Ontario Geological Survey 2003.
Surficial Geology of Southern Ontario, Miscellaneous Release, Data 128, Revised.

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Title:
MNDM Surficial Geology

File. No.:
1-18-0402-01

FIGURE :
4

APPENDICES

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APPENDIX A

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Legend

①▷	Photo Locations
/	Section Locations
⊕	OGS Geotechnical Boreholes (MNDM)
⊕	Ontario Well Records
notes →	Terraprobe Visual Inspection Notes
Geology of the Area *Visual Observation* Section 11 and 12: Armourstone along water's edge	Notes on Stratigraphy
Report: Nanticoke (2015) →	Terraprobe Reports

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Title:

Legend

File. No.:

FIGURE :

Lake Erie, Dunnville to Port Dover

1-18-0402

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Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Terraprobe Reports (Naticoke)

"Silty clay overburden, fissured, thin stratifications, Avg N=24, brownish grey, Bedrock Elev. 180.6 to 181.4 m, water table at Elev. 187.4 m." (1974)

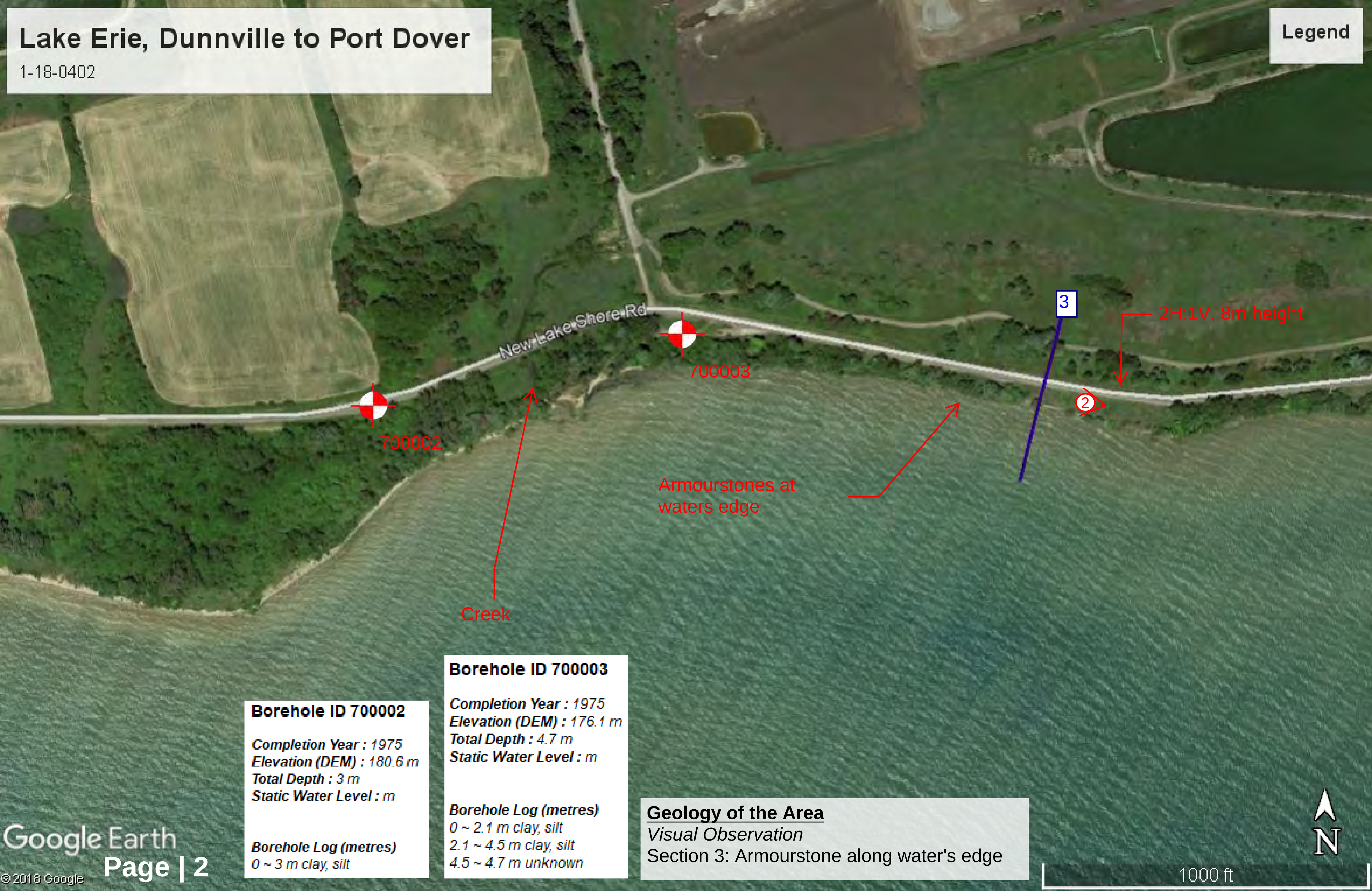
"Silty clay, brown to grey, silt seams, Avg N=19, Bedrock Elev. 183.6 m." (2015)

Visual Observation

Section 1 and 2: Silty clay, so sand, brown, moist, very stiff, thin stratifications, silt seams

Lake Erie, Dunnville to Port Dover

1-18-0402



Borehole ID 700002

Completion Year : *1975*
Elevation (DEM) : *180.6 m*
Total Depth : *3 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 3 m clay, silt

Borehole ID 700003

Completion Year : *1975*
Elevation (DEM) : *176.1 m*
Total Depth : *4.7 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 2.1 m clay, silt
2.1 ~ 4.5 m clay, silt
4.5 ~ 4.7 m unknown

Geology of the Area

Visual Observation

Section 3: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey
"Glaciolacustrine silt and clay, minor sand"

Terraprobe Reports (Naticoke)
"Silty clay overburden, fissured, thin stratifications, Avg N=24, brownish grey, Bedrock Elev. 180.6 to 181.4 m, water table at Elev. 187.4 m." (1974)

"Silty clay, brown to grey, silt seams, Avg N=19, Bedrock Elev. 183.6 m." (2015)

Visual Observation
Section 5: Silty clay, so sand, brown, moist, very stiff, thin stratifications, silt seams

Borehole ID 700004

Completion Year : *1975*
Elevation (DEM) : *179.4 m*
Total Depth : *4.9 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 2.1 m clay, silt, pebbles
2.1 ~ 4.5 m clay, silt, pebbles
4.5 ~ 4.9 m unknown

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Terraprobe Reports (Naticoke)

"Silty clay overburden, fissured, thin stratifications, Avg N=24, brownish grey, Bedrock Elev. 180.6 to 181.4 m, water table at Elev. 187.4 m." (1974)

"Silty clay, brown to grey, silt seams, Avg N=19, Bedrock Elev. 183.6 m." (2015)

Lake Erie, Dunnville to Port Dover

1-18-0402

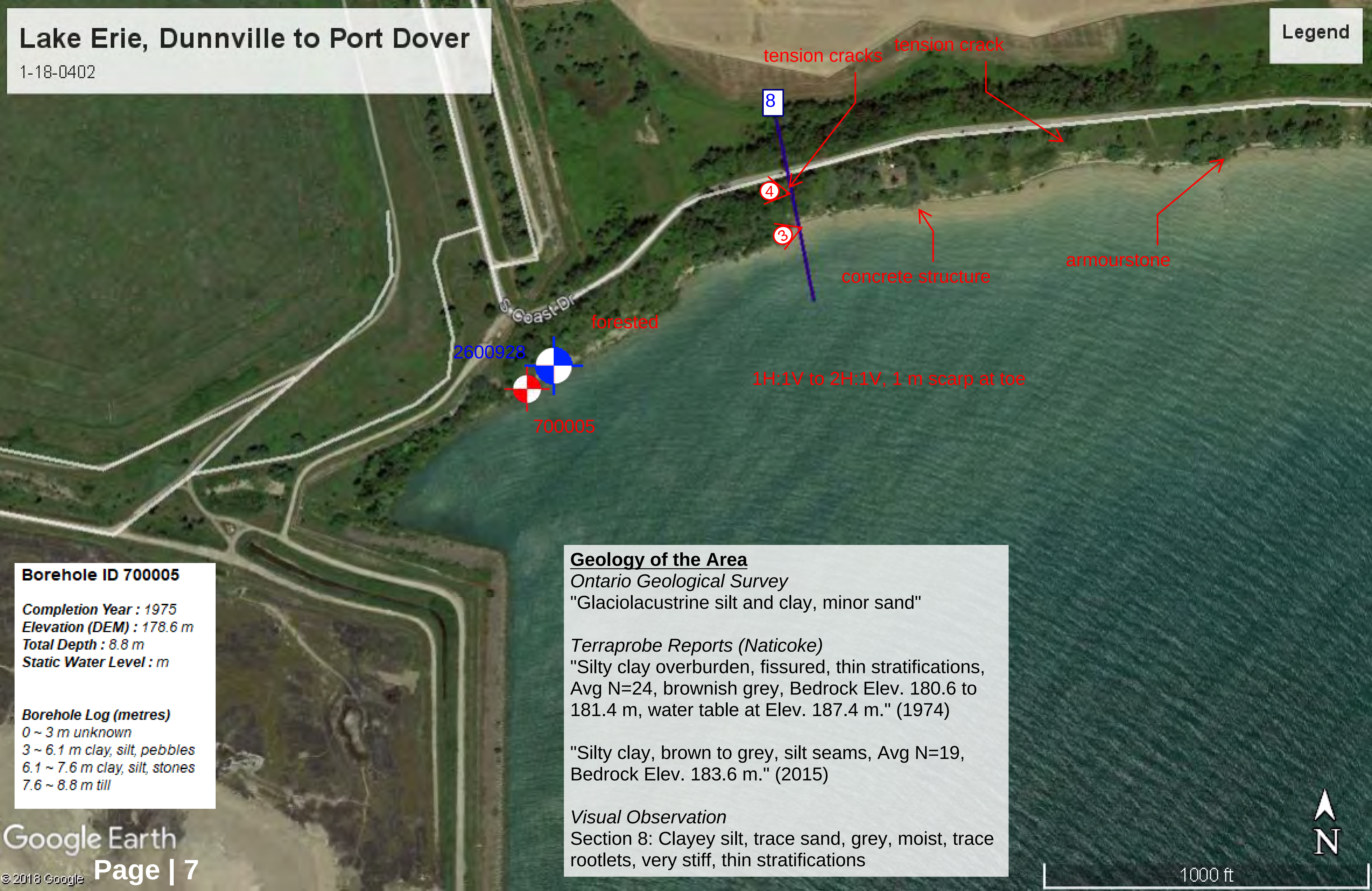
Geology of the Area

Visual Observation

Section 7: Earth fill embankment

Lake Erie, Dunnville to Port Dover

1-18-0402



Borehole ID 700005

Completion Year : *1975*
Elevation (DEM) : *178.6 m*
Total Depth : *8.8 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 3 m unknown
3 ~ 6.1 m clay, silt, pebbles
6.1 ~ 7.6 m clay, silt, stones
7.6 ~ 8.8 m till

Geology of the Area

Ontario Geological Survey
"Glaciolacustrine silt and clay, minor sand"

Terraprobe Reports (Naticoke)
"Silty clay overburden, fissured, thin stratifications, Avg N=24, brownish grey, Bedrock Elev. 180.6 to 181.4 m, water table at Elev. 187.4 m." (1974)

"Silty clay, brown to grey, silt seams, Avg N=19, Bedrock Elev. 183.6 m." (2015)

Visual Observation
Section 8: Clayey silt, trace sand, grey, moist, trace rootlets, very stiff, thin stratifications

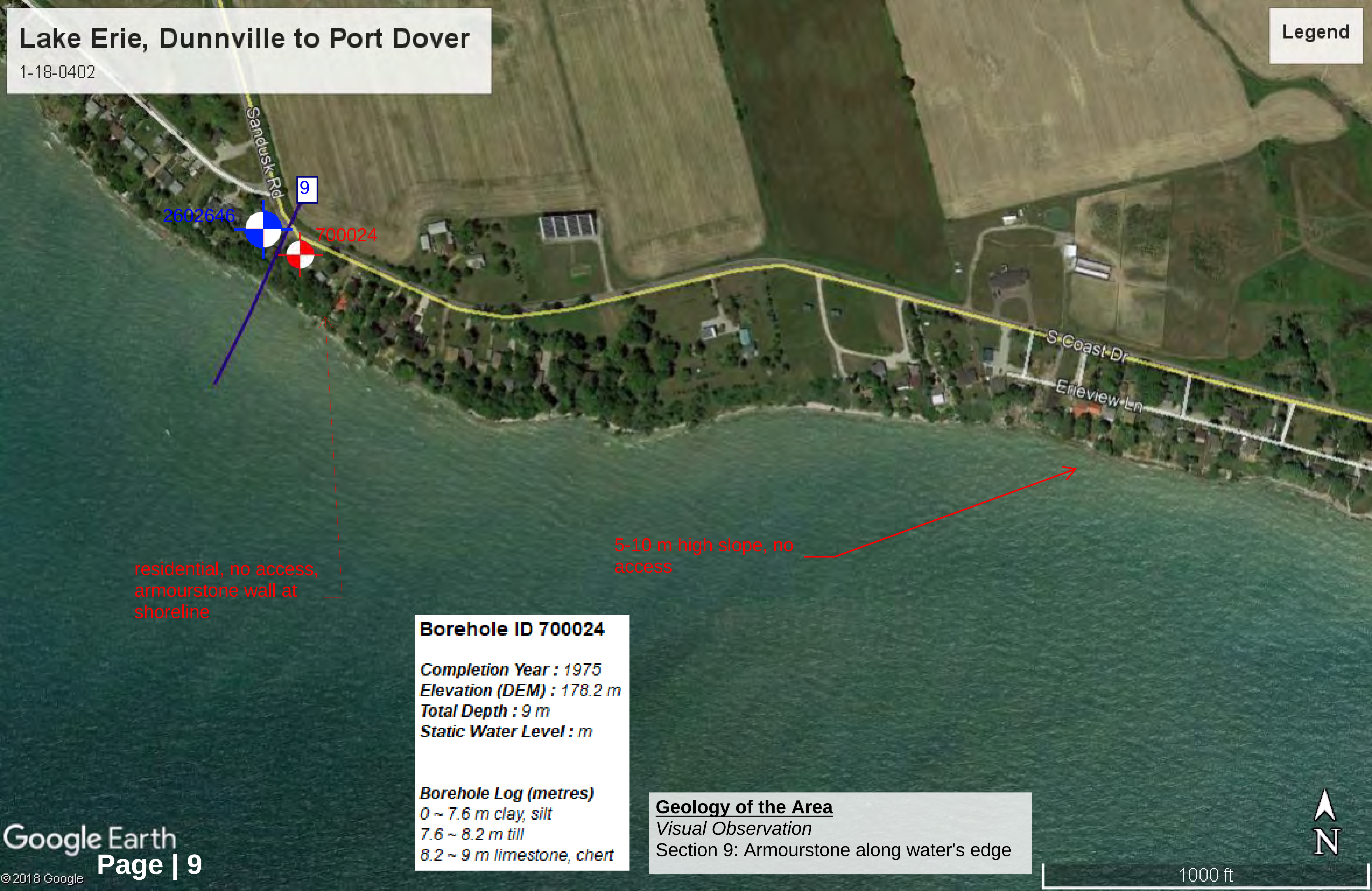
© 2018 Google

Lake Erie, Dunnville to Port Dover

1-18-0402

Lake Erie, Dunnville to Port Dover

1-18-0402



Borehole ID 700024

Completion Year : *1975*
Elevation (DEM) : *178.2 m*
Total Depth : *9 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 7.6 m clay, silt
7.6 ~ 8.2 m till
8.2 ~ 9 m limestone, chert

Geology of the Area
Visual Observation
Section 9: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Terraprobe Reports (Naticoke)

"Silty clay overburden, fissured, thin stratifications, Avg N=24, brownish grey, Bedrock Elev. 180.6 to 181.4 m, water table at Elev. 187.4 m." (1974)

"Silty clay, brown to grey, silt seams, Avg N=19, Bedrock Elev. 183.6 m." (2015)

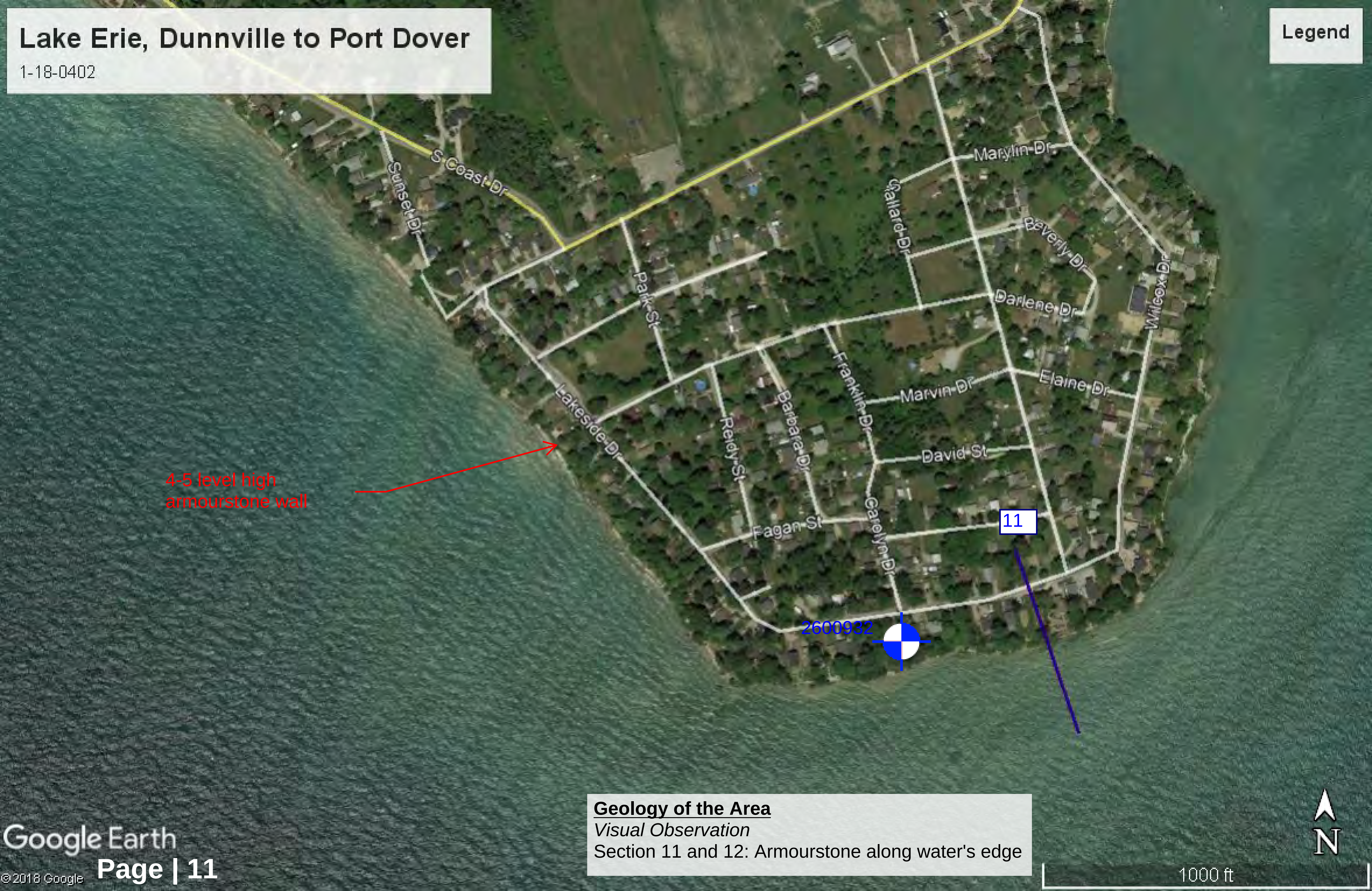
Borehole ID 700026

Completion Year : *1975*
Elevation (DEM) : *177 m*
Total Depth : *8.8 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 6.1 m clay, silt
6.1 ~ 8.2 m clay, pebbles
8.2 ~ 8.8 m unknown

Lake Erie, Dunnville to Port Dover

1-18-0402



Geology of the Area

Visual Observation

Section 11 and 12: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

~10 m high, 2H:1V, armourstone along shore, rip rap along slope face, vegetated

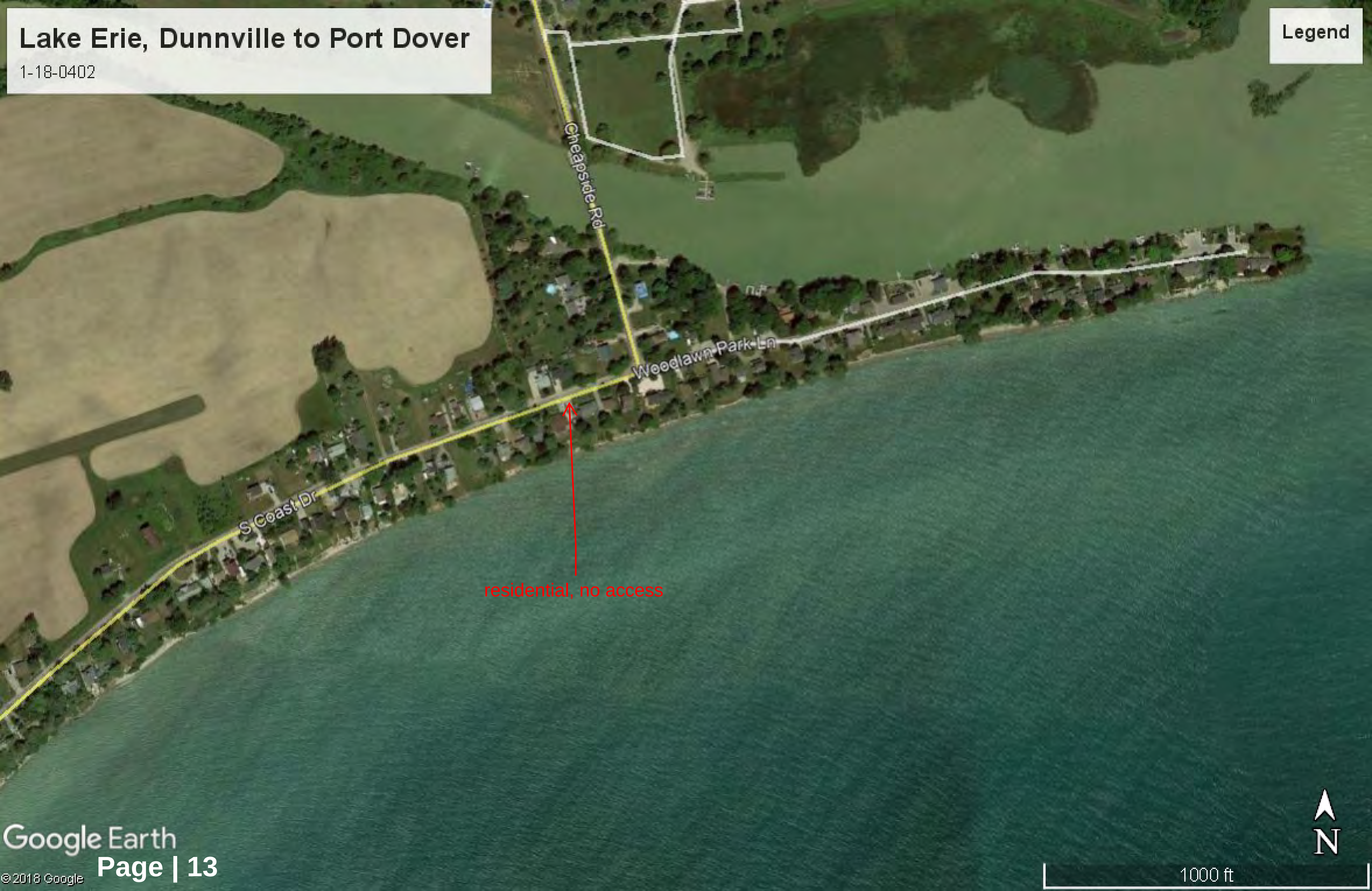
Geology of the Area

Visual Observation

Section 11 and 12: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402



Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Bedrock, post-Precambrian, undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by discontinuous, thin layer of drift"

Visual Observation

Section 13: sand and gravel beach at water's edge

Section 14: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area
Ontario Geological Survey
"Glaciolacustrine silt and clay, minor sand"

Visual Observation
Section 15-18: Armourstone along water's edge

Geology of the Area
Visual Observation
Section 15-18: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Limestone shelf, with sand and gravel beach

Legend

Geology of the Area

Visual Observation

Section 19: Sand and gravel beach at water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Visual Observation

Section 20-22: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Terraprobe Reports (Rainham)

"Silty clay, trace sand and gravel, brown, Avg N=21, Bedrock at 5 m depth." (2004)

Visual Observation

Section 23: silty clay, so sand, brown, moist

Section 24: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

inclination around 3H:1V

Geology of the Area

Ontario Geological Survey
"Glaciolacustrine silt and clay, minor sand"

Terraprobe Reports (Rainham)
"Silty clay, trace sand and gravel, brown, Avg N=21, Bedrock at 5 m depth." (2004)

Visual Observation
Section 25 to 28: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Terraprobe Reports (Rainham)

"Silty clay, trace sand and gravel, brown, Avg N=21, Bedrock at 5 m depth." (2004)

Visual Observation

Section 25 to 28: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Visual Observation

Section 25 to 28: Armourstone along water's edge

Section 29 to 34: Sand beach along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Visual Observation

Section 29 to 34: Sand beach along water's edge

Lake Erie, Dunnville to Port Dover

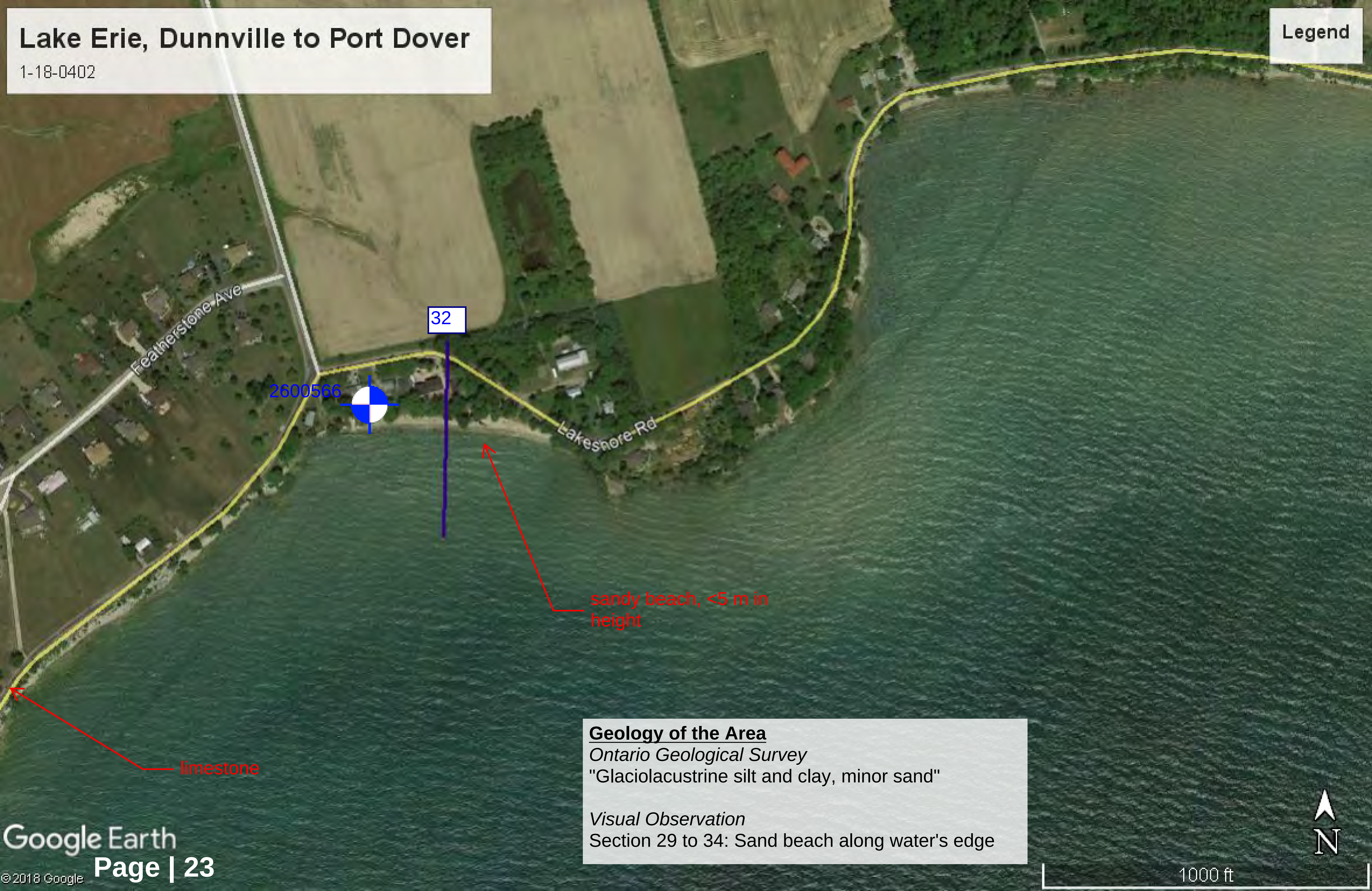
1-18-0402

Geology of the Area
Ontario Geological Survey
"Glaciolacustrine silt and clay, minor sand"

Visual Observation
Section 29 to 34: Sand beach along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402



Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Visual Observation

Section 29 to 34: Sand beach along water's edge

Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Visual Observation

Section 29 to 34: Sand beach along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

sandy beach over visible limestone

Borehole ID 856345

Completion Year : *1970*
Elevation (DEM) : *174.1 m*
Total Depth : *5.9 m*
Static Water Level : *0.9 m*

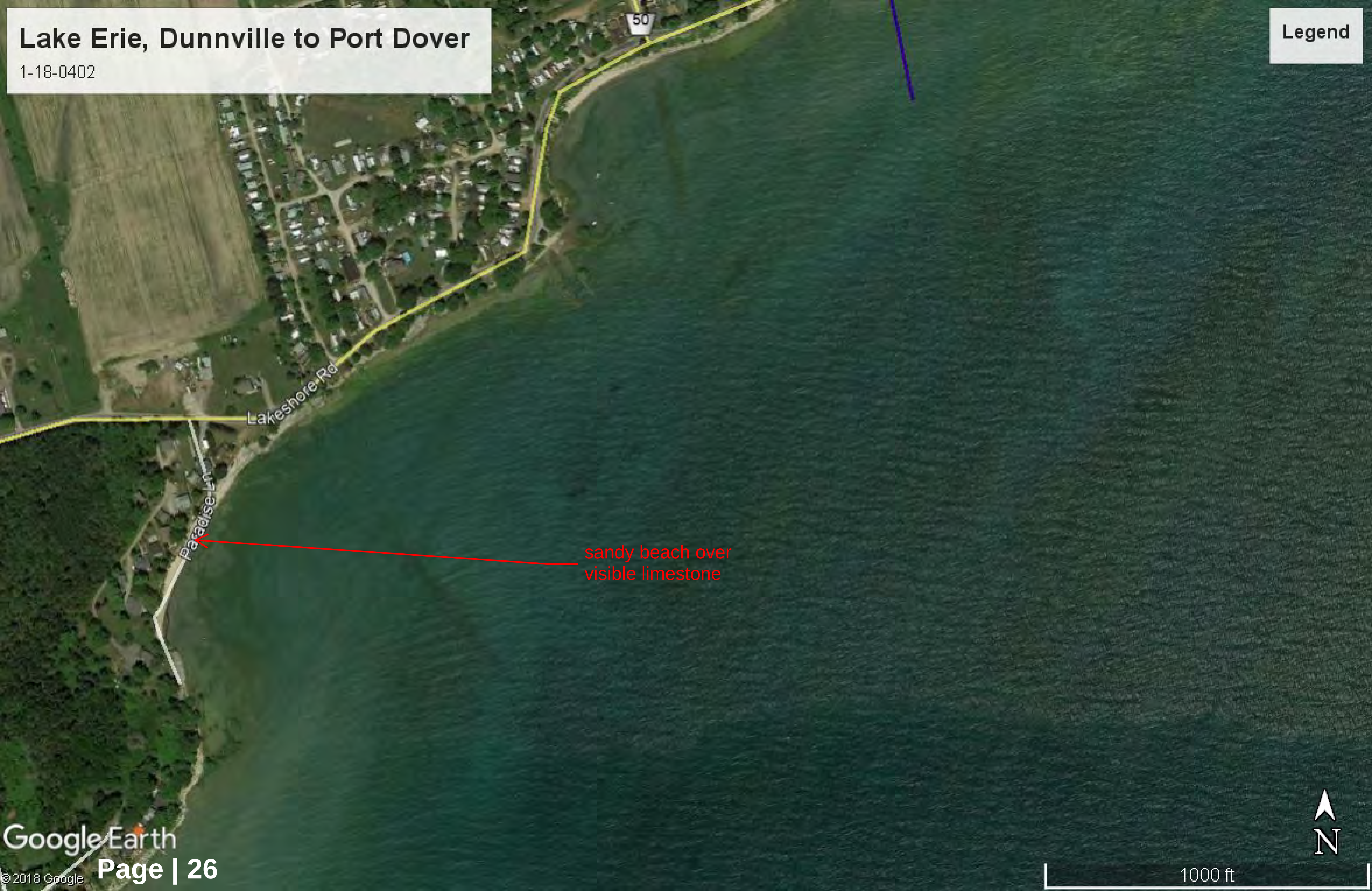
Borehole Log (metres)
0 ~ 0.3 m topsoil
0.3 ~ 4.9 m clay, silt, silt, fine sand, brown, very stiff
4.9 ~ 5.9 m till, silt, sand, gravel, brown, dense

Geology of the Area
Ontario Geological Survey
"Glaciolacustrine silt and clay, minor sand"

Visual Observation
Section 35: Armourstone along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402



sandy beach over visible limestone

Lake Erie, Dunnville to Port Dover

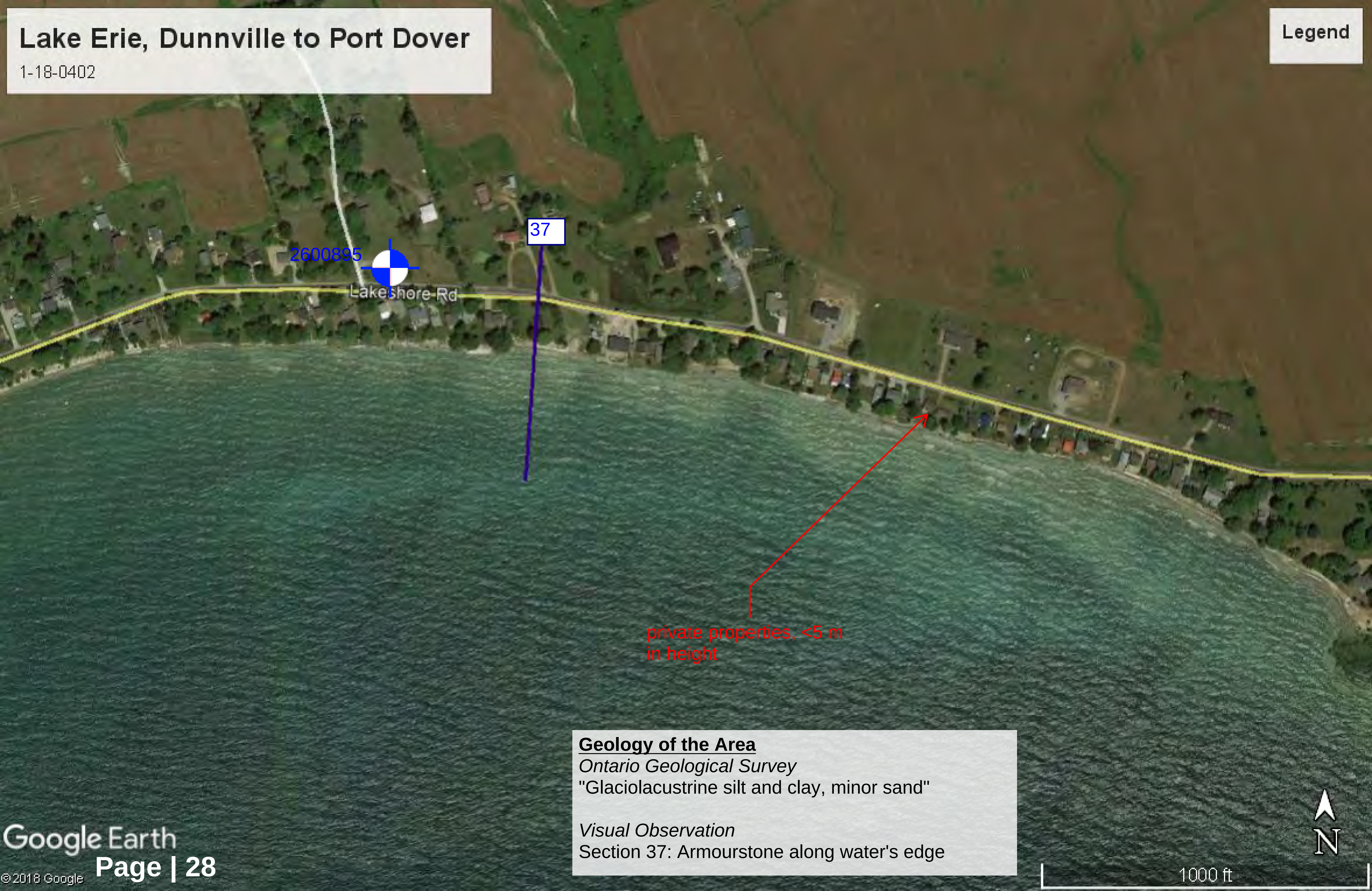
1-18-0402

Geology of the Area
Ontario Geological Survey
"Glaciolacustrine silt and clay, minor sand"

Visual Observation
Section 36: Sand beach along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402



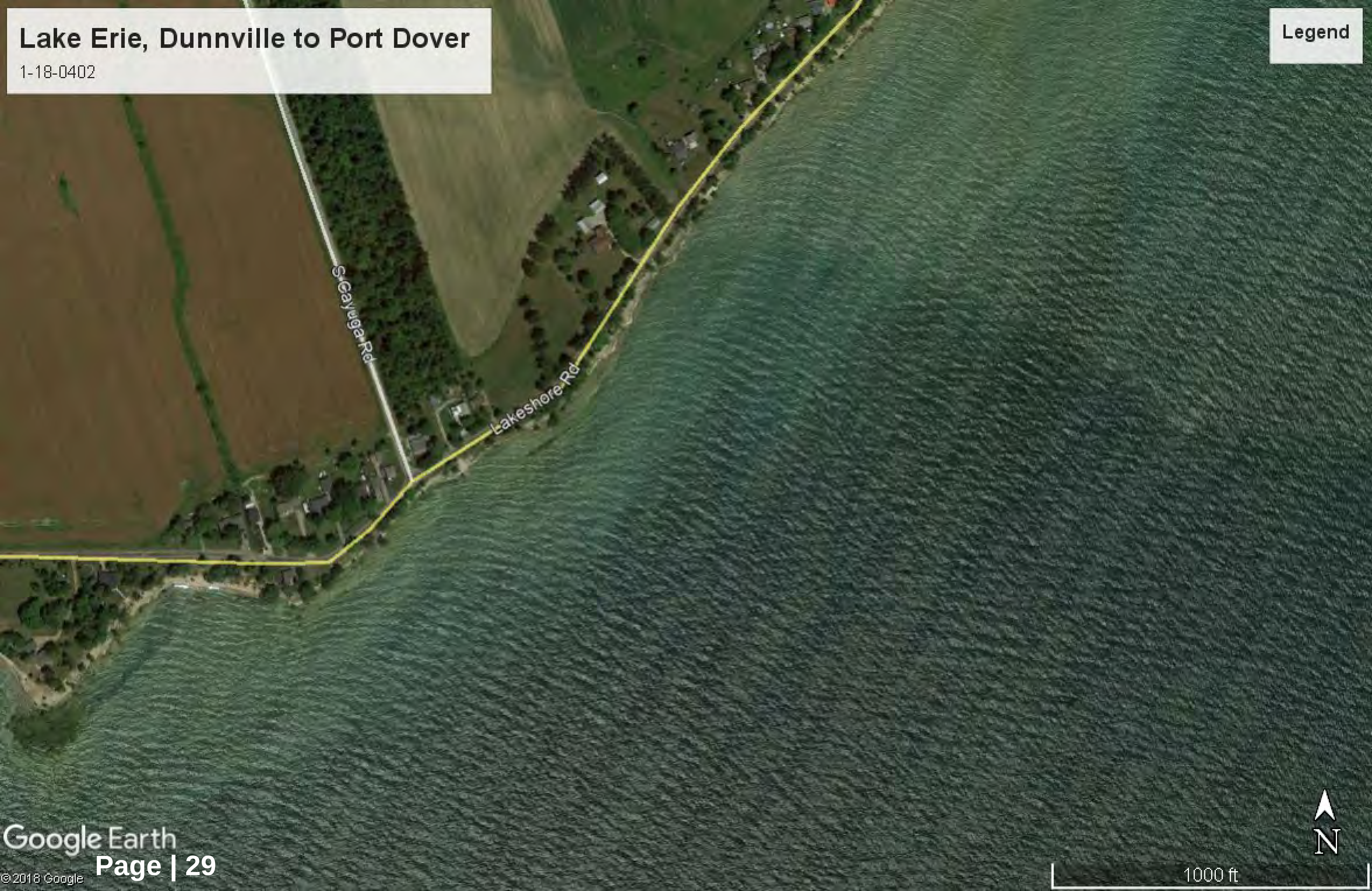
Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Visual Observation

Section 37: Armourstone along water's edge



Lake Erie, Dunnville to Port Dover

1-18-0402

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Visual Observation

Section 38: Sand beach along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Report:
South Cayuga (2018)

private properties,
flatter than 3H:1V

Lake Erie, Dunnville to Port Dover

1-18-0402

Legend

Geology of the Area

Ontario Geological Survey

"Halton Till, predominantly silt to silty clay"

Visual Observation

Section 39: Armourstone along water's edge

©2018 Google

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Halton Till, predominantly silt to silty clay"

Visual Observation

Section 40: Sand beach along water's edge


Lake Erie, Dunnville to Port Dover
1-18-0402
Legend
Paradise Line
Baygrove Line
Bryer Line
sand beaches
visible limestone
Google Earth
©2018 Google
N
1000 ft

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area

Ontario Geological Survey

"Glaciolacustrine silt and clay, minor sand"

Visual Observation

Section 41: Sand beach along water's edge


Lake Erie, Dunnville to Port Dover
1-18-0402
Legend
Sandy Bay Rd
<5 m in height, flatter than 3H:1V
visible limestone
Google Earth
©2018 Google
N
1000 ft

Lake Erie, Dunnville to Port Dover

1-18-0402

private property, no access

Lake Erie, Dunnville to Port Dover

1-18-0402

Geology of the Area
Ontario Geological Survey
"Halton Till, predominantly silt to silty clay"

Visual Observations
Section 42: Sand beach along water's edge


Lake Erie, Dunnville to Port Dover
1-18-0402
Legend
Lighthouse Dr
Google Earth
©2018 Google
N
1000 ft

Lake Erie, Dunnville to Port Dover

1-18-0402

Sand beaches, < 5m in height, flatter than 3H:1V

Lake Erie, Dunnville to Port Dover

1-18-0402

sand beach, <5 m in height

Geology of the Area

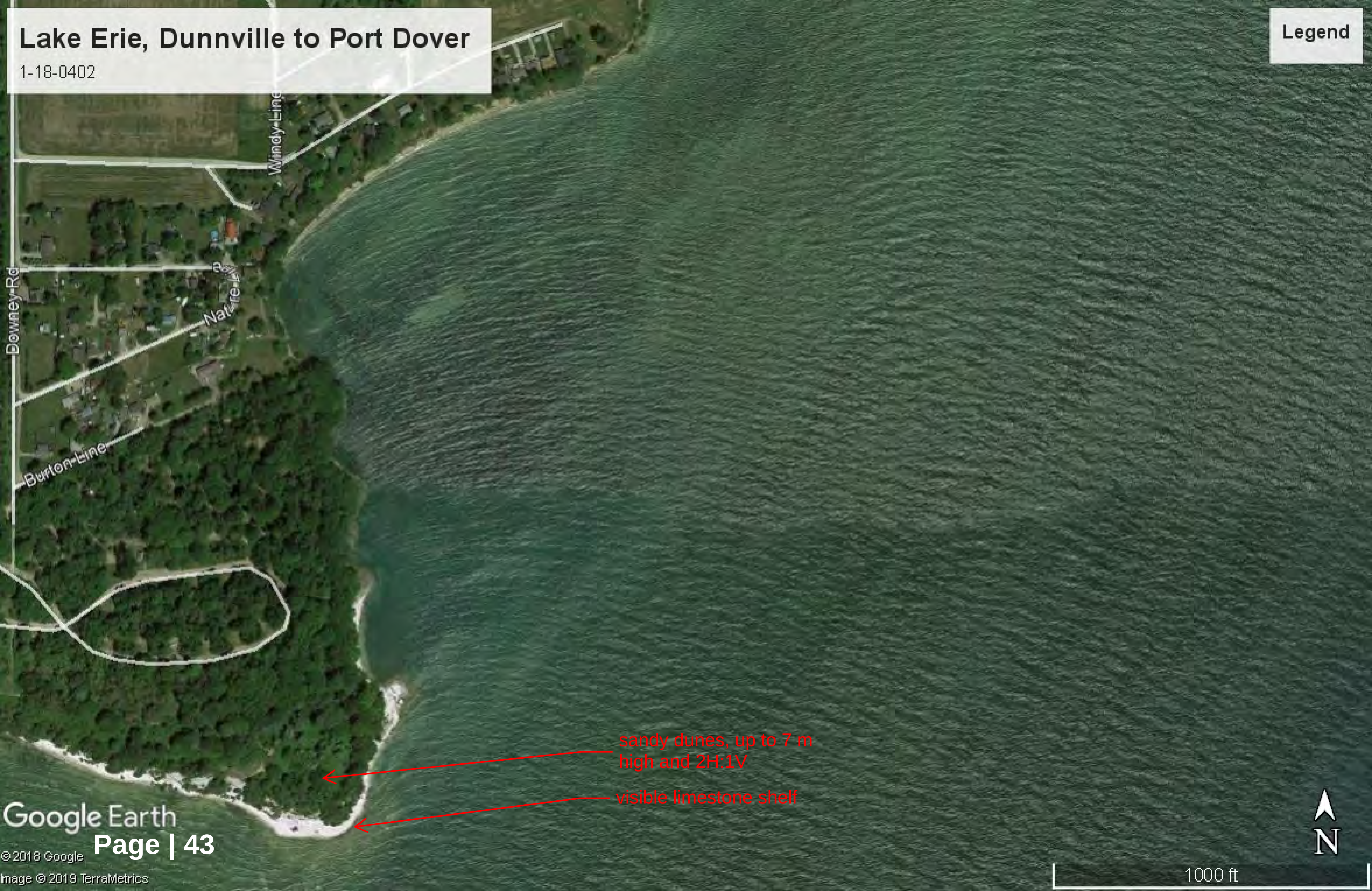
Ontario Geological Survey

"Fluvial Deposits, gravel, sand, silt and clay, deposited on modern flood plains"

Visual Observation

Section 43: *Sand beach along water's edge*


Lake Erie, Dunnville to Port Dover
1-18-0402
Legend
Nature Line
Burton Line
N
1000 ft
Google Earth
©2018 Google



Lake Erie, Dunnville to Port Dover

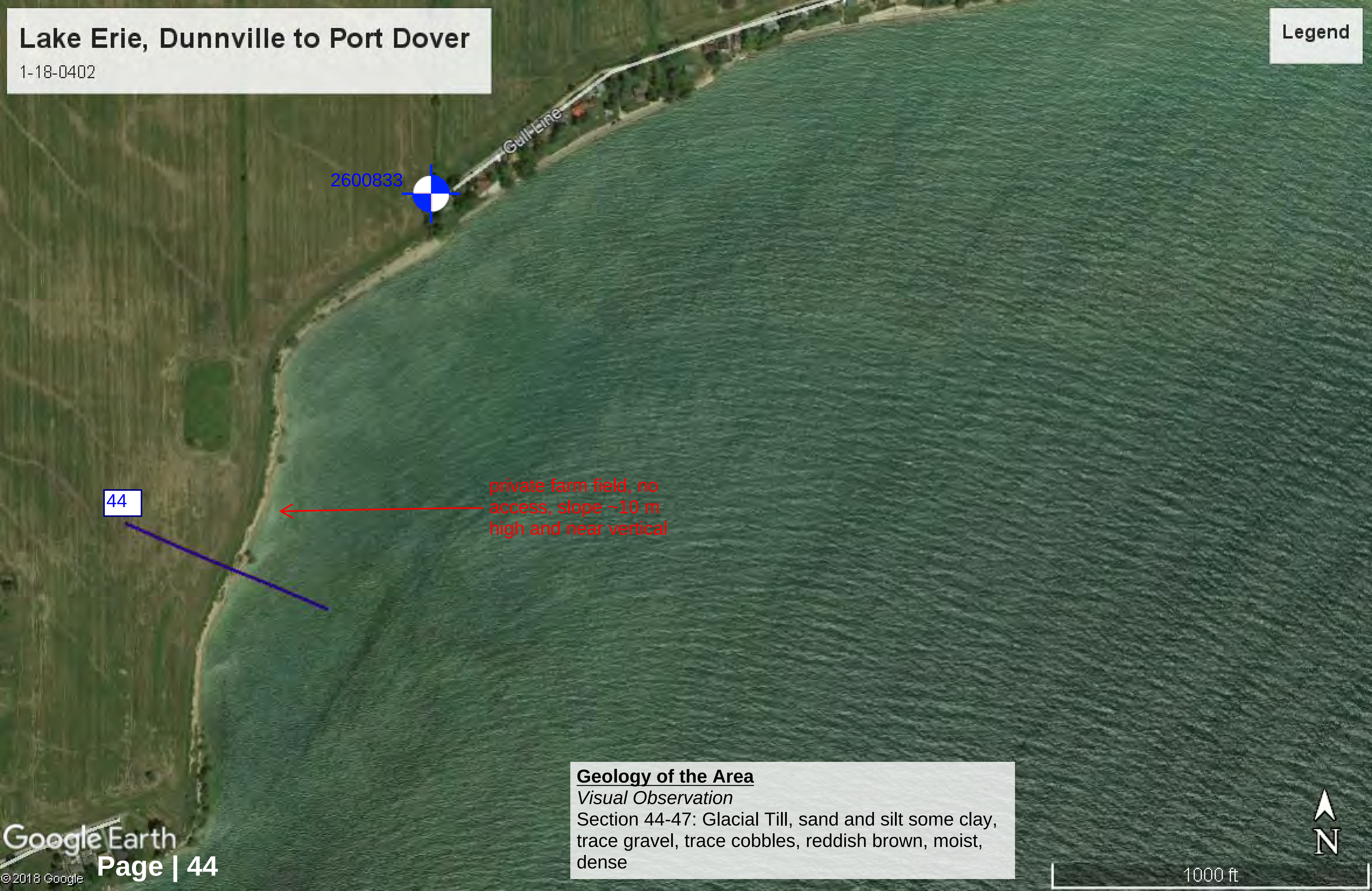
1-18-0402

sandy dunes, up to 7 m high and 2H:1V

visible limestone shelf

Lake Erie, Dunnville to Port Dover

1-18-0402



Geology of the Area

Visual Observation

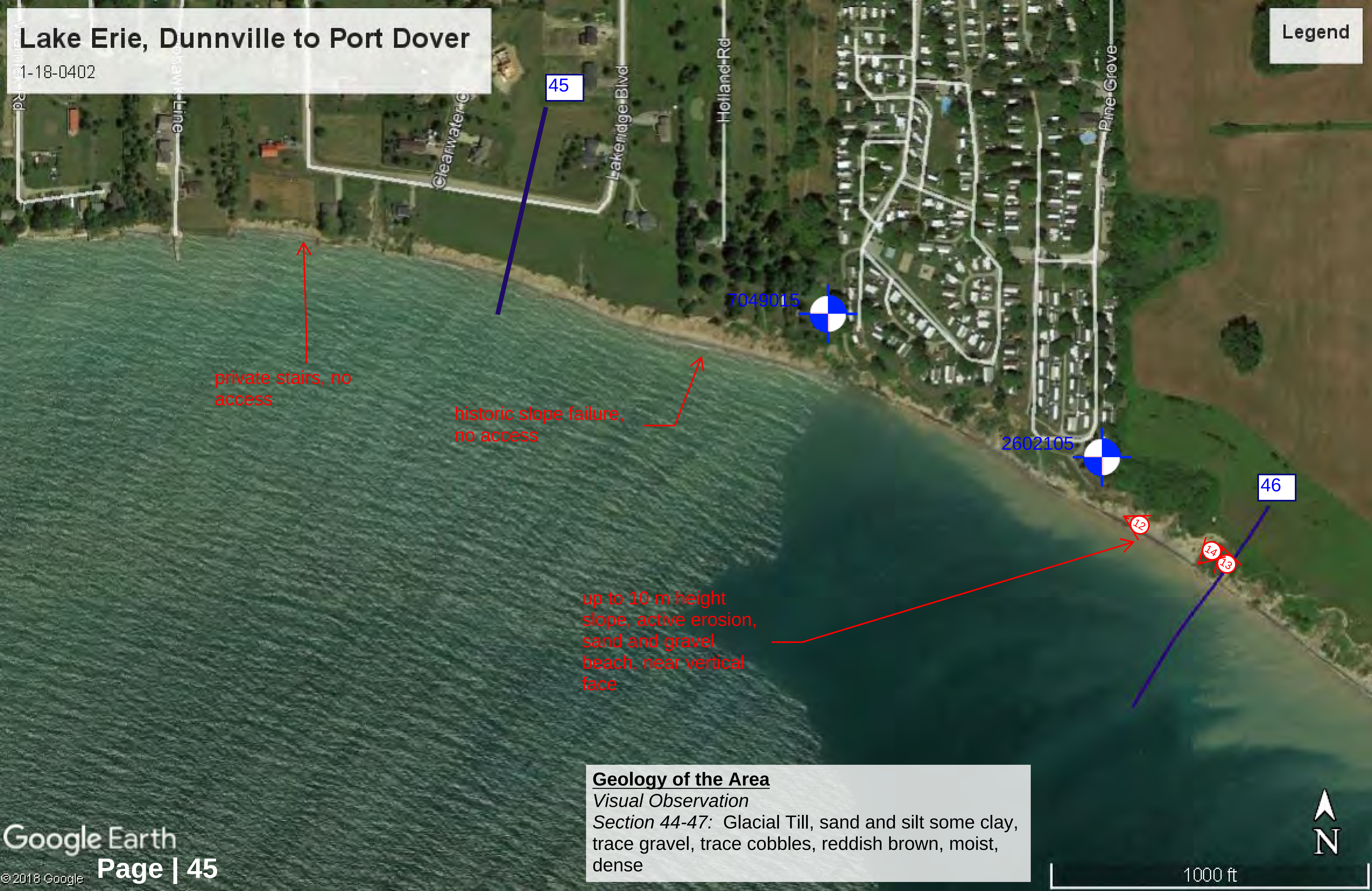
Section 44-47: Glacial Till, sand and silt some clay, trace gravel, trace cobbles, reddish brown, moist, dense

©2018 Google

Lake Erie, Dunnville to Port Dover

1-18-0402

Legend



private stairs, no access

historic slope failure, no access

up to 10 m height slope, active erosion, sand and gravel beach, near vertical face

Geology of the Area

Visual Observation

Section 44-47: Glacial Till, sand and silt some clay, trace gravel, trace cobbles, reddish brown, moist, dense

Lake Erie, Dunnville to Port Dover

1-18-0402

armourstone wall along shoreline

>10 m high slope, construction of gabion stone walls ~6-7 m high

Borehole ID 700802

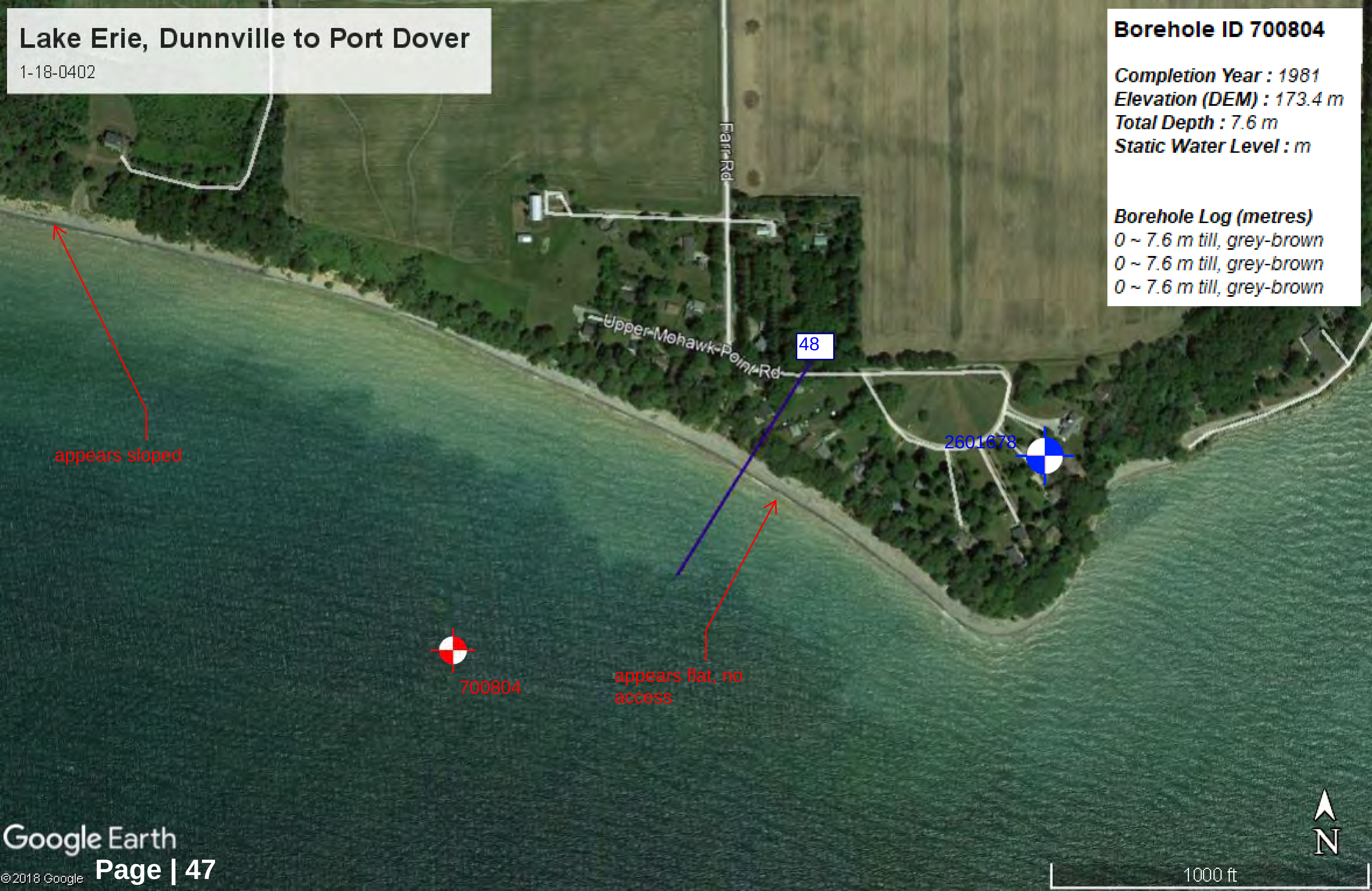
Completion Year : *1981*
Elevation (DEM) : *175.5 m*
Total Depth : *8.2 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 8.2 m till, grey-brown
0 ~ 8.2 m till, grey-brown

Geology of the Area
Visual Observation
Section 44-47: Glacial Till, sand and silt some clay, trace gravel, trace cobbles, reddish brown, moist, dense

Lake Erie, Dunnville to Port Dover

1-18-0402



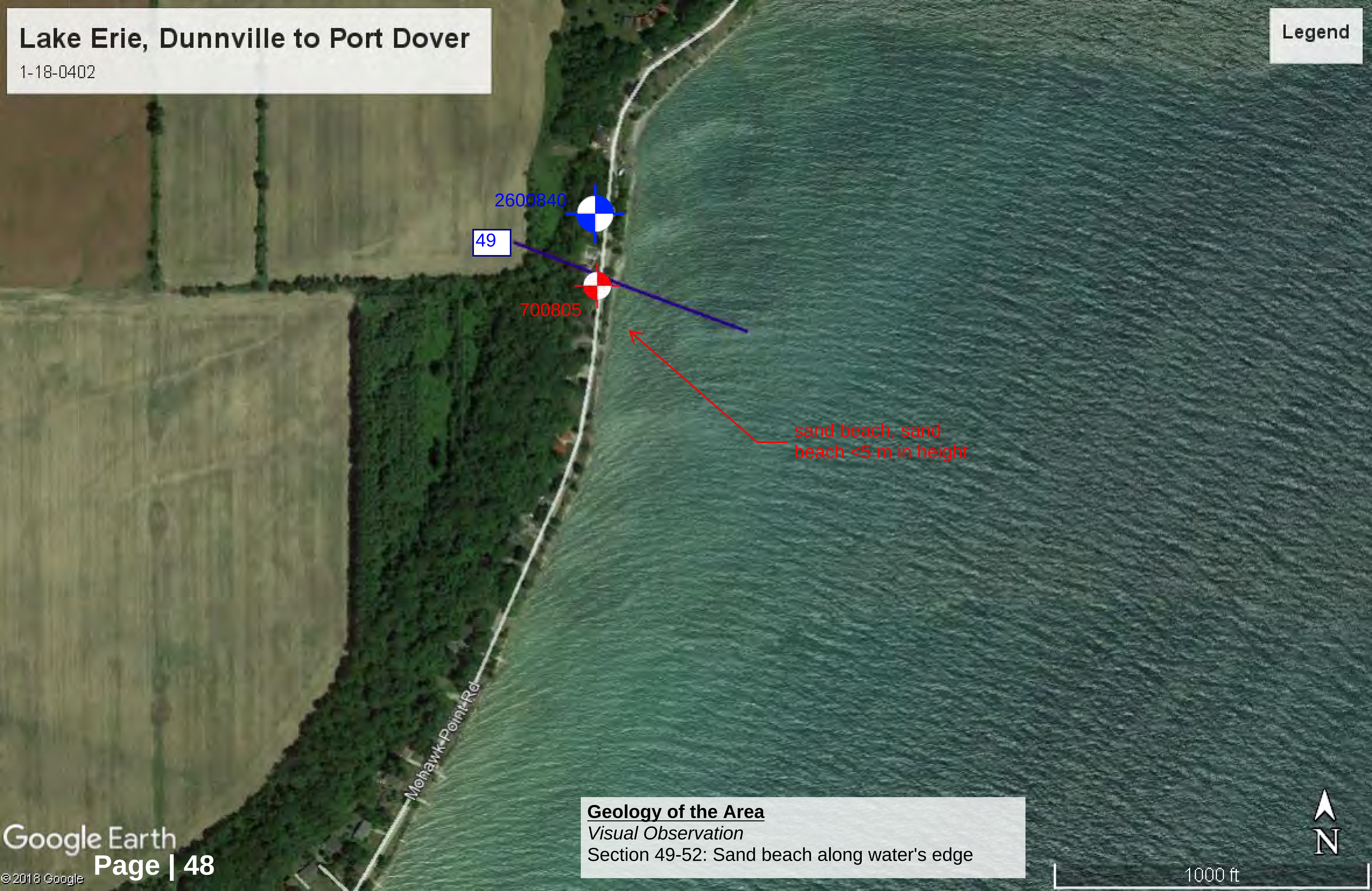
Borehole ID 700804

Completion Year : *1981*
Elevation (DEM) : *173.4 m*
Total Depth : *7.6 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 7.6 m till, grey-brown
0 ~ 7.6 m till, grey-brown
0 ~ 7.6 m till, grey-brown

Lake Erie, Dunnville to Port Dover

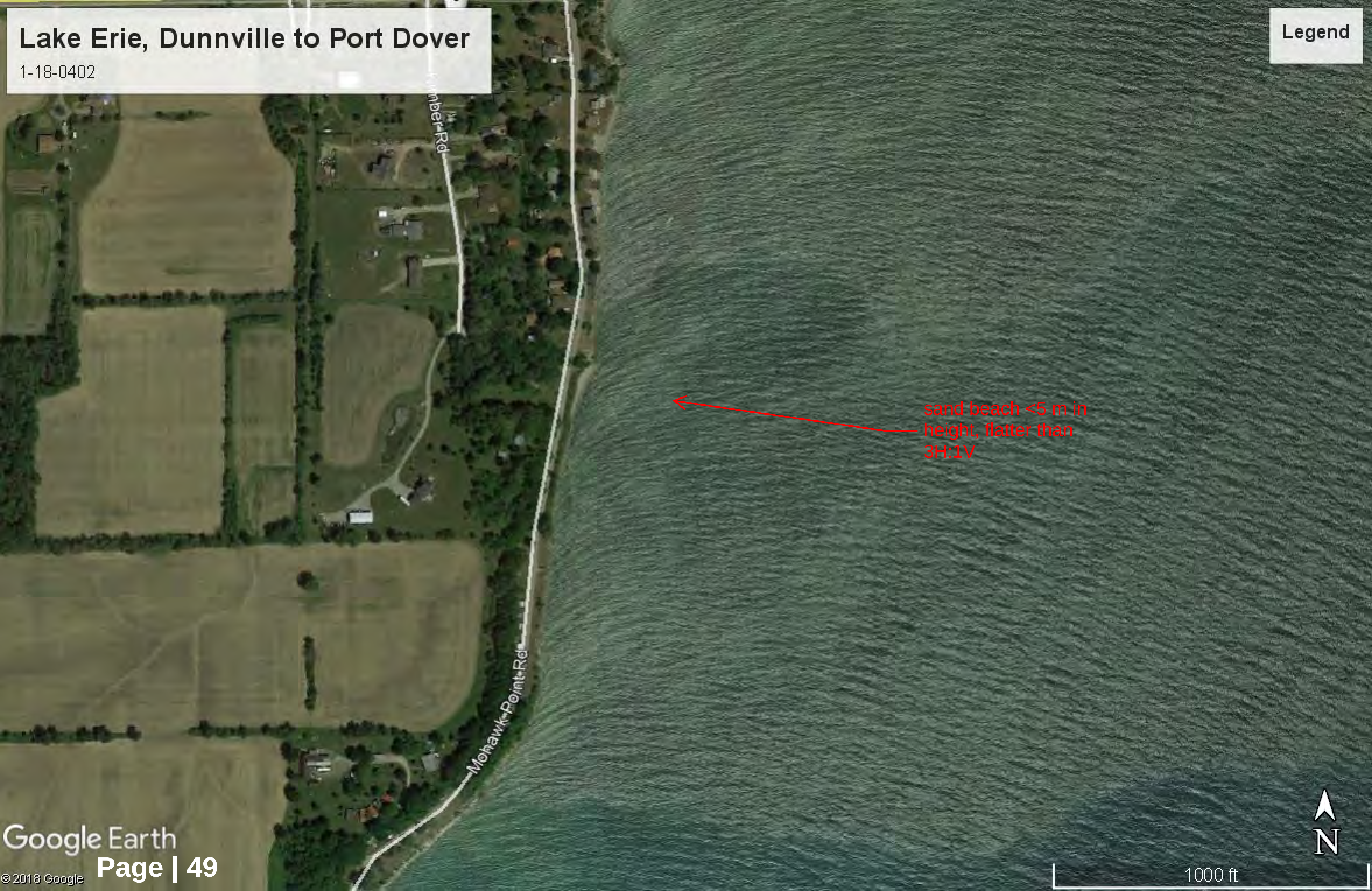
1-18-0402



Geology of the Area

Visual Observation

Section 49-52: Sand beach along water's edge

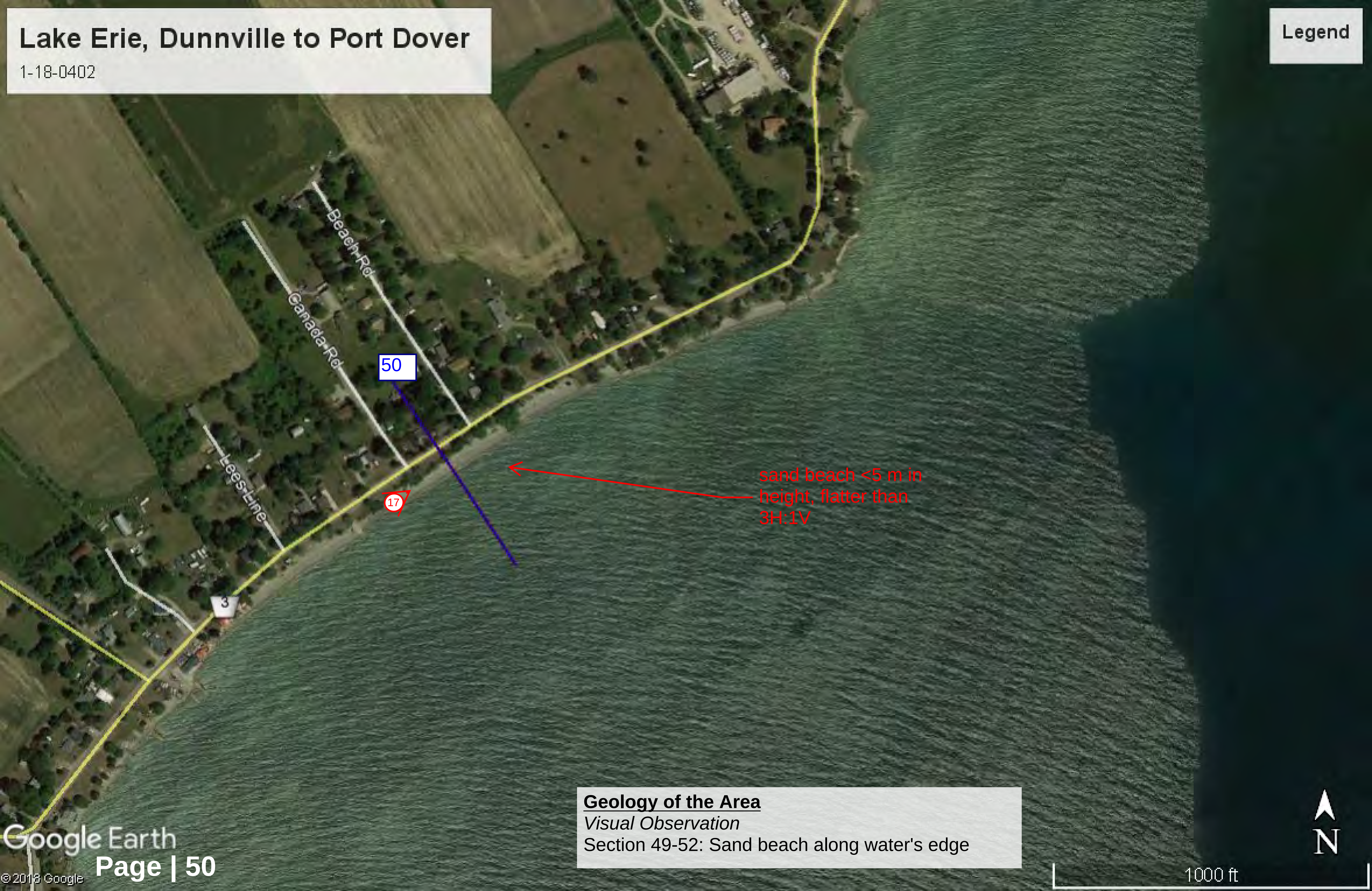


Lake Erie, Dunnville to Port Dover

1-18-0402

Lake Erie, Dunnville to Port Dover

1-18-0402



sand beach <5 m in height, flatter than 3H:1V

Geology of the Area

Visual Observation

Section 49-52: Sand beach along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Borehole ID 700801

Completion Year : *1981*
Elevation (DEM) : *172.6 m*
Total Depth : *1.5 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 1.5 m gravel, sand

Geology of the Area
Visual Observation
Section 49-52: Sand beach along water's edge

Lake Erie, Dunnville to Port Dover

1-18-0402

Report:
Wainfleet (2017)

Report:
Burnaby (2016)

beaches, flat

"Lowbanks"
beaches, <5 m
in height, flatter
than 3H:1V

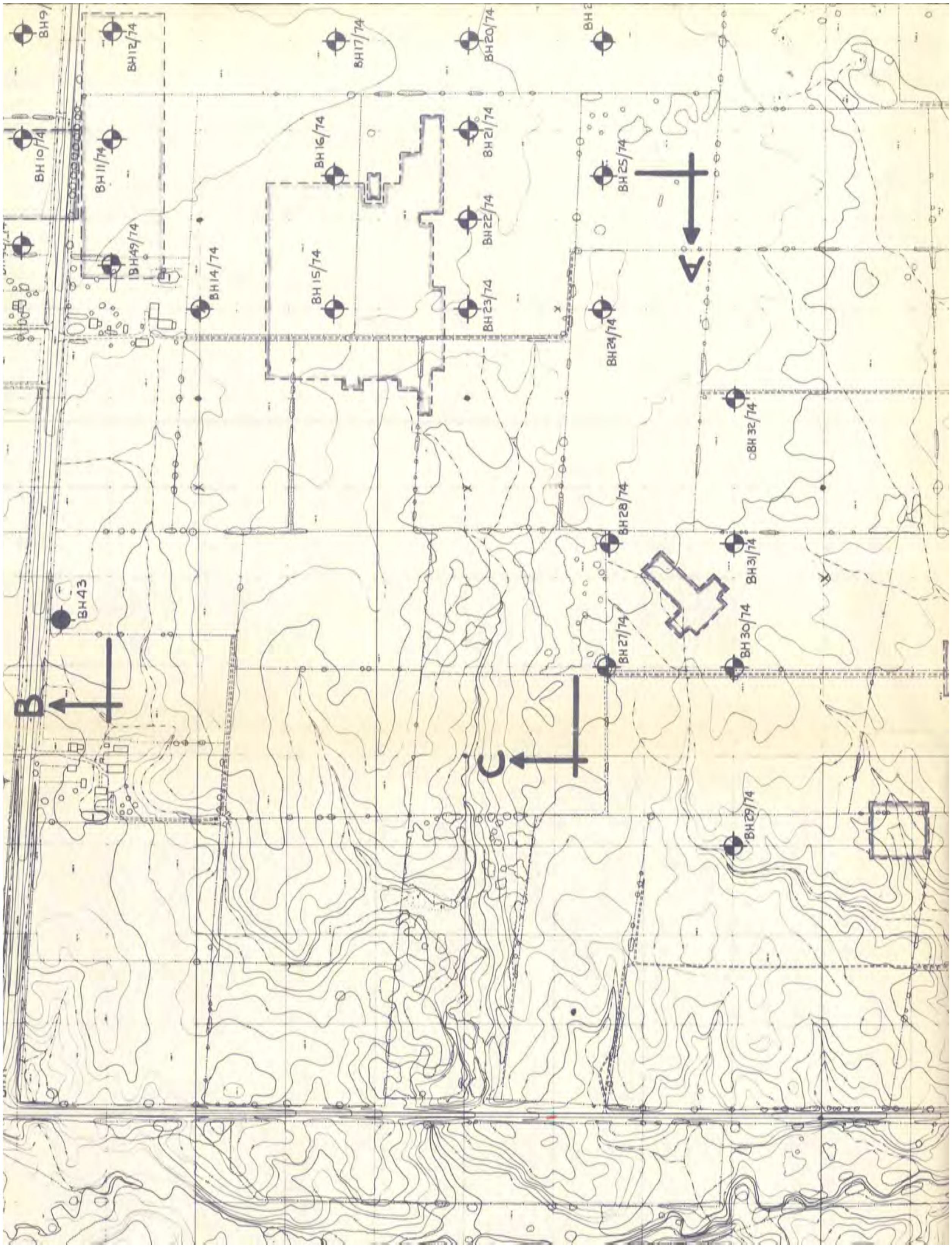
Geology of the Area

Visual Observation

Section 49-52: Sand beach along water's edge

APPENDIX B

TERRAPROBE INC.



Terraprobe

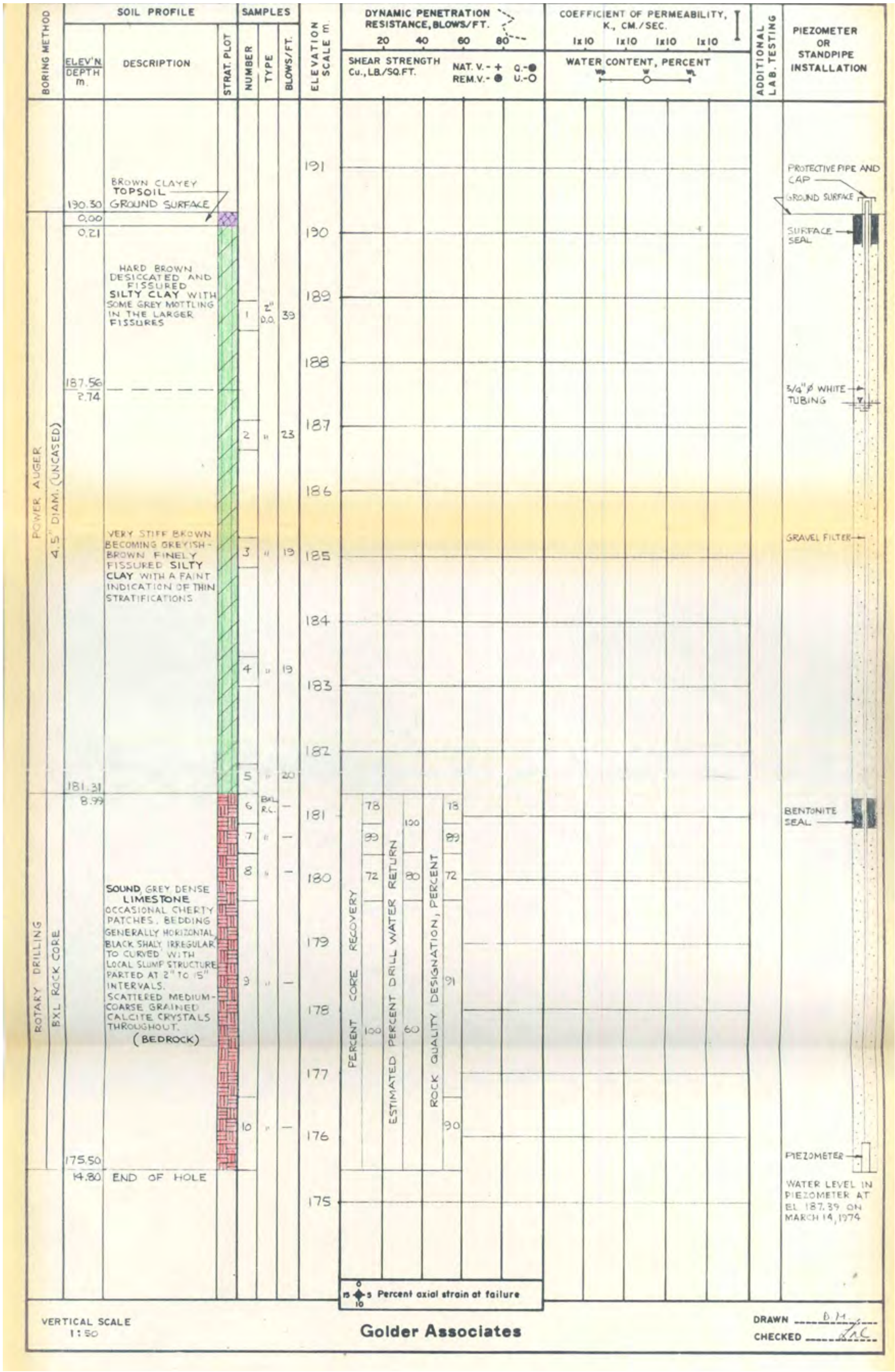
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

Borehole Location Plan from Nanticoke (1974) Report

File. No.:

FIGURE :



BORING METHOD	SOIL PROFILE ELEV'N DEPTH m	DESCRIPTION	SAMPLES NUMBER	TYPE	BLOWS/FT.
	190.30	BROWN CLAYEY **TOPSOIL** GROUND SURFACE			
POWER AUGER 4.5" DIAM. (UNCASED)	0.00 0.21	HARD BROWN DESICCATED AND FISSURED **SILTY CLAY** WITH SOME GREY MOTTLING IN THE LARGER FISSURES	1	2" D.O.	39
	187.56 2.74		2	"	23
		VERY STIFF BROWN BECOMING GREYISH-BROWN FINELY FISSURED **SILTY CLAY** WITH A FAINT INDICATION OF THIN STRATIFICATIONS	3	"	19
			4	"	19
			5	"	20
ROTARY DRILLING BXL ROCK CORE	181.31 8.99	**SOUND**, GREY DENSE **LIMESTONE** OCCASIONAL CHERTY PATCHES, BEDDING GENERALLY HORIZONTAL, BLACK SHALY, IRREGULAR TO CURVED WITH LOCAL SLUMP STRUCTURE PARTED AT 2" TO 15" INTERVALS. SCATTERED MEDIUM-COARSE GRAINED CALCITE CRYSTALS THROUGHOUT. (**BEDROCK**)	6	BXL R.C.	—
			7	"	—
			8	"	—
			9	"	—
			10	"	—
	175.50 14.80	END OF HOLE			

SAMPLES NUMBER	PERCENT CORE RECOVERY	ESTIMATED PERCENT DRILL WATER RETURN	ROCK QUALITY DESIGNATION, PERCENT
6	78	100	78
7	89		89
8	72	80	72
9	100	60	91
10			90

WATER LEVEL IN PIEZOMETER AT EL. 187.39 ON MARCH 14, 1974

VERTICAL SCALE
1 : 50

Golder Associates

DRAWN D.M.
CHECKED

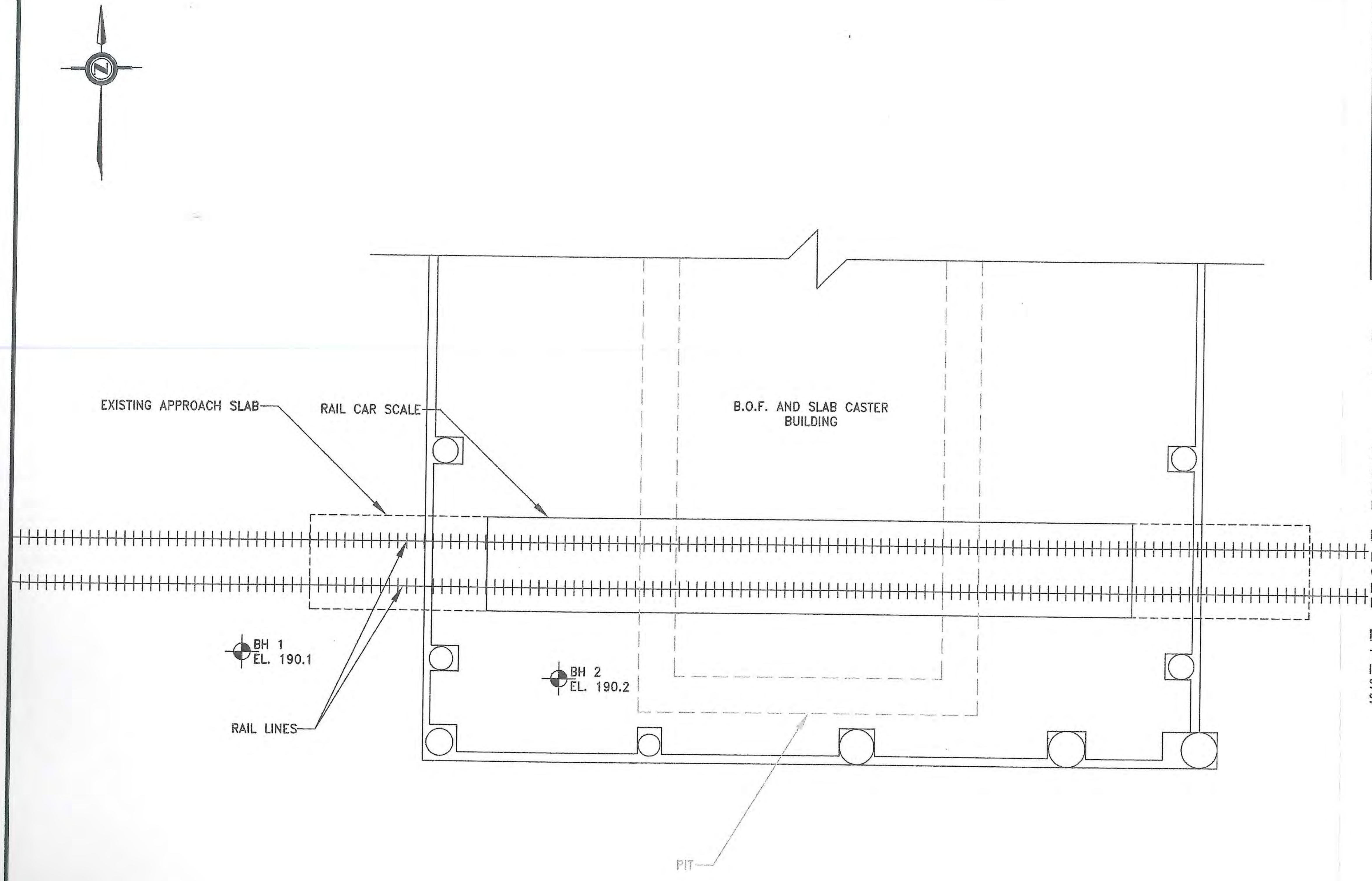
Terraprobe

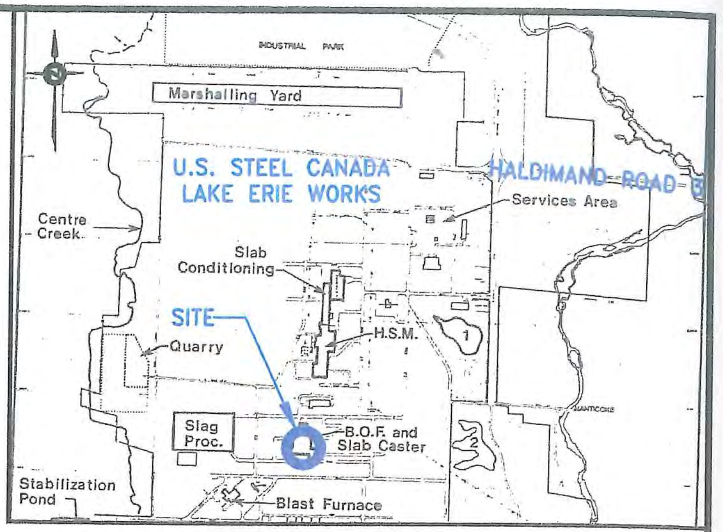
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title: Borehole Log from Nanticoke (1974) Report

File. No.:

FIGURE :





KEY PLAN

U.S. STEEL, NANTICOKE, ONTARIO

LEGEND:

⊕ BH 2 EL. 190.2	PML BOREHOLE (BH) LOCATION

TEMPORARY BENCHMARK:

FINISHED FLOOR ELEVATION OF CONCRETE FLOOR SLAB ELEVATION: 190.2 m (GEODETIC, FROM REFERENCE DRAWING)

REFERENCE:

PLAN PRODUCED FROM A PLAN TITLED "LED-BOF CATSER COMPLEX DESULFIRIZATION PROJECT – SLAB ON GRADE PLAN" BY RANDERS ENGINEERING INCORPORATED, DATED MARCH 13, 1997

NOTE:

THE INFERRED STRATIGRAPHY REFERRED TO IN THE REPORT IS BASED ON THE DATA FROM THESE BOREHOLES SUPPLEMENTED BY GEOLOGICAL EVIDENCE. THE ACTUAL STRATIGRAPHY BETWEEN THE BOREHOLES MAY VARY.

0m 2.5 5 7.5 10

SCALE
(1:150)

, NANTICOKE

BOREHOLE LOCATION PLAN

DRAWN	KF	DATE	SCALE	PML REF.	DRAWING NO.
CHECKED	KF	JUNE 2015	AS SHOWN	15HF013	1
APPROVED	MDS				

LOG OF BOREHOLE NO. 1

17T 0573908E
4739327N

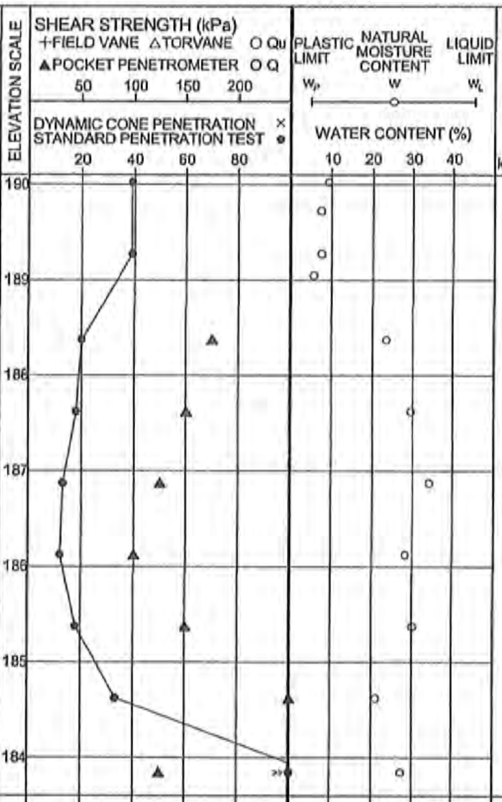
1 of 1

LOCATION Nanticoke, ON **BORING DATE** June 2, 2015

BORING METHOD Continuous Flight Solid Stem Augers

SOIL PROFILE		SAMPLES		
DEPTH / ELEV (meters)	DESCRIPTION	NUMBER	TYPE	"N" VALUES
	SURFACE ELEVATION 190.1			
0.2 189.9	FILL: Dense, grey crushed limestone gravel, some sand, damp	1A 1B*	SS	39
0.7	Dense, grey crushed slag and limestone sand and gravel mixed fill, damp			
0.9 189.2	Dense, grey crushed limestone granular base, moist; with filter cloth at tip	2A 2B	SS	39
1.4 188.7	Dense, grey crushed limestone granular subbase, wet			
	CLAY: Very stiff, brown silty clay, trace sand and gravel, DTPL: with iron staining, grey fissures and occasional silt lenses and shale fragments	3*	SS	20
		4	SS	18
2.9 187.2	becoming stiff, WTPL	5	SS	13
3.7 186.4	becoming grey	6	SS	12
4.4 185.7	becoming very stiff	7	SS	18
5.2 184.9	becoming hard, brown; with numerous silt seams	8	SS	33
5.9 184.2	becoming grey, with occasional limestone fragments	9	SS	57/200mm
6.5 183.6	BOREHOLE TERMINATED AT 6.5 m UPON PRACTICAL REFUSAL TO AUGER ON PROBABLE BEDROCK			

0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0



UNIT WEIGHT kN/m³

GROUND WATER OBSERVATIONS AND REMARKS

GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

Upon completion of augering, no free water, no cave

* Sample submitted for chemical testing

NOTES

LOG OF BOREHOLE NO. 2

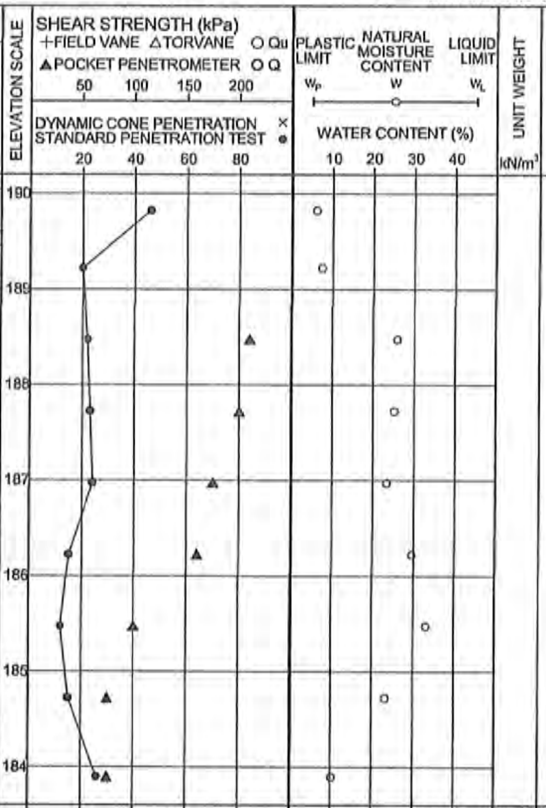
17T 0573914E
4739332N

1 of 1

Nanticoke, ON **BORING DATE** June 2, 2015

BORING METHOD Continuous Flight Solid Stem Augers

DEPTH / ELEV (meters)	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	"N" VALUES
0.0	SURFACE ELEVATION 190.2			
190.1	CONCRETE: 100 mm concrete slab			
	FILL: Dense to compact, grey crushed slag fill, damp	1*	SS	46
		2	SS	20
1.4 / 188.8	CLAY: Very stiff, brown silty clay, trace sand and gravel, DTPL: with occasional shale fragments, silt seams and iron staining	3*	SS	22
		4	SS	23
		5	SS	24
3.7 / 186.5	becoming grey, WTPL	6	SS	15
4.4 / 185.8	becoming stiff, with some sand	7	SS	12
5.2 / 185.0	with numerous grey silt seams	8	SS	15
		9	SS	26
6.6 / 183.6	BOREHOLE TERMINATED AT 6.6 m UPON PRACTICAL REFUSAL TO AUGER ON PROBABLE BEDROCK			



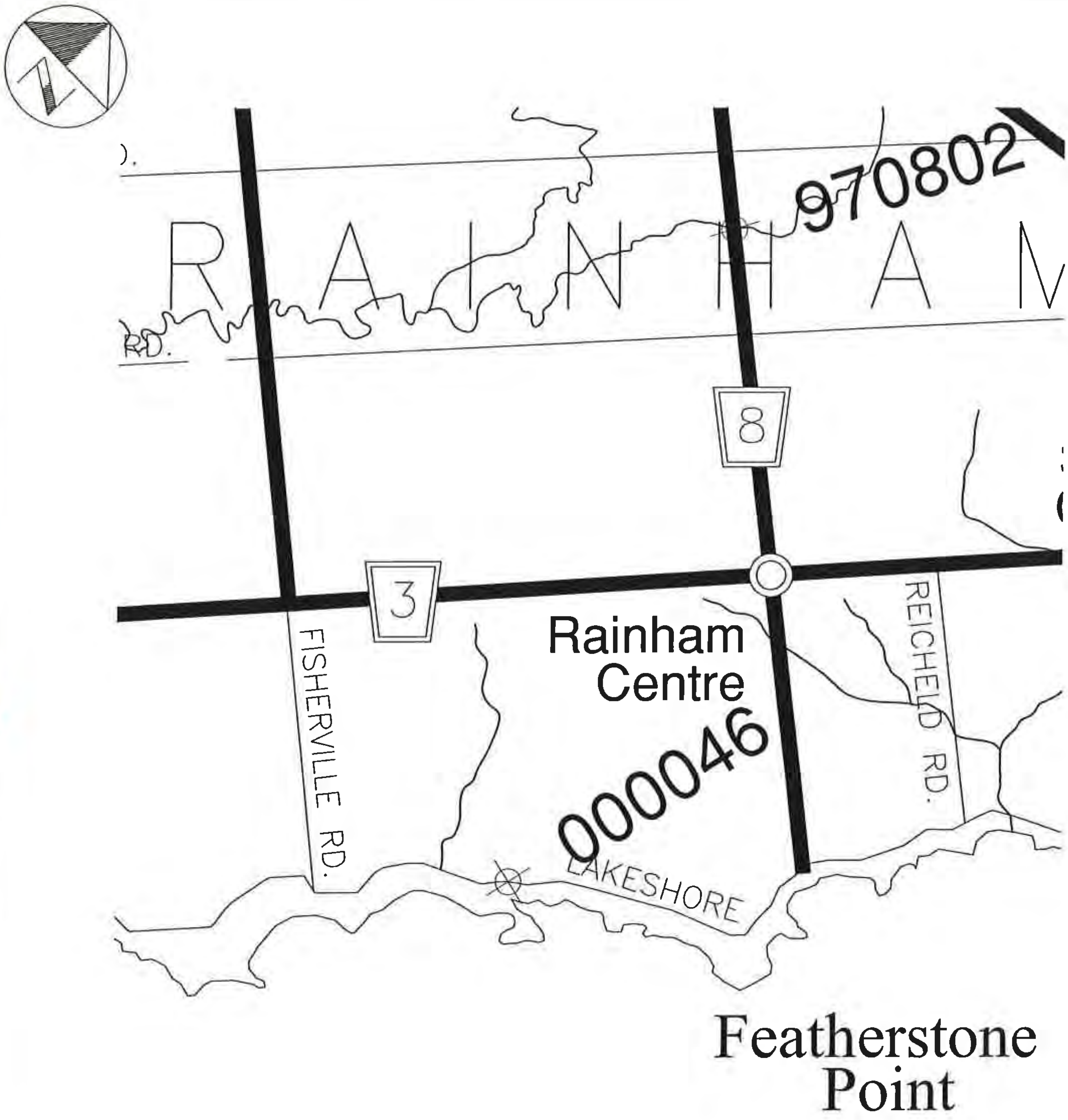
GROUND WATER OBSERVATIONS AND REMARKS

GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

Upon completion of augering, no free water, no cave

* Sample submitted for chemical testing

NOTES



KEY PLAN
RICHERT ROAD
HALDIMAND COUNTY, ONTARIO

Terraprobe
903 Barton Street, Unit 22
Stoney Creek, Ontario, L8E 5P5
(905) 643-7560 / Fax (905) 643-7559

Drawn By:	A.C.	Scale:	N.T.S.	Project	
Checked By:	G.M.	Date:	FEB. 2004	Figure No.:	1

Terraprobe

LOG OF BOREHOLE 1

LOCATION: Lakeshore Road - Haldimand County

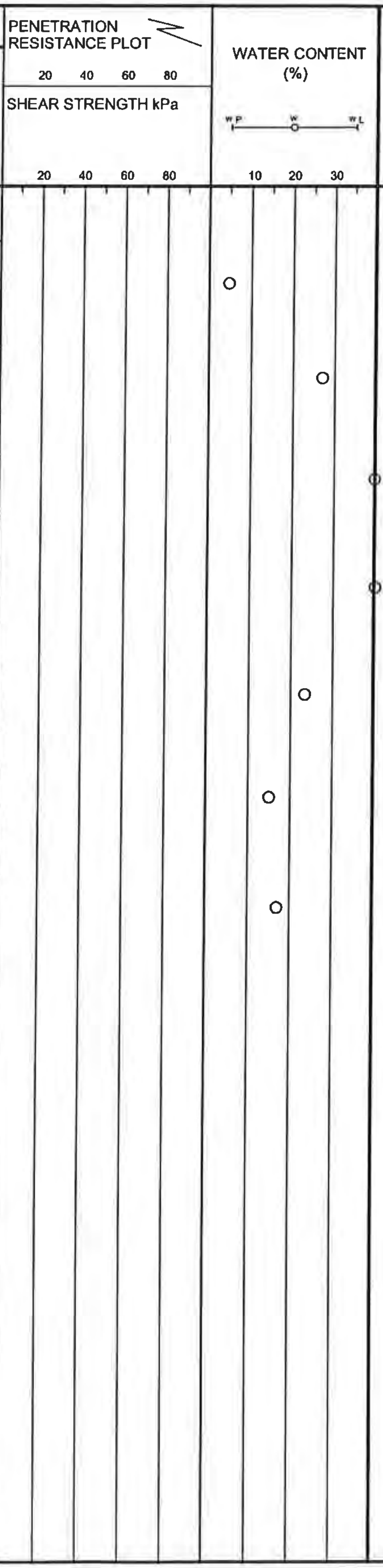
BORING DATE: February 10, 2004

ELEVATION DATUM: Local

SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: CME 75 TRUCKMOUNT

DEPTH SCALE IN METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	"N" VALUE
0	**GROUND SURFACE**	100.08 0.0			
	(FILL) **GRANULAR BASE/SUBBASE**		1	AS	
		99.53 0.55			
1	Soft to stiff, black to dark grey, **SILTY CLAY (ORGANIC)**		2	SS	13
2			3	SS	3
			4	SS	4
3		96.88 3.20			
	Very stiff, brown; **SILTY CLAY,** with silt seams and layers		5	SS	18
4			6	SS	27
5			7	SS	20
	END OF BOREHOLE (Auger Refusal... ...Probably Bedrock)	94.85 5.23			
6					
7					
8					
9					



INSTALLATION INFORMATION

Feb 10/04 ▼

NOTES:
Water level in open borehole at elevation 95.36m after drilling.

SHEET 1 OF 1

A. CUMMINGS

7-04-0006-6-1.DWC

Terraprobe

LOG OF BOREHOLE 2

BORING DATE: February 10, 2004

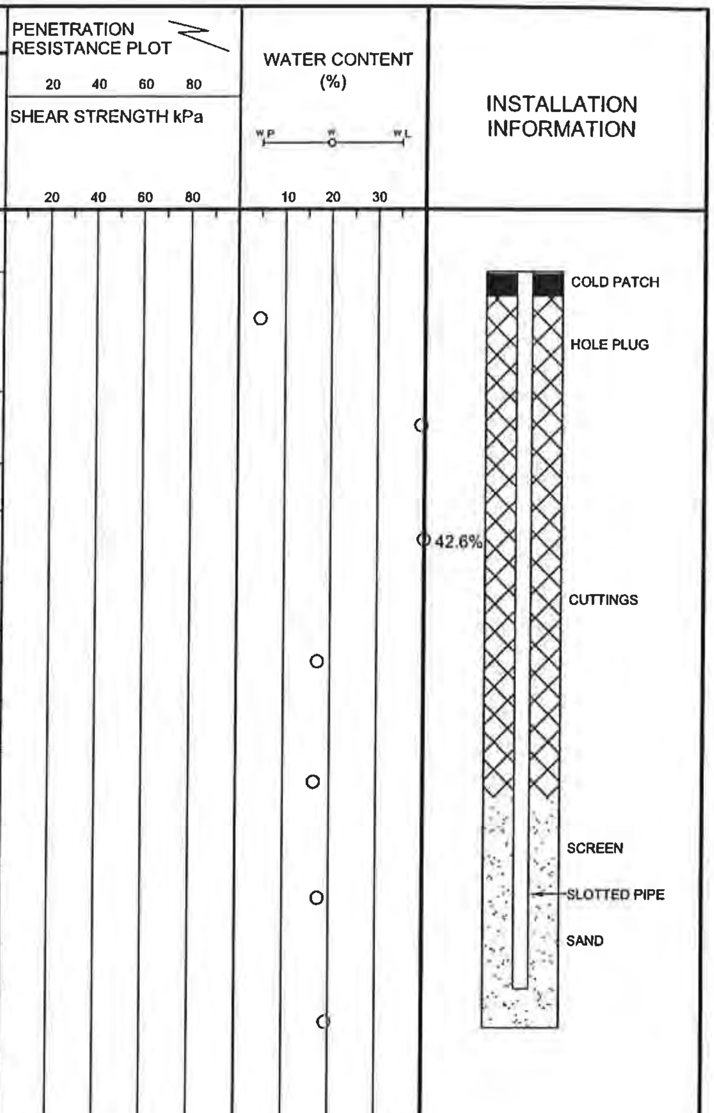
ELEVATION DATUM: Local

LOCATION: Lakeshore Road - Haldimand County

SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: CME 75 TRUCKMOUNT

SOIL PROFILE		SAMPLES		
DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	"N" VALUE
GROUND SURFACE	100.00			
25mm Asphalt	0.0			
(FILL) **GRANULAR BASE/SUBBASE**	99.50 0.50	1	AS	
(FILL) Compact, black; **SILTY TOPSOIL**	98.60 1.40	2	SS	10
Firm, grey and black; **SILTY CLAY (Organic)**	97.60 2..40	3	SS	8
Very stiff to hard, brown; **SILTY CLAY,** trace sand and gravel	94.97 5.03	4	SS	15
		5	SS	30
		6	SS	21
		7	SS	19
END OF BOREHOLE (Auger Refusal... ...Probably Bedrock)				

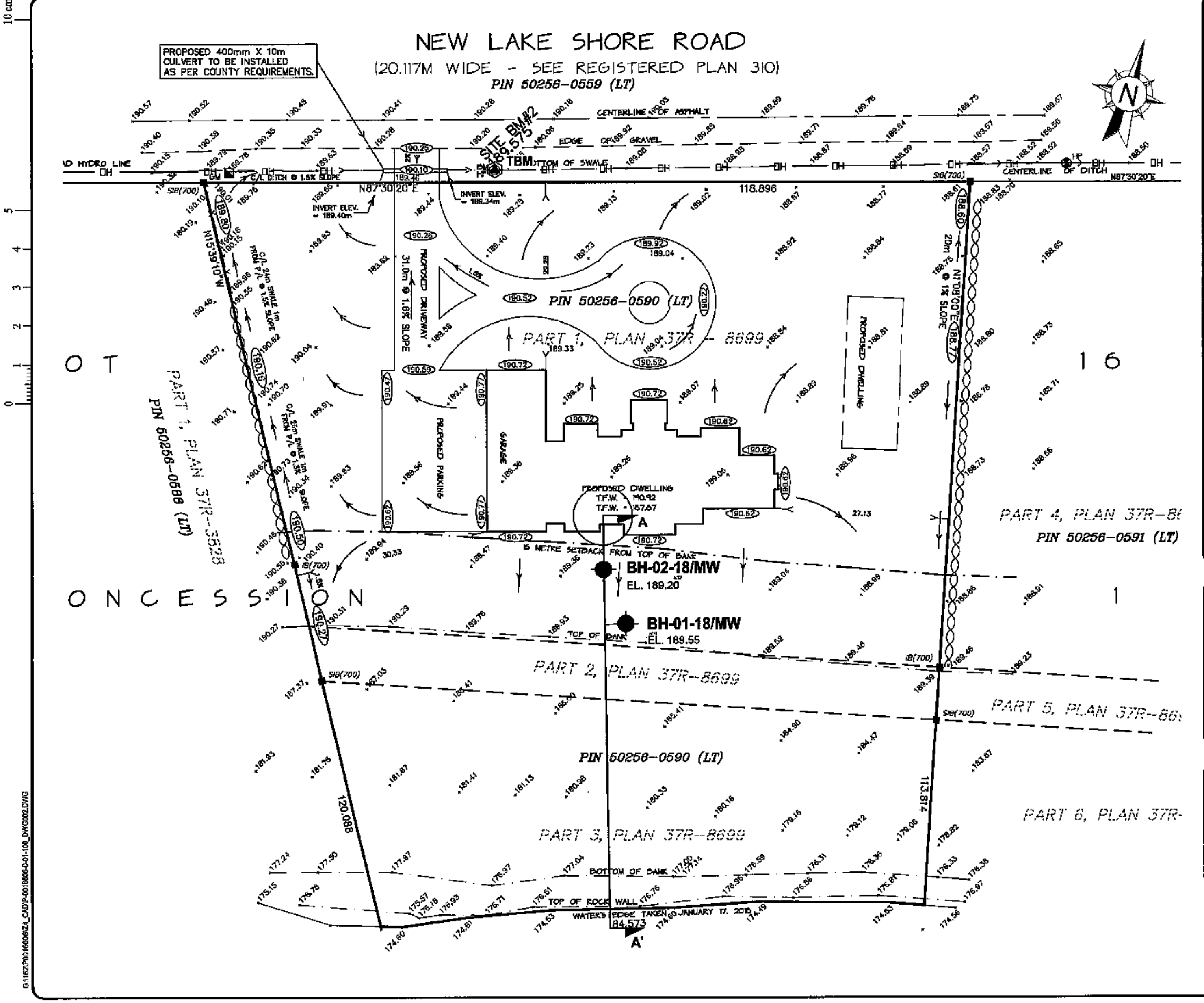


NOTES:
Borehole dry upon completion of drilling.

SHEET 1 OF 1

A. CUMMINGS

7-04-0006-6-2.DWG



LEGEND :

●	BOREHOLE LOCATION
EL. 189.20	GROUND SURFACE ELEVATION (m)
⊛	TEMPORARY BENCHMARK
A A'	CROSS SECTION

0 5 10 15 20 25 m

SCALE 1:600

NOTES :

1-REFERENCES: JEWITT and DIXON LTD. Ontario Land Surveyors, Project No.17-1747, Drawing No.18 03 A5968, April 17, 2018.

2-TEMPORARY BENCHMARK : Nail in hydro pole Site BM#2, Elevation 189.575 m (assumed local datum).

3-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

4-MW refers to monitoring well installed at borehole location.

Project

Slope Stability

232 New Lakeshore Road, Port Dover, Ontario

Title

SITE PLAN

Englobe

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Clochon	Discipline	GEOTECHNICAL
Drawn	E.Clochon	Scale	1:600
Checked	E.Childerhose	Date	2018-07-11

Project manager
E.Childerhose

Sequence no.
02 of 03

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0016606-0-01-100	GE	002	00

G:\16Z\P0016606\Z4_CAD\P-0016606-0-01-100_DWG002.DWG

Englobe

Ground Elevation: *189.55 m*

Borehole Number: **BH-01-18**

Job N°: *P-0016606-0-01-100*

Drill Date: *2018-07-06*

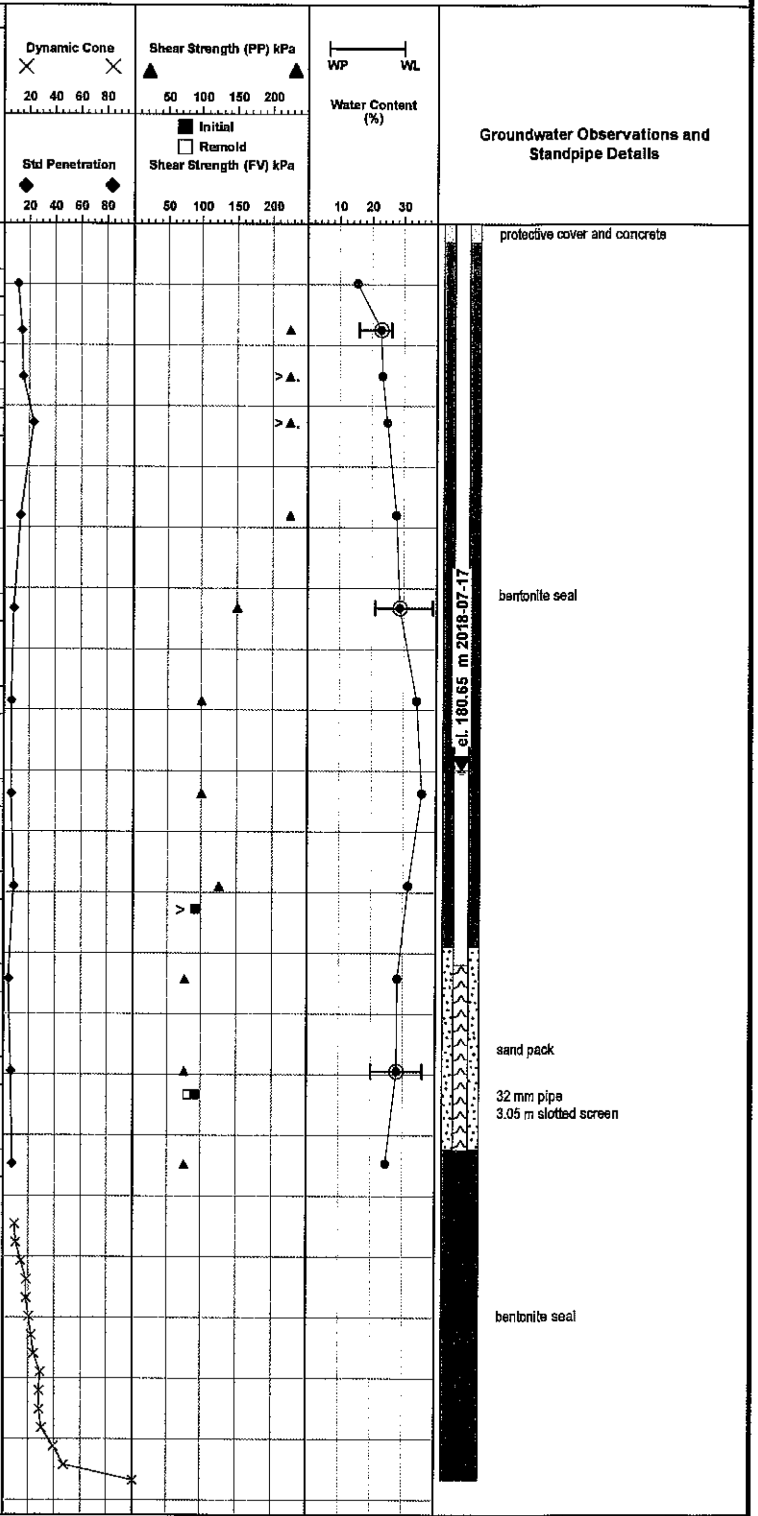
Field Tech: *D.Souter*

Drill Method: *Hollow Stem Auger*

Project: *Slope Stability*

Location: *232 New Lakeshore Road, Port Dover, Ontario*

SOIL PROFILE	SAMPLE			
Description	Elevation (m) Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
Ground Elevation	189.55			
TOPSOIL: dark brown silt, trace sand, clay and gravel, moist	0.00 189.14 0.41			
SAND: brown silty sand, trace gravel, very moist to wet	188.64 0.91	SS-1	3-5 6	11
SILT: compact brown silt, some clay, trace sand and gravel, moist	188.03 1.52	SS-2	4-6 8	14
		SS-3	3-6 9	15
hard mottled grey/brown clayey silt, trace sand, DTPL to APL		SS-4	6-11 12	23
CLAY: hard grey silty clay, WTPL	184.98 4.57	SS-5	4-6 7	13
very stiff	183.45 6.10	SS-6	2-4 4	8
stiff	181.93 7.62	SS-7	2-3 3	6
		SS-8	2-3 3	6
stiff to very stiff	178.88 10.67	SS-9	2-3 5	8
firm to stiff	177.38 12.19	SS-10	1-2 2	4
		SS-11	1-3 3	6
trace gravel	174.31 15.24	SS-12	1-2 5	7
Borehole terminated at 20.68 m	168.88 20.68			



Vertical Scale = 1 : 120.0

Reviewed by: *E.Childerhose*

Drafted by: *E.Ciochon*

Sheet: *1 of 1*

Notes: *MOECC Well Tag No.A246280.*

Z:\Style_LVM_Ontario\Log Borehole_Log_LVM_Ontario.sty - Printed : 2018-08-02 10 h

Englobe

Ground Elevation: *189.20 m*

Borehole Number: **BH-02-18**

Job N°: *P-0016606-0-01-100*

Drill Date: *2018-07-06*

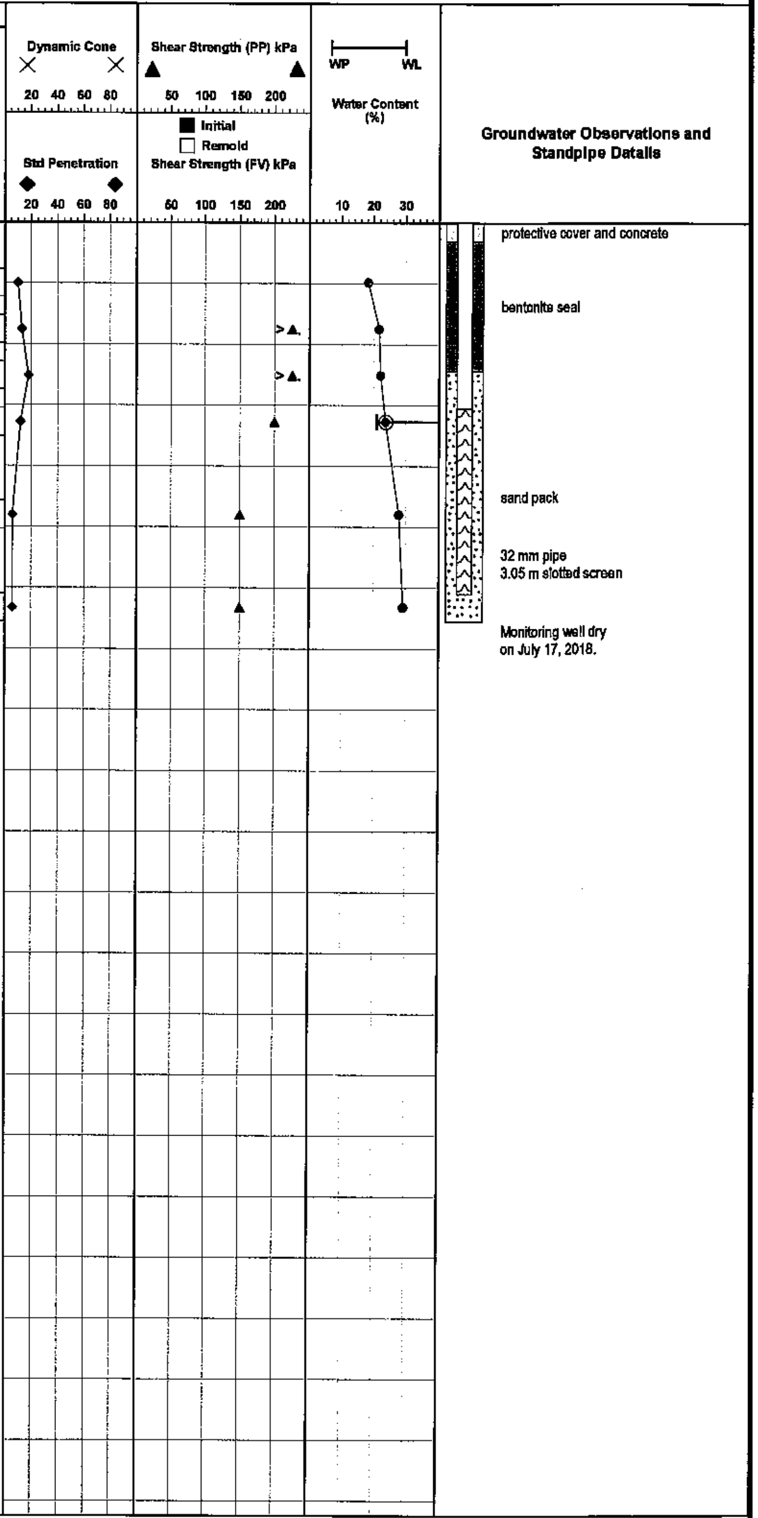
Project: *Slope Stability*

Field Tech: *D.Souter*

Location: *232 New Lakeshore Road, Port Dover, Ontario*

Drill Method: *Hollow Stem Auger*

SOIL PROFILE				SAMPLE		
Depth (m)	Description	Symbol	Elevation (m) Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		189.20			
	TOPSOIL: dark brown silt, trace sand, gravel and clay, moist		0.00 188.95 0.25			
1	***SILT:*** compact brown silt, some clay and sand, trace gravel and topsoil, moist		187.68 1.52	SS-1	3-5 5	10
2			186.91 2.29	SS-2	3-5 8	13
	hard brown clayey silt, trace sand and gravel, DTPL		186.15	SS-3	4-10 8	18
3	grey/brown		3.05	SS-4	3-5 7	12
4	***CLAY:*** hard grey silty clay, APL		184.63			
5	WTPL		4.57	SS-5	2-3 3	6
6			182.65	SS-6	2-3 3	6
7	Borehole terminated at 6.55 m		6.55			
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						



Vertical Scale = 1 : 120.0

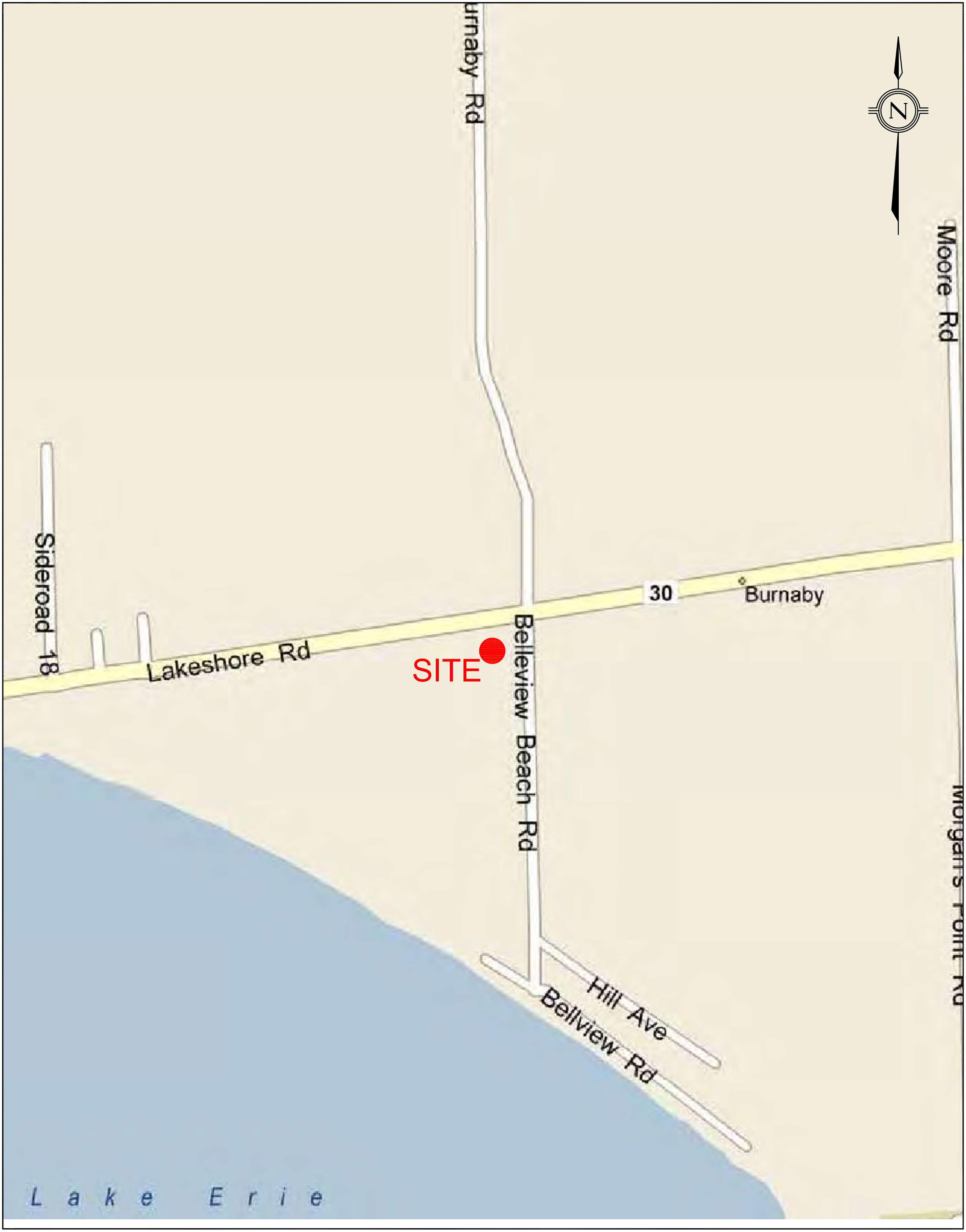
Reviewed by: *E.Childerhose*

Drafted by: *E.Ciochon*

Sheet: *1 of 1*

Notes: *MOECC Well Tag No.A246245.*

EQ-09-Ge-72 R.1 18.02.2011



Terraprobe

903 Barton Street - Unit 22, Stoney Creek, Ontario, L8E 5R7
Tel: (905) 643-7560, Fax: (905) 643-7559

Title:

SITE LOCATION PLAN

File No.

FIGURE :

1

LOG OF BOREHOLE 1

Originated by : AF

Date started : October 2, 2016

Compiled by : GM

Sheet No. : 1 of 1

Location : Burnaby , Ontario

Checked by : GM

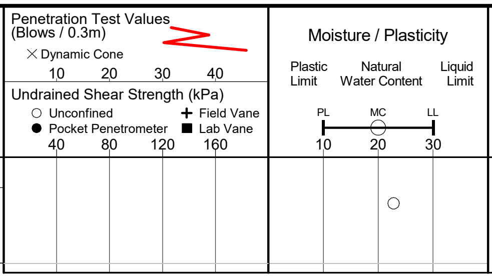
Position : E: 634287, N: 4747565 (UTM 17T)

Elevation Datum : Geodetic (NAD83)

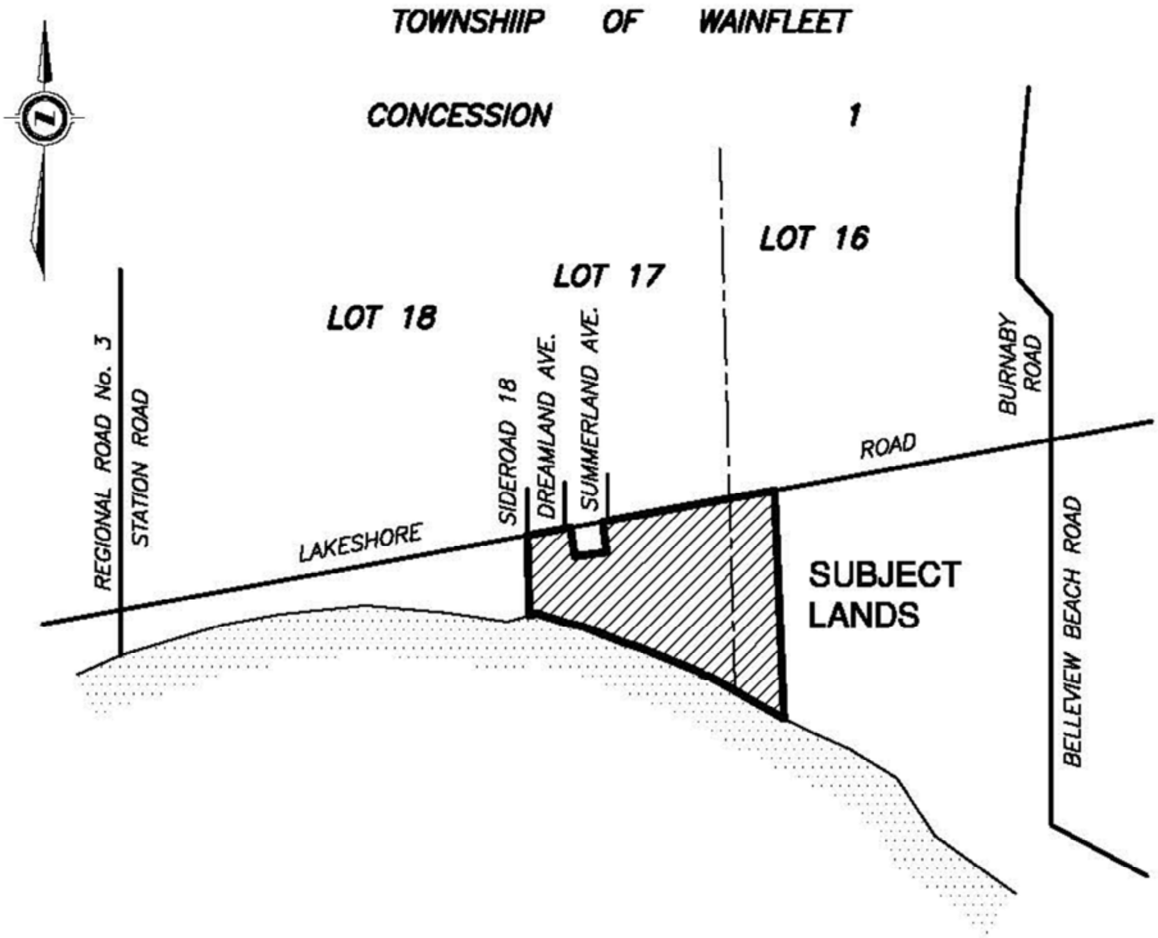
Rig type : CME 55, track-mounted

Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	SOIL PROFILE Description	Graphic Log	SAMPLES Number	SAMPLES Type	SAMPLES SPT 'N' Value	Elevation Scale (m)
0	**180.7**	**GROUND SURFACE**					
		300mm **TOPSOIL**					
	180.4 0.3	**CLAYEY SILT**, very stiff, brownish black (GLACIAL TILL)		1	SS	19	180
	179.9 0.8	**END OF BOREHOLE** Auger refusal on inferred bedrock Borehole was dry and open upon completion of drilling.					



Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL



Terraprobe

903 Barton Street - Unit 22, Stoney Creek, Ontario, L8E 5R7
Tel: (905) 643-7560, Fax: (905) 643-7559

Title:

SITE LOCATION PLAN

File No.

FIGURE :

1

Terraprobe

LOG OF BOREHOLE 3

Originated by : KB

Date started : March 13, 2017

Compiled by : KB

Sheet No. : 1 of 1

Location : Wainfleet, Ontario

Checked by : GM

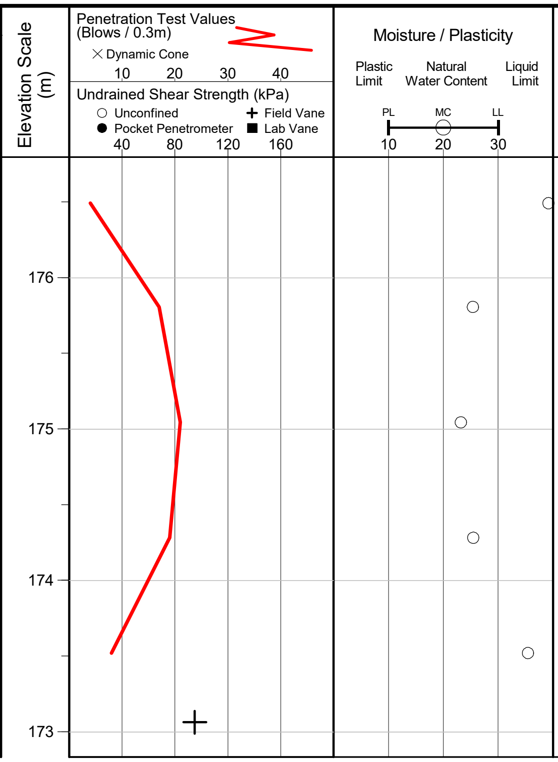
Position : E: 4747227, N: 633984 (UTM 17T)

Elevation Datum : Geodetic (NAD83)

Rig type : CME 55, track-mounted

Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value	Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
	176.8	**GROUND SURFACE**								
0		200mm **TOPSOIL**								
	176.6 0.2	**SILTY CLAY**, trace topsoil, trace rootlets, firm, brown		1	SS	4				
1	175.9 0.9	**SILTY CLAY**, occasional seams and layers of silt, very stiff, brown		2	SS	17				
				3	SS	21				
2				4	SS	19				
3	173.8 3.0	**SILTY CLAY**, firm, brown		5	SS	8				
					FV					
	172.8 4.0									



END OF BOREHOLE
Auger refusal on inferred bedrock

Borehole was dry and open upon completion of drilling.

file: 7-16-0082-01- 17165 lakeshore road.gpj

APPENDIX C

TERRAPROBE INC.

RRS

30L 13E

GROUND WATER BRANCH
AUG 15 1961
26 № 94
ONTARIO WATER
RESOURCES COMMISSION

UTM 17 Z 608766 E
~~4744011~~ N
Con. ~~4~~ Elev. R 10575
Lot 83 Basin 83 HALDIMAND

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District Rainham
Township, Village, Town or City ~~South Cayuga~~ Dunn
Con. ~~I~~
Lot 11
Date completed 21 (day) July (month) 1961 (year)

Owner [redacted] (print in block letters)
Address

Casing and Screen Record [redacted]

Inside diameter of casing 6 1/4
Total length of casing 28 ft.
Type of screen —
Length of screen —
Depth to top of screen —
Diameter of finished hole 6 1/4

Pumping Test

Static level 15 ft.
Test-pumping rate 3 G.P.M.
Pumping level bottom 41'
Duration of test pumping 2 hrs.
Water clear or cloudy at end of test clear
Recommended pumping rate 2 G.P.M.
with pump setting of 35 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
brown clay	0	2	38	fresh
blue clay	2	27		
flint rock	27	41		

For what purpose(s) is the water to be used? Cottage
Is well on upland, in valley, or on hillside? upland
Drilling or Boring Firm
Address
Licence Number 318
Name of Driller or Borer Frank Ince
Address 175 Aldercrest Ave. Hamilton
Date July 21.

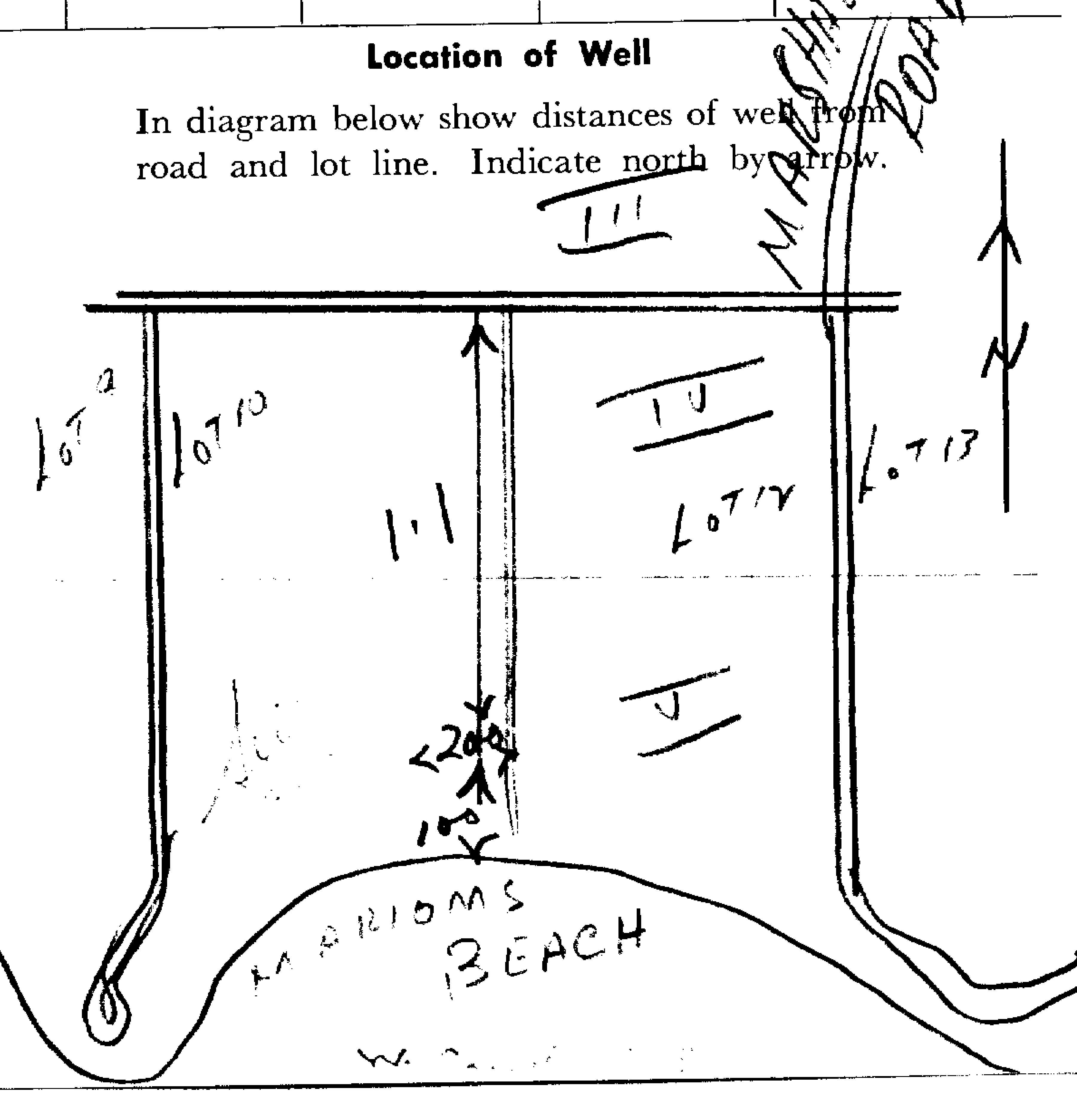
(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M Sets 60-5930

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



30L 13 E

UTM 17 Z 6110803 E
9 R 4743686 N
Elev. 9 R 0575 597
Basin 23

RECEIVED
AUG 15 1952
GEOLOGICAL BRANCH
DEPARTMENT of MINES

26 № 101

The Well Drillers Act
Department of Mines, Province of Ontario

Water Well Record

[redacted]o, ~~Village, Town or City~~ Huron
Town or City)
s Welland

Date Completed 7 (day) aug (month) 1952 (year) Cost of Well (excluding pump) 192

Pipe and Casing Record

Casing diameter(s) 6 ft
Length(s) of casing(s) 33 ft
Type of screen
Length of screen
Distance from top of screen to ground level
Is well a gravel-wall type?

Pumping Test

Date aug 7
Static level 6 ft down
Pumping level dry
Pumping rate 10 minutes
Duration of test 1
Distance from cylinder or bowls to ground level 48 ft

Water Record

Kind (fresh or mineral) mineral
Quality (hard, soft, contains iron, sulphur, etc.) sulphur
Appearance (clear, cloudy, coloured) clear
For what purpose(s) is the water to be used? cottage
How far is well from possible source of contamination? 50 ft gas well
What is the source of contamination?
Enclose a copy of any mineral analysis that has been made of water

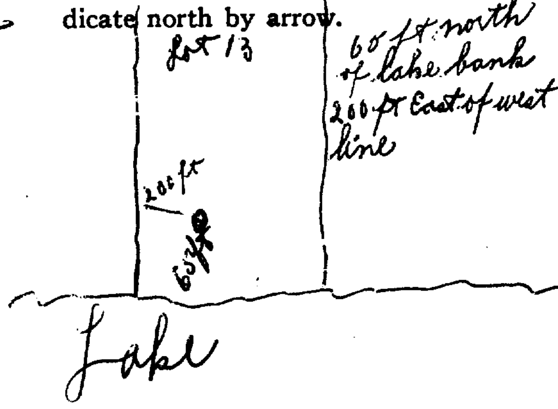
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
48	sulphur	42 ft

Well Log

Overburden and Bedrock Record	From	To
Sand	0 ft.	8 ft.
clay	8	33 ft
flint	33	48 ft

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



60 ft north of lake bank 200 ft East of west line

Situation: Is well on upland, in valley, or on hillside? ~~upland~~ hillside
Drilling Firm Caughell Bros
Address Dunnville R.R.4
Name of Driller Grant Caughell
Address R.R.4
Date aug 7
Licence Number 408

Grant Caughell
Signature of Licensee

Form 5

CSS.S8

LP

30L 14W

26 No. 251

Y

UTM 17 Z 627411 E

5 R 4748071 N

Elev. 5 R 0575

Basin 24

The Ontario Water Resources Commission Act, 1957

WATER WELL RECORD

GROUND WATER BRANCH
JAN 5 1962
ONTARIO WATER
RESOURCES COMMISSION

County or District Haldiman .... Township, Village, Town or City Moulton

[redacted]

Date completed 5 (day) April (month) /61 (year)

ess ....

Casing and Screen Record

Inside diameter of casing 5 in

Total length of casing 170

Type of screen

Length of screen

Depth to top of screen

Diameter of finished hole 5 in

Pumping Test

Static level 17'

Test-pumping rate 16 G.P.M.

Pumping level 25

Duration of test pumping 2½ hours

Water clear or cloudy at end of test Clear

Recommended pumping rate 10 G.P.M.

with pumping level of 20'

Well Log / Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, sulphur)
clay	0	40	170	153'	Fresh
Sand Hard Packed	40	50			
Water sand Silt	50	55			
Quick sand	55	100			
Hard sand	100	160			
Some clay	160	168			
Water sand fine	168	170			

For what purpose(s) is the water to be used?

Domestic

Is well on upland, in valley, or on hillside?

upland

Drilling Firm Sidney N Merritt

Address R.R. 1 Smithville Ont.

Licence Number 35

Name of Driller Sidney N Merritt

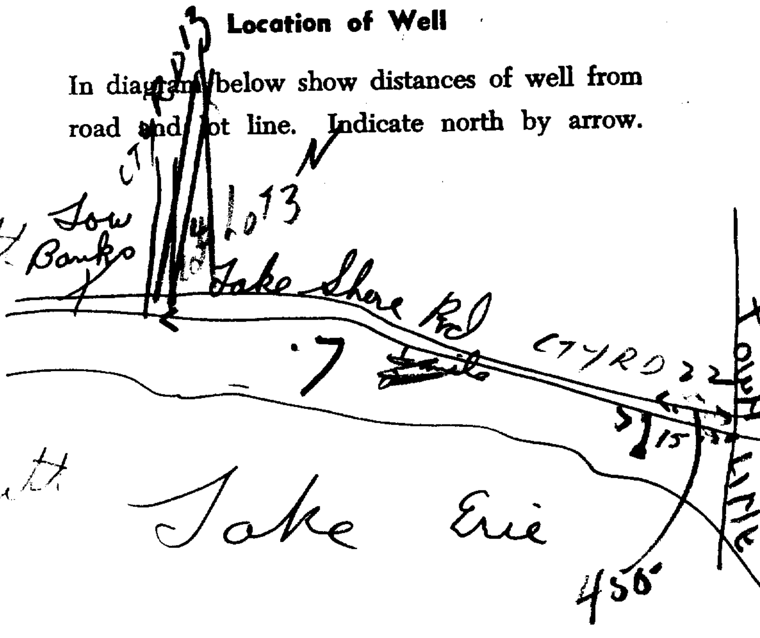
Address R.R. 1 Smithville Ont

Date Dec 61

Sidney Merritt
(Signature of Licensed Drilling Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

8 30L13W

UTM 17 Z 589019 E
9 R 4741178 N
Elev. - 9 R 0580
Basin 23

26 № 471

ONTARIO

The Well Drillers Act

Department of Mines, Province of Ontario

Water Well Record

[redacted] Con. 1 Lot 3 Pt. Lot West half
Acres 80
Date Completed Jan 1940 Cost of Well (not including pump)

Pipe and Casing Record		**Pumping Test**	
Casing diameter(s)	6 1/4	Date	
Length(s) of casing(s)	19 ft	Developed Capacity	
Length of screen		Duration of Test	
Type of screen		Pumping Rate	
Type of pump		Drawdown	
Capacity of pump		Static level of completed well	20 ft
Depth of pump setting		Is well a gravel-wall type?	

Water Record

Kind (fresh or mineral) fresh
Quality (hard, soft, contains iron, sulphur etc.)
Appearance (clear, cloudy, coloured)
For what purpose(s) is the water to be used?
How far is well from possible source of contamination?
What is source of contamination?
Enclose a copy of any mineral analysis that has been made of water

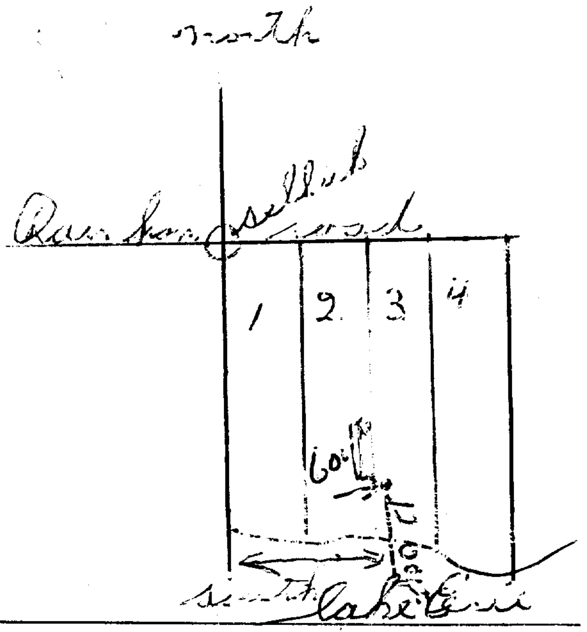
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
44 ft	fresh	29 ft

Well Log

Drift and Bedrock Record	From	To
Sub soil	0 ft.	3 ft.
red clay	3	12
blue clay	12	19
flint	19	50

Location of Well

In diagram below show distances of well from road and lot line



Situation: Is well on upland, in valley, or on hillside? 1 mi east of Town line
Drilling Firm
Address
Recorded by Address
Date Licence Number

CSS.S8

30L13W

26 № 474

UTM 17 Z ~~589890~~ 590245 E

9 ~~5~~ R 47~~43260~~ 40930 N

Elev. 9 ~~5~~ R ~~0650~~ 595

Basin 23

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District Haldimand

Township, Village, Town or City Rainham

Date completed 7 (day) June (month) 1967 (year)

1 Lot 4

[redacted]

ess R.R.#1 Selkirk, Ontario

Casing and Screen Record

Inside diameter of casing 6¼"

Total length of casing 15 ft. 5"

Type of screen

Length of screen

Depth to top of screen

Diameter of finished hole 6¼"

Pumping Test

Static level 18 ft.

Test-pumping rate 1 G.P.M.

Pumping level pumps dry

Duration of test pumping 1 hr

Water clear or cloudy at end of test clear

Recommended pumping rate 1 G.P.M.

with pump setting of 29 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Surface (clay)	0	15		
Flint	15	30	22½	Fresh

Well pumps dry but in 1 hr is back up to the 18 ft. level

For what purpose(s) is the water to be used? Summer cottage

Is well on upland, in valley, or on hillside? Upland

Drilling or Boring Firm

Address

Licence Number 2438

Name of Driller or Borer Earl Culver

Address R.R.#1 Selkirk Ont.

Date June 9, 1967

Earl Culver

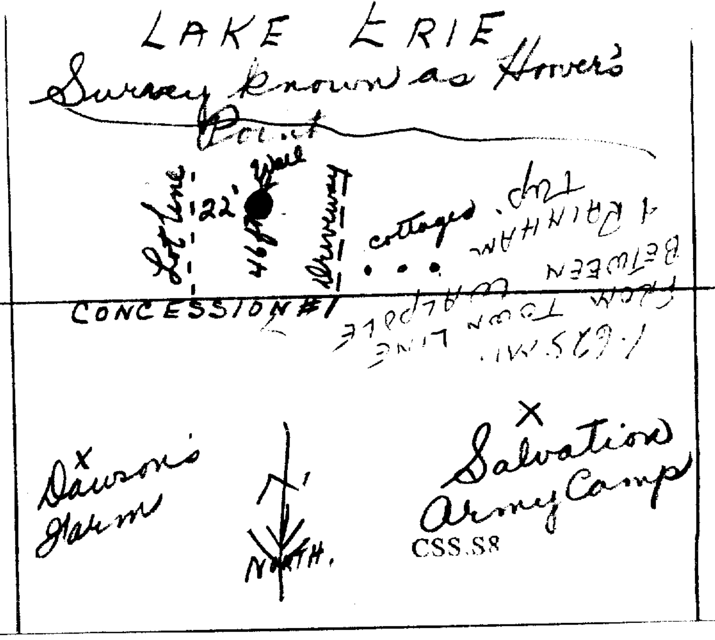
(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M-60-4138

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

30L 13W

WAM

UTM |1|7| Z |5|9|6|4|1|2| E
|9| R |4|7|4|2|3|1|8| N
Elev. |9| R - |0|5|8|0|
Basin |2|3| |_|_|_|

ONTARIO

26 No 517

GROUND WATER BRANCH
MAY 27 1958
ONTARIO WATER RESOURCES COMMISSION

The Water-well Drillers Act, 1954
Department of Mines

Water-Well Record

County or Territorial District [illegible] Township, Village, Town or City [illegible]
Con. I Lot 11 Street and Number (if in Village, Town or City)
Owner [redacted] Address HAMILTON
Date completed 19 (day) APRIL (month) 1958 (year)

Pipe and Casing Record

Casing diameter(s) 6¼
Length(s) 16'
Type of screen —
Length of screen —

Pumping Test

Static level 8'
Pumping rate 2 G.P.M.
Pumping level 20'
Duration of test 1 hr.

Well Log

Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, or sulphur)
CLAY	0	16	24	16	SULPHUR
ROCK	16	24			

For what purpose(s) is the water to be used? COTTAGE
Is water clear or cloudy? CLEAR
Is well on upland, in valley, or on hillside? UPLAND
Drilling firm HOWARD CROSS
Address RYCKMAN'S CORNERS

Name of Driller ARTHUR CROSS
Address RYCKMAN'S CORNERS

Licence Number

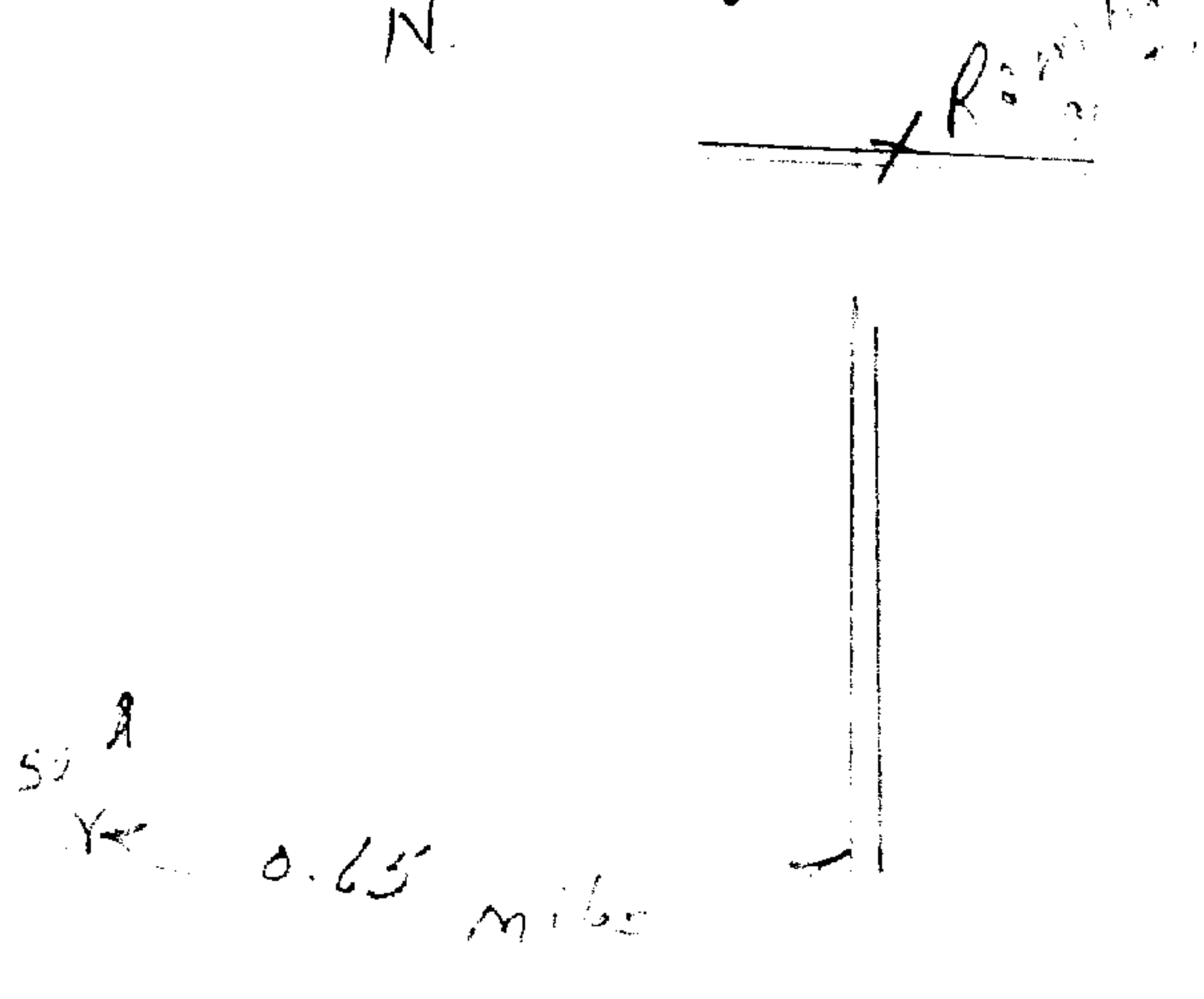
I certify that the foregoing statements of fact are true.

Date MAY 26 Howard Cross
Signature of Licensee

WAM

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 5

CSS.S8

30L 13W

26 №. 525

UTM 17 Z 5969311 E

5 R 4742605 N

Elev. 5 R 6575

Basin 2312

The Ontario Water Resources Commission Act, 1957

WATER WELL RECORD

GROUND WATER BRANCH
JAN 13 1960
ONTARIO WATER RESOURCES COMMISSION

County or District Haldimand Township, Village, Town or City ~~Walpole~~ RAINHAM

[redacted]

Date completed 2 May 1959 (day month year)

Address est of Featherstone Point Selkirk Lake Erie

Casing and Screen Record

Inside diameter of casing 6"

Total length of casing 16'

Type of screen none

Length of screen

Depth to top of screen

Diameter of finished hole 6"

Pumping Test

Static level 12'

Test-pumping rate 14' G.P.M.

Pumping level 12'

Duration of test pumping ½ hr. May 2/59

Water clear or cloudy at end of test Clearing

Recommended pumping rate 8 G.P.M.

with pumping level of 12 feet

Well Log			Water Record		
Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, sulphur)
Clay	0	15			
Flint rock.	15	22	22'	10'	fresh

For what purpose(s) is the water to be used? domestic

Is well on upland, in valley, or on hillside? upland

Drilling Firm Sidney W. Merritt

Address R.R. 1 Smithville, Ont.

Licence Number 35

Name of Driller Sidney W. Merritt

Address R.R. 1 Smithville

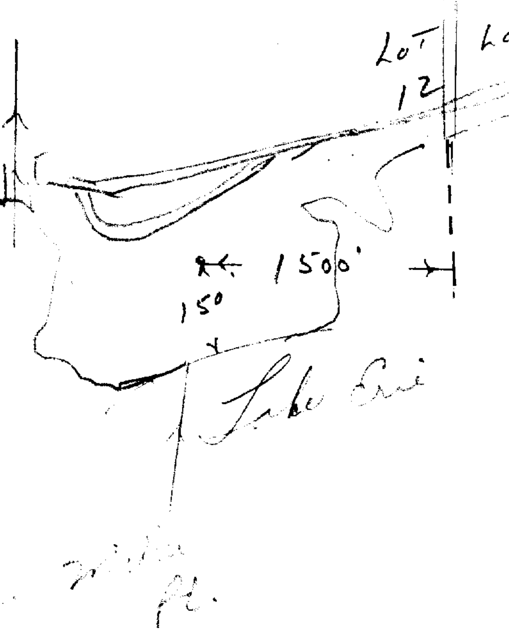
Date Oct 2/59.

Sidney Merritt

(Signature of Licensed Drilling Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 5
15M-58-4149

CSS.S8

30L 13W

UTM |1|7| Z |5|9|6|2|4|9| E

|9| R |4|7|4|3|3|7|5| N

Elev. |9| R |0|5|8|0|

Basin |2|3| | | | |

26 № 534

GROUND WATER BRANCH

JAN 13 1958

ONTARIO WATER RESOURCES COMMISSION

The Water-well Drillers Act, 1954

Department of Mines

Water-Well Record

[redacted]

ip, Village, Town or City Rainham

Village, Town or City)

ddress Selkirk

Date completed
(day) (month) (year)

Pipe and Casing Record

Casing diameter(s) 6 1/4

Length(s) 10 - 8

Type of screen

Length of screen

Pumping Test

Static level 4 ft

Pumping rate 460 gal per hr

Pumping level 7 ft

Duration of test 10 hour

Well Log

Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, or sulphur)
Clay surface	0	10			
Flint	10	20	15	11	fresh

For what purpose(s) is the water to be used? Cottage

Is water clear or cloudy? clear

Is well on upland, in valley, or on hillside? upland

Drilling firm David E. Werner

Address Fisherville

Name of Driller David E. Werner

Address Fisherville

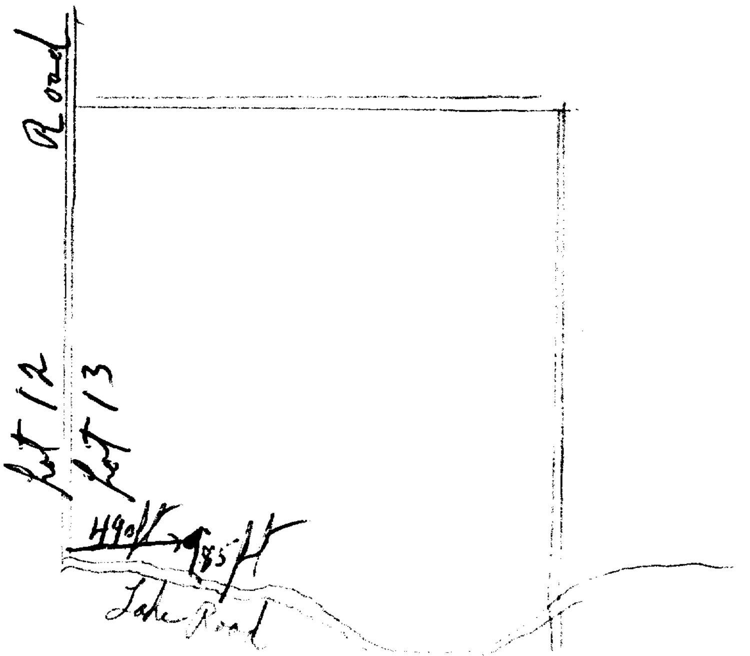
Licence Number 1210

I certify that the foregoing statements of fact are true.

Date Jan 8/58 David E Werner
Signature of Licensee

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 5

CSS.S8

30L13W

RECEIVED 26 No. 536

OCT 10 1962
ONTARIO WATER RESOURCES COMMISSION

GROUND WATER BRANCH
OCT 10 1962
ONTARIO WATER RESOURCES COMMISSION

UTM 1 7 6 9 6 3 0 1 0 E
5 R 4 7 4 4 4 6 8 N
Elev. 5 R 1 0 5 8 6
Basin 23

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District Haldimand
Township, Village, Town or City Rainham
Con. 1 SP Lot 14
Date completed 17 (day) Sept. (month) 1962 (year)
[redacted]
ss 90 Hixon St. Hamilton Ont.

Casing and Screen Record

Inside diameter of casing 6¼"
Total length of casing 10' - 7"
Type of screen
Length of screen
Depth to top of screen
Diameter of finished hole 6"

Pumping Test

Static level 14 ft.
Test-pumping rate 10 G.P.M.
Pumping level 20 ft
Duration of test pumping 20 mins.
Water clear or cloudy at end of test cloudy
Recommended pumping rate 10 G.P.M.
with pump setting of 20 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Surface Clay	0	10		at first fresh, then turned slightly sulphur.
Flint	10	25	23	

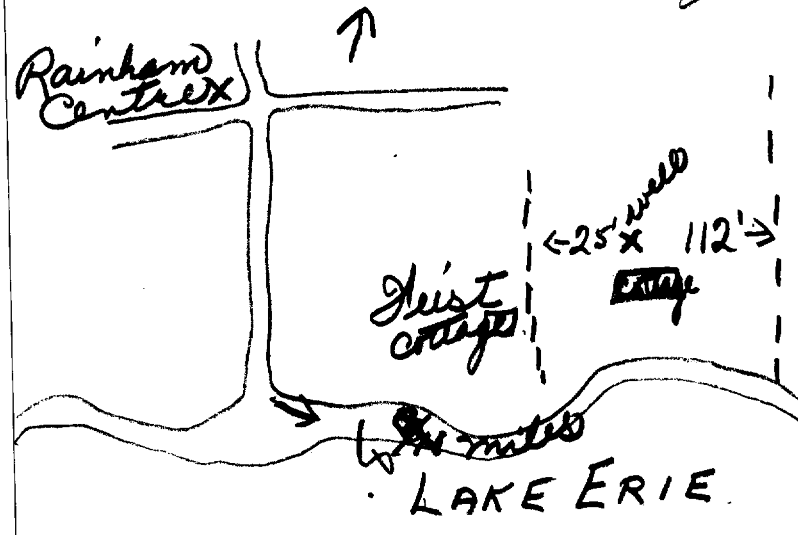
For what purpose(s) is the water to be used? Summer cottage
Is well on upland, in valley, or on hillside? Upland
Drilling or Boring Firm Earl Culver
Address RR #2. Selkirk Ontario
Licence Number 471
Name of Driller or Borer Earl Culver
Address R.R. #2. Selkirk
Date Sept 24/62.
Earl Culver
(Signature of Licensed Drilling or Boring Contractor)

Form 7 10M-62-1152

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

30L 13W

UTM 17 Z 5916933 E
5 R 4745737 N
Elev. 5 R 0575
Basin 23

The Ontario Water Resources Commission Act

WATER WELL RECORD

WATER RESOURCES
DIVISION 26
APR 8 1965
ONTARIO WATER
RESOURCES COMMISSION

№ 559

B

County or District Haldimand Township, Village, Town or City Rainham

Con. 1 Lot 17 Date completed 11 (day) March (month) 1965 (year)

[redacted] ess 83 Province St. S. Hamilton Ontario

Casing and Screen Record

Inside diameter of casing 6 1/4

Total length of casing 5 ft 6 inches

Type of screen

Length of screen

Depth to top of screen

Diameter of finished hole 5 5/8

Pumping Test

Static level 6 ft.

Test-pumping rate 1/2 G.P.M.

Pumping level Well produces 30 gal water every hour.

Duration of test pumping 2 hrs.

Water clear or cloudy at end of test Clear

Recommended pumping rate 1/2 G.P.M.

with pump setting of 30 feet below ground surface

Well Log			Water Record	
Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Clay & stone	0	2		
Flint	2	38	37	Slightly sulphur

For what purpose(s) is the water to be used? Summer Cottage

Is well on upland, in valley, or on hillside? On lakeshore

Drilling or Boring Firm Earl Culver

Address RR#1 Selkirk Ontario

Licence Number 1596

Name of Driller or Borer

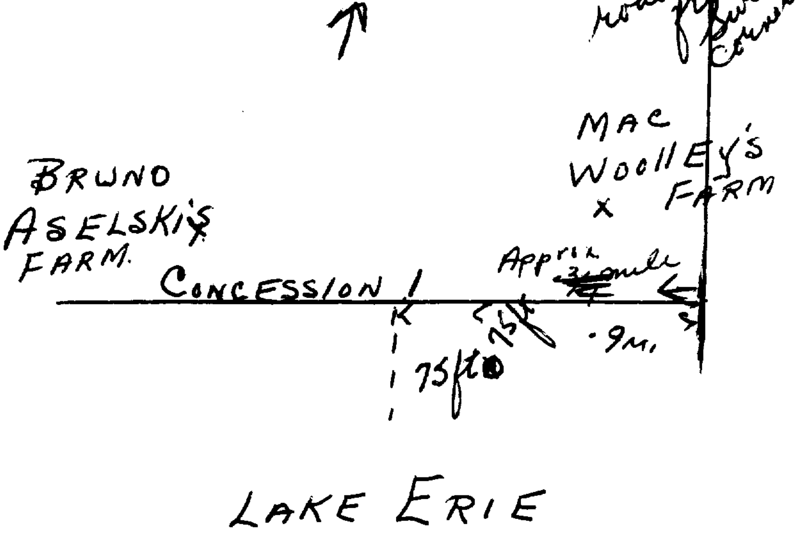
Address

Date March 31/65

Earl Culver
(Signature of Licensed Drilling or Boring Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 7 15M-60-4138

OWRC COPY

CSS SS

30L13W

UTM 1 7 Z 5 9 6 5 9 9 E

5 R 4 7 4 7 0 8 2 N

Elev. 5 R 0 5 8 3

Basin 2 3

26 № 566

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District HALDIMAND

Township, Village, Town or City RAINHAM

Date completed 20 (day) Nov (month) 1965 (year)

Con. 1 Lot 19

Owner [redacted] (print in block letters)

Address SELKIRK RR1

HAMILTON – 158 McANULTY BLVD.

Casing and Screen Record

Inside diameter of casing 5"

Total length of casing 11 ft

Type of screen —

Length of screen —

Depth to top of screen —

Diameter of finished hole 5"

Pumping Test

Static level

Test-pumping rate G.P.M.

Pumping level

Duration of test pumping

Water clear or cloudy at end of test [illegible]

Recommended pumping rate 100 [illegible] G.P.M.

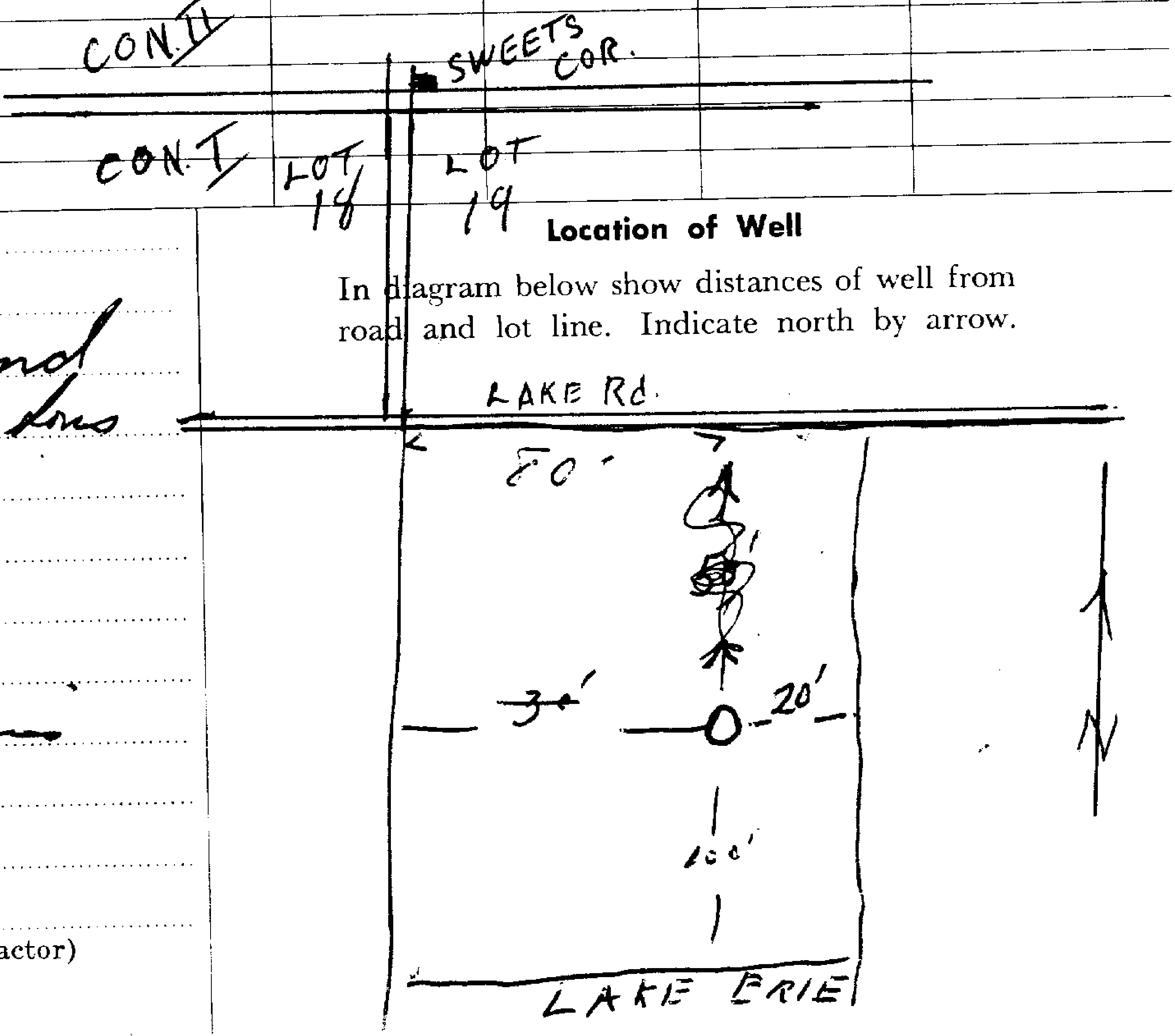
with pump setting of 22' feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Overburden Brown Clay	0	10'		
Flint Rock	10'	26'	23'	Sulphur

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



For what purpose(s) is the water to be used? Household

Is well on upland, in valley, or on hillside? Upland

Drilling or Boring Firm W A. Dennis & Sons

Address RR-6 Waterford

Licence Number 1938

Name of Driller or Borer Robert Dennis

Address RR-5 Waterford

Date Nov 30/65

Robert Dennis

(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M-60-4138

OWRC COPY

CSS.S8

30 L 13 W

UTM	17 Z	6 0 0 3 5 7 E	
	9 R	4 7 4 4 1 8 4 N	
Elev.	9 R	0 5 8 0	
Basin	23		

RECEIVED 26
JAN 31 1952
GEOLOGICAL BRANCH
DEPARTMENT OF MINES

№ 570

The Well Drillers Act
Department of Mines, Province of Ontario

Water Well Record

[redacted] ~~Village, Town~~ or City... Rainham

wn or City)...

South Cayuga P.O. R.R.2

Date Completed 1 (day) Dec (month) 1951 (year) Cost of Well (excluding pump)...

Pipe and Casing Record

Casing diameter(s) 5-5/8
Length(s) of casing(s) 18'
Type of screen...
Length of screen...
Distance from top of screen to ground level...
Is well a gravel-wall type?...

Pumping Test

Date...
Static level 9'
Pumping level Bailer Test
Pumping rate No draw down
Duration of test...
Distance from cylinder or bowls to ground level...

Water Record

Kind (fresh or mineral) Fresh
Quality (hard, soft, contains iron, sulphur, etc.) Hard
Appearance (clear, cloudy, coloured) Clear
For what purpose(s) is the water to be used? Farm use
How far is well from possible source of contamination?...
What is the source of contamination?...
Enclose a copy of any mineral analysis that has been made of water...

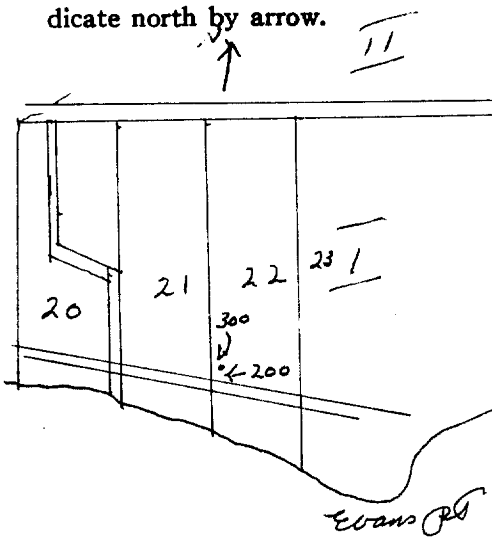
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
25'	fresh	16

Well Log

Overburden and Bedrock Record	From 0 ft.	To ....ft.
Clay	0	18
Flint	18	25'

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Situation: Is well on upland, in valley, or on hillside? Level
Drilling Firm Montgomery Bros
Address R.R. #2 Selkirk Ont
Name of Driller Ralph & Blake Montgomery Address R.R.2 Selkirk Ont.
Date Jan 28/52 Licence Number 432-433
Blake O. Montgomery
Signature of Licensee

Form 5

W

30L 13W

GROUND WATER BRANCH
26 No. 574
JUN - 5 1963
ONTARIO WATER
RESOURCES COMMISSION

8

X

UTM 1 7 Z 6 0 1 1 1 9 2 E
5 R 4 7 4 4 0 0 2 N
Elev. 5 R 0 5 7 5

The Ontario Water Resources Commission Act

WATER WELL RECORD

Basin 2 3
County or District ~~Haldimand~~ 23 HB Township, ~~Village, Town or City~~ Rainham

Date completed 17 (day) May (month) 1963 (year)

[redacted] R.R.#1 Stoney Creek, Ont.

Casing and Screen Record

Inside diameter of casing 6 1/4"
Total length of casing 23 ft 5 inches
Type of screen
Length of screen
Depth to top of screen
Diameter of finished hole 6 1/4"

Pumping Test

Static level 14 ft.
Test-pumping rate 1 G.P.M.
Pumping level 28 ft.
Duration of test pumping 30 mins
Water clear or cloudy at end of test cloudy
Recommended pumping rate 1 G.P.M.
with pump setting of 28 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Sand	0	5		
Clay	5	20		
Gravel	20	21		
Flint	21	30	27	Fresh

For what purpose(s) is the water to be used? Summer cottage

Is well on upland, in valley, or on hillside? Hillside

Drilling or Boring Firm Earl Culver

Address R.R. 2 Selkirk
Ontario

Licence Number 878

Name of Driller or Borer Earl Culver

Address R.R.#2 Selkirk

Date June 3/63

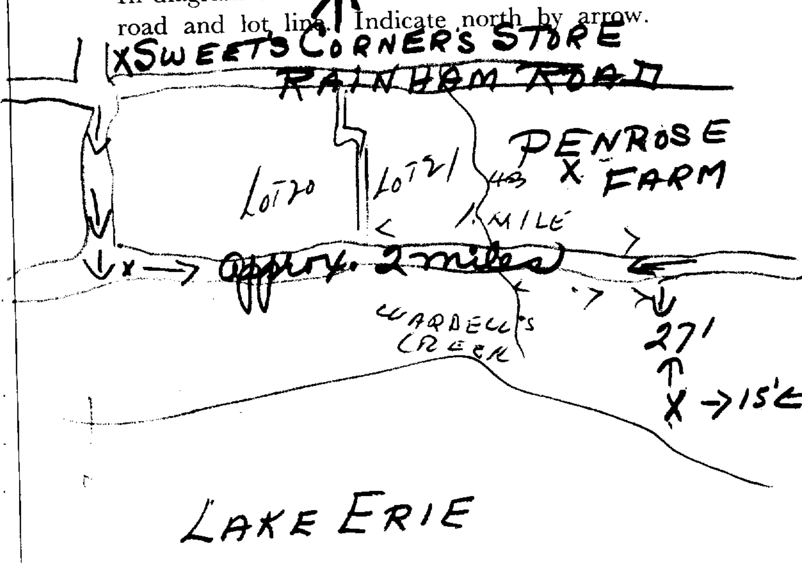
Earl Culver
(Signature of Licensed Drilling or Boring Contractor)

Form 7 10M-62-1152

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

30L 13E

UTM 1 7 Z 6 0 2 7 1 3 E
~~1~~9 R 4 7 4 4 7 2 6 N
Elev. 9 R 0 5 8 0
I
~~Basin~~ 2 3
23

RECEIVED
OCT - 9 1953
GEOLOGICAL BRANCH
DEPARTMENT of MINES

26 № 579

ONTARIO

The Well Drillers Act
Department of Mines, Province of Ontario

Water Well Record

[redacted] ~~Village, Town or City~~ Rainham
own or City)
Hamilton

Date Completed 10 (day) Sept (month) 53 (year) Cost of Well (excluding pump)

Pipe and Casing Record

Casing diameter(s) 5-5/8
Length(s) of casing(s) 11 ft
Type of screen
Length of screen
Distance from top of screen to ground level
Is well a gravel-wall type?

Pumping Test

Date Sept 10 ~~[illegible]~~
Static level 12 ft from top
Pumping level 14 ft " "
Pumping rate 1000 gal hr.
Duration of test ½ hr
Distance from cylinder or bowls to ground level 30 ft

Water Record

Kind (fresh or mineral) mineral
Quality (hard, soft, contains iron, sulphur, etc.) sulphur
Appearance (clear, cloudy, coloured) cloudy
For what purpose(s) is the water to be used? cottage
How far is well from possible source of contamination? do not know
What is the source of contamination? sulphur gas
Enclose a copy of any mineral analysis that has been made of water

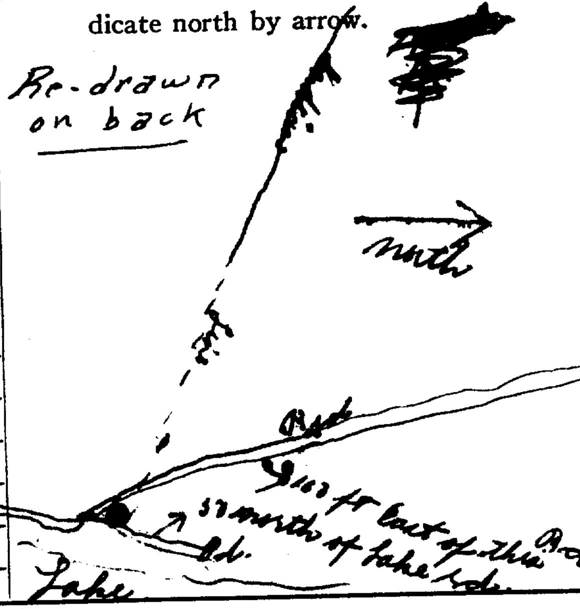
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
30 ft	cloudy	18 ft

Well Log

Overburden and Bedrock Record	From	To
	0 ft.	11 ft.
Clay		
flint	11	30 ft

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Situation: Is well on upland, in valley, or on hillside? upland
Drilling Firm Caughell Bros
Address Hannville
Name of Driller Grant Caughell Address
Date Sept 28 Licence Number 408
Grant Cau
Signature of Licens

Form 5

CSS.S8

L.P.

30L13E

GROUND WATER BRANCH
26 No
NOV 21 1961
ONTARIO WATER
ESOURCES COMMISSION

83

UTM 1 7 z | 6 1 9 5 0 9 E

5 R | 4 7 4 5 2 4 8 N

Elev. 5 R | 0 5 7 5

Basin 2 3 | 4

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District Haldimand Township, Village, Town or City Sherbrooke

Con. Con 1 Lot 8 Date completed 19 (day) July (month) 1961 (year)

[redacted]ddress Hamilton

Casing and Screen Record

Inside diameter of casing 6

Total length of casing 81

Type of screen

Length of screen

Depth to top of screen

Diameter of finished hole 5½

Pumping Test

Static level 26ft from top

Test-pumping rate 2000 33 GPH G.P.~~M~~H.

Pumping level 26ft

Duration of test pumping 2 hrs

Water clear or cloudy at end of test Cloudy

Recommended pumping rate 5 G.P.M.

with pump setting of 35 ft feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Clay		70 ft	101	sulphur
hard pan	70	81		
flint rock	81	102		

For what purpose(s) is the water to be used? house

Is well on upland, in valley, or on hillside? upland

Drilling or Boring Firm Caughell Bros.

Address Hunnville RR 4

Licence Number 28

Name of Driller or Borer Grant Caughell

Address Hunnville RR 4

Date July 20

Grant Caughell
(Signature of Licensed Drilling or Boring Contractor)

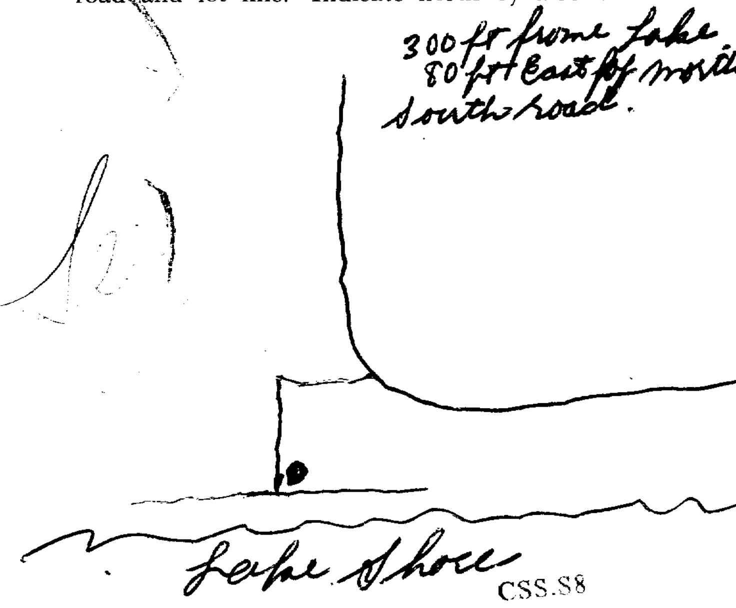
Form 7 15M Sets 60-5930

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.

300 ft frome lake
80 ft East of north south road.



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L.P.

30L13E

GROUND WATER BRANCH
26 No
NOV 21 1961
ONTARIO WATER
RESOURCES COMMISSION

83

UTM 1|7 Z 6|1|9|5|0|9 E

5 R 4|7|4|5|2|4|8 N

Elev. 5 R 0|5|7|5

Basin 2|3 | | 4

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District Haldimand Township, Village, Town or City Sherbrooke

Con. Con 1 Lot 8 Date completed 19 (day) July (month) 1961 (year)

[redacted] ddress Hamilton

Casing and Screen Record

Inside diameter of casing 6

Total length of casing 81

Type of screen

Length of screen

Depth to top of screen

Diameter of finished hole 5½

Pumping Test

Static level 26 ft from top

Test-pumping rate 2000 33 GPH G.P.~~M~~H.

Pumping level 26 ft

Duration of test pumping 2 hrs

Water clear or cloudy at end of test cloudy

Recommended pumping rate 5 G.P.M.

with pump setting of 35 ft feet below ground surface

Well Log

Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Clay		70 ft	101	sulphur
hard pan	70	81		
flint rock	81	102		

For what purpose(s) is the water to be used? house

Is well on upland, in valley, or on hillside? upland

Drilling or Boring Firm Caughell Bros.

Address Hunnville R R 4

Licence Number 28

Name of Driller or Borer Grant Caughell

Address Hunnville R R 4

Date July 20

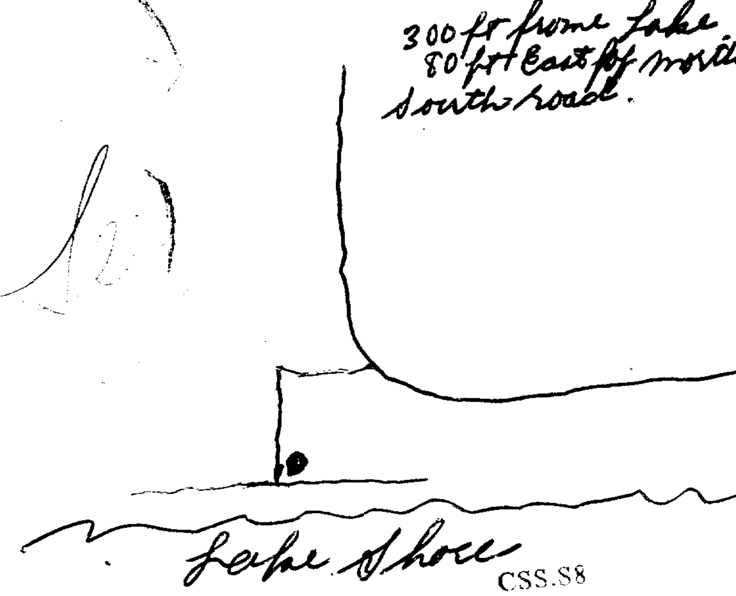
Grant Caughell
(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M Sets 60-5930

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

30L 14W

19

26 No. 840

GROUND WATER BRANCH
JUN 30 1959
ONTARIO WATER
RESOURCES COMMISSION

JTM | 1 | 7 | Z | 6 | 2 | 4 | 4 | 6 | 6 | E
| 9 | R | 4 | 7 | 4 | 4 | 9 | 7 | 9 | N
Elev. | 9 | R | 0 | 5 | 7 | 5 | C
Basin | 23 | | | | |

Lot - 19

The Ontario Water Resources Commission Act, 1957

WATER WELL RECORD

County or District Haldimand

Township, Village, Town or City Sherbrooke

[redacted]

te completed 10 (day) June month 1959 year)

ress Bufflo

Casing and Screen Record

Inside diameter of casing 6¼
Total length of casing 10 ft
Type of screen
Length of screen
Depth to top of screen
Diameter of finished hole 5 5/8

Pumping Test

Static level 19 down
Test-pumping rate 20 G.P.M.
Pumping level 21 ft
Duration of test pumping 1 hrs
Water clear or cloudy at end of test Cloudy
Recommended pumping rate 30 G.P.M.
with pumping level of 21 ft

Well Log

Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, sulphur)
Clay	0	2			
large gravle	2	10	36 ft	17 ft	sulphur gas
Flint	10	36			

For what purpose(s) is the water to be used?
cottage

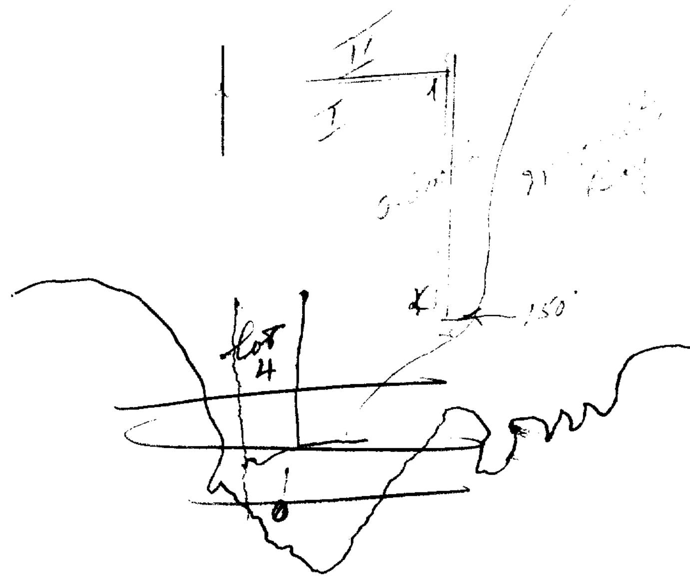
Is well on upland, in valley, or on hillside? upland

Drilling Firm Caughell Bros.
Address Dunnville R.R. 4

Licence Number 19
Name of Driller Grant Caughell
Address Dunnville R.R. 4
Date June 28
Grant Caughell
(Signature of Licensed Drilling Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

Form 5
15M-58-4149

30L 13E

UTM 17 Z 6057~~66~~ 35 E
9 R 4745~~985~~ 030 N
Elev. 9 R ~~0575~~ 595
Basin 23
T. R. S.
Con VII
lot 13

RECEIVED
SEP - 8 1954
GEOLOGICAL BRANCH
DEPARTMENT of MINES
No. 26

884

The Well Drillers Act
Department of Mines, Province of Ontario

Water Well Record

County or Territorial District Haldimand Township, ~~Village, Town or City~~ South Cayuga
[redacted] own or City) ....
.... Thorald
Date Completed 20 (day) July (month) 54 (year) Cost of Well (excluding pump) ....

Pipe and Casing Record

Casing diameter(s) 5 5/8
Length(s) of casing(s) 29 ft
Type of screen ....
Length of screen ....
Distance from top of screen to ground level ....
Is well a gravel-wall type? rock

Pumping Test

Date July 20
Static level 18 ft from top
Pumping level dry
Pumping rate comes in 3 gallon minute
Duration of test ½ hr
Distance from cylinder or bowls to ground level 36 ft

Water Record

Kind (fresh or mineral) mineral
Quality (hard, soft, contains iron, sulphur, etc.) hard - sulphur
Appearance (clear, cloudy, coloured) cloudy
For what purpose(s) is the water to be used? cottage
How far is well from possible source of contamination? ....
What is the source of contamination? ....
Enclose a copy of any mineral analysis that has been made of water

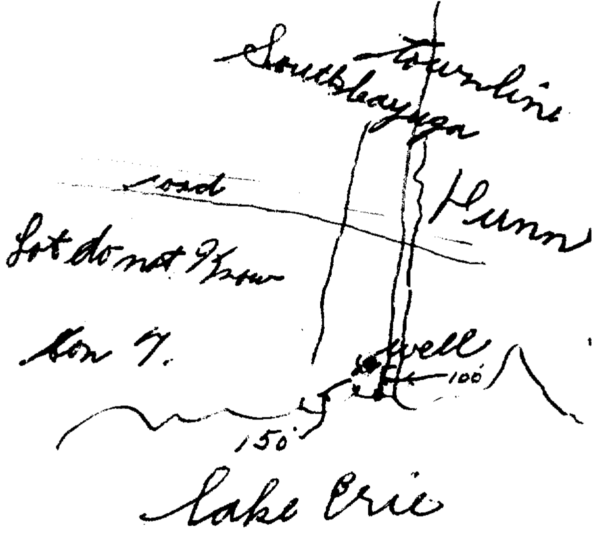
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
36 ft	sulphur	18 ft

Well Log

Overburden and Bedrock Record	From	To
Clay	0 ft.	29 ft.
flint	29	38

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Situation: Is well on upland, in valley, or on hillside? upland
Drilling Firm Caughell Bros
Address Dunnville R R 4
Name of Driller Grant Caughell Address Dunnville
Date Sept 1 Licence Number 408
Grant Caughell
Signature of Licensee

Form 5

30L 13E

UTM 17 Z 6035616 E

9 R 4745710 N

~~Elev~~ 9 R 9375

~~Talbot Rd South~~

Basin 23

Con — VII

Lot — ~~15~~ 16

ONTARIO

26 № 895

RECEIVED
OCT 29 1956
GEOLOGICAL BRANCH
DEPARTMENT OF MINES

The Well Drillers Act
Department of Mines, Province of Ontario

Water Well Record

County or Territorial District Haldimand Township, Village, Town or City South Cayuga

[redacted]

Town or City) St Catharines

Date Completed [illegible] Aug [illegible] (day) (month) (year) Cost of Well (excluding pump)

Pipe and Casing Record

Casing diameter(s) 6 5/8

Length(s) of casing(s) 21 ft

Type of screen

Length of screen

Distance from top of screen to ground level

Is well a gravel-wall type? Rock

Pumping Test

Date ~~[illegible]~~ Aug 25

Static level 8 ft from top

Pumping level 30 ft from top

Pumping rate 1500 gall per hr

Duration of test 1/2 hr

Distance from cylinder or bowls to ground level 45 ft

Water Record

Kind (fresh or mineral)

Quality (hard, soft, contains iron, sulphur, etc.) sulphur

Appearance (clear, cloudy, coloured) cloudy

For what purpose(s) is the water to be used? for camp use

How far is well from possible source of contamination?

What is the source of contamination?

Enclose a copy of any mineral analysis that has been made of water

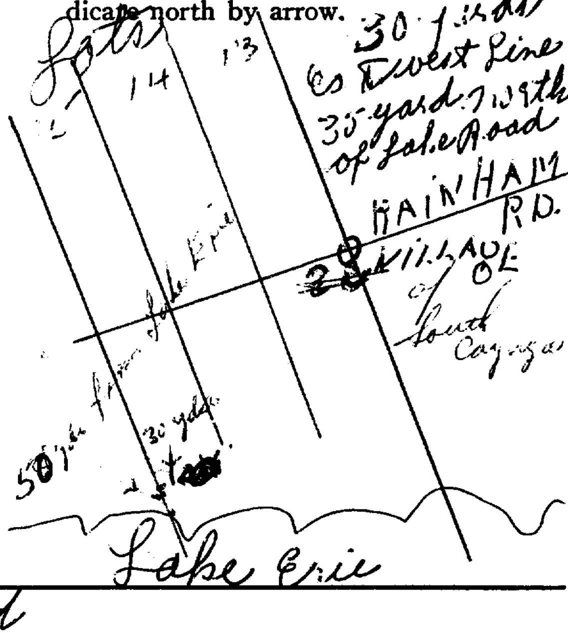
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
45 ft	sulphur	37 ft

Well Log

Overburden and Bedrock Record	From	To
clay	0 ft.	21 ft.
flint	21	47

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Situation: Is well on upland, in valley, or on hillside? upland

Drilling Firm Caughell Bros.

Address Dunnville

Name of Driller Grant Caughell Address Dunnville R.R. 4

Date ~~Aug~~ Oct. 25/56 Licence Number 408

Grant Caughell
Signature of Licensee

Form 5

CSS.S8

40I16E

UTM 17 Z 5741240 E
9 R 4737622 N
Elev. 9 R 0575
Basin 23

RECEIVED
AUG 21 1952
GEOLOGICAL BRANCH
DEPARTMENT OF MINES

26 № 917

ONTARIO

The Well Drillers Act
Department of Mines, Province of Ontario

Water Well Record

[redacted] HALDIMAND Township, ~~Village, Town or City~~ WALPOLE

Town or City)

ss Dundas

Date Completed 9 (day) May (month) [illegible] (year) Cost of Well (excluding pump)

Pipe and Casing Record

Casing diameter(s) 6 1/4
Length(s) of casing(s) 30 ft
Type of screen
Length of screen
Distance from top of screen to ground level
Is well a gravel-wall type?

Pumping Test

Date
Static level 25 ft
Pumping level [illegible]
Pumping rate good supply [illegible]
Duration of test
Distance from cylinder or bowls to ground level

Water Record

Kind (fresh or mineral) mineral
Quality (hard, soft, contains iron, sulphur, etc.) sulphur
Appearance (clear, cloudy, coloured) coloured
For what purpose(s) is the water to be used? Domestic
How far is well from possible source of contamination?
What is the source of contamination?
Enclose a copy of any mineral analysis that has been made of water

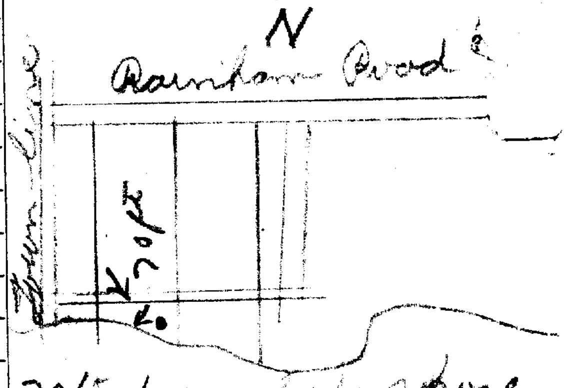
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rise
42	[illegible]	17

Well Log

Overburden and Bedrock Record	From	To
[illegible]	0 ft.	2 ft.
Clay	2	30
[illegible]	30	62

Location of W

In diagram below show distance well from road and lot line. dicate north by arrow.



70 ft / on lake shore
700 ft from west line of lot 2

Situation: Is well on upland, in valley, or on hillside? level
Drilling Firm [illegible] + Sons
Address Jarvis
Name of Driller [illegible] Address Jarvis
Date July 22-52 Licence Number 27

Signature of Licensee

Form 5

CSS.S8

13 40I16E

UK
26 No 919

UTM 17 Z 5 7 4 7 5 7 6 E
9 R 4 7 3 7 6 7 7 N
Elev. 9 R 0 5 7 5
Basin 23

ONTARIO

The Well Drillers Act

Department of Mines, Province of Ontario

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JAN 12 1950
GEOLOGICAL BRANCH
DEPARTMENT OF MINES

Water Well Record

[redacted] Haldimand Tp. Walpole. Con. 1 Lot 3 Pt. Lot ....
Paris. .... Acres ....
ncluding pump) ....

Pipe and Casing Record

Casing diameter(s) 6 1/4
Length(s) of casing(s) 32 ft.
Length of screen ....
Type of screen ....
Type of pump ....
Capacity of pump ....
Depth of pump setting ....

Pumping Test

Date ....
Developed Capacity ....
Duration of Test ....
Pumping Rate ....
Drawdown ....
Static level of completed well 18
Is well a gravel-wall type? ....

Water Record

Kind (fresh or mineral) fresh
Quality (hard, soft, contains iron, sulphur etc.) hard.
Appearance (clear, cloudy, coloured) clear
For what purpose(s) is the water to be used? House.
How far is well from possible source of contamination? ....
What is source of contamination? ....
Enclose a copy of any mineral analysis that has been made of water ....

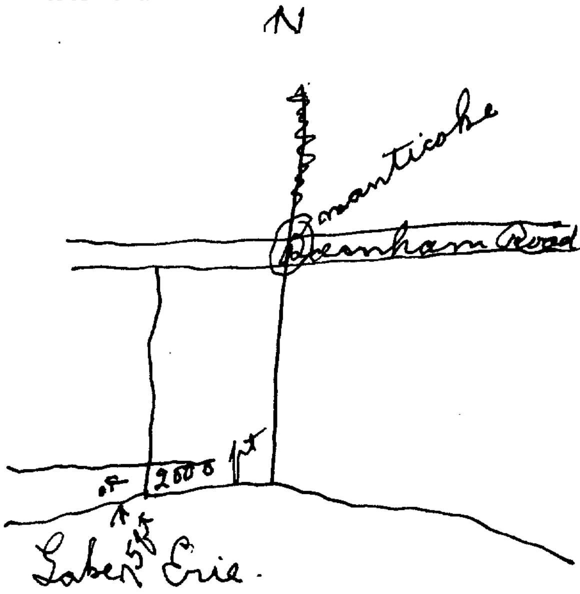
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
36	fresh.	24

Well Log

Drift and Bedrock Record	From	To
Sub-soil	0 ft.	3 ft.
Clay	3	32
Flint	32.	40

Location of Well

In diagram below show distances of well from road and **lot** line



Situation: Is well on upland, in valley, or on hillside? level
Drilling Firm Ivan Smelser
Address Jarvis
Recorded by I. Smelser Address Jarvis
Date Dec 30/49 Licence Number 417

CSS.S8

12 40I16E

OK

26 No. 922

UTM 17 Z 5758411 E
9 R 4738288 N
Elev. 9 R 0600
Basin 23

ONTARIO

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JAN 12 1950
GEOLOGICAL BRANCH
DEPARTMENT OF MINES

The Well Drillers Act

Department of Mines, Province of Ontario

Water Well Record

[redacted] Con. 1 Lot 5 Pt. Lot
Dover RR#3 Acres
cluding pump)

Pipe and Casing Record		**Pumping Test**	
Casing diameter(s)	6 1/4	Date	
Length(s) of casing(s)	48 ft.	Developed Capacity	
Length of screen		Duration of Test	
Type of screen		Pumping Rate	
Type of pump		Drawdown	
Capacity of pump		Static level of completed well	24 ft.
Depth of pump setting		Is well a gravel-wall type?	

Water Record

Kind (fresh or mineral) mineral
Quality (hard, soft, contains iron, sulphur etc.) sulfur
Appearance (clear, cloudy, coloured) dark
For what purpose(s) is the water to be used? farm use
How far is well from possible source of contamination?
What is source of contamination?
Enclose a copy of any mineral analysis that has been made of water

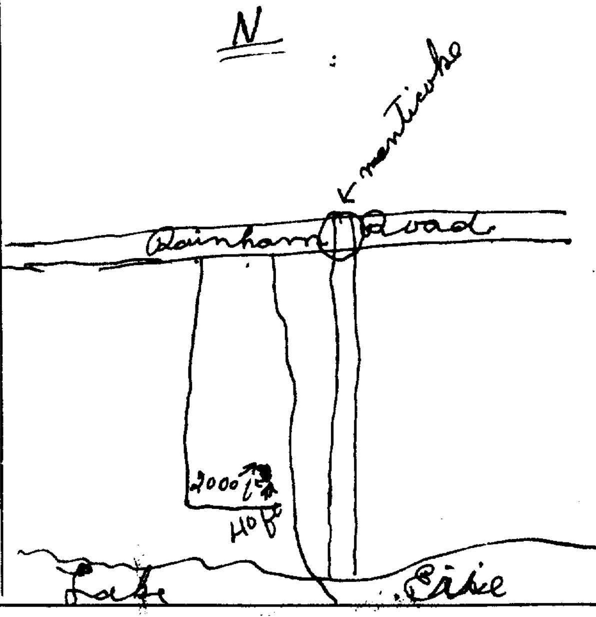
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
50 ft	hard	26 ft

Well Log

Drift and Bedrock Record	From	To
Clay surface	0 ft.	48 ft.
flint	48	56

Location of Well

In diagram below show distances of well from road and **lot** line



Situation: Is well on upland, in valley, or on hillside?
Drilling Firm Ivan Smelser
Address Jarvis
Recorded by I. Smelser Address Jarvis
Date Dec 30/49 Licence Number 417

CSS.S8

UTM 17 Z 576716 E

Co 5 R 4738602 N

Elev. 5 R 0575

Basin 23

40 I 16 E

GROUND WATER BRANCH
26
APR 14 1964
ONTARIO WATER RESOURCES COMMISSION

Nº 927

8

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District ~~Haldimand~~ Township, Village, Town or City Walpole township

Con 1 Lot 6 Date completed Mar.11/64 (day month year)

[redacted]ress 57 Burris St. Hamilton Ont.

Casing and Screen Record

Inside diameter of casing 6¼ in.

Total length of casing 32f t.

Type of screen

Length of screen

Depth to top of screen

Diameter of finished hole 6¼in.

Pumping Test

Static level 25ft.

Test-pumping rate 15-20 G.P.M.

Pumping level 25ft.

Duration of test pumping 1½hr.

Water clear or cloudy at end of test cloudy

Recommended pumping rate 10-15 G.P.M.

with pump setting of 30 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
clay	0	31		
flint	31	70	69	sulphur

For what purpose(s) is the water to be used? summer cottage

Is well on upland, in valley, or on hillside? upland

Drilling or Boring Firm Ray W.Swayze

Address R.R.5 Simcoe

Licence Number 1266

Name of Driller or Borer Ray Swayze

Address R.R.5 Simcoe

Date Mar.11/64

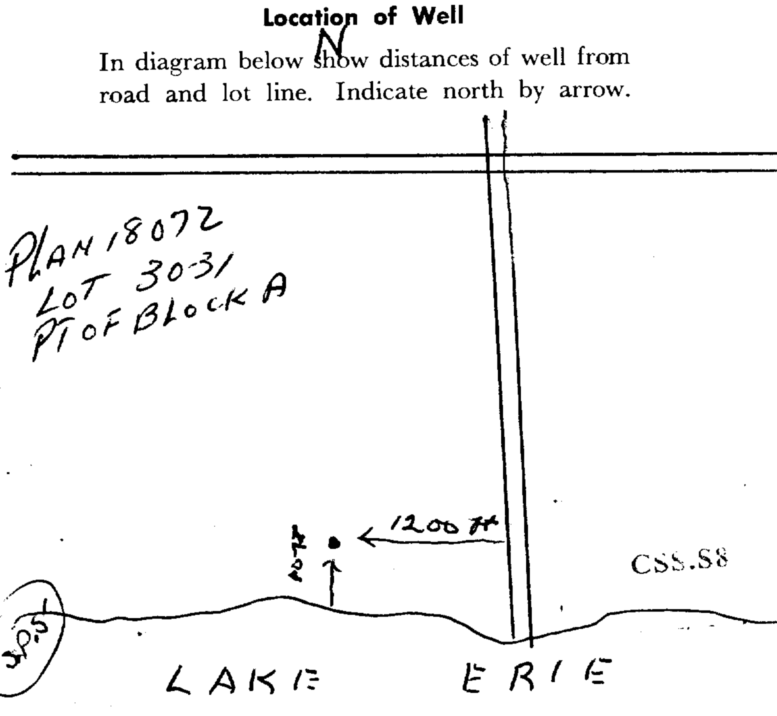
Ray Swayze
(Signature of Licensed Drilling or Boring Contractor)

Form 7 10M-62-1152

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

UTM 17 Z 578687 E
5 R 4739472 N
Elev. 5 R 04600
Basin 2B 9

40I16E

26 No. 928

GROUND WATER BRANCH
SEP 1 1960
RESOURCES COMMISSION

The Ontario Water Resources Commission Act, 1957

WATER WELL RECORD

County or District Haldimand Township, Village, Town or City ~~NANTICOKE~~ WALPOLE

~~8~~ T Lot # 9 Date completed 20 (day) aug. (month) 1960 (year)

[redacted]

ress

Casing and Screen Record

Inside diameter of casing 2"
Total length of casing 27
Type of screen —
Length of screen —
Depth to top of screen
Diameter of finished hole 2.

Pumping Test

Static level —
Test-pumping rate — G.P.M.
Pumping level —
Duration of test pumping —
Water clear or cloudy at end of test —
Recommended pumping rate — G.P.M.
with pumping level of —

Well Log / Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, sulphur)
Grey Clay and sand.	0	27	Dry Hole	—	—
Grey shale	27	190			

For what purpose(s) is the water to be used?
~~Home~~ Dry

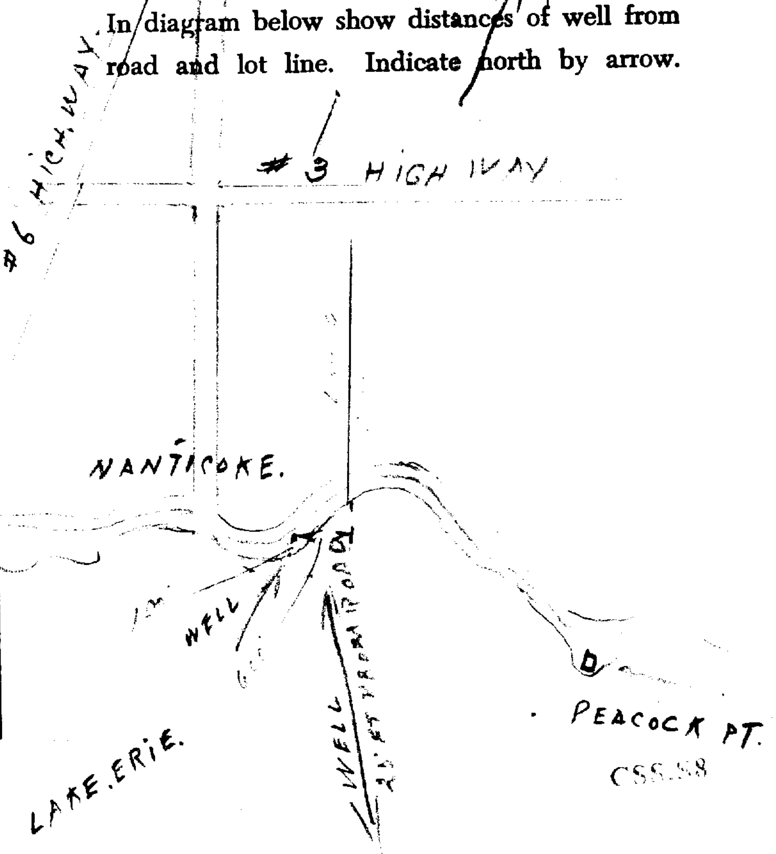
Is well on upland, in valley, or on hillside?
upland 1102

Drilling Firm Allard Bros
Address 54 Bay St N
Hamilton

Licence Number 521
Name of Driller O C Allard.
Address 54 Bay St N.
Date Sept 6th 1960.
Allard Bros Per O C Allard.
(Signature of Licensed Drilling Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.58

30/13W

UTM 17 Z 5783110 E
9 R 4738022 N
Elev. 9 R 0580 580
Basin 23

GROUND WATER BRANCH
JUL 29 1958
ONTARIO WATER RESOURCES COMMISSION

26 № 932

The Water-well Drillers Act, 1954
Department of Mines

Water-Well Record

County or Territorial District Haldimand Township, Village, Town or City twp of Walpole

[redacted]

Village, Town or City)

dress Nanticoke, Ont

Date completed
(day) (month) (year)

Pipe and Casing Record

Casing diameter(s) 6 1/4"
Length(s) 47'
Type of screen —
Length of screen —

Pumping Test

Static level 25' from surface
Pumping rate 250 G.P.H.
Pumping level 30'
Duration of test 1/2 hr.

Well Log

Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, or sulphur)
Redish Clay	0	47'			
flint	47'	60'	60'	35'	Sulphur

For what purpose(s) is the water to be used?
Public drinking water
Is water clear or cloudy? Clear
Is well on upland, in valley, or on hillside?

Drilling firm Elgin Stewart
Address Jarvis

Name of Driller
Address

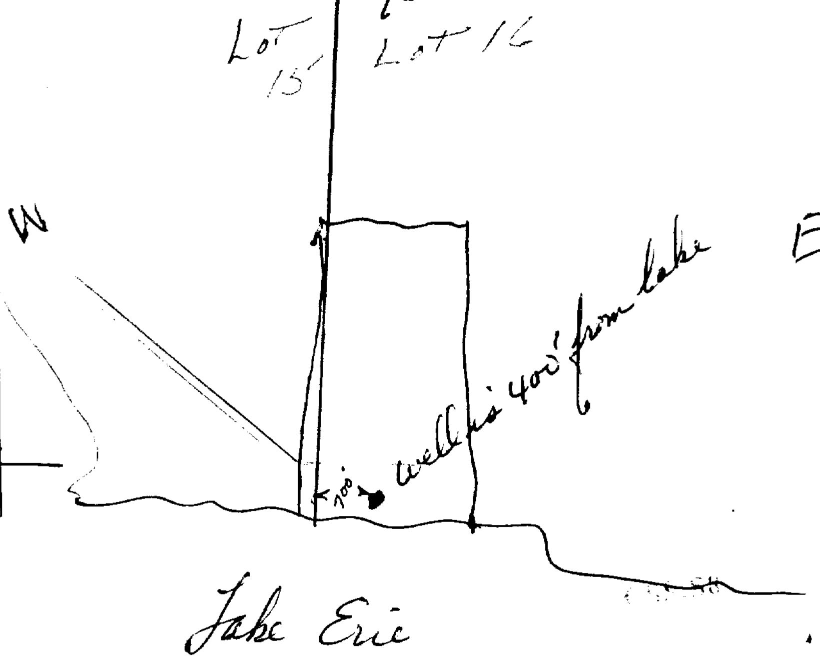
Licence Number 988

I certify that the foregoing statements of fact are true.

Date July 28/58 Elgin Stewart
Signature of Licensee

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 5

30113W

UTM 17 Z 585323 E
9 R 4739864 N
Elev. 9 R 0575
Basin 23

Con I
lot 20

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GEOLOGICAL BRANCH
DEPARTMENT OF MINES

26 № 939

M

ONTARIO

The Well Drillers Act
Department of Mines, Province of Ontario

Water Well Record

[redacted] Village, Town or City .... Tp Walpole

wn or City) .... Selkirk RR1

Date Completed 23 (day) 6 (month) / 55 (year) Cost of Well (excluding pump)

Pipe and Casing Record

Casing diameter(s) .... 3"
Length(s) of casing(s) .... 12'
Type of screen .... —
Length of screen .... —
Distance from top of screen to ground level .... —
Is well a gravel-wall type? .... Rock

Pumping Test

Date
Static level .... 12'
Pumping level .... 12'
Pumping rate .... 600 gal Pr hr
Duration of test
Distance from cylinder or bowls to ground level

Water Record

Kind (fresh or mineral) .... mineral
Quality (hard, soft, contains iron, sulphur, etc.) .... Iron
Appearance (clear, cloudy, coloured) .... clear
For what purpose(s) is the water to be used? .... domestic
How far is well from possible source of contamination? .... 15'
What is the source of contamination? .... septic
Enclose a copy of any mineral analysis that has been made of water

Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
water found at 26'	mineral	14'

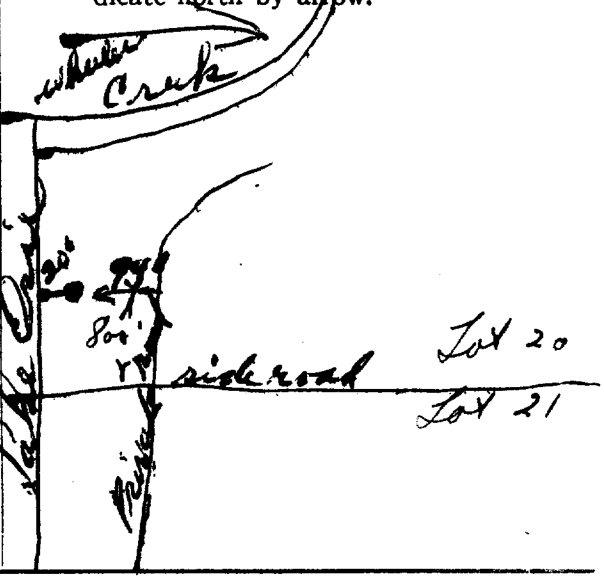
Well Log

Overburden and Bedrock Record	From	To
	0 ft.	....ft.
clay	0	11
Flint	11	29

Location of Well

M

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Situation: Is well on upland, in valley, or on hillside? .... upland
Drilling Firm .... F. A. Dennis & Sons
Address .... Selkirk RR1
Name of Driller .... F. A. Dennis
Address .... Selkirk Ont RR1
Date .... Aug 31/55
Licence Number 82

F. A. Dennis
Signature of Licensee

Form 5

WAM

UTM 17 Z 587273 E
9 R 4740561 N
Elev. 9 R 0575
CON 3
Basin 23
LOT 23

30 L13W

ONTARIO

26 No 982

GROUND WATER BRANCH
MAY 27 1958
ONTARIO WATER RESOURCES COMMISSION

The Water-well Drillers Act, 1954
Department of Mines

Water-Well Record

[redacted] ip, Village, Town or City Walpole
Village, Town or City)
ddress ALDERSHOT

Date completed 6 (day) MAY (month) 1958 (year)

Pipe and Casing Record

Casing diameter(s) 5 5/8
Length(s) 18'
Type of screen —
Length of screen —

Pumping Test

Static level 6'
Pumping rate 4 G.P.M.
Pumping level 20'
Duration of test 1 hr.

Well Log

Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, or sulphur)
CLAY	0	18	26	20	SULPHUR
[illegible] ROCK	18	26			

WAM

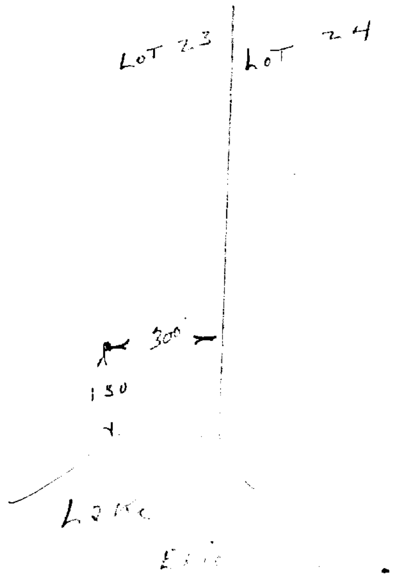
For what purpose(s) is the water to be used? COTTAGE
Is water clear or cloudy? CLOUDY
Is well on upland, in valley, or on hillside? UPLAND
Drilling firm HOWARD CROSS
Address RYCKMAN'S CORNERS
Name of Driller ARTHUR CROSS
Address RYCKMAN'S CORNERS
Licence Number

I certify that the foregoing statements of fact are true.

Date MAY 26 Howard Cross
Signature of Licensee

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 5

CSS.S8

UTM ~~17~~ Z 587666 E 30413W
9 R 4740830 N
Elev. 9 R 0575
Basin 23
Con I
lot 24

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AUG 8 195[illegible]
GEOLOGICAL BRANCH
DEPARTMENT of MINES

26 No 1001

ONTARIO

The Water-well Drillers Act, 1954

Department of Mines

Water-Well Record

County or Territorial District Haldimand Township, ~~Village, Town or City~~ Walpole

[redacted]

Village, Town or City)

Address Cooksville Ont

(day) (month) (year)

Pipe and Casing Record

Casing diameter(s) 6 1/4"
Length(s) 11 ft
Type of screen
Length of screen

Pumping Test

Static level 13 ft
Pumping rate 20 gals per minute
Pumping level 20'
Duration of test

Well Log

Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, or sulphur)
Clay	0	10			
Flint	10	22	21	8 ft	sulphur

For what purpose(s) is the water to be used? Cottage

Is water clear or cloudy? Clear

Is well on upland, in valley, or on hillside? Upland

Drilling firm Ray Swayze
Address Simcoe R R 5

Name of Driller Ray Swayze
Address Simcoe R R 5

Licence Number 271

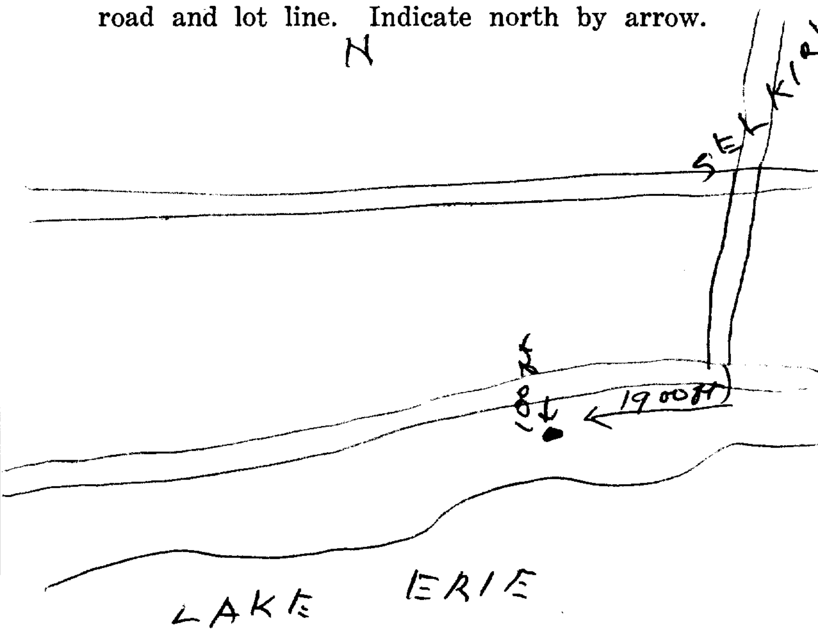
I certify that the foregoing statements of fact are true.

Date July 19 Ray Swayze
Signature of Licensee

BW

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

Form 5

UTM 17 | 5912 2~~8~~0 6
4R | 4741 8 ~~70~~ 65
~~LS 6988~~ 599
n | 23 |

Con I
Lot 8
CODED

30 L/13 W
(30 L/13 C)
2601275 - 1
3 9

DIVISION OF
WATER RESOURCES
DEC 16 1968
ONTARIO WATER
RESOURCES COMMISSION

~~30 L/13 W~~ B.

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or ~~District~~ HALDIMAND ~~SOUTH CAYUGA.~~ Township, Village, Town or City RAINHAM ~~HALD~~

Date completed 5 (day NOV month 68 year)

[redacted]

ess ~~FISHERSVILLE~~. 75 SELKIRK ONT ~~HOUSE~~

Casing and Screen Record

Inside diameter of casing 6½"
Total length of casing 12'
Type of screen NIL
Length of screen NIL
Depth to top of screen NIL
Diameter of finished hole 6½.

Pumping Test

Static level 13'
Test-pumping rate 10 G.P.M.
Pumping level 19'
Duration of test pumping 2 HOURS
Water clear or cloudy at end of test CLEAR
Recommended pumping rate 10 G.P.M.
with pump setting of 25' feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
CLAY	0	11		
FLINT	11	28½	27'	~~27'~~ FRESH

For what purpose(s) is the water to be used? HOUSE

Is well on upland, in valley, or on hillside? LEVEL

Drilling or Boring Firm ELGIN MITCHELL,

Address JARVIS,

Licence Number 2928

Name of Driller or Borer FRED M,

Address

Date NOV. 11 / 68.

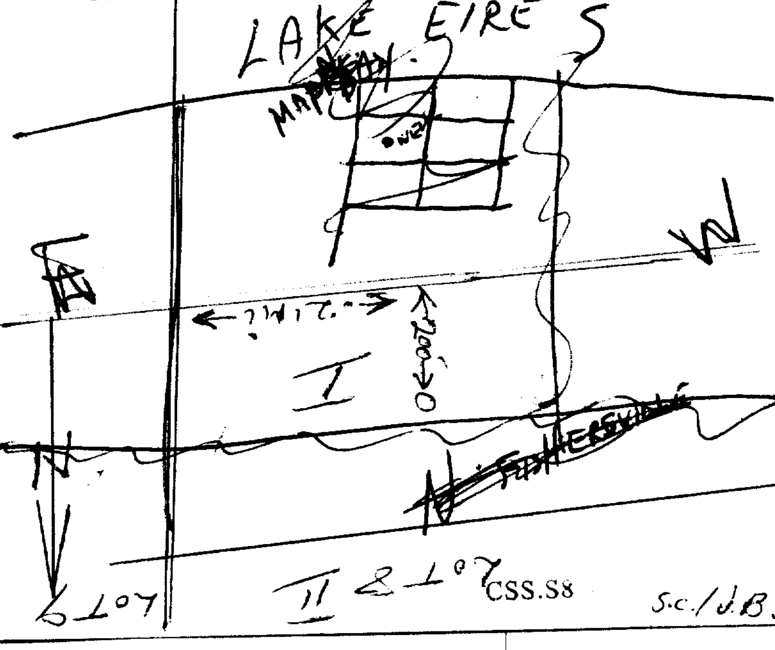
Elgin Mitchell
(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M-60-4138

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

S.c./J.B.

17 59086~~8~~5
15TR 4740 9~~6~~10
~~4B~~ 105 ~~79~~ 50
23

Con I
Lot 5
CODED

2601283
3 9

304/13W
(304/13d) 7

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or ~~District~~ HALDIMAND Township, ~~Village, Town or City~~ RAINHAM

Con 1 Lot 5 Date completed 1 (day) JUNE month 1968 year)

[redacted]ress Riverdrive PT-Davey

Casing and Screen Record

Inside diameter of casing 6 5/8"
Total length of casing 27'
Type of screen —
Length of screen —
Depth to top of screen —
Diameter of finished hole 6"

Pumping Test

Static level 17'
Test-pumping rate 5 G.P.M.
Pumping level 32'
Duration of test pumping 2 hrs
Water clear or cloudy at end of test clearing
Recommended pumping rate 3 G.P.M.
with pump setting of 32' feet below ground surface

Well Log			Water Record	
Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
BLACK SOIL	0	3		
BLUE CLAY	3	27		
FLINT	27	41	[illegible]	
			~~[illegible]~~ 40'	
			~~[illegible]~~	
			17	FRESH
			40	SULPHUR
			PLUGGED OFF	

For what purpose(s) is the water to be used? HOUSEHOLD

Is well on upland, in valley, or on hillside? UPLAND

Drilling or Boring Firm Robert Dennis

Address RR2 BRANTFORD

Licence Number 2813

Name of Driller or Borer SAME

Address

Date June 4/68

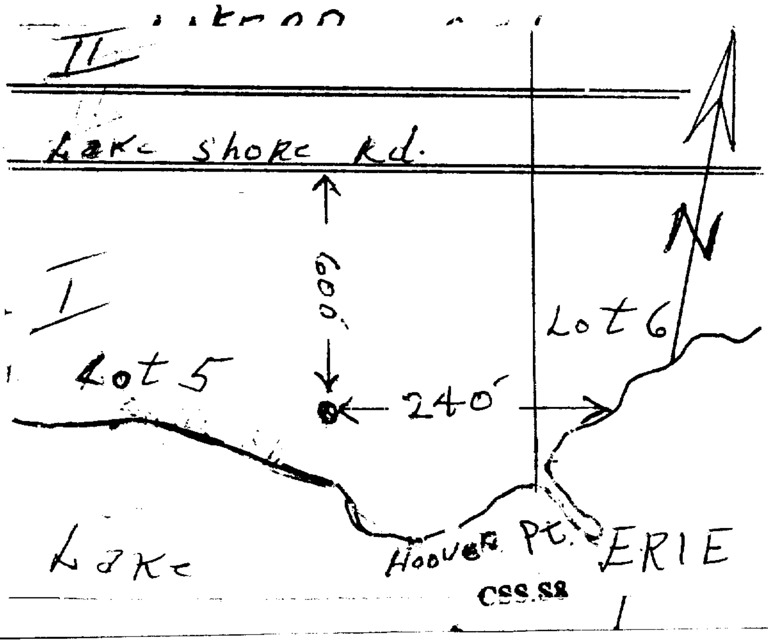
Robert Dennis
(Signature of Licensed Drilling or Boring Contractor)

Form 7 5M 60-20912

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

UTM 17 Z 387680 E

5 R 4740~~4~~580 N

Elev. R 05~~35~~80

Basin 23

Con I
Lot 24

CODED

2601309-P

304/13W
(304/13d)
71

WATER RESOURCES DIVISION
AUG 19 1968

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District: HALDIMAND
Township, Village, Town or City: WALPOLE
Con.: ~~#~~ I
Lot: ~~9~~ 24
Date completed: June 1968 (day month year)

[redacted]ress: 1671 King St. E.

Casing and Screen Record

Inside diameter of casing: 5 5/8"
Total length of casing: 11'
Type of screen: —
Length of screen: —
Depth to top of screen: —
Diameter of finished hole: 5"

Pumping Test

Static level: 12'
Test-pumping rate: 3 G.P.M.
Pumping level: 15'
Duration of test pumping: 2 HRS
Water clear or cloudy at end of test: CLEAR
Recommended pumping rate: 2 G.P.M.
with pump setting of 24 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
BROWN CLAY	0	11	24	FRESH
FLINT	11	26		

For what purpose(s) is the water to be used? ~~UPLAND~~ HOUSEHOLD

Is well on upland, in valley, or on hillside? UPLAND

Drilling or Boring Firm: ROBERT DENNIS

Address: RR2, BRANTFORD

Licence Number: 2813

Name of Driller or Borer: SAME

Address:

Date: June 24/68

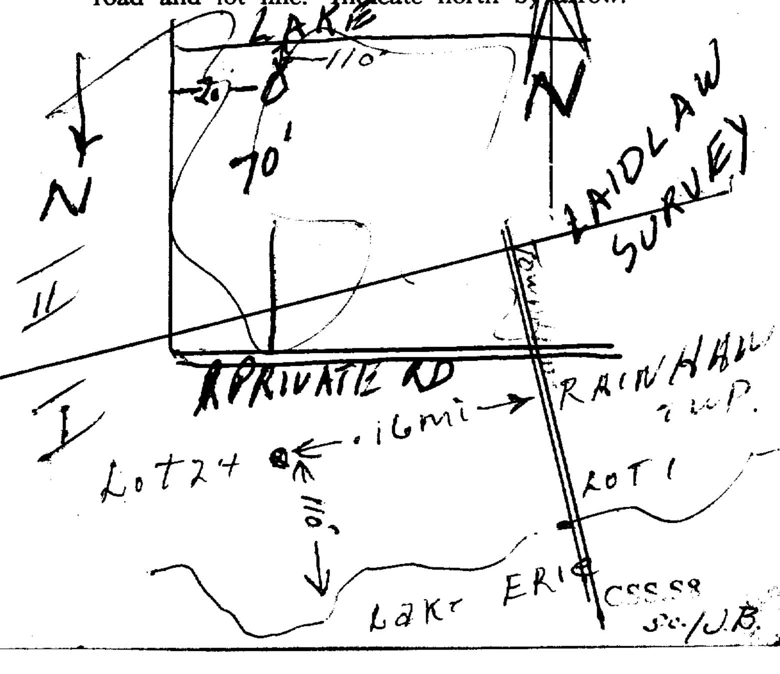
Robert Dennis
(Signature of Licensed Drilling or Boring Contractor)

Form 7 5M 60-20912

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



UTM 17 E ~~4739~~ 581700 Con I
5 N 4739028 R **CODED**
Elev. 4 ~~8~~ R 585 ~~78~~ 92
Basin 23

2601326
3 9

40I/16E J.B.
(40I/16a)

2 1968

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District Haldimand Township, ~~Village, Town or City~~ Walpole
Con. I Lot # 14 Date completed 7 (day) May (month) 19.68 (year)

[redacted]ss 47 Eccl[illegible]in St Brantford

Casing and Screen Record

Inside diameter of casing 6¼
Total length of casing 56
Type of screen –
Length of screen –
Depth to top of screen –
Diameter of finished hole 6"

Pumping Test

Static level 70
Test-pumping rate 2 G.P.M.
Pumping level 63
Duration of test pumping 2 hours
Water clear or cloudy at end of test Clear
Recommended pumping rate 2 G.P.M.
with pump setting of 60 feet below ground surface

Well Log

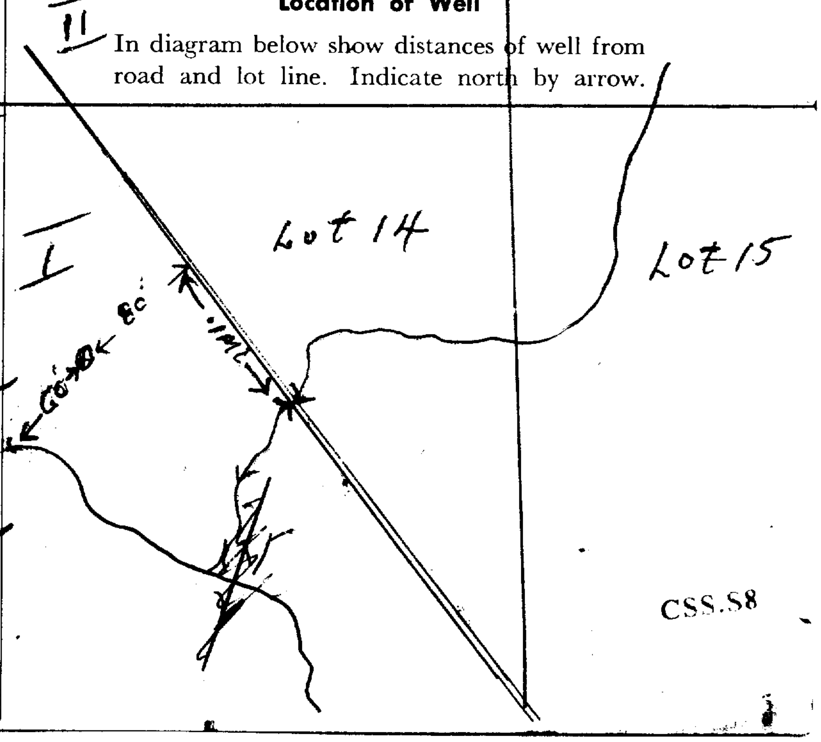
Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Brown Clay	0	18	63	Sulphur
Blue Clay	18	56		
Limerock	56	63		

For what purpose(s) is the water to be used? Cottage
Is well on upland, in valley, or on hillside? upland
Drilling or Boring Firm as below
Address
Licence Number 2943
Name of Driller or Borer Frank Ince
Address 175 Aldercrest Ave.
Date May 7. Hamilton Ont.
(Signature of Licensed Drilling or Boring Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

Form 7 15M-60-4138

OWRC COPY

304/13E
(304/13a)

The Ontario Water Resources Commission Act

WATER WELL RECORD

Water management in Ontario

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 2601412

MUNICIP. 26009 CON. CON 01

COUNTY OR DISTRICT [redacted]

TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: Sherbrooke

CON., BLOCK, TRACT, SURVEY, ETC.: 1

LOT 013

Dennistown Welland

DATE COMPLETED DAY 10 MO. ~~June~~ 06 YR. 70

44 RC. 4 ELEVATION 860 5 BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH – FEET FROM	DEPTH – FEET TO
Gray	Clay			0	45
"	Clay & gravel			45	65
Gray & white	Rock			65	76

31 0045205 0065205 11 0076226

32

41 WATER RECORD

WATER FOUND AT – FEET	KIND OF WATER
0076	~~1 ☐ FRESH~~ ~~3 ☐ SULPHUR~~ 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH – FEET FROM	DEPTH – FEET TO
~~6~~ 06	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	188	0	0065 ~~65~~
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE		65	0076 ~~76~~
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.) DIAMETER INCHES LENGTH FEET

MATERIAL AND TYPE DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT – FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD 1 ☐ PUMP 2 ☒ BAILER

PUMPING RATE ~~6~~ 0006 GPM.

DURATION OF PUMPING 01 HOURS 30 MINS.

WATER LEVELS DURING 1 ☒ PUMPING 2 ☐ RECOVERY

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
042 FEET	065 FEET	065 FEET	FEET	FEET	FEET

IF FLOWING, GIVE RATE GPM.

PUMP INTAKE SET FEET

WATER AT END OF TEST 1 ☒ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE ☐ SHALLOW ☒ DEEP

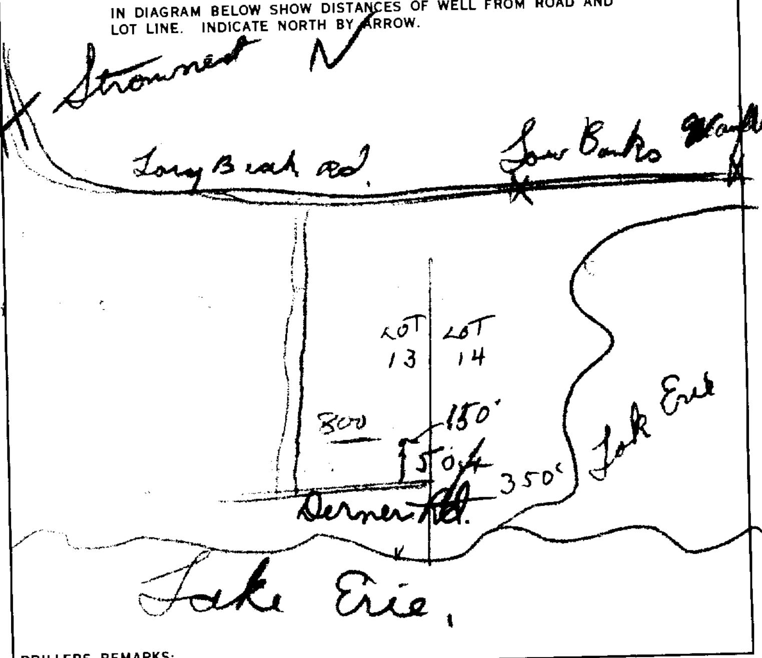
RECOMMENDED PUMP SETTING 070 FEET

RECOMMENDED PUMPING RATE 0005 GPM.

000.3 GPM./FT. SPECIFIC CAPACITY

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

FINAL STATUS OF WELL

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING

1 ☒ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR: S.W. Merritt LICENCE NUMBER 3609

ADDRESS: R.R.1 Smithville

NAME OF DRILLER OR BORER: Sidney Merritt LICENCE NUMBER 3609

SIGNATURE OF CONTRACTOR: Sidney Merritt

SUBMISSION DATE DAY 10 MO. June YR. 70

OFFICE USE ONLY

DATA SOURCE 1 CONTRACTOR 3609 DATE RECEIVED 300970

DATE OF INSPECTION 10.5.71 INSPECTOR 7 LP 5.C.7

REMARKS:

CSS.S8

OWRC COPY

CODED

2601421
3 9

30L/13
(30L/13c)
Oct. 30, 1970

UTM 17 Z 596640
4 R 47429 ~~8~~ 6 0
~~8~~ 4 R 0 ~~6~~ 5 ~~2~~ 8 5

Water management in Ontario

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District 23 19 Haldimand
Township, Village, Town or City Rainham
Con. 1
Lot 15
Date completed 19 (day) May month 19/70 year)
Owner [redacted] (print in block letters)
Address Hamilton.

Casing and Screen Record

Inside diameter of casing 6¼
Total length of casing 17 ft.
Type of screen —
Length of screen —
Depth to top of screen
Diameter of finished hole 6¼

Pumping Test

Static level 8½ ft.
Test-pumping rate 10 G.P.M.
Pumping level 18 ft.
Duration of test pumping 1 hr.
Water clear or cloudy at end of test cloudy
Recommended pumping rate 8 G.P.M.
with pump setting of 19 feet below ground surface

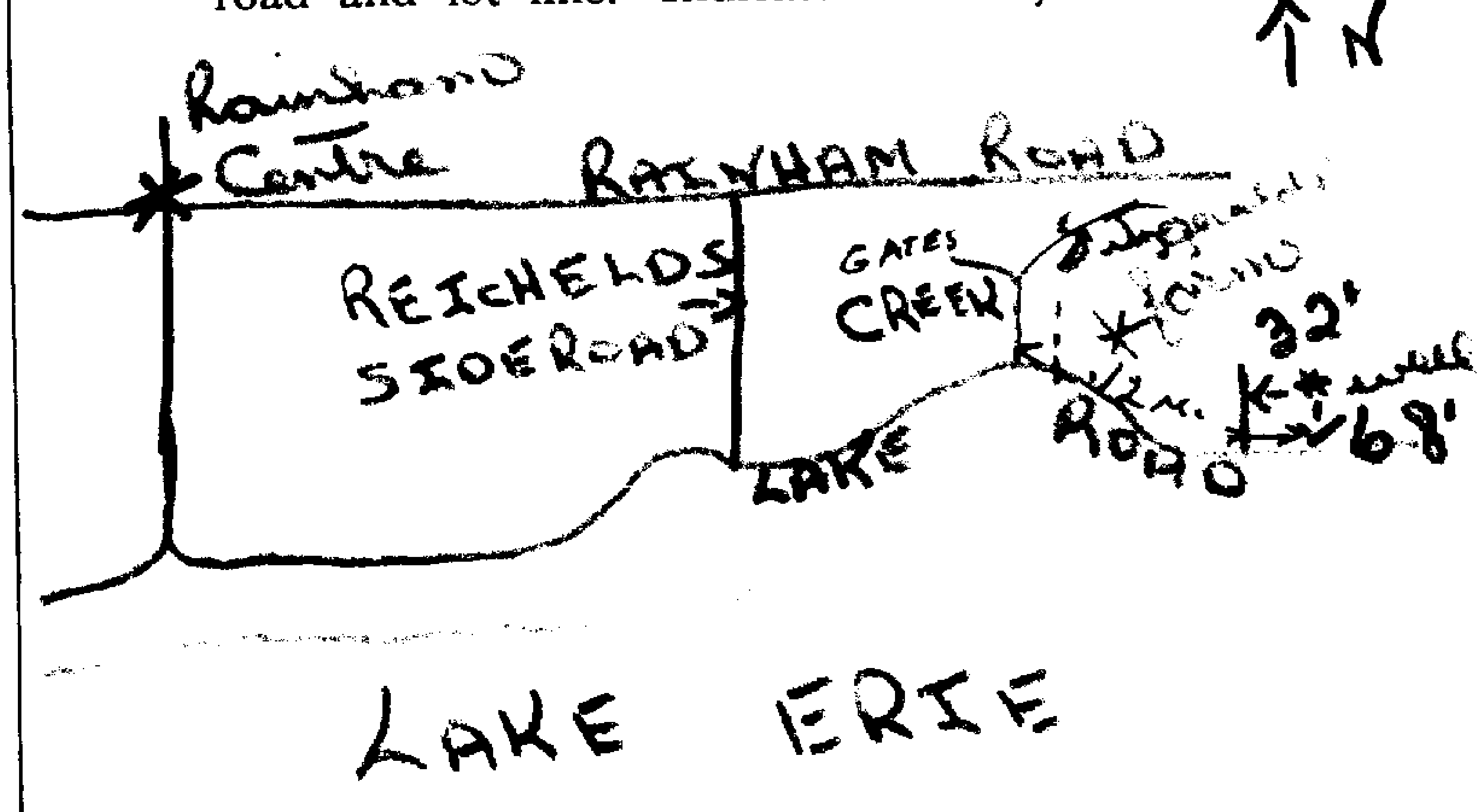
Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Clay	0	15		
Flint	15	22		
			19-20	Slightly Sulphur

For what purpose(s) is the water to be used? Summer cottage
Is well on upland, in valley, or on hillside? upland
Drilling or Boring Firm Jack Culver.
Address R.R. 1 Selkirk
Licence Number 1662
Name of Driller or Borer Jack Culver.
Address R R 1 Selkirk
Date Aug 19/70
Jack Culver
(Signature of Licensed Drilling or Boring Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 7

OWRC COPY

CSS.S8

30 L13 W
(30 L/13 d)

The Ontario Water Resources Commission Act

WATER WELL RECORD

Water management in Ontario

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11

2601511

MUNICIP. 26007 CON. CON 01

COUNTY OR ~~DISTRICT~~ WALDIMAND
TOWNSHIP, ~~BOROUGH, CITY, TOWN, VILLAGE~~ RAINHAM
CON., ~~BLOCK, TRACT, SURVEY, ETC.~~ 1
LOT 007

[redacted]

49 UPPE SHERMAN AVE
HAMILTON
DATE COMPLETED DAY 10 MO. 12 YR. 71

41590 4 R.C. ELEVATION 6575 5 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH – FEET FROM	DEPTH – FEET TO
GREY	CLAY			0	11
	FLINT			11	23

31 0011205 0023 15

32

41 WATER RECORD

WATER FOUND AT – FEET	KIND OF WATER
0022	1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH – FEET FROM	DEPTH – FEET TO
~~6~~ 06	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	.188	0 ~~11-6~~	~~11-6~~ ~~Top~~ 0012
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE		11-6"	~~23~~ 0023
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)
DIAMETER INCHES
LENGTH FEET
MATERIAL AND TYPE
DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT – FEET FROM	DEPTH SET AT – FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD 1 ☒ PUMP 2 ☐ BAILER
PUMPING RATE — GPM.
DURATION OF PUMPING 08 HOURS 00 MINS.

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
012 ~~8~~ FEET	~~23~~ NIL 023 FEET	~~a low~~ FEET	~~8 hrs~~ FEET	~~10'~~ FEET	FEET

WATER LEVELS DURING 1 ☐ PUMPING 2 ☒ ~~RECOVERY~~

IF FLOWING, GIVE RATE GPM.
PUMP INTAKE SET AT FEET
WATER AT END OF TEST 1 ☒ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE ☒ SHALLOW ☐ DEEP
RECOMMENDED PUMP SETTING 022 FEET
RECOMMENDED PUMPING RATE 0000 ~~4 GPM~~ GPM.
____________ GPM./FT. SPECIFIC CAPACITY

FINAL STATUS OF WELL

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

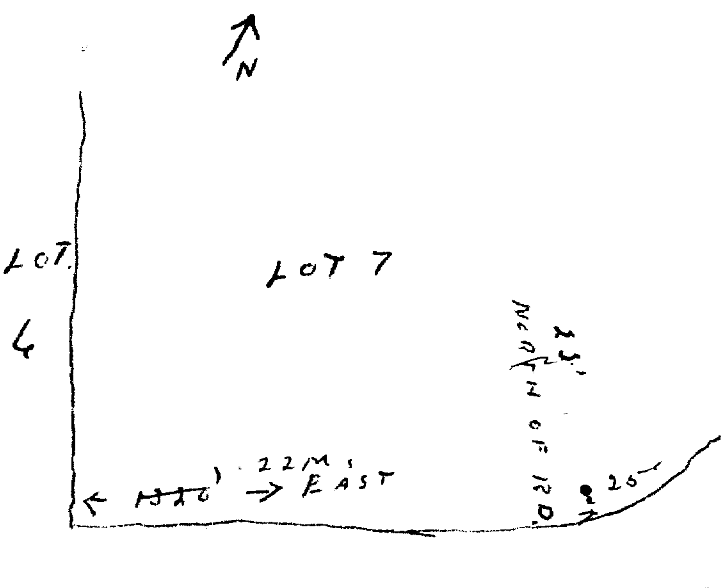
1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER SOMMER COTTAGE
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING

1 ☒ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS: LAKE ERIE

CONTRACTOR

NAME OF WELL CONTRACTOR J.R. NAUMAN
LICENCE NUMBER 3801
ADDRESS FISHERVILLE ONT
NAME OF DRILLER OR BORER J.R. NAUMAN
LICENCE NUMBER 3801
SIGNATURE OF CONTRACTOR J. R. Nauman
SUBMISSION DATE DAY 4 MO. 1 YR. 72

OFFICE USE ONLY

DATA SOURCE 1
CONTRACTOR 3801
DATE RECEIVED 120172
DATE OF INSPECTION 25/1/72
INSPECTOR
REMARKS:
CSS.S8

OWRC COPY

30-/140 ~~30-/135~~

MINISTRY OF THE ENVIRONMENT

The Ontario Water Resources Act

WATER WELL RECORD

Ontario

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11

2601678 MUNICIP. 126009 CON. CON 01

COUNTY OR DISTRICT Haldimand	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE Sherbrooke	CON., BLOCK, TRACT, SURVEY, ETC. Con 1	LOT 017

[redacted] 2 Else Street St. Catherines

DATE COMPLETED DAY 21 MO. 08 Aug. YR. 74

744280 RC 4 ELEVATION 0620 RC 4 BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
brown	clay	stones	packed	0	12·6
grey	limestone	flint	layered	12·6	45

31 00136051 2 0045215

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0043	1 ☐ FRESH 3 ☒ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
~~6¼~~ 06	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	.188	0	~~12·6~~ 0013
06	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE		12·6	~~45~~ 0045
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET

MATERIAL AND TYPE — DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD 1 ☐ PUMP 2 ☒ BAILER

PUMPING RATE 0001 GPM.

DURATION OF PUMPING 01 HOURS 00 MINS.

WATER LEVELS DURING 1 ☐ PUMPING 2 ☒ RECOVERY

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
012 FEET	045 FEET	030 FEET	015 FEET	012 FEET	012 FEET

IF FLOWING, GIVE RATE GPM.

PUMP INTAKE SET AT FEET

WATER AT END OF TEST 1 ☐ CLEAR 2 ☒ CLOUDY

RECOMMENDED PUMP TYPE ☐ SHALLOW ☒ DEEP

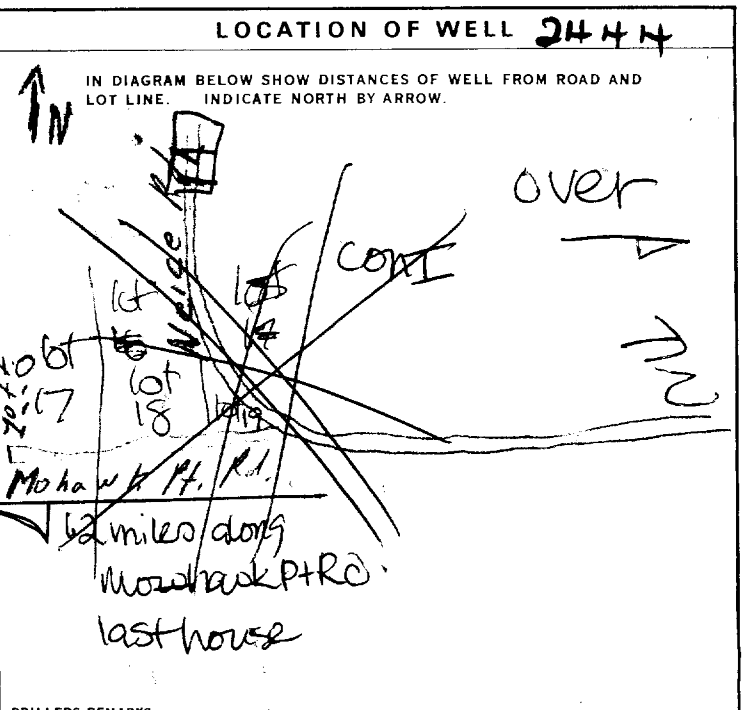
RECOMMENDED PUMP SETTING 043 FEET

RECOMMENDED PUMPING RATE 0001 GPM.

GPM./FT. SPECIFIC CAPACITY

LOCATION OF WELL 2444

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

FINAL STATUS OF WELL 1

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 1

1 ☒ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR Donald Merritt — LICENCE NUMBER 3640

ADDRESS RR #1 Smithville

NAME OF DRILLER OR BORER Donald Merritt — LICENCE NUMBER 3640

SIGNATURE OF CONTRACTOR Donald Merritt — SUBMISSION DATE DAY 21 MO. Aug. YR. 74

OFFICE USE ONLY

DATA SOURCE 1 — CONTRACTOR 3640 — DATE RECEIVED 040974

DATE OF INSPECTION — INSPECTOR

REMARKS: CSS.S8

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FORM 7 07-091

Ontario

MINISTRY OF THE ENVIRONMENT
The Ontario Water Resources Act

WATER WELL RECORD

30L/13W

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11 | 12601721 | MUNICIP. 26007 | CON. CØN | 01

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT
[redacted]	Rainham	1	8 009

[redacted] 25 Bay St. N. Hamilton

DATE COMPLETED DAY 07 MO. 06 YR. 75

741850 | RC. 5 | ELEVATION 0575 | RC. 5 | BASIN CODE 23 | II | III | IV

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
Br	Clay			0	10
Grey	Clay			10	18
Grey	Flint			18	27½

31 | 0010605 | 0018205 | 0028240

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0027	1 ☐ ~~FRESH~~ 3 ☑ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
06 6¼	1 ☑ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☑ OPEN HOLE	.188	0 19	0019 27½
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☑ OPEN HOLE			0028
	1 ☐ STEEL 2 ☐ CALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET

MATERIAL AND TYPE | DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD 1 ☐ PUMP 2 ☑ BAILER

PUMPING RATE 0020 GPM.

DURATION OF PUMPING 01 HOURS 00 MINS

WATER LEVELS DURING 1 ☒ PUMPING 2 ☐ RECOVERY

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
010 FEET	FEET	013 FEET	014 FEET	014 FEET	014 FEET

IF FLOWING, GIVE RATE GPM

PUMP INTAKE SET AT FEET

WATER AT END OF TEST 1 ☐ CLEAR 2 ☑ CLOUDY

RECOMMENDED PUMP TYPE ☑ SHALLOW ☐ DEEP

RECOMMENDED PUMP SETTING 022 FEET

RECOMMENDED PUMPING RATE 0010 GPM.

GPM./FT. SPECIFIC CAPACITY

FINAL STATUS OF WELL 1

1 ☑ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

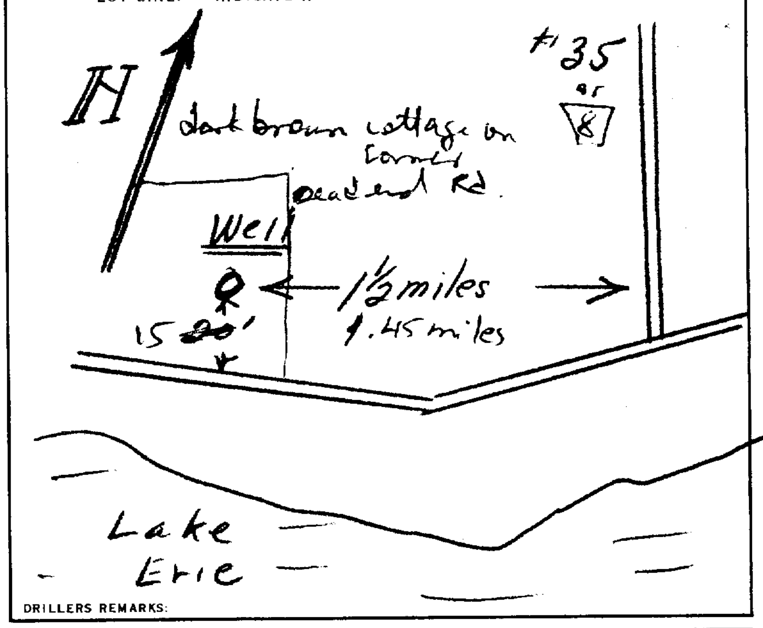
1 ☑ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 1

1 ☑ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

CONTRACTOR

NAME OF WELL CONTRACTOR C. J. Wallis

LICENCE NUMBER 5417

ADDRESS RR #2 Stoney Creek

NAME OF DRILLER OR BORER

LICENCE NUMBER

SIGNATURE OF CONTRACTOR C. J. Wallis

SUBMISSION DATE DAY ____ MO. ____ YR. ____

OFFICE USE ONLY

DATA SOURCE 1 | CONTRACTOR 5417 | DATE RECEIVED 02 07 75

DATE OF INSPECTION July 29/77 | INSPECTOR EG

REMARKS:

CSS

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FORM 7 07-091

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11

2602105

MUNICIP 10 14 | CON. 15 22 23 24

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT 25-27
[redacted]	SHERBROOK	ONE	P.T. 10

RR#2 LOWBANKS

DATE COMPLETED 48-53 DAY 25 MO OCT YR 83

RC 25 | ELEVATION 26 | RC 30 | BASIN CODE 31 | II | III | IV 47

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
REDISH	SANDY			0	35
GREY	REDISH BROWN			35	94
BROWN	CLAY & SAND			94	109
FLINTROCK				109	
	DRY HOLE	OWNER WANTED TO QUIT DRILLING			
			PULLED CASING		

31

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
10-13	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
15-18	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
20-23	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
25-28	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
30-33	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
10-11 6 1/4	12 1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE		0	13-16 109
17-18	19 1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			20-23
24-25	26 1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			27-30

SCREEN

SIZE(S) OF OPENING (SLOT NO.) 31-33	DIAMETER 34-38	LENGTH 39-40
	6 1/4 INCHES	FEET
MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN 41-44 FEET	30

61 PLUGGING & SEALING RECORD

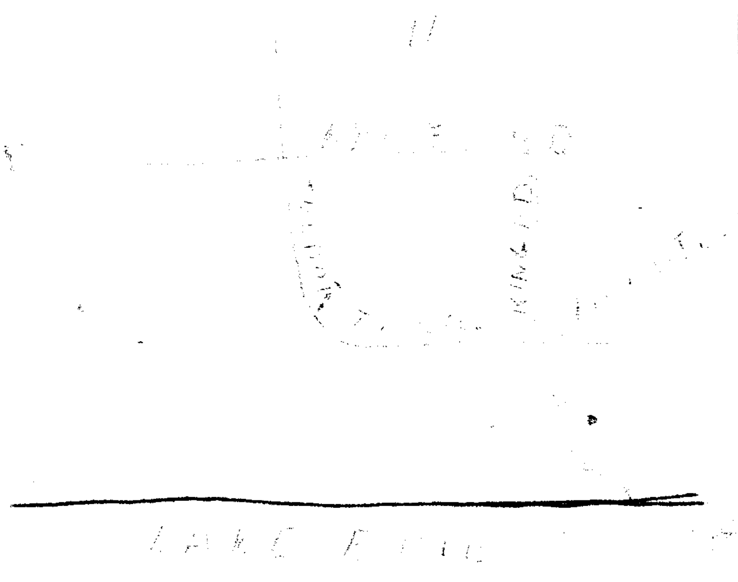
DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
10-13	14-17	PLUGGED
18-21	22-25	
26-29	30-33	80

71 PUMPING TEST

PUMPING TEST METHOD 10: 1 ☐ PUMP 2 ☐ BAILER
PUMPING RATE 11-14 GPM
DURATION OF PUMPING 15-16 HOURS 17-18 MINS
STATIC LEVEL 19-21 FEET
WATER LEVEL END OF PUMPING 22-24 FEET
25 WATER LEVELS DURING 1 ☐ PUMPING 2 ☐ RECOVERY
15 MINUTES 26-28 FEET | 30 MINUTES 29-31 FEET | 45 MINUTES 32-34 FEET | 60 MINUTES 35-37 FEET
IF FLOWING GIVE RATE 38-41 GPM
PUMP INTAKE SET AT FEET
WATER AT END OF TEST 42: 1 ☐ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE ☐ SHALLOW ☐ DEEP
RECOMMENDED PUMP SETTING 43-45 FEET
RECOMMENDED PUMPING RATE 46-49 GPM
50-53

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS

FINAL STATUS OF WELL

54
1 ☐ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE

55-56
1 ☐ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING

57
1 ☐ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR: James F Wickett | LICENCE NUMBER: 5405
ADDRESS: RR#2 Lowbanks N0A 1K0
NAME OF DRILLER OR BORER: James Wickett | LICENCE NUMBER: 5405
SIGNATURE OF CONTRACTOR: James | SUBMISSION DATE: DAY 29 MO Jan YR 84

OFFICE USE ONLY

DATA SOURCE 58 | CONTRACTOR 59-62 | DATE RECEIVED 63-68 120184 | 80
DATE OF INSPECTION | INSPECTOR
REMARKS

CSS.ES

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506—4—77 FORM 7

Ministry of Environment and Energy
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

11

2602506

Municipality 26009 Con.

HALDIMAND

39 GRAND RIVER LANE

County or District [redacted]

Township/Borough/City/Town/Village: DUNNVILLE

Con block tract survey, etc.: BECKLEY BEACH

Lot

Address: 39 GRAND RIVER LINE

Date completed: 9 day 8 month 96 year

21 Northing RC Elevation RC Basin Code ii iii iv

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth – feet From	Depth – feet To
BROWN	TOP-SOIL			0	1
BROWN	SAND			1	17
BROWN	SAND		COARSE.	17	22
BROWN	SAND & GRAVEL		COARSE	22	28

31

32

41 WATER RECORD

Water found at – feet	Kind of water
17-28	☑ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

51 CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth – feet From	Depth – feet To
36	☐ Steel ☐ Galvanized ☑ Concrete ☐ Open hole ☐ Plastic	3	0	27½
24	☐ Steel ☑ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	18g	16	28
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Sizes of opening (Slot No.)
Diameter inches
Length feet
Material and type: PEA STONE
Depth at top of screen feet

61 PLUGGING & SEALING RECORD

☐ Annular space ☐ Abandonment

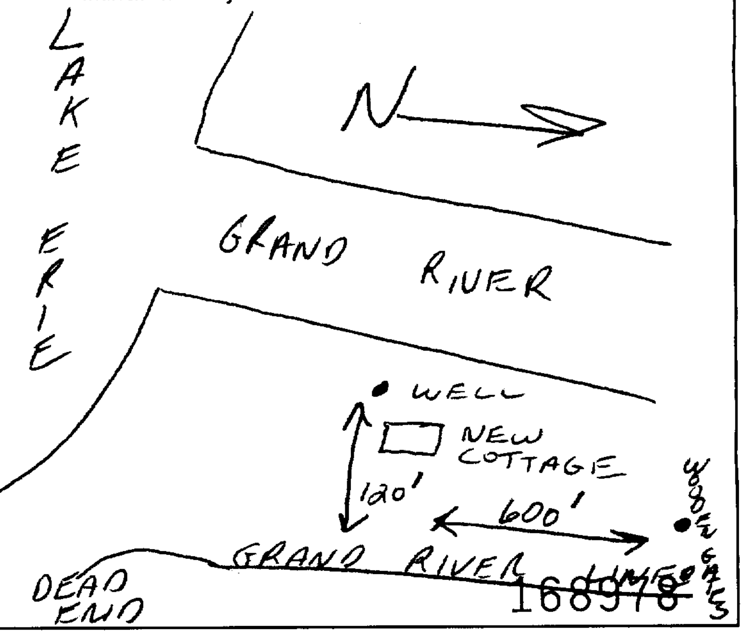
Depth set at – feet From	Depth set at – feet To	Material and type (Cement grout, bentonite, etc.)
0	7½	SAKRITE &
		BENTINITE JOINTS

71 PUMPING TEST

Pumping test method ☐ Pump ☐ Bailer
Pumping rate GPM
Duration of pumping .... Hours .... Mins
Static level: 17 feet
Water level end of pumping feet
Water levels during ☐ Pumping ☐ Recovery
15 minutes feet
30 minutes feet
45 minutes feet
60 minutes feet
If flowing give rate GPM
Pump intake set at feet
Water at end of test ☐ Clear ☐ Cloudy
Recommended pump type ☑ Shallow ☐ Deep
Recommended pump setting 25 feet
Recommended pump rate 3 GPM

LOCATION OF WELL

In diagram below show distances of well from road and lot line.
Indicate north by arrow.



FINAL STATUS OF WELL

- ☑ Water supply
- ☐ Observation well
- ☐ Test hole
- ☐ Recharge well
- ☐ Abandoned, insufficient supply
- ☐ Abandoned, poor quality
- ☐ Abandoned (Other)
- ☐ Dewatering
- ☐ Unfinished
- ☐ Replacement well

WATER USE

- ☑ Domestic
- ☐ Stock
- ☐ Irrigation
- ☐ Industrial
- ☐ Commercial
- ☐ Municipal
- ☐ Public supply
- ☐ Cooling & air conditioning
- ☐ Not used
- ☐ Other ....

METHOD OF CONSTRUCTION

- ☐ Cable tool
- ☐ Rotary (conventional)
- ☐ Rotary (reverse)
- ☐ Rotary (air)
- ☐ Air percussion
- ☑ Boring
- ☐ Diamond
- ☐ Jetting
- ☐ Driving
- ☐ Digging
- ☐ Other ....

Name of Well Contractor: JOHNSON & BAETZ
Well Contractor's Licence No.: 3030
Address: RR#1, MT. PLEASANT
Name of Well Technician: DON BAETZ
Well Technician's Licence No.: T-0338
Signature of Technician/Contractor
Submission date day mo yr

MINISTRY USE ONLY
Data source
Contractor 3030
Date received SEP 19 1996
Date of inspection
Inspector
Remarks

CSS.ES

0506 (07/94) Front Form 9

2 - MINISTRY OF ENVIRONMENT & ENERGY COPY

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 | 2602646 | MUNICIP. 26010 | CON. CON 01

COUNTY OR DISTRICT: HALDIMAND
TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: WALPOLE
CON, BLOCK, TRACT, SURVEY ETC: I
LOT 25-27: 13
[redacted] NANTICOKE
DATE COMPLETED 48-53: DAY 6 MO 7 YR 01
RC. ELEVATION RC. BASIN CODE II III IV

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
BROWN	TOP SOIL			0	1
GREY	CLAY			1	31
GREY	BROWNLIME			31	70

31
32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
68	1 ☑ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
6	1 ☑ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	.188	0	32
6	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☑ OPEN HOLE		32	70
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.) | DIAMETER INCHES | LENGTH FEET
MATERIAL AND TYPE | DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

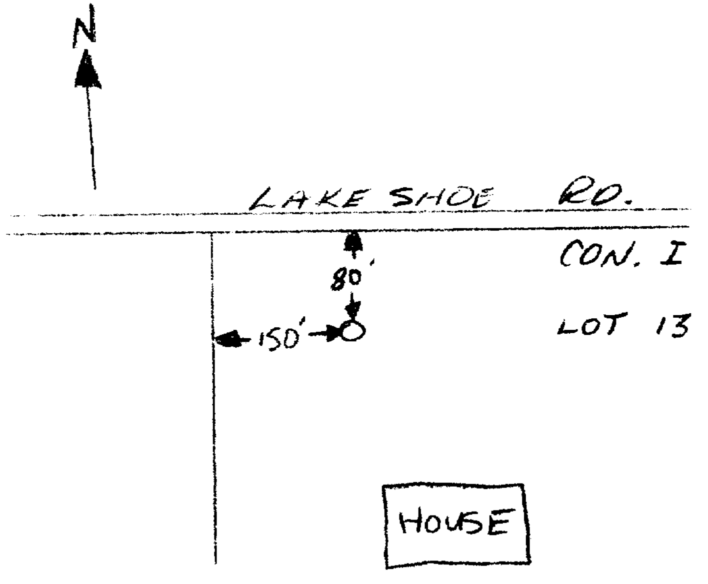
DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☑ PUMP 2 ☐ BAILER
PUMPING RATE: 25 GPM
DURATION OF PUMPING: 1 HOURS 0 MINS
STATIC LEVEL: 23 FEET
WATER LEVEL END OF PUMPING: 33 FEET
WATER LEVELS DURING: 1 ☐ PUMPING 2 ☐ RECOVERY
15 MINUTES: 26 FEET | 30 MINUTES: 29 FEET | 45 MINUTES: 32 FEET | 60 MINUTES: 33 FEET
IF FLOWING, GIVE RATE: — GPM
PUMP INTAKE SET AT: 67 FEET
WATER AT END OF TEST: 1 ☑ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☑ DEEP
RECOMMENDED PUMP SETTING: 65 FEET
RECOMMENDED PUMPING RATE: 15 GPM

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS

FINAL STATUS OF WELL

1 ☑ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE

1 ☑ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING

1 ☐ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☑ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR: ELGIN MITCHELL & SONS
LICENCE NUMBER: 3604
ADDRESS: R 5 SIMCOE ONT. N3Y 4K4
NAME OF DRILLER OR BORER: ROGER MITCHELL
LICENCE NUMBER: T-0461
SIGNATURE OF CONTRACTOR: Roger Mitchell
SUBMISSION DATE: DAY 31 MO 8 YR. 01

OFFICE USE ONLY

DATA SOURCE
CONTRACTOR: 3604
DATE RECEIVED: FEB 18 2002
DATE OF INSPECTION
INSPECTOR
REMARKS
CSS.ES2

FORM NO. 0506—4—77 FORM 7

MINISTRY OF THE ENVIRONMENT COPY

401116E

UTM 17 Z 5,12800 E

5 R 4737500 N

Elev. 5 R 0600

44 № 1956

The Ontario Water Resources Commission Act

WATER WELL RECORD

Basin 23 County or District NORFOLK Township, Village, Town or City WOODHOUSE

Con. I Lot # 24 Date completed 12 (day) JUNE (month) 67 (year)

Owner [redacted] Address PORT DOVER RR # 3

Casing and Screen Record

Inside diameter of casing 6 1/4

Total length of casing 31

Type of screen

Length of screen

Depth to top of screen

Diameter of finished hole 6 1/4

Pumping Test

Static level 21

Test-pumping rate 4 G.P.M.

Pumping level 30

Duration of test pumping 14 HOURS

Water clear or cloudy at end of test CLEAR

Recommended pumping rate 3 G.P.M.

with pump setting of 35 feet below ground surface

Well Log / Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
CLAY	0	31		✓
BROWN LIME	31	35	33	SLIGHT sulphur
FLINT	35			

For what purpose(s) is the water to be used? (COTTAGE) HOUSEHOLD

Is well on upland, in valley, or on hillside? LEVEL

Drilling or Boring Firm ELGIN A MITCHELL JARVIS

Address ELIZABETH ST

Licence Number 2646

Name of Driller or Borer DON PATTEN

Address JARVIS

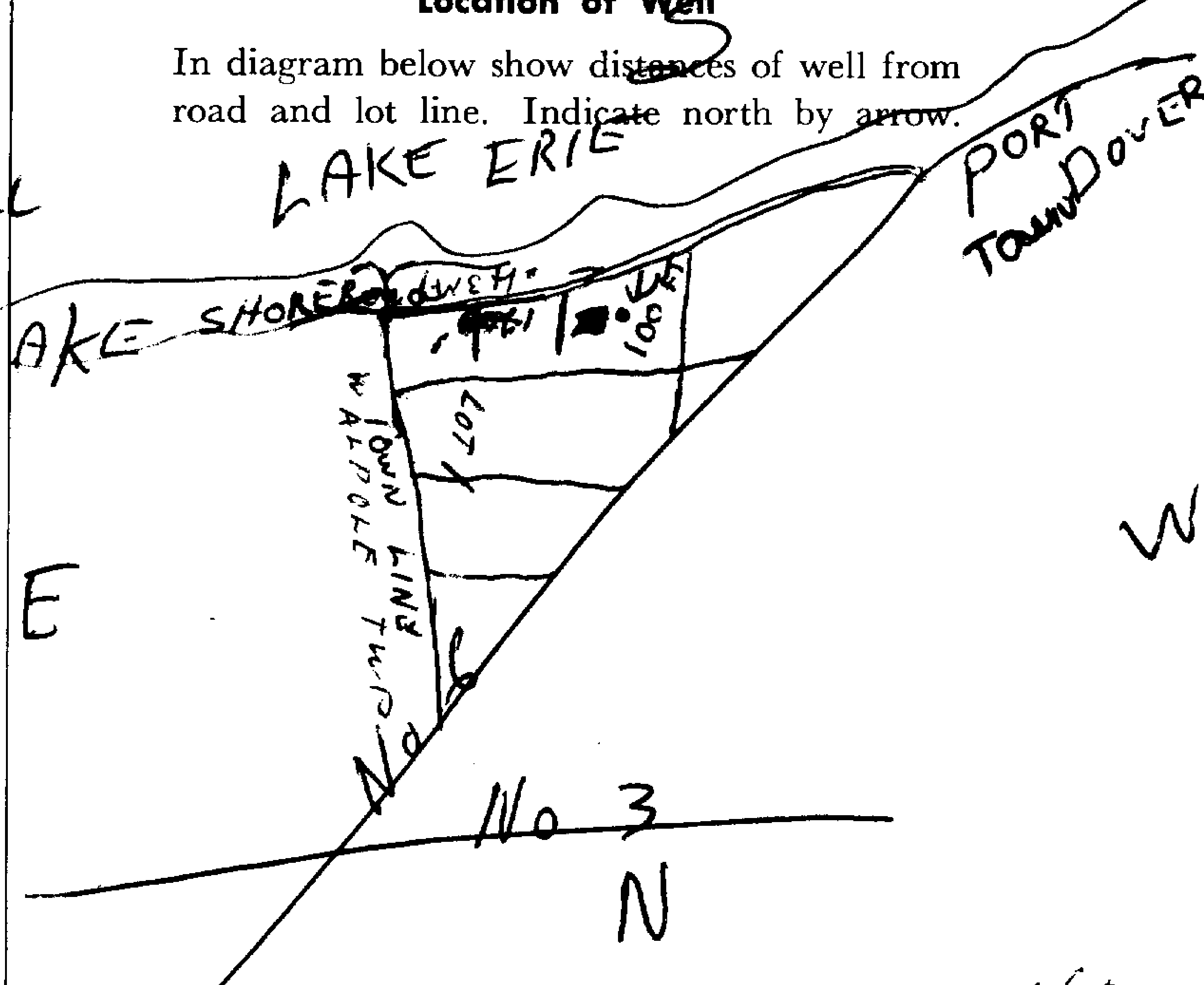
Date JUNE 13/67

Elgin Mitchell

(Signature of Licensed Drilling or Boring Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 7 15M-60-4138

OWRC COPY

CSS.S8 S.C.

Ontario Ministry of the Environment

Well Tag Number (Place sticker and/or print number below)
A 044120
A044120

Well Record

Regulation 903 Ontario Water Resources Act

page ___ of ___

Instructions for Completing Form

- For use in the **Province of Ontario** only. This document is a permanent **legal** document. Please retain for future reference.
- All Sections **must** be completed in full to avoid delays in processing. Further instructions and explanations are available on the back of this form.
- Questions regarding completing this application can be directed to the Water Well Management Coordinator at 416-235-6203.
- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only

[redacted]

Address of Well Location (County/District/Municipality): Same
Township:
Lot: 10
Concession: 01

RR#/Street Number/Name: UTM 4745661
City/Town/Village:
Site/Compartment/Block/Tract etc.:

GPS Reading NAD 83 Zone Easting Northing: 17T0620869 42°51.238
Unit Make/Model:
Mode of Operation: ☐ Undifferentiated ☒ Averaged ☐ Differentiated, specify ______

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth Metres From	Depth Metres To
BROWN	sand			0	36
GREY	clay			36	89
GREY	clay	boulders		89	104
GREY	limestone		Bedrock.	104	157

Hole Diameter

Depth Metres From	Depth Metres To	Diameter Centimetres
0	20	8"

Water Record

Water found at ___ Metres / Kind of Water

- ___ m ☐ Fresh ☒ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other: ______
- ___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other: ______
- ___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other: ______

After test of well yield, water was
☒ Clear and sediment free
☐ Other, specify ______

Chlorinated ☒ Yes ☐ No

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth Metres From	Depth Metres To
Casing				
6"	☒ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	188		
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
Screen				
Outside diam	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	Slot No.		
No Casing or Screen				
	☐ Open hole			

Test of Well Yield

Pumping test method: Sub
Pump intake set at - (metres):
Pumping rate - (litres/min) 15
Duration of pumping 1 hrs + 0 min
Final water level end of pumping 60 ~~metres~~
Recommended pump type. ☐ Shallow ☒ Deep
Recommended pump depth. ______ metres
Recommended pump rate. (litres/min) 12GPM
If flowing give rate - (litres/min)
If pumping discontinued, give reason.

Draw Down Time min	Draw Down Water Level Metres	Recovery Time min	Recovery Water Level Metres
Static Level	40'		
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Plugging and Sealing Record

☐ Annular space ☐ Abandonment

Depth set at - Metres From	Depth set at - Metres To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)

Method of Construction

☐ Cable Tool ☐ Rotary (conventional) ☐ Rotary (reverse) ☒ Rotary (air) ☐ Air percussion ☐ Boring ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Other ______

Water Use

☐ Domestic ☐ Stock ☐ Irrigation ☐ Industrial ☐ Commercial ☐ Municipal ☒ Public Supply ☐ Not used ☐ Cooling & air conditioning ☐ Other ______

Final Status of Well

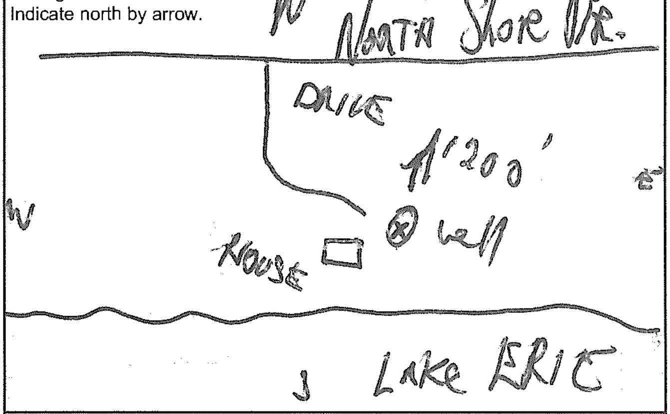
☒ Water Supply ☐ Observation well ☐ Test Hole ☐ Recharge well ☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Unfinished ☐ Dewatering ☐ Replacement well ☐ Abandoned, (Other) ______

Well Contractor/Technician Information

Name of Well Contractor: FIELD WELL DRILLING
Well Contractor's Licence No.: 2123
Business Address (street name, number, city etc.): RR#1 Vineland
Name of Well Technician (last name, first name): Marshall R FIELD
Well Technician's Licence No.: T0365
Signature of Technician/Contractor: X
Date Submitted YYYY MM DD: 2007 8 15

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.



Audit No. Z 49286
Date Well Completed YYYY MM DD: 2007 8 15
Was the well owner's information package delivered? ☐ Yes ☒ No
Date Delivered YYYY MM DD: 2007 8 15

Ministry Use Only

Data Source:
Contractor: 2123
Date Received YYYY MM DD:
Date of Inspection YYYY MM DD:
Remarks: SEP 10 2007
Well Record Number:

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☐ Well Owner's Copy ☐

Cette formule est disponible en français

Ontario Ministry of the Environment

Measurements recorded in: ☑ Metric ☐ Imperial

Well Tag No. A 073984

A073984

Well Record

Regulation 903 Ontario Water Resources Act

Page 1 of 1

[redacted]

Address of Well Location (Street Number/Name)	Township Woodhouse	Lot 23	Concession 1
County/District/Municipality Norfolk	City/Town/Village	Province **Ontario**	Postal Code
UTM Coordinates Zone Easting Northing NAD 83 17 572211 4738016	Municipal Plan and Sublot Number	Other	

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	To
Brown	Silty Clay		firm to stiff, some grey + rust mottling, finely laminated at lower depths, no odour or discolouration	0.00	8.79
Grey-Brown	Silty Clay	fine gravel, coarse sand	very soft to firm, gravel + sand near bedrock and in discrete rust brown or grey layers 12-25mm thick throughout	8.79	11.13
Grey	Limestone	a 0.15-0.15m thick coral fossil w 1-3mm dia. voids comprised entire core diameter at 12.95m	fresh, thinly - thickly laminated, weak to medium strong, slight oily odour, fractures near top of bedrock appear slightly weathered	11.13	16.28

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
0.00	0.30	Concrete	
0.30	12.50	Bentonite	
12.50	16.28	Sand	

Method of Construction

☐ Cable Tool
☐ Rotary (Conventional)
☐ Rotary (Reverse)
☐ Boring
☐ Air percussion
☑ Other, specify HSA - 4.25"
☑ Diamond HQ
☐ Jetting
☐ Driving
☐ Digging

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	To
	10.0	Steel	.70	+0.83	1.00
A	2.6	Plastic	.40	+0.83	13.23

Construction Record - Screen

	Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
A	3.4	Plastic	.010	13.23	16.28

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) Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, specify

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

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

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0.00	11.13	20.0
11.13	16.28	9.3

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, specify

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping
hrs + min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

Well production (l/min / GPM)

Disinfected?
☐ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.

Please see attached map.
Overburden wells B+C are each in separate holes from Bedrock well A.
(B) - 4.25" HSA from 0 - 11.13m (diamlter - 20cm)
- 2" x 3.05m screen installed at 11.13m
- Sand 11.13m - 7.50m, Bentonite 7.50m - 0.30m.
Concrete 0.30m - surface + protective casing.
(C) - 4.25" HSA from 0 - 4.30m (diameter - 20cm)
- 2" x 3.05m screen installed at 4.30m
- Sand 4.30m - 0.90m, Bentonite 0.90m - 0.30m.
Concrete 0.30m - surface + steel protective casing

Comments: (A = tagged Bedrock well, B = overburden well,
BH08-2 C = overburden well - each in a separate hole)

Well Contractor and Well Technician Information

Business Name of Well Contractor: All-Terrain Drilling Ltd.
Well Contractor's Licence No.: 1129
Business Address (Street Number/Name): 3-661 Colby Drive
Municipality: Waterloo
Province: ON.
Postal Code: N2V1C2
Business E-mail Address: allterrain@golden.net
Bus. Telephone No. (inc. area code): 5198868810
Name of Well Technician (Last Name, First Name): Pollice, Mike / Leggo, Dawen
Well Technician's Licence No.: 268
Signature of Technician and/or Contractor
Date Submitted: 20090430

Well owner's information package delivered ☐ Yes ☑ No

Date Package Delivered Y Y Y Y M M D D

Date Work Completed 20080818

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Audit No. Z 85636
Received MAY 14 2009

0506E (12/2007)

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Ontario Ministry of the Environment

Measurements recorded in: ☐ Metric ☒ Imperial

Well Tag No. (Place Sticker and/or Print Below)
A 073916

Well Record

Regulation 903 Ontario Water Resources Act

Page______ of______

[redacted]

Address of Well Location (Street Number/Name) #52 Weatherburn LINE	Township Dunnville	Lot Pt. 19-20	Concession 05
County/District/Municipality Haldimand.	City/Town/Village Dunnville	Province **Ontario**	Postal Code N1A2W2
UTM Coordinates NAD 8 3 Zone 17 Easting T06/3897 Northing 42°50.743	Municipal Plan and Sublot Number	Other UTM 4744625	

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
BROWN	clay			0	4
GREY	clay	boulders		4	16
GREY	limestone			16	42

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
0	20	Benseal	

Method of Construction

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

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
8"	OPEN		0	22
6	Steel	188	0	22

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

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	42	6"

Results of Well Yield Testing

After test of well yield, water was:
☒ Clear and sand free
☐ Other, specify

If pumping discontinued, give reason:

Pump intake set at (m/ft) 30'

Pumping rate (l/min / GPM) 10 GPM

Duration of pumping 1 hrs + 0 min

Final water level end of pumping (m/ft) 18'

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft) 30'

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

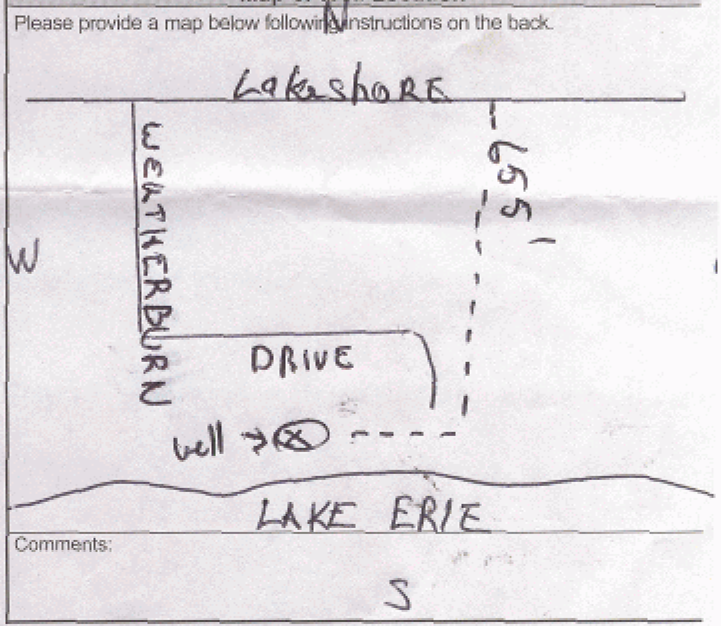
Well production (l/min / GPM) 13 GPM

Disinfected? ☐ Yes ☒ No

Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	18'		
1		1	
2	3	2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor: FIELD WELL DRILLING
Well Contractor's Licence No.: 2123
Business Address (Street Number/Name): 4703 Spring Creek
Municipality: Vineland
Province: ONT.
Postal Code: L0R2C0
Business E-mail Address:
Bus. Telephone No. (inc. area code): 9055637355
Name of Well Technician (Last Name, First Name): FIELD MARSHALL
Well Technician's Licence No.: T0365
Signature of Technician and/or Contractor:
Date Submitted: 2 0 1 0 M 5 D 6

Well owner's information package delivered ☐ Yes ☒ No
Date Package Delivered Y Y Y Y M M D D
Date Work Completed Y Y Y Y M M D D

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Audit No. Z099760
MAY 13 2010
Received

0506E (12/2007)

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APPENDIX D

TERRAPROBE INC.

Photograph 1

Location:	Toe of slope around Section 1
Viewing:	East
Description:	The slope face is forested, the toe of slope is bare. Clayey silt soil is visible. There is a limestone shelf at the toe.

Photograph 2

Location:	Mid-slope around Section 3
Viewing:	East
Description:	The slope is vegetated with grass. There is an armourstone wall at the toe of slope. No bare soil was observed.

Photograph 3

Location:	Toe of Section 8
Viewing:	East
Description:	There is an approximately 2 m high erosion scarp at the toe. The soil is clayey silt, trace sand, grey and moist, and layered.

Photograph 4

Location:	Top of slope around Section 8
Viewing:	East
Description:	There are tension cracks visible in the upper slope face of the slope around Section 8.

Photograph 5

Location:	Toe of slope around Section 12
Viewing:	East
Description:	The slope at this section is vegetated with shrubs and young trees. There is rip rap along the toe of slope and slope face.

Photograph 6

Location:	Toe of slope around Section 14
Viewing:	West
Description:	There is an armourstone wall along the toe of slope. The tableland is relatively flat.

Photograph 7

Location:	Toe of slope around Section 18
Viewing:	West
Description:	There is rip rap along the toe of slope. The tableland appears to be relatively flat, and vegetated with grass and young trees.

Photograph 8

Location:	Slope around Section 23
Viewing:	West
Description:	There is sand at the toe of slope. The shoreline is vegetated with glass and shrubs.

Photograph 9

Location:	Between Section 31 and 32
Viewing:	West
Description:	There is a sand and pebble beach along the shoreline. The tableland is vegetated with grass, and mature to young trees.

Photograph 10

Location:	Slope around Section 39
Viewing:	East
Description:	There is an approximately a 5 m high slope at the shoreline with erosion protection. The tableland is vegetated with grass.

Photograph 11

Location:	Slope around Section 40
Viewing:	West
Description:	There is a sand beach around Section 40.

Photograph 12

Location:	Slope around Section 45
Viewing:	East
Description:	There are glacial till bluffs at the shoreline. The bluffs at Section 45 are near vertical. The glacial till is a reddish brown sand and silt, with some clay, trace gravel trace cobbles, moist, and dense.

Photograph 13

Location: Slope at Section 46

Viewing: North

Description: There is a near vertical scarp in the upper slope face, with talus accumulation on the mid to lower slope face. The talus is vegetated with grass and shrubs.

Photograph 14

Location: Slope at Section 46

Viewing: Slope

Description: Talus accumulation at the toe of slope along the shoreline at Section 46.

Photograph 15

Location: Slope at Dickout Road

Viewing: Gabion and Limestone retaining walls

Description: At the end of Dickout Road there is construction of retaining walls at the toe of slope, with a drainage pipe down the slope face. The retaining walls are up to 6-7 m in height.

Photograph 16

Location:	Slope at Dickout Road
Viewing:	Retaining walls
Description:	There is a limestone toe wall across from the gabion stone wall up to approximately 5 m in height. There is a gravel beach in between the two walls.

Photograph 17

Location:	Slope around Section 50
Viewing:	West
Description:	Shoreline is composed of a sand and gravel beach with some rip rap.

APPENDIX E

TERRAPROBE INC.

Terraprobe
Consulting Geotechnical & Environmental Engineers
Construction Materials Inspection & Testing

SLOPE INSPECTION FORM

1. INSPECTION DATE (DD-MM-YYYY): August 10, 2018.

FILE NO. 1-18-0402.

WEATHER (circle): ☒ sunny ○ partly cloudy ○ cloudy ○ clear ○ fog ○ rain ○ snow

○ calm ☒ breeze ○ windy ○ cold ○ cool ○ warm ○ hot

estimated air temperature: 20° c.

INSPECTED BY (name): Tony Hunter.

2. SITE LOCATION / DIRECTIONS (describe main roads, features)

Lake Erie North Shoreline from Port Dover to Dunnville.

SKETCH

3. WATERSHED

Lake Erie

4. PROPERTY OWNERSHIP (name, address, phone):

LEGAL DESCRIPTION

Lot

Concession

Township

County

CURRENT LAND USE (circle and describe)

☒ **vacant** - field, bush, woods, forest, wilderness, tundra,

○ **passive** - recreational parks, golf courses, non-habitable structures, buried utilities, swimming pools,

☒ **active** - habitable structures, residential, commercial, industrial, warehousing and storage,

○ **infra-structure or public use** - stadiums, hospitals, schools, bridges, high voltage power lines, waste management sites,

5. SLOPE DATA

HEIGHT
☒ 3 - 6 m ○ 6 - 10 m ○ 10 - 15 m ☒ 15 - 20 m
↳ beaches & armourstone. ↳ bluffs & slopes.
○ 20 - 25 m ○ 25 - 30 m ○ > 30 m

estimated height (m): up to 22m (Lidar)

INCLINATION AND SHAPE
○ 4:1 or flatter 25 % 14°
○ up to 3:1 33 % 18½°
○ up to 2:1 50 % 26½°
☒ up to 1:1 100 % 45°
○ up to ½:1 200 % 63½°
○ steeper than ½:1 > 63½°
Some near vertical.

6. SLOPE DRAINAGE (describe)

TOP
Where there are dwellings in the tableland there may be drainage over the Slope

FACE
→ ground water seepage observed through the face of the bluffs at the eastend of the study area.

BOTTOM
None observed.

7. SLOPE SOIL STRATIGRAPHY (describe, positions, thicknesses, types)

TOP
Earth fill or sand.

FACE
Clayey silt or glacial till

BOTTOM
limestone bedrock.

8. WATER COURSE FEATURES (circle and describe)

SWALE, CHANNEL

GULLY

STREAM, CREEK, RIVER

POND, BAY, [✓ LAKE] Lake Erie at the toe of slopes.

SPRINGS

MARSHY GROUND

9. VEGETATION COVER (grasses, weeds, shrubs, saplings, trees)

TOP

→ generally landscaped.
→ grass, shrubs, some young to mature trees.
→ some farm land in table land

FACE

→ Where there are bluffs or scarps the slope face is generally bare
→ generally shrubs or grass
→ at west end of study area some forested parts of slope.

BOTTOM

→ bare, armourstone or beaches generally

10. STRUCTURES (buildings, walls, fences, sewers, roads, stairs, decks, towers,)

TOP

→ generally dwellings or roadways in the tableland.

FACE

→ armourstone walls or concrete walls. No access to these areas.
→ earth fill embankment at Section 7.

BOTTOM

→ armourstone walls or concrete walls. No access to these areas.

11. EROSION FEATURES (scour, undercutting, bare areas, piping, rills, gully)

TOP

→ none observed.

FACE

→ none observed.

BOTTOM

→ erosion scarps at toe around 1m in height

12. SLOPE SLIDE FEATURES (tension cracks, scarps, slumps, bulges, grabens, ridges, bent trees)

TOP

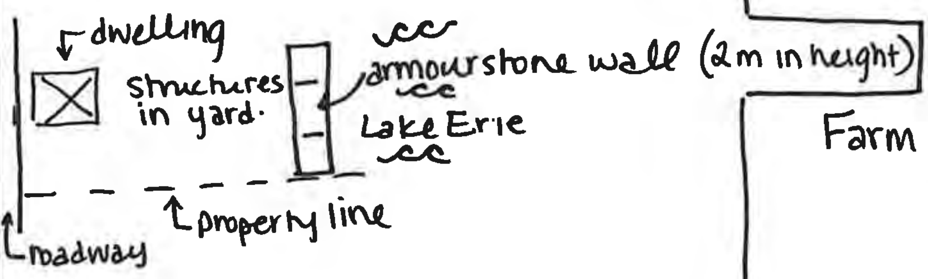
→ At section B, tension cracks in the upper slope face.

FACE

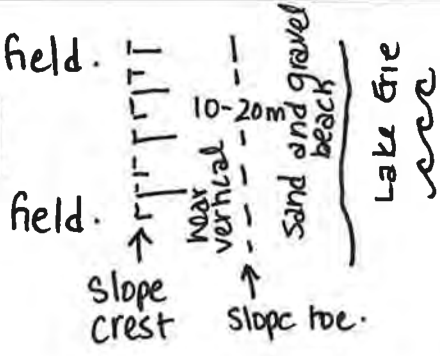
BOTTOM

→ talus accumulation in bluffs at east end of study area.

13. PLAN SKETCH OF SLOPE

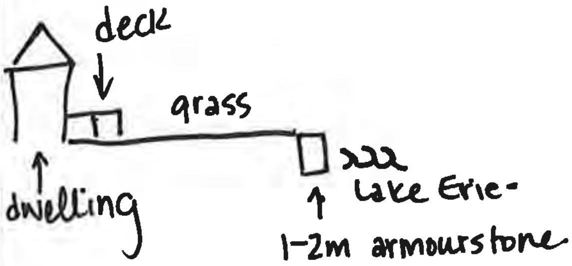


Typical Dwelling, no access

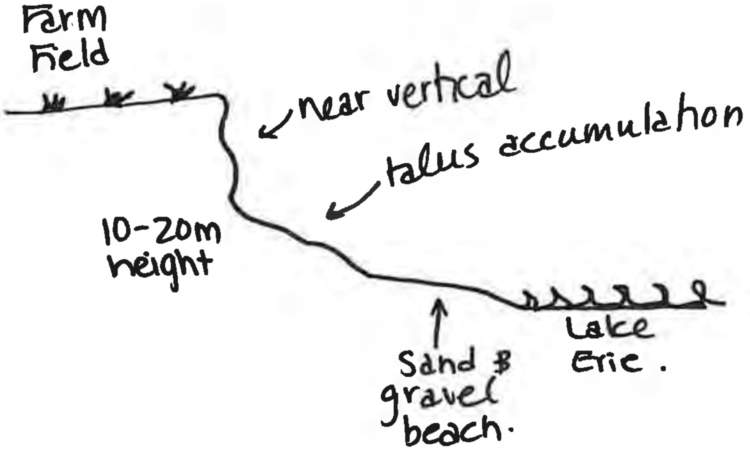


Typical Bluff.

14. PROFILE SKETCH OF SLOPE



Typical Dwelling



Typical Bluff.

TABLE 8.1 - SLOPE STABILITY RATING CHART

Site Location: Port Dover to Dunnville.
File No. 1-18-0402.
Property Owner:
Inspection Date:
Inspected By: Tony Hunter.
Weather:

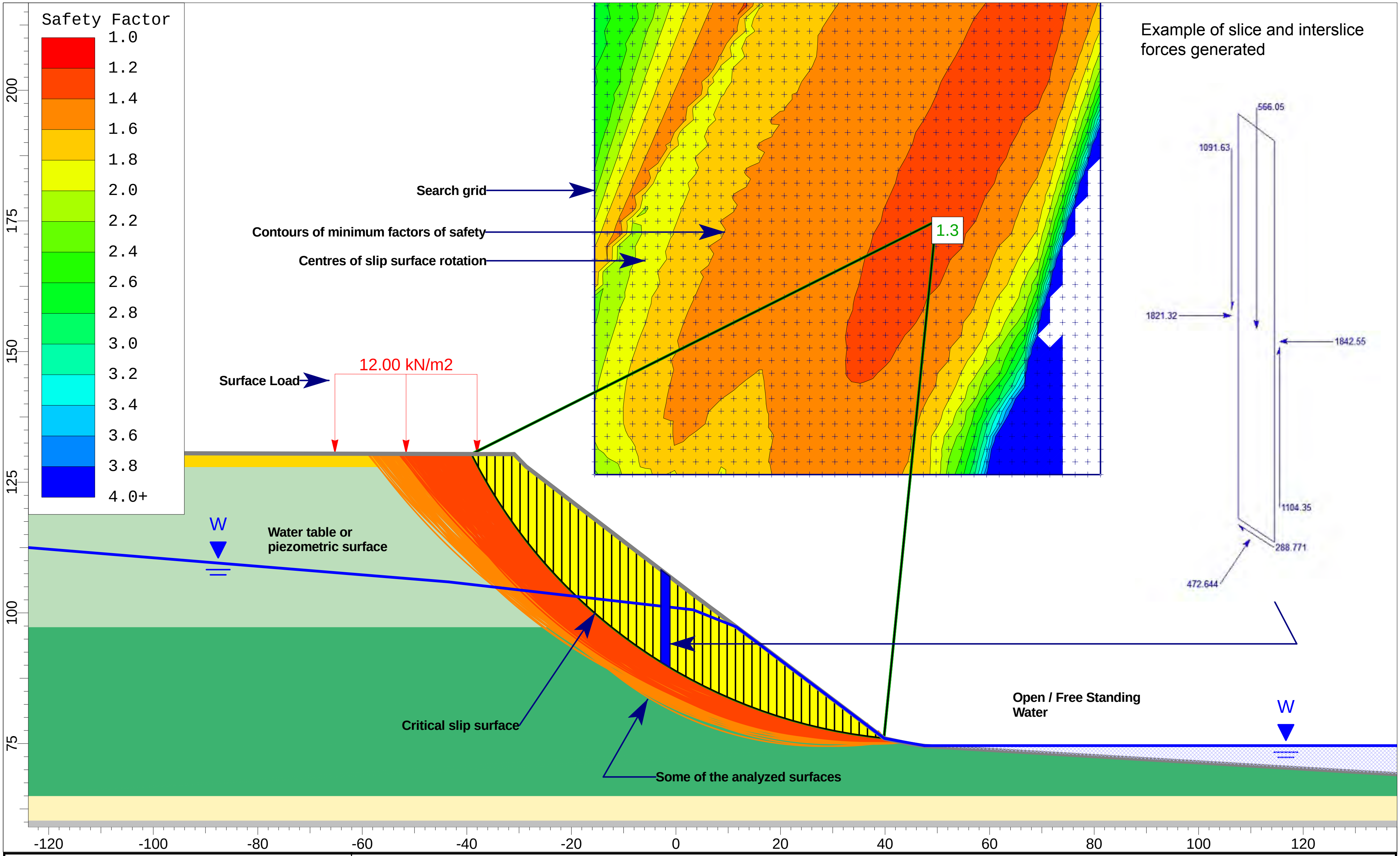
				Rating Value		
				west	mid	east.
1.	**SLOPE INCLINATION**	**degrees**	**horiz. : vert.**			
	a)	18 or less	3 : 1 or flatter	0	[✓ 0]	0
	b)	18 - 26	2 : 1 to more than 3 : 1	[✓ 6]	[✓ 6]	6
	c)	more than 26	steeper than 2 : 1	16	16	[✓ 16]
2.	**SOIL STRATIGRAPHY**					
	a)	Shale, Limestone, Granite (Bedrock)		0	0	0
	b)	Sand, Gravel		6	6	6
	c)	Glacial Till		9	9	[✓ 9]
	d)	Clay, Silt		[✓ 12]	[✓ 12]	12
	e)	Fill		16	16	16
	f)	Leda Clay		24	24	24
3.	**SEEPAGE FROM SLOPE FACE**					
	a)	None or Near bottom only		[✓ 0]	[✓ 0]	0
	b)	Near mid-slope only		6	6	[✓ 6]
	c)	Near crest only or, From several levels		12	12	12
4.	**SLOPE HEIGHT**					
	a)	2 m or less		0	0	0
	b)	2.1 to 5 m		2	[✓ 2]	2
	c)	5.1 to 10 m		[✓ 4]	4	4
	d)	more than 10 m		8	8	[✓ 8]
5.	**VEGETATION COVER ON SLOPE FACE**					
	a)	Well vegetated; heavy shrubs or forested with mature trees		[✓ 0]	[✓ 0]	0
	b)	Light vegetation; Mostly grass, weeds, occasional trees, shrubs		4	4	4
	c)	No vegetation, bare		8	8	[✓ 8]
6.	**TABLE LAND DRAINAGE**					
	a)	Table land flat, no apparent drainage over slope		[✓ 0]	[✓ 0]	[✓ 0]
	b)	Minor drainage over slope, no active erosion		2	2	2
	c)	Drainage over slope, active erosion, gullies		4	4	4
7.	**PROXIMITY OF WATERCOURSE TO SLOPE TOE**					
	a)	15 metres or more from slope toe		0	0	0
	b)	Less than 15 metres from slope toe		[✓ 6]	[✓ 6]	[✓ 6]
8.	**PREVIOUS LANDSLIDE ACTIVITY**					
	a)	No		[✓ 0]	[✓ 0]	0
	b)	Yes		6	6	[✓ 6]
	TOTAL			28	26	59

	SLOPE INSTABILITY RATING	RATING VALUES TOTAL	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.

APPENDIX F

TERRAPROBE INC.



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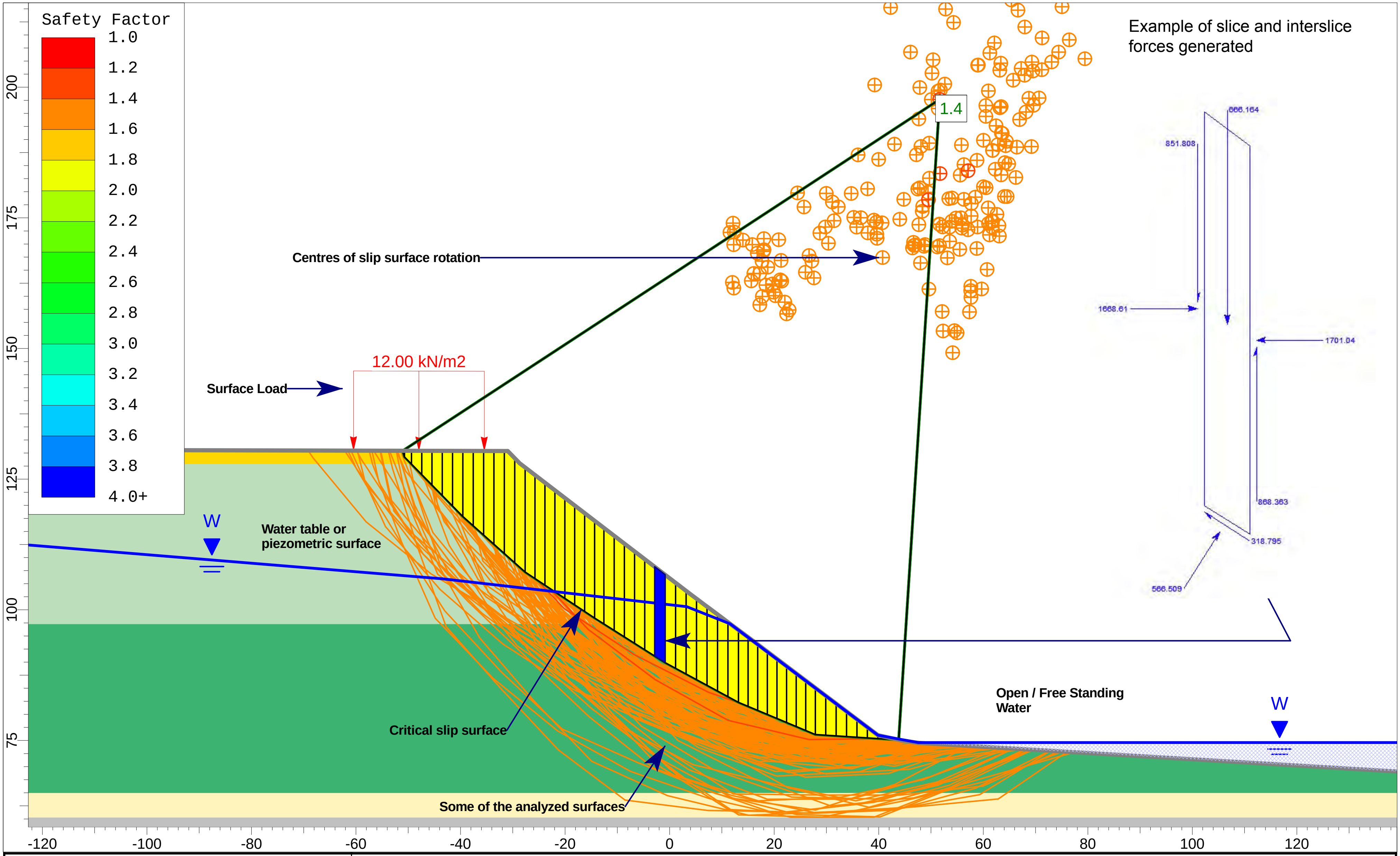
SLIDEINTERPRET 6.026

Project

Slope Stability Analysis - Explanation with Slices and Slice Forces

Analysis Description

Circular Analysis (example)



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SLIDEINTERPRET 6.026

Project

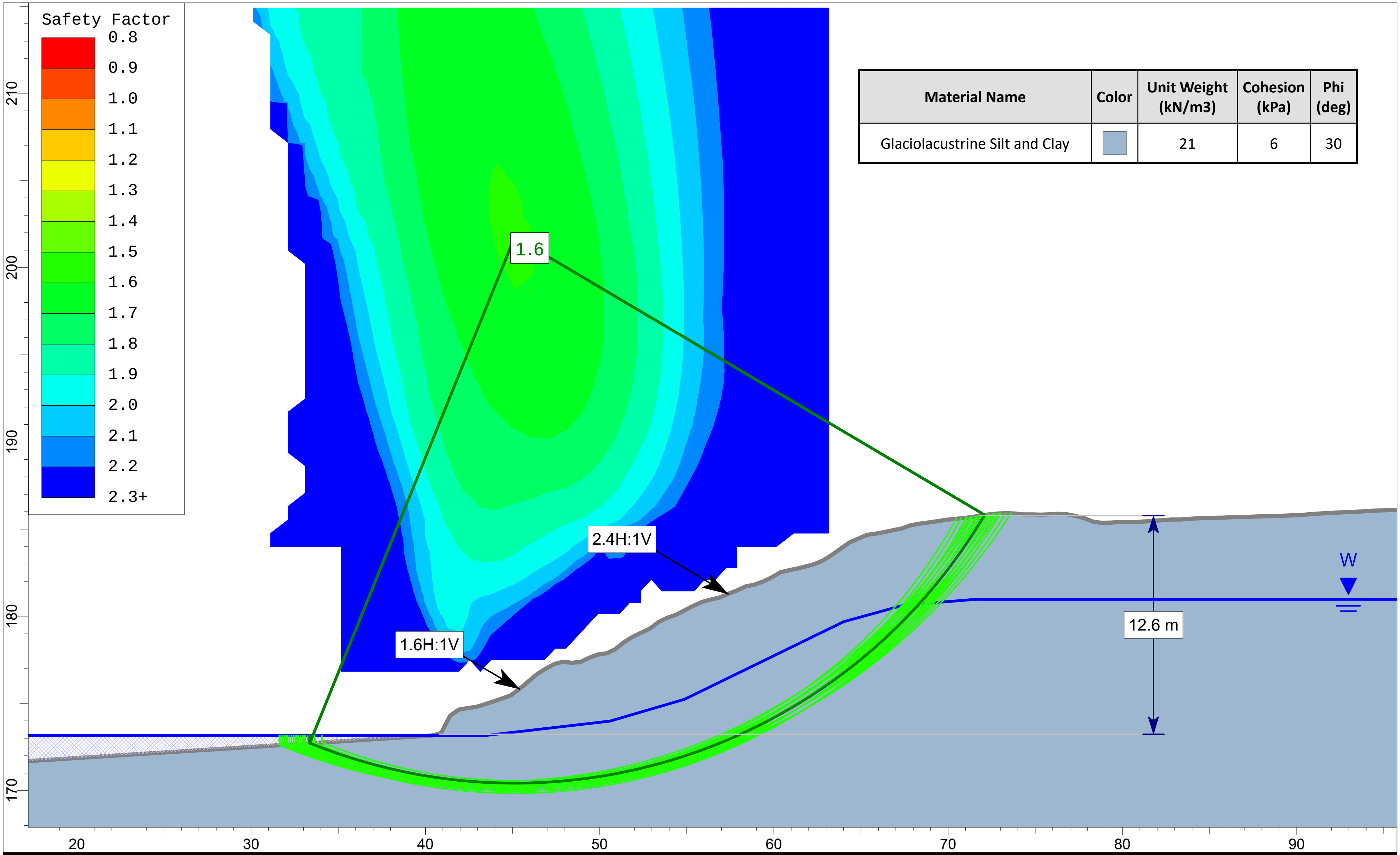
Slope Stability Analysis - Explanation with Slices and Slice Forces

Analysis Description

Non-Circular Analysis (example)

APPENDIX G

TERRAPROBE INC.



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30

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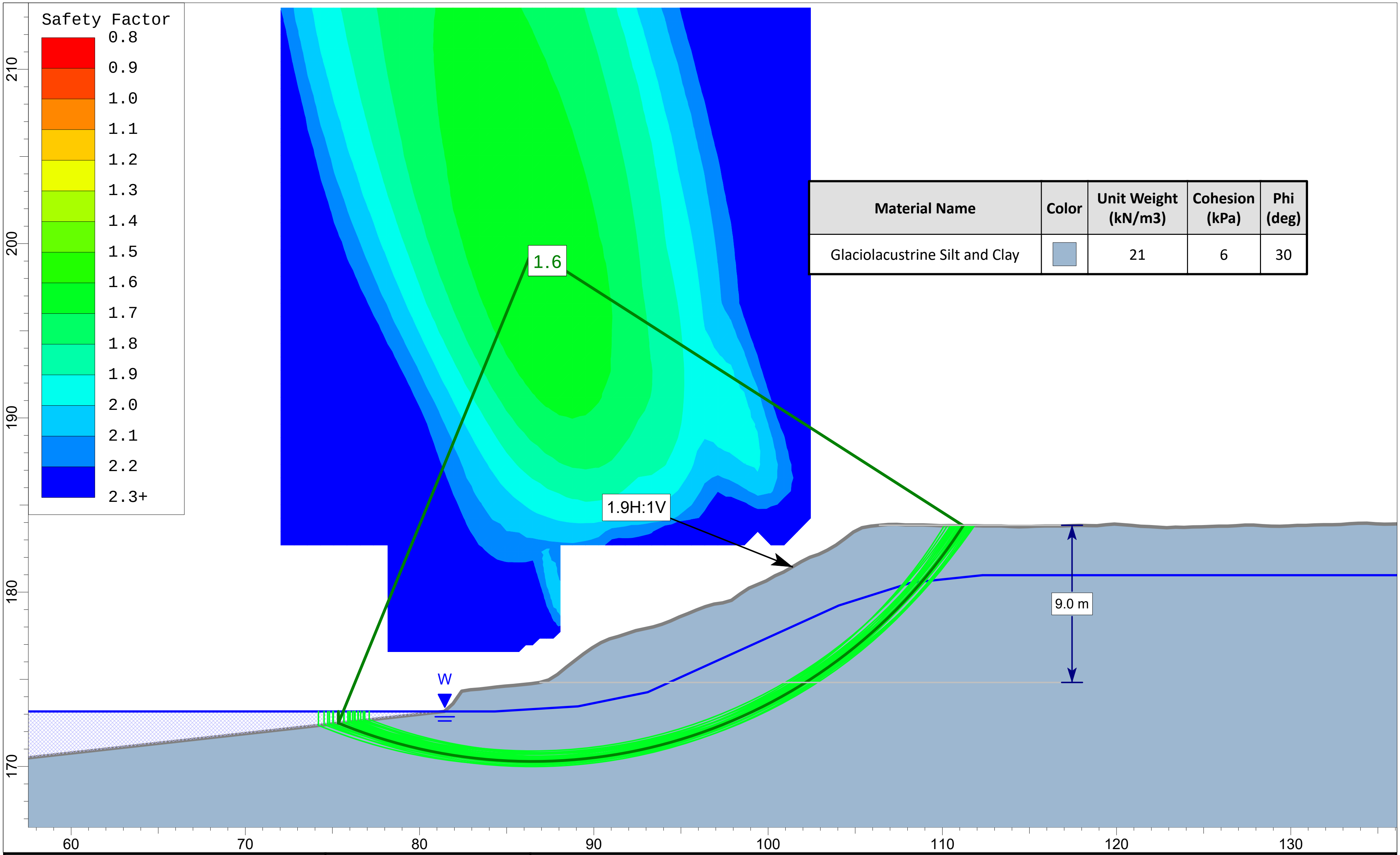
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 1, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 1 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

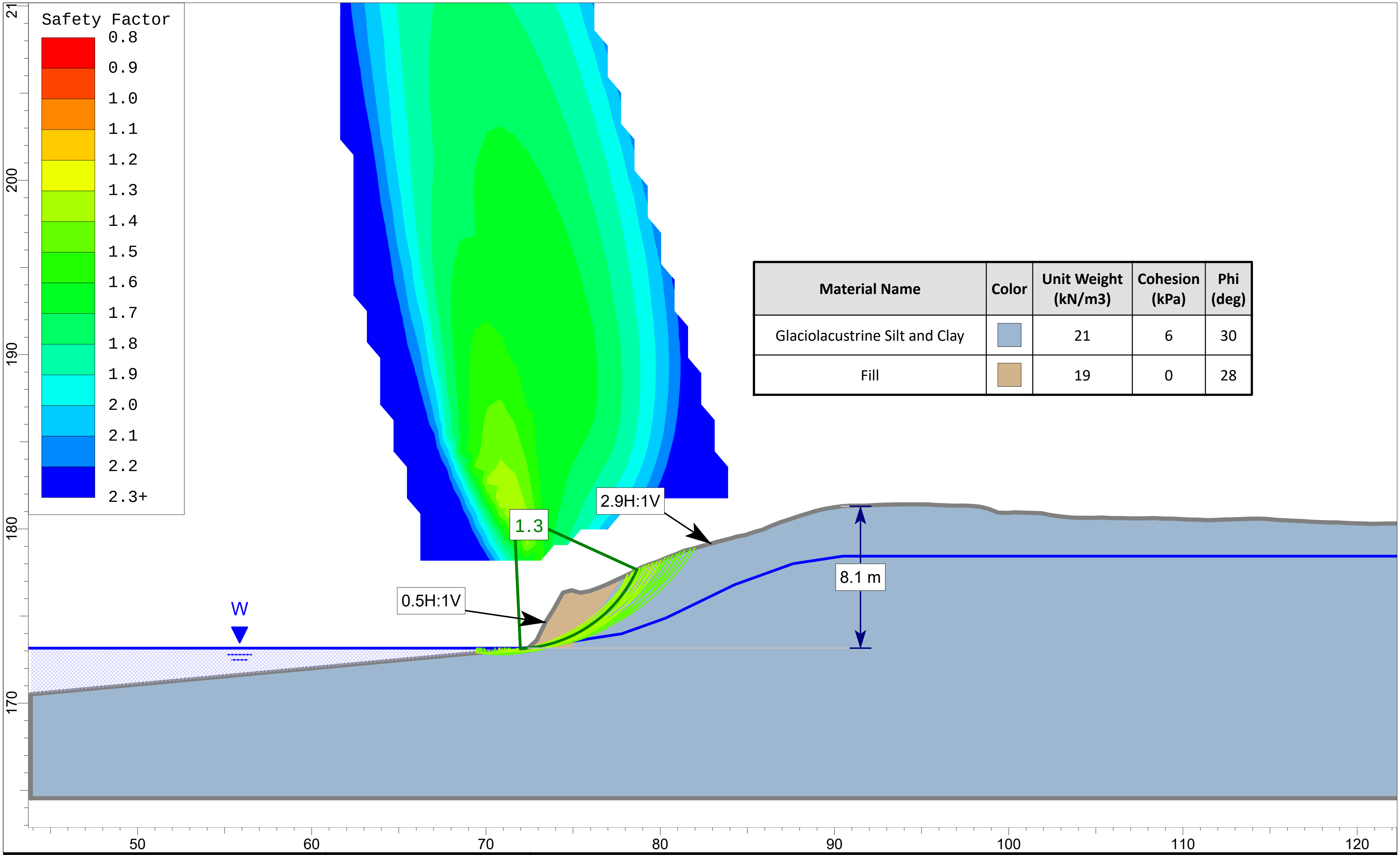
Project

Halimand County Slope Stability | 1-18-0402-01

Analysis

Global Stability: Section 2, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 1 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

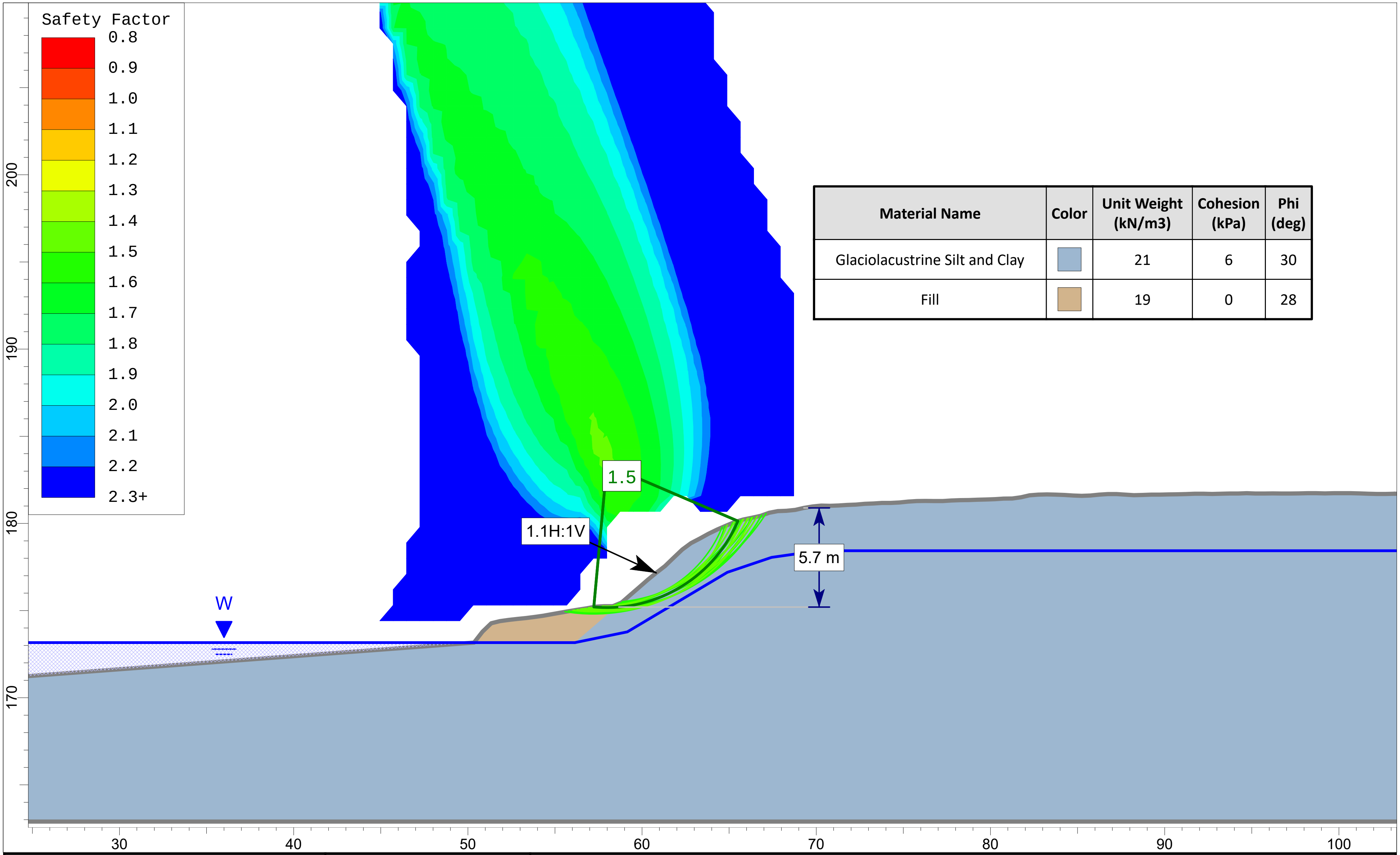
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 3, Master Scenario

Date 5/14/2019
Scale 1:300
File Halimand Part 1 v2.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

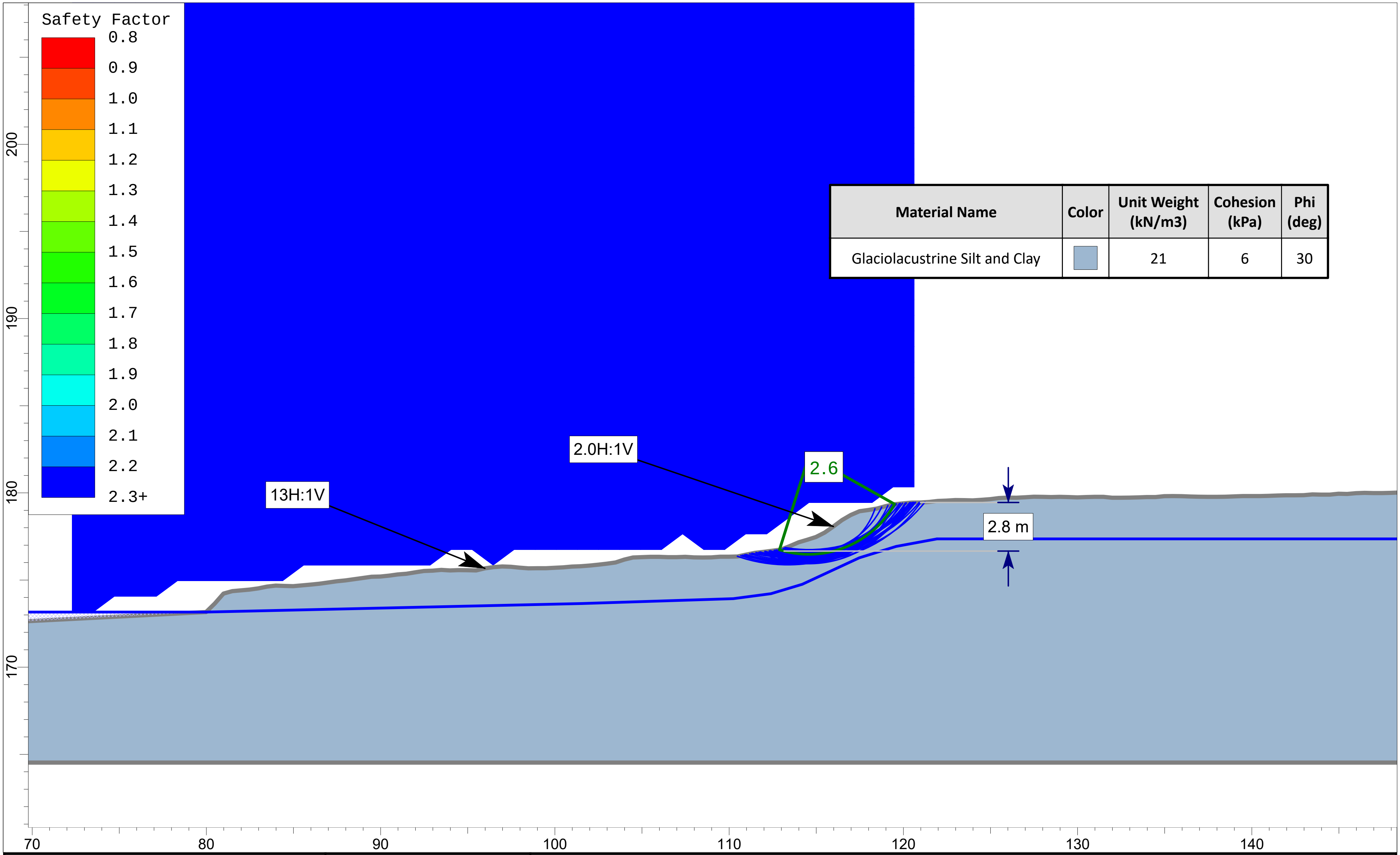
Project

Halimand County Slope Stability | 1-18-0402-01

Analysis

Global Stability: Section 4, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 1 v2.slmd
By	JH/JC	Ref.			2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	▨	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

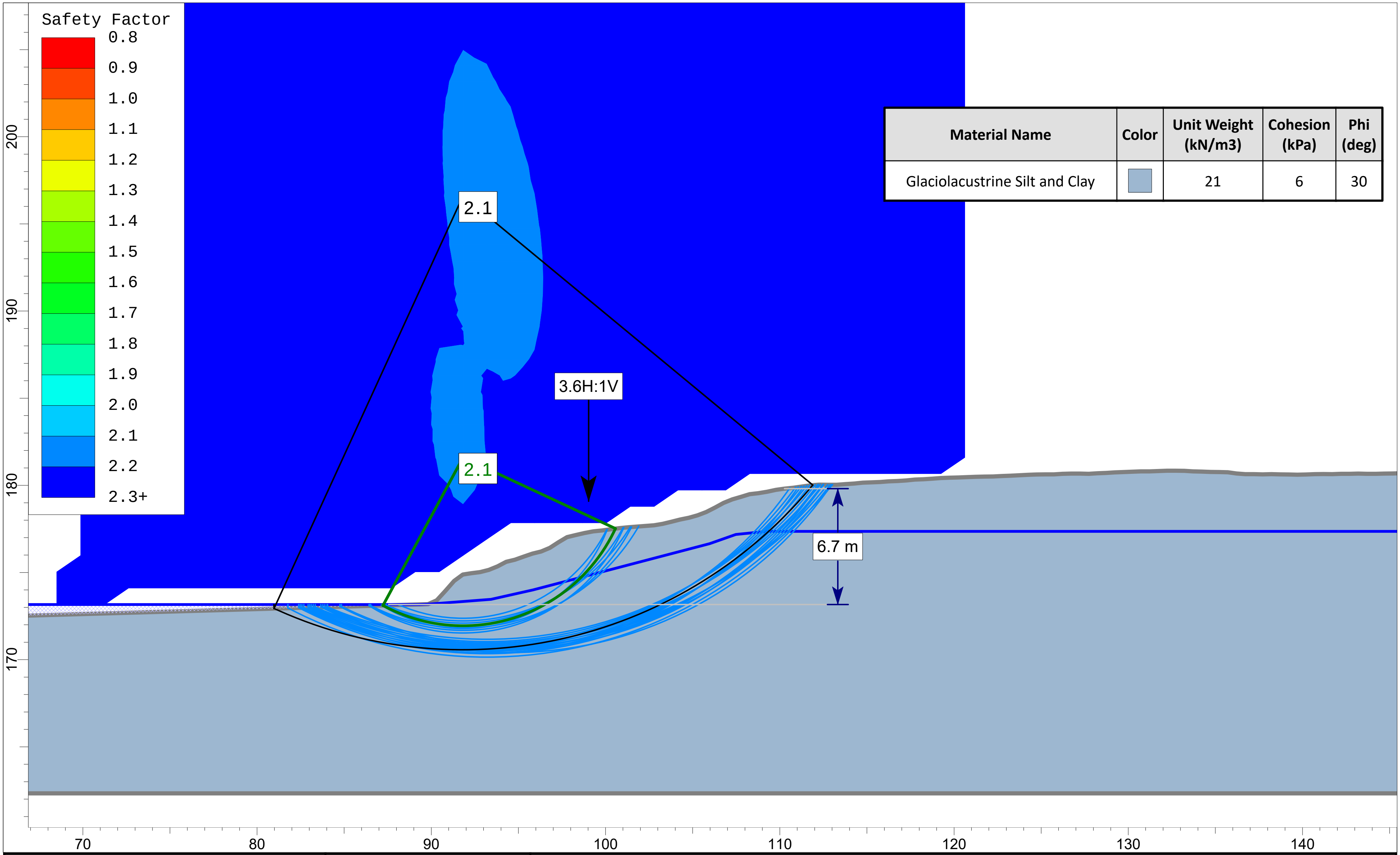
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 5, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 2 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	■	21	6	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

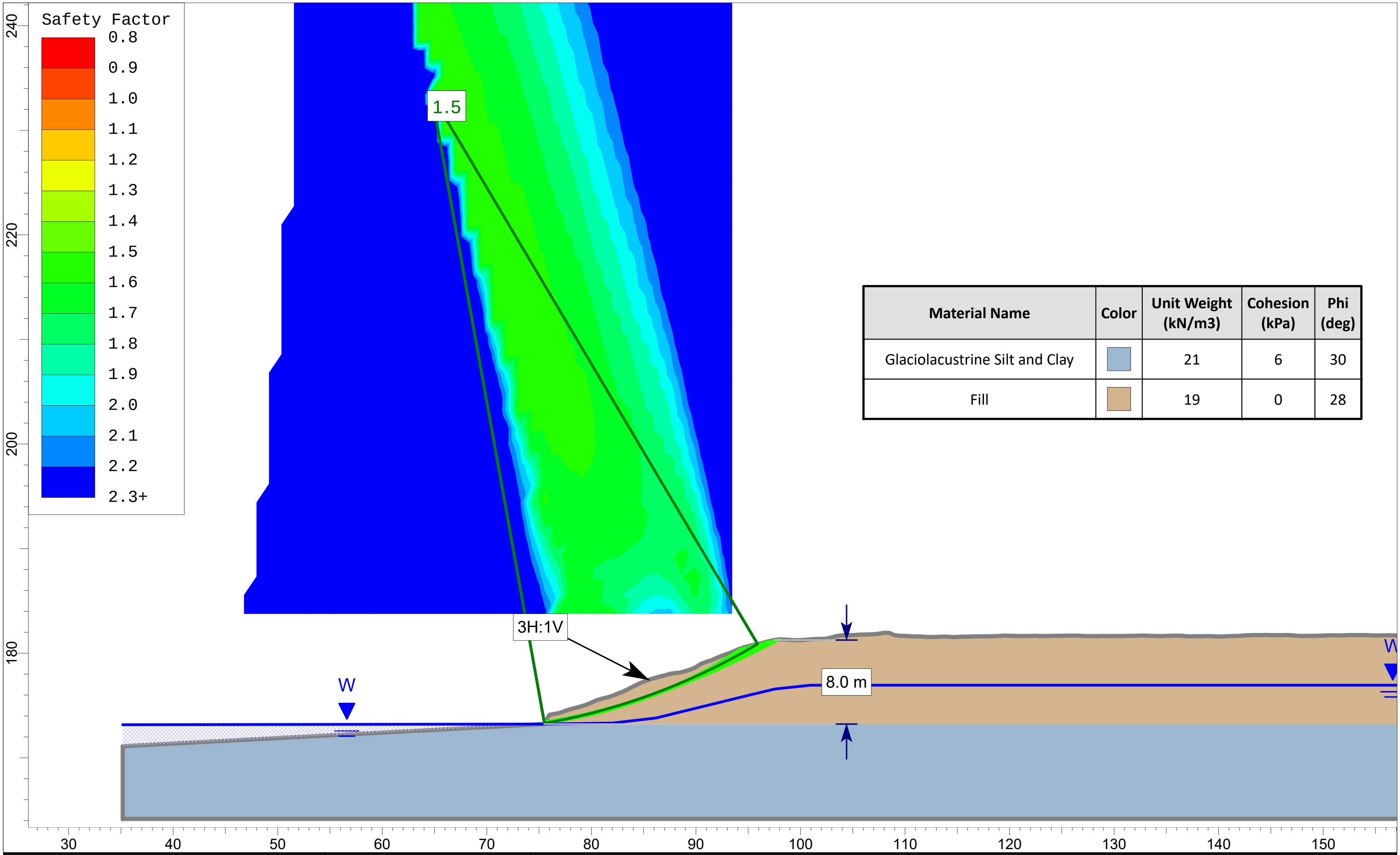
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 6, Master Scenario

Date 5/14/2019	Scale 1:300	File Halimand Part 2 v2.slmd
By JH/JC	Ref. 2017 LiDar data, provided by Baird on March 13, 2019	



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

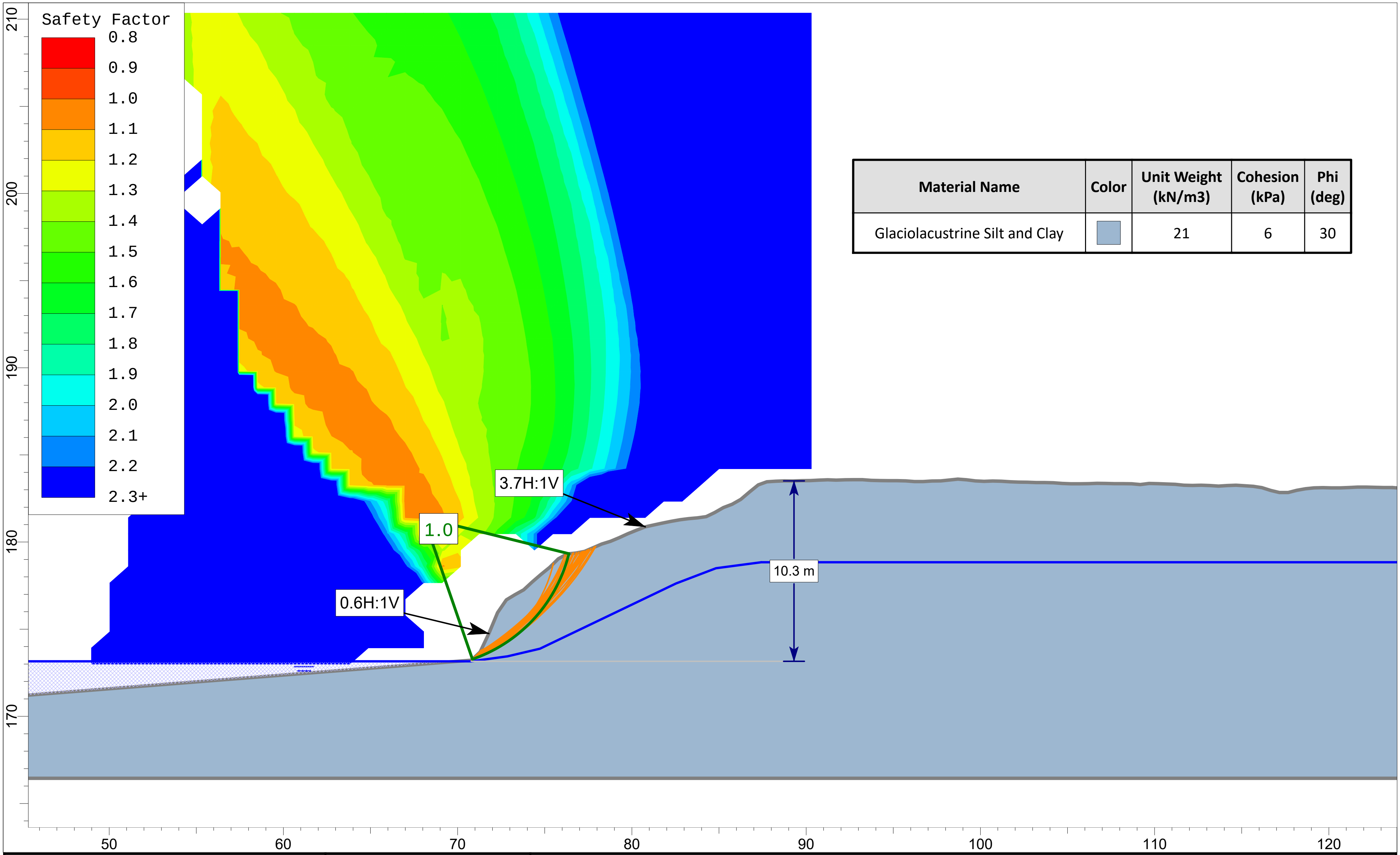
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 7, Master Scenario

Date 5/14/2019
Scale 1:500
File Halimand Part 2 v2.slmd

By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	▨	21	6	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

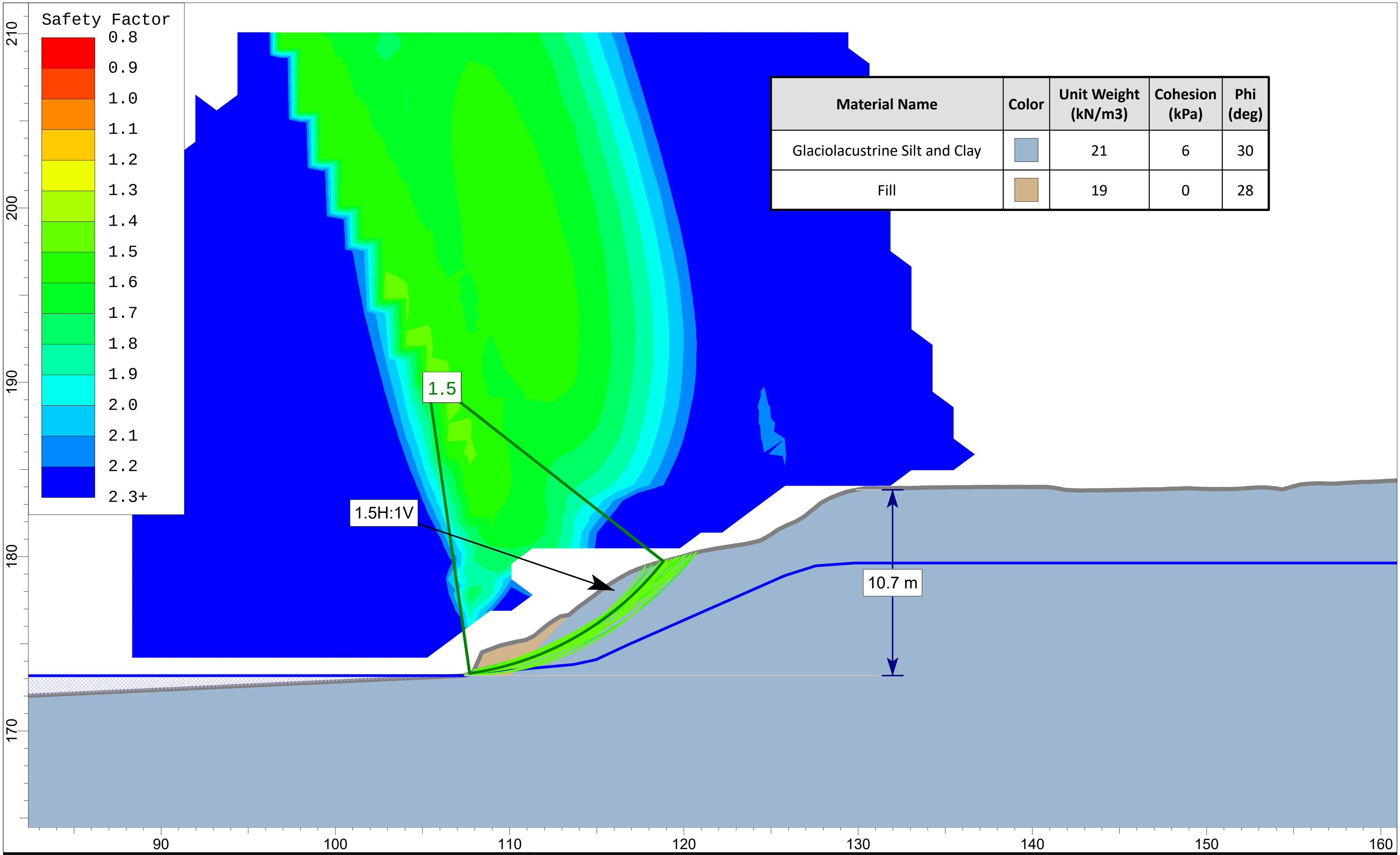
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 8, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 2 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

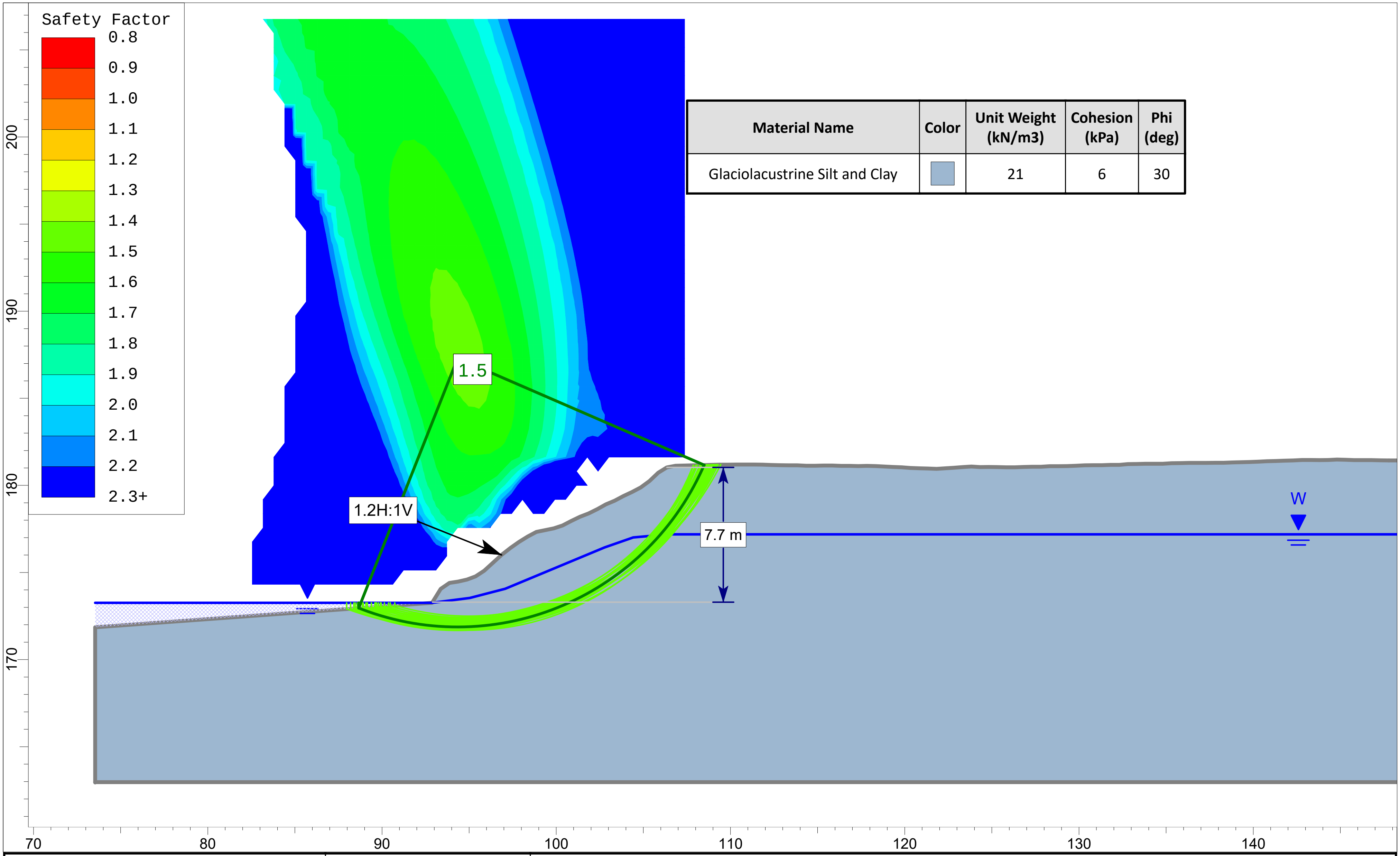
Project

Halimand County Slope Stability | 1-18-0402-01

Analysis

Global Stability: Section 9, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 3 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Halimand County Slope Stability | 1-18-0402-01

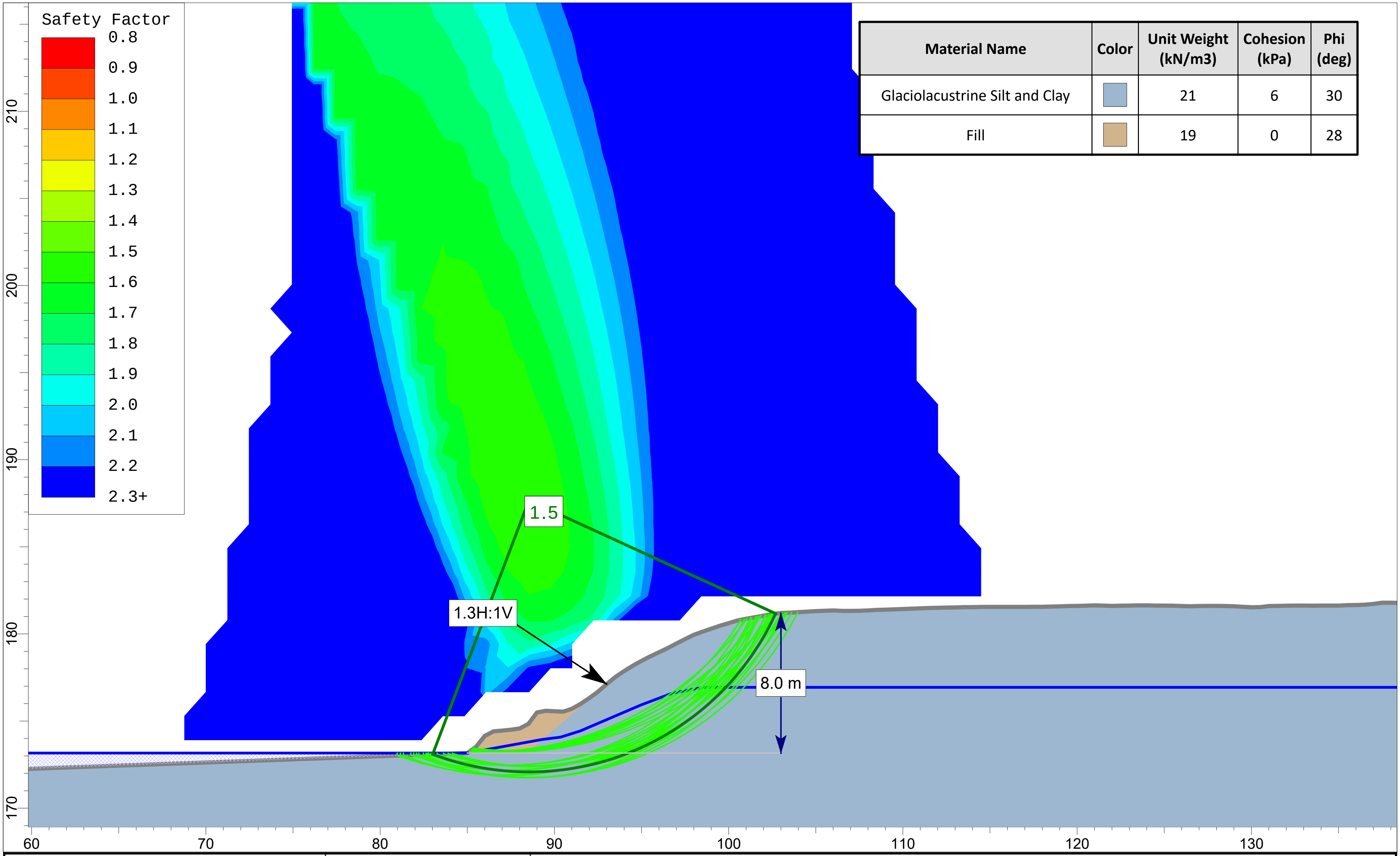
Analysis

Global Stability: Section 10, Master Scenario

Date	Scale	File
5/14/2019	1:300	Halimand Part 3 v2.slmd

By JH/JC

Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

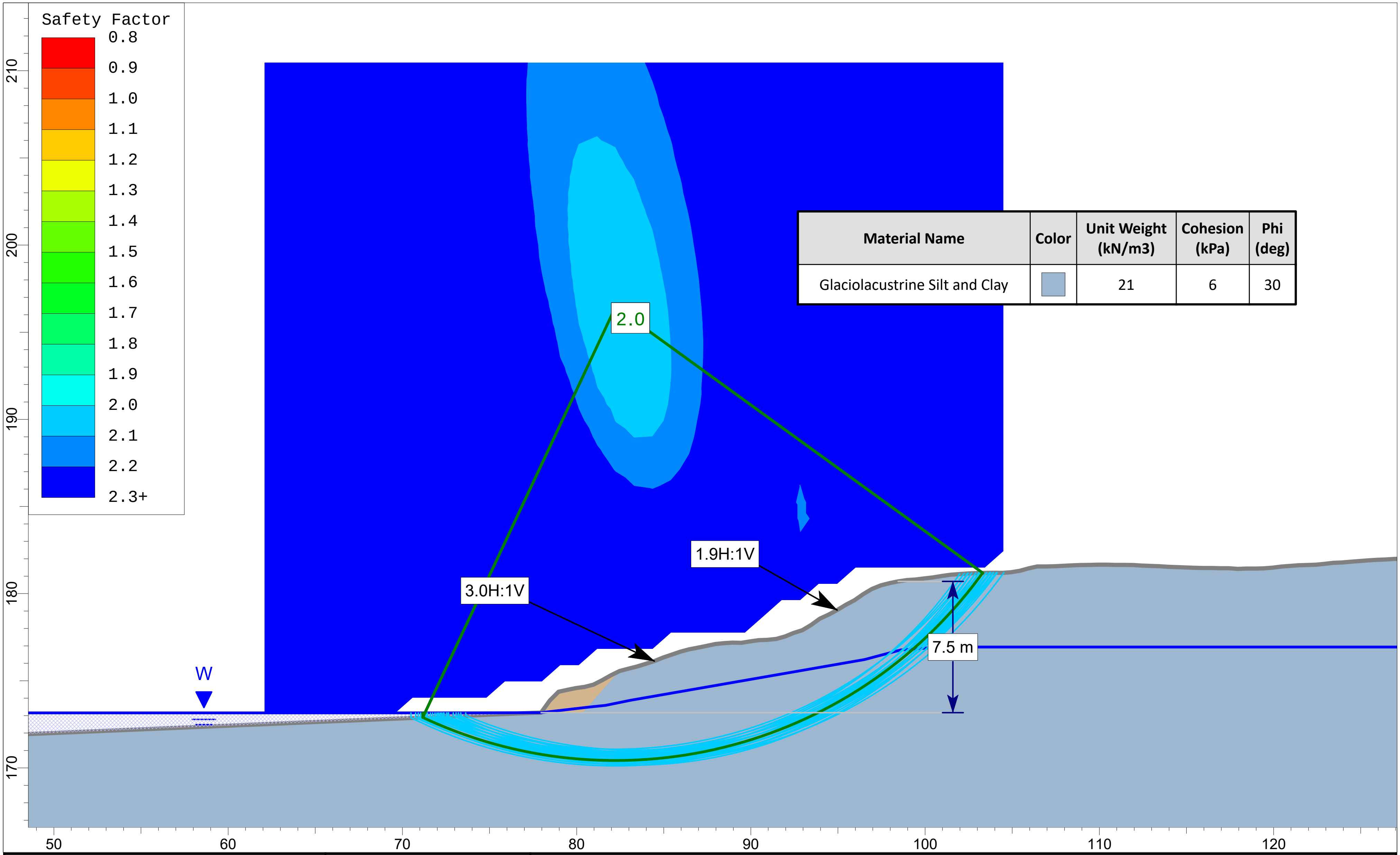
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project: **Halimand County Slope Stability | 1-18-0402-01**

Analysis: Global Stability: Section 11, Master Scenario

Date: 5/14/2019
Scale: 1:300
File: Halimand Part 3 v2.slmd

By: JH/JC
Ref.: 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	▨	21	6	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

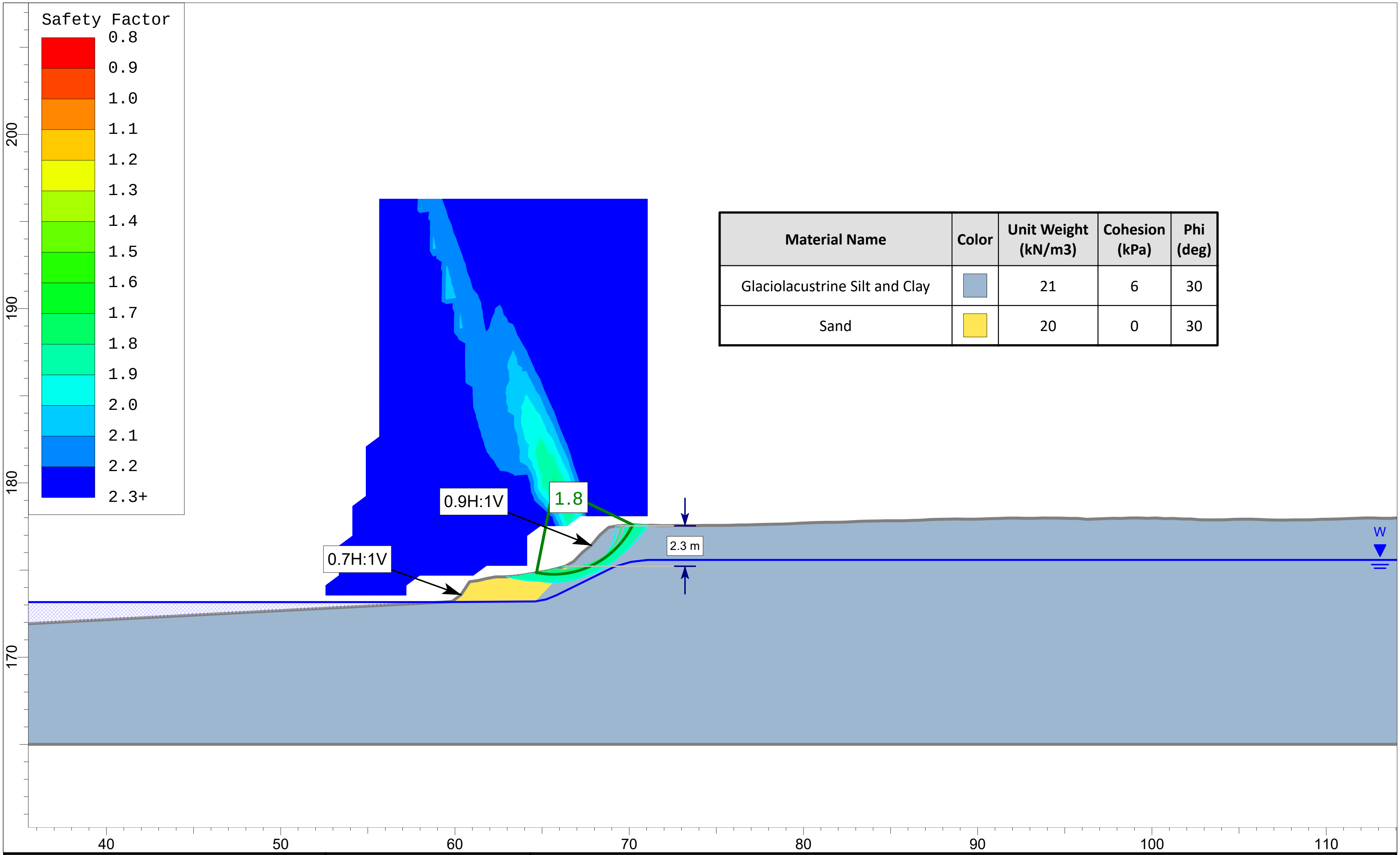
Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 12, Master Scenario

Date	Scale	File
5/14/2019	1:300	Halimand Part 3 v2.slmd

By JH/JC

Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

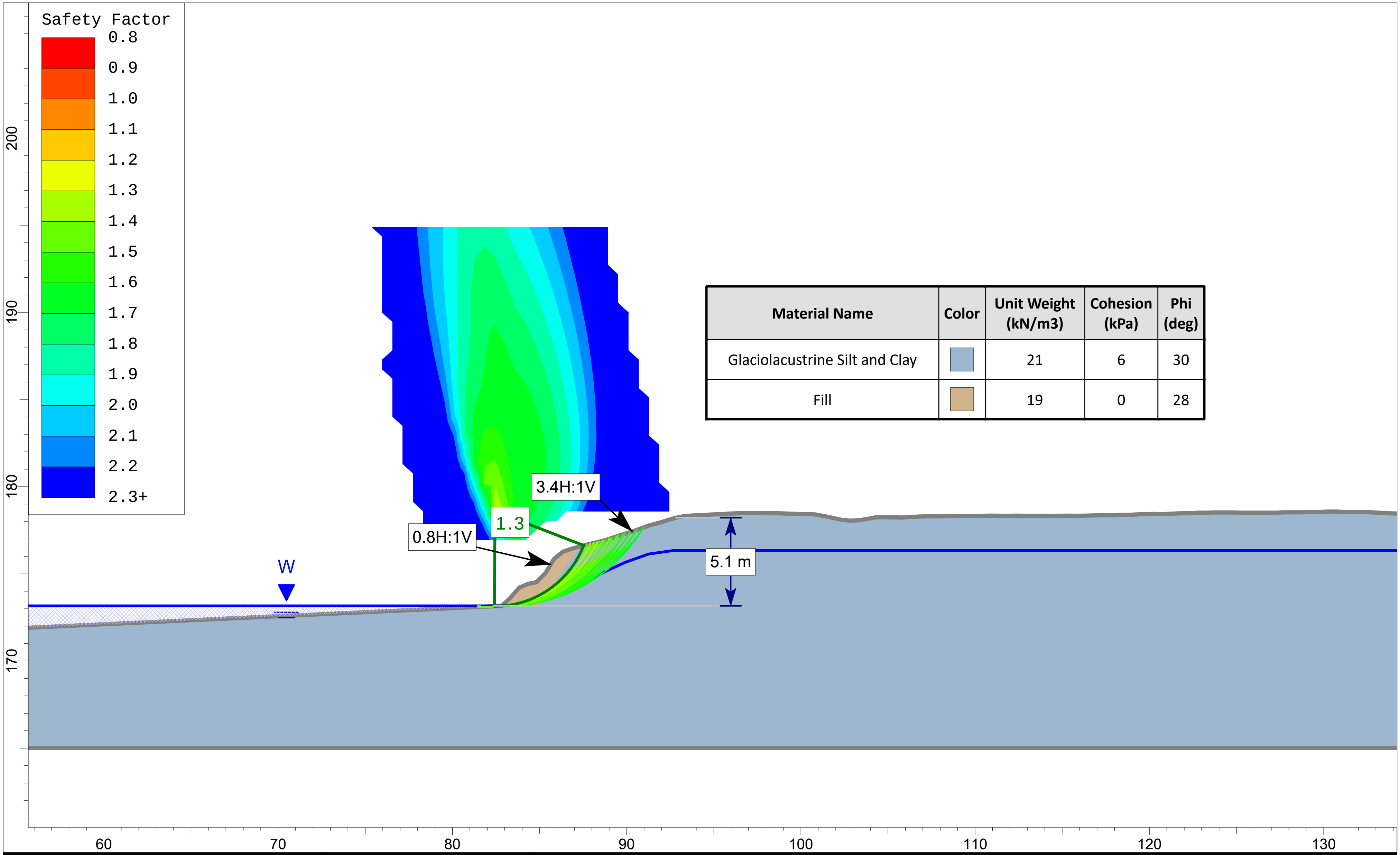
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 13, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 4 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
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Construction Materials Inspection & Testing

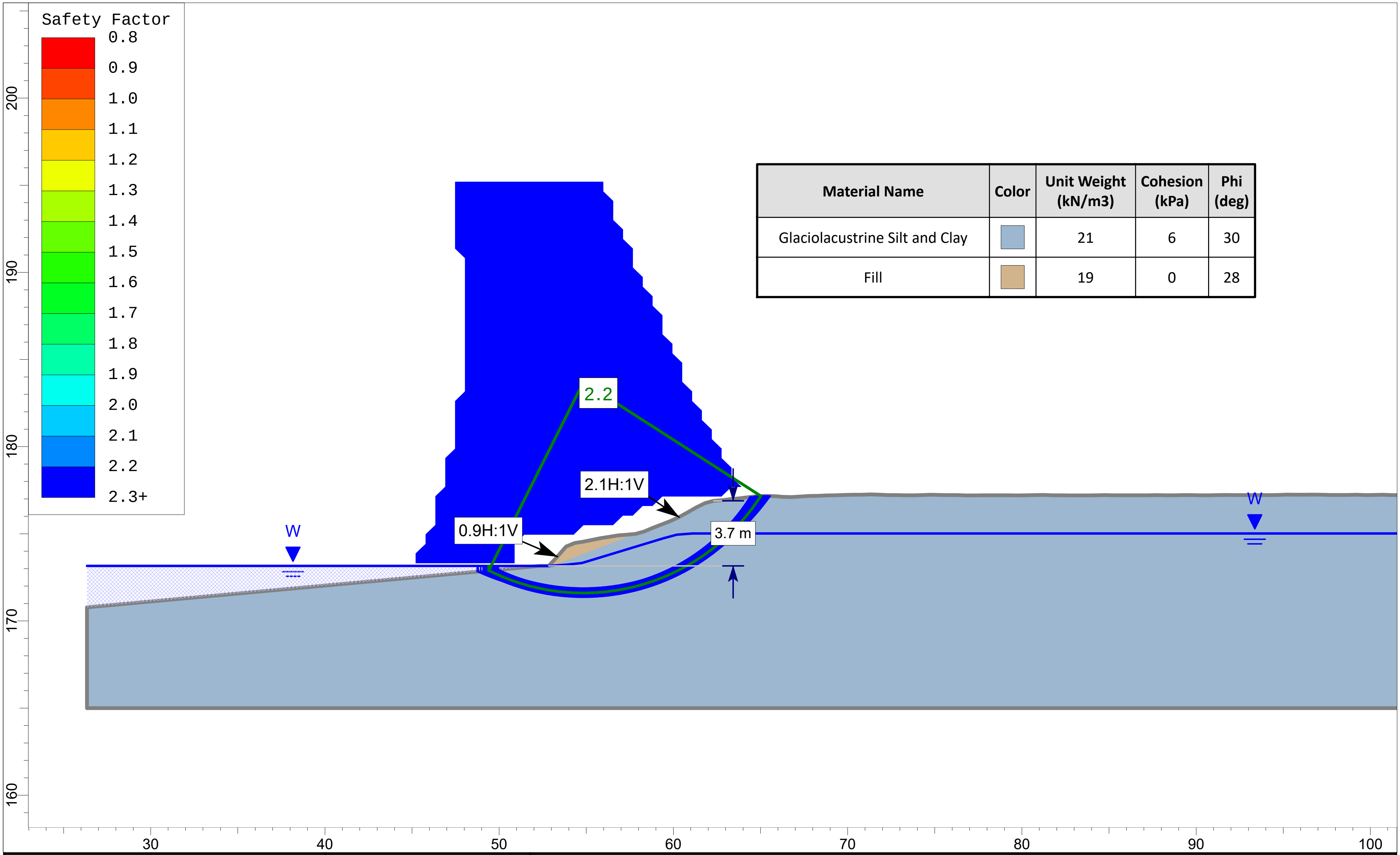
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 14, Master Scenario

Date 5/14/2019
Scale 1:300
File Halimand Part 4 v2.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

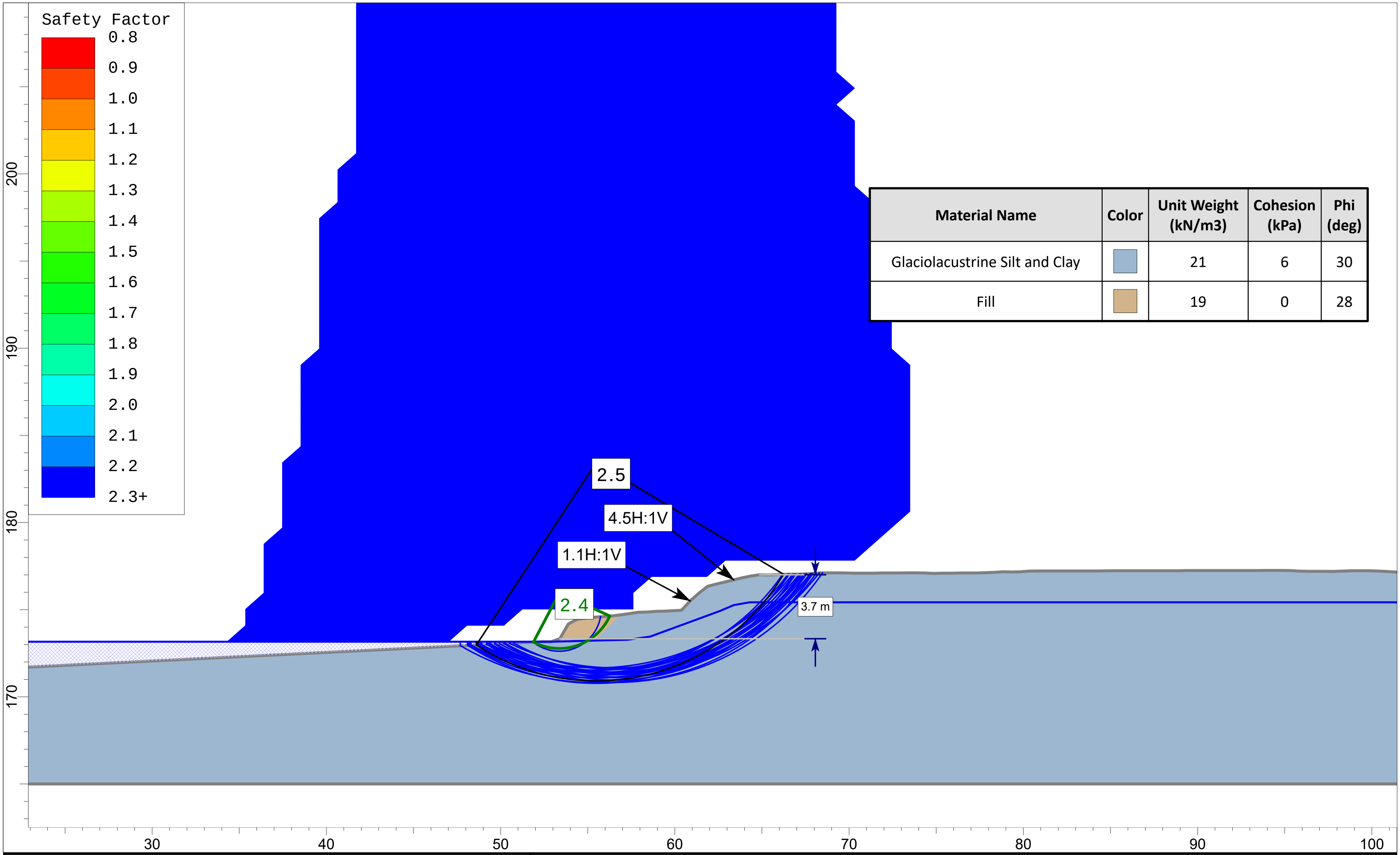
Project

Halimand County Slope Stability | 1-18-0402-01

Analysis

Global Stability: Section 15, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 4 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

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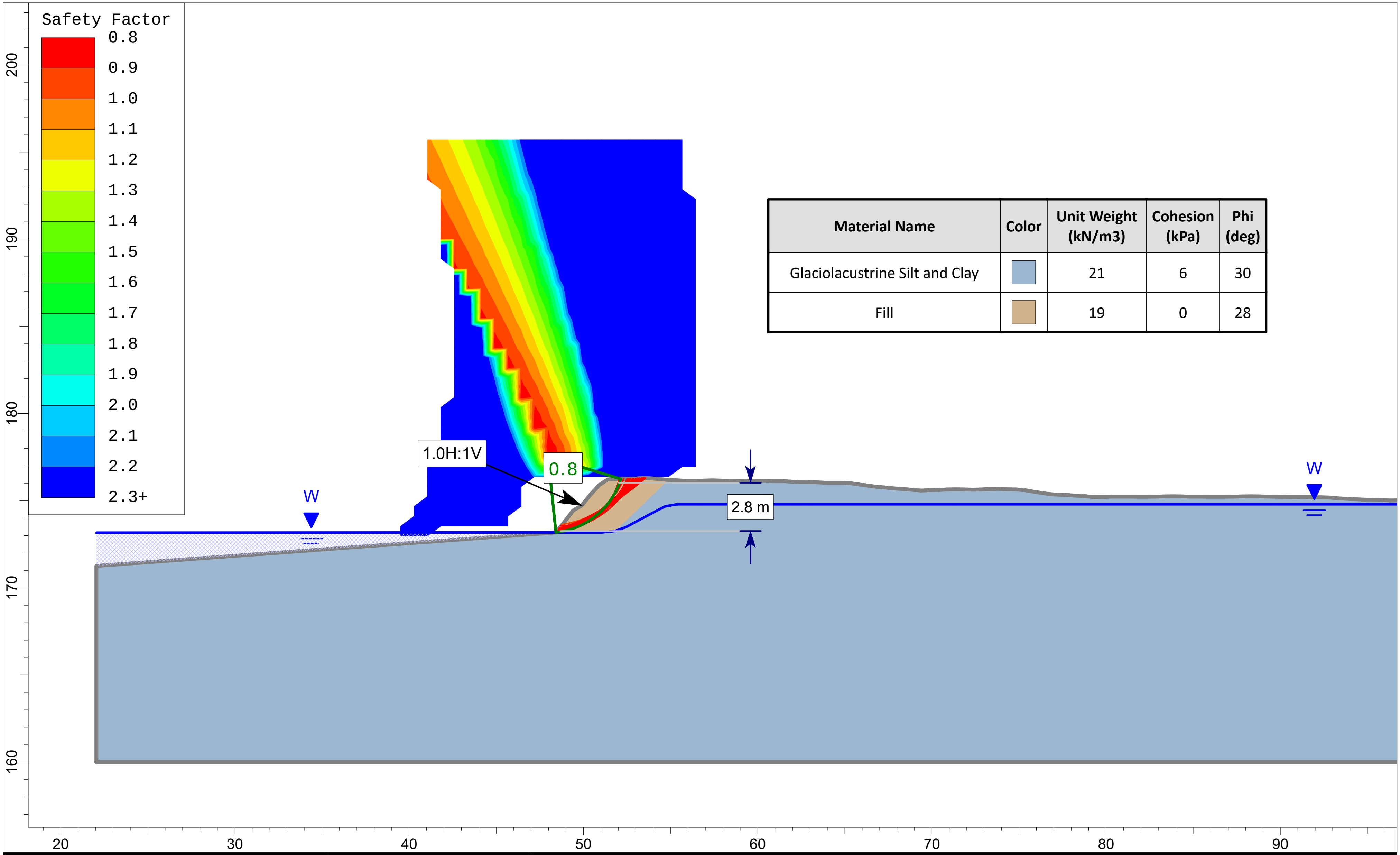
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 16, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 4 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	■	21	6	30
Fill	■	19	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

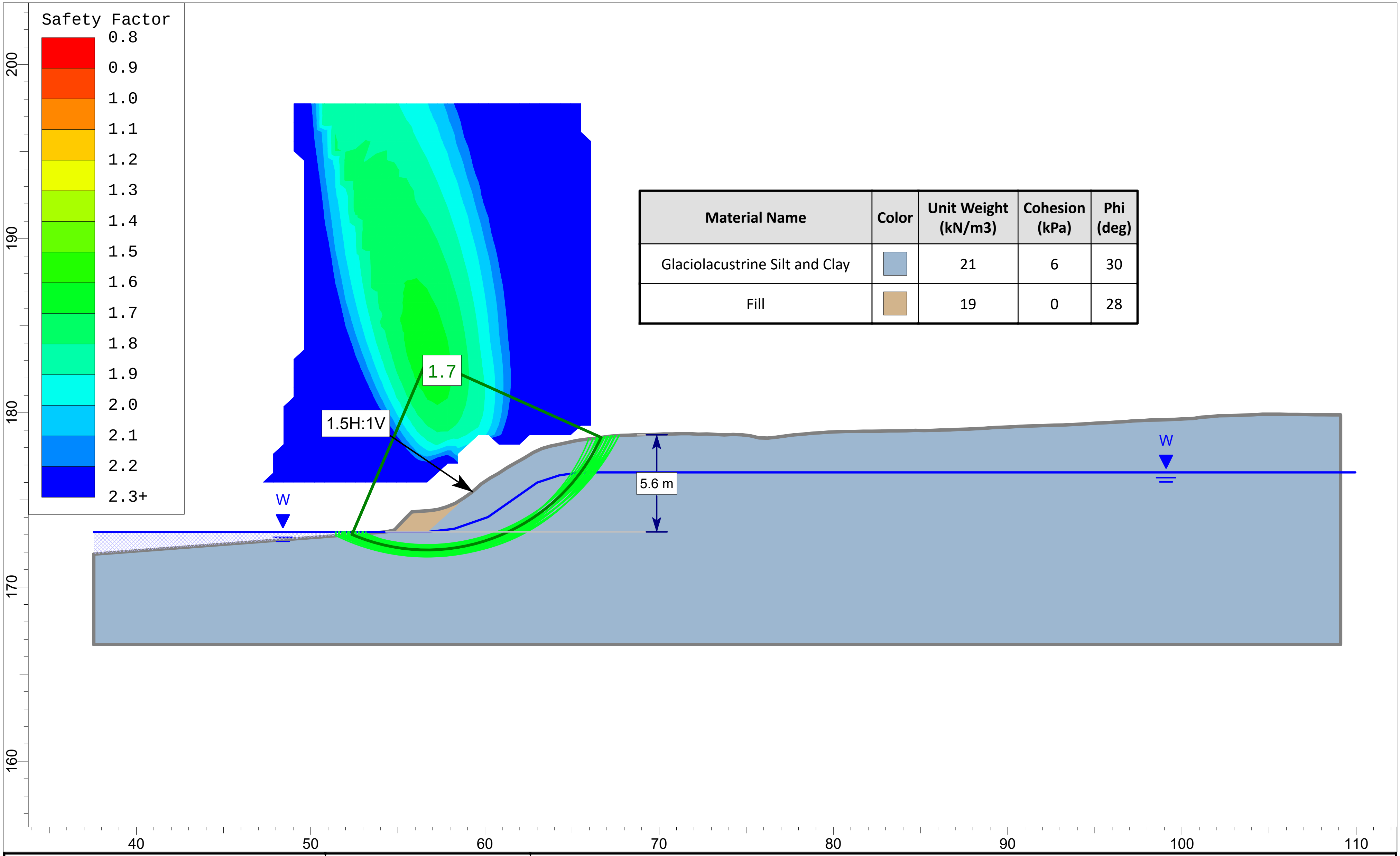
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 17, Master Scenario

Date 5/14/2019
Scale 1:300
File Halimand Part 5 v2.slmd

By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

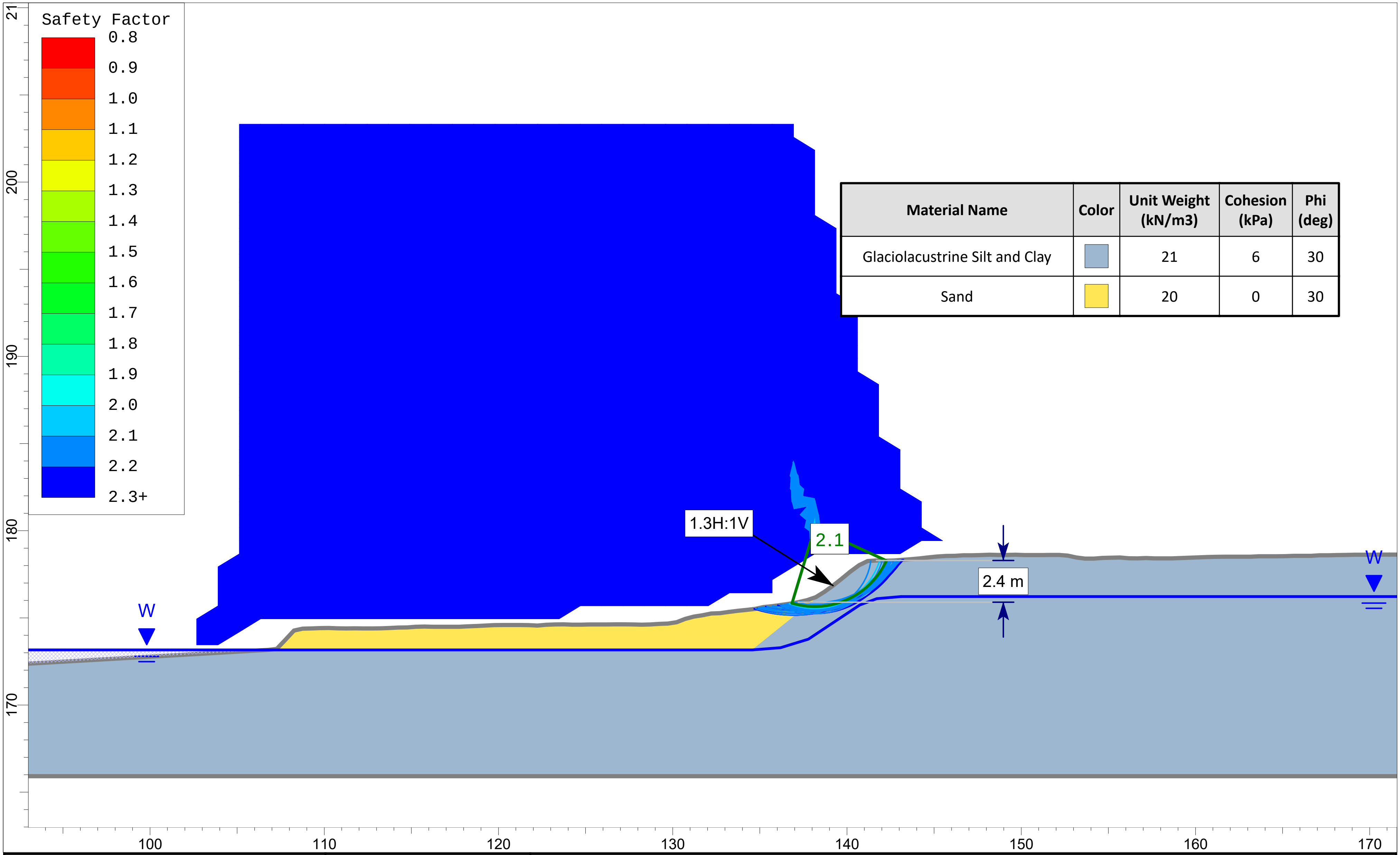
Project

Halimand County Slope Stability | 1-18-0402-01

Analysis

Global Stability: Section 18, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 5 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe
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Construction Materials Inspection & Testing

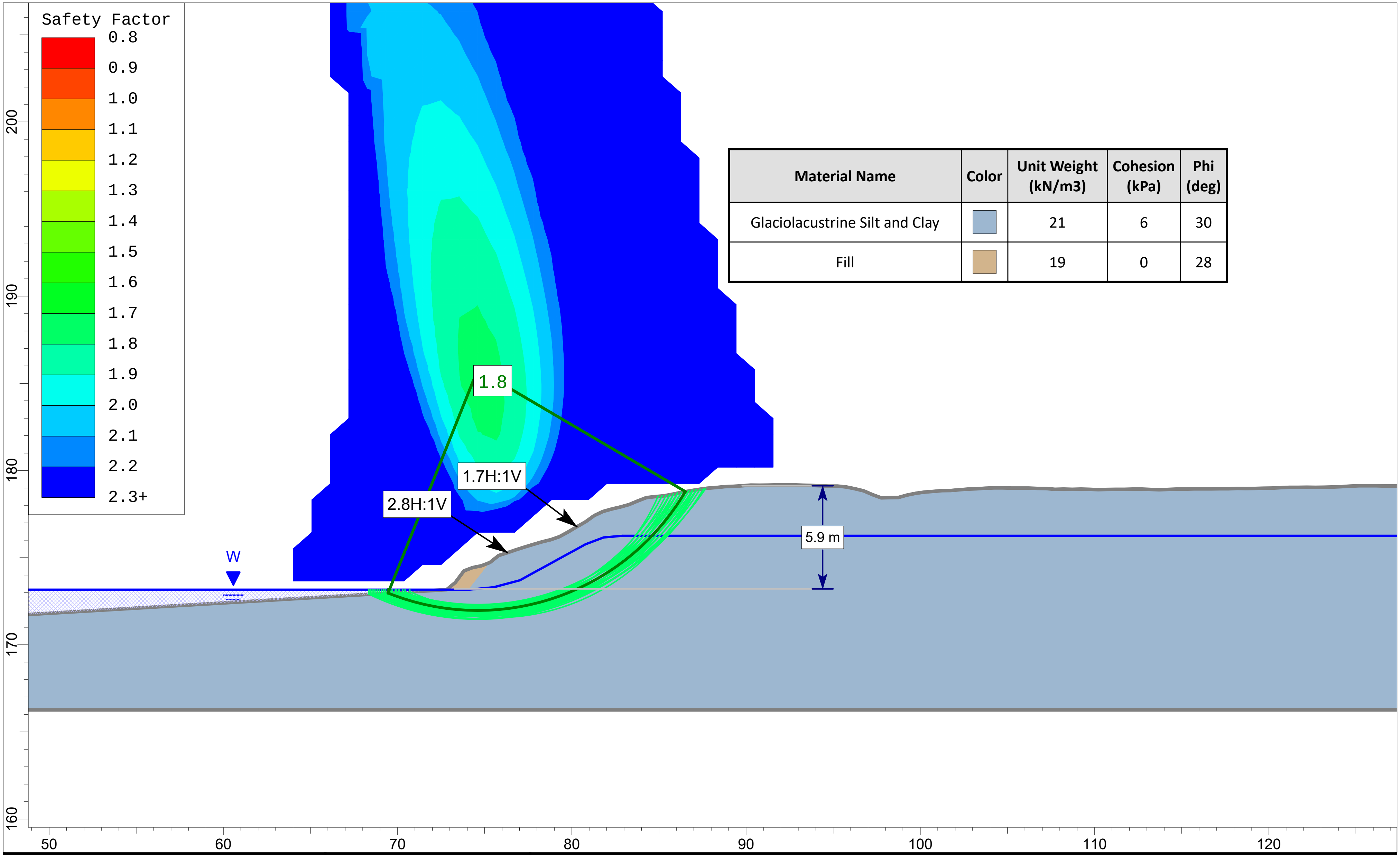
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 19, Master Scenario

Date 5/14/2019
Scale 1:300
File Halimand Part 5 v2.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
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Construction Materials Inspection & Testing

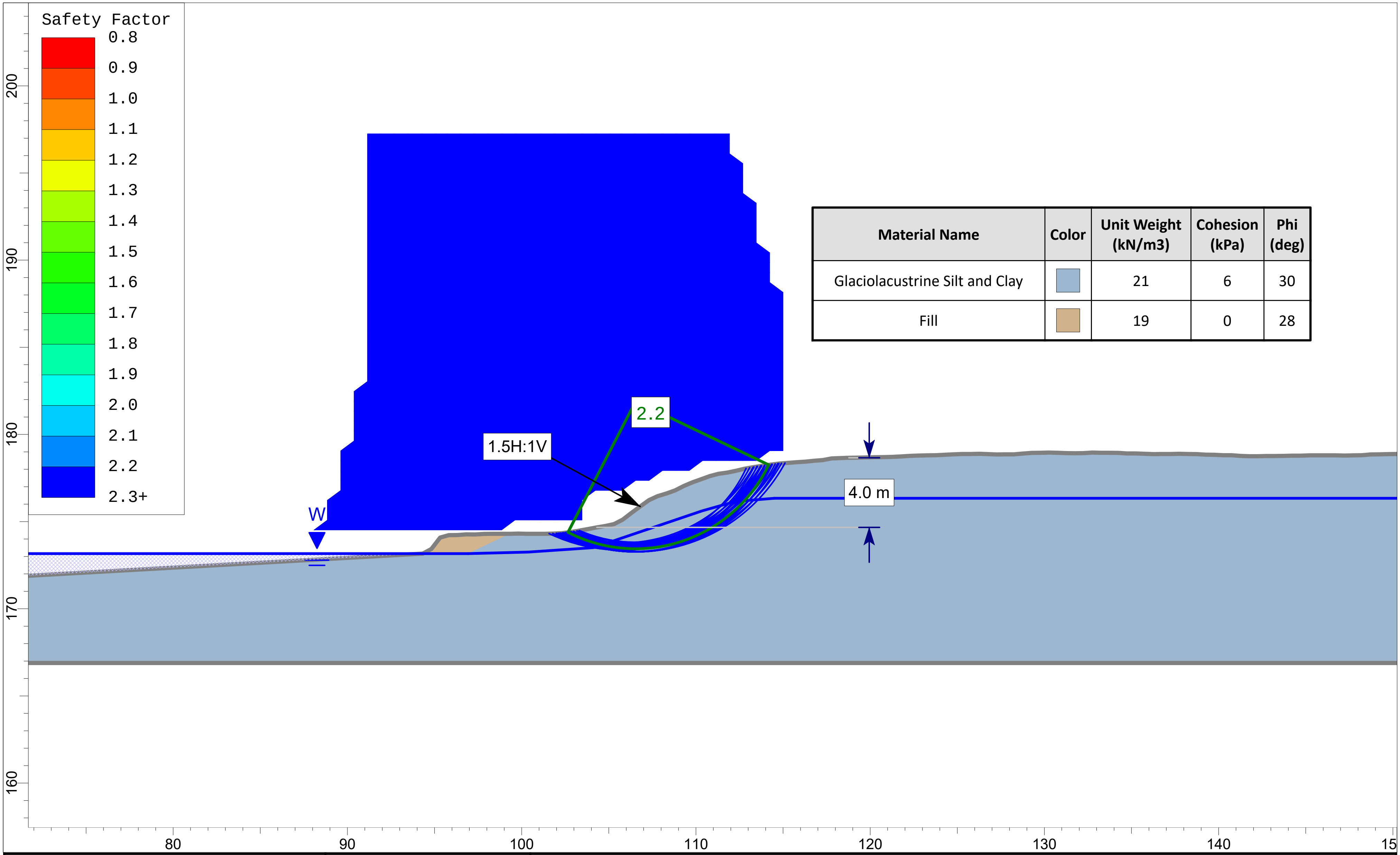
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 20, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 5 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
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Construction Materials Inspection & Testing

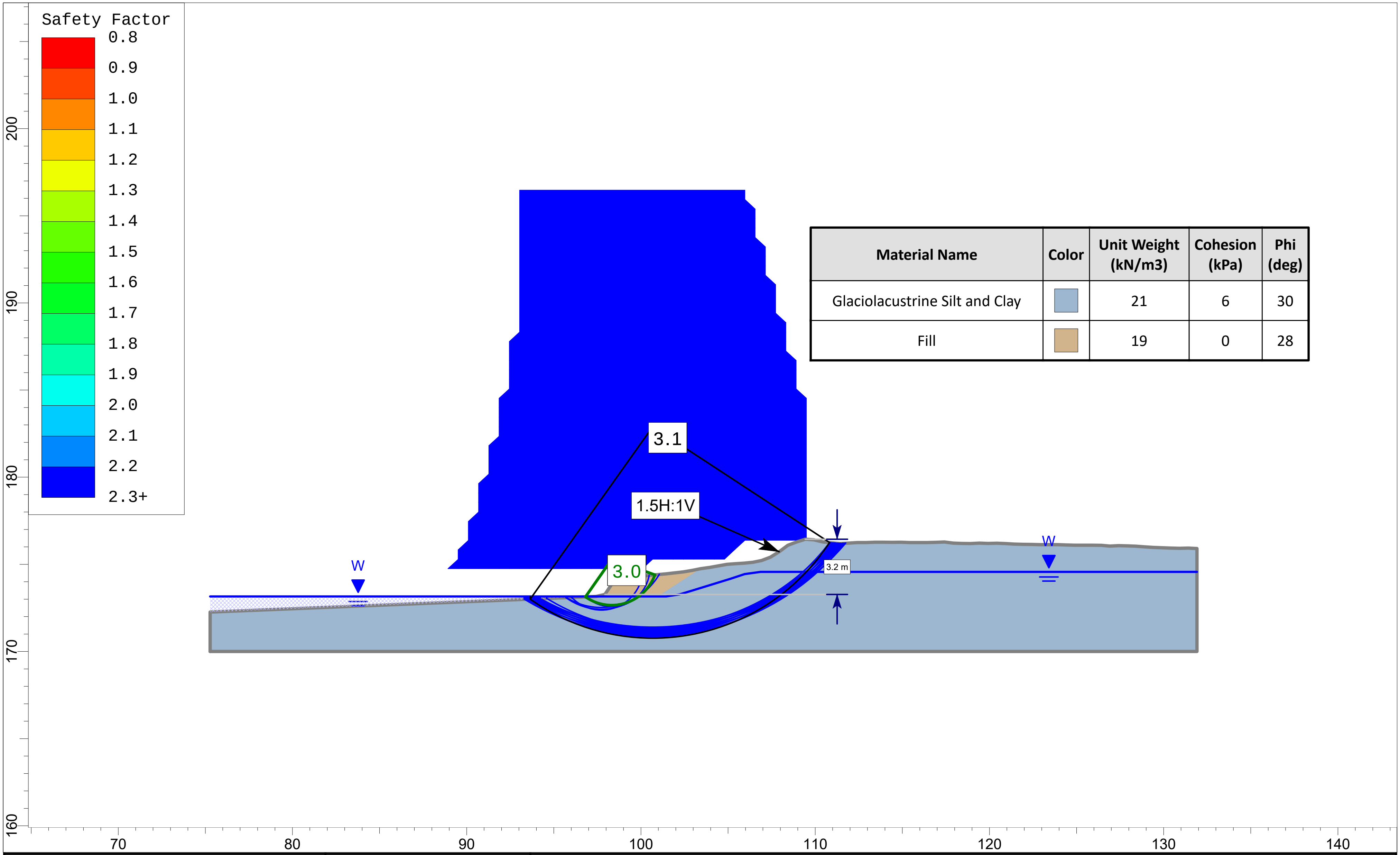
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 21, Master Scenario

Date 5/14/2019
Scale 1:300
File Halimand Part 6 v2.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

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Construction Materials Inspection & Testing

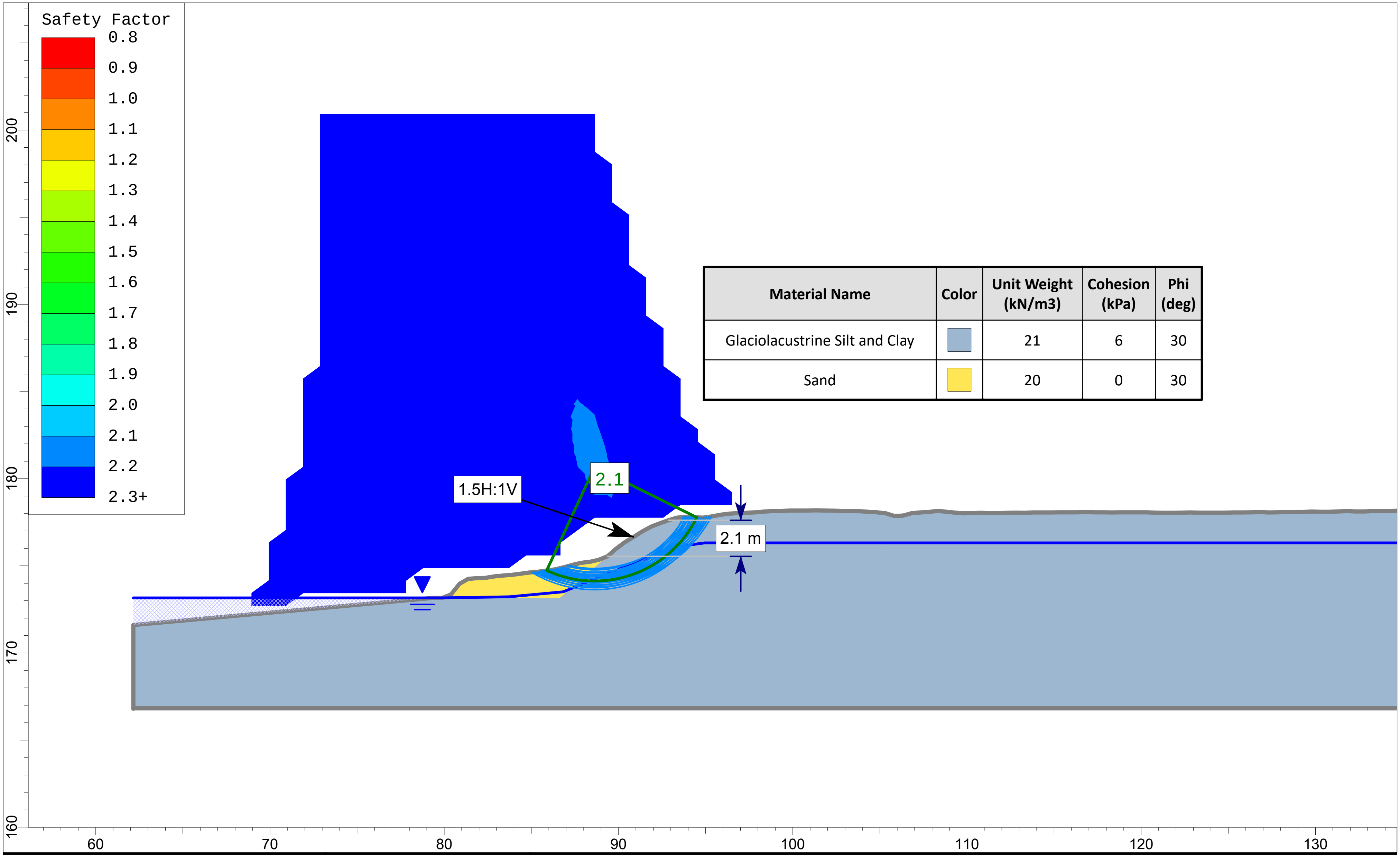
SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 22, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 6 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	▨	21	6	30
Sand	▨	20	0	30

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 23, Master Scenario

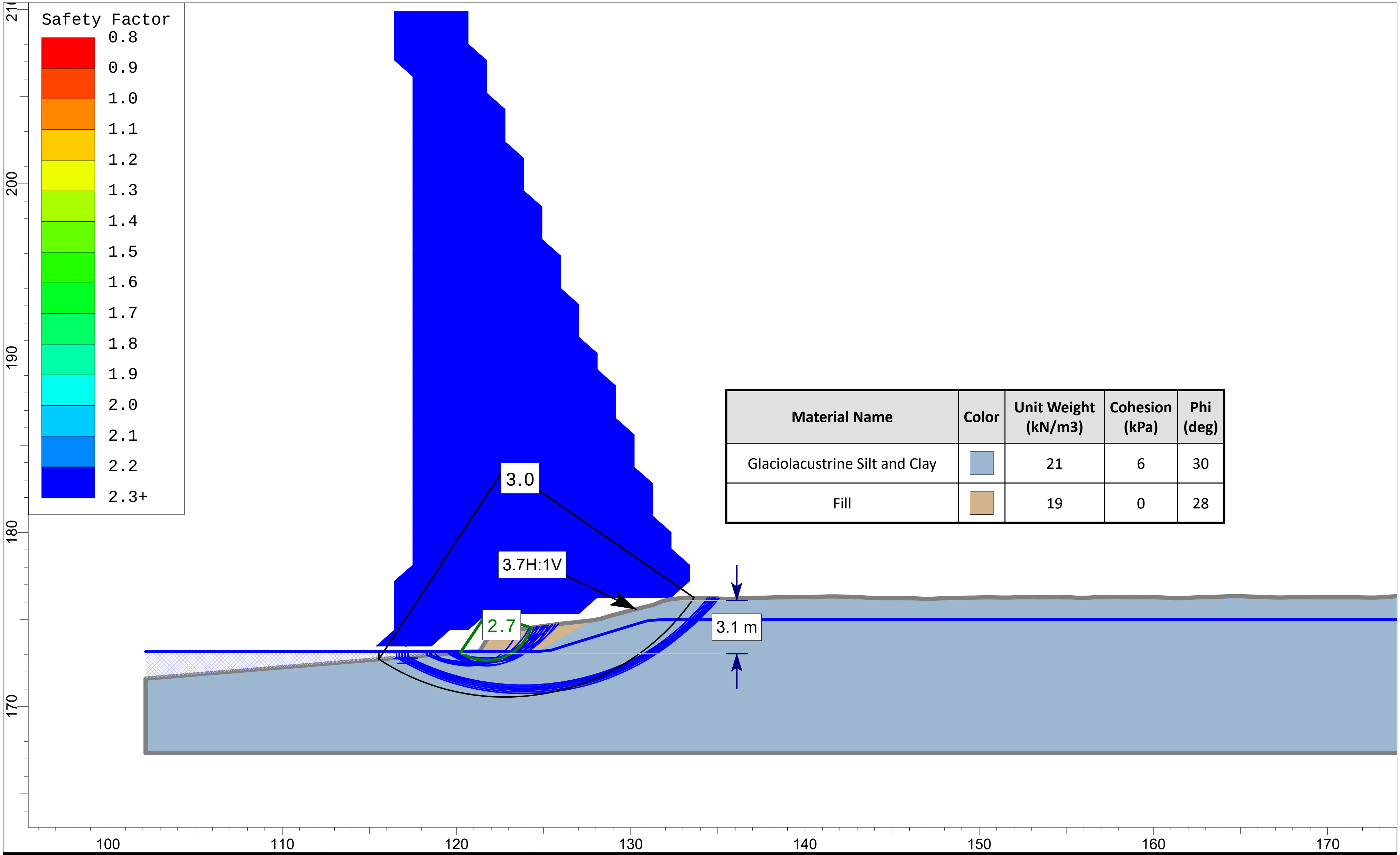
Date 5/14/2019

Scale 1:300

File Halimand Part 6 v2.slmd

By JH/JC

Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	**Color**	**Unit Weight (kN/m3)**	**Cohesion (kPa)**	**Phi (deg)**
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

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Construction Materials Inspection & Testing

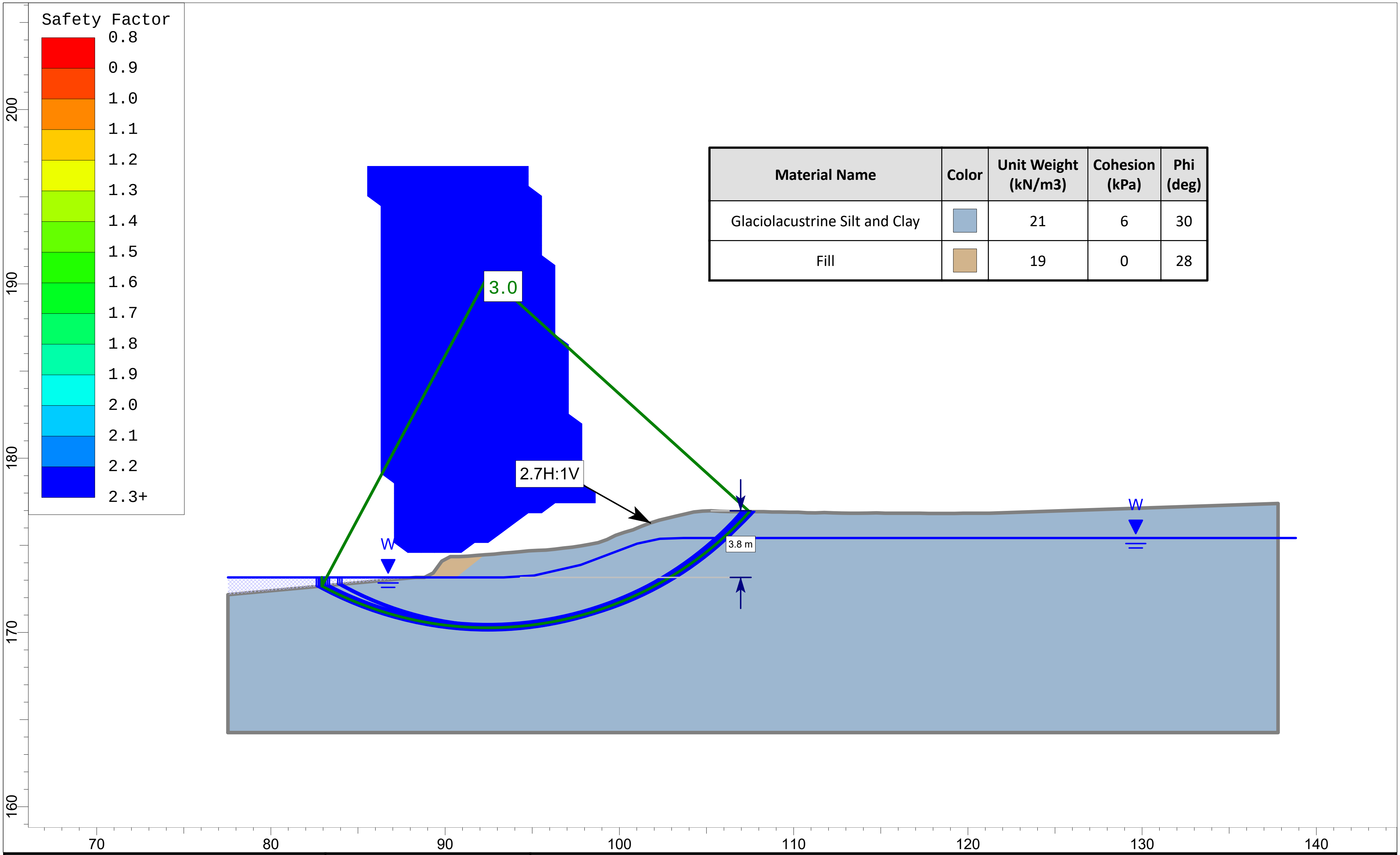
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 24, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 6 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 25, Master Scenario

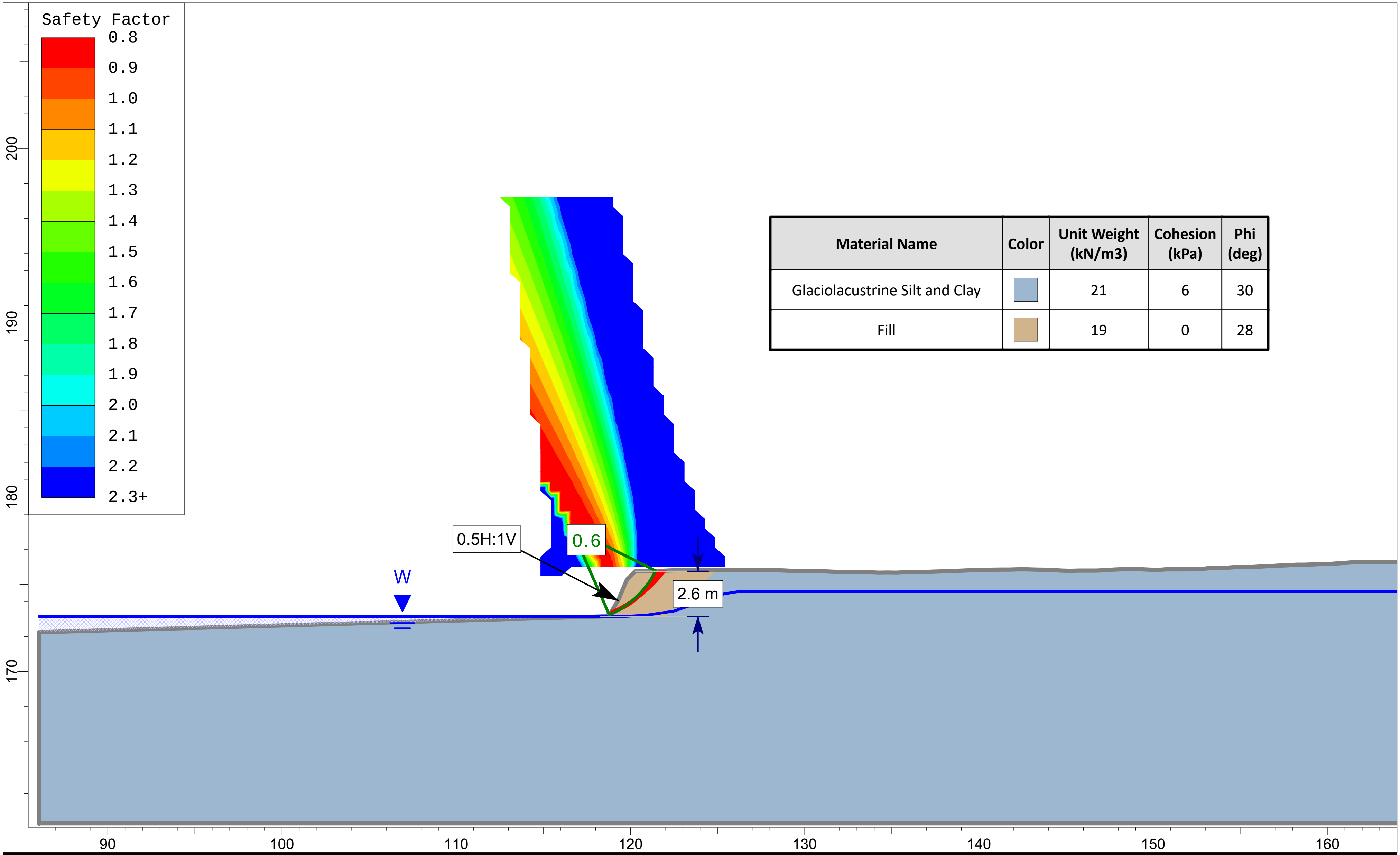
Date 5/14/2019

Scale 1:300

File Halimand Part 7 v2.slmd

By JH/JC

Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
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Construction Materials Inspection & Testing

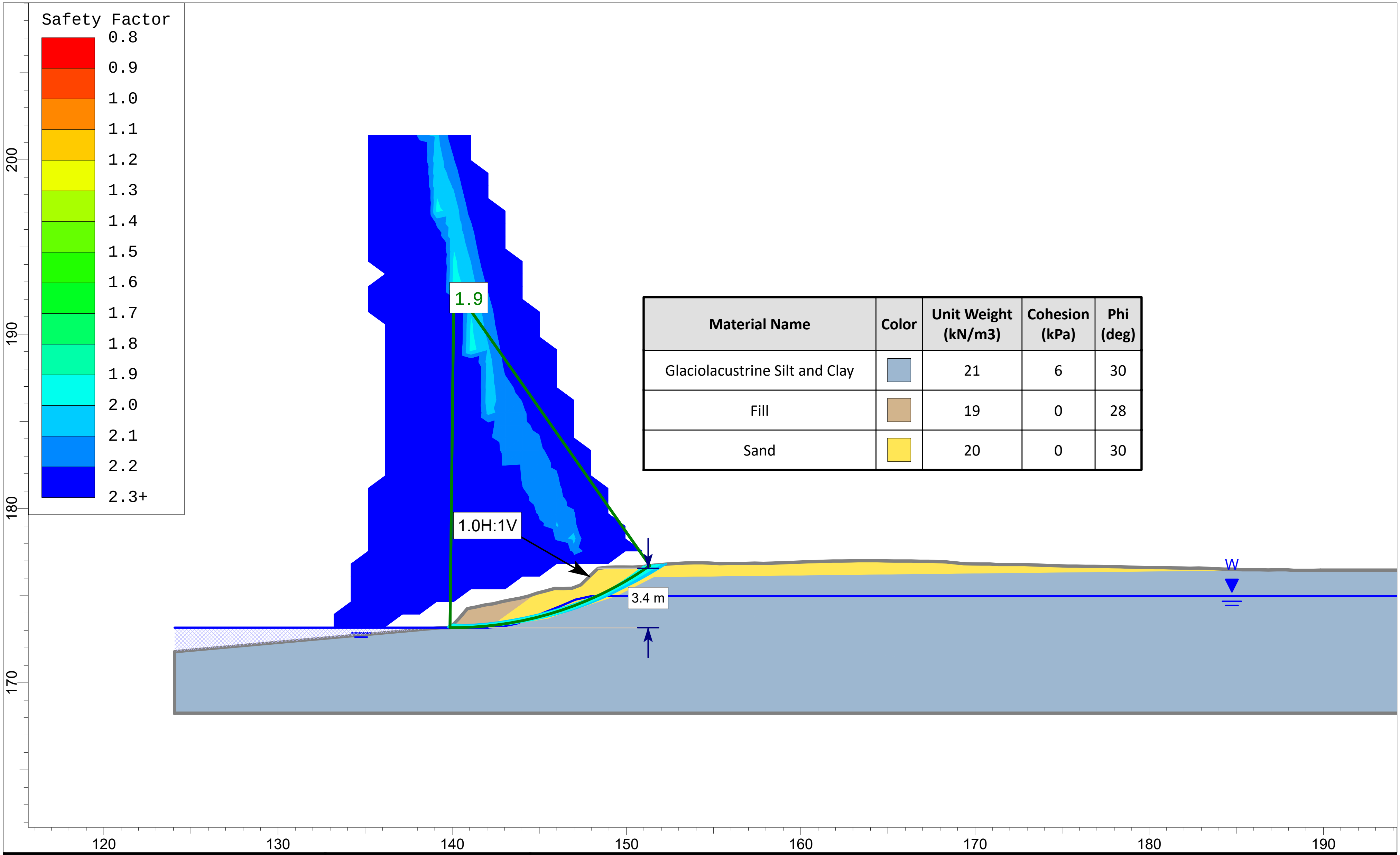
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 26, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 7 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28
Sand	🟨	20	0	30

Terraprobe

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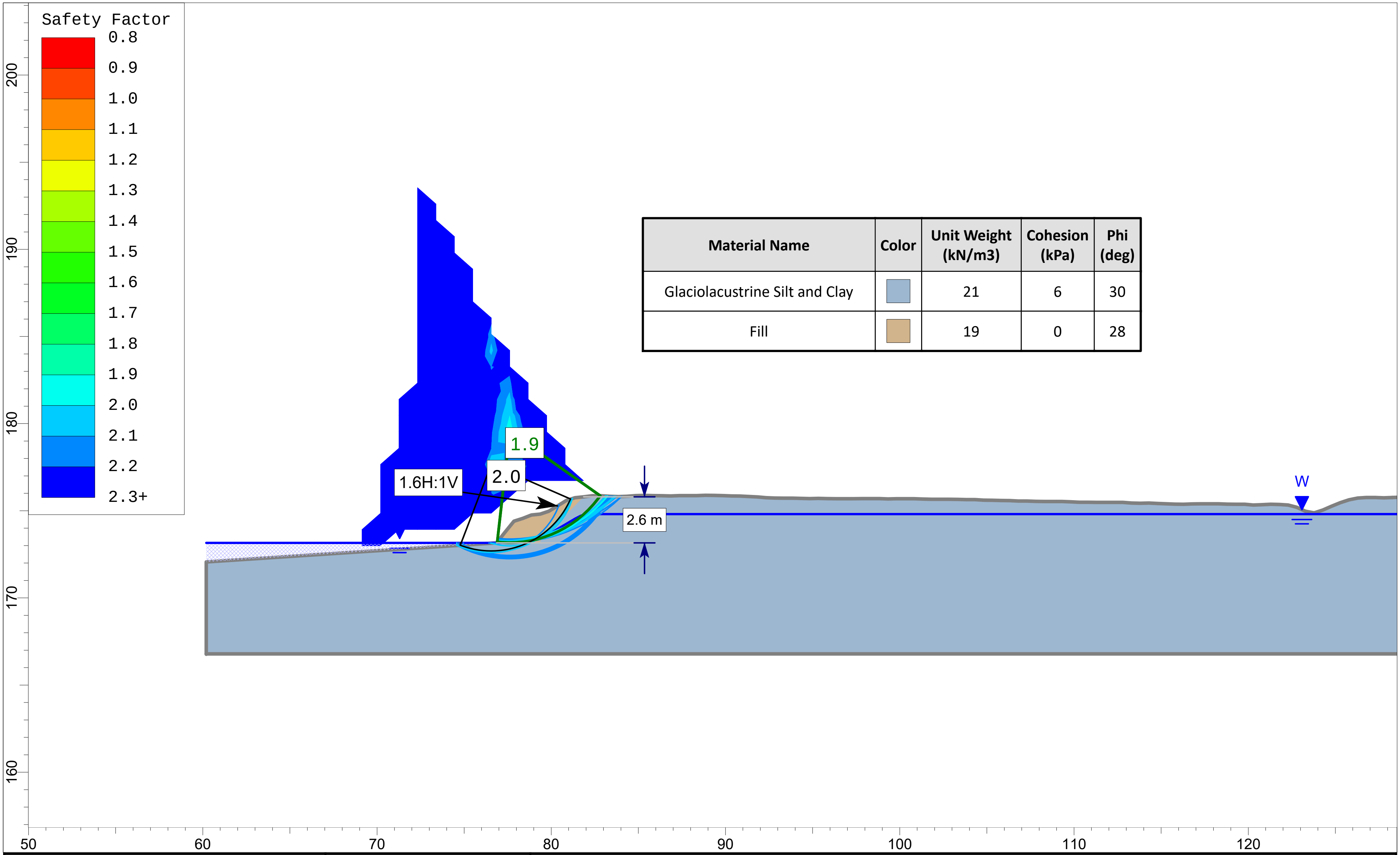
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 27, Master Scenario
Date	5/17/2019
Scale	1:300
File	Halimand Part 7 v2.slmd
By	JH/JC
Ref.	2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

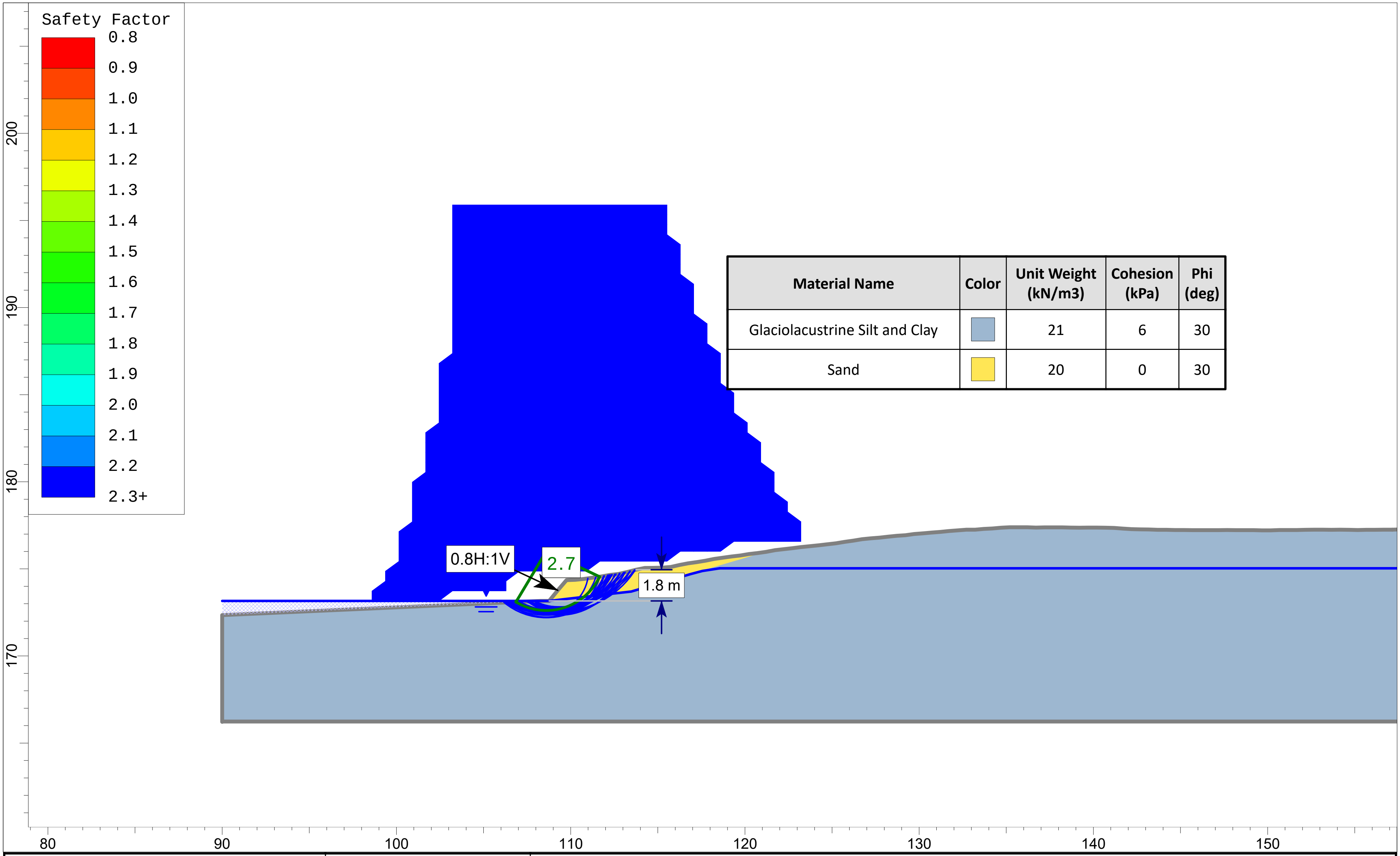
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 28, Master Scenario

Date	Scale	File
5/14/2019	1:300	Halimand Part 7 v2.slmd

By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

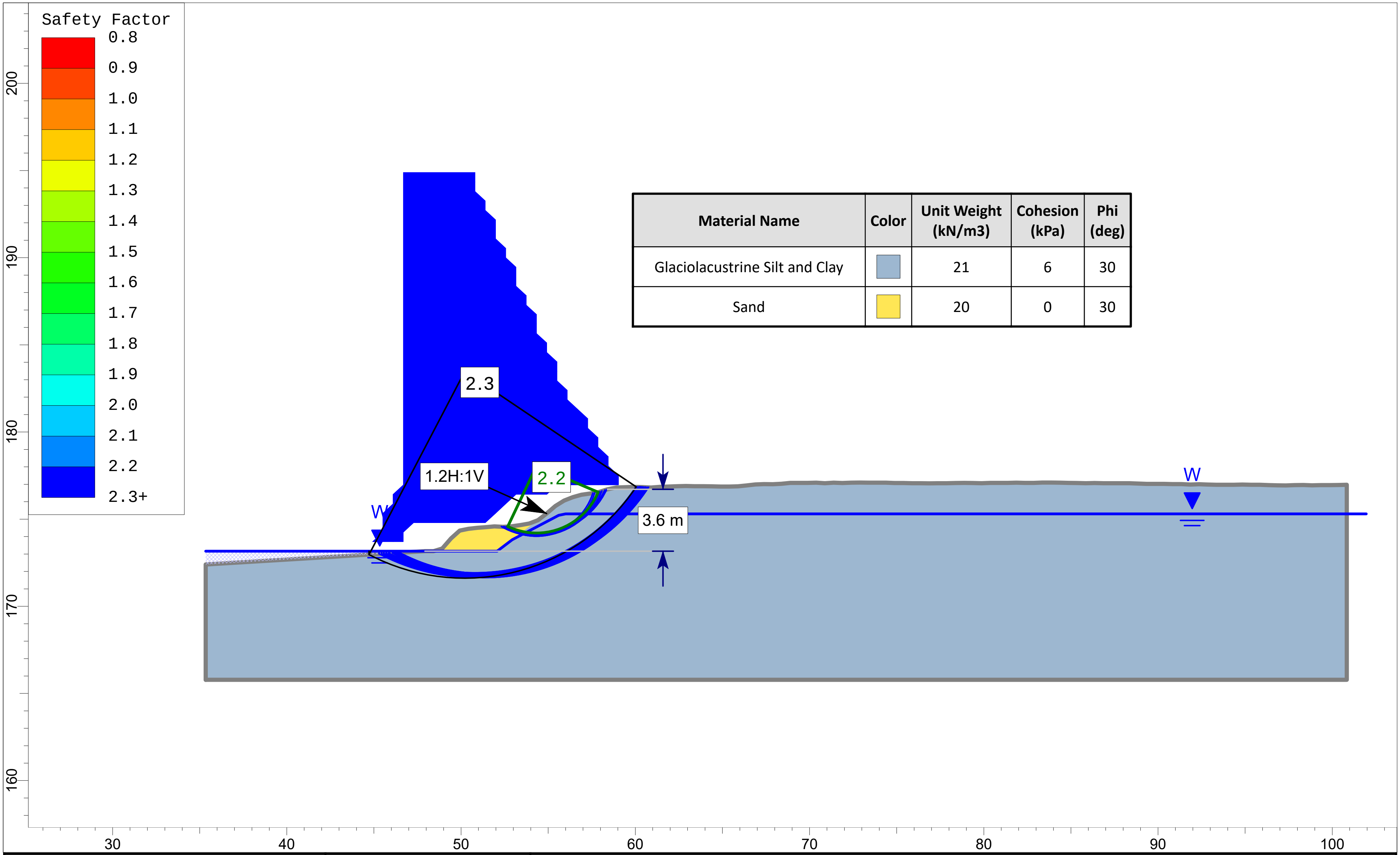
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 29, Master Scenario

Date 5/14/2019
Scale 1:300
File Halimand Part 8 v2.slmd

By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

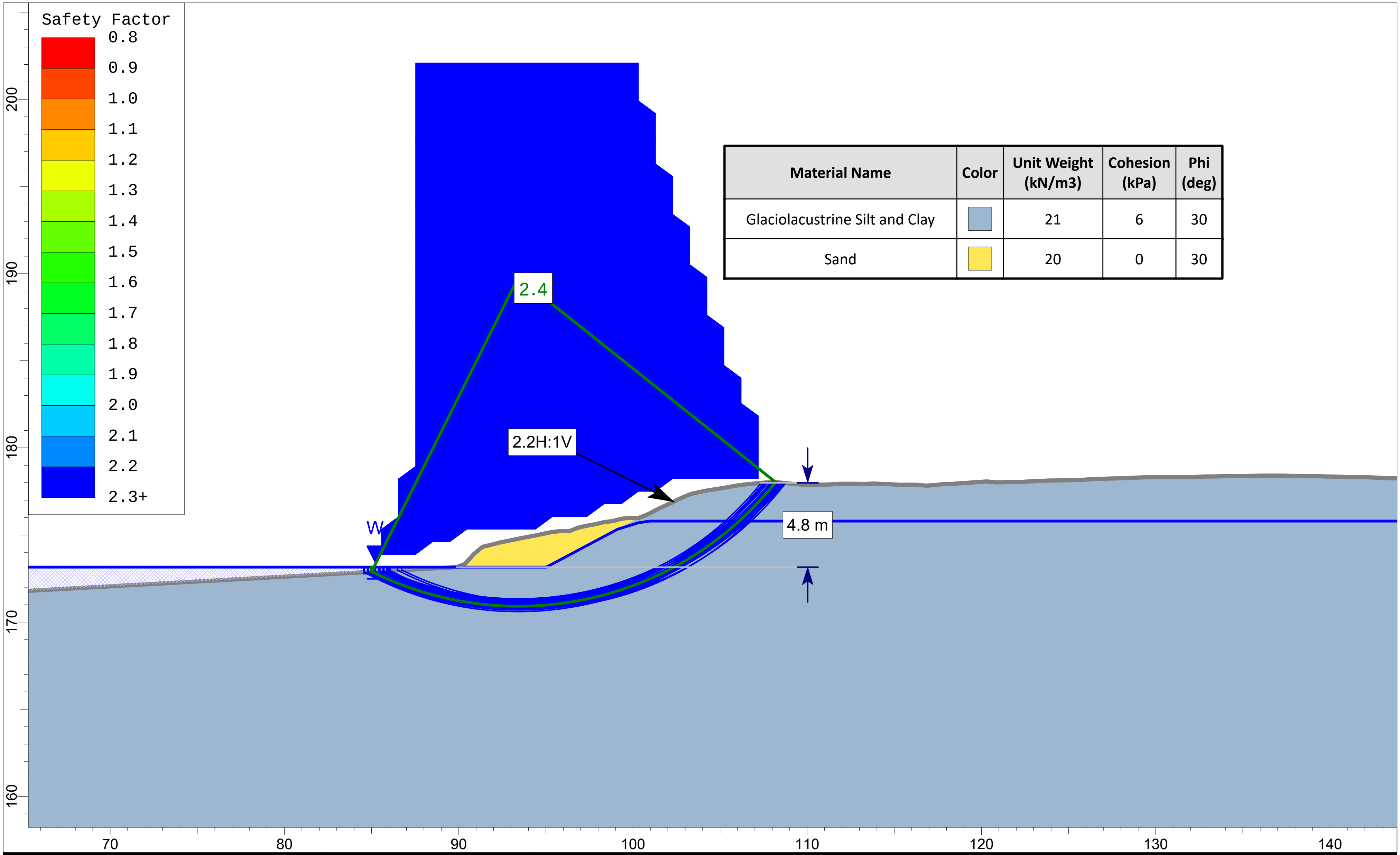
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 30, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 8 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



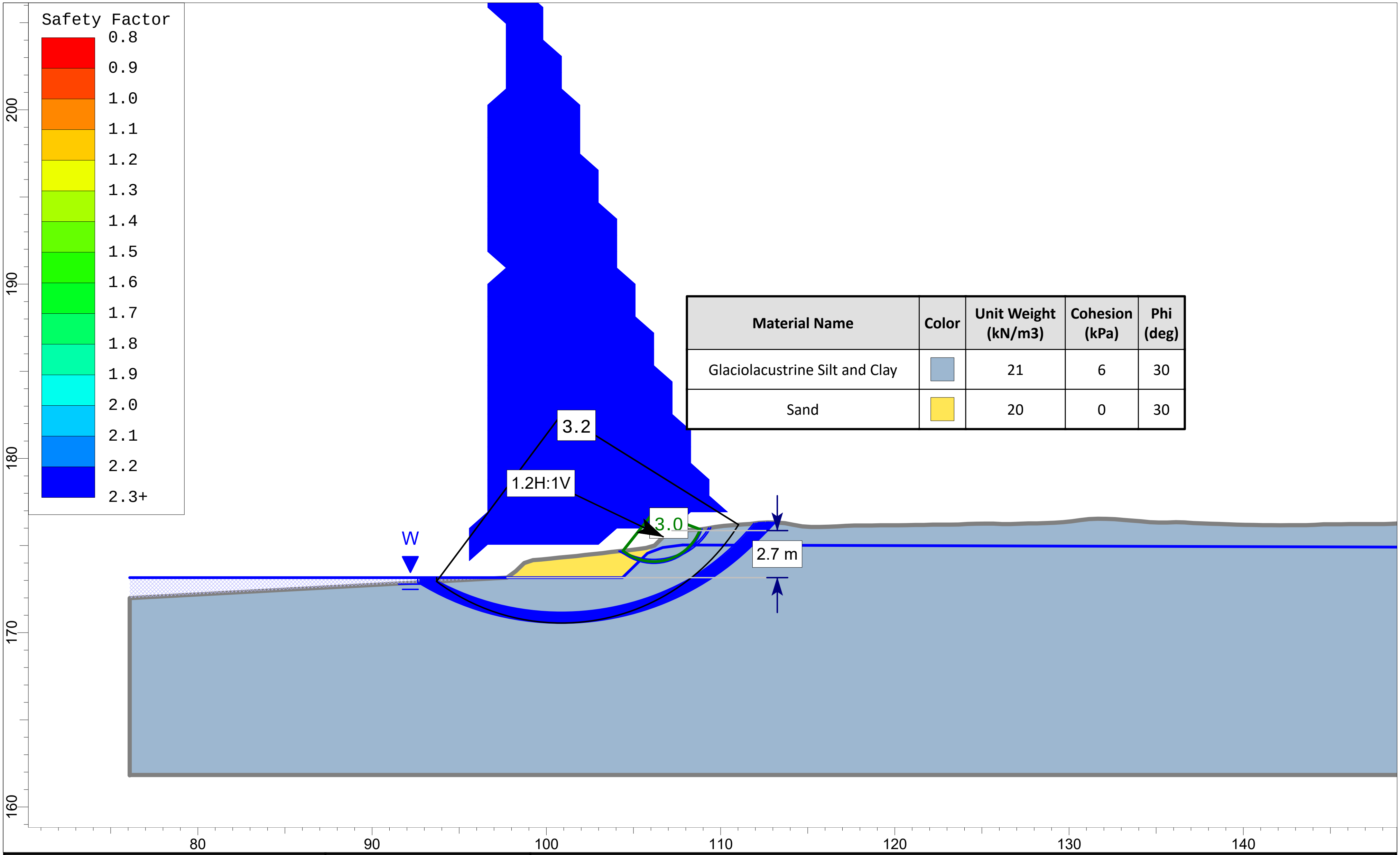
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 31, Master Scenario
Date	5/14/2019
Scale	1:300
File	Halimand Part 8 v2.slmd
By	JH/JC
Ref.	2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

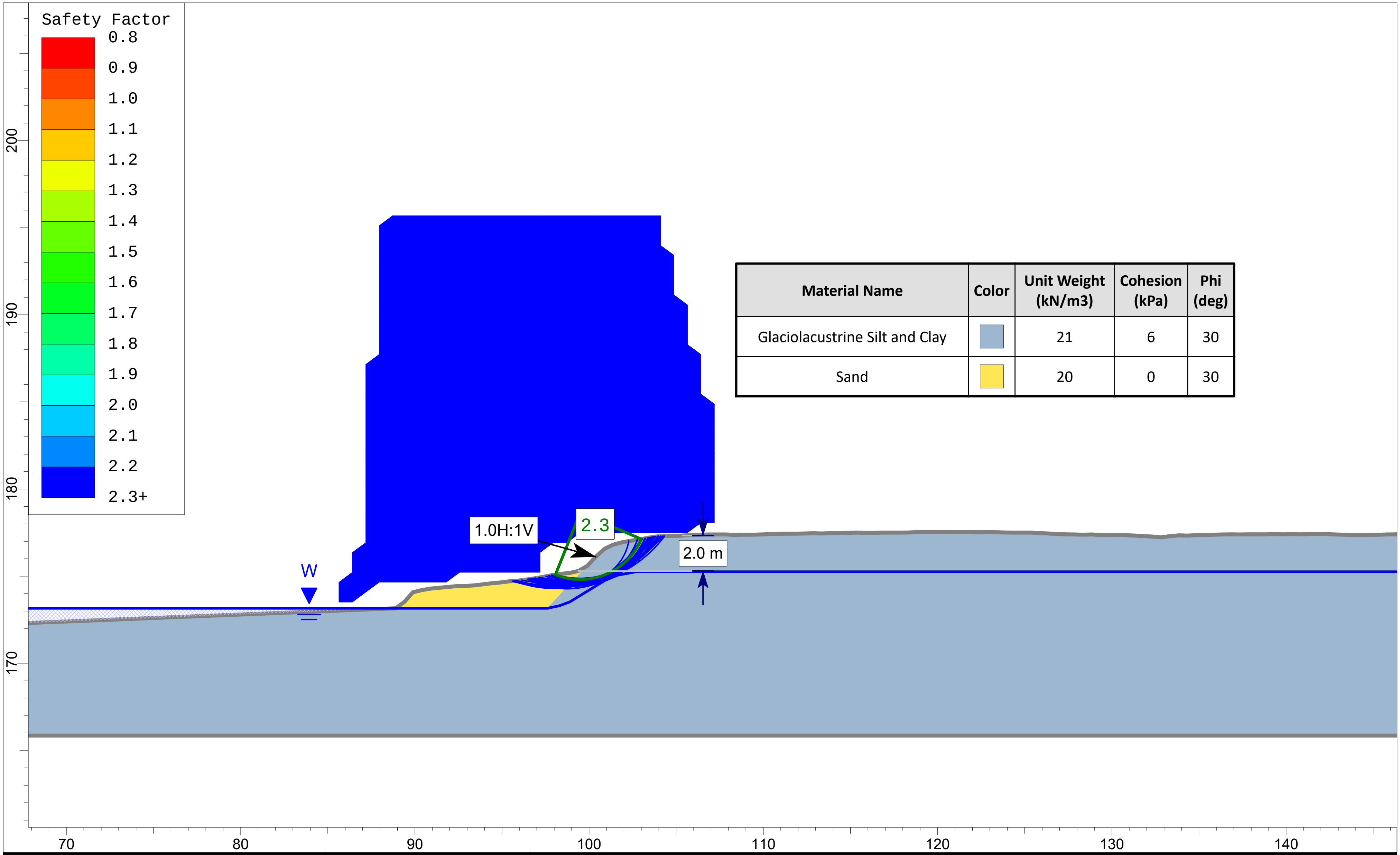
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 32, Master Scenario

Date 5/14/2019
Scale 1:300
File Halimand Part 8 v2.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

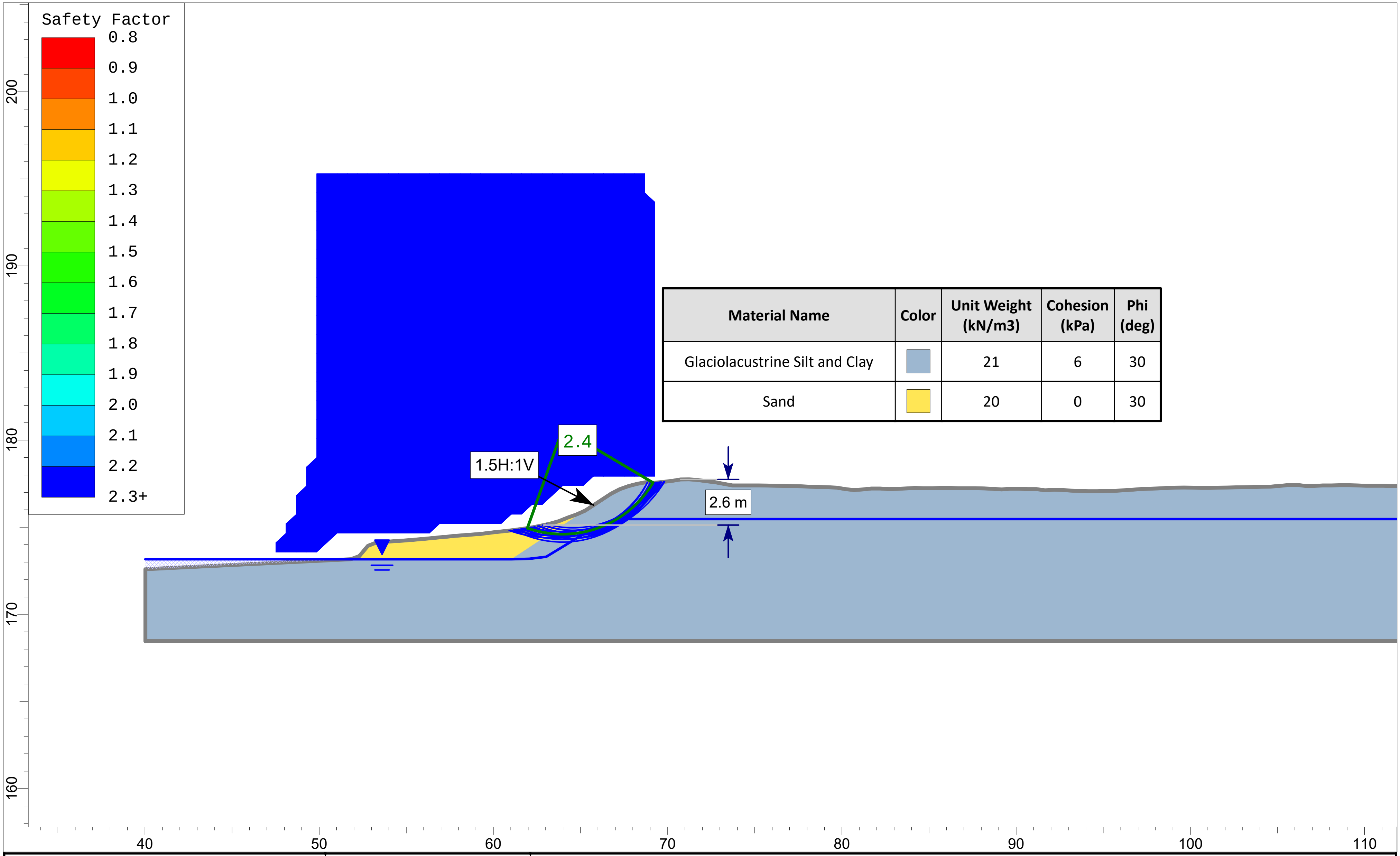
Project

Halimand County Slope Stability | 1-18-0402-01

Analysis

Global Stability: Section 33, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 9 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

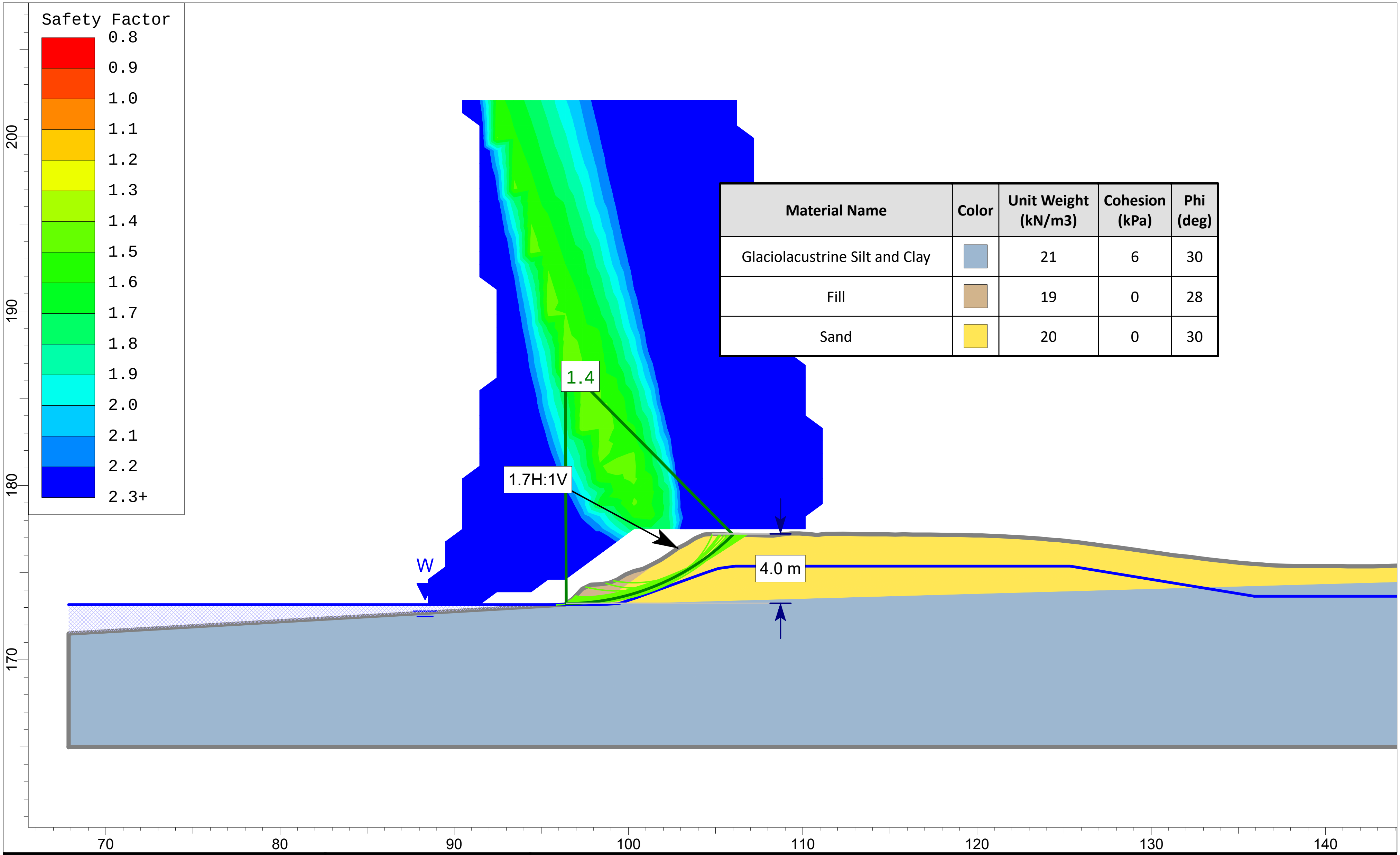
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 34, Master Scenario

Date	Scale	File
5/14/2019	1:300	Halimand Part 9 v2.slmd

By	Ref.
JH/JC	2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28
Sand	🟨	20	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

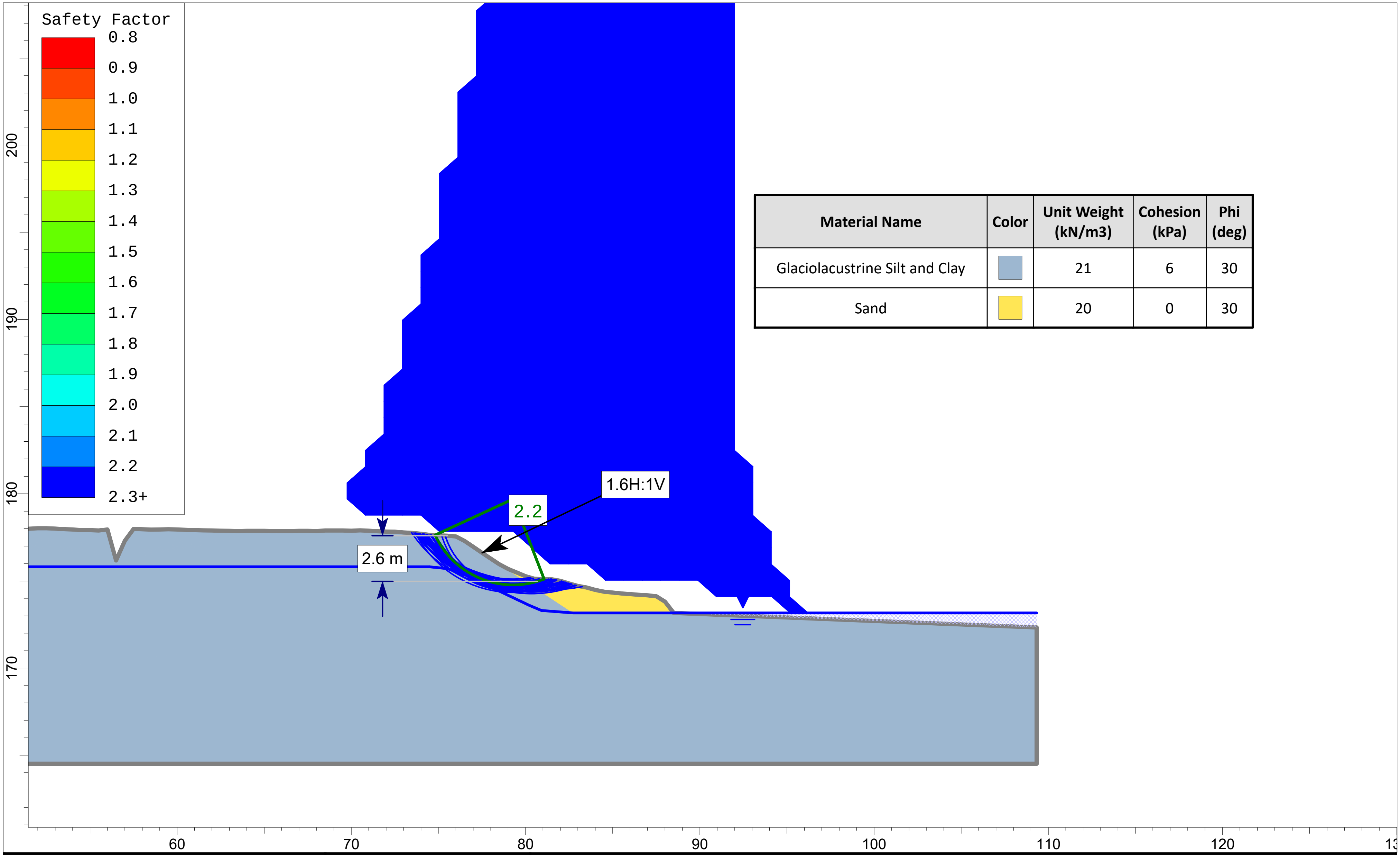
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 35, Master Scenario

Date	Scale	File
5/17/2019	1:300	Halimand Part 9 v2.slmd

By	Ref.
JH/JC	2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

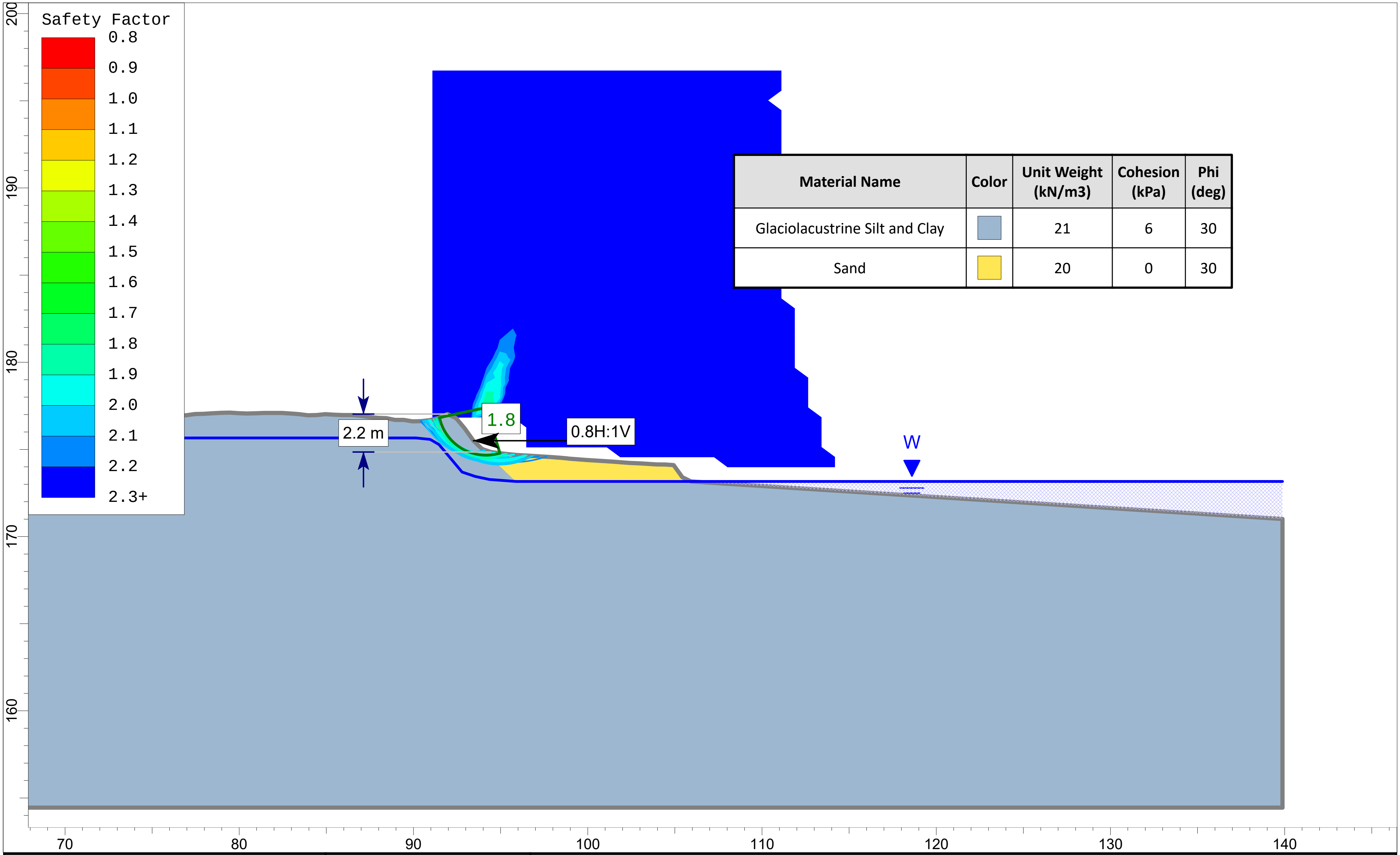
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 36, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 9 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Halimand County Slope Stability | 1-18-0402-01

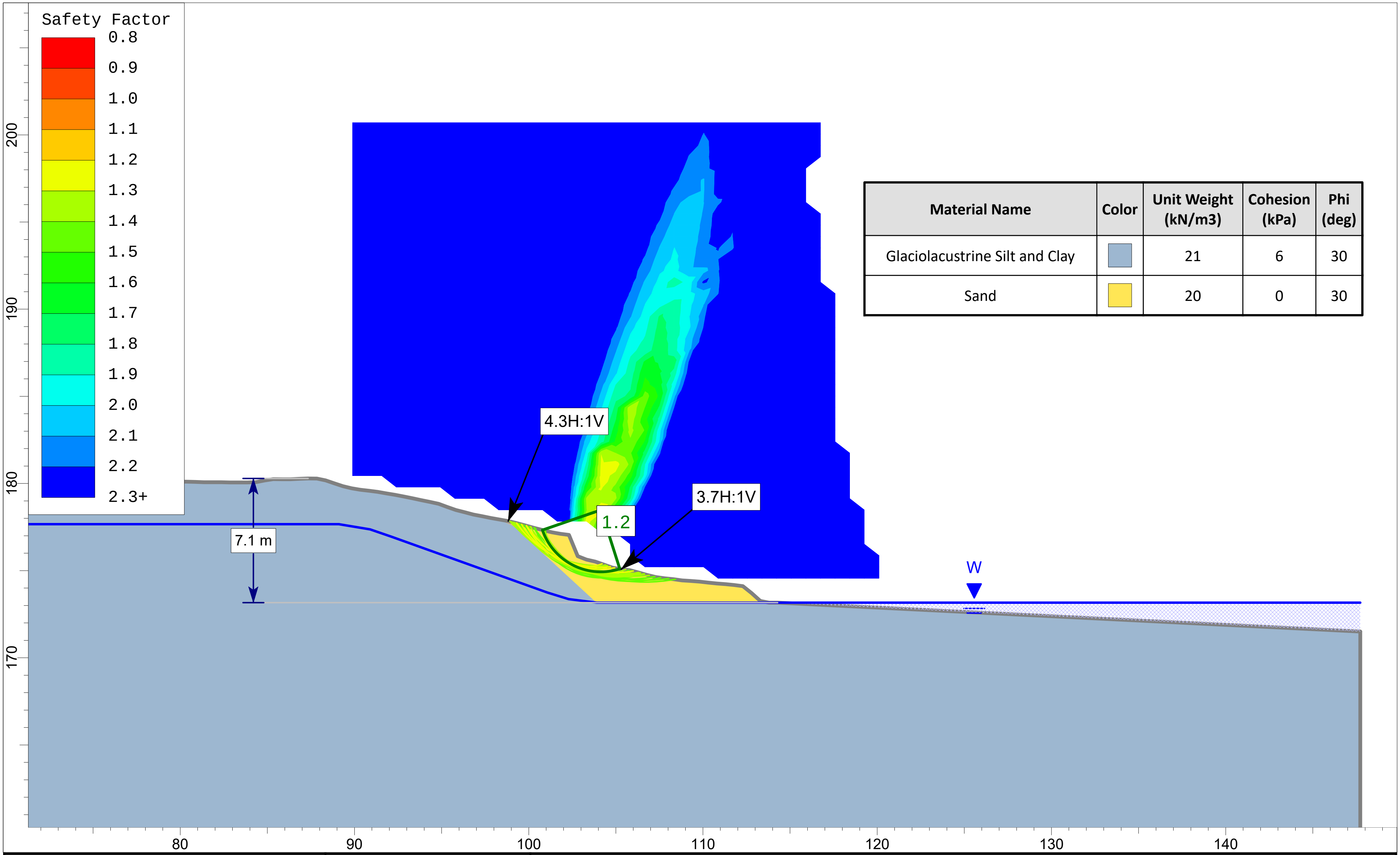
Analysis

Global Stability: Section 37, Master Scenario

Date	Scale	File
5/14/2019	1:300	Halimand Part 10 v2.slmd

By JH/JC

Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

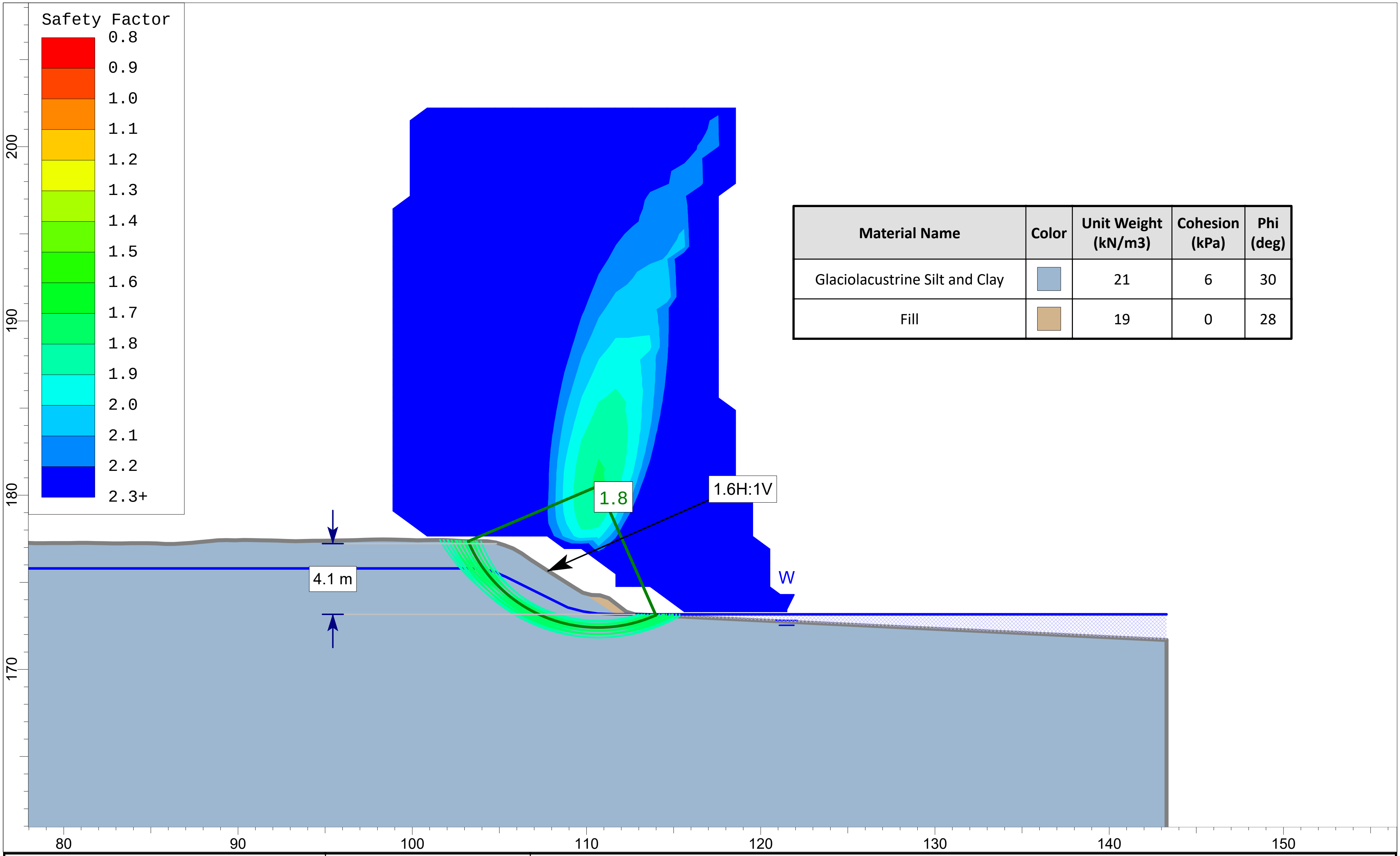
Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 38, Master Scenario

Date	8/20/2019	Scale	1:300	File	Halimand Part 10 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

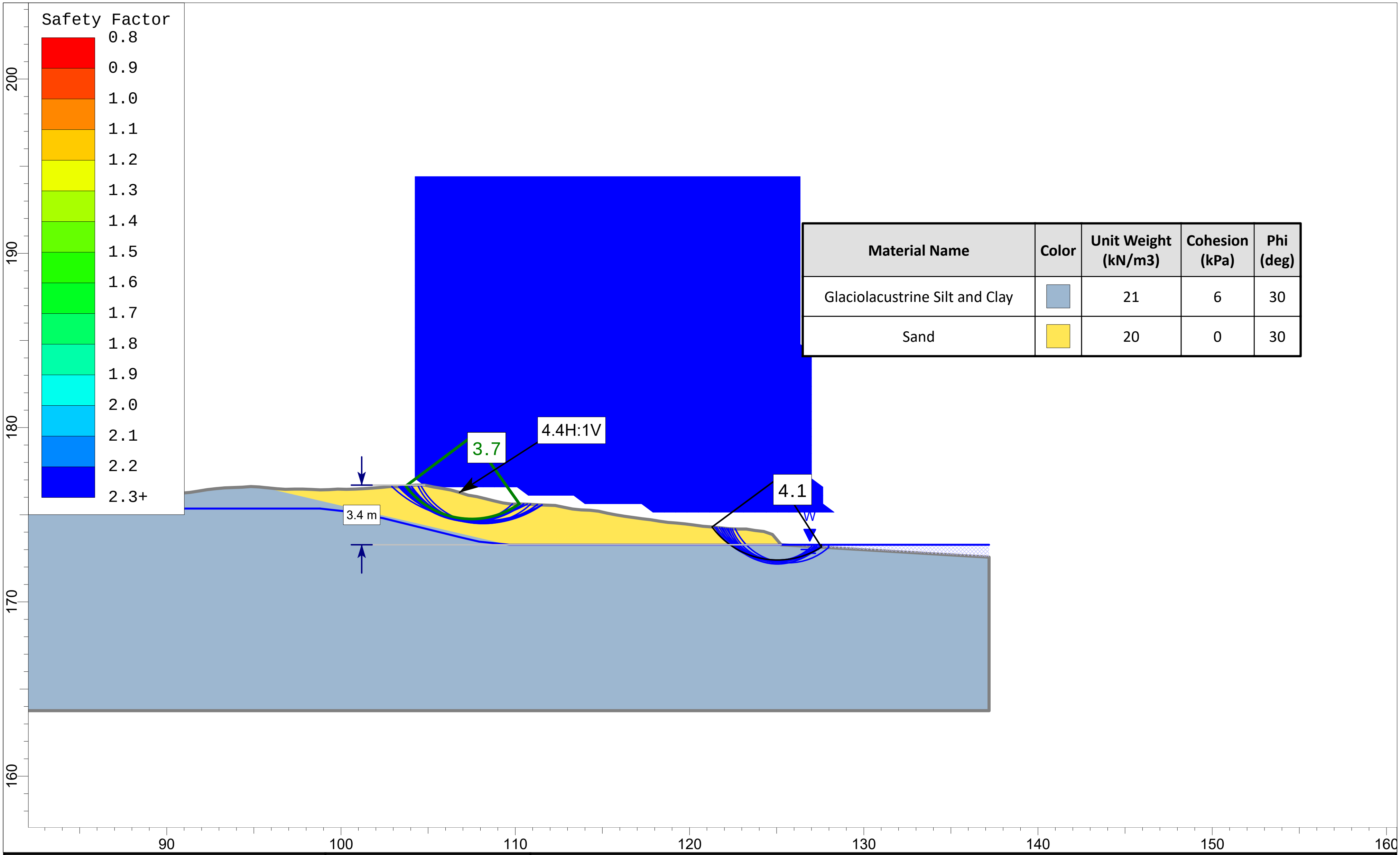
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 39, Master Scenario

Date 8/20/2019
Scale 1:300
File Halimand Part 10 v2.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

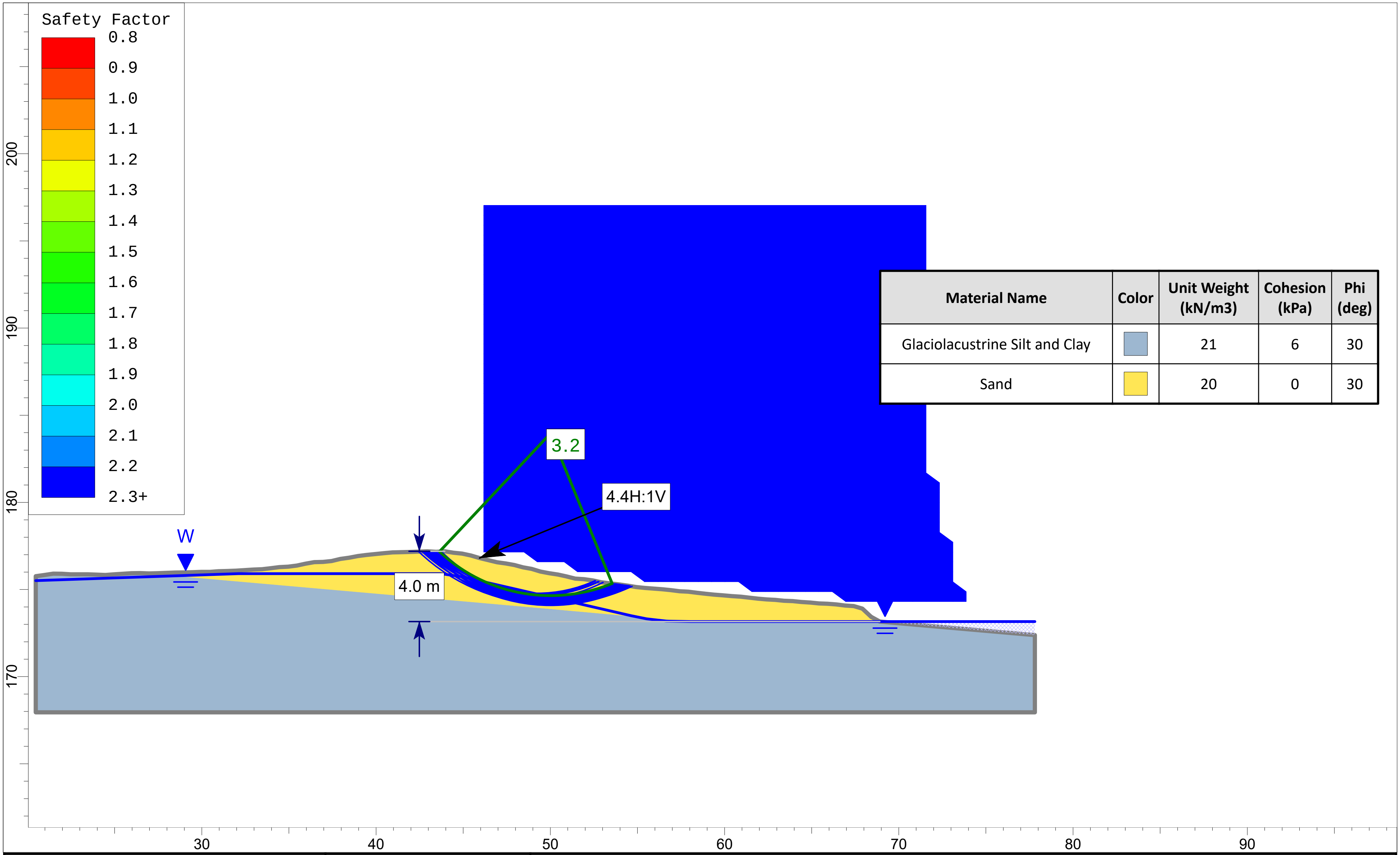
Project

Halimand County Slope Stability | 1-18-0402-01

Analysis

Global Stability: Section 40, Master Scenario

Date	8/20/2019	Scale	1:300	File	Halimand Part 10 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	▨	21	6	30
Sand	🟨	20	0	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 41, Master Scenario

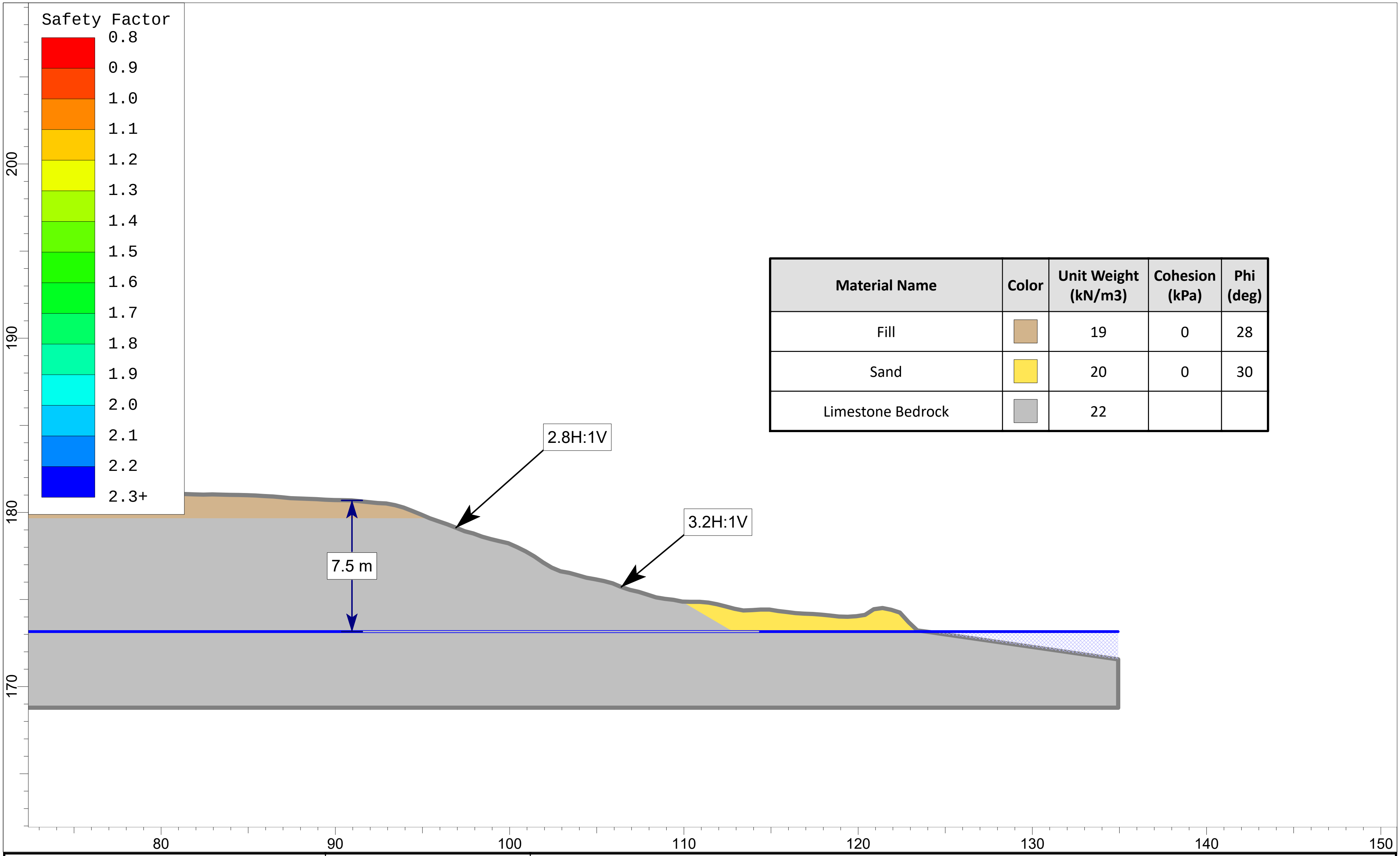
Date 5/17/2019

Scale 1:300

File Halimand Part 11 v2.slmd

By JH/JC

Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill	🟫	19	0	28
Sand	🟨	20	0	30
Limestone Bedrock	⬜	22		

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

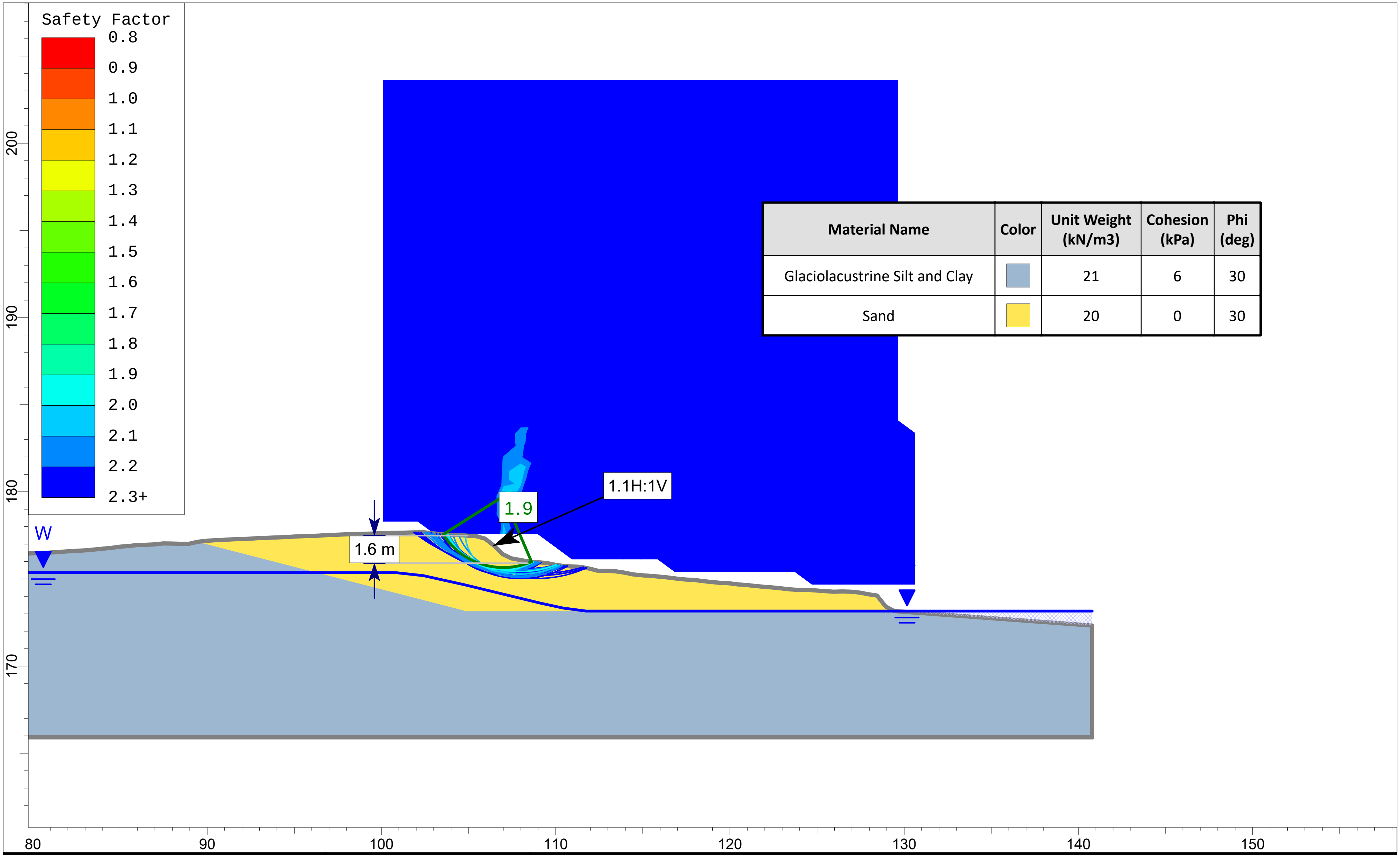
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 42, Master Scenario

Date	4/29/2019	Scale	1:300	File	Halimand Part 11.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Sand	🟨	20	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

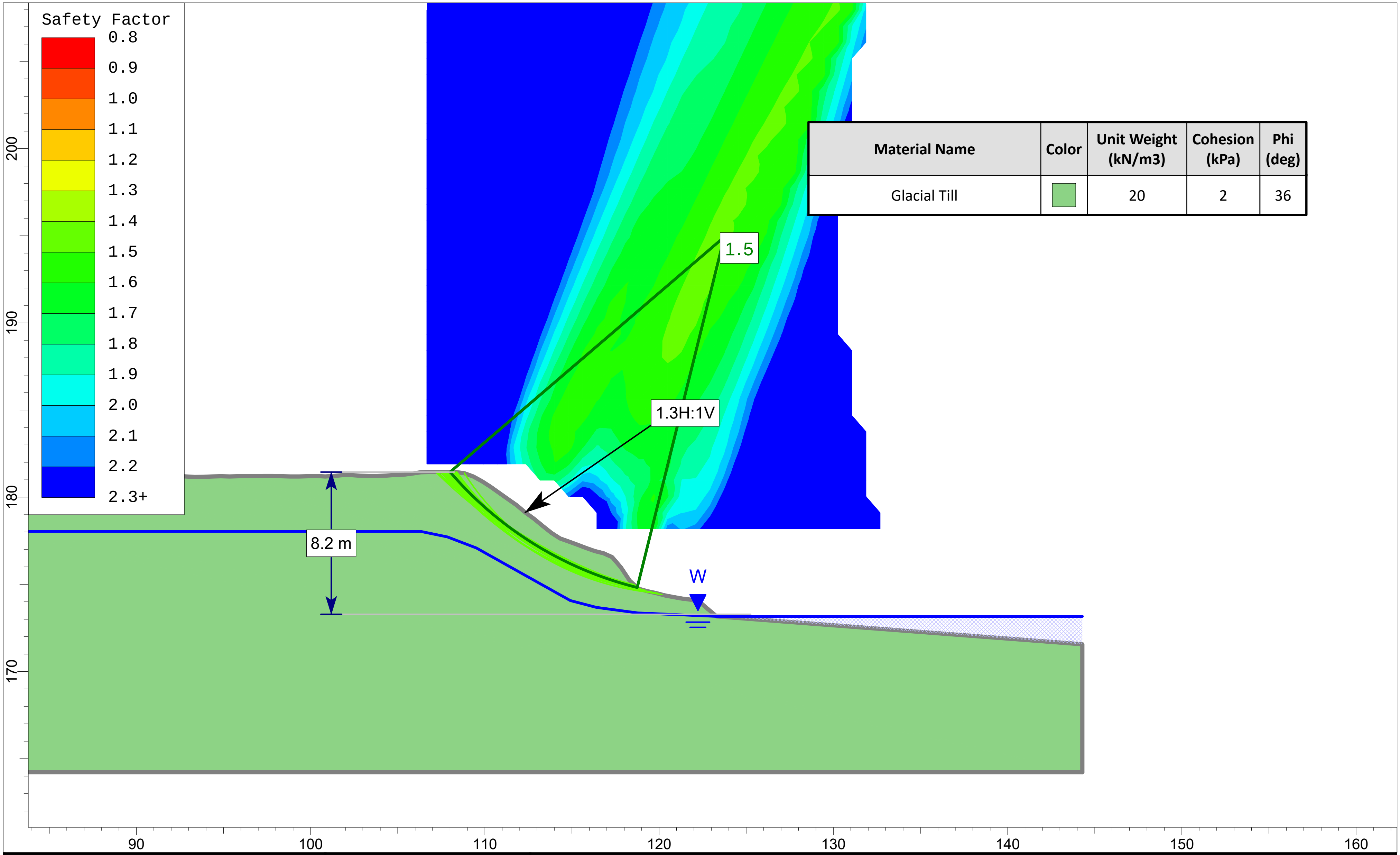
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 43, Master Scenario

Date 5/14/2019
Scale 1:300
File Halimand Part 11 v2.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glacial Till	🟩	20	2	36

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

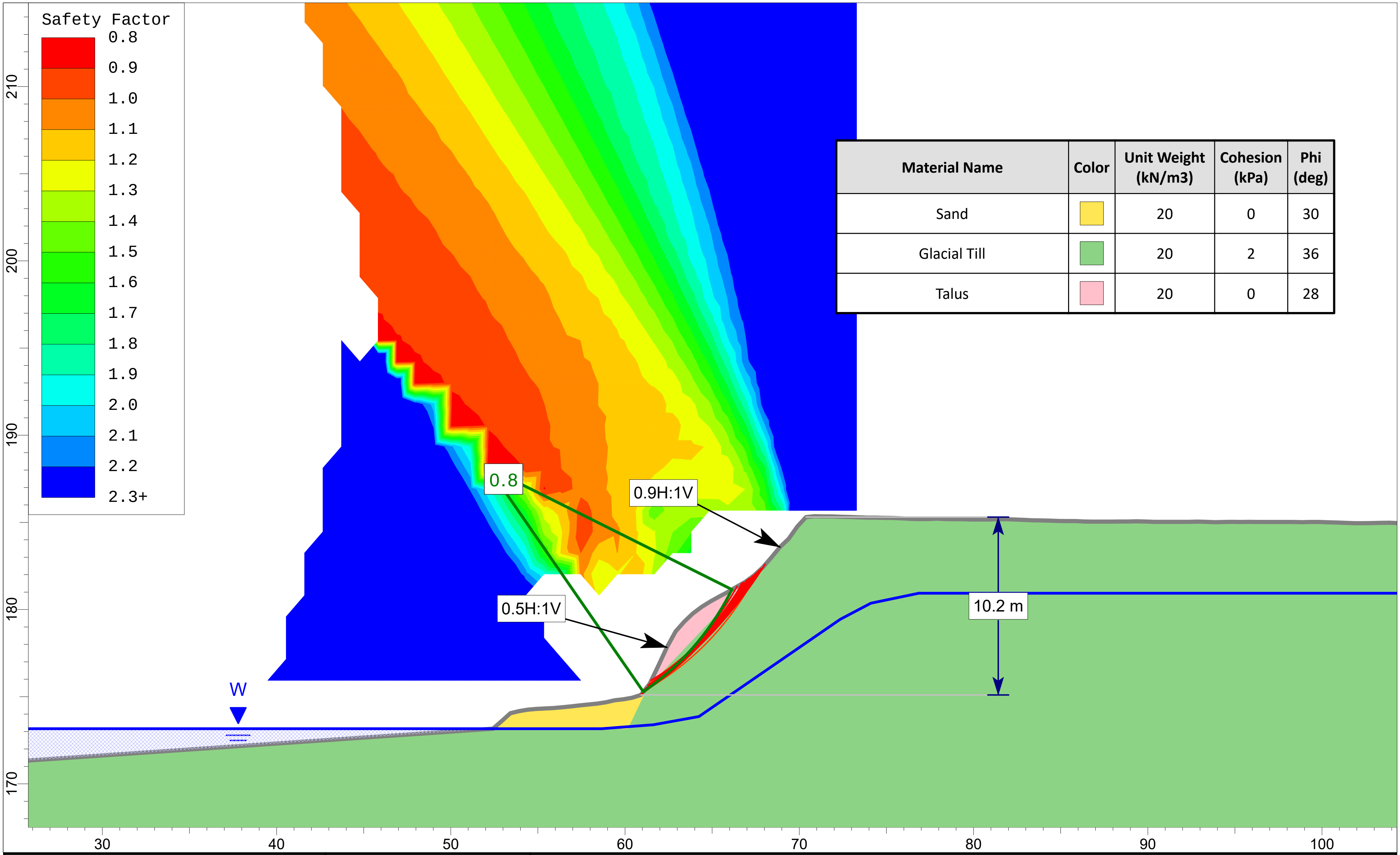
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 44, Master Scenario

Date 4/29/2019
Scale 1:300
File Halimand Part 11.slmd

By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36
Talus	🟥	20	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

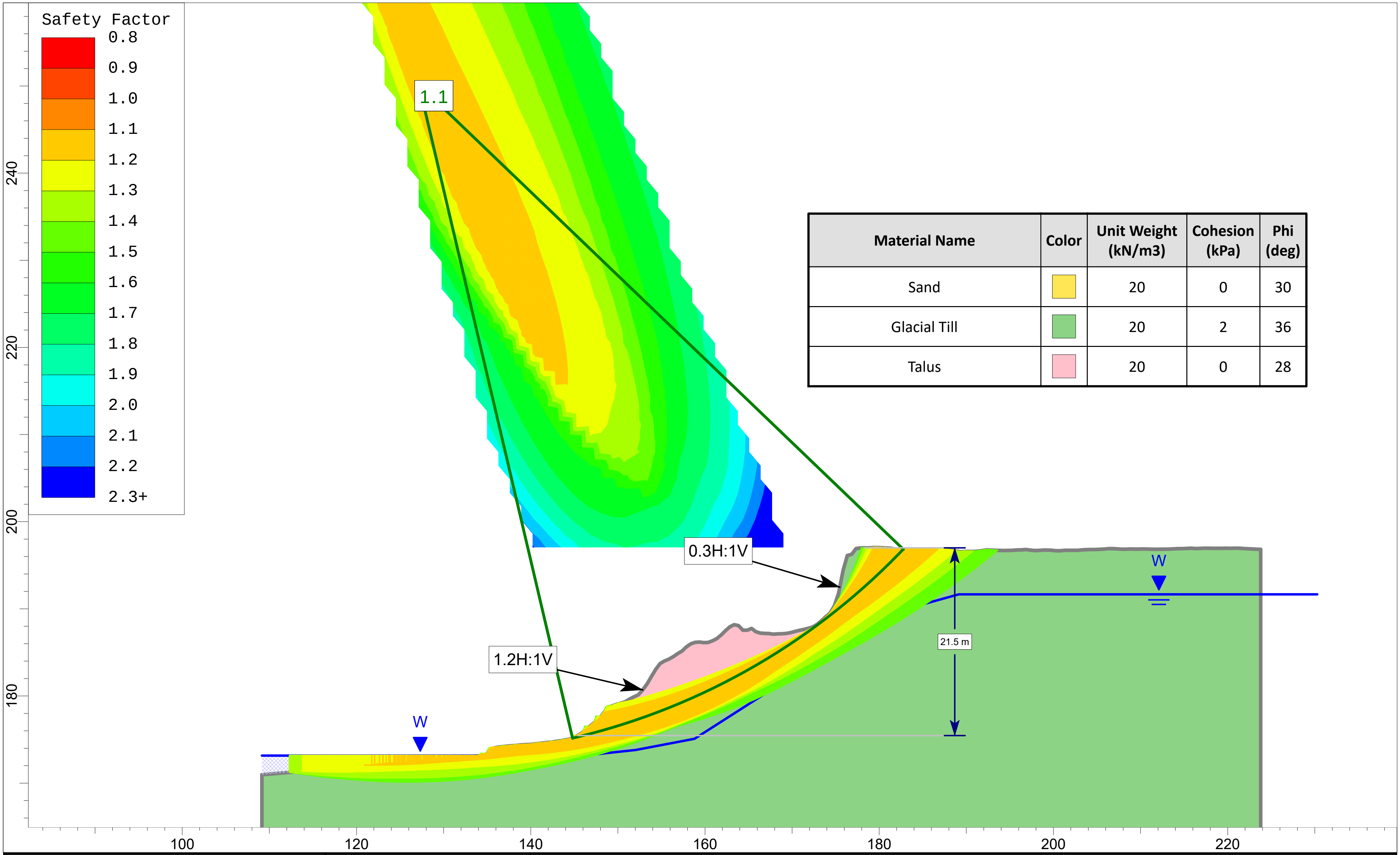
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 45, Master Scenario

Date	4/30/2019	Scale	1:300	File	Halimand Part 12.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36
Talus	■	20	0	28

Terraprobe

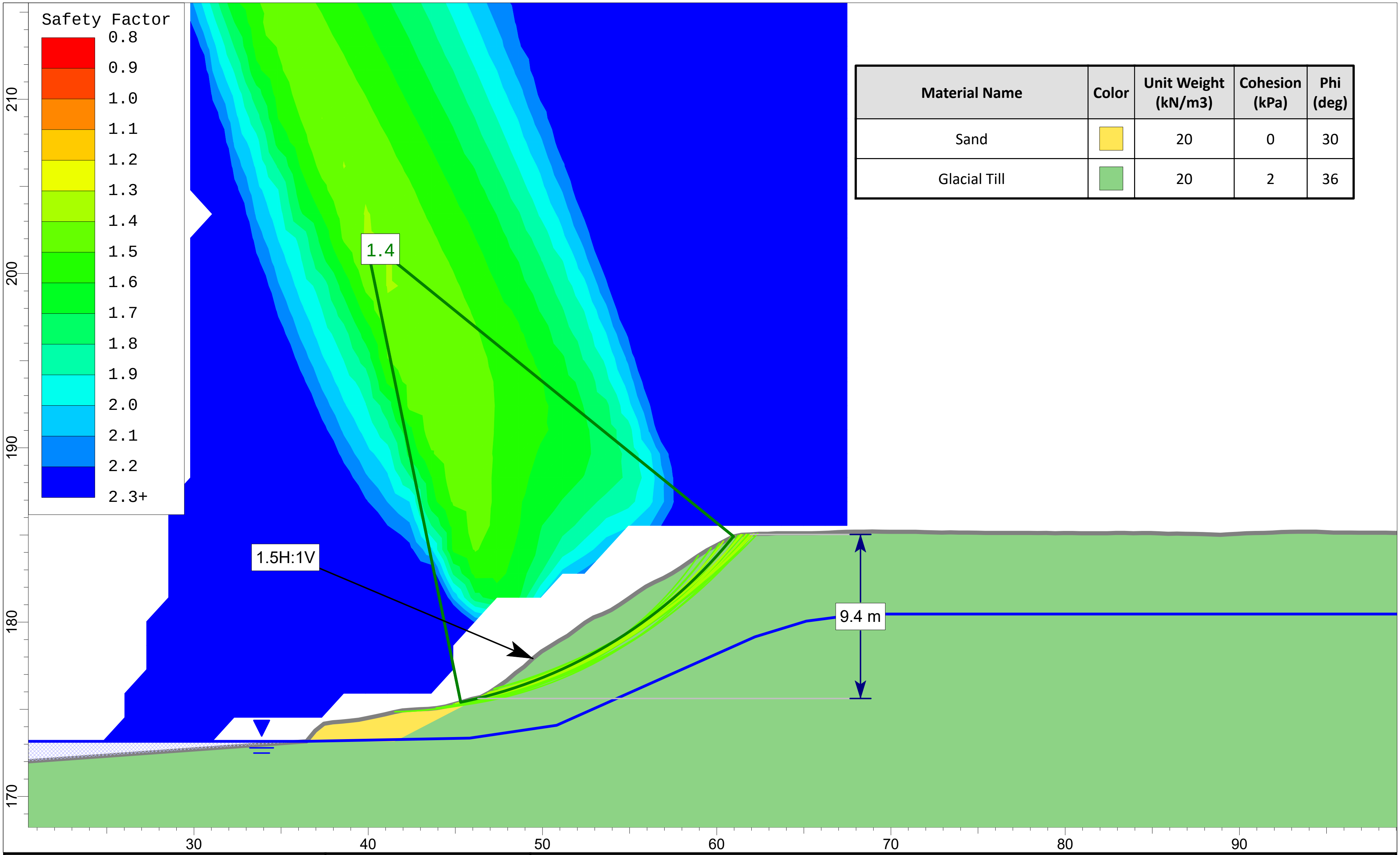
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**		
Analysis	Global Stability: Section 46, Master Scenario		
Date 4/30/2019	Scale 1:600	File	Halimand Part 12.slmd
By JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019	



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

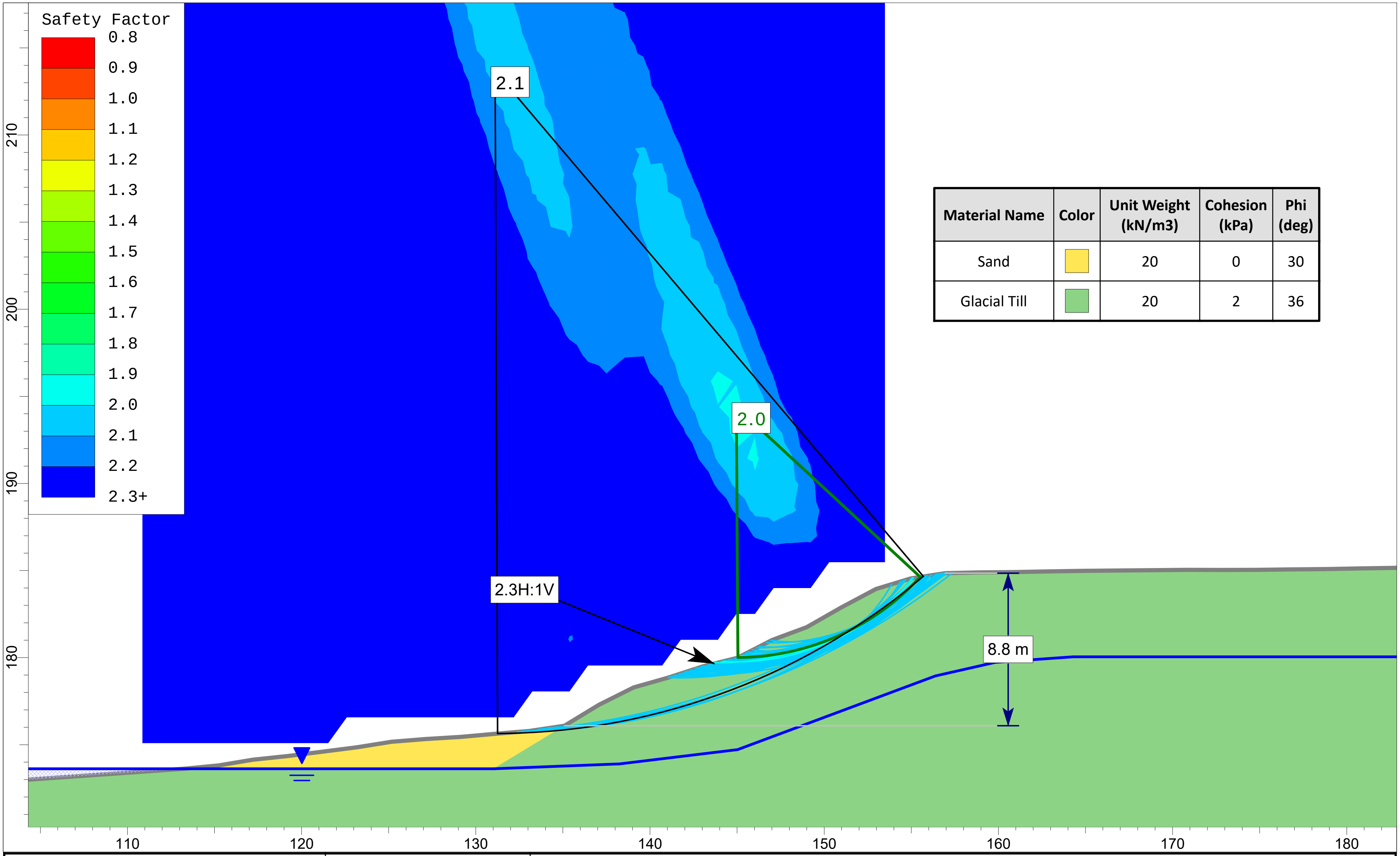
Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 47, Master Scenario

Date	Scale	File
4/30/2019	1:300	Halimand Part 12.slmd

By	Ref.
JH/JC	2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

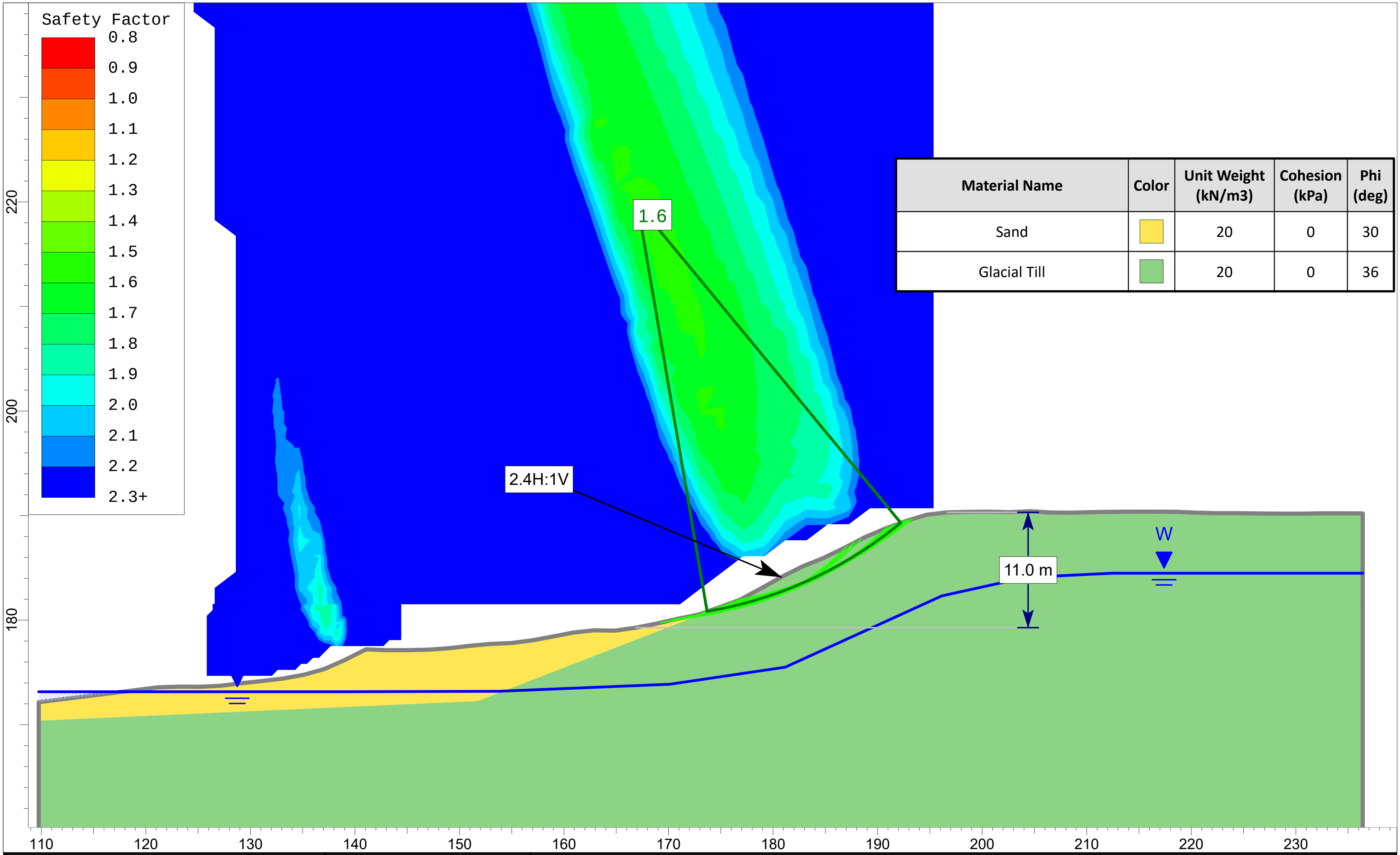
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 48, Master Scenario

Date	4/30/2019	Scale	1:300	File	Halimand Part 12.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	0	36

Terraprobe

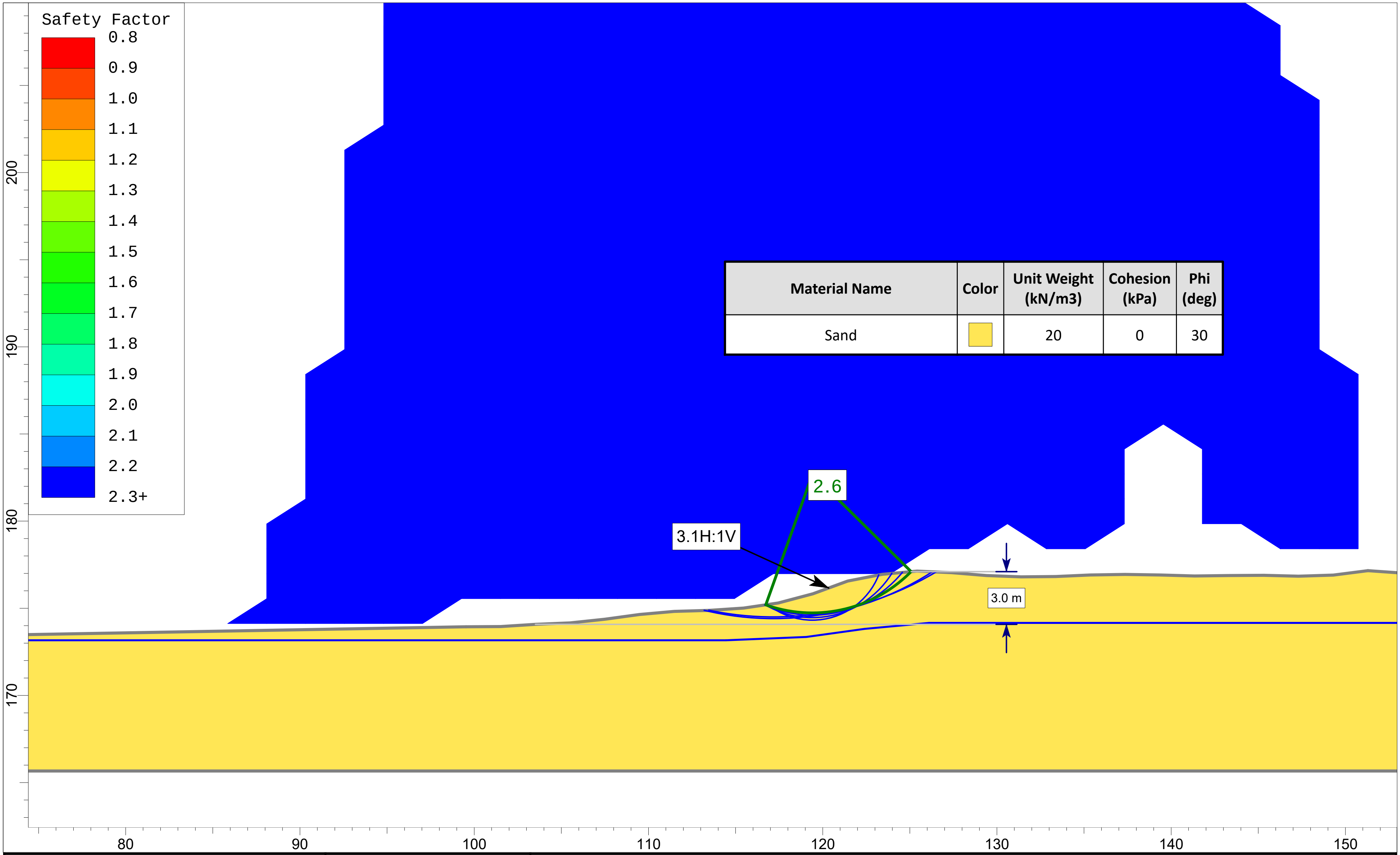
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 49, Master Scenario

Date	5/17/2019	Scale	1:500	File	Halimand Part 13 v2.slmd
By	JH/JC	Ref.			2015 SWOOP data, provided by Baird on March 22, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

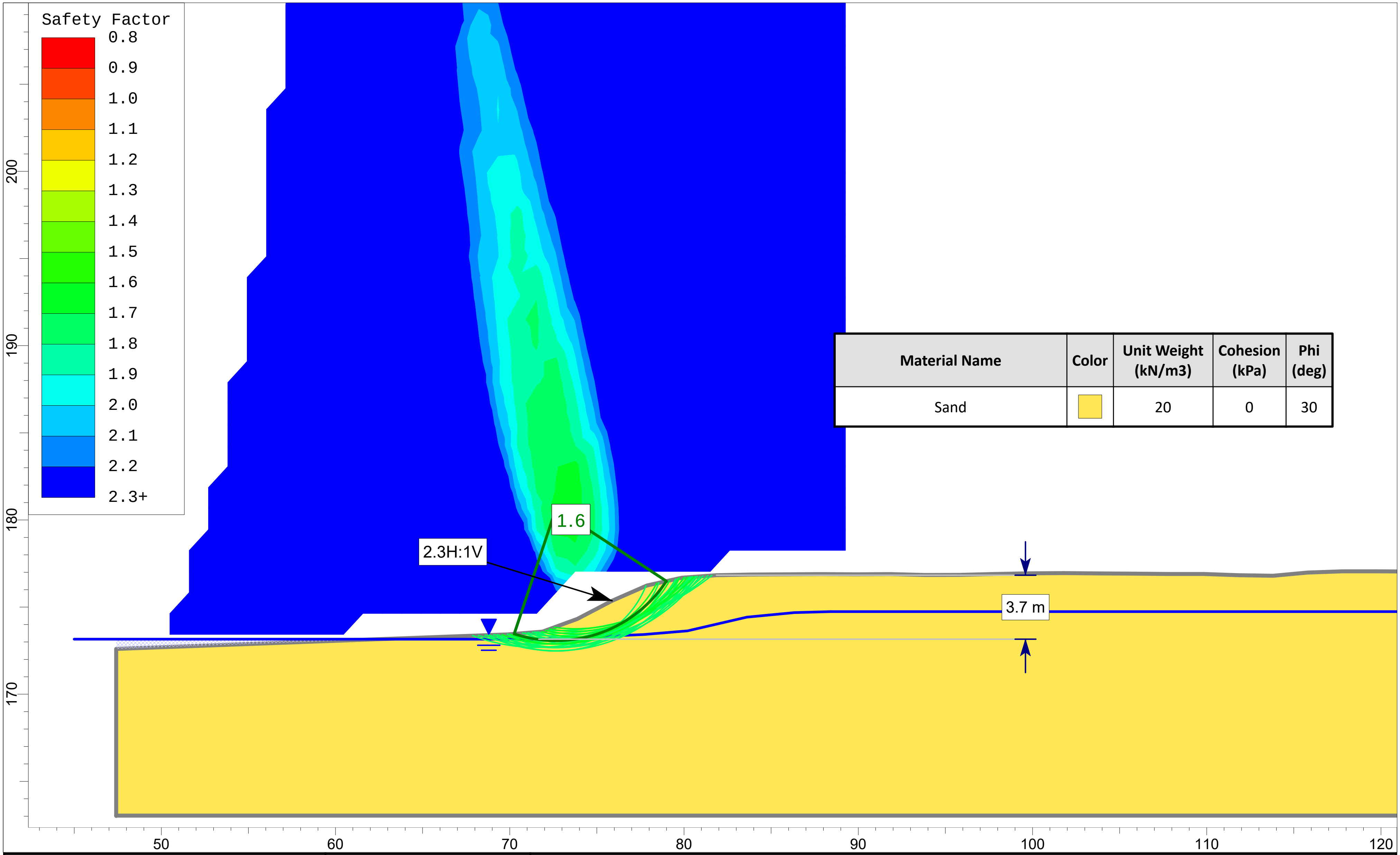
Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 50, Master Scenario

Date	4/30/2019	Scale	1:300	File	Halimand Part 13.slmd
By	JH/JC	Ref.	2015 SWOOP data, provided by Baird on March 22, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

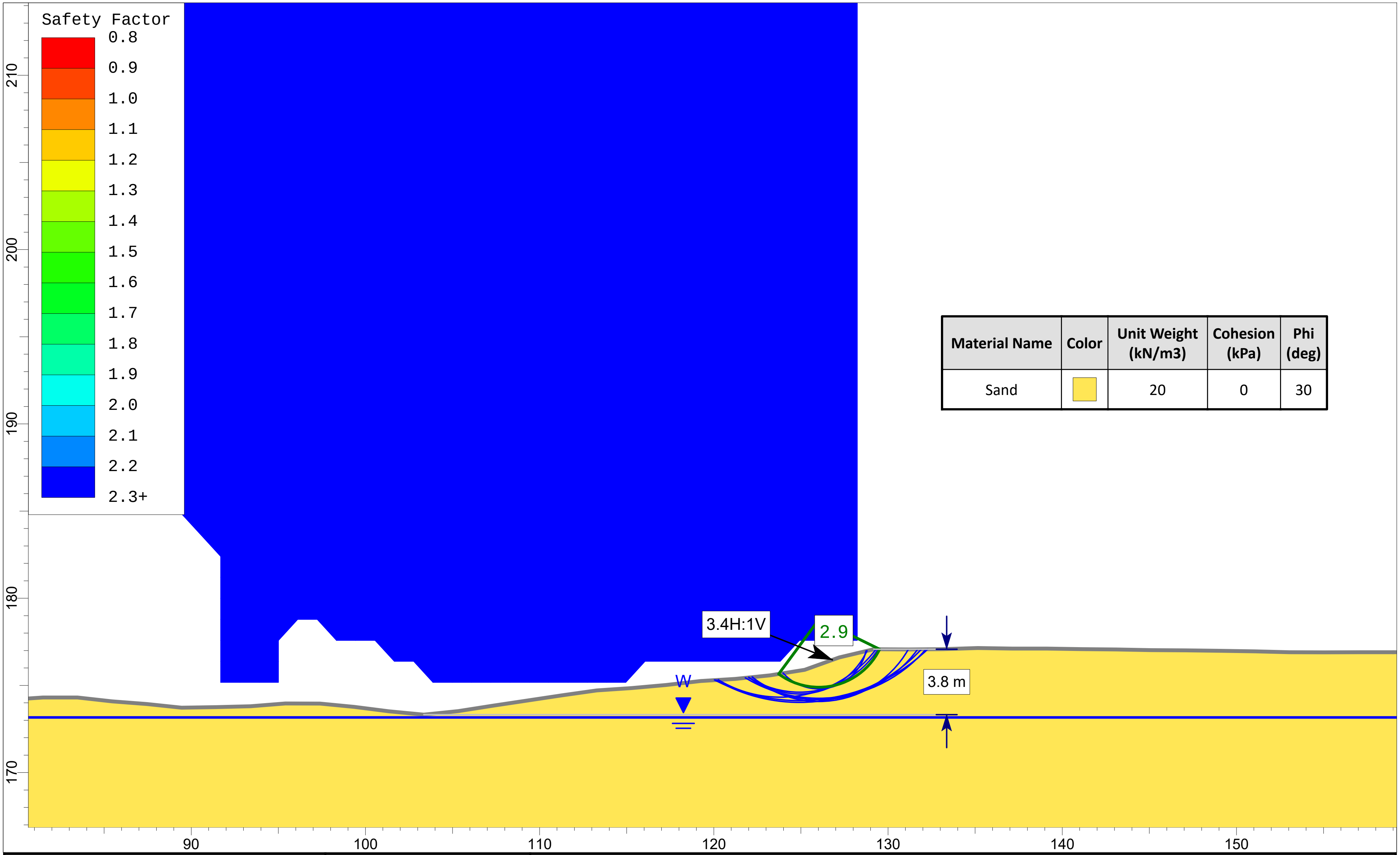
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 51, Master Scenario

Date 4/30/2019
Scale 1:300
File Halimand Part 13.slmd
By JH/JC
Ref. 2015 SWOOP data, provided by Baird on March 22, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

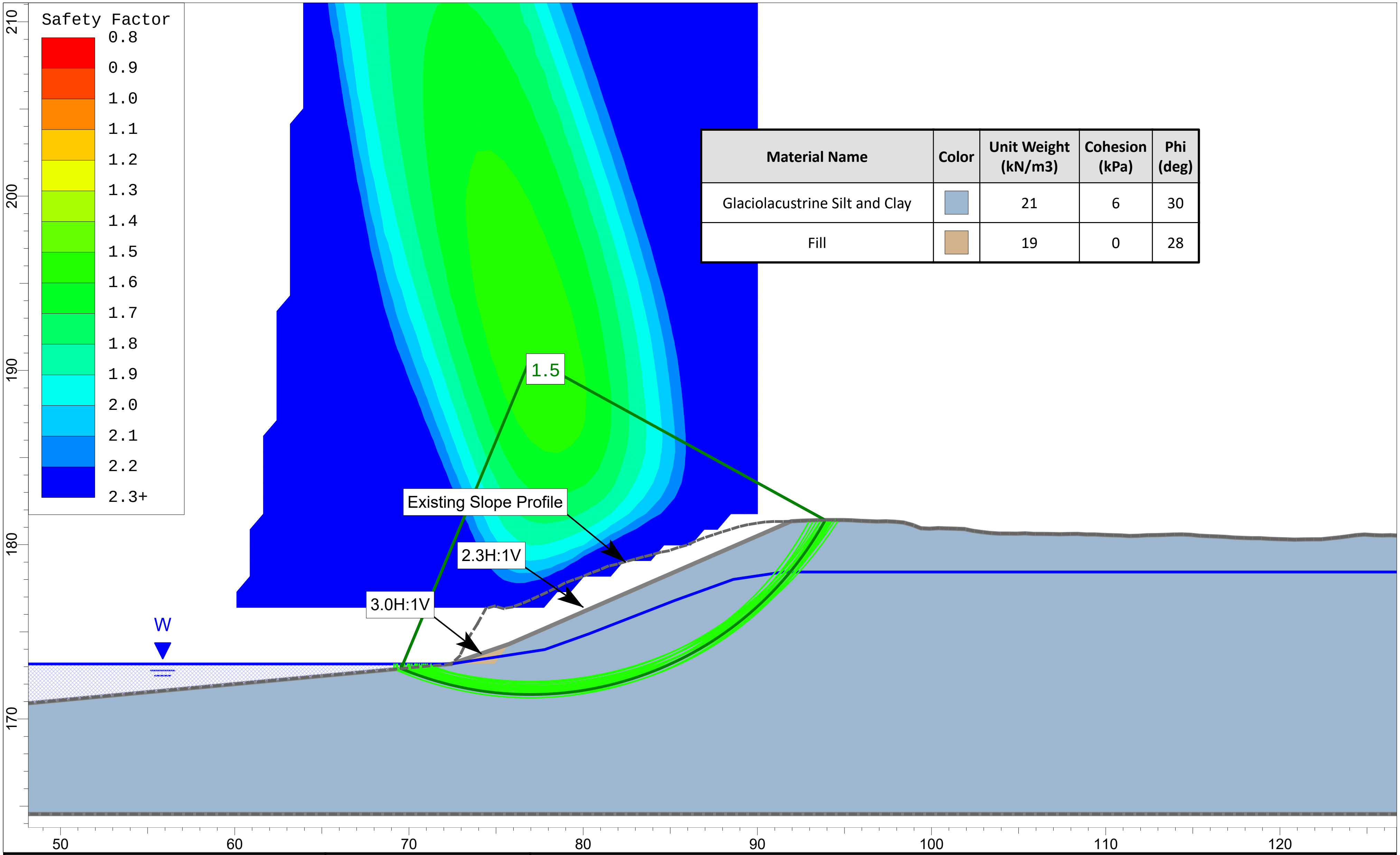
Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 52, Master Scenario

Date 4/30/2019
Scale 1:300
File Halimand Part 13.slmd
By JH/JC
Ref. 2015 SWOOP data, provided by Baird on March 22, 2019

APPENDIX H

TERRAPROBE INC.



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

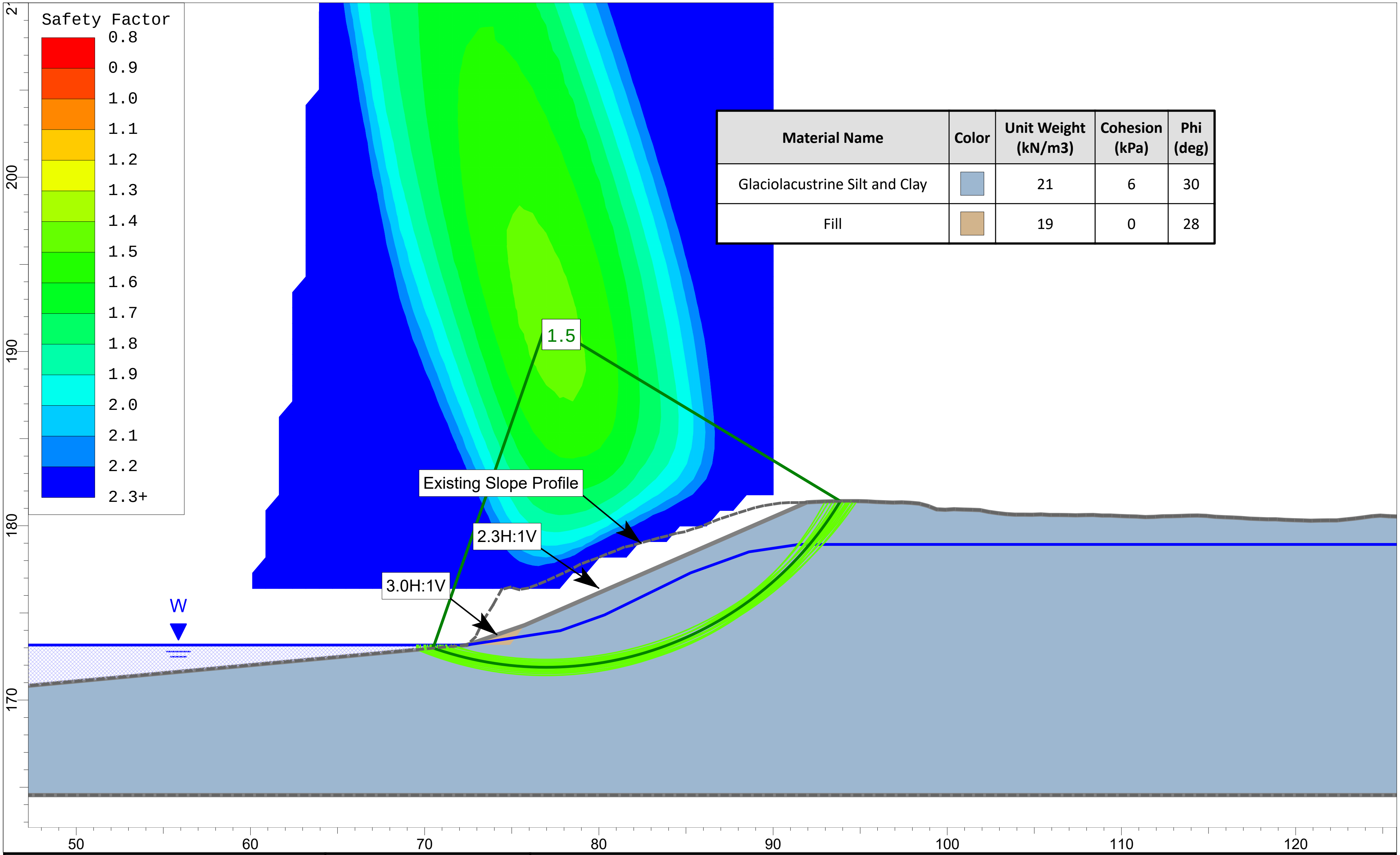
Project

Halimand County Slope Stability | 1-18-0402-01

Analysis

Global Stability: Section 3 - SSI, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 1 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

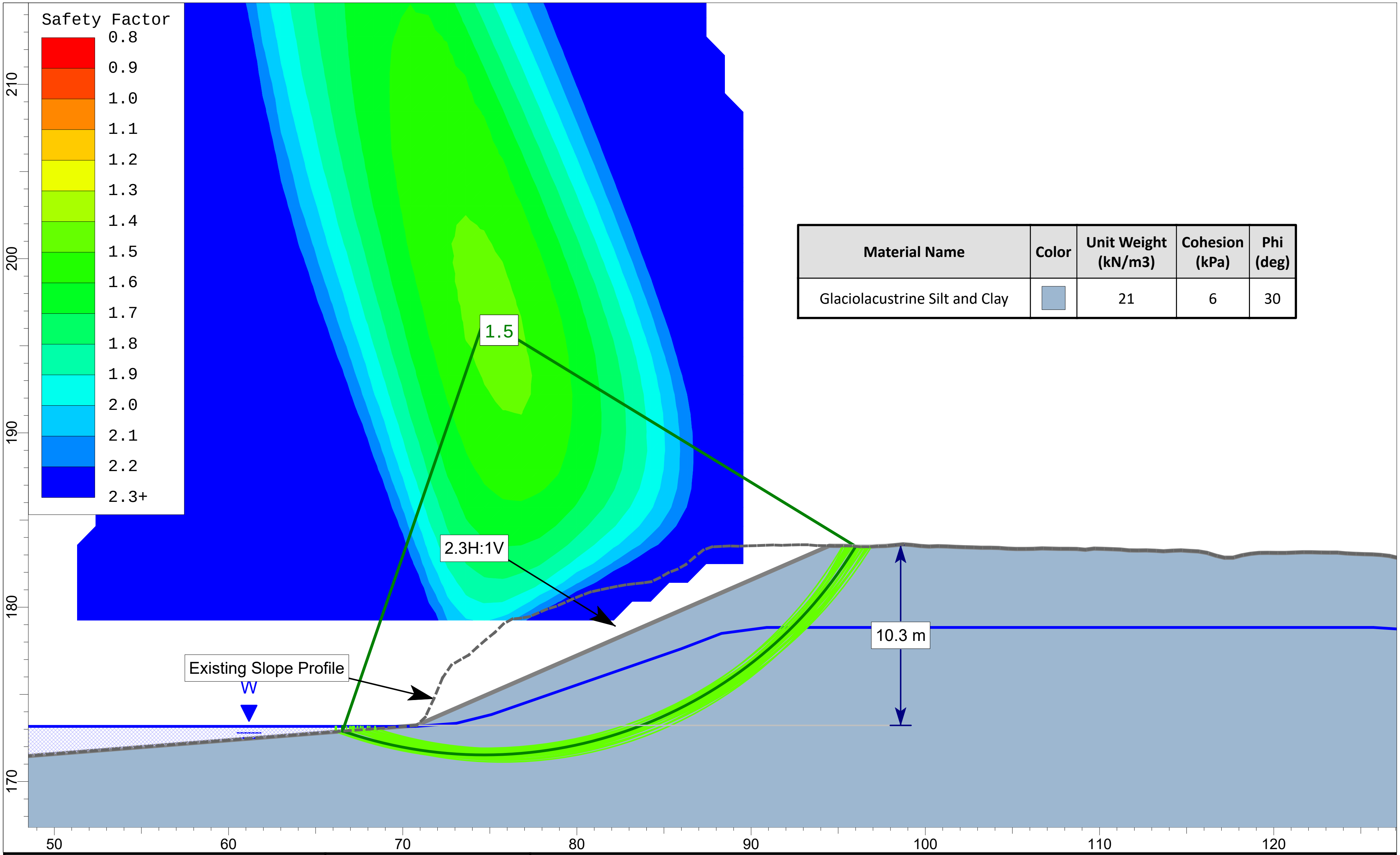
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 3 - SSI, high gwt

Date	Scale	File
5/14/2019	1:300	Halimand Part 1 v2.slmd

By	Ref.
JH/JC	2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

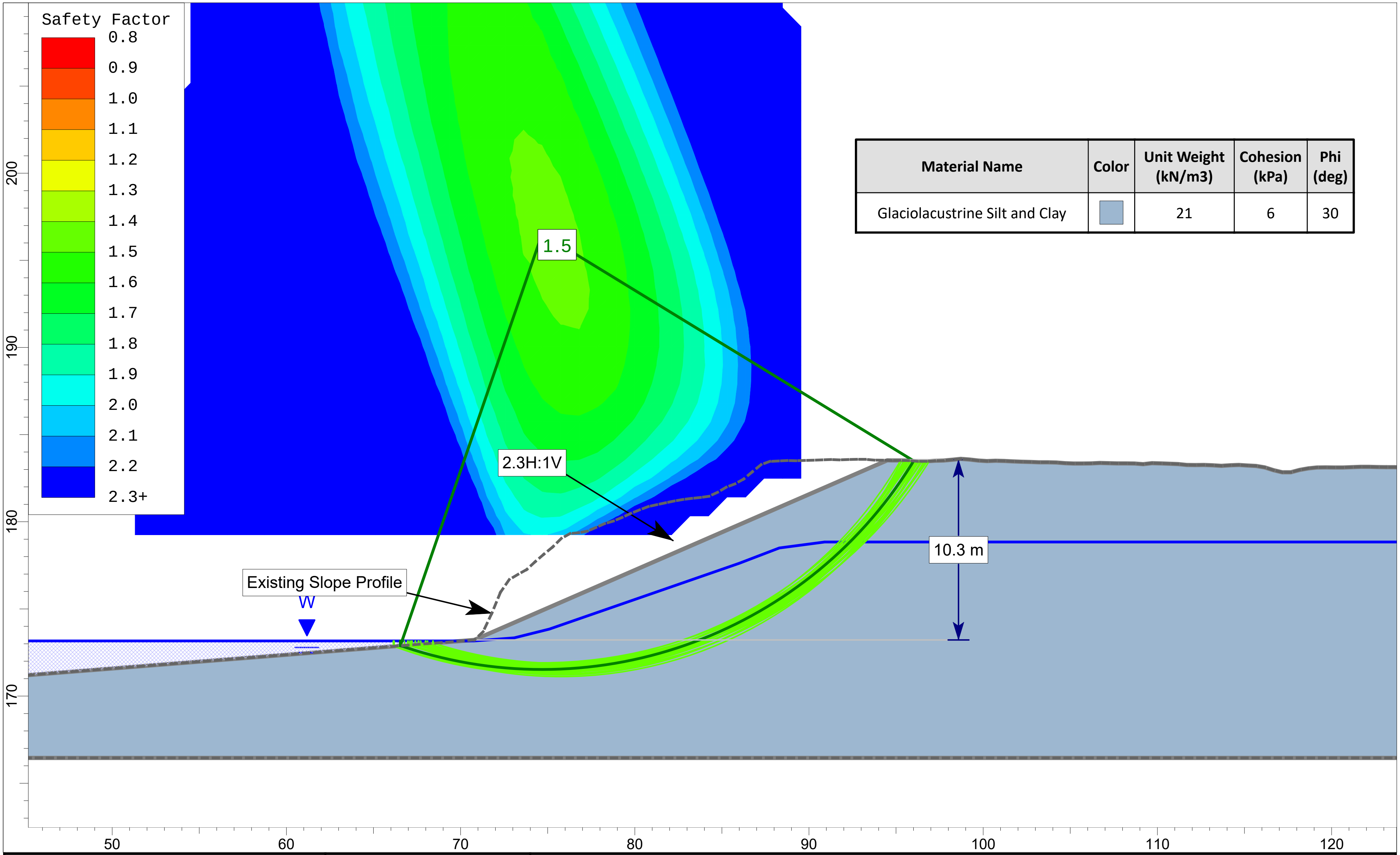
Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 8 SSI, Master Scenario

Date	5/14/2019	Scale	1:300	File	Halimand Part 2 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	▨	21	6	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Halimand County Slope Stability | 1-18-0402-01**

Analysis Global Stability: Section 8 SSI, high gwt

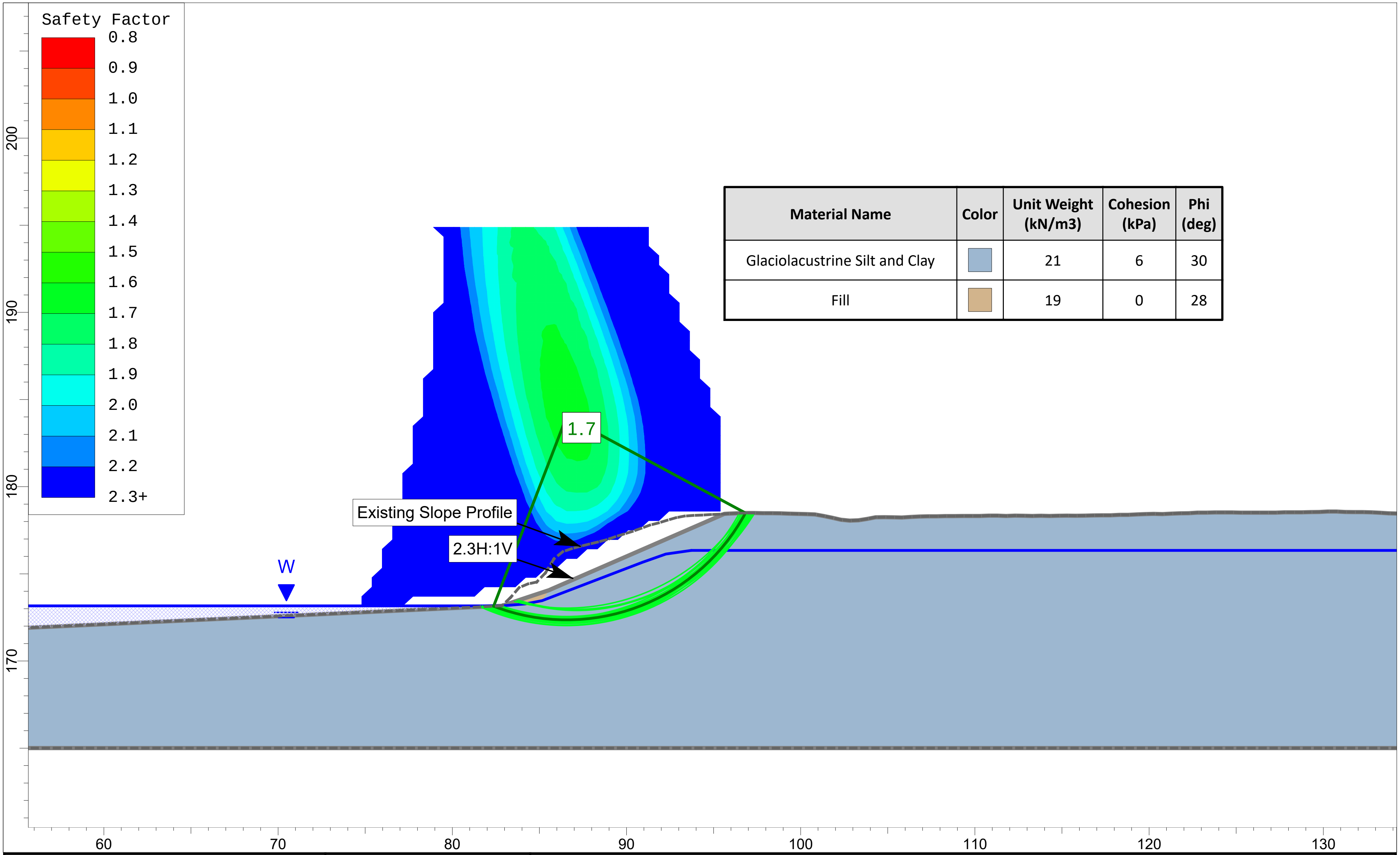
Date 5/14/2019

Scale 1:300

File Halimand Part 2 v2.slmd

By JH/JC

Ref. 2017 LiDar data, provided by Baird on March 13, 2019



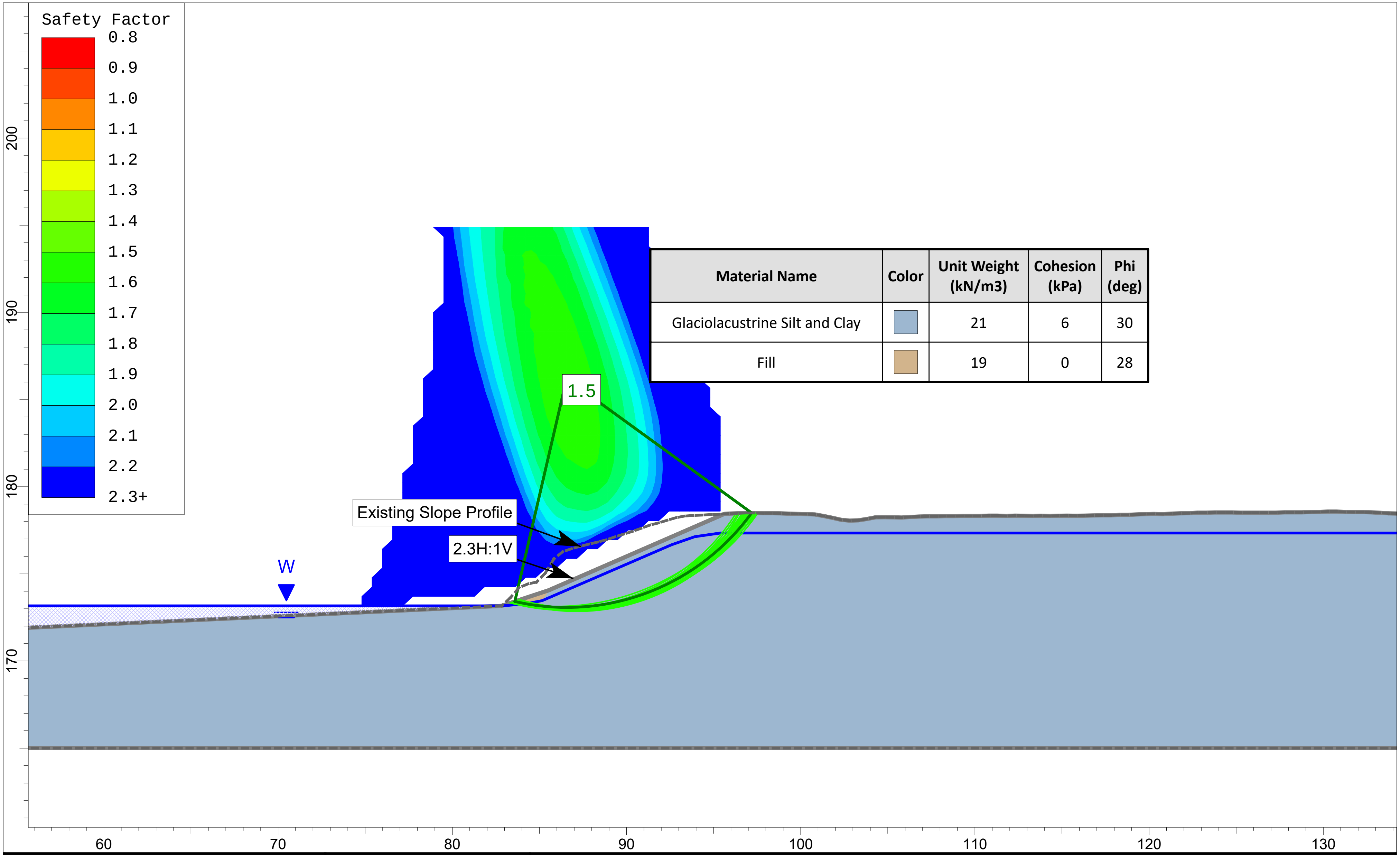
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 14 - SSI, Master Scenario
Date	5/14/2019
Scale	1:300
File	Halimand Part 4 v2.slmd
By	JH/JC
Ref.	2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Glaciolacustrine Silt and Clay	🟦	21	6	30
Fill	🟫	19	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

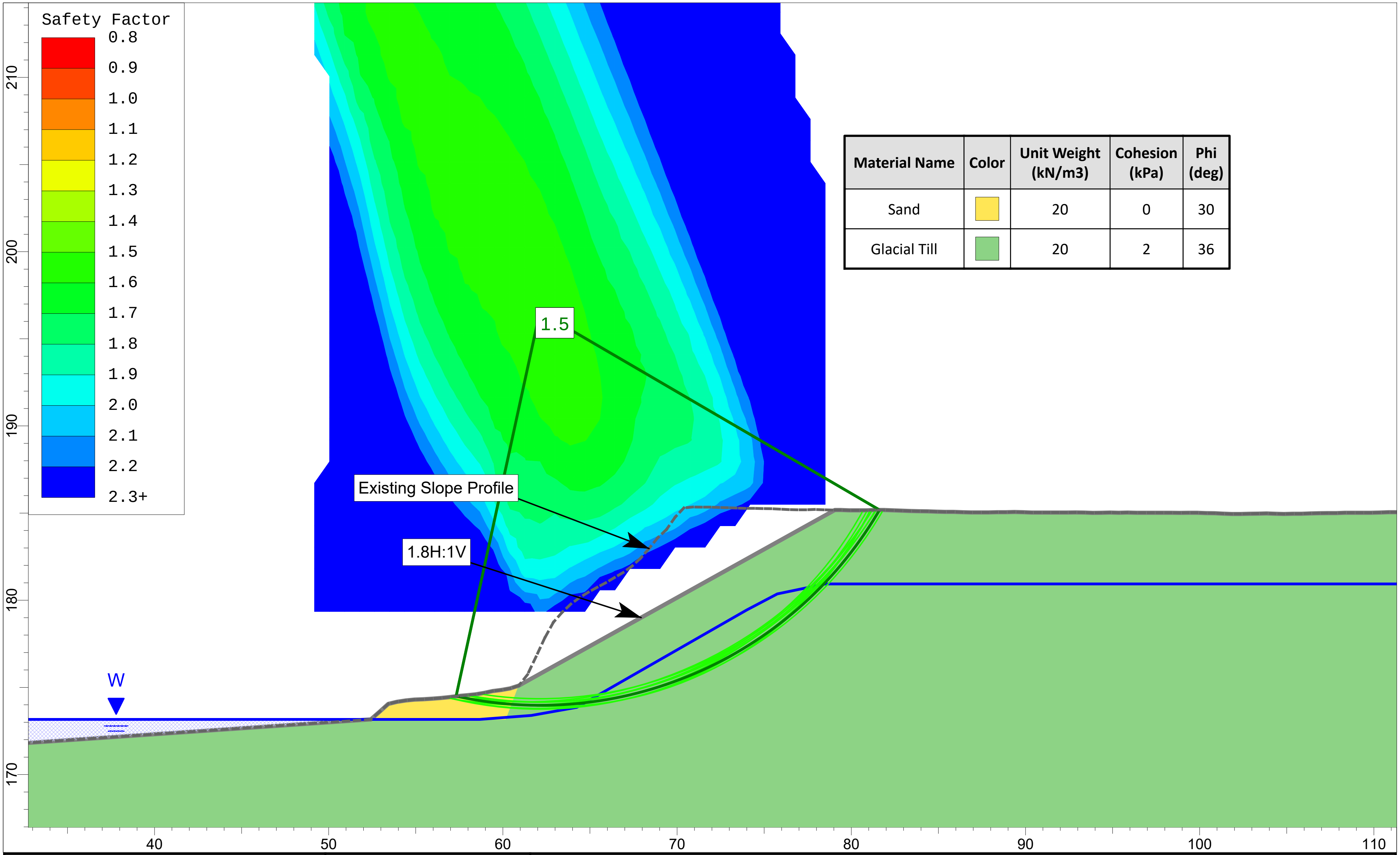
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 14 - SSI, high gwt

Date	5/14/2019	Scale	1:300	File	Halimand Part 4 v2.slmd
By	JH/JC	Ref.	2017 LiDar data, provided by Baird on March 13, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36

Terraprobe
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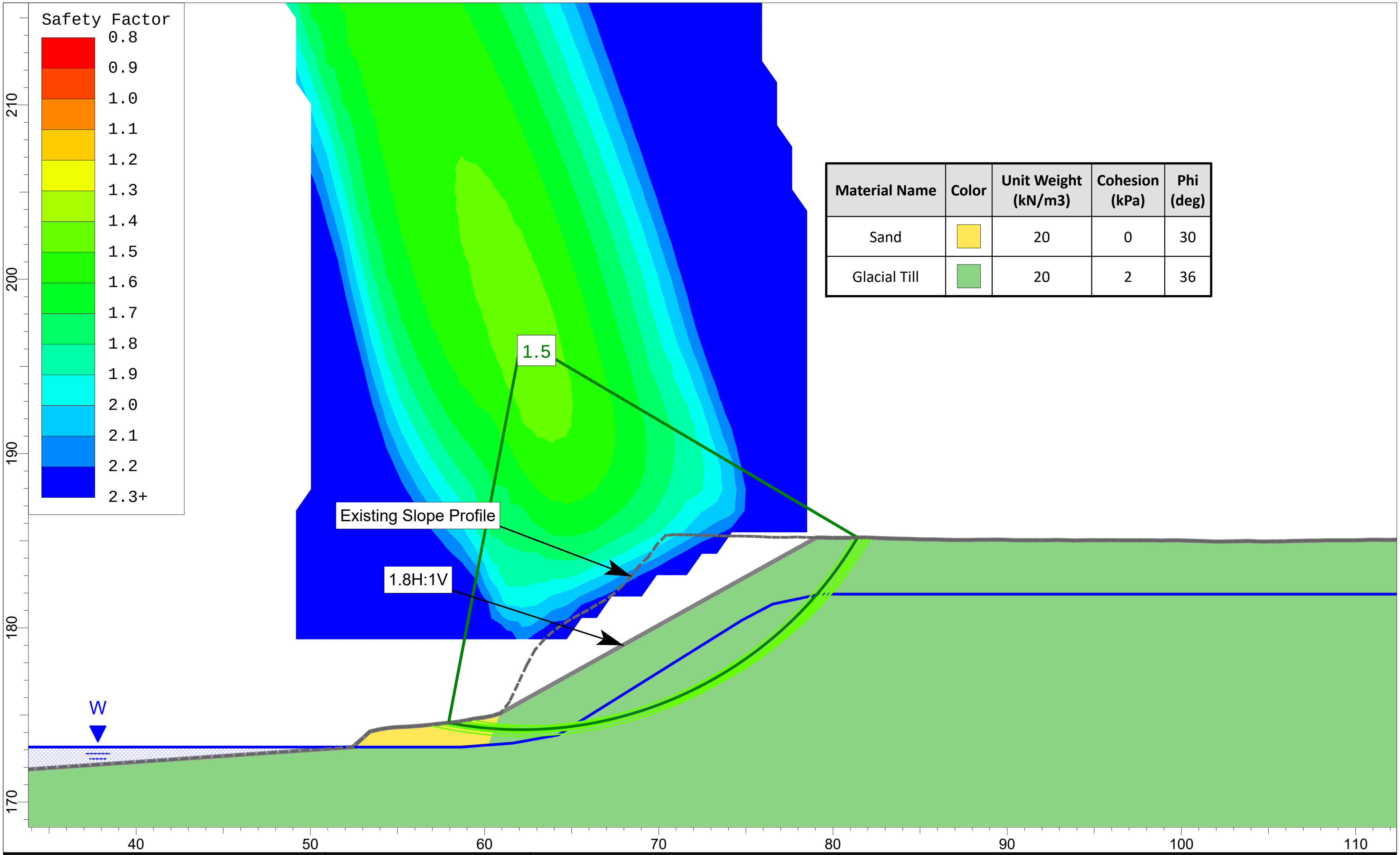
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 45 - SSI, Master Scenario

Date 4/30/2019
Scale 1:300
File Halimand Part 12.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

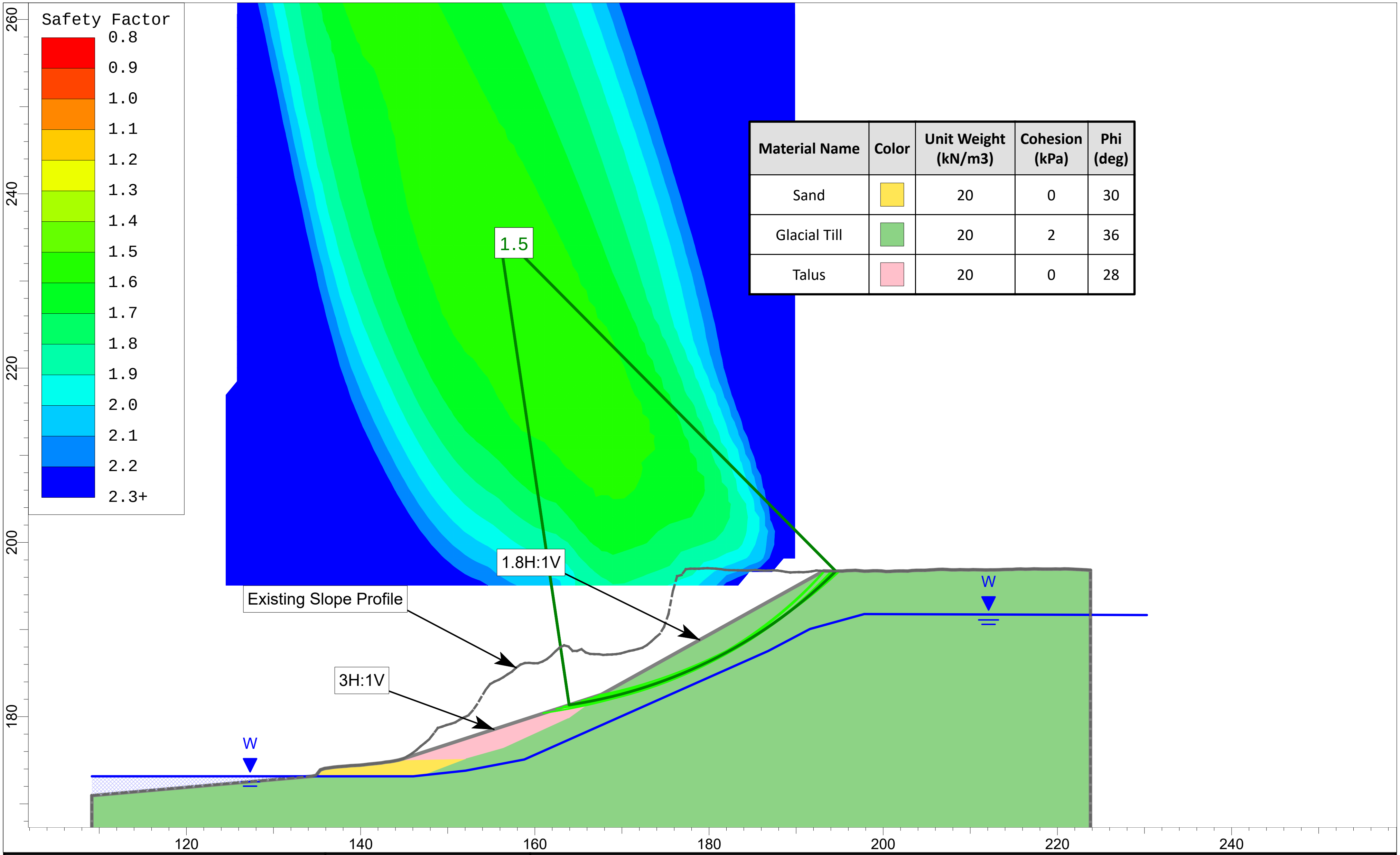
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 45 - SSI, high gwt

Date 4/30/2019
Scale 1:300
File Halimand Part 12.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36
Talus	🟥	20	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

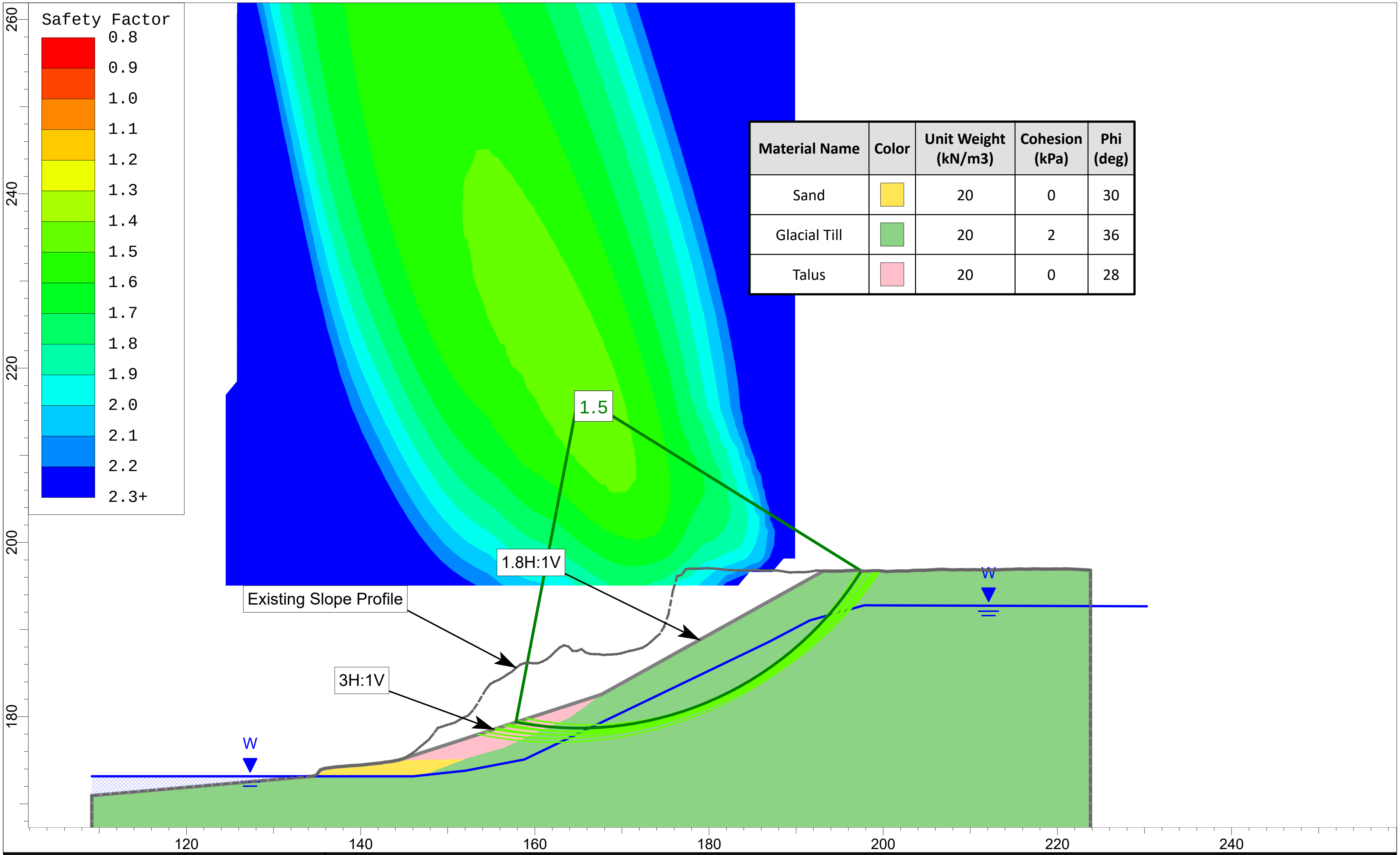
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 46 - SSI, Master Scenario

Date 4/30/2019
Scale 1:600
File Halimand Part 12.slmd

By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36
Talus	🟥	20	0	28

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

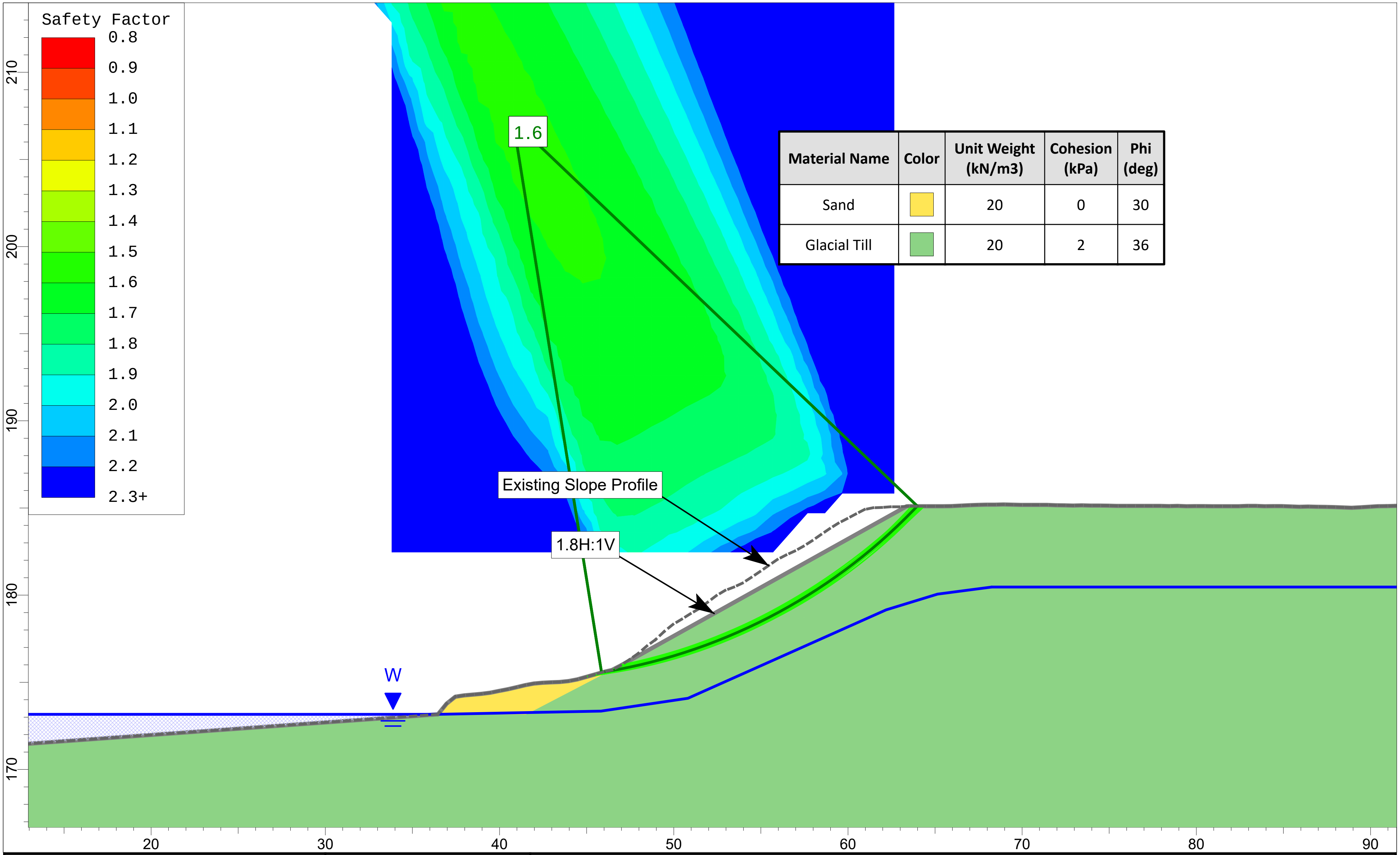
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 46 - SSI, high gwt

Date 4/30/2019
Scale 1:600
File Halimand Part 12.slmd
By JH/JC
Ref. 2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

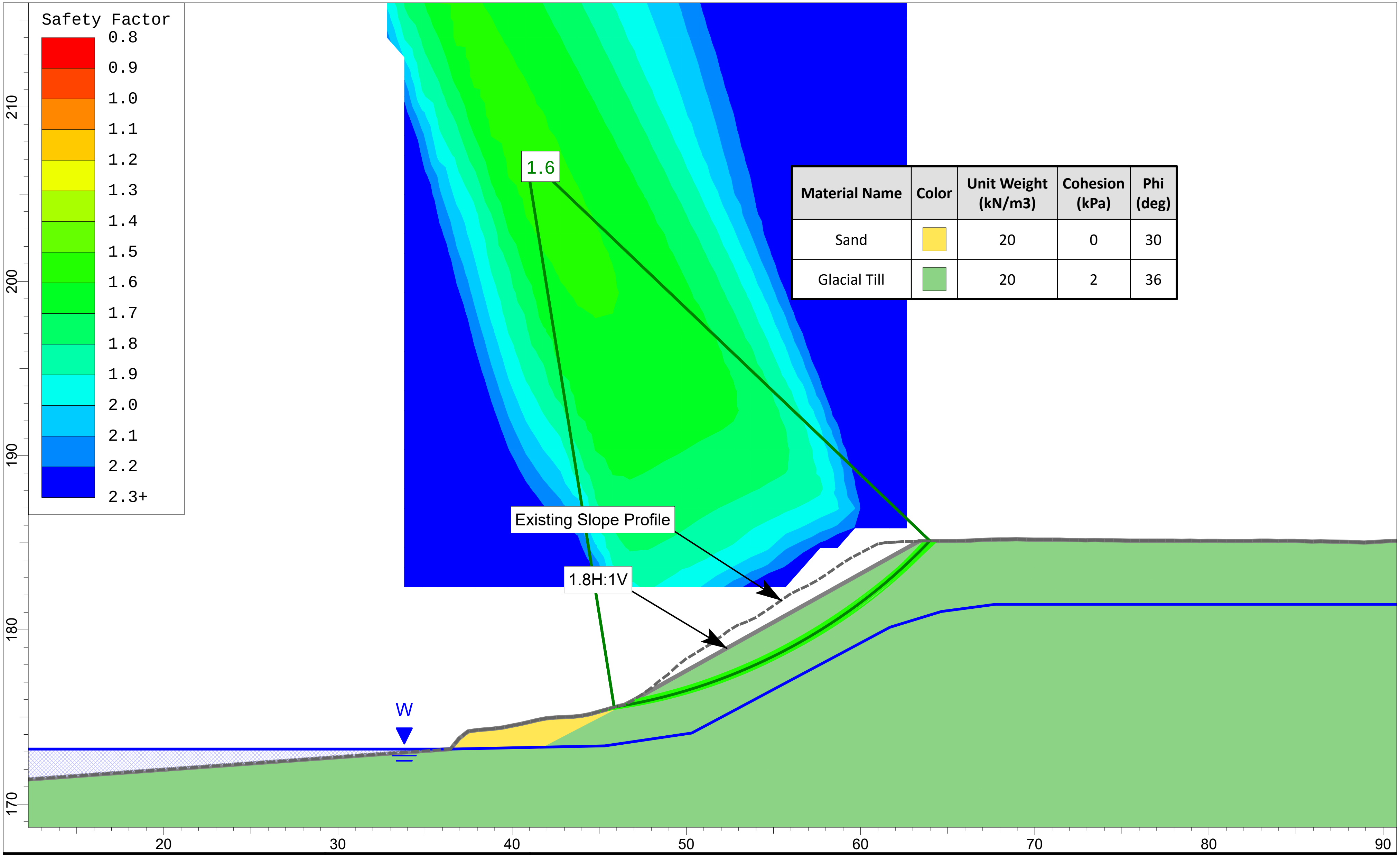
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Halimand County Slope Stability | 1-18-0402-01

Analysis
Global Stability: Section 47 - SSI, Master Scenario

Date	Scale	File
4/30/2019	1:300	Halimand Part 12.slmd

By	Ref.
JH/JC	2017 LiDar data, provided by Baird on March 13, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	20	0	30
Glacial Till	🟩	20	2	36

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

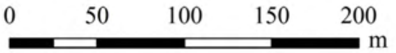
Project	**Halimand County Slope Stability | 1-18-0402-01**
Analysis	Global Stability: Section 47 - SSI, high gwt

Date	Scale	File
4/30/2019	1:300	Halimand Part 12.slmd

By	Ref.
JH/JC	2017 LiDar data, provided by Baird on March 13, 2019

Appendix B

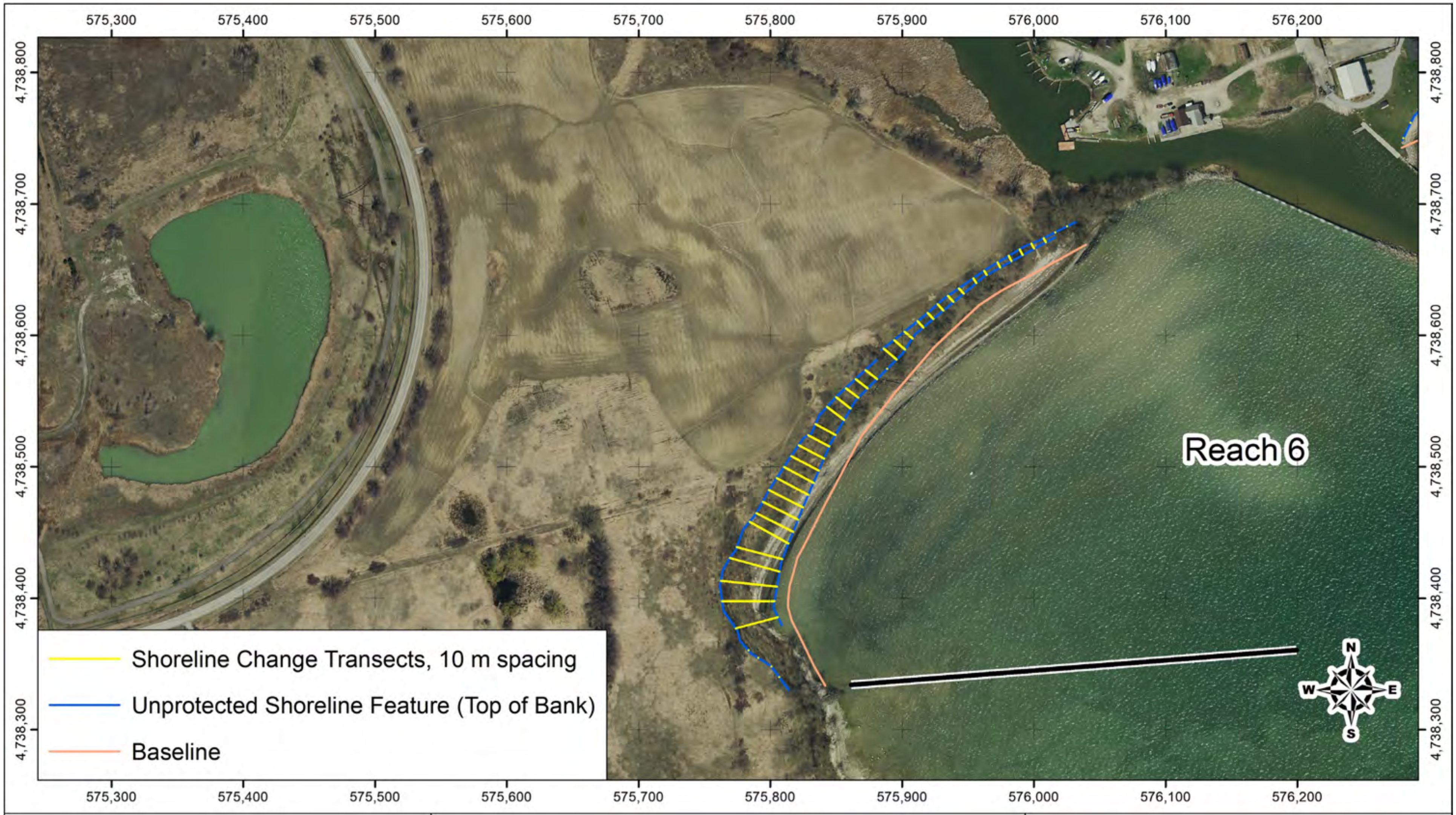
Shoreline Change Maps



1:5,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

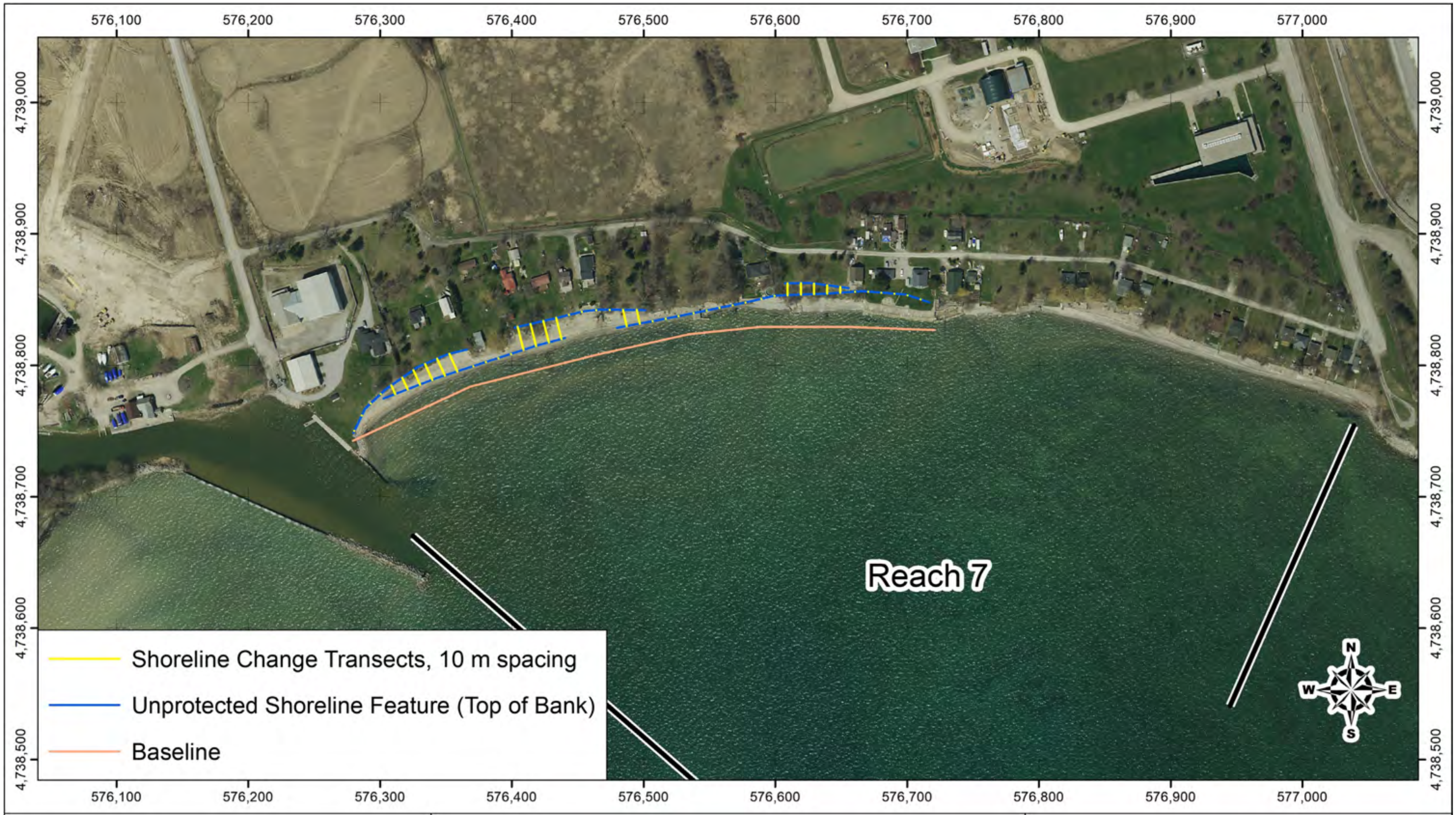


0 50 100 150 200 m

1:5,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



0 50 100 150 200
m

1:5,000

Historic Shoreline Change

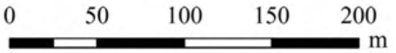
Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 60 120 180 240
m

1:6,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



1:5,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

Historic Shoreline Change

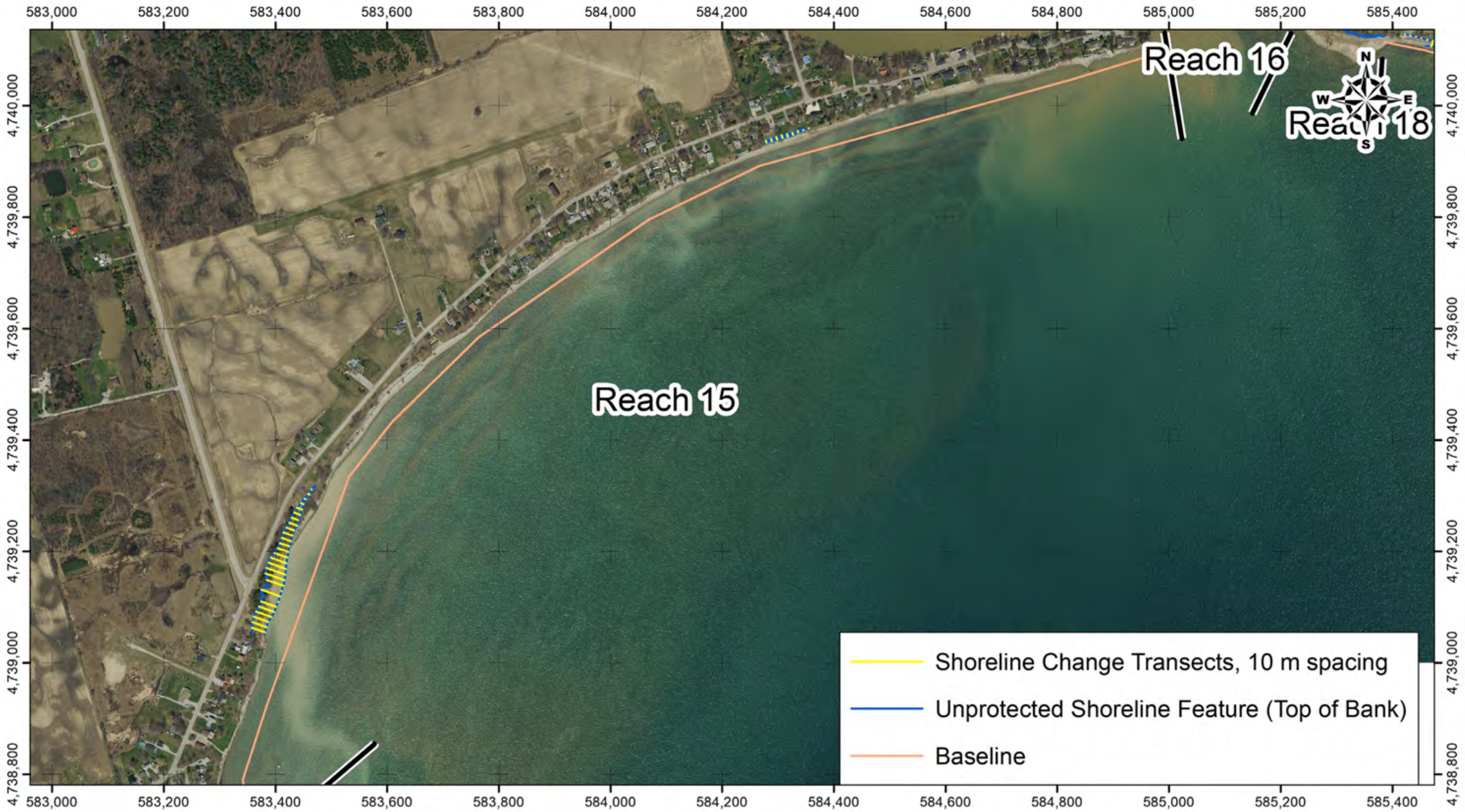
Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 80 160 240 320 m

1:8,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



0 120 240 360 480 m

1:12,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 50 100 150 200 m

1:5,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 50 100 150 200 m

1:5,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

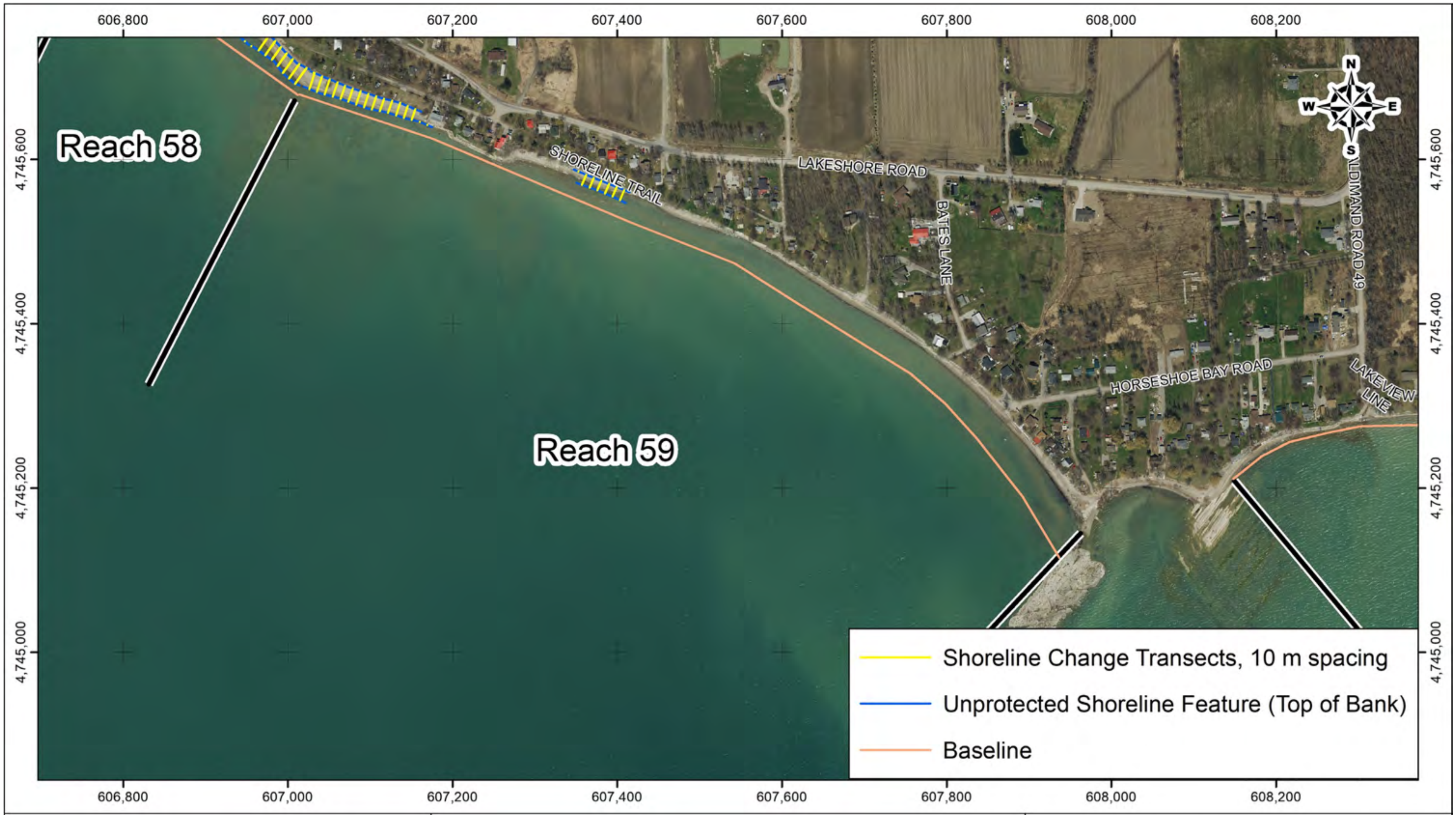
Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

1:5,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



0 80 160 240 320 m

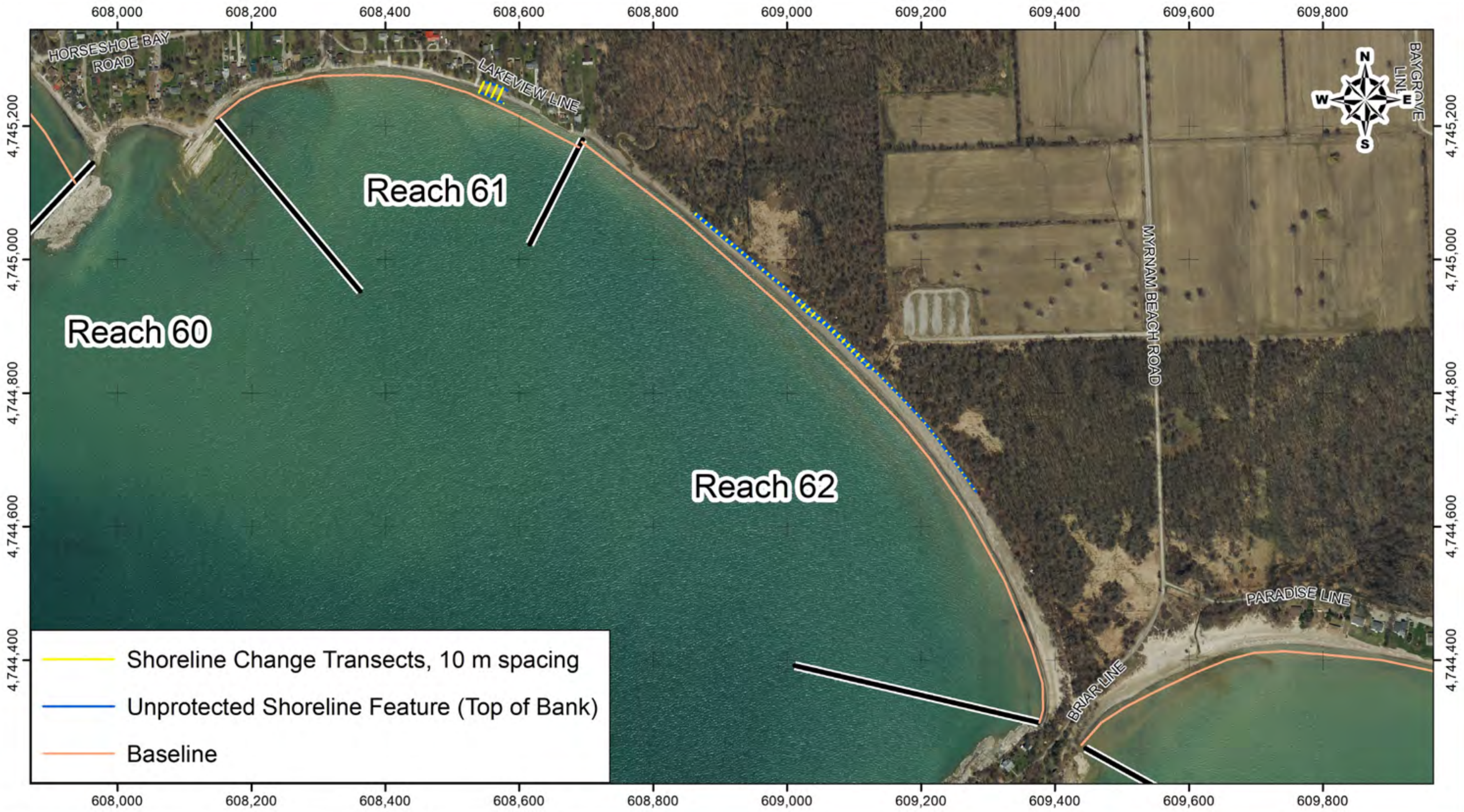
1:8,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

Historic Shoreline Change

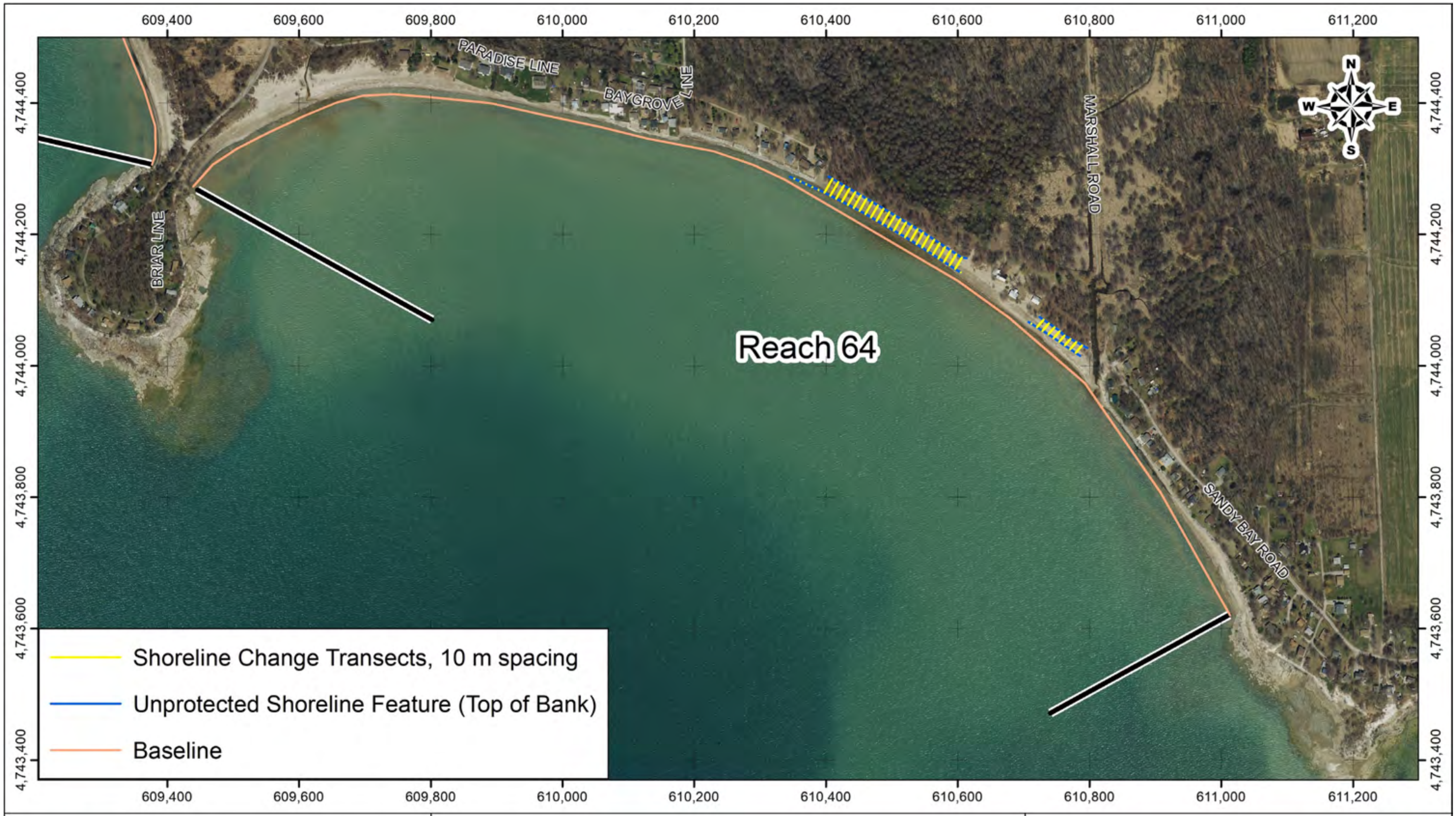
Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

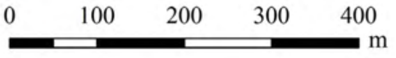


1:10,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N





1:10,000

Historic Shoreline Change

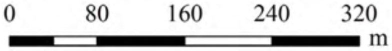
Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 50 100 150 200
m

1:5,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



1:8,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 60 120 180 240
m

1:6,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

1:6,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 80 160 240 320
m

1:8,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 50 100 150 200 m

1:5,000

Historic Shoreline Change

Basemap Imagery: SWOOP 2015.
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

Appendix C

Hazard Mapping Data

Table C.1: 100-year flood level and wave uprush allowance by reach, used to map Flooding Hazard

Reach	Stillwater Level (m)		Horizontal Wave Uprush (m)[1]	Uprush elevation (m)	
	CGVD2013	CGVD28 / IGLD85		CGVD2013	CGVD28 / IGLD85
1	175.9	176.4	5[1]	179.7	180.2
2	175.9	176.4	11[1]	181.0	181.5
3	175.9	176.4	13[1]	180.4	180.9
4	175.9	176.4	5[1]	179.5	180.0
5	175.9	176.4	10[1]	180.2	180.7
6	175.9	176.4	20	180.1	180.6
7	175.9	176.4	19	181.1	181.6
8	176.0	176.5	17	183.0	183.5
9	176.0	176.5	10[1]	180.6	181.1
10	176.0	176.5	19	181.3	181.8
11	176.0	176.5	10[1]	180.6	181.1
12	176.0	176.5	14[1]	179.8	180.3
13	176.0	176.5	17	181.4	181.9
14	176.0	176.5	11[1]	181.1	181.6
15	176.0	176.5	12[1]	181.2	181.7
16	176.0	176.5	11[1]	180.8	181.3
17	176.0	176.5	10[1]	180.2	180.7
18	176.0	176.5	17	177.8	178.3
19	176.0	176.5	10[1]	180.9	181.4
20	176.0	176.5	10[1]	180.4	180.9
21	176.0	176.5	14[1]	182.0	182.5
22	176.0	176.5	10[1]	179.9	180.4
23	176.0	176.5	22	178.0	178.5
24	176.0	176.5	15	180.6	181.1
25	176.0	176.5	12[1]	178.3	178.8
26	176.0	176.5	14[1]	181.0	181.5
27	176.0	176.5	11[1]	179.8	180.3
28	176.0	176.5	14[1]	180.5	181.0
29	176.1	176.6	8[1]	178.7	179.2
30	176.1	176.6	15	181.3	181.8
31	176.1	176.6	16	181.2	181.7

Reach	Stillwater Level (m)		Horizontal Wave Uprush (m)[1]	Uprush elevation (m)	
	CGVD2013	CGVD28 / IGLD85		CGVD2013	CGVD28 / IGLD85
32	176.1	176.6	22	178.0	178.5
33	176.1	176.6	11[1]	180.7	181.2
34	176.1	176.6	10[1]	180.3	180.8
35	176.1	176.6	13[1]	179.9	180.4
36	176.1	176.6	13[1]	181.3	181.8
37	176.1	176.6	8[1]	179.4	179.9
38	176.1	176.6	21	177.2	177.7
39	176.1	176.6	20	177.4	177.9
40	176.1	176.6	11[1]	178.0	178.5
41	176.1	176.6	14[1]	178.1	178.6
42	176.1	176.6	18	178.4	178.9
43	176.1	176.6	14[1]	180.4	180.9
44	176.1	176.6	10[1]	179.7	180.2
45	176.1	176.6	19	178.1	178.6
46	176.1	176.6	10[1]	179.9	180.4
47	176.1	176.6	17	178.1	178.6
48	176.1	176.6	18	181.5	182.0
49	176.1	176.6	13[1]	181.7	182.2
50	176.1	176.6	14[1]	179.6	180.1
51	176.1	176.6	15	182.7	183.2
52	176.1	176.6	12[1]	181.1	181.6
53	176.1	176.6	12[1]	181.3	181.8
54	176.1	176.6	12[1]	179.1	179.6
55	176.1	176.6	13[1]	180.8	181.3
56	176.1	176.6	14[1]	182.4	182.9
57	176.1	176.6	24	183.4	183.9
58	176.1	176.6	14[1]	181.6	182.1
59	176.1	176.6	12[1]	182.3	182.8
60	176.1	176.6	13[1]	182.0	182.5
61	176.1	176.6	13[1]	181.4	181.9
62	176.1	176.6	14[1]	182.9	183.4
63	176.2	176.7	11[1]	180.7	181.2

Reach	Stillwater Level (m)		Horizontal Wave Uprush (m)[1]	Uprush elevation (m)	
	CGVD2013	CGVD28 / IGLD85		CGVD2013	CGVD28 / IGLD85
64	176.2	176.7	14[1]	180.6	181.1
65	176.2	176.7	24	184.1	184.6
66	176.2	176.7	16	181.7	182.2
67	176.2	176.7	18	178.7	179.2
68	176.2	176.7	18	185.2	185.7
69	176.2	176.7	20	180.3	180.8
70	176.2	176.7	10[1]	181.7	182.2
71	176.2	176.7	7[1]	180.7	181.2
72	176.2	176.7	7[1]	182.9	183.4
73	176.2	176.7	7[1]	181.1	181.6
74	176.2	176.7	11[1]	183.2	183.7
75	176.2	176.7	21	182.0	182.5
76	176.2	176.7	19	184.6	185.1
77	176.3	176.8	16	181.7	182.2
78	176.3	176.8	24	180.0	180.5
79	176.3	176.8	25	179.2	179.7
80	176.3	176.8	17	182.8	183.3
81	176.3	176.8	23	178.3	178.8
82	176.3	176.8	33	178.3	178.8
83	176.3	176.8	22	178.0	178.5
84	176.3	176.8	17	182.1	182.6

[1] Note that all values with horizontal wave uprush calculated as less than 15 m were mapped as 15 m due to possible variability in wave exposure, nearshore slope, water depth at the toe, and bluff height within a reach.

Table C.2: Stable slope allowance and erosion allowance used to map Erosion Hazard

Reach	**Staple Slope Allowance**		**Erosion Allowance**	
	Geotechnical Analysis Section	Final Stable Slope for Mapping (H:V)	AARR+1SD (m)	Erosion Allowance (m)
1	1	2.3:1		30
2	2	2.3	0.25	25
3	3	2.3:1		30
4	4	2.3:1		30
5		2.3:1		10
6	5	2.3:1	0.43	43
7	6	2.3:1	0.23	23
8	7	3:1		30
9	8	2.3:1	0.09	9
10		2.3:1	0.22	22
11	9	2.3:1	0.08	8
12	10	2.3:1	0.44	44
13		2.3:1		30
14	11	2.3:1		10
15	12	2.3:1	0.69	69
16		3:1		30
17		3:1		10
18	13	2.3:1	0.28	28
19	14	2.3:1		30
20	15	2.3:1		30
21	16	2.3:1		30
22	17	2.3:1		30
23		2.3:1		10
24	18	2.3:1		30
25		2.3:1		30
26		2.3:1		30
27	19	3:1		10
28	20	2.3:1		30
29		2.3:1		10
30		2.3:1		30
31	21	2.3:1		10
32	22	2.3:1	0.26	26

Reach	Staple Slope Allowance		Erosion Allowance	
	Geotechnical Analysis Section	Final Stable Slope for Mapping (H:V)	AARR+1SD (m)	Erosion Allowance (m)
33	23	2.3:1		10
34	24	2.3:1		30
35		2.3:1		10
36	25	2.3:1	0.08	8
37		2.3:1		10
38	26	2.3:1		30
39	27	3:1		10
40	28	2.3:1		30
41	29	2.3:1		10
42	30	2.3:1		30
43	31	2.3:1		30
44	32	2.3:1		30
45		2.3:1		10
46	33	2.3:1		30
47	34	2.3:1		30
48		3:1		10
49	35	3:1		30
50		3:1		10
51		3:1		10
52		3:1		30
53	36	2.3:1		30
54		2.3:1		10
55	37	2.3:1		30
56		2.3:1		10
57	38	2.3:1	0.21	21
58		3:1	0.39	39
59		3:1	0.30	30
60		3:1		30
61	39	2.3:1	0.34	34
62	40	3:1	0.08	8
63		3:1		10
64	41	3:1	0.38	38
65	42	1.4:1		10
66		3:1		30

Reach	Staple Slope Allowance		Erosion Allowance	
	Geotechnical Analysis Section	Final Stable Slope for Mapping (H:V)	AARR+1SD (m)	Erosion Allowance (m)
67		3:1		30
68	43	3:1		30
69		3:1		10
70		3:1	0.14	14
71	44	1.8:1	0.33	33
72	45	1.8:1	0.40	40
73	46	1.8:1	0.51	51
74	47	1.8:1	0.34	34
75		1.8:1	0.20	20
76	48	1.8:1		30
77		1.8:1		10
78		1.8:1		40
79	49	3:1		40
80	50	3:1		30
81		3:1		30
82	51	3:1		30
83		3:1		30
84	52	3:1		30

Table C.3: Examples of estimated flood proofing elevations by reach for selected shoreline treatments

Notes:

1. Lake Erie 100-year Static Lake Level (values from Baird analysis used, as they are more conservative):
   175.16 m IGLD85
   174.70 m CGVD2013
2. Depth limited breaking wave assumed; Tp=10s
3. Uprush on beach calculated using Stockdon et. Al. (2006)
4. All other uprush calculated using EurOTop (2018)
5. Tables provide examples only. Flood proofing elevation should be determined on a site specific basis by a Professional Engineer with experience in flood proofing.

Lake Erie 100-year Storm Surge

Reaches		Reach number from MNR (1989)	100-year storm surge (m) from MNR (1989)	100-year static lake level plus 100-year storm surge (m CGVD2013)	100-year flood level (m CGVD2013)
1 to 7	West County Limit to Nanticoke	E-18	1.77	176.41	175.9
8 to 28	Nanticoke to Hoover Point	E-18/E-19	1.84	176.48	176.0
29 to 62	Hoover Point to Low Point	E-19	1.84	176.48	176.1
63 to 76	Low Point to Mohawk Point	E-20/E-21	2.04	176.68	176.2
77 to 84	Mohawk Point to Lowbanks	E-22	2.32	176.96	176.3

Lake Erie Minimum Floodproofing Standard Elevation (m)

***Note: does not include freeboard allowance, minimum 0.3 m recommended**

Reaches	100-year static lake level plus 100-year storm surge (m CGVD2013)	Structure	Toe Elevation (m CGVD2013)	Water depth (m)	Wave Height (m)	Uprush (m)	Uprush Elevation (m CGVD2013)	Uprush Elevation (m IGLD85)
1 to 7	176.4	1:50 sloped beach	172.4	4.0	3.1	1.0	177.4	177.9
		1:10 sloped dune	175.4	1.0	0.8	2.2	178.6	179.1
		1:10 sloped dune	174.4	2.0	1.6	2.5	178.9	179.4
		1:10 sloped dune	173.4	3.0	2.3	3.0	179.4	179.9
		1:10 sloped dune	172.4	4.0	3.1	3.5	179.9	180.4
		1:2 sloped revetment	175.4	1.0	0.8	2.4	178.8	179.3
		1:2 sloped revetment	174.4	2.0	1.6	4.7	181.1	181.6
		1:2 sloped revetment	173.4	3.0	2.3	6.9	183.3	183.8
		1:2 sloped revetment	172.4	4.0	3.1	9.0	185.4	185.9
		vertical wall	175.4	1.0	0.8	3.3	179.7	180.2
		vertical wall	174.4	2.0	1.6	3.0	179.4	179.9
		vertical wall	173.4	3.0	2.3	4.5	180.9	181.4
		vertical wall	172.4	4.0	3.1	6.0	182.4	182.9
8 to 28	176.5	1:50 sloped beach	172.5	4.0	3.1	1.0	177.5	177.9
		1:10 sloped dune	175.5	1.0	0.8	2.2	178.7	179.1
		1:10 sloped dune	174.5	2.0	1.6	2.5	179.0	179.4

Reaches	100-year static lake level plus 100-year storm surge (m CGVD2013)	Structure	Toe Elevation (m CGVD2013)	Water depth (m)	Wave Height (m)	Uprush (m)	Uprush Elevation (m CGVD2013)	Uprush Elevation (m IGLD85)
		1:10 sloped dune	173.5	3.0	2.3	3.0	179.5	179.9
		1:10 sloped dune	172.5	4.0	3.1	3.5	180.0	180.4
		1:2 sloped revetment	175.5	1.0	0.8	2.4	178.9	179.3
		1:2 sloped revetment	174.5	2.0	1.6	4.7	181.2	181.6
		1:2 sloped revetment	173.5	3.0	2.3	6.9	183.4	183.8
		1:2 sloped revetment	172.5	4.0	3.1	9.0	185.5	185.9
		vertical wall	175.5	1.0	0.8	3.3	179.8	180.2
		vertical wall	174.5	2.0	1.6	3.0	179.5	179.9
		vertical wall	173.5	3.0	2.3	4.5	181.0	181.4
		vertical wall	172.5	4.0	3.1	6.0	182.5	182.9
29 to 62	176.5	1:50 sloped beach	172.5	4.0	3.1	1.0	177.5	177.9
		1:10 sloped dune	175.5	1.0	0.8	2.2	178.7	179.1
		1:10 sloped dune	174.5	2.0	1.6	2.5	179.0	179.4
		1:10 sloped dune	173.5	3.0	2.3	3.0	179.5	179.9
		1:10 sloped dune	172.5	4.0	3.1	3.5	180.0	180.4
		1:2 sloped revetment	175.5	1.0	0.8	2.4	178.9	179.3
		1:2 sloped revetment	174.5	2.0	1.6	4.7	181.2	181.6
		1:2 sloped revetment	173.5	3.0	2.3	6.9	183.4	183.8
		1:2 sloped revetment	172.5	4.0	3.1	9.0	185.5	185.9
		vertical wall	175.5	1.0	0.8	3.3	179.8	180.2
		vertical wall	174.5	2.0	1.6	3.0	179.5	179.9
		vertical wall	173.5	3.0	2.3	4.5	181.0	181.4
		vertical wall	172.5	4.0	3.1	6.0	182.5	182.9

Reaches	100-year static lake level plus 100-year storm surge (m CGVD2013)	Structure	Toe Elevation (m CGVD2013)	Water depth (m)	Wave Height (m)	Uprush (m)	Uprush Elevation (m CGVD2013)	Uprush Elevation (m IGLD85)
63 to 76	176.7	1:50 sloped beach	172.7	4.0	3.1	1.0	177.7	178.1
		1:10 sloped dune	175.7	1.0	0.8	2.2	178.9	179.3
		1:10 sloped dune	174.7	2.0	1.6	2.5	179.2	179.6
		1:10 sloped dune	173.7	3.0	2.3	3.0	179.7	180.1
		1:10 sloped dune	172.7	4.0	3.1	3.5	180.2	180.6
		1:2 sloped revetment	175.7	1.0	0.8	2.4	179.1	179.5
		1:2 sloped revetment	174.7	2.0	1.6	4.7	181.4	181.8
		1:2 sloped revetment	173.7	3.0	2.3	6.9	183.6	184.0
		1:2 sloped revetment	172.7	4.0	3.1	9.0	185.7	186.1
		vertical wall	175.7	1.0	0.8	3.3	180.0	180.4
		vertical wall	174.7	2.0	1.6	3.0	179.7	180.1
		vertical wall	173.7	3.0	2.3	4.5	181.2	181.6
		vertical wall	172.7	4.0	3.1	6.0	182.7	183.1
77 to 84	177.0	1:50 sloped beach	173.0	4.0	3.1	1.0	178.0	178.4
		1:10 sloped dune	176.0	1.0	0.8	2.2	179.2	179.6
		1:10 sloped dune	175.0	2.0	1.6	2.5	179.5	179.9
		1:10 sloped dune	174.0	3.0	2.3	3.0	180.0	180.4
		1:10 sloped dune	173.0	4.0	3.1	3.5	180.5	180.9
		1:2 sloped revetment	176.0	1.0	0.8	2.4	179.4	179.8
		1:2 sloped revetment	175.0	2.0	1.6	4.7	181.7	182.1
		1:2 sloped revetment	174.0	3.0	2.3	6.9	183.9	184.3
		1:2 sloped revetment	173.0	4.0	3.1	9.0	186.0	186.4
		vertical wall	176.0	1.0	0.8	3.3	180.3	180.7
		vertical wall	175.0	2.0	1.6	3.0	180.0	180.4

Reaches	100-year static lake level plus 100-year storm surge (m CGVD2013)	Structure	Toe Elevation (m CGVD2013)	Water depth (m)	Wave Height (m)	Uprush (m)	Uprush Elevation (m CGVD2013)	Uprush Elevation (m IGLD85)
		vertical wall	174.0	3.0	2.3	4.5	181.5	181.9
		vertical wall	173.0	4.0	3.1	6.0	183.0	183.4

Appendix D

Flood Depth Mapping for Flood Preparedness

Dunnville

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

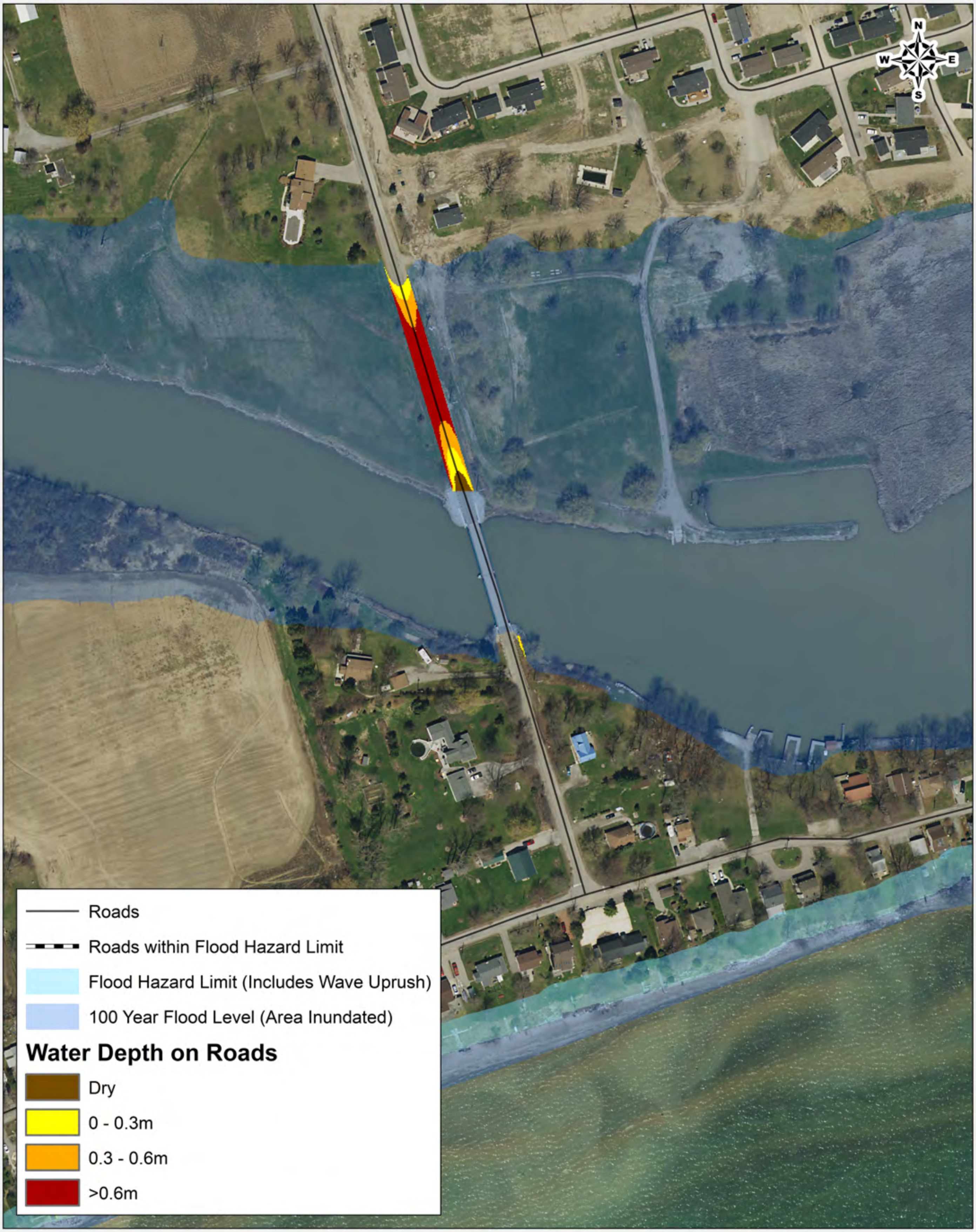
Baird.

0 40 80 120 m

Reach 6

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.

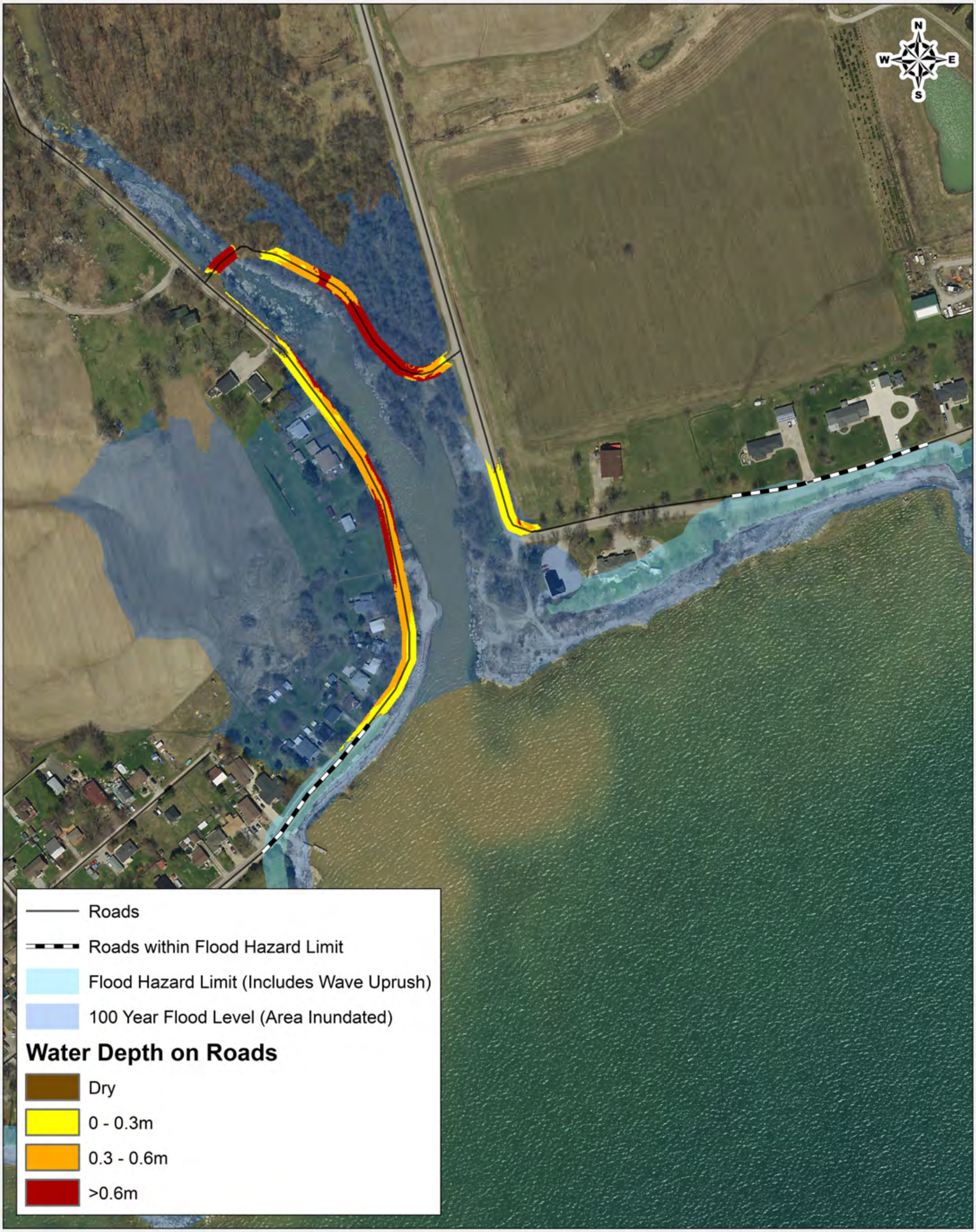


0 25 50 75 m

Reach 15

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.

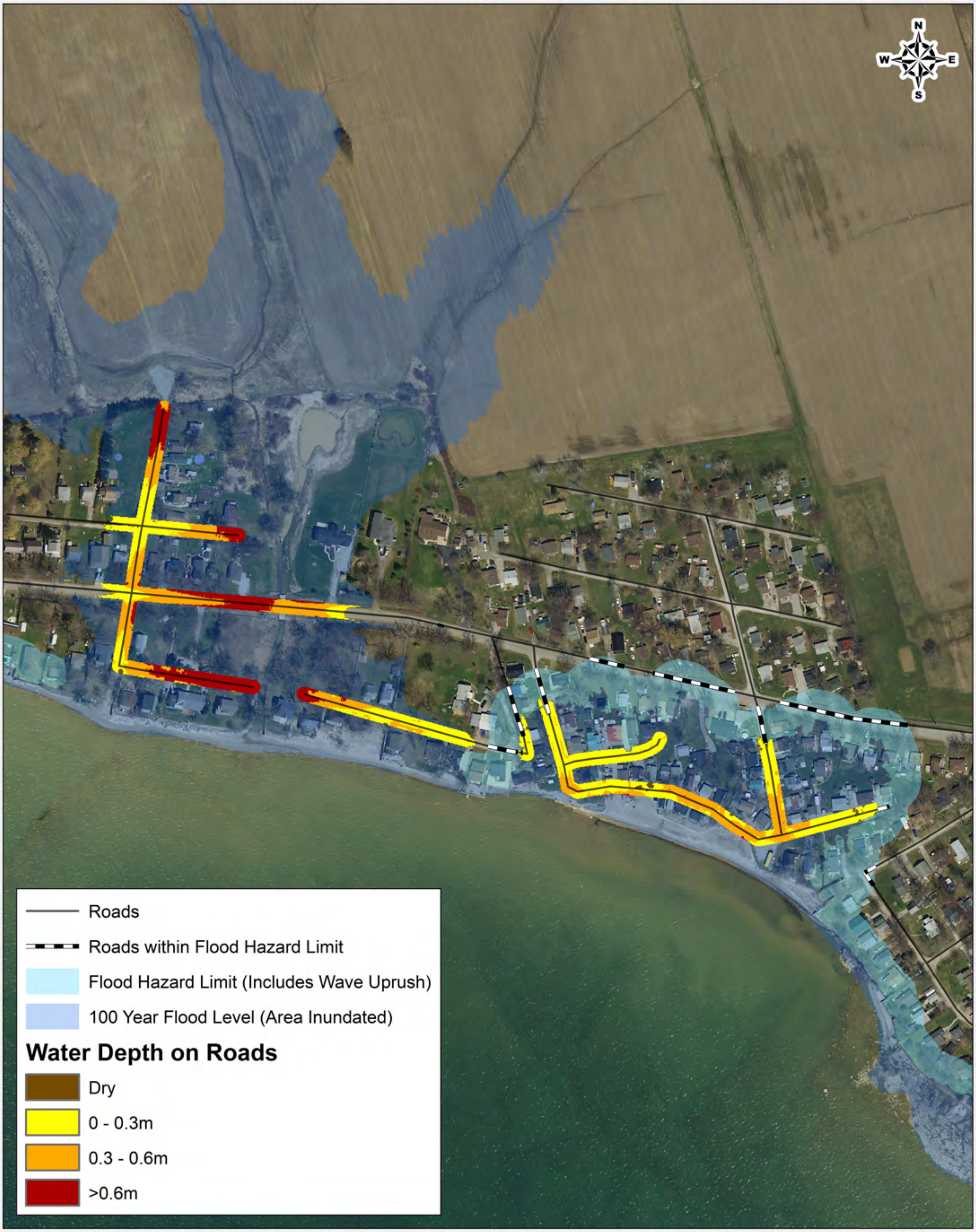


0 40 80 120 m

Reach 22

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.



0 40 80 120
m

Reach 38

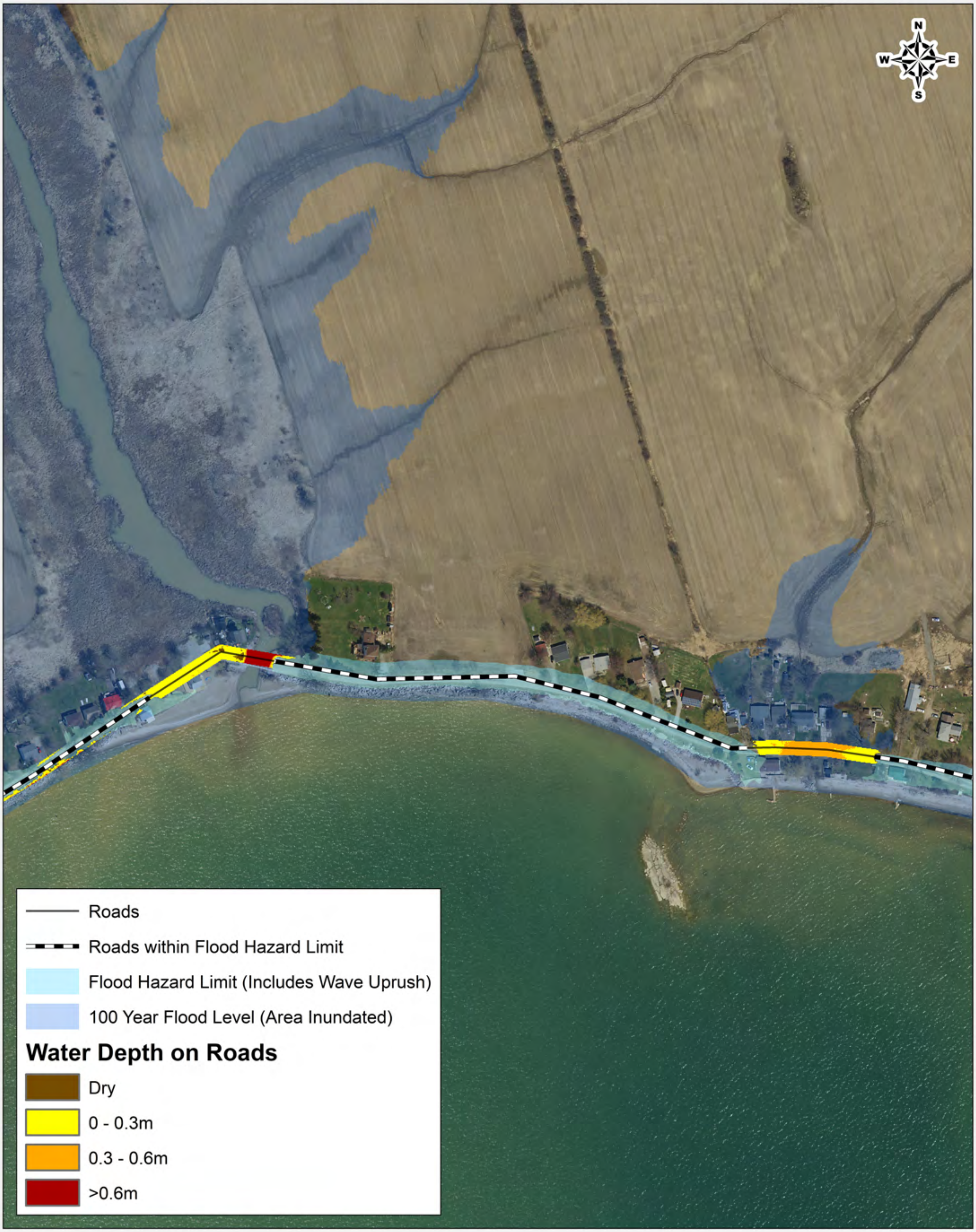
Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.

Reach 40

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

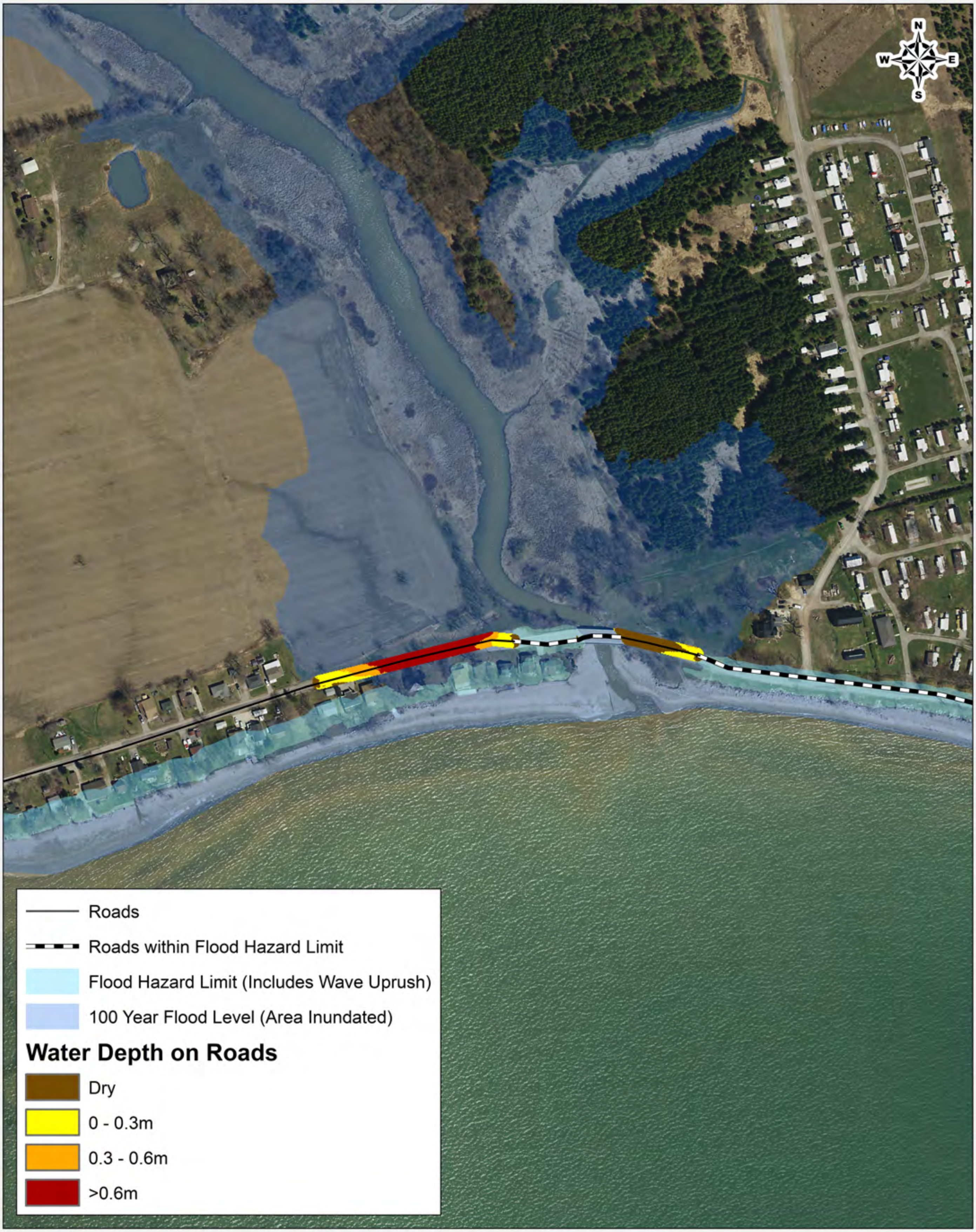
Baird.



Reach 42

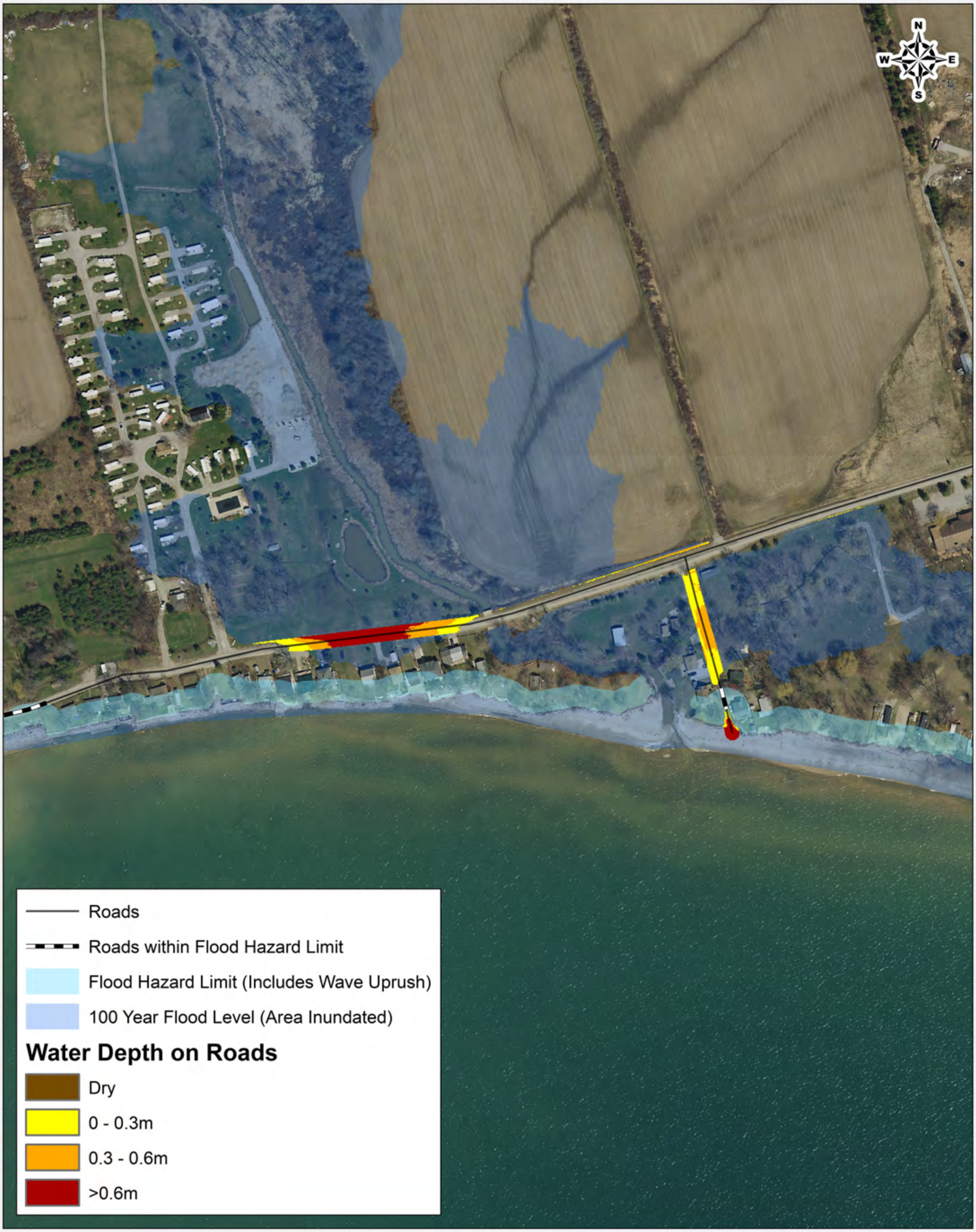
Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.



Reach 47

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

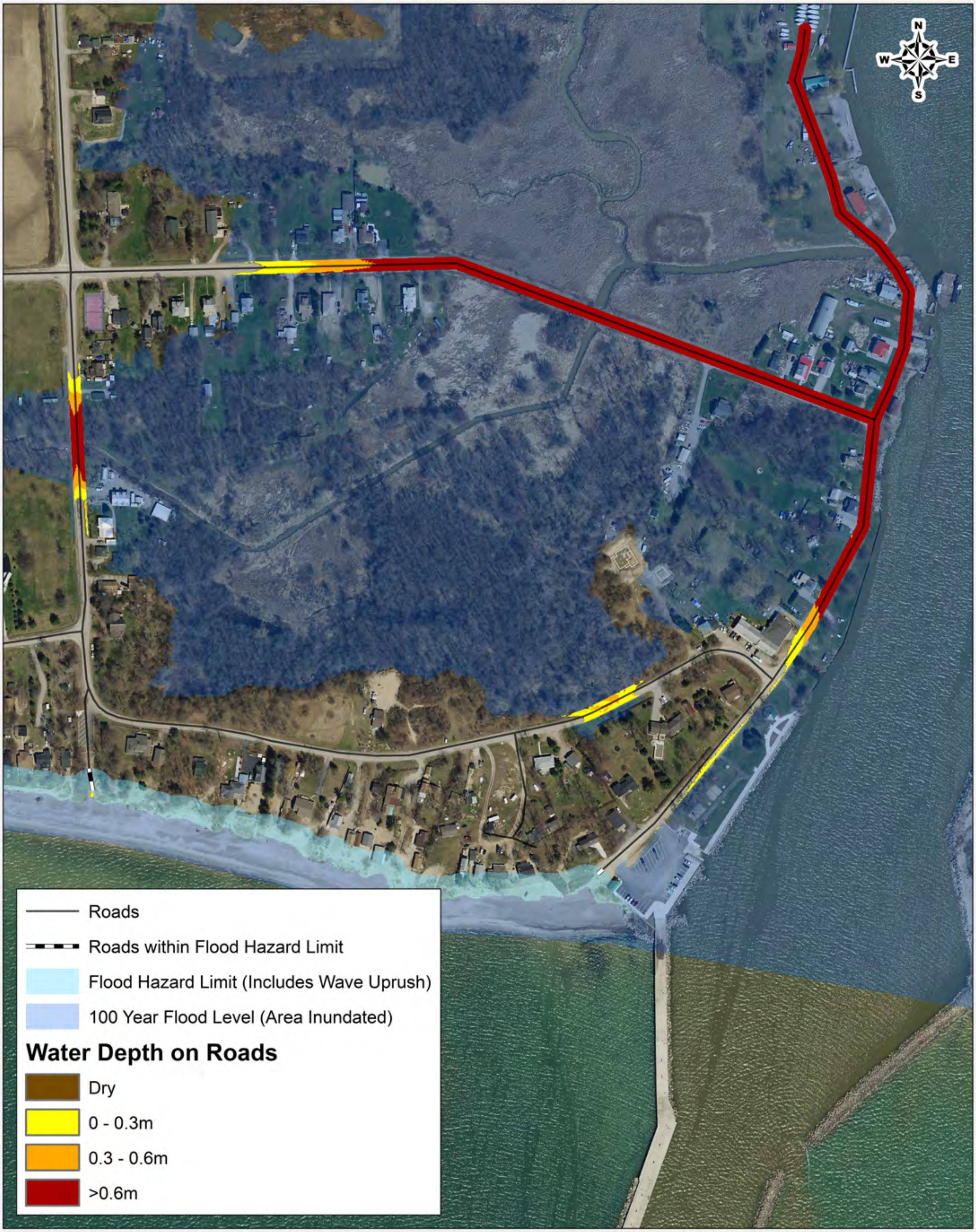


0 40 80 120
m

Reach 49

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

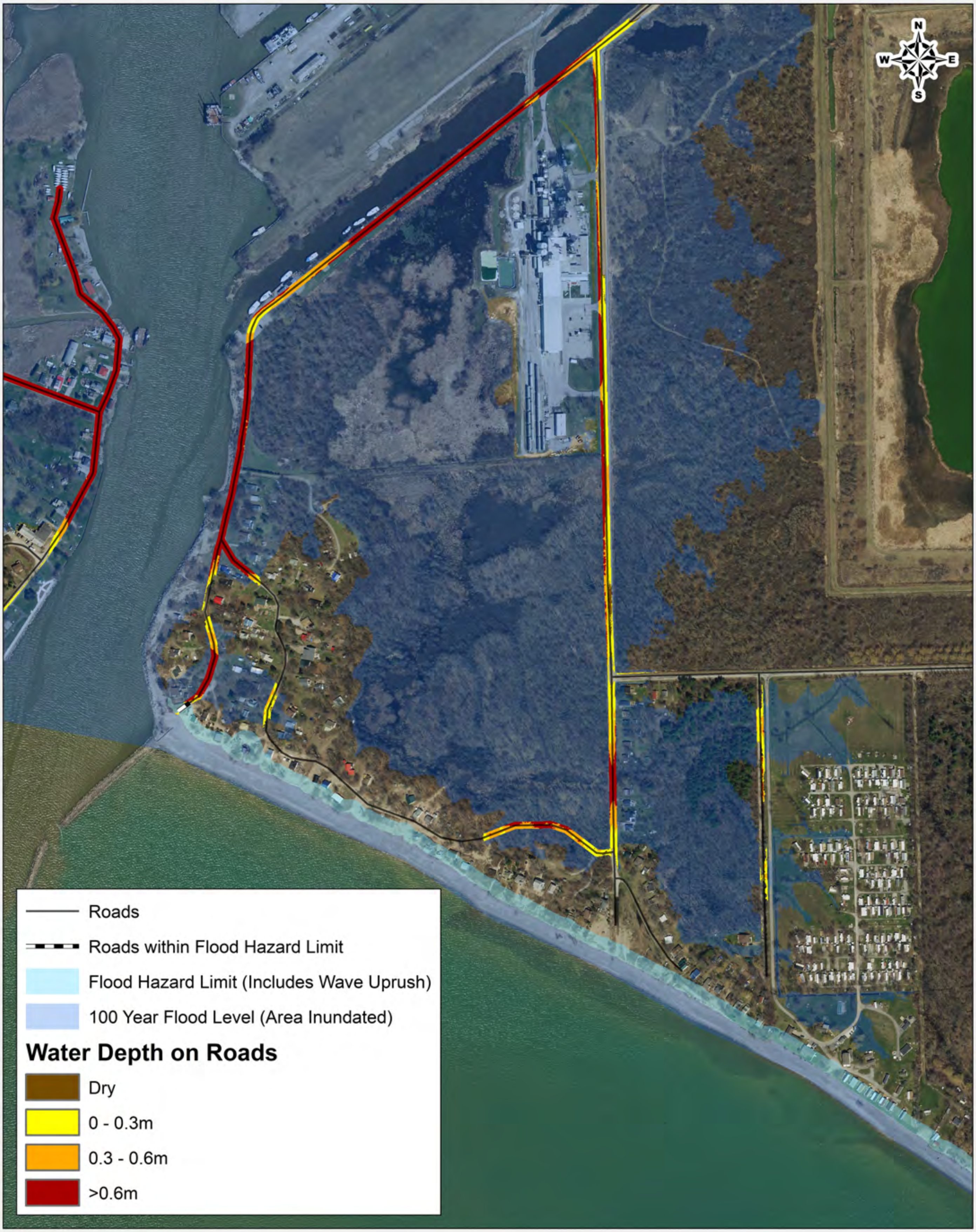
Baird.



0 40 80 120
m

Reach 67

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N



0 80 160 240
m

Reach 68

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.

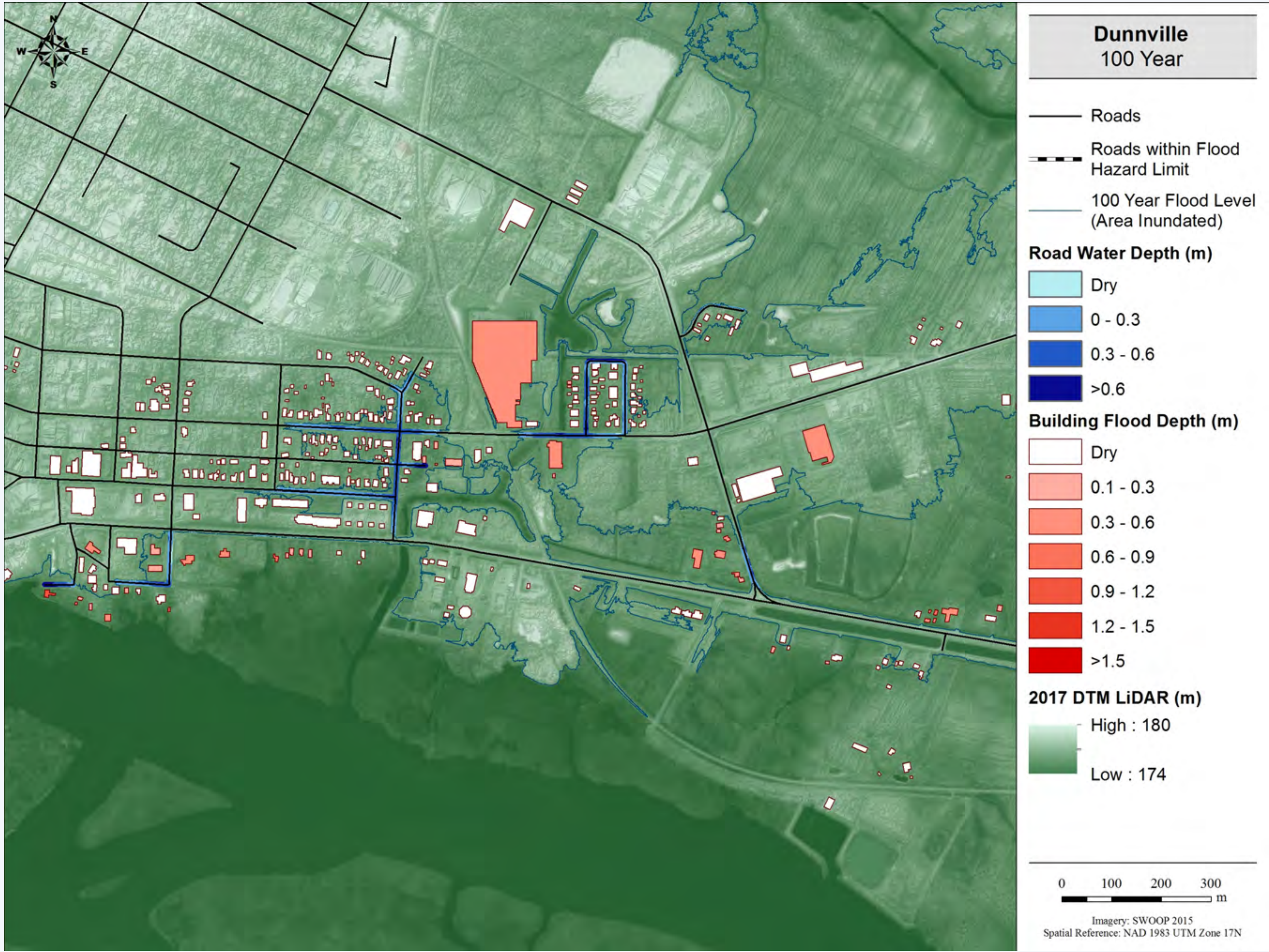
Appendix E

Road and Building Flood Depth Mapping

Area #1 – Dunnville 100-year Flood Depths

100-yr flood level = 176.2m CGVD2013

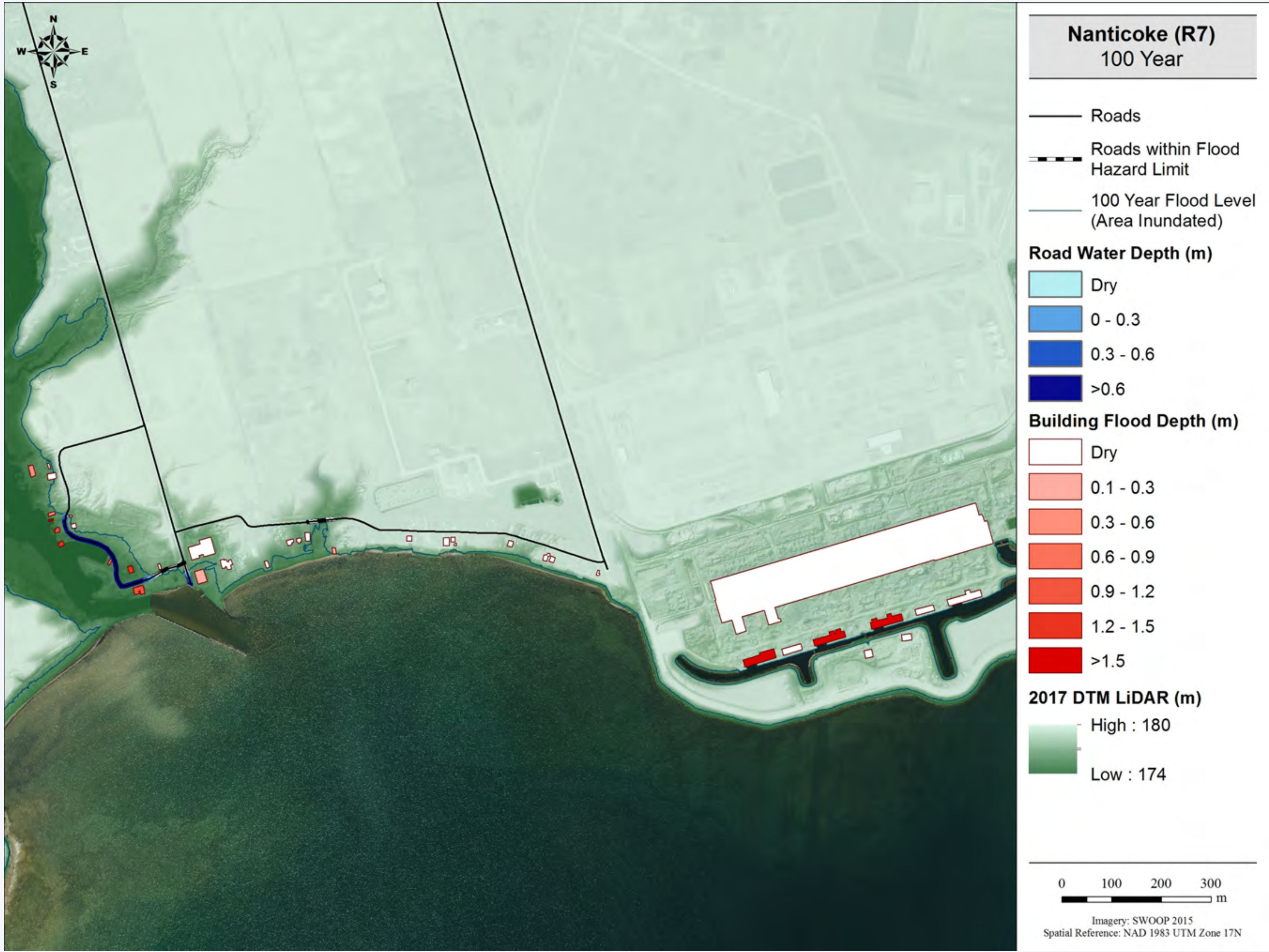
Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
HYDRO STREET	175.2	175.7
TAMARAC STREET & FRONT STREET	175.8	176.2
BROAD STREET EAST	175.7	176.1
NIAGARA STREET	175.6	176.1
CENTRAL LANE	175.3	175.8
QUEEN STREET	175.8	176.3
BRANT STREET & BRACE STREET	175.6	176.1
TAYLOR ROAD	176.0	176.5



Area #2 – Nanticoke 100-year Flood Depths

100-yr flood level = 175.9m CGVD2013

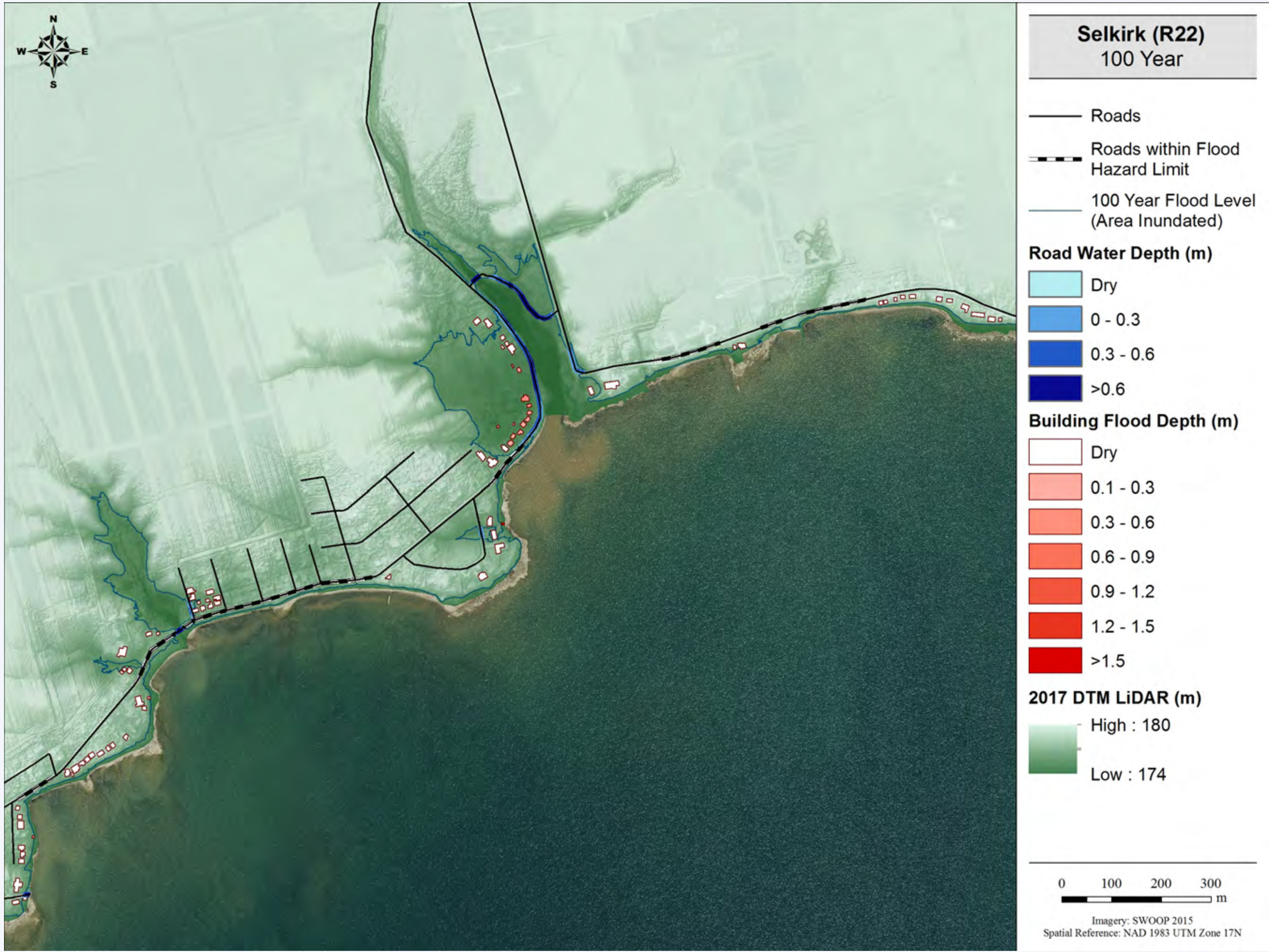
Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
ERIE AVENUE	174.9	175.4
ERIE STREET	174.9	175.4



Area #3 – Selkirk 100-year Flood Depths

100-yr flood level = 176.0m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
BLUE WATER PKWY	175.3	175.8
EAST LAKESHORE RD	174.1	174.6
HALDIMAND ROAD 53	175.7	176.2



Area #4 – Hoover Point 100-year Flood Depths

100-yr flood level = 176.1m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
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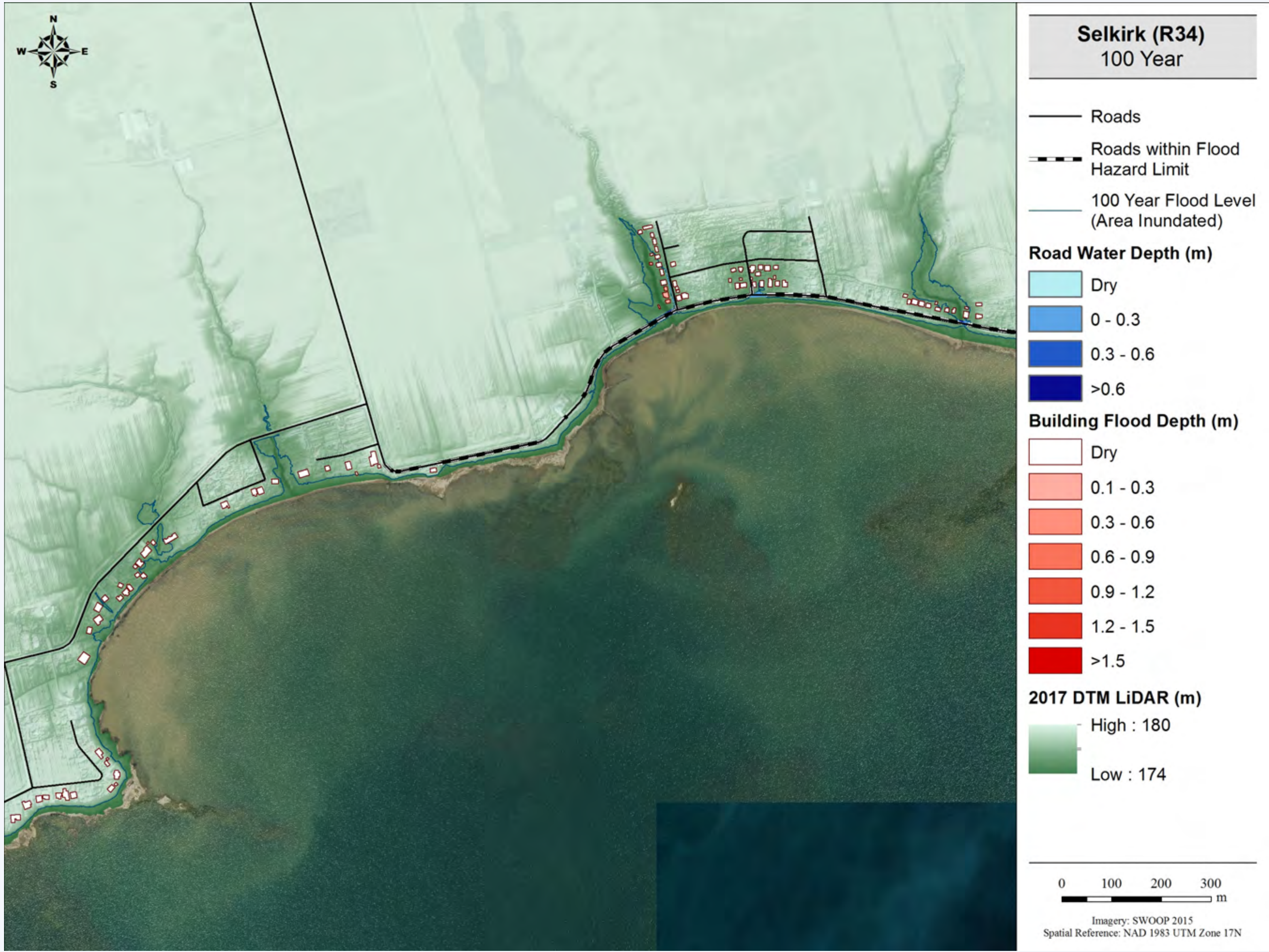
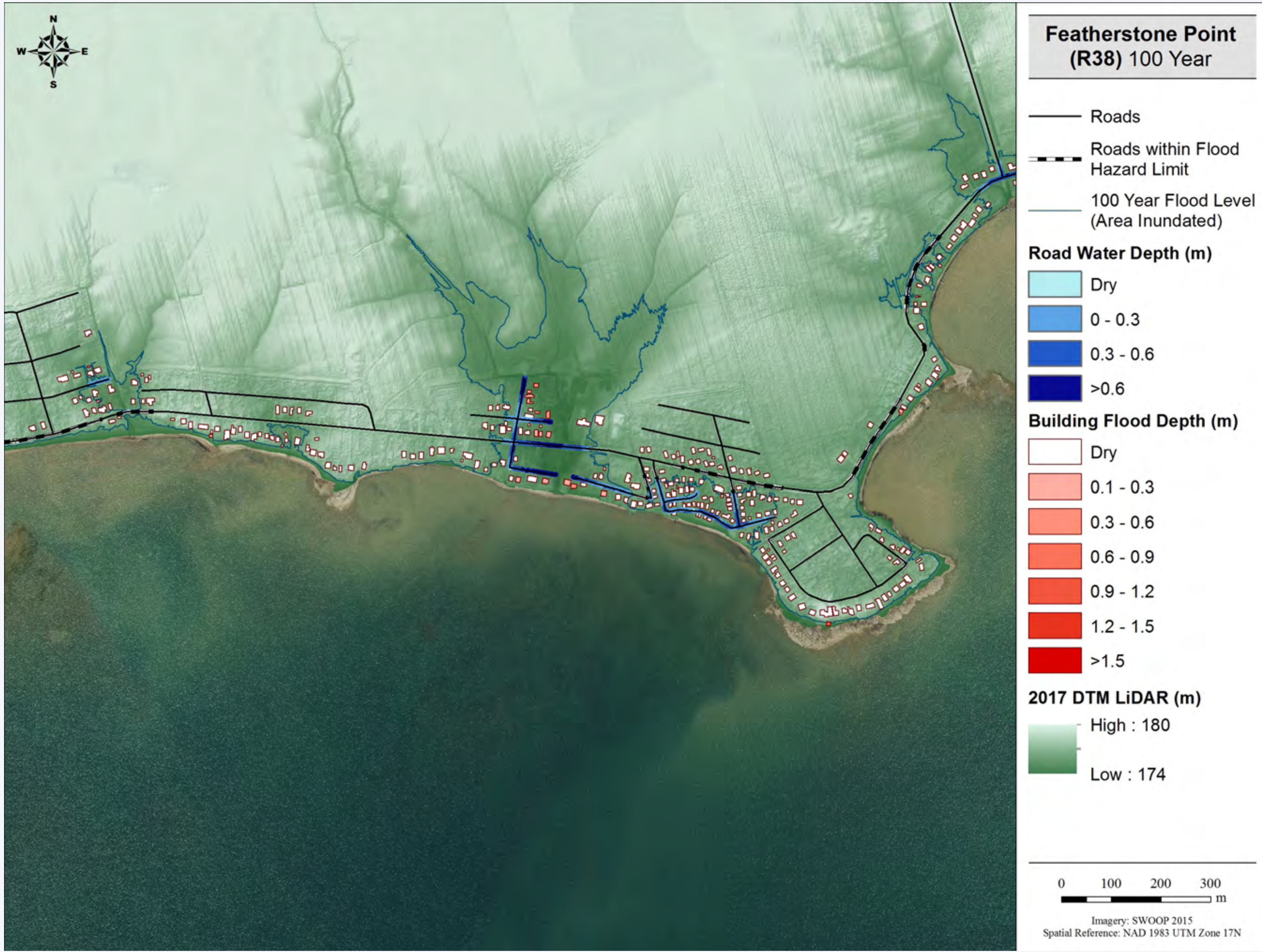


Area #5 – Featherstone Point 100-year Flood Depths

100-yr flood level = 176.1m CGVD2013

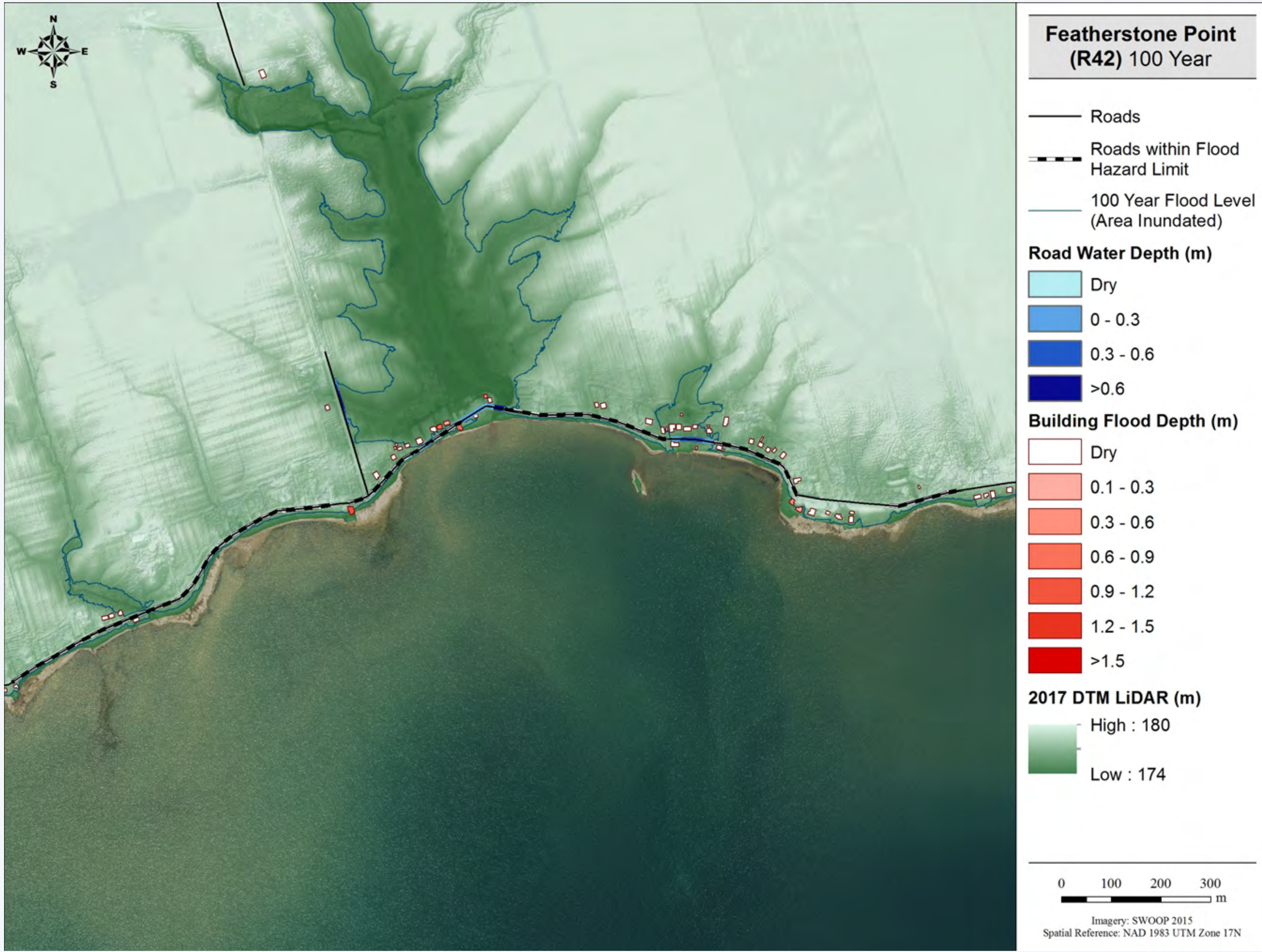
Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
BIRCH LANE	175.4	175.9
SWALLOW LANE	175.3	175.8
LAKESHORE ROAD	175.5	175.9
SEAGULL LANE	174.6	175.1
WINGER BAY LANE	175.4	175.8
AULD LANE	176.0	176.4
VIDEOWAY LANE	175.8	176.3
HEATHER LANE	175.5	176.0
PIKE LANE	175.8	176.2
LAKESHORE ROAD (at KOHLER ROAD)	175.6	176.0



Area #6 – Featherstone Point 100-year Flood Depths

100-yr flood level = 176.1m CGVD2013

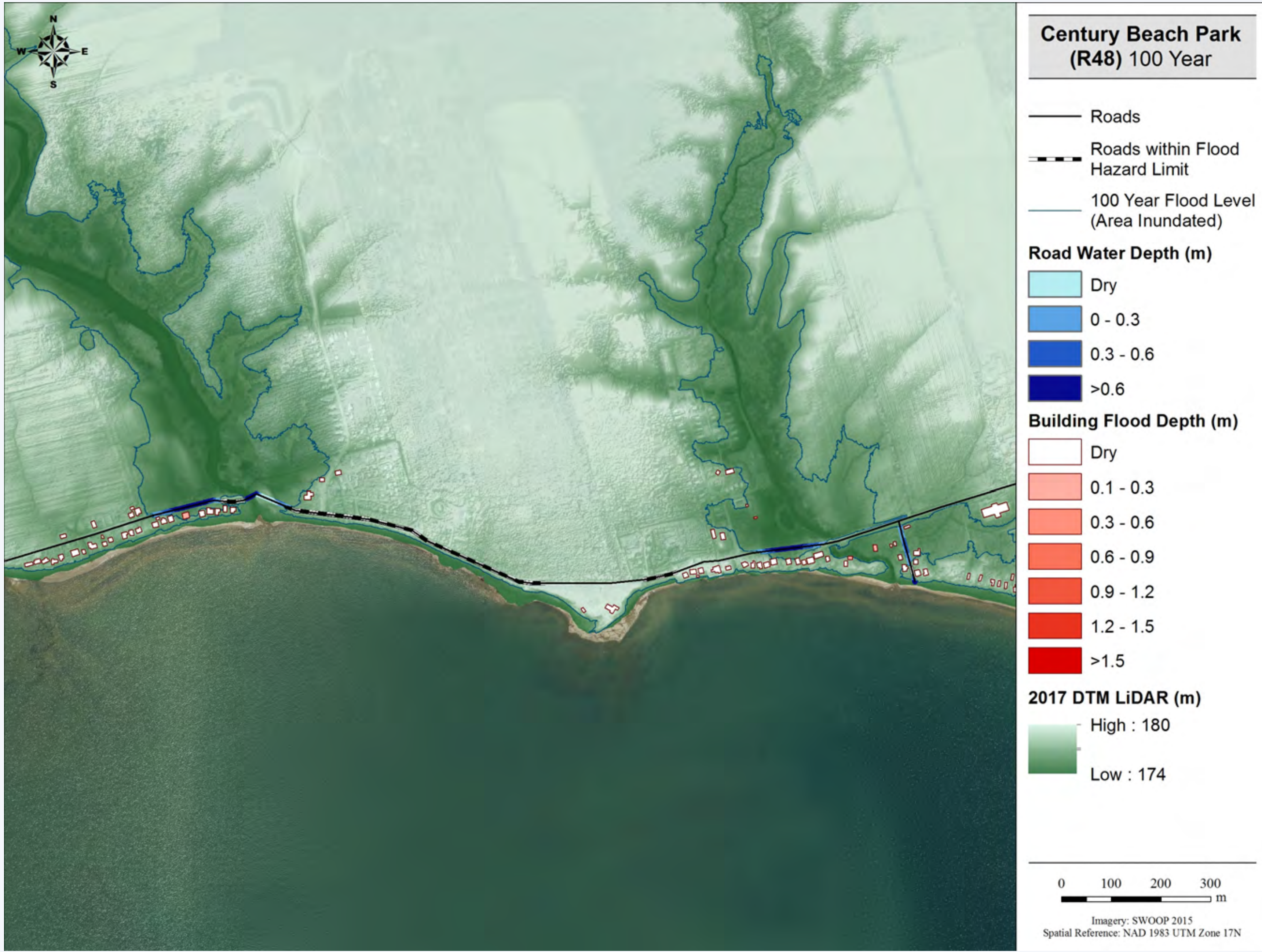
Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
REICHELD ROAD	175.1	175.6
LAKESHORE ROAD	175.7	176.2



Area #7 – Century Beach Park 100-year Flood Depths

100-yr flood level = 176.1m CGVD2013

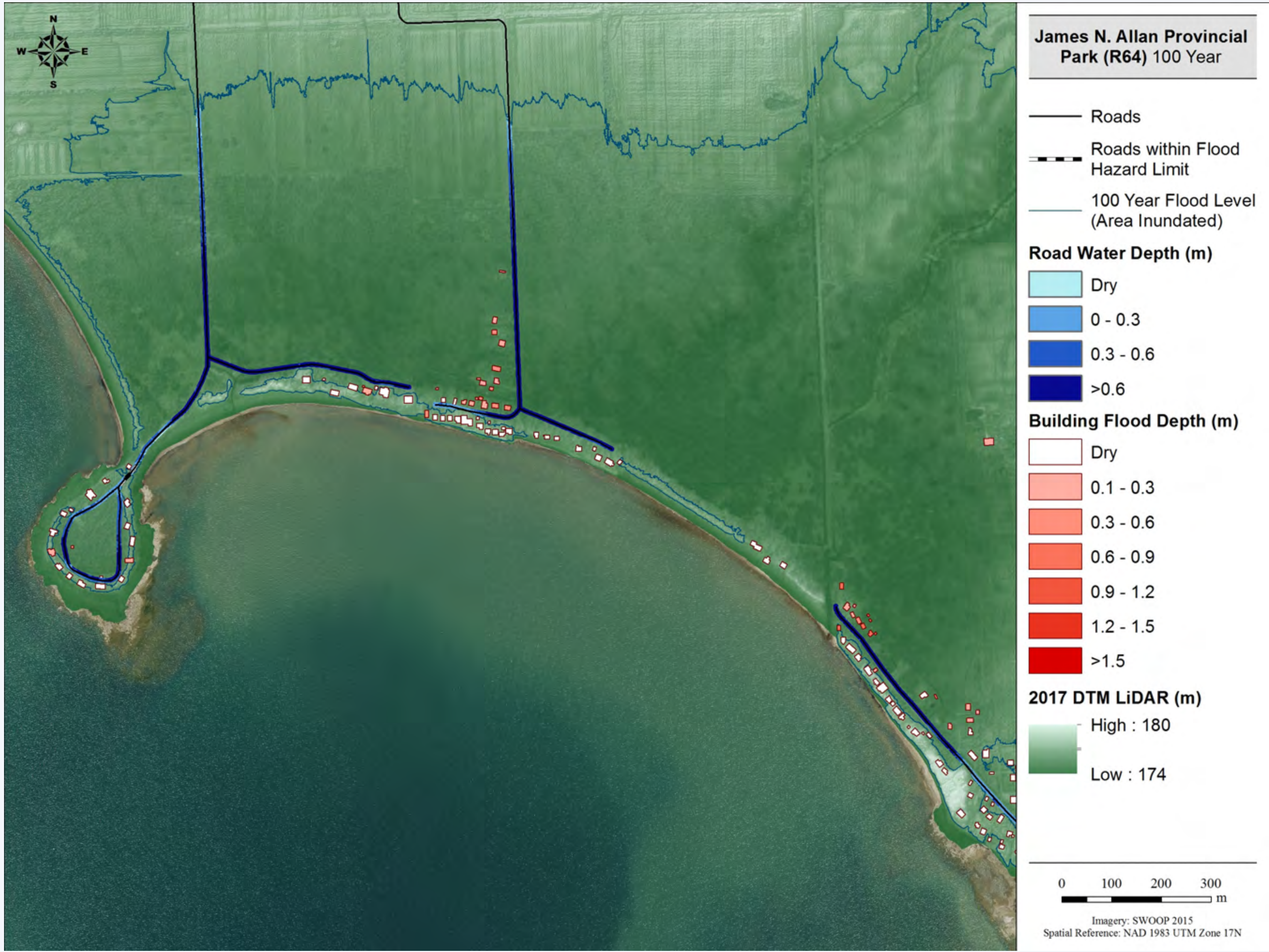
Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
LAKESHORE ROAD (at R47)	175.1	175.6
LAKESHORE ROAD (at R49)	175.3	175.7
WHITE CAP LANE	174.5	175.0
EVAN'S POINT LANE	175.6	176.0



Area #8 – James Allan Provincial Park 100-year Flood Depths

100-yr flood level = 176.2m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
MYRNAM BEACH ROAD	174.9	175.4
BRIAR LINE	175.0	175.5
PARADISE LINE	174.9	175.4
BAYGROVE LINE (parallel to shore)	175.2	175.7
BAYGROVE LINE	175.0	175.5
SANDY BAY ROAD	174.8	175.2

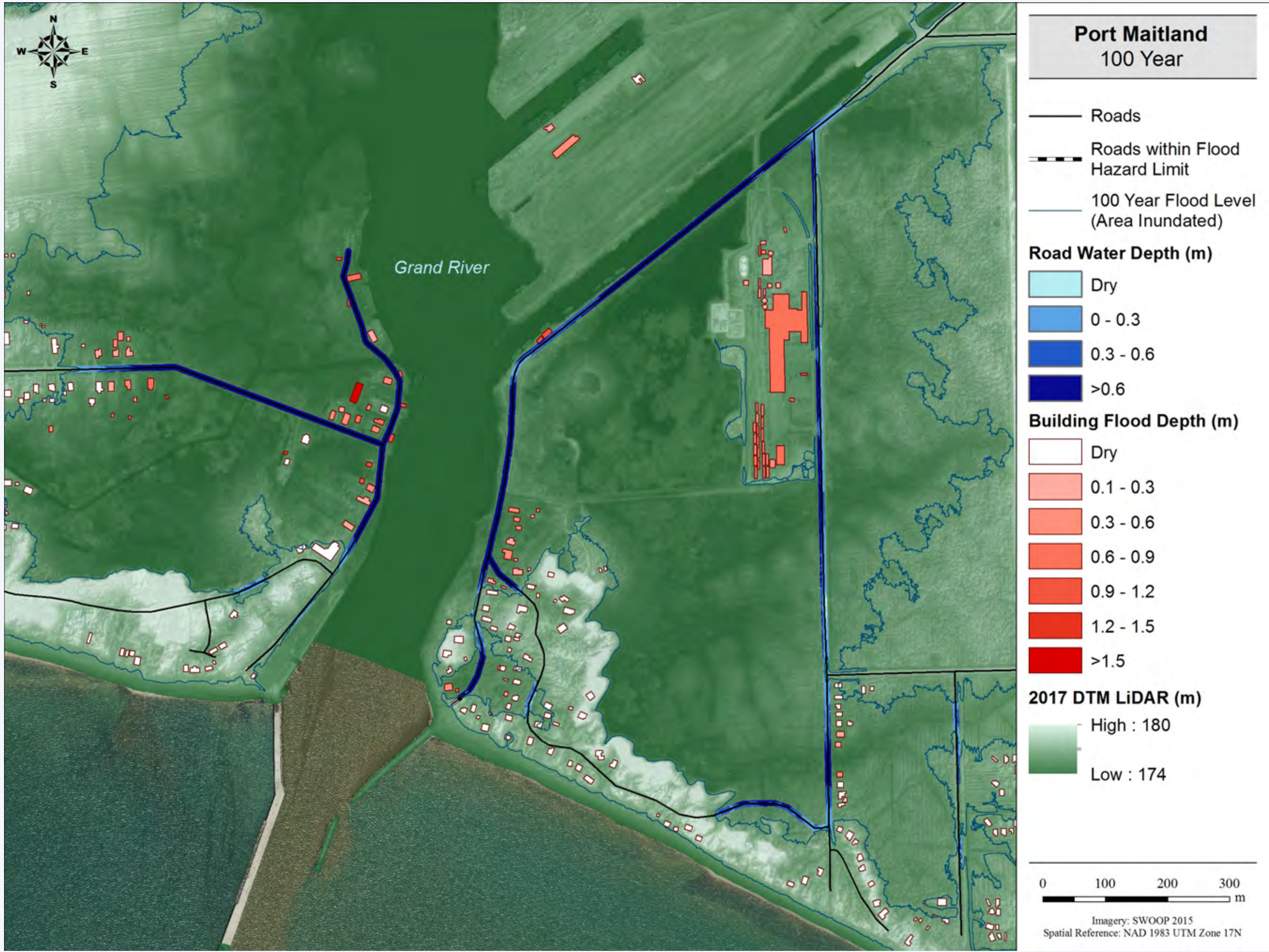


Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Area #9 – Port Maitland 100-year Flood Depths

100-yr flood level = 176.2m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
DOVER STREET	175.8	176.3
PORT MAITLAND RD	174.9	175.4
THE ESPLANADE	174.6	175.0
FEEDER CANAL RD	175.0	175.4
SIDDALL ROAD	175.5	176.0
BECKLY LINE	175.0	175.5
SIDDALL LINE	175.3	175.8
CONNOR BAY LINE	175.8	176.3



Area #10 – Lowbanks 100-year Flood Depths

100-yr flood level = 176.3m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
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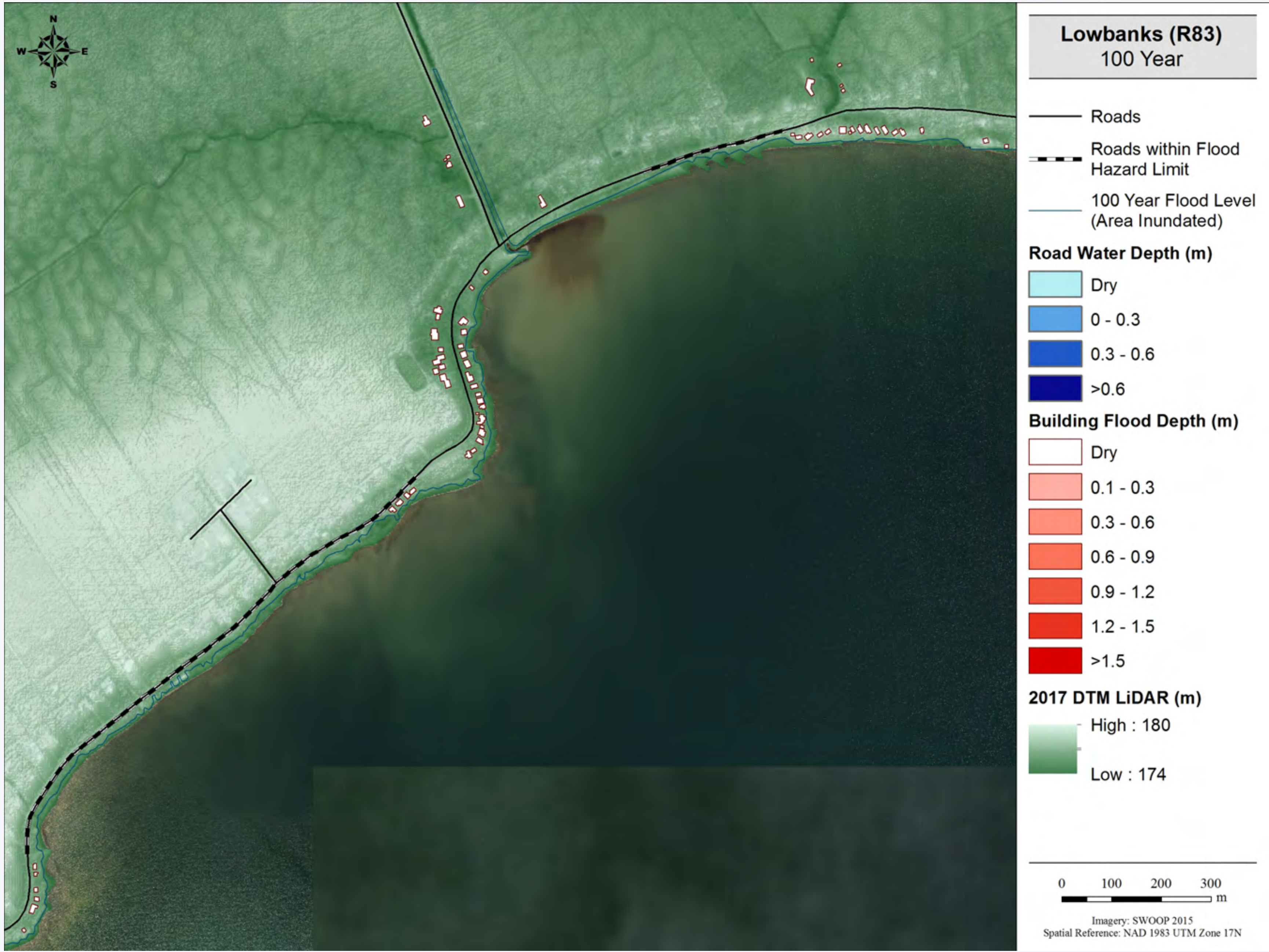

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N