

**Municipal Master Plan for
Town-Wide Water Distribution System**

**Appendix 'A'
Geotechnical and Hydrogeological Study**



REPORT

Geotechnical Desktop Study

*Town of Blue Mountains
Water Supply Master Plan
Town of Blue Mountains, Ontario*

Submitted to:

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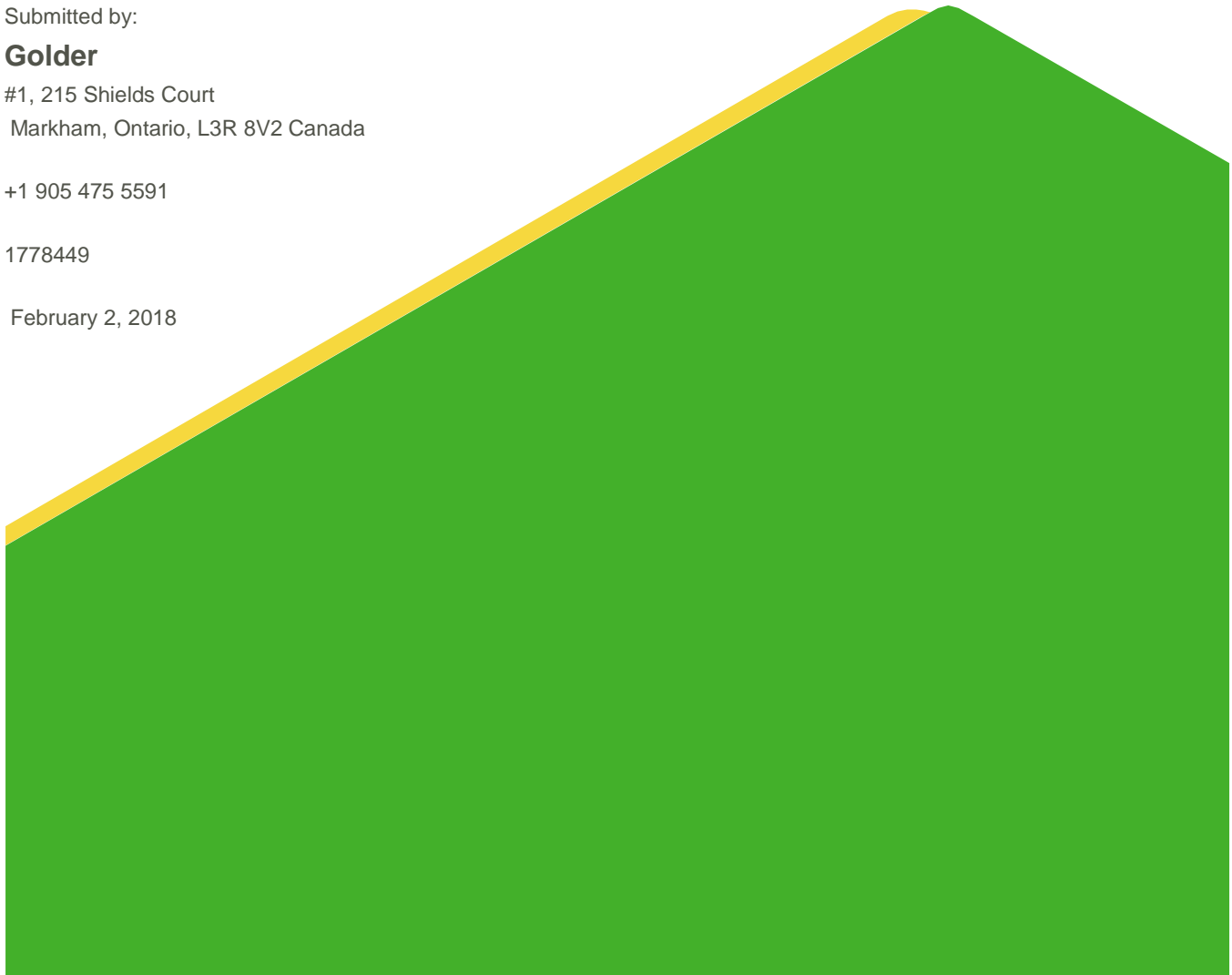
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1.0 INTRODUCTION

This report presents the results of the desktop geotechnical study carried out by Golder Associates Ltd. (Golder) in the Town of The Blue Mountains, Grey County, in southwestern Ontario, as shown on the Key Plan, Figure 1. This desktop study was carried out in general conformance with our proposal No. P178449 dated April 10, 2017. The purpose of the study was to review the existing published subsurface soil, rock and groundwater information and to provide preliminary geotechnical engineering comments and recommendations for planning purposes. Authorization to proceed with this desktop study was given in the form of the standard agreement between Golder and J.L. Richards & Associates Limited dated August 24, 2017.

J.L Richards and Associates Limited (JLR) is proceeding to undertake a Water Supply Master Plan Assessment for the Town of The Blue Mountains. As part of this study, a geotechnical desktop study is required for planning purposes.

This report provides the results of the review of the available background information and should be read in conjunction with the *“Important Information and Limitations of This Report”* (Appendix A, attached). The reader’s attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report. The collected factual data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location.

2.0 SITE AND PROJECT DESCRIPTION

The study area for this project is shown on the Key Plan, Figure 1 and generally includes the urbanized areas of the Town of Blue Mountains. The study area is located within the Town of The Blue Mountains in Grey County and it generally runs in a northwest to southeast direction mostly along the western shore of Nottawasaga Bay from the Christie Beach to Craigleith. The study area includes municipal communities from Christie Beach through Thornbury, Clarksburg, Camperdown to Craigleith and areas southeast of Craigleith. The study area is bounded on the northwest by the municipality of Meaford, on the north by Nottawasaga Bay (Georgian Bay), and on the southeast by the Town of Collingwood.

The Town of The Blue Mountains recently completed a study of the Town’s water distribution system which identified areas of concern and deficiencies related to existing conditions and future growth. Two previous Class EA Master Plans were completed for water and wastewater servicing in the early 2000’s. A new Water Distribution System Master Plan is required to evaluate, refine, and extend the findings of the recent water model study. The intention of developing a new Water Distribution System Master Plan is to enable the findings of the Master Plan to be implemented as required as the Town grows, so that the available water service matches the Town’s growth. The Water Distribution System Master is being carried out under the Municipal Class Environmental Assessment (EA) process for the Town’s distribution system including trunk mains, storage reservoirs, pumping stations and other infrastructure found necessary to address deficiencies throughout the Town’s current system and for growth needs.

The aim of this desktop study was to provide general information about the general subsurface soil, rock and groundwater conditions within the study area which will be used for planning purposes. The communities within the study area generally consist of low to mid rise residential and commercial buildings which are serviced by an interconnected municipal water system.

3.0 BACKGROUND INFORMATION AND AVAILABLE DATA

For the purpose of this desktop study, information about the subsurface conditions was obtained from the following sources:

- Chapman, L.J., and Putnam, D.F., 2007, "*The Physiography of Southern Ontario*"; Ontario Geological Survey.
- Ontario Geological Survey 2010, "Surficial Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release – Data 128 – Revised";
- Burwasser, G.J. 1974, "Drift Thickness of the Collingwood-Nottawasaga Area, Southern Ontario; Ontario Div. Mines," Preliminary Map P.925, Drift Thickness Ser., Scale 1:50,000.
- Geotechnical investigations carried by Golder and others within the study area.
 - **Thornbury**
 - C.C. Tatham and Associates Ltd., 2017, "189 Lake Drive, Town of The Blue Mountains, 1st Engineering Submission," (Report 1).
 - Peto MacCallum Ltd., 2008, "Geotechnical Investigation, Lake Drive Water and Waste Water Extension Project, Town of Blue Mountains, Ontario," (Report 2).
 - Peto MacCallum Ltd., 1989, "Geotechnical Investigation, Trailwood Subdivision Part Lots 35 & 36, Concession 10, Collingwood," (Report 3).
 - Peto MacCallum Ltd., 2017, "Thornbury West End Road Improvement Project, Town of Blue Mountains, Ontario," (Report 4).
 - WSP, 2017, "Geotechnical Investigation, Elma St. South and Alice Street West, Town of Blue Mountains," (Report 5).
 - **Clarksburg**
 - Peto MacCallum Ltd., 2016, "Proposed Watermain Replacement on Mary Street and Charles Street, Town of Blue Mountains, Ontario," (Report 6).
 - Golder Associates Ltd., 2017, "Proposed Municipal Sewer and Water Servicing Clarksburg, The town The Blue Mountains, Ontario," (Report 7).
 - **Camperdown**
 - Peto MacCallum Ltd., 2004, "Geotechnical Investigation, Camperdown External Servicing, Proposed Trunk Sanitary Sewer and Forcemain, Highway 26, Town of The Blue Mountains, County of Grey, Ontario," (Report 8).
 - Peto MacCallum Ltd., 2006, "Geotechnical Investigation, Proposed Neighbourhoods of Delphi Point, Town of The Blue Mountains, Ontario," (Report 9).
 - Peto MacCallum Ltd., 2011, "Geotechnical Investigation, Proposed Wensley Drive Sanitary Sewer and Road Reconstruction, Town of The Blue Mountains, Ontario," (Report 10).
 - **Craigeleith**
 - Terraprobe, 2010, "Geotechnical Investigation, Proposed Bannerman Subdivision, Lakeshore Road – Craigeleith, Town of the Blue Mountains, Ontario," (Report 11).
 - Terraprobe., 2011, "Proposed Trunk Sanitary Sewer, Grey Road 21, the Town of Blue Mountains, Ontario" (Report 12)

- Terraprobe., 2014, “Natural Hazard Setback and Slope Stability Requirements, Proposed Residential Development, Home Farm, Grey Road 19 at Helen Street, Town of Blue Mountains, Ontario” (Report 13)
- Peto MacCallum Ltd., 2016, “Slope Stability Assessment, Proposed Residential Subdivision, 161 Lakeshore Road East, Town of Blue Mountains, Ontario,” (Report 14).

■ MTO GEOCRETS Reports

- Thornbury
 - No.: 41A-209 (Report 15)
 - No.: 41A-047 (Report 16)
 - No.: 41A-226 (Report 17)
 - No.: 41A00-045 & 41A00-046 (Report 18 & 19)

4.0 TOPOGRAPHY

As described previously the site mostly lies along the west shore of the Nottawasaga Bay. In general, the terrain closer to the shore is relatively flat and then it slopes upwards towards to the Niagara Escarpment to the west of the site as shown on Figure 2, Ground Surface Elevations.

In the Christie Beach area, the approximate elevations from the shore to Highway 26 range from approximately 190 m to 230 m and west of Highway 26 the west boundary of the site the elevations increase to approximately 365 m. The area southwest of Highway 26 is mostly undeveloped. The built up areas where the water supply system is to be located are generally north/northeast of Highway 26.

In the areas of Thornbury/Clarksburg the ridge is further west and the elevations generally range from about 180 m to about 230 m. At this location the built up areas are located at the mouth of several rivers/creeks (such as Indian Brook and Beaver River with its two main tributaries of Little Beaver Creek and Mill Pond) and the remaining areas along the rivers/creeks are generally used for farming.

Highway 26 is closer to the shore between Thornbury and Camperdown as the coast narrows with elevations ranging from approximately 180 m to 220 m. The proposed watermain upgrades are planned close to Highway 26 or the built up areas which hug the shore at the foot of the Blue Mountains (Niagara Escarpment, see Figure 4).

The coast widens from Camperdown to Craigleith where elevations on the coast varies from approximately 180 m to 230 m. In the area of Craigleith the proposed upgrades will extend southwards and east along Grey County Road 19 to Osler Bluff Road/Collingwood Clearview Townline. Along Osler Bluff Road, the upgrades will extend southwards and then westward on the south section of Grey County Road 19 which leads to Castle Glen Estates. The elevations southward vary significantly ranging from approximately 200 m to 235 m and as high as approximately 455 m in Castle Glen Estates.

5.0 SUBSURFACE CONDITIONS

The generalized description of the subsurface conditions are based on a review of existing available published surficial geology and bedrock geology maps and Golder’s previous experience in the area.

5.1 Regional Geology

The surficial geology and the physiographic regions of the study area are presented on Figures 2 and 3, respectively.

5.1.1 Surficial Geology

Based on the surficial geology mapping shown on Figure 3, the study area consists of variable subsurface conditions but in general it is predominantly comprised of non-cohesive and frequently granular deposits.

From the west boundary limits of the study area, Christie Beach Road, to approximately Highway 26 and 10th line, the prevalent surficial geology consists of till deposits with stone poor sandy silt to silty sand textured till on Paleozoic terrain. In the Christie Beach Road areas and to the west, the surficial geology indicates Paleozoic bedrock. Modern alluvial deposits containing clay, silt, sand and gravel which may contain organic remains, were identified in the area around the intersection of Christie Beach Road and Highway 26.

The municipalities of Thornbury and Clarksburg generally consist of coarse textured glaciolacustrine deposits of sand and gravel with minor silt and clay which are foreshore and basinal deposits. Modern alluvial deposits containing clay, silt, sand and gravel which may contain organic remains, are present along the Beaver River and its tributaries and Indian Brook Creek. These deposits consist of generally unconsolidated, loose clay, sand, silt and gravel soils which have been eroded over time from the river currents and would be present in the flood plains of these water bodies. The west end of Thornbury also contains scattered areas of fine textured glaciolacustrine deposits of massive to well laminated silt and clay with minor amounts of sand and gravel.

The community of Camperdown consists predominantly of coarse textured glaciolacustrine deposits consisting of sand and gravel with minor silt and clay presence which are foreshore and basinal deposit. The surficial mapping indicates Paleozoic bedrock south of the Highway 26 but also partially on the shore.

Between the community of Craigeith towards the east and southeast limits of the study area; sandy silt to silty sand till, coarse textured glaciolacustrine and Paleozoic bedrock deposits are most common. Isolated ice-contact stratified deposits are also present on the east side of the study area consisting of sand and gravel with minor presence of silts, clays and till. South of Grey County Road 19, the surficial geology mapping indicates predominantly stone poor sandy silt to silty sand textured till. The Paleozoic bedrock is present as the terrain slopes upwards.

5.1.2 Physiographic Regions¹

Physiographic mapping shown on Figure 4, indicates that the northeastern about half of the site to just west of Camperdown lies within a physiographic region known as Beaver Valley. The remainder of the site consist of the built up areas located within the Simcoe Lowlands which is bordered to the south by the Niagara Escarpment region. South of the Escarpment, the site consists of the Horseshoe Moraines Region but no water system upgrades are anticipated in this region.

The Beaver Valley Region is one of the most scenic features of Southern Ontario occupying a sharply cut indentation in the Niagara cuesta, opening upon Georgian Bay. The wider, northern part of the valley contains many streams and rivers which drain into the Georgian Bay independently. The flowing currents of these streams have caused numerous valleys in the northern part of the region through erosion of the shale slopes as can be seen in the municipality of Thornbury. In general, the physical topography in the region consists of valleys as mentioned

¹ Chapman, L.J., & Putnam, D.F., (1984), "The Physiography of Southern Ontario," 3 Ed., Ontario Geological Survey Special Volume 2

above with only a few scattered drumlins. The gradient of the slopes on the shale in this open part of the valley is roughly 38 m per 1.6 km and the streams have cut very sharp juvenile valleys.

The Simcoe Lowlands borders Georgian Bay and Lake Simcoe and the south eastern corner of the study area lies within this region. The Simcoe Lowlands are generally divided into two major sub-regions known as Nottawasaga Basin from the West and Lake Simcoe Basin to the East as defined by Chapman and Putnam (1984) which are connected at Barrie by a flat floored valley and by similar valleys among the upland plateaux farther north. Both the lowlands and transverse valleys were flooded by Lake Algonquin and are bordered by shore cliffs, beaches and bouldery terraces. Thus they are floored by sand, silt and clay.

The Niagara Escarpment region as defined by Chapman and Putnam (1984), extends from the Niagara River to the northern tip of the Bruce Peninsula and continuing through the Manitoulin Islands displays an association of landforms not found elsewhere in Ontario. Vertical cliffs along the brow often mostly outline the edge of the dolostone of the Lockport and Amabel Formations while the slopes below are carved in red shale. In many areas of the northern portion of the escarpment, overburden soils have been stripped exposing the rock chiseled topography producing vertical cliffs up to 45 m high. The highest and one of the most picturesque parts of the escarpment is the Blue Mountain Section near Collingwood, which stands over 300 m above the waters of the Georgian Bay. Here the dolostone cap rock is exposed in cliffs 45 m high, while huge blocks breaking away from the wall have left the deep crevasses known as “the caves”. West of Collingwood and immediately between Craigeith and Camperdown, occurs the steepest and most mountainous part of the escarpment. In the curious flat-topped mesa at Blue Mountain Peaks, the brow of the escarpment approaches within a mile of the Bay, and the wooded slope of this promontory is a well known landmark.

5.1.3 Bedrock

Burwasser, G.J. 1974, “Drift Thickness of the Collingwood-Nottawasaga Area, Southern Ontario; Ontario Div. Mines,” Preliminary Map P.925, indicates the bedrock surface in the area varies significantly over short distances. Along the Niagara Escarpment, the bedrock surface is at higher elevations becoming deeper into the Beaver Valley and Simcoe Lowlands physiographic regions. Bedrock surface elevations are shown on Bedrock Surface Elevations, Figure 6.

In the Christie Beach area, the drift thicknesses range from approximately 20 m to 40 m.

The municipalities of Thornbury, Clarksburg and surrounding areas typically observe bedrock surfaces range from approximately 15 m to 45 meters below ground surface.

In the area of the community of Camperdown drift thicknesses range from approximately 1.5 m to 15 meters with bedrock closer to the ground surface near the shore line. Bedrock surfaces are at a lower elevation as you move west towards Indian Brook ranging from approximately 27 m to 38 m. East of Camperdown towards Delphi Point, drift thicknesses range from approximately 0 m at the shore to 8 m moving south of the Georgian Bay.

From Craigeith to the eastern study area limit at Grey Road 21, bedrock surface is encountered typically between 0.5 m to 20 m below ground surface with bedrock closer to the surface along the Georgian Bay shoreline. Moving south towards the south eastern corner of the study area, bedrock elevations are encountered between approximately 8 m to 15 m following various isopachs of similar elevations traversing north to south.

Based on “Ontario Geological Survey 2011 Map; 1:250 000 scale; Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release-Data 126-Revision 1,” the bedrock consists of shale, limestone, dolostone and siltstone of the Georgian Bay Formation, Blue Mountain Formation, Billings Formation, Collingwood Member and Eastview Member. Along the Niagara Escarpment, from east to west, the bedrock consists of:

- Queenston Formation – shale, limestone, dolostone and siltstone;
- Clinton Group, Cataract Group – Sandstone, shale, dolostone and siltstone; and
- Amabel Formation - Sandstone, shale, dolostone and siltstone.

5.2 Subsurface Conditions Based on Existing Boreholes

The following subsurface geotechnical/hydrogeological investigations carried out by Golder and others which have been made available to Golder within the limits of the study area are generally consistent with the surficial geology described in **Section 5.1.1**. Five other investigations available from Ministry of Transportation’s Geocres library are also consistent with the surficial geology. A brief general summary of the investigations carried out by others within the study area are presented below:

Table 1: Summary of Investigations Within Limits of Study Area

Nearby Communities	Location	Subsurface Conditions	Groundwater Levels
Thornbury	189 Lake Dr. (Report 1)	Surficial peat and fill underlain by silt, sandy silt, silty sand, sand and silty sand till.	Groundwater between 0 and 2.4 m. Georgina Bay water levels near elevation 176.5 m.
	Lake Drive and 10 th Line (Report 2)	Surficial fill encountered from 0.3 m to 2.9 m consisting of a mixture of silty sand, sandy silt and gravel. Localized sand deposits of about 0.3 m thickness observed below the fill. Compact silt and clayey silt layer extending up to 5 m below ground surface underlying the fill and localized sand deposit. Localized, very dense sandy silt till deposits encountered at 1.0 m to 3.8 m below ground surface.	Groundwater levels interpreted to be between 1 m to 1.5 m below grade.
	Peel St. North at Hwy 26 MTO Geocres. No.: 41A-209 (Report 15)	Organic fill deposits are underlain by silty clay layers which are subsequently underlain by silt to silt clay and sand/silt till encountered at 2.1 m to 3.2 m depth.	Groundwater between 1.2 m and 5.0 m.

Nearby Communities	Location	Subsurface Conditions	Groundwater Levels
Thornbury	Trailwood Subdivision, between 10 th Line and Peel St. (Report 3)	Surficial fill to about 0.8 m overlying dense to very dense silt till deposits with localized sand and silt layers	Groundwater 0.4 m to 2.2 m below grade.
	Thornbury west end Test Pit (North-east corner of Alice St. W and Victoria St. S) (Report 4)	Surficial fill and topsoil up to 0.7 m consisting of mixture of sand, silt, clay and gravel. Underlying the fill, layer of silty clay and clayey silt till encountered at a depth of about 1.4 m.	Borehole terminated at 2.45 m and dry.
	Alice St. West and Elma St. South (Report 5)	Surficial fill comprising of silty sand to sandy silt from 0.8 m to 2.6 m. Silt deposits underlay fill extending up to 5 m depth. Localized sand and silty sands encountered below silt layer.	1.5 m to 5.1 m on Alice St. West. Dry on Elma St. South
	Hwy 26, Beaver River Crossing MTO Geocres. No.:41A-047 (Report 16)	Sandy fill overlying dense to very dense sandy silt till. Interlayers of sand, clayey silt and sandy silt seams encountered in till.	Groundwater levels closely controlled by Beaver River water level.
	Hwy 26 and Georgian Trail MTO Geocres. No.: 41A-226 (Report 17)	Topsoil and surficial fill is underlain by mixture of silt, sand and gravel. Silty sand and sandy silt till encountered below 4.6 m to 6 m.	Groundwater measured between 1.2 m to 6.4 m.
	Hwy 26 and Indian Brook crossing MTO Geocres No.: 41A-045 & 41A-046 (Report 18 & 19)	Sand, silt and gravel underlying the surficial fill from a depth of about 1.0 m to 1.7 m. Silty sand, sandy silt to clayey silt till overburdens the shale bedrock encountered at a depth of about 6 m.	Groundwater levels correspond closely to Indian Brook water levels.
Clarksburg	Charles Street and Mary Street (Report 6)	Sandy silt to sand fill up to 1.5 m to	Groundwater between 0.8 m to 1.4 m below grade.

Nearby Communities	Location	Subsurface Conditions	Groundwater Levels
		<p>2.4 m depth. Silt layer underlying fill between depths of 1.8 m to 5.5 m.</p> <p>Localized silty sand till below silt.</p>	
Camperdown	<p>Clarksburg (Margaret St. N, Hill St., Beaver River at Marsh St., William St. and Arthur Taylor Ln)</p> <p>(Report 7)</p>	<p>Underlying the sandy silt to silty sand fill, deposits of silt and localized glacial till encountered.</p>	<p>Groundwater between 0 m to 2.4 m.</p>
Craigleith	<p>Hwy 26, between Grey St N and just East of Delphi Point</p> <p>(Report 8)</p>	<p>Fill layer consisting primarily of sands extending to about 1 m to 2 m below grade.</p> <p>Localized and discontinuous layers of sand and cohesive silty clay layers on eastern portion of Hwy 26.</p> <p>Localized sandy silt till layers on western portion of Hwy 26. Shale bedrock between 1.4 m to 6.1 m depths but at shallower depths near Delphi Point.</p>	<p>Groundwater levels between 0.6 to 4.3 m below grade. Assumed to be perched between pervious layers and less pervious underlying layers.</p>
Camperdown	<p>Proposed neighbourhoods of Delphi Point</p> <p>(Report 9)</p>	<p>Sand deposits underlying fill extending to depths of about 1.7 m and 3.6 m.</p> <p>Non-cohesive clayey silt and silty sand underlying sand deposits. Bedrock inferred at depths ranging from about 2.1 m to 4.3 m.</p>	<p>Groundwater between 0.5 m and 2.7 m below grade.</p>
Camperdown	<p>Wensley Street near Peaks Road</p> <p>(Report 10)</p>	<p>Surficial fill up to 1.6 m consisting of sandy silt to gravelly sands.</p> <p>Sand deposits underlying fill with localized clayey silt layers. Weathered shale bedrock between 2.4 m and 4.6 m.</p>	<p>Groundwater between 1.2 m to 2.8 m below grade.</p>
Craigleith	<p>Schoolhouse Court at Lakeshore Rd Test Pits</p> <p>(Report 11)</p>	<p>Peaty topsoil up to 0.4 m deep underlain by loose to compact sandy silt.</p> <p>Bedrock encountered between 1.4 m to 1.9 m below grade.</p>	<p>Groundwater between 1.3 m to 1.5 m below grade.</p>

Nearby Communities	Location	Subsurface Conditions	Groundwater Levels
	Grey Road 21, between Hwy 26 and Grey Road 19 (Report 12)	Surficial fill encountered between depths of 0.2 m to 0.7 m consisting of sand and gravel with organics. Interlayers of sand, silt, clayey silt and glacial tills encountered below the fill.	Groundwater levels between 1.2 m to 2.5 m below grade.
	Grey Road 19 at Helen Street (Report 13)	Up to 0.6 m of topsoil overlying sandy silt till with cobbles and boulders. Bedrock at two locations at 1.2 m and 5.2 m.	Groundwater levels between 0.2 m to 4.4 m below grade.
	161 Lakeshore Road East (Report 14)	Sand to silty sand deposit extending to about 2.9 m to 4.0 m underlying topsoil. Silt and sand to silt underlying sand layer and extended to about 10.0 m to 13.0 m below grade followed by silty sand till extending to 18.0 m to 19.0 m below grade.	Groundwater level at about 13 m below grade.

5.2.1 General Comments

It is understood that the proposed water supply system will consist of trunk mains, storage reservoirs and pumping stations. The details of the various water delivery system have not yet been established. Based on the results of our review, we offer the following generalized comments:

- In general, no major constraints to the successful design and construction of the proposed water supply system has been identified as a result of this study. Based on the results of our review of available data and local experience, we consider that the proposed water supply system may be constructed in most part using conventional techniques.
- Once the preferred route is selected, site specific geotechnical investigations will be required as appropriate for the various water supply system components

Excavations

- In general, it is expected that the overburden soils can generally be excavated using conventional hydraulic equipment, although excavating into very dense tills may affect progress rates and may require cobble/boulder removal.
- Where shallow bedrock is encountered and depending on pipeline invert, excavation would require heavy excavating equipment in conjunction with pneumatic rock breakers (hoe rams).
- Glacially derived till soils should be expected to contain cobbles and boulders which could affect excavations.
- Soils are generally considered to be suitable for pipeline installation.

- Localized organic deposits were identified in the surficial geology and in some of the previous investigations. In these areas, the organic deposits may have to be removed and replaced with engineered fill, unshrinkable fill or the water mains may have to be alternatively supported depending upon the actual conditions encountered during site specific geotechnical investigations.
- Although it is anticipated that, in most areas where excavations are carried out above the groundwater table or the groundwater is sufficiently controlled, conventional open cut excavations with slopes of 1 Horizontal to 1 Vertical (1H:1V) are likely feasible. Where excavations are carried out within very soft to soft cohesive or very loose non-cohesive soils temporary trench support (shoring) would be indicated. All excavation work must be carried out in accordance with the Ontario Health and Safety Act (OHSA) and regulations for construction projects.

Groundwater Control

- High groundwater conditions have been encountered within the study area. Site specific geotechnical and hydrogeological investigations will be required to address these conditions as required. We note that when excavations extend below the groundwater table (especially in granular soil deposits such as gravel, sand and silty sand) pro-active dewatering methods, such as well points or educator wells are likely to be required.
- Water takings in excess of 50 m³/day are regulated by the Ontario Ministry of the Environment and Climate Change (MOECC). Certain takings of groundwater and storm water for construction site dewatering purposes with a combined total less than 400 m³/day qualify for self-registration on the MOECC's Environmental Activity and Sector Registry (EASR). A Category 3 Permit To Take Water (PTTW) from the MOECC is required where the proposed water taking is greater than 400 m³/day.

Pipe Bedding

- Where indicated, conventional soil bedding would be considered to be appropriate for pipe support in most areas. Additional bedding or other means of pipe support may be required in areas where very soft or organic soils are encountered.

Trench Backfill

- In most areas, excavated soils free of organics and other deleterious materials may be used as backfill provided that the soils are maintained at water contents close to the optimum water content for compaction. Where the excavated soils are overly wet, they may require drying or replacement with appropriate imported materials.

Other Considerations

- Clays and silts mostly located within the Beaver Valley Region (see Figure 3) may locally be capable of supporting only moderate to low foundation loads.
- Where soft to very soft clays are encountered, long term consolidation settlement may also locally have an impact on design, construction and scheduling.

6.0 LIMITATIONS

This report has been prepared for the exclusive use of JLR and their agents for specific application to the new Water Distribution System Master Plan for the Town of Blue Mountains, Ontario. The findings presented in this report were prepared in accordance with generally accepted geotechnical engineering practice at the time of this study. It is stressed that the information in this report is provided for planning purposes only. This report is not intended for preliminary or detailed design or construction purposes.

The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

7.0 CLOSURE

This report is intended to summarise available data on subsurface soil and groundwater conditions for the Study Area as identified in Figure 1 Key Plan. The data contained in this report was obtained from published geological data, previous investigation carried out in the area by others provided by the Town, and previous subsurface investigations carried out by Golder in the study area.

We trust this report provides sufficient information for your requirements. If you have any questions regarding the contents of this report or require additional information, please do not hesitate to contact this office.

Signature Page

Golder Associates Ltd.



Rafael Abdulla, M.Eng., P.Eng., PMP
Geotechnical Engineer



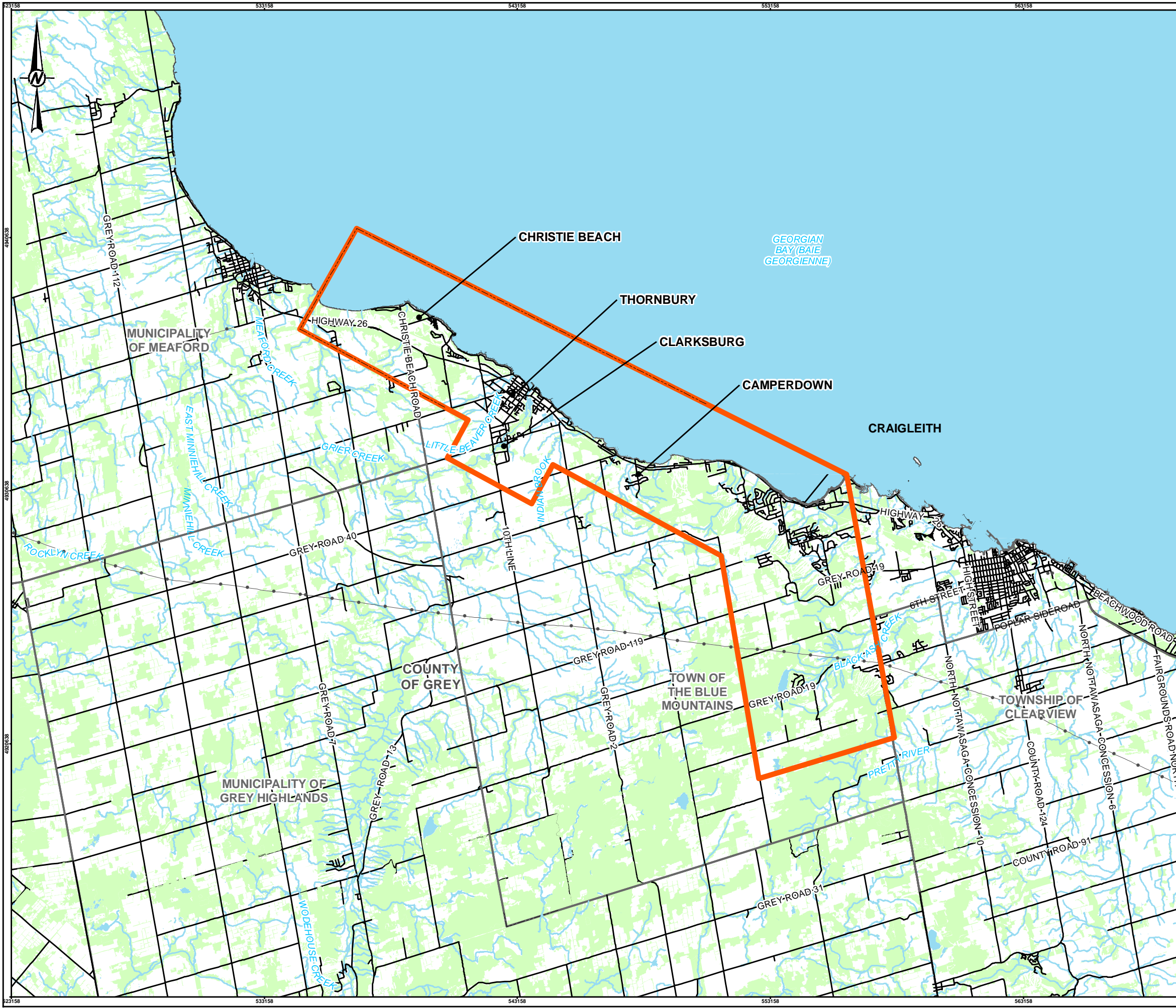
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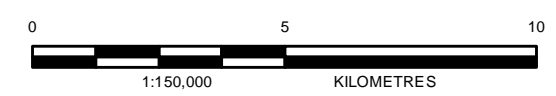
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FIGURES



- LEGEND**
- APPROXIMATE DESKTOP STUDY AREA
 - ROAD
 - UTILITY LINE
 - WATERCOURSE
 - WATERBODY
 - MUNICIPAL BOUNDARY
 - WOODED AREA



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 J.L. RICHARDS & ASSOCIATES LTD.

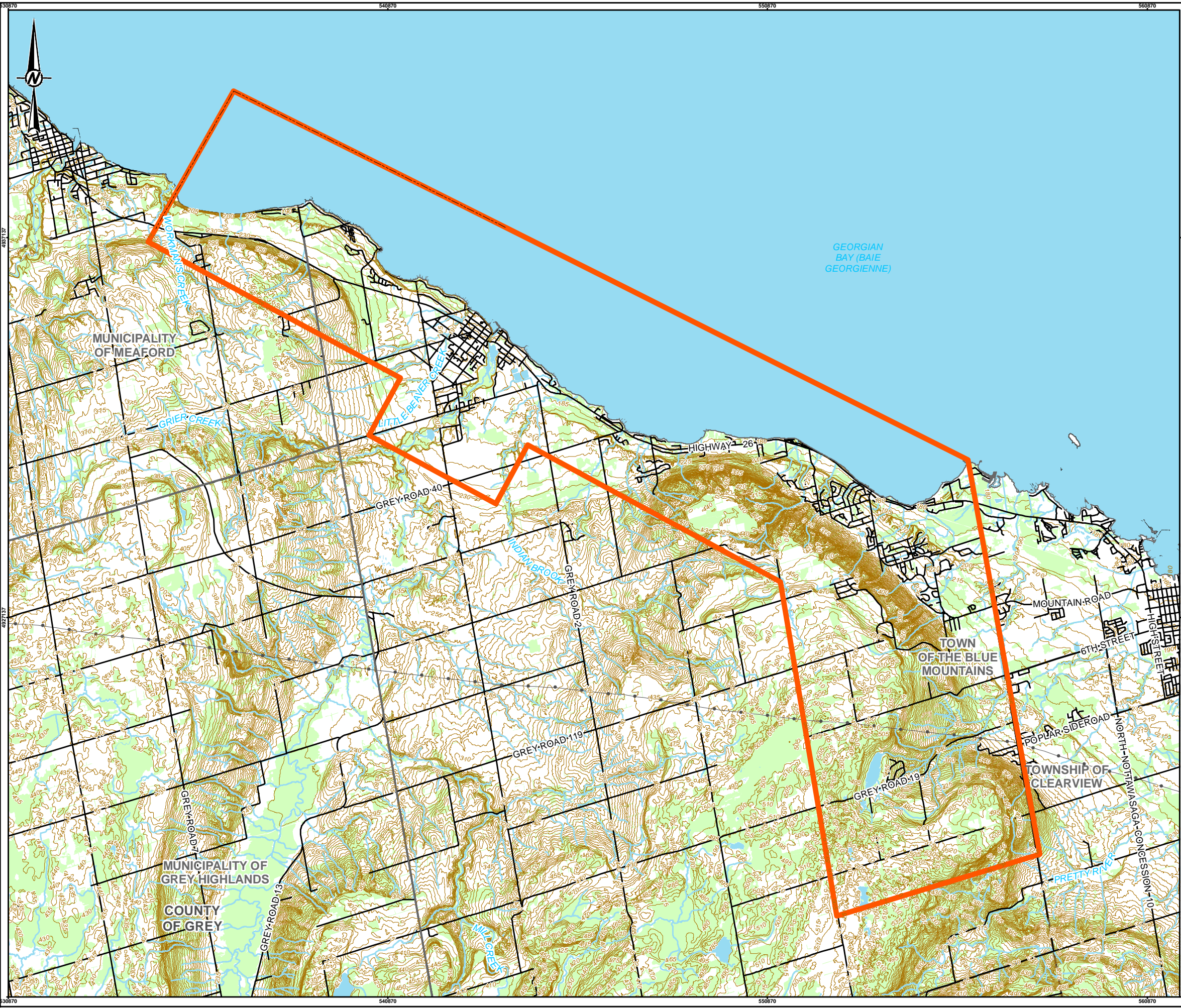
PROJECT
 GEOTECHNICAL DESKTOP STUDY
 TOWN OF THE BLUE MOUNTAINS
 WATER SUPPLY MASTER PLAN

TITLE
KEY PLAN

CONSULTANT	YYYY-MM-DD	2018-01-17
	DESIGNED	JT
	PREPARED	JT
	REVIEWED	RA
	APPROVED	AJH

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- LEGEND**
- APPROXIMATE DESKTOP STUDY AREA
 - ROAD
 - UTILITY LINE
 - WATERCOURSE
 - CONTOURS (M)
 - WATERBODY
 - MUNICIPAL BOUNDARY
 - WOODED AREA



REFERENCE(S)
 BASE DATA - MNR LIO, OBTAINED 2017
 PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2017
 INDEX MAP
 PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
 J.L. RICHARDS & ASSOCIATES LTD.

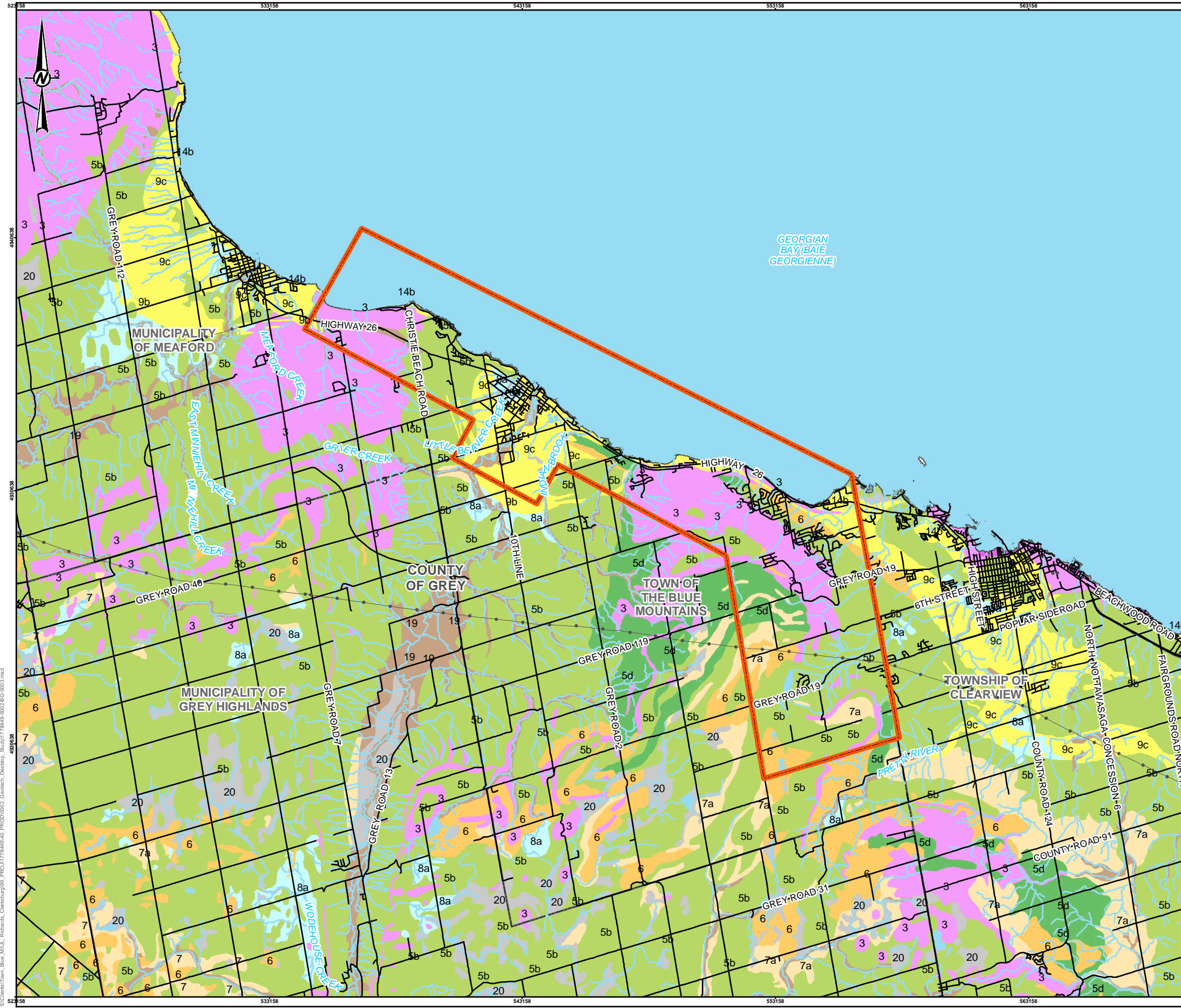
PROJECT
 GEOTECHNICAL DESKTOP STUDY
 TOWN OF THE BLUE MOUNTAINS
 WATER SUPPLY MASTER PLAN

TITLE
 GROUND SURFACE ELEVATIONS

CONSULTANT	YYYY-MM-DD	2018-01-17
	DESIGNED	JT
	PREPARED	JT
	REVIEWED	RA
	APPROVED	AJH

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- LEGEND**
- APPROXIMATE DESKTOP STUDY AREA
 - ROAD
 - UTILITY LINE
 - ~ WATERCOURSE
 - WATERBODY
 - ▭ MUNICIPAL BOUNDARY
- SURFICIAL GEOLOGY**
- 3: PALEOZOIC BEDROCK
 - 5B: STONE-POOR, CARBONATE-DERIVED SILTY TO SANDY TILL
 - 5D: GLACIOLACUSTRINE-DERIVED SILTY TO CLAYEY TILL
 - 6: ICE-CONTACT STRATIFIED DEPOSITS
 - 7: GLACIOFLUVIAL DEPOSITS
 - 7A: SANDY DEPOSITS
 - 8A: MASSIVE-WELL LAMINATED
 - 9B: LITTORAL-FORESHORE DEPOSITS
 - 9C: FORESHORE-BASINAL DEPOSITS
 - 12: OLDER ALLUVIAL DEPOSITS
 - 14B: LITTORAL-FORESHORE DEPOSITS
 - 19: MODERN ALLUVIAL DEPOSITS
 - 20: ORGANIC DEPOSITS
 - 21: MAN-MADE DEPOSITS



REFERENCE(S)
 BASE DATA - MNR LIO, OBTAINED 2017
 SURFICIAL GEOLOGY - THE PHYSIOGRAPHY OF SOUTHERN ONTARIO, THIRD EDITION BY CHAPMAN AND PUTMAN, 1984
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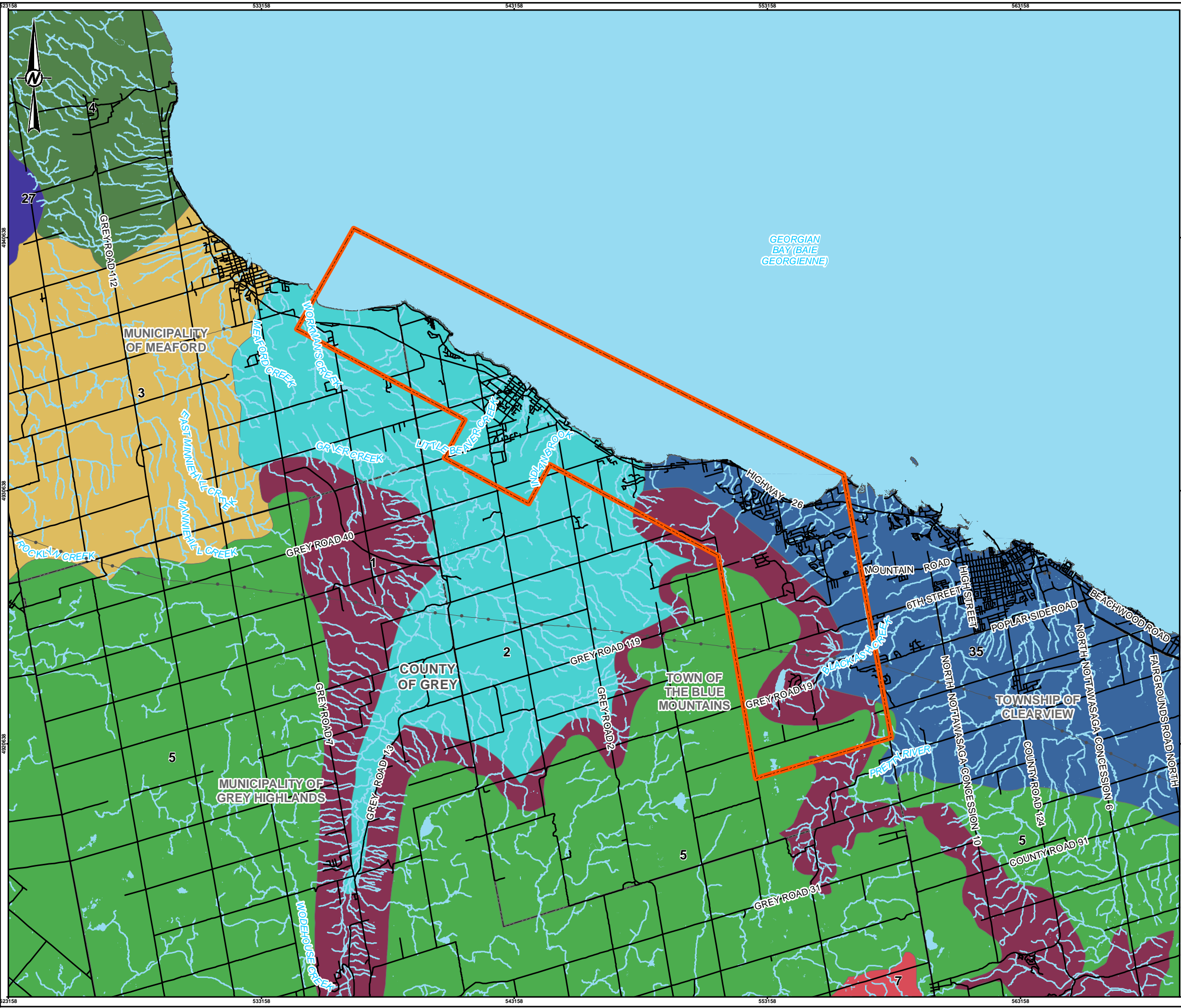
PROJECT
**GEOTECHNICAL DESKTOP STUDY
 TOWN OF THE BLUE MOUNTAINS
 WATER SUPPLY MASTER PLAN**

TITLE
SURFICIAL GEOLOGY

CONSULTANT	DATE
	YYYY-MM-DD 2018-01-17
	DESIGNED JT
	PREPARED JT
	REVIEWED RA
	APPROVED AJH

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LEGEND

- APPROXIMATE DESKTOP STUDY AREA
- ROAD
- UTILITY LINE
- ~ WATERCOURSE
- WATERBODY
- ▭ MUNICIPAL BOUNDARY

PHYSIOGRAPHIC REGIONS

UNIT, REGION

- 1, NIAGARA ESCARPMENT
- 2, BEAVER VALLEY
- 3, BIGHEAD VALLEY
- 4, CAPE RICH STEPS
- 5, HORSESHOE MORAINES
- 7, DUNDALK TILL PLAIN
- 27, BRUCE PENINSULA
- 35, SIMCOE LOWLANDS

0 5 10
1:150,000 KILOMETRES

REFERENCE(S)
 BASE DATA - MNR LIO, OBTAINED 2017
 PHYSIOGRAPHY GEOLOGY - MRD228-PHYSIOGRAPHY OF SOUTHERN ONTARIO, 2007, PROVIDED BY
 MINISTRY OF NORTHERN DEVELOPMENT MINES
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CLIENT
 J.L. RICHARDS & ASSOCIATES LTD.

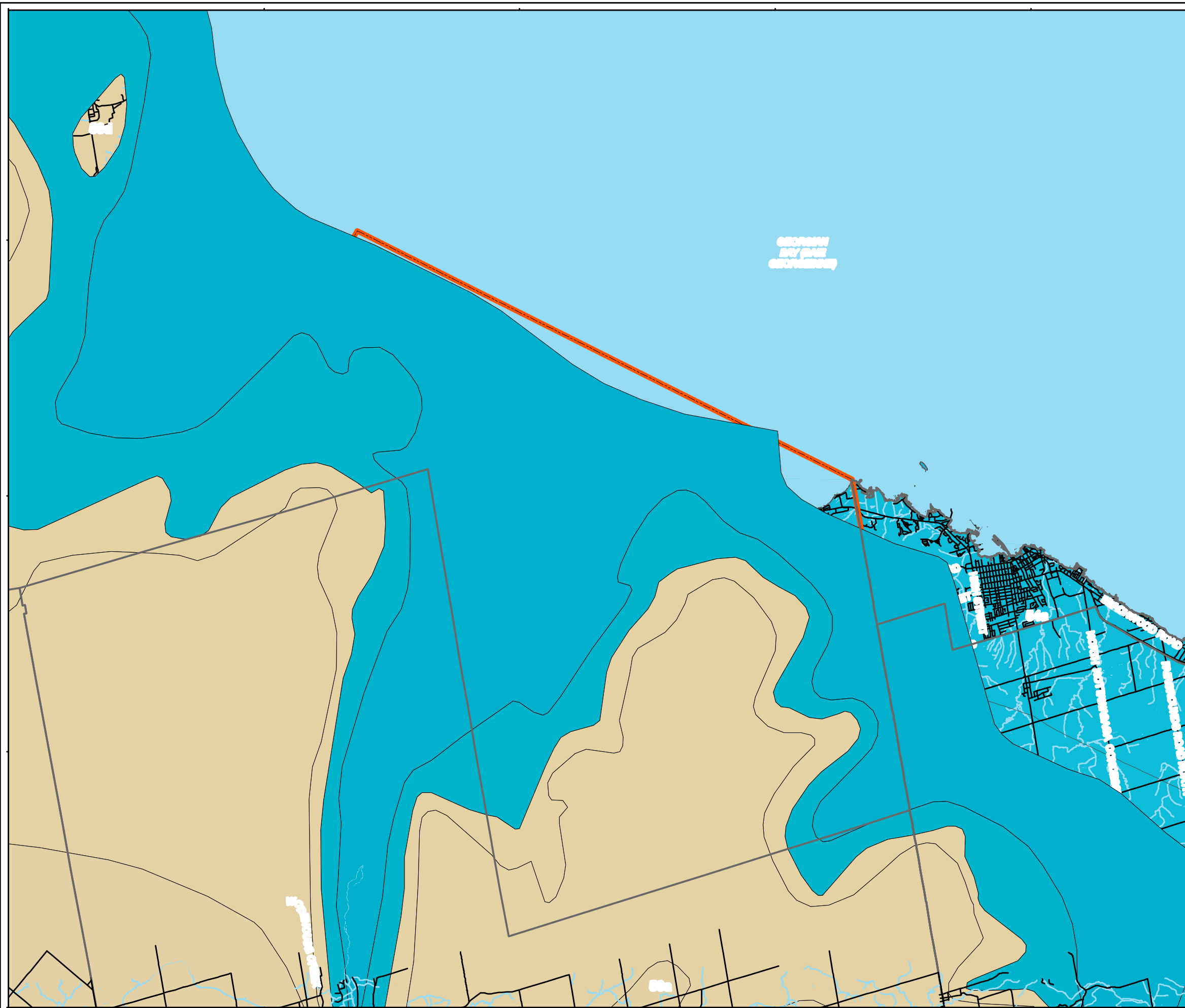
PROJECT
 GEOTECHNICAL DESKTOP STUDY
 TOWN OF THE BLUE MOUNTAINS
 WATER SUPPLY MASTER PLAN

TITLE
PHYSIOGRAPHIC REGIONS

CONSULTANT	YYYY-MM-DD	2018-01-17
Golder Associates	DESIGNED	JT
	PREPARED	JT
	REVIEWED	RA
	APPROVED	AJH

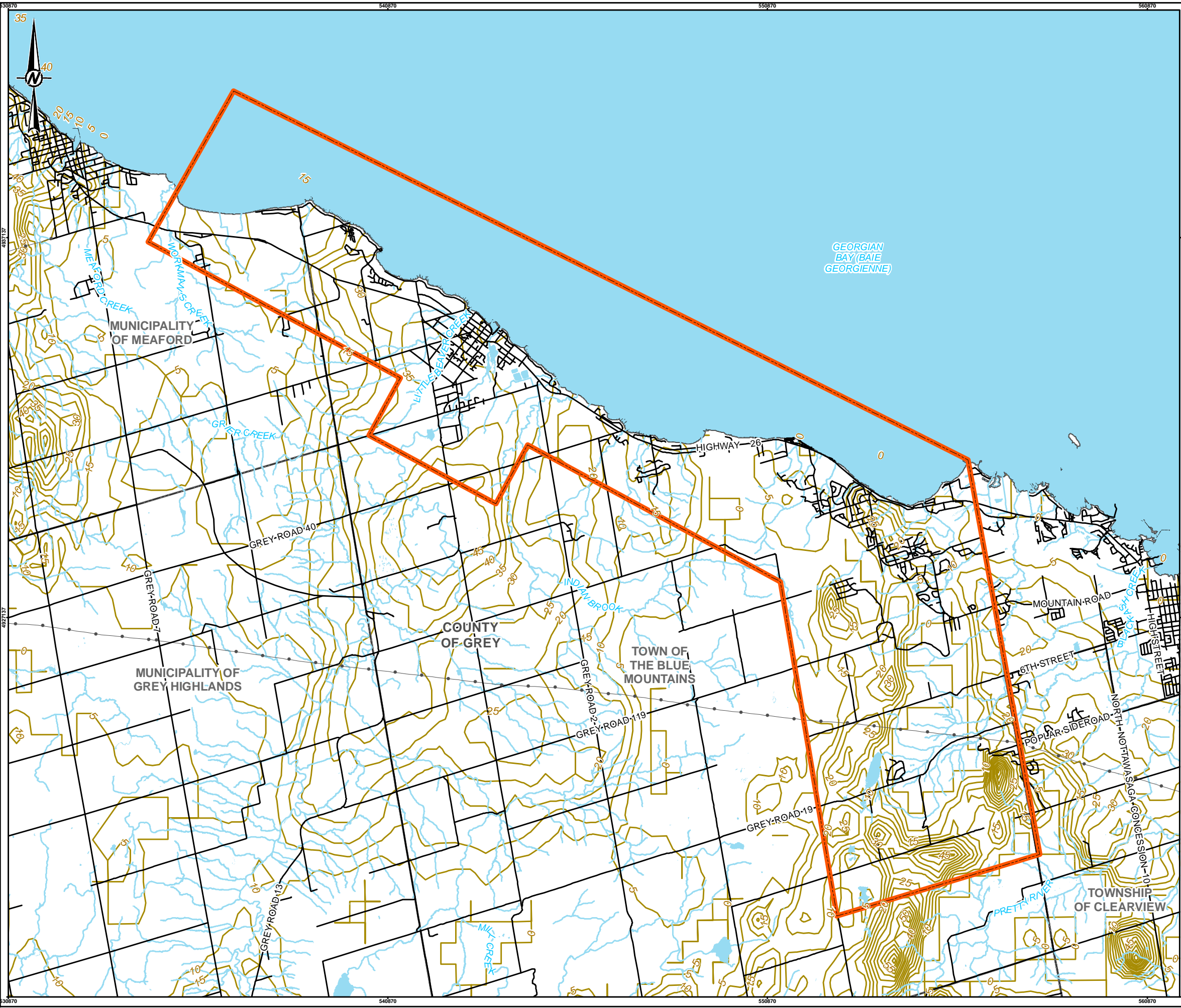
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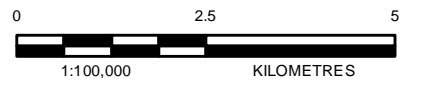


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- LEGEND**
- APPROXIMATE DESKTOP STUDY AREA
 - ROAD
 - UTILITY LINE
 - WATERCOURSE
 - WATERBODY
 - MUNICIPAL BOUNDARY
 - DRIFT THICKNESS (5M)



REFERENCE(S)
 BASE DATA - MNR LIO, OBTAINED 2017
 BEDROCK CONTOURS - MRD207 GAO, C., SHIROTA, J., KELLY, R. I., BRUNTON, F.R., VAN HAAFTEN, S.
 2006. BEDROCK TOPOGRAPHY AND OVERBURDEN THICKNESS MAPPING, SOUTHERN ONTARIO,
 ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE-DATA 207. ISBN 1-4249-2550-9.
 PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL
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 PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
 J.L. RICHARDS & ASSOCIATES LTD.

PROJECT
 GEOTECHNICAL DESKTOP STUDY
 TOWN OF THE BLUE MOUNTAINS
 WATER SUPPLY MASTER PLAN

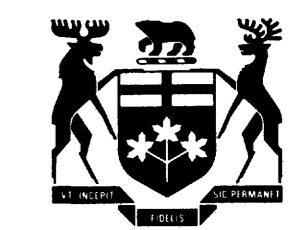
TITLE
 DRIFT THICKNESS CONTOURS

CONSULTANT	YYYY-MM-DD	2018-01-17
	DESIGNED	JT
	PREPARED	JT
	REVIEWED	RA
	APPROVED	AJH

PROJECT NO. 1778449 (1000) CONTROL REV. FIGURE 6

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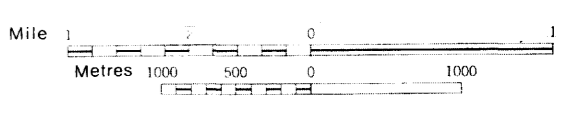
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Ontario
Division of Mines
HONOURABLE LEO BERNIER, Minister of Natural Resources
W. Q. MACNEE, Deputy Minister of Natural Resources
G. A. Jewett, Executive Director, Division of Mines E. G. Pyle, Director, Geological Branch

PRELIMINARY MAP P. 925
DRIFT THICKNESS SERIES
**COLLINGWOOD-NOTTAWASAGA
AREA**

SOUTHERN ONTARIO
Scale 1:50,000
1.25 inches to 1 mile approximately



NTS Reference: 41 G/8, 41 G/9

© ODM 1974
Parts of this publication may be quoted if credit is given to the Ontario Division of Mines and the material is properly referenced.

- SYMBOLS**
- 26 Well which penetrates bedrock with depth of drift in feet
 - △ 42 Well which does not penetrate bedrock with termination depth in feet
 - 25 Drift thickness isopach (contour interval 25 feet); approximate thickness, minimum possible thickness (based on available data)
 - X Area of outcrop

DRIFT THICKNESS
This map is based on subsurface data in the files of the Hydrologic Data Branch, Ontario Ministry of Environment. Outcrop information obtained from published maps by the Geological Survey of Canada and from unpublished maps by the Ontario Division of Mines, is indicated on the bedrock topography map (Burwasser, in press) and plotted with formation names on the Paleozoic geology map (Telford, in press) of the Collingwood-Nottawasaga Area. Solid contour lines are based on wells which penetrate the bedrock surface. Dashed contour lines are interpreted from wells which terminate above the bedrock surface and therefore supply only minimum values of drift thickness. Some field checking of data was undertaken but other possible errors in the records remain uncorrected.
Interpretation of well data by G.J. Burwasser with the assistance of W.S. Clarke.
Base map from National Topographic Series 41 A/8 and A/9 revised 1950.

REFERENCES
Burwasser, G.J.
in press: Bedrock Topography of the Collingwood-Nottawasaga Area, Southern Ontario; Ontario Div. Mines, Prelim. Map P.924, Bedrock Topography Series, scale 1:50,000. To be released early 1974.
Telford, P.G.
in press: Paleozoic Geology of the Collingwood-Nottawasaga Area, Southern Ontario; Ontario Div. Mines, Prelim. Map. To be released early 1974.
Issued 1974.

Parts of this publication may be quoted if credit is given to the Ontario Division of Mines. It is recommended that reference to this map be made in the following form:
Burwasser, G.J.
1974: Drift Thickness of the Collingwood-Nottawasaga Area, Southern Ontario; Ontario Div. Mines, Prelim. Map P.925, Drift Thickness Ser., scale 1:50,000. Geological Compilation, 1973.

APPENDIX A

Important Information and Limitations



IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.



IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.



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