APPENDIX

G

Preliminary Hydrogeologic Assessment Report

If technical reports are required in an alternative format for accessibility needs, please contact:

Maged Elmadhoon, M.Eng., P.Eng.
Manager, Transportation Planning - Public Works, Niagara Region
Phone: 905-980-6000 ext. 3583
Email: Maged.Elmadhoon@niagararegion.ca

NIAGARA REGION

PRELIMINARY HYDROGEOLOGICAL INVESTIGATION – SEGMENT 1

MERRIT ROAD AND RICE ROAD MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT

SEPTEMBER 13, 2022

PRELIMINARY HYDROGEOLOGICAL INVESTIGATION – SEGMENT 1

MERRITT ROAD AND RICE ROAD MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT

NIAGARA REGION
ATT: MAGED ELMAHOON, M. ENG., P ENG.

PROJECT NO. IM20103036
DATE: SEPTEMBER 22, 2022

WSP E&I CANADA LIMITED
3450 HARVESTER ROAD, SUITE 100
BURLINGTON, ONTARIO
L7N 3W5 CANADA

SIGNATURES

PREPARED BY

DRAFT
Ryan Phillips
Hydrogeological Technician

APPROVED[1] BY *(must be reviewed for technical accuracy prior to approval)*

DRAFT
Nick Schmidt, B.Sc., P.Geo.
Senior Hydrogeologist

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TABLES

FIGURES

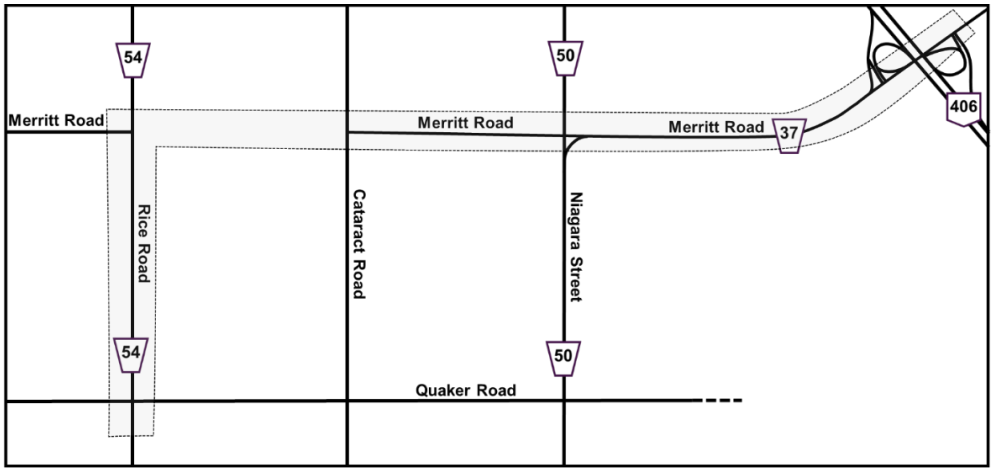
APPENDICES

1 INTRODUCTION

The Regional Municipality of Niagara (Niagara Region) has retained WSP E&I Canada Limited (Previously Wood E&IS) to undertake a Schedule 'C' Municipal Class Environmental Assessment (MCEA) study for improvements to Regional Road 37 (Merritt Road) and Regional Road 54 (Rice Road), in the Town of Pelham, City of Thorold, and City of Welland, Ontario. The study area for the MCEA study includes the following four road segments:

- Segment 1 – Merritt Road between Rice Road and Cataract Road
- Segment 2 – Merritt Road between Cataract Road and Merrittville Highway / Niagara Street
- Segment 3 – Merritt Road between Merrittville Highway / Niagara Street and Highway 406
- Segment 4 – Rice Road between Merritt Road and Quaker Road

Study Area for Merritt Road-Rice Road MCEA Study



This hydrogeological investigation was completed for Segment 1 based on the input received from the Niagara Peninsula Conservation Authority. The unopened road allowance identified as Segment 1 requires a characterization of the hydrogeological conditions in support of the wetland hydrological characterization for the MCEA study to identify whether the wetland receives groundwater contribution.

1.1 PROJECT DESCRIPTION

The MCEA study is being completed to assess potential improvements to Merritt Road between Rice Road and Highway 406 and Rice Road between Merritt Road and Cataract Road. One of these proposed improvements is connecting the existing sections of Merritt Road by extending the Merritt Road between Rice Road and Cataract Road (i.e., Segment 1). This is being proposed to improve traffic flow and create a direct route from Highway 406 to the southern sections of Fonthill following the twinning of Hwy 406 which resulted in the elimination of Port Robinson Road as an Hwy 406 exit.

1.2 PRELIMINARY HYDROGEOLOGICAL INVESTIGATION

The preliminary hydrogeological investigation was completed for Segment 1, which consists of an unopened road allowance of Merritt Road between Rice Road in Pelham, ON and Cataract Road in Thorold, ON as shown in Figure 1. The investigation involved a desktop-based assessment followed by field investigation, which included the drilling of boreholes and the installation of monitoring wells at the locations shown on Figure 2. Hydraulic conductivity testing and groundwater level monitoring was undertaken to assist in the hydrogeological characterization of the subsurface soils, to assess seasonal groundwater level variations.

The purpose of the preliminary hydrogeological investigation is ultimately to assess the hydrogeological function, in simple terms the role of groundwater in the wetlands located within the study area.

2 DESKTOP ASSESSMENT

To support the preliminary hydrogeological investigation, a desktop assessment was completed to provide publicly available information for the investigation.

2.1 SITE DESCRIPTION

The site for the preliminary hydrogeological investigation consists of an unopened road allowance of Merritt Road between Rice Road in Pelham, ON and Cataract Road in Thorold, ON as shown in Figure 1.

2.2 SITE FEATURES

The site is located in a rural area with residential properties along the existing local roads, farming and other property uses, while the rest of the area is forested or wetland area.

To the west of the site is the hydrogeologically significant Fonthill Kame that was created during the last glaciation. The approximate extent of the Fonthill Kame is shown on Figure 3. The extent of the kame as shown on Figure 3 is based on the selection of the coarse-textured glaciolacustrine deposits provided in the 2010 Surficial Geology of Southern Ontario Miscellaneous Release – Data 128 REV, published by the Ontario Geologic Survey. The Fonthill Kame is a large isolated hill created by the deposition of materials from the glaciers. The soils of the kame contain a substantial amount of sandy material and is considered an aquifer that provides groundwater to the area of the kame.

2.3 TOPOGRAPHY

According to topographical data provided in Figure 4, the site is relatively flat with an overall downslope from west to east. 5 m contour lines show that west of the site on Merritt Road, the ground surface elevation is 190 metres above sea level (masl) which slopes to elevating 185 masl within the western portion of the site. A survey of the borehole locations (shown in Figure 2) indicates that the existing ground surface elevation is approximately 185.1 masl at BH/MW1, and is inferred to gently slope downwards to an elevation of approximately 181.9 masl at BH/MW3 (BH refers to Borehole and MW refers to Monitoring Well). To the west of the site the topography increases as part of the Fonthill Kame.

2.4 SURFACE WATER

According to waterbody mapping from Land Information Ontario (LIO), surface water at the site as shown in Figure 4 includes wetlands that comprise much of the site including the central and eastern portions. Within these wetland areas, two creeks cross the site flowing northernly which then confluence with another creek and flow easternly. It is noted that there is a small pond that is located just north of the site at the western limit of the mapped wetland area.

The creeks that flow through the site receive baseflow from groundwater from the Fonthill Kame. At the outer extent of the Fonthill Kame, groundwater becomes surface water and creates the headwaters for the creeks as a result of the underlaying lower permeability soils that cannot receive groundwater at the same rate it flows through the more permeable soils of the kame.

2.5 PHYSIOGRAPHY

According to the 2007 Physiography of Southern Ontario Miscellaneous Release – Data 228, published by the Ontario Geological Survey (OGS), the physiography as shown in Figure 5 is mapped as Sand Plains (11) across the entire site.

2.6 GEOLOGY

According to the 2010 Surficial Geology of Southern Ontario Miscellaneous Release – Data 128 REV, published by the Ontario Geologic Survey, the surficial soils as shown in Figure 6 are mapped as fine-textured glaciolacustrine deposits (8a) including silt and clay, with minor sand and gravel. To the west of the site the surficial geology is mapped as coarse-textured glaciolacustrine deposits (9) including sand and gravel, with minor silt and clay which represents the soils of the Fonthill Kame.

According to Drift Thickness data (of Southern Ontario), published by the Ontario Geological Survey (2006), the drift thickness in the area of the site as shown in Figure 7 ranges from approximately 46 m at the western site limit to approximately 38 m at the eastern site limit.

According to the 2007 Paleozoic Bedrock Geology of Ontario, Miscellaneous Release – Data 219 Rev. 1, published by the Ontario Geological Survey, as shown in Figure 8, the top unit of bedrock at the site is mapped as the Lockport Formation for the majority of the site and the Guelph Formation to the eastern limit of the site. Both the Lockport Formation and the Guelph Formation are comprised primarily of dolostone.

3 HYDROGEOLOGICAL FIELDWORK & ANALYSIS

A hydrogeological field assessment was conducted to assess the hydrogeological conditions at the site. The hydrogeological assessment included field work including a drilling program well development, hydraulic conductivity testing and groundwater level monitoring.

3.1 BOREHOLE DRILLING AND MONITORING WELL INSTALLATIONS

Three (3) boreholes (BH/MW1, BH/MW2, and BH/MW3) were drilled along the unopened road allowance of Merritt Road. All three boreholes were completed using a track mounted drill rig and solid stem augers to a termination depth of approximately 6.1 meters below ground surface (mbgs).

Upon reaching the termination depth in each borehole, a monitoring well was installed using a 3 m long PVC 10-slot screen with a 0.05 m (2") inside diameter, which was joined with sections of PVC riser pipe. Sand was then slowly added to surround the installed screen to approximately 0.3 m above the screen. Bentonite chips were then poured into the borehole to approximately 0.3 m below ground surface. The bentonite was hydrated to provide a seal from the ground surface. The monitoring wells were completed with lockable J-plug caps and protective stickup casings embedded into ground surface. The wells were tagged and labelled in accordance with Ontario Regulation 903 (O. Reg. 903) of the Ontario Water Resources Act by the well drillers and the water well records were submitted to the MECP by the drilling subcontractor. The locations of the borehole and monitoring wells are shown in Figure 2.

3.1.1 SUBSURFACE CONDITIONS

All boreholes drilled during this investigation were through topsoil ranging between 75 mm and 150 mm in thickness. In addition, 75 mm of gravel was encountered in BH/MW3. Underneath the surficial soils were fine grain soils of either Silty Clay or Clayey Silt. In BH/MW1, Silty Clay soils were encountered to approximately 3.8 mbgs which transitioned to Sandy Silt for the full depth of the borehole. In BH/MW2, alternating soils of Clayey Silt followed by Silty Clay were encountered to approximately 0.8 mbgs, 3.8 mbgs, 4.6 mbgs and to the full depth of the borehole. In BH/MW3, Clayey Silt soils were encountered to approximately 0.8 mbgs which transitioned to Silty Clay for the full depth of the borehole. No bedrock was encountered in any boreholes. The borehole logs can be found in Appendix A.

3.1.2 MONITORING WELL SURVEY

The top of the monitoring well casings were surveyed using a Sokkia GXC3 GPS unit to provide UTM coordinates and a surveyed elevation. Measured distances from the top of casing to the top of monitoring well pipe and to the ground surface were used to determine the elevations of the top of monitoring well and the approximate ground surface. UTM coordinates are in UTM zone 17 NAD83 and the elevations are in CGVD28:78.

3.2 WELL DEVELOPMENT

The monitoring wells were developed on July 7, 2022 using a Waterra® inertial lift pump (i.e. foot valve) fitted with dedicated polyethylene tubing installed in each monitoring well. Well development was carried out by purging a minimum of three (3) well volumes of water from each monitoring well or purging the well practically dry. Well development was carried out to remove some fine particles from the sand filter pack and the native soils immediately surrounding the well screen in preparation for the hydraulic conductivity testing.

3.3 HYDRAULIC CONDUCTIVITY TESTING

Hydraulic conductivity testing was completed to quantitatively estimate the rate at which groundwater could move through the soil under saturated conditions. Hydraulic Conductivity testing in the form of a single well response slug test (slug test) was completed for each monitoring well to assess the hydraulic conductivity of the screened soils. A slug test was completed for BH/MW1 following full recovery from well development on July 7, 2022. Slug tests for BH/MW2 and BH/MW3 were initiated on July 26, 2022 and according to the transducer data both reached equilibrium conditions (i.e. fully recovered) on August 3, 2022.

For each slug test, a non-vented pressure transducer programmed to record pressure readings at either a one-second interval (BH/MW1) or a fifteen second interval (BH/MW2 and BH/MW3) was placed in the monitoring well prior to the start of the test and recorded throughout the test. A separate pressure transducer (barologger) placed above the groundwater level was used to compensate for barometric changes over the testing period. Manual water levels were taken prior to the start, during, and after the completion of the test for BH/MW1 and prior to the start and during the early portion of the tests (BH/MW2 and BH/MW3) to match the transducer's pressure data to the measured manual water levels, which provides a continuous record of the water level in the monitoring well during the test. Rising head tests were conducted in all monitoring wells tested. The rising head test conditions were created by purging water from the well using the Waterra® inertial pump systems installed during well development and allowing the water level in the monitoring well to recover back to equilibrium.

The data from the slug tests were analyzed using the Bouwer-Rice method in AQTESOLV version 4.50.002. The software incorporates transducer water level data collected during the slug tests as well as monitoring well construction details in the estimation of the hydraulic conductivity of the screened soils. Based on the conditions encountered during drilling, the slug tests were analyzed using unconfined aquifer conditions.

The estimated hydraulic conductivities from the testing are presented in the following table.

Table 1: Hydraulic Conductivity Testing Results

Borehole ID	Hydraulic Conductivity (m/s)	Screened Material
BH/MW1	7.3×10^{-7}	Silty Clay / Sandy Silt
BH/MW2	1.0×10^{-8}	Clayey Silt / Silty Clay
BH/MW3	9.2×10^{-9}	Silty Clay

The hydraulic conductivity analysis can be found in Appendix B. The hydraulic conductivities obtained for the monitoring wells are considered reasonable based on the soil lithology descriptions in the borehole logs as well as published values provided in Groundwater by Freeze and Cherry, 1979.

Generally low hydraulic conductivities like BH/MW2 and BH/MW3 would be expected across the site where clayey silt / silty clay soils were encountered. Based on the subsurface conditions encountered during drilling, similar hydraulic conductivities would be expected in the surficial soils at BH/MW1, and the full depth of soils encountered at BH//MW2 and BH/MW3. These hydraulic conductivities would convert to a rate of approximately 0.001 m/d. The relatively higher hydraulic conductivity of BH/MW1 would be expected within the sandy silt soils encountered at depth in BH/MW1. The hydraulic conductivity would convert to a rate of approximately 0.06 m/d.

3.4 GROUNDWATER LEVEL MONITORING

Monitoring of the groundwater level and corresponding groundwater elevation was conducted following the installation of the monitoring wells. The monitoring record includes July to September 2022 as shown on Figure 9a and 9b respectively.

The long-term monitoring record utilizes the water level monitoring conducted following well development and during hydraulic conductivity testing. Following completion of those tasks, the pressure transducer in each monitoring well as well as the barologger were reprogrammed to record pressure readings at a 10-minute interval. Manual water levels were taken during each download event. It is noted that the groundwater level / elevation is affected by the testing conducted (well development, hydraulic conductivity testing and the removal of waterra tubing) as indicated on the hydrographs. It is also noted that the manual water level recorded in BH/MW1 on July 26, 2022 appears anomalous likely due to human error. It is further noted that upon initial

assessment of the manual levels on September 2, 2022, there appeared to be some concern with the measured water level, and a subsequent water level event was conducted the following day, however this was due to the removal of the waterra tubing and the water levels were reasonable.

During the monitoring period to date, the groundwater level at BH/MW1 has been artesian, ranging from approximately 0.2 m to 0.5 m above ground surface. The groundwater levels are representative of the sandy silt soils at depth which are confined by lower permeability silty clay soils near surface. The groundwater level at BH/MW2 has ranged from approximately at ground surface to 0.4 m below ground surface. The groundwater level at BH/MW3 has been found to range from approximately 1.2 m to 1.6 m below ground surface.

Further groundwater monitoring will be conducted over a period of approximately one (1) year, until July 2023 to capture seasonal groundwater level variations and to provide groundwater level response data to precipitation events. At the conclusion of the monitoring period, the groundwater level monitoring data will be provided to the Niagara Region in the form of a brief memo. It is expected that the hydrograph data will be useful to support the expected detailed design phase of the project, particularly for any further hydrogeological assessment to be conducted.

4 DISCUSSION

Surficial geology mapping indicates that the site area is fine textured glaciolacustrine deposits containing silt and clay, however, just to the west is roughly the termination of the geological area known as the Fonthill Kame. The soils of the kame contain a substantial amount of sandy material and is considered an aquifer that provides groundwater to the area of the kame. Groundwater within the kame generally flows radially towards the edges of the kame. As groundwater reaches the edge of the kame, much of it becomes surface water because the underlaying lower permeability soils cannot receive groundwater at the same rate it flows through the sandy soils. The surface water that results are the headwaters of many of the local creeks, including the creeks that flow through the site.

Silty clay / clayey silt soils were encountered within the study area, with the exception of the sandy silt soils encountered at depth at BHMW1. These silty clay / clayey silt soils have relatively low hydraulic conductivities where groundwater cannot readily move through the subsurface. As groundwater cannot readily move through the subsurface within these soils, groundwater is not expected to be a significant source of water to the wetland areas and thus this would generally limit the hydrogeological function of the wetland areas. However, these low permeability soils found near surface would also limit the infiltration of precipitation water into the ground, which can result in ponded water and contribute to wetland conditions especially during the wetter seasons when evaporation is less. Groundwater levels within these silty clay / clayey silt soils at BHMW2 and BHMW3 were found to be near surface and just over a meter below ground surface respectively. The groundwater levels were slightly declining during the monitoring period to date as expected based on the summer period monitored thus far.

Sandy silt soils were encountered at depth at BHMW1. These sandy silt soils have a relatively higher hydraulic conductivity where groundwater can move through the subsurface at a relatively higher rate. Artesian groundwater conditions may suggest that these soils could be hydraulically connected to the permeable soils of the Fonthill Kame. If connected to the soils of the Fonthill Kame, this would provide a steady source of water to the area. However, based on the soils encountered at BHMW2, while limited borehole locations exist to support this, these sandy silt soils do not extend to the locations of the mapped wetland areas.

5 CONCLUSIONS

Based on the information available and the assessment conducted as part of this preliminary hydrogeological investigation, groundwater is not expected to be a substantial source of water in terms of quantity to support the wetland areas. However, the hydraulic heads that exist in the subsurface of artesian and near surface conditions limit infiltration which would be expected to be a supporting function of the wetland areas.

APPENDIX

FIGURES

641000

4766000

Rice Road

Cataract Road

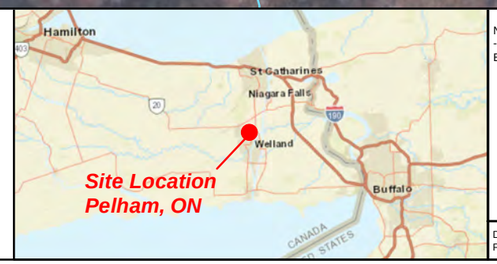
Merritt Road

Merritt Road

P:\2020\Projects_Other\IM20103036_NiagaraMerrittRiceRoad\11_GIS\MXD\HydroGeo\Site_Location_1.mxd

LEGEND

- Unopened Road Allowance (Merritt Rd)
- Waterbody
- Watercourse



NOTES:
- Aerial imagery extracted from ESRI Basemaps, 2020

Datum: NAD83
Projection: UTM Zone 17N

0 0.25 0.5 Kilometres

N W E S

Niagara Region

wsp

MERRITT ROAD AND RICE ROAD MUNICIPAL CLASS EA – PRELIMINARY HYDROGEOLOGICAL INVESTIGATION OF SEGMENT 1

SITE LOCATION PLAN

PROJECT N°: IM20103036	**FIGURE: 1**
SCALE: 1:2,500	DATE: September 2022

641000

4766000

Rice Road

Cataract Road

Merritt Road

Merritt Road

BH/MW 1

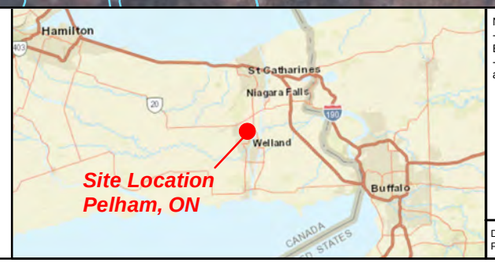
BH/MW 2

BH/MW 3

P:\2020\Projects_Other\IM20103036_NiagaraMerittRiceRoad\11_GIS\MXD\HydroGeo\BoreholeLocationplan.mxd

LEGEND

- Unopened Road Allowance (Merritt Rd)
- Approximate Borehole Location
- Waterbody
- Watercourse



NOTES:
- Aerial imagery extracted from ESRI Basemaps, 2020
- Location of features is approximate

Datum: NAD83
Projection: UTM Zone 17N

0 0.25 0.5 Kilometres

N W E S

Niagara Region

wsp

MERRITT ROAD AND RICE ROAD MUNICIPAL CLASS EA – PRELIMINARY HYDROGEOLOGICAL INVESTIGATION OF SEGMENT 1

BOREHOLE LOCATION PLAN

PROJECT N^{O}: IM20103036 | **FIGURE: 2**

SCALE: 1:2,500 | DATE: September 2022

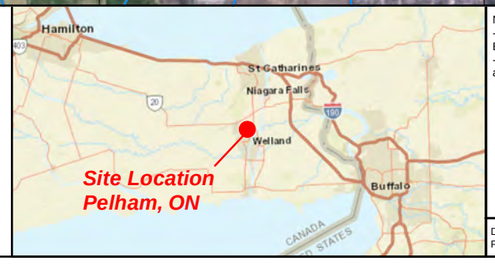
632000 634000 636000 638000 640000 642000

4770000 4768000 4766000 4764000

Fifteen Road
Maple Street
Balfour Street
Cream Street
Centre Street
Kilman Road
Hansler Street
Hollow Road
Barron Road
MerrittVille Highway
Hansler Road
McSherry Lane
Highway 20
Turner Road
Metler Road
Overholt Road
Moore Drive
Tice Road
Victoria Avenue
Brady Street
Lookout Street
Hurricane Road
Highway 20 East
Station Street
Rice Road
Cataract Road
Highway 20
Highway 20 West
Port Robinson Road
Canboro Road
Pancake Lane
Stella Street
Memorial Drive
Merritt Road
Ramp
Vaughan Road
Sandra Drive
Haist Street
Effingham Street
Welland Road
Line Avenue
Pelham Street
Quaker Road
Niagara Street
Canborough Road
Farr Street
Church Street
First Avenue
Foss Road
Clare Avenue
Woodlawn Road

LEGEND

- Unopened Road Allowance (Merritt Rd)
- Fonthill Kame
- Ontario Hydro Network (OHN) - Waterbody
- Ontario Hydro Network (OHN) - Watercourse



NOTES:
- Aerial imagery extracted from ESRI Basemaps, 2020
- Location of features is approximate

Datum: NAD83
Projection: UTM Zone 17N

0 2.5 5 Kilometres

Niagara Region

wsp

MERRITT ROAD AND RICE ROAD MUNICIPAL CLASS EA – PRELIMINARY HYDROGEOLOGICAL INVESTIGATION OF SEGMENT 1

EXTENT OF FONTHILL KAME

PROJECT N°: IM20103036 | **FIGURE: 3**

SCALE: 1:31,000 | DATE: September 2022

P:\2020Projects_Other\IM20103036_NiagaraMerrittRiceRoad\11_GIS\MXD\HydroGeo\FonthillKame.mxd

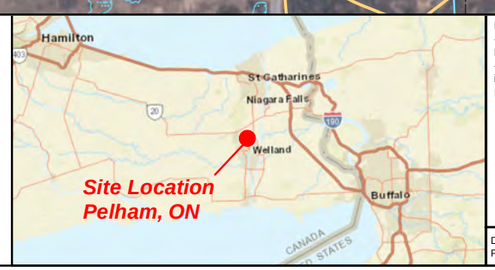
640000
641000
642000
4766000
Walker Road
Cataract Road
Merritville Highway
Merritt Road
Merritt Road
Stefiar Street
Bacon Lane
Timber Creek Crescent
Rosewood Crescent
Line Avenue
Crerar Avenue
Montgomery Road
Rice Road
First Avenue
Niagara Street
195
190
185
180

P:\2020\Projects_Other\IM20103036_NiagaraMerittRiceRoad\11_GIS\MXD\HydroGeo\Topographyand

LEGEND

- Unopened Road Allowance (Merritt Rd)
- Niagara Street Cataract Road Woodlot Wetland Complex (Provincially Evaluated)
- Contour (5m Interval)
- Waterbody
- Watercourse

0 0.5 1 Kilometres



NOTES:
- Aerial imagery extracted from ESRI Basemaps, 2020
- Contour data and Waterbody information retrieved from Land Information Ontario (LIO)

Datum: NAD83
Projection: UTM Zone 17N

N W E S

Niagara Region

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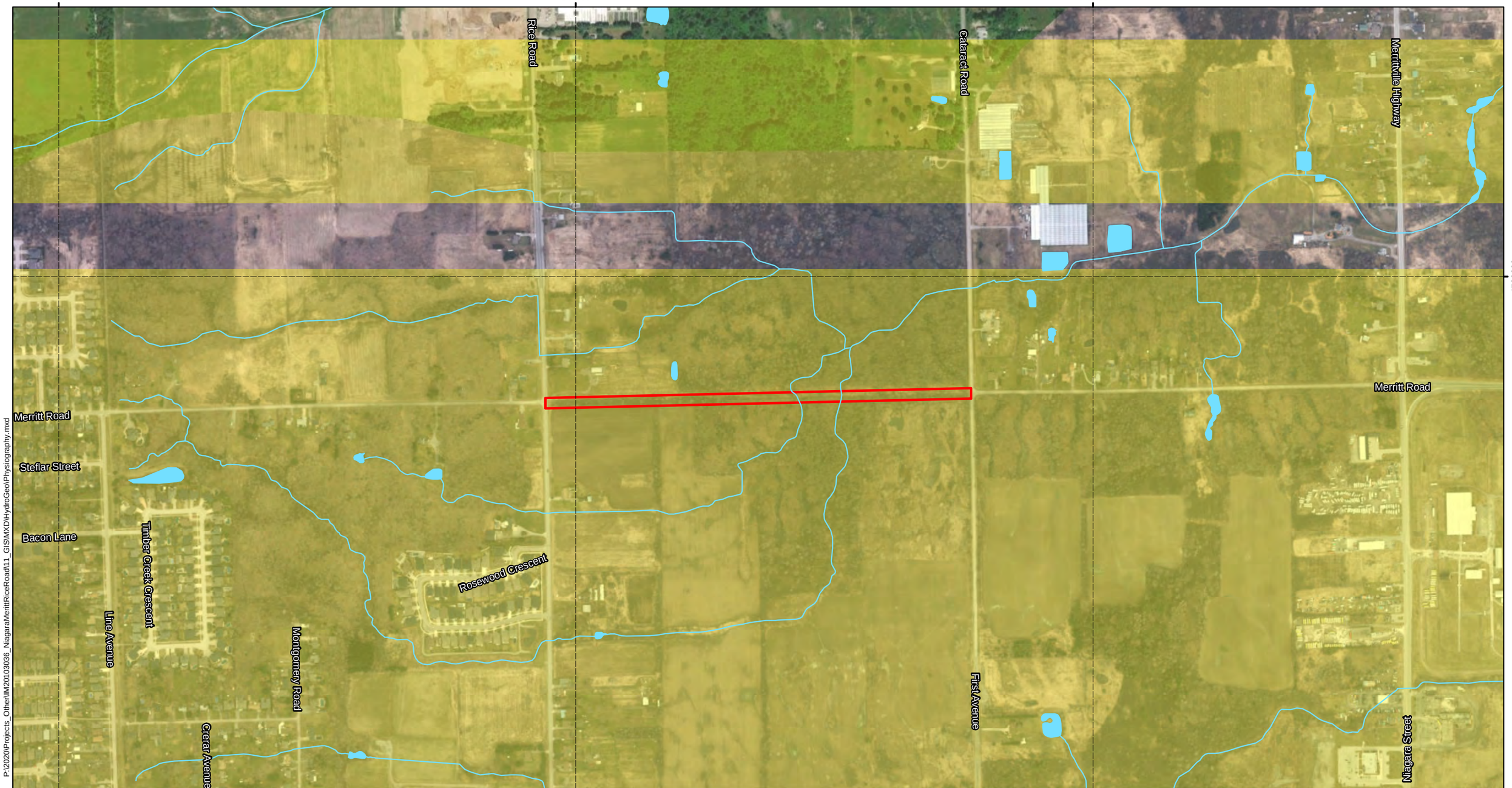
MERRITT ROAD AND RICE ROAD MUNICIPAL CLASS EA – PRELIMINARY HYDROGEOLOGICAL INVESTIGATION OF SEGMENT 1

TOPOGRAPHY AND SURFACE WATER

PROJECT N°: IM20103036 | **FIGURE: 4**

SCALE: 1:7,000 | DATE: September 2022



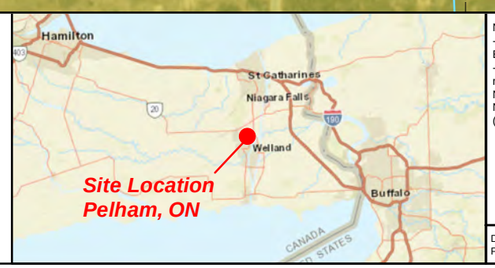
P:\2020\Projects_Other\IM20103036_NiagaraMerrittRiceRoad\11_GIS\MXD\HydroGeo\Physiography.mxd

LEGEND

- Unopened Road Allowance (Merritt Rd)
- Waterbody
- Watercourse

Physiographic Description

- 11: Sand Plains



NOTES:
- Aerial imagery extracted from ESRI Basemaps, 2020
- Physiography of Southern Ontario retrieved from the Ministry of Northern Development, Mines, Natural Resources and Forestry (MNDM)

Datum: NAD83
Projection: UTM Zone 17N

0 0.5 1 Kilometres

Niagara Region

wsp

MERRITT ROAD AND RICE ROAD MUNICIPAL CLASS EA – PRELIMINARY HYDROGEOLOGICAL INVESTIGATION OF SEGMENT 1

PHYSIOGRAPHY

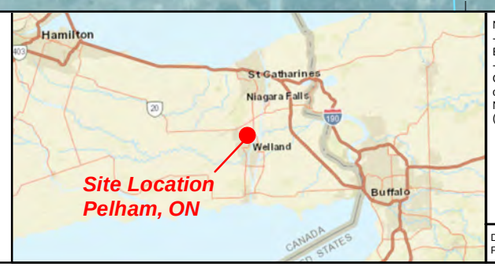
PROJECT N°: IM20103036 | **FIGURE: 5**

SCALE: 1:7,000 | DATE: September 2022

640000
641000
642000
4766000
Rice Road
Cataract Road
Merritville Highway
Merritt Road
Merritt Road
Stellar Street
Bacon Lane
Timber Creek Crescent
Line Avenue
Rosewood Crescent
Grerar Avenue
Montgomery Road
First Avenue
Niagara Street
P:\2020\Projects_Other\IM20103036_NiagaraMerittRiceRoad11_GIS\MXD\HydroGeo\SurficialGeography.mxd

LEGEND

- Waterbody
- Watercourse
- Unopened Road Allowance (Merritt Rd)
- 8: Fine-textured glaciolacustrine deposits
- 9: Coarse-textured glaciolacustrine deposits



NOTES:
- Aerial imagery extracted from ESRI Basemaps, 2020
- Surficial Geology of Southern Ontario retrieved from the Ministry of Northern Development, Mines, Natural Resources and Forestry (MNDM)

Datum: NAD83
Projection: UTM Zone 17N

0 0.5 1 Kilometres

Niagara Region

wsp

MERRITT ROAD AND RICE ROAD MUNICIPAL CLASS EA – PRELIMINARY HYDROGEOLOGICAL INVESTIGATION OF SEGMENT 1

SURFICIAL GEOGRAPHY

PROJECT N°: IM20103036 | **FIGURE: 6**

SCALE: 1:7,000 | DATE: September 2022

640000
641000
642000
4766000

Drift Thickness: 54 m
Drift Thickness: 46 m
Drift Thickness: 42 m
Drift Thickness: 38 m
Drift Thickness: 29 m

Rice Road
Cataract Road
Merritville Highway
Merritt Road
Merritt Road
Ramp
Steflar Street
Bacon Lane
Timber Creek Crescent
Rosewood Crescent
Line Avenue
Montgomery Road
Grerar Avenue
First Avenue
Niagara Street

P:\2020\Projects_Other\IM20103036_NiagaraMerittRiceRoad\11_GIS\MXD\HydroGeo\DriftThickness.mxd

LEGEND

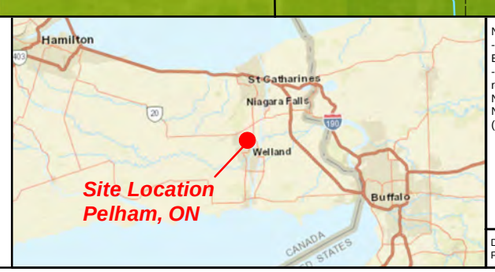
- Unopened Road Allowance (Merritt Rd)
- Waterbody
- Watercourse

Drift Thickness (m)

High : 96

Low : 16

0 0.5 1 Kilometres



NOTES:
- Aerial imagery extracted from ESRI Basemaps, 2020
- Drift Thickness of Southern Ontario retrieved from the Ministry of Northern Development, Mines, Natural Resources and Forestry (MNDM)

Datum: NAD83
Projection: UTM Zone 17N

Niagara Region

wsp

MERRITT ROAD AND RICE ROAD MUNICIPAL CLASS EA – PRELIMINARY HYDROGEOLOGICAL INVESTIGATION OF SEGMENT 1

DRIFT THICKNESS

PROJECT N°: IM20103036 | **FIGURE: 7**

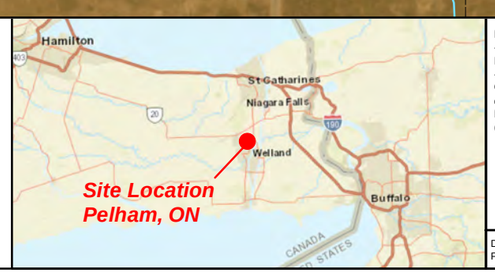
SCALE: 1:7,000 | DATE: September 2022

640000
641000
642000
4766000
Lockport
Goat Island,
Gasport, Vinemount
Merritt Road
Lockport
Eramosa
Guelph
Merritt Road
Merritville Highway
Steflar Street
Bacon Lane
Timber Creek Crescent
Rice Road
Rosewood Crescent
Line Avenue
Montgomery Road
Summerlea Avenue
Cataract Road
First Avenue
Niagara Street
P:\2020\Projects_Other\IM20103036_NiagaraMerittRiceRoad\11_GIS\MXD\HydroGeo\BedRockGeology.mxd

LEGEND

- Unopened Road Allowance (Merritt Rd)
- Guelph Formation
- Lockport Formation
- Waterbody
- Watercourse

0 0.5 1 Kilometres



NOTES:
- Aerial imagery extracted from ESRI Basemaps, 2020
- Bedrock Geology of Southern Ontario retrieved from the Ministry of Northern Development, Mines, Natural Resources and Forestry (MNDM)

Datum: NAD83
Projection: UTM Zone 17N

Niagara Region

wsp

MERRITT ROAD AND RICE ROAD MUNICIPAL CLASS EA – PRELIMINARY HYDROGEOLOGICAL INVESTIGATION OF SEGMENT 1

BEDROCK GEOLOGY

PROJECT N°: IM20103036 | **FIGURE: 8**

SCALE: 1:7,000 | DATE: September 2022

Figure 9a: Hydrograph of Groundwater Levels

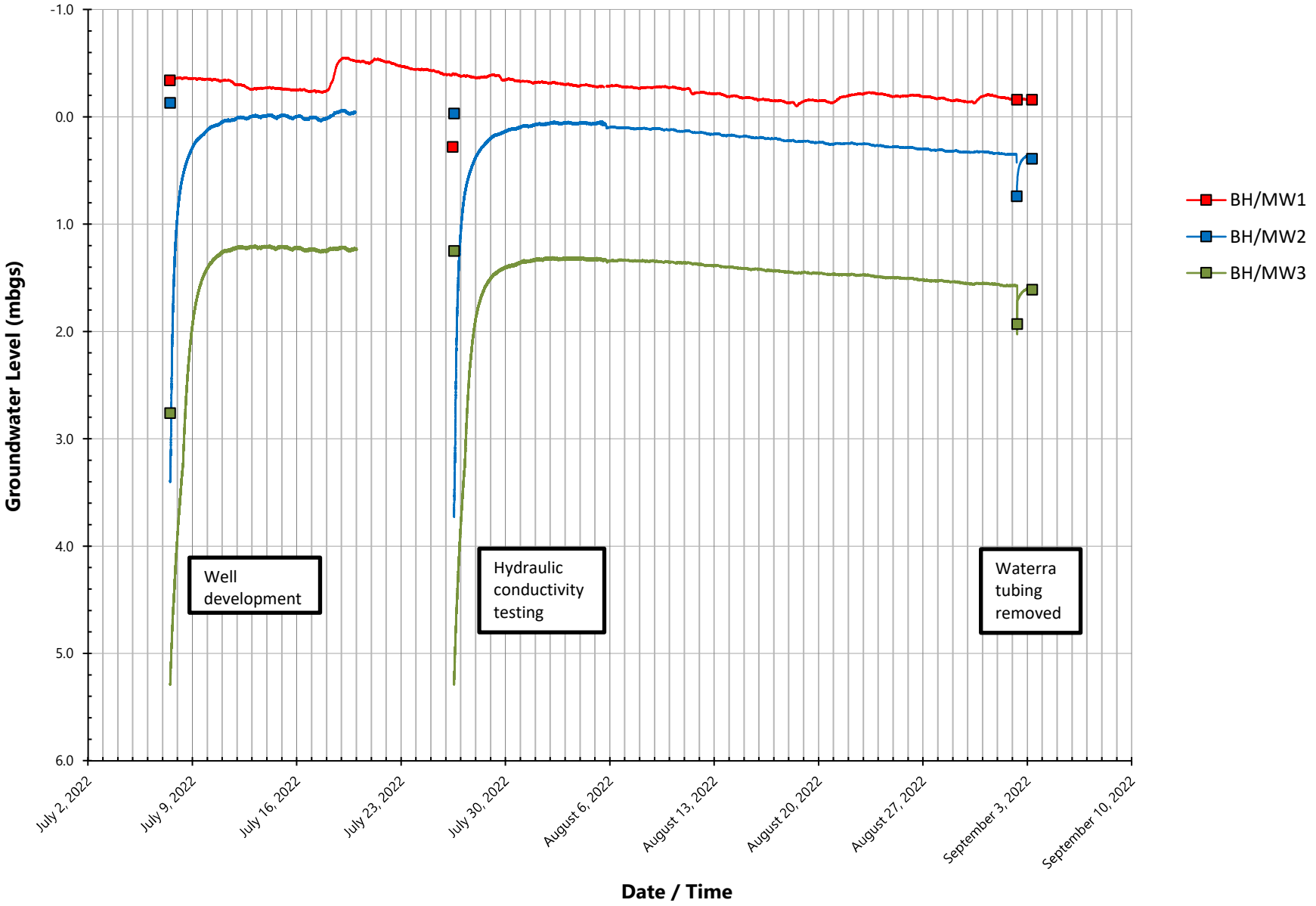
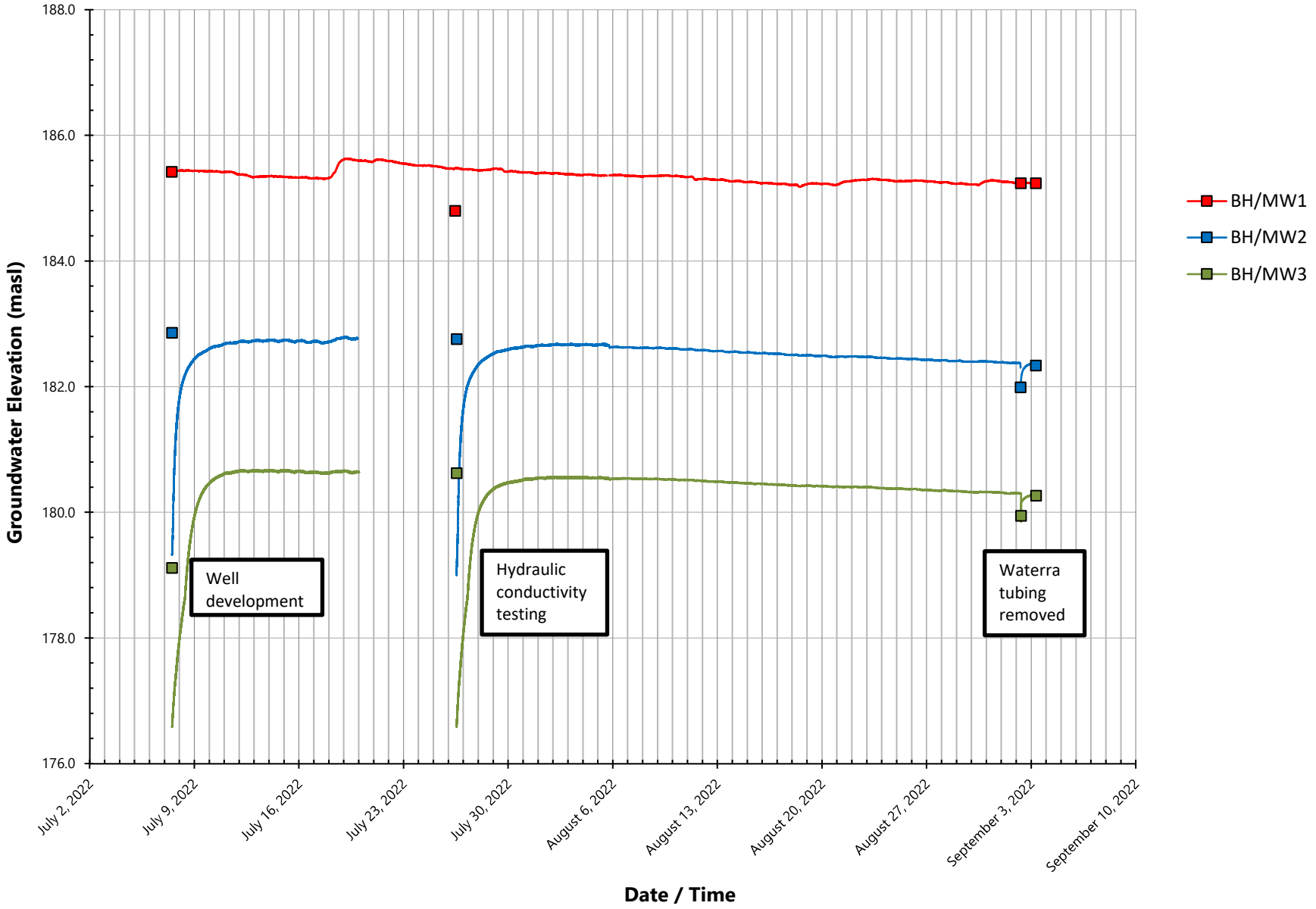


Figure 9b: Hydrograph of Groundwater Elevations



APPENDIX

A BOREHOLE LOGS

RECORD OF BOREHOLE No. BH/MW1

Project Number: IM20103036.6.2
Drilling Location: N:4765760, E:641028
Project Client: Regional Municipality of Niagara
Drilling Method: 150 mm Solid Stem Augering
Project Name: Merritt Road - Rice Road
Drilling Machine: Track Mounted Drill
Project Location: Pelham, Ontario
Date Started: Jun 27, 22
Date Completed: Jun 27, 22

Logged by: CH
Compiled by: TF
Reviewed by: TR
Revision No.: 0, 9/7/22

Lithology Plot	DESCRIPTION (Geodetic Ground Surface Elevation: 185.1 m)		Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)
	75 mm **Topsoil**	185.0						
	Brown **Silty Clay** Some clay, trace sand Firm to very stiff DTPL	0.1	SS	1	100	7		
			SS	2	100	16	1	184
			SS	3	100	13	2	183
			SS	4	100	16		
	Grey		SS	5	83	12	3	182
		181.3						
	Grey **Sandy Silt** Some clay Compact Moist	3.8	SS	6	83	11	4	181
		180.5						
	Brownish grey **Sandy Silt** Compact to dense Wet	4.6	SS	7	83	23	5	180
			SS	8	100	33		
		179.0					6	
	Borehole terminated	6.1						

FIELD TESTING: Penetration Testing — SPT, PPT, DCPT; MTO Vane* (Intact, Remould); Nilcon Vane* (Intact, Remould); * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Soil Vapour Reading — COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

DTPL- Drier than plastic limit
APL- Around plastic limit
WTPL- Wetter than plastic limit

WSP E&I Canada Limited
3450 Harvester Road
Burlington, Ontario, L7N 3W5
Canada
Tel. No.: 1 (905) 335-2353

Groundwater encountered on completion of drilling on 6/27/2022 at a depth of: 0.6 m.
Groundwater depth observed on 7/7/2022 at a depth of: 0.6 m.

Scale: 1 : 55

RECORD OF BOREHOLE No. BH/MW2

Project Number: **IM20103036.6.2** Drilling Location: **N:4765769, E:641211**

Project Client: **Regional Municipality of Niagara** Drilling Method: **150 mm Solid Stem Augering**

Project Name: **Merritt Road - Rice Road** Drilling Machine: **Track Mounted Drill**

Project Location: **Pelham, Ontario** Date Started: **Jun 27, 22** Date Completed: **Jun 27, 22**

Logged by: **CH** Compiled by: **TF** Reviewed by: **TR** Revision No.: **0, 9/7/22**

LITHOLOGY PROFILE			SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION Geodetic Ground Surface Elevation: 182.7 m		Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	150 mm **Topsoil**	182.5										DTPL- Drier than plastic limit APL- Around plastic limit WTPL- Wetter than plastic limit
	Mottled brown **Clayey Silt** Some sand Firm DTPL	0.2 181.9	SS	1	100	5						
	Brown **Silty Clay** Trace sand Stiff to very stiff DTPL	0.8	SS	2	100	10	1	182				
			SS	3	100	14	2	181				
			SS	4	67	16	3	180				
	Grey WTPL	178.9	SS	5	100	8		179				
	Grey **Clayey Silt** Trace sand Stiff WTPL	3.8 178.1	SS	6	67	9	4	178				
	Grey **Silty Clay** Trace sand Firm WTPL	4.6	SS	7	100	7	5					
			SS	8	100	4	6	177				
	Borehole terminated	176.6 6.1										

WSP E&I Canada Limited

3450 Harvester Road
Burlington, Ontario, L7N 3W5
Canada
Tel. No.: 1 (905) 335-2353

▽ Groundwater encountered on completion of drilling on 6/27/2022 at a depth of: 6.0 m.

▼ Groundwater depth observed on 7/7/2022 at a depth of: 0.0 m.

Scale: 1 : 55

RECORD OF BOREHOLE No. BH/MW3

Project Number: IM20103036.6.2
Drilling Location: N:4765775, E:641732
Project Client: Regional Municipality of Niagara
Drilling Method: 150 mm Solid Stem Augering
Project Name: Merritt Road - Rice Road
Drilling Machine: Track Mounted Drill
Project Location: Pelham, Ontario
Date Started: Jun 27, 22
Date Completed: Jun 27, 22

Logged by: CH
Compiled by: TF
Reviewed by: TR
Revision No.: 0, 9/7/22

Geodetic Ground Surface Elevation: 181.9 m

Description	Elev.	Depth	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)
75 mm **Topsoil**	181.8	0.1				
75 mm **Gravel**	181.7	0.2				
Mottled brown **Clayey Silt** Some sand Firm DTPL	181.1	0.8	SS	1	67	5
Brown **Silty Clay** Trace sand Stiff APL to DTPL		1	SS	2	100	12
		2	SS	3	100	15
			SS	4	100	13
	178.9	3				
Grey Firm to soft WTPL			SS	5	83	6
		4	SS	6	100	8
		5	SS	7	100	4
			SS	8	100	3
	175.8	6				
Borehole terminated	6.1					

DTPL- Drier than plastic limit
APL- Around plastic limit
WTPL- Wetter than plastic limit

WSP E&I Canada Limited
3450 Harvester Road
Burlington, Ontario, L7N 3W5
Canada
Tel. No.: 1 (905) 335-2353

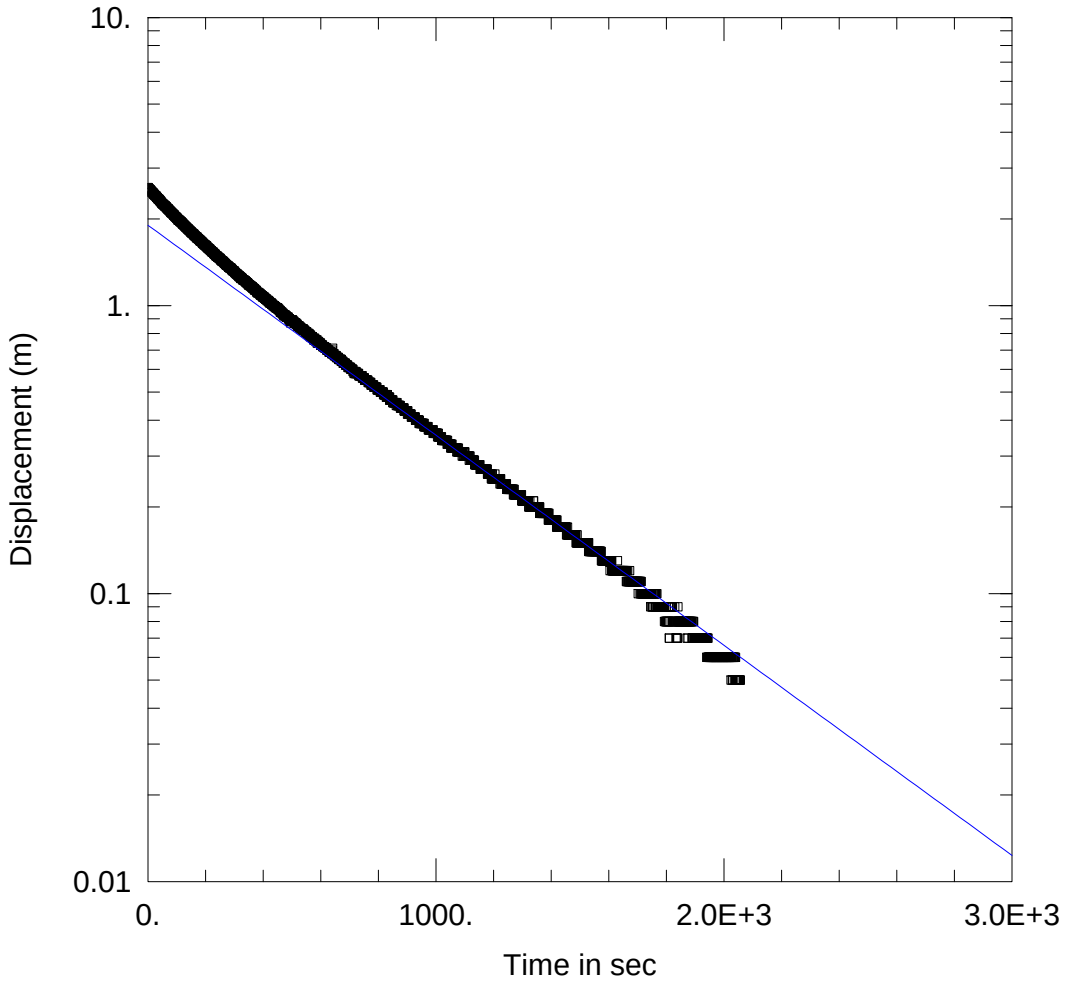
No freestanding groundwater observed in open borehole upon completion of drilling.
Groundwater depth observed on 7/7/2022 at a depth of: 2.8 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

Scale: 1 : 55

APPENDIX

B HYDRAULIC CONDUCTIVITY ANALYSIS



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: WSP
Client: Niagara Region
Project: IM20103036
Location: Thorold, Ontario
Test Well: BH/MW1
Test Date: July 7, 2022

AQUIFER DATA

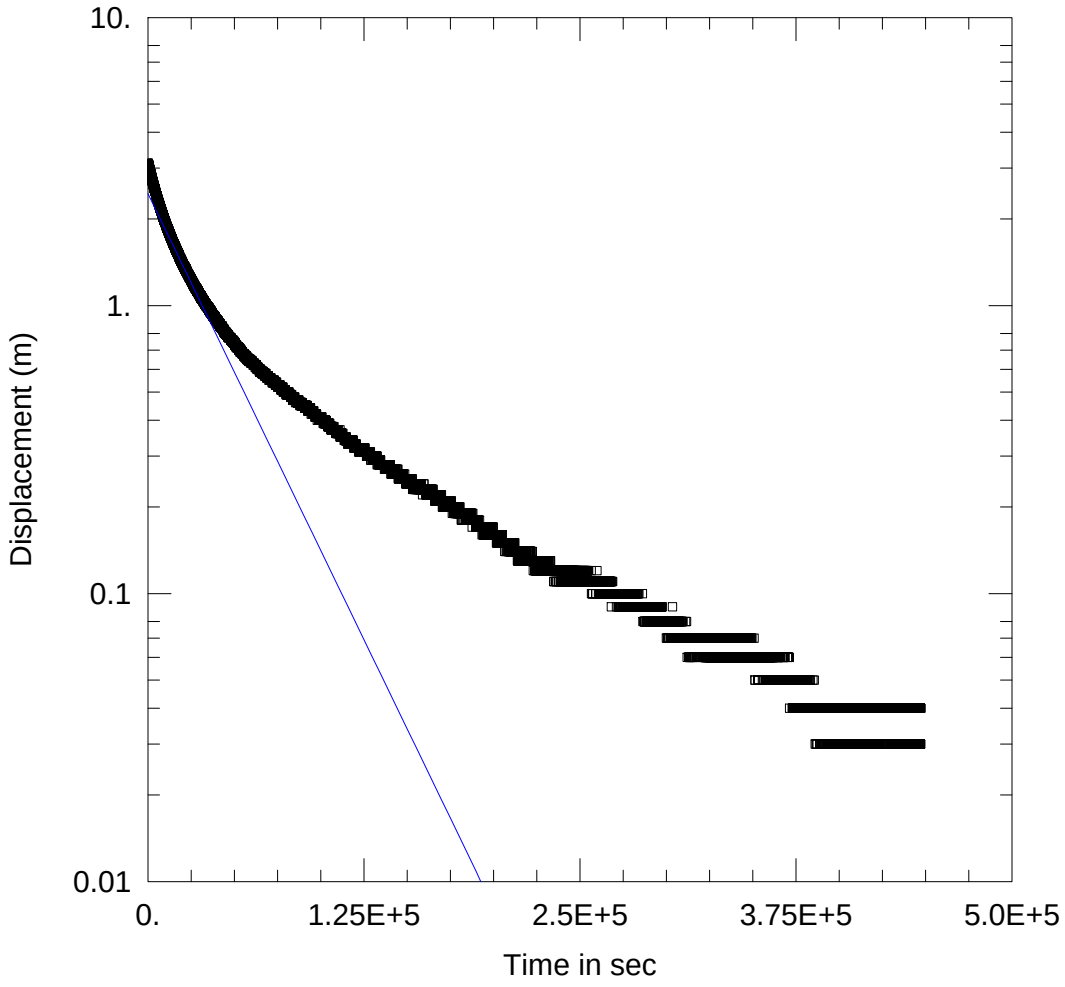
Saturated Thickness: 6.43 m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH/MW 1)

Initial Displacement: 2.57 m
Total Well Penetration Depth: 6.43 m
Casing Radius: 0.025 m
Static Water Column Height: 6.43 m
Screen Length: 3.05 m
Well Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined
K = 7.272E-7 m/sec
Solution Method: Bouwer-Rice
y0 = 1.9 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: WSP
Client: Niagara Region
Project: IM20103036
Location: Thorold, Ontario
Test Well: BH/MW2
Test Date: July 26, 2022

AQUIFER DATA

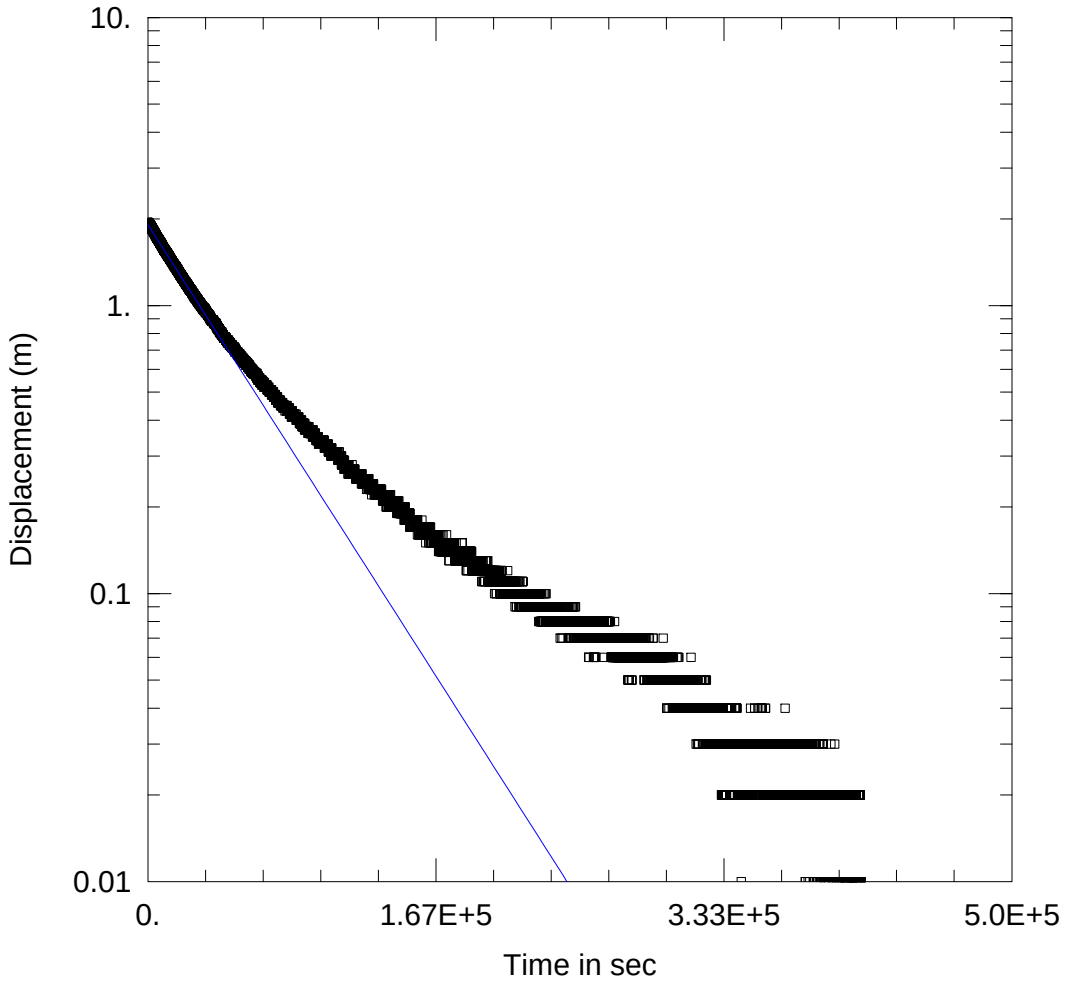
Saturated Thickness: 5.35 m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH/MW2)

Initial Displacement: 3.12 m
Total Well Penetration Depth: 5.35 m
Casing Radius: 0.0254 m
Static Water Column Height: 5.35 m
Screen Length: 3.7 m
Well Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined
K = 1.033E-8 m/sec
Solution Method: Bouwer-Rice
y0 = 2.444 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: WSP
Client: Niagara Region
Project: IM20103036
Location: Thorold, Ontario
Test Well: BH/MW3
Test Date: July 26, 2022

AQUIFER DATA

Saturated Thickness: 4.5 m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH/MW3)

Initial Displacement: 1.94 m
Total Well Penetration Depth: 4.5 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.5 m
Screen Length: 3.05 m
Well Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined
K = 9.16E-9 m/sec
Solution Method: Bouwer-Rice
y0 = 1.906 m

APPENDIX

C LIMITATIONS

Limitations

1. The work performed in the preparation of this document and the data, interpretations and recommendations presented are subject to the following:

   (a) WSP's Standard Terms and Conditions;

   (b) The Scope of Services;

   (c) Time and Budgetary limitations as described in our Contract; and,

   (d) The Limitations stated herein.

2. No other warranties or representations, either expressed or implied, are made as to the professional services provided under the terms of our Contract.

3. This document was prepared with the assumption that the design and construction will be in accordance with all applicable standards, codes and regulations of authorities having jurisdiction, as well as good engineering practice. Further, the recommendations and opinions in this document are applicable only to the subject project described above. Contractors should be aware that the data and their interpretations presented in this report might not be sufficient to assess all factors that may have an impact on the construction process.

4. The conditions presented in this document were based, in part, on visual observations of the site and on subsurface investigation. The number of boreholes may not be sufficient to determine all of the factors that may affect construction methods and costs. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations. Conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation.

5. Where testing was performed, it was carried out in accordance with the terms of our contract providing for testing. Other conditions may be present on site and may be revealed by different of other testing not provided for in our contract.

6. Because of the limitations referred to above, different conditions from those stated in our report may exist. There should be an ongoing liaison with WSP to ensure that the recommendations in this report have been interpreted and implemented as intended. In addition, if any further clarification and/or elaboration are needed, WSP should be contacted immediately.

7. This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or contract. Any use which any third party makes of the report, in whole or in part, or any reliance thereon, or decisions made based on any information in the report, is the sole responsibility of such third party. WSP accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on the report or anything set out therein.

WSP E&I Canada Limited .