Hydrogeological Study Report

Heritage Line Residential Development

Lot 14, Concession 6, Otonabee-South Monaghan

D.M. Wills Project Number 21-10985

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

September 2021

Prepared for:
Alina Stewart & Shawn Elmhirst

WILLS

Submissions Summary

Submission No.	Submission Title	Date of Release	Submissions Summary
0	Draft Hydrogeological Study Report	September 3, 2021	Draft Submission to Client
1	Final Hydrogeological Study Report	September 8, 2021	Final Submission to Client

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

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1.0 Introduction

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

Wills understands the Subject Property is approximately 5.6 hectares (ha) and the Client wishes to sever 20 residential lots that are expected to range in size from approximately 0.16 to 0.29 ha. Each residential lot is proposed to be serviced with a private on-site sewage disposal system and potable water supply will be provided via the Keene Heights Municipal Drinking Water System. The Study was requested in order to evaluate the suitability of the Subject Property to accommodate private on-site sewage disposal systems, and to determine the infiltration capacity of the subsurface soils as input to the design of the proposed Low Impact Development (LID) features.

Wills' field investigation was conducted concurrently under a shared scope with a Geotechnical Investigation (Geotechnical Report prepared by PRI Engineering Corp.) to ensure cost efficiencies and to provide additional data to inform both the Hydrogeological Study Report and the Geotechnical Investigation Report.

Legend

Subject Property

Subject Property Plan

Hydrogeological Study

Heritage Line Residential Development

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Checked: IA	Date: March, 2021
Project No.: 21-10985	Drawing File No.: Figure 1

2.0 Scope of Work

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

- Prior to initiating field investigations, public and private utility service locates were obtained and reviewed by Wills staff. Additionally, a Site-Specific Health and Safety Plan (HASP), and Fieldwork Plan were prepared to ensure a safe and efficient field work program.
- Twenty-one (21) boreholes were advanced on the Subject Property, four (4) of which were completed as monitor wells to facilitate groundwater level monitoring and sample collection.
- Eight (8) test pits were excavated proximal to the proposed sewage disposal system leaching bed. Test pits were originally located to investigate tentative locations for a communal sewage disposal system, however, private individual systems were ultimately chosen for the Proposed Development in view of site specific and regulatory constraints.
- Soil samples were collected and submitted to an accredited laboratory for analysis of Natural Moisture Content and Particle Size Distribution.
- Three (3) single ring infiltrometers were installed in the separate boreholes to determine representative infiltration rates of the shallow subsurface soils for LID design.
- Three (3) groundwater samples were collected from the monitor wells and submitted to an accredited laboratory for analysis of nitrate concentrations to support the Development Impact Assessment.
- A Development Impact Assessment was conducted to determine the carrying capacity of the Subject Property with respect to the Proposed Development.
- The results of Wills' field investigation and modelling were summarized in this Hydrogeological Study Report.

3.0 Subsurface Investigation

Wills retained Canadian Environmental Drilling & Contractors Inc. to advance twenty-one (21) boreholes at locations selected by Wills staff on the Subject Property from May 3 to May 5, 2021. A Client provided excavator was made available to Wills staff on April 28, 2021, and eight (8) test pits were excavated across the Subject Property. **Table 1** provides a summary of the boreholes, monitor wells and test pits completed for the subsurface investigation. Borehole, monitor well, test pit, and infiltration test locations are shown on **Figure 2.**

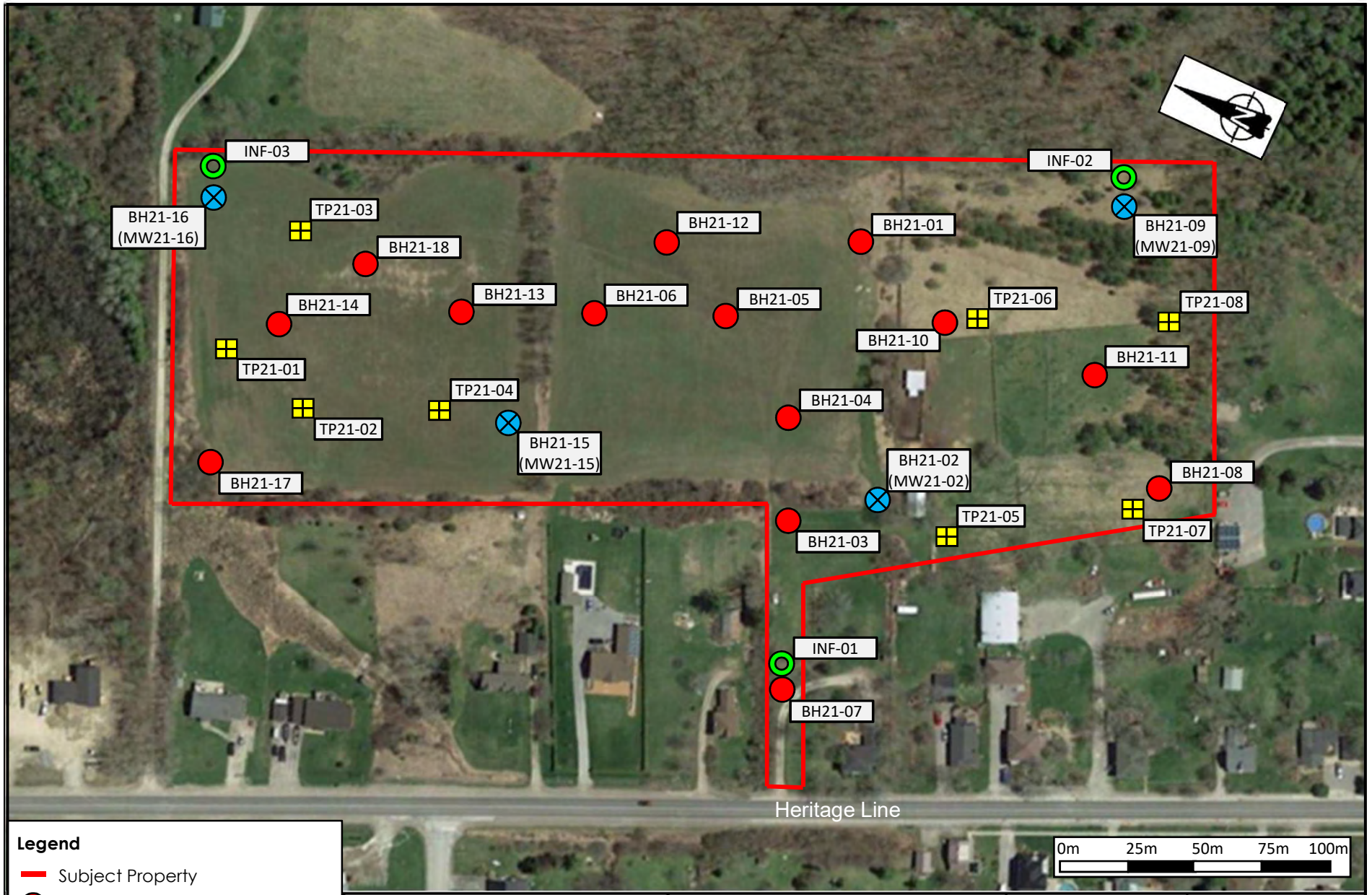
Table 1 – Borehole Summary

Borehole ID	Depth (mbg)	UTM Coordinates (Zone, Easting Northing)	Borehole Application
BH21-01	6.55	17T 0726565 4903233	Stratigraphic logging and soil sampling
BH21-02 (MW21-02)	6.55	17T 0726472 4903186	Stratigraphic logging and soil sampling, monitor well installation
BH21-03	2.00	17T 0726456 4903212	Stratigraphic logging and soil sampling
BH21-04	2.00	17T 0726491 4903229	Stratigraphic logging and soil sampling
BH21-05	2.00	17T 0726511 4903260	Stratigraphic logging and soil sampling
BH21-06	2.00	17T 0726496 4903309	Stratigraphic logging and soil sampling
BH21-07	2.00	17T 0726403 4903191	Stratigraphic logging and soil sampling
INF-01	1.45	Proximal to BH21-07	In-situ infiltration testing
BH21-08	6.55	17T 0726523 4903086	Stratigraphic logging and soil sampling
BH21-09 (MW21-09)	6.55	17T 0726615 4903148	Stratigraphic logging and soil sampling, monitor well installation
INF- 02	1.50	Proximal to BH21-09	In-situ infiltration testing
BH21-10	2.00	17T 0726552 4903179	Stratigraphic logging and soil sampling
BH21-11	5.05	17T 0726548 4903141	Stratigraphic logging and soil sampling
BH21-12	6.55	17T 0726526 4903296	Stratigraphic logging and soil sampling
BH21-13	2.00	17T 0726477 4903356	Stratigraphic logging and soil sampling
BH21-14	2.00	17T 0726452 4903413	Stratigraphic logging and soil sampling
BH21-15 (MW21-15)	6.55	17T 0726456 4903318	Stratigraphic logging and soil sampling, monitor well installation

Borehole ID	Depth (mbg)	UTM Coordinates (Zone, Easting Northing)	Borehole Application
BH21-16 (MW21-16)	6.55	17T 0726499 4903461	Stratigraphic logging and soil sampling, monitor well installation
INF-03	1.20	Proximal to BH21-16	In-situ infiltration testing
BH21-17	6.55	17T 0726401 4903421	Stratigraphic logging and soil sampling
BH21-18	6.55	17T 0726487 4903388	Stratigraphic logging and soil sampling
TP21-01	3.00	17T 0726438 4903429	Stratigraphic logging and soil sampling
TP21-02	3.30	17T 0726449 4903348	Stratigraphic logging and soil sampling
TP21-03	3.30	17T 0726497 4903410	Stratigraphic logging and soil sampling
TP21-04	3.30	17T 0726449 4903348	Stratigraphic logging and soil sampling
TP21-05	3.00	17T 0726474 4903154	Stratigraphic logging and soil sampling
TP21-06	3.00	17T 0726563 4903164	Stratigraphic logging and soil sampling
TP21-07	3.30	17T 0726517 4903086	Stratigraphic logging and soil sampling
TP21-08	3.30	17T 0726574 4903116	Stratigraphic logging and soil sampling

Subsurface soil samples collected by Wills staff during the field program were classified based on grain size, stratigraphy, and relative soil compactness. Representative soil samples were submitted to a Canadian Certified Independent Laboratory (CCIL) [PRI Engineering Corp.] for analysis of Natural Moisture Content and Particle Size Distribution, including sieve and hydrometer analysis. Laboratory testing results were compared to the Ministry of Municipal Affairs and Housing, Building and Development Branch (MMAH) Supplementary Standard SB-6 – Percolation Time and Soil Descriptions Table 2 and Table 3 values (Ontario Building Code [OBC], 2012) (OBC Table 2/3).

Borehole and test pit logs detailing the encountered subsurface conditions and monitor well construction details are included in **Appendix A**. The boreholes used to facilitate the installation of infiltrometers were advanced adjacent to existing boreholes and were not logged. In addition, soil samples were not collected from these boreholes due to the close proximity to the adjacent boreholes.



Subsurface Investigation Plan

Hydrogeological Study
Heritage Line Residential
Development

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Drawn By	HW	Scale	See scale bar
Checked	AT	Date	May, 2021
Project No.	21-10985	Drawing File No.	Figure 2

3.1 Soil Profile Summary

The Subject Property is located in the Physiographic Region of the Peterborough Drumlin Field (*The Physiography of Southern Ontario, Chapman and Putnam, 1984*), which is characterized by drumlinized till plains. Ontario Geological Survey (OGS) mapping suggests that surficial geology on the Subject Property consists of primarily coarse textured glaciolacustrine deposits. The western boundary borders a bedrock-drift complex in Paleozoic terrain, while the northwestern corner of the Subject Property includes fine textured glaciolacustrine deposits. Glaciolacustrine deposits were not encountered on the Subject Property, and the shallow subsurface soils were more closely aligned with silty sand till deposits that are suggested to be present directly northwest and southeast of the Subject Property. OGS classifies the underlying bedrock geology to be from the upper Ordovician period, and may be comprised of limestone, dolostone, shale, arkose, or sandstone. Geological mapping of the Subject Property has been included in **Appendix B**.

The results of the drilling program indicate the overburden is generally consistent across the Subject Property, with slight variations in gravel, sand, silt, and clay content. Generally, the subsurface profile consists of a surficial layer of silty sand topsoil variably underlain by silty sand, gravelly sand, and sandy silt, and a basal layer of gravelly to silty sand till material.

3.1.1 Top Soil

Top soil material was encountered at all of the borehole and test pit locations, and extended to depths ranging from approximately 0.30 to 0.75 meters below grade (mbg). The top soil material was generally described as silty sand, with trace amounts of clay and gravel. At the time of the field investigation, the top soil material was described as being moist to wet. The natural moisture content as determined by laboratory tests ranged from 17% to 33%. Based on Standard Penetration Test (SPT) N values between 1 to 4 blows per 305 mm of penetration, the topsoil material has a very loose relative compactness.

3.1.2 Silty Sand to Gravelly Sand

Silty sand to gravelly sand material was encountered beneath the topsoil layer at all boreholes with the exception of BH21-09 (MW21-09) and BH21-17, and extended to depths ranging from approximately 2.30 to 3.05 meters below grade (mbg). BH21-03 through BH21-14 were all terminated in the silty sand to gravelly sand material at an approximate depth of 2.0 mbg. This layer was described as sand with some gravel and some silt in BH21-11, and extended to a depth of approximately 2.3 mbg.

The silty sand to gravelly sand material generally contained some clay and occasional cobble material. At the time of the field investigation, this material was described as being moist to saturated. The natural moisture content as determined by laboratory tests for select boreholes ranged from 8% to 16%. Based on SPT N values between 3 to 65 blows per 305 mm of penetration, the silty sand to gravelly sand material has a very loose to very dense relative compactness. This material was predominantly loose to

compact, and it is likely that cobble material in select boreholes may have resulted in higher relative compactness values where encountered.

Three (3) laboratory particle size distribution analyses were completed on samples of the silty sand to gravelly sand. The results are summarized in **Table 2**, on the basis of the Unified Soil Classification System (USCS). Certificates of Analysis for the physical soil testing results are included in **Appendix C**.

The silty sand to gravelly sand material was visually and compositionally similar to the underlying glacial till material, and is interpreted to represent a naturally reworked deposit (i.e. secondary till deposit). A distinction between the primary and secondary deposits is shown on the borehole logs based on the contrasting SPT N values (lower SPT N Values for the shallower materials).

3.1.3 Sandy Silt

Sandy silt material was encountered beneath the topsoil layer at BH21-09 (MW21-09) and BH21-17, and extended to depths ranging from approximately 2.30 to 3.05 mbg, respectively.

The sandy silt material generally contained some clay, trace to some gravel, and occasional cobble material. At the time of the field investigation, this material was described as moist to wet. The natural moisture content as determined by laboratory tests ranged from 9% to 14%. Based on SPT N values between 8 to 15 blows per 305 mm of penetration, the sandy silt material has a loose to compact relative compactness.

Two (2) laboratory particle size distribution analyses were completed on samples of the sandy silt material. The results are summarized in **Table 2**, on the basis of the USCS. Certificates of Analysis for the physical soil testing results are included in **Appendix C**.

The sandy silt material is interpreted to represent a naturally reworked deposit (i.e. secondary till deposit). A distinction between the primary and secondary deposits is shown on the borehole logs based on the contrasting SPT N values.

3.1.4 Silty Sand to Gravelly Sand Till

Silty sand to gravelly sand till material was encountered beneath the inferred secondary till deposits in BH21-01, BH21-08, BH21-09, BH21-11, BH21-12, and BH21-15 through BH21-18. The till material was generally encountered below a depth of approximately 2.3 mbg, and was distinguished from the overlying secondary till deposits by SPT N Values that were generally greater than 20 blows per 305 mm of penetration. The till material contained trace to some clay, and occasional cobbles and/or boulders throughout the investigated depth.

At the time of the field investigation, the till material was described as moist to saturated. The natural moisture content as determined by laboratory tests ranged from 5% to 16%. Based on SPT N values between 19 to greater than 50 blows per 305 mm of penetration, the silty sand till material has a compact to very dense relative compactness.

Six (6) laboratory particle size distribution analyses were completed on samples of the till material. The results are summarized in **Table 2**, on the basis of the USCS. Certificates of Analysis for the physical soil testing results are included in **Appendix C**.

Table 2 – Summary of Particle Size Distribution

Borehole ID	Sample No.	Soil Unit	Gravel (3 in. to No. 4 Sieve) (%)	Sand (No. 4 to No. 200 Sieve) (%)	Silt and Clay (Passing No. 200 Sieve) (%)
BH21-01	SS6	Till	21	41	38
BH21-07	SS2	Silty Sand	6	47	47
BH21-08	SS4	Gravelly Sand	28	43	29
BH21-09	SS3	Sandy Silt	2	25	73
BH21-11	SS6	Till	19	48	33
BH21-12	SS6	Till	14	50	36
BH21-16	SS3	Silty Sand	5	46	49
BH21-17	SS5	Sandy Silt	10	35	55
TP21-02	GS2	Till	24	41	35
TP21-04	GS2	Till	7	57	36
TP21-05	GS2	Till	6	51	43

3.1.5 Bedrock

Bedrock was not encountered at any of the borehole locations. Although bedrock classification was beyond the scope of the Study, OGS Mapping (2007) indicates the local underlying bedrock geology includes limestone, dolostone, shale, arkose, or sandstone from the upper Ordovician period.

3.1.6 Groundwater

Four (4) boreholes were completed as monitor wells to facilitate groundwater level monitoring and sampling. **Table 3** summarizes the construction details and static groundwater levels and elevations measured during the Study. Additionally, **Table 3** provides a summary of groundwater level measurements recorded (where encountered) in the open boreholes prior to backfilling. Groundwater elevations were inferred from a topographic survey completed by Elliot and Parr (Peterborough) Ltd. On March 26, 2021 (Reference No.: 21-19-079-00). Ground surface elevations are shown on the borehole logs in **Appendix B.**

Table 3 – Monitor Well Construction and Groundwater Level Summary

Borehole ID	Construction Date	Borehole Depth/Screened Interval	Screened Material	Stick-Up	Groundwater Level Measurement Date	Groundwater Level/Elevation
BH21-02 (MW21-02*)	May 3, 2021	6.55 mbg 3.05 - 6.10 mbg	Till	0.09 mbg	May 11, 2021	0.70 mbg 224.78 masl
BH21-09 (MW21-09)	May 4, 2021	6.55 mbg 3.05 - 6.1mbg	Till	1.07 mag	May 11, 2021	3.99 mbg 209.24 masl
BH21-15 (MW21-15)	May 5, 2021	6.55 mbg 3.05 – 6.1 mbg	Till	0.98 mag	May 11, 2021	0.91 mbg 224.43 masl
BH21-16 (MW21-16)	May 5, 2021	6.55 mbg 3.05 – 6.1 mbg	Till	0.92 mag	May 11, 2021	1.74 mbg 221.07 masl
BH21-03	May 3, 2021	2.00 mbg	-	-	May 5, 2021	1.32 mbg 223.79 masl
BH21-05	May 3, 2021	2.00 mbg	-	-	May 3, 2021	1.20 mbg 223.58 masl
BH21-08	May 4, 2021	6.55 mbg	-	-	May 4, 2021	2.80 mbg 219.79
BH21-11	May 4, 2021	5.05 mbg	-	-	May 4, 2021	4.60 mbg 219.10 masl
BH21-12	May 4, 2021	6.55 mbg	-	-	May 4, 2021	2.10 mbg 223.21 masl
BH21-13	May 4, 2021	2.00 mbg	-	-	May 4, 2021	1.22 mbg 222.83 masl
BH21-17	May 5, 2021	6.55 mbg	-	-	May 5, 2021	4.00 mbg 216.53 masl
BH21-18	May 5, 2021	6.55 mbg	-	-	May 5, 2021	4.60 mbg 219.09 masl

Notes: Monitor wells installed with monument casing unless otherwise noted.

*Monitor wells installed with flush mount casing.

Mbg – meters below grade, mag – meters above grade, masl – meters above sea level

3.1.7 Groundwater Analysis

Three (3) groundwater water samples were collected from monitor well MW21-02, MW21-09, and MW21-16 on May 11, 2021, and submitted to SGS Canada Inc. (SGS) for total nitrogen analysis. The total nitrogen analysis results were used to support Wills Development Impact Assessment discussed in **Section 5.0**. Certificates of Analysis are included in **Appendix D**.

3.2 In-Situ Infiltration Testing

In-situ infiltration testing was completed in boreholes INF-01, INF-02, and INF-03. Infiltrometer construction details are summarized in **Table 4** and infiltration testing locations are shown on **Figure 2**. Infiltration tests were completed adjacent to deeper boreholes as a means of verifying the underlying stratigraphy below the infiltration testing depth. INF-01, INF-02, and INF-03 were positioned in select locations across the Subject Property at the discretion of Wills engineering design team, as a means of confirming the infiltration capacity of the underlying soils for LID design. Wills understands that the proposed LID features will be situated within the roadside ditches that generally transect the central portion of the Subject Property in an east-west direction. A Preliminary Servicing and Grading Plan showing the location of the proposed roadway is included in **Appendix E.**

Table 4 – Infiltrometer Construction Summary

Infiltrometer ID	Construction Date	Construction Details	Stick-Up
INF-01	May 10, 2021	51 mm diameter open-end single ring infiltrometer	0.02 mbg
INF-02	May 10, 2021	51 mm diameter open-end single ring infiltrometer	0.01 mag
INF-03	May 10, 2021	51 mm diameter open-end single ring infiltrometer	0.30 mag

The infiltrometers were seated into the undisturbed material at the base of each borehole prior to initiating the infiltration tests. Hydrated bentonite pellets were used as an annular seal above the infiltrometer opening, to ensure that water used during the test could only migrate into the underlying soils.

Water levels within the infiltrometer casings were manually monitored using a Solinst water level tape at each location. The infiltration tests were conducted for a maximum of 24.6-hours, with water levels measured at 30-second intervals for the first 5-minutes, and increasing intervals as the test progressed.

An additional infiltration test was proposed to be completed proximal to BH21-08; however, following completion of the infiltration test borehole, shallow groundwater was observed in above the proposed infiltration testing depth of 1.7 mbg.

Based on input from Wills engineering design team, the infiltration test proximal to BH21-08 was determined to be unnecessary, as the shallow groundwater conditions (saturated soils) would preclude an effective design for LID features in the proposed location.

3.3 In-situ Infiltration Testing Results

The infiltration testing results at each location are summarized in **Table 5, Table 6** and **Table 7.** Detailed calculations and supporting infiltration graphs are provided in **Appendix F.**

Table 5 – In-situ Infiltration Testing Results (INF-01)

	Test INF-01
Test Duration (seconds)	88,560
Total Drop Distance (mm)	1395
Total Number of Measured Intervals	39
Infiltration Rate (mm/sec) - Test Average	1.01
Infiltration Rate (mm/hour)	**3.65×10^3**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)	**0.16**

Notes: 1. Observed infiltration rate was determined using manual measurements of falling head in periodic intervals.

Table 6 – In-situ Infiltration Testing Results (INF-02)

	Test INF-02
Test Duration (seconds)	5,880
Total Drop Distance (mm)	621
Total Number of Measured Intervals	36
Infiltration Rate (mm/sec) - Test Average	0.148
Infiltration Rate (mm/hour)	**532**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)	**1.13**

Notes: 1. Observed infiltration rate was determined using manual measurements of falling head in periodic intervals.

Table 7 – In-situ Infiltration Testing Results (INF-03)

	Test INF-03
Test Duration (seconds)	70,860
Total Drop Distance (mm)	250
Total Number of Measured Intervals	23
Infiltration Rate (mm/sec) - Test Average	3.25×10^{-3}
Infiltration Rate (mm/hour)	**11.7**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)	**51.30**

Notes: 1. Observed infiltration rate was determined using manual measurements of falling head in periodic intervals.

4.0 Permeability and Percolation Time

Percolation rates were estimated on the basis of physical soil characteristics determined through laboratory testing, and were compared against the in-situ infiltration testing results.

From the field observations and the physical soil testing results, the encountered soils within the investigation area were classified based on the USCS. **Table 8** summarizes the permeability and percolation times of the encountered soils on the basis of OBC Table 2.

Table 8 – Permeability and Percolation Time Summary

Borehole ID	Sample ID	Physical Soil Testing Results	Percolation Range	Laboratory Estimated Percolation (T)	Permeability
BH21-09 (MW21-09) *Proxy for INF-02*	SS-3	SM envelope	T = 8 – 20 min/cm or 30 – 75 mm/hr	T = 30 min/cm	Medium to low
		ML envelope	T = 20 – 50 min/cm or 12 – 30 mm/hr		Medium to low
BH21-16 (MW21-16) *Proxy for INF-03*	SS-3	SM envelope	T = 8 – 20 min/cm or 30 – 75 mm/hr	T = 20 min/cm	Medium to low
		ML envelope	T = 20 – 50 min/cm or 12 – 30 mm/hr		Medium to low
TP21-02	GS-2	SM envelope	T = 8 – 20 min/cm or 30 – 75 mm/hr	T = 15 min/cm	Medium to low
		ML envelope	T = 20 – 50 min/cm or 12 – 30 mm/hr		Medium to low
TP21-04	GS-2	SM envelope	T = 8 – 20 min/cm or 30 – 75 mm/hr	T = 13 min/cm	Medium to low
		ML envelope	T = 20 – 50 min/cm or 12 – 30 mm/hr		Medium to low
TP21-05	GS-2	SM envelope	T = 8 – 20 min/cm or 30 – 75 mm/hr	T = 20 min/cm	Medium to low
		ML envelope	T = 20 – 50 min/cm or 12 – 30 mm/hr		Medium to low

Notes: 1. SM envelope –silty sands, sand-silt mixtures
ML envelope – inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity

In-situ infiltration tests INF-01 and INF-02 were conducted in the gravelly sand to silty sand material, and INF-03 were conducted the sandy silt material. The gravelly sand to silty sand material is expected to generally fall within the SM soil envelope due to its coarse-grained nature. The sandy silt material is expected to generally fall within the ML envelope due to it fine-grained nature.

In-situ infiltration testing completed at INF-01and INF-02 suggests the shallow subsurface soils have a much lower T-Time (higher infiltration rate) than that provided in OBC Table 2 for the SM and ML soil envelopes. It should be noted that it was difficult to properly seat the infiltrometer in the coarse soils (which included coarse gravel and cobble components), and thus, the in-situ T-times may have been impacted as a result.

In-situ infiltration testing completed at INF-03 suggests the shallow subsurface soils have a T-Time that approximates the upper limit for that which is provided in OBC Table 3 for the ML soil envelope.

T-Time for the tested soils as derived from the infiltration tests were as follows:

- INF-01: T-Time = 0.16 min/cm
- INF-02: T-Time = 1.13 min/cm
- INF-03: T-Time = 51.30 min/cm

T-Times for INF-01 and INF-02 more closely approximate that for the gravels and gravel sand mixtures on the basis of OBC Table 2. In view of the relative compactness, and well graded nature of the tested soils (including notable clay and silt fractions that are expected to reduce the infiltration capacity) the observed infiltration rates are more likely a result of the testing deficiencies noted above.

It should be noted that sandy silt material (INF-03) was only encountered in two (2) boreholes that were located on the periphery of the Subject Property, and this material is not likely to be encountered beneath the proposed LID features. Wills anticipates that the proposed LID features will be situated over the gravelly sand to silty sand soils that are expected to generally fall with the SM soil envelope.

In view of the in-situ infiltration results, physical soils testing results, and locations of the proposed LID features in context of the encountered subsurface soils, Wills recommends that a T-time of 20 min/cm be used as input into the design of proposed LID features of the subject property. This T-time reflects the upper limit provided for the SM soil envelope in OBC Table 2, and is considered conservative. Furthermore, in view of the consistent subsurface profile encountered across the Subject Property, Wills recommends that the T-time of 20 min/cm should also be used an input into the design of the proposed on-site sewage disposal systems.

5.0 Development Impact Assessment

Wills understands that the Proposed Development will include 20 residential lots, with each lot containing a three-bedroom dwelling. Anticipated daily flows to the sewage disposal systems were estimated to be 3,500 L/day on the basis of *Table 8.2.1.3.A. Residential Occupancy* in the OBC Part 8 – Sewage System. As average flows are anticipated to be less than 4,500 L/day/lot, Wills' Development Impact Assessment was conducted on the basis of the Ministry of the Environment, Conservation and Parks (MECP) *Procedure D-5-4 (D-5-4) Technical Guideline for Individual On-Site Sewage Systems: Water Quality Risk Assessment* to determine the feasibility and potential for

impacts to down-gradient water resources arising from the installation of the proposed on-site sewage disposal systems.

Nitrate, a conservative parameter, was used to assess the impact of sewage effluent on the groundwater environment. D-5-4 requires that the effluent plume at the boundary of the Subject Property to be within the Ontario Drinking Water Quality Standards (ODWQS) limit of 10 mg/L for nitrate to prevent off-site contamination. Although natural processes and soil interaction can result in nitrate being attenuated in the receiving aquifer system, D-5-4 states that dilution is to be used as the principal attenuation mechanism. As such, a mass balance calculation is required to determine the impact of development on the Subject Property.

5.1 Total Available Dilution

The total available dilution for the Subject Property was obtained using the following equation:

$$\mathbf{Q_i = A \times S \times I}$$

Where Q_i = Volume of available dilution water

A = Area of the Subject Property

S = Surplus of water

I = Infiltration Factor

$Q_i = 46{,}010\ m^2 \times 0.273$ m per year $\times\ 0.7$

$Q_i \approx 8{,}800\ m^3$ per year

$$\mathbf{Q_i \approx 24.1\ m^3\ per\ day \approx 24{,}100\ L\ per\ day}$$

The methods used to determine the inputs into the above equation are described in **Section 5.1.1** through **Section 5.1.3.**

5.1.1 Area of Subject Property

The area of the Subject Property was calculated using information provided by Wills engineering design team, as summarized in **Table 9.**

Table 9 – Area of Subject Property Calculations

Parameter	Value
Site Property Area including impervious surfaces	5.63 ha (56,300 m^2)
Area of Impervious Surfaces (Includes houses, driveways, roadways, and paved walkways)	1.029 ha (10,290 m^2)
Site Property Area (Q_i)	**4.601 (ha) (46,010 m^2)**

On the basis of D-5-4, impervious surfaces were excluded from the dilution calculations, as these surfaces are expected to limit the amount of precipitation that can infiltrate into the shallow subsurface and contribute to dilution.

5.1.2 Surplus Water

The Environment Canada climate database was consulted for historical precipitation and climate information pertaining to the Subject Property. The information provided below was obtained from the Peterborough Trent University climatology station, which is located approximately 16 km northwest of the Subject Property. Climate normals for the years 1981-2010 are summarized in **Table 10** (Environment Canada, 2019).

Table 10 – Climate Normals (Peterborough Trent University 1981-2010)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Daily Temp (°C)	-8.4	-6.5	-1.3	6.3	12.8	18.0	20.7	19.4	15.0	8.4	2.4	-4.0
Rainfall (mm)	22.4	23.1	34.0	60.9	88.7	83.0	73.6	87.0	92.4	75.7	73.3	35.0
Snowfall (mm)	38.9	28.8	23.7	6.1	0.0	0.0	0.0	0.0	0.0	1.4	13.9	34.3
Precipitation (mm)	57.3	48.8	56.5	66.4	88.7	83.0	73.6	87.0	92.4	77.0	85.5	66.0

Wills collected monthly temperature and precipitation data from the Peterborough Trent University Climatological Station to calculate monthly annual precipitation and monthly annual surplus after evapotranspiration (Thornthwaite method), which informed the amount of available surplus water that could can be used for dilution. Temperature and precipitation data are summarized in **Table 11**.

Table 11 – Water Budget

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Daily Temp (°C)	-8.4	-6.5	-1.3	6.3	12.8	18.0	20.7	19.4	15.0	8.4	2.4	-4.0
Evapotranspiration (mm)	0.0	0.0	0.0	32.4	62.9	114.0	133.6	126.5	88.5	40.7	9.5	0.0
Precipitation (mm)	57.3	48.8	56.5	66.4	88.7	83.0	73.6	87.0	92.4	77.0	85.5	66.0
Surplus (mm)	57.3	48.8	56.5	34.0	25.8	-31.0	-60.6	-39.5	3.9	36.3	76.0	66.0

The following information is provided based on the Peterborough Trent University climatology station information summarized in **Table 11**:

Total Annual Precipitation: 822 mm

Average Annual Surplus after evapotranspiration: 273 mm (Thornthwaite Monthly Water Balance Model)

Maximum Monthly Deficit: approximately 61 mm (in July)

5.1.3 Infiltration Factor

To determine the fraction of surplus water that infiltrates in the shallow subsurface soils, the volume of surplus water is multiplied by an infiltration factor. The infiltration factor ranges from 0 to 1 and is estimated based on topography, soils and cover (as per the *Stormwater Management Planning and Design Manual* [Ministry of the Environment, 2003]). Input used to determine the infiltration factor are summarized in **Table 12:**

Table 12 – Infiltration Factor Determination

Factor	Value
Topography	0.25
Soils	0.3
Cover	0.15
Infiltration Factor	**0.7**

5.2 Predictive Assessment

Based on the 2012 OBC, each of the proposed twenty (20) three-bedroom dwellings (one [1] per lot) are expected have a daily design flow of 3,500 L/day. Total nitrogen (all species) are assumed to convert to nitrate through the wastewater treatment process. Nitrate is considered the critical contaminant in sewage effluent. On the basis of D-5-4, a nitrate loading of 40 g/lot/day is recommended to be used in determining the effluent loading from conventional sewage disposal systems on the receiving groundwater.

In order to properly evaluate the impact of a sewage disposal system on a groundwater resource, a reference point or value is established to assist in determining the extent of the impact, if any. Groundwater samples were collected from monitor wells located on the Subject Property, and analyzed for nitrogen (all species) as discussed in **Section 3.1.5**. The lowest total nitrogen value (0.063 mg/L) was used as the background nitrate concentration, as the other two (2) values were significantly higher, and were collected from monitor wells located directly adjacent to a horse-barn, grazing area, and known agricultural uses.

To determine the adequate lot density for the Subject Property, a mass balance calculation was used to determine the sewage loading for nitrate at the property boundary.

$$\mathbf{Q_tC_t = Q_eC_e + Q_iC_i}$$

Where Q_t = Total Volume (Q_e + Q_i)

Note: As per the requirements of D-5-4, the maximum volume of effluent allowed to be used as dilution water is 1000L/day/lot.

C_t = Total Concetration of nitrate at property boundary

Q_e = volume of septic effluent

C_e = Concentration of nitrate in effluent (40 mg/L)

Q_i = Volume of available dilution water

C_i = Concentration of nitrate in dilution water (0.063 mg/L)

In order to determine the concertation of the nitrate at the property boundary (C_t), the mass balance equation is rearranged to the following:

$$\boldsymbol{Ct = \frac{QeCe + QiCi}{Qt}}$$

The results from using the above equation are outlined below:

Table 13 – Predictive Assessment of Nitrate Concentration

Parameter	Value
Number of Lots	20
Volume of Effluent (Q_e)	20 lots x 3,500 L/day = 70,000 L/day
C_e	40 mg/L
Q_i	24,100 L/day
C_i	0.063 mg/L
Q_t	20 Lots x 1,000 L/day = 20,000 L/day 20,000 L/day + 24,100 L/day = 44,100 L/day
C_t	**63.5 mg/L**

In view of the results presented in **Table 3,** Wills concludes that without advanced treatment, the Proposed Development would result in unacceptable levels of nitrate at the property boundary.

In order to achieve acceptable nitrate levels as outlined in the ODWQS, Wills has determined that the sewage effluent must be treated to contain no more than **6.3 mg/L** nitrate as N when leaving the system.

6.0 Conclusions and Recommendations

D.M. Wills Associates Limited (Wills) was retained to complete a Hydrogeological Study (Study) for the property located on Lot 14, Concession 6 in the municipality of Otonabee-South Monaghan, east of Heritage Line in Keene, Ontario. The Study was conducted to inform the suitability and design of proposed on-site sewage disposal systems, and to determine the infiltration capacity of the subsurface soils and shallow groundwater conditions as input to the design proposed LID features. The following conclusions with respect to Wills' Study are provided.

- Twenty-one (21) boreholes were advanced on the Subject Property between May 3 to May 5, 2021, and eight (8) test pits were excavated on the Subject Property on April 28, 2021.
- Shallow subsurface soils were generally consistent across the Subject Property, and included a thin layer of silty sand topsoil underlain by silty to gravelly sand with minor

sandy silt (secondary till deposit), and a basal layer silty to gravelly sand till (primary till deposit), with varying amounts of clay, cobble, and boulder material.

- Four (4) monitor wells were installed and static groundwater level measurements were recorded on May 11, 2021.
- Static groundwater levels ranged from 0.70 mbg (224.78 masl) to 3.99 mbg (209.24 masl) in the four (4) monitor wells.
- Groundwater level measurements recorded in open boreholes prior to backfilling ranged from 1.20 mbg (223.79 masl) to 4.6 mbg (219.10 masl).
- All eight (8) test pits were free of groundwater accumulation prior to backfilling, however, minor and isolated groundwater seepage was noted from discontinuous centimeter to decimeter-scale coarse-grained lenses.
- Three (3) groundwater samples were submitted for total nitrogen analysis to support the Development Impact Assessment.
- Eleven (11) laboratory particle size distribution analyses and laboratory percolation estimates were completed on representative samples of the till material.
- Three (3) in-situ infiltration tests INF-01, INF-02, and INF-03 were conducted on May 10, 2021. T-Times were calculated to be 0.16, 1.13, and 51.3 min/cm, respectively.
- The relatively low T-times (high infiltration rate) determined for INF-01 and INF-02 were attributed to infiltration test deficiencies. The T-time for INF-03 approximates the high end of the range provided for the M.L. soil envelope, however, these soils were only encountered on the margins of the Subject Property and are not anticipated to underlie the proposed LID features or sewage disposal systems.
- A review of the physical soil characteristics and comparison against OBC Table 2 and Table 3 suggests a percolation time (T-Time) between 8 to 50 min/cm for the native till material. Laboratory percolation estimates suggest the T-time ranges from 13 min/cm to 30 min/cm.
- In view of the in-situ infiltration testing and physical soil testing results, and the location of the proposed LIDs features and sewage disposal systems in context of the encountered subsurface soils, Wills recommends that a T-time of 20 min/cm be used for design purposes. This T-time reflects the upper limit provided for the SM soil envelope in OBC Table 2, and is considered conservative.
- Any proposed LID and sewage disposal system design should consider the shallow groundwater depths encountered on the Subject Property, which are expected to impact the respective designs in the areas investigated by Wills.
- Infiltration rates and percolation times may vary across the Subject Property, as topography, moisture content, soil gradation and relative compactness will affect in-situ infiltration rates.
- A Development Impact Assessment was conducted by Wills to determine the suitability of the Subject Property to accommodate private on-site sewage disposal systems.

- The Development Impact Assessment considered 20 residential lots, each containing one (1) three-bedroom dwelling and an on-site sewage disposal system with a daily design flow of 3,500 L/day. Each residential dwelling will require advanced treatment of the sewage effluent in order to meet the 6.3 mg/L requirement at the property boundary.
- The Subject Property is able to support the Proposed Development, provided that the sewage effluent is treated to contain no more than 6.3 mg/L nitrate as N prior to leaving the systems.

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

Respectfully submitted,

Prepared by: _____
Steven Krieger, P.Eng.
Environmental Engineer

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

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

SK/IA/avg

Statement of Limitations

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

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

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

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

Appendix A

Borehole and Test Pit Logs

BORING NUMBER BH21-01

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/3/21 **COMPLETED** 5/3/21
GROUND ELEVATION 225.24 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726565 **NORTHING** 4903233
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	69	2-2-2-3 (4)			Topsoil: Dark brown silty sand topsoil, trace gravel, moist, very loose	
						0.75	224.49
1	SS 2	93	6-9-5 (14)			Silty Gravelly Sand: Light brown silty gravelly sand, some clay, occasional cobble, moist, compact	
	SS 3	85	3-4-6 (10)				
2							
						2.30	222.94
	SS 4	96	4-5-14 (19)			Till: Light brown silty gravelly sand till, some clay, occasional cobble, moist to wet, compact	
3							
	SS 5	89	8-18-27 (45)			-Grey, dense to very dense	
4	SS 6	59	18-35-50 (85)	GSA SS-6: Gravel: 21% Sand: 41% Silt: 25% Clay: 13%			
	SS 7	100	18-35-38 (73)				
5							
6							
	SS 8	22	50			-Light brown	
						6.55	218.69
						Borehole terminated at 6.55 meters below grade in silty gravelly sand till. Borehole open, no ponded water prior to backfill.	

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-03

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/3/21 **COMPLETED** 5/3/21
GROUND ELEVATION 225.11 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING 1.32 m / Elev 223.79 m
EASTING 726456 **NORTHING** 4903212
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	79	1-1-1-2 (2)		Topsoil: Dark brown silty sand topsoil, moist, very loose	
					0.75	224.36
1	SS 2	91	6-12-12 (24)		Gravelly Sand: Light brown gravelly sand, some silt, some clay, occasional cobble, wet to saturated, compact	
	SS 3	92	1-5-6 (11)			
2					2.00	223.11

Borehole terminated at 2.0 meters below grade in gravelly sand till. Borehole open, groundwater at 1.3 meters below grade following completion.

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-04

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/3/21 **COMPLETED** 5/3/21
GROUND ELEVATION 224.39 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726491 **NORTHING** 4903229
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	69	1-1-1-2 (2)		Topsoil: Dark brown silty sand topsoil, moist, very loose	
					0.75	223.64
1	SS 2	93	5-4-7 (11)		Gravelly Sand: Light brown/grey gravelly sand, some silt, some clay, orange-brown mottles, moist to wet, compact	
	SS 3	75	7-6-5 (11)			
2					2.00	222.39
					Borehole terminated at 2.0 meters below grade in gravelly sand till. Borehole open, no ponded water prior to backfill.	

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-05

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/3/21 **COMPLETED** 5/3/21
GROUND ELEVATION 224.78 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING 1.20 m / Elev 223.58 m
EASTING 726511 **NORTHING** 4903260
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	75	0-0-2-3 (2)		Topsoil: Dark brown silty sand topsoil, moist, very loose	
					0.40	224.38
					Gravelly Sand: Light brown gravelly sand, some silt, some clay, moist, loose	
1	SS 2	74	5-5-2 (7)		-Wet to saturated	
					-Grey, silty, some gravel, compact	
2	SS 3	90	4-5-7 (12)		2.00	222.78

Borehole terminated at 2.0 meters below grade in gravelly sand till. Borehole open, groundwater at 1.2 meters below grade following completion.

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-06

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/3/21 **COMPLETED** 5/3/21
GROUND ELEVATION 224.77 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726496 **NORTHING** 4903309
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	70	0-0-2-3 (2)		Topsoil: Dark brown silty sand topsoil, moist, very loose	
					0.75	224.02
1	SS 2	93	5-7-10 (17)		Gravelly Sand: Light brown gravelly sand, some silt, some clay, moist, compact	
	SS 3	52	3-7-10 (17)			
2					2.00	222.77
					Borehole terminated at 2.0 meters below grade in gravelly sand till. Borehole open, no ponded water prior to backfill.	

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-07

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/3/21 **COMPLETED** 5/3/21
GROUND ELEVATION 227.56 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726403 **NORTHING** 4903191
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	44	1-2-1-2 (3)			Topsoil: Dark brown silty sand topsoil, trace gravel, moist, very loose	
						0.75	226.81
1	SS 2	80	4-6-25 (31)	GSA SS-2: Gravel: 6% Sand: 47% Silt: 30% Clay: 17%		Silty Sand: Light brown silty sand, some clay, trace gravel, moist, dense	
	SS 3	71	4-4-7 (11)			-Light brown/grey, gravely, occasional cobble, compact	
2						2.00	225.56

Borehole terminated at 2.0 meters below grade in silty sand till. Borehole open, no ponded water prior to backfill.

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-08

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/4/21 **COMPLETED** 5/4/21
GROUND ELEVATION 222.49 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING 2.70 m / Elev 219.79 m
EASTING 726523 **NORTHING** 4903086
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION
	SS 1	52	0-1-0-1 (1)	MC = 20%		Topsoil: Dark brown silty sand topsoil, moist, very loose
				GSA SS-2: Gravel: 28% Sand: 43% Silt: 17% Clay: 12%		0.75 221.74 Gravelly Sand: Light brown gravelly sand, some silt, some clay, moist, compact
1	SS 2	59	7-4-7 (11)	MC = 10%		
	SS 3	33	3-3-3 (6)	MC = 12%		-Light brown/grey, wet to saturated, loose
2						
	SS 4	89	4-5-10 (15)	MC = 8%		-Compact ▼
3						3.05 219.44
	SS 5	100	7-15-27 (42)	MC = 10%		Till: Light brown/grey gravelly sand till, some silt, some clay, wet to saturated, dense
4	SS 6	54	23-50	MC = 10%		-Very dense
	SS 7	33	50	MC = 10%		-Occasional cobble
5						
6						
	SS 8	43	20-50	MC = 7%		6.55 215.94
						Borehole terminated at 6.55 meters below grade in gravelly silty sand till. Borehole caved to 3.7 meters below grade, groundwater at 2.7 meters below grade.

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-10

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/4/21 **COMPLETED** 5/4/21
GROUND ELEVATION 224.3 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726552 **NORTHING** 4903179
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	61	1-1-1-3 (2)		Topsoil: Dark brown silty sand topsoil, moist, very loose	
					0.75	223.55
1	SS 2	100	8-11-10 (21)		Gravelly Sand: Light brown gravelly sand, some silt, some clay, moist, compact	
	SS 3	75	2-2-5 (7)		-Loose	
2					2.00	222.30
					Borehole terminated at 2.0 meters below grade in gravelly sand till. Borehole open, no ponded water prior to backfill.	

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-11

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/4/21 **COMPLETED** 5/4/21
GROUND ELEVATION 223.7 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING 4.60 m / Elev 219.10 m
EASTING 726548 **NORTHING** 4903141
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION
	SS 1	41	1-1-1-6 (2)			Topsoil: Dark brown silty sand topsoil, trace gravel, moist, very loose
						0.75 222.95
1	SS 2	78	6-23-7 (30)			Sand: Light brown sand, some gravel, some silt, some clay, occasional cobble, moist, compact
	SS 3	100	1-5-5 (10)			-Wet
2						2.30 221.40
	SS 4	100	4-10-13 (23)			Till: Light brown sand till, some gravel, some silt, some clay, occasional cobble, moist to wet, compact
3	SS 5	89	10-23-18 (41)			-Dense
4	SS 6	83	13-20-37 (57)	GSA SS-6: Gravel: 19% Sand: 48% Silt: 19% Clay: 14%		-Very dense
	SS 7	69	9-22-50 (72)			-Light brown/grey
5						5.05 218.65
						Borehole terminated at 5.05 meters below grade on assumed boulder material. Borehole open, groundwater at 4.6 meters below grade following completion.

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-12

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/4/21 **COMPLETED** 5/4/21
GROUND ELEVATION 225.31 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING 2.10 m / Elev 223.21 m
EASTING 726526 **NORTHING** 4903296
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION
	SS 1	67	1-1-1-3 (2)	MC = 17%		Topsoil: Dark brown silty sand topsoil, moist, very loose
						0.75 224.56
1	SS 2	72	4-5-2 (7)	MC = 10%		Silty Sand: Light brown silty sand, some clay, trace gravel, occasioanl cobble, wet, loose
	SS 3	61	2-2-7 (9)	MC = 9%		
2						▼
						2.30 223.01
	SS 4	93	3-10-15 (25)	MC = 8%		Till: Light brown silty sand till, some clay, trace gravel, occasional cobble, wet, compact
3						
	SS 5	28	50	MC = 9%		-Very dense
				GSA SS-6: Gravel: 14% Sand: 50% Silt: 21% Clay: 15%		
4	SS 6	93	17-31-50 (81)	MC = 7%		-Some gravel, moist
	SS 7	83	23-20-50 (70)	MC = 8%		-Moist to wet
5						
6						
	SS 8	89	3-8-50 (58)	MC = 10%		-Light brown/grey, wet
						6.55 218.76
						Borehole terminated at 6.55 meters below grade in silty sand till. Borehole caved to 2.1 meters below grade, groundwater at 2.1 meters below grade following completion.

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-13

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/4/21 **COMPLETED** 5/4/21
GROUND ELEVATION 224.05 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING 1.22 m / Elev 222.83 m
EASTING 726477 **NORTHING** 4903356
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	87	0-1-1-1 (2)		Topsoil: Dark brown silty sand topsoil, moist, very loose	
				0.30		223.75
					Gravelly Sand: Light brown gravelly sand, some silt, some clay, moist, loose	
1	SS 2	104	1-2-3 (5)		-Moist to wet	
	SS 3	88	3-8-10 (18)		-Compact	
2				2.00		222.05

Borehole terminated at 2.0 meters below grade in gravelly sand till. Borehole open, groundwater at 1.2 meters below grade following completion.

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-14

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/4/21 **COMPLETED** 5/4/21
GROUND ELEVATION 222.71 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726452 **NORTHING** 4903413
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	59	0-1-3-2 (4)		Topsoil: Dark brown silty sand topsoil, moist, very loose	
					0.75	221.96
1	SS 2	80	7-7-7 (14)		Silty Sand: Light brown silty sand, some clay, trace gravel, occasional cobbles, moist, compact	
	SS 3	92	2-3-7 (10)			
2					2.00	220.71
					Borehole terminated at 2.0 meters below grade in silty sand till. Borehole open, no ponded water prior to backfill.	

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

BORING NUMBER BH21-17

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/5/21 **COMPLETED** 5/5/21
GROUND ELEVATION 220.53 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING 4.00 m / Elev 216.53 m
EASTING 726401 **NORTHING** 4903421
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION
	SS 1	48	0-0-1-2 (1)	MC = 20%		Topsoil: Dark brown silty sand topsoil, trace clay, moist to wet, very loose
						0.75 219.78
1	SS 2	85	6-6-2 (8)	MC = 12%		Sandy Silt: Light brown sandy silt, some clay, trace gravel, occasional cobble, wet, loose
	SS 3	89	3-5-6 (11)	MC = 11%		-Compact
2						
	SS 4	41	7-7-8 (15)	MC = 9%		
3	SS 5	85	5-5-4 (9)	GSA SS-5: Gravel: 10% Sand: 35% Silt: 38% Clay: 17% MC = 10%		-Light grey, moist to wet, loose
						3.80 216.73
4	SS 6	65	18-27-50 (77)	MC = 7%		Till: Light grey sandy silt till, some clay, trace gravel, occasional cobble, moist, very dense
	SS 7	54	23-22-50 (72)	MC = 6%		-Wet
5						
6						
	SS 8	83	15-29-50 (79)	MC = 15%		-Very dense
						6.55 213.98
						Borehole terminated at 6.55 meters below grade in silty sand till. Borehole caved to 4.0 meters below grade, groundwater at 4.0 meters below grade.

BORING NUMBER BH21-18

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/5/21 **COMPLETED** 5/5/21
GROUND ELEVATION 223.69 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING 4.60 m / Elev 219.09 m
EASTING 726487 **NORTHING** 4903388
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	
	SS 1	77	0-1-2-3 (3)		Topsoil: Dark brown silty sand topsoil, trace gravel, moist, very loose	
					0.75	222.94
1	SS 2	20	5-6-6 (12)		Silty Sand: Light brown silty sand, trace clay, trace gravel, occasional cobble, moist, compact	
2	SS 3	100	5-9-11 (20)			
	SS 4	100	12-12-9 (21)			
3					3.05	220.64
	SS 5	54	5-50		Till: Light brown silty sand till, trace clay, trace gravel, occasional cobble, moist, very dense	
4	SS 6	59	8-33-50 (83)		-Moist to wet	
5	SS 7	33	50		-Some gravel	
6						
	SS 8	78	10-32-50 (82)		-Wet	
					6.55	217.14
					Borehole terminated at 6.55 meters below grade in silty sand till. Borehole caved to 4.6 meters below grade, groundwater at 4.6 meters.	

GENERAL BH / TP / WELL 10985 GINT BH LOGS.GPJ GINT STD CANADA LAB.GDT 7/21/21

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

WELL NUMBER MW21-02

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/3/21 **COMPLETED** 5/3/21
GROUND ELEVATION 225.48 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726472 **NORTHING** 4903186
AFTER DRILLING 0.70 m / Elev 224.78 m

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	SS 1	62	0-1-3-4 (4)	MC = 33%		Topsoil: Dark brown silty sand topsoil, trace clay, moist, very loose	
						0.75 ▼ 224.73	
1	SS 2	72	10-13-24 (37)	MC = 8%		Silty Sand: Light brown silty sand, some clay, trace to some gravel, occasional cobble, moist, dense	Bentonite
	SS 3	100	1-1-2 (3)	MC = 10%		-Wet to saturated, very loose	Riser
2						2.30 223.18	
	SS 4	78	5-7-13 (20)	MC = 8%		Till: Light brown silty sand till, some clay, trace gravel, occasional cobble, saturated, compact to very dense	
3							
	SS 5	100	8-11-24 (35)	MC = 7%			
4	SS 6	65	14-50	MC = 15%			Sand
							Screen
5	SS 7	65	14-50	MC = 10%			
6				Split spoon refusal at 5.33 m. Augered to 6.55 m approximately 1 m west.			
	SS 8	52	11-50	MC = 5%		-Grey	
						6.55 218.93	
						Borehole terminated at 6.55 meters below grade in silty sand till. Static groundwater in monitoring well at 0.70 meters below grade on May 11, 2021.	

WELL NUMBER MW21-09

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/4/21 **COMPLETED** 5/4/21
GROUND ELEVATION 213.23 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726615 **NORTHING** 4903148
AFTER DRILLING 3.99 m / Elev 209.25 m

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	SS 1	54	0-1-1-2 (2)	MC = 19%		Topsoil: Dark brown silty sand topsoil, trace gravel, moist, very loose	Casing Top Elev: 214.23 (m) Casing Type: Monument
						0.76 / 212.47	
1	SS 2	80	4-6-4 (10)	MC = 14%		Sandy Silt: Light brown sandy silt, some clay, trace to some gravel, moist to wet, compact	Riser
				GSA SS-3: Gravel: 2% Sand: 25% Silt: 57% Clay: 16%			Bentonite
2	SS 3	100	3-5-6 (11)	MC = 14%			
						2.29 / 210.94	
	SS 4	100	4-7-15 (22)	MC = 15%		Till: Light brown sandy silt till, some clay, trace to some gravel, moist to wet, compact	
3							
	SS 5	100	10-14-15 (29)	MC = 10%			
4	SS 6	100	13-17-21 (38)	MC = 13%		-Dense	Sand
							Screen
5	SS 7	100	23-26-26 (52)	MC = 15%		-Very dense	
6							
	SS 8	100	45-37-50 (87)	MC = 12%		-Grey, saturated	
						6.55 / 206.68	

Borehole terminated at 6.55 meters below grade in sandy silt till. Static groundwater level in monitoring well at 4.0 meters below grade on May 11, 2021.

WELL NUMBER MW21-15

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/5/21 **COMPLETED** 5/5/21
GROUND ELEVATION 225.34 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726456 **NORTHING** 4903318
AFTER DRILLING 0.91 m / Elev 224.44 m

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	SS 1	64	0-2-2-4 (4)		Topsoil: Dark brown silty sand topsoil, moist, very loose	Casing Top Elev: 226.28 (m) Casing Type: Monument
					0.76 — 224.58	
1	SS 2	74	12-15-50 (65)		Silty Sand: Light brown silty sand, some gravel, occasional cobbles, moist, very dense	Riser
						Bentonite
2	SS 3	96	2-2-3 (5)		-Trace gravel, wet, loose	
					2.29 — 223.05	
3	SS 4	83	6-9-16 (25)		Till: Light brown silty sand till, some gravel, trace clay, occasional cobbles, wet, compact	
	SS 5	91	11-14-20 (34)		-Dense	
4	SS 6	100	12-21-25 (46)		-Light brown/grey, trace to some gravel, moist to wet	Sand
						Screen
5	SS 7	74	12-26-50 (76)		-Some gravel, very dense	
6						
	SS 8	63	20-28-50 (78)		-Light grey	
					6.55 — 218.79	
					Borehole terminated at 6.55 meters below grade in silty sand till. Static groundwater level in monitoring well at 0.9 meters below grade on May 11, 2021.	

WELL NUMBER MW21-16

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, ON K9J 0B9

CLIENT Alina Stewart and Shawn Elmhirst
PROJECT NAME Heritage Line
PROJECT NUMBER 21-10985
PROJECT LOCATION 1197 Heritage Line, Keene ON
DATE STARTED 5/5/21 **COMPLETED** 5/5/21
GROUND ELEVATION 222.81 m **HOLE SIZE** 6'
DRILLING CONTRACTOR Canadian Environmental Drilling
GROUND WATER LEVELS:
DRILLING METHOD 6" O.D. Solid stem augers and split spoon samplers
AT TIME OF DRILLING ---
LOGGED BY IM **CHECKED BY** IA
AT END OF DRILLING ---
EASTING 726499 **NORTHING** 4903461
AFTER DRILLING 1.74 m / Elev 221.07 m

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	SS 1	87	0-1-1-1 (2)	MC = 18%		Topsoil: Dark brown silty sand topsoil, moist, very loose	Casing Top Elev: 223.69 (m) Casing Type: Monument
						0.76 / 222.05	
1	SS 2	100	4-3-5 (8)	MC = 10%		Silty Sand: Light brown silty sand, some clay, trace gravel, occasional cobble, moist, loose	Riser
				GSA SS-3: Gravel: 5% Sand: 46% Silt: 35% Clay: 14% MC = 16%			Bentonite
2	SS 3	63	1-0-0 (0)			-Moist to wet, very loose	
				Split spoon refusal at 2.29m. Augered to 2.29 m approximately 1 m west.		2.29 / 220.52	
	SS 4	61	9-23-50 (73)	MC = 11%		Till: Brown silty sand till, some gravel, some clay, occasional cobble, wet, very dense	
3							
	SS 5	91	12-17-50 (67)	MC = 6%		-Trace gravel	
4	SS 6	80	25-25-50 (75)	MC = 9%		-Moist to wet	Sand
							Screen
5	SS 7	65	15-31-50 (81)	MC = 7%		-Light brown, some gravel, wet	
6							
	SS 8	93	7-24-50 (74)	MC = 7%		-Trace gravel, moist	
						6.55 / 216.26	
						Borehole terminated at 6.55 meters below grade in silty sand till. Static groundwater level in monitoring well at 1.75 meters below grade on May 11, 2021.	

GENERAL BH / TP / WELL 10985 GINT BH LOGS.GPJ GINT STD CANADA LAB.GDT 7/21/21

WILLS

Test Pit Log – TP21-01

Depth (mbg)	Soil Description
0.0 – 0.4	Brown silty sand topsoil, rootlets, moist.
0.4 - 0.6	Light brown silty sand, trace to some clay, moist.
0.6 – 3.0	Grey silty sand till, some gravel, trace clay, occasional cobble, wet to saturated.

Grab Sample Summary

- GS-01 collected at approximately 0.4 mbg.
- CGS-02 collected between 0.6 mbg – 3.0 mbg.

Groundwater

- Minor and isolated groundwater seepage between 1.0 and 1.6 mbg.

Additional Notes

- Caving below 0.6 mbg.
- Test pit terminated at 3.0 mbg in till.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.

Test Pit Photos

D.M. Wills Associates Limited
150 Jameson Drive, Peterborough, Ontario, Canada K9J 0B9
P. 705.742.2297 **F**. 705.748.9944 **E**. wills@dmwills.com

WILLS

Test Pit Log – TP21-02

Depth (mbg)	Soil Description
0.0 – 0.3	Brown silty sand topsoil, rootlets, moist.
0.3 - 0.5	Light brown silty sand, moist.
0.5 – 3.3	Grey gravelly silty sand till, trace clay, occasional cobble.

Grab Sample Summary

- GS-01 collected at approximately 0.3 mbg.
- CGS-02 collected between 0.6 mbg – 3.3 mbg.

Groundwater

- Groundwater not encountered.

Additional Notes

- Minor caving between 0.6 mbg and 1.6 mbg.
- Test pit terminated at 3.3 mbg in till.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.

Test Pit Photos

D.M. Wills Associates Limited
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P. 705.742.2297 **F**. 705.748.9944 **E**. wills@dmwills.com

WILLS

Test Pit Log – TP21-03

Depth (mbg)	Soil Description
0.0 – 0.3	Brown silty sand topsoil, rootlets, moist.
0.3 - 0.5	Light brown silty sand, moist.
0.5 – 3.3	Grey silty sand till, some gravel, trace clay, occasional cobble and boulder, moist.

Grab Sample Summary

- GS-01 collected at approximately 0.4 mbg.
- CGS-02 collected between 0.5 mbg – 3.3 mbg.

Groundwater

- Groundwater not encountered

Additional Notes

- Test pit terminated at 3.3 mbg in till.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.

Test Pit Photos

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WILLS

Test Pit Log – TP21-04

Depth (mbg)	Soil Description
0.0 – 0.3	Brown silty sand topsoil, rootlets, moist.
0.3 - 0.4	Light brown silty sand, moist.
0.4 – 3.3	Grey silty sand till, some clay, trace gravel, occasional cobble and boulder.

Grab Sample Summary

- GS-01 collected at approximately 0.3 mbg.
- CGS-02 collected between 0.4 mbg – 3.3 mbg.

Groundwater

- Minor and isolated groundwater seepage at 1.8 mbg.

Additional Notes

- Caving below 1.8 mbg.
- Test pit terminated at 3.3 mbg in till.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.

Test Pit Photos

D.M. Wills Associates Limited
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WILLS

Test Pit Log – TP21-05

Depth (mbg)	Soil Description
0.0 – 0.4	Brown silty sand topsoil, rootlets, moist
0.4 - 0.5	Light brown silty sand, moist
0.5 – 3.0	Grey silty sand till, some clay, trace gravel, occasional cobble and boulder, moist to wet.

Grab Sample Summary

- GS-01 collected at approximately 0.5 mbg.
- GS-02 collected at approximately 2.0 mbg.

Groundwater

- Minor and isolated groundwater seepage at 1.3 mbg.

Additional Notes

- Caving below 0.5 mbg.
- Test pit terminated at 3.0 mbg in till.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.

Test Pit Photos

D.M. Wills Associates Limited
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WILLS

Test Pit Log – TP21-06

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, rootlets, moist.
0.2 - 0.4	Light brown silty sand, moist.
0.4 – 3.0	Grey silty sand till, some gravel, trace clay, occasional cobble and boulder, moist.

Grab Sample Summary

- GS-01 collected at approximately 0.3 mbg.
- GS-02 collected at approximately 1.5 mbg.
- GS-03 collected at approximately 2.5 mbg.

Groundwater

- Groundwater not encountered.

Additional Notes

- Test pit terminated at 3.0 mbg in till.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.

Test Pit Photos

D.M. Wills Associates Limited
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WILLS

Test Pit Log – TP21-07

Depth (mbg)	Soil Description
0.0 – 0.3	Brown silty sand topsoil, rootlets, moist.
0.3 - 0.5	Light brown silty sand, moist.
0.5 – 3.3	Grey silty sand till, some gravel, trace to some clay, occasional cobble and boulder, moist to wet.

Grab Sample Summary

- GS-01 collected at approximately 0.4 mbg.
- CGS-02 collected at approximately 1.0 – 2.0 mbg.

Groundwater

- Minor and isolated groundwater seepage at 2.0 mbg.

Additional Notes

- Caving below 0.5 mbg.
- Test pit terminated at 3.3 mbg in till.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.

Test Pit Photos

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WILLS

Test Pit Log – TP21-08

Depth (mbg)	Soil Description
0.0 – 0.3	Brown silty sand topsoil, rootlets, moist.
0.3 - 0.4	Light brown silty sand, moist.
0.4 – 3.3	Grey silty sand till, some gravel, trace clay, occasional cobble and boulder.

Grab Sample Summary

- GS-01 collected at approximately 0.3 mbg.
- CGS-02 collected between 0.4 mbg – 3.3 mbg.

Groundwater

- Minor and isolated groundwater seepage throughout till.

Additional Notes

- Caving below 2.0 mbg.
- Test pit terminated at 3.3 mbg in till.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.

Test Pit Photos

D.M. Wills Associates Limited
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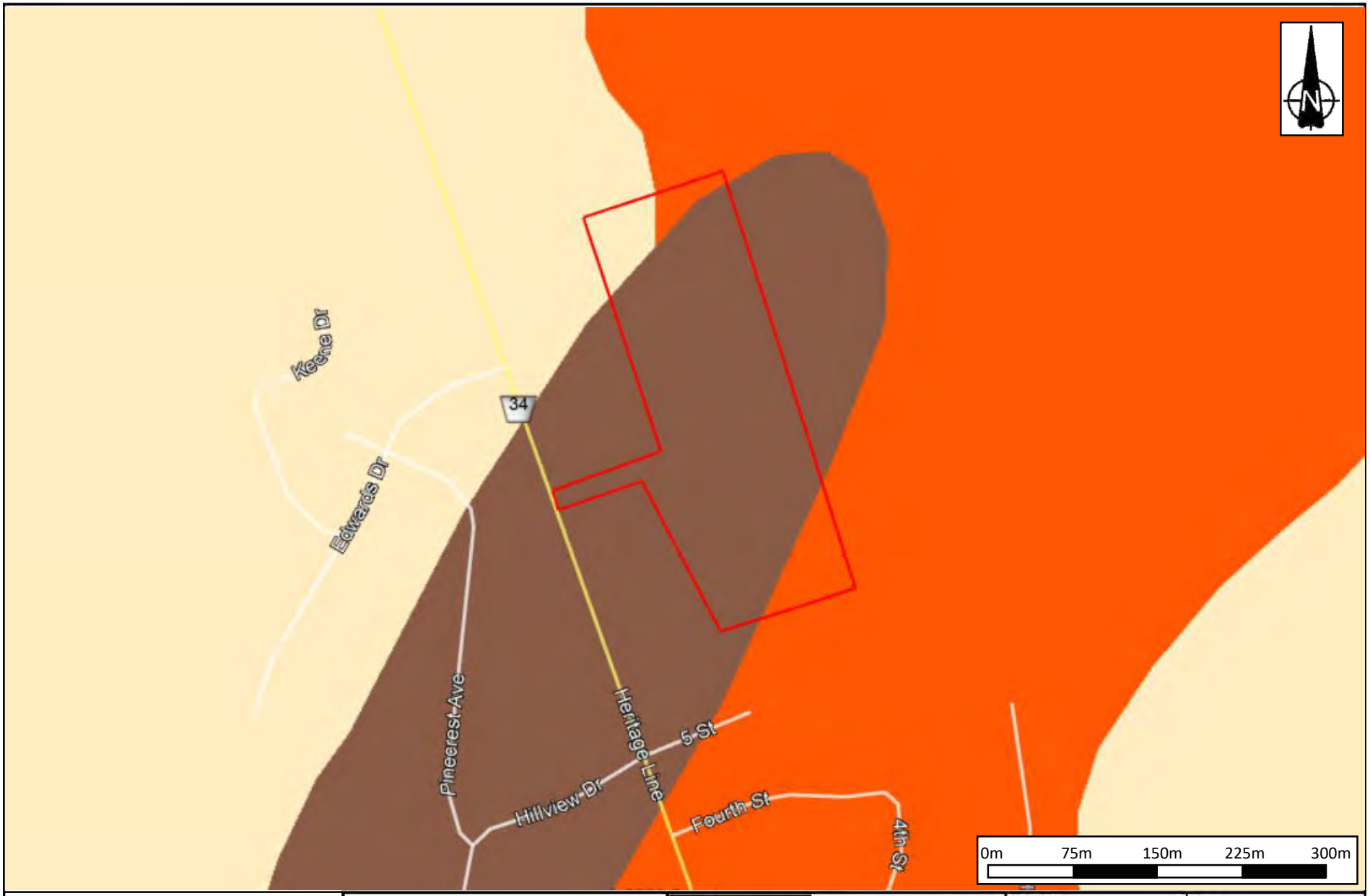
Appendix B

Geological Maps



Legend

- Subject Property
- Till Plains (Drumlinized)
- Drumlins
- Spillways

Physiography

Hydrogeological Study

Heritage Line Residential Development

WILLS

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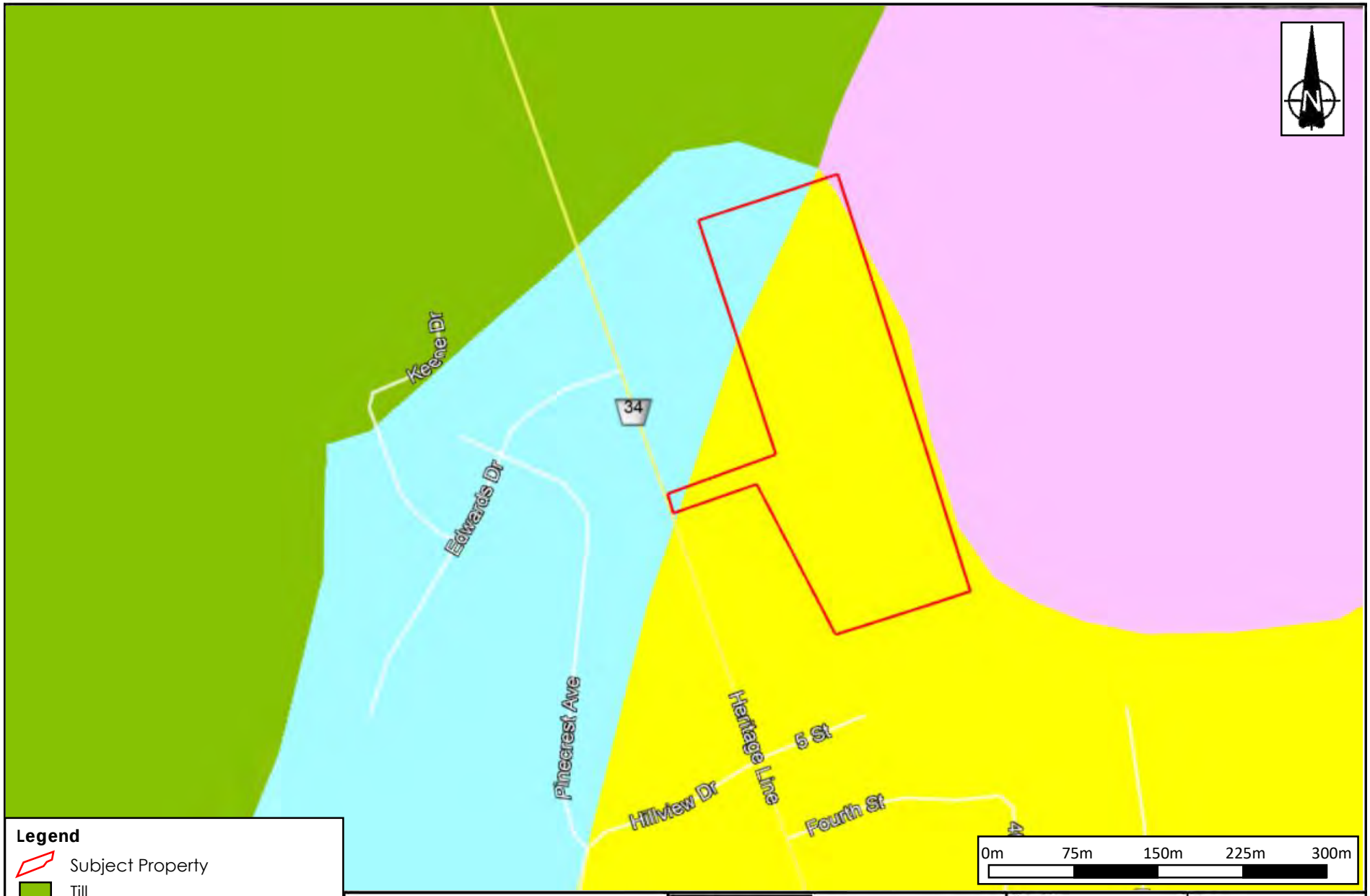
Drawn By: AT	Scale: See scale bar
Checked: IA	Date: March, 2021
Project No.: 21-10985	Drawing File No.: APP-B1



Surficial Geology

Hydrogeological Study

Heritage Line Residential Development

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Drawn By: AT	Scale: See scale bar
Checked: IA	Date: March, 2021
Project No.: 21-10985	Drawing File No.: APP-B2

Legend

Subject Property

Limestone, dolostone, shale, arkose, sandstone

Bedrock Geology

Hydrogeological Study

Heritage Line Residential Development

D.M. Wills Associates Limited
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Drawn By: AT	Scale: See scale bar
Checked: IA	Date: March, 2021
Project No.: 21-10985	Drawing File No.: APP-B3

Appendix C

Certificates of Analysis – Physical Soil Testing

PRI ENGINEERING
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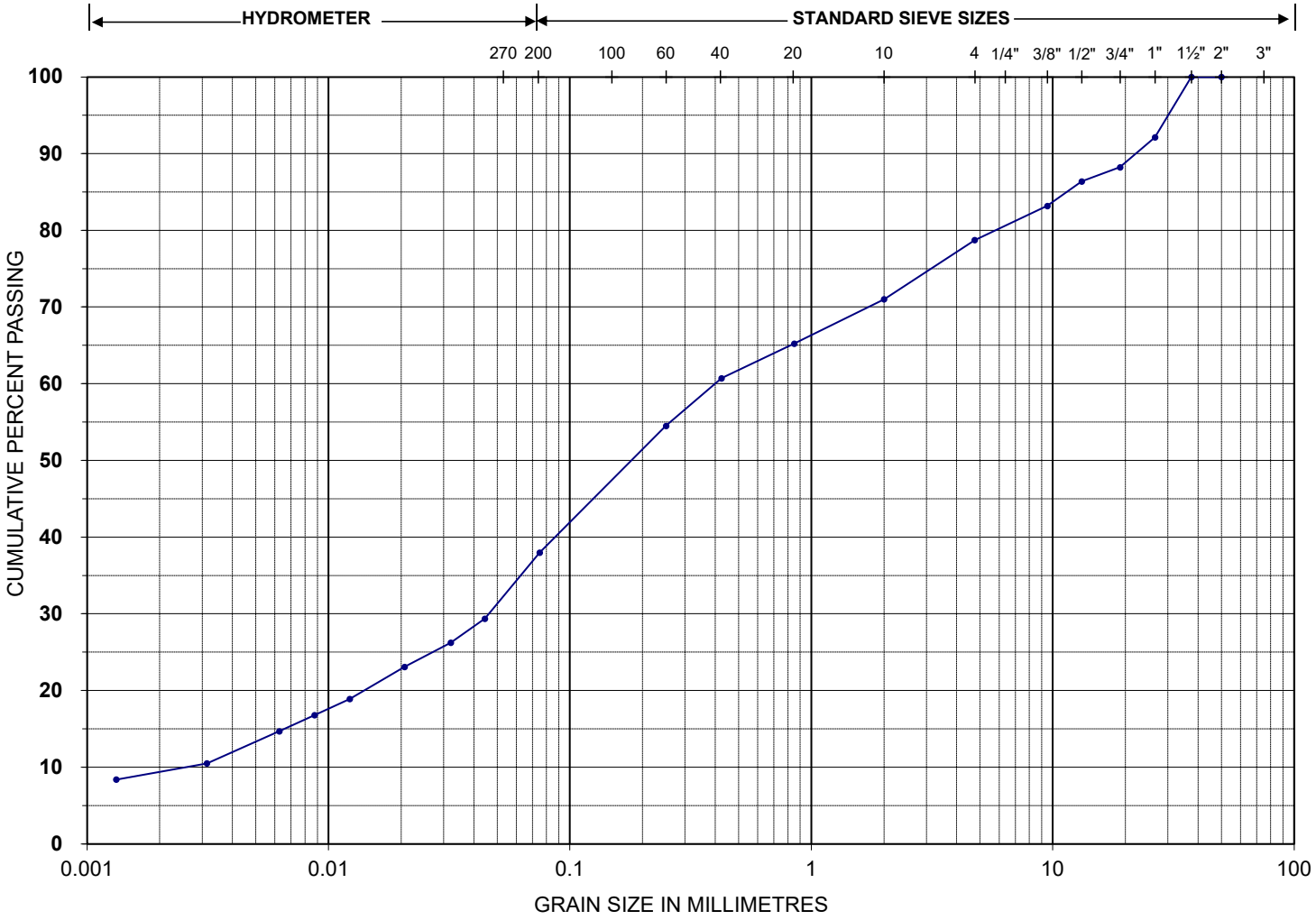
PARTICLE SIZE DISTRIBUTION
LS - 702

Project Name: Heritage Line **Project No.:** 21-049 **Sample Date:** 3-May-21

Borehole/Test Pit ID.: BH21-01 **Sample No./Depth:** SS6 @ 3.80m to 4.26m **Test Date:** 25-May-21



Silt or Clay	Sand	Gravel

Sieve Size (mm)	% Passing
37.5	100.0
26.5	92.1
19.0	88.2
13.2	86.4
9.5	83.2
4.750	78.7
2.000	71.0
0.850	65.2
0.425	60.7
0.250	54.5
0.075	38.0

Hydrometer (mm)	% Passing
0.044	29.4
0.032	26.2
0.021	23.1
0.012	18.9
0.009	16.8
0.006	14.7
0.003	10.5
0.001	8.4

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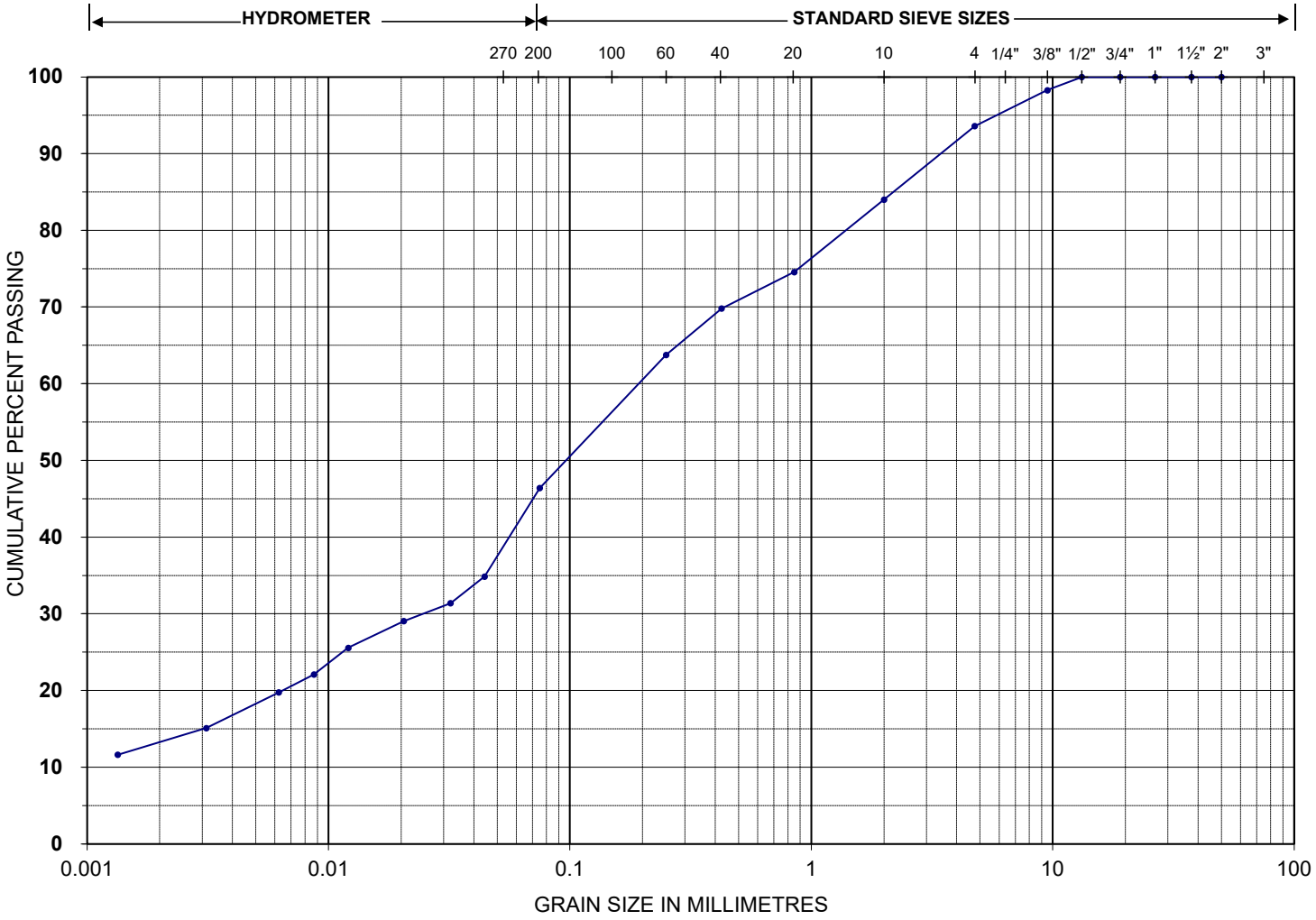
Project Name: Heritage Line **Project No.:** 21-049 **Sample Date:** 3-May-21

Borehole/Test Pit ID.: BH21-07 **Sample No./Depth:** SS2 @ 0.8 - 1.2 m **Test Date:** 25-May-21



Silt or Clay	Sand	Gravel

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	98.3
4.750	93.6
2.000	84.0
0.850	74.6
0.425	69.8
0.250	63.7
0.075	46.4

Hydrometer (mm)	% Passing
0.044	34.9
0.032	31.4
0.021	29.1
0.012	25.6
0.009	22.1
0.006	19.8
0.003	15.1
0.001	11.6

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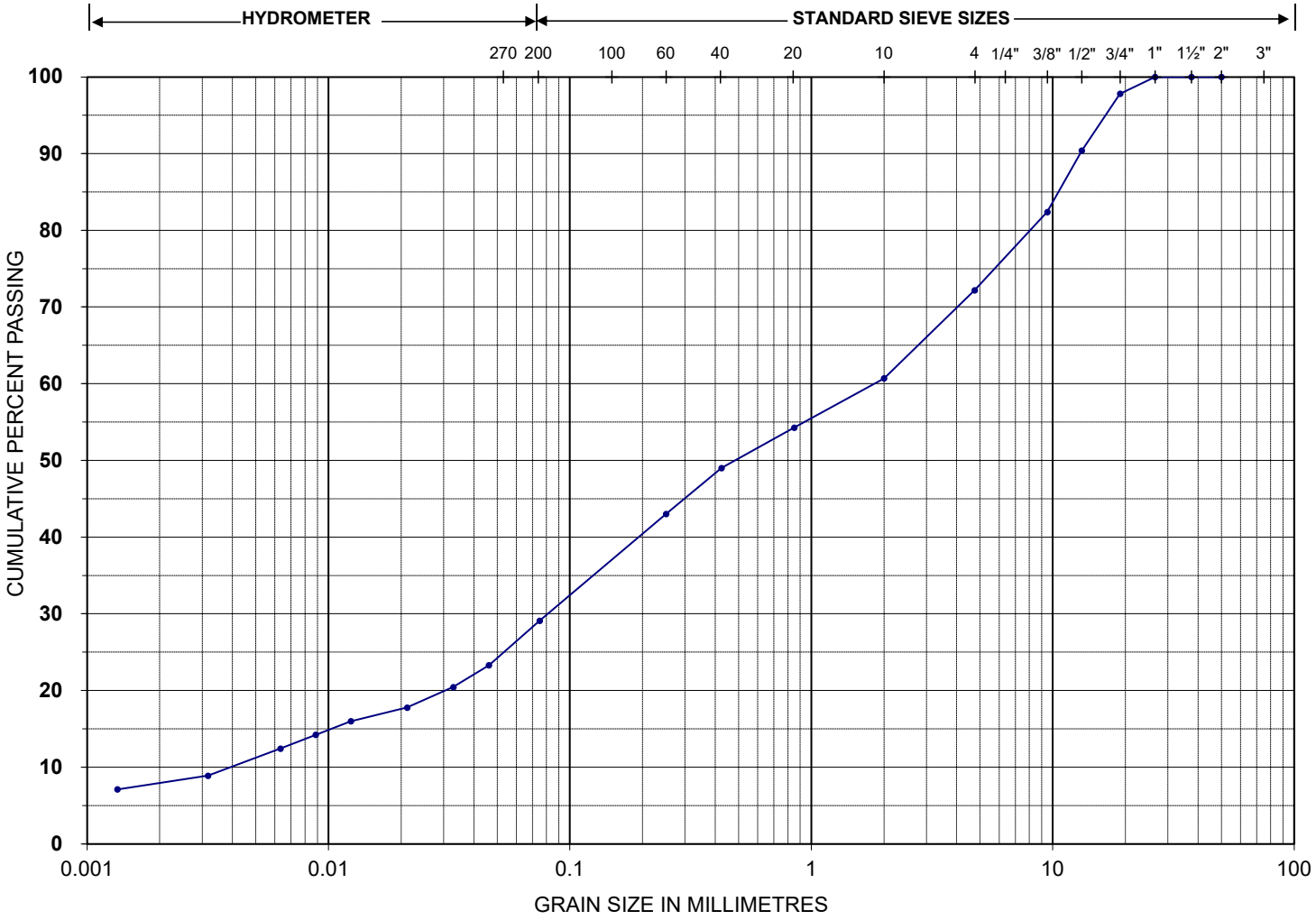
Project Name: Heritage Line **Project No.:** 21-049 **Sample Date:** 3-May-21

Borehole/Test Pit ID.: BH21-08 **Sample No./Depth:** SS2 @ 2.3 - 2.7 m **Test Date:** 25-May-21



Silt or Clay	Sand	Gravel

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	97.8
13.2	90.4
9.5	82.4
4.750	72.2
2.000	60.7
0.850	54.3
0.425	49.0
0.250	43.0
0.075	29.1

Hydrometer (mm)	% Passing
0.046	23.3
0.033	20.4
0.021	17.8
0.012	16.0
0.009	14.2
0.006	12.4
0.003	8.9
0.001	7.1

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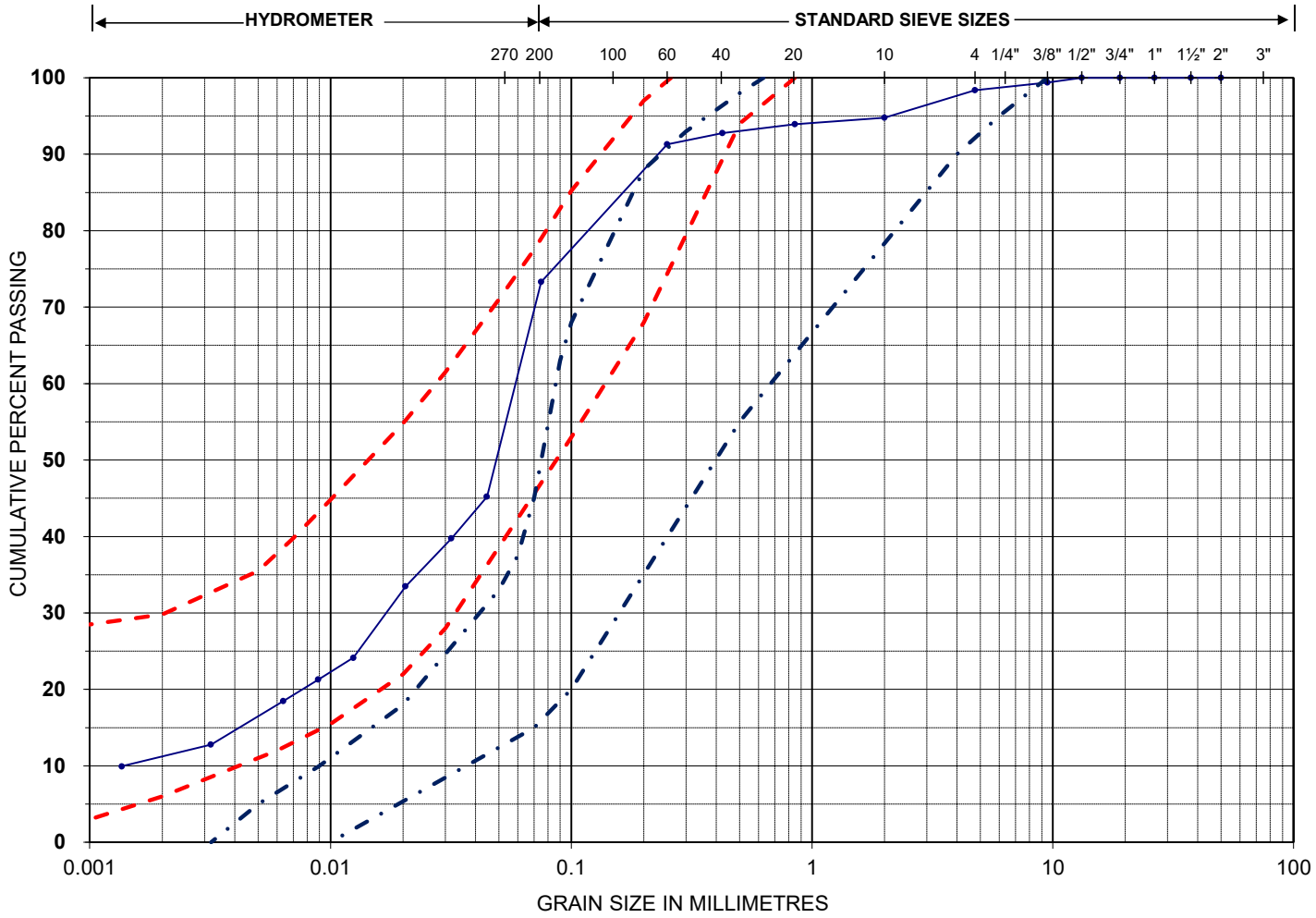
Project Name: Heritage Line **Project No.:** 21-049 **Date:** May 25 2021

Borehole/Test Pit ID.: BH21-09 **Sample No./Depth:** SS3 @ 1.5 - 1.9 m



Silt or Clay	Sand	Gravel

sm envelope T = 8 - 20 min/cm
ml envelope T = 20 - 50 min/cm

Estimated T = 30 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	99.4
4.750	98.4
2.000	94.8
0.850	93.9
0.425	92.7
0.250	91.3
0.075	73.3

Hydrometer (mm)	% Passing
0.045	45.2
0.032	39.8
0.021	33.5
0.012	24.1
0.009	21.3
0.006	18.5
0.003	12.8
0.001	9.9

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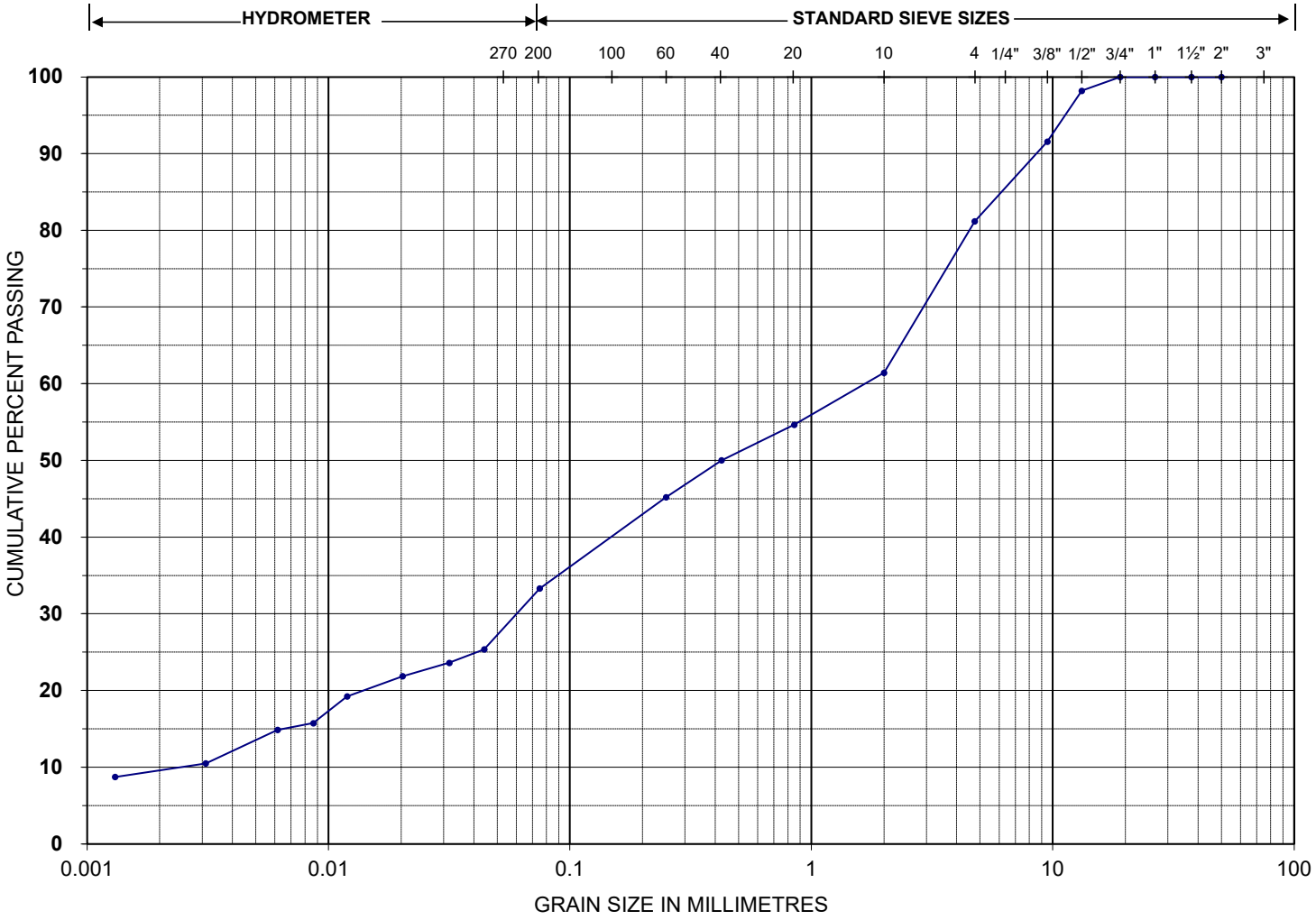
Project Name: Heritiage Line **Project No.:** 21-049 **Sample Date:** 4-May-21

Borehole/Test Pit ID.: BH21-11 **Sample No./Depth:** SS6 @ 3.8m to 4.3m **Test Date:** 25-May-21



Silt or Clay	Sand	Gravel

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	98.2
9.5	91.6
4.750	81.2
2.000	61.4
0.850	54.7
0.425	50.0
0.250	45.2
0.075	33.3

Hydrometer (mm)	% Passing
0.044	25.4
0.032	23.6
0.020	21.9
0.012	19.2
0.009	15.7
0.006	14.9
0.003	10.5
0.001	8.7

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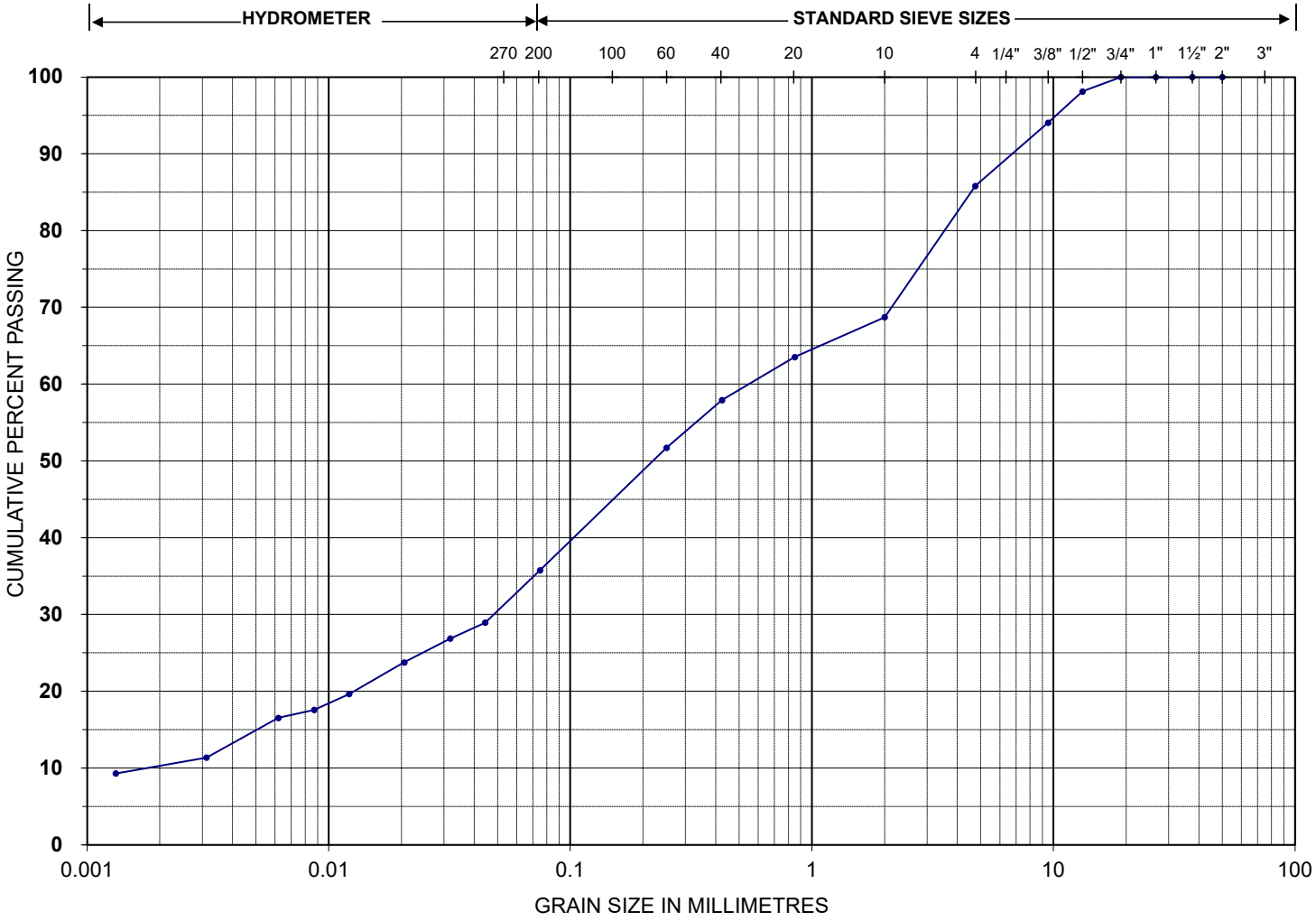
Project Name: Heritiage Line **Project No.:** 21-049 **Sample Date:** 4-May-21

Borehole/Test Pit ID.: BH21-12 **Sample No./Depth:** SS6 @ 3.8 - 4.3 m **Test Date:** 25-May-21



Silt or Clay	Sand	Gravel

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	98.1
9.5	94.0
4.750	85.8
2.000	68.7
0.850	63.5
0.425	57.9
0.250	51.7
0.075	35.8

Hydrometer (mm)	% Passing
0.044	28.9
0.032	26.9
0.021	23.8
0.012	19.6
0.009	17.6
0.006	16.5
0.003	11.4
0.001	9.3

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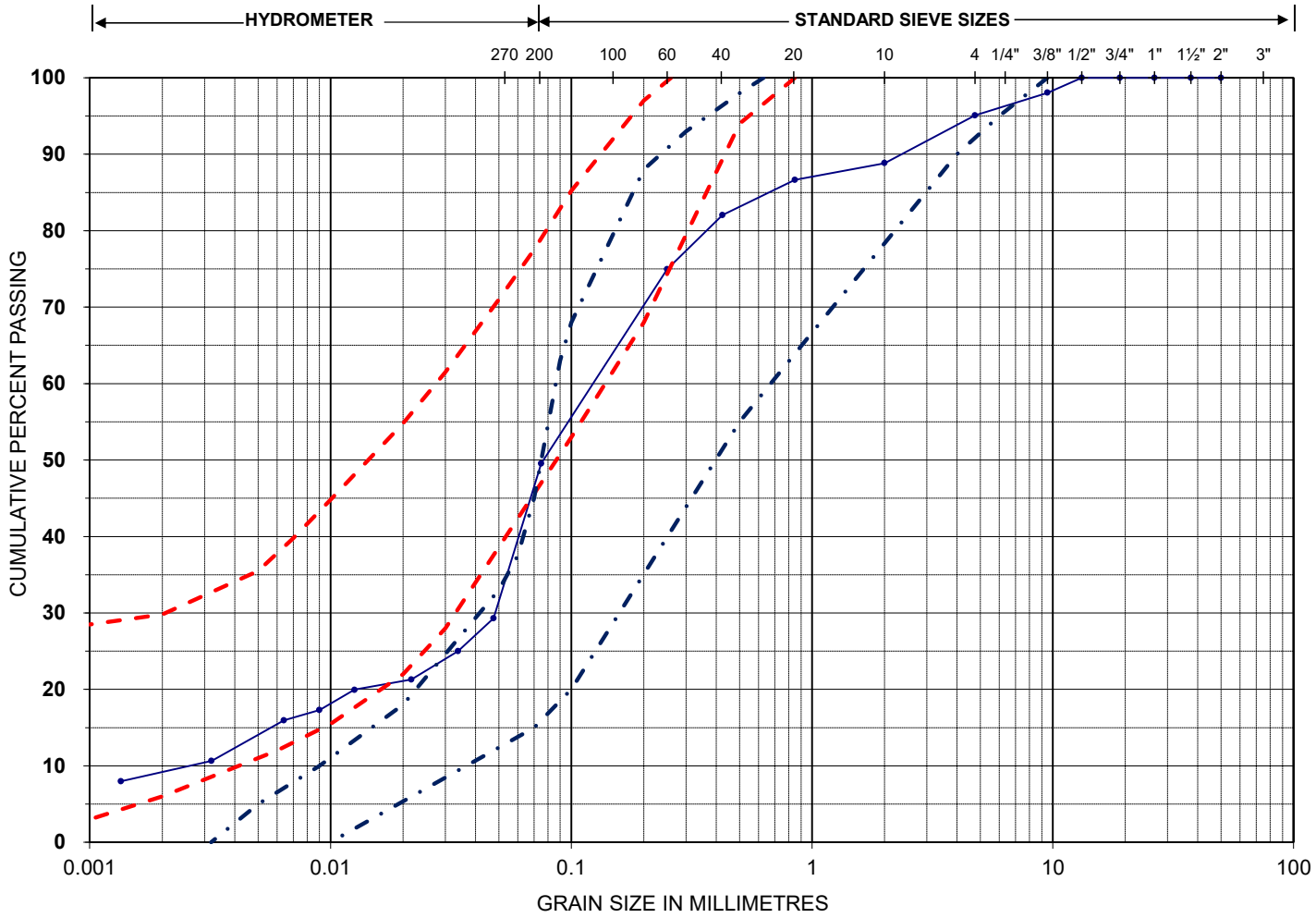
Project Name: Heritiage Line **Project No.:** 21-049 **Date:** 5-May-21

Borehole/Test Pit ID.: BH21-16 **Sample No./Depth:** SS3 @ 1.5 - 2.0 m



Silt or Clay	Sand	Gravel

sm envelope T = 8 - 20 min/cm
ml envelope T = 20 - 50 min/cm

Estimated T = 20 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	98.0
4.750	95.1
2.000	88.8
0.850	86.7
0.425	82.0
0.250	75.0
0.075	49.5

Hydrometer (mm)	% Passing
0.048	29.3
0.034	25.0
0.022	21.3
0.013	20.0
0.009	17.3
0.006	16.0
0.003	10.6
0.001	8.0

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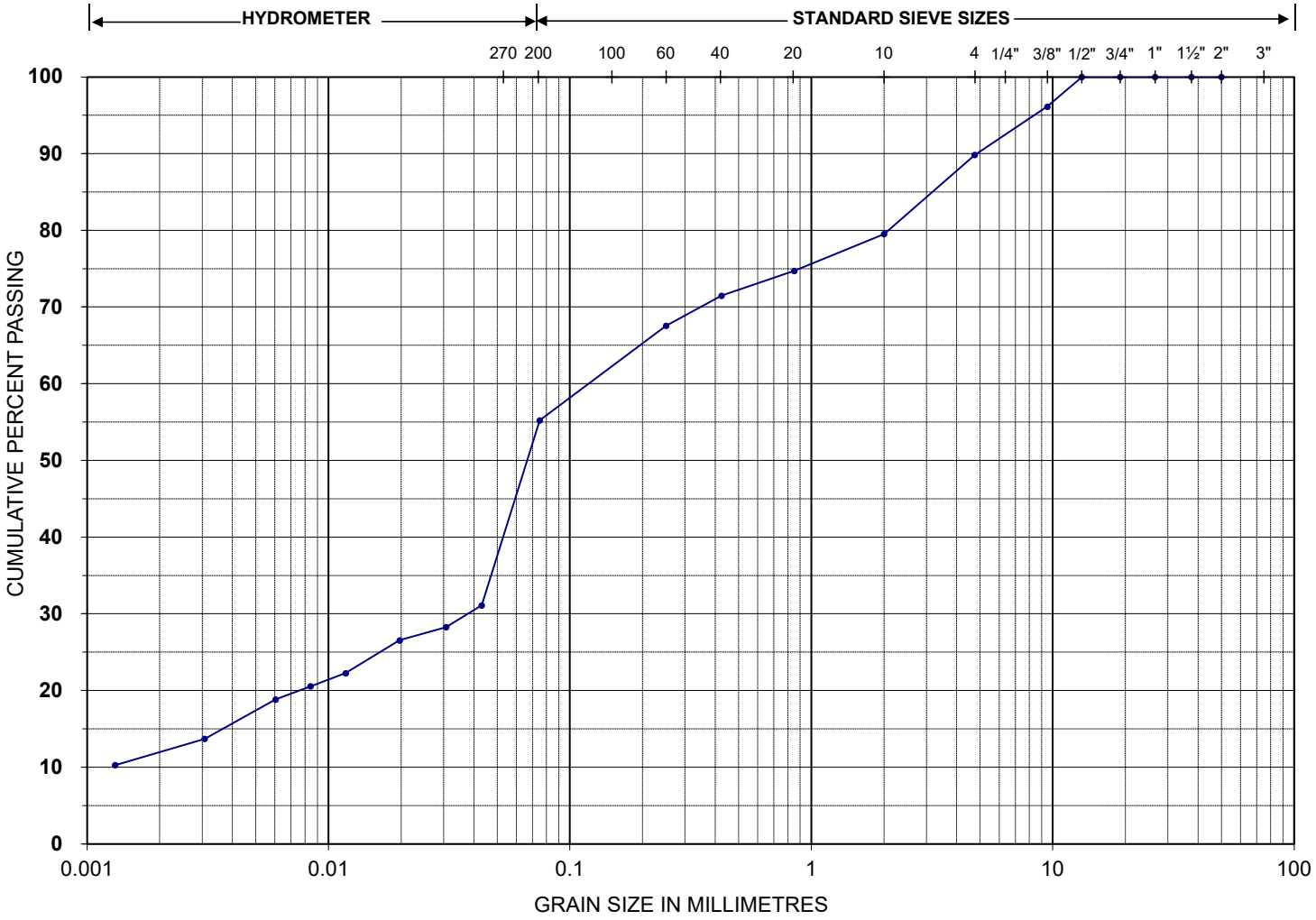
Project Name: Heritage Line **Project No.:** 21-049 **Sample Date:** 3-May-21

Borehole/Test Pit ID.: BH21-17 **Sample No./Depth:** SS5 @ 3.0 - 3.5 m **Test Date:** 25-May-21



Silt or Clay	Sand	Gravel

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	96.1
4.750	89.8
2.000	79.5
0.850	74.7
0.425	71.5
0.250	67.5
0.075	55.2

Hydrometer (mm)	% Passing
0.043	31.1
0.031	28.3
0.020	26.5
0.012	22.3
0.008	20.6
0.006	18.8
0.003	13.7
0.001	10.3

ATTERBERG LIMITS

ASTM D4318

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Project Name:	Heritage Line	**Project Number:**	21-049
Sample ID:	BH21-17 SS5	**Technician:**	KV
Sample Date:	5-May-21	**Test Date:**	June 8 2021

Liquid Limit Test

Number of Shocks	33	24	18
Tin No.	RAP	100	RJ2
Tin + Wet soil	21.1	24.0	23.4
Tin + Dry soil	20.1	22.4	22.0
Wt. of Water	1.0	1.6	1.4
Wt. of Tin	13.7	13.5	13.6
Wt. of Dry Soil	6.4	8.9	8.4
Water Content	16	18	17

Plastic Limit Test

Tin No.	V97	DMX
Tin + Wet soil	18.9	18.0
Tin + Dry soil	18.3	17.6
Wt. of Water	0.6	0.4
Wt. of Tin	13.5	13.5
Wt. of Dry Soil	4.8	4.1
Water Content	13	10

Natural Water Content

PR68
872.4
810.5
61.9
185.4
625.1
9.9

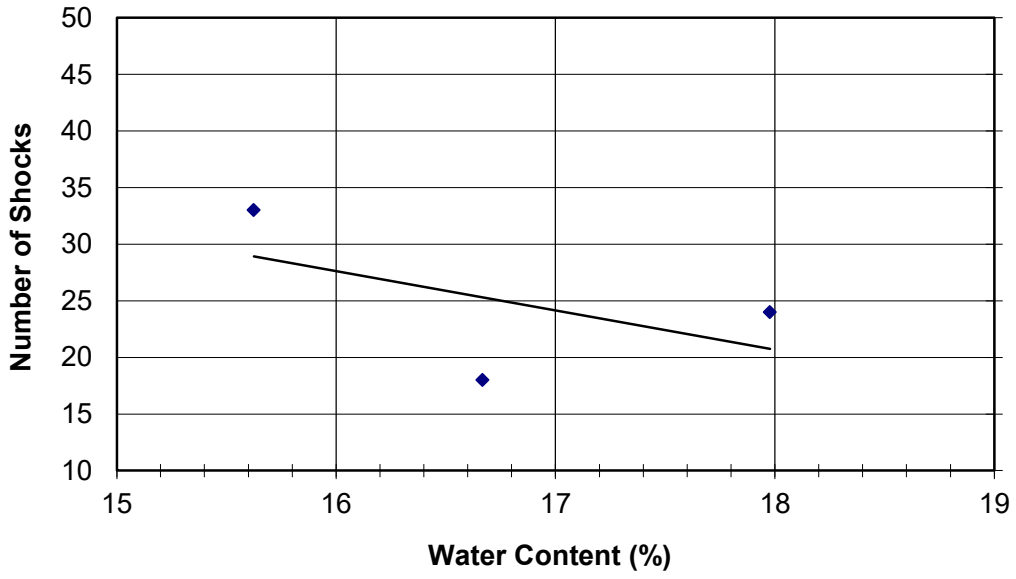
Sample Results

Liquid Limit, (W_L)	17
Plastic Limit, (WP)	11
Plasticity Index ($I_P=W_L-W_P$)	6
Natural Water Content, W	10
Liquidity Index ($I_L=W-W_P/W_L-W_P$)	0

Control Results

Liquid Limit, (W_L)	30.4
Plastic Limit, (WP)	19.3
Plasticity Index ($I_P=W_L-W_P$)	11.1

Liquid Limit



More information available upon request

Approver: VG
Issue Date: 2020-12-08
Issue/Revision Number: Issue 1, Revision 1

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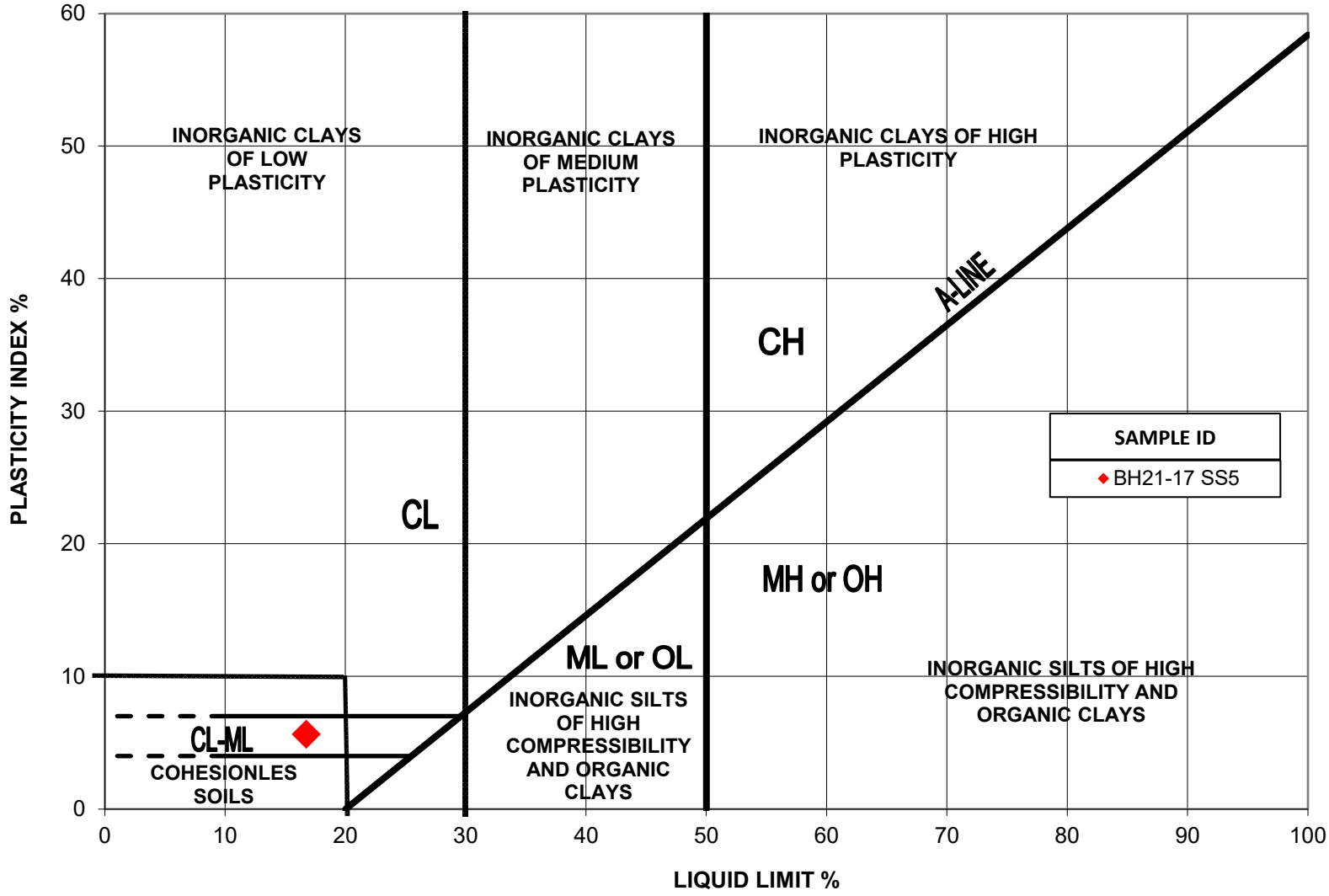
Atterberg Limits Plasticity Chart



https://oyaventures.sharepoint.com/sites/Labratory/Shared Documents/General/Test Results/21-049/21-049_BH21-17 SS5_Atterberg_Re-do

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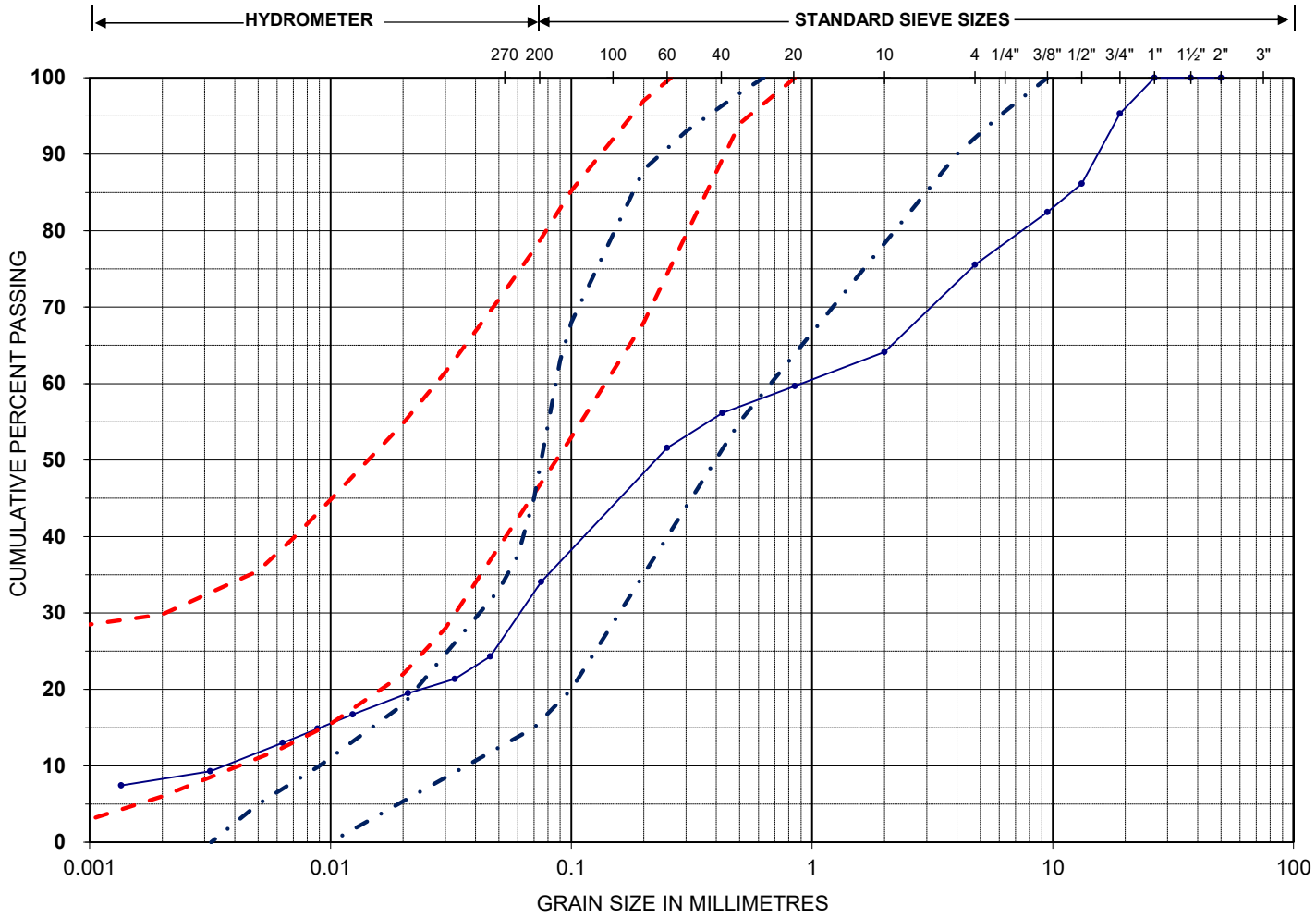
Project Name: Heritage Line **Project No.:** 21-049 **Date:** 25-May-21

Borehole/Test Pit ID.: TP21-02 **Sample No./Depth:** GS-02 @ 0.6 - 3.3 m



Silt or Clay	Sand	Gravel

sm envelope T = 8 - 20 min/cm
ml envelope T = 20 - 50 min/cm

Estimated T = 15 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	95.3
13.2	86.1
9.5	82.4
4.750	75.5
2.000	64.1
0.850	59.7
0.425	56.2
0.250	51.6
0.075	34.1

Hydrometer (mm)	% Passing
0.046	24.3
0.033	21.4
0.021	19.5
0.012	16.7
0.009	14.9
0.006	13.0
0.003	9.3
0.001	7.4

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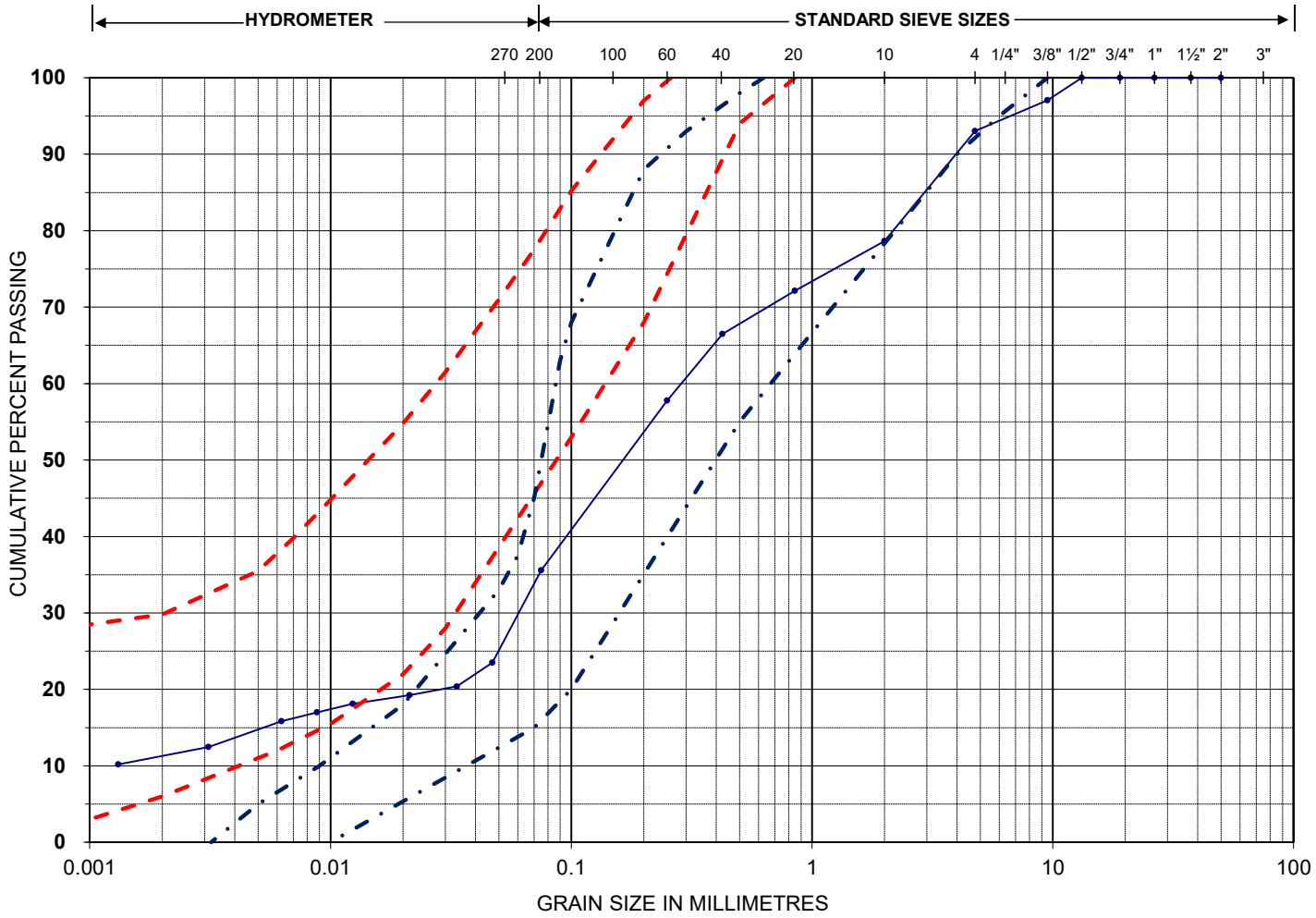
Project Name: Heritiage Line **Project No.:** 21-049 **Date:** 28-Apr-21

Borehole/Test Pit ID.: TP21-04 **Sample No./Depth:** GS2@ 0.4 - 3.3m



Silt or Clay	Sand	Gravel

sm envelope T = 8 - 20 min/cm
ml envelope T = 20 - 50 min/cm

Estimated T = 13 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	97.0
4.750	93.0
2.000	78.6
0.850	72.1
0.425	66.5
0.250	57.8
0.075	35.6

Hydrometer (mm)	% Passing
0.047	23.5
0.033	20.4
0.021	19.3
0.012	18.1
0.009	17.0
0.006	15.9
0.003	12.5
0.001	10.2

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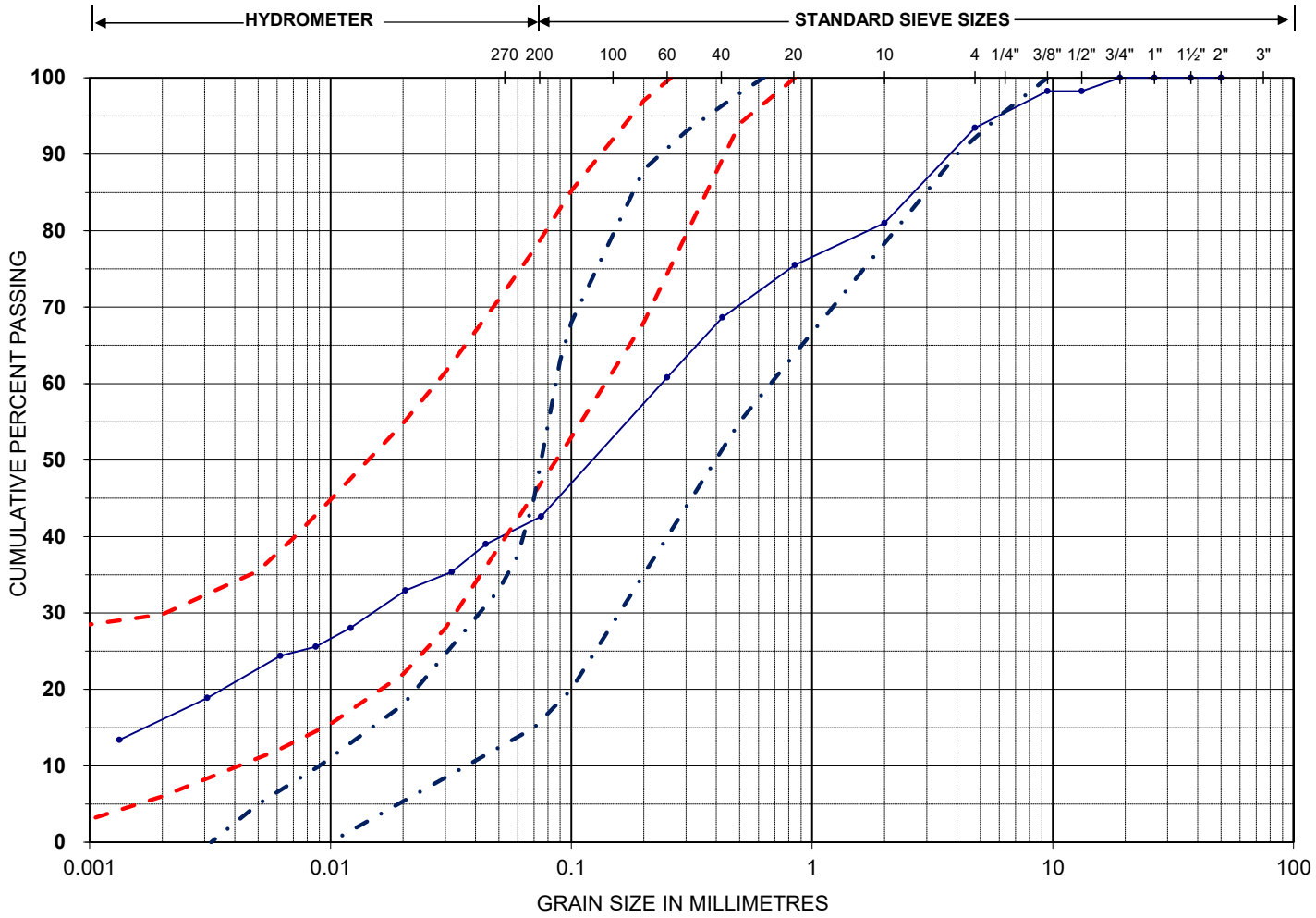
Project Name: Heritage Line **Project No.:** 21-049 **Date:** 25-May-21

Borehole/Test Pit ID.: TP21-05 **Sample No./Depth:** GS-2 @ 2m



Silt or Clay	Sand	Gravel

sm envelope T = 8 - 20 min/cm
ml envelope T = 20 - 50 min/cm

Estimated T = 20 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	98.3
9.5	98.3
4.750	93.5
2.000	81.0
0.850	75.5
0.425	68.6
0.250	60.8
0.075	42.6

Hydrometer (mm)	% Passing
0.044	39.0
0.032	35.4
0.020	32.9
0.012	28.0
0.009	25.6
0.006	24.4
0.003	18.9
0.001	13.4

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MOISTURE CONTENTS

Project Name: Heritage Line
Project Number: 21-049
Technician: AYJr
Test Date: 25-May-21

TIN NO.	72	DM8	E5	H5	G3
BOREHOLE NO.	BH21-17	BH21-17	BH21-17	BH21-17	BH21-17
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	143.7	112.1	134.1	136.5	126.1
WT of TIN & DRY SOIL (g)	131.5	106.0	118.3	124.0	106.7
WT of WATER (g)	12.2	6.1	15.8	12.5	19.4
TARE WT (g)	9.8	9.9	9.7	9.7	9.7
WT of DRY SOIL (g)	121.7	96.1	108.6	114.3	97.0
MOISTURE CONTENT	10.0%	6.3%	14.5%	10.9%	20.0%
TIN NO.	RN2	C5	WTF	J2	C7
BOREHOLE NO.	BH21-17	BH21-17	BH21-17	BH21-08	BH21-08
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	116.8	124.7	108.1	107.0	103.7
WT of TIN & DRY SOIL (g)	109.7	112.5	100.0	98.2	93.5
WT of WATER (g)	3.2	2.5	2.2	8.8	10.2
TARE WT (g)	10.3	9.7	10.3	9.9	9.7
WT of DRY SOIL (g)	99.4	102.8	89.7	88.3	83.8
MOISTURE CONTENT	7.1%	11.9%	9.0%	10.0%	12.2%
TIN NO.	I8	E7	KR29	X9	D7
BOREHOLE NO.	BH21-08	BH21-08	BH21-08	BH21-08	BH21-08
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	124.8	124.4	128.7	62.6	110.6
WT of TIN & DRY SOIL (g)	114.3	114.2	117.6	53.8	103.6
WT of WATER (g)	0.8	0.4	0.5	8.8	7.0
TARE WT (g)	9.7	9.8	10.6	10.4	9.7
WT of DRY SOIL (g)	104.6	104.4	107.0	43.4	93.9
MOISTURE CONTENT	10.0%	9.8%	10.4%	20.3%	7.5%
TIN NO.	I4	KR24	GI	Y4	H3
BOREHOLE NO.	BH21-08	BH21-12	BH21-12	BH21-12	BH21-12
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	76.4	99	68.8	127.5	120.4
WT of TIN & DRY SOIL (g)	71.9	92.4	63.8	117.0	112.1
WT of WATER (g)	5.2	3.7	4.7	10.5	8.3
TARE WT (g)	9.7	10.3	9.7	10.3	9.7
WT of DRY SOIL (g)	62.2	82.1	54.1	106.7	102.4
MOISTURE CONTENT	7.2%	8.0%	9.2%	9.8%	8.1%
TIN NO.	GH1	B8	F7	A4	
BOREHOLE NO.	BH21-12	BH21-12	BH21-12	BH21-12	
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	119.6	90.0	138.5	107.8	
WT of TIN & DRY SOIL (g)	110.4	78.2	126.5	101.8	
WT of WATER (g)	1.2	2.0	2.3	6.0	
TARE WT (g)	10.4	9.8	9.7	9.7	
WT of DRY SOIL (g)	100.0	68.4	116.8	92.1	
MOISTURE CONTENT	9.2%	17.3%	10.3%	6.5%	

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MOISTURE CONTENTS

Project Name: Heritage Line | **Technician:** AYJr
Project Number: 21-049 | **Test Date:** 25-May-21

TIN NO.	Q3	B4	G6	G9	X1
BOREHOLE NO.	BH21-16	BH21-16	BH21-16	BH21-16	BH21-16
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	112.0	93.8	115.2	81.6	86.6
WT of TIN & DRY SOIL (g)	104.1	81.3	107.9	77.4	78.8
WT of WATER (g)	7.9	12.5	7.3	4.2	7.8
TARE WT (g)	10.7	9.7	9.6	9.6	10.3
WT of DRY SOIL (g)	93.4	71.6	98.3	67.8	68.5
MOISTURE CONTENT	8.5%	17.5%	7.4%	6.2%	11.4%

TIN NO.	C1	I3	DP37	A9	E4
BOREHOLE NO.	BH21-16	BH21-16	BH21-16	BH21-02	BH21-02
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	109.1	103.0	94.1	103.9	100.7
WT of TIN & DRY SOIL (g)	100.0	90.1	88.5	95.3	88.9
WT of WATER (g)	0.7	3.2	4.6	8.6	11.8
TARE WT (g)	9.8	9.7	10.2	9.9	10.0
WT of DRY SOIL (g)	90.2	80.4	78.3	85.4	78.9
MOISTURE CONTENT	10.1%	16.0%	7.2%	10.1%	15.0%

TIN NO.	J7	C3	QE15	F5	G5
BOREHOLE NO.	BH21-02	BH21-02	BH21-02	BH21-02	BH21-02
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	74.9	103.0	77.2	86.8	93.1
WT of TIN & DRY SOIL (g)	69.1	96.7	60.9	81.1	87.3
WT of WATER (g)	4.0	3.4	5.6	5.7	5.8
TARE WT (g)	9.8	9.7	10.7	9.7	9.7
WT of DRY SOIL (g)	59.3	87.0	50.2	71.4	77.6
MOISTURE CONTENT	9.8%	7.2%	32.5%	8.0%	7.5%

TIN NO.	C9	RR7	6N	L23	7D
BOREHOLE NO.	BH21-02	BH21-09	BH21-09	BH21-09	BH21-09
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	94.4	91.6	98.1	136.3	113.6
WT of TIN & DRY SOIL (g)	90.3	78.7	87.4	122.3	100.5
WT of WATER (g)	5.5	2.7	1.3	14.0	13.1
TARE WT (g)	9.6	10.2	12.0	10.3	11.7
WT of DRY SOIL (g)	80.7	68.5	75.4	112.0	88.8
MOISTURE CONTENT	5.1%	18.8%	14.2%	12.5%	14.8%

TIN NO.	F6	H6	I9	F2	
BOREHOLE NO.	BH21-09	BH21-09	BH21-09	BH21-09	
SAMPLE & DEPTH					
WT of TIN & WET SOIL (g)	111.3	118.8	111.3	112.7	
WT of TIN & DRY SOIL (g)	101.7	107.2	97.8	100.1	
WT of WATER (g)	0.0	1.9	3.8	12.6	
TARE WT (g)	9.6	9.7	9.7	9.7	
WT of DRY SOIL (g)	92.1	97.5	88.1	90.4	
MOISTURE CONTENT	10.4%	11.9%	15.3%	13.9%	

Appendix D

Certificates of Analysis - Groundwater

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 21-10985

17-May-2021

D.M. Wills -Peterborough
Attn : Amanda Tse

150 Jameson Drive
Peterborough, ON
K9J 0B9, Canada

Phone: 289-385-3286
Fax:705-741-3568

Date Rec. : 11 May 2021
LR Report: **CA12346-MAY21**
Reference: 21-10985, Amanda Tse

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: MAC	6: AO/OG	7: MDL	8: GW-10985-MW21-16-2021-05-11	9: GW-10985-MW21-09-2021-05-11	10: GW-10985-MW21-02-2021-05-11
Sample Date & Time								11-May-21 14:30	11-May-21 14:45	11-May-21 14:55
Temp Upon Receipt [°C]	---	---	---	---	---	---	---	8.0	8.0	8.0
NO2 [as N mg/L]	12-May-21	20:44	17-May-21	15:23	1	---	0.003	0.007	0.004	0.010
NO3 [as N mg/L]	12-May-21	20:44	17-May-21	15:23	10	---	0.006	3.10	0.059	0.681
NO2+NO3 [as N mg/L]	12-May-21	20:44	17-May-21	15:23	---	---	0.006	3.10	0.063	0.691

MAC - Maximum Acceptable Concentration
AO/OG - Aesthetic Objective / Operational Guideline
MDL - SGS Method Detection Limit

Temperature of Sample upon Receipt: 8 degrees C
Cooling Agent Present:Yes
Custody Seal Present:Yes

Chain of Custody Number:021737

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 21-10985
LR Report : **CA12346-MAY21**

Jill Campbell

_____

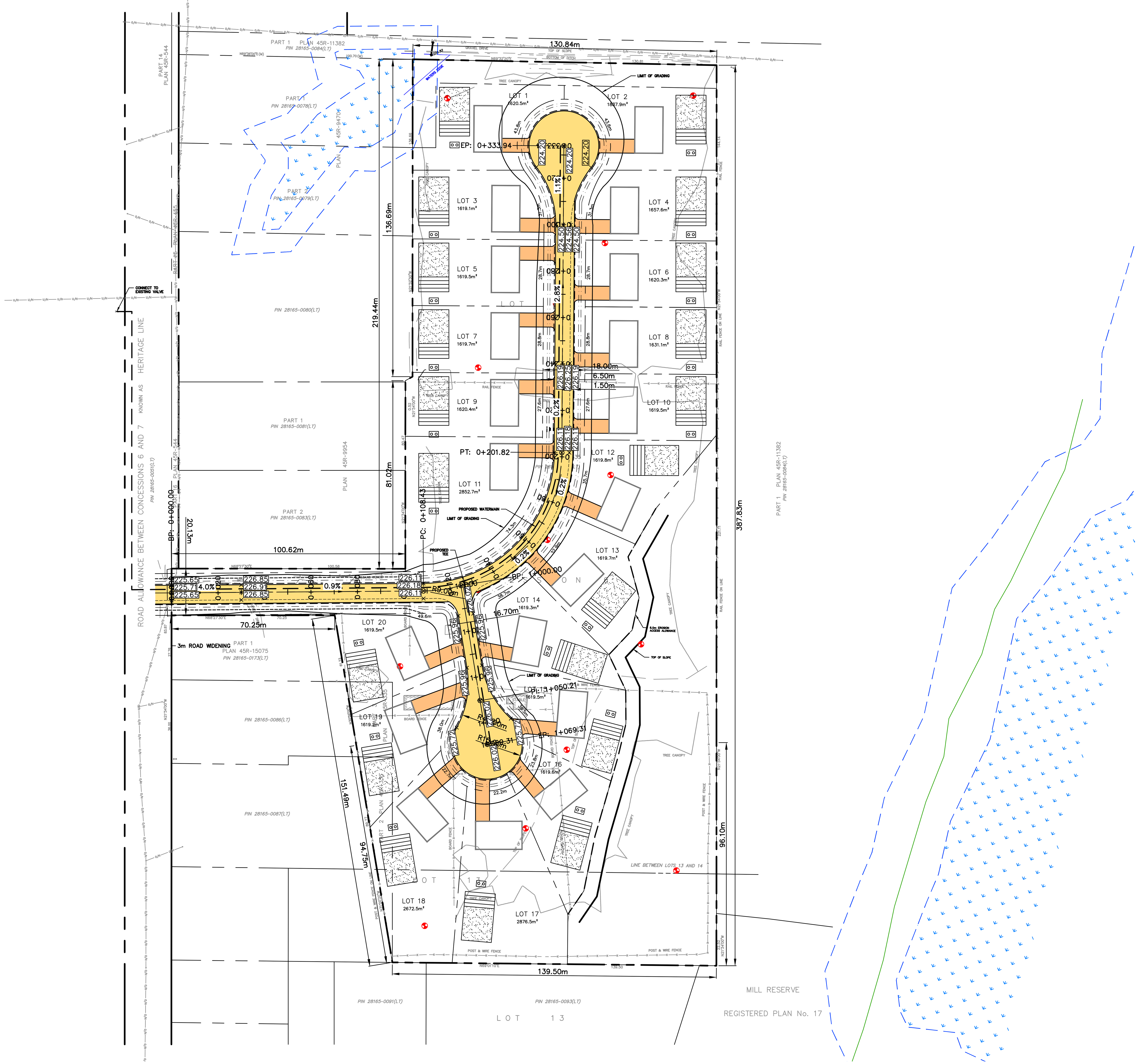
Jill Campbell, B.Sc.,GISAS
Project Specialist,
Environment, Health & Safety

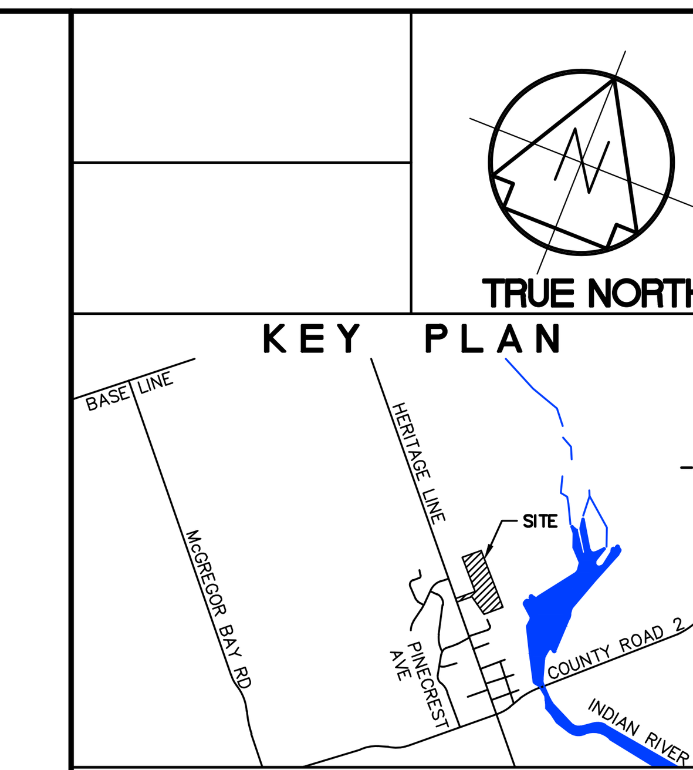
OnLine LIMS

0002498032

Appendix E

Preliminary Servicing and Grading Plan





REVISIONS		
No.	Description	Date

METRIC	Dimensions are in METRES and/or MILLIMETRES unless otherwise shown
LEGEND	TO BE READ IN CONJUNCTION WITH OPSD 100 SERIES

WILLS

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario
Canada K9J 0B9

P. 705.742.2297
F. 705.748.9944
E. wills@dmwills.com

Project Name/Location

HERITAGE LINE RESIDENTIAL

KEENE, ONTARIO

Drawing Title

PRELIMINARY SERVICING AND GRADING PLAN

Drawn By: M.B.	SCALE: Horz. 1:1000 Vert. –	
Designed By: M.B.	Issue Date: July 8, 2021	
Checked By: J.D.F.	Project No.: 21–10985	Sht. No.:
Engineer: – – –	Dwg File No.: 10985–SP	500

NOT FOR CONSTRUCTION

Printed By: mbell Printed On: August 30, 2021
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Appendix F

Infiltration Test Summaries

IN-SITU INFILTRATION TEST

Appendix F

Project:	Heritage Line Residential	**PROJECT NO.:**	10985
Site Location:	1197 Heritage Line, Keene ON	**Date:**	10-May-21
BOREHOLE ID:	INF-01	**Start Time:**	1:37 PM
		Test No.	1

Depth of Borehole (mbeg):	1.45	**Pipe Stickup (maeg):**	-0.019	**Infiltrometer Depth (mbTP):**	1.47	

Time* (Seconds)	**Measurement Interval (sec)**	**Depth** (mbTP)**	**Water Column Height (m)**	**Distance dropped per interval (m)**	**Infiltration Rate per Interval (m/sec)**	**Cumulative Infiltration Rate (m/sec)**
30	-	0.400	1.070	-	--	--
90	60	1.140	0.330	0.740	1.233E-02	1.233E-02
150	60	1.140	0.330	0.000	0.000E+00	6.167E-03
180	30	1.140	0.330	0.000	0.000E+00	4.933E-03
210	30	1.150	0.320	0.010	3.333E-04	4.167E-03
240	30	1.150	0.320	0.000	0.000E+00	3.571E-03
270	30	1.150	0.320	0.000	0.000E+00	3.125E-03
300	30	1.150	0.320	0.000	0.000E+00	2.778E-03
390	90	0.815	0.655	--	--	--
450	60	0.815	0.655	0.000	0.000E+00	0.000E+00
480	30	0.815	0.655	0.000	0.000E+00	0.000E+00
510	30	0.818	0.653	0.003	8.333E-05	2.083E-05
540	30	0.820	0.650	0.002	8.333E-05	3.333E-05
570	30	0.820	0.650	0.000	0.000E+00	2.778E-05
600	30	0.820	0.650	0.000	0.000E+00	2.381E-05
630	30	0.821	0.649	0.001	3.333E-05	2.500E-05
660	30	0.822	0.648	0.001	3.333E-05	2.593E-05
690	30	0.822	0.648	0.000	0.000E+00	2.333E-05
720	30	0.822	0.648	0.000	0.000E+00	2.121E-05
810	90	0.824	0.646	0.002	2.222E-05	2.143E-05
900	90	0.825	0.645	0.001	1.111E-05	1.961E-05
1020	120	0.825	0.645	0.000	0.000E+00	1.587E-05
1290	270	0.826	0.644	0.001	3.704E-06	1.222E-05
1350	60	0.827	0.643	0.001	1.667E-05	1.250E-05
1440	90	0.828	0.642	0.001	1.111E-05	1.238E-05
1500	60	0.829	0.641	0.001	1.667E-05	1.261E-05
1560	60	0.830	0.640	0.001	1.667E-05	1.282E-05
1635	75	0.831	0.639	0.001	1.333E-05	1.285E-05
1800	165	0.833	0.637	0.002	1.212E-05	1.277E-05
1860	60	0.834	0.636	0.001	1.667E-05	1.293E-05
1890	30	0.835	0.635	0.001	3.333E-05	1.333E-05
1980	90	0.836	0.634	0.001	1.111E-05	1.321E-05
2040	60	0.837	0.633	0.001	1.667E-05	1.333E-05
2190	150	0.839	0.631	0.002	1.333E-05	1.333E-05
2370	180	0.842	0.628	0.003	1.667E-05	1.364E-05
2490	120	0.845	0.625	0.003	2.500E-05	1.429E-05
2580	90	0.847	0.623	0.002	2.222E-05	1.461E-05
9000	6420	0.950	0.520	0.103	1.604E-05	1.568E-05
88560	79560	1.460	0.010	0.510	6.410E-06	7.315E-06

* Time at 0 indicates end of pour time into unit. Start of Test.

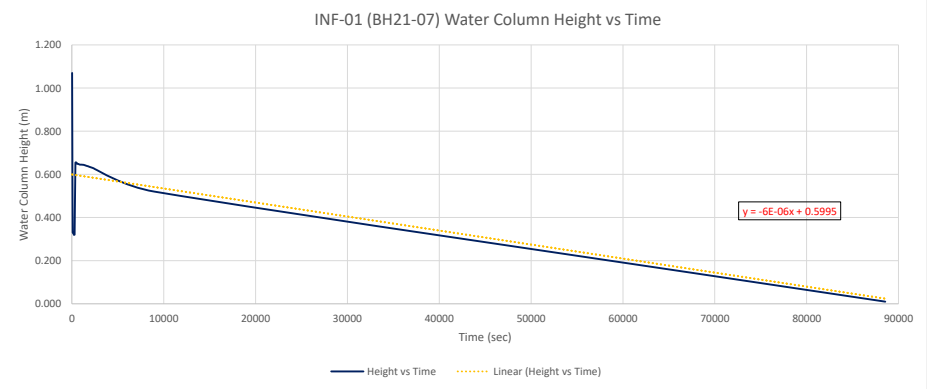
** Depth at time 0 indicates measurement below top of measuring pipe at the start of the test.

More water was added to the infiltrometer at time = 390s

Not used for statistical analysis

	(m/sec)	**(mm/sec)**	**(mm/hour)**
Maximum Infiltration Rate Between Sampling Intervals -	1.23E-02	1.23E+01	44400
Minimum Infiltration Rate Between Sampling Intervals -	0.00E+00	0.00E+00	0
Median Infiltration Rate Between Sampling Intervals -	1.33E-05	1.33E-02	48
Average Infiltration Rate Between Sampling Intervals -	**3.57E-04**	**3.57E-01**	**1284**
Average Cumulative Infiltration Rate for Entire Data Set -	**1.01E-03**	**1.01E+00**	**3654**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**1.01**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**3.65E+03**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**0.164**



		Test 1 - Observed
Test Duration (seconds)		**88,560**
Total Drop Distance (mm)		**1395**
Total Number of Measured Intervals		**39**
Infiltration Rate (mm/sec) - Test Average		**1.01**
Infiltration Rate (mm/hour) - Test Average		**3.65E+03**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**0.164**

IN-SITU INFILTRATION TEST

Appendix F

Project: Heritage Line Residential
Site Location: 1197 Heritage Line, Keene ON
BOREHOLE ID: INF-02

PROJECT NO.: 10985
Date: 10-May-21
Start Time: 2:43 PM
Test No. 1

Depth of Borehole (mbeg):	1.47	Pipe Stickup (maeg):	0.006	Infiltrometer Depth (mbTP):	1.51	

Time* (Seconds)	Measurement Interval (sec)	Depth** (mbTP)	Water Column Height (m)	Distance dropped per interval (m)	Infilitration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)	
0	-	0.150	1.360	-	--	--	
30	30	0.160	1.350	0.010	3.333E-04	3.333E-04	
60	30	0.165	1.345	0.005	1.667E-04	2.500E-04	
90	30	0.166	1.344	0.001	3.333E-05	1.778E-04	
120	30	0.170	1.340	0.004	1.333E-04	1.667E-04	
150	30	0.173	1.337	0.003	1.000E-04	1.533E-04	
180	30	0.180	1.330	0.007	2.333E-04	1.667E-04	
210	30	0.185	1.325	0.005	1.667E-04	1.667E-04	
240	30	0.191	1.319	0.006	2.000E-04	1.708E-04	
270	30	0.194	1.316	0.003	1.000E-04	1.630E-04	
300	30	0.199	1.311	0.005	1.667E-04	1.633E-04	
330	30	0.202	1.308	0.003	1.000E-04	1.576E-04	
360	30	0.206	1.304	0.004	1.333E-04	1.556E-04	
390	30	0.210	1.300	0.004	1.333E-04	1.538E-04	
420	30	0.213	1.297	0.003	1.000E-04	1.500E-04	
480	60	0.218	1.292	0.005	8.333E-05	1.417E-04	
540	60	0.224	1.286	0.006	1.000E-04	1.370E-04	
600	60	0.233	1.277	0.009	1.500E-04	1.383E-04	
660	60	0.240	1.270	0.007	1.167E-04	1.364E-04	
720	60	0.246	1.264	0.006	1.000E-04	1.333E-04	
780	60	0.254	1.256	0.008	1.333E-04	1.333E-04	
840	60	0.257	1.253	0.003	5.000E-05	1.274E-04	
900	60	0.266	1.244	0.009	1.500E-04	1.289E-04	
960	60	0.275	1.235	0.009	1.500E-04	1.302E-04	
1020	60	0.280	1.230	0.005	8.333E-05	1.275E-04	
1080	60	0.287	1.223	0.007	1.167E-04	1.269E-04	
1140	60	0.294	1.216	0.007	1.167E-04	1.263E-04	
1200	60	0.300	1.210	0.006	1.000E-04	1.250E-04	
1320	120	0.313	1.197	0.013	1.083E-04	1.235E-04	
1440	120	0.324	1.186	0.011	9.167E-05	1.208E-04	
1560	120	0.336	1.174	0.012	1.000E-04	1.192E-04	
1680	120	0.345	1.165	0.009	7.500E-05	1.161E-04	
1800	120	0.356	1.154	0.011	9.167E-05	1.144E-04	
1920	120	0.371	1.139	0.015	1.250E-04	1.151E-04	
2160	240	0.392	1.118	0.021	8.750E-05	1.120E-04	
5880	3720	0.771	0.739	0.379	1.019E-04	1.056E-04	
74520	68640	1.510	0.000	0.739	1.077E-05	1.825E-05	DRY

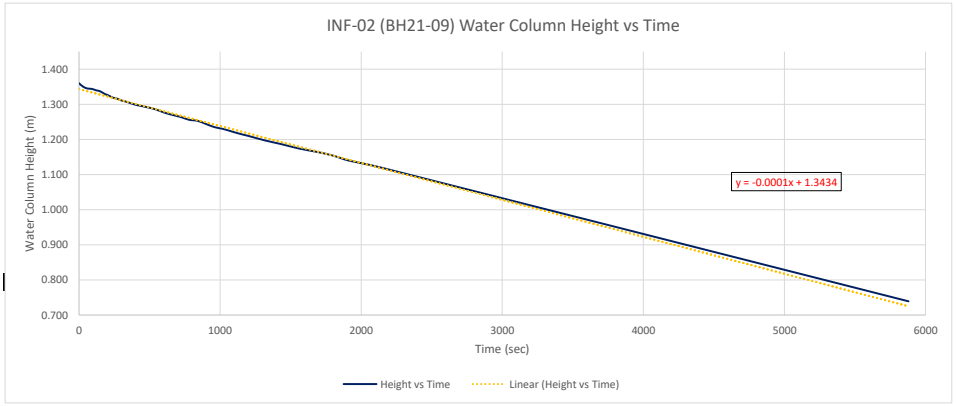
* Time at 0 indicates end of pour time into unit. Start of Test.
** Depth at time 0 indicates measurement below top of measuring pipe at the start of the test.
Not used for statistical analysis

	(m/sec)	(mm/sec)	(mm/hour)
Maximum Infiltration Rate Between Sampling Intervals -	3.33E-04	3.33E-01	1200
Minimum Infiltration Rate Between Sampling Intervals -	3.33E-05	3.33E-02	120
Median Infiltration Rate Between Sampling Intervals -	1.08E-04	1.08E-01	390
Average Infiltration Rate Between Sampling Intervals -	**1.24E-04**	**1.24E-01**	**445**
Average Cumulative Infiltration Rate for Entire Data Set -	**1.48E-04**	**1.48E-01**	**532**

In-situ Infiltration Rate Measured in the Field (mm/sec): **0.148**

In-situ Infiltration Rate Measured in the Field (mm/hour): **532**

Calculated Percolation Time (T) based on field infiltration (min/cm): **1.13**



		Test 1 - Observed
Test Duration (seconds)		**5,880**
Total Drop Distance (mm)		**621**
Total Number of Measured Intervals		**36**
Infiltration Rate (mm/sec) - Test Average		**0.148**
Infiltration Rate (mm/hour) - Test Average		**532**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**1.13**

IN-SITU INFILTRATION TEST

Appendix F

Project:	Heritage Line Residential	**PROJECT NO.:**	10985
Site Location:	1197 Heritage Line, Keene ON	**Date:**	10-May-21
BOREHOLE ID:	INF-03	**Start Time:**	3:29 PM
		Test No.	1

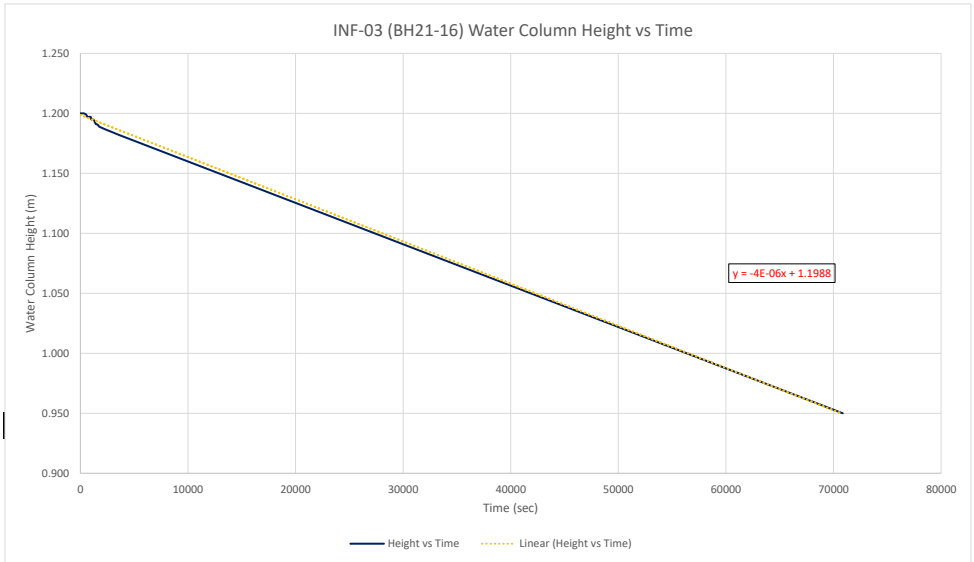
Depth of Borehole (mbeg):	1.19	Pipe Stickup (maeg):	0.29	Infiltrometer Depth (mbTP):	1.50	

Time* (Seconds)	Measurement Interval (sec)	Depth** (mbTP)	Water Column Height (m)	Distance dropped per interval (m)	Infiltration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)
0	-	0.300	1.200	-	--	--
30	30	0.300	1.200	0.000	0.000E+00	0.000E+00
60	30	0.300	1.200	0.000	0.000E+00	0.000E+00
90	30	0.300	1.200	0.000	0.000E+00	0.000E+00
120	30	0.300	1.200	0.000	0.000E+00	0.000E+00
150	30	0.300	1.200	0.000	0.000E+00	0.000E+00
180	30	0.300	1.200	0.000	0.000E+00	0.000E+00
300	120	0.300	1.200	0.000	0.000E+00	0.000E+00
540	240	0.301	1.199	0.001	4.167E-06	1.852E-06
660	120	0.303	1.197	0.002	1.667E-05	4.545E-06
780	120	0.303	1.197	0.000	0.000E+00	3.846E-06
960	180	0.303	1.197	0.000	0.000E+00	3.125E-06
1,020	60	0.305	1.195	0.002	3.333E-05	4.902E-06
1,140	120	0.305	1.195	0.000	0.000E+00	4.386E-06
1,290	150	0.306	1.194	0.001	6.667E-06	4.651E-06
1,320	30	0.307	1.193	0.001	3.333E-05	5.303E-06
1,380	60	0.308	1.192	0.001	1.667E-05	5.797E-06
1,440	60	0.309	1.191	0.001	1.667E-05	6.250E-06
1,500	60	0.309	1.191	0.000	0.000E+00	6.000E-06
1,680	180	0.310	1.190	0.001	5.556E-06	5.952E-06
1,740	60	0.311	1.189	0.001	1.667E-05	6.322E-06
3,600	1860	0.318	1.182	0.007	3.763E-06	5.000E-06
70,860	67260	0.550	0.950	0.232	3.449E-06	3.528E-06

* Time at 0 indicates end of pour time into unit. Start of Test.
** Depth at time 0 indicates measurement below top of measuring pipe at the start of the test.
Not used for statistical analysis

	(m/sec)	(mm/sec)	(mm/hour)
Maximum Infiltration Rate Between Sampling Intervals -	3.33E-05	3.33E-02	120
Minimum Infiltration Rate Between Sampling Intervals -	0.00E+00	0.00E+00	0
Median Infiltration Rate Between Sampling Intervals -	1.72E-06	1.72E-03	6
Average Infiltration Rate Between Sampling Intervals -	**7.13E-06**	**7.13E-03**	**26**
Average Cumulative Infiltration Rate for Entire Data Set -	**3.25E-06**	**3.25E-03**	**12**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**3.25E-03**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**11.7**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**51.3**



		Test 1 - Observed
Test Duration (seconds)		**70,860**
Total Drop Distance (mm)		**250**
Total Number of Measured Intervals		**23**
Infiltration Rate (mm/sec) - Test Average		**3.25E-03**
Infiltration Rate (mm/hour) - Test Average		**11.7**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**51.3**