Hydrogeological Study Report

Osaca Hillstreet Subdivision

County Road 65, Osaca, Ontario

D.M. Wills Project Number 22-11056

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

December 2022

Prepared for:
Hillstreet Developments Ltd.
c/o Larry MacDonell

WILLS

Submissions Summary

Submission No.	Submission Title	Date of Release	Submissions Summary
1	Draft Hydrogeological Study Report	December 6, 2022	Draft Submission for Client Review
2	Final Hydrogeological Study Report	December 7, 2022	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 Hillstreet Developments Ltd. c/o Larry MacDonell (Client) to complete a Hydrogeological Study (Study) for the property located at Pt Lot 27 Concession 5, in the village of Osaca, Ontario (Subject Property). Wills understands the Subject Property is approximately 24.6 hectares (ha) and is proposed to be developed as a residential subdivision with 59 individual lots (Proposed Development). The location of the Subject Property is shown on **Figure 1**.

The Study was requested by the Municipality of Port Hope (Pre-Consultation – Planning Review dated May 25, 2022) to confirm sewage servicing capabilities in context of the Proposed Development, and to confirm that adequate water supply is available. Furthermore, infiltration rates of the subsurface soils and shallow groundwater conditions were evaluated as input to the design of proposed stormwater management features and sewage disposal systems on the Subject Property.

Wills' Hydrogeological Study Report includes a preliminary assessment of water supply for the purpose of the initial Draft Plan submission and relies on surrounding water well records and historic hydrogeological investigations for the neighboring property. Prior to the second Draft Plan submission, water supply wells will be installed and tested on the Subject Property to confirm Wills' findings.

2.0 Scope of Work

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

- A review of available Ministry of Environment, Conservation, and Parks (MECP) well records within 500 meters (m) of the Subject Property to provide a preliminary characterization of the local hydrogeological conditions.
- Prior to initiating field investigations, public and private utility services locates were obtained and reviewed by Wills staff. A Site-Specific Health and Safety Plan and Field Work plan were prepared to ensure a safe and efficient fieldwork program.
- Steenburgh Sand and Gravel (Steenburgh) excavated 12 test pits on the Subject Property to a depth of 3.0 metres below ground (mbg) between September 23 and September 26, 2022.
- Eight single ring infiltrometers were installed on the Subject Property to determine representative infiltration rates for stormwater management and sewage disposal system design between September 26 and September 27, 2022.
- Retained soils samples were reviewed by Wills prior to submitting select samples to PRI Engineering (PRI), a Canadian Certified Independent Laboratory (CCIL) for analysis of Particle Size Distribution and percolation time estimation.
- Three groundwater samples were collected from on-site monitor wells on October 5, 2022 and analyzed by SGS to determine background nitrate concentrations.

- High-level assessment of groundwater availability was conducted on the basis of nearby MECP Well Records, encountered geological and hydrogeological conditions, and findings included in the report titled *Groundwater Supply Assessment Report – Hope Concession 5, Part Lot 27 County Road No. 65*, prepared by Ted Rannie M.Sc., P. Geo (September 2018) for the adjacent property to the south.
- Assessment of the Subject Property's capacity to support private on-site sewage disposal systems (Groundwater Impact Assessment) was conducted based on the Preliminary Draft Plan configuration and MECP *Guideline D-5-4 Individual On-site Sewage Systems: Water Quality Impact Risk Assessment (Guideline D-5-4)*.
- Evaluation of Wills' desktop review and field investigations findings, and preparation of this Hydrogeological Study Report.

It should be noted that Wills' approved Scope of Work includes the construction and testing of three water supply wells on the Subject Property. The results of the pumping tests will be included as addendum to Wills' Study in 2023.

3.0 Subsurface Investigation

Test pit and infiltration test locations completed between September 23 and September 27 are shown on **Figure 2**.

Representative soil samples were submitted to PRI for analysis of Particle Size Distribution and percolation time estimation. 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 & Table 3 values (Ontario Building Code [OBC], 2012) (OBC Table 2 & OBC Table 3). Percolation times are discussed in **Section 4.0**.

Test pit logs detailing the encountered subsurface conditions are included in **Appendix A**. Boreholes advanced for the purpose of installing infiltrometers were completed using an excavator-mounted auger, and were positioned adjacent to existing test pits where possible as a means of confirming the underlying soils. These boreholes were not logged or sampled.

3.1 Soil Profile Summary

The Subject Property is located in the Physiographic Region of the Iroquois Plain (*The Physiography of Southern Ontario, Chapman and Putnam, 1984*), which is characterized by lacustrine deposits including sand plains and beaches associated the former Lake Iroquois. Ontario Geological Survey (OGS) mapping suggests that surficial geology on the Subject Property consists of alluvial deposits.

The results of the test pit program indicate the overburden is generally aligned with published mapping, and includes a surficial layer of silty sand topsoil underlain by sand with slight variations in gravel, silt, and clay content. A generally north-south trending band of silt and clay rich soils was observed on the western side of the Subject Property

at TP22-10, TP22-08, and TP22-11. This material was encountered at a depth ranging from approximately 1.3 to 1.7 mbg and extended to the test pit termination depths of approximately 3.0 mbg.

Seven laboratory particle size distribution analyses were completed on the collected soil samples. The analytical results are summarized in **Table 1** on the basis of the Unified Soil Classification System (USCS). Certificates of Analysis for the physical soil analysis are included in **Appendix B**.

Table 1 – Summary of Particle Size Distribution

Test Pit ID	Sample No.	Sample Depth (mbg)	Soil Unit	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
TP22-01	GS-01	1.4	Sand	3	93	3	1
TP22-02	GS-02	2.9	Sand	3	94	3	0
TP22-03	GS-03	1.0	Sand	0	97	3	0
TP22-05	GS-01	1.7	Sand	2	78	18	2
TP22-08	GS-02	2.0	Silt & Clay	0	4	56	40
TP22-10	GS-02	1.9	Silt & Clay	0	3	62	35
TP22-11	GS-02	2.7	Silt & Clay	0	4	71	25

3.2 Bedrock

Bedrock was not encountered at any of the test pit locations, and a review of nearby MECP well records suggests that bedrock is in excess of 34 mbg in the vicinity of the Subject Property. OGS classifies the underlying bedrock geology to be from the Ottawa and Simcoe group, and may include dolostone, shale, arkose, and sandstone. Nearby MECP well records suggest the underlying bedrock consists of limestone material.

3.3 Groundwater

Groundwater level monitoring was conducted at the five drive point monitor well locations, as well as three on-site monitor wells installed by Cambium Inc. and detailed in their November 2022 report titled *Geotechnical Investigation – Proposed Residential Development, 5868 County Road 65, Port Hope, ON* (Geotechnical Report). **Figure 2** shows the locations of the monitor wells included in Wills' Study. **Table 2** summarizes the static water levels measured on the Subject Property by Wills. Groundwater elevations for select monitor wells were inferred using the relative elevations provided in the Geotechnical Report, and are referenced to a local (assumed) benchmark.

Table 2 – Groundwater Level Summary

Monitor Well ID	Stick-Up (mag)	Date	Static Water Level (mbg)	Groundwater Elevation (masl)
MW22-01	0.73	September 27, 2022	2.71	-
		October 5, 2022	Damaged	-
MW22-02	0.56	September 27, 2022	Dry	-
		October 5, 2022	Dry	-
MW22-05	0.50	September 27, 2022	2.53	-
		October 5, 2022	2.58	-
MW22-08	0.48	September 27, 2022	2.59	-
		October 5, 2022	2.63	-
MW22-11	0.73	September 27, 2022	2.30	-
		October 5, 2022	2.34	-
BH101-22 (proximal to MW22-01)	0.88	September 27, 2022	-	--
		October 5, 2022	2.66	197.24
BH107-22 (proximal to MW22-11)	1.06	September 27, 2022	-	-
		October 5, 2022	2.54	197.86
BH110-22 (proximal to MW22-05)	0.92	September 27, 2022	-	-
		October 5, 2022	2.58	196.12

*mbg – metres below ground masl – metres above sea level, measured against an assumed datum (local benchmark)

3.3.1 Groundwater Flow Direction and Hydraulic Gradients

Shallow groundwater flow direction was calculated using Wills' field measurements and monitor well elevations provided in the Geotechnical Report. Based on this information, Wills infers the shallow groundwater flows direction to be to the southeast on the Subject Property. The steepest hydraulic gradient was calculated to be 0.0043 between BH107-22 and BH110-22, and shallower hydraulic gradients between BH101-22 to BH110-22 and from BH107-22 to BH101-22 were calculated to be 0.00195 and 0.00156 respectively. The inferred groundwater flow direction is shown on **Figure 2**.

4.0 In-Situ Infiltration Testing

In-situ Infiltration tests were conducted at select locations on the Subject Property to determine representative shallow infiltration rates for stormwater management and sewage disposal system design. Infiltration testing locations are shown on **Figure 2**.

The tests were conducted at depths ranging from 0.6 to 2.1 mbg and were completed using 51-millimetre open-end single ring infiltrometers. Water levels within the infiltrometer casings were manually monitored using a Solinst water level tape. The infiltration tests were conducted for a maximum of 96 minutes, with water levels measured at 30-second intervals for the first 5-minutes and increasing intervals as the test progressed. Detailed calculations and supporting infiltration graphs are provided in **Appendix C.**

4.1 Permeability and Percolation Time

Table 3 summarizes the permeability and percolation times of the tested soils on the basis of the in-situ testing, and laboratory results compared to OBC Table 2 & Table 3.

Table 3 – Permeability and Percolation Time Summary

ID	Sample ID	In-situ Testing	Physical Soil Testing Results	Percolation Range (OBC Table 2 and 3)	Laboratory Estimated Percolation (T)	Permeability (Inferred Soil Envelope)
TP22-01 Proxy for INF-01	GS-01	T= 0.42 min/cm or 1429 mm/hr	SP envelope	T = 2 – 8 min/cm or 75 – 300 mm/hr	T = 6 min/cm	Medium
TP22-02 Proxy for INF-02	GS-02	T= 0.49 min/cm or 1224 mm/hr	SP envelope	T = 2 – 8 min/cm or 75 – 300 mm/hr	T = 7 min/cm	Medium
TP22-03 Proxy for INF-03	GS-01	T=0.35 min/cm or 1714 mm/hr	SP envelope	T = 2 – 8 min/cm or 75 – 300 mm/hr	T = 6 min/cm	Medium
TP22-05 Proxy for INF-05	GS-01	T=0.22 min/cm or 2727 mm/hr	SM envelope	T = 8 – 20 min/cm or 30 – 75 mm/hr	T = 12 min/cm	Medium to Low
INF-06	N/A	T=0.78 min/cm or 769 mm/hr	SM envelope	T = 8 – 20 min/cm or 30 – 75 mm/hr	N/A	Medium to Low
INF-07	N/A	T=0.33 min/cm or 1818 mm/hr	SP envelope	T = 2 – 8 min/cm or 75 – 300 mm/hr	N/A	Medium
INF-08A	N/A	T=1.11 min/cm or 540 mm/hr	SP envelope	T = 2 – 8 min/cm or 75 – 300 mm/hr	N/A	Medium
TP22-08 Proxy for INF-08B	GS-02	T= 0 min/cm or 0 mm/hr	OH envelope	T = > 50 min/cm or >50 mm/hr	T = > 50 min/cm	Unacceptable
INF-11	N/A	T= 0.81 min/cm or 740 mm/hr	SM envelope	T = 8 – 20 min/cm or 30 – 75 mm/hr	N/A	Medium to Low

Notes: 1. SM envelope –silty sands, sand-silt mixtures
SP envelope – poorly graded sands, gravelly sand, little or no fines
OH envelope – Organic clays of medium to high plasticity, organic silts

Wills provides the following considerations as they related for the proposed stormwater management and sewage disposal system designs:

- The encountered soils are anticipated to generally fall within the SP and SM soils envelopes. Sewage disposal system and stormwater management feature design should take into account the silt and clay rich soils identified at TP22-08, TP22-10, and TP22-11 that were encountered between 1.3 to 3.0 mbg. Based on INF-08B, these soils do not have an acceptable permeability on the basis of the OBC.
- A Subsurface Infiltration Plan showing the inferred contact between these two distinct shallow soil units is included as **Figure 3**. Subsurface stratigraphy was inferred from the findings of Wills' test pit program and considers soil properties above a depth of 3.0 mbg.
- Wills recommends using the mid point of the T-time ranges provided in the OBC for stormwater management and sewage disposal system design on the Subject Property, as shown on **Figure 3**. Although these T-time values (mid range) are slower than that measured in the in-situ tests, Wills considers these conservative for the purpose of design, and should account for any lateral or vertical variation in infiltration rates.

5.0 Groundwater Availability

Wills' preliminary water supply assessment included a review of nearby MECP Well Records and historic hydraulic testing on the neighboring property to the south. Three water supply wells are proposed to be installed and tested on the Subject Property in 2023, to confirm that adequate groundwater supply and quality its available to the Proposed Development.

5.1 MECP Water Well Record Survey

Wills completed a database review and desktop evaluation of MECP Well Records to assist in characterizing the local hydrogeological conditions within 500 m of the Subject Property. The MECP Well Location Plan showing the relative locations of the MECP wells and their respective identifiers is included as **APP- D1** in **Appendix D**. Details for each MECP Well are summarized as **APP-D2** in **Appendix D**.

Nine well records were identified within the 500 m search radius and are summarized below.

- Seven wells were designated as domestic use and two of the wells had an unknown use.
    - One of the unknown uses had incomplete details on the well record, and the other was in relation to a clean-out of sand and gravel from the well bore.
- Five wells were installed in overburden material and four wells were installed in bedrock.

- Well depths ranged from approximately 7.6 to 46 mbg for the wells installed in overburden (25.5 mbg average), and from 34.1 to 44.8 mbg for those installed in bedrock (40.9 mbg average).
- Static water levels ranged from approximately 5.5 to 9.1 mbg for the wells that were installed in overburden (6.9 mbg average), and from 8.5 to 29 mbg for those installed in bedrock (18.3 mbg average).
- The recommended pumping rates ranged from approximately 7.6 to 30.2 litres per minute (L/min) for the overburden wells (19.9 L/min average), and from 3.8 to 37.8 L/min for the bedrock wells (20.2 L/min average).

Based on Wills review, a viable aquifer is present on lands adjacent to the Subject Property. Several wells directly north of the Subject Property and directly west of the 500 m buffer (within the community of Osaca), are dug wells that are screened within a shallow sand layer. These wells are less useful for inferring available water supply as they are non-compliant with Ontario Regulation 903 with respect to the depth of construction.

The most useful information can be inferred from wells to the south and southeast of the Subject Property, which all intercept a productive aquifer directly above, or within the bedrock stratum. Overburden wells in this area are generally screened within a coarse sand and gravel layer, and have recommended pumping rates between approximately 15 and 30 L/min. Adjacent bedrock wells are noted as supplying fresh groundwater with recommended pumps rates that range from approximately 19 to 38 L/min. Based on the short-term pumping test results provided on the Well Records, all of these Wells satisfy the minimum yield requirement of 13.7 L/min (four bedroom dwelling) provided in the MECP *Guideline D-5-5 Private Wells: Water Supply Assessment* (*Guideline D-5-5*).

Based on the proximity of these wells to the Subject Property, it is likely that the hydrogeological/aquifer conditions extend north below the Subject Property, provided that the underlying bedrock structure and overburden deposits are similar in nature.

5.2 Historic Groundwater Supply Evaluation

Three of the water wells included in Wills' MECP records search were subject to long-term pumping tests and detailed in the report titled *Groundwater Supply Assessment Report – Hope Concession 5, Part Lot 27 County Road No. 65*, prepared by Ted Rannie M.Sc., P. Geo in September 2018 (2018 Report). This report was prepared to support the development of a 20 lot subdivision on lands directly south of the Subject Property. The wells included in this assessment were MECP Well ID 7314568 (overburden), 7314570 (bedrock), and 7314569 (overburden).

The 2018 Report concluded the following:

- The wells screened in overburden (coarse gravel layers) were confirmed to have high K (hydraulic conductivity) values ($2x10^{-2}$ m/s to $8x10^{-1}$ m/s), quickly stabilizing drawdowns, and impressive recovery characteristics (94 - 95% recovery in 75 min and 60 min).

- The well screened in bedrock had a K value 3 orders of magnitude less than the overburden wells ($2x10^{-5}$ m/s), however, also showed impressive recovery (88% recovery in 60 min).
- Groundwater testing results indicated relatively good overall chemical quality, which would require commercial water treatment for several aesthetic parameters.
- Off-site impacts to neighboring water users or surface water resources were not expected in view of the large available drawdown in the tested wells.
- Adequate groundwater supply was inferred for the 20 lot development on the basis of the long duration pumping test results at the three well locations.
- The permeable overburden gravel layers were determined to have the best potential for groundwater source on the property considered.

The results of the 2018 Report speak favorably to the prospect of adequate water supply and quality on the Subject Property. On-site testing will be required to confirm Wills' preliminary findings; however, our desktop review has concluded that coarser grained water-bearing layers are present surrounding the Subject Property, and both overburden and bedrock aquifers may provide viable options and/or alternatives for supplying the Proposed Development.

6.0 Groundwater Impact Assessment

A Groundwater Impact Assessment was conducted on the basis of the *Guideline D-5-4* to determine the feasibility and potential for impacts to down-gradient water resources arising from the proposed sewage disposal systems. The Groundwater Impact Assessment considered the following:

- Based on the Preliminary Draft Plan prepared by D.G. Biddle & Associates Limited (**Appendix E**) the Proposed Development will include 59 residential lots.
    - Wills understands that each lot is proposed to be serviced with a private on-site sewage disposal system.
- At the time of preparing this report, actual dwelling sizes and anticipated sewage flows were not available, however, 1,000 L/day is considered to be an acceptable sewage effluent loading rate.
- Nitrate was used to assess the impact of sewage effluent on the groundwater environment. *Guideline D-5-4* requires that the effluent plume at the boundary of the Subject Property cannot exceed the ODWQS limit of 10 mg/L for nitrate to prevent off-site groundwater impacts.
- Wills' inputs to the mass balance equation used a standard nitrate loading of 40 mg/lot/day (*Guideline D-5-*4) for a conventional sewage disposal system.
- A background nitrate concentration of 0.53 mg/L was used for the Groundwater Impact Assessment and was based on the average of two groundwater samples collected from monitor wells BH107-22 and BH110-22.

- In determining a representative background nitrate concentration for the Subject Property, Wills' disregarded the nitrate concentration measured in shallow groundwater from MW22-08. This measured value was significantly higher (4.35 mg/L), and is expected to have been locally impacted by topsoil that was inadvertently backfilled into the test pit containing the drive-point well. It should be noted that the majority of the Subject Property has been used for agricultural purposes, and elevated levels of nitrate should be expected in the shallow soils/topsoil. Certificates of Analysis for the nitrate samples are included in **Appendix F.**

- Available post-development dilution/recharge water for the Subject Property was estimated through a water balance analysis. A summary of the water balance calculations, including the Groundwater Impact Assessment, is included in **Appendix G**. The water balance analysis considered the following elements:
  - Historical Climate Normals – Oshawa WPCP (Climate ID 6155878).
  - The total monthly water surplus available for dilution was calculated - accounting for evapotranspiration using the Thornthwaite method.
  - Infiltration factors for topography, soils, and cover were applied based on the MOEE document, *Hydrogeological Technical Information Requirements For Land Development Applications*, April 1995.
- The mass balance equation used in Wills' Groundwater Impact Assessment is included in **Appendix H**.

6.1 Predictive Assessment

The results from the Predictive Assessment are outlined below:

Table 4 – Predictive Assessment of Nitrate Concentration

Parameter	Value
Number of Lots	59
Volume of Effluent (Q_e)	59 lots x 1,000 L/day = 59,000 L/day
Effluent nitrate concentration	40 mg/L
Available dilution water	169,648 L/day
Dilution water nitrate concentration	0.053 mg/L
Total Volume	228,648 L/day
Total nitrate concentration at property boundary	**10.7 mg/L**

In view of the results presented in **Table 4,** Wills concludes that the current configuration of the Proposed Development would result in unacceptable levels of nitrate at the property boundary, unless advanced treatment is considered.

Wills provides the following mitigation options to ensure that acceptable nitrate concentrations are achieved at the boundary of the Subject Property:

- The sewage effluent should be treated to contain no more than **37 mg/L** nitrate when leaving the system if the Client wishes to maintain 59 residential lots.
- If the proposed number of lots is reduced to 53, conventional sewage disposal systems (nitrate loading of 40 mg/L) without advanced treatment would result in acceptable nitrate concentrations to the satisfaction of *Guideline D-5-4*.

7.0 Conclusions and Recommendations

The following conclusions and recommendations are provided with respect to Wills' Study.

- Shallow subsurface soils were generally consistent across the Subject Property and included a thin layer of silty sand topsoil underlain by sand with slight variations in gravel, silt, and clay content. A north-south trending band of silt and clay rich soils was observed on the western side of the Subject Property at TP22-10, TP22-08, and TP22-11 at a depth of approximately 1.3 to 1.7 mbg and extended to the test pit termination depths of approximately 3.0 mbg.
- Five drivepoint monitor wells were installed in the base of select test pits to monitor groundwater levels above a depth of 3 mbg. Static water levels were also monitored in 3 monitor wells installed by Cambium Inc. to support their geotechnical investigation.
- Static groundwater levels were generally consistent across the Subject Property and ranged from 2.34 mbg to 2.71 mbg on September, and from 2.34 mbg to 2.66 mbg on October 5, 2022.
    - Monitor well MW22-05 was observed to be dry on both events.
- Groundwater seepage was encountered in all test pits at an approximate depth of 2.9 mbg to 3 mbg, with the exception of TP22-06, TP22-07, and TP22-10, which were found to be dry prior to backfilling.
- Three groundwater samples were submitted for total nitrogen analysis to support the Groundwater Impact Assessment.
- Seven laboratory particle size distribution analyses and laboratory percolation time estimates were completed on representative samples of the shallow subsurface soils.
- Eight in-situ infiltration tests were conducted between September 26 and September 27, 2022. T-Times were calculated to range from 0 min/cm to 0.81 min/cm, with an average of 0.46 min/cm across all eight tests.

- A review of the physical soil characteristics and comparison against OBC Table 2 and Table 3 suggests a percolation time (T-Time) that is generally between 2 to 12 min/cm for the shallow sand to silty sand soils, and > 50 min/cm for the clayey silt to silt material. Laboratory percolation estimates suggest the T-time ranges from 6 min/cm to 12 min/cm for the sand to silty sand material, and > 50 min/cm for the clayey silt to silt material.
- In view of the in-situ infiltration testing and physical soil testing results, Wills recommends using the middle of the T-time range for the individual soil units/soil envelopes (OBC Table 2 and Table 3) to be conservative. The individual shallow soil types and respective envelopes are shown **Figure 3.**
- Any proposed LID and sewage disposal system design should consider the shallow groundwater depths encountered on the Subject Property, which may 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 Groundwater Impact Assessment was conducted by Wills to determine the suitability of the Subject Property to accommodate private on-site sewage disposal systems.
- The Groundwater Impact Assessment considered 59 residential lots, and anticipated flows to the sewage disposal systems of 1,000 L/day with a nitrate loading of 40 mg/lot/day on the basis of *D-5-4*.
- The Groundwater Impact Assessment concludes that a groundwater nitrate concentration of 10.7 mg/L will be achieved at the property boundary, which exceeds the ODWS and does not satisfy the requirements of *D-5-4*. The following mitigation options are provided:
    - If the number of lots is maintained at 59, Each proposed sewage disposal system would require advanced treatment to ensure that effluent leaving the system does not contain more than 37 mg/L nitrogen.
    - Alternatively, If the number of lots is reduced to 53, conventional sewage disposal systems (nitrate loading of 40 mg/L) without advanced treatment would result in acceptable nitrate concentrations at the property boundaries.
- The following is provided with respect to Wills' interpretation of the MECP Well Records and historic groundwater investigations on neighboring properties:
    - Viable water supply aquifers have been identified within both coarse grained sand and gravel layers, as well as within the underlying bedrock stratum.
    - The recommended pumping rates ranged from approximately 7.6 to 30.2 litres per minute (L/min) for the nearby overburden wells (19.9 L/min average), and from 3.8 to 37.8 L/min for the bedrock wells (20.2 L/min average).

- Shallow aquifers were generally more high-producing north of the Subject Property, and deeper wells installed in overburden and bedrock south of the Subject Property were generally more high-performing.
- Detailed hydraulic assessment (2018 Ted Rannie Report) completed for the property directly south of the Subject Property, concluded that the underlying aquifer could support a 20 lot residential development without causing off-site impacts to neighbouring water users or surface resources.
- Based on Wills' desktop review of surrounding well performances and understanding of the local geological conditions, it is likely that these aquifer conditions may extend beneath the Subject Property and be available to the Proposed Development.

- The installation and testing of water supply wells on the Subject Property is scheduled for 2023, to ensure that adequate water supply and quality is available to the Proposed Development. The results of this testing will be included as an addendum to this Hydrogeological Study Report.

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: _____
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Environmental Project Technologist

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

LT/IA/mp

Statement of Limitations

This report is intended solely for Hillstreet Developments Ltd. c/o Larry MacDonell (Client) for the Proposed Development located on Pt Lot 27Concession 5, in the village of Osaca, 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.

FIGURES

Legend

Subject Property

Subject Property Plan

Hydrogeological Study
County Road 65
Osaca, ON

WILLS

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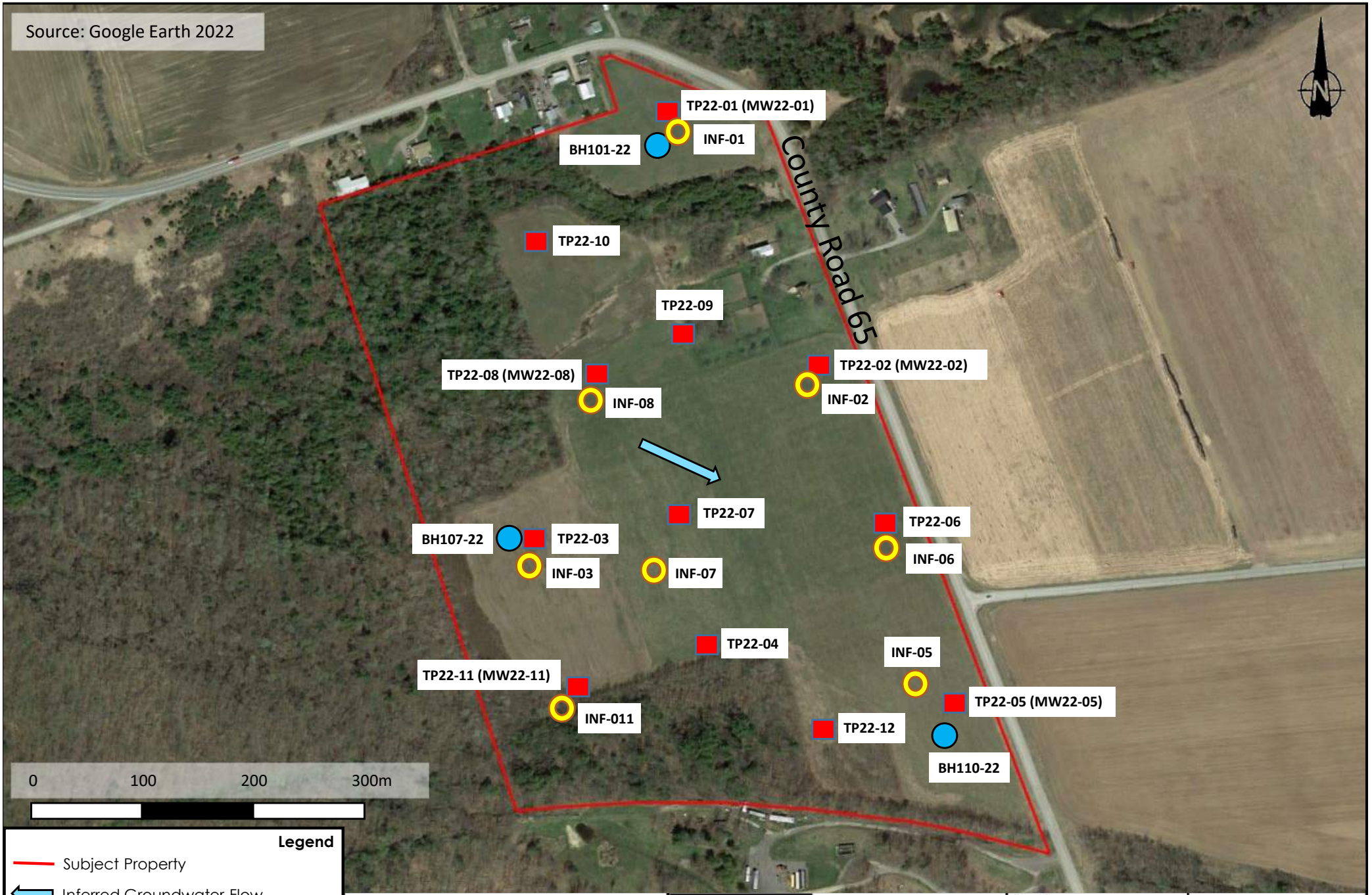
Drawn By	LT	Scale	See Scale Bar
Checked	IA	Date	November 2022
Project No.	22-11056	Drawing File No.	Figure 1



Subsurface Investigation Plan

Hydrogeological Study
County Road 65
Osaca, ON

D.M. Wills Associates Limited
150 Jameson Drive
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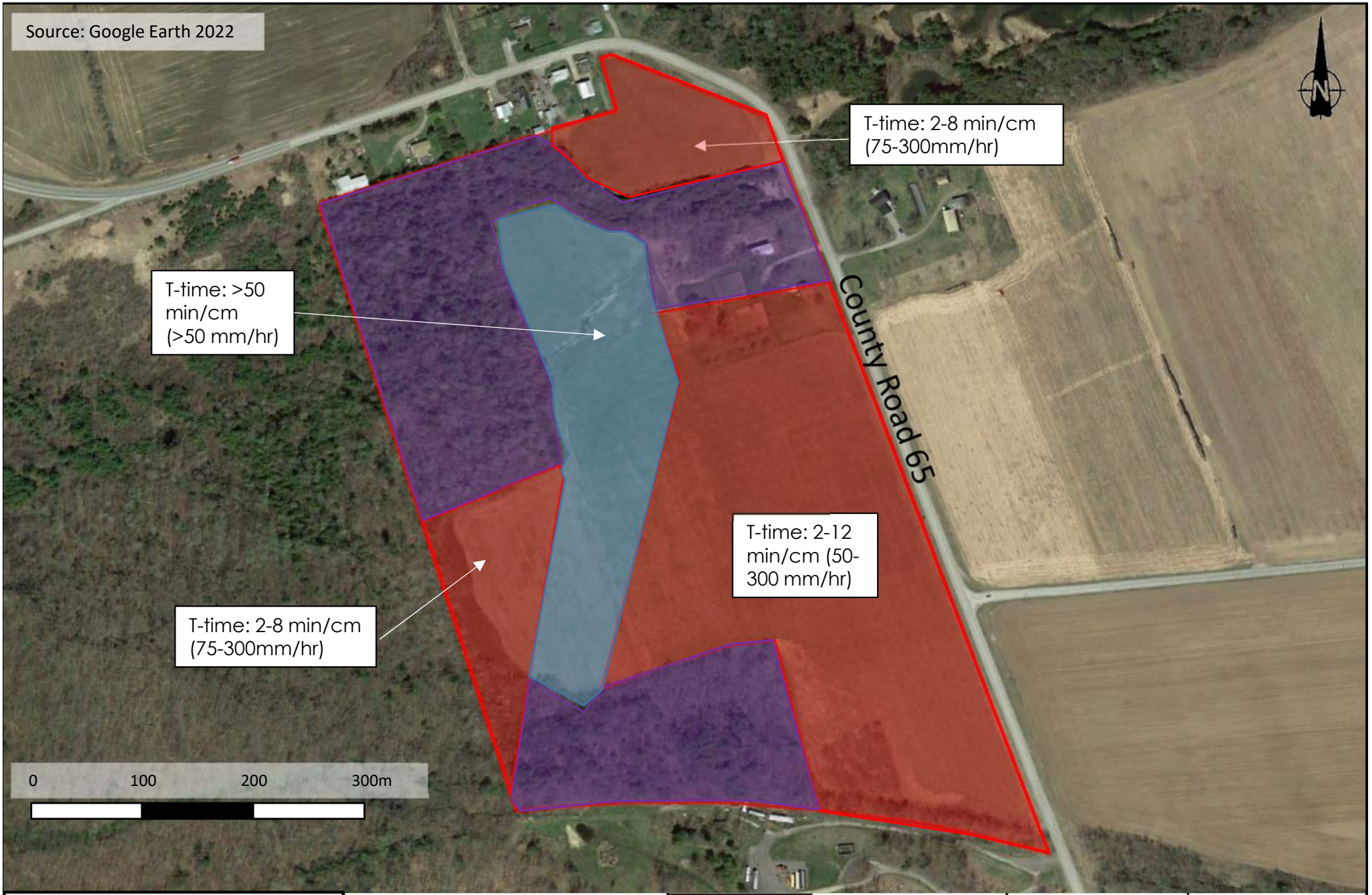
Drawn By	LT	Scale	See Scale Bar
Checked	IA	Date	November 2022
Project No.	22-11056	Drawing File No.	Figure 2



Legend

- Subject Property
- Clayey silt to silt and clay above 3 .0 mbg
- Sand to silty sand above 3.0 mbg
- Uncharacterized

Subsurface Infiltration Plan

Hydrogeological Study
County Road 65
Osaca, ON

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

P. 705.742.2297
F. 705.749.9944
E. wills@dmwills.com

Drawn By	LT	Scale	See Scale Bar
Checked	IA	Date	November 2022
Project No.	22-11056	Drawing File No.	Figure 3

Appendix A

Test Pit Logs

WILLS

Test Pit Log – TP22-01

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, moist.
0.2 – 3.0	Brown to grey sand, trace gravel, trace silt, moist to saturated.
Grab Sample Summary	
GS-01 collected at approximately 1.4 mbg.	<u>GS-01 GSA:</u> 3% Gravel 93% Sand 3% Silt 1% clay

Groundwater

- Groundwater encountered at 3.0 mbg.

Additional Notes

- Test pit terminated at 3.0 mbg.
- Water pooling at the bottom of test pit upon completion.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.
- MW22-01 installed in test pit prior to backfilling.

Test Pit Photos

TP22-01
September 26, 2022
17T
705479 mE
4875999 mN

WILLS

Test Pit Log – TP22-02

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, rootlets, moist.
0.2 – 3.0	Brown sand, trace gravel, trace silt, moist.
Grab Sample Summary	
GS-02 collected at approximately 2.9 mbg.	<u>GS-02 GSA:</u> 3% Gravel 94% Sand 3% Silt 0% Clay
Groundwater	
• No groundwater encountered.	
Additional Notes	
• Test pit terminated at 3.0 mbg. • Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling. • MW22-02 installed in test pit prior to backfilling.	
Test Pit Photos	

TP22-02
September 23, 2022
17T
705628 mE
4875766 mN

WILLS

Test Pit Log – TP22-03

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, moist.
0.2 – 3.0	Brown to grey sand, trace gravel, moist to saturated.
Grab Sample Summary	
GS-01 collected at approximately 1.0 mbg.	<u>GS-01 GSA:</u> 0% Gravel 97% Sand 3% Silt 0% Clay

Groundwater

- Groundwater encountered at 3.0 mbg.

Additional Notes

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

Test Pit Photos

TP22-03
September 23, 2022
17T
705389 mE
4875605 mN

WILLS

Test Pit Log – TP22-04

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, moist.
0.2 – 0.5	Brown sand, some silt, moist.
0.5 – 3.0	Brown to grey sand, trace gravel, trace silt, moist to saturated.

Groundwater

- Groundwater encountered at 3.0 mbg.

Additional Notes

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

Test Pit Photos

TP22-04
September 23, 2022
17T
705528 mE
4875523 mN

WILLS

Test Pit Log – TP22-05

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, rootlets, moist.
0.2 - 2.4	Brown sand, some silt, trace gravel, trace clay, moist.
2.4 – 3.0	Brown to grey sand, some silt, trace gravel, trace clay, moist to saturated.
Grab Sample Summary	
GS-01 collected at approximately 1.7 mbg.	<u>GS-01 GSA:</u> 2% Gravel 78% Sand 18% Silt 2% Clay

Groundwater

- Groundwater encountered at 2.9 mbg.

Additional Notes

- Test pit terminated at 3.0 mbg.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.
- MW22-05 installed in test pit prior to backfilling.

Test Pit Photos

TP22-05
September 23, 2022
17T
705743 mE
4875493 mN

WILLS

Test Pit Log – TP22-06

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, some rootlets, moist.
0.2 – 3.0	Brown to grey sand, some silt, trace gravel, trace clay, moist.

Groundwater

- No groundwater encountered.

Additional Notes

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

Test Pit Photos

TP22-06
September 23, 2022
17T
705682 mE
4875632 mN

WILLS

Test Pit Log – TP22-07

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, moist.
0.2 - 3.0	Brown to grey sand, some silt, moist to wet.

Groundwater

- Groundwater not encountered.

Additional Notes

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

Test Pit Photos

TP22-07
September 23, 2022
17T
705514 mE
4875641 mN

WILLS

Test Pit Log – TP22-08

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, moist.
0.2 – 1.3	Brown to grey sand, some silt, trace clay, moist.
1.3 – 3.0	Brown to grey silt and clay, trace sand, about plastic limit to much wetter than plastic limit.
Grab Sample Summary	
GS-02 collected at approximately 2.0 mbg.	<u>GS-02 GSA:</u> 0% Gravel 4% Sand 56% Silt 40% Clay

Groundwater

- Groundwater encountered at 3.0 mbg.

Additional Notes

- Test pit terminated at 3.0 mbg.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.
- MW22-08 installed in test pit prior to backfilling.

Test Pit Photos

TP22-08
September 23, 2022
17T
705426 mE
4875745 mN

WILLS

Test Pit Log – TP22-09

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, rootlets, moist.
0.2 - 2.4	Brown sand, trace silt, trace gravel, moist.
2.4 – 3.0	Brown to grey silty sand, some clay, moist to saturated.

Groundwater

- Groundwater encountered at 3.0 mbg.

Additional Notes

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

Test Pit Photos

TP22-09
September 23, 2022
17T
705509 mE
4875797 mN

WILLS

Test Pit Log – TP22-10

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, moist.
0.2 - 1.7	Brown silty sand, trace clay, moist
1.7 – 3.0	Brown to grey silt and clay, trace sand, about plastic limit.
Grab Sample Summary	
GS-02 collected at approximately 1.9 mbg.	<u>GS-02 GSA:</u> 0% Gravel 3% Sand 62% Silt 35% Clay
Groundwater	
• Groundwater not encountered.	
Additional Notes	
• Test pit terminated at 3.0 mbg • Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.	
Test Pit Photos	
TP22-10 September 23, 2022 17T 705372 mE 4875876 mN	

WILLS

Test Pit Log – TP22-11

Depth (mbg)	Soil Description
0.0 – 0.2	Brown silty sand topsoil, moist.
0.2 - 1.7	Brown silty sand, trace clay, moist.
1.7 – 3.0	Brown to grey silt and clay, trace sand, about plastic limit.
Grab Sample Summary	
GS-03 collected at approximately 2.7 mbg.	<u>GS-03 GSA:</u> 0% Gravel 4% Sand 71% Silt 25% Clay
Groundwater	
• Groundwater encountered at 3.0 mbg.	
Additional Notes	
• Test pit terminated at 3.0 mbg • Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling. • MW22-11 installed in test pit prior to backfilling.	
Test Pit Photos	

TP22-11
September 23, 2022
17T
705435 mE
4875489 mN

WILLS

Test Pit Log – TP22-12

Depth (mbg)	Soil Description
0.0 – 0.1	Brown silty sand topsoil, moist.
0.1 - 0.8	Brown sand, some silt, moist.
0.8 – 2.6	Brown to grey sand, trace silt, trace gravel, moist to wet.
2.6 – 2.8	Grey sand, some gravel, trace silt, saturated.

Groundwater

- Groundwater encountered at 2.6 mbg.

Additional Notes

- Test pit terminated at 2.8 mbg.
- Test pit backfilled and compacted using excavator following completion of stratigraphic logging and sampling.

Test Pit Photos

TP22-12
September 23, 2022
17T
705636 mE
4875461 mN

Appendix B

Certificates of Analysis – Physical Soil Testing

PRI ENGINEERING
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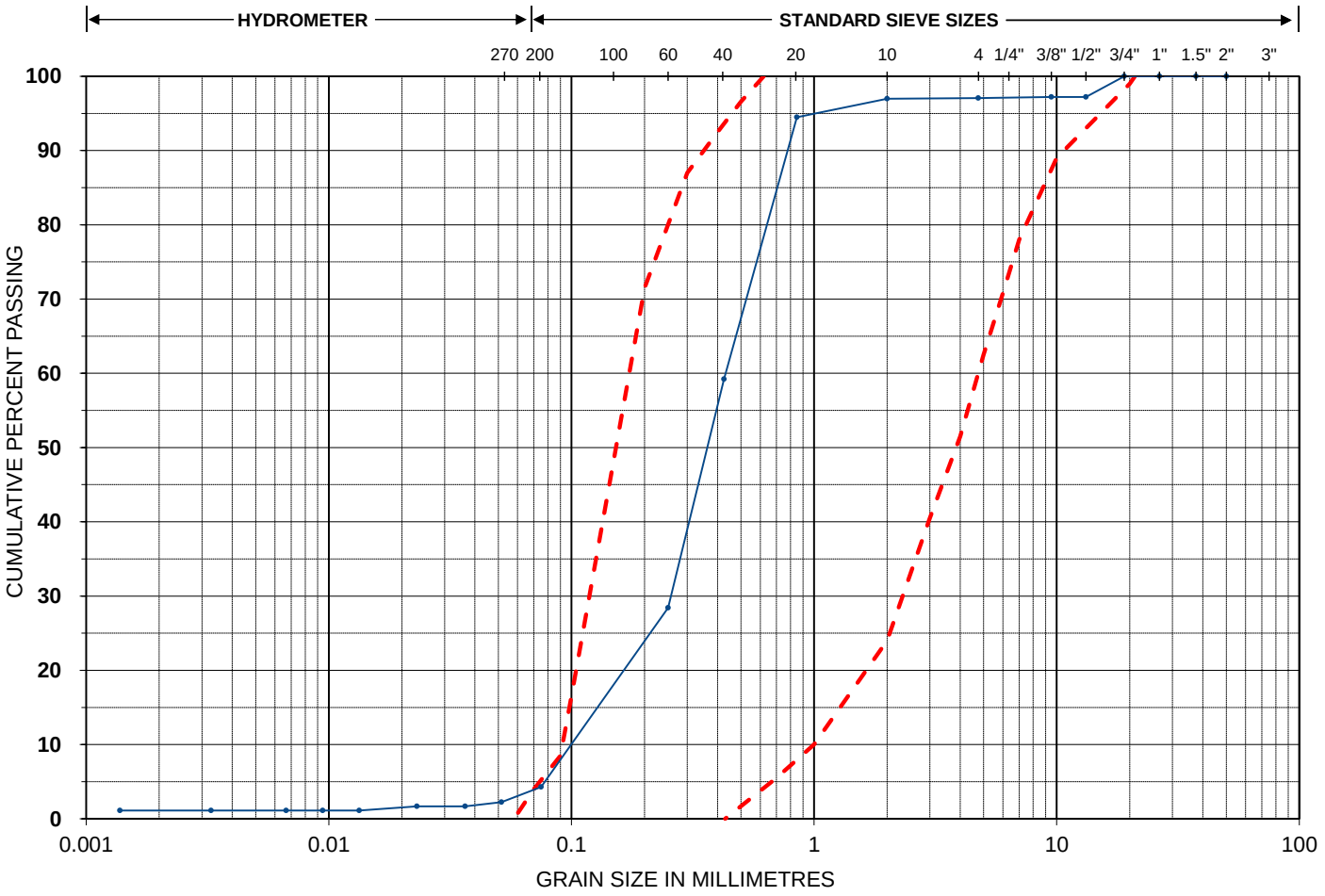
www.priengineering.com

PARTICLE SIZE DISTRIBUTION
LS - 702

Project Name: Osaca (11056) **Project No.:** 22-154 **Sample Date:** 26-Sep-22

Borehole/Test Pit ID.: TP22-01 **Sample No./Depth:** GS1 **LAB ID:** 22HYD-224



Silt or Clay	Sand	Gravel

sp envelope T = 2 - 8 min/cm

Estimated T = 6 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	97.2
9.5	97.2
4.750	97.1
2.000	97.0
0.850	94.5
0.425	59.2
0.250	28.4
0.075	4.3

Hydrometer (mm)	% Passing
0.051	2.2
0.036	1.7
0.023	1.7
0.013	1.1
0.009	1.1
0.007	1.1
0.003	1.1
0.001	1.1

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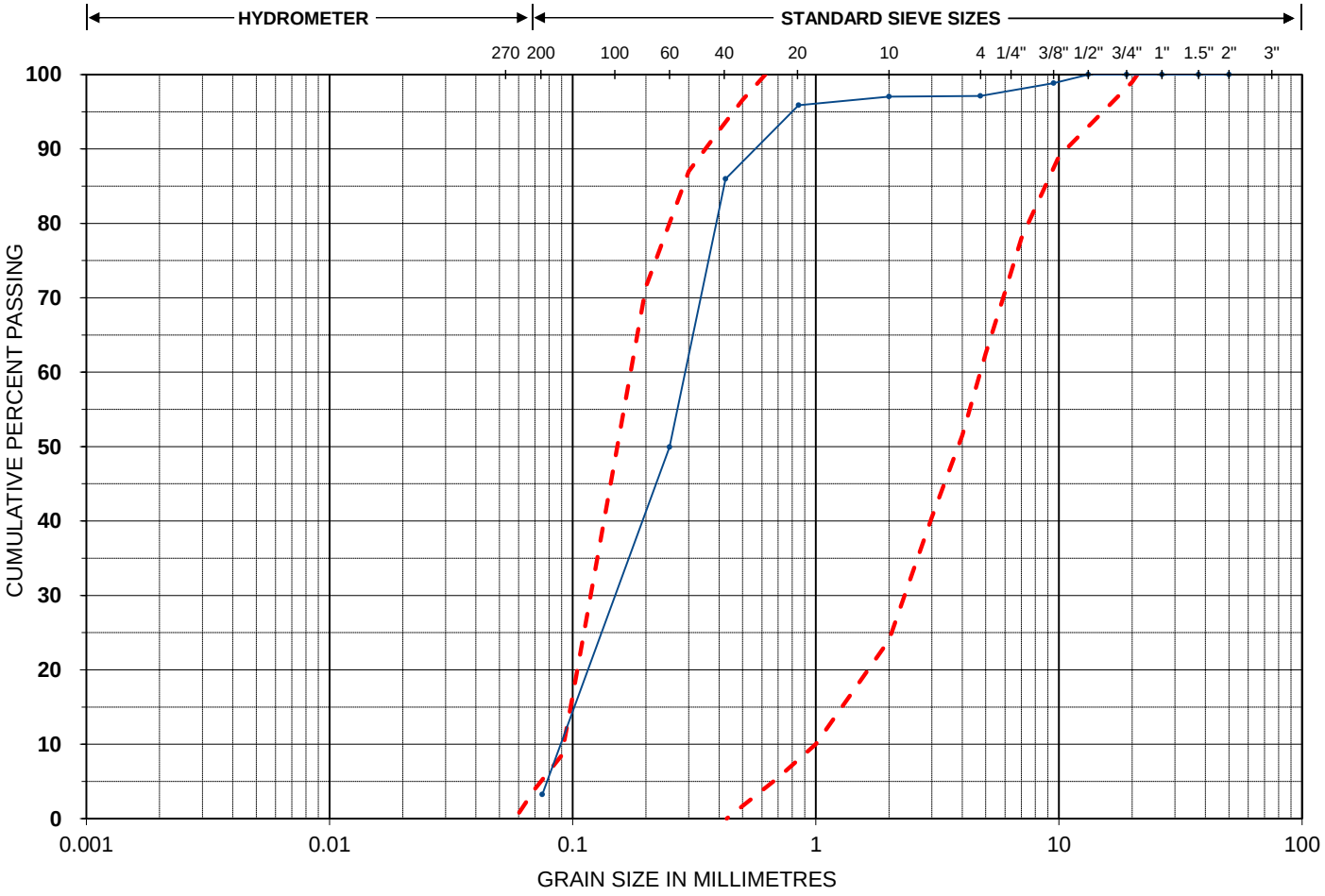
Project Name: Osaca (11056) **Project No.:** 22-154 **Sample Date:** 23-Sep-22

Borehole/Test Pit ID.: TP22-02 **Sample No./Depth:** GS2 **LAB ID:** 22HYD-225



Silt or Clay	Sand	Gravel

sp envelope T = 2 - 8 min/cm

Estimated T = 7 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	98.8
4.750	97.1
2.000	97.0
0.850	95.9
0.425	86.0
0.250	49.9
0.075	3.2

Hydrometer (mm)	% Passing
0.052	0.0
0.036	0.0
0.023	0.0
0.013	0.0
0.009	0.0
0.007	0.0
0.003	0.0
0.001	0.0

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PARTICLE SIZE DISTRIBUTION
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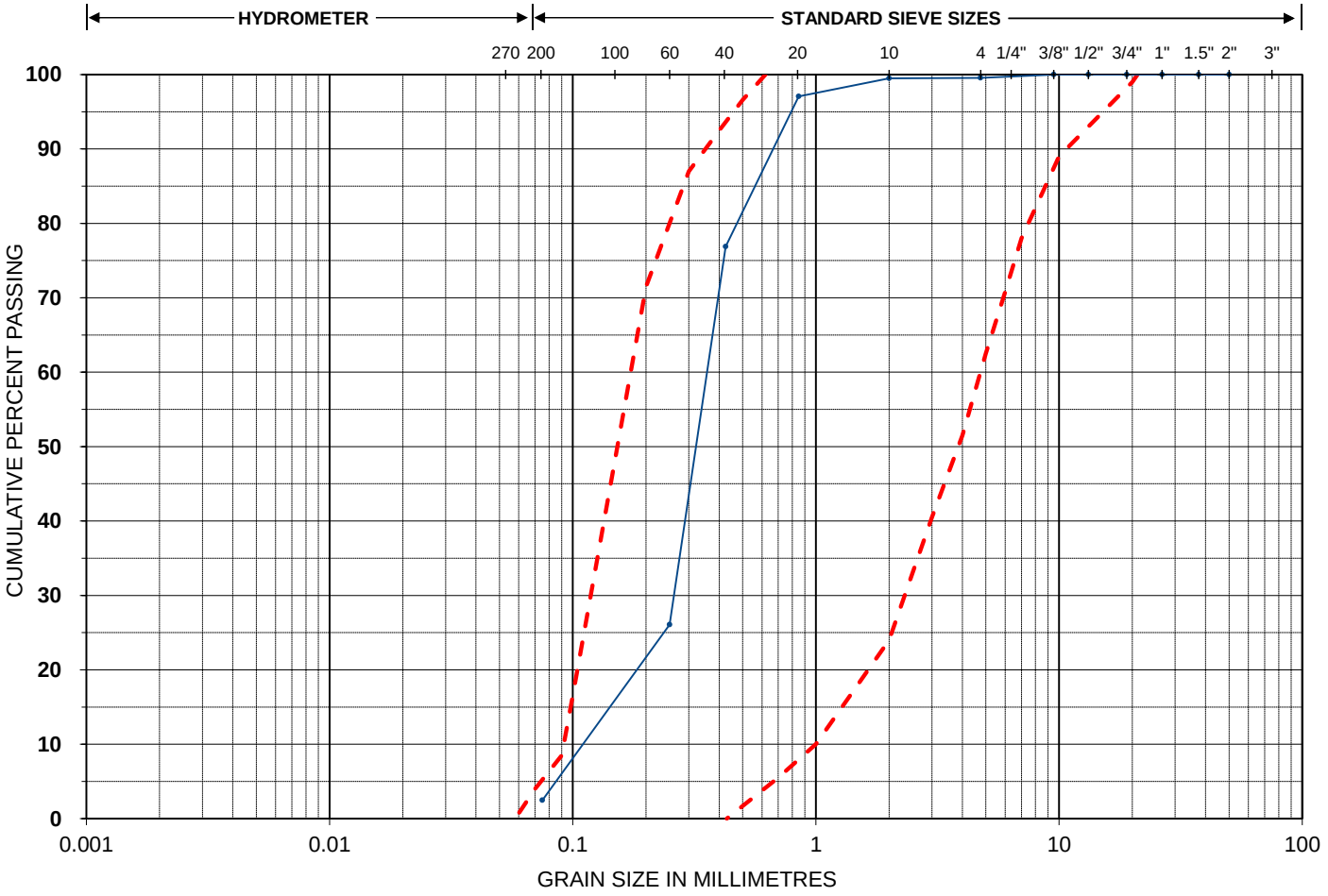
Project Name: Osaca (11056) **Project No.:** 22-154 **Sample Date:** 23-Sep-22

Borehole/Test Pit ID.: TP22-03 **Sample No./Depth:** GS1 **LAB ID:** 22HYD-226



Silt or Clay	Sand	Gravel

sp envelope T = 2 - 8 min/cm

Estimated T = 6 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	100.0
4.750	99.6
2.000	99.5
0.850	97.1
0.425	76.9
0.250	26.1
0.075	2.5

Hydrometer (mm)	% Passing
0.052	0.0
0.037	0.0
0.023	0.0
0.013	0.0
0.009	0.0
0.007	0.0
0.003	0.0
0.001	0.0

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PARTICLE SIZE DISTRIBUTION
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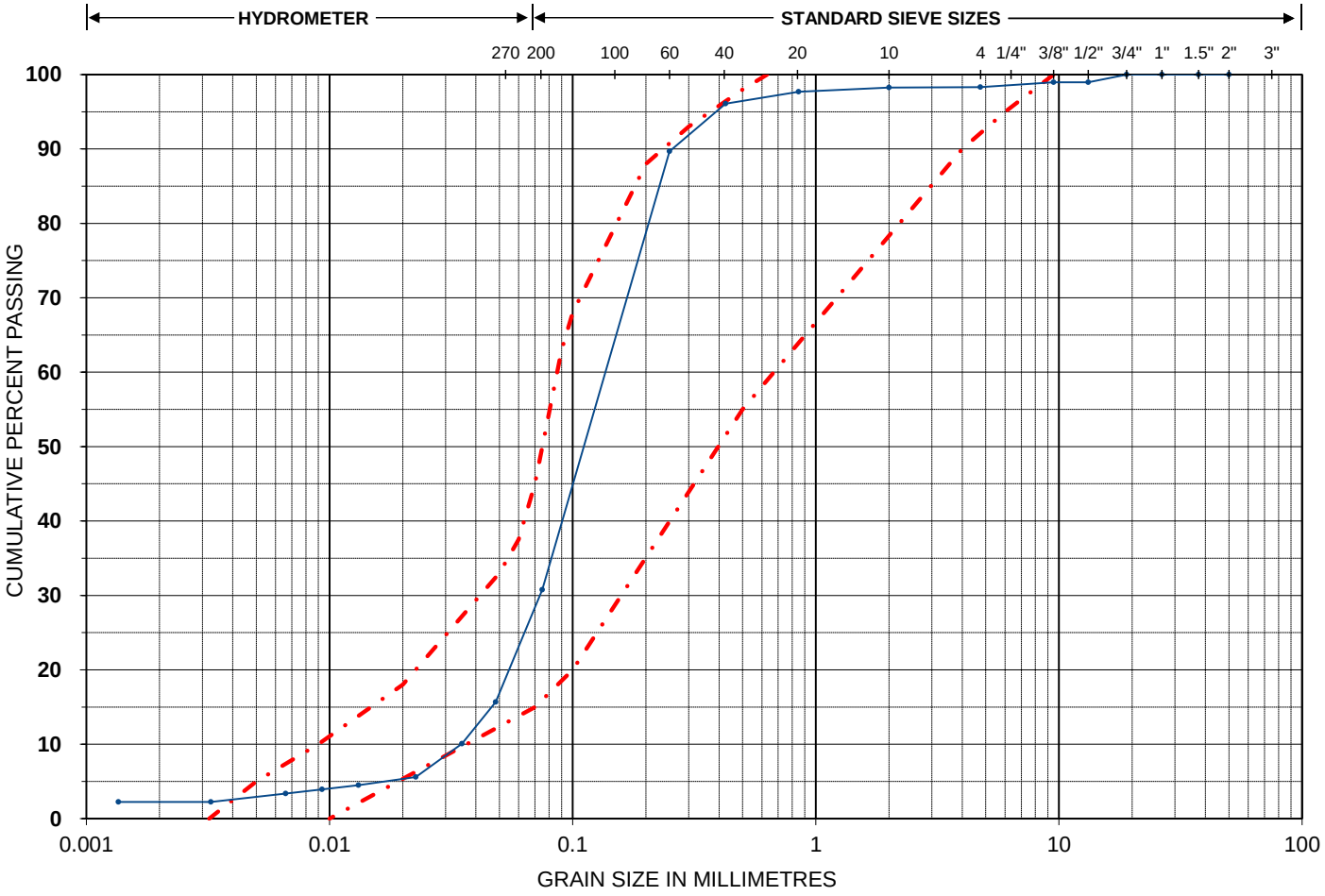
Project Name: Osaca (11056) **Project No.:** 22-154 **Sample Date:** 23-Sep-22

Borehole/Test Pit ID.: TP22-05 **Sample No./Depth:** GS1 **LAB ID:** 22HYD-227



Silt or Clay	Sand	Gravel

sm envelope T = 8 - 20 min/cm

Estimated T = 12 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	99.0
9.5	99.0
4.750	98.3
2.000	98.3
0.850	97.7
0.425	96.1
0.250	89.7
0.075	30.8

Hydrometer (mm)	% Passing
0.048	15.7
0.035	10.1
0.023	5.6
0.013	4.5
0.009	3.9
0.007	3.4
0.003	2.2
0.001	2.2

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PARTICLE SIZE DISTRIBUTION
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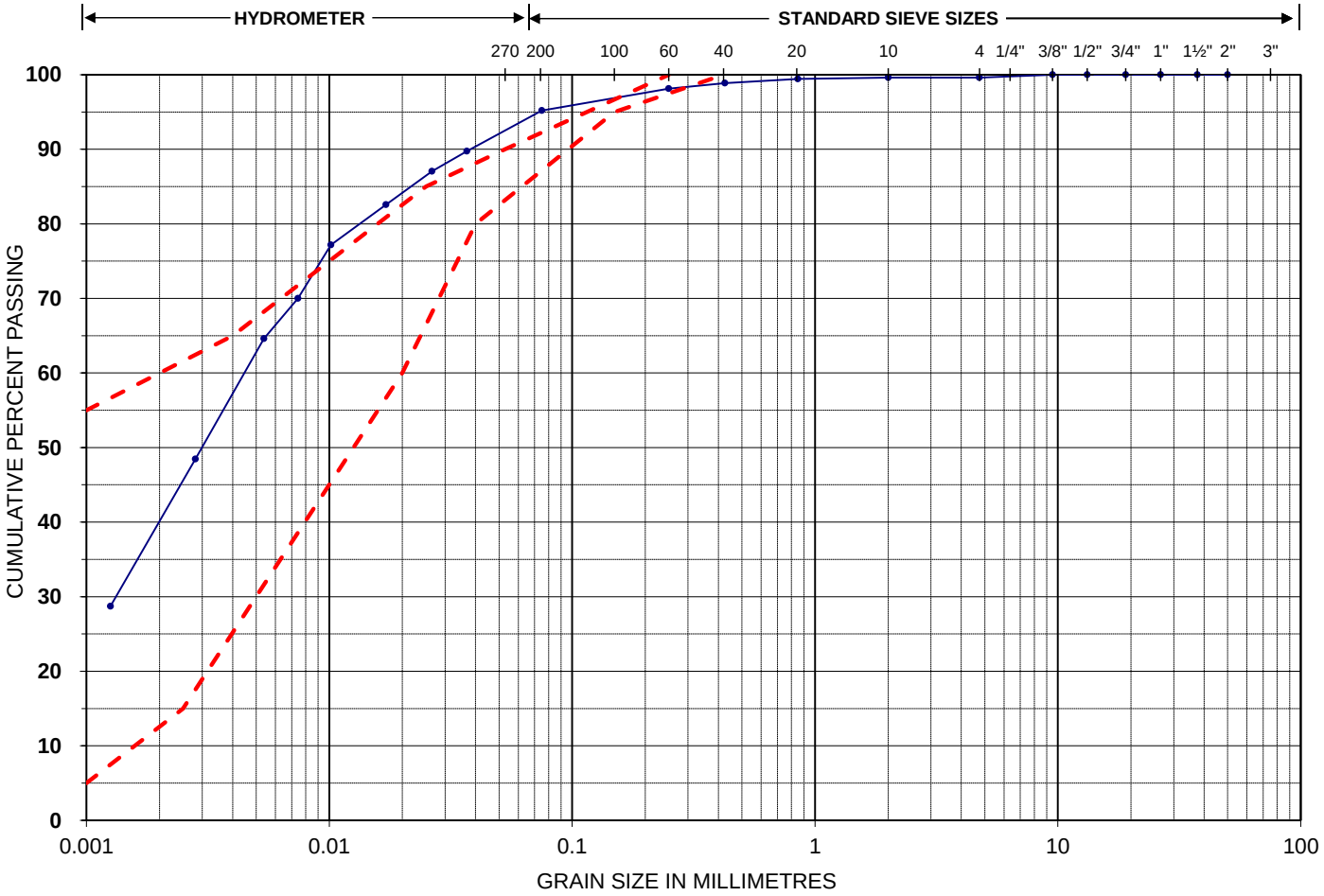
Project Name: Osaca (11056) **Project No.:** 22-154 **Sample Date:** 23-Sep-22

Borehole/Test Pit ID.: TP22-08 **Sample No./Depth:** GS2 **LAB ID:** 22HYD-228



Silt or Clay	Sand	Gravel

OH envelope T > 50 min/cm

Estimated T > 50 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	100.0
4.750	99.6
2.000	99.6
0.850	99.4
0.425	98.9
0.250	98.1
0.075	95.2

Hydrometer (mm)	% Passing
0.037	89.7
0.026	87.0
0.017	82.6
0.010	77.2
0.007	70.0
0.005	64.6
0.003	48.5
0.001	28.7

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PARTICLE SIZE DISTRIBUTION
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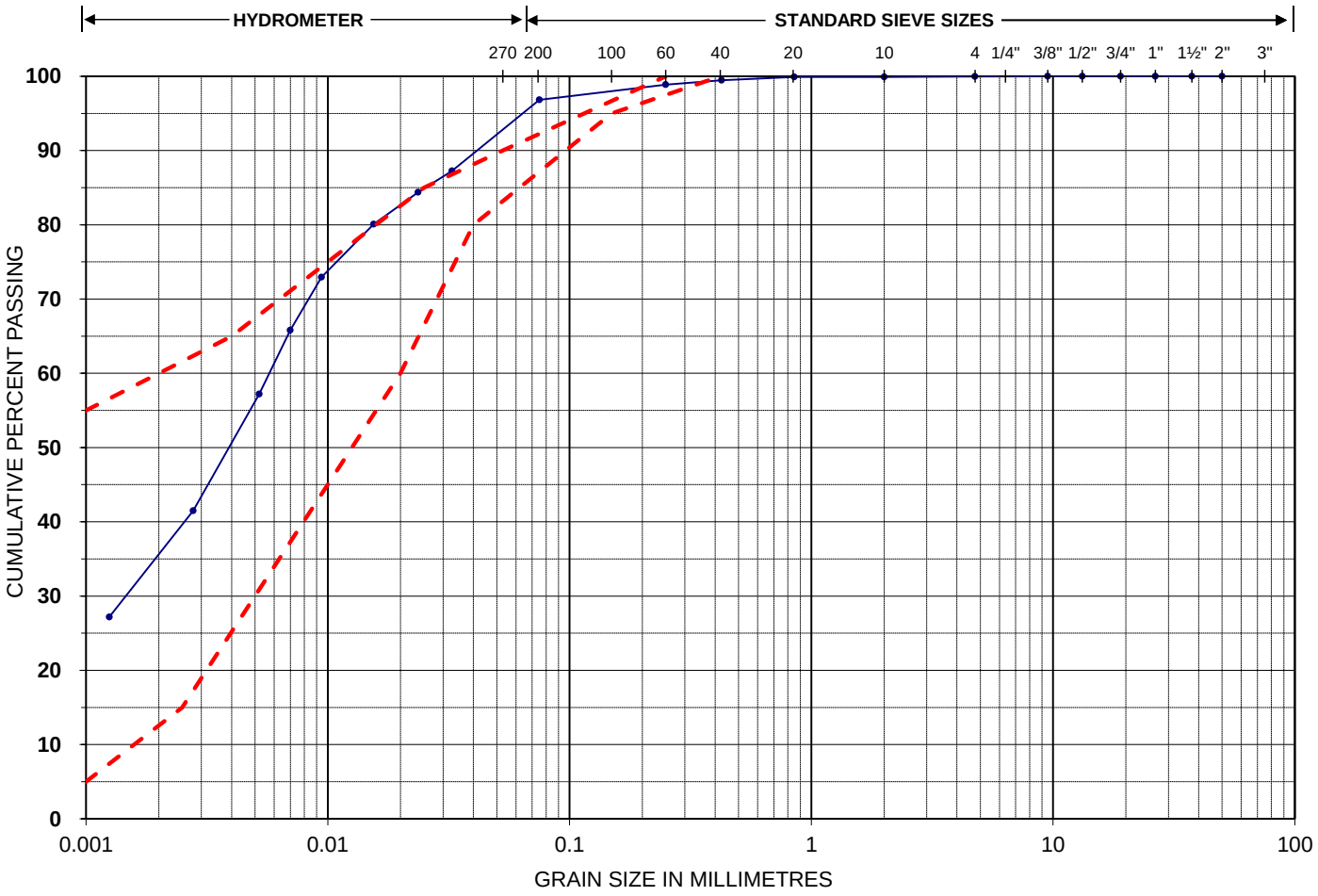
Project Name: Osaca (11056) **Project No.:** 22-154 **Sample Date:** 23-Sep-22

Borehole/Test Pit ID.: TP22-10 **Sample No./Depth:** GS2 **LAB ID:** 22HYD-229



Silt or Clay	Sand	Gravel

OH envelope T > 50 min/cm

Estimated T > 50 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	100.0
4.750	100.0
2.000	99.9
0.850	99.9
0.425	99.5
0.250	98.9
0.075	96.8

Hydrometer (mm)	% Passing
0.033	87.2
0.024	84.4
0.015	80.1
0.009	72.9
0.007	65.8
0.005	57.2
0.003	41.5
0.001	27.2

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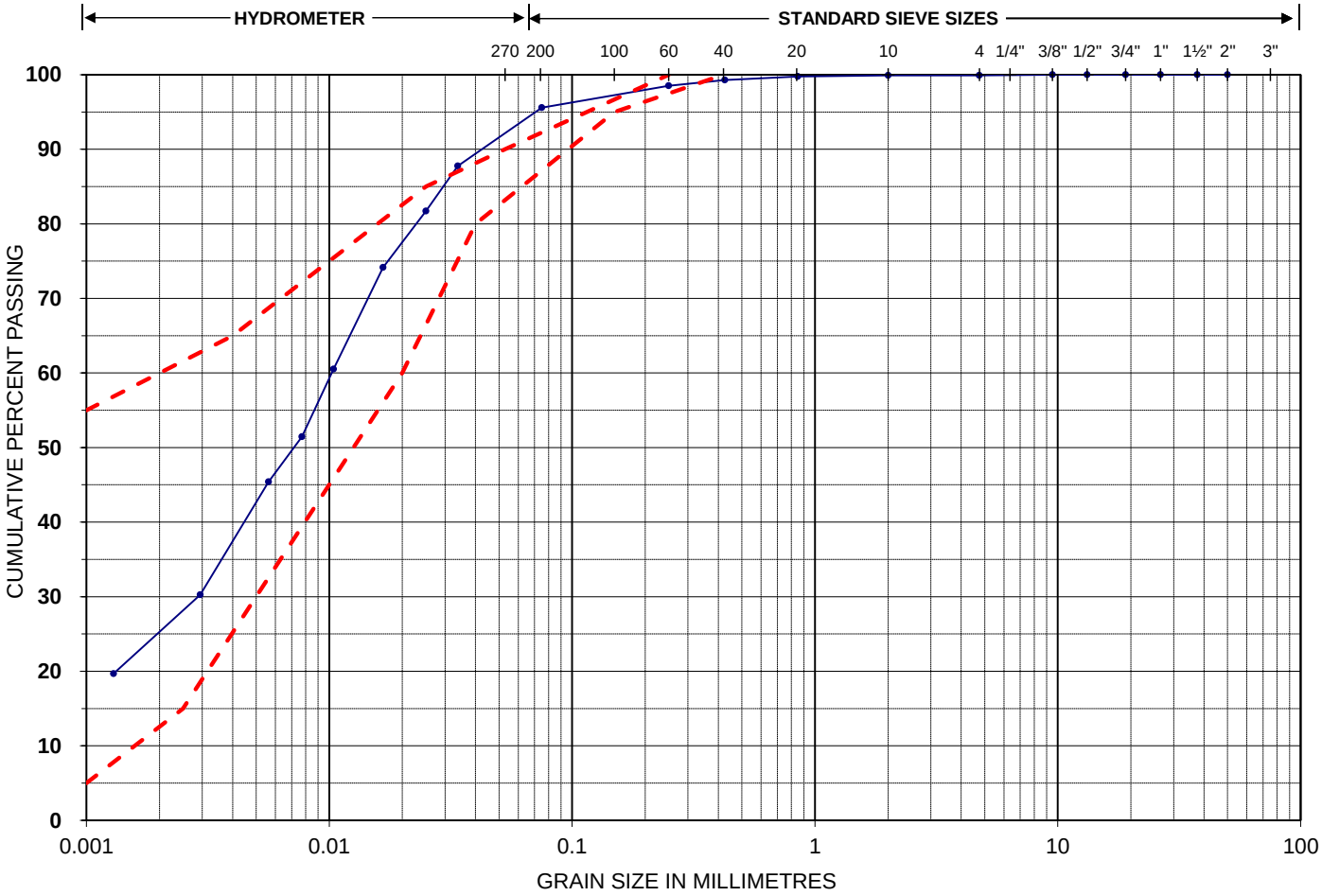
Project Name: Osaca (11056) **Project No.:** 22-154 **Sample Date:** 23-Sep-22

Borehole/Test Pit ID.: TP22-11 **Sample No./Depth:** GS3 **LAB ID:** 22HYD-230



Silt or Clay	Sand	Gravel

OH envelope T > 50 min/cm

Estimated T > 50 min/cm

Sieve Size (mm)	% Passing
37.5	100.0
26.5	100.0
19.0	100.0
13.2	100.0
9.5	100.0
4.750	99.9
2.000	99.9
0.850	99.8
0.425	99.3
0.250	98.5
0.075	95.6

Hydrometer (mm)	% Passing
0.034	87.8
0.025	81.7
0.017	74.1
0.010	60.5
0.008	51.4
0.006	45.4
0.003	30.3
0.001	19.7

Appendix C

Infiltration Graphs

IN-SITU INFILTRATION TEST **APPENDIX C**

Project:	Osaca Hillstreet subdivision	**PROJECT NO.:**	11056
Site Location:	5868 County road 65, Osaca, ON	**Date:**	26-Sep-22
Test ID:	INF-01	**Start Time:**	12:30 PM
		Test No.	1

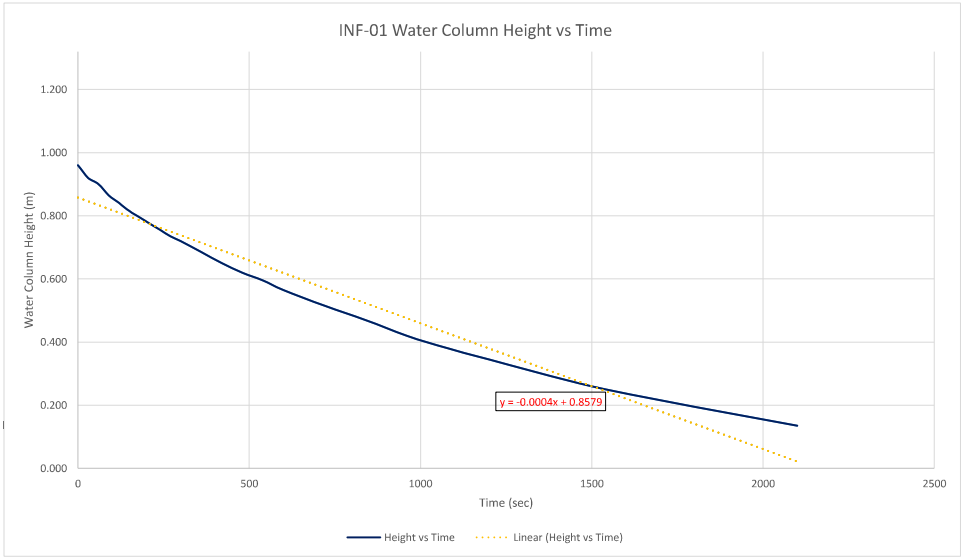
Depth of Test Pit (m):	1.4	**Pipe Stickup (m):**	0.34	**Total Pipe Length(m):**	1.56

Time* (Seconds)	Measurement Interval (sec)	Depth** (m)	Water Column Height (m)	Distance dropped per interval (m1)	Infiltration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)
0	-	0.600	0.960	-	--	--
30	30	0.640	0.92	0.040	1.333E-03	1.333E-03
60	30	0.660	0.90	0.020	6.667E-04	1.000E-03
90	30	0.695	0.87	0.035	1.167E-03	1.056E-03
120	30	0.720	0.84	0.025	8.333E-04	1.000E-03
150	30	0.745	0.82	0.025	8.333E-04	9.667E-04
180	30	0.765	0.80	0.020	6.667E-04	9.167E-04
210	30	0.785	0.78	0.020	6.667E-04	8.810E-04
240	30	0.805	0.76	0.020	6.667E-04	8.542E-04
270	30	0.825	0.74	0.020	6.667E-04	8.333E-04
300	30	0.840	0.72	0.015	5.000E-04	8.000E-04
360	60	0.875	0.69	0.035	5.833E-04	7.639E-04
420	60	0.910	0.65	0.035	5.833E-04	7.381E-04
480	60	0.940	0.62	0.030	5.000E-04	7.083E-04
540	60	0.965	0.60	0.025	4.167E-04	6.759E-04
600	60	0.995	0.57	0.030	5.000E-04	6.583E-04
720	120	1.045	0.52	0.050	4.167E-04	6.181E-04
840	120	1.090	0.47	0.045	3.750E-04	5.833E-04
960	120	1.140	0.42	0.050	4.167E-04	5.625E-04
1,080	120	1.180	0.38	0.040	3.333E-04	5.370E-04
1,200	120	1.215	0.35	0.035	2.917E-04	5.125E-04
1,500	300	1.300	0.26	0.085	2.833E-04	4.667E-04
1,800	300	1.365	0.20	0.065	2.167E-04	4.250E-04
2,100	300	1.425	0.14	0.060	2.000E-04	3.929E-04

** 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 -	1.33E-03	1.33E+00	4800
Minimum Infiltration Rate Between Sampling Intervals -	2.00E-04	2.00E-01	720
Median Infiltration Rate Between Sampling Intervals -	5.00E-04	5.00E-01	1800
Average Infiltration Rate Between Sampling Intervals -	**5.70E-04**	**5.70E-01**	**2053**
Cumulative Infiltration Rate for Entire Data Set -	**3.93E-04**	**3.93E-01**	**1414**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**0.39**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**1414**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**0.42**



		Test 1 - Observed
Test Duration (seconds)		**2,100**
Total Drop Distance (mm)		**825**
Total Number of Measured Intervals		**24**
Infiltration Rate (mm/sec) - Test Average		**0.39**
Infiltration Rate (mm/hour) - Test Average		**1414**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**0.42**

IN-SITU INFILTRATION TEST **APPENDIX C**

Project:	Osaca Hillstreet subdivision	**PROJECT NO.:**	11056
Site Location:	5868 County road 65, Osaca, ON	**Date:**	27-Sep-22
Test ID:	INF-02	**Start Time:**	10:40 AM
		Test No.	1

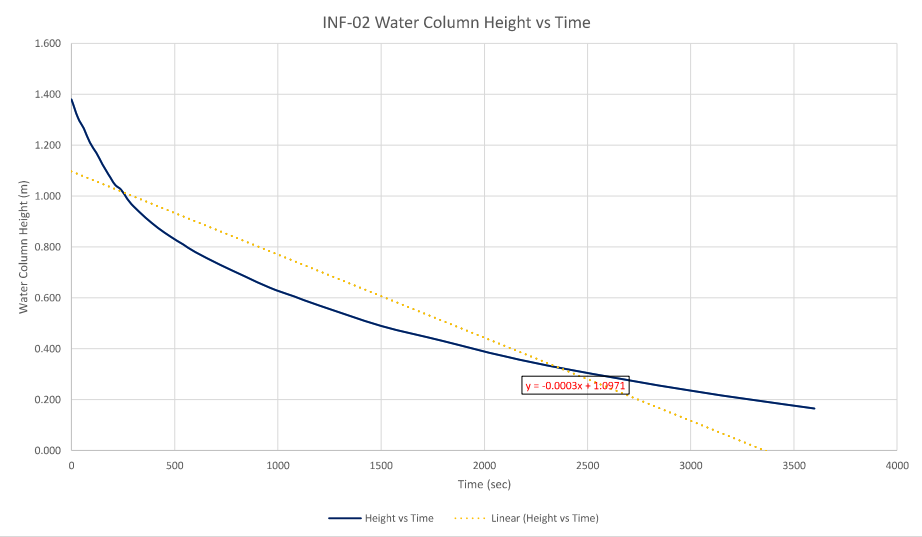
Depth of Test Pit (m):	1	**Pipe Stickup (m):**	1.245	**Total Pipe Length(m):**	2.41	

Time* (Seconds)	Measurement Interval (sec)	Depth** (m)	Water Column Height (m)	Distance dropped per interval (m1)	Infilitration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)
0	-	1.025	1.380	-	--	--
30	30	1.095	1.31	0.070	2.333E-03	2.333E-03
60	30	1.140	1.27	0.045	1.500E-03	1.917E-03
90	30	1.195	1.21	0.055	1.833E-03	1.889E-03
120	30	1.235	1.17	0.040	1.333E-03	1.750E-03
150	30	1.280	1.13	0.045	1.500E-03	1.700E-03
180	30	1.320	1.09	0.040	1.333E-03	1.639E-03
210	30	1.360	1.05	0.040	1.333E-03	1.595E-03
240	30	1.380	1.03	0.020	6.667E-04	1.479E-03
270	30	1.415	0.99	0.035	1.167E-03	1.444E-03
300	30	1.445	0.96	0.030	1.000E-03	1.400E-03
360	60	1.490	0.92	0.045	7.500E-04	1.292E-03
420	60	1.530	0.88	0.040	6.667E-04	1.202E-03
480	60	1.565	0.84	0.035	5.833E-04	1.125E-03
540	60	1.595	0.81	0.030	5.000E-04	1.056E-03
600	60	1.625	0.78	0.030	5.000E-04	1.000E-03
720	120	1.675	0.73	0.050	4.167E-04	9.028E-04
840	120	1.720	0.69	0.045	3.750E-04	8.274E-04
960	120	1.765	0.64	0.045	3.750E-04	7.708E-04
1,080	120	1.800	0.61	0.035	2.917E-04	7.176E-04
1,200	120	1.835	0.57	0.035	2.917E-04	6.750E-04
1,500	300	1.915	0.49	0.080	2.667E-04	5.933E-04
1,800	300	1.975	0.43	0.060	2.000E-04	5.278E-04
2,100	300	2.035	0.37	0.060	2.000E-04	4.810E-04
2,400	300	2.085	0.32	0.050	1.667E-04	4.417E-04
3,000	600	2.170	0.24	0.085	1.417E-04	3.817E-04
3,600	600	2.240	0.17	0.070	1.167E-04	3.375E-04

** 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 -	2.33E-03	2.33E+00	8400
Minimum Infiltration Rate Between Sampling Intervals -	1.17E-04	1.17E-01	420
Median Infiltration Rate Between Sampling Intervals -	5.42E-04	5.42E-01	1950
Average Infiltration Rate Between Sampling Intervals -	**7.63E-04**	**7.63E-01**	**2747**
Cumulative Infiltration Rate for Entire Data Set -	**3.38E-04**	**3.38E-01**	**1215**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**0.34**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**1215**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**0.49**



		Test 1 - Observed
Test Duration (seconds)		**3,600**
Total Drop Distance (mm)		**1215**
Total Number of Measured Intervals		**27**
Infiltration Rate (mm/sec) - Test Average		**0.34**
Infiltration Rate (mm/hour) - Test Average		**1215**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**0.49**

IN-SITU INFILTRATION TEST **APPENDIX C**

Project:	Osaca Hillstreet subdivision	**PROJECT NO.:**	11056
Site Location:	5868 County road 65, Osaca, ON	**Date:**	27-Sep-22
Test ID:	INF-03	**Start Time:**	1:44 PM
		Test No.	1

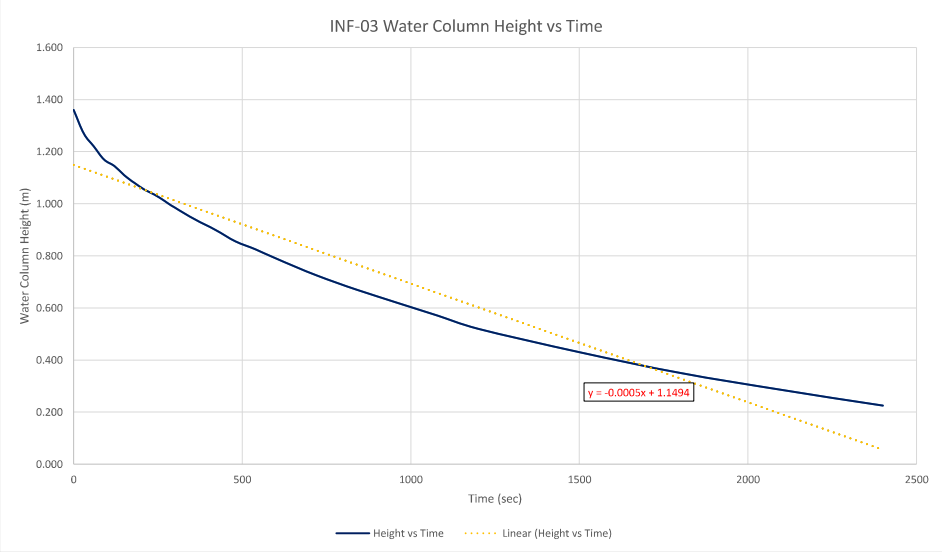
Depth of Test Pit (m):	0.9	**Pipe Stickup (m):**	1.17	**Total Pipe Length(m):**	2.27

Time* (Seconds)	Measurement Interval (sec)	Depth** (m)	Water Column Height (m)	Distance dropped per interval (m1)	Infilitration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)
0	-	0.910	1.360	-	--	--
30	30	1.000	1.27	0.090	3.000E-03	3.000E-03
60	30	1.050	1.22	0.050	1.667E-03	2.333E-03
90	30	1.100	1.17	0.050	1.667E-03	2.111E-03
120	30	1.125	1.15	0.025	8.333E-04	1.792E-03
150	30	1.160	1.11	0.035	1.167E-03	1.667E-03
180	30	1.190	1.08	0.030	1.000E-03	1.556E-03
210	30	1.215	1.06	0.025	8.333E-04	1.452E-03
240	30	1.235	1.04	0.020	6.667E-04	1.354E-03
270	30	1.260	1.01	0.025	8.333E-04	1.296E-03
300	30	1.285	0.99	0.025	8.333E-04	1.250E-03
360	60	1.330	0.94	0.045	7.500E-04	1.167E-03
420	60	1.370	0.90	0.040	6.667E-04	1.095E-03
480	60	1.415	0.86	0.045	7.500E-04	1.052E-03
540	60	1.445	0.83	0.030	5.000E-04	9.907E-04
600	60	1.480	0.79	0.035	5.833E-04	9.500E-04
720	120	1.545	0.73	0.065	5.417E-04	8.819E-04
840	120	1.600	0.67	0.055	4.583E-04	8.214E-04
960	120	1.650	0.62	0.050	4.167E-04	7.708E-04
1,080	120	1.700	0.57	0.050	4.167E-04	7.315E-04
1,200	120	1.750	0.52	0.050	4.167E-04	7.000E-04
1,500	300	1.840	0.43	0.090	3.000E-04	6.200E-04
1,800	300	1.920	0.35	0.080	2.667E-04	5.611E-04
2,100	300	1.985	0.29	0.065	2.167E-04	5.119E-04
2,400	300	2.045	0.23	0.060	2.000E-04	4.729E-04

** 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 -	3.00E-03	3.00E+00	10800
Minimum Infiltration Rate Between Sampling Intervals -	2.00E-04	2.00E-01	720
Median Infiltration Rate Between Sampling Intervals -	6.67E-04	6.67E-01	2400
Average Infiltration Rate Between Sampling Intervals -	**7.91E-04**	**7.91E-01**	**2848**
Cumulative Infiltration Rate for Entire Data Set -	**4.73E-04**	**4.73E-01**	**1703**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**0.47**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**1703**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**0.35**



		Test 1 - Observed
Test Duration (seconds)		**2,400**
Total Drop Distance (mm)		**1135**
Total Number of Measured Intervals		**25**
Infiltration Rate (mm/sec) - Test Average		**0.47**
Infiltration Rate (mm/hour) - Test Average		**1703**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**0.35**

IN-SITU INFILTRATION TEST **APPENDIX C**

Project:	Osaca Hillstreet subdivision	**PROJECT NO.:**	11056
Site Location:	5868 County road 65, Osaca, ON	**Date:**	27-Sep-22
Test ID:	INF-05	**Start Time:**	8:02 AM
		Test No.	1

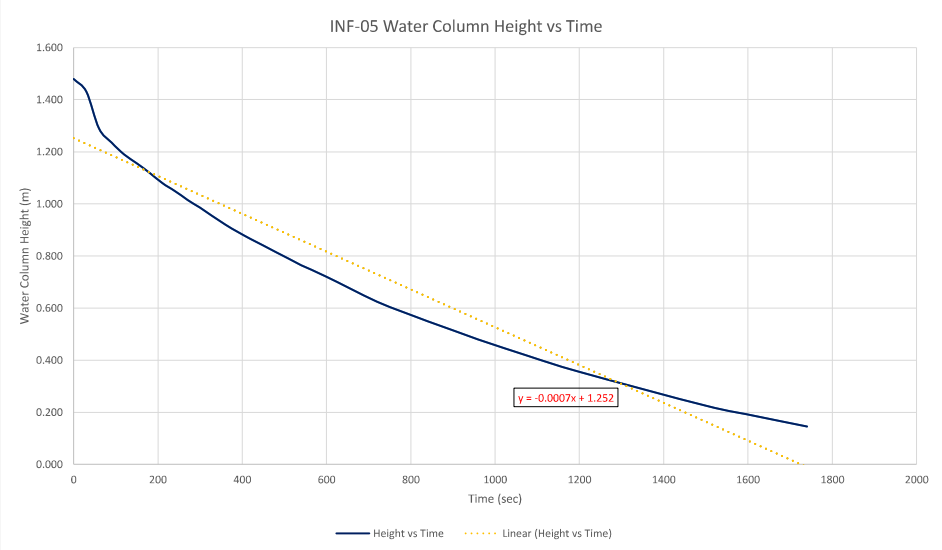
Depth of Test Pit (m):	1.14	**Pipe Stickup (m):**	1.37	**Total Pipe Length(m):**	2.38

Time* (Seconds)	Measurement Interval (sec)	Depth** (m)	Water Column Height (m)	Distance dropped per interval (m1)	Infilitration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)
0	-	0.900	1.480	-	--	--
30	30	0.950	1.43	0.050	1.667E-03	1.667E-03
60	30	1.090	1.29	0.140	4.667E-03	3.167E-03
90	30	1.145	1.24	0.055	1.833E-03	2.722E-03
120	30	1.190	1.19	0.045	1.500E-03	2.417E-03
150	30	1.225	1.16	0.035	1.167E-03	2.167E-03
180	30	1.260	1.12	0.035	1.167E-03	2.000E-03
210	30	1.300	1.08	0.040	1.333E-03	1.905E-03
240	30	1.330	1.05	0.030	1.000E-03	1.792E-03
270	30	1.365	1.02	0.035	1.167E-03	1.722E-03
300	30	1.395	0.99	0.030	1.000E-03	1.650E-03
360	60	1.460	0.92	0.065	1.083E-03	1.556E-03
420	60	1.515	0.87	0.055	9.167E-04	1.464E-03
480	60	1.565	0.82	0.050	8.333E-04	1.385E-03
540	60	1.615	0.77	0.050	8.333E-04	1.324E-03
600	60	1.660	0.72	0.045	7.500E-04	1.267E-03
720	120	1.755	0.63	0.095	7.917E-04	1.188E-03
840	120	1.830	0.55	0.075	6.250E-04	1.107E-03
960	120	1.900	0.48	0.070	5.833E-04	1.042E-03
1,080	120	1.965	0.42	0.065	5.417E-04	9.861E-04
1,200	120	2.025	0.36	0.060	5.000E-04	9.375E-04
1,500	300	2.155	0.23	0.130	4.333E-04	8.367E-04
1,620	120	2.195	0.19	0.040	3.333E-04	7.994E-04
1,740	120	2.235	0.15	0.040	3.333E-04	7.672E-04

** 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 -	4.67E-03	4.67E+00	16800
Minimum Infiltration Rate Between Sampling Intervals -	3.33E-04	3.33E-01	1200
Median Infiltration Rate Between Sampling Intervals -	9.17E-04	9.17E-01	3300
Average Infiltration Rate Between Sampling Intervals -	**1.09E-03**	**1.09E+00**	**3922**
Cumulative Infiltration Rate for Entire Data Set -	**7.67E-04**	**7.67E-01**	**2762**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**0.77**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**2762**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**0.22**



		Test 1 - Observed
Test Duration (seconds)		**1,740**
Total Drop Distance (mm)		**1335**
Total Number of Measured Intervals		**24**
Infiltration Rate (mm/sec) - Test Average		**0.77**
Infiltration Rate (mm/hour) - Test Average		**2762**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**0.22**

IN-SITU INFILTRATION TEST **APPENDIX C**

Project:	Osaca Hillstreet subdivision	**PROJECT NO.:**	11056
Site Location:	5868 County road 65, Osaca, ON	**Date:**	27-Sep-22
Test ID:	INF-06	**Start Time:**	9:04 AM
		Test No.	1

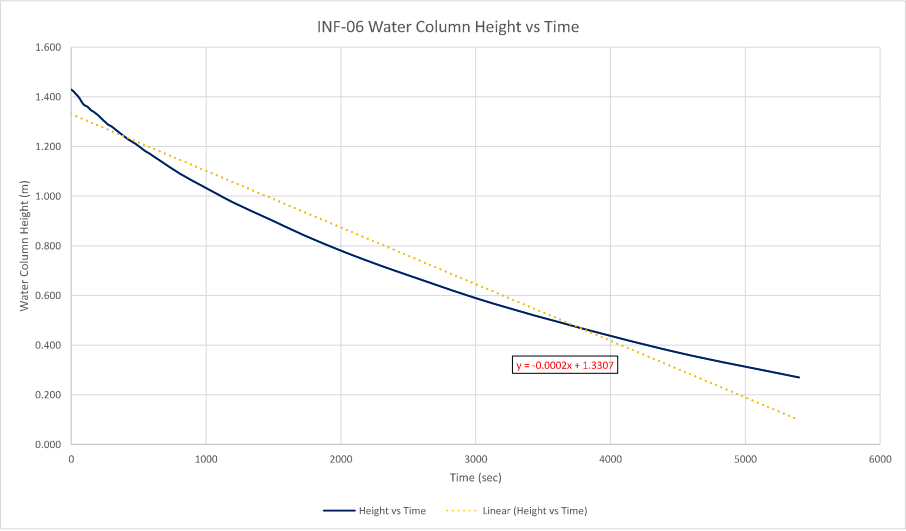
Depth of Test Pit (m):	1.1	**Pipe Stickup (m):**	1.165	**Total Pipe Length(m):**	2.27

Time* (Seconds)	Measurement Interval (sec)	Depth** (m)	Water Column Height (m)	Distance dropped per interval (m1)	Infiltration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)
0	-	0.840	1.430	-	--	--
30	30	0.855	1.42	0.015	5.000E-04	5.000E-04
60	30	0.875	1.40	0.020	6.667E-04	5.833E-04
90	30	0.900	1.37	0.025	8.333E-04	6.667E-04
120	30	0.910	1.36	0.010	3.333E-04	5.833E-04
150	30	0.925	1.35	0.015	5.000E-04	5.667E-04
180	30	0.935	1.34	0.010	3.333E-04	5.278E-04
210	30	0.950	1.32	0.015	5.000E-04	5.238E-04
240	30	0.965	1.31	0.015	5.000E-04	5.208E-04
270	30	0.980	1.29	0.015	5.000E-04	5.185E-04
300	30	0.990	1.28	0.010	3.333E-04	5.000E-04
360	60	1.015	1.26	0.025	4.167E-04	4.861E-04
420	60	1.040	1.23	0.025	4.167E-04	4.762E-04
480	60	1.060	1.21	0.020	3.333E-04	4.583E-04
540	60	1.085	1.19	0.025	4.167E-04	4.537E-04
600	60	1.105	1.17	0.020	3.333E-04	4.417E-04
720	120	1.150	1.12	0.045	3.750E-04	4.306E-04
840	120	1.190	1.08	0.040	3.333E-04	4.167E-04
960	120	1.225	1.05	0.035	2.917E-04	4.010E-04
1,080	120	1.260	1.01	0.035	2.917E-04	3.889E-04
1,200	120	1.295	0.98	0.035	2.917E-04	3.792E-04
1,500	300	1.370	0.90	0.075	2.500E-04	3.533E-04
1,800	300	1.445	0.83	0.075	2.500E-04	3.361E-04
2,100	300	1.510	0.76	0.065	2.167E-04	3.190E-04
2,400	300	1.570	0.70	0.060	2.000E-04	3.042E-04
3,000	600	1.680	0.59	0.110	1.833E-04	2.800E-04
3,600	600	1.775	0.50	0.095	1.583E-04	2.597E-04
4,500	900	1.900	0.37	0.125	1.389E-04	2.356E-04
5,400	900	2.000	0.27	0.100	1.111E-04	2.148E-04

** 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 -	8.33E-04	8.33E-01	3000
Minimum Infiltration Rate Between Sampling Intervals -	1.11E-04	1.11E-01	400
Median Infiltration Rate Between Sampling Intervals -	3.33E-04	3.33E-01	1200
Average Infiltration Rate Between Sampling Intervals -	**3.57E-04**	**3.57E-01**	**1287**
Cumulative Infiltration Rate for Entire Data Set -	**2.15E-04**	**2.15E-01**	**773**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**0.21**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**773**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**0.78**



		Test 1 - Observed
Test Duration (seconds)		**5,400**
Total Drop Distance (mm)		**1160**
Total Number of Measured Intervals		**29**
Infiltration Rate (mm/sec) - Test Average		**0.21**
Infiltration Rate (mm/hour) - Test Average		**773**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**0.78**

IN-SITU INFILTRATION TEST **APPENDIX C**

Project:	Osaca Hillstreet subdivision	**PROJECT NO.:**	11056
Site Location:	5868 County road 65, Osaca, ON	**Date:**	27-Sep-22
Test ID:	INF-07	**Start Time:**	4:07 PM
		Test No.	1

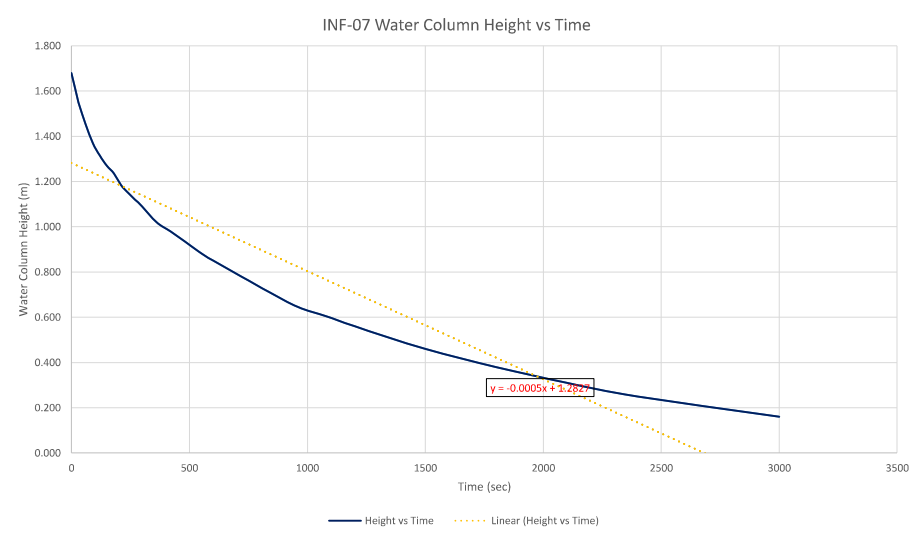
Depth of Test Pit (m):	0.97	**Pipe Stickup (m):**	1.41	**Total Pipe Length(m):**	2.38	

Time* (Seconds)	Measurement Interval (sec)	Depth** (m)	Water Column Height (m)	Distance dropped per interval (m1)	Infilitration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)
0	-	0.700	1.680	-	--	--
30	30	0.830	1.55	0.130	4.333E-03	4.333E-03
60	30	0.925	1.46	0.095	3.167E-03	3.750E-03
90	30	1.010	1.37	0.085	2.833E-03	3.444E-03
120	30	1.065	1.32	0.055	1.833E-03	3.042E-03
150	30	1.110	1.27	0.045	1.500E-03	2.733E-03
180	30	1.145	1.24	0.035	1.167E-03	2.472E-03
210	30	1.195	1.19	0.050	1.667E-03	2.357E-03
240	30	1.230	1.15	0.035	1.167E-03	2.208E-03
270	30	1.260	1.12	0.030	1.000E-03	2.074E-03
300	30	1.290	1.09	0.030	1.000E-03	1.967E-03
360	60	1.360	1.02	0.070	1.167E-03	1.833E-03
420	60	1.400	0.98	0.040	6.667E-04	1.667E-03
480	60	1.445	0.94	0.045	7.500E-04	1.552E-03
540	60	1.490	0.89	0.045	7.500E-04	1.463E-03
600	60	1.530	0.85	0.040	6.667E-04	1.383E-03
720	120	1.600	0.78	0.070	5.833E-04	1.250E-03
840	120	1.670	0.71	0.070	5.833E-04	1.155E-03
960	120	1.735	0.65	0.065	5.417E-04	1.078E-03
1,080	120	1.775	0.61	0.040	3.333E-04	9.954E-04
1,200	120	1.820	0.56	0.045	3.750E-04	9.333E-04
1,500	300	1.920	0.46	0.100	3.333E-04	8.133E-04
1,800	300	2.000	0.38	0.080	2.667E-04	7.222E-04
2,100	300	2.070	0.31	0.070	2.333E-04	6.524E-04
2,400	300	2.130	0.25	0.060	2.000E-04	5.958E-04
3,000	600	2.220	0.16	0.090	1.500E-04	5.067E-04

** 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 -	4.33E-03	4.33E+00	15600
Minimum Infiltration Rate Between Sampling Intervals -	1.50E-04	1.50E-01	540
Median Infiltration Rate Between Sampling Intervals -	7.50E-04	7.50E-01	2700
Average Infiltration Rate Between Sampling Intervals -	**1.09E-03**	**1.09E+00**	**3926**
Cumulative Infiltration Rate for Entire Data Set -	**5.07E-04**	**5.07E-01**	**1824**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**0.51**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**1824**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**0.33**



		Test 1 - Observed
Test Duration (seconds)		**3,000**
Total Drop Distance (mm)		**1520**
Total Number of Measured Intervals		**26**
Infiltration Rate (mm/sec) - Test Average		**0.51**
Infiltration Rate (mm/hour) - Test Average		**1824**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**0.33**

IN-SITU INFILTRATION TEST **APPENDIX C**

Project:	Osaca Hillstreet subdivision	**PROJECT NO.:**	11056
Site Location:	5868 County road 65, Osaca, ON	**Date:**	27-Sep-22
Test ID:	INF-08-A	**Start Time:**	12:08 PM
		Test No.	1

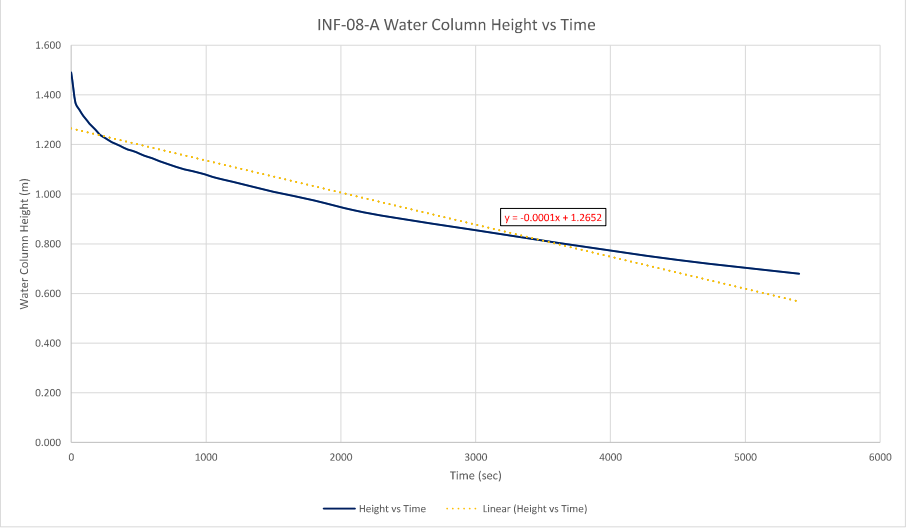
Depth of Test Pit (m):	0.55	**Pipe Stickup (m):**	0.945	**Total Pipe Length(m):**	1.56	

Time* (Seconds)	**Measurement Interval (sec)**	**Depth** (m)**	**Water Column Height (m)**	**Distance dropped per interval (m1)**	**Infiltration Rate per Interval (m/sec)**	**Cumulative Infiltration Rate (m/sec)**
0	-	0.070	1.490	-	--	--
30	30	0.190	1.37	0.120	4.000E-03	4.000E-03
60	30	0.220	1.34	0.030	1.000E-03	2.500E-03
90	30	0.245	1.32	0.025	8.333E-04	1.944E-03
120	30	0.265	1.30	0.020	6.667E-04	1.625E-03
150	30	0.285	1.28	0.020	6.667E-04	1.433E-03
180	30	0.300	1.26	0.015	5.000E-04	1.278E-03
210	30	0.320	1.24	0.020	6.667E-04	1.190E-03
240	30	0.330	1.23	0.010	3.333E-04	1.083E-03
270	30	0.340	1.22	0.010	3.333E-04	1.000E-03
300	30	0.350	1.21	0.010	3.333E-04	9.333E-04
360	60	0.365	1.20	0.015	2.500E-04	8.194E-04
420	60	0.380	1.18	0.015	2.500E-04	7.381E-04
480	60	0.390	1.17	0.010	1.667E-04	6.667E-04
540	60	0.405	1.16	0.015	2.500E-04	6.204E-04
600	60	0.415	1.15	0.010	1.667E-04	5.750E-04
720	120	0.440	1.12	0.025	2.083E-04	5.139E-04
840	120	0.460	1.10	0.020	1.667E-04	4.643E-04
960	120	0.475	1.09	0.015	1.250E-04	4.219E-04
1,080	120	0.495	1.07	0.020	1.667E-04	3.935E-04
1,200	120	0.510	1.05	0.015	1.250E-04	3.667E-04
1,500	300	0.550	1.01	0.040	1.333E-04	3.200E-04
1,800	300	0.585	0.98	0.035	1.167E-04	2.861E-04
2,100	300	0.625	0.94	0.040	1.333E-04	2.643E-04
2,400	300	0.655	0.91	0.030	1.000E-04	2.438E-04
3,000	600	0.705	0.86	0.050	8.333E-05	2.117E-04
3,600	600	0.755	0.81	0.050	8.333E-05	1.903E-04
4,500	900	0.825	0.74	0.070	7.778E-05	1.678E-04
5,400	900	0.880	0.68	0.055	6.111E-05	1.500E-04

** 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 -	4.00E-03	4.00E+00	14400
Minimum Infiltration Rate Between Sampling Intervals -	6.11E-05	6.11E-02	220
Median Infiltration Rate Between Sampling Intervals -	1.88E-04	1.88E-01	675
Average Infiltration Rate Between Sampling Intervals -	**4.28E-04**	**4.28E-01**	**1543**
Cumulative Infiltration Rate for Entire Data Set -	**1.50E-04**	**1.50E-01**	**540**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**0.15**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**540**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**1.11**



		Test 1 - Observed
Test Duration (seconds)		**5,400**
Total Drop Distance (mm)		**810**
Total Number of Measured Intervals		**29**
Infiltration Rate (mm/sec) - Test Average		**0.15**
Infiltration Rate (mm/hour) - Test Average		**540**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**1.11**

IN-SITU INFILTRATION TEST **APPENDIX C**

Project:	Osaca Hillstreet subdivision	**PROJECT NO.:**	11056
Site Location:	5868 County road 65, Osaca, ON	**Date:**	27-Sep-22
Test ID:	INF-08-B	**Start Time:**	11:48 AM
		Test No.	1

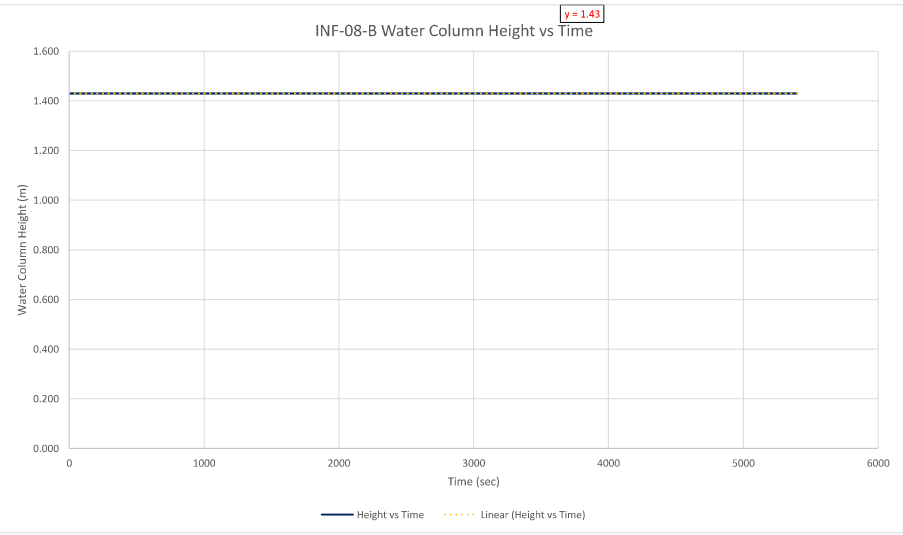
Depth of Test Pit (m):	2.08	**Pipe Stickup (m):**	0.925	**Total Pipe Length(m):**	3.08	

Time* (Seconds)	Measurement Interval (sec)	Depth** (m)	Water Column Height (m)	Distance dropped per interval (m1)	Infilitration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)
0	-	1.650	1.430	-	--	--
30	30	1.650	1.43	0.000	0.000E+00	0.000E+00
60	30	1.650	1.43	0.000	0.000E+00	0.000E+00
90	30	1.650	1.43	0.000	0.000E+00	0.000E+00
120	30	1.650	1.43	0.000	0.000E+00	0.000E+00
150	30	1.650	1.43	0.000	0.000E+00	0.000E+00
180	30	1.650	1.43	0.000	0.000E+00	0.000E+00
210	30	1.650	1.43	0.000	0.000E+00	0.000E+00
240	30	1.650	1.43	0.000	0.000E+00	0.000E+00
270	30	1.650	1.43	0.000	0.000E+00	0.000E+00
300	30	1.650	1.43	0.000	0.000E+00	0.000E+00
360	60	1.650	1.43	0.000	0.000E+00	0.000E+00
420	60	1.650	1.43	0.000	0.000E+00	0.000E+00
480	60	1.650	1.43	0.000	0.000E+00	0.000E+00
540	60	1.650	1.43	0.000	0.000E+00	0.000E+00
600	60	1.650	1.43	0.000	0.000E+00	0.000E+00
720	120	1.650	1.43	0.000	0.000E+00	0.000E+00
840	120	1.650	1.43	0.000	0.000E+00	0.000E+00
960	120	1.650	1.43	0.000	0.000E+00	0.000E+00
1,080	120	1.650	1.43	0.000	0.000E+00	0.000E+00
1,200	120	1.650	1.43	0.000	0.000E+00	0.000E+00
1,500	300	1.650	1.43	0.000	0.000E+00	0.000E+00
1,800	300	1.650	1.43	0.000	0.000E+00	0.000E+00
2,100	300	1.650	1.43	0.000	0.000E+00	0.000E+00
2,400	300	1.650	1.43	0.000	0.000E+00	0.000E+00
3,000	600	1.650	1.43	0.000	0.000E+00	0.000E+00
3,600	600	1.650	1.43	0.000	0.000E+00	0.000E+00
4,500	900	1.650	1.43	0.000	0.000E+00	0.000E+00
5,400	900	1.650	1.43	0.000	0.000E+00	0.000E+00

** 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 -	0.00E+00	0.00E+00	0
Minimum Infiltration Rate Between Sampling Intervals -	0.00E+00	0.00E+00	0
Median Infiltration Rate Between Sampling Intervals -	0.00E+00	0.00E+00	0
Average Infiltration Rate Between Sampling Intervals -	**0.00E+00**	**0.00E+00**	**0**
Cumulative Infiltration Rate for Entire Data Set -	**0.00E+00**	**0.00E+00**	**0**

In-situ Infiltration Rate Measured in the Field (mm/sec):	**0.00**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**0**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**#DIV/0!**



		Test 1 - Observed
Test Duration (seconds)		**5,400**
Total Drop Distance (mm)		**0**
Total Number of Measured Intervals		**29**
Infiltration Rate (mm/sec) - Test Average		**0.00**
Infiltration Rate (mm/hour) - Test Average		**0**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**#DIV/0!**

IN-SITU INFILTRATION TEST **APPENDIX C**

Project:	Osaca Hillstreet subdivision	**PROJECT NO.:**	11056
Site Location:	5868 County road 65, Osaca, ON	**Date:**	27-Sep-22
Test ID:	INF-11	**Start Time:**	2:53 PM
		Test No.	1

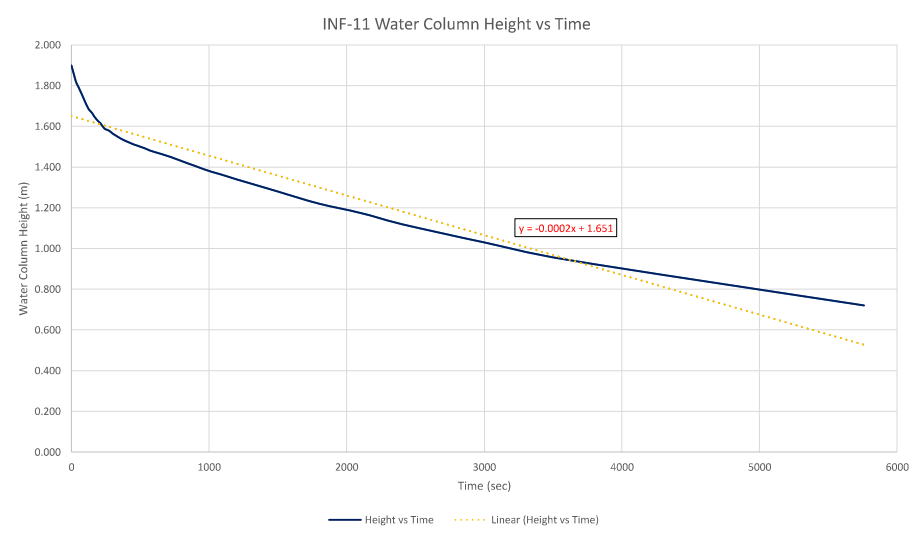
Depth of Test Pit (m):	1.13	**Pipe Stickup (m):**	1.02	**Total Pipe Length(m):**	2.30	

Time* (Seconds)	Measurement Interval (sec)	Depth** (m)	Water Column Height (m)	Distance dropped per interval (m1)	Infilitration Rate per Interval (m/sec)	Cumulative Infiltration Rate (m/sec)
0	-	0.400	1.900	-	--	--
30	30	0.475	1.83	0.075	2.500E-03	2.500E-03
60	30	0.520	1.78	0.045	1.500E-03	2.000E-03
90	30	0.565	1.74	0.045	1.500E-03	1.833E-03
120	30	0.610	1.69	0.045	1.500E-03	1.750E-03
150	30	0.635	1.67	0.025	8.333E-04	1.567E-03
180	30	0.665	1.64	0.030	1.000E-03	1.472E-03
210	30	0.685	1.62	0.020	6.667E-04	1.357E-03
240	30	0.710	1.59	0.025	8.333E-04	1.292E-03
270	30	0.720	1.58	0.010	3.333E-04	1.185E-03
300	30	0.735	1.57	0.015	5.000E-04	1.117E-03
360	60	0.760	1.54	0.025	4.167E-04	1.000E-03
420	60	0.780	1.52	0.020	3.333E-04	9.048E-04
480	60	0.795	1.51	0.015	2.500E-04	8.229E-04
540	60	0.810	1.49	0.015	2.500E-04	7.593E-04
600	60	0.825	1.48	0.015	2.500E-04	7.083E-04
720	120	0.850	1.45	0.025	2.083E-04	6.250E-04
840	120	0.880	1.42	0.030	2.500E-04	5.714E-04
960	120	0.910	1.39	0.030	2.500E-04	5.313E-04
1,080	120	0.935	1.37	0.025	2.083E-04	4.954E-04
1,200	120	0.960	1.34	0.025	2.083E-04	4.667E-04
1,500	300	1.020	1.28	0.060	2.000E-04	4.133E-04
1,800	300	1.080	1.22	0.060	2.000E-04	3.778E-04
2,100	300	1.125	1.18	0.045	1.500E-04	3.452E-04
2,400	300	1.180	1.12	0.055	1.833E-04	3.250E-04
3,000	600	1.270	1.03	0.090	1.500E-04	2.900E-04
3,600	600	1.355	0.95	0.085	1.417E-04	2.653E-04
5,760	2,160	1.580	0.72	0.225	1.042E-04	2.049E-04

** 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 -	2.50E-03	2.50E+00	9000
Minimum Infiltration Rate Between Sampling Intervals -	1.04E-04	1.04E-01	375
Median Infiltration Rate Between Sampling Intervals -	2.50E-04	2.50E-01	900
Average Infiltration Rate Between Sampling Intervals -	**5.53E-04**	**5.53E-01**	**1989**
Cumulative Infiltration Rate for Entire Data Set -	**2.05E-04**	**2.05E-01**	**738**

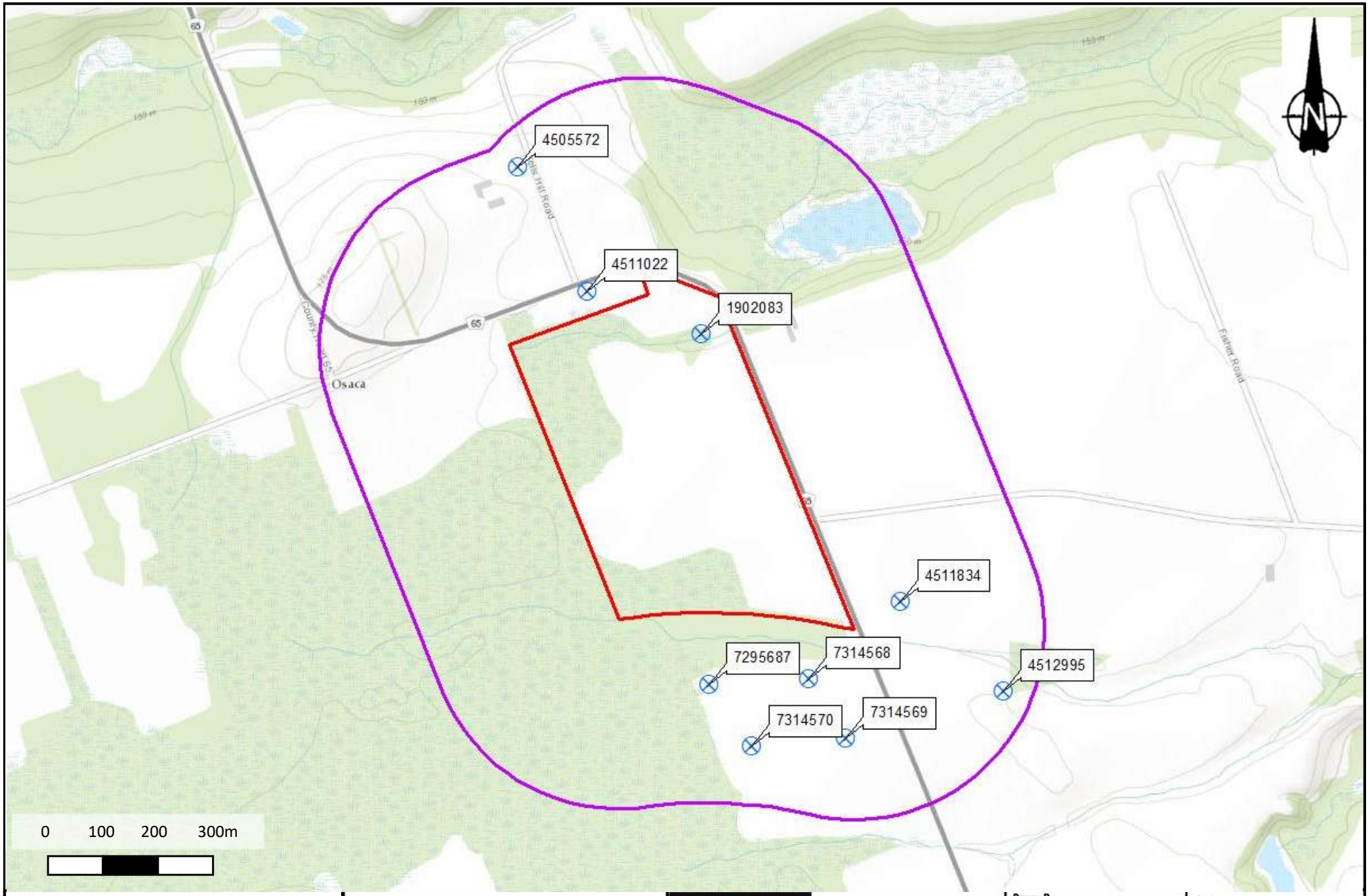
In-situ Infiltration Rate Measured in the Field (mm/sec):	**0.20**
In-situ Infiltration Rate Measured in the Field (mm/hour):	**738**
Calculated Percolation Time (T) based on field infiltration (min/cm):	**0.81**



		Test 1 - Observed
Test Duration (seconds)		**5,760**
Total Drop Distance (mm)		**1180**
Total Number of Measured Intervals		**28**
Infiltration Rate (mm/sec) - Test Average		**0.20**
Infiltration Rate (mm/hour) - Test Average		**738**
Calculated Percolation Time (T) based on Field Infiltration (min/cm)		**0.81**

Appendix D

MECP Well Record Survey



Legend

- MECP Well Survey – 500 m buffer
- Subject Property
- WECP Well Location and ID

MECP Well Location Plan

Hydrogeological Study
Part Lot 27, Concession 5, Village of Osaca, Ontario

WILLS

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

P. 705.742.2297
F. 705.749.9944
E. wills@dmwills.com

Drawn By	LT	Scale	See Scale Bar
Checked	IA	Date	July 2022
Project No.	22-11056	Drawing File No.	APP-D1

APPENDIX D-2 - MECP WELL SUMMARY
Well Record Summary - Bedrock
Project No.: 11056

Lot No.	UTM	M.O.E. Well No.	Well Use	Water Found Feet	Water Found Metres	Static Level Feet	Static Level Metres	REC Pump Rate Igpm	REC Pump Rate L/min	Well Depth Feet	Well Depth Metres	Depth to Bedrock Feet	Depth to Bedrock Metres	Comments
Con. 05														
Lot 27	705556 4875265	7295687	Unknown	-	-	-	-	-	-	-	-	-	-	No information available
Lot 26	Unknown	4512995	Domestic	44	13.4	57	17.4	4.16	18.9	156	47.5	144	43.9	Fresh water observed from 44-156 ft. in limestone bedrock.
Lot 27	705637 4875147	7314570	Domestic	32	9.8	27.9	8.5	8.33	37.8	157	47.9	147	44.8	Fresh water observed at 32 ft. in limestone bedrock.
Con. 6														
Lot 27	Unknown	4505572	Domestic	130	39.6	95	29.0	0.83	3.8	135	41.1	112	34.1	Fresh water observed at 130 ft. in limestone bedrock.

Number of Wells = 4

	Water Found Feet	Water Found Metres	Static Level Feet	Static Level Metres	REC Pump Rate Igpm	REC Pump Rate L/min	Well Depth Feet	Well Depth Metres	Depth to Bedrock Feet	Depth to Bedrock Metres
AVERAGE	68.7	20.9	60.0	18.3	4.4	20.2	149.3	45.5	134.3	40.9
MAXIMUM	130.0	39.6	95.0	29.0	8.3	37.8	157.0	47.9	147.0	44.8
MINIMUM	32.0	9.8	27.9	8.5	0.8	3.8	135.0	41.1	112.0	34.1

APPENDIX D-2 - MECP WELL SUMMARY
Well Record Summary - Overburden
Project No.: 11056

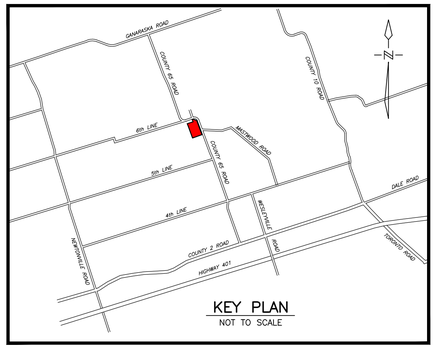
Lot No.	UTM	M.O.E. Well No.	Well Use	Water Found Feet	Water Found Metres	Static Level Feet	Static Level Metres	REC Pump Rate Igpm	REC Pump Rate L/min	Well Depth Feet	Well Depth Metres	Depth to Bedrock Feet	Depth to Bedrock Metres	Comments
Con. 5														
Lot 26	Unknown	4511834	Domestic	58	17.7	30	9.1	3.33	15.1	58	17.7	-	-	Fresh water observed at 58 ft. in brown sand
Lot 27	705815 4875162	7314569	Domestic	32	9.8	21.6	6.6	5.83	26.5	151	46.0	-	-	Fresh water observed at 32 ft. in coarse gravel
Lot 27	705746 4875275	7314568	Domestic	40	12.2	21	6.4	6.66	30.2	101	30.8	-	-	Fresh water observed at 40 ft. in coarse gravel
Lot 27	705527 4875703	1902083	Domestic	17	5.2	18	5.5	1.67	7.6	25	7.6	-	-	Fresh water observed at 17 ft. in clay material
Lot 27	-	4511022	-	-	-	-	-	10	45.4	13	4.0	-	-	No information - well record in relation to well cleanout of sand and gravel

Number of Wells = 5

	Water Found Feet	Water Found Metres	Static Level Feet	Static Level Metres	0 Igpm	0 L/min	Well Depth Feet	Well Depth Metres	Depth to Bedrock Feet	Depth to Bedrock Metres
AVERAGE	36.8	11.2	22.7	6.9	5.5	25.0	69.6	21.2	-	-
MAXIMUM	58.0	17.7	30.0	9.1	10.0	45.4	151.0	46.0	-	-
MINIMUM	17.0	5.2	18.0	5.5	1.7	7.6	13.0	4.0	-	-

Appendix E

Draft Plan



LAND USE SCHEDULE

PROPOSED USE	LOT/BLK #	# OF LOTS/BLKS	# OF UNITS	AREA (ha)
LOW DENSITY RESIDENTIAL				
SINGLE DETACHED	LOTS 1 – 59	59	59	16.012
NON RESIDENTIAL				
OPEN SPACE	BLOCKS 60 & 61	2	2	6.379
ROADS	20.0m ROW			2.223
TOTALS		61	59	24.623

ADDITIONAL INFORMATION REQUIRED UNDER SECTION 51 OF THE PLANNING ACT

E NORTH –RURAL RESIDENTIAL
SOUTH –RURAL RESIDENTIAL
EAST –AGRICULTURAL
WEST –AGRICULTURAL
H –PIPED MUNICIPAL WATER
I –TILL
K –NO MUNICIPAL SERVICES AVAILABLE

No.	REVISION	DATE	BY	APPROVED

REVISIONS

OWNER'S AUTHORIZATION

I/WE LAND OWNER

BEING THE REGISTERED OWNER OF THE SUBJECT LANDS HEREBY AUTHORIZE

D.G.BIDDLE AND ASSOC. LTD.

TO PREPARE AND SUBMIT A DRAFT PLAN OF SUBDIVISION FOR APPROVAL

SIGNED _____
TITLE

DATE _____

SURVEYOR'S CERTIFICATE

I HEREBY CERTIFY THAT THE BOUNDARY OF THE LANDS TO BE SUBDIVIDED AS SHOWN ON THIS PLAN AND THEIR RELATIONSHIP TO ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN

ONTARIO LAND SURVEYOR
ONTARIO LAND SURVEYORS

SIGNED _____
O.L.S

DATE _____

D.G.Biddle & Associates Limited
consulting engineers and planners
96 KING STREET EAST • OSHAWA,ON L1H 1B6
PHONE (905)576-8500 • FAX (905)576-9730
info@dgbiddle.com

PRELIMINARY

DRAFT PLAN

PART OF LOT 27, CONCESSION 5
FORMERLY IN THE TOWNSHIP OF HOPE
NOW IN THE
MUNICIPALITY OF PORT HOPE
COUNTY OF NORTHUMBERLAND

SCALE:	1:1000
DRAWN BY:	B.B.
DESIGN BY:	M.F.
CHECKED BY:	M.F.
PLOT DATE:	26/08/2022

122049

DP-1

Y:\JOB FILES\122000\122049 5868 COUNTY RD 65\122049 DRAWINGS\122049 ENGINEERING DRAWINGS\122049-2D-LOT PLAN - 1.DWG

Appendix F

Certificates of Analysis – Nitrates

FINAL REPORT

CA12213-OCT22 R---

11056 - OSAC.A

Prepared for

D.M. Wills -Peterborough

FINAL REPORT

CA12213-OCT22 R---

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	D.M. Wills -Peterborough	Project Specialist	Brad Moore Hon. B.Sc
		Laboratory	SGS Canada Inc.
Address	150 Jameson Drive Peterborough, ON K9J 0B9. Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Lynsey Tuters	Telephone	705-652-2143
Telephone	289-385-6230	Facsimile	705-652-6365
Facsimile	705-741-3568	Email	brad.moore@sgs.com
Email	ltuters@dmwills.com	SGS Reference	CA12213-OCT22
Project	11056 - OSAC.A	Received	10/05/2022
Order Number		Approved	10/18/2022
Samples	Ground Water (3)	Report Number	CA12213-OCT22 R---
		Date Reported	10/18/2022

COMMENTS

Temperature of Sample upon Receipt: 20 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes
Chain of Custody Number: 031488

SIGNATORIES

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

FINAL REPORT

CA12213-OCT22 R---

Client: D.M. Wills -Peterborough
Project: 11056 - OSAC.A
Project Manager: Lynsey Tuters
Samplers: L. Tuters

MATRIX: WATER

L1 = ODWS_MAC / WATER / - - Table 1,2 and 3 - Drinking Water - Reg O.169_03

Sample Number				5	6	7
Sample Name				11056 - MW22 - 08	11056 - MW05 - Geotech3	11056 - MW11 - Geotech 2
Sample Matrix				Ground Water	Ground Water	Ground Water
Sample Date				05/10/2022	05/10/2022	05/10/2022
Parameter	**Units**	**RL**	**L1**	**Result**	**Result**	**Result**
Metals and Inorganics						
Nitrite (as N)	as N mg/L	0.03	1	< 0.03	< 0.03	< 0.03
Nitrate (as N)	as N mg/L	0.06	10	4.35	0.39	0.68
Nitrate + Nitrite (as N)	as N mg/L	0.06		4.35	0.39	0.68

EXCEEDANCE SUMMARY

No exceedances are present above the regulatory limit(s) indicated

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Nitrate + Nitrite (as N)	DIO0214-OCT22	mg/L	0.06	<0.06	NA		NA			NA		
Nitrite (as N)	DIO0214-OCT22	mg/L	0.03	<0.03	ND	20	93	90	110	95	75	125
Nitrate (as N)	DIO0214-OCT22	mg/L	0.06	<0.06	0	20	99	90	110	NV	75	125
Nitrate + Nitrite (as N)	DIO0229-OCT22	mg/L	0.06	<0.06	NA		NA			NA		
Nitrite (as N)	DIO0229-OCT22	mg/L	0.03	<0.03	0	20	94	90	110	84	75	125
Nitrate (as N)	DIO0229-OCT22	mg/L	0.06	<0.06	0	20	100	90	110	96	75	125

QC SUMMARY

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.
RL Reporting Limit.
↑ Reporting limit raised.
↓ Reporting limit lowered.
NA The sample was not analysed for this analyte
ND Non Detect

Results relate only to the sample tested.
Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.
"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.
Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This report supersedes all previous versions.

-- End of Analytical Report --

Request for Laboratory Services and CHAIN OF CUSTODY

SGS Industries & Environment - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

No: 031488 Page ____ of ____

Laboratory Information Section - Lab use only

Received By: Sindoori Satheesh
Received Date: OCT 05 2022 (mm/dd/yy)
Received Time: 14 : 40 (hr : min)
Received By (signature):
Custody Seal Present: Yes ☑ No ☐
Custody Seal Intact: Yes ☑ No ☐
Cooling Agent Present: Yes ☑ No ☐ Type: ice
Temperature Upon Receipt (°C) 20 x 3
LAB LIMS #: CA12213-OCT22

REPORT INFORMATION	INVOICE INFORMATION
Company: D.M. Wills	☑ (same as Report Information)
Contact: L. Tuers	Company:
Address: 150 Jameson Dr. Peterborough	Contact:
Phone: 289-385-6230	Address:
Fax:	Phone:
Email: ltuers@dmwills.com	Email: accounts@dmwills.com

Quotation #:
P.O. #: 11056
Project #: 11056-OSACA
Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days)

TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:

*NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

☐ O.Reg 153/04 ☐ O.Reg 406/19
☐ Table 1 ☐ Res/Park Soil Texture:
☐ Table 2 ☐ Ind/Com ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ Medium/Fine
☐ Table ____ Appx. ____
Soil Volume ☐ <350m3 ☐ >350m3

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA
☑ ODWS Not Reportable *See note

Sewer By-Law:
☐ Sanitary
☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED ✓	TIME SAMPLED	# OF BOTTLES	MATRIX
1	11056-MW22-08	oct 5/22	AM	1	GW
2	11056-MW05-Geotech3	oct 5/22	AM	1	GW
3	11056-MW11-Geotech2	oct 5/22	AM	1	GW
4					
5					
6					
7					
8					
9					
10					
11					
12					

M & I				SVOC		PCB	PHC		VOC		Pest	Other (please specify)						SPLP	TCLP	COMMENTS:
Field Filtered (Y/N)	Metals & Inorganics incl CrVI, CN,Hg pH,(BI(HWS),EC,SAR-soil) (Cl, Na-water)	Full Metals Suite ICP metals plus B(HWS-soil only) Hg, CrVI	ICP Metals only Sb,As,Ba,Be,B,Cd, Cr,Co,Cu,Pb,Mo,Ni,Se,Ag,Tl,U,V,Zn	PAHs only	SVOCs all incl PAHs, ABNs, CPs	PCBs Total ☐ Aroclor ☐	F1-F4 + BTEX	F1-F4 only no BTEX	VOCs all incl BTEX	BTEX only	Pesticides Organochlorine or specify other	Nitrates				Sewer Use: Specify pkg:	Water Characterization Pkg General ☐ Extended ☐	Specify tests ☐ Metals ☐ VOC ☐ 1,4-Dioxane ☐ OCP ☐ ABN	Specify tests ☐ M&I ☐ VOC ☐ PCB ☐ B(a)P ☐ ABN ☐ Ignit.	
												✓								
												✓								
												✓								

Observations/Comments/Special Instructions

Sampled By (NAME): L. Tuers Signature: L Tuers Date: Oct 05 2022 (mm/dd/yy)
Relinquished by (NAME): L. Tuers Signature: L Tuers Date: Oct 05 2022 (mm/dd/yy)

Pink Copy - Client
Yellow & White Copy - SGS

Revision #: 1.6
Date of Issue: 02 May 2022

Appendix G

Water Balance

Monthly Water Budget Calculations

Project No: 11056
Project Name: Osaca
Designed/Checked By: LT/IA
Date: 21-Nov-22

CANADIAN CLIMATE NORMALS FOR 'Oshawa WPCP' (1971-2000)

Climate ID = 6155878
Latitude = 0
Longitude = 0

Thornthwaite (1948) Inputs				Monthly Water Budget Analysis				
Month	Mean Temperature (°C)[1]	Total Precipitation (mm)[1]	Heat Index	PET (mm)	Daylight Correction Factor	Adjusted PET (mm)	Surplus (mm)	Deficit (mm)
January	-5.3	71.0	0.00	0.0	1.01	0.0	71.0	0.0
February	-4.4	52.7	0.00	0.0	1.01	0.0	52.7	0.0
March	0.1	62.3	0.00	0.3	1.01	0.3	62.0	0.0
April	6.3	73.1	1.42	28.6	1.01	28.8	44.5	0.0
May	12.3	74.7	3.91	60.9	1.01	61.5	13.8	0.0
June	17.2	80.6	6.49	84.7	1.01	85.6	0.0	5.0
July	20.3	67.3	8.34	104.7	1.01	105.8	0.0	38.5
August	19.6	83.3	7.91	100.8	1.01	101.8	0.0	18.5
September	15.5	87.9	5.55	75.7	1.01	76.4	12.2	0.0
October	9.2	66.3	2.52	44.5	1.01	44.9	21.8	0.0
November	4.0	79.9	0.71	17.5	1.01	17.7	62.4	0.0
December	-2.0	78.7	0.00	0.0	1.01	0.0	78.7	0.0
Totals		**877.8**	36.85			**522.7**	**419.1**	**61.9**
Thornthwaite Coefficient (α)			**1.082**	Total Water Surplus (mm)				**355.1**

Notes:

1. Temperature and Precipitation are taken from Canadian Climate Normals 1981-2010
2. Water budget adjusted for latitude and length of daylight
3. Potential Evapotranspiration (PET) is calculated based on the Thornthwaite 1948 equation
4. Total Water Surplus (Thornthwaite, 1948) is calculated as total precipitation minus adjusted evapotranspiration

Water Balance Calculations for Existing Conditions

Project No: 11056
Project Name: Osaca
Designed/Checked By: LT/IA
Date: 21-Nov-22

Catchment Parameters	Ex.										Total
Drainage Area (m^2)	244000										**244000**
Pervious Area (m^2)	244000										**244000**
Impervious Area (m^2)	0										**0**
Evapotranspiration Factors											
Pervious PET Ratio	0.60										**0.60**
Impervious Evapotranspiration[3]	0.20										**0.00**
Infiltration Factors											
Topography Infiltration Factor	0.25										**0.25**
Soil Infiltration Factor	0.40										**0.40**
Land Cover Infiltration Factor	0.13										**0.13**
MOE Infiltration Factor	0.78										**0.78**
Actual Infiltration Factor	0.78										**0.78**
Run-Off Coefficient	0.22										**0.22**
Runoff from Impervious Surfaces	0.80										
Inputs (mm/yr)											
Precipitation	877.8										**877.8**
Run-On	0.0										**0.0**
Other Inputs	0.0										**0.0**
Total Inputs	877.8										**877.8**
Outputs (mm/yr)											
Precipitation Surplus	355.1										**355.1**
Net Surplus	355.1										**355.1**
Evapotranspiration	522.7										**522.7**
Infiltration	275.6										**275.6**
Infiltration Features[4]	0.0										**0.0**
Total Infiltration	**275.6**										**275.6**
Runoff Pervious Areas	79.5										**79.5**
Runoff Impervious Areas	0.0										**0.0**
Total Unadjusted Runoff	79.5										**79.5**
Total Adjusted Runoff[5]	**79.5**										**79.5**
Total Outputs	**877.8**										**877.8**
Inputs (m^3/yr)											
Precipitation	214,183										**214,183**
Run-On	0										**0**
Other Inputs	0										**0**
Total Inputs	**214,183**										**214,183**
Outputs (m^3/yr)											
Precipitation Surplus	86,633										**86,633**
Net Surplus	86,633										**86,633**
Evapotranspiration	127,550										**127,550**
Infiltration	67,247										**67,247**
Infiltration Features[4]	0										**0**
Total Infiltration	67,247										**67,247**
Runoff Pervious Areas	19,386										**19,386**
Runoff Impervious Areas	0										**0**
Total Unadjusted Runoff	19,386										**19,386**
Total Adjusted Runoff[5]	19,386										**19,386**
Total Outputs	**214,183**										**214,183**

Notes:

1. Water Balance Calculations area in based on methodology described in the Conservation Authority Guidelines for Hydrogeological Assessments (June 2013)
2. Annual Precipitation and Evapotranspiration values were determined using the Thornthwaite (1948) method for monthly water budget calculations
3. Evaporation from impervious areas was assumed to be 0% of Precipitation
4. Infiltration Features are calculated using daily Precipitation data and averaged over the number of years of available data. The entire Catchment is assumed to contribute with no infiltration occuring during months with a negative average temperature.
5. Total Adjusted Runoff is calculated as (Pervious Runoff + Impervious Runoff) - (Infiltration Features)

Water Balance Calculations for Proposed Conditions

WILLS

Project No: 11056
Project Name: Osaca
Designed/Checked By: LT/IA
Date: 21-Nov-22

Catchment Parameters	Pr.										Total
Drainage Area (m^2)	244000										**244000**
Pervious Area (m^2)	224000										**224000**
Impervious Area (m^2)	20000										**20000**
Evapotranspiration Factors											
Pervious PET Ratio	0.60										**0.60**
Impervious Evapotranspiration[3]	0.20										**0.20**
Infiltration Factors											
Topography Infiltration Factor	0.25										**0.25**
Soil Infiltration Factor	0.40										**0.40**
Land Cover Infiltration Factor	0.13										**0.13**
MOE Infiltration Factor	0.78										**0.78**
Actual Infiltration Factor	0.78										**0.78**
Run-Off Coefficient	0.22										**0.22**
Runoff from Impervious Surfaces	0.80										**0.80**
Inputs (mm/yr)											
Precipitation	877.8										**877.8**
Run-On	0.0										**0.0**
Other Inputs	0.0										**0.0**
Total Inputs	877.8										**877.8**
Outputs (mm/yr)											
Precipitation Surplus	383.5										**383.5**
Net Surplus	383.5										**383.5**
Evapotranspiration	494.3										**494.3**
Infiltration	253.8										**253.8**
Infiltration Features[4]	0.0										**0.0**
Total Infiltration	**253.8**										**253.8**
Runoff Pervious Areas	78.6										**78.6**
Runoff Impervious Areas	702.2										**702.2**
Total Unadjusted Runoff	129.7										**129.7**
Total Adjusted Runoff[5]	129.7										**129.7**
Total Outputs	**877.8**										**877.8**
Inputs (m^3/yr)											
Precipitation	214,183										**214,183**
Run-On	0										**0**
Other Inputs	0										**0**
Total Inputs	**214,183**										**214,183**
Outputs (m^3/yr)											
Precipitation Surplus	93,577										**93,577**
Net Surplus	93,577										**93,577**
Evapotranspiration	120,606										**120,606**
Infiltration	61,922										**61,922**
Infiltration Features[4]	0										**0**
Total Infiltration	61,922										**61,922**
Runoff Pervious Areas	17,611										**17,611**
Runoff Impervious Areas	14,045										**14,045**
Total Unadjusted Runoff	31,656										**31,656**
Total Adjusted Runoff[5]	31,656										**31,656**
Total Outputs	**214,183**										**214,183**

Notes:

1. Water Balance Calculations area in based on methodology described in the Conservation Authority Guidelines for Hydrogeological Assessments
2. Annual Precipitation and Evapotranspiration values were determined using the Thornthwaite (1948) method for monthly water budget calculations
3. Evaporation from impervious areas was assumed to be 20% of Precipitation
4. Infiltration Features are calculated using daily Precipitation data and averaged over the number of years of available data. The entire Catchment is assumed to contribute with no infiltration occuring during months with a negative average temperature.
5. Total Adjusted Runoff is calculated as (Pervious Runoff + Impervious Runoff) - (Infiltration Features)

Water Balance Assessment

WILLS

Project No: 11056
Project Name: Osaca
Designed/Checked By: LT/IA
Date: 21-Nov-22

Characteristic	Existing	Proposed No Mitigation	Change	Proposed With Mitigation	Change
Inputs (m^3/yr)					
Precipitation	214,183	214,183	0.0%	214,183	0.0%
Run-On	0	0	0.0%	0	0.0%
Other Inputs	0	0	0.0%	0	0.0%
Total Inputs	214,183	214,183	0.0%	214,183	0.0%
Outputs (m^3/yr)					
Precipitation Surplus	86,633	93,577	8.0%	93,577	8.0%
Net Surplus	86,633	93,577	8.0%	93,577	8.0%
Evapotranspiration	127,550	120,606	-5.4%	120,606	-5.4%
Infiltration	67,247	61,922	-7.9%	61,922	-7.9%
Infiltration Features	0	0	0.0%	0	0.0%
Total Infiltration	**67,247**	**61,922**	**-7.9%**	**61,922**	**-7.9%**
Runoff Pervious Areas	19,386	17,611	-9.2%	17,611	-9.2%
Runoff Impervious Areas	0	14,045	0.0%	14,045	0.0%
Total Runoff	**19,386**	**31,656**	**63.3%**	**31,656**	**63.3%**
Total Outputs	214,183	214,183	0.0%	214,183	0.0%

Nitrate Dilution Calculations

Total Dilution Area	24.40	ha
No. of Lots	59	
Sewage Flow per Lot	1000	L/day
Total Daily Sewage Loading	59,000	L/day
Nitrate in Septic Effluent	40	mg/L
Background Nitrates	0.54	mg/L
Stormwater Effluent Nitrates	0	mg/L
Infiltration Rates		
Infiltration Rate (Clean Water)		mm/year
Infiltration Rate (Clean Water)	169,648	L/day
Infiltration Rate (Stormwater)	-	mm/year
Infiltration Rate (Stormwater)	-	L/day
Nitrate Concentrations		
Nitrate Loading - Development	2,360,000	mg/day
Nitrate Loading - Rainfall	91,610	mg/day
Nitrate Loading - Runoff	0	mg/day
Total Nitrate Loading	2,451,610	mg/day
Dilution - Development	59,000	L/day
Dilution - Groundwater Recharge	169,648	L/day
Total Dilution	228,648	L/day
Boundary Nitrate Concentration	**10.72**	**mg/L**

Appendix H

Mass Balance Equation

Appendix H – D-5-4 Groundwater Impact Assessment: Mass Balance Equation

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

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

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

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