August 20, 2020 (Rev. 1) Reference No. 19-1243B

2745230 Ontario Inc.

Attn: Dr. Behrooz Azizi

RE: In-Situ Infiltration Testing
Proposed Commercial Development
441 Huronia Road, Barrie, Ontario

Dear Dr. Azizi,

This letter provides the results of the infiltration testing conducted at 441 Huronia Road in Barrie, Ontario, in support of the design of proposed Low Impact Development (LID) measures. This revision (Revision 1, dated August 20, 2020) is being provided to include a factored saturated hydraulic conductivity value for design purposes.

Introduction & Background Information

CEE previously prepared the following reports in support of the proposed commercial development:

- "*Geotechnical Report, Proposed Commercial Development, 441 Huronia Road, Barrie, Ontario*", Ref. No. 19-1243A, dated Jan. 9, 2020; and
- "*Hydrogeological Report, Proposed Commercial Development, 441 Huronia Road, Barrie, Ontario*", Ref. No. 19-1243A, dated Jan. 13, 2020.

As part of the subsurface investigation conducted for these reports, four boreholes were advanced with three of the boreholes having a monitoring wells installed. In general, the entire site had a 1.5 to 2.3 metre thick layer of earth fill at surface, under which a cohesionless and competent glacial till deposit was encountered to the full depth of investigation (up to 9.6 metres below existing grade). Groundwater was encountered at 5.3 metres below existing grade (Elev. 256.74 metres) in one of the monitoring wells, with the other two monitoring wells remaining dry.

CEE was also sent the following drawings/documents for review in preparation of this report:

- "*441 Huronia Road, Functional Servicing & Stormwater Management Report*", Project No. 2019-083, dated April 24, 2020, by CAPES Engineering; and
- Civil Engineering Drawing Set: "*441 Huronia Road Site Plan, City of Barrie*", Project No. 2019-083, Drawings C1 to C10, dated 20/04/24, by CAPES Engineering.

Based on our review of the aforementioned drawings/documents, it is proposed to infiltrate a total water volume of 21 m^3 per annum. It is noted that this amount is relatively small, but is due to the fact that only

run-off from the roof is allowed to infiltrate due to the site being commercial in nature and being within a Highly Vulnerable Aquifer and Wellhead Protection Area. A Low Impact Development (LID) measure consisting of an Atlantis Flo-Tank system is proposed at the northeast corner of the site that will infiltrate the rooftop run-off. Another Atlantis Flo-Tank system is located on the south corner of the site but will be lined with an impermeable liner such that no infiltration can occur. Proposed grades in the northeastern corner of the site will be near Elev. 262.5 metres (close to existing grades), and the base of the LID measure at the northeast corner of the site will be set at Elev. 260.42 metres (approximately 2 metres below existing grade). The Atlantis tanks will be underlain by a minimum 100 mm of clean washed river sand.

It is understood that the LSRCA has provided comments regarding the most recent submission that need to be addressed for this development. The comment that pertains to what CEE will address in this infiltration letter report is as follows:

LSRCA First Submission Hydrogeology Review, 441 Huronia Rd - Barrie (APID104811), June 16, 2020 - Comment H3:

> *The initial hydraulic conductivity testing estimated that infiltration will occur at a rate of about 12 mm/hr. In-situ percolation testing is to be carried out in the vicinity of and at the base of any proposed LID infiltration facilities, this will better establish the local infiltration rate and will aid in sizing the facility appropriately.*

The geotechnical and hydrogeological reports prepared for this site provided an estimate of infiltration rate based on grain size distribution curves. To address the comments from the LSRCA, additional field work has been completed to determine the in-situ infiltration rate of the soils within the footprint of the LID measure.

Field Methodology and Subsurface Conditions

The infiltration testing conducted conformed to the requirements laid out in the *CVC Low Impact Development Stormwater Management Planning and Design Guide,* Appendix C, Section C2.3. The requirements are summarized as follows:

- Conduct infiltration testing using a Guelph Permeameter (or other approved method) to determine the field-saturated hydraulic conductivity;
- Conduct up to two infiltration tests per test pit, one test at the bottom elevation of the LID measure and one test up to 1.5 metres below the bottom elevation of the LID measure should it be warranted due to changes in soil characteristics;
- Convert the saturated hydraulic conductivity to infiltration rate using the approximate relationships provided within Table C1 of the guideline and applying the appropriate factor of safety based on Figure C1.

Measurement of the field-saturated hydraulic conductivity (K_{fs}) was carried out using a Guelph Permeameter apparatus (Model 2800K1) on July 24, 2020, in two (2) test pits shown on the enclosed location plan. CEE directed a backhoe to dig to a depth of 2 metres below existing grade in the LID measure footprint, and this depth is near the proposed infiltration level of Elev. 260.42 metres for the LID measure. Once the base elevation was reached, infiltration tests were performed using the Guelph

Permeameter. A sample and description of the soil at this elevation was then obtained. An additional 1.5 metres was excavated below the proposed base of the LID measure. Additional samples were collected and another test was completed in the soil deposit encountered below the proposed infiltration depth.

The logs for Test Pits 1 and 2 are enclosed. The test pits encountered 150 to 200 mm of topsoil at the ground surface, underlain by earth fill that extended to depths of 2.3 to 2.4 metres below grade. The earth fill consisted of sand with trace to some silt and trace to some gravel. Both test pits encountered a 0.10 to 0.15-metre-thick layer of clayey and sandy silt glacial till at a depth of 2.3 to 2.4 metres below grade (about 0.3 to 0.4 metres below the infiltration depth). The clayey silt till was underlain by silty sand glacial till with some clay that extended from a depth of about 2.4 to 2.55 metres below grade to beyond a depth of 3.5 metres.

Infiltration tests were completed in both test pits in the earth fill at 2 metres below grade. Infiltration of the thin clayey silt glacial till layer could not be accurately measured with the Guelph Permeameter testing apparatus due to the limited thickness of the deposit. An additional infiltration test was completed in the test pits at 2.8 to 2.9 metres below grade in the silty sand glacial till deposit.

Analysis Methods

The field-saturated hydraulic conductivity of the soil was calculated using the one-head method which is calculated as follows:

$$K_{fs} = \frac{C_1 Q_1}{2H_1^2 + \pi a^2 C_1 + 2\pi \frac{H_1}{a^*}}$$

Where:
- C1 = shape factor
- Q = flow rate (cm^3/s)
- H_1 = water column height (cm)
- a = well radius (cm)
- α* = alpha factor (0.12 cm^{-1})

Hydraulic conductivity and infiltration rate are two different concepts and conversion from one parameter to another must account for the hydraulic gradient and consequently cannot be done through unit conversion. In accordance with the CVC guidelines, the infiltration rate was determined as per the relationship with the field-saturated hydraulic conductivity provided within the: "*Ontario Ministry of Municipal Affairs and Housing (OMMAH). 1997. Supplementary Guidelines to the Ontario Building Code 1997. SG-6 Percolation Time and Soil Descriptions. Toronto, Ontario*", which is summarized below.

Hydraulic Conductivity, K_{fs} (cm/s)	Percolation Time, T (min/cm)	Infiltration Rate, I (mm/hr)
0.1	2	300
0.01	4	150
0.001	8	75
0.0001	12	50
0.00001	20	30
0.000001	50	12

Infiltration rate is the inverse of percolation time. The approximate relationship (as provided in Figure C1 of the CVC guideline) in which the infiltration rate can be directly calculated is as follows:

$$K_{fs} = 6 * 10^{-11}(I)^{3.7363}$$

A factor of safety is then applied to the calculated infiltration rate to account for soil variability, gradual accumulation of fine soil sediments during the lifespan of the facility, and compaction during construction. A higher factor of safety is applied if a soil with a lower infiltration rate is encountered within 1.5 metres of the base of the infiltration measure.

Results of Infiltration Testing

The results of the infiltration tests are provided on the enclosed Guelph Permeameter analysis spreadsheets and are summarized below. The test depth of 1.9 to 2.0 metres is at the proposed LID infiltration elevation.

Test Pit	Test Depth (m)	Soil Type	Field-Saturated Hydraulic Conductivity		Infiltration Rate (mm/hr)
			cm/sec	mm/hr	
1	2.0	Fill: Sand, Trace to Some Silt	2.11×10^{-4}	7.6	56.5
	2.9	Silty Sand Glacial Till	3.42×10^{-4}	12.3	64.3
2	1.9	Fill: Sand, Trace to Some Silt	1.57×10^{-3}	5.7	96.6
	2.8	Silty Sand Glacial Till	1.28×10^{-3}	46.1	91.6

As previously mentioned, a factor of safety is applied depending on the soil strata encountered within 1.5 metres below the infiltration elevation. The infiltration rate of the thin clayey silt glacial till layer encountered at 2.3 to 2.4 metres below grade could not be accurately measured with the Guelph Permeameter (the deposit was too thin to measure). Despite being a thin layer, the clayey silt till is expected to have a substantially lower infiltration rate compared to the cohesionless earth fill and underlying silty sand till and will increase the safety factor per the CVC Guideline Table C2. It is assumed the clayey silt till will have an infiltration about 15 to 25% of the infiltration measured for the earth fill, indicating an estimated ratio of infiltration rates between 4.1 to 8.0 and a recommended safety correction factor of 4.5. If the subgrade below the LID measure is over-excavated by about 0.5 metres and backfilled with the clean washed river sand, the infiltration would be made into the silty sand glacial till and the safety correction factor can be reduced to 2.5.

It is recommended to use the lower infiltration or field-saturated hydraulic conductivity values measured in the test pits for design to account for variability within the soil strata. The recommended infiltration and field-saturated hydraulic conductivity rates with applied factors of safety are summarized below for design purposes.

- LID measure as proposed set at 2.0 metres below grade - Infiltration will be made into the earth fill consisting of sand with trace to some silt:
    - Factored Field-Saturated Hydraulic Conductivity is 2 mm/hr.
    - Factored Infiltration rate is 12 mm/hr.
- LID measure if subgrade is over-excavated to silty sand glacial till near 2.5 metres below grade and backfilled with clean washed river sand:

- Factored Field-Saturated Hydraulic Conductivity is 3 mm/hr.
- Factored Infiltration rate is 26 mm/hr.

Closure

We trust this information is sufficient for your present purposes. Should you have any questions concerning the above, or can be of any further assistance, please do not hesitate to contact the undersigned.

Regards,

Central Earth Engineering Inc.

Alexander Winkelmann, P.Eng.
President, Geotechnical Engineer

Russell Wiginton, P.Eng.
Geotechnical Engineer

TEST PIT LOCATION PLAN


19-1243A, 441 Huronia Rd., Barrie
Testpit Location Plan
Legend
TPs
TP1
TP2
PROPOSED 1-STOREY BLDG.
(MEDICAL OFFICE)
UNIT 'B'
UNIT 'A'
ELLIS DRIVE
HURONIA ROAD
76.38m
121.92m
Google Earth
© 2020 Google
70 m
N

TEST PIT LOGS

TEST PIT LOG 1

Project Name:	441 Huronia Road	Test Pit #:	1
Project #:	19-1243B	Date/Time:	July 24, 2020
Project Loc.:	Barrie, Ontario	Inspector:	R. Dodds
Client:	Mr. Behrooz Azizi	Weather:	
Contractor:	Eisses Brothers Excavating	Equipment:	John Deere Backhoe
Northing:	4911679 m	Easting:	606525 m

Depth (m)		Symbol	Stratigraphy	Samples	Notes
Top	Bottom				
0	0.2		Topsoil		
0.2	2.4		FILL: Sand, Trace to Some Silt, Trace to Some Gravel, Brown, Moist	GS1	
2.4	2.55		CLAYEY SILT GLACIAL TILL, Sandy, Brown, Moist	GS2	
2.55	3.5		SILTY SAND GLACIAL TILL, Some Clay, Brown, Moist	GS3	

Additional Notes

Seepage:	
Caving:	
Other:	

Central Earth ENGINEERING
647 Welham Road, Unit 14
Barrie, Ontario, L4N 0B7
T: (705) 719-7994
E: info@centralearth.ca

TEST PIT LOG 2

Project Name:	441 Huronia Road	Test Pit #:	2
Project #:	19-1243B	Date/Time:	July 24, 2020
Project Loc.:	Barrie, Ontario	Inspector:	R. Dodds
Client:	Mr. Behrooz Azizi	Weather:	
Contractor:	Eisses Brothers Excavating	Equipment:	John Deere Backhoe
Northing:	4911662 m	Easting:	606521 m

Depth (m)		Symbol	Stratigraphy	Samples	Notes
Top	Bottom				
0	0.15		Topsoil		
0.15	2.3		FILL: Sand, Trace to Some Silt, Trace to Some Gravel, Brown, Moist	GS1	
2.3	2.4		CLAYEY SILT GLACIAL TILL, Sandy, Brown, Moist	GS2	
2.4	3.5		SILTY SAND GLACIAL TILL, Some Clay, Brown, Moist	GS3	

Additional Notes

Seepage:	
Caving:	
Other:	

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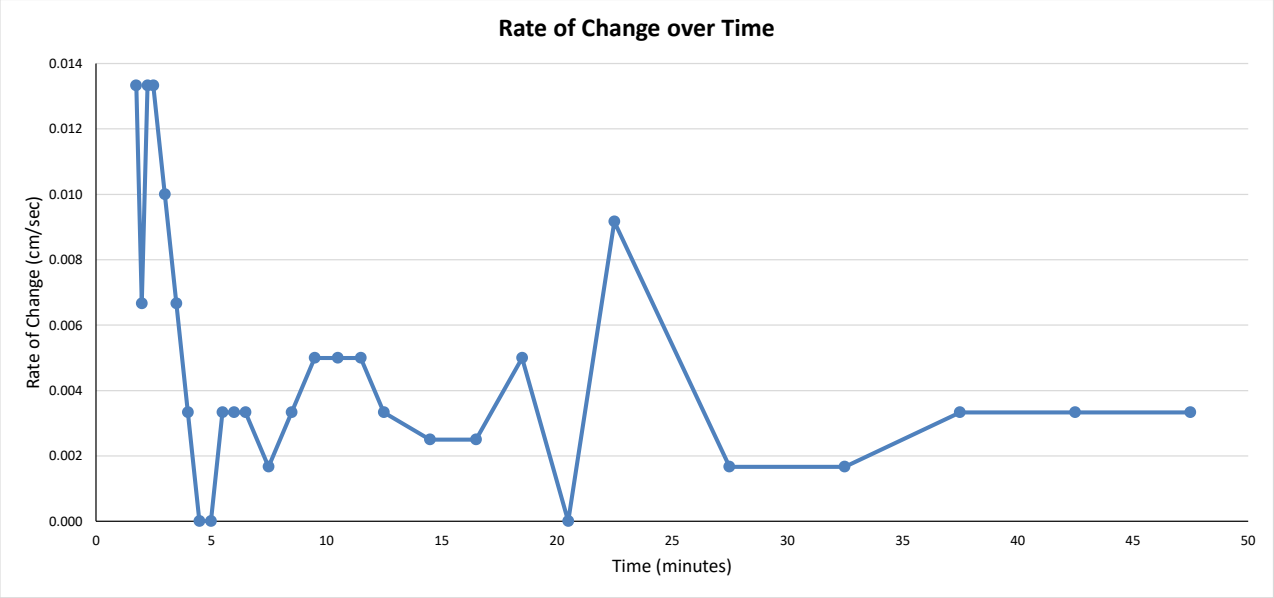
E: info@centralearth.ca

GUELPH PERMEATER ANALYSIS RESULTS

Central Earth ENGINEERING

Guelph Permeameter
Infiltration Rate Determination

Test Location: Test Pit 1 at 2.0 metres



INPUT PARAMETERS

α* =	0.12	cm^{-1}
H =	5	cm
a =	3	cm
X =	35.22	cm^2
R =	0.0033	cm/sec

SHAPE FACTOR

Shape Factor (1, 2 or 3) =	1
Shape Factor Value (cm^{-1}) =	0.803

CALCULATED PARAMETERS

H_a =	1.67	unitless
Q_1 =	0.116226	cm^3/sec

CALCULATED DESIGN VALUES

k_{fs}=	2.11E-04	cm/sec
Φ_m=	1.76E-03	cm^2/s
Infiltration:	56.5	mm/hr

Variable Glossary

α* **1)** is the ratio of gravity to capillarity forces during infiltration or drainage
2) determined from table 1 on page 47 of the manual (or the adjacent table)

H **1)** is the water head in the BH
2) determined by the height that the inner tube is pulled up during field operation

a **1)** is the radius of the borehole
2) determine by the size of the auger

X **1)** is the resevoir constant
2) determined by the reservoir knob at the top of the unit
- if the knob is up X = 35.22 (outer and inner reservoir)
- if the knob is down X = 2.16 (inner reservoir)

R **1)** is the steady state rate of flow per minute
2) is determined by timing the drop of water in the Guelph Permeameter

Equation Glossary

Ha is the ratio of head to borehole radius

Q1 is the flow rate

$C_{(1, 2 or 3)}$ is the shape factor which accounts for the saturated area of the soil
- Select C_1 if α* is ≥ 0.12 cm^{-1}
- Select C_2 if α* = 0.04 cm^{-1}
- Select C_3 if α* = 0.01 cm^{-1}

k_{fs} is the field saturated hydraulic conductivity of the soil

Φ_m is an indicator of the capillary pull exerted by the unsaturated soil on the water

Table 1. Soil texture-structure categories for site-estimation of α* (adapted from Elrick et al., 1989)

Soil Texture - Structure Category	α* (cm^{-1})
Compacted, structureless, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12
Coarse and gravelly sands; may also include some highly structured soils with large and/or numerous cracks, macropores, etc.	0.36

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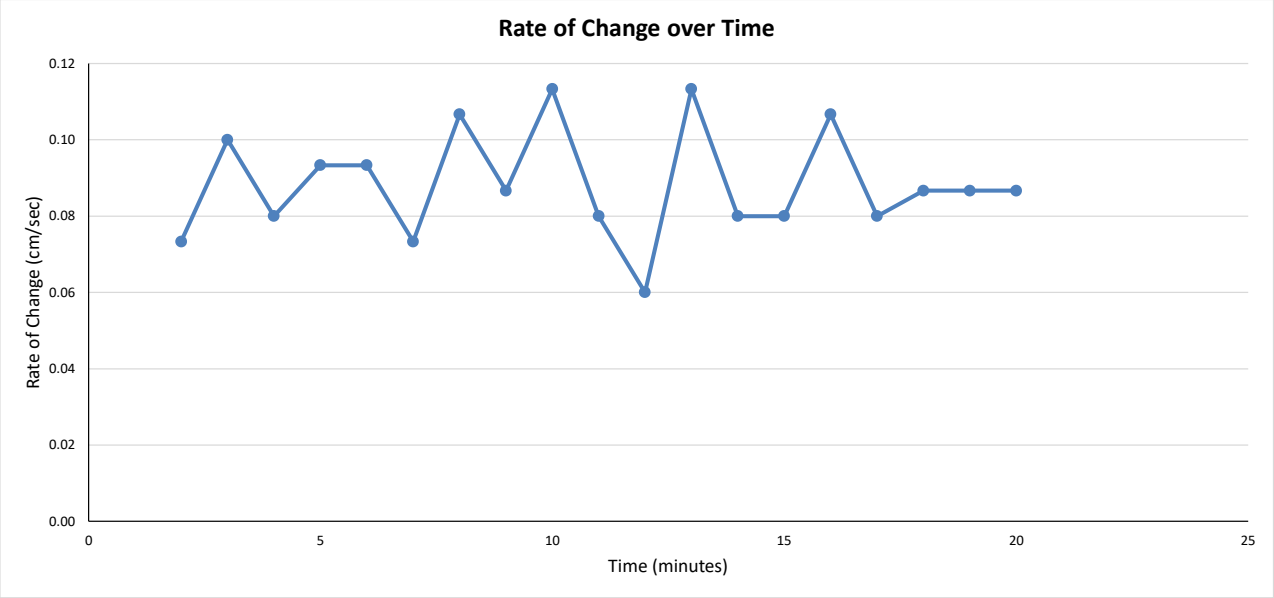
P: (705) 719-7994
E: info@centralearth.ca

Guelph Permeameter
Infiltration Rate Determination

Test Location: Test Pit 1 at 2.9 metres



INPUT PARAMETERS

α* =	0.12	cm^{-1}
H =	5	cm
a =	3	cm
X =	2.16	cm^2
R =	0.087	cm/sec

SHAPE FACTOR

Shape Factor (1, 2 or 3) =	1
Shape Factor Value (cm^{-1}) =	0.803

CALCULATED PARAMETERS

H_a =	1.67	unitless
Q_1 =	0.18792	cm^3/sec

CALCULATED DESIGN VALUES

k_{fs}=	3.42E-04	cm/sec
Φ_m=	2.85E-03	cm^2/s
Infiltration:	64.3	mm/hr

Variable Glossary

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2) determined from table 1 on page 47 of the manual (or the adjacent table)

H **1)** is the water head in the BH
2) determined by the height that the inner tube is pulled up during field operation

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Equation Glossary

Ha is the ratio of head to borehole radius

Q1 is the flow rate

$C_{(1, 2 or 3)}$ is the shape factor which accounts for the saturated area of the soil
- Select C_1 if α* is ≥ 0.12 cm^{-1}
- Select C_2 if α* = 0.04 cm^{-1}
- Select C_3 if α* = 0.01 cm^{-1}

k_{fs} is the field saturated hydraulic conductivity of the soil

Φ_m is an indicator of the capillary pull exerted by the unsaturated soil on the water

Table 1. Soil texture-structure categories for site-estimation of α* (adapted from Elrick et al., 1989)

Soil Texture - Structure Category	α* (cm^{-1})
Compacted, structureless, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12
Coarse and gravelly sands; may also include some highly structured soils with large and/or numerous cracks, macropores, etc.	0.36

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Barrie, Ontario
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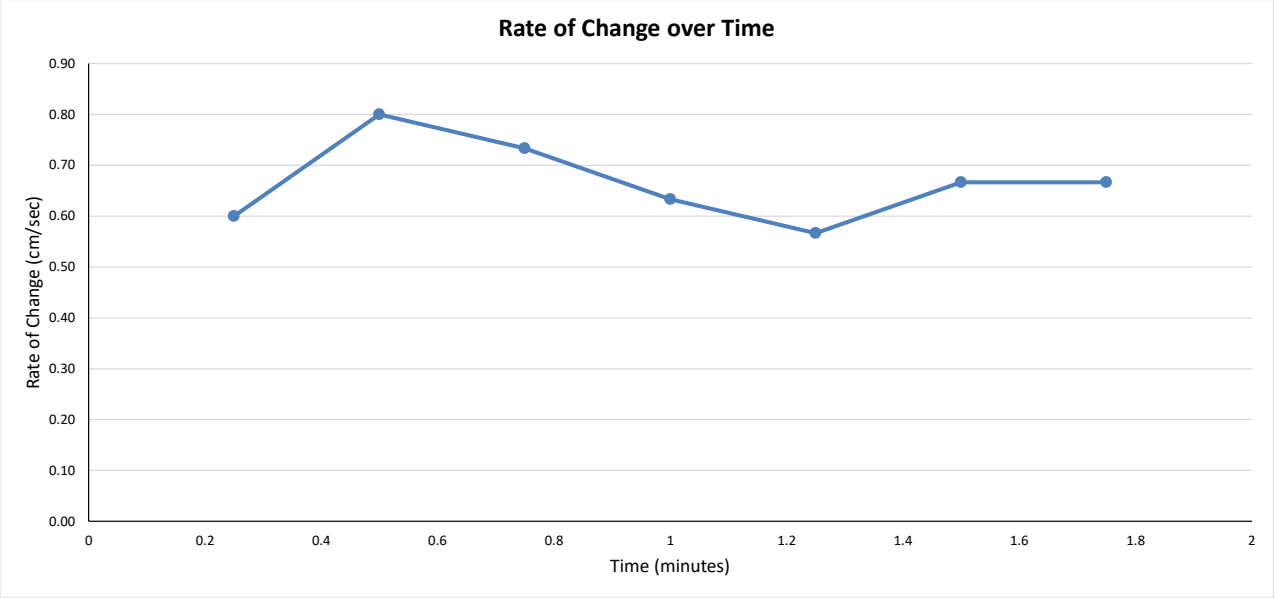
P: (705) 719-7994
E: info@centralearth.ca

Guelph Permeameter
Infiltration Rate Determination

Test Location: Test Pit 2 at 1.9 metres



INPUT PARAMETERS

α* =	0.12	cm^{-1}
H =	10	cm
a =	3	cm
X =	2.16	cm^2
R =	0.67	cm/sec

SHAPE FACTOR

Shape Factor (1, 2 or 3) =	1
Shape Factor Value (cm^{-1}) =	1.288

CALCULATED PARAMETERS

H_a =	3.33	unitless
Q_1 =	1.4472	cm^3/sec

CALCULATED DESIGN VALUES

k_{fs}=	1.57E-03	cm/sec
Φ_m=	1.31E-02	cm^2/s
Infiltration:	96.6	mm/hr

Variable Glossary

α* **1)** is the ratio of gravity to capillarity forces during infiltration or drainage
2) determined from table 1 on page 47 of the manual (or the adjacent table)

H **1)** is the water head in the BH
2) determined by the height that the inner tube is pulled up during field operation

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Equation Glossary

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Q1 is the flow rate

$C_{(1, 2 or 3)}$ is the shape factor which accounts for the saturated area of the soil
- Select C_1 if α* is ≥ 0.12 cm^{-1}
- Select C_2 if α* = 0.04 cm^{-1}
- Select C_3 if α* = 0.01 cm^{-1}

k_{fs} is the field saturated hydraulic conductivity of the soil

Φ_m is an indicator of the capillary pull exerted by the unsaturated soil on the water

Table 1. Soil texture-structure categories for site-estimation of α* (adapted from Elrick et al., 1989)

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Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04
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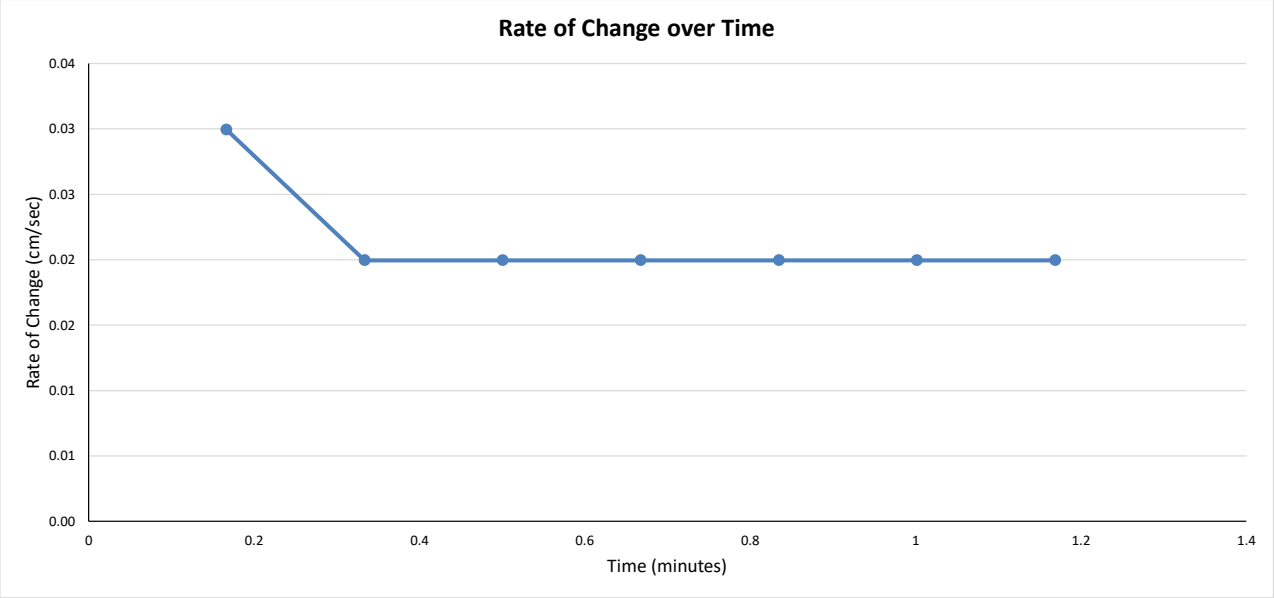
P: (705) 719-7994
E: info@centralearth.ca

Guelph Permeameter
Infiltration Rate Determination

Test Location: Test Pit 2 at 2.8 metres



INPUT PARAMETERS

α* =	0.12	cm^{-1}
H =	5	cm
a =	3	cm
X =	35.22	cm^2
R =	0.02	cm/sec

SHAPE FACTOR

Shape Factor (1, 2 or 3) =	1
Shape Factor Value (cm^{-1}) =	0.803

CALCULATED PARAMETERS

H_a =	1.67	unitless
Q_1 =	0.7044	cm^3/sec

CALCULATED DESIGN VALUES

k_{fs}=	1.28E-03	cm/sec
Φ_m=	1.07E-02	cm^2/s
Infiltration:	91.6	mm/hr

Variable Glossary

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