Geotechnical Investigation Report

Proposed Enbridge Operations Centre
2571 Lancaster Road, Ottawa ON

Prepared for: BluMetric Environmental Inc.

September 16, 2021
File: 1505.00-101

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Enbridge – 1 PDF copy
Malroz Engineering Inc. – 1 PDF copy

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Respectfully submitted,

Malroz Engineering Inc.

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1.0 Introduction

Malroz Engineering Inc. (Malroz) was retained by BluMetric Environmental Inc. (the Client) to conduct a geotechnical investigation in support of the proposed Enbridge operations centre to be located at 2571 Lancaster Road in Ottawa, Ontario (the Site). We understand that the proposed development will consist of the construction of a new two storey industrial/commercial building with no below grade levels. The building will consist of a multi-storey office, and a single storey office and shop space. The remainder of the Site will consist of paved parking space and outdoor storage/laydown areas.

This report summarizes the results of the investigation completed by Malroz in support of the proposed development. Work for this investigation was completed in general accordance with Malroz's approved proposal (ref. 1505.00-100, March 26, 2021). It is noted that a portion of Malroz's fieldwork for this project was conducted in conjunction with the Client's required fieldwork for a Phase II Environmental Site Assessment. The agreed upon scope of work consisted of the following:

- Attending a portion of the Client's fieldwork program for the Phase II Environmental Site Assessment to make site observations during drilling;
- Supplemental geotechnical characterization consisting of advancement of an additional four borings to a depth of 11.3 m or to practical auger refusal;
- Further advancing an additional two borings by approximately 3 m into rock;
- Submittal of up to four hydrometer grain size analyses, four Atterberg limits tests, one 1D consolidation test with a single recompression, as well as two unconfined compressive strength tests of recovered rock core; and
- Reporting of field and laboratory results, and provision of comments recommendations for the proposed development.

The recommendations and comments contained herein are based on factual information obtained during the investigation and are intended only for the use of project designers and engineers. They have been prepared with the understanding that the design will be carried out in accordance with applicable codes and standards. The General Conditions and Limitations (Section 0 of this report) form an integral part of this report.

2.0 Site Description

The Site is presently occupied by the existing Minto arena, occupying most of the footprint of the Site. It is surrounded by paved parking and laneway areas. The former railway easement to the north is presently unoccupied and covered in brush and some tree cover. Some sparse refuse and debris was noted throughout this area at surface.

Figure 1 – Site from the former railway easement at north corner, looking south

The Site is surrounded by a tennis facility and parking area and commercial/industrial developments to the north; by the existing railway easement and commercial/industrial development to the east; and by Lancaster Road, commercial developments and a residential subdivision to the south and west. The topography at the Site is both locally and regionally, generally flat, with drainage ditching located in the easement in the northern portion of the Site.

3.0 Method of Investigation

3.1 Fieldwork

A total of nine borings, identified as BH1 through BH7, MW5-21 and MW6-21; were advanced on April 6 and 7, 2021, under the supervision of the Client's field staff and drilling subcontractor. Malroz attended a portion of this drilling work and was subsequently provided with boring logs by the Client. Malroz advanced four supplemental borings on May 5, 2021 identified as BH8 through BH11, proximal to the proposed building location in the sketch provided to us by the Client at the time the proposal for this work was developed. Locations were modified based on available access to drilling equipment (e.g. in relation to existing building, laneways etc) and existing buried utilities. A Borehole Location Plan (Figure 1) is presented in Appendix A.

Boreholes BH1 to BH7 advanced by the Client were advanced to a depth of 2.9 m below existing grade (mbg) or to practical auger refusal, while MW5-21 and MW6-21 were advanced to depths of 4.9 and 3.8 mbg, respectively. Borings BH8 through BH11 were advanced to practical auger refusal.

Figure 2 – Drilling with CME-55LC during May 5, 2021 mobilization

Boreholes drilled under the supervision of the Client were advanced using a truck mounted CME-55 drill rig, equipped with solid stem continuous flight augers. Boreholes drilled under the supervision of Malroz were advanced using a CME-55LC drill rig on a rubber tracked carrier, and drilled to practical refusal. Boreholes BH9 and BH11 were further advanced into rock using 'N' sized double tube wireline coring equipment. 50 mm diameter PVC monitoring wells were installed at MW5-21 and MW6-21, by the Client, screened within overburden soils.

Locations and ground surface elevations at each boring were surveyed by the Client and provided to Malroz, and presented in the following table:

Table 1 – Borehole Locations

Test Location	Easting	Northing	Elevation (mASL)
BH1	452154.1	5027693.6	68.2
BH2	452179.4	5027649.5	67.8
BH3	452212.0	5027637.6	67.8
BH4	452230.7	5027603.4	67.8
BH5	452276.8	5027583.3	67.6
BH6	452296.5	5027544.6	67.6
BH7	452337.9	5027524.7	67.6
BH8	452079.4	5027638.9	67.6
BH9	452046.0	5027601.9	68.3
BH10	452141.1	5027551.7	67.3
BH11	452178.5	5027602.0	67.6
MW5-21	452127.2	5027650.1	67.9
MW6-21	452107.3	5027535.7	67.5

Input By: DPH
Validated By: RF

Soil samples were collected while performing the Standard Penetration Test (SPT) at all locations, in general accordance with the procedure as described in ASTM D1586. This consisted of freely dropping a 63.5 kg (140 lb) hammer from a vertical distance of 0.76 m (30 in), to drive a 51 mm (2 in) outer diameter split-barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground a distance of 300 mm (12 in) was recorded as the SPT 'N'

value, which correlates to the relative density of non-cohesive soils and is, in certain cases, indicative of the consistency of cohesive soils.

Each sample retrieved during Malroz's supplemental mobilization to the Site was placed in a resealable plastic bag and transported to our geotechnical laboratory in Kingston, Ontario for further review and testing.

Borehole logs for borings completed by Malroz and the Client are attached in Appendices B and C, respectively. Bedrock core photographs are presented in Appendix D.

4.0 Subsurface Assessment

Details of the subsurface conditions encountered are presented in the borehole records presented in Appendices B and C of this report. We strongly emphasize, however, that the soil types, their sequence, thickness, and physical properties may vary between boreholes, sample and test locations, both vertically and horizontally. This information is solely for general planning purposes and should not be used for detailed quantity take-offs.

4.1 Local Geology / Physiography

The site is located in east Ottawa, approximately 1,400 m west of Highway 417 and 1,000 m west of Green's Creek. The physiography of the site was described by the Ontario Geological Survey (OGS) as clay plains (Chapman and Putnam, 2007). The OGS mapped the Quaternary geology (OGS, 2010) of the area predominantly as fine textured glaciomarine deposits of silt and clay. Bedrock geology was mapped by the OGS (Armstrong and Dodge, 2007) near the site as interbedded shale and limestone of the Carlsbad Formation. Strata in the area are generally flat lying except in and around fault zones.

4.2 Borings Logged by Others

Assessment of subsurface conditions at borings logged by the Client are summarized in the following sections. The reader is referred to detailed borehole logs as prepared by the Client, enclosed in Appendix C of this report.

BH1 through BH7 were located in the former railway easement. Subsurface conditions in this area generally consisted of a surficial covering of topsoil (up to roughly 0.5 m in thickness), overlying sand to gravel fill, overlying a native clayey soil extending to termination depth. Shallow refusal was encountered at borings BH1 and BH3. Buried asphaltic material was noted within the fill soils at these borings, with a distinct layer noted at BH1. The native soil was observed to be generally soft to very soft within the depths investigated in this area.

Borings MW5-21 and MW6-21 were drilled approximately at the north and south extents of the existing arena, respectively. Both borings were advanced to practical refusal on

inferred bedrock. Observed soil conditions consisted of surficial coverings of asphaltic concrete overlying a granular fill and in turn native clayey soil which extended to practical refusal at approximately 3.7 m at MW6-21 and to approximately 4.3 mbg at MW5-21. A thin layer of gravelly till was noted at MW5-21 below the clay, extending to refusal at approximately 4.9 mbg. The consistency of the native clay in these two borings was estimated to be soft to stiff, based on the SPT 'N' values measured.

4.3 Borings Logged by Malroz

Assessment of subsurface conditions at borings logged by Malroz are summarized in the following sections. The reader is referred to detailed borehole logs enclosed in Appendix C of this report.

4.3.1 Surficial Materials –Asphalt

A surficial covering of asphaltic concrete was observed at boreholes BH8 through BH11, with thickness of approximately 50 mm at each location.

4.4 Pavement Base Fill

A grey crushed limestone fill was observed below the surficial covering of asphaltic concrete at boreholes BH8 through BH11. This material was visually described as being generally damp. Moisture contents measured in this material ranged from 3 to 33% by dry weight. SPT 'N' values were measured from 23 to 49 blows per 300 m penetration, indicating a relative density ranging from compact to dense.

4.5 Native Silty Clay

A blueish grey to brown or grey native silty clay with trace sand and gravel was observed at borings BH8 through BH11. This material was visually described as being generally moist to wet, with occasional siltier seams that were observed to be wet and dilatant with applied pressure. Moisture contents measured in this material ranged from 20 to 53% by dry weight. SPT 'N' values of 3 to 6 blows per 300 mm of penetration were measured in this material, indicating an estimate of soft to firm consistency.

4.6 Glacial Till (Sandy Silty Clay to Silty Gravelly Sand)

A dark brown to grey native glacial till was observed below the native silty clay at borings BH8 through BH11. This material was visually described as being generally moist. While containing sand and gravel, this material was observed to exhibit plastic behaviour. SPT 'N' values of 4 to 9 blows per 300 mm of penetration were measured in this material, indicating a firm to stiff consistency.

4.7 Limestone Bedrock

Upon encountering refusal at boreholes BH9 and BH11, 46.7 mm diameter cores were retrieved to confirm bedrock type and quality. A summary of the information obtained from the core drilling is presented the following table, and core information and material descriptions are reported on the respective records of boreholes.

Table 2 – Bedrock Core Information Summary

Borehole / Core Run ID	Depth to Rock Surface (mbg/mASL)	Total Core Recovery, TCR (%)	Solid Core Recovery, SCR (%)	Rock Quality Designation, RQD (%)
BH9/RC1	3.0 / 65.3	97	90	47
BH9/RC2		100	97	20
BH11/RC1	6.1 / 61.5	67	57	10
BH11/RC2		100	94	71

Input By: DPH
Validated By: RF

Bedrock cores were described as grey limestone with occasional shaley partings. Core photographs are attached in Appendix D.

Total core recovery (TCR) of the obtained core was found to range from 67 to 100%. Solid core recovery (SCR) was found range from 57 to 94%. The solid core recovery is generally influenced by the orientations of joints and is low when joints oblique to the axis are intercepted. The rock quality designation (RQD) is highly dependent on the frequency of joints/bedding plane partings in the retrieved cores. On the basis of the recorded RQD values of 10 to 71%, the rock quality is estimated to be poor to very poor excellent at the Site.

4.8 Groundwater

A detailed hydrogeological investigation was not included as a part of this work. However, groundwater observations were made in open borings prior to backfilling. No accumulation of groundwater was noted in boreholes BH8 through BH11 upon completion. However, it should be noted that insufficient time is available prior to backfilling of holes for stabilized static groundwater observations to be made.

Water level observations were made by the Client in the installed monitoring wells MW5-21 and MW6-21, in addition to two previously installed monitoring wells installed by others at the north end of the Site. Further details can be found in the Phase II Environmental Assessment report ref. 210294-01 by BluMetric Environmental Inc.

Groundwater observations made by the Client at the installed monitoring wells are summarized in the following table:

Table 3 – Groundwater Observations, by Client (April, 2021)

Borehole ID	Groundwater Observation, April 7, 2021 (mbg/mASL)	Groundwater Observation, April 15, 2021 (mbg/mASL)
MW5-21	1.1 / 66.7	1.6 / 66.2
MW6-21	1.6 / 65.9	1.1 / 66.4

Input By: DPH
Validated By: RF

Groundwater levels can fluctuate greatly and vary based on the prevailing seasonal and atmospheric conditions (e.g., heavy rains, spring thaw, dry spells, etc.).

5.0 Laboratory Testing

5.1 Geotechnical Laboratory

Samples recovered during drilling were transported to Malroz's geotechnical laboratory in Kingston, Ontario. A total of four samples were submitted for hydrometer grain size analysis (one in addition to the three as per our agreed upon scope of work, as samples were found to be generally non-plastic, and not suitable for Atterberg limits testing). Moisture contents were measured on all recovered soil samples with sufficient available quantity to test. Results are summarized in the following table.

Table 4 – Summary of Gradation and Plasticity Testing Results

Sample ID	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	LL (%)	PL (%)	PI
BH8-SS3	2	7	62	29	33.2	19.4	13.8
BH9-SS3	0	4	62	34	38.6	19.7	18.9
BH10-SS2	0	2	57	41	38.7	20.0	18.6
BH11-SS7	26	35	26	13	17.1	11.7	5.3

Input By: DPH
Validated By: RF

Table 5 – Summary of Unconfined Compressive Strength Testing

Sample ID	Unconfined Compressive Strength (MPa)
BH9/RC1	42.3
BH11/RC2	29.7

Input By: DPH
Validated By: RF

Detailed laboratory test reports are included in Appendix E of this report, and moisture contents are summarized in borehole logs in Appendix B.

5.2 Analytical Testing

One soil sample collected by the Client from each of MW5-21 and MW6-21 were submitted to assess parameters related to attack of buried concrete and metals. Results of soil testing is summarized in the following tables. Laboratory certificates of analysis, as provided by the Client, are presented in Appendix F of this report.

Table 6 – Summary of Corrosivity Testing

Sample ID	Parameters					Total Points[(1)]	Corrosivity Potential
	Resistivity (ohm·cm)	pH	Redox Potential (mV)	Sulphides (%)	Moisture/Drainage		
MW5-21 / S4	2080	7.27	251	<RDL	Moist	**8**	**NO**
MW6-21 / S5	680	7.45	246	<RDL	Moist	**13**	**YES**

Note: (1) Soil test evaluation carried out using AWWA C105/A21.5-05. A score of ten points or more indicates the soil is corrosive to ductile iron. Additional protection would be recommended if the score is 10 or greater. It was assumed that samples with a laboratory result of less than the reportable detection limit (RDL) for sulphides would be considered a trace condition (score of 2) and results greater than the RDL would be considered positive (score of 3.5).

Input By: DPH
Validated By:DH

As one sample was noted to show potential for attack to buried ductile iron at this Site, we recommend that supplemental provisions be considered for protection, which may include application of supplemental cathodic protection or increased cross-sectional area for any buried steel elements, for example.

Table 3 of CSA A23.1/A23.2 ‘Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Procedure for Concrete’ divides the degree of exposure of concrete structures to sulphate attack into the following classes:

Table 7 – Sulphate Exposure Classes

Degree of Exposure (Class)	Water Soluble Sulphate (SO4) in Soil Sample (%)
Very Severe (S-1)	> 2.0
Severe (S-2)	0.2 – 2.0
Moderate (S-3)	0.1 – 0.2

The laboratory results indicated that the sulphate content of samples MW5-21/S4 and MW6-21/S5 were 0.06 and 0.04% respectively, indicating a low potential for sulphate attack on concrete. Based on these results, sulphate resistant concrete mixes are not necessary for use on this project.

6.0 Discussion and Recommendations

Based on our present understanding of the proposed development, consisting of a two-storey building with no below grade levels, foundations may consist of shallow spread, strip or pad foundations. Foundations may be constructed on a suitable Engineered Fill pad overlying bedrock, or potentially directly over native glacial till soils subject to evaluation in the field at the time of construction. Alternatively, deep foundation elements such as auger cast piers, micropiles or large diameter drilled shafts, along with associated grade beams, could be considered.

Sufficient space is expected to be available to construct the structure in an open excavation. However, due to the relatively high groundwater table elevations identified, lowering the groundwater table to at least 0.5 m below the base of the proposed excavations will be necessary. Use of deep foundations would alleviate the need for extensive dewatering.

Existing foundation elements should not be utilized for the proposed new construction. They may also conflict with new foundation design (particularly in the case of deep foundations), if the building overlaps with the footprint of the existing arena building. We highly recommend as-builts are thoroughly reviewed by the design team to ensure that existing foundations can be managed/removed as necessary.

6.1 Excavation and Temporary Shoring

Open cut excavations up to a depth of approximately 4 to 6 m from the existing site grades may be necessary if foundations are constructed directly on limestone bedrock, on an Engineered Fill pad, or for trenching to place backfill materials.

All excavations and construction of any shoring should be carried out in accordance with the latest edition of the OHSA and Regulations for Construction Projects. The OHSA regulations require that if workers must enter an excavation deeper than 1.2 m, the excavation must be suitably sloped and/or braced in accordance with OHSA requirements. However, if a mass lean mix concrete pour is utilized to raise subgrade elevations, the depth in which personnel may have to enter trenching could be reduced to approximately 1.8 m (e.g. frost depth). We would expect that sufficient area would be available to backslope excavations without the use of shoring. Excavations for buried

utilities may extend deeper, depending on final site grading. OHSA specifies the maximum slope of excavations into four broad soil types, summarized as follows:

Table 8 – OHSA Soil Types

Soil Type	Maximum Slope Inclination	Base of Slope Location
Type 1	1 horizontal to 1 vertical	Within 1.2 m of base of excavation
Type 2	1 horizontal to 1 vertical	Within 1.2 m of base of excavation
Type 3	1 horizontal to 1 vertical	From bottom of excavation
Type 4	3 horizontal to 1 vertical	From bottom of excavation

At this Site, fill and native clayey soils should be considered as Type 4, while native glacial till soils could be considered as Type 2 to 3. Any soils affected by seepage must be considered as Type 4, and the lowest soil type in any given excavation shall govern its sideslopes

Excavations into overburden soils should be relatively easy using conventional excavating equipment; however, contractors should be prepared to manage any large particles, and zones of cobbles and boulders that may be encountered within the glacial till soils.

Stockpiles of excavated materials should be kept away from the edges of open excavations by a distance at least equivalent to the depth of the excavation to avoid slope instability. Care should be taken to avoid overloading any underground services/structures from any construction stockpiles. It should be noted that this distance is also applicable to the passage of heavy machinery near excavations. This condition should be respected at all times, unless specific studies are conducted for individual cases.

A shoring system will be required anywhere appropriate backsloping is not possible, e.g. potentially in utility trenching or adjacent to existing structures or roadways to be maintained. Shoring systems must be designed by a professional engineer licensed in the province of Ontario, in accordance with relevant codes, standards and regulations such as the latest version of the Canadian Foundation Engineering Manual and the Ontario Occupational Health and Safety Act (OHSA) Regulations for Construction Projects. The system should be designed to resist full earth and hydrostatic pressures,

as well as surcharges due to construction and highway traffic loadings. The following parameters may be used in the design of temporary shoring:

Table 9 – Lateral Earth Pressure Parameters

Soil Type	Bulk Unit Weight (kN/m^3)	Angle of Internal Friction (deg.)	Coefficient of Lateral Earth Pressure		
			K_a	K_o	K_p
Native Clay Deposits	18.0	30	0.33	0.50	3.00
Native Silty/Sandy Deposits	19.0	32	0.31	0.47	3.25
Compacted Gran. 'A'	21.0	34	0.28	0.44	3.54
Compacted Gran. 'B' Type II	21.5	35	0.27	0.43	3.69

At rest parameters should be utilized for non-yielding shoring elements. We recommend shoring plans be reviewed by a geotechnical engineer prior to the start of construction.

6.2 Dewatering

Groundwater was observed at elevations between 65.9 and 66.7 mASL in the installed monitoring wells, by the Client. Excavations penetrating below these elevations could encounter influx of groundwater and potential basal instability. Dewatering should lower the groundwater level to at least 0.5 m below the base of any excavation with a soil base – this may be effected with use of a number of passive relief wells and conventional pumping equipment, or active vacuum dewatering via wellpoints. A specialist dewatering contractor should be consulted if active dewatering methodology is to be considered. Single well response testing in MW5-21 and MW6-21 by the Client indicated hydraulic conductivities may be in the range of approximately 1×10^{-6} cm/s to 8×10^{-8} cm/s. Groundwater pumping volumes may be able to be calculated based on these hydraulic conductivities, however additional analysis based on the expected final excavation size/duration would be required.

Dewatering efforts may be lessened if excavations are carried out during drier months. Ground at excavation level should be sloped away from any open excavations to reduce the volume of surface water entering these excavations.

6.3 Foundations

6.3.1 Shallow Foundations

Design of foundations for the proposed building consisting of conventional spread, strip of pad foundations constructed directly over limestone bedrock, or on lean concrete backfill placed directly on rock to achieve a uniform founding elevation, can consider a factored bearing resistance of 2.5 MPa under Ultimate Limit State (ULS) conditions. There would be no corresponding Serviceability Limit State (SLS) bearing resistance as brittle failure of the rock would be expected prior to any settlements occurring. In an earth-formed excavation for placement of lean mix, the excavation should extend laterally at least half the depth of the excavation below the footings, from the outside edge of footings (e.g. if depth to rock is 2 m below underside of footings, concrete should extend laterally at least 1 m from each side of the footings).

If foundations are constructed over competent native glacial till soils, or on a granular pad placed over rock or Engineered Fill, a bearing resistance of 125 kPa under SLS conditions and a factored bearing resistance of 250 kPa under factored ULS conditions, could be considered. Any granular fill pad must be compacted to 100% of its Standard Proctor Maximum Dry Density in loose lifts not exceeding 0.2 m. It should be noted that thickness of glacial till soil was variable across the Site, between 0.5 and 1.8 m encountered, and therefore transition details may be necessary if foundations were to cross multiple subgrade types.

Footings should not be stepped at an angle steeper than 10H:7V. Excavations adjacent to new footings (e.g. for sumps, utilities etc.), should not penetrate a zone extending downwards from the outside edge of those, or any existing footings, at 10H:7V.

6.3.2 Deep Foundations

If deep foundation elements are considered, steel pile elements (pipes or H-pile sections, micropiles) that are driven to refusal on rock would be expected to be able to mobilize the full structural capacity of the piles prior to exhibiting brittle failure. Settlements at the SLS could be considered as three times the maximum elastic compression of the pile under service loads. The use of drive shoes or points is prudent,

given the potentially sloping rock surface, in addition to potential for large particles (cobbles and boulders) within glacial till soils.

Auger cast piers or other large diameter shafts can consider a unit side resistance of 560 kPa within the rock sockets under factored ULS conditions. Side friction resistance in the overburden soil should be considered as negligible.

6.3.3 Design for Earthquakes

In accordance with the Ontario Building Code 2012 (OBC), foundations must be designed to withstand a minimum earthquake force. Based on the measured SPT 'N' values in overburden and a rational assumption of 100 assumed for calculation purposes in bedrock, a Site Classification for Seismic Site Response of 'C' could be considered by designers in accordance with OBC Table 4.1.8.4.A.

6.3.4 Foundation Dewatering

Provided no below grade levels are constructed, and slabs are constructed at least 0.3 m above surrounding ground surface grades, no foundation drainage would be necessary. Surface grades should be sloped away from the building, and landscaped areas directly adjacent to the building should be capped with impermeable soils, if practicable. Otherwise, perimeter drainage should be installed around the building. A detail consistent with that described in the Canadian Foundation Engineering Manual 4th Edition would be suitable.

6.3.5 Frost Protection

Design frost depth in the Ottawa area should be considered 1.8 m below unprotected surface grades. Suitable soil cover or its equivalent in thermal insulation should be provided for all foundations.

6.4 Slab on Grade

A slab on grade constructed on a minimum of 150 mm of new Granular 'A' bedding overlying native soil subgrades or bedrock can be designed considering a modulus of subgrade reaction of 25 MPa/m. A proof roll of native soil subgrades under slabs on

grade should be conducted if practicable, which would involve running a loaded tandem or triaxle dump truck over the subgrade area to identify any localized weak areas. Any areas identified should be subexcavated and replaced with suitable fill soils as directed. Fill soils may be also be able to remain in place under slabs with the same design modulus, provided a proof roll is successfully completed, as well as any pockets of deleterious materials or organics within the fill, as identified by qualified personnel.

6.5 Backfilling

Backfill around the building should consist of non-frost susceptible, free draining granular material. Below hardscaped areas, all backfill material should be compacted to a minimum of 98% of its Standard Proctor Maximum Dry Density (SPMDD) to 1 m below the hardscape base or pavement subbase, and 100% thereafter. Elsewhere, all backfill should be compacted to 95% of its SPMDD.

Earth pressure parameters provided in Table 5 above can be used for any walls subjected to such pressures (e.g. for sump pits, etc.).

6.6 Pavement Design

Malroz carried out the design in accordance with the AASHTO 1993 Guide for the Design of Pavement Structures. Input parameters were selected in accordance with MI-183. Our design is based on assumptions regarding future traffic. If traffic projection data is available or projection assumptions should be adjusted, Malroz should be contacted to re-evaluate the proposed design section.

Given the size of the proposed development, an AADT of 100 vehicles with 50% heavy vehicle traffic was selected for new design purposes for the new pavement. No growth factor was considered. Table D-5 of the MTO Materials Information Report MI-183 – Adaptation and Verification of AASHTO Pavement Design Parameters for Ontario Conditions (March, 2008) (MI-183). Based on the above, the projected number of ESALs over a standard 20 year design period would be approximately 489,435. It should be noted that a relatively low subgrade reaction modulus of 10 MPa was selected for a pavement constructed over native soils.

Based on the above noted design inputs, a pavement section consisting of 50 mm of HL3 (or SP 12.5 Cat. B) and 90 mm of HL8 (or SP19.0 Cat B), overlying a base layer of 300 mm of new OPSS Granular ‘A’ and subbase layer of 360 mm of OPSS Granular ‘B’ Type I or II would be suitable for the estimated traffic and subgrade conditions. This section could be reduced using mechanical reinforcement, to 50 mm of HL3 (or SP 12.5 Cat. B) and 60 mm of HL8 (or SP 19.0 Cat B), overlying a base layer of 275 mm of OPSS Granular ‘A’ reinforced with Tensar TX7 geogrid and 250 mm of new Granular ‘B’ Type I or II.

6.6.1 Materials and Construction Considerations

For Site preparation, existing surficial coverings should be removed and pavement structure or fill present should be subexcavated to the required depth. Existing materials should not be reused as new granular material for pavement without further testing. The underlying subgrade should be proof rolled with heavy construction equipment. New pavement granular materials should be placed as an Engineered Fill operation as described in the section below.

Paving work should be completed in accordance with the requirements of applicable OPSS and municipal standards. All asphalt mix designs should be reviewed prior to the commencement of construction.

HMA used in this project should meet the minimum requirements of OPSS 1150/1151 (depending on whether Marshall or Superpave mixes are utilized). Asphalt cements should be minimum grade of PG 58-34, and meet the requirements of OPSS 1101. Given high volume of trucks expected in this type of facility, a high grade increase should be considered (e.g. to 64-34).

Tack coat should be applied between any vertical surfaces or joints including curbs, abutting and walls, etc., butt and lap joints and at all tie-ins to other existing asphalt. SS-1 emulsified asphalts used for this purpose should meet requirements of OPSS 1101.

6.7 Engineered Fill

Engineered Fill application may be required on this project to raise subgrade elevations and during backfilling of new building. For any operation to be considered Engineered Fill, the following criteria must be satisfied:

- Materials used as Engineered Fill must be uniform and homogenous. The material should be free of deleterious materials and organics;
- Prior to the placement of Engineered Fill, it must be assessed in a geotechnical laboratory for, at a minimum, gradation and Standard Proctor analyses;
- The material must be within +/- 2% of its optimum moisture content, as determined through laboratory testing;
- Engineered Fill operations must take place under the supervision of a geotechnical engineer or their designate;
- Suitable compaction equipment must be selected for the operation, based on the material to be compacted;
- Materials should be placed in lifts which are suitable for the compaction equipment utilized, but generally not greater than 0.2 m loose lifts;
- Density testing must be taken on each lift of Engineered Fill. Any Engineered Fill which is tested and found to be outside of the specified density range shall be either removed, reworked or retested; and
- Under no circumstances shall frozen material be placed in any Engineered Fill operation.

7.0 General Conditions and Limitations

This report was completed for the specific needs of BluMetric Environmental Limited and is based on a specific scope of work which is defined in the mutually agreed upon workplan. The scope of work has limitations as described throughout the report and in the notice to reader. Data, tables, charts, and interpretive illustrations presented in this document are instruments of service for this mandate and can only be properly evaluated when reviewed together with the accompanying report. Reference to this report should only be made to the complete signed document.

By issuing this report, Malroz is the Geotechnical Engineer of Record for this project. It is recommended that Malroz be retained during construction of all foundations, for earthwork operations and for paving. The intent of this requirement is to verify conditions encountered during construction are consistent with the findings in the report and, that inherent knowledge developed as a part of our study is correctly carried forward to construction phases. We should be retained to review whether our recommendations have been applied appropriately, once drawings and specifications are complete. Without this review, Malroz will not be liable for any misunderstanding of our recommendations or their application and adaptation into final designs.

The work performed in this report was carried out in accordance with the terms and conditions made as a part of our proposal and/or contract pursuant to which this report was issued, in a manner consistent with that level of care and skill ordinarily exercised by members of the Geotechnical Engineering profession currently practicing under similar conditions in the same locality. The conclusions presented in the report are based solely upon the scope of services, governed by the time and budgetary considerations to which this work was subject.

The factual data, recommendations and comments in this report pertain to the specific project as described in the report and are not applicable to any other project or location. If the project is conceptually modified or changes location, or if it is not initiated within twelve months of the date of this report, Malroz should be given an opportunity to confirm that the information in this report is still valid and/or applicable.

The comments in this report are intended only for the guidance of project designers and engineers. Contractors bidding on or undertaking the work should rely on their own

investigations, as well as their own interpretations of the factual borehole and in-situ test information, and how subsurface conditions may affect their work.

This report must be read as a whole, as sections taken out of context can be misleading. Drafts and working copies, whether or not marked as “draft”, “for discussion purposes” or otherwise, do not necessarily reflect Malroz’s final opinion following consideration of all matters which are subject to the study giving rise thereto; they are issued for comment and information purposes only, and are subject to change and should not be relied upon in any way or for any purpose.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based solely on the results obtained at the borehole locations only. Soil and groundwater conditions between and beyond the borehole locations may differ both horizontally and vertically from those encountered at the borehole locations and may become apparent during construction, which could not be detected or anticipated at the time of our investigation. Should any conditions at the site be encountered which differ from those found during this investigation, we request that we be notified immediately in order to permit a reassessment of our comment and recommendations. If changed conditions are identified during construction, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by Malroz has been completed.

8.0 Closure

We trust that this report meets your present requirements. Please do not hesitate to contact us should there be any further questions or comments.

Respectfully Submitted,

Malroz Engineering Inc.,

per: Dylan Hill, P. Eng.
Geotechnical Engineer, Project Manager

reviewed: David Hodgson, P.Eng.
Senior Engineer, Principal

9.0 References

Armstrong, D.K. and Dodge, J.E.P. (2007) Paleozoic geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 219.

Canadian Geotechnical Society. (2006). Canadian Foundation Engineering Manual, 4th Edition.

Chapman, L.J., and Putnam, D.F. (2007) Physiography of southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 228.

[MTO] Ministry of Transportation of Ontario (2008) Materials Information Report MI-183 –Adaptation and Verification of AASHTO Pavement Design Parameters for Ontario Conditions (March, 2008).

[OGS] Ontario Geological Survey (2010) Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128-REV.

Appendix A
Figures

Legend

- approximate property boundary
- borehole advanced under the supervision of the Client
- borehole and monitoring well advanced under the supervision of the Client
- borehole advanced under the supervision of Malroz

Data Sources: Figure based on Google Earth imagery, field observations by Malroz and observations provided by the Client.

Rev	Date	Description	By	Chkd
D0	2021-09-16	issued in final	RV	DPH

Borehole Location Plan

Geotechnical Investigation Report
Proposed Enbridge Operations Centre
2571 Lancaster Road, Ottawa, ON

File: 1505.00-101

Figure 1

MALROZ

Appendix B
Record of Boreholes (Malroz)

BOREHOLE LOG

Enclosure No.: 1

Project Name: **Geotechnical Investigation - Proposed Enbridge Ottawa Operations Centre**		Project Number: **1505**
Client: **Blumetric Environmenal Inc.**	Borehole Number: **BH08**	Page: **1** of **1**
Location: **2571 Lancaster Rd., Ottawa, Ontario**	Date Started: **May 5, 2021**	Datum: **NAD86, Zone 18T**
Drilling Contractor: **George Downing Estate Drilling Ltd.**	Date Finished: **May 5, 2021**	Elevation: **67.6 m**
Drilling Equipment: **CME 55LC**	Easting: **452079.4 m**	Northing: **5027638.9 m**
Drilling and Sampling Method: **200mm Hollow-Stem Augers, 50mm Split Spoons**	Logged By: **M. Storms**	Checked By: **D. Hill**

Depth BGS (m)	Elevation (m)	Stratigraphy	Description	Sample Type	Sample Number	Recovery (%)	Penetration Index / RQD	Shear Strength (kPa) 50 100 150 200 ■DCPT■ ●SPT-N● PL MC LL 20 40 60 80
0.2	67.5		**ASPHALT** approx. 50mm.					
0.4					SS1	84	29	○ ●
0.6			**FILL** crushed limestone, some silt, grey, damp, compact.					
0.8								
1.0	66.7		**SILTY CLAY** trace sand, trace gravel, greyish-brown, light mottling, moist, firm.		SS2	42	7	● ○
1.2								
1.4								
1.6								
1.8			G: 2%, S: 7%, SI: 62%, CL: 29%.		SS3	100	5	● ○
2.0								
2.2								
2.4								
2.6					SS4	100	5	● ○
2.8	64.8		**SANDY SILTY CLAY** dark brown becoming grey, trace to some gravel with depth, moist, stiff..					
3.0								
3.2					SS5	38		○
3.4								
3.6								
3.8								
4.0					SS6	56	R	○
4.2	63.4		Borehole terminated with auger refusal at 4.2m.					
4.4								
4.6								
4.8								
5.0								
5.2								
5.4								
5.6								
5.8								
6.0								
6.2								
6.4								
6.6								
6.8								
7.0								
7.2								
7.4								
7.6								
7.8								
8.0								
8.2								
8.4								
8.6								
8.8								
9.0								
9.2								
9.4								
9.6								
9.8								
10.0								
10.2								
10.4								
10.6								
10.8								

NOTES: G, S, SI and CL denotes gravel, sand, silt and clay, respectively.

BOREHOLE LOG

Enclosure No.: 2

Project Name: **Geotechnical Investigation - Proposed Enbridge Ottawa Operations Centre**		Project Number: **1505**
Client: **Blumetric Environmenal Inc.**	Borehole Number: **BH09**	Page: **1** of **1**
Location: **2571 Lancaster Rd., Ottawa, Ontario**	Date Started: **May 5, 2021**	Datum: **NAD86, Zone 18T**
Drilling Contractor: **George Downing Estate Drilling Ltd.**	Date Finished: **May 5, 2021**	Elevation: **68.3 m**
Drilling Equipment: **CME 55LC**	Easting: **452046.0 m**	Northing: **5027601.9 m**
Drilling and Sampling Method: **200mm Hollow-Stem Augers, 50mm Split Spoons**	Logged By: **M. Storms**	Checked By: **D. Hill**

Depth BGS (m)	Elevation (m)	Stratigraphy	Description	Sample Type	Sample Number	Recovery (%)	Penetration Index / RQD	Shear Strength (kPa) 50 100 150 200 ■DCPT■ ●SPT-N● PL MC LL 20 40 60 80
0.2	68.2		**ASPHALT** approx. 50mm.					
0.4					SS1	50	23	○ ●
0.6			**FILL**					
0.8	67.5		crushed limestone, some silt, grey, damp, compact.					
1.0			**SILTY CLAY**		SS2	29	5	● ○
1.2			trace sand, bluish-grey, moist, firm.					
1.4								
1.6	66.7		Becoming grey, light mottling, moist with occasional wet/dilatent					
1.8			silt layers.		SS3	100	5	● ○
2.0			G: 0%, S: 4%, SI: 62%, CL: 34%.					
2.2								
2.4	65.8							
2.6			**SANDY SILTY CLAY**		SS4	100	4	● ○
2.8			trace to some gravel, moist, firm.					
3.0	65.3		**LIMESTONE**					
3.2			grey, poor to very poor quality.					
3.4								
3.6								
3.8					RC1	97	47	
4.0			UCS: 42.3 MPa.					
4.2								
4.4								
4.6								
4.8								
5.0								
5.2								
5.4					RC2	100	21	
5.6								
5.8								
6.0	62.2		Borehole terminated within limestone bedrock at 6.1m.					
6.2								
6.4								
6.6								
6.8								
7.0								
7.2								
7.4								
7.6								
7.8								
8.0								
8.2								
8.4								
8.6								
8.8								
9.0								
9.2								
9.4								
9.6								
9.8								
10.0								
10.2								
10.4								
10.6								
10.8								

NOTES: G, S, SI and CL denotes gravel, sand, silt and clay, respectively.

BOREHOLE LOG

Enclosure No.: 3

Project Name: **Geotechnical Investigation - Proposed Enbridge Ottawa Operations Centre**		Project Number: **1505**
Client: **Blumetric Environmenal Inc.**	Borehole Number: **BH10**	Page: **1** of **1**
Location: **2571 Lancaster Rd., Ottawa, Ontario**	Date Started: **May 5, 2021**	Datum: **NAD86, Zone 18T**
Drilling Contractor: **George Downing Estate Drilling Ltd.**	Date Finished: **May 5, 2021**	Elevation: **67.3 m**
Drilling Equipment: **CME 55LC**	Easting: **452141.1 m**	Northing: **5027551.7 m**
Drilling and Sampling Method: **200mm Hollow-Stem Augers, 50mm Split Spoons**	Logged By: **M. Storms**	Checked By: **D. Hill**

Depth BGS (m)	Elevation (m)	Stratigraphy	Description	Sample Type	Sample Number	Recovery (%)	Penetration Index / RQD	Shear Strength (kPa) 50 100 150 200 ■DCPT ●SPT-N● PL MC LL 20 40 60 80
0.2	67.2		**ASPHALT** approx. 50mm.					
0.4								
0.6			**FILL**					
0.8	66.5		crushed limestone, some silt, grey, damp.					
1.0			**SILTY CLAY** brown, moist, soft to firm.		SS1	71	4	● ○
1.2								
1.4								
1.6								
1.8					SS2	100	4	● ○
2.0			G: 0%, S: 2%, SI: 57%, CL: 41%.					
2.2								
2.4			Becoming grey, moist to wet.					
2.6					SS3	100	6	● ○
2.8								
3.0								
3.2								
3.4					SS4	59	6	● ○
3.6	63.8		**SANDY SILTY CLAY**					
3.8			dark grey, trace to some gravel with depth, moist, stiff.		SS5	67	R	○
4.0								
4.2	63.1		Borehole terminated with auger refusal at 4.2m.					
4.4								
4.6								
4.8								
5.0								
5.2								
5.4								
5.6								
5.8								
6.0								
6.2								
6.4								
6.6								
6.8								
7.0								
7.2								
7.4								
7.6								
7.8								
8.0								
8.2								
8.4								
8.6								
8.8								
9.0								
9.2								
9.4								
9.6								
9.8								
10.0								
10.2								
10.4								
10.6								
10.8								

NOTES: G, S, SI and CL denotes gravel, sand, silt and clay, respectively.

BOREHOLE LOG

Enclosure No.: 4

Project Name: **Geotechnical Investigation - Proposed Enbridge Ottawa Operations Centre**		Project Number: **1505**
Client: **Blumetric Environmenal Inc.**	Borehole Number: **BH11**	Page: **1** of **1**
Location: **2571 Lancaster Rd., Ottawa, Ontario**	Date Started: **May 5, 2021**	Datum: **NAD86, Zone 18T**
Drilling Contractor: **George Downing Estate Drilling Ltd.**	Date Finished: **May 5, 2021**	Elevation: **67.6 m**
Drilling Equipment: **CME 55LC**	Easting: **452178.5 m**	Northing: **5027602.0 m**
Drilling and Sampling Method: **200mm Hollow-Stem Augers, 50mm Split Spoons**	Logged By: **M. Storms**	Checked By: **D. Hill**

Depth BGS (m)	Elevation (m)	Description	Sample Type	Sample Number	Recovery (%)	Penetration Index / RQD
0.0	67.6	**ASPHALT** approx. 50mm.				
0.2		**FILL** crushed limestone, some silt, coarse after 0.6m, grey, damp, compact.		SS1	79	49
1.2	66.4	**SILTY CLAY** bluish-grey becoming greyish-brown, soft.		SS2	34	28
2.0				SS3	4	5
2.4		Becoming moist to wet.		SS4	100	3
3.2		Occasional wet/dilatent seams.		SS5	100	3
4.0				SS6	100	3
4.4	63.3	**SILTY GRAVELLY SAND** some clay, dark grey, moist, stiff. G: 26%, S: 35%, SI: 26%, CL: 13%.		SS7	42	9
6.0	61.5	**LIMESTONE** grey, poor quality.		RC1	67	10
7.6		Becoming fair quality.				
8.4		UCS: 29.7 MPa.		RC2	100	71
9.0	58.6	Borehole terminated within limestone bedrock at 9.0m.				

Shear Strength (kPa)
50 100 150 200
■ DCPT ■
● SPT-N ●
PL MC LL
20 40 60 80

NOTES: G, S, SI and CL denotes gravel, sand, silt and clay, respectively.

BOREHOLE LOG 1505 - BH LOGS.GPJ MALROZ ENGINEERING.GDT 5-26-21

Appendix C
Record of Boreholes (Client)

BOREHOLE ID: BH1

Project No.: 210294
Client: Enbridge Inc.
Report: Enbridge Phase II ESA- Lancaster Rd.
Site Address: 2571-2595 Lancaster Rd.
Ottawa, ON

Elevation Ground: *68.22 m*
TOP: *NA*

UTM 18 (Zone): 5027694 N
452154 E

SUBSURFACE PROFILE				SAMPLE						WELL COMPLETION	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	Blow Counts	Recovery (%)	Lab Analysis	Headspace Vapour Level CGD (ppm) 10 100	Construction	Notes
0		**Organics** Moist, brown, silty organics with roots		S1		1,4,7,10	75%	PHCs, PAH, VOCs, Metals	0.0		
			0.51 / 67.71								
		Fill Moist, brown, silty sand, trace clay									
			0.76 / 67.46	S2		40, 28, 50	42%	PAH, VOCs, Metals	0.0		
1		**Fill** Moist, brown coarse sand and gravel									
		Asphalt									
		Silt Moist, brown, sandy silt with asphalt									
		End of borehole at 1.07 m									
2		Refusal at 1.07 m bgs									
3											
4											
5											
6											
7											
8											
9											

Drill Date: 2021 April 7
Drilled By: Strata Drilling Group
Drilling Method: Direct Push
Hole Diameter: 0.127 m (OD)
Logged By: LJ
Checked By: RH

Notes: SPLIT SPOON

Sheet 1 of 1

BH MW OB LOGV1.0 210294- ENBRIDGE- LANCASTER RD.GPJ WESA TEMPLATE V1.2.GDT 21-4-15

BOREHOLE ID: BH2

Project No.: 210294
Client: Enbridge Inc.
Report: Enbridge Phase II ESA- Lancaster Rd.
Site Address: 2571-2595 Lancaster Rd.
Ottawa, ON

Elevation Ground: *67.79 m*
TOP: *NA*

UTM 18 (Zone): 5027649 N
452179 E

SUBSURFACE PROFILE				SAMPLE						WELL COMPLETION	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	Blow Counts	Recovery (%)	Lab Analysis	Headspace Vapour Level CGD (ppm) 10 100	Construction	Notes
0		**Organics** Moist, brown, silty sand organics, trace gravel and roots		S1		4,8,11,14	58		5.0		
		Fill Moist, brown, sandy silt, trace clay	0.76 / 67.03								
		Trace asphalt		S2		17,8,2,1	71	VOCs	5.0		
1		**Clay** Moist, grayish brown, silty clay, low plasticity	1.01 / 66.78								
				S3		Weight of Hammer for 24"	0				
2				S4		Weight of Hammer for 18", 2	100	PHCs, PAH, VOCs, Metals	5.0		
			2.90 / 64.89								
3		End of borehole at 2.90 m									
4											
5											
6											
7											
8											
9											

Drill Date: 2021 April 7
Drilled By: Strata Drilling Group
Drilling Method: Direct Push
Hole Diameter: 0.127 m (OD)
Logged By: LJ
Checked By: RH

Notes: SPLIT SPOON

BOREHOLE ID: BH3

Project No.: 210294
Client: Enbridge Inc.
Report: Enbridge Phase II ESA- Lancaster Rd.
Site Address: 2571-2595 Lancaster Rd.
Ottawa, ON

Elevation Ground: *67.81 m*
TOP: *NA*

UTM 18 (Zone): 5027638 N
452212 E

SUBSURFACE PROFILE				SAMPLE						WELL COMPLETION	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	Blow Counts	Recovery (%)	Lab Analysis	Headspace Vapour Level CGD (ppm) 10 100	Construction	Notes
0		**Organics** Moist, brown silty organics with roots		S1		2,18,25,46	83	PAH, VOCs, Metals	0.0		
		Fill Damp, brown, silty sand with some gravel, trace asphalt	0.76 / 67.05								
1		**Fill** Coarse sand and asphalt		S2		16,30,28,50	33		0.0		
		End of borehole at 1.37 m	1.37 / 66.44								
2		Refusal at 1.37 m bgs									
3											
4											
5											
6											
7											
8											
9											

Drill Date: 2021 April 7
Drilled By: Strata Drilling Group
Drilling Method: Direct Push
Hole Diameter: 0.127 m (OD)
Logged By: LJ
Checked By: RH

Notes: SPLIT SPOON

Sheet 1 of 1

BH MW OB LOGV1.0 210294- ENBRIDGE- LANCASTER RD.GPJ WESA TEMPLATE V1.2.GDT 21-4-15

BOREHOLE ID: BH4

Project No.: 210294
Client: Enbridge Inc.
Report: Enbridge Phase II ESA- Lancaster Rd.
Site Address: 2571-2595 Lancaster Rd.
Ottawa, ON

Elevation Ground: *67.78 m*
TOP: *NA*

UTM 18 (Zone): 5027603 N
452231 E

SUBSURFACE PROFILE				SAMPLE						WELL COMPLETION	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	Blow Counts	Recovery (%)	Lab Analysis	Headspace Vapour Level CGD (ppm) 10 100	Construction	Notes
0		**Organics** Moist, brown, silty organics with roots		S1		2,3,4,4	46		0.0		
		Fill Moist, brown, silty sand, trace angular gravel	0.61 67.17								
		Clay Moist, brown silty clay with some sand	0.89 66.89	S2		Weight of Hammer for 24"	46		0.0		
1		**Sand** Coarse sand with trace fine gravel									
		Clay Moist, brownish gray, non-plastic silty clay		S3		1,1,1,2	79	PHCs, PAH, VOCs, Metals	0.0		
2		increasing water content	2.13 65.65	S4		Weight of Hammer for 24"	100	PHCs, PAH, VOCs, Metals	0.0		
		End of borehole at 2.90 m	2.90 64.88								
3											
4											
5											
6											
7											
8											
9											

Drill Date: 2021 April 7
Drilled By: Strata Drilling Group
Drilling Method: Direct Push
Logged By: LJ
Hole Diameter: 0.127 m (OD)
Checked By: RH

Notes: SPLIT SPOON

Sheet 1 of 1

BH MW OB LOGV1.0 210294- ENBRIDGE- LANCASTER RD.GPJ WESA TEMPLATE V1.2.GDT 21-4-15

BOREHOLE ID: BH5

Project No.: 210294
Client: Enbridge Inc.
Report: Enbridge Phase II ESA- Lancaster Rd.
Site Address: 2571-2595 Lancaster Rd.
Ottawa, ON

Elevation Ground: *67.59 m*
TOP: *NA*

UTM 18 (Zone): 5027583 N
452277 E

SUBSURFACE PROFILE				SAMPLE						WELL COMPLETION	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	Blow Counts	Recovery (%)	Lab Analysis	Headspace Vapour Level CGD (ppm) 10 100	Construction	Notes
0		**Organics** Moist, brown, silty organics with roots		S1		1,2,2,1	71		0.0		
		Fill Moist, brown, silty sand with gravel, trace clay	0.99 66.60	S2		1,4,1 for 12"	46		5.0		
1		**Clay** Moist, brownish gray, non-plastic silty clay, with some brown mottling	1.37 66.22	S3		1,1,1,1	100	PHCs, PAH, VOCs, Metals	0.0		
		increasing water conntent		S4		Weight of Hammer for 24"	100	PHCs, PAH, VOCs, Metals	0.0		
2		End of borehole at 2.90 m	2.90 64.69								
3											
4											
5											
6											
7											
8											
9											

Drill Date: 2021 April 7
Drilled By: Strata Drilling Group
Drilling Method: Direct Push
Hole Diameter: 0.127 m (OD)
Logged By: LJ
Checked By: RH

Notes: SPLIT SPOON

Sheet 1 of 1

BH MW OB LOGV1.0 210294- ENBRIDGE- LANCASTER RD.GPJ WESA TEMPLATE V1.2.GDT 21-4-15

BOREHOLE ID: BH6

Project No.: 210294
Client: Enbridge Inc.
Report: Enbridge Phase II ESA- Lancaster Rd.
Site Address: 2571-2595 Lancaster Rd.
Ottawa, ON

Elevation Ground: *67.62 m*
TOP: *NA*

UTM 18 (Zone): 5027545 N
452296 E

SUBSURFACE PROFILE				SAMPLE							WELL COMPLETION	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	Blow Counts	Recovery (%)	Lab Analysis	Headspace Vapour Level CGD (ppm) 10 100		Construction	Notes
0		**Organics** Moist, brown silty organics, with roots		S1		1,2,5,2	63		0.0			
		Fill Moist, brown medium sand with silt and small angular gravel	0.61 67.01									
1		**Clay** Damp, graish brown, non-plastic silty clay	0.89 66.73	S2		Weight of Hammer for 6", 1,2,3	71	PHCs, PAH, VOCs, Metals	0.0			
		Clay Moist, light brown sandy clay	1.37 66.25									
		Clay Moist, graish brown, non-plastic silty clay Increasing water content		S3		2,3,3,4	96	PHCs, PAH, VOCs, Metals	0.0			
2		Slight increase in plasticity	2.13 65.49	S4		Weight of Hammer for 18",1	100		0.0			
		End of borehole at 2.90 m	2.90 64.72									
3												
4												
5												
6												
7												
8												
9												

Drill Date: 2021 April 7
Drilled By: Strata Drilling Group
Drilling Method: Direct Push
Hole Diameter: 0.127 m (OD)
Logged By: LJ
Checked By: RH

Notes: SPLIT SPOON

Sheet 1 of 1

BH MW OB LOGV1.0 210294- ENBRIDGE- LANCASTER RD.GPJ WESA TEMPLATE V1.2.GDT 21-4-15

BOREHOLE ID: BH7

Project No.: 210294
Client: Enbridge Inc.
Report: Enbridge Phase II ESA- Lancaster Rd.
Site Address: 2571-2595 Lancaster Rd.
Ottawa, ON

Elevation Ground: *67.58 m*
TOP: *NA*

UTM 18 (Zone): 5027525 N
452338 E

SUBSURFACE PROFILE				SAMPLE							WELL COMPLETION	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	Blow Counts	Recovery (%)	Lab Analysis	Headspace Vapour Level CGD (ppm) 10 100		Construction	Notes
0		**Organics** Moist brown silty organics with roots		S1		1,5,5,4	75		0.0			
		Fill Moist, brown, sand with silt and angular gravel	0.61 66.97									
1		**Clay** Moist, grayish brown, non-plastic, silty clay, with some brown mottling		S2		Weight of Hammer for 24"	100	PHCs, PAH, VOCs, Metals	0.0			
				S3		2,2,2,3	100	PHCs, PAH, VOCs, Metals	0.0			
2		increasing water content	2.13 65.45	S4		Weight of Hammer for 12",1,1	100		0.0			
		End of borehole at 2.90 m	2.90 64.68									
3												
4												
5												
6												
7												
8												
9												

Drill Date: 2021 April 7
Drilled By: Strata Drilling Group
Drilling Method: Direct Push
Hole Diameter: 0.127 m (OD)
Logged By: LJ
Checked By: RH

Notes: SPLIT SPOON

Sheet 1 of 1

BH MW OB LOGV1.0 210294- ENBRIDGE- LANCASTER RD.GPJ WESA TEMPLATE V1.2.GDT 21-4-15

BOREHOLE ID: MW5-21

Project No.: 210294
Client: Enbridge Inc.
Report: Enbridge Phase II ESA- Lancaster Rd.
Site Address: 2571-2595 Lancaster Rd.
Ottawa, ON

Elevation Ground: *67.90 m*
TOP: *67.78 m*
MOECC Well Tag: A269395
UTM 18 (Zone): 5027650 N
452127 E

Depth (m)	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	Blow Counts	Recovery (%)	Lab Analysis	Headspace Vapour Level CGD (ppm)	Construction	Notes
	Ground Surface	0.00 / 67.90								
0	**Asphalt**									
	Fill Dry, brown, coarse sand and angular gravel fill	0.61 / 67.29	S1		14,12,22,27	46		0.0		flushmount, jplug, cement
	Fill Moist, brown, coarse sand and gravel fill with some silt	1.22 / 66.68	S2		17,50	25		0.0		3/8" Hole plug
1	**Clay** Moist, brown medium plasticity clay with some darker brown mottling, trace silt	1.83 / 66.07	S3		8,8,1,1	63		0.0		
	Turning wet		S4		1,2,2,2	100	PHCs, PAH, VOCs, Metals	0.0		
2	**Clay** Moist, brown medium plasticity clay with some darker brown mottling, trace silt and gravel	2.44 / 65.46	S5		18,6,9,6	42		0.0		
	Clay Wet, brown, non-plastic clay with some silt, gravel, and sand	3.05 / 64.85	S6		1,3,4,4	50		0.0		3.05 m x 50.8 mm slot 10 PVC screen with #3 silica sand pack
3			S7		5,7,14,24	100	PHCs, PAH, VOCs, Metals	0.0		
	Gravel Wet angular gravel with silt	4.27 / 63.63	S8		9,15,16,15	75				
4		4.88 / 63.02								
	End of borehole at 4.88 m									
5	Bedrock Refusal at 4.88 m bgs WL Taken on April 15, 2021: 1.58 m bgs									
6										
7										
8										
9										

Drill Date: 2021 April 6
Drilled By: GET Drilling Ltd.
Drilling Method: Solid Stem Auger
Hole Diameter: 0.127 m (OD)
Logged By: LJ
Checked By: RH

Notes: SPLIT SPOON

Sheet 1 of 1

BH MW OB LOGV1.0 210294- ENBRIDGE- LANCASTER RD.GPJ WESA TEMPLATE V1.2.GDT 21-4-15

BOREHOLE ID: MW6-21

Project No.: 210294
Client: Enbridge Inc.
Report: Enbridge Phase II ESA- Lancaster Rd.
Site Address: 2571-2595 Lancaster Rd.
Ottawa, ON

Elevation Ground: *67.50 m*
TOP: *67.39 m*
MOECC Well Tag: A269396
UTM 18 (Zone): 5027535 N
452107 E

SUBSURFACE PROFILE				SAMPLE						WELL COMPLETION	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	Blow Counts	Recovery (%)	Lab Analysis	Headspace Vapour Level CGD (ppm) 10 100	Construction	Notes
		Ground Surface	0.00								
0		**Asphalt**	67.50								flushmount, jplug, cement
		Fill Dry, brown coarse sand and gravel fill, some silt		S1		10,14,2,2	38		0.0		
			0.71								
		Clay Damp, brown, non plastic silty clay	66.79	S2		4,2,3,5	79	PHCs, PAH, VOCs, Metals	20.0		3/8" Hole plug
1			1.22								
		getting softer	66.28	S3		1,1,1,2	100		5.0		
			1.83								
		trace small angular gravel	65.67	S4		1,2,3,4	100				
2				S5		2,2,2,7	100	PHCs, PAH, VOCs, Metals	15.0		2.13 m x 50.8 mm slot 10 PVC screen with #3 silica sand pack
				S6		1,1,50	50				
3			3.66								
		Shale	63.84								
		End of borehole at 3.81 m									
4		Bedrock Refusal at 3.81 m bgs WL Taken on April 15, 2021: 1.07 m bgs									
5											
6											
7											
8											
9											

Drill Date: 2021 April 6
Drilled By: GET Drilling Ltd.
Drilling Method: Solid Stem Auger
Logged By: LJ
Hole Diameter: 0.127 m (OD)
Checked By: RH

Notes: SPLIT SPOON

Sheet 1 of 1

BH MW OB LOGV1.0 210294- ENBRIDGE- LANCASTER RD.GPJ WESA TEMPLATE V1.2.GDT 21-4-15

Appendix D
Bedrock Core Photographs

Figure 1 – BH9/RC1

Figure 2 – BH9/RC2

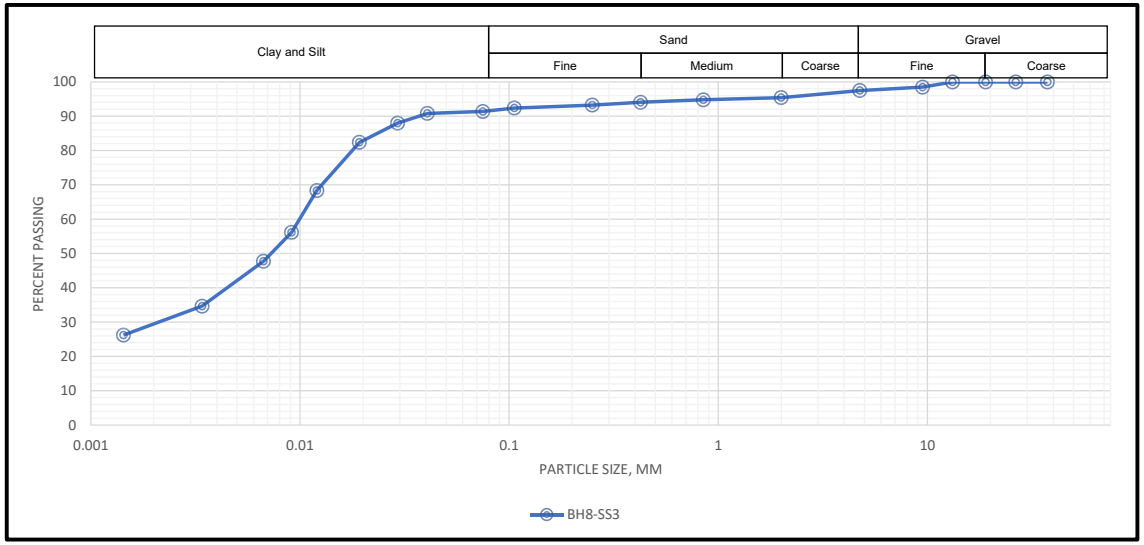
Figure 3 – BH11/RC1

Figure 4 – BH11/RC2

Appendix E
Geotechnical Laboratory Results

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

Particle Size Analysis (LS-702)



Clay (%)	Silt (%)	Sand (%)	Gravel (%)
29	62	7	2
Clayey SILT, trace Sand, trace Gravel			

Lab No.: 0164H
Project No.: 1505
Client: BluMetric
Location : 2571 Lancaster Road, Ottawa ON
Sample: BH8-SS3

Tested: JS
Date: 2021-05-17

Notes:

Validated:
Date: 2021-05-25

Supplementary Data:

Volume of bulb, V_B (cm^3)	57	Specific Gravity, GS (assumed):	2.7
Length of Bulb, L_2 (cm)	13.60	Dispersing Agent (g/L):	40
Scale Dimension, h_s (cm/Div.)	0.18	Area of Cylinder, A (cm^2)	28.3
Maximum Particle Size (mm):	9.5	0' to Top of Bulb, L_1 (cm)	11.0

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

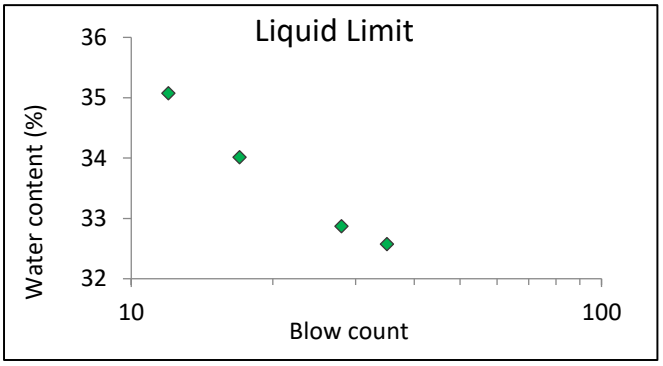
Atterberg Limits Test Summary (LS 703/704)

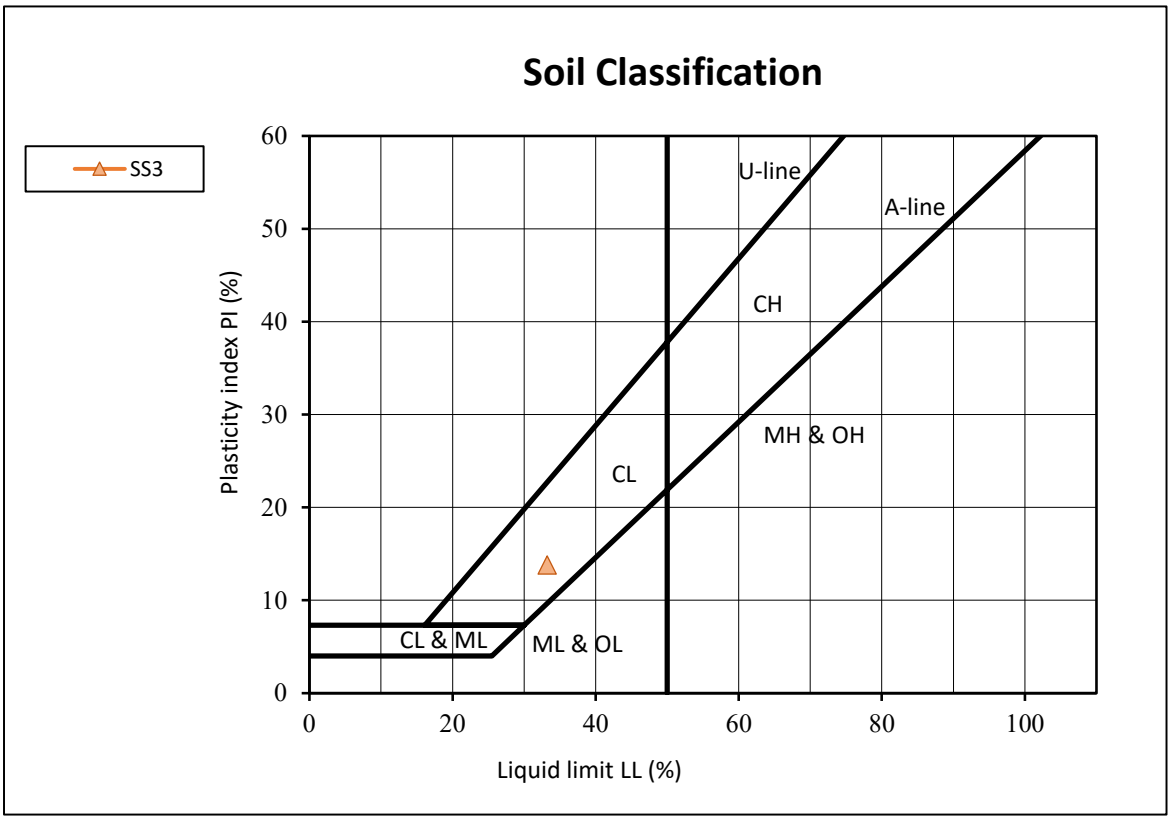
Client: BluMetric
Project No.: 1505
Location: 2571 Lancaster Road, Ottawa ON
BH: 8
Depth: -
Sample: SS3

Lab No. 164D
Tested By: JS
Date Tested: 19-May-21

Atterberg Limits

Liquid Limit	**33.2%**
Plastic Limit	**19.4%**
Plasticity Index	**13.8%**



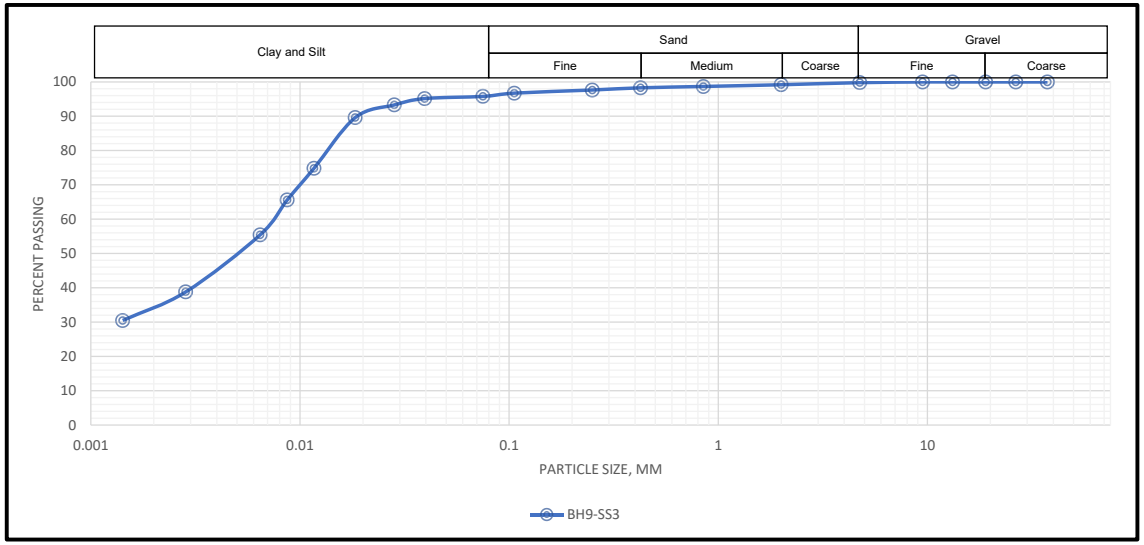


Validated By:

Date: 2021-05-25

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

Particle Size Analysis (LS-702)



Clay (%)	Silt (%)	Sand (%)	Gravel (%)
34	62	4	0
Clayey SILT, trace Sand			

Lab No.: 0164G
Project No.: 1505
Client: BluMetric Environmental Inc.
Location : 2571 Lancaster Road, Ottawa ON
Sample: BH9-SS3

Tested: JS
Date: 2021-05-17

Notes:

Validated:
Date: 2021-05-25

Supplementary Data:

Volume of bulb, V_B (cm^3)	57	Specific Gravity, GS (assumed):	2.7
Length of Bulb, L_2 (cm)	13.60	Dispersing Agent (g/L):	40
Scale Dimension, h_s (cm/Div.)	0.18	Area of Cylinder, A (cm^2)	28.3
Maximum Particle Size (mm):	4.75	0' to Top of Bulb, L_1 (cm)	11.0

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

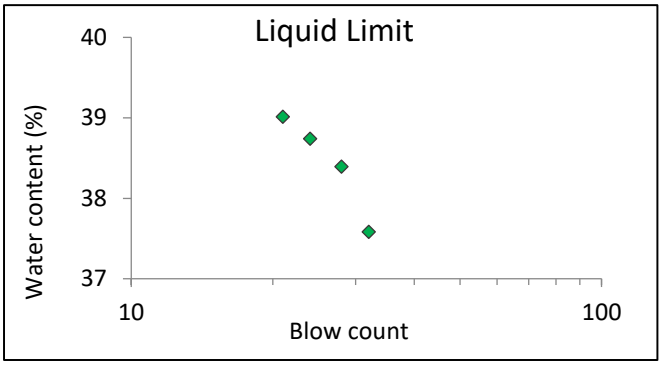
Atterberg Limits Test Summary (LS 703/704)

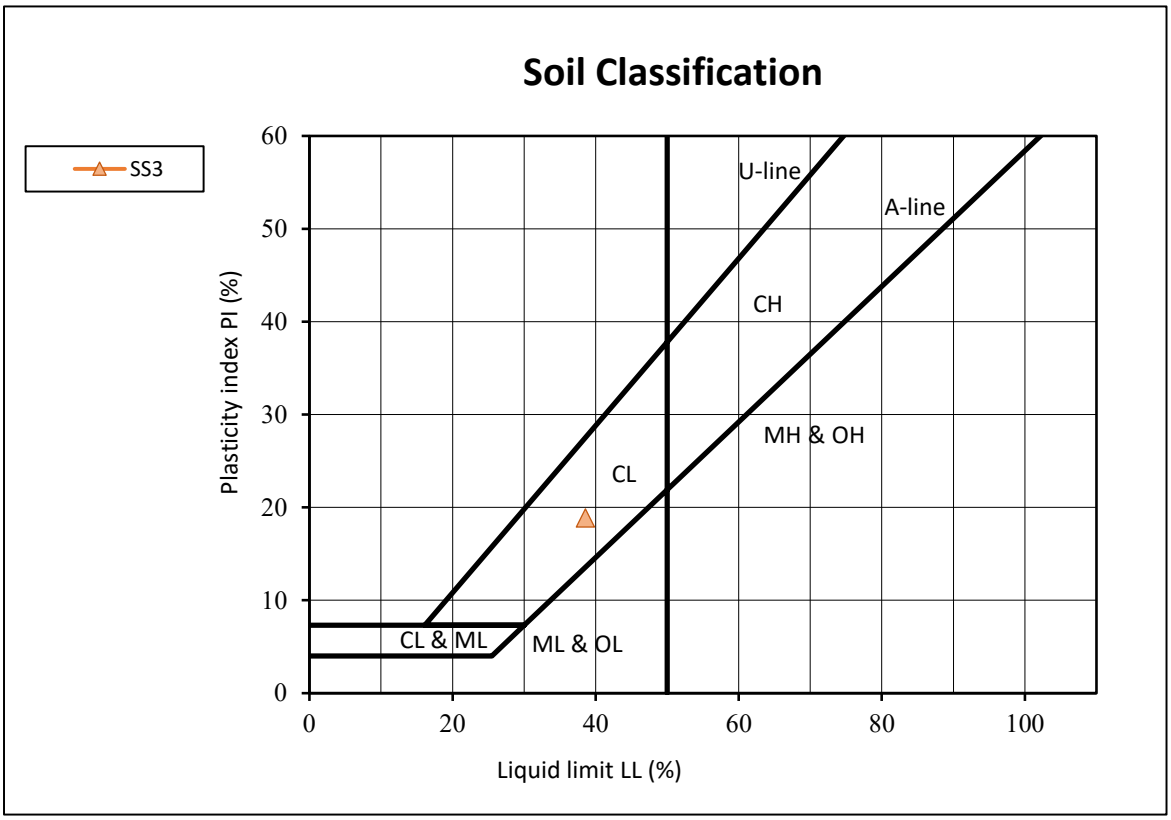
Client: BluMetric
Project No.: 1505
Location: 2571 Lancaster Road, Ottawa ON
BH: 9
Depth: -
Sample: SS3

Lab No. 164B
Tested By: JS
Date Tested: 18-May-21

Atterberg Limits

Liquid Limit	**38.6%**
Plastic Limit	**19.7%**
Plasticity Index	**18.9%**



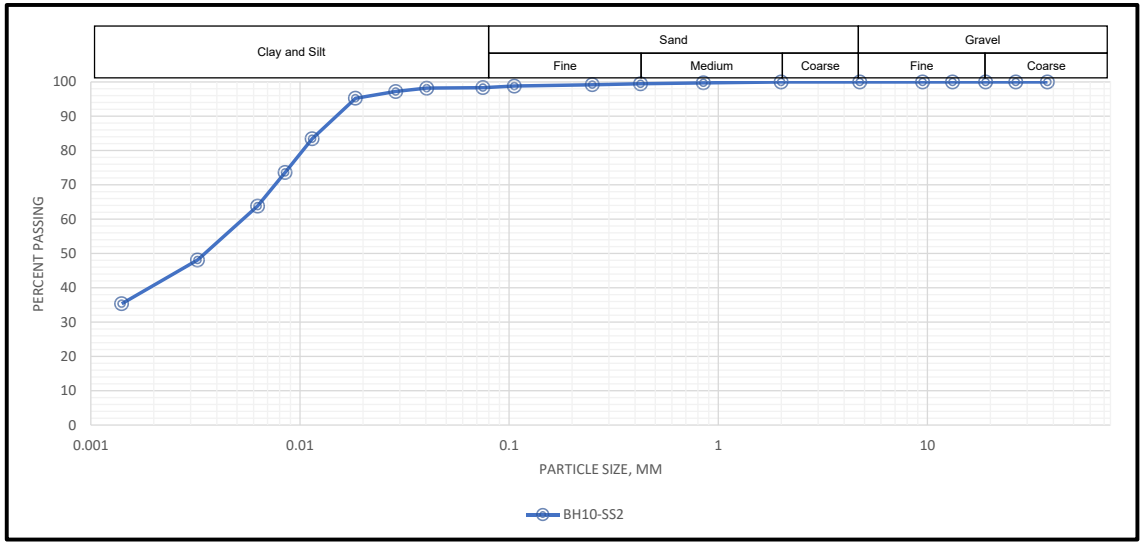


Validated By:

Date: 2021-05-25

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

Particle Size Analysis (LS-702)



Clay (%)	Silt (%)	Sand (%)	Gravel (%)
41	57	2	0
CLAY and SILT, trace Sand			

Lab No.: 0164F
Project No.: 1505
Client: BluMetric Environemtal Inc.
Location : 2571 Lancaster Road, Ottawa ON
Sample: BH10-SS2

Tested: JS
Date: 2021-05-17

Notes:

Validated:
Date: 2021-05-25

Supplementary Data:

Volume of bulb, V_B (cm^3)	57	Specific Gravity, GS (assumed):	2.7
Length of Bulb, L_2 (cm)	13.60	Dispersing Agent (g/L):	40
Scale Dimension, h_s (cm/Div.)	0.18	Area of Cylinder, A (cm^2)	28.3
Maximum Particle Size (mm):	0.85	0' to Top of Bulb, L_1 (cm)	11.0

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

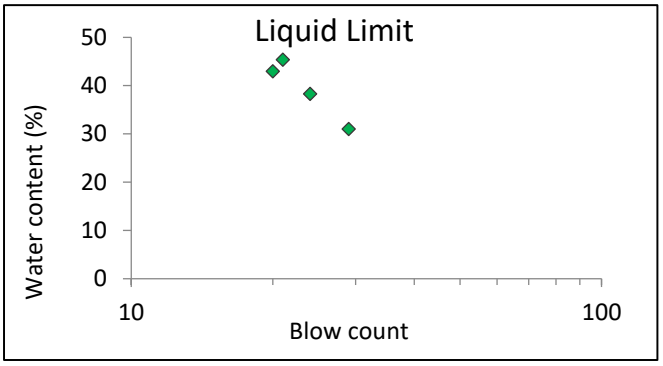
Atterberg Limits Test Summary (LS 703/704)

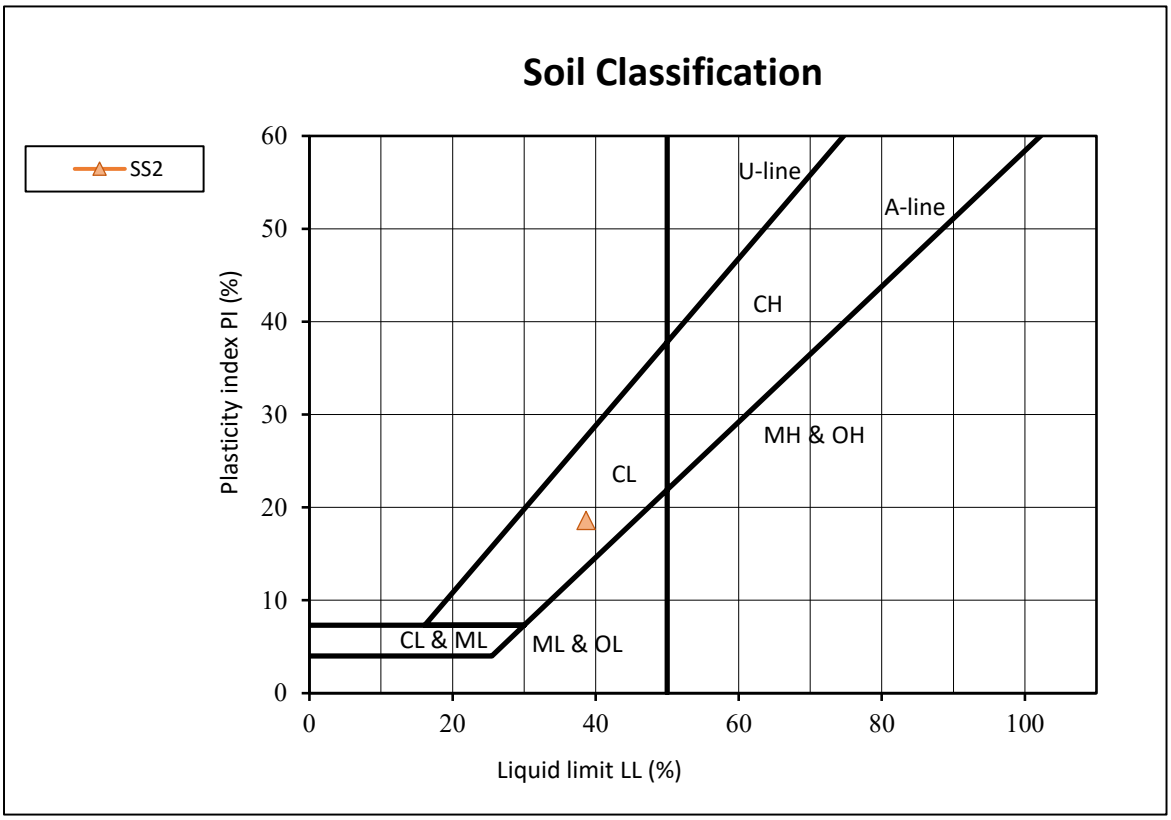
Client: BluMetric
Project No.: 1505
Location: 2571 Lancaster Road, Ottawa ON
BH: 10
Depth: -
Sample: SS2

Lab No. 164C
Tested By: JS
Date Tested: 18-May-21

Atterberg Limits

Liquid Limit	**38.7%**
Plastic Limit	**20.0%**
Plasticity Index	**18.6%**



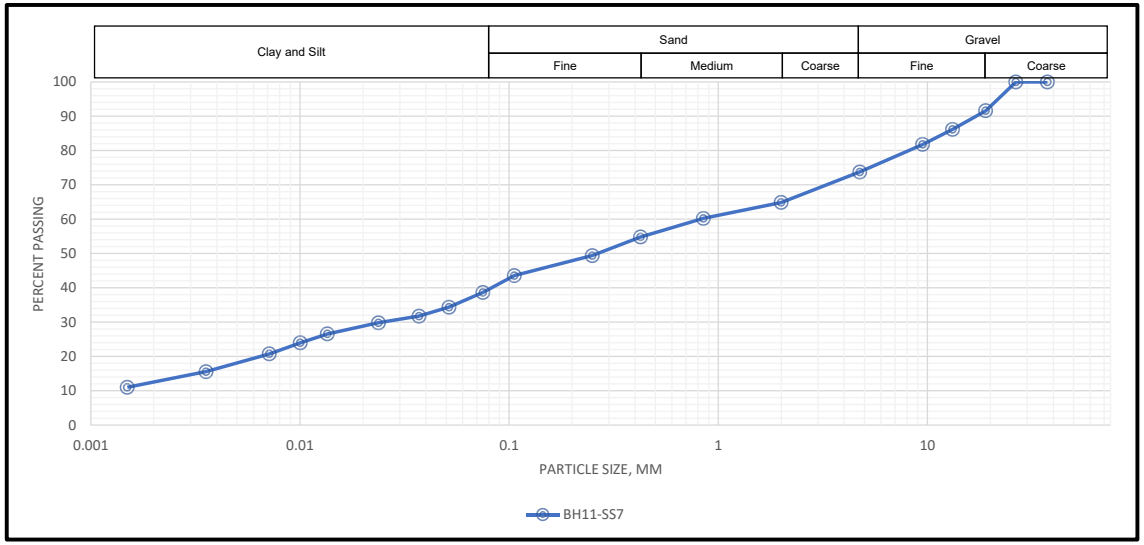


Validated By:

Date: 2021-05-25

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

Particle Size Analysis (LS-702)



Clay (%)	Silt (%)	Sand (%)	Gravel (%)
13	26	35	26
Silty Gravelly SAND, some clay			

Lab No.: 0164E
Project No.: 1505
Client: BluMetric Environmental Inc.
Location : 2571 Lancaster Road, Ottawa ON
Sample: BH11-SS7

Tested: JS
Date: 2021-05-17

Notes:

Validated:
Date: 2021-05-25

Supplementary Data:

Volume of bulb, V_B (cm^3)	57	Specific Gravity, GS (assumed):	2.7
Length of Bulb, L_2 (cm)	13.60	Dispersing Agent (g/L):	40
Scale Dimension, h_s (cm/Div.)	0.18	Area of Cylinder, A (cm^2)	28.3
Maximum Particle Size (mm):	19	0' to Top of Bulb, L_1 (cm)	11.0

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

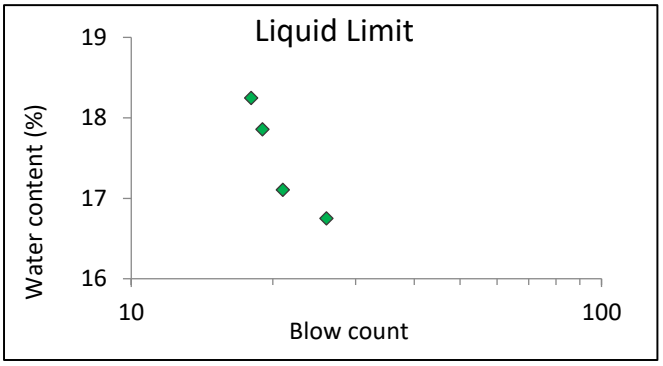
Atterberg Limits Test Summary (LS 703/704)

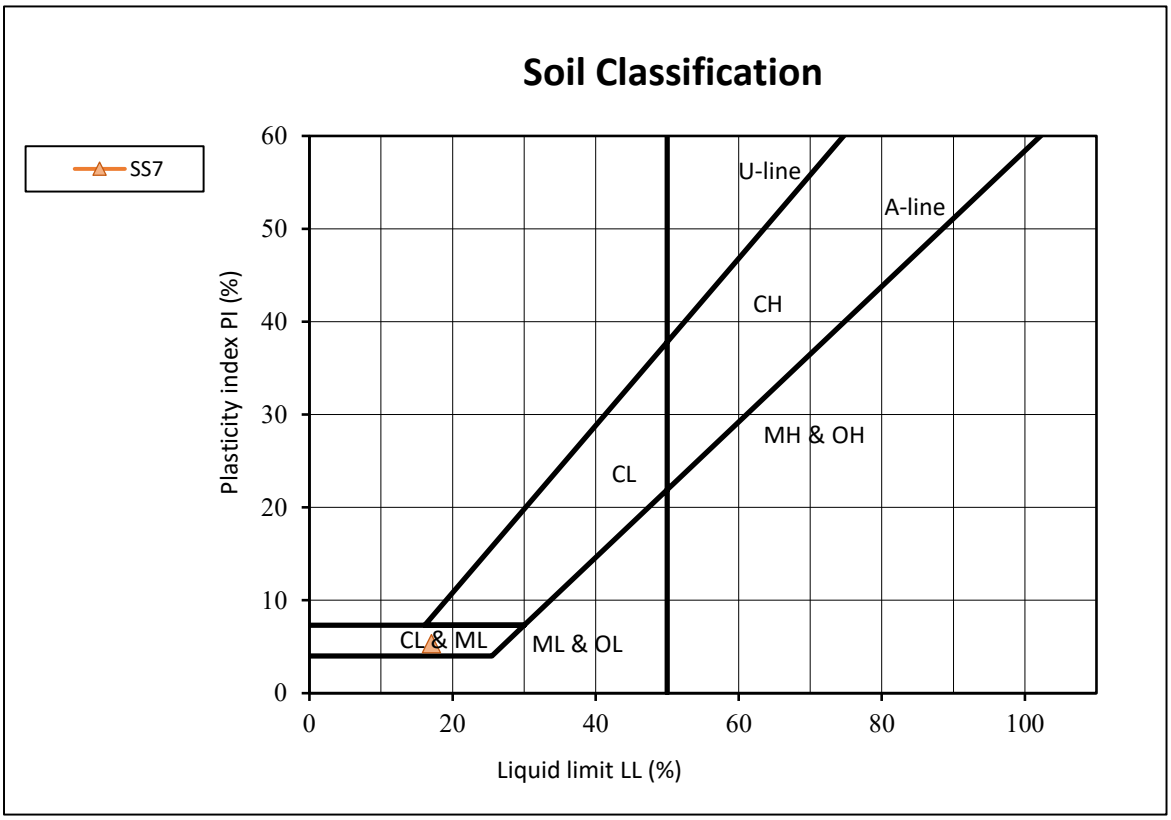
Client: BluMetric
Project No.: 1505
Location: 2571 Lancaster Road, Ottawa ON
BH: 11
Depth: -
Sample: SS7

Lab No. 164A
Tested By: JS
Date Tested: 18-May-21

Atterberg Limits

Liquid Limit	**17.1%**
Plastic Limit	**11.7%**
Plasticity Index	**5.3%**





Validated By:

Date: 2021-05-25

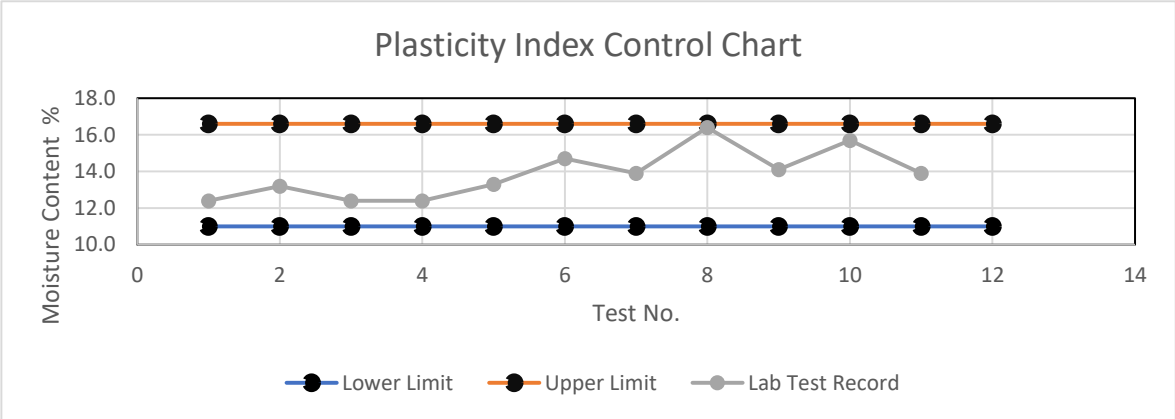
Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

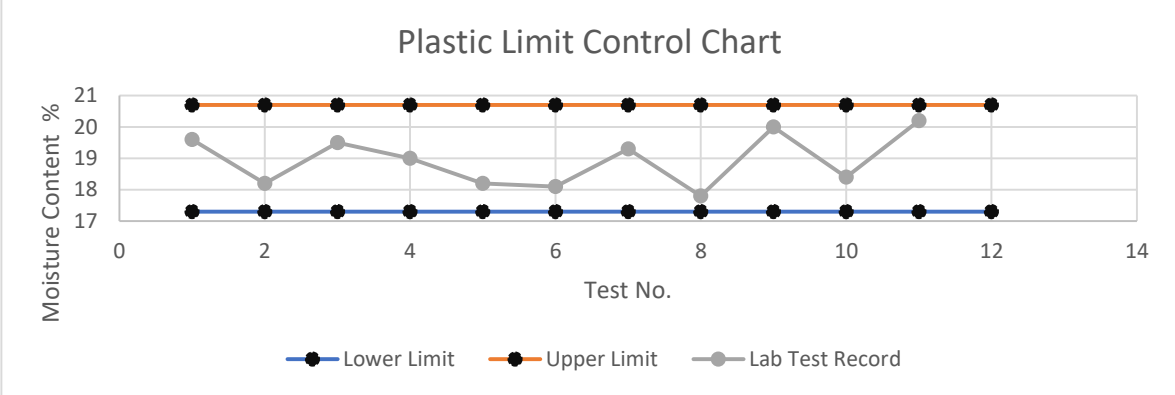
Dresden Clay Reference Material

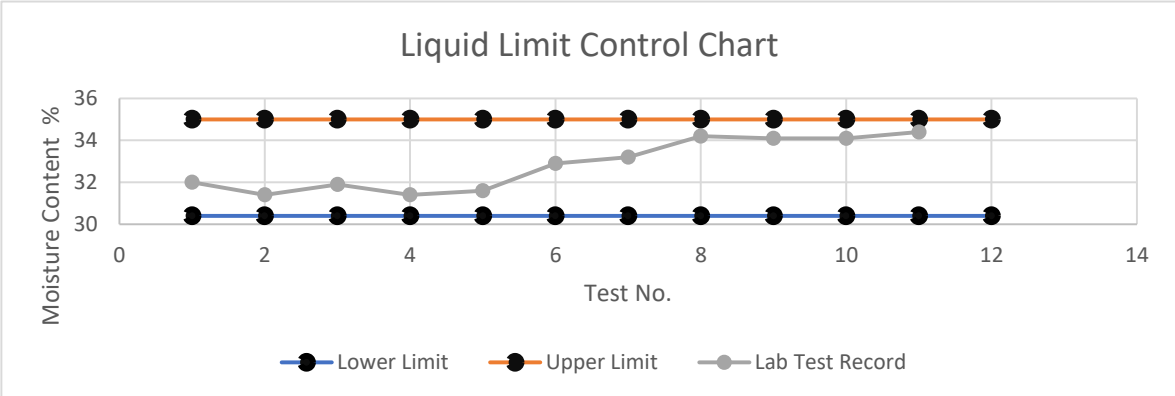
Atterberg Limits

Tested By: JS
Date Tested: 18-May-21

Liquid Limit	**34.4%**
Plastic Limit	**20.2%**
Plasticity Index	**13.9%**







Appendix F
Analytical Laboratory Results, as Provided by the Client

Certificate of Analysis

Client: Blumetric Environmental Inc.-Carp
1682 Woodward Drive
Carp, ON
K2C 3R8
Attention: Mr. Rob Hillier
PO#:
Invoice to: Blumetric Environmental Inc.

Report Number: 1953424
Date Submitted: 2021-05-18
Date Reported: 2021-05-27
Project: 210294-03
COC #: 870348

Dear Rob Hillier:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: _____
Sarah Horner, Inorganics Technician

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: http://www.cala.ca/scopes/2602.pdf.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

Certificate of Analysis

eurofins | Environment Testing

Client: Blumetric Environmental Inc.-Carp
1682 Woodward Drive
Carp, ON
K2C 3R8
Attention: Mr. Rob Hillier
PO#:
Invoice to: Blumetric Environmental Inc.

Report Number: 1953424
Date Submitted: 2021-05-18
Date Reported: 2021-05-27
Project: 210294-03
COC #: 870348

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1557569 Soil 2021-04-06 MW6-21 S5	1557793 Soil 2021-05-06 MW5-21 S4
Anions	Cl	0.002	%			0.079	0.017
	SO4	0.01	%			0.04	0.06
General Chemistry	Electrical Conductivity	0.05	mS/cm			1.48	0.48
	pH	2.00				7.45	7.27
	Resistivity	1	ohm-cm			680	2080
Redox Potential	REDOX Potential		mV			246	251
Subcontract	S2-	0.2	mg/kg			<0.20	<0.20

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

Client: Blumetric Environmental Inc.-Carp
1682 Woodward Drive
Carp, ON
K2C 3R8
Attention: Mr. Rob Hillier
PO#:
Invoice to: Blumetric Environmental Inc.

Report Number: 1953424
Date Submitted: 2021-05-18
Date Reported: 2021-05-27
Project: 210294-03
COC #: 870348

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 401106 **Analysis/Extraction Date** 2021-05-19 **Analyst** AET **Method** SUBCONTRACT-A			
S2-	<0.20 mg/kg	96	
Run No 401170 **Analysis/Extraction Date** 2021-05-25 **Analyst** MW **Method** Cond-Soil			
Electrical Conductivity	<0.05 mS/cm	100	90-110
pH	3.64	99	90-110
Resistivity			
Run No 401190 **Analysis/Extraction Date** 2021-05-25 **Analyst** MW **Method** C SM2580B			
REDOX Potential	298 mV	100	
Run No 401227 **Analysis/Extraction Date** 2021-05-26 **Analyst** AET **Method** AG SOIL			
SO4	<0.01 %	100	70-130
Run No 401319 **Analysis/Extraction Date** 2021-05-27 **Analyst** MW **Method** C CSA A23.2-4B			
Chloride		100	90-110
Run No 401393 **Analysis/Extraction Date** 2021-05-27 **Analyst** R S **Method** SUBCONTRACT-A			

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

eurofins | Environment Testing

Certificate of Analysis

Client: Blumetric Environmental Inc.-Carp
1682 Woodward Drive
Carp, ON
K2C 3R8
Attention: Mr. Rob Hillier
PO#:
Invoice to: Blumetric Environmental Inc.

Report Number: 1953424
Date Submitted: 2021-05-18
Date Reported: 2021-05-27
Project: 210294-03
COC #: 870348

QC Summary

Analyte	Blank	QC % Rec	QC Limits
S2-	<0.20 mg/kg	95	

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range