



Dain City Forcemain (Phases 3, 4 and 5)

Kerry T. Howe Engineering Ltd.

Type of Document:

Geotechnical Investigation Report

Project Name:

Dain City Forcemain (Phases 3, 4 and 5)
Forks Road East to Southworth Street South
Welland, Ontario

Project Number:

HAM-00801772-A0

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Date Submitted:

February 28, 2020

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1. Introduction and Background

This report presents the results of the geotechnical investigation carried out at the site of the proposed sanitary forcemain installation in Dain City (Welland), Ontario. The site includes Phases 3, 4 and 5 of the project which extends from Forks Road East at the Logan Avenue road allowance, along Kingsway/Canal Bank Street, Townline Tunnel Road, and Humberstone Road, and terminates on Southworth Street South at the intersection with Gordon Street.

The investigation was authorized by Mr. Kerry Howe Jr. on behalf of Kerry T. Howe Engineering Ltd.

The purpose of this investigation was to determine the subsoil and groundwater conditions at the site by advancing thirty-six (36) boreholes and based on an assessment of the factual borehole data provide an engineering report containing general geotechnical recommendations pertinent to the proposed construction.

The comments and recommendations given in this report assume that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations or the requirement of additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.

1.1 Site Description & Geological Setting

As noted above, the site includes Phases 3, 4 and 5 of the sanitary forcemain project which extends from Forks Road East at the Logan Avenue road allowance, along Kingsway/Canal Bank Street, Townline Tunnel Road, and Humberstone Road, and terminates on Southworth Street South at the intersection with Gordon Street. Forks Road East, Kingsway, and Southworth Street South are set in low-rise residential neighbourhoods. Canal Bank Street is bordered by the Welland Canal to the west and a former industrial facility (John Deere) to the east. Townline Tunnel Road and Humberstone Road are surrounded by vegetated vacant properties, a storage yard, and a transformer station.

Based on the Ministry of Natural Resources and Forestry Map 2496 *Niagara-Welland Southern Ontario, Quaternary Geology*, the native soil at the site consists of glaciolacustrine clay and silt, which is overlain by fill material along Canal Bank Street, likely associated with the Welland Canal construction.

2. Field Investigation

2.1 General Fieldwork

As requested by the client, a total of thirty-six (36) boreholes were advanced at the site of the proposed construction at the approximate locations shown on Drawings No. 1A to 1L in Appendix A. The boreholes were numbered BH-01 to BH-34, with an additional two (2) boreholes subsequently added to the scope of work west of the Humberstone Road dead end and numbered BH-101 and BH-102. The boreholes were advanced to depths ranging from 5.0 to 8.7 m below grade.

The fieldwork for this investigation was carried out on October 11, 22 to 25, and December 23, 2019. Drilling and sampling operations were completed by a combination of auger and split-spoon techniques using truck and track mounted drilling equipment owned and operated by specialist drilling subcontractors. Prior to the commencement of the drilling operations, the public-owned underground services were located to minimize the risk of contacting any such services during the drilling operations.

Soil samples were obtained using a 51 mm (2 inch) outside diameter split spoon sampler in conjunction with Standard Penetration Tests (ASTM D1586) at depths noted on the borehole logs in Appendix A. The Standard Penetration Test (SPT) N values were recorded as indicated on the borehole logs. Pocket penetrometer and in-situ shear vane tests were carried out in the cohesive soils to estimate the undrained shear strength and provide an assessment of the consistency of the in-situ soils.

Groundwater levels within the boreholes were measured prior to backfilling. 50 mm diameter monitoring wells equipped with flush-mount protective caps were installed at fifteen (15) of the borehole locations to allow for stabilized groundwater level measurements and subsequent hydrogeological testing (if required). The remaining boreholes were backfilled upon completion of drilling in accordance with O.Reg. 903 and capped with cold patch asphalt.

The boreholes were advanced at the approximate locations requested by the client in accessible areas at the site as directed by EXP field personnel. Ground surface elevations at the borehole locations were interpolated by EXP from the Kerry T. Howe Engineering Ltd. drawings entitled *Dain City Forcemain Phase 3, Proposed Forcemain Location, City of Welland*, File No. 18-020 Rev. 1, dated November 14, 2019.

2.2 Environmental Testing

Limited environmental testing was conducted on selected soil samples recovered from the boreholes as part of this geotechnical investigation. Due to limited historical knowledge of the site and surrounding properties, the test parameters selected were metals and inorganics (O.Reg. 153) and one (1) to two (2) samples were submitted from each borehole (47 samples total) to a certified laboratory for analytical testing to determine the chemical quality of the material for off-site disposal during construction. Based on the findings of the investigation and the results of above testing, two (2) samples were submitted for Toxicity Characteristic Leaching Procedure (TCLP) testing: a sample of the Macadam from near Borehole BH-03 as well as the subgrade soil from near Borehole BH-13.

The soil samples were placed in laboratory-supplied glass jars and clean ice-packed coolers prior to and during transportation to the subcontracted laboratory, AGAT Laboratories (AGAT) of Mississauga, Ontario. Dedicated nitrile gloves (i.e. one pair per sample) were used during sample handling. The samples were transported/submitted under Chain of Custody documentation.

A portion of each soil sample was placed in a sealed plastic bag and allowed to reach ambient temperature prior to field screening using an RKI Eagle 2, calibrated with isobutylene. The measurements were made by inserting the instrument's probe into the plastic bag while manipulating the sample to ensure volatilization of the soil gases. These readings provide a real-time indication of the relative concentration of combustible vapours encountered in the soils and are used to aid in the assessment of potential contamination and the selection of soil samples for analysis. The soil vapour readings ranged from 0 to 3 ppm and are considered negligible and as such soil testing for Petroleum Hydrocarbon Fractions 1 to 4 (PHCs F1-F4) or Volatile Organic Compounds (VOCs) was not considered warranted.

2.3 Site Assessment Criteria

The assessment criteria, Site Condition Standards (SCS), applicable to a given site in Ontario are established under subsection 168.4(1) of the Environmental Protection Act. Tabulated generic criteria are provided in “Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act” (“the SGWS Standards”), MECP, July 2011. These criteria are based on site sensitivity (sensitive or non-sensitive), groundwater use (potable or non-potable), property use (residential, parkland, institutional, commercial, industrial, community and agricultural/other), soil type (coarse or medium to fine textured) and restoration depth (full or stratified restoration). In addition, site specific criteria may be established based on the findings of a risk assessment carried out in accordance with Part IX and Schedule C of Ontario Regulation 153 (O. Reg. 153). The SGWS Standards specify SCS for soil, groundwater and sediment that are tabulated as follows:

Table 1: applicable to sites where background concentrations must be met (full depth) such as sensitive sites where site-specific criteria have not been derived

Table 2: applicable to sites with potable groundwater and full depth restoration

Table 3: applicable to sites with non-potable groundwater and full depth restoration

Table 4: applicable to sites with potable groundwater and stratified restoration

Table 5: applicable to sites with non-potable groundwater and stratified restoration

Table 6: applicable to sites with potable groundwater and less than 2 m of overburden above bedrock

Table 7: applicable to sites with non-potable groundwater and less than 2 m of overburden above bedrock

Table 8: applicable to sites with potable groundwater and less than 30 m from a water body

Table 9: applicable to sites with non-potable groundwater and less than 30 m from a water body

The project can be divided into several parcels/owners based on publicly available mapping data. Parcels located within 30 m of a water body are classified as Table 9 and the remaining parcels are classified as Table 3 as summarized in the table below:

Table 2-1: Applicable Site Condition Standards (SCS) by Borehole

Parcel Description	Applicable Boreholes	Applicable SCS
Forks Road	BH-01 to BH-03	Table 9
Kingsway/Canal Bank Street	BH-04 to BH-17	Table 9
Townline Tunnel Road (MTO)	BH-18 to BH-24	Table 3
Humberstone Road	BH-101, BH-102, BH-24 to BH-31	Table 3
Southworth Street	BH-32 to BH-36	Table 3

The results provided in Table D-1 were compared to the applicable SCS as well as Table 3 (ICC) and Table 1 (Agricultural) SCS to provide additional options for disposal, i.e. Boreholes BH-01 to BH-17 were compared to the applicable Table 9 as well as Table 3 and Table 1 while the results from the remaining boreholes were compared to the applicable Table 3 as well as Table 1. The selection of Table 3 and 9 for the sites is based on the following factors:

- It is understood that the site is not considered a sensitive site
- To the best of EXP's knowledge, all properties within 250 m of the site are serviced by the municipal water supply and groundwater is not used as a potable water source either on or within 250 m of the site
- The site is not located in an area designated in a municipal official plan as a well-head protection area or other designation identified by the municipality for the protection of groundwater
- There is no intention to carry out a stratified restoration at the site
- A water body (Welland Canal) is located within 30 m of the Forks Road and Canal Bank Street parcels
- The predominant soil type on the site is considered to be fine textured

3. Subsurface Conditions

Details of the subsurface conditions encountered during the drilling program are summarized on the borehole logs in Appendix A.

The logs include textural descriptions of the subsoil and groundwater conditions and indicate the soil boundaries inferred from non-continuous sampling and observations during drilling. These boundaries reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The "Notes on Sample Description" preceding the borehole logs form an integral part of and should be read in conjunction with this report.

3.1 Soil Stratigraphy

The boreholes were typically advanced along the travelled roadway or shoulder area, with the exception of Boreholes BH-22 to BH-24 which were advanced on temporary granular pads and BH-101 and BH-102 which were advanced along the path west of the Humberstone Road dead end. The boreholes typically encountered the pavement structure or granular fill overlying a layer of silty clay fill, with the underlying native soil consisting of very stiff to hard silty clay which became stiff to soft with depth. Details of the encountered materials are provided in the following subsections.

3.1.1 Pavement

The boreholes advanced on the travelled roadway encountered a layer of surface asphalt with a thickness ranging from 60 to 390 mm (average of 190 mm, excluding the maximum and minimum values). The underlying granular ranged in thickness from approximately 300 to 1,600 mm (average 620 mm, excluding measurements from Borehole BH-04 which is likely associated with trench backfill, Borehole BH-17 obtained in the shoulder, and the remaining maximum and minimum values). The encountered pavement thicknesses are summarized in the table below.

Table 3-1: Pavement Summary

Borehole No.	Asphalt Thickness (mm)	Granular Thickness (mm)	Borehole No.	Asphalt Thickness (mm)	Granular Thickness (mm)
BH-01	110	800	BH-17	---	600
BH-02	150	410	BH-18	300	300
BH-03	150	430	BH-19	200	390
BH-04	170	1,600	BH-20	240	1280
BH-05	390	680	BH-21	250	1270
BH-06	300	550	BH-25	100	620
BH-07	300	900	BH-26	120	320
BH-08	290	800	BH-27	140	640
BH-09	290	780	BH-28	140	560
BH-10	290	940	BH-29	140	920
BH-11	250	660	BH-30	120	550
BH-12	130	400	BH-31	130	580
BH-13	200	400	BH-32	90	300
BH-14	235	450	BH-33	90	410
BH-15	60	1,100	BH-34	120	380
BH-16	230	500	Average	190	620

A buried bituminous layer, known locally as Macadam, was encountered in the granular fill at Boreholes BH-01 to BH-03. The layer was noted to be approximately 180 mm thick at a depth of 300 mm below the ground surface at Borehole BH-03 but was not readily observed at the other locations. Evidence of a possible Macadam layer was also encountered on Canal Bank Street between BH-05 and BH-11, though could not be confirmed. A series of test pits is recommended to confirm if the Macadam layer is present.

3.1.2 Fill

Silty clay fill was encountered at ground surface or below the granular fill at Boreholes BH-01 to BH-06, BH-11 to BH-14, BH-16 to BH-21, BH-24 to BH-26 (including BH-101 and BH-102), BH-28 to BH-30, BH-32, and BH-34. The fill extended to depths ranging from approximately 1.5 to 3.4 m below existing grade. The silty clay fill contained trace sand and occasional rootlets/organic staining, was brown to grey, and in a moist to very moist state. Moisture contents of the fill ranged from 17 to 39 percent.

3.1.3 Silty Clay

Native glaciolacustrine silty clay was encountered below the fill and/or pavement structure and extended to the borehole termination depth at all borehole locations. The silty clay contained trace sand, was brown to grey, and in a moist to wet state. Moisture contents of the stratum ranged from 17 to 46 percent. SPT N values of the stratum ranged from 1 to 20 blows per 305 mm of penetration. Based on estimated undrained shear strengths from pocket

penetrometer measurements and in-situ shear vane tests ranging from 25 kPa to greater than 225 kPa, the stratum is classified as stiff to hard in consistency. The silty clay was typically noted to become weaker with depth.

Based on twenty (20) grain size analyses of the stratum, the material contained between 20 and 67 percent clay, 29 to 80 percent silt, 0 to 4 percent sand, and 0 to 2 percent gravel. The material is classified as a medium to high plasticity clay (CI to CH) with liquid limit values ranging from 41 to 68 and plasticity indices ranging from 22 to 45. The complete set of laboratory results are presented in Appendix B.

3.2 Groundwater Conditions

Groundwater conditions were monitored in the open boreholes during and upon completion of the drilling operations. The boreholes contained no free water upon completion. 50 mm diameter groundwater monitoring wells were installed at fifteen (15) borehole locations with the groundwater depths and elevations summarized in the table below. Note that groundwater level measurements at some monitoring wells were not feasible on January 23, 2020 as the wells were covered with ice and snow; additional readings will be presented in a revised report.

Table 3-2: Groundwater Level Measurements

Borehole No.	Groundwater Depth and Elevation (m)				
	Upon Completion		November 8, 2019		January 23, 2020
BH-02	no free water		2.7	173.2	2.8 173.1
BH-05	no free water		5.7	172.3	-- ---
BH-08	no free water		2.2	175.4	1.8 175.0
BH-10	no free water		4.6	173.3	2.5 175.4
BH-12	no free water		4.9	172.9	--- ---
BH-14	no free water		3.9	173.5	1.4 176.0
BH-16	no free water		1.3	176.2	--- ---
BH-18	no free water		---	---	2.4 175.4
BH-20	no free water		---	---	--- ---
BH-21	7.3	170.7	---	---	2.3 175.7
BH-101	no free water		---	---	0.6 176.5
BH-26	no free water		1.5	176.1	--- ---
BH-29	no free water		3.5	175.4	3.3 175.6
BH-31	no free water		2.3	175.6	1.2 176.7
BH-33	6.1	170.9	1.6	175.4	1.5 175.5

Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry weather conditions.

4. Environmental Considerations

In accordance with the scope of work, chemical analyses were performed on selected soil samples recovered from the boreholes. Copies of the laboratory Certificates of Analysis for the tested soil samples are provided in Appendix D.

4.1 Soil Analysis

EXP submitted one (1) to two (2) soil samples from each borehole (47 samples total) for metals and inorganics analysis. The results of the metals and inorganics analysis together with the applicable Table 3 (Industrial/Commercial/Community), Table 9, and Table 1 (Agricultural) SCS are presented in Table D-1 in Appendix D.

The following Table 3 (Industrial/Commercial/Community) SCS exceedances were noted:

- Electrical Conductivity: BH-02 SS6, BH-4 SS4/SS6, BH-05 SS2, BH-06 SS6, BH-07 SS3, BH-08 SS6, BH-10 SS6, BH-13 SS2, BH-14 SS3, BH-15 SS3, BH-16 SS4, BH-17 SS2, BH-18 SS8, BH-19 SS8, BH-20 SS3, BH-21 SS1, BH-22 SS1, BH-23 SS4, BH-28 SS5, BH-30 SS6, BH-31 SS2/SS6, BH-32 SS2/SS6, BH-33 SS2/SS6, BH-34 SS2/SS6

Where applicable, the following Table 9 (Industrial/Commercial/Community) SCS exceedances were noted, in addition to the Table 3 SCS exceedances noted above:

- Electrical Conductivity: BH-01 SS3, BH-03 SS2, BH-09 SS3, BH-11 SS2, BH-12 SS6
- Sodium Absorption Ratio: BH-05 SS2, BH-09 SS3, BH-11 SS2, BH-12 SS6, BH-13 SS2, BH-17 SS2
- Cobalt: BH-17 SS2

The following Table 1 (Agricultural) SCS exceedances were noted, in addition to the Table 3 and Table 9 SCS exceedances noted above:

- Electrical Conductivity: BH-24 SS1, BH-101 SS5, BH-25 SS2/SS5, BH-27 SS2/SS5, BH-28 SS2, BH-29 SS3/SS7, BH-30 SS2
- Sodium Absorption Ratio: BH-02 SS6, BH-03 SS2, BH-04 SS4/SS6, BH-06 SS6, BH-07 SS3, BH-08 SS6, BH-10 SS6, BH-14 SS3, BH-15 SS3, BH-16 SS4, BH-18 SS8, BH-20 SS3, BH-21 SS8, BH-22 SS1, BH-23 SS4, BH-24 SS1, BH-101 SS5, BH-25 SS2, BH-27 SS5, BH-28 SS2/SS5, BH-29 SS3/SS7, BH-30 SS2/SS6, BH-31 SS2/SS6, BH-32 SS2/SS6, BH-33 SS2/SS6, BH-34 SS2/SS6
- Nickel: BH-01 SS3
- Cobalt: BH-12 SS6, BH-15 SS3
- Barium: BH-13 SS2
- Arsenic: BH-31 SS6

The source of the elevated concentrations of Arsenic, Barium, Cobalt, and Nickel is unknown. The site is a municipal roadway and as such, elevated levels of salt-related parameters (EC/SAR) are likely associated with the application of de-icing and salting substances for the purpose of snow and ice removal. As per Section 2 of Ontario Regulation 339 of the Revised Regulations of Ontario, 1990 (Classes of Contaminants – Exceptions) and section 48 (3) of Ontario Regulation 153/04, the concentrations of EC/SAR are deemed to not be an exceedance and therefore these parameters are not considered contaminants of concern.

Based on these results and the understanding that Macadam must be disposed of at a landfill, TCLP testing was conducted on a sample of the Macadam near Borehole BH-03 as well as a subgrade sample from near Borehole BH-13. The results of the TCLP Metals and Inorganics, TCLP PCBs, and TCLP VOCs are presented in Table D-2 in

Appendix D. As shown in Table D-2, the concentrations of TCLP Metals and Inorganics, PCBs, and VOCs parameters in the tested samples were either detected at concentrations below the Schedule 4 criteria or not detected above the laboratory Reported Detection Limits (RDLs). The RDLs were below the Schedule 4 criteria.

Based on the above, the following options for soil disposal are presented:

Table 4-1: Summary of Soil Disposal Options

Option	Description	Advantages	Disadvantages/Considerations
1	Re-use excess soil on site	<ul style="list-style-type: none"> Least expensive option 	<ul style="list-style-type: none"> Must be geotechnically suitable for re-use and meet project specifications Potential limitations for stockpiling/temporary storage Soil with exceedances above the applicable SCS should not be re-used (i.e. BH-17)
2	Dispose of excess soil at third party site	<ul style="list-style-type: none"> Less expensive than landfill disposal All samples meet Table 3 and 9 SCS (as EC/SAR exceedances are deemed exempt) 	<ul style="list-style-type: none"> Sites may be difficult to find at time of construction Soil exceeding the SCS of receiving site must be disposed of at a landfill
3	Dispose excess soil at licensed landfill	<ul style="list-style-type: none"> Landfills usually open to accepting soils TCLP samples tested met Schedule 4 criteria for landfill disposal 	<ul style="list-style-type: none"> Most expensive option Environmentally unsustainable
4	Delineation for Table 1 or 9 Exceedances	<ul style="list-style-type: none"> Potential to limit the volume of soil disposal at landfill 	<ul style="list-style-type: none"> Not practical for EC/SAR exceedances due to widespread use of road salts Additional time and costs required May not necessarily produce favourable results

4.2 Quality Assurance

Details regarding quality assurance measures taken in the field, including instrument calibration, decontamination procedures, use of dedicated equipment, sample storage and Chain of Custody documentation are provided above.

The subcontracted laboratory used during this investigation, AGAT Laboratories, is accredited by the Standards Council of Canada/Canadian Association of Laboratory Accreditation in accordance with ISO/IEC 17025 – “General Requirements for the Competence of Testing and Calibration Laboratories” for the analysis of all parameters for all samples in the scope of work for which SCS have been established under Ontario Regulation 153/04 as amended by Ontario Regulation 511/09 and Ontario Regulation 179/11.

The “Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act” (“the Analytical Protocol”), MECP, July 2011, establishes criteria used in assessing the performance of analytical laboratories when the data are used in support of the filing of Records of Site Condition.

The laboratory quality assurance program included the analysis of laboratory duplicate (replicate) samples, method blanks, spiked blanks, spiked samples and samples of reference materials in accordance with the Analytical Protocol. These analytical results comprise portions of the Certificates of Analysis in Appendix D.

5. Discussion and Recommendations

It is understood that the proposed sanitary forcemain will consist of a 300 to 675 mm diameter PVC pipe installed at depths ranging from approximately 1.5 to 6.0 m below grade (more typically in the order of 4 to 6 m). The pipe is generally planned to be installed in open-cut excavations, with culvert and rail infrastructure to be temporarily supported or reconstructed. The forcemain will be installed using a trenchless installation technique on the MTO property to cross the Canal Bank Street and Townline Tunnel Road intersection (Boreholes BH-18 to BH-20). The roadways will be reinstated following construction and full road reconstruction is not anticipated.

The sanitary forcemain installation should be in accordance with the Niagara Peninsula Standard Contract Document, applicable OPSS/OPSD requirements, and industry standard practices. We offer the following comments and recommendations for the planned construction.

5.1 Sanitary Forcemain Installation by Open-Cut

5.1.1 Excavations

Trench boxes or other shoring methods may be used to limit the lateral extent of excavations. Recommendations for temporary shoring are included in the following subsection.

Based on the proposed forcemain installation depths which are typically in the order of 4 to 6 m below grade, the excavations are anticipated to be carried out below the pavement structure/topsoil and silty clay fill and into the native stiff to hard glaciolacustrine silty clay. Provided positive groundwater control measures are implemented where required, the open-cut excavations may be undertaken using a mechanical shovel capable of excavating hard silty clay.

The contractor should be aware that the slope height, slope inclination, or excavation depths must in no case exceed those specified in local, provincial, or federal safety regulations. For guidance, above the groundwater level the fill materials and stiff native silty clay can be classified as Type 3 Soil, while the very stiff to hard native silty clay can be classified as Type 2 Soil. The silty clay became soft below a depth of 7.6 m in the area of deeper exploration at Boreholes BH-18 to BH-23; this soft silty clay is classified as Type 4 Soil.

In accordance with OHSA regulations, if the excavation contains more than one type of soil, the excavation shall be constructed according to the type with the highest number. Sloughing may be encountered from the granular pavement layer and where loose fill or water bearing zones are present. Locally, where loose/soft materials are encountered, or within zones of persistent seepage at depth, it may be necessary to flatten the slopes.

5.1.2 Temporary Shoring

The need for temporary shoring will depend on the geometry of the required excavations and nearby infrastructure. Protection systems (design, materials, construction, maintenance, monitoring and removal) will be required to meet the specifications set out in OPSS 539. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539.

Trench boxes may be used to reduce lateral extent of the excavations for the open-cut forcemain installation, including adjacent to MTO roadways (subject to MTO approval). To mitigate potential for settlement of adjacent infrastructure, support system are to be placed so backfilling can occur while the support system is gradually removed. Note that trench boxes must not be used in Type 4 soils or excavations exceeding a depth of 6.0 m or width of 3.6 m and a site-specific engineered support system must be used in those cases. The lateral earth pressure acting on supported excavation walls may be computed using the following equation:

$$p = K (\gamma h + q)$$

where

- p = lateral earth pressure intensity at depth h (kPa)
- K = earth pressure coefficient
- γ = unit weight of retained soil
- h = depth to point of interest (m)
- q = surcharge load acting adjacent to the wall at the ground surface (kPa)

The above expression does not consider hydrostatic pressure as it is assumed dewatering will be carried out as required, otherwise the hydrostatic pressure must be included for the groundwater levels measured on the site. The table below lists earth pressure parameters for given materials. These recommendations assume level backfill and ground surface behind the temporary shoring.

Table 5-1: Material Types and Earth Pressure Properties

Material	Friction Angle, ϕ' (unfactored)	Coefficient of Active Earth Pressure, K_a	Coefficient of Passive Earth Pressure, K_p	Coefficient of Earth Pressure at Rest, K_o	Unit Weight, γ (kN/m ³)
Granular A or Granular B Type II	33	0.29	3.39	0.46	22
Silty Clay Fill	25	0.41	2.46	0.58	18
Native Silty Clay	28	0.36	2.77	0.53	20

The mobilization of full active or passive resistance requires a measurable and perhaps significant shoring movement or rotation. Therefore, unless the structural element can tolerate these deflections, the at-rest earth pressure should be used in design.

If applicable, the effect of compaction surcharge should be considered in the calculations of active and at rest earth pressures. The lateral pressure due to compaction should be taken as at least 12 kPa at the surface, and its magnitude should be assumed to diminish linearly with depth to zero at the depth where the active (or at rest) pressure is equal to 12 kPa. This pressure distribution should be added to the calculated active (or at rest) pressure. Notwithstanding, lighter compaction equipment and smaller lifts should be used adjacent to walls to prevent overstressing.

5.1.3 Groundwater Control

The boreholes contained no free water upon completion of drilling, though insufficient time had passed for the groundwater level to stabilize in the open boreholes. Groundwater levels measured in the monitoring wells ranged from 1.2 to 5.7 m below grade and the soil samples were typically noted to become wet across the site at depths below 3.1 to 4.6 m (and as high as 2.3 m at Borehole BH-27). As such, excavations below the groundwater level are anticipated and dewatering will be required.

Perched water infiltration from fill materials and existing utility bedding as well as seepage from native soils should be anticipated. Given the predominantly fine-grained nature of the encountered fill and native soils, groundwater infiltration into the excavations is expected to be controllable using construction sump pumping techniques. The length of excavation can be limited to minimize the amount of dewatering and ensure that a Permit to Take Water (PTTW) is not required. In order to avoid potential delays during construction and allow for additional length of trench to be excavated, an EASR/PTTW may be obtained.

During construction, measures should be implemented to manage accumulation of precipitation, seasonal fluctuations in the groundwater table, flow from bedding of existing services, and variation in soil and hydrogeological properties beyond those encountered during the course of this study. Note that it is the responsibility of the contractor to ensure dry conditions are maintained within the excavation at all times. Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry weather conditions.

All collected water should discharge a sufficient distance away from the excavated area to prevent the discharge from re-entering the excavation. Sediment control measures such as silt fences should be provided at the discharge point of the dewatering system. Caution should also be taken to avoid any adverse impact to the environment.

5.1.4 Pipe Bedding

Based on the borehole data and the anticipated invert levels, the encountered native soils will generally provide adequate support for the proposed PVC sanitary forcemain.

Bedding and cover materials shall conform to and shall be placed and compacted as specified by the local specifications and the applicable Ontario Provincial Standards such as OPSS 401, OPSS 501, OPSS 1010 and/or OPSS 1359. In order to obtain uniform pressure conditions around the pipe, the supporting bedding should be extended to at least 300 mm on each side of the pipe and for the entire width of the trench. The cover and bedding should be placed in thin (maximum 200 mm) lifts and compacted as specified by the owner. Particular attention should be given to ensure material placed beneath the bottom quadrants of the pipe is adequately compacted and shaped to receive the pipe. The degree of compaction achieved in the field should be checked by in-situ nuclear density tests.

The silty clay was noted to become weaker with depth and in areas where wet or soft subgrade conditions are encountered, subgrade stabilization or improvement may be required. Increased bedding thickness or a 300 mm thick layer of 19 mm clear stone wrapped in geotextile (Terrafox 360R or equivalent) may be used to provide a stable working platform.

5.1.5 Frost Considerations

If construction proceeds during the winter months, the base of the trench and all fill materials should not be allowed to freeze. In the Welland area, a frost penetration depth of approximately 1.2 m can occur in open, unheated areas without snow cover. Any services without a minimum of 1.2 m of earth cover (or minimum depths specified by the Region) will require equivalent insulation for frost protection.

5.1.6 Backfilling Operations

The backfilling operation should be subject to the approval of the City of Welland/MTO. Trench backfilling procedures and materials should be in accordance with the owner requirements and specifications. Some water content adjustment of re-used materials may be required for efficient compaction, depending on the depth and weather conditions at the time of construction. Any soil which contains organics or deleterious material or is excessively wet should not be used for backfilling. Any shortfall of suitable on-site excavated material can be made-up with imported and approved fill or granular material, e.g. Granular A in accordance with OPSS 1010. Above the pipes, a minimum 300 mm thick layer of Granular A is recommended for pipe protection. All backfill and compaction operations must be closely monitored by a geotechnical consultant to ensure uniform compaction and compliance with specifications, especially in the vicinity of manholes, catch basins, and areas that are not readily accessible to compaction equipment. To mitigate the potential for differential settlement, the fill around catch basins and manholes should consist of granular fill, e.g. Granular A or Granular B.

All backfill should be placed in loose lifts not exceeding a thickness of 200 mm. Compaction equipment used should be soil specific (i.e. sheepsfoot roller for cohesive soils and smooth drum for non-cohesive soils). To minimize potential problems, backfilling operations should follow closely after excavation, so that only a minimal length of trench is exposed. This will minimize wetting of the subgrade material. Should construction extend to the winter season, particular attention should be given to ensure that frozen material is not used as backfill.

5.1.7 Thrust Blocks

It is recommended that all thrust blocks for the proposed forcemain be poured neat against the native soils without the use of forms in order to achieve the maximum restraint with minimum deflection. Horizontal restraint for the thrust block is provided by the passive earth pressure developed in the soil behind the block and the friction along the base. The passive earth pressure may be estimated using the following equation and geotechnical parameters:

$$p = K (\gamma h + q)$$

where

p = lateral earth pressure intensity at depth h (kPa)

K = earth pressure coefficient

γ = unit weight of soil (kN/m^3)

h = depth to point of interest (m)

q = surcharge load acting adjacent to the wall at the ground surface (kPa)

In general, an earth pressure coefficient of 2.2 and a unit weight of 20 kN/m^3 may be used. An assumed coefficient of sliding friction of 0.35 may be used on the native silty clay.

5.2 Sanitary Forcemain Installation by Trenchless Methods

It is understood that the forcemain will be installed for a length of approximately 50 m using a trenchless method to minimize traffic disruptions at the MTO-owned intersection of Townline Tunnel Road (Highway 58A) and Canal Bank Street (Boreholes BH-18 to BH-20). Though not anticipated to be required, the tunneling may also continue eastward to the MTO property limit, located approximately 200 m west of the Humberstone Road dead end (Boreholes BH-21 to BH-24).

At the tunneled location, the sanitary forcemain is planned to consist of a 300 mm diameter PVC pipe installed in a 508 mm diameter steel casing approximately 3.5 m below grade (MTO *low complexity*). A plan and profile drawing with subsurface geotechnical information for the proposed trenchless installation is provided in Drawing No. 1AA in Appendix A. Comments and recommendations for the proposed trenchless installation are included in the subsections below.

5.2.1 Trenchless Installation Methods

The following tables summarize some of the possible alternatives for the pipe installation and the subsections below provide a discussion of the various trenchless installation options in order to determine the rank shown in Table 5-2.

Table 5-2: General Comparison of Trenchless Installation Methods

Installation Method	Advantages	Disadvantages	Rank
Horizontal Directional Drilling (HDD)	<ul style="list-style-type: none"> Handles wide variety of ground conditions Steerable both horizontally and vertically to maintain and adjust alignment Does not require staging pits if site is able to accommodate maximum entry and exit angles Suitable for tunneling under groundwater table Local contractors available Short mobilization time Rapid drilling Only minor settlement are expected if fluid is well controlled Suitable for installation of pipes up to 1.2 m in diameter (max 750 mm is more common) and longer lengths 	<ul style="list-style-type: none"> Potential for inadvertent drilling returns Requires drilling fluid to maintain the bore which could allow subsidence May require longer bore or staging pits to meet required entry and exit angles Obstructions problematic, but alignment can be adjusted to avoid obstructions Annular space filling required (fluid or grouting) May not be suitable for high degree of alignment accuracy (such as would be required for gravity sewer) 	1

Installation Method	Advantages	Disadvantages	Rank
Jack and Bore	<ul style="list-style-type: none"> Handles wide variety of ground conditions Auger can be manually removed to permit removal of obstructions such as cobbles and boulders Minimal surface disruption Vertically accurate (slope of 0.2% achievable) Relatively simple operation Commonly used in Ontario Short mobilization time Suitable for steel pipes up to 1.8 m in diameter Lower relative cost than microtunneling 	<ul style="list-style-type: none"> Requires large area for jacking shaft and support equipment Obstructions can be problematic Pipe can be difficult to steer Short and long-term settlement possible Fluid to support annular space required Water ingress problematic Difficulty in squeezing, fast raveling, and flowing soils and requires a soil plug for face support or may not be feasible 	2
Microtunneling	<ul style="list-style-type: none"> Handles wide variety of ground conditions Steerable horizontally to maintain and adjust alignment Suitable for tunneling under groundwater table Alignment can be adjusted to avoid obstructions Suitable for steel, reinforced concrete, and fiberglass pipes Local contractors available 	<ul style="list-style-type: none"> Obstructions problematic Requires large area for jacking shaft and support equipment Requires sophisticated equipment Higher relative cost over jack and bore, pipe ramming, or HDD Best suited for installation of pipes with minimum 0.6 m diameter and 150 m length 	3
Pipe Ramming	<ul style="list-style-type: none"> Not very sensitive to ground condition Suitable for steel pipes up to 1.8 m in diameter and best up to 50 m long Accommodates obstructions well Little surface settlement Soil removed after pipe in place 	<ul style="list-style-type: none"> Pipe can be difficult to steer/direct Ground heave possible Large entry pit size Slower than other trenchless methods Difficulty in squeezing, fast raveling, and flowing soils 	4

Table 5-3: General Comparison of Technical Issues Associated with Trenchless Methods

Typical Limitations	Tunneling Method			
	Jack & Bore	Horizontal Directional Drilling (HDD)	Pipe Ramming	Microtunneling
Length of drive and diameter	<ul style="list-style-type: none"> Drive lengths to 150 m Diameters up to 1800 mm are feasible 	<ul style="list-style-type: none"> Drive pullback lengths of several hundred meters are feasible In Southern Ontario, HDD diameters less than 750 mm are commonplace but larger bores add risk, complexity and considerable cost 	<ul style="list-style-type: none"> Generally best suited to short watercourse crossings where risks of ground heave are low 30 to 60 m drives are typical Diameters of 1800 mm are technically feasible with a large hammer; however, the stability and integrity of the soil plug in the lead pipe segment is less certain with larger diameters 	<ul style="list-style-type: none"> Drive lengths of 300 m are typical, provided that Intermediate Jacking Stations (IJS) are launched every 75 m Micro tunnels up to 1500 mm dia. can be readily constructed in Ontario; 3000 mm dia. may be feasible by specialists
Ability to control line and grade	<ul style="list-style-type: none"> Average control of line and grade Limited ability to steer and to correct grade 	<ul style="list-style-type: none"> Specialized tracker system is needed to control line and grade Fair to good 	<ul style="list-style-type: none"> Relatively poor 	<ul style="list-style-type: none"> Good Line and grade control to within ± 40 mm is feasible over 300 m drive
Ability to control ground surface displacement	<ul style="list-style-type: none"> Poor No ability to retain running ground 	<ul style="list-style-type: none"> Fair Ground heave and hydro fracturing may result from excessive rates of pullback Bore stability relies on good quality control and circulation of drilling mud 	<ul style="list-style-type: none"> Poor Risk of ground heave is moderate to high If soil plug washes out or is breached, then excessive ground loss and settlement will occur 	<ul style="list-style-type: none"> Good Slurry shield MTBM can balance earth pressures in the shield to a variety of soil and groundwater conditions Full and immediate ground support by means of jacking pipe
Ability to deal with mixed face ground conditions	<ul style="list-style-type: none"> Mixed face conditions will likely cause line and grade deviations to occur Overmining may result when augering is labored due to hard ground Augers may jam on rock slabs 	<ul style="list-style-type: none"> Mixed ground may interfere with line and grade control 	<ul style="list-style-type: none"> Mixed face conditions will likely deviate the line and grade 	<ul style="list-style-type: none"> Good High pressure water jets are necessary to breakdown cohesive clays

Typical Limitations	Tunneling Method			
	Jack & Bore	Horizontal Directional Drilling (HDD)	Pipe Ramming	Microtunneling
Ability to deal with flowing or unstable face conditions	<ul style="list-style-type: none"> No ability to deal with flowing or unstable face conditions Flowing soils may result in total collapse or excessive ground loss Method is unsuitable in cohesionless soils below the water table 	<ul style="list-style-type: none"> Bore wall stability can be maintained with suitably viscous drilling fluid and filter cake buildup on bore wall Risk of pipe jamming during pullback if stones or cobbles become dislodged from crown of bore 	<ul style="list-style-type: none"> The ability to retain flowing ground depends entirely on maintaining a soil plug in the lead pipe segment; if the plug breaches, then the bore may fail 	<ul style="list-style-type: none"> Slurry shield MTBMs are better suited to flowing ground conditions than any other trenchless method
Ability to deal with cobbles, boulders, and other obstructions	<ul style="list-style-type: none"> For bores >900 mm, auger removal and personnel entry are needed to break up boulders, however the tunnel face must be cohesive for this to be safely conducted 	<ul style="list-style-type: none"> Cobbles and rock slabs may jam pipe in bore during pullback Boulders will result in a failed bore 	<ul style="list-style-type: none"> May require removal of soil plug to remove/breakup boulder which could possibly compromise tunnel stability 	<ul style="list-style-type: none"> Combination of disk and pick cutters is needed Person entry not practical Wood troublesome

5.2.1.1 Jack and Bore Technique

The jack and bore method involves drilling a borehole from a jacking pit (entry pit) with a rotary cutter head within the confines of a steel casing or liner which is jacked ahead at least one pipe diameter for support. The casing is pushed through the soil with a hydraulic ram, and soil is removed with an auger. The auger transports spoils from the cutting head back to the jacking pit. Installation should follow the requirements in OPSS 415 and 416.

Based on the proposed tunnel diameter, pipe jacking using mechanical means is feasible for the proposed installation. However, the elevation and gradient of the pipe must be closely controlled during the course of the jack and bore. Lubricant selected based on the characteristics of the surrounding soil may be provided to reduce the friction between the casing and the tunnel walls. Though not encountered during the investigation, any obstacles such as cobbles or boulders could make the pipe jacking difficult. However, one of the advantages of using the jack and bore method for the pipe installation is that the auger can be manually removed to permit clearing of these obstructions or it may be equipped with rock-cutting teeth.

Considering the low permeability of silty clay, groundwater inflow into the tunnel is typically anticipated to be relatively minor and controllable by using pumps of sufficient capacity from the jacking and/or receiving pit. To reduce potential for loss of ground and associated disturbance, it is recommended the lead auger be kept at least one casing diameter behind the lead end of the casing. The jacking and boring operations should be continued without stoppage until completion. Furthermore, any significant voids between the casing and the surrounding soil should be filled with pressurized cementitious grout to mitigate the potential for settlement.

Generally, tunneling using pipe jacking method is a relatively slow and labour-intensive process. The actual tunnel advance rate is a function of soil conditions encountered, method of soil excavation, spoil removal, pipe liners materials, and field conditions.

5.2.1.2 Horizontal Directional Drilling (HDD) Technique

If there is enough space to achieve entry and exit angles as recommended in ASTM F1962 (12° to 15° for bore entry and 10° for bore exit), Horizontal Directional Drilling (HDD) may be considered for the installation, provided the drill hole is at all times supported with a properly designed drilling fluid. The drilling may also be conducted from within an excavation to achieve the required entry and exit angles, though this mitigates one of the benefits of the HDD method. The drilling fluid should be designed by a specialist contractor, based on such factors as the soil type, diameter and depth of the opening, rate of drilling etc., and may have to be adjusted as construction proceeds. The fluid pressure should not exceed the in-situ overburden pressure. Higher pressure could cause fracturing of the soils and loss of the drilling fluid, which in turn could cause instability and even collapse of the drill hole. Installation should follow requirements in OPSS 415 and 450.

The cutting tool and the drilling fluid must be able to handle the different materials encountered (silty clay fill and very stiff to hard silty clay). With good construction control and no loss of drilling fluid, settlement at the area directly above the drill hole should be minimal.

5.2.1.3 Microtunneling Technique

The microtunneling method provides continuous support of the excavation face is suitable to install the proposed forcemain. The Microtunneling Boring Machine (MTBM) is usually equipped with a slurry spoil removal system to control any groundwater inflow and counterbalance the earth and hydrostatic pressure while tunneling.

Considering the site conditions, the major advantage of micro-tunneling method for this project is that its performance should be less affected by groundwater levels. The major disadvantages of micro-tunneling for this project is considered to be the relatively high costs of mobilization and installation, especially given the relatively small tunnel diameter and short tunnel length. This option will be less expensive if potential bidders have equipment available in-house.

5.2.1.4 Pipe Ramming Technique

Pipe ramming involves the use of a steel casing inserted from a launch pit and driven by a pneumatic percussion hammer system. The leading edge or head of the initial steel casing is fitted with a cutting shoe/band to reinforce the pipe for open-face pipe ramming and reduce friction by creating a slight overcut. Additional lengths of steel casing are welded on to the preceding piece, as the casing advances towards the exit pit. Lubricants (bentonite or polymer) may be used to facilitate advancement of the casing. In some conditions, this method is well suited to installation of pipes below operating railways if no material is removed from within the pipe until it emerges sufficiently beyond the far edges of the tracks. Material within the casing is removed by augering usually after the casing is installed. In some cases, or when resistance to driving becomes too great, materials are partially or fully removed from within the casing prior to completion.

5.2.2 Discussion of Trenchless Installation Methods

The proposed tunnel invert will be constructed at approximately Elev. 172.5 m, or about 5 m below the existing pavement surface. The soil conditions anticipated along the tunnel alignment predominantly consists of moist, stiff to very stiff silty clay of medium to high plasticity. Depending on the tunnelling methodology, this may also include the silty clay fill or granular fill. A groundwater level measurement 2.4 m below grade (Elev. 175.4 m) was obtained from the monitoring well at Boreholes BH-18. The silty clay is classified as *slow ravelling* to *squeezing* soil in Terzaghi's Tunnelman's Ground Classification (Appendix C). The undrained shear strength of the undisturbed silty clay along the proposed alignment is estimated to be 100 to 150 kPa based on pocket penetrometer measurements and in-situ

shear vane tests; the overload factor (ratio of overburden pressure at anticipated spring line elevation to undrained shear strength) does not exceed 3.0.

The chosen method of tunneling and specific equipment must be capable of dealing with the encountered subsurface conditions. The encountered cohesive materials will have a “sticky” behaviour which can bind to the tunneling equipment, significantly slowing progress or requiring alternative procedures or removal before progress can continue.

Though not encountered during the investigation, a review of potential obstructions from previous construction, such as existing or abandoned piles, tiebacks, conduits, etc. should be carried out. Existing utilities and the age and condition of those within the zone of influence should also be established. It is recommended that the horizontal distance between pipes be at least 3 pipe diameters. The installation procedures must conform to the Niagara Peninsula Standard Contract Document, applicable OPSS and ASTM standards, manufacturer requirements, and industry standard practices.

Given the subsurface conditions encountered along the proposed tunnel alignment, HDD, jack and bore, microtunneling, and pipe ramming methods would each be considered suitable. Given the proposed diameter and length of the crossing, the jack and bore and pipe ramming methods have minimal risk of ground settlement in silty clay conditions. However, ramming through the stiff silty clay may be difficult and require lubricants and/or additional equipment to permit removal of any obstructions. Any groundwater inflow with these methods is expected to be minor and readily controllable with conventional pumps. Given the relatively high cost of microtunneling and the potential above-mentioned difficulties with jack and bore and pipe ramming, the HDD method is preferred as indicated in Table 5-2.

Provided construction is carried out in accordance with the recommendations herein and applicable standards and industry standard practice, any settlement/heave of the overlying pavement is anticipated to be minimal.

5.2.3 Access Pit Construction and Backfill

The following subsections include recommendations for excavations, dewatering, lateral earth pressures, and backfill pertaining to the construction of the access pits used in trenchless pipe installation.

5.2.3.1 Access Pit Excavations

Depending on the tunneling method chosen and the excavations that will be required to implement them, protection system(s) will likely be required to protect existing infrastructure. Recommendations for temporary shoring are included in the subsequent section.

Excavations for the proposed access pits are not anticipated to extend below depths of approximately 5 m and are expected to be carried out below the pavement structure/topsoil and silty clay fill and into the native stiff to hard glaciolacustrine silty clay. Provided positive groundwater control measures are implemented where required, open-cut excavations may be undertaken using a mechanical shovel capable of excavating hard silty clay.

The contractor should be aware that the slope height, slope inclination, or excavation depths must in no case exceed those specified in local, provincial, or federal safety regulations. For guidance, above the groundwater level, the fill materials and stiff native silty clay can be classified as Type 3 Soil, while the very stiff to hard native silty clay can be classified as Type 2 Soil. The silty clay became soft below a depth of 7.6 m in the area of deeper exploration at Boreholes BH-18 to BH-23; this soft silty clay is classified as Type 4 Soil.

In accordance with OHSA regulations, if the excavation contains more than one type of soil, the excavation shall be constructed according to the type with the highest number. Sloughing may be encountered from the granular pavement layer and where loose fill or water bearing zones are present. Locally, where loose/soft materials are encountered, or within zones of persistent seepage at depth, it may be necessary to flatten the slopes.

The boreholes contained no free water upon completion of drilling, though insufficient time had passed for the groundwater level to stabilize in the open boreholes. A groundwater level measurement 2.4 m (Elev. 175.4 m) was obtained from the monitoring well at Boreholes BH-18 and the soils were noted to become very moist to wet below approximately 6 m from ground surface. As such, excavations below the groundwater level should be anticipated and some dewatering will be required and should be completed in accordance with OPSS 517 and SP 517F01.

Perched water infiltration from fill materials and existing utility bedding as well as seepage from native soils should be anticipated. Given the predominantly fine-grained nature of the encountered fill and native soils, groundwater infiltration into the excavations is expected to be controllable using construction sump pumping techniques.

During construction, measures should be implemented to manage accumulation of precipitation, seasonal fluctuations in the groundwater table, flow from bedding of existing services, and variation in soil and hydrogeological properties beyond those encountered during the course of this study. Note that it is the responsibility of the contractor to ensure dry conditions are maintained within the excavation at all times. Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry weather conditions.

All collected water should discharge a sufficient distance away from the excavated area to prevent the discharge from re-entering the excavation. Sediment control measures such as silt fences should be provided at the discharge point of the dewatering system. Caution should also be taken to avoid any adverse impact to the environment.

5.2.3.2 Temporary Shoring of Access Pits

The need for temporary shoring will depend on the geometry of the required excavations and nearby infrastructure and are anticipated for this project. Protection systems (design, materials, construction, maintenance, monitoring and removal) will be required to meet the specifications set out in OPSS 539. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539.

To mitigate potential for settlement of adjacent infrastructure, support system are to be placed so backfilling can occur while the support system is gradually removed. The lateral earth pressure acting on supported excavation walls may be computed using the following equation:

$$p = K (\gamma h + q)$$

where

- p = lateral earth pressure intensity at depth h (kPa)
- K = earth pressure coefficient
- γ = unit weight of retained soil
- h = depth to point of interest (m)
- q = surcharge load acting adjacent to the wall at the ground surface (kPa)

The above expression does not consider hydrostatic pressure as it is assumed dewatering will be carried out as required, otherwise the hydrostatic pressure must be included for the groundwater levels measured on the site. The table below lists earth pressure parameters for given materials. These recommendations assume level backfill and ground surface behind the temporary shoring.

Table 5-4: Material Types and Earth Pressure Properties

Material	Friction Angle, ϕ' (unfactored)	Coefficient of Active Earth Pressure, K_a	Coefficient of Passive Earth Pressure, K_p	Coefficient of Earth Pressure at Rest, K_0	Unit Weight, γ (kN/m ³)
Granular A or Granular B Type II	33	0.29	3.39	0.46	22
Silty Clay Fill	25	0.41	2.46	0.58	18
Native Silty Clay	28	0.36	2.77	0.53	20

The mobilization of full active or passive resistance requires a measurable and perhaps significant shoring movement or rotation. Therefore, unless the structural element can tolerate these deflections, the at-rest earth pressure should be used in design.

If applicable, the effect of compaction surcharge should be considered in the calculations of active and at rest earth pressures. The lateral pressure due to compaction should be taken as at least 12 kPa at the surface, and its magnitude should be assumed to diminish linearly with depth to zero at the depth where the active (or at rest) pressure is equal to 12 kPa. This pressure distribution should be added to the calculated active (or at rest) pressure. Notwithstanding, lighter compaction equipment and smaller lifts should be used adjacent to walls to prevent overstressing.

5.2.4 Ground Movement Monitoring

Ground movement monitoring is required at all MTO crossings. Condition surveys should be carried out before the construction takes place and after the completion of the tunneling. The survey should document the pavement surface conditions (i.e. cracks, distortion and deviations, heaves, and depressions) and any surrounding infrastructure (bridges, culverts, etc.). The methodology of the settlement monitoring program is outlined in the following subsections.

5.2.4.1 Monitoring Points

The monitoring should consist of surface and deep settlement points along the center line of the proposed tunnel. The deep settlement points should be installed above the crown of the tunnel and below the frost penetration depth of 1.2 m. The spacing of the surface and deep settlement points should not exceed 5.0 m. Locations of the settlement points are subject to the landowner approval where traffic disruption might occur.

5.2.4.2 Reading Frequency

An average of at least two (2) readings should be taken to establish the initial conditions. A minimum of three (3) sets of readings should be taken daily during construction and work stoppages. The monitoring should be extended after the construction completion for at least two (2) weeks provided all settlements have stopped.

5.2.4.3 Data Collection and Data Transfer

A procedure should be established in consultation with the Region and landowners to ensure that the monitoring data will reach all parties as soon as possible. The consultant and the contractor should interpret monitoring data as needed. The Geotechnical Engineer should be contacted for technical support in the interpretation of the ground movements and review of the contractor response when review and alert levels are reached.

5.2.4.4 Criteria for Assessment – Review and Alert Levels

An average of two initial readings shall be recorded as baseline readings, all the subsequent readings should be compared to the baseline reading. A maximum value of 10 mm relative to the baseline reading shall be considered as a review level, at which, the method, rate and sequence of construction, or ground stabilization measures should be reviewed or modified to mitigate further ground movement before construction proceeds. Movements of 15 mm relative to the baseline should be considered as an alert level; operations must stop and the pre-planned measures are to be implemented to mitigate further movement and ensure public safety.

5.3 Soil Corrosivity

The parameters used to analyze the soil potential to corrode ductile iron are from the appendix to ANSI/AWWA C105/A21.5 Standard and were developed for ductile iron piping. This “10 point” soil evaluation system considers the effect of soil resistivity, pH, redox potential, sulfides, and moisture, and assigns points for various values of each parameter. Soil is considered corrosive to ductile iron when 10 or more points are tabulated. The complete test results are included in the Certificate of Analysis in Appendix D.

Table 5-5: Determination of Points for Soil Corrosion of Ductile Iron

Borehole and Sample No.	pH	Sulphate (µg/g)	Sulphide (%)	Chloride (µg/g)	Resistivity (Ω-cm)	Redox Potential (mV)	Moisture/ Drainage
BH-3 SS6 Corrosivity Points (Total = 12)	8.13	1,530	<0.05	100	585	445	wet
	0	---	0	---	10	0	2
BH-8 SS6 Corrosivity Points (Total = 15)	8.54	1,670	<0.05	68	602	398	wet
	3	---	0	---	10	0	2
BH-13 SS5 Corrosivity Points (Total = 11)	7.96	1,040	<0.05	213	735	332	moist
	0	---	0	---	10	0	1
BH-18 SS8 Corrosivity Points (Total = 13)	8.06	1,710	0.25	59	613	155	moist
	0	---	2	---	10	0	1
BH-20 SS8 Corrosivity Points (Total = 11)	8.24	1,010	<0.05	23	917	220	moist
	0	---	0	---	10	0	1
BH-22 SS4 Corrosivity Points (Total = 13)	8.06	1,730	0.06	148	568	204	moist
	0	---	2	---	10	0	1
BH-24 SS5 Corrosivity Points (Total = 12)	8.12	1,290	<0.05	37	775	207	wet
	0	---	0	---	10	0	2
BH-25 SS5	8.15	449	<0.05	68	1,400	313	moist

Borehole and Sample No.	pH	Sulphate (µg/g)	Sulphide (%)	Chloride (µg/g)	Resistivity (Ω-cm)	Redox Potential (mV)	Moisture/ Drainage
Corrosivity Points (Total = 11)	0	---	0	---	10	0	1
BH-29 SS5	7.94	994	0.08	113	800	230	moist
Corrosivity Points (Total = 13)	0	---	2	---	10	0	1
BH-32 SS6	7.83	3,340	<0.05	95	341	359	wet
Corrosivity Points (Total = 12)	0	---	0	---	10	0	2

The calculated points for the soil samples tested range from 11 to 15 as shown in the table above. Therefore, the soil material represented by the samples tested indicate that the soil is corrosive to ductile iron piping. The results should be presented to the material supplier to determine the appropriate protective measures required.

The concentration of soluble sulphate in the soil samples collected ranged from 449 to 3,340 µg/g (0.0449 to 0.3340%), indicating a negligible to severe degree of sulphate exposure for buried concrete structures. The samples tested typically indicated a moderate degree of sulphate attack (exposure class S-2), with the results from the vicinity of Borehole BH-32 indicating a severe degree of sulphate attack (exposure class S-3). However, it should be noted that these are localized samples and results from different areas may potentially indicate higher soluble sulphate concentrations.

5.4 Road Reinstatement

It is understood that following the sewer installation, the roadway will be reinstated at the trench, i.e. full roadway reconstruction is not anticipated. The roadway reinstatement should be in accordance with the local specifications. The asphalt (HL3 surface course and HL8 binder course) should generally match existing conditions to minimize potential for differential movements and surface cracking. A minimum of 450 mm of Granular A compacted in lifts to 100 percent Standard Proctor Maximum Dry Density (SPMDD) is recommended on local roads and 525 mm on collector roads.

Use of a key-in joint transition where old asphalt pavement and new asphalt pavement abut is recommended: the existing pavement beyond the excavation limits should be milled for a width of at least 600 mm and for a partial depth of 50 mm (where practical) and overlaid when placing the surface asphalt course.

A tack coat between the binder and surface course and on abutting surfaces of existing asphalt is to be placed in accordance with OPSS 308.

6. General Comments

The information presented in this report is based on a limited investigation designed to provide information to support an overall assessment of the current geotechnical conditions of the subject property. The conclusions presented in this report reflect site conditions existing at the time of the investigation.

EXP Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, EXP Services Inc. will assume no responsibility for interpretation of the recommendations in the report.

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

More specific information, with respect to the conditions between samples, or the lateral and vertical extent of materials, may become apparent during excavation operations. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent; should this occur, EXP Services Inc. should be contacted to assess the situation and additional testing and reporting may be required. EXP Services Inc. has qualified personnel to provide assistance in regard to future geotechnical and environmental issues related to this property.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.



Jeffrey Golder, P.Eng.
Manager, Hamilton Geotechnical Services



Silvana Micic, Ph.D., P.Eng.
Senior Geotechnical Engineer

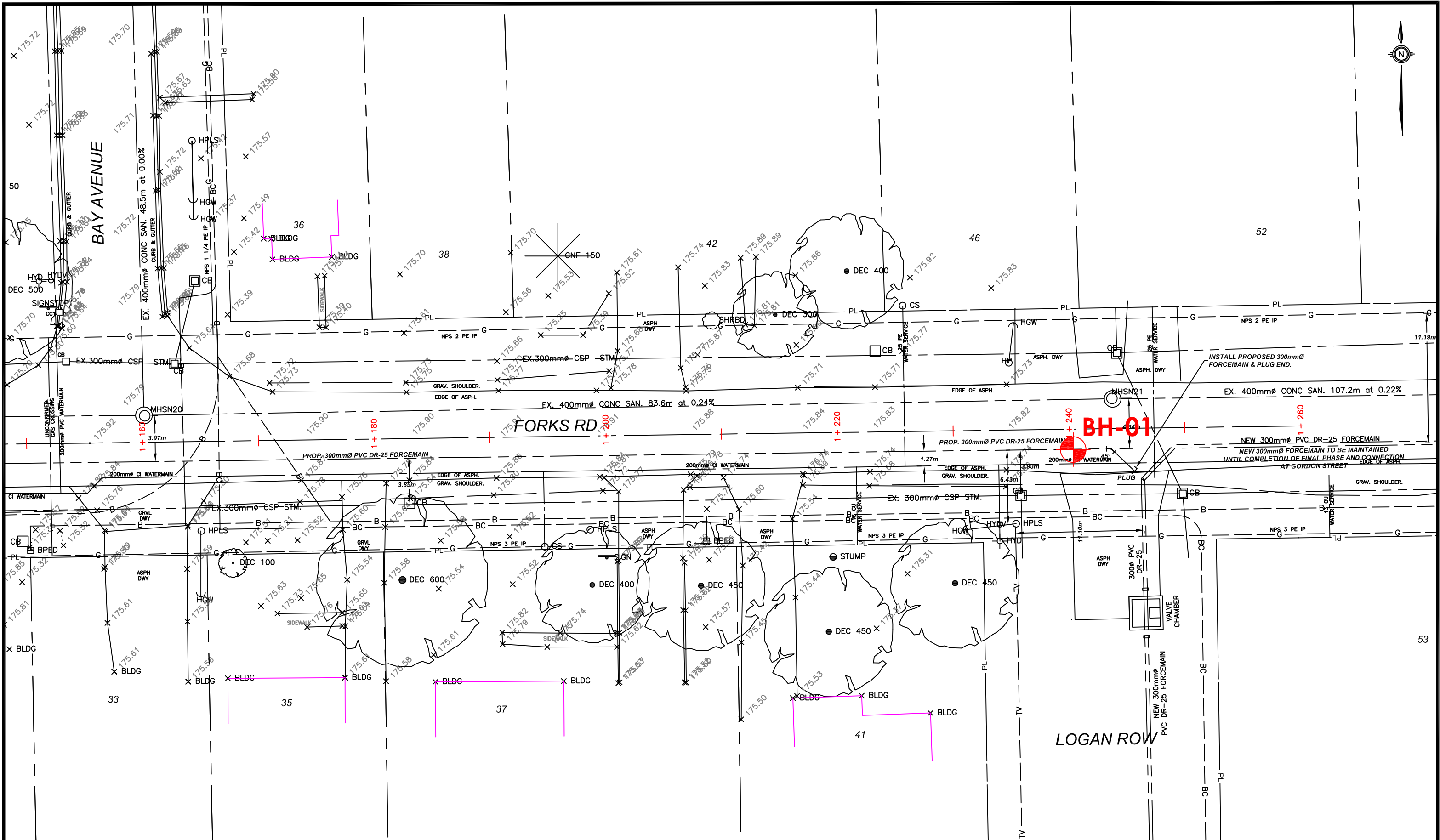


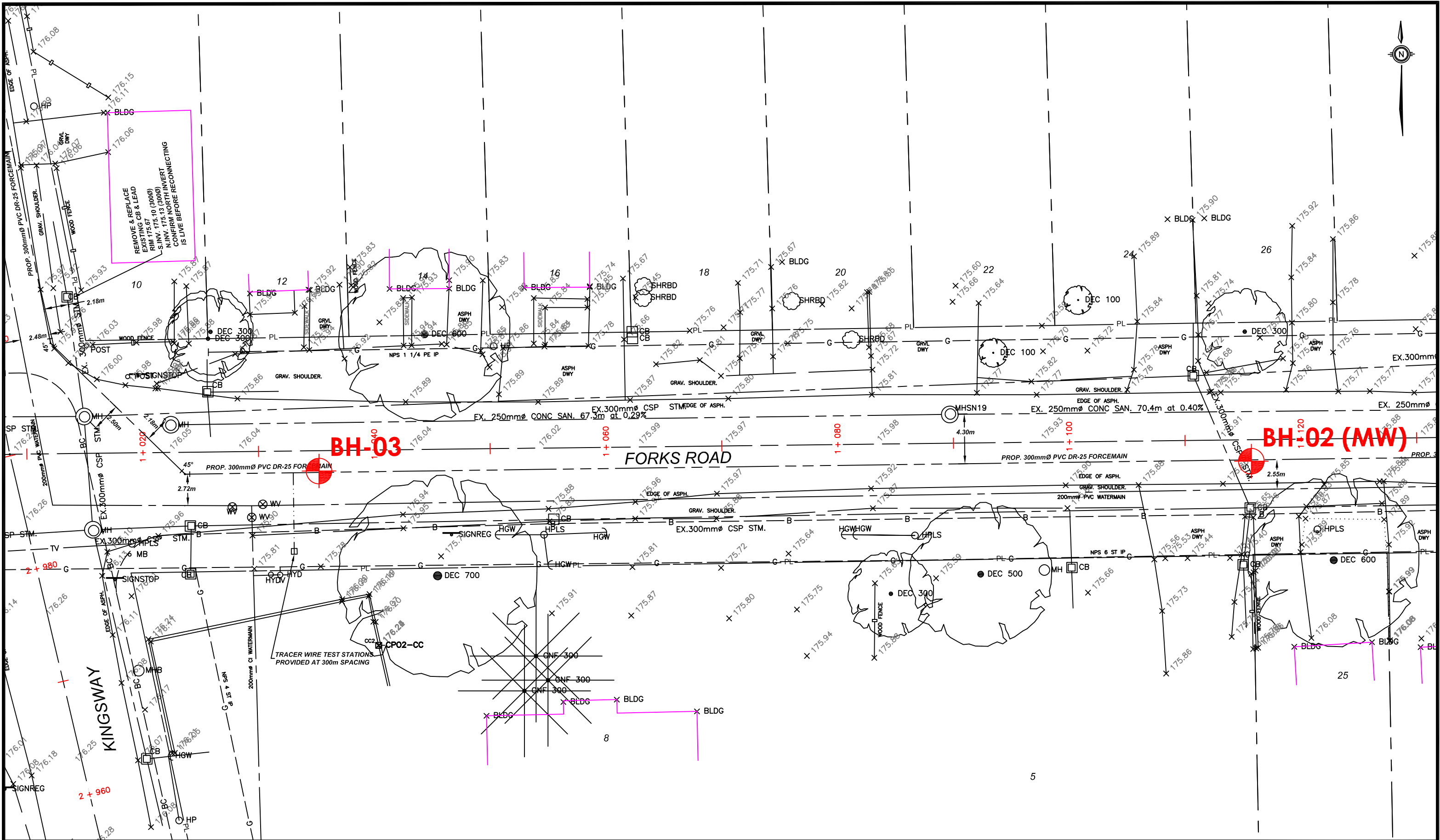
Stan Gonsalves, M.Eng., P.Eng.
Executive Vice President
MTO Designated Contact



Appendix A

Drawings & Borehole Logs

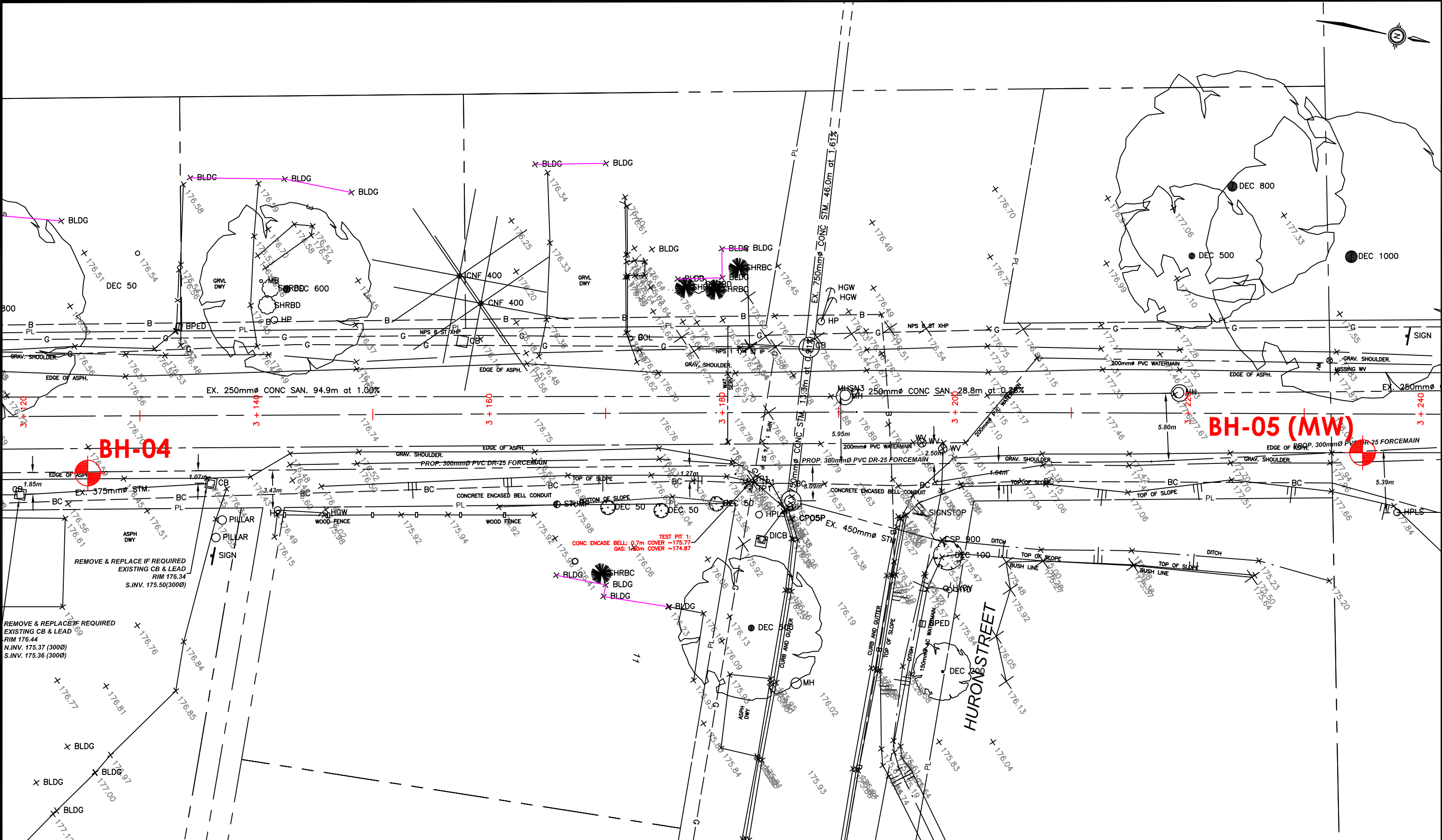




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LEGEND:
 APPROXIMATE BOREHOLE (MONITORING WELL) LOCATION

TITLE AND LOCATION: DAIN CITY SANITARY FORCEMAIN BOREHOLE LOCATION PLAN WELLAND, ON		JOB NO.: HAM-00801772-A0	DRAWN BY: DB
		SCALE: NTS	CHECKED BY: JG
		DATE: NOVEMBER 2019	DWG NO.: 1B



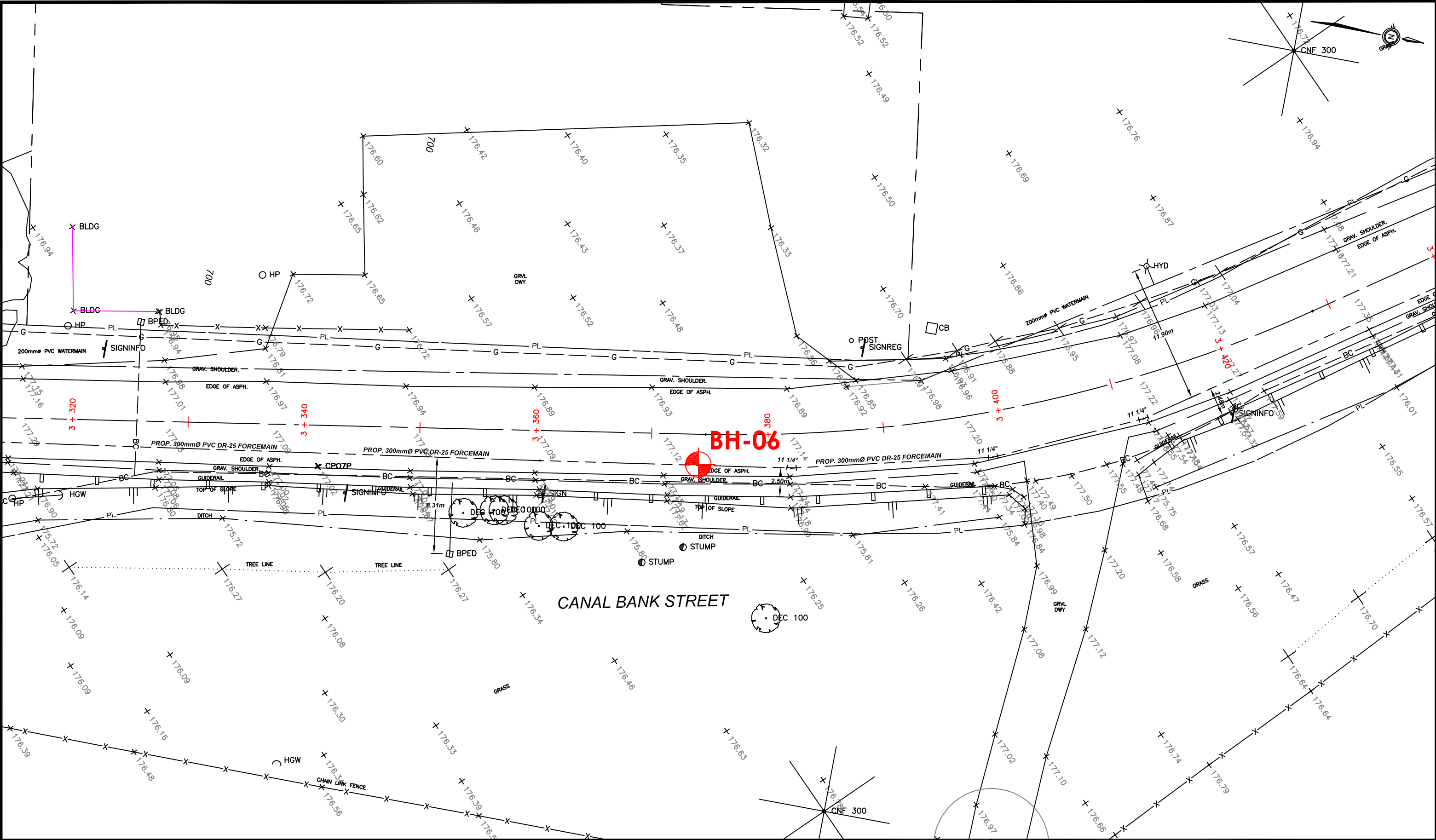
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LEGEND:
 APPROXIMATE BOREHOLE (MONITORING WELL) LOCATION

TITLE AND LOCATION:
DAIN CITY SANITARY FORCEMAIN
BOREHOLE LOCATION PLAN
WELLAND, ON

JOB NO.: HAM-00801772-A0	DRAWN BY: DB
SCALE: NTS	CHECKED BY: JG
DATE: NOVEMBER 2019	DWG NO.: 1C




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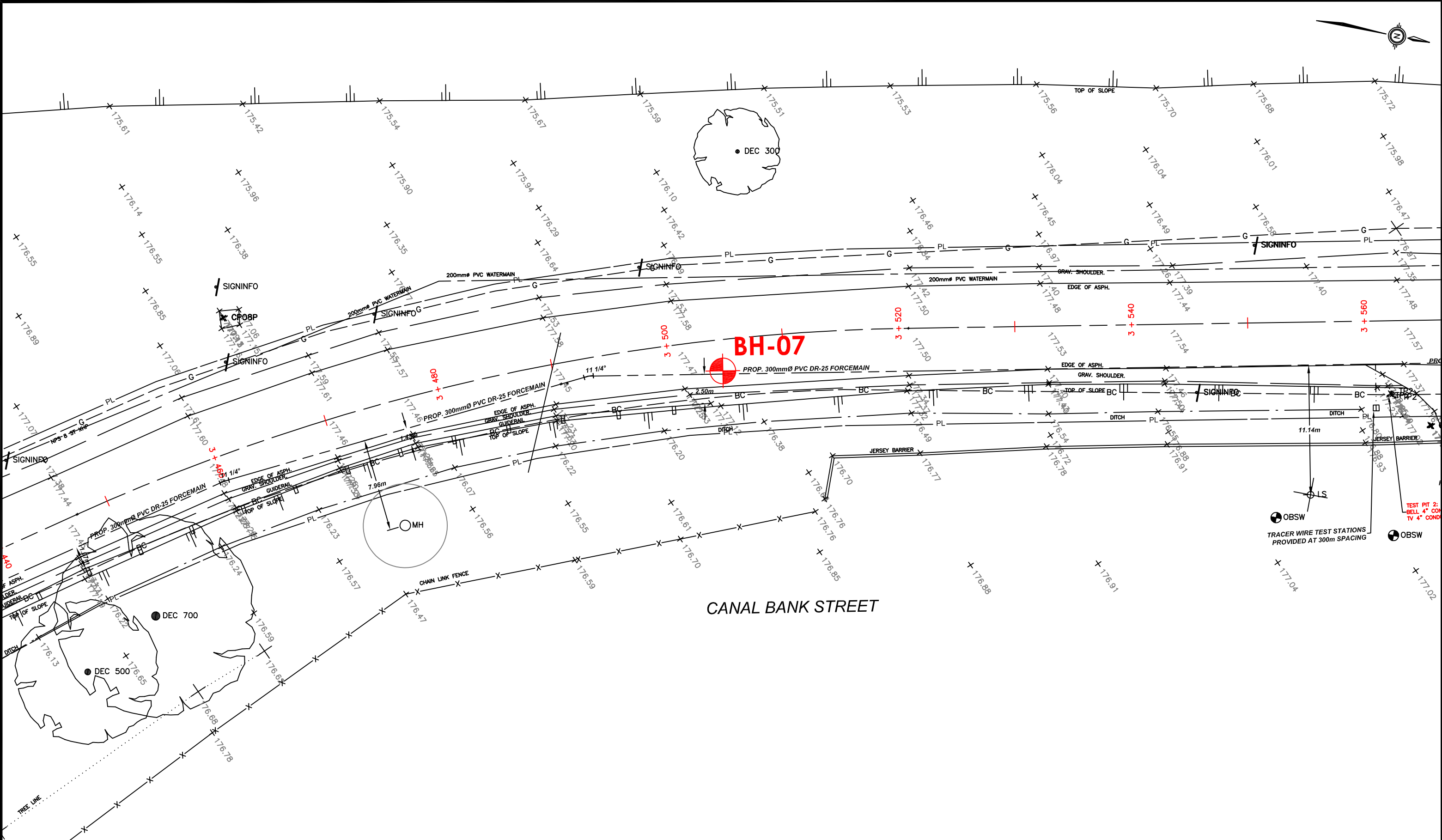
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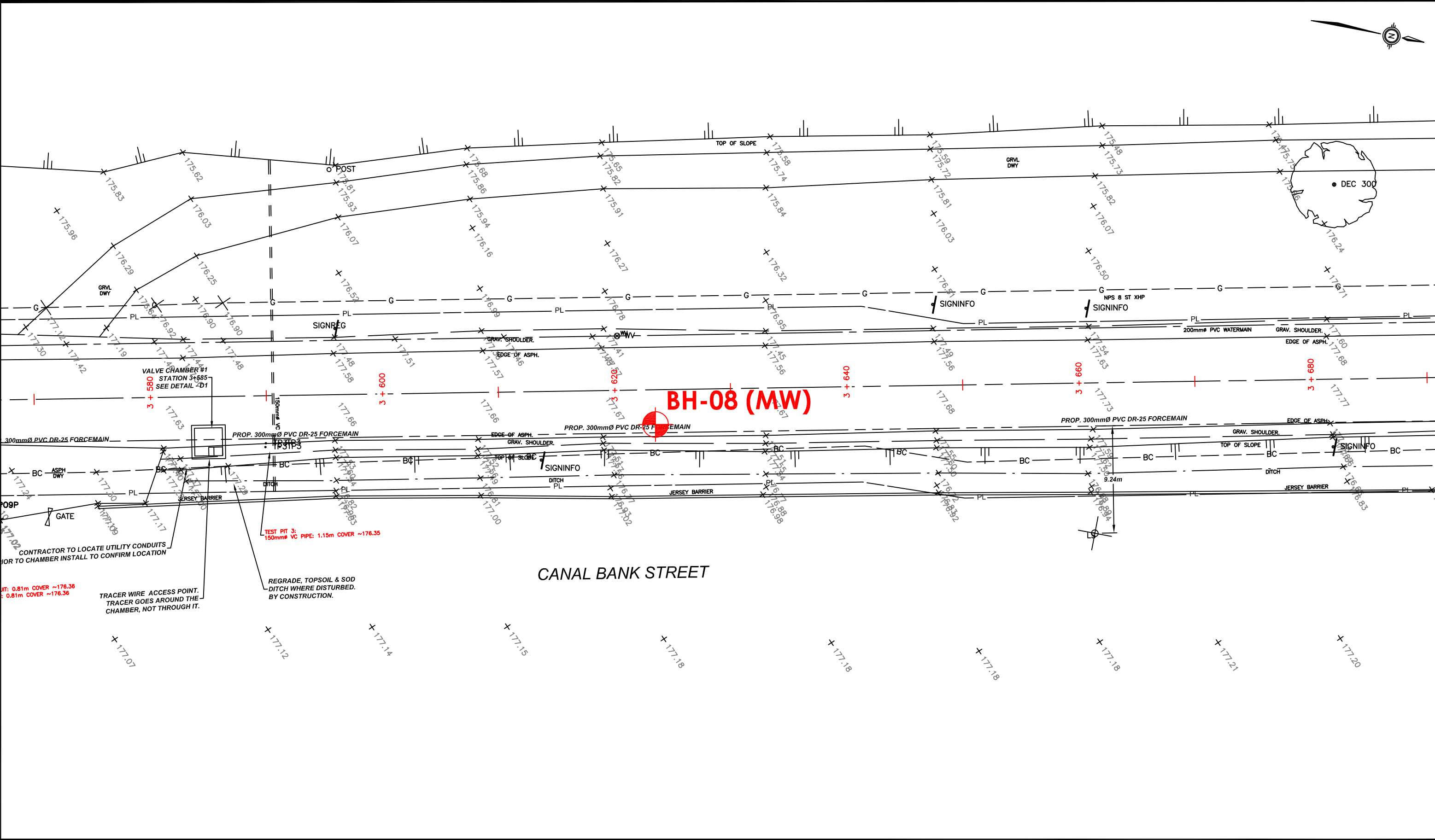
 APPROXIMATE BOREHOLE (MONITORING WELL) LOCATION

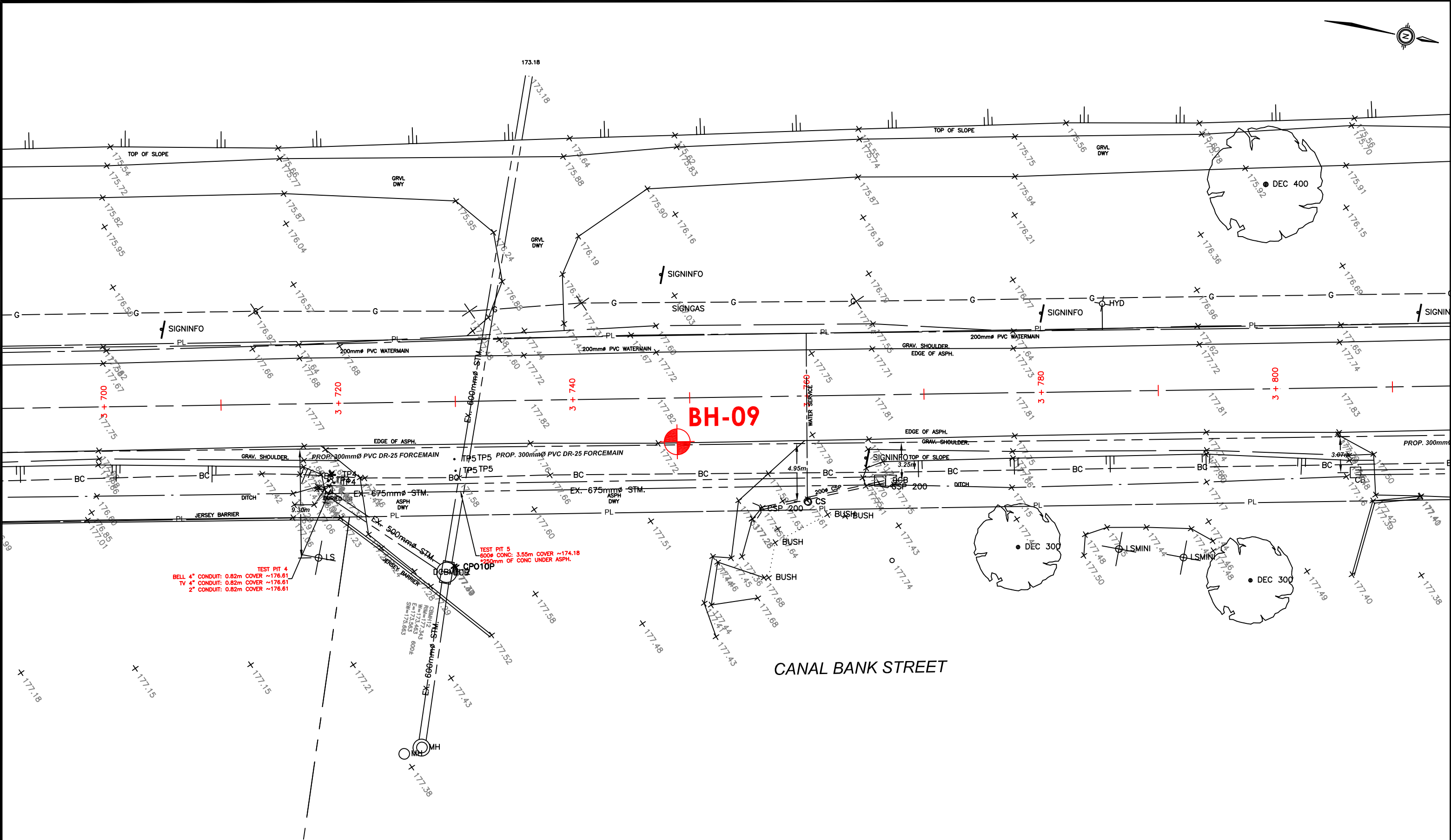
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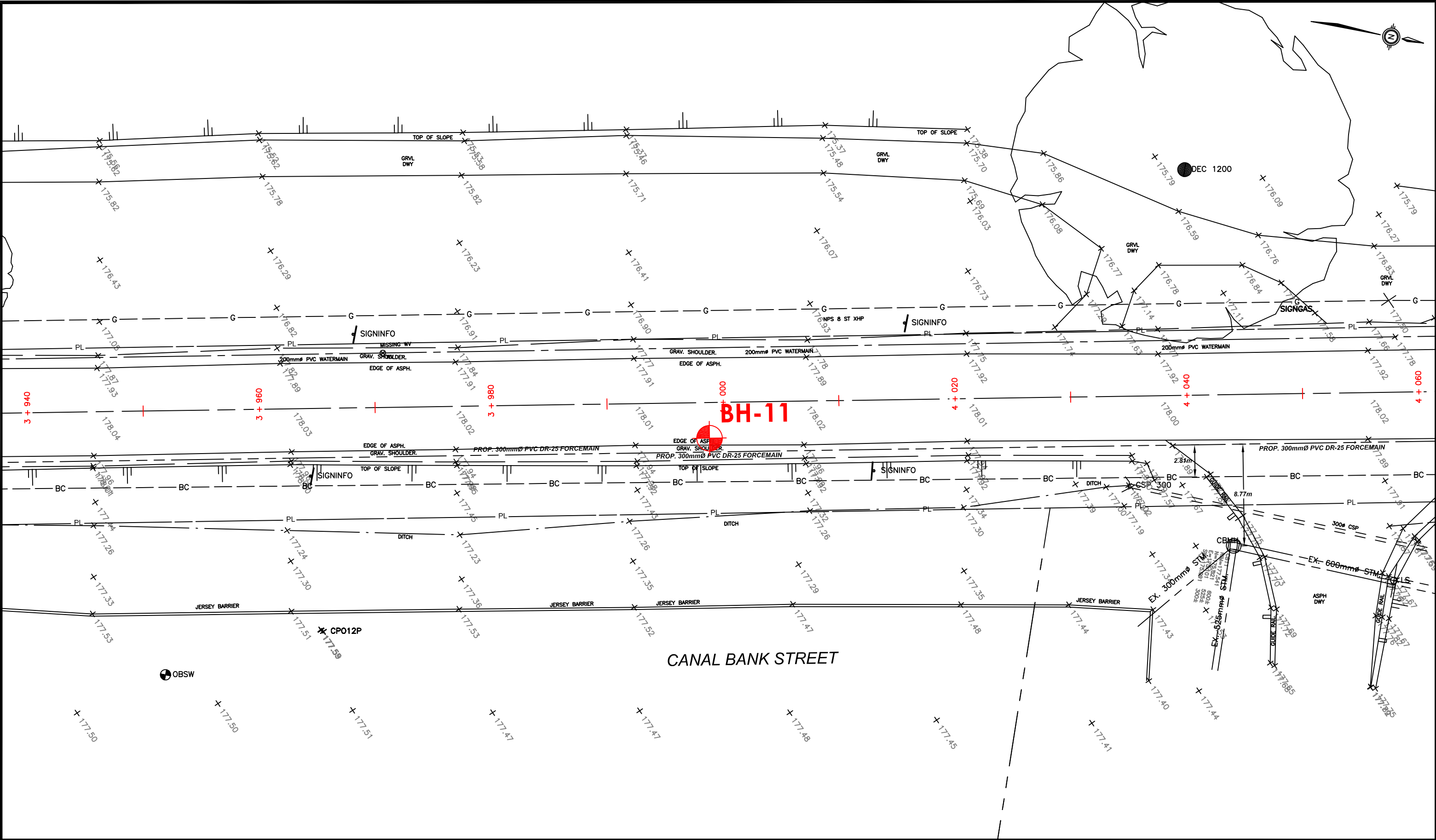
DAIN CITY SANITARY FORCEMAIN
BOREHOLE LOCATION PLAN
WELLAND, ON

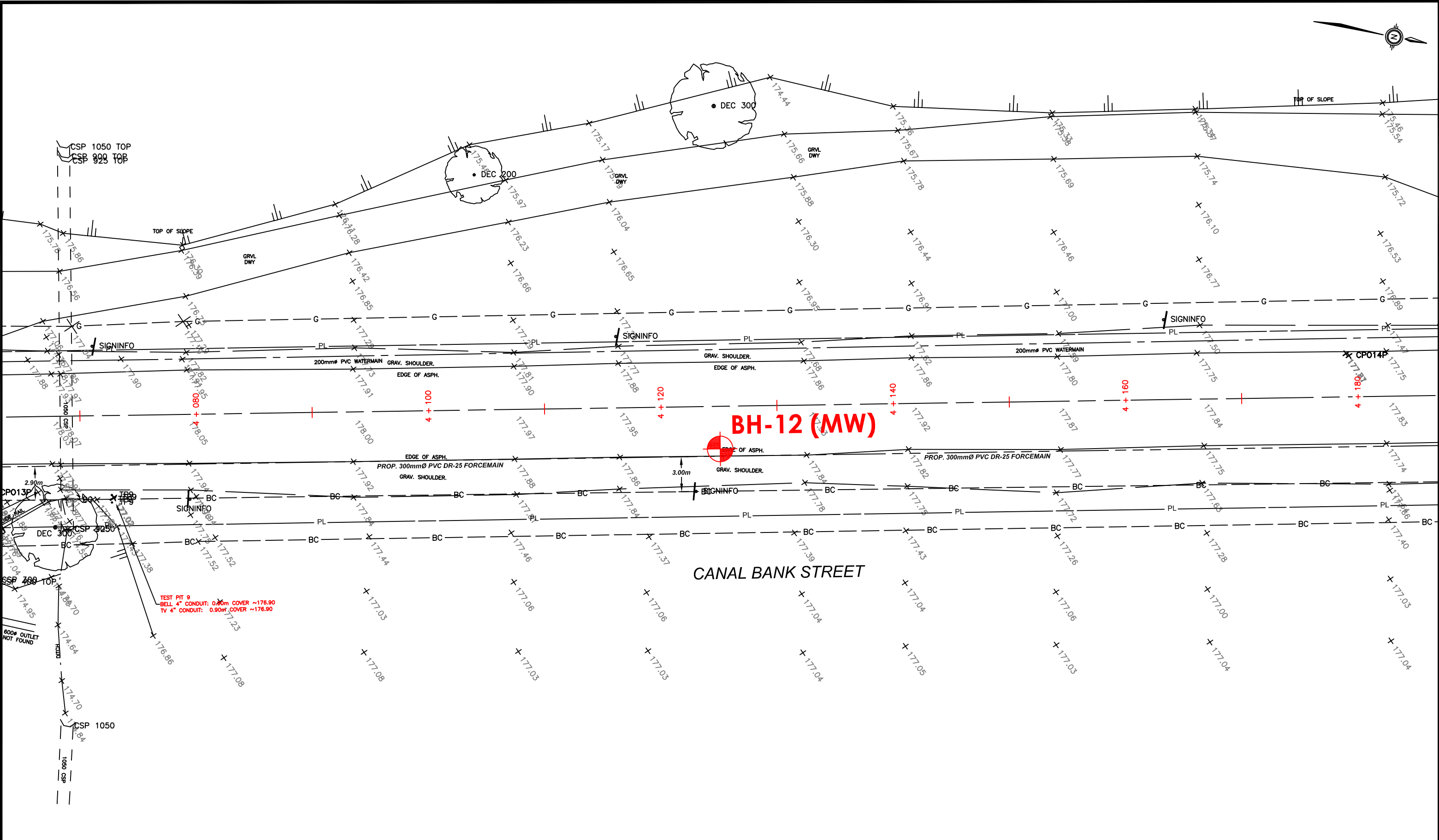
JOB NO.:	DRAWN BY:
HAM-00801772-A0	DB
SCALE:	CHECKED BY:
NTS	JG
DATE:	DWG NO.:
NOVEMBER 2019	1D

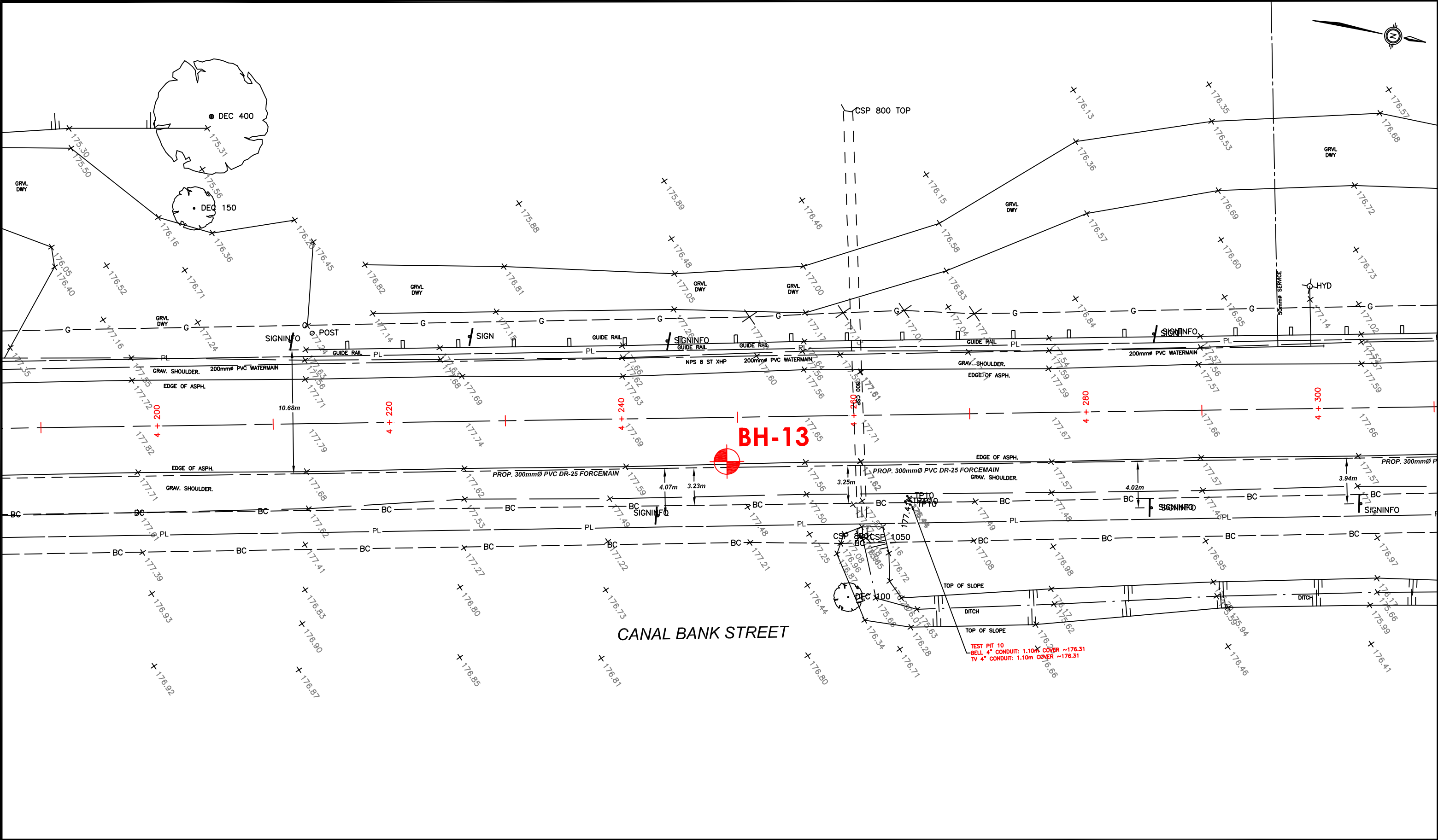


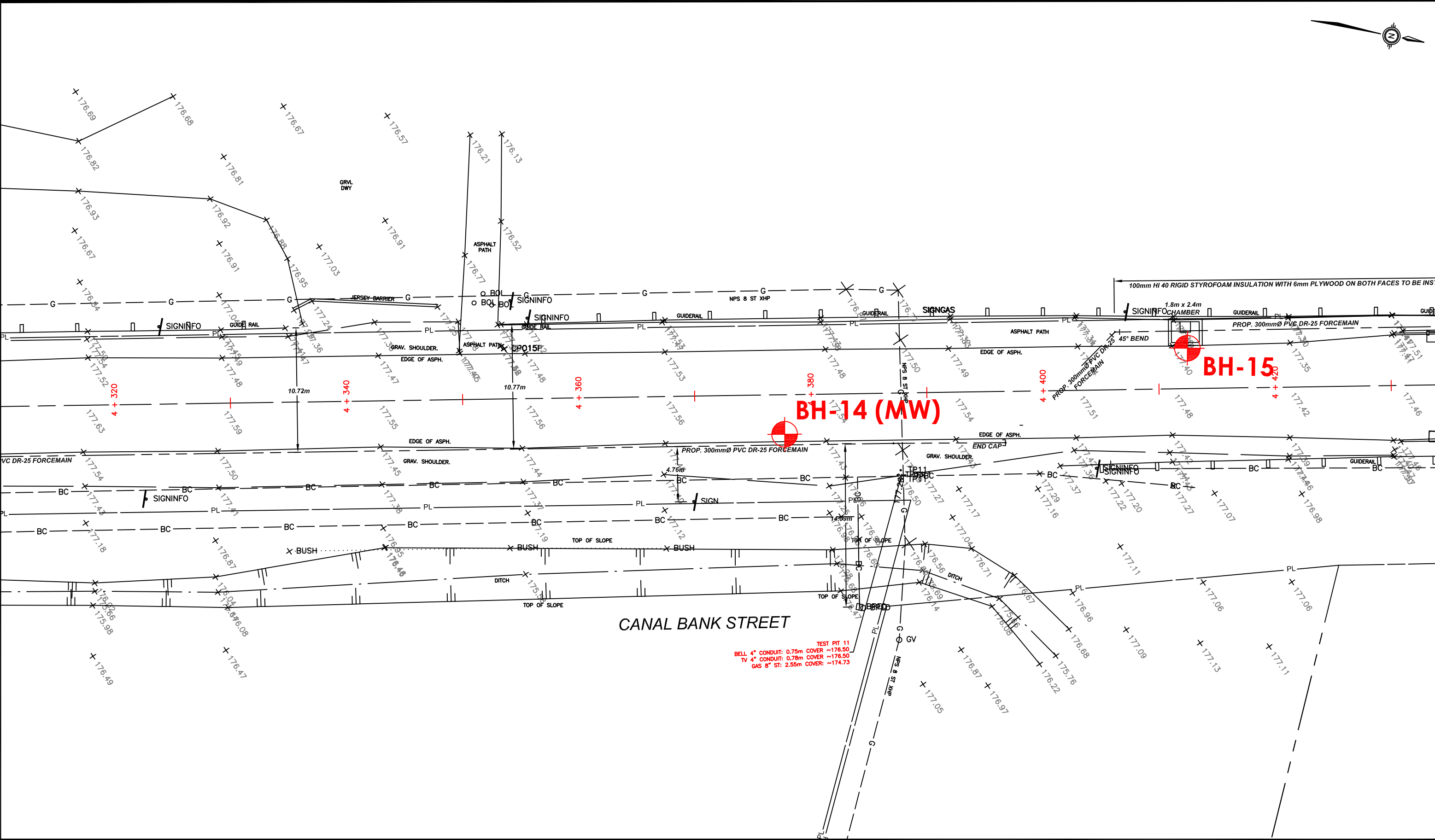












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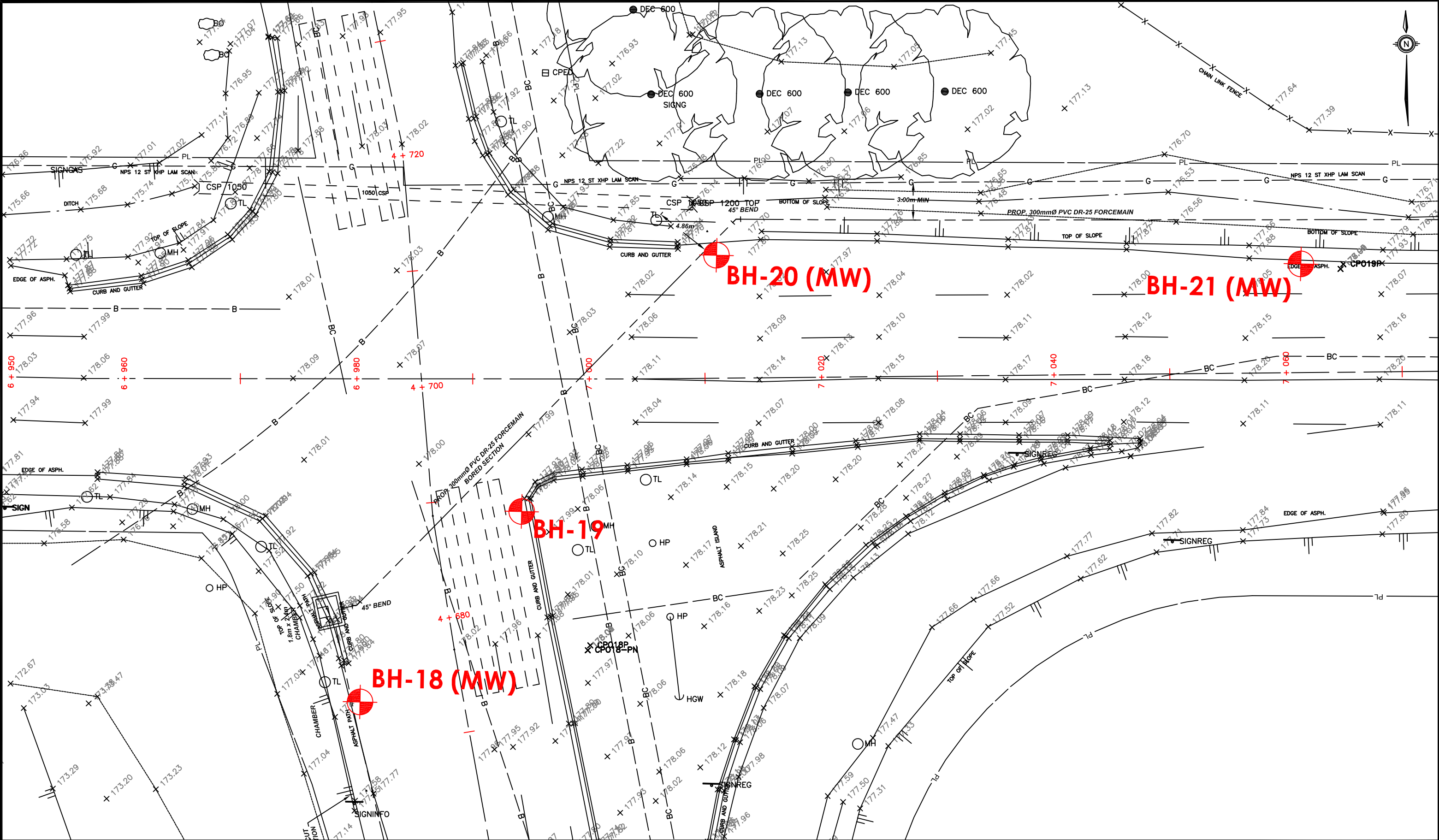
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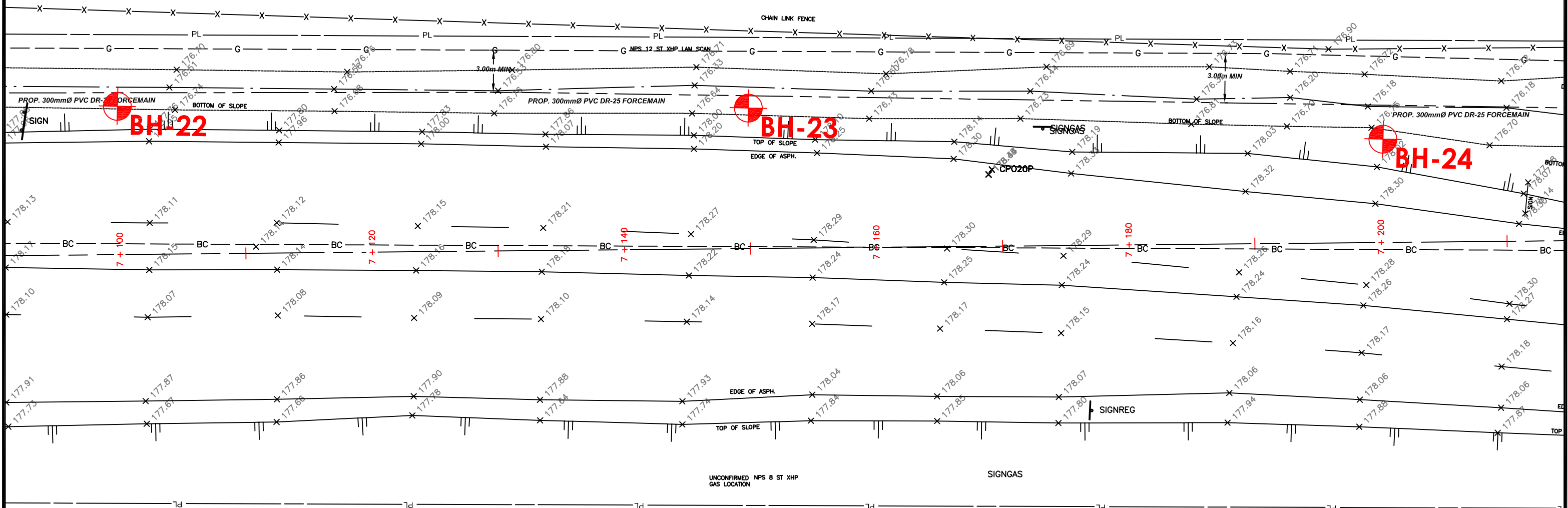
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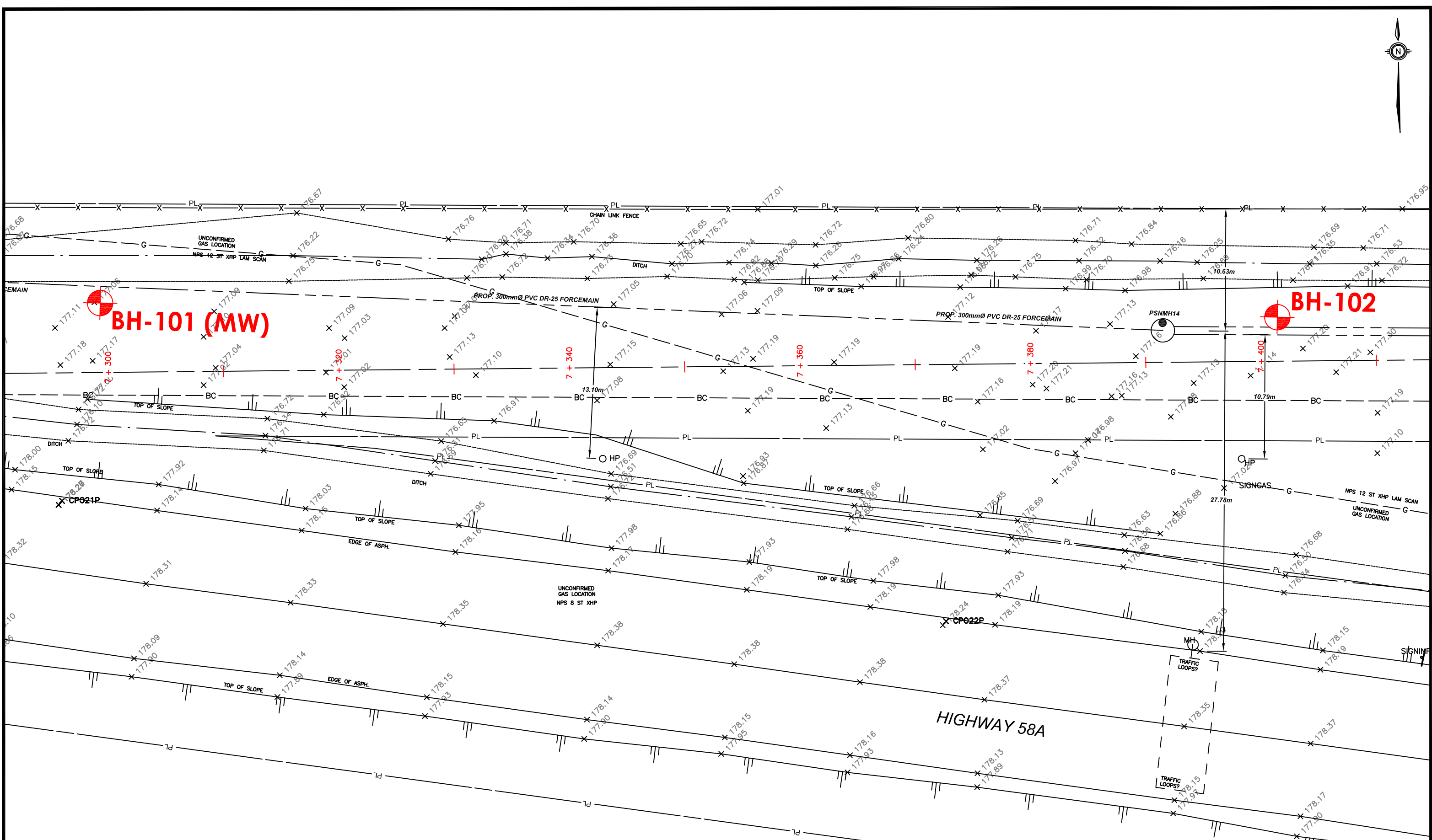
TITLE AND LOCATION:

DAIN CITY SANITARY FORCEMAIN
BOREHOLE LOCATION PLAN
WELLAND, ON

JOB NO.: HAM-00801772-A0	DRAWN BY: DB
SCALE: NTS	CHECKED BY: JG
DATE: NOVEMBER 2019	DWG NO.: 1L









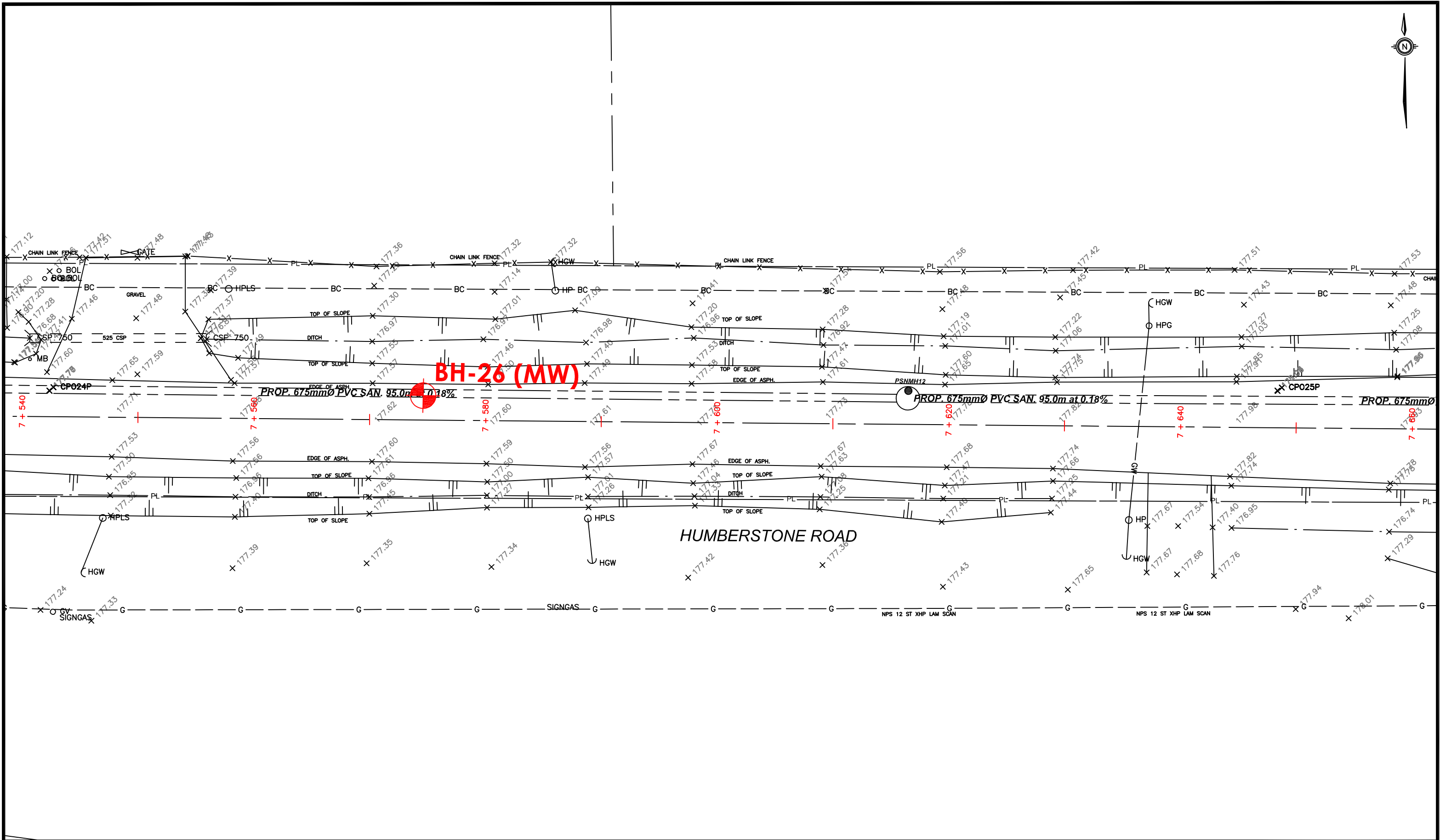
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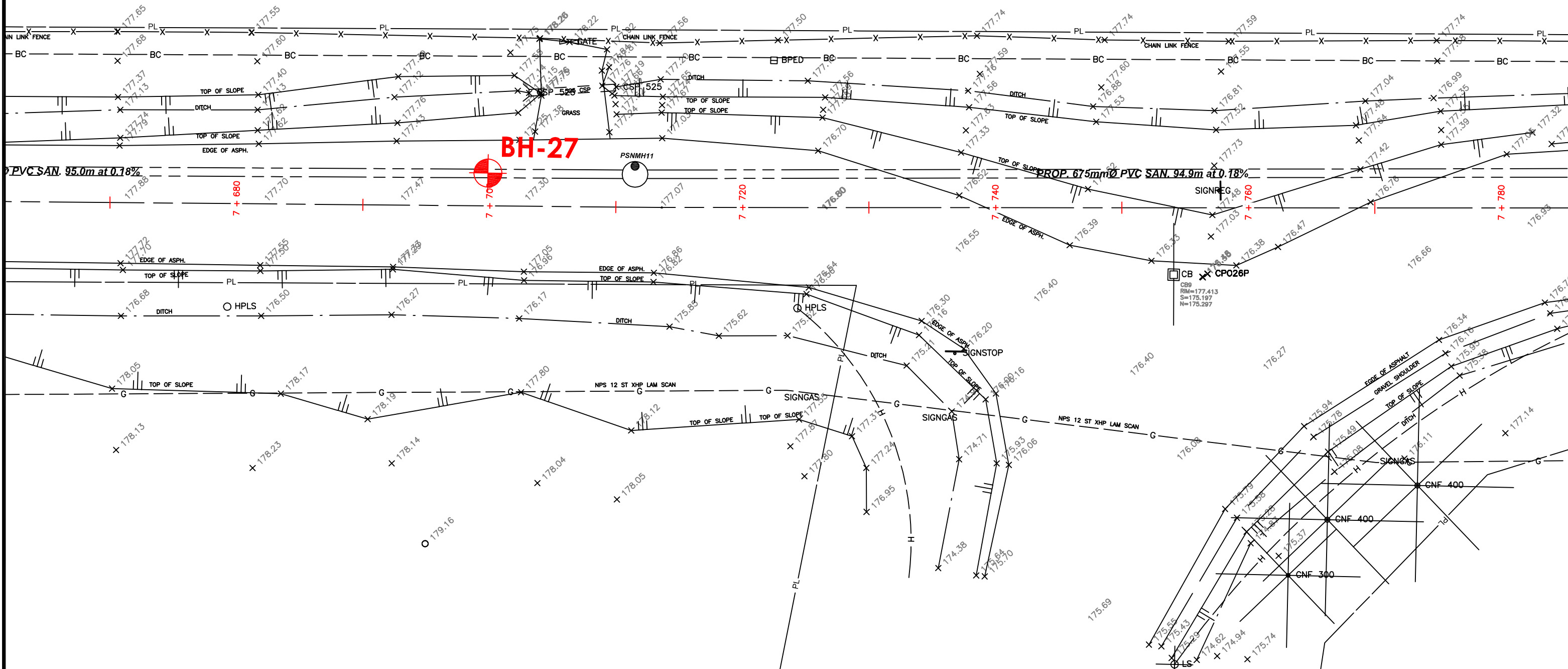
LEGEND:
 APPROXIMATE BOREHOLE (MONITORING WELL) LOCATION

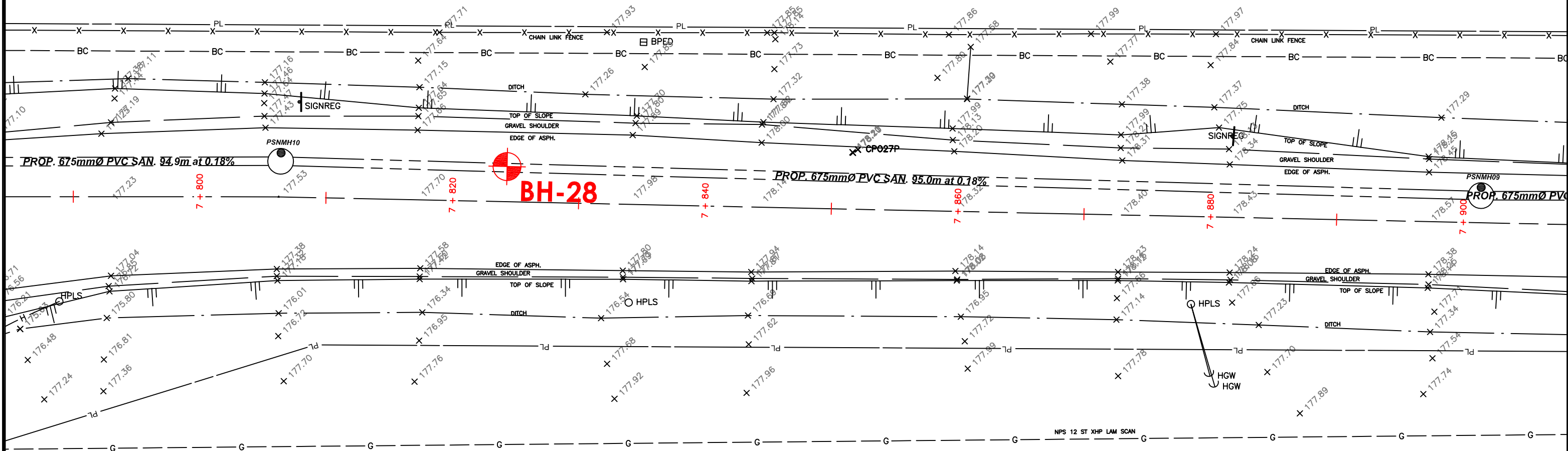
TITLE AND LOCATION:

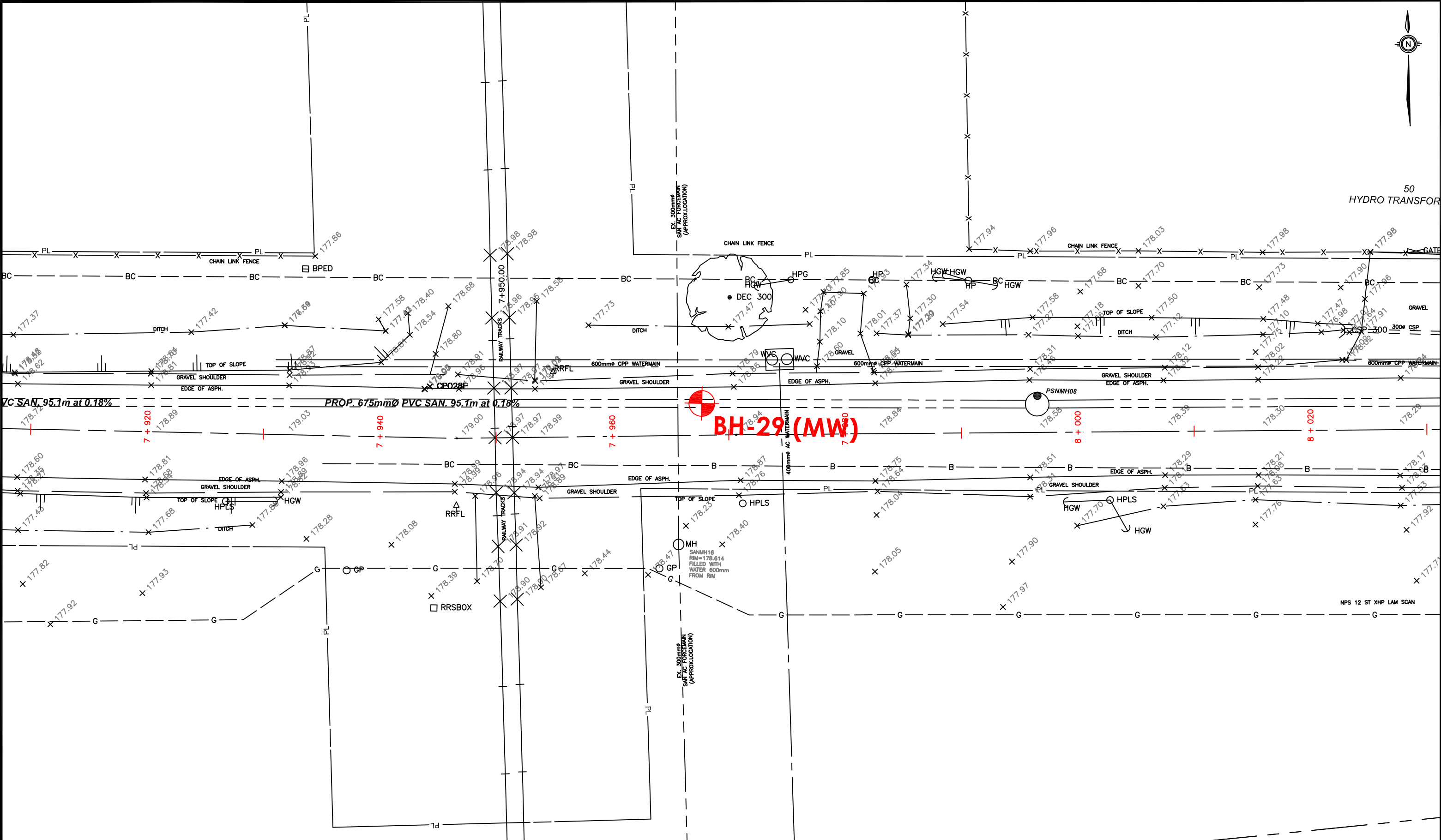
DAIN CITY SANITARY FORCEMAIN
BOREHOLE LOCATION PLAN
WELLAND, ON

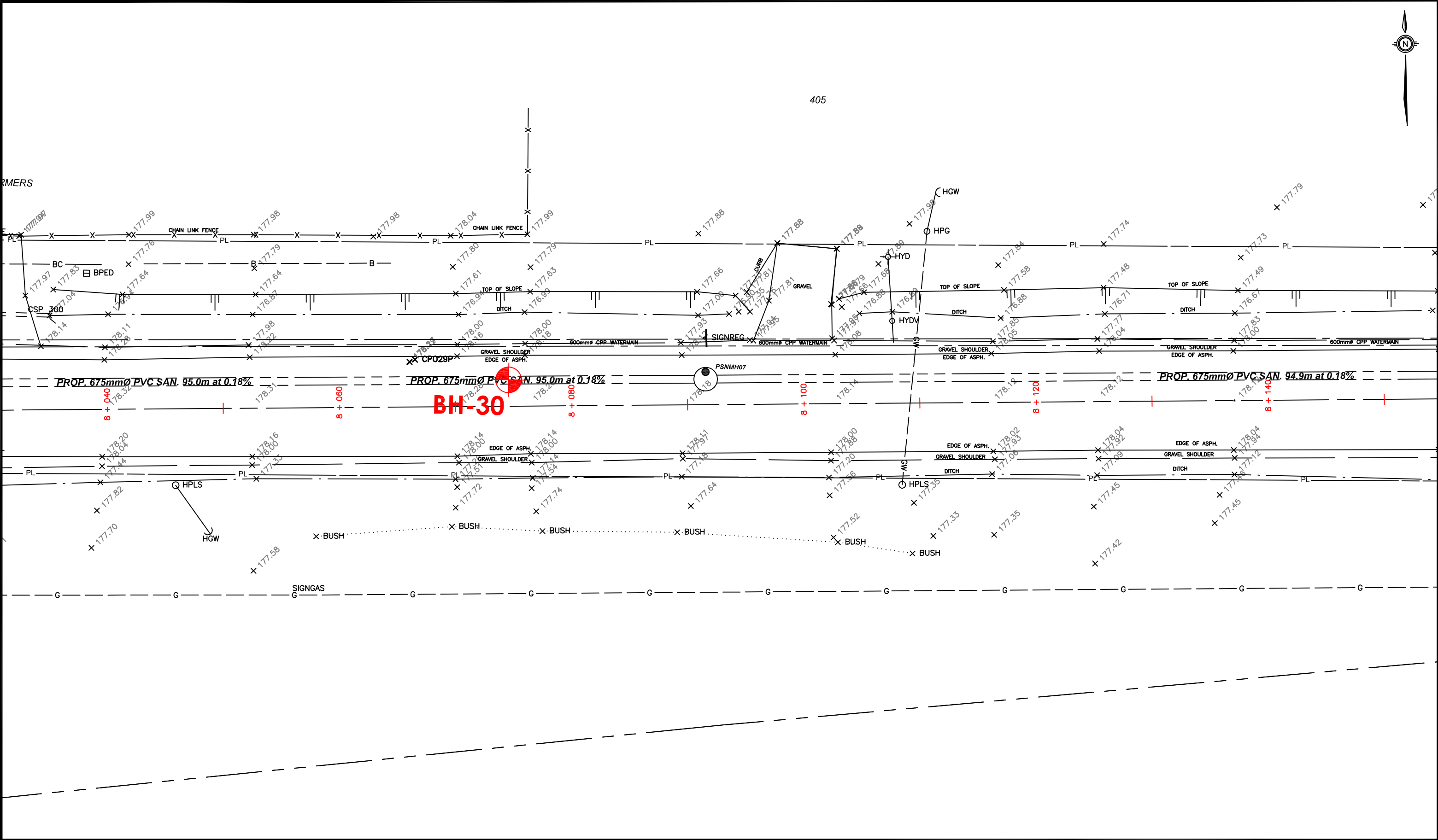
JOB NO.:	HAM-00801772-A0	DRAWN BY:	DB
SCALE:	NTS	CHECKED BY:	JG
DATE:	JANUARY 2020	DWG NO.:	1Q

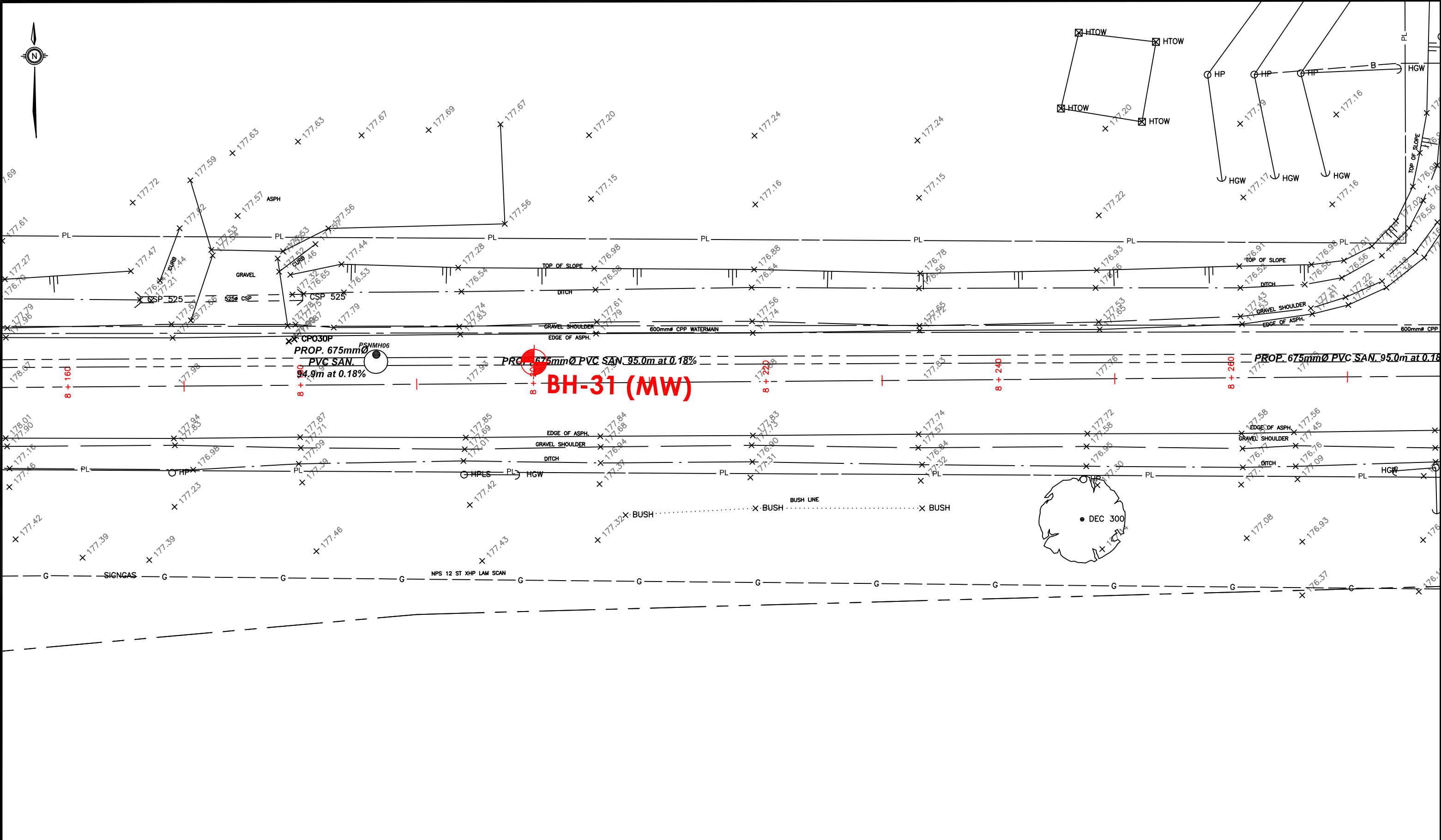


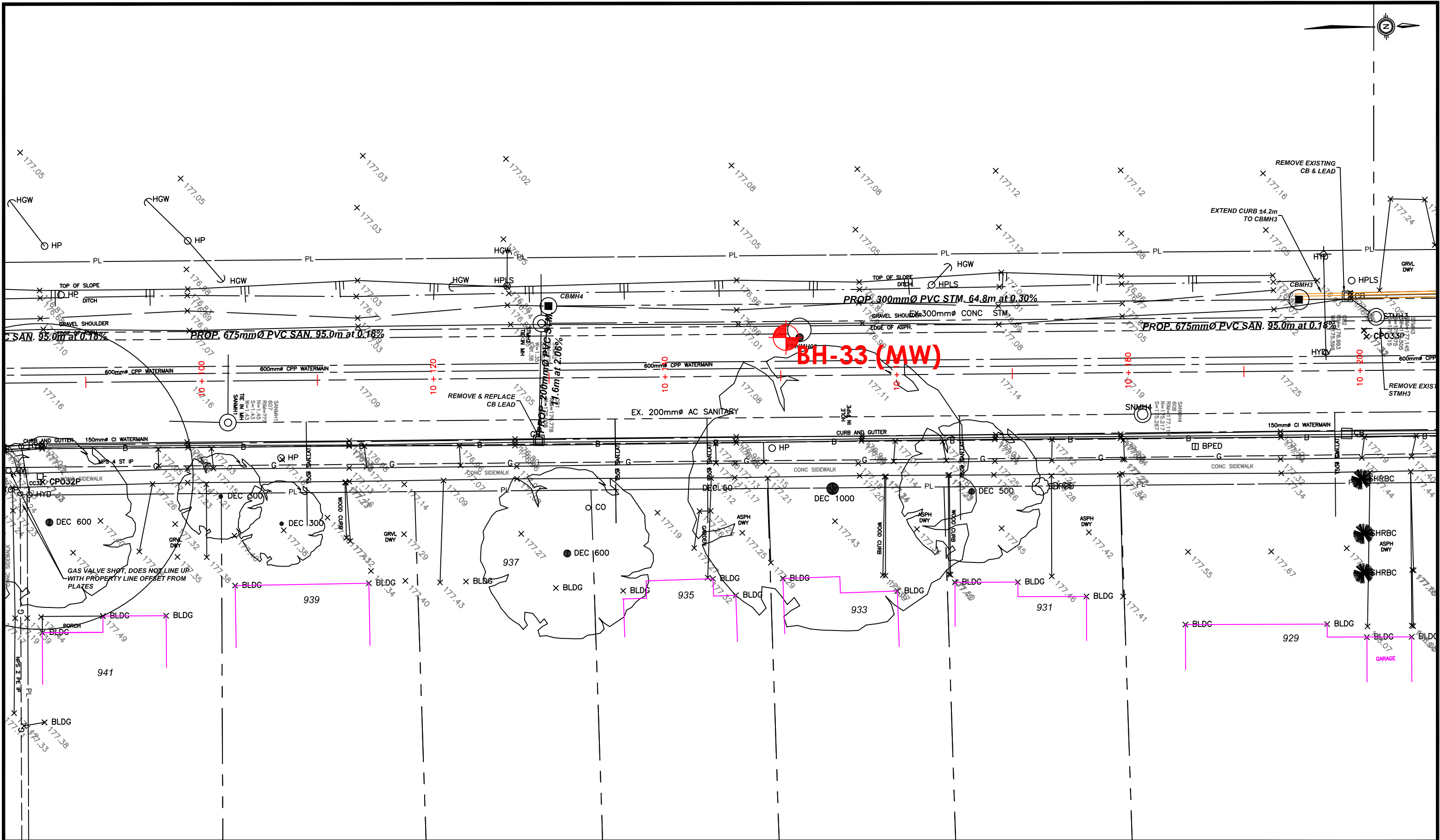












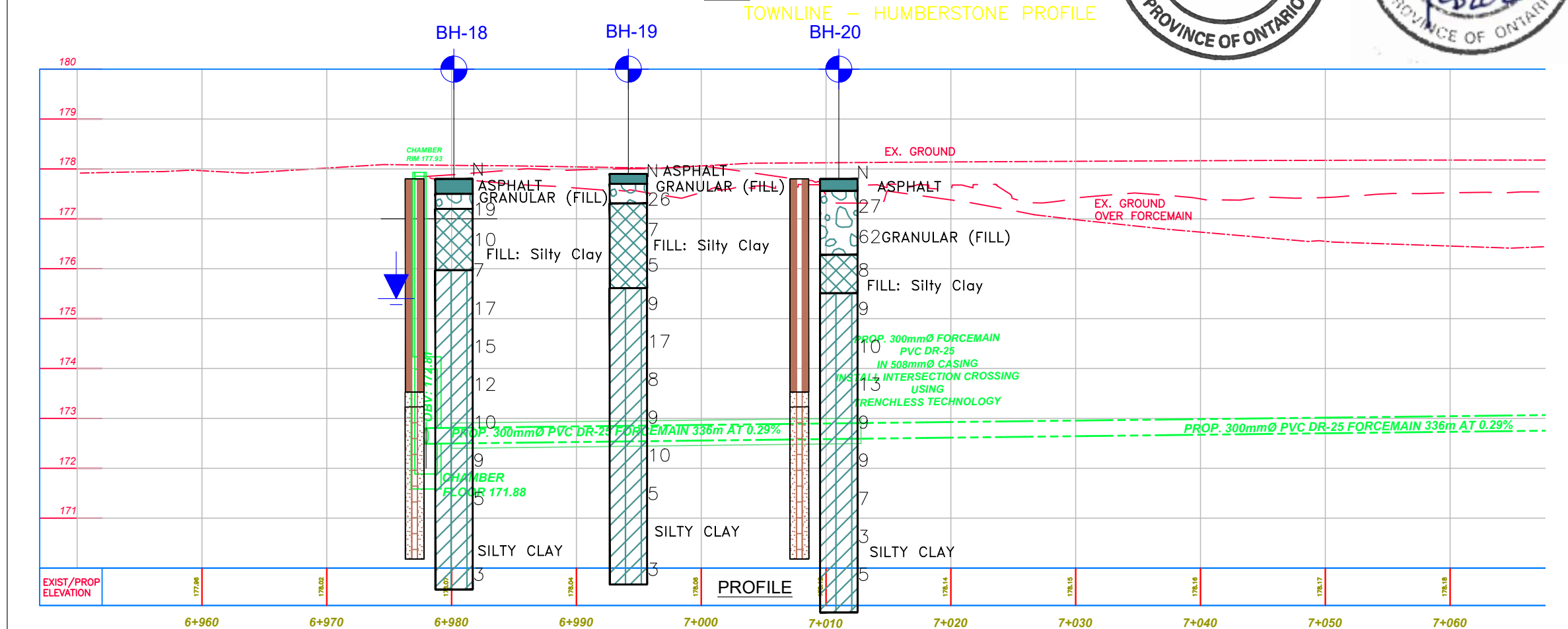
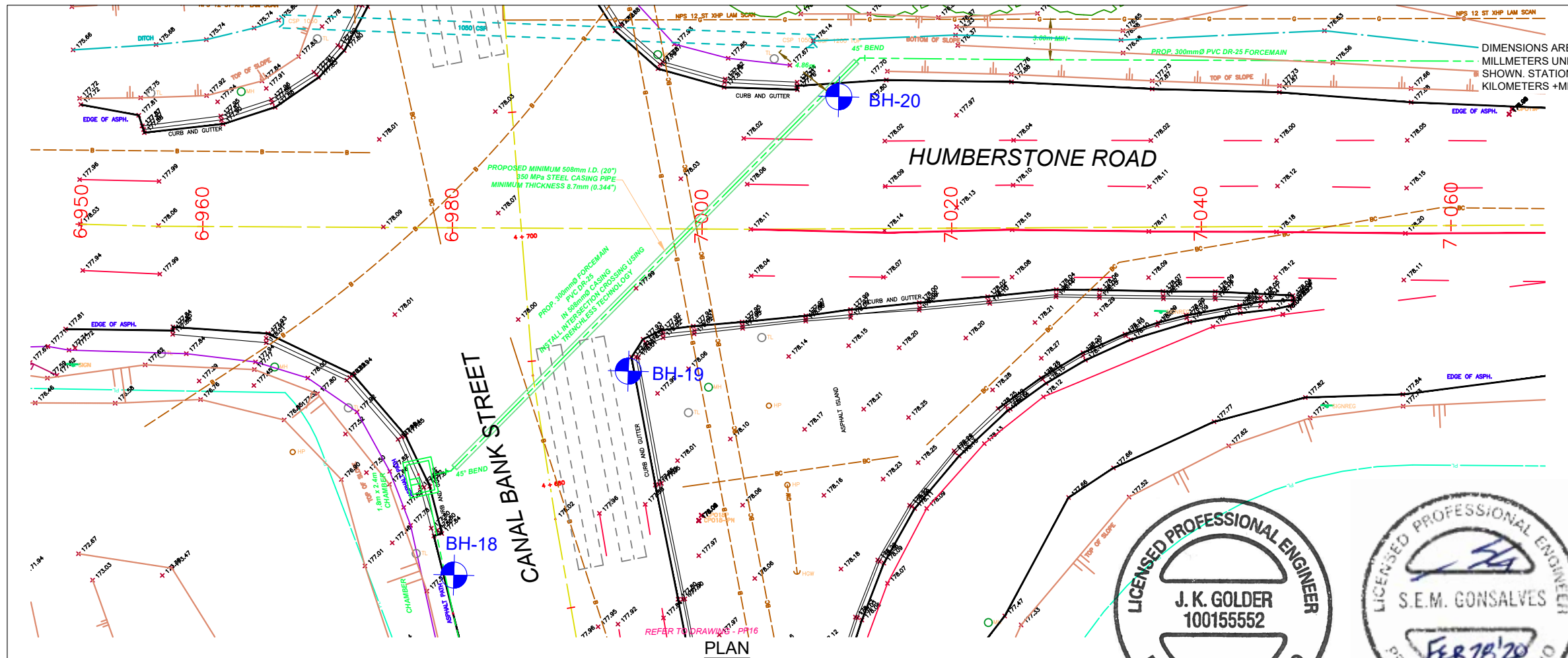


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LEGEND:
 APPROXIMATE BOREHOLE (MONITORING WELL) LOCATION

TITLE AND LOCATION:
**DAIN CITY SANITARY FORCEMAIN
BOREHOLE LOCATION PLAN
WELLAND, ON**

JOB NO.:	HAM-00801772-A0	DRAWN BY:	DB
SCALE:	NTS	CHECKED BY:	JG
DATE:	JANUARY 2020	DWG NO.:	12



METRIC
DIMENSIONS ARE IN METERS AND/OR
MILLIMETERS UNLESS OTHERWISE
SHOWN. STATIONS ARE IN
KILOMETERS +METERS

CONT. -
WP -

BOREHOLE LOCATION PLAN AND SOIL STRATA

18-020
DAIN CITY FORCEMAIN
PROPOSED FORCEMAIN LOCATION
CITY OF WELLAND

exp. EXP Services Inc.

KEY PLAN

LEGEND

Borehole Location

Standard Penetration Test (Blows/0.3 m)

Groundwater level measured in open hole

ASPHALT

GRANULAR FILL

FILL

SILTY CLAY

BH No.	ELEV. (m)	CO-ORDINATES/ ZONE UTM17	
		NORTHING	EASTING
BH-18	177.8	4758071.5	642552.8
BH-19	177.9	4758088.2	642566.3
BH-20	177.8	4758110.6	642582.6

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

SCALE: HOR 0 2 10 m
VERT 0 1 2 2.5 m

SUBMISSION FOR MTO REVIEW

DESCRIPTION

GEOCRES NO.

PROJECT NO. HAM-00801772-A0

SUBM'D SH

CHECKED -

DATE

Jan. 30, 2020

DRAWN SH

CHECKED -

APPROVED JG

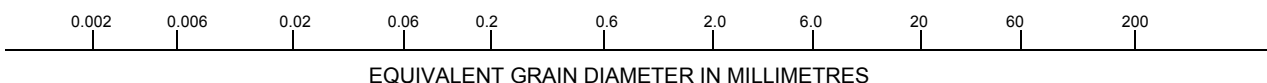
DWG. 1AA

Notes on Sample Descriptions

1. All sample descriptions included in this report follow the International Society for Soil Mechanics and Foundation Engineering (ISSMFE), as outlined in the Canadian Foundation Engineering Manual. Note, however, that behavioral properties (i.e. plasticity, permeability) take precedence over particle gradation when classifying soil. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

UNIFIED SOIL CLASSIFICATION

CLAY (PLASTIC) TO SILT (NONPLASTIC)	FINE	MEDIUM	CRS.	FINE	COARSE
	SAND			GRAVEL	



ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.
3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (75 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Notes On Soil Descriptions

4. The following table gives a description of the soil based on particle sizes. With the exception of those samples where grain size analyses have been performed, all samples are classified visually. The accuracy of visual examination is not sufficient to differentiate between this classification system or exact grain size.

Soil Classification		Terminology	Proportion
Clay and Silt	<0.060 mm	"trace" (e.g. Trace sand)	1% to 10%
Sand	0.060 to 2.0 mm	"some" (e.g. Some sand)	10% to 20%
Gravel	2.0 to 75 mm	adjective (e.g. sandy, silty)	20% to 35%
Cobbles	75 to 200 mm	"and" (e.g. and sand)	35% to 50%
Boulders	>200 mm		

The compactness of Cohesionless soils and the consistency of the cohesive soils are defined by the following:

Cohesionless Soil		Cohesive Soil		
Compactness	Standard Penetration Resistance "N" Blows / 0.3 m	Consistency	Undrained Shear Strength (kPa)	Standard Penetration Resistance "N" Blows / 0.3 m
Very Loose	0 to 4	Very soft	<12	<2
Loose	4 to 10	Soft	12 to 25	2 to 4
Compact	10 to 30	Firm	25 to 50	4 to 8
Dense	30 to 50	Stiff	50 to 100	8 to 15
Very Dense	Over 50	Very Stiff	100 to 200	15 to 30
		Hard	>200	>30

5. ROCK CORING

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundness of the rock mass. It is obtained from the rock cores by summing the length of the core covered, counting only those pieces of sound core that are 100 mm or more length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

RQD Classification	RQD (%)
Very Poor Quality	<25
Poor Quality	25 to 50
Fair Quality	50 to 75
Good Quality	75 to 90
Excellent Quality	90 to 100




$$\text{Recovery Designation \% Recovery} = \frac{\text{Length of Core Per Run}}{\text{Total Length of Run}} \times 100$$

RECORD OF BOREHOLE No BH-01

1 OF 1

METRIC

W.P. _____ LOCATION STA 1+240 Forks Road ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.23 - 2019.10.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20					40	60	80				
175.6	Road Surface																						
175.6 0.1	ASPHALT: (~110 mm thick) GRANULAR FILL: (~800 mm thick) Macadam layer encountered within the granular fill		1	SS	69/ 250 mm		175																
174.7 0.9	FILL: silty clay, trace sand, greyish brown, very moist		2	SS	9		174																
			3	SS	9																		
173.3 2.3	SILTY CLAY: trace sand, brown, moist, hard wet, stiff to very stiff below 3.1 m grey below 4.6 m		4	SS	17		173																
			5	SS	9		172																
			6	SS	3		171																
170.1 5.5	Borehole terminated at 5.5 m depth NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.			VANE																			

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-02

1 OF 1

METRIC

W.P. _____ LOCATION STA 1+116 Forks Road ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.23 - 2019.10.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×					
175.9	Road Surface						20	40	60	80	100						
175.8	ASPHALT: (~150 mm thick)		1	SS	50/ 100 mm												
0.2	GRANULAR FILL: (~410 mm thick)																
175.3	Macadam layer encountered within the granular fill																
0.6	FILL: silty clay, trace sand, greyish brown, moist, black organic staining and odour		2	SS	8												
174.4																	
1.5	SILTY CLAY: trace sand, brown, moist, very stiff to hard		3	SS	10												
			4	SS	16												
	wet, stiff below 3.1 m		5	SS	10												
			6	SS	6												
			7	SS	4												
169.2																	
6.7	Borehole terminated at 6.7 m depth																
NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 2.7 m depth on November 8, 2019 and 2.8 m depth on January 23, 2020.																	

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-03

1 OF 1

METRIC

W.P. _____ LOCATION STA 1+035 Forks Road ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.23 - 2019.10.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
176.0	Road Surface																
175.9	ASPHALT: (~150 mm thick)																
0.2	GRANULAR FILL: (~430 mm thick)		1	SS	50/ 100 mm												
175.4	180 mm thick Macadam layer encountered within the granular fill at a depth of 0.3 m.																
0.6	FILL: silty clay, trace sand, grey, moist, black organic staining and odour		2	SS	9												
174.5																	
1.5	SILTY CLAY: trace sand, brown, moist, hard trace rootlets at 1.5 m		3	SS	15												
			4	SS	14												
	very moist, very stiff below 3.1 m																
			5	SS	10												
	wet, stiff below 4.6 m																
			6	SS	5												
	grey below 6.1 m																
			7	SS	2												
				VANE													
169.0																	
7.0	Borehole terminated at 7.0 m depth																
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-04

1 OF 1

METRIC

W.P. _____ LOCATION STA 3+126 Kingsway ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.22 - 2019.10.22 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
176.7	Road Surface							20	40	60	80	100					
176.3	ASPHALT: (~170 mm thick)																
0.2	GRANULAR FILL: (~1600 mm thick)		1	SS	14		176										
			2	SS	9												
174.9							175										
1.8	FILL: silty clay, trace sand, brown, moist		3	SS	3												
174.4																	
2.3	SILTY CLAY: trace sand, brown, very moist, very stiff		4	SS	11		174										
			5	SS	12		173										
							172										
			6	SS	3												
							171										
			7	SS	2												
							170										
169.7																	
7.0	Borehole terminated at 7.0 m depth																
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole caved at 1.5 m depth.																

ONTARIO MTO LOGS MTO.GPJ ONTARIO MTO.GDT 2/10/20

RECORD OF BOREHOLE No BH-06

1 OF 1

METRIC

W.P. _____ LOCATION STA 3+374 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.23 - 2019.10.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×					
177.1	Road Surface						20	40	60	80	100	20	40	60			
0.0	ASPHALT: (~300 mm thick)																
176.8																	
0.3	GRANULAR FILL: (~550 mm thick) Possible macadam layer within the granular fill		1	SS	50/ 100 mm												
176.3																	
0.9	FILL: silty clay, trace sand, grey, very moist, black organic staining and odour		2	SS	12												
175.6																	
1.5	SILTY CLAY: trace sand, brown, moist, hard		3	SS	14												
			4	SS	13												
	very moist, very stiff below 3.1 m		5	SS	12												
	wet, stiff below 4.6 m		6	SS	5												
	grey below 6.1 m		7	SS	3												
170.1																	
7.0	Borehole terminated at 7.0 m depth			VANE													
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																

ONTARIO MTO LOGS MTO.GPJ ONTARIO MTO.GDT 2/10/20

RECORD OF BOREHOLE No BH-07

1 OF 1

METRIC

W.P. _____ LOCATION STA 3+505 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.23 - 2019.10.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)					
177.4	Road Surface						20	40	60	80	100						
0.0	ASPHALT: (~300 mm thick)																
177.1																	
0.3	GRANULAR FILL: (~900 mm thick) Possible macadam layer within the granular fill		1	SS	50/100 mm												
			2	SS	50/100 mm												
176.2																	
1.2	SILTY CLAY: trace sand, brown, moist, hard																
			3	SS	12								○				
			4	SS	11								○				
	very moist, very stiff below 3.1 m																
			5	SS	14								○				
	wet, stiff below 4.6 m		6	SS	5									○			
	grey below 6.1 m		7	SS	4									○			
170.4																	
7.0	Borehole terminated at 7.0 m depth			VANE													
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																

ONTARIO MTO LOGS MTO.GPJ ONTARIO MTO.GDT 2/10/20

RECORD OF BOREHOLE No BH-08

1 OF 1

METRIC

W.P. _____ LOCATION STA 3+624 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.24 - 2019.10.24 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE					
								WATER CONTENT (%)								
177.6	Road Surface						20	40	60	80	100	20	40	60		
0.0	ASPHALT: (~290 mm thick)															
177.3																
0.3	GRANULAR FILL: (~800 mm thick)															
	Possible macadam layer within the granular fill		1	SS	32											
176.5																
1.1	SILTY CLAY: trace sand, greyish brown, moist, hard		2	SS	7											
			3	SS	17											
			4	SS	13											
	wet, very stiff below 3.1 m		5	SS	10											

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-09

1 OF 1

METRIC

W.P. _____ LOCATION STA 3+745 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.24 - 2019.10.24 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa														
								○ UNCONFINED	+	FIELD VANE												
								● QUICK TRIAXIAL	×	LAB VANE												
177.7	Road Surface						20	40	60	80	100											
0.0	ASPHALT: (~290 mm thick)																					
177.4																						
0.3	GRANULAR FILL: (~780 mm thick) Possible macadam layer within the granular fill		1	SS	87/ 250 mm																	
176.6																						
1.1	SILTY CLAY: trace sand, greyish brown, moist, hard		2	SS	5																	
			3	SS	18																	
			4	SS	14																	
			5	SS	11																	
			6	SS	3																	
			7	SS	2																	
170.7																						
7.0	Borehole terminated at 7.0 m depth			VANE																		
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																					

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-10

1 OF 1

METRIC

W.P. _____ LOCATION STA 3+875 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.24 - 2019.10.24 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE												
177.9	Road Surface							20	40	60	80	100											
0.0	ASPHALT: (~290 mm thick)																						
177.6	GRANULAR FILL: (~940 mm thick)																						
0.3	Possible macadam layer within the granular fill		1	SS	66																		
			2	SS	50/ 100 mm																		
176.7	SILTY CLAY: trace sand, greyish brown, moist, hard		3	SS	12																		
1.2			4	SS	15																		
	very moist, very stiff below 3.1 m		5	SS	14																		
			6	SS	5																		
	wet, stiff below 4.6 m		7	SS	2																		
	grey below 6.1 m																						
170.9	Borehole terminated at 7.0 m depth			VANE																			
7.0	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 4.6 m depth on November 8, 2019 and 2.5 m depth on January 23, 2020.																						




+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-101

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+299 ORIGINATED BY DB
 DIST Welland HWY _____ BOREHOLE TYPE Marooka Track Mount. Hollow Stem. COMPILED BY DB
 DATUM Geodetic DATE 2019.12.23 - 2019.12.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	20	40	60						80	100	20
177.1 0.0	FILL: silty clay, trace sand and gravel, greyish brown, moist, black organic staining and odour		1	SS	7		177													
176.3 0.8																				
very stiff below 3.1 m			2	SS	13		176													
	3		SS	17																
	4		SS	10																
	5		SS	9																
			6	SS	9															
			7	SS	8															
172.0 5.0	Borehole terminated at 5.0 m depth																			
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 0.6 m depth on January 23, 2020.																			



+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-102

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+401 ORIGINATED BY DB
 DIST Welland HWY _____ BOREHOLE TYPE Marooka Track Mount. Hollow Stem. COMPILED BY DB
 DATUM Geodetic DATE 2019.12.23 - 2019.12.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE												
						20	40	60	80	100	20	40	60							
177.2	0.0		1	SS	7		177													
	greyish brown, very moist, rootlets below 0.8 m		2	SS	13		176													
			3	SS	17		175													
174.8	2.4		4	SS	10			174												
	SILTY CLAY: trace sand, greyish brown, moist, hard		5	SS	9			173												
			6	SS	9															
			7	SS	8															
	grey, very stiff below 3.8 m																			
172.2	5.0																			
	Borehole terminated at 5.0 m depth																			
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																			

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-11

1 OF 1

METRIC

W.P. _____ LOCATION STA 3+999 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.24 - 2019.10.24 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE															
177.9	Road Surface							20	40	60	80	100											
0.0	ASPHALT: (~250 mm thick)																						
177.7																							
0.3	GRANULAR FILL: (~660 mm thick) Possible macadam layer within the granular fill		1	SS	74/ 250 mm																		
177.0																							
0.9	FILL: silty clay, trace sand, grey, moist, black organic staining and odour		2	SS	8																		
176.4																							
1.5	SILTY CLAY: trace sand, greyish brown, moist, very stiff to hard		3	SS	17																		
			4	SS	12																		
			5	SS	12																		
	very moist, stiff below 4.6 m		6	SS	3																		
	grey, wet below 6.1 m		7	SS	3																		
170.9																							
7.0	Borehole terminated at 7.0 m depth			VANE																			
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																						

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-12

1 OF 1

METRIC

W.P. _____ LOCATION STA 4+125 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.24 - 2019.10.24 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×					
177.8	Road Surface						20	40	60	80	100						
170.0	ASPHALT: (~130 mm thick)																
0.1	GRANULAR FILL: (~400 mm thick)		1	SS	8												
177.3	FILL: silty clay, trace sand, grey, moist, black organic staining and odour																
0.5			2	SS	4												
176.3	SILTY CLAY: trace sand, greyish brown, moist, hard very moist, very stiff below 3.1 m grey, wet, stiff below 4.6 m		3	SS	10												
1.5																	
			4	SS	14												
			5	SS	12												
			6	SS	4												
			7	SS	3												
				VANE													
170.8																	
7.0	Borehole terminated at 7.0 m depth																
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 4.9 m depth on November 8, 2019.																

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-13

1 OF 1

METRIC

W.P. _____ LOCATION STA 4+249 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.24 - 2019.10.24 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE									○		
								● QUICK TRIAXIAL × LAB VANE											
177.6	Road Surface						20	40	60	80	100								
0.0	ASPHALT: (~200 mm thick)																		
177.4																			
0.2	GRANULAR FILL: (~400 mm thick)																		
177.0			1	SS	22														
0.6	FILL: silty clay, trace sand, grey, very moist, black organic staining and odour, rootlets																		
			2	SS	7														
176.1																			
1.5	SILTY CLAY: trace sand, greyish brown, moist, hard		3	SS	9														
			4	SS	13														
			5	SS	13														
	grey, very moist, stiff below 4.6 m		6	SS	4														
				VANE															
172.1																			
5.5	Borehole terminated at 5.5 m depth																		
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																		

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-14

1 OF 1

METRIC

W.P. _____ LOCATION STA 4+378 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.25 - 2019.10.25 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
177.4	Road Surface							20	40	60	80	100					
0.0 177.2	ASPHALT: (~235 mm thick)																
0.2	GRANULAR FILL: (~450 mm thick)																
176.7			1	SS	21		177										
0.7	FILL: silty clay, trace sand, greyish brown, moist, occasional black organic staining		2	SS	7												
175.9							176										
1.5	SILTY CLAY: trace sand, brown, moist, very stiff to hard		3	SS	10												
			4	SS	12		175										
	wet, stiff below 3.1 m																
			5	SS	6		174										
							173										
	grey below 4.6 m		6	SS	3												
				VANE													
171.9							172										
5.5	Borehole terminated at 5.5 m depth																
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 3.9 m depth on November 8, 2019 and 1.4 m depth on January 23, 2020.																

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-15

1 OF 1

METRIC

W.P. _____ LOCATION STA 4+412 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.25 - 2019.10.25 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20					40	60	80				
177.4 0.1	Road Surface ASPHALT: (~60 mm thick) GRANULAR FILL: (~1100 mm thick)		1	SS	22																		
176.2 1.2	SILTY CLAY: trace sand, brown, moist, hard		2	SS	15																		
			3	SS	15																		
			4	SS	12																		
	very moist, very stiff below 3.1 m		5	SS	9																		
			6	SS	4																		
	grey, stiff below 4.6 m			VANE																			
171.9 5.5	Borehole terminated at 5.5 m depth NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																						

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-16

1 OF 1

METRIC

W.P. _____ LOCATION STA 4+617 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.25 - 2019.10.25 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×						LAB VANE		
177.5	Road Surface							20	40	60	80	100								
0.0	ASPHALT: (~230 mm thick)																			
177.3																				
0.2	GRANULAR FILL: (~500 mm thick)		1	SS	12															
176.8																				
0.7	FILL: silty clay, trace sand, grey, moist, black organic staining and odour		2	SS	8															
175.7			3	SS	8															
1.8	SILTY CLAY: trace sand, brown, moist, hard		4	SS	14															
	very stiff below 3.1 m		5	SS	11															
	very moist, stiff below 4.6 m		6	SS	3															
				VANE																
172.0																				
5.5	Borehole terminated at 5.5 m depth																			
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 1.3 m depth on November 8, 2019.																			

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-17

1 OF 1

METRIC

W.P. _____ LOCATION STA 4+646 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.25 - 2019.10.25 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20					40	60	80				
177.6	Shoulder Surface																						
0.0	GRANULAR FILL: (~600 mm thick)		1	SS	22																		
177.0	FILL: silty clay, trace sand and gravel, brown, moist, occasional black organic staining		2	SS	9																		
175.9	SILTY CLAY: trace sand, brown, moist, hard		3	SS	12																		
1.7	sand and gravel seams at 2.3 m		4	SS	17																		
	very moist, very stiff below 3.1 m		5	SS	14																		
																							
																							
172.4	Borehole terminated at 5.2 m depth		6	SS	12																		
5.2	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																						

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-18

1 OF 1

METRIC

W.P. _____ LOCATION STA 4+673 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.12.23 - 2019.12.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×						LAB VANE		
177.8	Road Surface							20	40	60	80	100								
0.0	ASPHALT: (~300 mm thick)																			
177.5																				
0.3	GRANULAR FILL: (~300 mm thick)																			
177.2																				
0.6	FILL: silty clay, trace sand and gravel, greyish brown, moist, black organic staining, rootlets		1	SS	19		177													
			2	SS	10															
176.0			3	SS	7		176													
1.8	SILTY CLAY: trace sand, brown, moist, hard																			
			4	SS	17		175													
	very stiff below 3.1 m		5	SS	15															
			6	SS	12		174													
			7	SS	10		173													
	stiff below 5.3 m		8	SS	9		172													
	wet below 6.1 m		9	SS	5		171													
				VANE																
	soft below 7.6 m																			
			10		3		170													
169.6	Borehole terminated at 8.2 m depth																			
8.2	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 2.4 m depth on January 23, 2020.																			















+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-19

1 OF 1

METRIC

W.P. _____ LOCATION STA 4+688 Canal Bank Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.12.23 - 2019.12.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
177.9	Road Surface																
0.0	ASPHALT: (~200 mm thick)																
177.7																	
0.2	GRANULAR FILL: (~390 mm thick)																
177.3																	
0.6	FILL: silty clay, trace sand and gravel, greyish brown, moist, trace black organic staining																
177.3			1	SS	26												
			2	SS	7												
			3	SS	5												
175.6																	
2.3	SILTY CLAY: trace sand, brown, moist, hard		4	SS	9												
			5	SS	17												
	very stiff below 3.8 m		6	SS	8												
			7	SS	9												
			8	SS	10												
	greyish brown, very moist below 6.1 m		9	SS	5												
				VANE													
	soft below 7.6 m		10		3												
169.7	Borehole terminated at 8.2 m depth																
8.2	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-20

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+011 Townline Tunnel Road ORIGINATED BY DB
DIST Welland HWY 58 A BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.12.23 - 2019.12.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	20	40	60						80	100	20
177.8	Road Surface																			
0.0	ASPHALT: (~240 mm thick)																			
177.6																				
0.2	GRANULAR FILL: (~1280 mm thick)		1	SS	27		177													
			2	SS	62															
176.3																				
1.5	FILL: silty clay, trace sand, greyish brown, moist, black organic staining and odour		3	SS	8		176						○							
175.5													○							
2.3	SILTY CLAY: trace sand, brown, moist, hard		4	SS	9		175													
	very stiff below 3.1 m		5	SS	10								○	—		19.6	0 1 50 49			
			6	SS	13		174						○							
			7	SS	9		173						○	—		20.0	0 0 80 20			
			8	SS	9		172						○	—		23.2	0 0 65 34			
	greyish brown, very moist below 6.1 m		9	SS	7		171						○							
			10	SS	3		170						○							
			11	SS	5								○							
169.1																				
8.7	Borehole terminated at 8.7 m depth																			
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																			

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-21

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+061 Townline Tunnel Road ORIGINATED BY DB
DIST Welland HWY 58 A BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.12.23 - 2019.12.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL					
178.0	Road Surface						20	40	60	80	100					
0.0	ASPHALT: (~250 mm thick)						20	40	60	80	100					
177.8																
0.3	GRANULAR FILL: (~1270 mm thick)		1	SS	56											
			2	SS	51											
176.5																
1.5	FILL: silty clay, trace sand, greyish brown, moist, black organic staining and odour, rootlets		3	SS	5								○			
175.7													○			
2.3	SILTY CLAY: trace sand, brown, moist, hard		4	SS	16								○			
	very stiff below 3.1 m		5	SS	12								○			
			6	SS	8								○			
	greyish brown below 4.6 m		7	SS	8								○			
			8	SS	9								○			
	very moist, stiff below 6.1 m		9	SS	3								○			
				VANE												
	soft below 7.6 m		10	SS	2								○			
169.8																
8.2	Borehole terminated at 8.2 m depth															
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Water level at 7.3 m depth upon completion. Water level at 2.3 m depth on January 23, 2020.															

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO LOGS MTO.GPJ ONTARIO MTO.GDT 2/10/20

RECORD OF BOREHOLE No BH-22

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+100 Townline Tunnel Road ORIGINATED BY DB
DIST Welland HWY 58 A BOREHOLE TYPE Marooka Track Mount. Hollow Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.12.23 - 2019.12.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20	40	60	80	100								
								○ UNCONFINED	+	FIELD VANE										
								● QUICK TRIAXIAL	×	LAB VANE										
								20	40	60	80	100								
0.0	GRANULAR FILL: (~2135 mm thick) temporary granular pad																			
2.1	SILTY CLAY: trace sand, brown, moist, very stiff to hard		1	SS	13											18.7				
			2	SS	13												0 2 31 67			
			3	SS	18															
			4	SS	15											21.0	0 0 55 45			
	very moist, stiff below 5.3 m		5	SS	8															
	greyish brown, firm below 6.1 m		6	SS	4															
			7	SS	4															
	soft below 7.6 m		8	SS	2															
8.1	Borehole terminated at 8.1 m depth																			
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Water level at 5.0 m depth upon completion.																			

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



ONTARIO MTO LOGS MTO.GPJ ONTARIO MTO.GDT 2/10/20

RECORD OF BOREHOLE No BH-23

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+149 Townline Tunnel Road ORIGINATED BY DB
DIST Welland HWY 58 A BOREHOLE TYPE Marooka Track Mount. Hollow Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.12.23 - 2019.12.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE						LAB VANE		
								20	40	60	80	100								
0.0	GRANULAR FILL: (~2290 mm thick) temporary granular pad																			
2.3	SILTY CLAY: trace sand, brown, moist, very stiff to hard		1	SS	11															
			2	SS	13															
	very moist below 3.8 m		3	SS	18															
			4	SS	13															
			5	SS	9															
	stiff below 6.1 m		6	SS	4															
				VANE																
	soft below 7.6 m																			
			8	SS	1															
8.1	Borehole terminated at 8.1 m depth																			
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Water level at 7.9 m depth upon completion.																			




+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-24

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+200 Townline Tunnel Road ORIGINATED BY DB
DIST Welland HWY 58 A BOREHOLE TYPE Marooka Track Mount. Hollow Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.12.23 - 2019.12.23 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
							20	40	60	80	100	WATER CONTENT (%)					kN/m ³	GR	SA	SI	CL
0.0	GRANULAR FILL: (~1520 mm thick) temporary granular pad																				
1.5	FILL: silty clay, trace sand and gravel, greyish brown, moist, black organic staining and odour		1	SS	10																
2.3	SILTY CLAY: trace sand, brown, moist, hard		2	SS	13																
			3	SS	20																
	very moist to wet, very stiff below 3.8 m		4	SS	8																
			5	SS	8																
	grey, stiff below 5.3 m		6	SS	7																
			7	SS	5																
				VANE																	
	firm below 7.6 m		8	SS	6																
8.1	Borehole terminated at 8.1 m depth																				
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 7.9 m depth upon completion.																				

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-25

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+450 Humberstone Road ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.11 - 2019.10.11 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED	+	FIELD VANE								
						● QUICK TRIAXIAL	×	LAB VANE	WATER CONTENT (%)									
177.8	Road Surface							20	40	60	80	100		20	40	60		
177.0	ASPHALT: (~100 mm thick)																	
0.1	GRANULAR FILL: (~620 mm thick)		1	SS	16													
177.1							177											
0.7	FILL: silty clay, trace sand, grey, very moist, black organic staining and odour, trace rootlets		2	SS	5													
176.3																		
1.5	SILTY CLAY: trace sand, brown, very moist, very stiff		3	SS	7		176											
			4	SS	12		175											
			5	SS	11													
							174											
	wet, stiff below 4.6 m		6	SS	8		173											
172.6																		
5.2	Borehole terminated at 5.2 m depth																	
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Water at 4.6 m depth upon completion.																	

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-26

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+575 Humberstone Road ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.11 - 2019.10.11 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×						LAB VANE		
177.6	Road Surface							20	40	60	80	100								
177.6	ASPHALT: (~120 mm thick)																			
0.1	GRANULAR FILL: (~320 mm thick)																			
177.2			1	SS	19		177													
0.4	FILL: silty clay, trace sand, grey, moist, black organic staining and odour, trace rootlets																			
176.5			2	SS	8															
1.1	SILTY CLAY: trace sand, brown, moist, very stiff																			
	very moist below 2.3 m		3	SS	12		176													
			4	SS	6		175													
	wet, stiff below 3.1 m		5	SS	5		174													
				VANE																
	grey below 4.6 m		6	SS	1		173													
				VANE																
172.1																				
5.5	Borehole terminated at 5.5 m depth																			
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 1.5 m depth on November 8, 2019.																			

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-27

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+700 Humberstone Road ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.11 - 2019.10.11 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE												
177.4	Road Surface																						
177.9	ASPHALT: (~140 mm thick)																						
0.1	GRANULAR FILL: (~640 mm thick)		1	SS	17																		
176.6																							
0.8	SILTY CLAY: trace sand, brown, very moist, very stiff		2	SS	11																		
	brown and grey, rootlets at 1.5 m		3	SS	15																		
	wet, stiff below 2.3 m		4	SS	5																		
	grey below 3.1 m		5	SS	6																		
			6	SS	2																		
				VANE																			
171.9																							
5.5	Borehole terminated at 5.5 m depth																						
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Water at 4.6 m depth upon completion.																						

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-28

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+824 Humberstone Road ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.11 - 2019.10.11 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
177.7	Road Surface							20	40	60	80	100		20	40	60	kN/m ³	GR	SA	SI	CL
179.8	ASPHALT: (~140 mm thick)																				
0.1	GRANULAR FILL: (~560 mm thick)		1	SS	33		177														
177.0	FILL: silty clay, trace sand, grey, moist, black organic staining and odour		2	SS	10																
176.2	SILTY CLAY: trace sand, brown and grey, moist to very moist, very stiff rootlets at 1.5 m		3	SS	13		176														
1.5	brown below 2.3 m		4	SS	14		175														
	stiff below 3.1 m		5	SS	8		174														
	grey below 4.6 m		6	SS	4		173														
	wet below 6.1 m		7	SS	2		172														
170.7							171														
7.0	Borehole terminated at 7.0 m depth			VANE																	
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																				

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-29

1 OF 1

METRIC

W.P. _____ LOCATION STA 7+967 Humberstone Road ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.11 - 2019.10.11 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+	FIELD VANE	×	LAB VANE					
178.9	Road Surface						20	40	60	80	100						
178.8	ASPHALT: (~140 mm thick)						20	40	60	80	100						
0.1	GRANULAR FILL: (~920 mm thick)		1	SS	34												
177.8			2	SS	16												
1.1	FILL: silty clay, trace sand and gravel, grey, moist, black organic staining and odour																
			3	SS	5												
176.6																	
2.3	SILTY CLAY: trace sand, brown, moist, hard		4	SS	10												
	very stiff below 3.1 m																
			5	SS	15												
			6	SS	10												
	grey, very moist, stiff below 6.1 m		7	SS	3												
			8	SS	1												
				VANE													
170.4																	
8.5	Borehole terminated at 8.5 m depth																
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 3.5 m depth on November 8, 2019 and 3.3 m depth on January 23, 2020.																

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-31

1 OF 1

METRIC

W.P. _____ LOCATION STA 8+200 Humberstone Road ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.22 - 2019.10.22 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)									
177.9	Road Surface							20	40	60	80	100		20	40	60	kN/m ³	GR	SA	SI	CL
177.8	ASPHALT: (~130 mm thick)																				
0.1	GRANULAR FILL: (~580 mm thick)		1	SS	28																
177.2	SILTY CLAY: trace sand, brown, moist, hard		2	SS	8		177														
0.7																					
	very moist below 1.5 m		3	SS	12		176														
	very stiff below 2.3 m		4	SS	9		175														
			5	SS	6		174														
			6	SS	8		173														
							172														
	wet below 6.1 m		7	SS	3																
170.9	Borehole terminated at 7.0 m depth			VANE			171														
7.0	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion. Water level at 2.3 m depth on November 8, 2019 and 1.2 m depth on January 23, 2020.																				

ONTARIO MTO LOGS MTO.GPJ ONTARIO MTO.GDT 2/10/20

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-32

1 OF 1

METRIC

W.P. _____ LOCATION STA 10+026 Southworth Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.22 - 2019.10.22 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20					40	60	80				
177.2	Road Surface																						
177.0	ASPHALT: (~90 mm thick)																						
0.1	GRANULAR FILL: (~300 mm thick)																						
176.8																							
0.4	FILL: silty clay, trace sand, brown, moist, black organic staining and odour		1	SS	18																		
176.4																							
0.8	SILTY CLAY: trace sand, brown, moist, hard trace rootlets at 0.8 m		2	SS	8																		
	very moist below 2.3 m		3	SS	14																		
	very stiff below 3.1 m		4	SS	8																		
	stiff below 4.6 m		6	SS	6																		
	wet below 6.1 m		7	SS	7																		
170.5																							
6.7	Borehole terminated at 6.7 m depth																						
	NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others. 3. Borehole remained dry upon completion.																						

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-33

1 OF 1

METRIC

W.P. _____ LOCATION STA 10+151 Southworth Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.22 - 2019.10.22 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×					
177.0	Road Surface							20	40	60	80	100					
176.9	ASPHALT: (~90 mm thick)							20	40	60	80	100					
0.1	GRANULAR FILL: (~410 mm thick)							20	40	60	80	100					
176.5	SILTY CLAY: trace sand, brown, moist, hard		1	SS	32												
0.5																	
										</							





+ ³, × ³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-34

1 OF 1

METRIC

W.P. _____ LOCATION STA 10+275 Southworth Street ORIGINATED BY DB
DIST Welland HWY _____ BOREHOLE TYPE CME-75 Truck Mount. Solid Stem. COMPILED BY DB
DATUM Geodetic DATE 2019.10.22 - 2019.10.22 LATITUDE _____ LONGITUDE _____ CHECKED BY JG

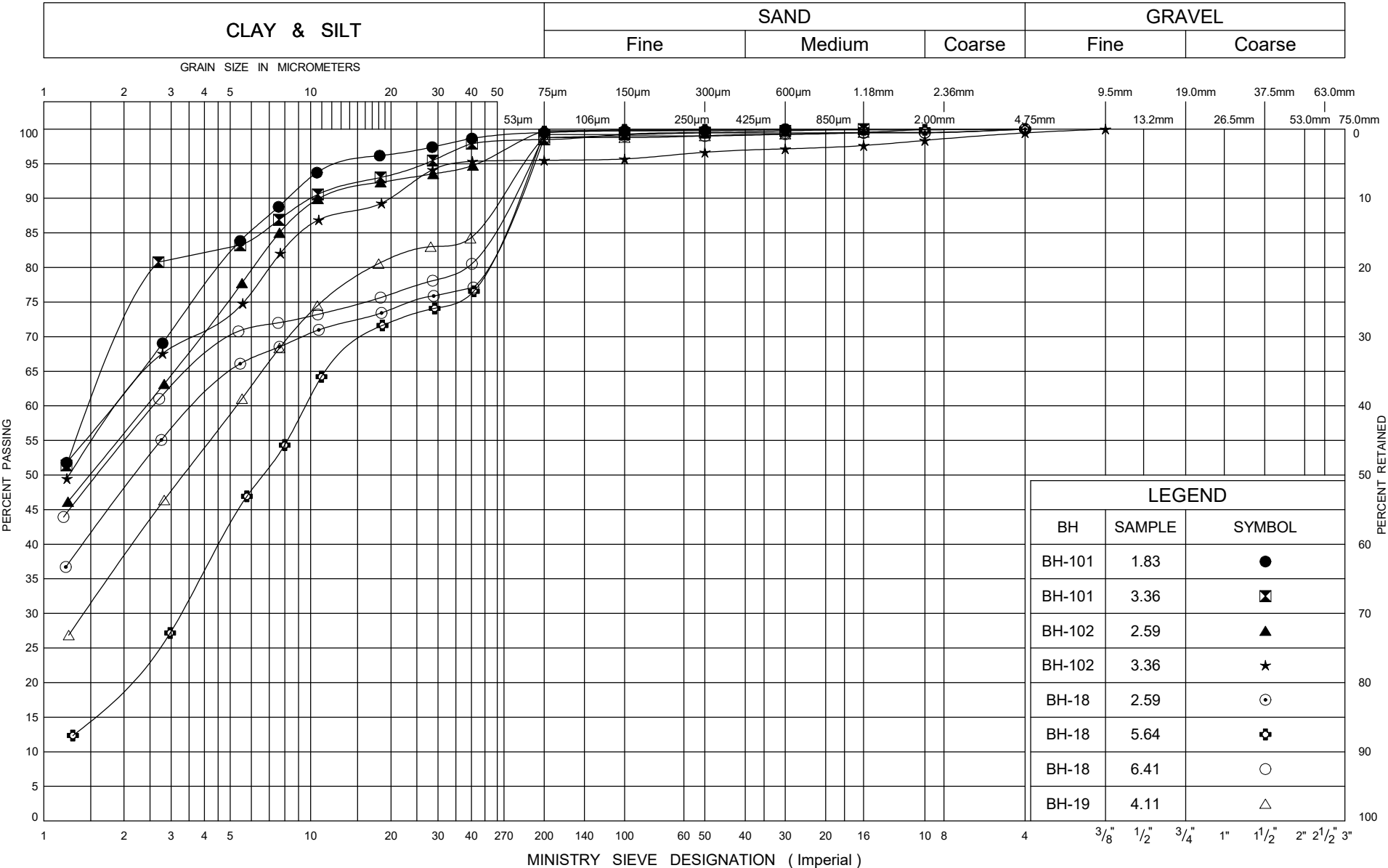
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
								○ UNCONFINED	+	FIELD VANE	○							
								● QUICK TRIAXIAL	×	LAB VANE								
177.4	Road Surface						177											
177.0	ASPHALT: (~120 mm thick)																	
0.1	GRANULAR FILL: (~380 mm thick)		1	SS	27													
176.9																		
0.5	FILL: silty clay, trace sand and gravel, brown, moist, black organic staining and odour, roots																	
176.6																		
0.8	SILTY CLAY: trace sand, brown, moist, hard		2	SS	14													
				3	SS		15											
				4	SS	10												
	very stiff below 3.1 m			5	SS	12												
							176											

ONTARIO MTO LOGS MTO.GPJ ONTARIO MTO.GDT 2/10/20

Appendix B

Laboratory Testing

UNIFIED SOIL CLASSIFICATION SYSTEM



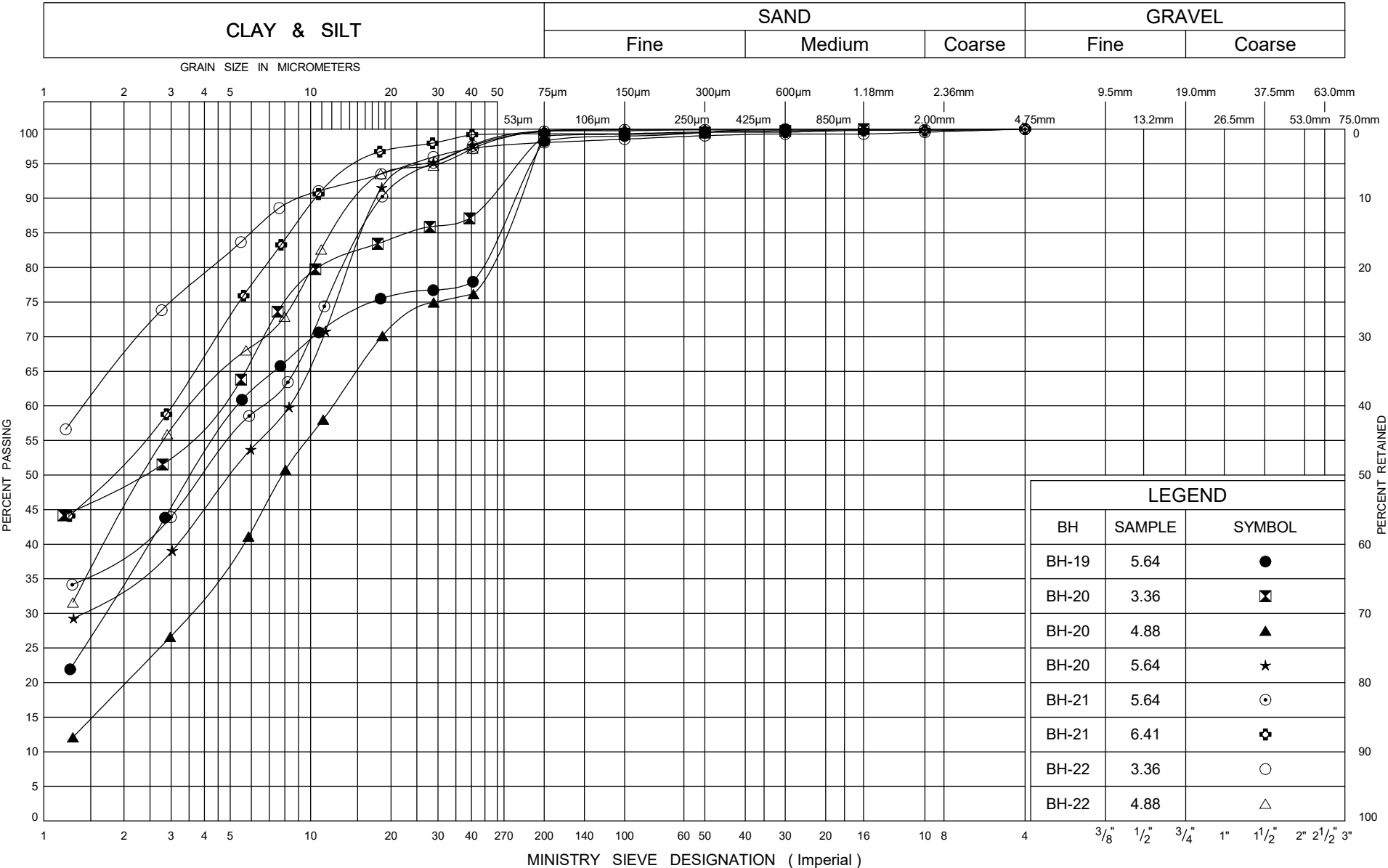
GRAIN SIZE DISTRIBUTION

FIG No 1

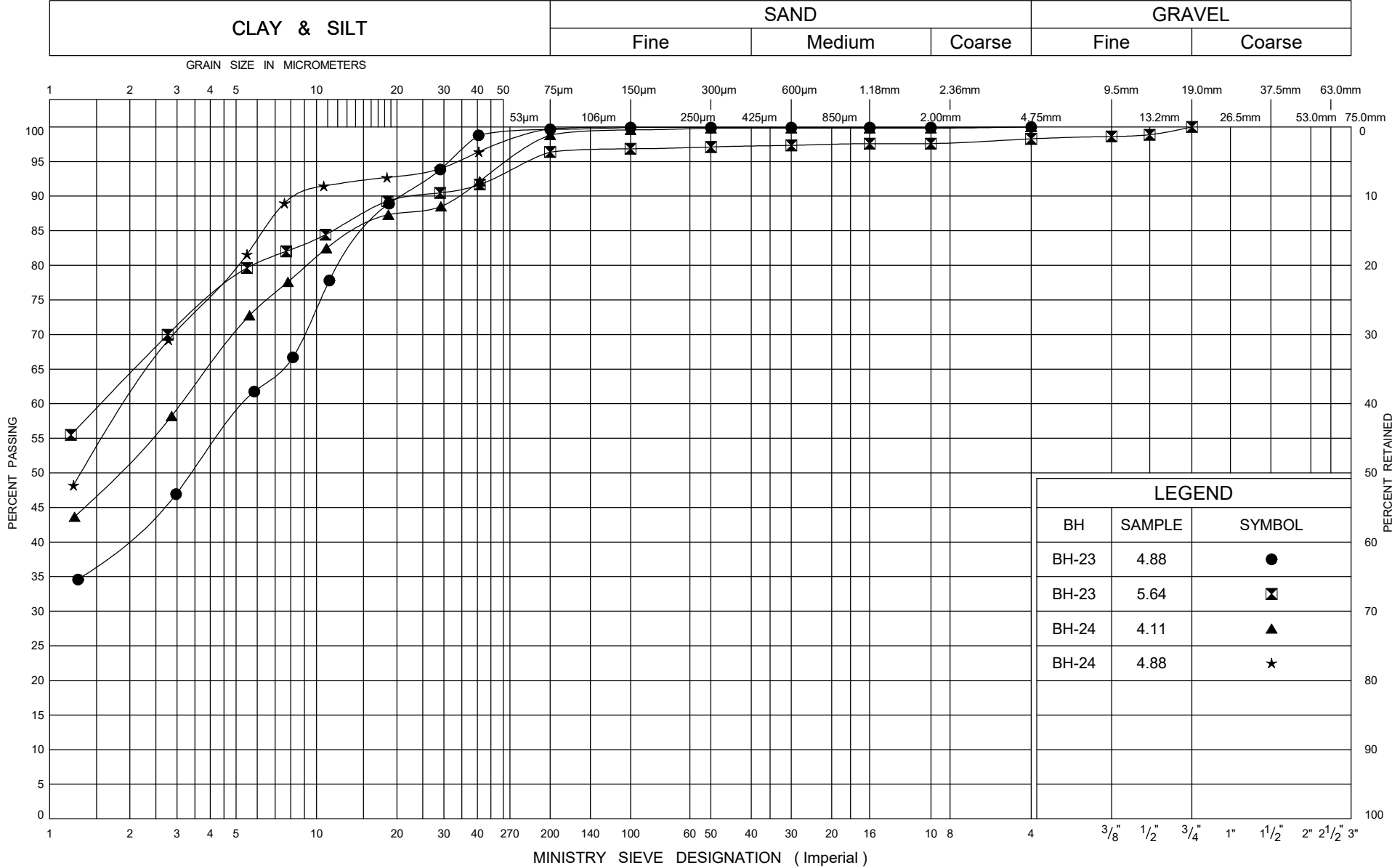
W P

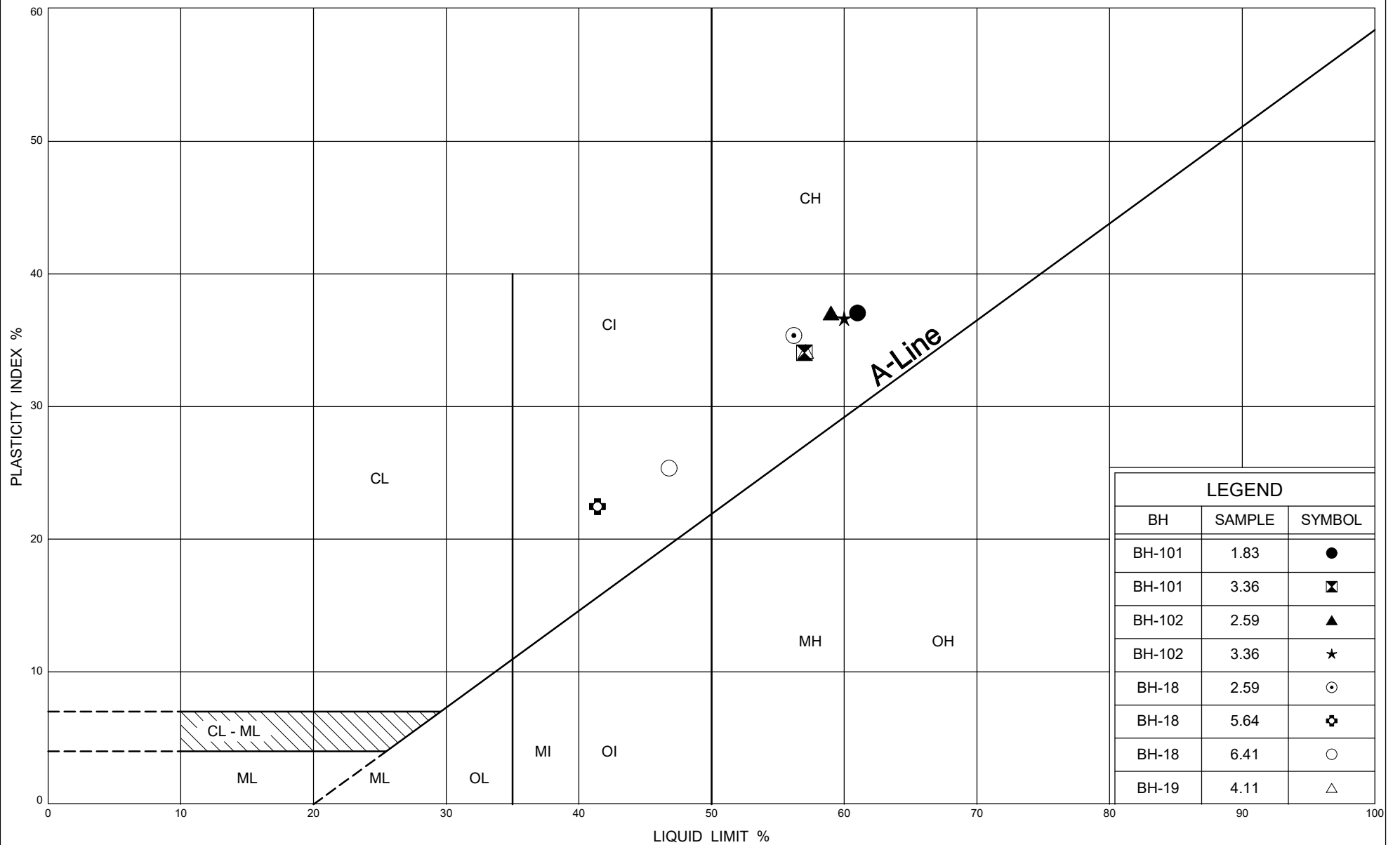
HAM-00801772-A0

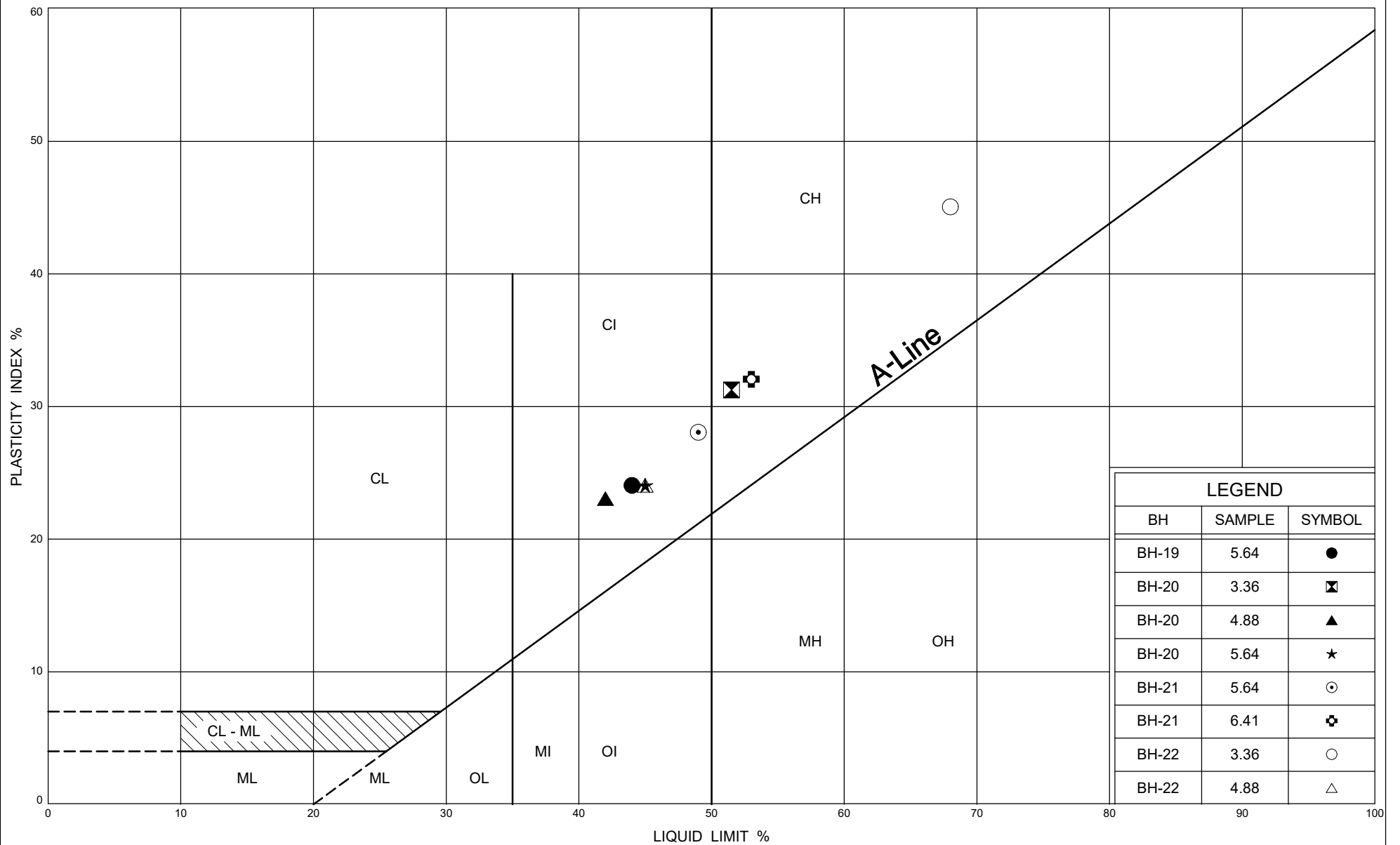
UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM







LEGEND		
BH	SAMPLE	SYMBOL
BH-19	5.64	●
BH-20	3.36	⊠
BH-20	4.88	▲
BH-20	5.64	★
BH-21	5.64	⊙
BH-21	6.41	⊕
BH-22	3.36	○
BH-22	4.88	△

PLASTICITY CHART

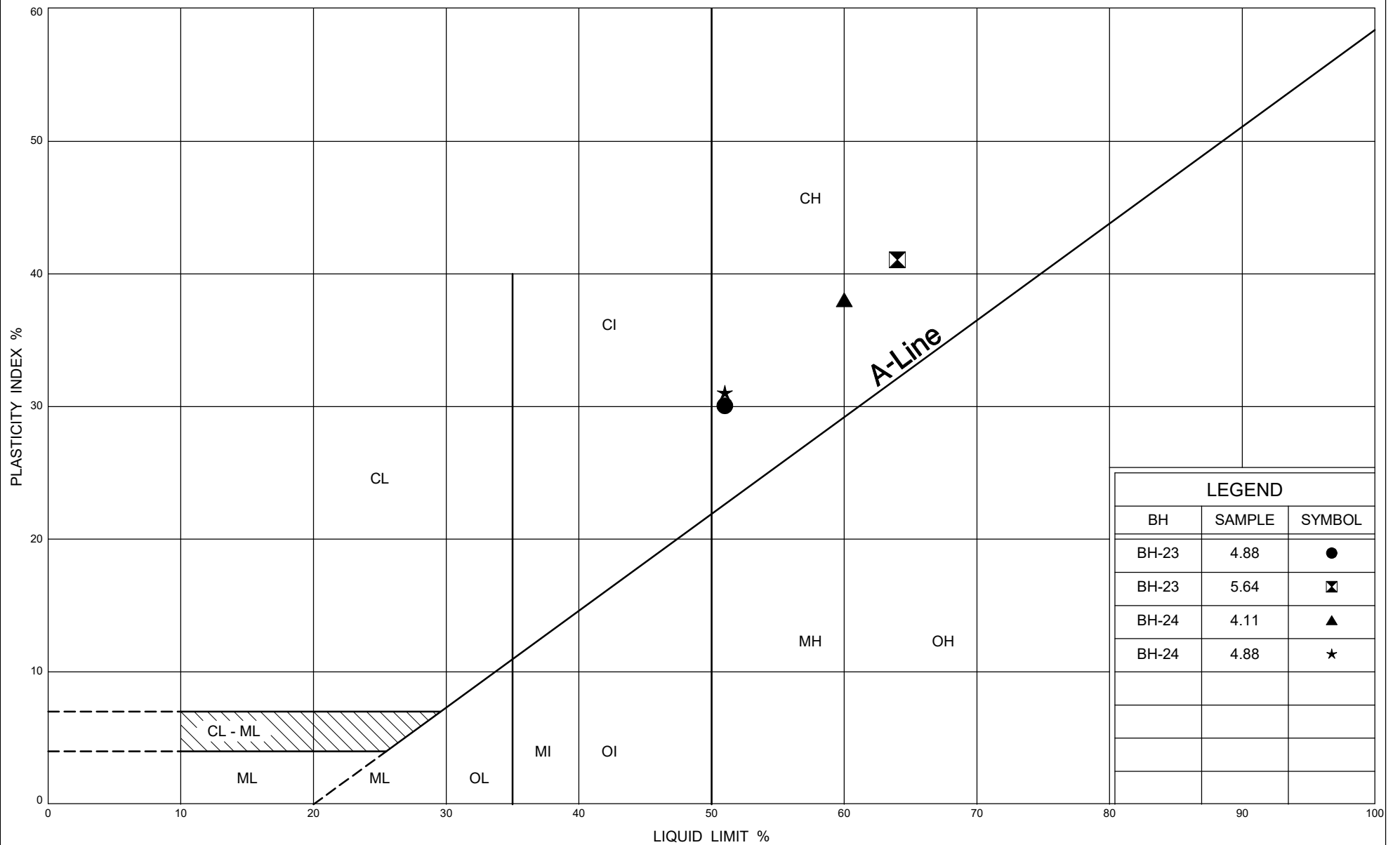


Ministry of
Transportation

FIG No 3

W P

HAM-00801772-A0



PLASTICITY CHART

FIG No 4

W P

HAM-00801772-A0



Ministry of
Transportation

Ontario

Appendix C

Soil and Rock Tunneling Behaviour

Table C-1: Typical Classification for Soils and Rocks

Classification		Behavior	Typical Soil Types
Firm		Heading can be advanced without initial support, and final lining can be constructed before ground starts to move.	Loess above water table; hard clay, marl, cemented sand and gravel when not highly overstressed.
Raveling	Slow raveling	Chunks or flakes of material begin to drop out of the arch or walls sometime after the ground has been exposed, due to loosening or to over-stress and "brittle" fracture (ground separates or breaks along distinct surfaces, opposed to squeezing ground). In fast raveling ground, the process starts within a few minutes, otherwise the ground is slow raveling.	Residual soils or sand with small amounts of binder may be fast raveling below the water tale, slow raveling above. Stiff fissured clays may be slow or fast raveling depending upon degree of overstress.
	Fast raveling		
Squeezing		Ground squeezes or extrudes plastically into tunnel, without visible fracturing or loss of continuity, and without perceptible increase in water content. Ductile, plastic yield and flow due to overstress.	Ground with low frictional strength. Rate of squeeze depends on degree of overstress. Occurs at shallow to medium depth in clay of very soft to medium consistency. Stiff to hard clay under high cover may move in combination of raveling at excavation surface and squeezing at depth behind surface.
Running	Cohesive – running	Granular materials without cohesion are unstable at a slope greater than their angle of repose (approx. 30° - 35°). When exposed at steeper slopes they run like granulated sugar or dune sand until the slope flattens to the angle of repose.	Clean, dry granular materials. Apparent cohesion in moist sand, or weak cementation in any granular soil, may allow the material to stand for a brief period of raveling before it breaks down and runs. Such behavior is cohesive-running.
	Running		
Flowing		A mixture of soil and water flows into the tunnel like a viscous fluid. The material can enter the tunnel from the invert as well as from the face, crown, and walls, and can flow for great distances, completely filling the tunnel in some cases.	Below the water table in silt, sand, or gravel without enough clay content to give significant cohesion and plasticity. May also occur in highly sensitive clay when such material is disturbed.
Swelling		Ground absorbs water, increases in volume, and expands slowly into the tunnel.	Highly preconsolidated clay with plasticity index in excess of about 30, generally containing significant percentages of montmorillonite.

*Modified by Heuer (1974) from Terzaghi (1950)

Table C-2: Tunnel Behavior: Sands and Gravels

Designation	Degree of Compactness	Tunnel Behavior	
		Above Water Table	Below Water Table
Very Fine Clean Sand	Loose, $N \leq 10$	Cohesive Running	Flowing
	Dense, $N > 30$	Fast Raveling	Flowing
Fine Sand with Clay Binder	Loose, $N \leq 10$	Rapid Raveling	Flowing
	Dense, $N > 30$	Firm or Slowly Raveling	Slowly Raveling
Sand or Sandy Gravel with Clay Binder	Loose, $N < 10$	Rapid Raveling	Rapidly Raveling or Flowing
	Dense, $N > 30$	Firm	Firm or Slowly Raveling
Sandy Gravel and Medium to Coarse Sand		Running ground. Uniform ($C_u < 3$) and loose ($N < 10$) materials with round grains run much more freely than well graded ($C_u > 6$) and dense ($N > 30$) ones with angular grains.	Flowing conditions combined with extremely heavy discharge of water.

Table C-3: Soft-ground Characteristics (after British Tunneling Society, BTS, 1990)

Ground	Description
Firm ground	Ground in which the tunnel can be advanced safely without providing direct support to the face during the normal excavation cycle and in which ground support or the lining can be installed before problematic ground movement occurs. Where this short-term stability may be attributable to the development of negative pore pressure in the fine-grained soils, significant soil movements and/or ground loading of the tunnel lining may occur later. Examples may include stiff clays and some dewatered sands. A closed-face tunneling machine may not be needed in this ground type.
Raveling ground	Ground characterized by material that tends to deteriorate with time through a process of individual particles or blocks of ground falling from the excavation surface. Examples may include glacial tills, sands and gravels. In this ground a closed-face tunneling system may be required to provide immediate support to the ground.
Running or flowing ground	Ground characterized by material such as sands, silts and gravels in the presence of water, and some highly sensitive clays that tend to flow into an excavation. Above the water table running ground may occur in granular materials such as dry sands and gravels. Below the water table a fluidized mixture of soil and water may flow as a liquid. This is referred to as running or flowing ground. Such materials can sometimes pass rapidly through small openings and may completely fill a heading in a short period of time. In all running or flowing ground types there will be considerable potential for rapid over-excavation. Hence, a closed-face tunneling system will be required to support such ground safely unless some other method of stabilization is used.
Squeezing ground	Ground in which the excavation-induced stress relief leads to ductile, plastic yield of ground into the tunnel opening. The phenomenon usually is exhibited in soft clays and stiffer clays over a more extended period of time. A closed-face machine may be required to provide resistance to squeezing ground, although in some conditions there is also a risk of the TBM shield becoming trapped.
Swelling ground	Soil characterized by a tendency to increase in volume due to absorption of water. This behavior is most likely to occur either in highly over-consolidated clay or in clays containing minerals naturally prone to significant swelling. A closed-face machine may be useful in providing resistance to swelling ground although, as with squeezing ground, there is a risk of the shield becoming trapped.
Weak rock	Weak rock may be regarded effectively as a soft-ground environment for tunneling because systems used to excavate soft-ground types may also be applied to weak rock materials such as chalk. Weak rock will often tend to be self-supporting in the short term with the result that closed face tunneling systems may not be needed. However, groundwater may be significant issue. In these instances a closed-face machine is an effective method of protecting the works against high volumes of water ingress that could also be under high hydrostatic pressure.
Hard rock	A closed-face TBM may also be deployed in normally self-supporting hard rock conditions. The main reason would be to provide protection against groundwater pressures and prevent inundation of the heading.
Mixed ground conditions	Potentially, the most difficult of situations for a closed-face tunneling system is that of having to cope with a mixture of different ground types either along the tunnel from zone to zone or sometimes from meter to meter, or within the same tunnel face. Ideally the vertical alignment would be optimized to avoid, as far as possible, a mixed ground situation, however, in urban locations the alignment may be constrained by other considerations. For changes in ground types longitudinally, a closed-face machine may have to convert from a closed-face pressurized mode to an open non-pressurized mode when working in harder ground types to avoid over stressing the machine's mechanical functions. Such a change may require some modification of the machine and the reverse once again when the alignment enters a reach of soft, potentially unstable ground. In the case of mixed ground types across the same face, the tunneling machine will almost certainly have to operate in a compromise configuration. In such cases great care will be needed to ensure that this provides effective ground control. A common problem, for example, is a face with a hard material in the bottom and running ground at the top. In this situation the TBM will generally advance slowly while cutting the hard ground but may tend to draw in the less stable material at the top leading to over-excavation of the less stable material and subsequent subsidence or settlement at the surface. Different ground types at levels above the tunnel will also be of significance. For example, in the event that over-excavation occurs, the presence of running or flowing materials at horizons above the tunnel will increase the potential quantity of ground that may be over-excavated and again lead to subsidence or surface settlement. Another potential problem occurs when a more competent layer exists over potentially running ground in which case possible over-excavation would create voids above the tunnel and below the competent material, giving rise to potential longer-term instability problems.

Appendix D

Certificates of Analysis

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: HAM-00801772-A0

AGAT WORK ORDER: 19T536967

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

DATE REPORTED: Nov 12, 2019

PAGES (INCLUDING COVER): 7

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T536967

PROJECT: HAM-00801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

SAMPLING SITE:

ATTENTION TO: Jeff Golder

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2019-10-29

DATE REPORTED: 2019-11-12

		SAMPLE DESCRIPTION: BH03 SS 6	
		SAMPLE TYPE: Soil	
		DATE SAMPLED: 2019-10-23	
Parameter	Unit	G / S	RDL
Chloride (2:1)	µg/g		100
Sulphate (2:1)	µg/g		1530
pH (2:1)	pH Units		8.13
Electrical Conductivity (2:1)	mS/cm		1.71
Resistivity (2:1) (Calculated)	ohm.cm		585
Redox Potential 1	mV		445
Redox Potential 2	mV		447
Redox Potential 3	mV		443

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

663482 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter. Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results. Elevated RDL indicates the degree of sample dilution prior to the analysis in order to keep analytes within the calibration range of the instrument and to reduce matrix interference.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:





Certificate of Analysis

AGAT WORK ORDER: 19T536967

PROJECT: HAM-00801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-10-29

DATE REPORTED: 2019-11-12

		SAMPLE DESCRIPTION:		BH01 SS 3	BH02 SS 6	BH03 SS 2	BH05 SS 2	BH06 SS 6	BH07 SS 3
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-10-23	2019-10-23	2019-10-23	2019-10-23	2019-10-23	2019-10-23
Parameter	Unit	G / S	RDL	663477	663480	663481	663483	663486	663487
Antimony	µg/g	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g	1	5	11	6	6	11	7	
Barium	µg/g	2	208	125	153	182	200	170	
Beryllium	µg/g	0.5	1.0	0.7	0.6	0.9	0.8	0.7	
Boron	µg/g	5	10	12	7	8	13	9	
Boron (Hot Water Soluble)	µg/g	0.10	0.14	0.72	0.10	0.28	0.65	0.11	
Cadmium	µg/g	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Chromium	µg/g	2	36	29	27	32	32	29	
Cobalt	µg/g	0.5	17.3	15.8	11.9	15.4	15.9	15.6	
Copper	µg/g	1	24	26	23	25	24	23	
Lead	µg/g	1	13	12	13	13	11	13	
Molybdenum	µg/g	0.5	0.7	0.8	<0.5	0.8	1.1	0.7	
Nickel	µg/g	1	38	33	27	35	35	29	
Selenium	µg/g	0.4	0.4	<0.4	0.5	<0.4	<0.4	<0.4	
Silver	µg/g	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Thallium	µg/g	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	
Uranium	µg/g	0.5	1.0	1.0	0.7	0.9	0.9	0.9	
Vanadium	µg/g	1	48	37	37	43	42	43	
Zinc	µg/g	5	82	72	59	81	77	63	
Chromium VI	µg/g	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Cyanide	µg/g	0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	
Mercury	µg/g	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	
Electrical Conductivity	mS/cm	0.005	0.775	1.90	0.990	1.80	2.39	1.58	
Sodium Adsorption Ratio	NA	NA	0.686	1.84	1.92	10.6	2.04	3.72	
pH, 2:1 CaCl2 Extraction	pH Units	NA	7.75	7.88	7.75	7.88	7.97	7.83	

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

663477-663487 EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio. SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Ananjot Bhela
CHARTERED
ANANJOT BHELA
CHEMIST
ONTING

Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19T536967

PROJECT: HAM-00801772-A0

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

Soil Analysis

RPT Date: Nov 12, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE			MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Corrosivity Package

Chloride (2:1)	663482	663482	100	99	1.0%	< 2	102%	80%	120%	105%	80%	120%	107%	70%	130%
Sulphate (2:1)	663482	663482	1530	1530	0.0%	< 2	106%	80%	120%	107%	80%	120%	100%	70%	130%
pH (2:1)	663482	663482	8.13	8.15	0.2%	NA	100%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	663482	663482	1.71	1.70	0.2%	< 0.005	98%	90%	110%	NA			NA		
Redox Potential 1	1						100%	90%	110%						

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

O. Reg. 153(511) - Metals & Inorganics (Soil)

Antimony	663510	663510	< 0.8	< 0.8	NA	< 0.8	119%	70%	130%	98%	80%	120%	96%	70%	130%
Arsenic	663510	663510	8	8	0.0%	< 1	108%	70%	130%	100%	80%	120%	103%	70%	130%
Barium	663510	663510	212	193	9.4%	< 2	106%	70%	130%	99%	80%	120%	97%	70%	130%
Beryllium	663510	663510	0.9	0.9	NA	< 0.5	93%	70%	130%	110%	80%	120%	85%	70%	130%
Boron	663510	663510	13	14	NA	< 5	79%	70%	130%	107%	80%	120%	79%	70%	130%
Boron (Hot Water Soluble)	663728		0.24	0.24	NA	< 0.10	108%	60%	140%	96%	70%	130%	91%	60%	140%
Cadmium	663510	663510	< 0.5	< 0.5	NA	< 0.5	91%	70%	130%	100%	80%	120%	105%	70%	130%
Chromium	663510	663510	33	32	3.1%	< 2	89%	70%	130%	102%	80%	120%	106%	70%	130%
Cobalt	663510	663510	16.3	15.8	3.1%	< 0.5	97%	70%	130%	99%	80%	120%	98%	70%	130%
Copper	663510	663510	25	24	4.1%	< 1	95%	70%	130%	103%	80%	120%	113%	70%	130%
Lead	663510	663510	12	11	8.7%	< 1	107%	70%	130%	100%	80%	120%	101%	70%	130%
Molybdenum	663510	663510	1.0	1.0	NA	< 0.5	102%	70%	130%	103%	80%	120%	101%	70%	130%
Nickel	663510	663510	36	36	0.0%	< 1	97%	70%	130%	100%	80%	120%	98%	70%	130%
Selenium	663510	663510	< 0.4	< 0.4	NA	< 0.4	107%	70%	130%	98%	80%	120%	99%	70%	130%
Silver	663510	663510	< 0.2	< 0.2	NA	< 0.2	91%	70%	130%	101%	80%	120%	96%	70%	130%
Thallium	663510	663510	< 0.4	< 0.4	NA	< 0.4	102%	70%	130%	99%	80%	120%	101%	70%	130%
Uranium	663510	663510	0.9	0.8	NA	< 0.5	109%	70%	130%	97%	80%	120%	102%	70%	130%
Vanadium	663510	663510	41	41	0.0%	< 1	90%	70%	130%	93%	80%	120%	100%	70%	130%
Zinc	663510	663510	81	80	1.2%	< 5	102%	70%	130%	105%	80%	120%	108%	70%	130%
Chromium VI	690167		< 0.2	< 0.2	NA	< 0.2	81%	80%	120%	94%	70%	130%	89%	70%	130%
Cyanide	679401		<0.040	<0.040	NA	< 0.040	108%	70%	130%	110%	80%	120%	114%	70%	130%
Mercury	663510	663510	< 0.10	< 0.10	NA	< 0.10	111%	70%	130%	100%	80%	120%	102%	70%	130%
Electrical Conductivity	694092		0.159	0.163	2.5%	< 0.005	NA	90%	110%	NA			NA		
Sodium Adsorption Ratio	693944		0.124	0.127	2.4%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	663477	663477	7.75	7.78	0.4%	NA	100%	80%	120%	NA			NA		

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.



Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-00801772-A0

SAMPLING SITE:

AGAT WORK ORDER: 19T536967

ATTENTION TO: Jeff Golder

SAMPLED BY:

Soil Analysis (Continued)

RPT Date: Nov 12, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE			MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Certified By:

Amanjot Bhella

Method Summary

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-00801772-A0

SAMPLING SITE:
AGAT WORK ORDER: 19T536967

ATTENTION TO: Jeff Golder

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6068	SW 846 Method 3060A; Method 7196A	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A;SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl ₂ Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER



Laboratory Use Only

Work Order #:

19T536967

Cooler Quantity:

Arrival Temperatures:

3.6 9.4 9.2
2.4 6 6.4

Custody Seal Intact:

☐ Yes ☐ No ☐ N/A

Notes:

ice

Turnaround Time (TAT) Required:

Regular TAT

☒ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ 1 Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
*TAT is exclusive of weekends and statutory holidays

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Report Information:

Company: EXP Services Inc.

Contact: Jeffrey Golder

Address: 80 Bancroft Street

Hamilton, ON L8E 2W5

Phone: 905.573.4000 x5022 Fax:

Reports to be sent to: jeffrey.golder@exp.com

1. Email: dilsher.bhangal@exp.com

Project Information:

Project: HAM-00801772-AD

Site Location: Welland, ON

Sampled By: DB

AGAT Quote #: 159061 PO:

Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☒ No ☐

Company:

Contact:

Address:

Email:

Regulatory Requirements:

☐ No Regulatory Requirement

(Please check all applicable boxes)

☒ Regulation 153/04

☐ Sewer Use

☐ Regulation 558

Table ☐ Indicate One

☐ Ind/Corn

☐ Res/Park

☐ Agriculture

☐ Sanitary

☐ CCME

☐ Storm

☐ Prov. Water Quality Objectives (PWQO)

☐ Other

Soil Texture (Check One)

☐ Coarse

☐ Fine

Region

Indicate One

Indicate One

Is this submission for a
Record of Site Condition?

☐ Yes ☒ No

Report Guideline on
Certificate of Analysis

☐ Yes ☐ No

Sample Matrix Legend

B Biota
GW Ground Water
O Oil
P Paint
S Soil
SD Sediment
SW Surface Water

Field Filtered - Metals, Hg, CrVI (Please Circle)	Y / N	(Check Applicable)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
		Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: <input type="checkbox"/> B-HWS <input type="checkbox"/> Cl <input type="checkbox"/> CN <input type="checkbox"/> Cr ⁶⁺ <input type="checkbox"/> EC <input type="checkbox"/> FOC <input type="checkbox"/> NO ₃ /NO ₂ <input type="checkbox"/> Total N <input type="checkbox"/> Hg <input type="checkbox"/> pH <input type="checkbox"/> SAR	Nutrients: <input type="checkbox"/> TP <input type="checkbox"/> NH ₄ <input type="checkbox"/> TKN <input type="checkbox"/> NO ₃ <input type="checkbox"/> NO ₂ <input type="checkbox"/> NO ₃ /NO ₂	Volatiles: <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM	CCME Fractions 1 to 4	ABNS	PAHS	Chlorophenols	FCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	CORROSIVITY PACKAGE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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Samples Relinquished By (Print Name and Sign): Dilsher Bhangal	Date: Oct 29, 2019	Time: 11:45 AM	Samples Received By (Print Name and Sign): John Chyapcha	Date: Oct 29	Time: 1:15	Page: _____ of _____
Samples Relinquished By (Print Name and Sign): Dilsher Bhangal	Date: Oct 29	Time: 4:15	Samples Received By (Print Name and Sign): John Chyapcha	Date: Oct 29	Time: 4:15	Nº: _____

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: HAM-00801772-A0

AGAT WORK ORDER: 19T538959

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

DATE REPORTED: Nov 12, 2019

PAGES (INCLUDING COVER): 7

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T538959

PROJECT: HAM-00801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

SAMPLING SITE:

ATTENTION TO: Jeff Golder

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2019-11-01

DATE REPORTED: 2019-11-12

		SAMPLE DESCRIPTION:		BH08 SS6	BH13 SS5
		SAMPLE TYPE:		Soil	Soil
		DATE SAMPLED:		2019-10-24	2019-10-24
Parameter	Unit	G / S	RDL	675753	675762
Chloride (2:1)	µg/g		4	68	213
Sulphate (2:1)	µg/g		4	1670	1040
pH (2:1)	pH Units		NA	8.54	7.96
Electrical Conductivity (2:1)	mS/cm		0.005	1.66	1.36
Resistivity (2:1) (Calculated)	ohm.cm		1	602	735
Redox Potential 1	mV		NA	406	365
Redox Potential 2	mV		NA	397	307
Redox Potential 3	mV		NA	390	325

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

675753-675762 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter. Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results. Elevated RDL indicates the degree of sample dilution prior to the analysis in order to keep analytes within the calibration range of the instrument and to reduce matrix interference.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:





AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T538959

PROJECT: HAM-00801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-11-01

DATE REPORTED: 2019-11-12

		SAMPLE DESCRIPTION:		BH08 SS6	BH09 SS3	BH10 SS6	BH11 SS2	BH12 SS6	BH13 SS2
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-10-24	2019-10-24	2019-10-24	2019-10-24	2019-10-24	2019-10-24
Parameter	Unit	G / S	RDL	675753	675754	675757	675758	675760	675761
Antimony	µg/g	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g	1	6	7	4	5	7	6	
Barium	µg/g	2	190	165	133	130	129	212	
Beryllium	µg/g	0.5	0.8	0.7	0.7	1.0	0.9	1.2	
Boron	µg/g	5	13	9	12	<5	<5	<5	
Boron (Hot Water Soluble)	µg/g	0.10	0.89	0.13	0.72	0.66	0.26	0.36	
Cadmium	µg/g	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Chromium	µg/g	2	34	29	30	28	31	37	
Cobalt	µg/g	0.5	17.5	16.0	15.5	12.8	21.6	10.7	
Copper	µg/g	1	28	26	28	12	24	25	
Lead	µg/g	1	13	13	10	14	17	18	
Molybdenum	µg/g	0.5	0.7	0.8	0.5	<0.5	0.6	0.8	
Nickel	µg/g	1	36	33	33	22	26	26	
Selenium	µg/g	0.4	<0.4	0.5	<0.4	0.6	0.5	0.6	
Silver	µg/g	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Thallium	µg/g	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	
Uranium	µg/g	0.5	0.9	0.7	0.8	0.7	0.8	1.2	
Vanadium	µg/g	1	44	40	38	40	41	48	
Zinc	µg/g	5	79	66	72	61	79	73	
Chromium VI	µg/g	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Cyanide	µg/g	0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	
Mercury	µg/g	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	
Electrical Conductivity	mS/cm	0.005	1.66	0.958	1.41	1.37	1.11	1.61	
Sodium Adsorption Ratio	NA	NA	1.87	5.22	1.54	9.74	6.43	9.22	
pH, 2:1 CaCl2 Extraction	pH Units	NA	7.90	7.84	8.00	7.56	7.21	7.39	

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

675753-675761 EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio. SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Ananjot Bhela


Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19T538959

PROJECT: HAM-00801772-A0

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

Soil Analysis

RPT Date: Nov 12, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - Metals & Inorganics (Soil)															
Antimony	671922		1.8	1.7	NA	< 0.8	118%	70%	130%	103%	80%	120%	85%	70%	130%
Arsenic	671922		9	9	0.0%	< 1	114%	70%	130%	109%	80%	120%	107%	70%	130%
Barium	671922		41	41	0.0%	< 2	115%	70%	130%	100%	80%	120%	112%	70%	130%
Beryllium	671922		<0.5	<0.5	NA	< 0.5	76%	70%	130%	104%	80%	120%	90%	70%	130%
Boron	671922		9	9	NA	< 5	78%	70%	130%	100%	80%	120%	94%	70%	130%
Boron (Hot Water Soluble)	671922		0.28	0.27	NA	< 0.10	106%	60%	140%	98%	70%	130%	94%	60%	140%
Cadmium	671922		<0.5	<0.5	NA	< 0.5	112%	70%	130%	101%	80%	120%	103%	70%	130%
Chromium	671922		28	27	3.6%	< 2	95%	70%	130%	102%	80%	120%	111%	70%	130%
Cobalt	671922		72.3	73.9	2.2%	< 0.5	101%	70%	130%	109%	80%	120%	100%	70%	130%
Copper	671922		226	232	2.6%	< 1	98%	70%	130%	109%	80%	120%	72%	70%	130%
Lead	671922		52	52	0.0%	< 1	106%	70%	130%	110%	80%	120%	98%	70%	130%
Molybdenum	671922		4.0	3.5	13.3%	< 0.5	104%	70%	130%	99%	80%	120%	114%	70%	130%
Nickel	671922		268	284	5.8%	< 1	99%	70%	130%	107%	80%	120%	90%	70%	130%
Selenium	671922		0.9	0.9	NA	< 0.4	96%	70%	130%	107%	80%	120%	109%	70%	130%
Silver	671922		<0.2	<0.2	NA	< 0.2	97%	70%	130%	105%	80%	120%	98%	70%	130%
Thallium	671922		<0.4	<0.4	NA	< 0.4	104%	70%	130%	106%	80%	120%	97%	70%	130%
Uranium	671922		0.7	0.7	NA	< 0.5	112%	70%	130%	108%	80%	120%	106%	70%	130%
Vanadium	671922		15	14	6.9%	< 1	99%	70%	130%	107%	80%	120%	108%	70%	130%
Zinc	671922		125	115	8.3%	< 5	104%	70%	130%	117%	80%	120%	83%	70%	130%
Chromium VI	690167		< 0.2	< 0.2	NA	< 0.2	81%	80%	120%	94%	70%	130%	89%	70%	130%
Cyanide	676529		<0.040	<0.040	NA	< 0.040	93%	70%	130%	94%	80%	120%	102%	70%	130%
Mercury	671922		<0.10	<0.10	NA	< 0.10	104%	70%	130%	100%	80%	120%	98%	70%	130%
Electrical Conductivity	671922		0.162	0.168	3.6%	< 0.005	99%	90%	110%	NA			NA		
Sodium Adsorption Ratio	680445		0.695	0.706	1.6%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	679401		7.52	7.52	0.0%	NA	100%	80%	120%	NA			NA		

Comments: NA signifies Not Applicable.

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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Corrosivity Package

Chloride (2:1)	668462		664	682	2.7%	< 2	98%	80%	120%	104%	80%	120%	104%	70%	130%
Sulphate (2:1)	668462		17400	17400	0.0%	< 2	95%	80%	120%	99%	80%	120%	106%	70%	130%
pH (2:1)	675753	675753	8.54	8.56	0.2%	NA	101%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	671922		0.162	0.168	3.6%	< 0.005	99%	90%	110%	NA			NA		
Redox Potential 1	1						100%	90%	110%						

Comments: NA signifies Not Applicable.

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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.



Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-00801772-A0

SAMPLING SITE:

AGAT WORK ORDER: 19T538959

ATTENTION TO: Jeff Golder

SAMPLED BY:

Soil Analysis (Continued)

RPT Date: Nov 12, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE			MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Certified By:

Amanjot Bhella


Method Summary

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-00801772-A0

SAMPLING SITE:

AGAT WORK ORDER: 19T538959

ATTENTION TO: Jeff Golder

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B, SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6068	SW 846 Method 3060A; Method 7196A	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A; SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl ₂ Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER



Laboratory Use Only

Work Order #: 19T538959

Cooler Quantity: _____

Arrival Temperatures: 5.7 | 4.8 | 4.6
4.6 | 4.8 | 4.4

Custody Seal Intact: ☐ Yes ☐ No ☐ N/A

Notes: jce

Turnaround Time (TAT) Required:

Regular TAT

☒ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ 1 Business Day

OR Date Required (Rush Surcharges May Apply): _____

Please provide prior notification for rush TAT
*TAT is exclusive of weekends and statutory holidays

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Report Information:

Company: EXP Services Inc.
Contact: Jeffrey Golder
Address: 80 Bancroft Street
Hamilton, ON L8E 2W5
Phone: 905.573.4000 x5022 Fax: _____
Reports to be sent to:
1. Email: jeffrey.golder@exp.com
2. Email: dilsher.bhargal@exp.com

Regulatory Requirements:

(Please check all applicable boxes)

☒ Regulation 153/04

☐ Sewer Use

☐ Regulation 558

Table Indicate One

☐ Ind/Com

☐ Sanitary

☐ CCME

☐ Res/Park

☐ Storm

☐ Prov. Water Quality

☐ Agriculture

Objectives (PWQO)

☐ Other

Soil Texture (Check One)

☐ Coarse

Region Indicate One

☐ Fine

Indicate One

Is this submission for a
Record of Site Condition?

☐ Yes ☒ No

Report Guideline on
Certificate of Analysis

☐ Yes ☐ No

Sample Matrix Legend

B Biota
GW Ground Water
O Oil
P Paint
S Soil
SD Sediment
SW Surface Water

Field Filtered - Metals, Hg, CrVI
(Please Circle)

(Check Applicable)

ORPs: ☐ B-HWS ☐ Cl⁻ ☐ CN⁻
☐ Cr⁶⁺ ☐ EC ☐ FOC ☐ NO₃/NO₂
☐ Total N ☐ Hg ☐ pH ☐ SAR
Nutrients: ☐ TP ☐ NH₃ ☐ TKN
☐ NO₃ ☐ NO₂ ☐ NO₃/NO₂
Volatiles: ☐ VOC ☐ BTEX ☐ THM

CCME Fractions 1 to 4

ABNS

PAHs

Chlorophenols

PCBs

Organochlorine Pesticides

TCLP Metals/Inorganics

Sewer Use

CORROSION PACKAGE

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Y / N	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: <input type="checkbox"/> B-HWS <input type="checkbox"/> Cl ⁻ <input type="checkbox"/> CN ⁻ <input type="checkbox"/> Cr ⁶⁺ <input type="checkbox"/> EC <input type="checkbox"/> FOC <input type="checkbox"/> NO ₃ /NO ₂ <input type="checkbox"/> Total N <input type="checkbox"/> Hg <input type="checkbox"/> pH <input type="checkbox"/> SAR	Nutrients: <input type="checkbox"/> TP <input type="checkbox"/> NH ₃ <input type="checkbox"/> TKN <input type="checkbox"/> NO ₃ <input type="checkbox"/> NO ₂ <input type="checkbox"/> NO ₃ /NO ₂	Volatiles: <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM	CCME Fractions 1 to 4	ABNS	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	CORROSION PACKAGE
BH08 SS3	Oct 24, 2019	AM	1				X															
BH08 SS6							X															
BH09 SS3							X															
BH09 SS6							X															
BH10 SS3							X															
BH10 SS6							X															
BH11 SS2		PM					X															
BH11 SS6							X															
BH12 SS2 & SS6			2				X															
BH13 SS2			1				X															
BH13 SS5							X															

Samples Relinquished By (Print Name and Sign): <u>Dilsher Bhargal</u>	Date: <u>Nov. 1, 2019</u>	Time: <u>11:00 AM</u>	Samples Received By (Print Name and Sign): <u>John Chyryha</u>	Date: <u>Nov 1</u>	Time: <u>12:00</u>	Page ____ of ____
Samples Relinquished By (Print Name and Sign): <u>[Signature]</u>	Date: _____	Time: _____	Samples Received By (Print Name and Sign): <u>John Chyryha</u>	Date: <u>Nov 1</u>	Time: <u>4:00</u>	

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: HAM-00801772-A0

AGAT WORK ORDER: 19T538957

SOIL ANALYSIS REVIEWED BY: Nivine Basily, Inorganics Report Writer

DATE REPORTED: Nov 11, 2019

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T538957

PROJECT: HAM-00801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-11-01

DATE REPORTED: 2019-11-11

		SAMPLE DESCRIPTION:		BH14 SS3	BH15 SS3	BH16 SS4	BH17 SS2
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-10-25	2019-10-25	2019-10-25	2019-10-25
Parameter	Unit	G / S	RDL	675748	675749	675751	675752
Antimony	µg/g		0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g		1	6	6	4	6
Barium	µg/g		2	142	152	147	154
Beryllium	µg/g		0.5	0.9	1.0	1.0	1.2
Boron	µg/g		5	12	9	13	7
Boron (Hot Water Soluble)	µg/g		0.10	0.35	0.12	0.63	0.44
Cadmium	µg/g		0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/g		2	31	32	32	33
Cobalt	µg/g		0.5	15.3	19.2	16.8	22.1
Copper	µg/g		1	25	27	24	25
Lead	µg/g		1	12	13	12	18
Molybdenum	µg/g		0.5	0.6	0.8	<0.5	0.7
Nickel	µg/g		1	33	36	36	33
Selenium	µg/g		0.4	<0.4	<0.4	<0.4	0.4
Silver	µg/g		0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g		0.4	<0.4	<0.4	<0.4	<0.4
Uranium	µg/g		0.5	1.3	0.7	1.0	1.0
Vanadium	µg/g		1	40	42	40	43
Zinc	µg/g		5	76	75	75	80
Chromium VI	µg/g		0.2	<0.2	<0.2	<0.2	<0.2
Cyanide	µg/g		0.040	<0.040	<0.040	<0.040	<0.040
Mercury	µg/g		0.10	<0.10	<0.10	<0.10	<0.10
Electrical Conductivity	mS/cm		0.005	1.45	1.55	1.83	2.85
Sodium Adsorption Ratio	NA		NA	2.26	1.96	1.28	10.9
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.75	7.71	7.82	7.59

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

675748-675752 EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio. SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Divine Basily

Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-00801772-A0

SAMPLING SITE:

AGAT WORK ORDER: 19T538957

ATTENTION TO: Jeff Golder

SAMPLED BY:

Soil Analysis

RPT Date: Nov 11, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - Metals & Inorganics (Soil)															
Antimony	680099		3.4	3.6	NA	< 0.8	104%	70%	130%	102%	80%	120%	93%	70%	130%
Arsenic	680099		29	29	0.0%	< 1	98%	70%	130%	106%	80%	120%	104%	70%	130%
Barium	680099		415	404	2.7%	< 2	101%	70%	130%	99%	80%	120%	93%	70%	130%
Beryllium	680099		0.7	0.7	NA	< 0.5	103%	70%	130%	118%	80%	120%	103%	70%	130%
Boron	680099		15	15	NA	< 5	89%	70%	130%	107%	80%	120%	95%	70%	130%
Boron (Hot Water Soluble)	680838		0.91	0.96	5.3%	< 0.10	112%	60%	140%	102%	70%	130%	98%	60%	140%
Cadmium	680099		1.2	1.2	NA	< 0.5	100%	70%	130%	100%	80%	120%	98%	70%	130%
Chromium	680099		1340	1300	3.0%	< 2	88%	70%	130%	101%	80%	120%	99%	70%	130%
Cobalt	680099		9.0	9.0	0.0%	< 0.5	99%	70%	130%	107%	80%	120%	98%	70%	130%
Copper	680099		128	126	1.6%	< 1	98%	70%	130%	104%	80%	120%	103%	70%	130%
Lead	680099		485	503	3.6%	< 1	100%	70%	130%	108%	80%	120%	98%	70%	130%
Molybdenum	680099		1.7	1.9	NA	< 0.5	93%	70%	130%	99%	80%	120%	93%	70%	130%
Nickel	680099		22	22	0.0%	< 1	98%	70%	130%	107%	80%	120%	94%	70%	130%
Selenium	680099		1.6	1.6	NA	< 0.4	94%	70%	130%	95%	80%	120%	99%	70%	130%
Silver	680099		1.2	1.1	8.7%	< 0.2	89%	70%	130%	97%	80%	120%	82%	70%	130%
Thallium	680099		0.5	0.5	NA	< 0.4	95%	70%	130%	98%	80%	120%	95%	70%	130%
Uranium	680099		0.7	0.7	NA	< 0.5	100%	70%	130%	104%	80%	120%	105%	70%	130%
Vanadium	680099		26	26	0.0%	< 1	96%	70%	130%	103%	80%	120%	97%	70%	130%
Zinc	680099		444	446	0.4%	< 5	101%	70%	130%	111%	80%	120%	112%	70%	130%
Chromium VI	690167		< 0.2	< 0.2	NA	< 0.2	81%	80%	120%	94%	70%	130%	89%	70%	130%
Cyanide	676529		<0.040	<0.040	NA	< 0.040	93%	70%	130%	94%	80%	120%	102%	70%	130%
Mercury	680099		0.83	1.1	28.0%	< 0.10	103%	70%	130%	99%	80%	120%	98%	70%	130%
Electrical Conductivity	679285		0.143	0.148	3.4%	< 0.005	101%	90%	110%						
Sodium Adsorption Ratio	693410		2.21	2.11	4.6%	NA	NA								
pH, 2:1 CaCl2 Extraction	679401		7.52	7.52	0.0%	NA	100%	80%	120%						

Comments: NA signifies Not Applicable.

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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Certified By:

AGAT QUALITY ASSURANCE REPORT (V1)

Page 3 of 5

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation. RPDs calculated using raw data. The RPD may not be reflective of duplicate values shown, due to rounding of final results.

Results relate only to the items tested. Results apply to samples as received.

Method Summary

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-00801772-A0

SAMPLING SITE:

AGAT WORK ORDER: 19T538957

ATTENTION TO: Jeff Golder

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6068	SW 846 Method 3060A; Method 7196A	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A; SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl ₂ Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER



Laboratory Use Only

Work Order #: 19T538957

Cooler Quantity: _____
Arrival Temperatures: 8.1 | 8 | 7.7
4.4 | 4 | 4.2
Custody Seal Intact: ☐ Yes ☐ No ☐ N/A
Notes: ice

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Report Information:

Company: EXP Services Inc.
Contact: Jeffrey Golder
Address: 80 Bancroft Street
Hamilton, ON L8E 2W5
Phone: 905.573.4000 x5022 Fax: _____
Reports to be sent to:
1. Email: jeffrey.golder@exp.com
2. Email: dilsher.bhargal@exp.com

Regulatory Requirements:

(Please check all applicable boxes)

☒ Regulation 153/04 ☐ No Regulatory Requirement
☐ Sewer Use ☐ Regulation 558
☐ Sanitary ☐ CCME
☐ Storm ☐ Prov. Water Quality Objectives (PWQO)
☐ Other
Soil Texture (Check One) ☐ Coarse ☐ Fine
Region: _____ Indicate One

Project Information:

Project: HAM-DD8D1772-AO
Site Location: CANAL BANK ST, Welland, ON
Sampled By: DB
AGAT Quote #: 159061 PO: _____
Please note: if quotation number is not provided, client will be billed full price for analysis.

Is this submission for a Record of Site Condition?

☐ Yes ☒ No

Report Guideline on Certificate of Analysis

☐ Yes ☐ No

Sample Matrix Legend

B Biota
GW Ground Water
O Oil
P Paint
S Soil
SD Sediment
SW Surface Water

Invoice Information:

Bill To Same: Yes ☒ No ☐

Company: _____
Contact: _____
Address: _____
Email: _____

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Y / N	Field Filtered - Metals, Hg, CrVI (Please Circle)	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: <input type="checkbox"/> B-HWS <input type="checkbox"/> Cl <input type="checkbox"/> CN <input type="checkbox"/> Cr ⁶⁺ <input type="checkbox"/> EC <input type="checkbox"/> FOC <input type="checkbox"/> NO ₃ /NO ₂ <input type="checkbox"/> Total N <input type="checkbox"/> Hg <input type="checkbox"/> pH <input type="checkbox"/> SAR Nutrients: <input type="checkbox"/> TP <input type="checkbox"/> NH ₃ <input type="checkbox"/> THN <input type="checkbox"/> NO ₃ <input type="checkbox"/> NO ₂ <input type="checkbox"/> NO ₃ /NO ₂	Volatiles: <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM	CCME Fractions 1 to 4	ABNS	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use
BH14 SS2	04/25/2019	AM	1					X													
BH14 SS3								X													
BH15 SS3								X													
BH16 SS2								X													
BH16 SS4								X													
BH17 SS2								X													
BH17 SS5								X													

Samples Relinquished By (Print Name and Sign): <u>Dilsher Bhargal</u>	Date: <u>11/1/2019</u> Time: <u>11:00 AM</u>	Samples Received By (Print Name and Sign): <u>John S. Gygis</u>	Date: <u>Nov 1</u> Time: <u>12:20</u>
Samples Relinquished By (Print Name and Sign): <u>[Signature]</u>	Date: _____ Time: _____	Samples Received By (Print Name and Sign): <u>John S. Gygis</u>	Date: <u>Nov 1</u> Time: <u>4:00</u>

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: HAM-00801772-A0

AGAT WORK ORDER: 20T561507

SOIL ANALYSIS REVIEWED BY: Yris Verastegui, Report Reviewer

DATE REPORTED: Jan 17, 2020

PAGES (INCLUDING COVER): 7

VERSION*: 2

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

VERSION 2: Revised report issued January 17, 2019.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 20T561507

PROJECT: HAM-00801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2020-01-07

DATE REPORTED: 2020-01-17

		SAMPLE DESCRIPTION:		BH18 SS8	BH20 SS8	BH22 SS4	BH24 SS5
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-12-23	2019-12-23	2019-12-23	2019-12-23
Parameter	Unit	G / S	RDL	849843	849846	849850	849853
Chloride (2:1)	µg/g	4	59	23	148	37	
Sulphate (2:1)	µg/g	4	1710	1010	1730	1290	
pH (2:1)	pH Units	NA	8.06	8.24	8.06	8.12	
Electrical Conductivity (2:1)	mS/cm	0.005	1.63	1.09	1.76	1.29	
Resistivity (2:1) (Calculated)	ohm.cm	1	613	917	568	775	
Redox Potential 1	mV	NA	156	217	205	219	
Redox Potential 2	mV	NA	153	221	205	202	
Redox Potential 3	mV	NA	157	222	202	201	

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

849843-849853 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter. Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

Elevated RDLs indicate the degree of sample dilutions prior to the analysis to keep analytes within the calibration range, reduce matrix interference and/or to avoid contaminating the instrument.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Iris Veraástegui



Certificate of Analysis

AGAT WORK ORDER: 20T561507

PROJECT: HAM-00801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2020-01-07

DATE REPORTED: 2020-01-17

		SAMPLE DESCRIPTION:		BH18 SS8	BH19 SS8	BH20 SS3	BH21 SS8	BH22 SS1	BH23 SS4	BH24 SS1	BH101 SS5
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-12-23	2019-12-23	2019-12-23	2019-12-23	2019-12-23	2019-12-23	2019-12-23	2019-12-23
Parameter	Unit	G / S	RDL	849843	849844	849845	849847	849849	849851	849852	849859
Antimony	µg/g	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g	1	5	5	5	6	6	5	6	6	6
Barium	µg/g	2	124	116	116	169	116	152	120	185	169
Beryllium	µg/g	0.5	0.8	0.7	1.0	0.7	1.0	0.8	1.2	0.9	0.9
Boron	µg/g	5	14	10	6	10	13	12	8	15	15
Boron (Hot Water Soluble)	µg/g	0.10	0.89	0.91	0.36	0.68	0.26	0.83	0.66	0.66	0.66
Cadmium	µg/g	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/g	2	30	22	37	26	35	28	39	34	34
Cobalt	µg/g	0.5	12.8	11.9	12.6	13.3	16.4	13.2	14.9	15.7	15.7
Copper	µg/g	1	28	23	19	26	28	26	19	25	25
Lead	µg/g	1	11	9	15	10	13	10	17	10	10
Molybdenum	µg/g	0.5	<0.5	<0.5	0.7	0.6	0.5	0.5	0.8	0.6	0.6
Nickel	µg/g	1	30	24	32	28	34	29	27	32	32
Selenium	µg/g	0.4	0.5	<0.4	0.4	<0.4	0.5	<0.4	0.5	<0.4	<0.4
Silver	µg/g	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Uranium	µg/g	0.5	0.8	0.7	0.8	0.8	1.2	0.9	1.2	1.2	1.2
Vanadium	µg/g	1	39	27	47	33	46	36	49	45	45
Zinc	µg/g	5	66	54	72	78	71	65	84	77	77
Chromium VI	µg/g	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanide	µg/g	0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Mercury	µg/g	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Electrical Conductivity	mS/cm	0.005	1.63	3.75	3.01	1.50	2.72	1.67	1.32	0.934	0.934
Sodium Adsorption Ratio	NA	NA	1.59	0.923	7.67	1.59	4.97	1.14	9.21	1.26	1.26
pH, 2:1 CaCl2 Extraction	pH Units	NA	8.05	7.85	7.72	7.96	7.87	7.94	7.53	7.85	7.85

Certified By:

José Verástegui



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 20T561507

PROJECT: HAM-00801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2020-01-07

DATE REPORTED: 2020-01-17

		SAMPLE DESCRIPTION: BH102 SS2	
		SAMPLE TYPE: Soil	
		DATE SAMPLED: 2019-12-23	
Parameter	Unit	G / S	RDL 849860
Antimony	µg/g	0.8	<0.8
Arsenic	µg/g	1	4
Barium	µg/g	2	197
Beryllium	µg/g	0.5	1.1
Boron	µg/g	5	<5
Boron (Hot Water Soluble)	µg/g	0.10	0.13
Cadmium	µg/g	0.5	<0.5
Chromium	µg/g	2	37
Cobalt	µg/g	0.5	14.7
Copper	µg/g	1	29
Lead	µg/g	1	15
Molybdenum	µg/g	0.5	<0.5
Nickel	µg/g	1	36
Selenium	µg/g	0.4	<0.4
Silver	µg/g	0.2	<0.2
Thallium	µg/g	0.4	<0.4
Uranium	µg/g	0.5	0.5
Vanadium	µg/g	1	44
Zinc	µg/g	5	74
Chromium VI	µg/g	0.2	<0.2
Cyanide	µg/g	0.040	<0.040
Mercury	µg/g	0.10	<0.10
Electrical Conductivity	mS/cm	0.005	0.460
Sodium Adsorption Ratio	NA	NA	0.554
pH, 2:1 CaCl2 Extraction	pH Units	NA	7.62

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

849843-849860 EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio. SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Iris Veraistegui

Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 20T561507

PROJECT: HAM-00801772-A0

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

Soil Analysis															
RPT Date: Jan 17, 2020			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

O. Reg. 153(511) - Metals & Inorganics (Soil)

Antimony	853051		<0.8	<0.8	NA	< 0.8	130%	70%	130%	91%	80%	120%	74%	70%	130%
Arsenic	853051		2	2	NA	< 1	109%	70%	130%	102%	80%	120%	106%	70%	130%
Barium	853051		32	32	0.0%	< 2	103%	70%	130%	109%	80%	120%	111%	70%	130%
Beryllium	853051		<0.5	<0.5	NA	< 0.5	130%	70%	130%	119%	80%	120%	107%	70%	130%
Boron	853051		9	9	NA	< 5	73%	70%	130%	110%	80%	120%	93%	70%	130%
Boron (Hot Water Soluble)	853850		0.41	0.40	NA	< 0.10	107%	60%	140%	95%	70%	130%	87%	60%	140%
Cadmium	853051		<0.5	<0.5	NA	< 0.5	100%	70%	130%	107%	80%	120%	102%	70%	130%
Chromium	853051		9	10	NA	< 2	99%	70%	130%	110%	80%	120%	109%	70%	130%
Cobalt	853051		2.0	2.1	NA	< 0.5	92%	70%	130%	107%	80%	120%	99%	70%	130%
Copper	853051		5	5	0.0%	< 1	89%	70%	130%	115%	80%	120%	97%	70%	130%
Lead	853051		5	5	0.0%	< 1	101%	70%	130%	109%	80%	120%	102%	70%	130%
Molybdenum	853051		<0.5	<0.5	NA	< 0.5	94%	70%	130%	103%	80%	120%	105%	70%	130%
Nickel	853051		4	4	NA	< 1	95%	70%	130%	109%	80%	120%	98%	70%	130%
Selenium	853051		2.0	1.9	NA	< 0.4	110%	70%	130%	107%	80%	120%	109%	70%	130%
Silver	853051		<0.2	<0.2	NA	< 0.2	98%	70%	130%	106%	80%	120%	90%	70%	130%
Thallium	853051		<0.4	<0.4	NA	< 0.4	106%	70%	130%	104%	80%	120%	95%	70%	130%
Uranium	853051		<0.5	<0.5	NA	< 0.5	109%	70%	130%	104%	80%	120%	106%	70%	130%
Vanadium	853051		15	15	0.0%	< 1	99%	70%	130%	104%	80%	120%	106%	70%	130%
Zinc	853051		24	24	NA	< 5	97%	70%	130%	113%	80%	120%	109%	70%	130%
Chromium VI	849706	849706	< 0.2	< 0.2	NA	< 0.2	86%	80%	120%	84%	70%	130%	75%	70%	130%
Cyanide	849706		<0.040	<0.040	NA	< 0.040	105%	70%	130%	103%	80%	120%	102%	70%	130%
Mercury	853051		<0.10	<0.10	NA	< 0.10	106%	70%	130%	96%	80%	120%	98%	70%	130%
Electrical Conductivity	847661		0.214	0.218	1.9%	< 0.005	101%	90%	110%	NA			NA		
Sodium Adsorption Ratio	851243		10.3	9.68	6.2%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	849706		8.15	8.12	0.4%	NA	NA	80%	120%	NA			NA		

Corrosivity Package

Chloride (2:1)	848656		44	45	2.2%	< 2	92%	80%	120%	103%	80%	120%	110%	70%	130%
Sulphate (2:1)	848656		47	47	0.0%	< 2	99%	80%	120%	105%	80%	120%	109%	70%	130%
pH (2:1)	849691		8.34	8.37	0.4%	NA	101%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	847661		0.214	0.218	1.9%	< 0.005	101%	90%	110%	NA			NA		
Redox Potential 1	1						100%	90%	110%						

Comments: NA signifies Not Applicable.

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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Certified By:


Method Summary

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-00801772-A0

SAMPLING SITE:

AGAT WORK ORDER: 20T561507

ATTENTION TO: Jeff Golder

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6068	SW 846 Method 3060A; Method 7196A	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A;SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl ₂ Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Report Information:

Company: EXP Services Inc.
Contact: Jeffrey Golder
Address: 80 Bancroft Street
Hamilton, ON L8E 2W5
Phone: 905.573.4000 x5022 Fax: _____
Reports to be sent to: jeffrey.golder@exp.com
1. Email: jeffrey.golder@exp.com
2. Email: dilsher.bhangal@exp.com

Regulatory Requirements:

(Please check all applicable boxes)

☒ Regulation 153/04

Table Indicate One

☐ Ind/Com

☐ Res/Park

☐ Agriculture

Soil Texture (Check One)

☐ Coarse

☐ Fine

☐ Sewer Use

☐ Sanitary

☐ Storm

Region Indicate One

☐ Regulation 558

☐ CCME

☐ Prov. Water Quality Objectives (PWQO)

☐ Other

Indicate One

Is this submission for a
Record of Site Condition?

☐ Yes ☒ No

Report Guideline on
Certificate of Analysis

☐ Yes ☐ No

Sample Matrix Legend

B Biota
GW Ground Water
O Oil
P Paint
S Soil
SD Sediment
SW Surface Water

Field Filtered - Metals, Hg, CrVI
(Please Circle)

Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	(Check Applicable)										CCME Fractions 1 to 4	ABNS	PAHS	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	CORROSIVITY PACKAGE
				ORPs: <input type="checkbox"/> B-HWS <input type="checkbox"/> Cl- <input type="checkbox"/> CN- <input type="checkbox"/> Cr6+ <input type="checkbox"/> EC <input type="checkbox"/> FOC <input type="checkbox"/> NO3/NO2 <input type="checkbox"/> Total N <input type="checkbox"/> Hg <input type="checkbox"/> pH <input type="checkbox"/> SAR	Nutrients: <input type="checkbox"/> TP <input type="checkbox"/> NH3 <input type="checkbox"/> TKN <input type="checkbox"/> NO3 <input type="checkbox"/> NO2 <input type="checkbox"/> NO/NO2	Volatiles: <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM																
X																						
X																						
X																						
X																						
X																						
X																						
X																						
X																						
X																						
X																						
X																						

Project Information:

Project: HAM-00801772-AD
Site Location: HWY 58A, WELLAND
Sampled By: DB
AGAT Quote #: 159061 PO: _____

Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☒ No ☐

Company: _____
Contact: _____
Address: _____
Email: _____

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Y/N	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: <input type="checkbox"/> B-HWS <input type="checkbox"/> Cl- <input type="checkbox"/> CN- <input type="checkbox"/> Cr6+ <input type="checkbox"/> EC <input type="checkbox"/> FOC <input type="checkbox"/> NO3/NO2 <input type="checkbox"/> Total N <input type="checkbox"/> Hg <input type="checkbox"/> pH <input type="checkbox"/> SAR	Nutrients: <input type="checkbox"/> TP <input type="checkbox"/> NH3 <input type="checkbox"/> TKN <input type="checkbox"/> NO3 <input type="checkbox"/> NO2 <input type="checkbox"/> NO/NO2	Volatiles: <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM	CCME Fractions 1 to 4	ABNS	PAHS	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	CORROSIVITY PACKAGE
BH18 SS8	23/12/19	PM	1				X															
BH19 SS8		↓	1				X															
BH20 SS3		AM	1				X															
BH20 SS8		↓	1				X															
BH21 SS8		↓	1				X															
BH22 SS1		PM	1				X															
BH22 SS4		↓	1				X															
BH23 SS4		↓	1				X															
BH24 SS1		AM	1				X															
BH24 SS5		↓	1				X															
BH101 SS5 & BH102 SS2		↓	2				X															

Samples Relinquished By (Print Name and Sign): Dilsher Bhangal	Date: JAN 7, 2020	Time: 11:30 AM	Samples Received By (Print Name and Sign): John Chyngba	Date: JAN 7	Time: 12:15	Page ____ of ____
Samples Relinquished By (Print Name and Sign): John Chyngba	Date: JAN 7	Time: 4:10	Samples Received By (Print Name and Sign): John Chyngba	Date: JAN 7	Time: 4:10	

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: HAM-801772-A0

AGAT WORK ORDER: 19T533810

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

DATE REPORTED: Oct 31, 2019

PAGES (INCLUDING COVER): 9

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T533810

PROJECT: HAM-801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

SAMPLING SITE:

ATTENTION TO: Jeff Golder

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2019-10-22

DATE REPORTED: 2019-10-31

		SAMPLE DESCRIPTION:		BH25 SS5		BH29 SS7	
		SAMPLE TYPE:		Soil		Soil	
		DATE SAMPLED:		2019-10-11		2019-10-11	
Parameter	Unit	G / S	RDL	639391	RDL	639399	
Chloride (2:1)	µg/g		2	68	4	113	
Sulphate (2:1)	µg/g		2	449	4	994	
pH (2:1)	pH Units		NA	8.15	NA	7.94	
Electrical Conductivity (2:1)	mS/cm		0.005	0.713	0.005	1.25	
Resistivity (2:1) (Calculated)	ohm.cm		1	1400	1	800	
Redox Potential 1	mV		NA	324	NA	257	
Redox Potential 2	mV		NA	308	NA	233	
Redox Potential 3	mV		NA	307	NA	200	

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

639391 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter. Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

639399 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter. Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

Elevated RDL indicates the degree of sample dilution prior to the analysis in order to keep analytes within the calibration range of the instrument and to reduce matrix interference.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:





AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T533810

PROJECT: HAM-801772-A0

5835 COOPERS AVENUE
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<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-10-22

DATE REPORTED: 2019-10-31

		SAMPLE DESCRIPTION:		BH25 SS2	BH25 SS5	BH26 SS2	BH26 SS5	BH27 SS2	BH27 SS5	BH28 SS2	BH28 SS5
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-10-11	2019-10-11	2019-10-11	2019-10-11	2019-10-11	2019-10-11	2019-10-11	2019-10-11
Parameter	Unit	G / S	RDL	639385	639391	639392	639393	639394	639395	639396	639397
Antimony	µg/g	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g	1	4	6	7	8	5	5	6	6	6
Barium	µg/g	2	148	183	149	142	164	109	148	159	159
Beryllium	µg/g	0.5	0.9	0.9	1.0	0.8	0.9	0.7	1.0	0.9	0.9
Boron	µg/g	5	<5	14	11	15	17	13	8	16	16
Boron (Hot Water Soluble)	µg/g	0.10	0.39	0.55	0.17	0.53	0.57	0.82	0.20	0.86	0.86
Cadmium	µg/g	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/g	2	29	33	32	30	33	27	31	33	33
Cobalt	µg/g	0.5	9.9	18.6	14.5	16.2	16.0	12.3	14.6	16.6	16.6
Copper	µg/g	1	16	24	25	23	24	27	23	26	26
Lead	µg/g	1	14	12	12	10	11	9	14	12	12
Molybdenum	µg/g	0.5	0.6	0.6	0.7	0.6	0.7	<0.5	<0.5	0.6	0.6
Nickel	µg/g	1	24	37	35	33	36	30	34	37	37
Selenium	µg/g	0.4	0.5	<0.4	<0.4	<0.4	<0.4	<0.4	0.4	<0.4	<0.4
Silver	µg/g	0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Uranium	µg/g	0.5	0.8	0.9	0.8	0.9	1.0	0.7	0.6	0.9	0.9
Vanadium	µg/g	1	36	42	47	38	43	34	44	44	44
Zinc	µg/g	5	62	76	69	74	75	63	67	78	78
Chromium VI	µg/g	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanide	µg/g	0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Mercury	µg/g	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Electrical Conductivity	mS/cm	0.005	0.487	0.713	0.425	0.377	0.947	1.38	0.622	1.59	1.59
Sodium Adsorption Ratio	NA	NA	1.28	1.00	0.760	0.930	0.852	1.23	1.55	1.32	1.32
pH, 2:1 CaCl2 Extraction	pH Units	NA	6.60	7.89	7.74	7.86	7.81	7.98	7.84	7.89	7.89

Certified By:





AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T533810

PROJECT: HAM-801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-10-22

DATE REPORTED: 2019-10-31

		SAMPLE DESCRIPTION:		BH29 SS3	BH29 SS7
		SAMPLE TYPE:		Soil	Soil
		DATE SAMPLED:		2019-10-11	2019-10-11
Parameter	Unit	G / S	RDL	639398	639399
Antimony	µg/g		0.8	<0.8	<0.8
Arsenic	µg/g		1	6	4
Barium	µg/g		2	123	118
Beryllium	µg/g		0.5	1.0	0.8
Boron	µg/g		5	10	15
Boron (Hot Water Soluble)	µg/g		0.10	0.39	0.78
Cadmium	µg/g		0.5	<0.5	<0.5
Chromium	µg/g		2	31	30
Cobalt	µg/g		0.5	15.8	14.7
Copper	µg/g		1	26	25
Lead	µg/g		1	14	12
Molybdenum	µg/g		0.5	0.7	0.7
Nickel	µg/g		1	35	35
Selenium	µg/g		0.4	0.4	0.5
Silver	µg/g		0.2	<0.2	<0.2
Thallium	µg/g		0.4	<0.4	<0.4
Uranium	µg/g		0.5	0.8	0.9
Vanadium	µg/g		1	45	38
Zinc	µg/g		5	72	77
Chromium VI	µg/g		0.2	<0.2	<0.2
Cyanide	µg/g		0.040	<0.040	<0.040
Mercury	µg/g		0.10	<0.10	<0.10
Electrical Conductivity	mS/cm		0.005	0.943	1.25
Sodium Adsorption Ratio	NA		NA	6.13	1.56
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.83	7.97

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

639385-639399 EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio. SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-801772-A0

SAMPLING SITE:

AGAT WORK ORDER: 19T533810

ATTENTION TO: Jeff Golder

SAMPLED BY:

Soil Analysis

RPT Date: Oct 31, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - Metals & Inorganics (Soil)															
Antimony	634551		<0.8	<0.8	NA	< 0.8	142%	70%	130%	96%	80%	120%	91%	70%	130%
Arsenic	634551		3	2	NA	< 1	109%	70%	130%	102%	80%	120%	104%	70%	130%
Barium	634551		26	26	0.0%	< 2	108%	70%	130%	100%	80%	120%	101%	70%	130%
Beryllium	634551		<0.5	<0.5	NA	< 0.5	86%	70%	130%	108%	80%	120%	102%	70%	130%
Boron	634551		<5	<5	NA	< 5	76%	70%	130%	114%	80%	120%	104%	70%	130%
Boron (Hot Water Soluble)	639385	639385	0.39	0.41	NA	< 0.10	102%	60%	140%	95%	70%	130%	91%	60%	140%
Cadmium	634551		<0.5	<0.5	NA	< 0.5	112%	70%	130%	101%	80%	120%	102%	70%	130%
Chromium	634551		8	8	NA	< 2	93%	70%	130%	106%	80%	120%	101%	70%	130%
Cobalt	634551		2.8	2.7	3.6%	< 0.5	97%	70%	130%	102%	80%	120%	101%	70%	130%
Copper	634551		12	13	8.0%	< 1	96%	70%	130%	107%	80%	120%	102%	70%	130%
Lead	634551		30	30	0.0%	< 1	107%	70%	130%	102%	80%	120%	98%	70%	130%
Molybdenum	634551		<0.5	<0.5	NA	< 0.5	97%	70%	130%	97%	80%	120%	102%	70%	130%
Nickel	634551		8	7	13.3%	< 1	98%	70%	130%	104%	80%	120%	101%	70%	130%
Selenium	634551		<0.4	<0.4	NA	< 0.4	123%	70%	130%	98%	80%	120%	103%	70%	130%
Silver	634551		<0.2	<0.2	NA	< 0.2	86%	70%	130%	94%	80%	120%	92%	70%	130%
Thallium	634551		<0.4	<0.4	NA	< 0.4	91%	70%	130%	100%	80%	120%	97%	70%	130%
Uranium	634551		<0.5	<0.5	NA	< 0.5	105%	70%	130%	99%	80%	120%	98%	70%	130%
Vanadium	634551		16	14	13.3%	< 1	96%	70%	130%	103%	80%	120%	100%	70%	130%
Zinc	634551		59	49	18.5%	< 5	102%	70%	130%	107%	80%	120%	92%	70%	130%
Chromium VI	639455		< 0.2	< 0.5	NA	< 0.2	82%	80%	120%	83%	70%	130%	86%	70%	130%
Cyanide	630732		<0.040	<0.040	NA	< 0.040	103%	70%	130%	98%	80%	120%	105%	70%	130%
Mercury	634551		<0.10	<0.10	NA	< 0.10	101%	70%	130%	100%	80%	120%	102%	70%	130%
Electrical Conductivity	639385	639385	0.487	0.489	0.4%	< 0.005	100%	90%	110%	NA			NA		
Sodium Adsorption Ratio	639385	639385	1.28	1.28	0.0%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	630732		7.71	7.70	0.1%	NA	100%	80%	120%	NA			NA		

Comments: NA signifies Not Applicable.

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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Antimony reference recovery is outside method's acceptance limit by more than an absolute maximum of 10% however, all other QCs i.e. duplicate, blank, blank spike and matrix spike are within method's QC acceptance criteria

Corrosivity Package

Chloride (2:1)	627030		626	625	0.2%	< 2	92%	80%	120%	97%	80%	120%	99%	70%	130%
Sulphate (2:1)	627030		16700	16700	0.0%	< 2	95%	80%	120%	97%	80%	120%	102%	70%	130%
pH (2:1)	635196		7.47	7.48	0.1%	NA	100%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	639385	639385	0.487	0.489	0.4%	< 0.005	100%	90%	110%	NA			NA		
Redox Potential 1	1						100%	90%	110%						

Comments: NA signifies Not Applicable.

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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

AGAT QUALITY ASSURANCE REPORT (V1)

Page 5 of 9

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation. RPDs calculated using raw data. The RPD may not be reflective of duplicate values shown, due to rounding of final results.

Results relate only to the items tested. Results apply to samples as received.



Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-801772-A0

SAMPLING SITE:

AGAT WORK ORDER: 19T533810

ATTENTION TO: Jeff Golder

SAMPLED BY:

Soil Analysis (Continued)

RPT Date: Oct 31, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE			MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Certified By:

Amanjot Bhella

QA Violation

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19T533810

PROJECT: HAM-801772-A0

ATTENTION TO: Jeff Golder

RPT Date: Oct 31, 2019				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE	
PARAMETER	Sample Id	Sample Description	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
				Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - Metals & Inorganics (Soil)											
Antimony		BH25 SS2	142%	70%	130%	96%	80%	120%	91%	70%	130%

Comments: NA signifies Not Applicable.

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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Antimony reference recovery is outside method's acceptance limit by more than an absolute maximum of 10% however, all other QCs i.e. duplicate, blank, blank spike and matrix spike are within method's QC acceptance criteria

Method Summary

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-801772-A0

SAMPLING SITE:
AGAT WORK ORDER: 19T533810

ATTENTION TO: Jeff Golder

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6068	SW 846 Method 3060A; Method 7196A	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A;SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl ₂ Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER



AGAT

Laboratories

1/10/22

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
web@agatlabs.com

Laboratory Use Only

Work Order #: 19T533810

Cooler Quantity: _____
Arrival Temperatures: 5.6 | 5.7 | 5.7
5.4 | 5.6 | 5.6
Custody Seal Intact: ☐ Yes ☐ No ☐ N/A
Notes: _____

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Report Information:

Company: EXP Services Inc.
Contact: Jeffrey Golder
Address: 80 Bancroft Street
Hamilton, ON L8E 2W5
Phone: 905.573.4000 x5022 Fax: _____
Reports to be sent to: jeffrey.golder@exp.com
1. Email: _____
2. Email: dilsher.bhangal@exp.com

Regulatory Requirements:

(Please check all applicable boxes)

☒ Regulation 153/04

☐ Sewer Use

☐ Regulation 558

Table Indicate One

☐ Ind/Com

☐ Sanitary

☐ CCME

☐ Res/Park

☐ Storm

☐ Prov. Water Quality
Objectives (PWQO)

☐ Agriculture

Soil Texture (Check One)

Region Indicate One

☐ Other

☐ Coarse

☐ Fine

Indicate One

Is this submission for a
Record of Site Condition?

☐ Yes ☒ No

Report Guideline on
Certificate of Analysis

☐ Yes ☐ No

Sample Matrix Legend

B Biota
GW Ground Water
O Oil
P Paint
S Soil
SD Sediment
SW Surface Water

Field Filtered - Metals, Hg, CrVI
(Please Circle)

(Check Applicable)

Metals and Inorganics
Metal Scan
Hydride Forming Metals
Client Custom Metals
ORPs: ☐ B-HWS ☐ Cr ☐ CN
☐ Cu ☐ EC ☐ FOC ☐ NO₃/NO₂
☐ Total N ☐ Hg ☐ pH ☐ SAR
Nutrients: ☐ TP ☐ NH₃ ☐ TKN
☐ NO₃ ☐ NO₂/NO₂
Volatiles: ☐ VOC ☐ BTEX ☐ THM
CCME Fractions 1 to 4
ABNs
PAHs
Chlorophenols
PCBs
Organochlorine Pesticides
TCPP Metals/Inorganics
Sewer Use

COEROSIVITY AVAILABLE

Project Information:

Project: HAMB01772 AD
Site Location: HUMBERSTONE ROAD, WELLAND
Sampled By: DB
AGAT Quote #: 159061 PO: _____
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☒ No ☐

Company: _____
Contact: _____
Address: _____
Email: _____

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Y / N	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: <input type="checkbox"/> B-HWS <input type="checkbox"/> Cr <input type="checkbox"/> CN <input type="checkbox"/> Cu <input type="checkbox"/> EC <input type="checkbox"/> FOC <input type="checkbox"/> NO ₃ /NO ₂ <input type="checkbox"/> Total N <input type="checkbox"/> Hg <input type="checkbox"/> pH <input type="checkbox"/> SAR	Nutrients: <input type="checkbox"/> TP <input type="checkbox"/> NH ₃ <input type="checkbox"/> TKN <input type="checkbox"/> NO ₃ <input type="checkbox"/> NO ₂ /NO ₂	Volatiles: <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCPP Metals/Inorganics	Sewer Use	COEROSIVITY AVAILABLE
BH25 SS2	Oct 11, 2019	AM	1				X															
BH25 SS5							X															
BH26 SS2							X															
BH26 SS5							X															
BH27 SS2							X															
BH27 SS5							X															
BH28 SS2		PM					X															
BH28 SS5							X															
BH29 SS2							X															
BH29 SS7							X															

Samples Relinquished By (Print Name and Sign): Dilsher Bhangal <i>[Signature]</i>	Date: <u>Oct 22, 2019</u>	Time: <u>12:35 PM</u>	Samples Received By (Print Name and Sign): <i>[Signature]</i>	Date: <u>10/10/22</u>	Time: <u>12:50</u>
Samples Relinquished By (Print Name and Sign): <i>[Signature]</i>	Date: <u>20/9/10/22</u>	Time: <u>4:05</u>	Samples Received By (Print Name and Sign): <i>[Signature]</i>	Date: <u>20/9/10/22</u>	Time: <u>4:05</u>
Samples Relinquished By (Print Name and Sign): _____	Date: _____	Time: _____	Samples Received By (Print Name and Sign): _____	Date: _____	Time: _____

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: HAM-801772-A0

AGAT WORK ORDER: 19T533824

SOIL ANALYSIS REVIEWED BY: Nivine Basily, Inorganics Report Writer

DATE REPORTED: Nov 01, 2019

PAGES (INCLUDING COVER): 7

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T533824

PROJECT: HAM-801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

SAMPLING SITE:

ATTENTION TO: Jeff Golder

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2019-10-22

DATE REPORTED: 2019-11-01

SAMPLE DESCRIPTION: BH32 SS6

SAMPLE TYPE: Soil

DATE SAMPLED: 2019-10-21

Parameter	Unit	G / S	RDL	639469
Chloride (2:1)	µg/g		8	95
Sulphate (2:1)	µg/g		8	3340
pH (2:1)	pH Units		NA	7.83
Electrical Conductivity (2:1)	mS/cm		0.005	2.93
Resistivity (2:1) (Calculated)	ohm.cm		1	341
Redox Potential 1	mV		NA	363
Redox Potential 2	mV		NA	357
Redox Potential 3	mV		NA	358

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

639469 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.

Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

Elevated RDL indicates the degree of sample dilution prior to the analysis in order to keep analytes within the calibration range of the instrument and to reduce matrix interference.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Divine Basily



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T533824

PROJECT: HAM-801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-10-22

DATE REPORTED: 2019-11-01

		SAMPLE DESCRIPTION:		BH30 SS2	BH30 SS6	BH31 SS2	BH31 SS6	BH32 SS2	BH32 SS6	BH33 SS2	BH33 SS6
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-10-21	2019-10-21	2019-10-21	2019-10-21	2019-10-21	2019-10-21	2019-10-21	2019-10-21
Parameter	Unit	G / S	RDL	639464	639465	639466	639467	639468	639469	639470	639471
Antimony	µg/g	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g	1	6	5	6	12	7	10	4	5	5
Barium	µg/g	2	147	118	152	120	160	112	175	202	202
Beryllium	µg/g	0.5	1.6	0.9	1.2	0.9	1.2	0.8	1.1	0.9	0.9
Boron	µg/g	5	6	14	13	15	12	13	14	16	16
Boron (Hot Water Soluble)	µg/g	0.10	0.21	0.83	0.29	0.91	0.28	0.90	0.37	0.77	0.77
Cadmium	µg/g	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/g	2	34	25	32	26	30	23	32	25	25
Cobalt	µg/g	0.5	17.2	12.6	15.6	18.6	15.4	15.0	16.7	12.3	12.3
Copper	µg/g	1	20	24	25	25	26	24	22	20	20
Lead	µg/g	1	16	9	13	10	13	9	12	10	10
Molybdenum	µg/g	0.5	0.6	<0.5	0.5	0.9	0.6	0.8	<0.5	0.7	0.7
Nickel	µg/g	1	33	28	36	32	34	30	36	29	29
Selenium	µg/g	0.4	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Silver	µg/g	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Uranium	µg/g	0.5	0.8	0.7	0.9	0.9	0.9	1.0	1.0	0.8	0.8
Vanadium	µg/g	1	45	32	42	33	41	31	41	32	32
Zinc	µg/g	5	84	61	69	62	71	59	69	66	66
Chromium VI	µg/g	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanide	µg/g	0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Mercury	µg/g	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Electrical Conductivity	mS/cm	0.005	1.40	1.52	2.46	1.94	1.90	2.93	1.74	1.48	1.48
Sodium Adsorption Ratio	NA	NA	3.08	1.35	1.37	1.74	1.74	1.62	1.32	1.33	1.33
pH, 2:1 CaCl2 Extraction	pH Units	NA	7.33	7.70	7.83	7.71	7.73	7.70	7.79	7.73	7.73

Certified By:

Divine Basily



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T533824

PROJECT: HAM-801772-A0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-10-22

DATE REPORTED: 2019-11-01

		SAMPLE DESCRIPTION:		BH34 SS2	BH34 SS6	BH4 SS4	BH4 SS
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-10-21	2019-10-21	2019-10-21	2019-10-21
Parameter	Unit	G / S	RDL	639472	639473	639474	639475
Antimony	µg/g		0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g		1	5	5	3	3
Barium	µg/g		2	151	164	157	105
Beryllium	µg/g		0.5	1.3	1.3	1.1	1.3
Boron	µg/g		5	16	21	18	21
Boron (Hot Water Soluble)	µg/g		0.10	0.35	0.99	0.93	0.63
Cadmium	µg/g		0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/g		2	33	32	30	36
Cobalt	µg/g		0.5	15.8	16.8	14.4	16.2
Copper	µg/g		1	23	25	24	23
Lead	µg/g		1	11	12	12	11
Molybdenum	µg/g		0.5	<0.5	0.7	<0.5	<0.5
Nickel	µg/g		1	36	36	34	37
Selenium	µg/g		0.4	<0.4	<0.4	<0.4	<0.4
Silver	µg/g		0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g		0.4	<0.4	<0.4	<0.4	<0.4
Uranium	µg/g		0.5	1.1	0.9	1.0	1.4
Vanadium	µg/g		1	43	41	39	44
Zinc	µg/g		5	70	80	72	81
Chromium VI	µg/g		0.2	<0.2	<0.2	<0.2	<0.2
Cyanide	µg/g		0.040	<0.040	<0.040	<0.040	<0.040
Mercury	µg/g		0.10	<0.10	<0.10	<0.10	<0.10
Electrical Conductivity	mS/cm		0.005	3.63	1.96	1.61	2.35
Sodium Adsorption Ratio	NA		NA	1.55	1.81	1.85	1.30
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.75	7.69	7.91	7.80

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

639464-639475 EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio. SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Divine Basily

Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19T533824

PROJECT: HAM-801772-A0

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

Soil Analysis															
RPT Date: Nov 01, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

O. Reg. 153(511) - Metals & Inorganics (Soil)

Antimony	645092		<0.8	<0.8	NA	< 0.8	113%	70%	130%	95%	80%	120%	90%	70%	130%
Arsenic	645092		<1	<1	NA	< 1	101%	70%	130%	100%	80%	120%	100%	70%	130%
Barium	645092		42	40	4.9%	< 2	102%	70%	130%	98%	80%	120%	95%	70%	130%
Beryllium	645092		<0.5	<0.5	NA	< 0.5	103%	70%	130%	118%	80%	120%	122%	70%	130%
Boron	645092		<5	<5	NA	< 5	82%	70%	130%	118%	80%	120%	118%	70%	130%
Boron (Hot Water Soluble)	648629		0.17	0.18	NA	< 0.10	118%	60%	140%	102%	70%	130%	99%	60%	140%
Cadmium	645092		<0.5	<0.5	NA	< 0.5	109%	70%	130%	101%	80%	120%	99%	70%	130%
Chromium	645092		21	21	0.0%	< 2	91%	70%	130%	102%	80%	120%	101%	70%	130%
Cobalt	645092		7.4	6.8	8.5%	< 0.5	90%	70%	130%	101%	80%	120%	96%	70%	130%
Copper	645092		41	43	4.8%	< 1	88%	70%	130%	104%	80%	120%	98%	70%	130%
Lead	645092		28	26	7.4%	< 1	105%	70%	130%	98%	80%	120%	97%	70%	130%
Molybdenum	645092		<0.5	<0.5	NA	< 0.5	84%	70%	130%	93%	80%	120%	92%	70%	130%
Nickel	645092		15	15	0.0%	< 1	95%	70%	130%	104%	80%	120%	100%	70%	130%
Selenium	645092		< 0.4	< 0.4	NA	< 0.4	87%	70%	130%	94%	80%	120%	96%	70%	130%
Silver	645092		<0.2	<0.2	NA	< 0.2	78%	70%	130%	90%	80%	120%	87%	70%	130%
Thallium	645092		<0.4	<0.4	NA	< 0.4	99%	70%	130%	105%	80%	120%	103%	70%	130%
Uranium	645092		0.9	0.8	NA	< 0.5	105%	70%	130%	100%	80%	120%	100%	70%	130%
Vanadium	645092		18	18	0.0%	< 1	89%	70%	130%	99%	80%	120%	97%	70%	130%
Zinc	645092		49	48	2.1%	< 5	98%	70%	130%	101%	80%	120%	105%	70%	130%
Chromium VI	639467	639467	< 0.2	< 0.2	NA	< 0.2	82%	80%	120%	83%	70%	130%	83%	70%	130%
Cyanide	639473	639473	<0.040	<0.040	NA	< 0.040	103%	70%	130%	98%	80%	120%	105%	70%	130%
Mercury	645092		0.12	0.10	NA	< 0.10	99%	70%	130%	97%	80%	120%	99%	70%	130%
Electrical Conductivity	639464	639464	1.40	1.40	0.0%	< 0.005	101%	90%	110%						
Sodium Adsorption Ratio	639464	639464	3.08	3.06	0.7%	NA									
pH, 2:1 CaCl2 Extraction	639464	639464	7.33	7.34	0.1%	NA	100%	80%	120%						

Corrosivity Package

Chloride (2:1)	635201		4	4	NA	< 2	94%	80%	120%	99%	80%	120%	98%	70%	130%
Sulphate (2:1)	635201		3	3	NA	< 2	91%	80%	120%	98%	80%	120%	96%	70%	130%
pH (2:1)	635196		7.47	7.48	0.1%	NA	100%	90%	110%						
Electrical Conductivity (2:1)	639464	639464	1.40	1.40	0.1%	< 0.005	101%	90%	110%						
Redox Potential 1	1					NA	102%	90%	110%						

Comments: NA signifies Not Applicable.

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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Certified By:

AGAT QUALITY ASSURANCE REPORT (V1)

Page 5 of 7

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation. RPDs calculated using raw data. The RPD may not be reflective of duplicate values shown, due to rounding of final results.

Results relate only to the items tested. Results apply to samples as received.

Method Summary

CLIENT NAME: EXP. SERVICES INC.

PROJECT: HAM-801772-A0

SAMPLING SITE:

AGAT WORK ORDER: 19T533824

ATTENTION TO: Jeff Golder

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6068	SW 846 Method 3060A; Method 7196A	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A;SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl ₂ Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: 19T536967

AGAT WORK ORDER: 19T539279

SOLID ANALYSIS REVIEWED BY: Sherin Moussa, Senior Technician

DATE REPORTED: Nov 07, 2019

PAGES (INCLUDING COVER): 5

Should you require any information regarding this analysis please contact your client services representative at (905) 501-9998

***NOTES**

All samples are stored at no charge for 90 days. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T539279

PROJECT: 19T536967

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

DATE SAMPLED: Nov 03, 2019

DATE RECEIVED: Nov 04, 2019

DATE REPORTED: Nov 07, 2019

SAMPLE TYPE: Other

Analyte: Sulfide

Unit: %

Sample ID (AGAT ID) RDL: 0.05

BH03 SS 6 (678887) <0.05

Comments: RDL - Reported Detection Limit

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Sherin Moosaj



AGAT Laboratories

Quality Assurance - Replicate

AGAT WORK ORDER: 19T539279

PROJECT: 19T536967

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

REPLICATE #1															
Parameter	Sample ID	Original	Replicate	RPD											
S	678887	0.067	0.053	23.3%											
Sulfate	678887	0.05	0.05	0.0%											
Sulfide	678887	< 0.05	<0.05	0.0%											



AGAT Laboratories

Quality Assurance - Certified Reference materials

AGAT WORK ORDER: 19T539279

PROJECT: 19T536967

5623 McADAM ROAD
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CANADA L4Z 1N9
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FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

CRM #1															
Parameter	Expect	Actual	Recovery	Limits											
S	0.8	0.8	100%	90% - 110%											
Sulfate	0.01	0.01	100%	90% - 110%											
Sulfide	0.8	0.79	98%	90% - 110%											

Method Summary

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19T539279

PROJECT: 19T536967

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Solid Analysis			
Sulfide	MIN-200-12037		LECO

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: 19T538959

AGAT WORK ORDER: 19T541004

SOLID ANALYSIS REVIEWED BY: Sherin Moussa, Senior Technician

DATE REPORTED: Nov 08, 2019

PAGES (INCLUDING COVER): 5

Should you require any information regarding this analysis please contact your client services representative at (905) 501-9998

***NOTES**



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T541004

PROJECT: 19T538959

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

DATE SAMPLED: Nov 06, 2019

DATE RECEIVED: Nov 07, 2019

DATE REPORTED: Nov 08, 2019

SAMPLE TYPE: Other

Analyte: Sulfide

Unit: %

Sample ID (AGAT ID) RDL: 0.05

BH08 SS6 (691645) <0.05

BH13 SS5 (691646) <0.05

Comments: RDL - Reported Detection Limit

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Sherin Hoossaf



AGAT Laboratories

Quality Assurance - Replicate

AGAT WORK ORDER: 19T541004

PROJECT: 19T538959

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

Parameter	REPLICATE #1				REPLICATE #2											
	Sample ID	Original	Replicate	RPD	Sample ID	Original	Replicate	RPD								
S	691645	0.095	0.094	1.1%	691646	0.043	0.042	2.4%								
Sulfate	691645	0.061	0.067	9.4%	691646	< 0.01	<0.01	0.0%								
Sulfide	691645	< 0.05	<0.05	0.0%	691646	< 0.05	<0.05	0.0%								



AGAT Laboratories

Quality Assurance - Certified Reference materials

AGAT WORK ORDER: 19T541004

PROJECT: 19T538959

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

Parameter	CRM #1				CRM #2											
	Expect	Actual	Recovery	Limits	Expect	Actual	Recovery	Limits								
S	0.8	0.81	101%	90% - 110%	0.8	0.8	100%	90% - 110%								
Sulfate	0.01	0.01	100%	90% - 110%	0.01	0.01	100%	90% - 110%								
Sulfide	0.8	0.8	100%	90% - 110%	0.8	0.79	98%	90% - 110%								

Method Summary

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19T541004

PROJECT: 19T538959

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Solid Analysis			
Sulfide	MIN-200-12037		LECO

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: 20T561507

AGAT WORK ORDER: 20T563116

SOLID ANALYSIS REVIEWED BY: Sherin Moussa, Senior Technician

DATE REPORTED: Jan 17, 2020

PAGES (INCLUDING COVER): 5

Should you require any information regarding this analysis please contact your client services representative at (905) 501-9998

***NOTES**

All samples are stored at no charge for 90 days. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 20T563116

PROJECT: 20T561507

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

DATE SAMPLED: Jan 12, 2020

DATE RECEIVED: Jan 13, 2020

DATE REPORTED: Jan 17, 2020

SAMPLE TYPE: Other

Analyte: Sulfide
Unit: %
Sample ID (AGAT ID) RDL: 0.05

BH18 SS8 (859361) 0.25

BH20 SS8 (859362) <0.05

BH22 SS4 (859363) 0.06

BH24 SS5 (859364) <0.05

Comments: RDL - Reported Detection Limit

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Sherin Moosaj



AGAT Laboratories

Quality Assurance - Replicate

AGAT WORK ORDER: 20T563116

PROJECT: 20T561507

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

(201-042) Sulfide															
	REPLICATE #1														
Parameter	Sample ID	Original	Replicate	RPD											
S	859361	0.3070	0.3080	0.3%											
Sulfate	859361	0.0586	0.0635	8.0%											
Sulfide	859361	0.25	0.24	4.1%											



AGAT Laboratories

Quality Assurance - Certified Reference materials

AGAT WORK ORDER: 20T563116

PROJECT: 20T561507

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

CRM #1															
Parameter	Expect	Actual	Recovery	Limits											
S	0.8	0.79	98%	90% - 110%											
Sulfate	0.01	0.01	100%	90% - 110%											
Sulfide	0.8	0.78	97%	90% - 110%											

Method Summary

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 20T563116

PROJECT: 20T561507

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Solid Analysis			
Sulfide	MIN-200-12037		LECO

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: 19T533810

AGAT WORK ORDER: 19T535272

SOLID ANALYSIS REVIEWED BY: Sherin Moussa, Senior Technician

DATE REPORTED: Oct 28, 2019

PAGES (INCLUDING COVER): 5

Should you require any information regarding this analysis please contact your client services representative at (905) 501-9998

***NOTES**

All samples are stored at no charge for 90 days. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T535272

PROJECT: 19T533810

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

DATE SAMPLED: Oct 24, 2019

DATE RECEIVED: Oct 25, 2019

DATE REPORTED: Oct 28, 2019

SAMPLE TYPE: Other

Analyte: Sulfide

Unit: %

Sample ID (AGAT ID) RDL: 0.05

BH25 SS5 (649228) <0.05

BH29 SS5 (649229) 0.08

Comments: RDL - Reported Detection Limit

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Sherin Moosaj



AGAT Laboratories

Quality Assurance - Replicate

AGAT WORK ORDER: 19T535272

PROJECT: 19T533810

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

Parameter	REPLICATE #1				REPLICATE #2											
	Sample ID	Original	Replicate	RPD	Sample ID	Original	Replicate	RPD								
S	649228	0.024	0.023	4.3%	649229	0.129	0.129	0.0%								
Sulfate	649228	< 0.01	<0.01	0.0%	649229	0.05	0.05	0.0%								
Sulfide	649228	< 0.05	<0.05	0.0%	649229	0.08	0.08	0.0%								



AGAT Laboratories

Quality Assurance - Certified Reference materials

AGAT WORK ORDER: 19T535272

PROJECT: 19T533810

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

Parameter	CRM #1				CRM #2											
	Expect	Actual	Recovery	Limits	Expect	Actual	Recovery	Limits								
S	0.80	0.81	101%	90% - 110%	0.80	0.81	101%	90% - 110%								
Sulfate	0.01	0.01	100%	90% - 110%	0.01	0.01	100%	90% - 110%								
Sulfide	0.80	0.80	100%	90% - 110%	0.80	0.80	100%	90% - 110%								

Method Summary

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19T535272

PROJECT: 19T533810

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Solid Analysis			
Sulfide	MIN-200-12037		LECO

**CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000**

ATTENTION TO: Jeff Golder

PROJECT: 19T533824

AGAT WORK ORDER: 19T536132

SOLID ANALYSIS REVIEWED BY: Sherin Moussa, Senior Technician

DATE REPORTED: Nov 01, 2019

PAGES (INCLUDING COVER): 5

Should you require any information regarding this analysis please contact your client services representative at (905) 501-9998

***NOTES**



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T536132

PROJECT: 19T533824

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MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
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<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

DATE SAMPLED: Oct 27, 2019

DATE RECEIVED: Oct 28, 2019

DATE REPORTED: Nov 01, 2019

SAMPLE TYPE: Soil

Analyte: Sulfide

Unit: %

Sample ID (AGAT ID) RDL: 0.05

BH32 SS6 (656061) <0.05

Comments: RDL - Reported Detection Limit

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Sherin Hoossaf



AGAT Laboratories

Quality Assurance - Replicate

AGAT WORK ORDER: 19T536132

PROJECT: 19T533824

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CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

REPLICATE #1															
Parameter	Sample ID	Original	Replicate	RPD											
S	656061	0.084	0.084	0.0%											
Sulfate	656061	0.07	0.07	0.0%											
Sulfide	656061	< 0.05	<0.05	0.0%											



AGAT Laboratories

Quality Assurance - Certified Reference materials

AGAT WORK ORDER: 19T536132

PROJECT: 19T533824

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CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

(201-042) Sulfide

CRM #1															
Parameter	Expect	Actual	Recovery	Limits											
S	0.8	0.81	101%	90% - 110%											
Sulfate	0.01	0.01	100%	90% - 110%											
Sulfide	0.8	0.8	100%	90% - 110%											

Method Summary

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19T536132

PROJECT: 19T533824

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Solid Analysis			
Sulfide	MIN-200-12037		LECO