

GEOTECHNICAL INVESTIGATION REPORT

**PROPOSED WEST TRANSITWAY AT RICHMOND ROAD
OTTAWA, ONTARIO**

PROJECT NO. 10923

REPORT TO

MORRISON HERSHFIELD LIMITED

ON

**GEOTECHNICAL INVESTIGATION
PROPOSED WEST TRANSITWAY AT RICHMOND ROAD
OTTAWA, ONTARIO**

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February 16, 1998



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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the design of the proposed Regional Municipality of Ottawa-Carleton (RMOC) West Transitway from Stations 6+740 to 7+070. This section of the West Transitway project includes the crossing of Richmond Road, construction of a new N-W ramp to the Queensway, and construction of 330 m of Transitway, beginning in the City of Nepean and ending in the City of Ottawa. The work was carried out in accordance with our proposal dated May 1, 1997. Authorization to proceed with the investigation was provided by Mr. John Douglas of Morrison Hershfield Limited.

This report has been prepared specifically and solely for the proposed work described herein. It contains all of our findings and includes the necessary geotechnical recommendations for the design of the section of the West Transitway described above, plus the associated ramps, structures and underground services.

2.0 BACKGROUND

As part of the 1994 Functional Design of the West Transitway, Jacques, Whitford Limited (JWL) prepared a general overall assessment of the geotechnical and environmental considerations based on the then existing information, supplemented by a limited number of boreholes.

The current investigation was carried out to obtain the necessary geotechnical information for the preliminary and detail design of the following section of the West Transitway:

- Transitway (Station 6+740 to 7+070) and associated works
- Richmond Road Bridge
- New N-W Ramp, approximately 250 m in length from Richmond Road to the Queensway
- N-W Ramp Bridge

Based on the Functional Design and discussions with Morrison Hershfield, the associated works is to include the following:

- Removal of the existing N-W ramp, approximately 350 m in length
- Storm sewer installation along the Transitway alignment
- Retaining walls associated with the realigned N-W ramp, between the West Transitway and the Queensway, as well as in front of the abutments for the Richmond Road bridge structure.

3.0 SCOPE OF WORK

The scope of work for the geotechnical investigation included the following:

- A field and laboratory investigation of the soil, bedrock and groundwater conditions at the site in order to provide the necessary foundation design parameters (as per OHBDC), and the pavement structure design for the preliminary and detail design of the section of the West Transitway described herein.
- A geotechnical investigation report complete with borehole records, all the findings of the investigation, and the necessary geotechnical recommendations for the preliminary and detail design of the proposed project, as well as for the preparation of the tender documents.

4.0 METHODOLOGY

4.1 Geotechnical Investigation

Prior to the start of the field investigation, a plan showing the proposed borehole locations was submitted to Morrison Hershfield Limited for approval. The borehole location plan was subsequently provided to the Regional Municipality of Ottawa-Carleton (RMOC) and the Ministry of Transportation of Ontario (MTO) for their review and approval. The borehole locations were laid out in the field after the required work permit was issued by MTO. The appropriate utility agencies were notified and the borehole locations were cleared of underground utilities.

A site meeting was held with representatives from Morrison Hershfield, the RMOC and MTO to review the proposed borehole locations. MTO expressed concerns regarding disruptions to traffic, traffic control safety, site access and drilling through existing MTO pavement structures. Many of the borehole locations were adjusted in order to comply with the work restrictions set out by MTO and due to the presence of underground utilities. Proposed Boreholes M-14, M-15 and M-17 were cancelled due to MTO restrictions. Borehole M-21 was drilled by Golder Associates for the adjacent West Transitway section. An agreement was made with the consulting team for the adjacent Transitway section to share borehole information at this location.

A total of nineteen (19) soil borings were put down during the field investigation. The borings were located as follows:



Element	No. of Borings	Boring Designations
Richmond Road bridge	5 Boreholes 2 Probeholes	M-1 to M-4 and M-21 M-20 and M-22
N-W ramp bridge	3 Boreholes	M-5 to M-7
N-W ramp	6 Boreholes	M-8 to M-13
Transitway, stn. 6+740 to 7+070	3 Boreholes	M-16, M-18 and M-19

The boreholes were advanced using a truck mounted CME 55 power auger drill rig suitably equipped for soil and bedrock sampling. Soil samples were recovered from the split-spoon sampler while carrying out Standard Penetration Tests (SPT). The subsurface conditions were identified in the field by our personnel and all samples were returned to our laboratory for detailed classification and testing. The subsurface conditions are described in detailed in the Borehole Records presented in Appendix 1. Standpipes were installed in Boreholes M-5 through M-8, M-10, M-11 and M-16. A monitoring well was installed in borehole M-19 to allow for borehole permeability testing to be carried out.

Prior to completing the investigation, the boreholes were backfilled by replacing (and tamping in layers) the augered material. The asphalt surface, where present, was reinstated to match the level of the existing surface with at least 100 mm of cold mix asphalt.

All soil samples will be stored for a period of three months after issuance of the final report. Unless otherwise directed, the stored samples will be disposed of after this period.

5.0 INVESTIGATION RESULTS

5.1 Surface Conditions

General

The investigated section of the proposed West Transitway and associated works lies entirely within the existing Richmond Road - Hwy 417 (Queensway) WBL interchange area. The majority of the ground surface presently consists of maintained grass or existing pavement structure. A large, heavily treed area is present east of Richmond Road between Stations 6+920 and 7+040 (approximate). Exposed bedrock is evident in the ditch along the north side of the Hwy 417 WBL between Stations 6+890 and 6+980 (approximate). The slopes of the Richmond Road overpass approach fill are covered with grass and small bushes.

Boreholes were put down within the existing pavement structure of Richmond Road and the gore area between the N-W ramp and the S-W ramp acceleration lane. Boreholes M-14, M-15 and M-17, all located within the N-W ramp or N-W ramp acceleration lane, were cancelled because MTO would not approve any borehole drilling within these pavement areas.

Based on Boreholes M-12 and M-13, the existing pavement structure within the gore area between the N-W ramp and the S-W ramp includes approximately 175 mm of asphaltic concrete. In this area, the subgrade soils are variable, ranging from silty clay to sand and gravel. Based on the Ministry of Transportation of Ontario classification, the subgrade soils range from low susceptibility to frost heave (LSFH) to high susceptibility to frost heave (HSFH).

Based on Boreholes M-1 through M-4 and M-21, the existing pavement structure within Richmond Road in the vicinity of the proposed Richmond Road bridge includes approximately 300 mm of asphaltic concrete. In this area, the subgrade soils consist of granular approach fill. The approach fill is a heterogeneous mixture of silty clay, silt, sand and gravel. Based on the Ministry of Transportation of Ontario classification, the subgrade soils would be considered as having low to medium susceptibility to frost heave (LSFH to MSFH).

5.2 Subsurface Conditions

The geology in the vicinity of the Richmond Road - Hwy 417 interchange is complex and varied. The two most significant geological features with respect to construction of the proposed West Transitway project are:

1. A dramatic change in the depth to bedrock, associated with a geological contact or discontinuity, occurs directly beneath Richmond Road. The bedrock surface elevation varies from 65.3 m beneath the northbound lanes to 47.9 m beneath the southbound lanes. In addition, the higher bedrock to the east of the discontinuity consists of sandstone with shaly partings, whereas the bedrock to the west consists of dolomite with shale seams. The discontinuity in the bedrock surface elevation also leads to very different overburden soil conditions.
2. The presence of loose, high permeability sand layers. These conditions can lead to sand and water flowing into open boreholes or excavations if control measures are not taken. The condition is commonly referred to as *running sands*. Drilling fluids and casing were required for drilling through these conditions.



The primary soil types encountered during the drilling investigation are described below.

5.2.1 Fill

A surficial layer of fill material was found at most borehole locations. In most cases, the fill is associated with the construction of the existing Richmond Road - Hwy 417 interchange. Typically the fill material immediately adjacent to paved areas consisted of sand and gravel. Within the Richmond Road approach fill, the material varied from silt and sand to silt and clay.

The moisture content of seven samples tested ranged from 7.4 % to 25.3 %, with an average of 17.4 %. The thickness of the fill deposit varied from approximately 1.5 m to 6.0 m beneath parts of Richmond Road.

5.2.2 Silt and Clay

Deposits of silt and clay were encountered in most of the deeper boreholes (M-1, M-3, M-4, M-5, M-6, M-7 and M-21) which are all directly above or west of the geological discontinuity discussed above. The deposits consisted of varying amounts of silt and clay, varying from clayey silt to silty clay, occasionally with trace amounts of sand and/or gravel. In many cases, the silt and clay deposits alternated with sand layers. The moisture contents of eight samples tested ranged from 16 % to 37 %, with an average of 28.6 %.

5.2.3 Sand / Sand and Gravel / Silty Sand

Deposits of sand, sand and gravel or silty sand were encountered in almost all boreholes. Some sand deposits were confined by layers of silt and clay. The relative density of the sand varied from loose to dense. Running sands were encountered in most boreholes where sand layers were encountered beneath the water table. The moisture contents of twelve samples tested ranged from 4 % to 23 %, with an average of 12.7 %. Grain size distribution tests were carried out on four samples. The results are summarized in the table below:

Borehole	Sample	Depth (m)	% Gravel	% Sand	% Silt and Clay
M-6	SS-7	11	0	57.7	42.3
M-6	SS-10	15.5	8.4	60.3	31.3
M-7	SS-11	15.3	0	96.2	3.8
M-7	SS-11	15.7	0	70.7	29.3

5.2.4 Glacial Till

A glacial till deposit consisting of a heterogeneous mixture of silt and sand with trace clay and gravel was encountered near the bottom of Boreholes M-4, M-5, M-19 and M-21, directly above the bedrock. In Borehole M-4, it was noted that the till deposit was considerably thicker and that a silt layer was confined within the till. In general, the till was in a compact state. Frequent boulders were encountered in the till in Borehole M-21. The moisture contents of two samples tested were 7.2 % to 19.5 %.

5.2.5 Bedrock

The bedrock conditions vary significantly across the site. The elevation of the bedrock surface drops off by over 17 m across the width of Richmond Road. In addition, the bedrock on the east side of the drop off is sandstone with shale seams and partings. To the west of the drop off, the bedrock is dolomite with shaly partings.

Exposed bedrock is evident in the ditch on the north side of the S-W ramp acceleration lane, to the east of the existing Richmond Road structure. The exposed bedrock appears to be relatively flat.

The above information suggests that a fault may lie beneath Richmond Road.

The core samples recovered from Boreholes M-1, M-2, M-4, M-18, M-19 and M-21 consisted of grey, sandstone with grey and/or green shale seams and partings. The rock quality designation (RQD) of the recovered sandstone core samples varied from 0 % to 66 %, with an average of 32 %, indicating that the bedrock is typically in a severely fractured condition. Based on geological maps, the bedrock is likely part of the Rockcliffe formation.

The core samples recovered from Boreholes M-3, M-5, M-6, and M-7 consisted of medium to dark grey, dolomite with shaly partings. The rock quality designation (RQD) of the recovered core samples varied from 18 % to 92 %, with an average of 45 %. The dolomite is typically in a fractured condition. Based on geological maps of the area, the rock mass is likely part of the Oxford Formation.

5.3 Groundwater Conditions

The groundwater level was measured in the standpipes and monitoring well on August 22, 1997, and again on August 28, 1997. The depths to groundwater, measured from ground surface are presented in the table below:



Groundwater Level Readings					Approx TWY Grade
Borehole	August 22, 1997		August 28, 1997		
	Depth (m)	Elev. (m)	Depth (m)	Elev. (m)	
M-5	7.2	62.3	7.2	62.3	± 65.0
M-6	dry to 3.9	<63.8	dry to 3.9	<63.8	± 65.1
M-7	4.7	61.8	dry to 4.9	<61.6	± 65.2
M-8	dry to 3.0	<62.6	dry to 3.0	<62.6	± 65.25
M-10	dry to 2.4	<63.8	dry to 2.4	<63.8	± 65.5
M-11	dry to 2.9	<63.2	dry to 2.9	<63.2	± 65.7
M-16	4.4	62.4	4.4	62.4	± 65.5
M-19	2.8	65.5	2.8	65.5	± 64.0

5.4 Environmental Conditions

No visual or olfactory evidence of hydrocarbon contamination was encountered during the field investigation. Environmental testing was carried out on select samples of existing granular fill material. The results of the environmental testing are presented in a separate report.

6.0 RECOMMENDATIONS

6.1 West Transitway Alignment, Stn. 6+740 to 7+070

Based on the functional design, the proposed West Transitway alignment between Stations 6+740 and 7+070 will be located within a cut section and will pass beneath Richmond Road and the proposed N-W ramp. The proposed finished grades for the West Transitway are approximately as follows:

Station	Finished Grade (m)
6+740	65.5
6+800	65.2
6+850	65
6+900	64.9
6+950	64.7
7+000	64.3
7+070	63.8

Based on the proposed grades and the borehole information, the West Transitway will be constructed within a rock cut approximately between Stations 6+840 and 7+070. The proposed finished grade of the West Transitway is close to the bedrock surface at Station 7+070. The bedrock drops off steeply to the west of Station 6+840, directly beneath Richmond Road.

6.1.1 Subgrade Preparation

It is anticipated that the full length of the West Transitway alignment for this project will be located within a cut section. In all areas, the cut material should be wasted or used as landscaping fill. Existing surficial organic topsoil will be removed as part of the general cut excavation, therefore stripping is only required if preservation of either the topsoil or the underlying material to be excavated is proposed.

An appropriate frost taper should be incorporated into the transition between the bedrock subgrade and the adjacent overburden subgrade sections to minimize differential frost action. The transition point treatments should be carried out using the applicable OPSD 205 series drawings, using a "t" depth of 1.2 m.

Where the exposed subgrade consists of existing fill material, the exposed subgrade should be proof rolled with a heavy vibratory roller under the direct supervision of experienced geotechnical personnel. Soft areas revealed during the proof rolling should be removed and replaced with approved subgrade fill. In addition, where the exposed subgrade consists of native sand and gravel, the subgrade surface should be compacted prior to placement of the granular subbase/base. Bedrock subgrade should be free of loose rock material.

Full-time inspection of the surface compaction should be carried out by qualified geotechnical personnel. If required for leveling purposes or for construction of transition point treatments, subgrade fill should consist of OPSS Select Subgrade Material (SSM), placed and compacted in lifts no greater than 300 mm thick, to 98 % Standard Proctor Maximum Dry Density (SPMDD).



6.1.2 Pavement Structure

In accordance with information provided in the RMO Transitway Design Manual, it is understood that the projected Transitway traffic is about 1,700 articulated buses per day in each direction. In carrying out the design, the AASHTO Axle Equivalent Factor, F_A , per vehicle used was 5.0 which reflects an average of 40% of the maximum design passenger capacity of the Orion - IKARUS articulated bus. Assuming a 20 year cumulative traffic load period and anticipating a 1.5% yearly growth, the design number of ESALs used in the pavement design analysis was 72 million. The following recommended pavement structures are based on the above design assumptions using the AASHTO design method.

Station		Anticipated Subgrade	Recommended Pavement Structure	
From	To			
6+740	6+840	Sand & Gravel or Fill	40 mm	OPSS HL1
			100 mm	OPSS Heavy Duty Binder (2 lifts) ²
			225 mm	OPSS Granular A
			850 mm	OPSS Granular B, Type II
6+840	7+070	Bedrock	40 mm	OPSS HL1
			100 mm	OPSS Heavy Duty Binder (2 lifts)
			225 mm	OPSS Granular A
			150 mm ¹	OPSS Granular B, Type II
			300 mm	rock shatter

Note: ¹ The OPSS Granular B, Type II is recommended over the bedrock surface to improve the internal drainage characteristics of the pavement structure. In addition, this layer will provide additional cushion over the rock shatter to smooth out variances on the rock shatter surface which frequently reflect through to the pavement surface which affects both the ride comfort and the local pavement life.

² Heavy Duty Binder (HDB) is recommended, instead of the HL8 identified in the Functional Reports to provide more resistance to rutting. The articulated buses are one of the heaviest and most damaging vehicles on Ontario roadways, and the use of HDB is considered warranted, especially when considering the low price premium when compared to HL8.

It is recommended that the rock shatter be designed to extend laterally to 500 mm behind the roadway curbs.

The transition between rock cut to earth cut should be constructed in accordance with OPSD-205.05. It is recommended that a transition treatment depth, t , of 1.5 m be used in the transitions.

It is understood that the RMOC is presently using performance graded asphalt for all new construction projects. It is recommended that the liquid asphalt consist of PG 58-34.

6.1.3 Pavement Structure Drainage

Satisfactory performance of the pavement structure is largely dependent on keeping the contact zone between the subgrade material and the subbase material in a dry condition. Failure to provide adequate internal drainage under conditions of heavy wheel loading can result in the reduction of the load carrying capacity of the pavement structure.

This section of the West Transitway is within a cut, and therefore provision of longitudinal subdrains, as detailed in Drawings TD-B-03 and 04 in the Transitway Design Manual or alternatively as detailed in the RMOC standard drawing J-3.13 should be incorporated in this project. These subdrains should be placed throughout this cut section, regardless of subgrade type with the exception of rock subgrade which includes both rock shatter and ditches where the shatter is carried through to the full width of the ditch base as shown in OPSD-201.01.

Within urban sections, it is noted that subdrains have not historically been placed in areas where rock shatter is present for reasons that the rock shatter is usually graded and that any water directed towards the shatter is drained towards low points in the profile where it is then collected and disposed of. However, areas in rock cuts have frequently been poor performing at the ends, and sometimes throughout. Based on the proposed transitway profile, between Station 6+850 to 7+000, which is within the rock cut area, the grade change represents a 0.5% fall which is not considered sufficient to ensure adequate internal drainage within rock shatter.

6.2 New N-W Ramp

To accommodate the proposed Transitway, the existing N-W ramp will be demolished and replaced with a new N-W ramp which will include a bridge structure over the proposed Transitway and retaining walls between the bridge and Hwy 417. The proposed ramp is to be located to the south and east of the existing ramp. The ramp will link Richmond Road (elev. = 72.2 m) with the west bound lanes of the Hwy. 417 (elev. = 66.4 m). It is anticipated that the proposed retaining walls and approach fill may be up to 5 m in height.



The site of the new N-W ramp was investigated by drilling nine boreholes, including the three boreholes put down for the N-W ramp structure. The three boreholes for the proposed structure were put down to bedrock. The six boreholes for the ramp pavement structure and approach fill were put down to a depth of 3.1 m (10 feet).

6.2.1 New Ramp Structure

The proposed N-W ramp will include a single lane bridge with a central pier support, located between the east and west bound lanes of the West Transitway. The soil conditions in the vicinity of the proposed bridge abutments consist of existing fill over alternating layers of sand, silt and clay, sand and gravel and glacial till overlying bedrock. The depth to bedrock varies from approximately 22.1 m (elev. = 47.4 m) to 24.4 m (elev. = 42.1 m).

The bridge abutments may be supported on driven H-piles end bearing on bedrock, as per the functional design. Due to the complex geology at this site, driven steel H-piles may encounter boulders or an uneven bedrock surface. It should be anticipated that pile lengths may vary significantly even within the same founding unit. Steel H-piles should be equipped with reinforced tips to facilitate pile penetration through boulders and to help seat the piles on uneven bedrock surfaces. The following table summarizes the bedrock elevations at the approximate abutment and pier locations:

Location	Borehole	Bedrock Elevation (m)
North Abutment	M-5	47.4
Central Pier	M-6	44.4
South Abutment	M-7	42.1

The following design parameters are recommended for vertical steel piles driven to refusal on the bedrock.

Pile Type	Factored Capacity at U.L.S. (kN)	Capacity at S.L.S (kN)
HP310x110	1600	1150
HP310x94	1300	960
HP310x79	1150	890

The above capacities are axial to the pile alignment and can be used for both vertical and battered piles. It is recommended that battered piles be equipped with pile points to avoid damaging the pile tips.

The lateral resistance of a single vertical pile should be computed in accordance with the following paper:

Broms, B.B., 1965. "Design of Laterally Loaded Piles", J. of Soil Mech. and Found. Div., ASCE, Vol. 91, SM3: 79-99.

The following unfactored design parameters are recommended to be used for calculation of the ULS lateral resistance of vertical piles:

Location	Elevation	γ	q_u	ϕ
M-5	69.5 - 64.5	20 kN/m ³	0	30°
	64.5 - 60.2	19 kN/m ³	150 kPa	0
	60.2 - 58.8	20 kN/m ³	0	30°
	58.8 - 57.3	19 kN/m ³	150 kPa	0
	57.3 - 51.0	21 kN/m ³	0	32°
	51.0 - 47.4	21 kN/m ³	0	30°
M-6	67.7 - 64.6	20 kN/m ³	0	30°
	64.6 - 62.8	19 kN/m ³	150 kPa	0
	62.8 - 59.9	20 kN/m ³	0	30°
	59.9 - 58.5	19 kN/m ³	150 kPa	0
	58.5 - 55.0	21 kN/m ³	0	32°
	55.0 - 54.0	19 kN/m ³	150 kPa	0
	54.0 - 44.4	21 kN/m ³	0	30°
M-7	66.5 - 65.0	20 kN/m ³	0	30°
	65.0 - 60.4	21.5 kN/m ³	0	34°
	60.4 - 58.9	19 kN/m ³	150 kPa	0
	58.9 - 51.0	21.5 kN/m ³	0	34°
	51.0 - 42.1	21 kN/m ³	0	30°

For the assessment of the SLS lateral resistance of vertical piles, it is recommended that the horizontal modulus of subgrade reaction approach be carried out. Should this type of analysis be proposed, the pile layout should be reviewed by the geotechnical engineer in order that the appropriate soil/structure stiffness parameters be developed to assess the SLS lateral resistance.



If the approach fills are to be placed after pile installation, downdrag forces on piles will need to be considered in the design. Based on the bedrock depths at the boreholes, the following non-factored downdrag loads would apply:

North Abutment	370 kN
Centre Pier	530 kN
South Abutment	650 kN

The down drag loads and live load do not combine, and therefore two separate loading cases must be considered: permanent load plus down drag load, but no live load; and permanent load and live load, but no down drag load.

The above steel piles should be driven with a pile hammer delivering an energy of at least 3.5 J/mm² of steel cross-sectional area. The refusal criteria for piles driven with this energy has two components, as follows:

1. 20 blows for the last 25 mm of penetration; **and**
2. A total of 50 blows for not more than 100 mm of penetration.

In cases where piles do not penetrate the glacial till stratum, the pile capacity should be controlled in the field using current MTO pile driving standards. Attempts should be made in all cases to drive the piles to the bedrock surface. All pile driving activities should be inspected by qualified geotechnical personnel and the pile capacities controlled in the field using MTO pile driving standards (MTO Standards SS103-10 or SS103-11). Furthermore, at least one conventional pile load test combined with the use of a dynamic pile analyzer is recommended for this project. The proposed test pile(s) should be loaded to twice the S.L.S. Type II bearing capacity. It is recommended that the pile analyzer be used to monitor at least ten (10) piles with a minimum of two (2) piles per founding unit during pile installation.

Pile caps should be protected from frost action with a minimum soil cover of at least 1.8 m or equivalent insulation.

6.2.2 Ramp Fill and Retaining Wall

Based on the functional design, the majority of the ramp fill south and west of the N-W Ramp Bridge will be contained between two retaining walls. The maximum height of the retaining walls is expected to be approximately 5 m. The southwest retaining wall is proposed to be a reinforced earth (RECO) type wall, while the southeast wall may be a combination of RECO wall, reinforced concrete cantilever wall, and a modified concrete toe wall.

Design parameters for reinforced earth retaining walls are given in Section 6.4.

In the long term, settlement of ramp fill is expected to be no greater than 25 mm.

6.2.3 Pavement Structure

The recommended pavement structure for the proposed N-W ramp based on the MTO Routine Design Method, the estimated AADT, and the existing subgrade conditions is:

40 mm	OPSS HL1
90 mm	OPSS HL8
150 mm	OPSS Granular A
450 mm	OPSS Granular B, Type II

6.3 Richmond Road Structure

A bridge is required to carry traffic on Richmond Road over the proposed West Transitway. The functional design incorporated a split structure (northbound and southbound lane structures) with pile-supported integral abutments. A central pier may be included in the design. Due to the complex soil and bedrock conditions at the Richmond Road structure location, several alternative foundation types have been considered for the support of the bridge abutments. Design parameters for each foundation type are discussed in the sections below.

It is noted that a combination of the foundation support systems discussed below will likely be required due to the bedrock conditions at the site.

6.3.1 Abutments - Spread Footings on Bedrock

Bridge abutments may be founded on clean, level bedrock using conventional spread footings. Based on the borehole information, it is anticipated that spread footings will be used for the north abutment of the eastern structure (northeast abutment). The bedrock surface elevation in the vicinity of this abutment is approximately 65 to 66 m. Based on the functional design the finished grade of the West Transitway will be approximately 65 m. The anticipated founding elevation for the northeast abutment is therefore 64 m. The bedrock beneath the northeast abutment consists of severely fractured sandstone with shale seams and partings.

The bedrock surface elevation beneath the proposed southwest abutment is too deep (approximately 45 to 49 m) for spread footings to be practical. The bedrock surface elevation beneath the northwest and southeast abutments dropped off sharply, prohibiting the use of spread footings. The approximate variation in the bedrock surface elevation at each of the proposed abutment locations is presented in the following table:



Abutment Location	Bedrock Surface Elevation (m)		Variation in Bedrock Surface Elevation (m)
	Minimum	Maximum	
Northeast	65	66 (estimated)	1
Northwest	51	62	11
Southeast	55	64	9
Southwest	45	49	4

Negligible settlement is expected for spread footings founded on bedrock, therefore serviceability limit states (S.L.S.) does not apply. The following design parameters may be used for the design of spread footings founded on clean, level bedrock:

Material	Factored Capacity at U.L.S. (kPa)
Sandstone	1,500
Dolomite	1,750

The bearing surface should be free of overburden soils and loose rock fragments and should be no steeper than 5 horizontal to 1 vertical. A minimum of 1.0 m of soil cover or equivalent insulation should be provided for frost protection.

6.3.2 Pile-Supported Integral Abutments

The bridge structure could be supported on end bearing steel H-piles that are free to move laterally within the upper part. The piles would extend up through the approach fill to just underneath the bridge structure. Retaining walls would be constructed parallel to the Transitway to retain the approach fill. Lateral movement of the piles would be accommodated by installing C.S.P.'s around the pile within the approach fill.

Geotechnical design recommendations for retaining walls are provided in section 6.4.

Due to the complex geology at this site, driven steel H-piles may encounter boulders or an uneven bedrock surface. It should be anticipated that pile lengths may vary significantly even within the same founding unit. Steel H-piles should be equipped with reinforced tips to facilitate pile penetration through boulders and to help seat the piles on uneven bedrock surfaces

Due to the uneven bedrock surface and potential for refusal on dislodged bedrock pieces the pile capacities presented below are based on a practical refusal criteria on boulders or dislodged rock pieces. The following

design parameters are recommended for vertical steel piles driven to practical refusal on the bedrock.

Pile Type	Factored Capacity at U.L.S. (kN)	Capacity at S.L.S (kN)
HP310x110	1000	760
HP310x94	825	640
HP310x79	700	540

It is noted that down drag forces need not be considered at this structure location.

The above steel piles should be driven with a pile hammer delivering an energy of at least 3.5 J/mm² of steel cross-sectional area. The refusal criteria (practical refusal) for piles driven with this energy has two components, as follows:

1. 5 blows for the last 25 mm of penetration; **and**
2. A total of 50 blows for not more than 300 mm of penetration.

All pile driving activities should be inspected by qualified geotechnical personnel and the pile capacities controlled in the field using MTO pile driving standards (MTO Standards SS103-10 or SS103-11). Furthermore, at least one conventional pile load test combined with the use of a dynamic pile analyzer is recommended for this project. The proposed test pile(s) should be loaded to twice the S.L.S. Type II bearing capacity. It is recommended that the pile analyzer be used to monitor at least ten (10) piles with a minimum of two (2) piles per founding unit during pile installation.

6.3.3 Perched Abutments

The bridge structure may be supported on spread footings founded on reinforced earth fill. The reinforced earth would be placed as part of the backfill with a retaining wall along the West Transitway.

The fill material for the reinforced earth embankment should consist of OPSS Granular A material placed and compacted in lifts no greater than 300 mm thick, and each lift compacted to 100% Standard Proctor Maximum Dry Density.

Assuming a minimum thickness Granular A pad of 3 m and a footing width ranging from 2.0 m to 4.0 m, the following bearing pressures are recommended:



SUGGESTED RESISTANCE VALUES ON COMPACTED GRANULAR A
Internal Stability of Reinforced Earth May Require Reduced Values Designer to Confirm

Bridge Seat Width	U.L.S. Factored Bearing Resistance (kPa)	S.L.S Bearing Resistance (kPa)
2.0	300	250
2.5	315	250
3.0	325	250
3.5	340	250
4.0	350	250

It is noted that the above SLS resistance will restrict settlements within the reinforced fill to a range of 5 mm to 10 mm. Where the overburden is deepest, the anticipated post bridge seat placement settlements below the reinforced earth wall is estimated to be 15 to 20 mm. Therefore, it is anticipated that the post bridge seat placement differential settlement could be in the order of about 15 mm.

6.3.4 Abutments - Caisson Wall

It is understood that consideration is being given to using a caisson wall to act as both the abutment support and as the retaining wall along the edge of the West Transitway beneath Richmond Road. The caisson wall approach would likely consist of every second caisson socketed into the bedrock with the in between caissons acting strictly in the lateral direction (i.e. filling in the face of the retaining wall).

It should be noted that due to the flowing sand conditions, drilling of caissons may prove difficult and will definitively require drilling fluid and the use of casing during drilling. Tremie techniques will be required for the concrete placement.

The compressive load carrying capacity of socketed caissons can be calculated from either end bearing or from bond capacity between the concrete and the rock face within the socket. Socketed caissons may be designed based on the following parameters:

- The capacity based on end bearing alone using a factored bearing capacity at U.L.S. of 2000 kPa, or
- The capacity based on bond stress alone using a factored ultimate concrete/rock bond stress of 750 kPa.

For design based on end bearing or bond, a minimum socket length of 1 m or equal to one (1) caisson diameter, whichever is greater, is recommended. Concrete for caisson sockets should have a minimum compressive strength of 30 Mpa. The base of the sockets should be well cleaned before concreting regardless whether the design is based on end bearing or bond.

The horizontal earth pressures which would act on the back of the caisson retaining wall should be calculated using the following parameters, which reflect the typical nature of the existing embankment fill at the site.

Material Type: Existing Embankment Fill	
Bulk Unit Weight Embankment Fill:	20 kN/m ³
Bulk Unit Weight of Water:	9.807 kN/m ³
Unfactored Angle of Internal Friction:	29°
Unfactored Coefficient of Active Earth Pressure:	0.35
Unfactored Coefficient of Earth Pressure at Rest:	0.52

The caisson retaining wall option does not include the provision for a free draining granular backfill with outlet drains, therefore the portion of the retaining wall below elevation 67.0 m, corresponding to existing surrounding grades, should include the addition of hydrostatic pressures over and above the earth pressures.

The horizontal capacity of the caisson retaining wall are dependent upon their embedment lengths in both the overburden and bedrock, the caisson diameters and stiffness, spacing, and loading. Horizontal design parameters and resistance will be provided once this design option is further developed.

Should the option be further developed, it is recommended that the facing of the retaining wall below elevation 68.5 m be protected against frost action, to prevent water from freezing behind the wall. The proposed elevation of 68.5 is preliminary and will need to be reviewed once the design details are further developed. The recommended insulation would be 75 mm thick sheets of extruded polystyrene such as DOW product styrofoam SM.

In order to prevent surface water from attaining an impermeable membrane design or a subddrain should be incorporated directly beneath the roadway granulars adjacent to the caisson wall.

6.3.5 Richmond Road Pavement Reconstruction

As part of the West Transitway construction project, it is anticipated that portions of the Richmond Road approaches will need to be reconstructed. The following recommendations will apply to reconstruction of the pavement structure within these areas.



Based on information from the borehole investigation, the approaches presently have the following approximate pavement structure:

Asphalt	230 mm
Base and Subbase	380 mm

The design criteria for the new pavement structure includes the following:

- Traffic
- Ensure that the bottom of the subbase is lower than the adjacent existing subbase.

Based on the above two points, the following pavement structure is recommended:

40 mm	OPSS HL1
100mm	OPSS HL8 (two lifts)
150 mm	OPSS Granular A
450 mm	OPSS Granular B, Type II

The provision of longitudinal subdrains, such as outlined in RMO standard drawing J-3.13, is recommended to ensure efficient internal drainage of the pavement structure.

Where the new pavement structure meets that existing, the transitions between the underside of the subbase materials should be constructed at a grade no steeper than 10H : 1V.

Where the new asphalt abuts existing asphalt, the construction should be stepped such that all existing asphalt within 300 mm of the construction excavation is sawcut full depth and removed. In addition, it is recommended that the asphalt immediately beyond the full depth sawcut be milled 40 mm deep for a minimum width of 300 mm adjacent to the sawcut in order to provide for a step joint within the asphalt.

6.4 Retaining Walls

Retaining walls will likely be required along the edges of the approach fill for the new N-W ramp and in front of the abutments for both the N-W Ramp structure and the Richmond Road Structure. Based on the functional design, all retaining walls will likely consist of reinforced earth retaining walls, except for those sections of the southeast wall of the N-W Ramp embankment which could be a reinforced concrete cantilever retaining wall (on spread footings or pile foundations) or modified toe wall.

The following recommendations apply to vertical Reinforced Earth and concrete retaining walls.

- A frost depth of 1.8 m should be used for design purposes. Retaining wall footings should have a minimum soil cover of 1.8 m or equivalent insulation to protect against frost action. In the case of reinforced earth retaining walls, the leveling pad should be protected against frost heaving by ensuring that any underlying soil within the frost penetration zone is subexcavated and replaced with a drained non-frost susceptible soil.
- The retaining walls should be backfilled with an approved free-draining granular material and the material drained at the base of the wall. The source of the granular material should be approved by a geotechnical engineer prior to delivery to the site. Particles greater than 75 mm nominal diameter should not be placed in direct contact with the back of the wall.
- The minimum zone of the free draining granular backfill should form a 45° wedge above a line projected upwards from the heel of the retaining wall. In the case of a RECO type wall, the heel of the retaining wall is defined as the lower back of the reinforced earth mass.
- Design parameters for conventional reinforced earth retaining walls with granular backfill are provided in the following table. Serviceability Limit States (SLS) do not apply for the coefficient of active earth pressure and coefficient of sliding.

Material Properties (OPSS Granular B Type I)		
Bulk Unit Weight	20.5 kN/m³	
Unfactored Angle of Internal Friction	33°	
Unfactored Coefficients of Active Earth Pressure, K _a		
Ground surface behind wall: Level ground surface	0.30	
Unfactored Coefficient of Sliding (Reinforced Earthwall, Granular B, TypeI)		
Sliding of Reinforced Earth Block	0.55	
Sliding of Concrete Footing	0.45	
Design Bearing Resistance - Base of Earth Block or Concrete Footing		
Bearing Material	U.L.S (factored)	S.L.S. (25mm settlement)
Bedrock	1500 kPa	N/A
Overburden	225 kPa	150 kPa

6.5 Cut Sections

6.5.1 Overburden

Temporary Cuts

Excavations for the proposed roadway subgrade are expected to be as deep as 8.5m. The overburden soils anticipated are topsoil, silty clay and sandy/silty clay sand; and should be considered as a Type 3 soil with respect to the Occupational Health and Safety Act, under dry conditions or when proper dewatering has been carried out using side slopes no steeper than 1H:1V from the bottom of the excavation. Without proper dewatering, the sandy/silty sand materials under the water table should be considered as a Type 4 soil. Open cut excavation side slopes in this case should be 3H:1V or flatter. Temporary cut slopes should be regularly inspected during construction and flattened if required. Shoring techniques discussed below in Section 6.6 will be required if steeper temporary cut slopes are required.

The deepest excavation is anticipated at the Richmond Road structure where both overburden and bedrock will be excavated beneath the existing groundwater table. Dewatering using sumps and pumping from outside of the excavation or using well points will likely be required during construction.

Permanent Cuts

Permanent cuts can be drained using conventional design such as slope interceptor drains, pavement subdrains, and drains behind retaining walls. Drawdown of the groundwater table beneath the adjacent Highway 417 and beneath nearby structures located within approximately 500 m from the construction is anticipated. However, the total settlement of the supporting subgrade materials as a result of this groundwater drawdown is predicted to be less than 10 mm in the immediate vicinity of the cut and reduces with distance from the excavation. Differential settlement within the affected area will be less. Permanent open cut slopes should be protected to prevent surficial instability and erosion using gravel blankets and standard RMOC landscaping techniques. Permanent open cut slopes may be constructed at 2.5H:1V or flatter. Steeper slopes will require internal reinforcement or external support.

Subgrade Preparation

Silty clay or loose sand/silty sand subgrade is anticipated for all cut sections from Station 6+740 to 6+870. It is recommended that the exposed subsoil be inspected by a geotechnical engineer prior to undertaking any surface treatment. As directed, the exposed subgrade should be proof rolled and soft areas subexcavated as required.

The Contractor should not be permitted to have construction equipment or vehicles directly on or within 1m above or below the final earth cut subgrade. The Contractor could construct and maintain haul roads from an interim subgrade at least 1m from the final earth cut subgrade, or could use the top of the OPSS Granular "B" as a haul road, as directed by the Engineer.

6.5.2 Bedrock

Based on the current profile and available information, bedrock excavation is anticipated between 6+860 to 7+070.

Bedrock may be excavated at slopes near vertical for temporary cuts, however, permanent bedrock cuts should be sloped no steeper than 4 vertical to 1 horizontal. It is noted that the quality of the bedrock encountered at the borehole locations was generally poor. Scaling operations must be restricted. Overly aggressive scaling will result in considerable over-excavation of this material.

A space of at least 2 m width should be maintained in front of the toe of permanent rock slopes. Some rock spalling should be anticipated from rock faces.

Where retaining wall foundations or sideslopes are to be constructed above the rock benches, the bench width should be at least equal to the height of the rock face, to a maximum bench width of 2 m.

Excavation in bedrock will likely require drilling and blasting techniques. A pre-blast survey should be carried out prior to construction to include all structures located within a minimum 500 m distance. Vibration control will be required in accordance with City Bylaws and should be monitored using seismographs. The stability of overburden cut slopes or retaining walls subjected to the acceleration due to blasting should be examined. The loose to very loose sand/silty sand soils may be prone to liquefaction if subject to significant vibration.

6.6 Temporary Shoring

The following temporary shoring methods may be considered for the proposed cut at the Richmond Road structure. Based on the subsurface conditions and estimated permeabilities obtained in this investigation, and based on our understanding of the proposed development, it is considered that conventional temporary shoring systems such as sheetpiles, or soldier piles and timber lagging system are feasible. As discussed above, depending on the actual groundwater levels at the time of the construction, groundwater control may be required.



The suitability of each system based on subsurface conditions and physical constraints at particular locations should be examined during the final design phase. The design of the shoring system is the responsibility of the contractor. The contractor designed shoring should be reviewed by the Geotechnical Engineer to confirm that the geotechnical conditions have been properly interpreted. The following outlines alternative shoring systems which may be considered.

Sheetpiles

Sheetpile walls may be considered at locations where the bedrock is deep enough to allow sufficient penetration to provide lateral stability of the sheetpiles and stability of the excavation bottom. The overburden within the major cut section consists of loose sand/silty sand materials. A preliminary assessment for functional design purposes may be based on the assumption that the sheetpile penetration below the excavation bottom should be equal to the retained height in order to achieve lateral and bottom stability.

In this case, minor dewatering inside the sheetpile walls will be required. Conventional sump and pumping techniques are likely sufficient.

Soldier Piles and Timber Lagging

A shoring system consisting of soldier piles and timber lagging also requires sufficient penetration of the soldier piles to develop lateral stability. Where the bedrock is shallow, the soldier piles may be grouted in pre-drilled holes in the bedrock to provide lateral stability.

Based on the loose sand/silty sand overburden and the relatively high groundwater table encountered within the area of the proposed cut, it is expected that dewatering from outside the excavation by well point or other method may be required to control the side slope prior to the installation of the timber lagging, and also to prevent excavation bottom instability (boiling).

6.7 Storm Sewer Installation

It is understood that a 1.2 m diameter storm sewer is to be installed beneath the proposed Transitway alignment. It is further understood that the bottom of the service trench will be approximately 5 m and 2.5 m below the finished Transitway grade at Stations 6+600 and 7+070, respectively.

Where retaining walls are present, it is recommended that the sewer alignment be maintained a lateral distance, away from the wall foundation, that is greater than the vertical excavation depth below the wall foundation level, plus 1.0 metre. In areas where the retaining walls are founded on bedrock, this offset

requirement can be reduced by half. If this offset cannot be maintained, the actual proposed geometric details should be reviewed by the geotechnical consultant to establish the construction restrictions which will be required to avoid undermining the foundations.

If the nearby retaining walls are to be constructed after sewer installation, it is recommended that the sewer be offset from the wall foundation a distance equal to or greater than the vertical excavation depth below the proposed wall foundation to avoid foundation stresses being exerted on the sewer. In rock subgrade, the recommended offset can be reduced to 1.0 m.

Excavation for the sewer trench east of Richmond Road will require bedrock excavation. Drilling and blasting techniques will be required. Open cut excavations within bedrock may be made near vertical provided all loose rock material is removed from the exposed rock faces prior to worker entry into the excavation. The excavation walls should be inspected daily for signs of rock fall hazard and remedial measures taken as required.

Within Transitway cut sections, temporary excavations for storm sewers in overburden soils could be carried out in an open cut provided the nearest edge of the sewer excavation is located at least equal to the depth of excavation from the toe of the nearest excavation slope. Plans for excavations located within this distance should be reviewed by a geotechnical engineer prior to construction.

Temporary excavations in the overburden soils may be made at near vertical slopes provided the depth of excavation is less than 1.2 m. Deeper excavations should be supported or flattened in accordance with the guidelines set out in the Occupational Health and Safety Act (OHSA).

Groundwater may be encountered during excavation for installation of the storm sewer. Based on preliminary information, the bottom of the sewer excavation may be as low as 60.5 m elevation. At the time of the geotechnical investigation, the groundwater table elevation was approximately 62 m. Flowing sand conditions were encountered at approximately 60.3 m in several of the boreholes. It is recommended that the groundwater levels be verified prior to the start of construction and that all excavations that extend below the static water table be dewatered using a combination of standard sump and pump techniques and a series of wells or sump pits located outside of the sewer trench excavation.

Dewatering from outside of the excavation will prevent the sand deposits from flowing into the excavation and thereby undermining the excavation side walls.

Pipe bedding should consist of an approved OPSS Granular A material placed and compacted in accordance with the pipe design requirements. Trench backfill, consisting of an approved OPSS Granular B, Type I material or Select Subgrade Material, should be placed above the pipe bedding to a depth of 1.5 m beneath the finished road grade. The Granular B or SSM should be placed in lifts and



compacted to at least 95 % of Standard Proctor maximum dry density. The material used within the upper 1.5 m should be similar to that exposed in the trench walls.

Excavated bedrock may be used as backfill if all pieces larger than 150 mm are removed. Rockfill should be placed in 500 mm lifts, with each lift being compacted. The upper rockfill should be well graded or covered with a geotextile filter barrier to prevent soils from percolating through.

6.8 General Construction Recommendations

6.8.1 Cement Type and Corrosion Potential

Five (5) soil samples were submitted to Accutest Laboratories in Nepean, Ontario for analysis of pH and water soluble sulphate and chloride, in order to determine cement type and reinforcing steel protection requirements. The results of the testing are summarized in the table below:

Borehole	Sample	Depth	pH	Sulphate	Chloride
M-1	SS-4	6.4 m	7.4	0.07%	0.129%
M-1	SS-9	15.6 m	8.0	0.04%	0.024%
M-4	SS-4	6.4 m	8.4	0.04%	0.039%
M-16	SS-11	7.9 m	8.3	0.06%	0.019%
M-19	SS-3	1.8 m	7.9	0.04%	0.003%

The water soluble sulphate results are all below 0.10 %, indicating that a negligible degree of sulphate attack is expected for concrete in contact with the site soils. Therefore, a normal Type 10 Portland cement should be suitable for use in concrete at this site.

The soil pH level and concentration of water soluble chloride give an indication to the level of potential attack on buried steel objects such as reinforcing steel. The pH level is within the normally acceptable range of 5.8 to 9, indicating no special corrosion potential problems. Several of the water soluble chloride concentration results are above 0.025 %, indicating an environment potentially favourable for the corrosion of buried steel.

It is noted that although most of the water soluble chloride ion test results are below or only marginally above 0.025 %, winter deicing practices along the Transitway typically result in high levels of chloride being introduced into the near surface soils and into the cover concrete. Consideration should be given to

providing special corrosion protection to buried steel located in close proximity to the Transitway lanes.

6.8.2 Assessment of Excavated Material

The overburden material encountered throughout the investigation does not generally meet the requirements for OPSS Select Subgrade Material. However, the silty sand and portions of the silty clay could be used as OPSS Earth Borrow depending upon the time of the construction season and construction techniques. Therefore, consideration could be given to using selected site cut materials in fill sections provided it can be compacted to at least 95 percent of Standard Proctor maximum dry density. To achieve this compaction, site selection of excavated cut material may be required at the time of construction. For design purposes, it is suggested that 50% of the material excavated after stripping would be acceptable for road subgrade fill placement. The actual amount will vary significantly depending on the weather during cut and fill operations as well as the construction techniques. Where encountered, unacceptable materials may need to be wasted or used for berm construction or other landscaping purposes.

6.9 Proposed Stormwater Management Pond

It is understood that a stormwater management pond is being designed on behalf of the RMOC by others. It is also understood that a separate geotechnical report will be prepared to address the pond design requirements. The following recommendations relate only to items of concern as they relate to the nearby transitway cut.

The area being considered for the pond is located north of the Transitway, east of Richmond Road, and specifically just east of the E-N/S Ramp. In this area, the overburden soils are shallow (≈ 2 m to bedrock) and are generally quite permeable. The following is recommended:

- The underlying soils can support berms with sideslopes as steep as 2.5 H:1V with no risk of rotational failure within the overburden. The actual berm sideslopes will need to reflect the construction materials, their permeability and the proposed construction heights.
- It is recommended that the toe of the berms be offset from the transitway cut slope or the heel of retaining wall (if applicable) by at least 2.0 m and at least a distance equal to the lesser of the following:
 - The depth of the local overburden
 - The depth of the local transitway cut.
- The pond should be designed to restrict inflow into the overburden.



6.10 Recreational Pathways

For the design of recreational pathways, RMO standard drawing J-1.2 may be used.

In areas where the subgrade type changes from rock to earth subgrade, it is recommended that transition treatments, such as defined in OPSD-205.05, be incorporated in the design using a "t" depth of 1.2 m.

If the pathway is to be located at the base of a slope, it is recommended that a single longitudinal subdrain be installed on the slope side of the pathway to prevent surface water from collecting within the granulars.

The subgrade of the pathway should be prepared by compacting the exposed surface to at least 95% of the Standard Proctor Maximum Dry Density (SPMDD).

7.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction, and other activities. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above conclusions.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Yours very truly,

JACQUES, WHITFORD LIMITED



Paul Carnaffan, M.Eng., P.Eng.



J.G.A. Raymond Haché, M.Sc., P.Eng.





KEY PLAN

1 : 20 000



SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Topsoil</i>	-	mixture of soil and humus capable of supporting good vegetative growth
<i>Peat</i>	-	fibrous aggregate of visible and invisible fragments of decayed organic matter
<i>Till</i>	-	unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	-	any materials below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	-	having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	-	having cracks, and hence a blocky structure
<i>Varved</i>	-	composed of regular alternating layers of silt and clay
<i>Stratified</i>	-	composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	-	> 75 mm
<i>Seam</i>	-	2 mm to 75 mm
<i>Parting</i>	-	< 2 mm
<i>Well Graded</i>	-	having wide range in grain sizes and substantial amounts of all intermediate particle sizes
<i>Uniformly Graded</i>	-	predominantly of one grain size

Terminology describing soils on the basis of grain size and plasticity is based on the Unified Soil Classification System (USCS) (ASTM D-2488). The classification excludes particles larger than 76 mm (3 inches). This system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%

The standard terminology to describe cohesionless soils includes the compactness (formerly "relative density"), as determined by laboratory test or by the Standard Penetration Test 'N' - value.

Relative Density	'N' Value	Compactness %
<i>Very Loose</i>	< 4	< 15
<i>Loose</i>	4-10	15-35
<i>Compact</i>	10-30	35-65
<i>Dense</i>	30-50	65-85
<i>Very Dense</i>	> 50	> 85

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests, or occasionally by standard penetration tests.



Consistency	Undrained Shear Strength		'N' Value
	kips/sq.ft.	kPa	
<i>Very Soft</i>	<0.25	<12.5	<2
<i>Soft</i>	0.25-0.5	12.5-25	2-4
<i>Firm</i>	0.5-1.0	25-50	4-8
<i>Stiff</i>	1.0-2.0	50-100	8-15
<i>Very Stiff</i>	2.0-4.0	100-200	15-30
<i>Hard</i>	>4.0	>200	>30

ROCK DESCRIPTION

Rock Quality Designation (RQD)

The classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures.

RQD

ROCK QUALITY

90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

Terminology describing rock mass:

Spacing (mm)	Bedding, Laminations, Bands	Discontinuities
2000-6000	<i>Very Thick</i>	<i>Very Wide</i>
600-2000	<i>Thick</i>	<i>Wide</i>
200-600	<i>Medium</i>	<i>Moderate</i>
60-200	<i>Thin</i>	<i>Close</i>
20-60	<i>Very Thin</i>	<i>Very Close</i>
<20	<i>Laminated</i>	<i>Extremely Close</i>
<6	<i>Thinly Laminated</i>	

Strength Classification	Uniaxial Compressive Strength (MPa)
<i>Very Low</i>	1-25
<i>Low</i>	25-50
<i>Medium</i>	50-100
<i>High</i>	100-200
<i>Very High</i>	>200

Terminology describing weathering:

<i>Slight</i>	-	Weathering limited to the surface of major discontinuities. Typically iron stained.
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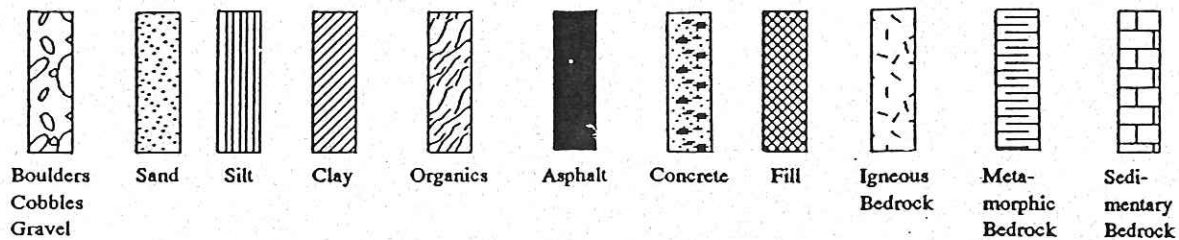


Moderate
High

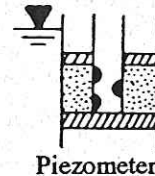
- Weathering extends throughout rock mass. Rock is not friable.
- Weathering extends throughout rock mass. Rock is friable.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)	BS	Bulk sample
ST	Shelby tube or thin wall tube	WS	Wash sample
PS	Piston sample	HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits.

N - VALUE

Numbers in this column are the results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and 'N' values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75).

OTHER TESTS

S	Sieve analysis	H	Hydrometer analysis
G _s	Specific gravity of soil particles	γ	Unit weight
k	Permeability (cm/sec)	C	Consolidation
↓	Single packer permeability test; test interval from depth shown to bottom of borehole	CD	Consolidated drained triaxial
↓		CU	Consolidated undrained triaxial with pore pressure measurements
↓	Double packer permeability test; test interval as indicated	UU	Unconsolidated undrained triaxial
○	Falling head permeability test using casing	DS	Direct shear
↓		Q _u	Unconfined compression
↓	Falling head permeability test using well point or piezometer	I _p	Point Load Index (I _p on Borehole Record equals I _p (50); the index corrected to a reference diameter of 50 mm)



DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield Limited

BOREHOLE No. M-1

LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON

PROJECT No. 10923

DATES: BORING 97-07-17

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS	
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200
0	72.39						mm					
	72.1	300 mm ASPHALT										
1		Compact, brown, sandy silt, trace clay, trace gravel : FILL										
2					SS	1	300	24				
3												
4					SS	2	25	21				
5	67.9	Very stiff, grey, silt and clay, trace sand : FILL			SS	3	460	8				
6	67.3	Loose, dark brown, SILT, trace organics										
7	66.3	Compact, grey, SILT, some sand, some clay			SS	4	560	10				
8	64.8	Stiff, grey, SILT and CLAY			SS	5	610	5				
9												
10		- sand seams			SS	6	610	7				

▽ Inferred Groundwater Level

▬ Groundwater Level Measured in Standpipe


▲ Proposed Pipe Invert

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield Limited

BOREHOLE No. M-1

LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON

PROJECT No. 10923

DATES: BORING 97-07-17

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	WATER CONTENT & ATTERBERG LIMITS									
							mm		50 100 150 200 W _p W _L DYNAMIC PENETRATION TEST, BLOWS/0.3m * STANDARD PENETRATION TEST, BLOWS/0.3m •									
									10 20 30 40 50 60 70 80 90									
-10		Stiff, grey, SILT and CLAY																
-11					SS	7	610	7										
-12	60.3	Dense, grey to brown, SAND, some silt			SS	8	510	30										
-13																		
-14																		
-15	57.3	Compact, grey to brown, SILT, some sand, some clay			SS	9	560	20										
-16																		
-17																		
-18	54.2	Dense, grey to brown, GRAVELLY SAND, some silt			SS	10	155	48										
-19																		
-20																		

Inferred Groundwater Level
 Groundwater Level Measured in Standpipe
 Proposed Pipe Invert

Field Vane Test, kPa
 Remoulded Vane Test, kPa
 Pocket Penetrometer Test, kPa

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DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield Limited
LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON
DATES: BORING 97-07-17 WATER LEVEL _____

BOREHOLE No. M-1
PROJECT No. 10923
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS	
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200
20		Dense, grey to brown, GRAVELLY SAND, some silt										
21	50.8											
22		Severely fractured to fractured, grey, sandstone with shale seams: BEDROCK			NQ	11	100%	35%				
23	49.2				NQ	12	100%	60%				
24		End of Borehole										
25												
26												
27												
28												
29												
30												

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-2LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-07-15

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m *	STANDARD PENETRATION TEST, BLOWS/0.3m •
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
0	72.21						mm							
	72.0	250 mm ASPHALT												
		Very stiff, brown, silt and clay, trace sand : FILL												
1														
2					SS	1	510	4						
3														
4					SS	2	460	11						
5	67.3	Very dense, brown, silty sand, some gravel : FILL			SS	3	400	54						
6	66.1	Hard, brown, SILTY CLAY			SS	4	580	24						
	65.7	Compact, brown, SAND												
	65.3	Severely fractured, grey, sandstone with shale seams: BEDROCK			NQ	5	100%	0%						
8					NQ	6	100%	37%						
	63.6	End of Borehole												
9														
10														

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield Limited

BOREHOLE No. M-3

LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON

PROJECT No. 10923

DATES: BORING 97-07-16

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS	
					TYPE	NUMBER	RECOVERY	N-VALUE OR Rqd	50	100	150	200
0	72.46											
	72.2	300 mm ASPHALT										
		Compact, brown to grey, silty sand : FILL										
1												
2					SS	1	300	11				
3	69.4											
		Dense, dark grey, sand and gravel, some silt, some asphalt: FILL			SS	2	155	Ref				
4												
5	67.9				SS	3	0	8				
		Loose to compact, greyish brown, SILTY SAND, some gravel										
6					SS	4	360	31				
7												
8	64.9				SS	5	610	24				
		Compact, brownish grey, SILT, trace clay and sand										
9	63.2											
	63.0				SS	6	460	48				
		Loose to compact, brownish grey, SAND										
10												

▽ Inferred Groundwater Level

▽ Groundwater Level Measured in Standpipe


▲ Proposed Pipe Invert

□ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield Limited
LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON
DATES: BORING 97-07-16 WATER LEVEL _____

BOREHOLE No. M-3
PROJECT No. 10923
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m *	STANDARD PENETRATION TEST, BLOWS/0.3m ●		
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200			W _p	W _L
10		Very stiff, grey, SILT and CLAY														
11				SS	7	610	8									
12																
13				SS	8	530	7									
14																
15	57.3	Very loose, brown and grey, SAND Hard, grey, SILT and CLAY, trace sand														
16	57.1			SS	9	500	19									
17																
18	54.1	Compact, grey, SAND, trace silt														
19				SS	10	610	-									
20																

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

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DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-3LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-07-16

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m ★	STANDARD PENETRATION TEST, BLOWS/0.3m ●
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
-20		Compact, grey, SAND, trace silt					mm							
-21	51.2													
-22		Grey, SILT, trace to some clay			SS	11	610	42						
-23														
-24	48.7													
-24	47.9	Dense to very dense, grey, SAND, trace gravel and silt			SS	12	460	65						
-25		Fractured to very sound, dolomite with shaly partings: BEDROCK			NQ	13	100%	92%						
-26	46.1				NQ	14	100%	69%						
-27		End of Borehole												
-28		Ref = > 50 blows for 150mm												
-29														
-30														

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield Limited

BOREHOLE No. M-4

LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON

PROJECT No. 10923

DATES: BORING 97-07-15

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLAT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50 100 150 200 WATER CONTENT & ATTERBERG LIMITS w_p w w_L DYNAMIC PENETRATION TEST, BLOWS/0.3m ★ STANDARD PENETRATION TEST, BLOWS/0.3m ●									
0	72.40						mm		10	20	30	40	50	60	70	80	90	
	72.1	300 mm ASPHALT																
1		Very stiff to hard, brown, silty clay, trace sand and gravel : FILL																
2					SS	1	250	7										
3																		
4					SS	2	430	6										
5	67.8	Dense, brown, sand, trace gravel : FILL			SS	3	410	39										
6	66.3																	
7		Dense, grey, SAND, trace silt, trace gravel			SS	4	460	48										
8	64.8																	
		Very stiff, grey, SILTY CLAY			SS	5	510	4										
9																		
10					SS	6	610	9										

Inferred Groundwater Level
 Groundwater Level Measured in Standpipe
 Proposed Pipe Invert

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Field Vane Test, kPa
 Remoulded Vane Test, kPa
 Pocket Penetrometer Test, kPa



DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-4LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-07-15

WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m		STANDARD PENETRATION TEST, BLOWS/0.3m						
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200	W _p	W	W _L	10	20	30	40	50	60
10		Very stiff, grey, SILTY CLAY						mm													
11					SS	7	610	9													
12	60.2	Very stiff, grey, SILTY CLAY, trace sand, trace gravel			SS	8	460	17													
13																					
14																					
15	57.2	Very dense, grey, silt and sand, some clay, some gravel : TILL			SS	9	-	Ref													
16	55.5																				
17		Fractured to very severely fractured, grey, sandstone with greenish-grey shale seams: BEDROCK			NQ	10	100%	66%													
18	54.1				NQ	11	92%	0%													
19		End of Borehole																			
20		Ref = >50 blows for 150mm																			

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-5LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-07-30WATER LEVEL 97-08-28DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	WATER CONTENT & ATTERBERG LIMITS									
								mm										
0	69.47																	
	69.0	Brown, sand, trace silt : FILL			BS	1	-	-										
1		Stiff, grey, clayey silt, trace sand, trace gravel: FILL																
2					SS	2	0	7										
3	66.5																	
		Dense, grey, sandy silt, trace gravel : FILL			SS	4	410	37										
4	64.8																	
5	64.5	Compact, brown, SAND			SS	5	380	32										
6		Very stiff, brownish-grey, SILT and CLAY, trace sand																
	62.9				SS	6	610	24										
7	62.8	Loose, grey, SAND																
		Very stiff, brownish-grey, SILT and CLAY, trace sand																
8					SS	7	280	26										
9	60.2																	
		Loose, grey, SAND			SS	8	480	20										
10																		

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-5LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-07-30WATER LEVEL 97-08-28DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m		STANDARD PENETRATION TEST, BLOWS/0.3m						
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200	W _p	W	W _L	10	20	30	40	50	60
-10	58.8	Loose, grey, SAND																			
-11		Very stiff, grey, CLAYEY SILT, trace sand			SS	9	560	8													
-12	57.3																				
-13		Dense, grey, sand and silt, some gravel, trace clay : TILL			SS	10	460	33													
-14					SS	11	530	25													
-15																					
-16					SS	12	560	Ref													
-17					SS	13	610	Ref													
-18																					
-19	51.0	Dense, grey, SILT, trace clay, trace sand			SS	14	460	39													
-20																					

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

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DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-5LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-07-30WATER LEVEL 97-08-28DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m *	STANDARD PENETRATION TEST, BLOWS/0.3m •		
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200			W _p	W
20		Dense, grey, SILT, trace clay, trace sand			SS	15	460	20								
21	48.2															
	47.8	Dense, grey, SAND			SS	16	510	78%								
22	47.4	Vey dense, grey, silt, some sand, trace clay, trace gravel: TILL														
23		Fractured, medium to dark grey, dolomite with shaly partings: BEDROCK			NQ	17	90%	52%								
	45.9															
24		End of Borehole														
		Standpipe Installed														
		Ref = >50 blows for 150mm														
25																
26																
27																
28																
29																
30																

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

☒ Field Vane Test, kPa

☐ Remoulded Vane Test, kPa

☐ Pocket Penetrometer Test, kPa

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
0	67.65	Compact, brown, silt and sand, trace clay: FILL					mm							
1														
2					SS	1	610	10						
3	64.6	Stiff to very stiff, grey, SILTY CLAY, trace sand			SS	2	530	7						
4														
5	62.8	Dense, grey, SAND			SS	3	460	28						
6	61.6													
6.5	61.5	Very stiff, grey, SILTY CLAY, trace sand			SS	4		12						
7		Loose to compact, grey, SAND												
8	59.9	Very stiff, grey, SILTY CLAY, trace sand			SS	5		10						
9	58.5	Dense, grey, SAND			SS	6		61						
10	58.1													

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

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DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-6LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-07-31WATER LEVEL 97-08-28DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m *	STANDARD PENETRATION TEST, BLOWS/0.3m •
					TYPE	NUMBER	RECOVERY	N-VALUE OR Rqd	50	100	150	200		
10		Dense, grey, SILTY SAND, trace clay					mm							
11					SS	7	610	43						
12	55.5													
	55.0	Compact, grey, SAND			SS	8	510	31						
13		Very stiff, grey, CLAYEY SILT, trace sand												
	54.0													
14		Dense, grey, SILT and SAND, trace clay, trace gravel			SS	9	410	39						
15	52.4													
		Compact to dense, grey, SILTY SAND, trace gravel			SS	10	510	36						
16														
17					SS	11	430	32						
18														
					SS	12	480	32						
19														
20														

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

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Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-6LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-07-31WATER LEVEL 97-08-28DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m		STANDARD PENETRATION TEST, BLOWS/0.3m								
					TYPE	NUMBER	RECOVERY	N-VALUE OR Rqd	50	100	150	200	W _p	W	W _L	10	20	30	40	50	60	70	80
20		Compact to dense, grey, SILTY SAND, trace gravel			SS	13	-	Ref															
21																							
22					SS	14	430	13															
23	44.4				SS	15	230	Ref															
24	42.9	Very severely fractured, medium to dark grey, dolomite with shaly partings: BEDROCK			NQ	16	95%	18%															
25		End of Borehole																					
26		Stanpipe Installed																					
27		Standpipe blocked @ 3.9 m. Dry to 3.9 m.																					
28		Ref = >50 blows for 150mm																					
29																							
30																							


Inferred Groundwater Level
 Groundwater Level Measured in Standpipe
 Proposed Pipe Invert


Field Vane Test, kPa
 Remoulded Vane Test, kPa
 Pocket Penetrometer Test, kPa


DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-7LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-08-01WATER LEVEL 97-08-28DATUM Geodetic


DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR Rqd	WATER CONTENT & ATTERBERG LIMITS									
								mm										
0	66.51																	
		Very dense, brown, sand and gravel : FILL			SS	1	50	Ref										
1																		
	65.0																	
		Very dense to compact, brown, SAND and GRAVEL			SS	2	155	68										
2																		
3					SS	3	100	48										
4																		
5					SS	4	100	26										
6	60.4																	
		Very stiff, grey, SILT and CLAY, trace sand			SS	5	510	25										
7																		
	58.9																	
		Compact to very dense, brownish-grey to grey, SAND			SS	6	560	11										
8																		
9					SS	7	460	48										
10																		


 Inferred Groundwater Level


 Groundwater Level Measured in Standpipe


 Proposed Pipe Invert

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 Field Vane Test, kPa

 Remoulded Vane Test, kPa

 Pocket Penetrometer Test, kPa



DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield Limited

BOREHOLE No. M-7

LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON

PROJECT No. 10923

DATES: BORING 97-08-01

WATER LEVEL 97-08-28

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m *	STANDARD PENETRATION TEST, BLOWS/0.3m ●			
					TYPE	NUMBER	RECOVERY	N-VALUE OR Rqd	50	100	150	200			W _p	W _L	
10		Compact to very dense, brownish-grey to grey, SAND - some silt															
11					SS	8	410	66									
12	54.1	Compact to very dense, grey, SAND, trace to some silt, occasional silty sand seams															
13					SS	9	480	31									
14					SS	10	610	66									
15					SS	11	610	21									
16																	
17																	
18																	
19	47.3	Compact, grey, SAND															
20					SS	13	610	17									

▽ Inferred Groundwater Level

≡ Groundwater Level Measured in Standpipe


◀ Proposed Pipe Invert

Continued Next Page

▣ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa



DRAFT BOREHOLE RECORD

BOREHOLE No. **M-7**PROJECT No. 10923WATER LEVEL 97-08-28

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	WATER CONTENT & ATTERBERG LIMITS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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-20		Compact, grey, SAND						mm																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

DRAFT BOREHOLE RECORD

BOREHOLE No. M-8

PROJECT No. 10923

WATER LEVEL 97-08-28

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	WATER CONTENT & ATTERBERG LIMITS									
									W _p	W _L								
						mm		DYNAMIC PENETRATION TEST, BLOWS/0.3m										
								STANDARD PENETRATION TEST, BLOWS/0.3m										
								10	20	30	40	50	60	70	80	90		
0	65.57	Compact to dense, brown, SAND and GRAVEL			SS	1	300	40										
1					SS	2	0	26										
2					SS	3	100	21										
3	62.5				SS	4	0	43										
4				End of Borehole														
5		Standpipe Installed																
6		Standpipe dry on 97-08-28																
7																		
8																		
9																		
10																		

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-9LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-08-14

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m ★	STANDARD PENETRATION TEST, BLOWS/0.3m ●
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
0	65.89						mm							
1	64.4	Compact, brown, sand, trace gravel, trace silt: FILL			SS	1	200	32						
2	63.4	Compact, brown, SAND, some gravel, trace silt			SS	2	180	14						
3	62.8	Dense, brown, SAND and GRAVEL			SS	3	130	34						
4		End of Borehole												
5														
6														
7														
8														
9														
10														

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedLOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONDATES: BORING 97-08-14WATER LEVEL 97-08-28BOREHOLE No. M-10PROJECT No. 10923DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
0	66.21						mm							
	65.7	Grey, sand and gravel (crushed stone) : FILL			BS	1	-	-						
		Dense, grey, gravel and sand (crushed stone) : FILL												
1					SS	2	200	33						
	64.7													
		Compact, brown, SAND, some gravel			SS	3	130	40						
2														
3	63.2				SS	4	230	16						
		End of Borehole												
		Standpipe Installed												
4		Standpipe dry to 2.4m on 97-08-28												
5														
6														
7														
8														
9														
10														

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	WATER CONTENT & ATTERBERG LIMITS									
									50 100 150 200 W _p W W _L DYNAMIC PENETRATION TEST, BLOWS/0.3m * STANDARD PENETRATION TEST, BLOWS/0.3m ● 10 20 30 40 50 60 70 80 90									
0	66.10						mm											
		Grey, gravel and sand (crushed stone) : FILL			BS	1	-	-										
1					SS	2	0	Ref										
	64.6																	
		Compact, brown, SAND, some gravel, trace silt			SS	3	510	21										
2																		
	63.7																	
		Firm, brown to grey, SILT and CLAY, some gravel, trace sand			SS	4	330	15										
3	63.1																	
		End of Borehole																
		Standpipe Installed																
4																		
		Standpipe dry on 97-08-28																
		Ref = > 50 blows for 150mm																
5																		
6																		
7																		
8																		
9																		
10																		

Inferred Groundwater Level
 Groundwater Level Measured in Standpipe
 Proposed Pipe Invert

Field Vane Test, kPa
 Remoulded Vane Test, kPa
 Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-12LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-08-14

WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m *	STANDARD PENETRATION TEST, BLOWS/0.3m •	
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200			W _p
0	66.19	Compact, grey, sand and gravel: FILL			BS	1	-	-							
1	64.7				SS	2	130	26							
2	63.1	Stiff, brown, SILTY CLAY, trace sand			SS	3	430	7							
3					SS	4	380	6							
4		End of Borehole													
5															
6															
7															
8															
9															
10															

Inferred Groundwater Level
 Groundwater Level Measured in Standpipe
 Proposed Pipe Invert

☐ Field Vane Test, kPa
☐ Remoulded Vane Test, kPa
☐ Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-13LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-08-14

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
0	66.39						mm							
		Grey, sand and gravel (crushed stone) : FILL			BS	1	-	-						
1	65.5													
		Stiff brown to grey, CLAYEY SILT, trace sand			SS	2	300	18						
2					SS	3	480	8						
3	63.3				SS	4	430	7						
		End of Borehole												
4														
5														
6														
7														
8														
9														
10														

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-16LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-08-07WATER LEVEL 97-08-28DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50 100 150 200									
									WATER CONTENT & ATTERBERG LIMITS w_p w w_L									
									DYNAMIC PENETRATION TEST, BLOWS/0.3m *									
									STANDARD PENETRATION TEST, BLOWS/0.3m •									
							mm		10	20	30	40	50	60	70	80	90	
0	66.80	Brown, sand and gravel, some silt : FILL			BS	1	-	-										
1	65.3				SS	2	25	12										
2		Compact, brown to grey, SAND and GRAVEL			SS	3	230	10										
3					SS	4	75	15										
4					SS	5	155	26										
5					SS	6	50	32										
6	60.7				SS	7	75	16										
7		Compact, brown, SAND, trace silt			SS	9	50	17										
8	59.2				SS	10	0	14										
9	57.7	Compact, grey, SAND and GRAVEL			SS	11	75	18										
					SS	12	0	14										
		End of Borehole																
		Standpipe installed																
10																		

▽

Inferred Groundwater Level

≡

Groundwater Level Measured in Standpipe

▲

Proposed Pipe Invert

■

Field Vane Test, kPa

□

Remoulded Vane Test, kPa

△

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

BOREHOLE No. M-18

PROJECT No. 10923

WATER LEVEL

DATUM _____ Geodetic

[illegible]

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-19LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-08-07WATER LEVEL 97-08-28DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m		STANDARD PENETRATION TEST, BLOWS/0.3m	
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200	W _p	W	W _L	*
0	68.27						mm									
	67.8	Dark brown, SILT and SAND, trace organics			BS	1	-	-								
1		Dense, olive brown, SAND, some gravel			SS	2	510	52								
	66.8															
2		Compact to dense, grey, sand and silt, some gravel and clay : TILL			SS	3	610	13								
	65.8				SS	4	0	Ref								
3		Very severely fractured to severely fractured, grey, sandstone with frequent shaly partings: BEDROCK			NQ	5	38%	0%								
4					NQ	6	93%	44%								
	63.5															
5		End of Borehole														
6		Monitoring well installed														
7		Ref = >50 blows for 150mm														
8																
9																
10																

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

PROBE HOLE RECORD

CLIENT Morrison Hershfield Limited

BOREHOLE No. M-20

LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON

PROJECT No. 10923

DATES: BORING 97-08-12

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m	
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200			W _p
0	72.32							mm							
1															
2															
3															
4		Solid auger probe through overburden to define inferred bedrock depth at 10.4 m													
5															
6															
7															
8															
9															
10															

Inferred Groundwater Level
 Groundwater Level Measured in Standpipe
 Proposed Pipe Invert

Field Vane Test, kPa
 Remoulded Vane Test, kPa
 Pocket Penetrometer Test, kPa

Continued Next Page

PROBE HOLE RECORD

CLIENT Morrison Hershfield Limited

BOREHOLE No. M-20

LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON

PROJECT No. 10923

DATES: BORING 97-08-12

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
10	61.9	End of Probe Hole						mm						
11		Auger refusal on inferred bedrock												
12														
13														
14														
15														
16														
17														
18														
19														
20														

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Proposed Pipe Invert

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield LimitedBOREHOLE No. M-21LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ONPROJECT No. 10923DATES: BORING 97-08-12

WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa				WATER CONTENT & ATTERBERG LIMITS				DYNAMIC PENETRATION TEST, BLOWS/0.3m *	STANDARD PENETRATION TEST, BLOWS/0.3m ●
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200	W _p	W	W _L			
0	72.43						mm											
	72.2	225 mm ASPHALT			BS	1	-	-										
		Grey, sand and gravel, some silt: FILL																
1																		
	70.8	Brown, sand, pockets of silty clay : FILL			SS	2	325	12										
2																		
	69.4	Firm to stiff, brown, silty clay, trace to some sand : FILL			SS	3	275	2										
3																		
	67.4	Compact, dark brown to black, sand, some silt, trace organics : FILL			SS	4	525	19										
4																		
	66.3	Very stiff, olive grey, CLAYEY SILT, trace to some sand			SS	5	-	13										
5																		
6																		
7																		
8																		
9																		
	62.7	Compact, grey, SAND			SS	6	610	9										
10																		

Inferred Groundwater Level
 Groundwater Level Measured in Standpipe
 Proposed Pipe Invert

Field Vane Test, kPa
 Remoulded Vane Test, kPa
 Pocket Penetrometer Test, kPa

Continued Next Page

DRAFT BOREHOLE RECORD

CLIENT Morrison Hershfield Limited
LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON
DATES: BORING 97-08-12 WATER LEVEL _____

BOREHOLE No. M-21
PROJECT No. 10923
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
10		Compact, grey, SAND					mm							
11														
12	60.2													
	59.8	Grey, SILT and CLAY			SS	7	610	21						
13		Compact, grey, SAND												
14														
15	57.2													
		Compact, grey, silt, trace sand, trace gravel, trace clay : TILL			SS	8	450	21						
16														
17		- boulders												
18														
19		- boulders												
20														

▽ Inferred Groundwater Level

▬ Groundwater Level Measured in Standpipe


▲ Proposed Pipe Invert

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Continued Next Page



DRAFT BOREHOLE RECORD


BOREHOLE No. **M-21**


PROJECT NO. 10923


WATER LEVEL.


DATUM **Geodetic**


DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS			DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m		
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200	W _p			W	W _L
-20								mm									
-21		Compact, grey, silt, trace sand, trace gravel, trace clay, frequent boulders: TILL															
-22																	
-23	49.4																
-24	48.3	Very severely fractured, grey sandstone with shaly partings: BEDROCK			NQ	9	100%	0%									
					NQ	10	70%	0%									
-25		End of Borehole															
-26																	
-27																	
-28																	
-29																	
-30																	


 Inferred Groundwater Level


 Groundwater Level Measured in Standpipe

 Proposed Pipe Invert

 Field Vane Test, kPa

 Remoulded Vane Test, kPa

 Pocket Penetrometer Test, kPa



PROBE HOLE RECORD

CLIENT Morrison Hershfield Limited

BOREHOLE No. M-22

LOCATION West Transitway Project, Stn. 6+740 to 7+070, Ottawa, ON

PROJECT No. 10923

DATES: BORING 97-08-12

WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m	
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200			W _p
0	72.45							mm							
1															
2															
3															
4															
5															
6															
7															
8															
9	64.2	Solid auger probe through overburden to define inferred bedrock depth at 8.3 m													
10		End of Probe Hole													
		Auger refusal on inferred bedrock													

▽ Inferred Groundwater Level


≡ Groundwater Level Measured in Standpipe

▲ Proposed Pipe Invert

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa



RECORD OF BOREHOLE No 3 (Formerly WP 909-64)

METRIC

W P 124-27-01 LOCATION Co-Ords N 5022 875.0; E 359 183.5 ORIGINATED BY PLW
 DIST 9 H.V. 417 BOREHOLE TYPE Washboring & Diamond Drilling COMPILED BY J.P.
 DATUM Geodetic DATE 1966 03 10 CHECKED BY TCK

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			20	40	60	80	100					
65.9	Ground Level																
0.0	Clayey Silt with Interbedded Sandy Silt Soft to Firm		1	SS	4	*											
64.1			2	TH	PM												
1.8			3	SS	14												
			4	SS	31												
	Silty Sand to Sand		5	SS	18												
	Some Gravel		6	SS	26												
	Compact to Very Dense		7	SS	12												
			8	SS	11												
			9	SS	62												
55.5	Clayey Silt with Interbedded Sandy Silt		10	SS	31												
10.4			11	TH	PM												
54.3	Very Stiff to Hard		12	SS	35												
11.6			13	SS	31												
	Silty Sand to Sand		14	SS	56												
	Dense to Very Dense		15	SS	48												
44.8			16	RC	REC												
21.1	Bedrock			AXT	100%												
43.7	Shale Sound																
22.2	END OF BOREHOLE																
	* Hole caved in at Elev. 64.8m Water Level Not Established																

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

METRIC

V.P. 124-87-01 LOCATION Co-Ords. N 5 022 884.2; E 359 214.1

DIST 9 HWY 417 BOREHOLE TYPE B-Casing, BX Rock Core

DATUM Geodetic DATE 88 08 09

ORIGINATED BY MS

COMPILED BY MS

CHECKED BY TCK

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			20	40	60	80	100					
72.5	Ground Surface																
0.0 71.9	Concrete Slab		1	RC	-		72										GR SA SI CL
0.6	Sand Fill						70										
66.4							68										
6.1			2	SS	10		66										
63.9	Silty Sand to Sand Compact		3	SS	23		64										0 46 36 18
8.6	Clayey Silt with interbedded Silty Sand Stiff to very Stiff		4	SS	11		62										
60.9			5	SS	29		60										0 46 37 17
11.6	Silty Sand to Sand Trace of Clay Very Dense		6	SS	63		58										0 78 16 6
57.9			7	SS	52		56										RQD = 8%
14.6	Bedrock Sandstone, Shale and Silty Sandstone		8	RC	REC 89%												
54.8			9	RC	REC 87%												RQD = 8%
17.7	END OF BOREHOLE																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 68-

METRIC

W.P. 12-97-01 LOCATION Co-Ords N 5022 887.9 E 359235.6 ORIGINATED BY me
 DIST 9 m.w. 417 BOREHOLE TYPE H-S Auger, 8% Rock Core COMPILED BY MS
 DATUM Geodetic DATE 88 08 05 CHECKED BY TCV

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
67.8	Ground Surface																
0.0	Sand and Gravel (Fill)					*											
66.6																	
1.2	Bedrock		1	RC	REC	76%	66										RQD = 0%
65.4	Sandstone		2	RC	REC	65%											RQD = 0%
2.4	END OF BOREHOLE																
	* Borehole Dry																

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6C-

METRIC

W P 124-87-01 LOCATION Co-Ords N 5022 897.4; E 359 221.2
 DIST 0 HWY 417 BOREHOLE TYPE H-S Auger, 'B' Casing, BZ Rock Core
 DATUM Geodetic DATE 88 08 05
 ORIGINATED BY MS
 COMPILED BY MC
 CHECKED BY TCK

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							WATER CONTENT (%)
								SHEAR STRENGTH (kPa) ○ UNCONFINED * FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
72.4	Ground Surface														
71.8	Asphalt						72								
0.6	Clayey Silt to Sand (Fill)		1	AS	-	*	70								
			2	SS	11		68								
			3	SS	60	15cm	66								
66.0			4	SS	39		64								
6.4	Silty Sand to Sand														
65.1															
7.3	Bedrock														
63.7	Sandstone		5	RC	REC 89%										
8.7	END OF BOREHOLE * Water Level Not Established													RQD = 0%	

+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OF REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-4

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,890.0; E 359,174.0 (HML C-5) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

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			20	40					
67.6	Ground Surface													
0.0	Silty Sand, some gravel; FILL.													
	Dark grey		1	SS	26									
	Very loose to Compact		2	SS	2									
64.9														
2.7	Silty Clay, some sand.													
	Grey stiff		3	SS	4									
63.6														
4.0	Sand, trace silt, trace to some gravel.		4	SS	11									
	Grey to greyish brown													
	Loose to compact													
	-cobbles 4.0m to 4.6m		5	SS	14									
	5.0m to 6.1m													
	-Clayey silt zone at 7.8m		6	SS	5									
			7	SS	11									
57.8														
9.8	End of Borehole													

*3, *5: Numbers refer to Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

BOREHOLE RECORD

94-2

Sta. 8+114 4.0m LT

CLIENT McCormick Rankin Consulting EngineersLOCATION West TransitwayPROJECT No. 10494DATES: BORING 94-06-27WATER LEVEL 94-07-13BOREHOLE No. 94-2DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
0	72.03													
	71.9	75 mm TOPSOIL & ROOTMAT			SS	1	600	10						
	71.3	Compact, brown silty sand, trace clay: FILL			SS	2	100	50/100						
1	71.1	Compact, brown SAND, some silt, trace gravel			RC	3	57%	10%						
2		Very severely fractured to sound shaly limestone: BEDROCK			RC	4	100%	91%						
3					RC	5	97%	97%						
	68.6	End of Borehole												
4		- monitoring well installed												
5														
6														
7														
8														
9														
10														

Legend:
□ Field Vane Test, kPa
□ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

Proposed Pipe Invert



BOREHOLE RECORD

94-5

Sta. 6+907 25.5 m LT

CLIENT McCormick Rankin Consulting Engineers

LOCATION West Transitway

PROJECT No. 10494


DATES: BORING 94-06-28

WATER LEVEL ---


BOREHOLE No. 94-5

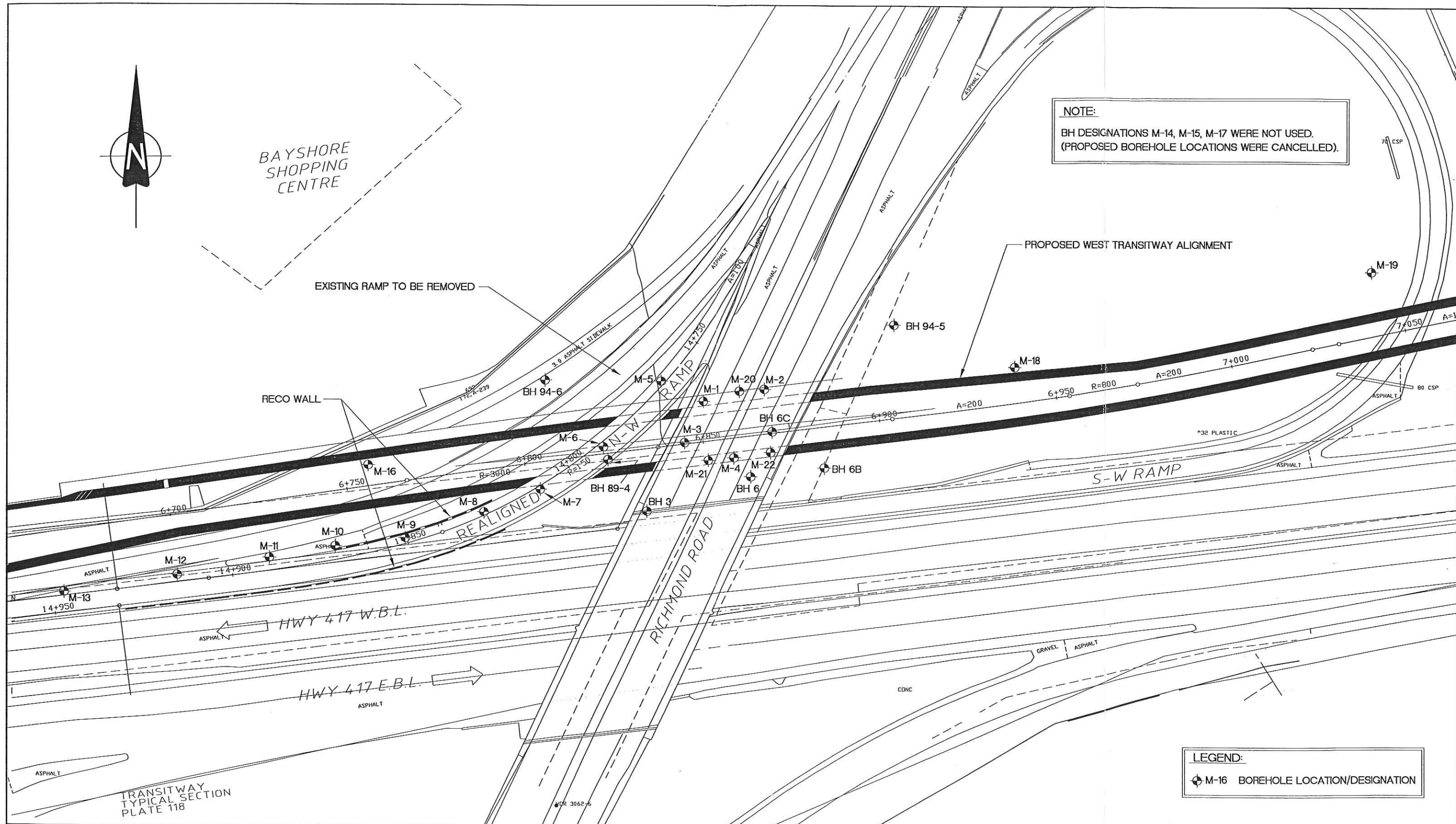
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa		WATER CONTENT & ATTERBERG LIMITS		DYNAMIC PENETRATION TEST, BLOWS/0.3m	STANDARD PENETRATION TEST, BLOWS/0.3m
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	50	100	150	200		
0	67.40						mm							
	66.8	Firm, brown silty clay, trace sand: FILL			SS	1	600	4						
1		End of Borehole												
2		Auger Refusal on Inferred Bedrock												
3		- standpipe installed												
4														
5														
6														
7														
8														
9														
10														

 Proposed Pipe Invert

☒ Field Vane Test, kPa
☐ Remoulded Vane Test, kPa
☐ Pocket Penetrometer Test, kPa





Jacques
Whitford

REFERENCE :

BASE PLAN PROVIDED BY
MORRISON HERSHFIELD LIMITED

SCALE : 1 : 1000

DATE : 97/09/12

DWN. BY : GBB

APP'D BY :

MORRISON HERSHFIELD LIMITED

PROPOSED WEST TRANSITWAY

OTTAWA,

ONTARIO

BOREHOLE
LOCATION PLAN

DRAWING No.:

10923-2