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CONSULTING ENGINEERS

TECHNICAL MEMORANDUM FOR CULVERTS IN PHASE 1 ADDENDUM TO FOUNDATION INVESTIGATION AND DESIGN REPORT CULVERT C62A - DELAMERE TOWNSHIP HIGHWAY 69 FOUR-LANING FOR 24.7 KM FROM 3.8 KM NORTH OF HIGHWAY 522 TO 4.5 KM NORTH OF HIGHWAY 64 SITE NO. 46-532 C1 NBL / 46-532 C2 SBL W.P. 5178-08-01 NBL / 5179-08-01 SBL G.W.P. 5206-06-00 (PART OF G.W.P. 5378-02-00) SUDBURY AREA, ONTARIO

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Dear Mr. Doyon

Technical Memorandum for Culverts in Phase 1
Addendum to Foundation Investigation and Design Report
Culvert C62A - Delamere Township
Highway 69 Four-Laning for 24.7 km
From 3.8 km North of Highway 522
to 4.5 km North of Highway 64, Site No. 46-532 C1 NBL / 46-532 C2 SBL
W.P. 5178-08-01 NBL / 5179-08-01 SBL, G.W.P. 5206-06-00 (Part of G.W.P. 5378-02-00)
Sudbury Area, Ontario

Planned within the 11.1 km long Phase 1 of the project is the installation of several concrete culverts. Nine of these culverts have been selected for foundation investigation.

This memorandum summarises the results of the field investigation conducted at the location of culverts 48 and 49 at station 13+938, Delamere Township which were assigned a reference number C62A. This memorandum also pertains to the design and construction of this proposed culvert and associated bedding/backfill zones.

A timber crib culvert was noted under the existing Highway 69 embankment in the vicinity of the proposed northbound culvert C62A.

The field work for culvert C62A was carried out during a period of November 4 to 6, 2008 and March 9 and 10, 2009. The subsurface investigation comprised a total of 6 boreholes with two locations refusing on surficial bedrock and other locations advanced to depths of 3.5 to 4.5 m below existing grade.

The locations of the boreholes put down along the culvert are shown on Drawing C62A-1. The borehole logs, drawing and figures are identified by the prefix codes to reflect the specific culvert number for ease of reference.

1. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, soil boundary elevations, standard penetration resistance values, in-situ vane shear and penetrometer test data and groundwater observations. The results of laboratory Atterberg plasticity limits tests, grain size distribution analyses and moisture content determinations are also shown on the Record of Borehole sheets.

Three boreholes were drilled along the original skewed alignment of culvert C62A from Sta. 13+938 to Sta. 14+014 in November 2008 (boreholes C62A-1 C62A-2 and C62A-3). In March of 2009, one additional borehole was drilled and two manual probes were conducted along the revised alignment at Sta. 13+938 (boreholes C62A-4, C62A-5 and C62A-6). The subsurface stratigraphy revealed in the boreholes along the revised alignment included, a 0.4 to 0.7 m thick layer of cobbles and boulders in boreholes C62A-3 and C62A-4 overlying bedrock and exposed bedrock in boreholes C62A-5 and C62A-6. Accordingly, bedrock was contacted from the surface to 0.7 m depth (elevations 195.5 to 201.8). Photographs of the exposed bedrock contacted at this location are appended. During the investigation in March 2009, snow measuring 700 mm in thickness was encountered at borehole C62A-4.

1.1 Cobbles and Boulders

From the surface and underlying the snow at 0.7 m depth in boreholes C62A-3 and C62A-4 was a deposit of cobbles and boulders which included layers of sand with trace silt. The deposits extended to the underlying bedrock at 0.4 and 0.7 m depth (elevations 195.5 and 196.6) in boreholes C62A-3 and C62A-4, respectively.

1.2 Bedrock

Along the revised alignment, bedrock was contacted at the surface to a depth of 0.7 m (elevations 195.5 to 202.0), with the bedrock surface elevation decreasing from west to east. The bedrock has a variable composition including pink Granite at borehole C62A-3 and light grey becoming dark grey Migmatite at borehole C62A-4. The rock exhibited medium to high strength in the borehole locations. A detailed description of the rock cores retrieved from boreholes C62A-1, C62A-2, C62A-3 and C62A-4 along the original and proposed alignment is given in Table A, appended.

Along the revised alignment the measured core recovery was 94 to 100%. The RQD determined from the rock cores typically was in a range of 70 to 97%, thus indicating fair to excellent quality rock. Locally, the rock core obtained from 1.4 to 2.7 m depth (elevations 196.6 to 195.3) in borehole C62A-4 had an RQD of 0 to 42%, indicating very poor to poor quality rock.

1.3 Groundwater

Groundwater was not observed along the revised culvert alignment. Seasonal perched water within the pervious cobble and boulder deposit above the bedrock should be anticipated for the northbound culvert location. The groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

2. ENGINEERING RECOMMENDATIONS

It is understood that precast box culverts are capable of withstanding some 100 mm of differential settlement, provided the settlement is not abrupt. Cast-in-place culverts typically tolerate a maximum of 25 mm of differential settlement, after which, cracking may appear within the culvert. Expansion joints should be provided at the design engineer’s discretion to accommodate the differential settlement.

The foundation frost penetration depth at the sites is 2.0 m according to OPSD 3090.101.

It is noted that no responsibility or liability is assumed by MTO or by the consultants for alerting the contractor and to "red-flag" all critical issues. The requirement to deliver acceptable construction quality remains the responsibility of the contractor.

All elevations in the memorandum are expressed in metres. A list of standard specifications referenced in this memorandum is compiled in Table 1. The Granular A and B materials referenced in this memorandum should conform to OPSS 1010.

For culvert C62A, separate box culverts are proposed under the northbound and southbound lanes of the new Highway 69 (designated northbound and southbound culverts). The invert levels of the proposed 3.0 m wide concrete box culverts are specified near elevation 197.4 at the west end of the southbound culvert and elevation 196.0 at the east end of the northbound culvert, indicating an west to east flow. The subgrade level of the granular bedding should be about 0.5 m below the proposed invert levels at elevations 195.5 to 196.9 allowing for the thickness of the concrete base of the culvert and for the granular bedding and levelling courses.

At the proposed southbound culvert location, bedrock cuts of up to 1.6 m from existing grade will be required to achieve the proposed road centreline grade elevation 200.4. At the proposed northbound culvert location, around 0.5 m of fill will be required to achieve the proposed road centreline grade elevation 199.1.

Three boreholes were drilled along the original skewed alignment of culvert C62A from Sta. 13+938 to Sta. 14+014 in November 2008. In March 2009, one additional borehole was drilled and two manual probes were conducted along the current revised alignment at Sta. 13+938. The subsurface stratigraphy revealed along the revised alignment included a 0.4 to 0.7 m thick layer of cobbles and boulders overlying bedrock at elevations 195.5 and 196.6 beyond the west and east ends of the proposed northbound culvert and exposed bedrock sloping downwards from west to east at elevations 202.0 to 198.4 beyond the west and east ends of the proposed southbound culvert.

A precast concrete box culvert is feasible at this site. An alternative foundation design using a rock base with side walls dowelled into the bedrock may also be constructed at this site.

Groundwater was not encountered during the time of the field investigation for the revised culvert alignment. Seasonal perched water within the pervious cobble and boulder deposit and in low lying areas above the bedrock should be anticipated for the northbound culvert location.

2.1 Foundations for Culvert C62A Under Southbound and Northbound Lanes

2.1.1 Box Culvert Considerations

For box culvert construction, the exposed and relatively shallow depth bedrock encountered at the proposed southbound and northbound culverts should be excavated to the culvert subgrade levels. Accordingly, excavation of up to 5.1 and 1.5 m of bedrock will be required at the respective west and east ends of the proposed southbound culvert location (to elevation 196.9), and the excavation of up to 1.1 m of bedrock at the west end of the proposed northbound culvert (to elevation 195.5). The 0.4 m thick cobble and boulder deposit at the east end of the proposed northbound culvert is overlying bedrock at elevation 195.5, the anticipated to subgrade level. Subgrade preparation should be carried out following careful removal of the existing skewed culvert under the northbound lanes.

The excavated rock should be replaced with Granular A or Granular B Type II material to raise the subgrade to the design level. Granular B Type II should be preferred for construction under wet conditions. The prepared subgrade should be inspected during construction and any bedrock less than 300 mm below the underside of the culvert should be removed to minimize the influence of point loads.

2.1.2 Rock Base Considerations

Alternatively, the culvert may be constructed with a rock base having the sidewalls dowelled into the bedrock.

The rock excavation should be carefully carried out to produce a shatter free bedrock mass/ surface that is adequate to receive the steel dowels. To this end, excavation using mechanical excavations will be preferred.

A bedding and levelling course is not required for this foundation scheme.

2.2 Geotechnical Bearing Resistance For Culvert C62A

The recommended geotechnical bearing resistances at ultimate and serviceability limit states (ULS and SLS) for the proposed 3.0 m wide box culvert typically constructed on the structural fill (Granular A or Granular B Type II) over bedrock, or directly on bedrock are as follows:

CULVERT SECTION	SOIL TYPE	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL RESISTANCE AT SLS (kPa)
Southbound Or Northbound	Structural Fill (Granular A or Granular B Type II)	900	350
	Bedrock	10,000	N/A

The geotechnical resistance at SLS normally allows for 25 mm compression of the founding medium. A foundation embedment depth of 2.0 m and groundwater at about 0.5 m below the culvert invert level were assumed for computation of the geotechnical resistance.

The geotechnical resistance at SLS for foundations on the bedrock is not applicable because the median is considered to be non-wielding.

If required, mass concrete could be placed to provide a level founding surface below the side walls of the culvert. Further recommendations in this regard are included in following section.

2.3 Subgrade Preparation

Preparation of the subgrade for construction of the culverts should be performed and monitored in accordance with OPSS 902 and SP 902S01. This should include site review by qualified geotechnical personnel during preparation of the subgrade as well as during placement and compaction of the granular fill and during the removal of existing culverts where applicable.

Where the Ministry has approved the substitution of precast box culverts for cast-in-place box culverts, it is recommended to provide 300 mm of granular bedding below the culvert. The bedding material should comprise Granular A compacted to 100% of the ASTM D-698 (standard Proctor) maximum dry density in conformance to OPSS 501 (Method A).

The topsoil and any other deleterious soils revealed at and below the subgrade level should be excavated prior to placement of the granular base below the box culvert and replaced with compacted Granular A or Granular B Type II.

Subgrade preparation, cover, backfill and frost treatment for the proposed culverts should be carried out in accordance with OPSD 803.010, OPSS 422 and SP 422S01. A foundation frost penetration depth in the area is at least 2.0 m according to OPSD 3090.101.

If culvert C62A is constructed with a bedrock base, mass concrete could be employed to raise the bedrock subgrade to the design level of the side walls, if required. Mass concrete could also be placed to provide a level founding surface for the wing wall or headwall footings, if required. Alternatively, the rock surface could be “stepped” to follow variations in the bedrock surface elevation thereby creating a level subgrade by a combination of rock excavation and placement of mass concrete.

The need to expand the plan area at the base of the mass concrete to provide for stress distribution (2V:1H), place reinforcing steel in the mass concrete and/or use high strength concrete to prevent overstressing will be dictated by the actual thickness of the mass concrete and structural design considerations.

Subject to these comments, the geotechnical bearing resistance provided for footings bearing on bedrock is considered to be appropriate for mass concrete with an unconfined compressive strength of at least 35 MPa.

Comments concerning excavation of bedrock to enable construction of the footings are provided in Section 5 of the memorandum.

2.4 Modulus of Subgrade Reaction

The estimated values of the modulus of subgrade reaction for culvert C62A constructed on structural fill (Granular A or B Type II) is as follows:

SOIL TYPE	MODULUS OF SUBGRADE REACTION MN/m^3
Granular A or B Type II	45

2.5 Sliding Resistance

The following parameters should be used for sliding resistance of cast-in-place culvert foundations. The friction angle in case of precast concrete should be reduced by a factor of 0.67.

SOIL TYPE	Friction Angle, degrees	Cohesion, kPa	Unit Weight, kN/m^3
GRANULAR A OR GRANULAR B TYPE II	35	0	22.8

The structural designer should use a factor of 0.8 for the above values of friction angle and cohesion when checking the sliding resistance.

If the footings are poured directly on the surface of the bedrock (bedrock surface not roughened by excavation/construction activities), an unfactored friction factor of 0.6 should be employed since this bedrock surface is relatively smooth, presumably as a result of weathering and/or glaciation. If excavation of the bedrock is required, an unfactored friction factor of 0.7 could be used.

The lateral resistance of footings founded on bedrock could be increased by means of a shear key and/or by installing dowels/anchors into the bedrock (SP 999S26). The increased lateral resistance will be provided by the shear strength of steel dowels if used, the horizontal resistance of the bedrock, the horizontal component of tensile forces developed in any inclined anchors and/or a greater frictional resistance between the footing and rock if the anchors are prestressed to increase the vertical pressure. The factored horizontal resistance at ULS of the bedrock is considered to be 5000 kPa.

If anchors are installed, a factored bond stress at the rock/grout interface of 1.4 MPa at ULS (a resistance factor of 0.4 is applied for a minimum 35 MPa grout) is recommended for design. The anchors should extend a minimum 30 bar diameters into sound bedrock and be spaced at a distance of at least four times the diameter of the anchor hole. The total capacity of a group of closely spaced anchors may be less than the summed capacities of the individual anchors; the impact of anchor interaction should be assessed if the spacing is less than one-fifth of the anchor length. Design, installation and testing of the anchors subjected to tensile stresses should be conducted in accordance with SP 999S26 and clause 6.10.4 of the Canadian Highway Bridge Design Code (CHBDC).

2.6 Seismic Site Coefficient

The seismic site coefficient for the conditions at the culvert sites is 1.0 – Type I soil profile as per clause 4.4.6 of the CHBDC.

3. CULVERT BACKFILL

Backfill adjacent to the culverts should be placed in accordance with OPSD 803.010, OPSS 422 and SP 422S01.

Backfill should be brought up simultaneously on each side of the culvert and operation of heavy equipment within 0.5 times the height of the culvert (each side) restricted to minimise the potential for movement and/or damage of the culvert due to the lateral earth pressure induced by compaction. Refer to SP 105S10 for additional comments.

The culverts and headwalls must be designed to support the stress imposed by the overlying fill as well as to resist the unbalanced lateral earth pressure and compaction pressure exerted by the backfill adjacent to the culvert walls. Recommendations for headwalls and wing walls are also provided in Section 4 of this memorandum.

The lateral earth and water pressure, p (kPa), should be computed using the equivalent fluid pressures presented in Section 6.9 of the CHBDC or employing the following equation assuming a triangular pressure distribution:

$$P = K(\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + Cp + Cs$$

where K = lateral earth pressure coefficient
γ = unit weight of free draining granular material above the design water level (kN/m^3)
γ' = unit weight of backfill submerged below the design water level (kN/m^3)
h_1 = depth below final grade (m), above the design water level
h_2 = depth below the design water level (m)
q = any surcharge load (kN/m^2)
γ_w = unit weight of water equal to 9.8 kN/m^3
Cp = compaction pressure (refer to clause 6.9.3 of CHBDC)
Cs = earth pressure induced by seismic events, kPa (refer to clause 4.6.4 of CHBDC)
where Ø = angle of internal friction of retained soil (35º for Granular A)
δ = angle of friction between soil and wall (23.5º for Granular A)

The following parameters are recommended for design:

PARAMETER	GRANULAR A, GRANULAR B TYPE II	ROCKFILL
Angle of Internal Friction, degrees	35	42
Unit Weight, kN/m^3	22.8	18.0
Active Earth Pressure Coefficient (K_a)	0.27	0.20
At-Rest Earth Pressure Coefficient (K_o)	0.43	0.33
Passive Earth Pressure Coefficient (K_p)	3.69	5.04

The design should consider both the maximum water level in the stream and the stabilised groundwater level condition. Groundwater was not encountered during the time of the field investigation for the revised culvert alignment. Seasonal perched water within the pervious cobble and boulder deposit and in low lying areas above the bedrock should be anticipated for the northbound culvert location. The maximum stream water level will be dictated by flood flow conditions and should be defined by the project hydraulic engineer.

The coefficient of earth pressure at rest should be employed to design rigid and unyielding walls and the active earth pressure coefficient for unrestrained structures.

4. HEADWALLS AND WINGWALLS

For headwalls and wingwalls, the previous recommendations and geotechnical parameters for culvert foundations and backfill should be used for the design of their foundations, and in accordance with OPSD 3121.150. The wall founding levels should match those of the respective culverts where the walls are designed integral with the culvert structure. For walls designed separately from the culvert structure, the founding levels should be established minimum 2.0 m below the culvert invert level for adequate frost protection.

The design of the walls should be checked for sliding resistance using the geotechnical parameters provided in Section 2.5 for cast-in-place concrete foundations.

For headwalls and wingwalls, a weeping tile system should be installed to minimise the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly designed granular filter or non-woven Class II geotextile (with an FOS of 75-150 µm according to OPSS 1860) placed to prevent migration of fines into the system. The wall drainage pipe should outlet onto a positive slope away from the wall and where possible lead to a frost free outlet.

5. EXCAVATION

Excavation to the anticipated founding level of the culverts is expected to extend through the existing embankment fill and cobbles and boulders. Provision for excavation of cobbles and boulders should be made. Subject to adequate groundwater control, excavation of the soils should be feasible using conventional equipment. All excavations should be conducted in accordance with OPSS 902 and SP 902S01.

According to the Occupational Health and Safety Act (Ontario Regulation 213/91) criteria, typically the in situ soils (cobbles and boulders) are classified as Type 3 soils necessitating temporary cut slopes to be inclined at 1H:1V.

Excavation of bedrock will likely be required at culvert C62A. Conventional rock excavation techniques such as blasting as per OPSS 120 and jack-hammering should be suitable. It is important that blasting/excavation of the rock is controlled to prevent fracturing and/or disturbance of the bedrock surface directly beneath the culverts. The equipment required and method of excavation within the bedrock will be dependent upon the actual geometry of cut and relative depth of excavation into the bedrock.

Mechanical means such as a large excavator equipped with a tiger-toothed bucket in conjunction with a jack-hammer or hoe ram is the preferred method of excavation to shallow depths in rock at foundation locations. Mass concrete could be employed to level minor variations in the bedrock surface.

If blasting is required, a NSSP should be prepared to provide specific direction to the contractor to control the blasting/excavation of the rock to prevent fracturing and/or disturbance of the bedrock surface, require that a blasting specialist be retained to establish the charge to minimise overbreak, advise that any overblasting/overexcavation will be the sole responsibility of the contractor and require that loosened rock resulting from blasting operations be removed by mechanical means.

The excavation at the culvert sites should allow for the backfill and cover requirements in accordance with OPSD 803.010. Near vertical sidewalls may be utilised for excavations in bedrock. Examination of the sidewalls and removal of any loosened rock fragments should be carried out continually for the safety of workmen.

6. GROUNDWATER CONTROL

Groundwater was not encountered during the time of the field investigation for the revised culvert alignment. Seasonal perched water within the pervious cobble and boulder deposit and in low lying areas above the bedrock should be anticipated for the northbound culvert location.

It is considered that dewatering with conventional sump pumping techniques will generally be sufficient to handle groundwater seepage or surface water inadvertently entering the excavations, provided surface water flow is controlled. The contract documents should have a specific item to clearly state that groundwater control of excavations is the contractor's responsibility.

It will be necessary to implement measures to control surface water flow at both of the culvert sites, but primarily at the northbound culvert given the existing grades. Conventional procedures such as dam and pump and/or diversion of the stream should be sufficient to control surface water flow.

Given the shallow depth to bedrock and provided that surface water flow is controlled it is considered that dewatering with conventional sump pumping techniques will generally be sufficient to handle and groundwater seepage or surface water inadvertently entering the excavations during the construction of cast-in-place headwalls, wing walls or cut-off walls.

In accordance with the Ontario Water Resources Act, the Water Taking and Transfer Regulation 387/04, a Permit to Take Water (PTTW) from the Ministry of Environment is required if the dewatering discharge is greater than 50,000 L/day.

It must be noted that the assessment of the need for an application for a PTTW will be undertaken by others. This will include the expected daily flows at each culvert location which should be assessed by the hydraulic engineer.

It is recommended that the work be carried out during the dry months of June to September to minimize the amount of groundwater inflow to be handled and the volume of surface water, if any, to be diverted from the construction area.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

All construction work should be carried out in accordance with the Occupational Health and Safety Act and with local/MTO regulations.

7. EMBANKMENT FILL

The anticipated subgrade for the embankments will comprise bedrock, existing embankment fill and cobbles and boulders. The construction specifications for grading in SP 206S03 should be followed. In particular, the topsoil and other excessively loose, soft, organic or otherwise deleterious materials within the limits of the embankment fill should be subexcavated prior to fill placement. The new embankment fill should be placed and compacted in accordance with OPSS 501 and SP 105S10.

The rockfill embankment side slopes should be inclined no steeper than 1.25H:1V. A vegetation cover over slope flattening material or other measures should be established to control surface runoff and minimise erosion of the embankment slopes.

8. EROSION CONTROL

The protective measures noted in the OPSD 800 series to deal with erosion (inlet/outlet treatment, headwalls, cut-off walls, etc.) are considered to be appropriate. The backfill should comprise OPSS Granular A or Granular B Type II. The cut-off walls should extend laterally to protect the granular backfill material and to a depth at least equal to the fluctuation of the water level at each culvert location to prevent flow below the culvert that could erode the granular base/bedding material. The requirements of CHBDC clauses 1.9.5.6 and 1.9.11.6.5 should be applied.

Inlet and outlet protection in accordance with OPSS 511 and 1004 and OPSD 810.010 is recommended to prevent erosion adjacent to the culvert as well as scour that could undermine the culvert and/or embankment foundation. The actual design requirements concerning the length and width of aprons at the inlet/outlet of the culvert as well as the rock size, apron thickness, height of erosion protection on the embankment slope and type of material (clay seals at the inlet, drainage and/or filter blankets at the outlet) will be dictated by stream hydraulics, stream configuration, the water level in the stream and should be established by a hydraulic engineer. A non-woven Class II geotextile with an FOS of 75-150 µm according to OPSS 1860 should be placed below the rip-rap to minimise the potential for erosion of fine particles from below the treatment.

All newly constructed embankment slopes and retained soils behind the headwalls and wingwalls (if provided) should be covered with topsoil or suitable excess earth material from swamps or muskeg areas and seeded in accordance with OPSS 570 and 572, as soon after grading as possible to prevent erosion. Where slopes are inclined at 2.5H:1V or steeper, the permanent slopes should be protected with erosion control blankets. Also, sod (as per OPSS 571) shall be placed where it currently exists with a view to aesthetics. Additional appropriate erosion control measures for the project should be assessed using the following erodibility K factor:

SOIL TYPE	K FACTOR
Clayey Silt	0.45
Clay / Silty Clay	0.2 to 0.3
Gravelly Sand	0.1

This technical memorandum was prepared by Mr. C.M.P. Nascimento, P.Eng. with the assistance of Mr. M.J. Narduzzi, BEng., and was independently reviewed by Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact.

Yours very truly

Peto MacCallum Ltd.

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Senior Project Engineer

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MTO Designated Principal Contact

MN/CN/BRG:mn-mi

Enclosure(s):
Table A – Rock Core Descriptions
Table 1 – List of Standard Specifications Referenced in Memorandum
Explanation of Terms Used in Report
Record of Borehole Sheets
Drawing C62A-1 – Borehole Locations and Soil Strata
Appendix A – Rock Core Photographs
Appendix B – Exposed Bedrock Photographs at Culvert C62A

TABLE A

ROCK CORE DESCRIPTION

LOCATION (BH)	CORE RECOVERY				CORE DESCRIPTION	
	RC	DEPTH (m)	REC (%)	RQD (%)	DEPTH (m)	DESCRIPTION
C62A-1	1 2 3	0.5 – 1.4 1.4 – 2.9 2.9 – 3.5	100 100 100	100 92 100	0.5 – 3.5	GRANITE (possible Syenite): Pink, fine grained, with localized zones of coarse grained Pegmatite, with concentrations of black Biotite, occasional dark layers (possible Amphibolite), high strength, slightly weathered to unweathered, close to moderate (locally very close) spaced flat cross joints, rough planar, tight to slightly altered with yellow to rust coloured oxidation zones extending 5 mm from parting, locally friable, locally with green silt or scale on partings, occasionally separates on Biotite concentrations, some vertical seams at depth but core remains intact (no discontinuity), excellent quality.
C62A-2	1 2 3	0.3 – 1.0 1.0 – 2.6 2.6 – 3.6	100 100 100	100 92 100	0.3 – 1.5	MIGMATITE: Grey, with pink bands, fine grained, high strength, slightly weathered to unweathered, moderate spaced flat cross joints, rough planar, tight, single dipping compound cross joint (25 mm), slightly altered with yellow to rust coloured oxidation zones, good quality.
					1.5 – 3.0	PEGMATITE: Pink, coarse crystalline, with small pockets of black Biotite, high strength, unweathered, generally massive, near vertical parting, rough planar, with silt on partings, fair quality.
					3.0 – 3.6	GRANITE (possible Syenite): Pink, fine grained, high strength, unweathered, close spaced flat cross joints, rough planar, tight to slightly altered with green mineralization and/or silt on parting surface, occasionally separates on Biotite concentrations, excellent quality.

Originated: FP
Compiled: JFW
Checked: MN / CN

TABLE A

ROCK CORE DESCRIPTION

LOCATION (BH)	CORE RECOVERY				CORE DESCRIPTION	
	RC	DEPTH (m)	REC (%)	RQD (%)	DEPTH (m)	DESCRIPTION
C62A-3	1 2 3	0.4 – 1.2 1.2 – 2.7 2.7 – 3.6	100 97 100	70 78 97	0.4 – 3.6	GRANITE: Pink, fine to medium grained, high strength, slightly weathered to unweathered, close to moderately spaced, flat to dipping cross joints, generally tight, with darker Biotite rich layer at 1.3 to 1.7 m depth, very close to close spaced dipping partings, rough planar to slickensided planar, black to reddish black on parting surface, locally oxidized or with friable Muscovite Mica, fair to excellent quality.
C62A-4	1	0.7 – 1.4	-	-	0.7 – 1.4	BOULDERS/COBBLES/GRAVEL
	2 3 4 5 6	1.4 – 2.3 2.3 – 2.5 2.5 – 2.7 2.7 – 3.9 3.9 – 4.5	94 100 100 100 100	42 0 0 82 70	1.4 – 4.5	MIGMATITE: Light grey with some banding, becoming predominantly dark grey, fine to medium crystalline, with occasional white dipping bands, coarse crystalline, medium to high strength, slightly to moderately weathered to unweathered, very close to close spaced flat to dipping (locally vertical) cross joints, generally rough planar, locally undulating planar and slickensided, tight to slightly altered with rust coloured oxidation on partings, locally friable, some loss of material at 1.8 m depth, very poor to poor becoming fair to good quality.

RQD = Rock Quality Designation

Originated: FP
Compiled: JFW
Checked: MN / CN

TABLE 1
LIST OF STANDARD SPECIFICATIONS REFERENCED IN MEMORANDUM

DOCUMENT	TITLE
OPSS 120	General Specification for the Use of Explosives
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 570	Construction Specification for Topsoil
OPSS 571	Construction Specification for Sodding
OPSS 572	Construction Specification for Seed and Cover
OPSS 902	Excavation and Backfilling of Structures
OPSS 1004	Material Specification for Aggregates – Miscellaneous
OPSS 1010	Material Specification for Aggregates, Base, Subbase, Select Subgrade and Backfill Material
OPSS 1860	Material Specification for Geotextiles
SP 105S10	Construction Specification for Compaction
SP 206S03	Construction Specification for Grading
SP 422S01	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers
SP 902S01	Excavation and Backfilling of Structures
SP 999S26	Design, Installation and Testing of Pre-Stressed Anchors in Soil and Rock
OPSD 803.010	Backfill and Cover for Concrete Culverts
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets
OPSD 3090.101	Foundation Frost Depth for Southern Ontario
OPSD 3121.150	Minimum Granular Backfill Requirements – Retaining Walls

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1,%	VOID RATIO

n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
DTPL		DRIER THAN PLASTIC LIMIT
APL		ABOUT PLASTIC LIMIT
WTPL		WETTER THAN PLASTIC LIMIT

e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_u	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No C62A-1

METRIC

Coords: 5 110 802 N; 328 683 E

G.W.P. 5206-06-00 LOCATION Hwy 69 (New), Sta. 14+014, o/s 24.9m Lt. CL ORIGINATED BY M.R.

DIST 54 HWY 69 BOREHOLE TYPE C.F.H.S.A. AND NQ DIAMOND CORING COMPILED BY M.N.

DATUM Geodetic DATE November 06, 2008 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.6 / 0.0	Ground Surface				*		
196.4 / 0.2	Peat, fine fibrous, Dark brown, Wet						
196.1 / 0.5	Silty clay, trace sand, Grey, Moist					196	
	Granite Bedrock; Slightly weathered to unweathered; High strength; Excellent quality	1	RC NQ	REC 100%			RQD 100%
		2	RC NQ	REC 100%		195 / 194	RQD 92%
		3	RC NQ	REC 100%			RQD 100%
193.1 / 3.5	End of borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

* Borehole charged with drilling water

C.F.H.S.A. Denotes Continuous Flight Hollow Stem Augers

$+^7$, $\times^5$: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C62A-2

METRIC

G.W.P. 5206-06-00	LOCATION Coords: 5 110 779 N; 328 721 E Hwy 69 (New), Sta. 13+975, o/s 3.7m Lt. CL	ORIGINATED BY	M.R.
DIST 54 HWY 69	BOREHOLE TYPE C.F.H.S.A. AND NQ DIAMOND CORING	COMPILED BY	M.N.
DATUM Geodetic	DATE November 05, 2008	CHECKED BY	C.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
196.8	Ground Surface						
0.0	Cobbles and boulders						
196.5 / 0.3	peat inclusions						
	Migmatite Bedrock Slightly weathered to unweathered High strength Good quality	1	RC NQ	REC 100%		196	RQD 79%
	Pegmatite Bedrock Unweathered High strength Fair quality	2	RC NQ	REC 100%		195	RQD 70%
						194	
193.2 / 3.6	Granite Bedrock Unweathered High strength Excellent quality	3	RC NQ	REC 100%			RQD 95%
	End of borehole						

Column headings also printed: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; GR SA SI CL.

* Borehole charged with drilling water

C.F.H.S.A. Denotes Continuous Flight Hollow Stem Augers

+7, ×5 : Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C62A-3

METRIC

G.W.P. 5206-06-00 LOCATION Coords: 5 110 770 N; 328 773 E Hwy 69 (New), Sta. 13+940, o/s 35.0m Rt. CL ORIGINATED BY M.R.

DIST 54 HWY 69 BOREHOLE TYPE C.F.H.S.A. AND NQ DIAMOND CORING COMPILED BY M.N.

DATUM Geodetic DATE November 4 & 5 2008 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.9	Ground Surface						
0.0	Cobbles and boulders sand trace silt layers						
195.5 / 0.4	Granite Bedrock Slightly weathered to unweathered High strength Fair to excellent quality	1	RC NQ	REC 100%		195	RQD 70%
		2	RC NQ	REC 97%		194	RQD 78%
		3	RC NQ	REC 100%		193	RQD 97%
192.3 / 3.6	End of borehole						

Chart columns: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

* Borehole charged with drilling water

C.F.H.S.A. Denotes Continuous Flight Hollow Stem Augers

+7, ×5: Numbers refer to Sensitivity

20, 15, 5, 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No C62A-4

METRIC

G.W.P. 5206-06-00 | LOCATION Coords: 5 110 754 N; 328 751 E, Hwy 69 (New), Sta. 13+938, o/s 8.0m Rt. CL | ORIGINATED BY M.R.

DIST 54 HWY 69 | BOREHOLE TYPE C.F.H.S.A. AND NQ DIAMOND CORING | COMPILED BY M.N.

DATUM Geodetic | DATE March 9 and 10, 2009 | CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
198.0	Ground Surface						
0.0	Snow						
197.3 / 0.7	Cobbles and boulders Sand trace silt layers Brown Moist	1	RC NQ	-		197	
196.6 / 1.4	Migmaite bedrock Slightly to moderately weathered Medium to high strength Very poor to poor quality	2	RC NQ	REC 94%		196	RQD 42%
		3	RC NQ	REC 100%			RQD 0%
		4	RC NQ	REC 100%			RQD 0%
	Unweathered Fair to good quality	5	RC NQ	REC 100%		195	RQD 82%
		6	RC NQ	REC 100%		194	RQD 70%
193.5 / 4.5	End of borehole						

Dynamic cone penetration resistance plot (20, 40, 60, 80, 100); Shear strength kPa: ○ Unconfined, + Field vane, ● Quick triaxial, × Lab vane (20, 40, 60, 80, 100); Plastic limit W_P, Natural moisture content W, Liquid limit W_L; Water content (%) (20, 40, 60); Unit weight γ kN/m³; Grain size GR SA SI CL.

* Borehole charged with drilling water

C.F.H.S.A. denotes Continuous Flight Hollow Stem Augers.

+7, ×5: Numbers refer to Sensitivity   20 / 15–○–5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No C62A-5

METRIC

G.W.P.	5206-06-00	LOCATION	Coords: 5 110 746 N; 328 737 E Hwy 69 (New), Sta. 13+938, o/s 8.0m Lt. CL	ORIGINATED BY	M.R.
DIST	54 HWY 69	BOREHOLE TYPE	Manual Probing	COMPILED BY	M.N.
DATUM	Geodetic	DATE	March 10, 2009	CHECKED BY	C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
198.4	Ground Surface										
0.0	Bedrock at surface										
	* Borehole dry										

$+^7$, $\times^5$: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No C62A-6

METRIC

G.W.P. 5206-06-00
LOCATION Coords: 5 110 732 N; 328 716 E
Hwy 69 (New), Sta. 13+938, o/s 33.0m Lt. CL
ORIGINATED BY M.R.

DIST 54 HWY 69
BOREHOLE TYPE Manual Probing
COMPILED BY M.N.

DATUM Geodetic
DATE March 10, 2009
CHECKED BY C.N.

SOIL PROFILE			SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		GROUND WATER CONDITIONS *	ELEVATION SCALE				
202.0	Ground Surface											
0.0	Bedrock at surface											
	* Borehole dry											

+7, ×5 : Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

CONT No	
WP No	5178-08-01
WP No	5179-08-01

CULVERT 48/49 (C62A)

HIGHWAY 69 FOUR-LANING

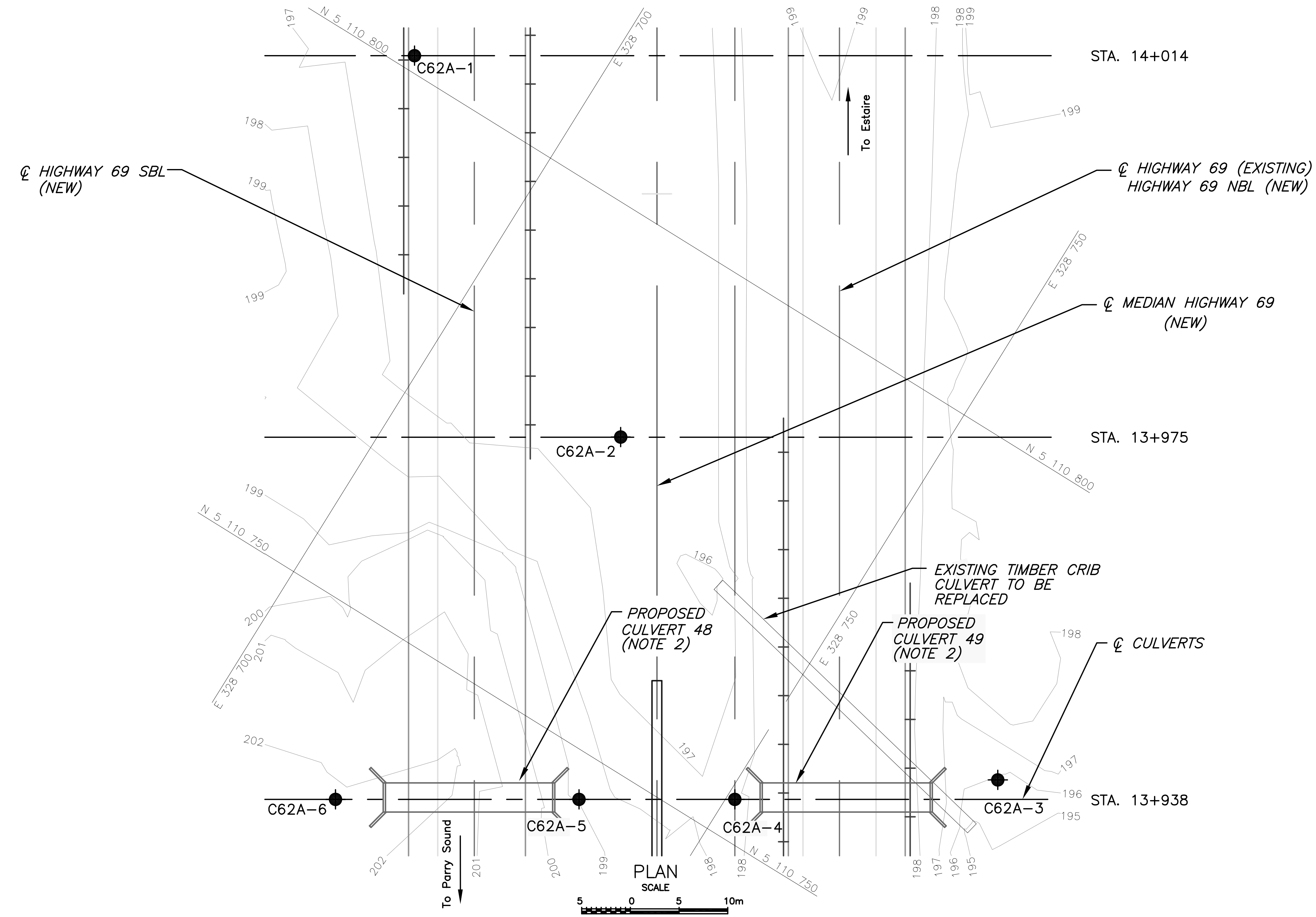
STA. 13+938 DELAMERE TWP

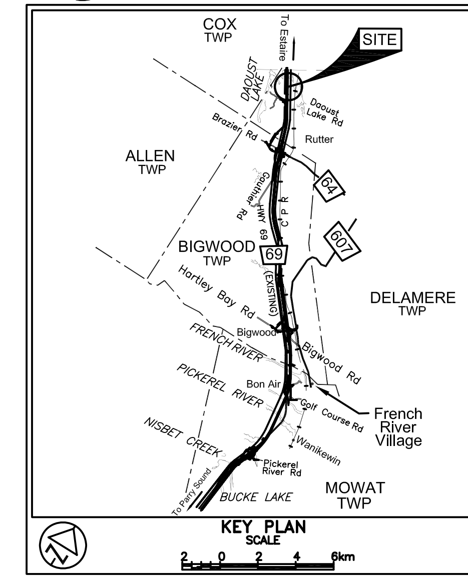
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Peto MacCallum Ltd.

CONSULTING ENGINEERS

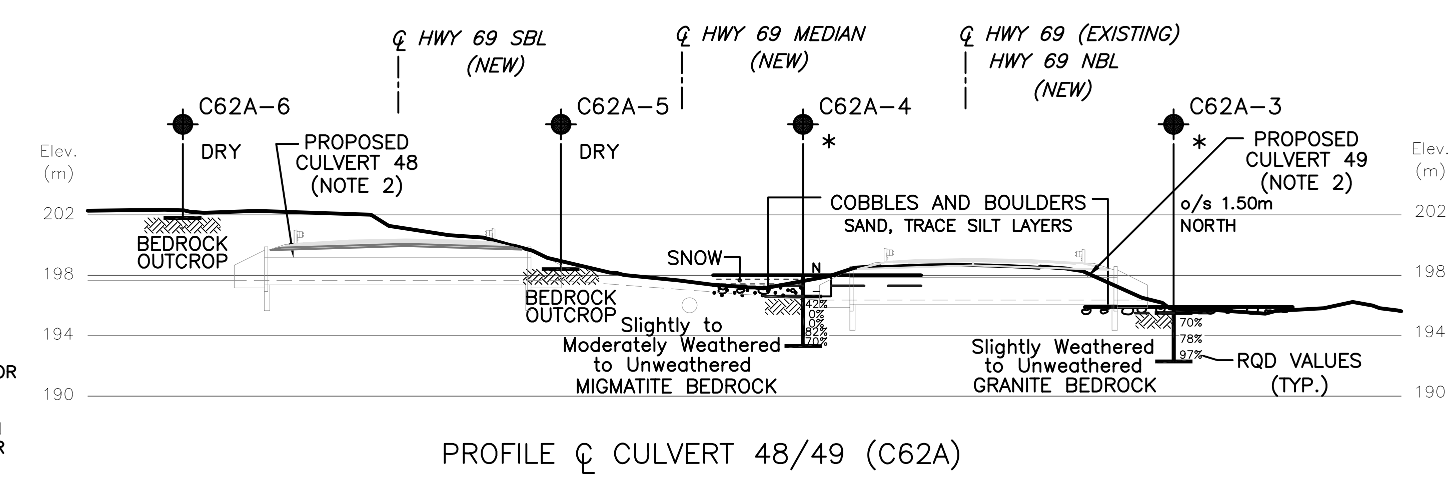




LEGEND

Symbol	Description
●	Borehole
⊕	Dynamic Cone Penetration Test (Cone)
●	Borehole & Cone
N	Blows/0.3m (Std. Pen Test, 475 J/blow)
CONE	Blows/0.3m (60° Cone, 475 J/blow)
*	Water Level not established
▽	W L at time of investigation Nov 2008 and March 2009
▽	Head
▽	ARTESIAN WATER Encountered
|	PIEZOMETER

BH No	ELEVATION	CO-ORDS NORTHINGS	EASTINGS
C62A-1	196.6	5 110 802	328 683
C62A-2	196.8	5 110 779	328 721
C62A-3	195.9	5 110 770	328 773
C62A-4	198.0	5 110 754	328 751
C62A-5	198.4	5 110 746	328 737
C62A-6	202.0	5 110 732	328 716



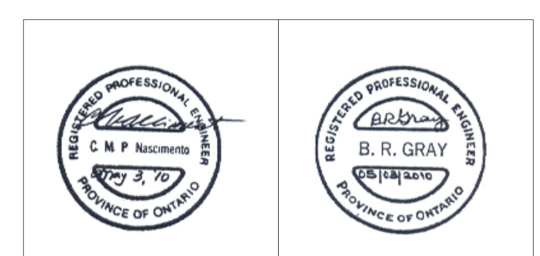
PROFILE ℄ CULVERT 48/49 (C62A)

SCALE

5 0 5 10m

NOTES:

1. DRAWING C62A-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLES.
2. CULVERTS 48/49 WERE DESIGNATED AS C62A FOR THE INVESTIGATION.
3. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
4. ALL DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



– NOTE –

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REF.: MRC DRAWINGS
H6454_PHASEI_XN01.dwg; H6454_PHASEI_XA01.dwg;
H6454_PHASEI_XU01.dwg; H6454_PHASEI_XY01.dwg; 6454 ds Plan View of Phase 1 Culverts 090821.dwg and 6454 ds Culvert Xsect Phase I Zone 12 Mainline Culverts 090821.dwg

REVISIONS

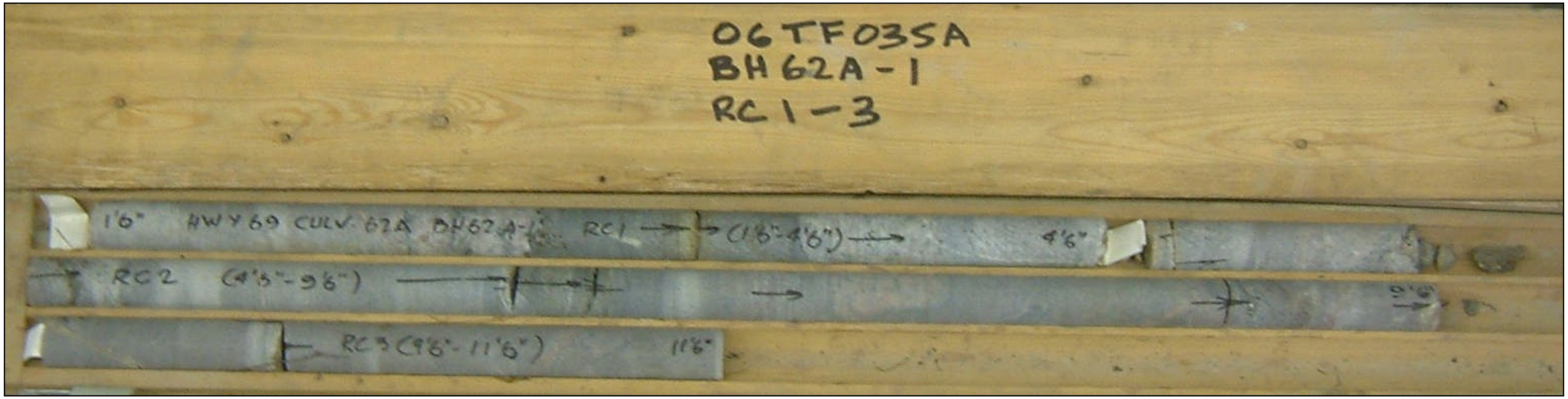
DATE	BY	DESCRIPTION
06/18/10	CN	WP No. AND SITE No. ADDED, AS PER MRC EMAIL DATED JUNE 17, 2010

Geocres No. 41I-257

HWY No 69			DIST 54
SUBM'D MN	CHECKED MN	DATE MAY 03, 2010	SITE 46-532/C1&C2
DRAWN NA	CHECKED CN	APPROVED BRG	DWG C62A-1

APPENDIX A

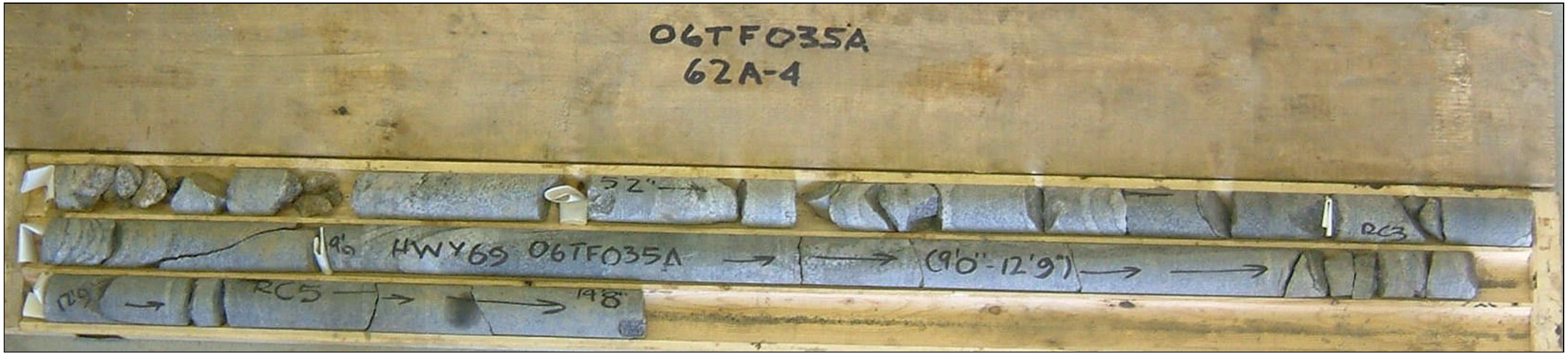
ROCK CORE PHOTOGRAPHS



Photograph 1: Culvert C62A, borehole C62A-1, samples RC-1, RC-2 and RC-3

Photograph 2: Culvert C62A, borehole C62A-2, samples RC-1, RC-2 and RC-3

Photograph 3: Culvert C62A, borehole C62A-3, samples RC-1, RC-2 and RC-3



Photograph 4: Culvert C62A, borehole C62A-4, samples RC-1, RC-2, RC-3, RC-4, RC-5 and RC-6

APPENDIX B

EXPOSED BEDROCK PHOTOGRAPHS AT CULVERT C62A

Photograph 1:

Bedrock outcrop at the proposed southbound lanes of the new Highway 69, Sta. 13+938, o/s 45.0 m Lt. CL

The proposed southbound culvert C62A will be some 10.0 to 28.0 m Lt. CL

Photograph 2:

Taken from the existing Highway 69 southbound shoulder, bedrock outcrop at the proposed southbound lanes of the new Highway 69, Sta. 13+938.

The proposed northbound and southbound culvert C62A will be some 10.0 m Rt. and Lt. of CL