



THURBER ENGINEERING LTD.

**FOUNDATION DESIGN REPORT
DILKE CREEK No. 1 CULVERT REPLACEMENT
HIGHWAY 11
DILKE TOWNSHIP, RAINY RIVER DISTRICT
W.P. 6904-12-01, SITE NO. 45-150/C**

Geocres Number: 52D-25

Report to

HATCH

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

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FOUNDATION DESIGN REPORT
DILKE CREEK No. 1 CULVERT REPLACEMENT
HIGHWAY 11, DILKE TOWNSHIP
RAINY RIVER DISTRICT, ONTARIO
W.P. 6904-12-01, SITE NO. 45-150/C
Geocres Number: 52D-25

1 INTRODUCTION

This report provides foundation design recommendations for the replacement of the existing Dilke Creek No. 1 Culvert located on Highway 11, 7.8 km west of Highway 617 in the Township of Dilke in the Rainy River District, Ontario.

The existing Dilke Creek culvert is a twin barrel timber box structure with a width of approximately 4.5 m, height of 1.8 m, and length of 30.5 m. The highway embankment is approximately 4.0 m in height at the culvert location with about 2.5 m of cover above the culvert.

It is understood that the culvert requires replacement due to leaning of the walls, decay and crushing of the bottom timbers, lifting of the top timbers off the walls, settlement of the central wall, and undermining at the inlet and outlet. An embankment grade raise will not be required for culvert replacement, and construction will be carried out in stages to maintain traffic on Highway 11.

The report was prepared based on interpretation of the geotechnical data in the factual report prepared by DST Consulting Engineers Inc. (DST) titled "Foundation Investigation Report, Dilke Creek Culvert, Dilke Township, Rainy River, Agreement No.: 6013-E-0023, Assignment No. 2, Site No. 45-150/C, Geocres No.: 52D-19", dated September 19, 2014, which was provided by MTO/Hatch.

Reference should be made to the above report for a written description of the subsurface conditions, borehole location plan, stratigraphic profile, record of borehole sheets and laboratory test results. It should be noted that DST is solely responsible for the subsurface information provided in the Foundation Investigation Report. The Borehole Location Plan and Record of Borehole sheets from the investigation report have been enclosed in Appendix A of this report for reference.

The discussions and recommendations presented in this report are based on information provided by Hatch on preliminary General Arrangement drawings dated January 2016 (box culvert) and September 2016 (CSP), and on the factual data presented in the Foundation Investigation Report noted above. The recommendations are intended to provide the designer with sufficient information to assess feasible foundation alternatives and to carry out the design of the foundations for the replacement culvert.

2 SUBSURFACE CONDITIONS

The foundation investigation carried out at this site consisted of four boreholes numbered BH1 to BH4. Boreholes BH1 and BH2 were advanced to a depth of 9.6 m from the top of the roadway embankment, and Boreholes BH3 and BH4 were advanced using portable hand augers to depths of 3.0 and 3.1 m at the inlet and outlet of the culvert. The locations are shown on the Borehole Location Plan in Appendix A.

A temporary local benchmark was assumed for preparation of the borehole logs presented in the investigation report. Based on topographic information shown on the preliminary General Arrangement drawing, the approximate ground surface elevations at the borehole locations have been referenced to Geodetic Datum as follows:

Borehole Number	Approximate Ground Surface Elevation	
	Assumed Local Datum	Geodetic Datum (m)
BH1	102.5	332.4
BH2	102.5	332.4
BH3	98.4	328.3
BH4	98.1	328.0

In summary, the soil stratigraphy encountered in the boreholes drilled from the roadway consisted of a pavement structure and embankment fill overlying a deposit of silty clay extending to the borehole termination depth. In the shallow hand-auger holes at the inlet and outlet, a 300 mm thick topsoil layer was encountered over the clay deposit.

The pavement structure encountered in Boreholes BH1 and BH2 consisted of 70 to 75 mm of asphalt underlain by approximately 0.7 m of crushed gravel and sand. The underlying embankment fill consisted of 2.3 m of silty clay over 0.7 m of sand in Borehole BH1, and 1.7 m of silt over 2.1 m of sand with some gravel in Borehole BH2. Standard Penetration Test (SPT) N-values obtained in the fill typically ranged from 4 to 20 blows/0.3 m, indicating a firm to very stiff consistency or loose to compact condition. One N-value of 46 blows/0.3 m (dense) was recorded in the sand fill in Borehole BH2. The underside of the fill was encountered at depths of 3.8 and 4.6 m (Elev. 328.6 and 327.8).

The embankment fill and topsoil are underlain by native stiff to very stiff silty clay of low to high plasticity. SPT N-values obtained in the clay ranged from 3 to 11 blows/0.3 m, and the undrained shear strength measured by field vane testing ranged from 95 to 115 kPa. All boreholes were terminated in the silty clay at depths between 3.0 and 9.7 m (Elev. 325.3 to 322.8).

Water was observed at the ground surface (Elev. 328.3 and 328.0) in Boreholes BH3 and BH4 during the field investigation conducted in May 2014. The water level will generally be governed by the water level in the creek.

3 CULVERT FOUNDATIONS

Based on the preliminary General Arrangement drawing, the replacement culvert will be installed along the same alignment as the existing culvert. It is understood that staged construction is envisioned for the culvert replacement.

The following culvert types are under consideration for this site:

- Concrete box (closed) culvert composed of pre-cast segments
- Round corrugated steel pipe (CSP).

From a foundations and constructability perspective, use of either culvert type is preferred over an open footing concrete/arch culvert or sheet pile wall culvert based on the following considerations:

- A CSP or pre-cast box culvert can be installed relatively quickly;
- The depth of excavation and groundwater control requirements will be minimized;
- CSP or segmental installation is amenable to staged construction; and
- A CSP or segmental pre-cast structure can accommodate potential differential settlement along the culvert axis.

Recommendations for design and installation of a box culvert and CSP are presented below.

3.1 Concrete Box Culvert

The preliminary General Arrangement drawing (January 2016) indicates that the replacement culvert will have an approximate width of 4.5 m, height of 2.0 m and length of 32.0 m. The base of the culvert will be placed at approximate Elev. 327.5 (inlet) to 327.1 (outlet).

Based on the borehole information, the subgrade at the level of the culvert base will consist of native stiff to very stiff silty clay. The stiff to very stiff clay subgrade is considered suitable for support of the replacement culvert.

In order to provide a uniform foundation subgrade, a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A requirements should be provided on the approved subgrade under the base of the box culvert, as per OPSS 422 and OPSS 803.010. A 75 mm thick levelling course should be placed on top of the bedding material as per OPSS 422. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

The factored geotechnical resistance at the Ultimate Limit State (ULS) and the geotechnical reaction at Serviceability Limit State (SLS) for a box culvert founded on bedding placed on stiff to very stiff silty clay as described above can be assumed as follows:

Factored Geotechnical Resistance at ULS of 225 kPa

Geotechnical Resistance at SLS (less than 25 mm settlement) of 150 kPa.

The resistance values provided are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC Clause 6.10.3 and Clause 6.10.4.

Preparation of the culvert subgrade should include removal of any organic soils or other unsuitable materials remaining after excavation to the subgrade level. In the event that subexcavation is required, the width of the subexcavation should be defined by a line extending from 0.3 m beyond the outside edge of the proposed culvert, outward and downward at 1H:1V. The subexcavated area should then be backfilled with granular material meeting OPSS.PROV 1010 Granular A or Granular B Type II requirements and compacted in accordance with OPSS.PROV 501.

The culvert should be designed to resist external loadings including lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

Foundation design for wing walls, if required, are discussed further in the report.

3.2 Corrugated Steel Pipe (CSP) Culvert

The preliminary General Arrangement drawing for a CSP option (September 2016) indicates a 4.4 m diameter pipe with an invert level near Elev. 326.8 (inlet) to 326.4 and a cover of 1.5 m. River stone will be placed in the culvert up to the streambed level.

Based on the borehole information, the subgrade at the level of the culvert base will consist of native stiff to very stiff silty clay. The stiff to very stiff clay subgrade is considered suitable for support of the replacement culvert.

In order to provide a uniform foundation subgrade, a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A requirements should be provided on the approved subgrade under the base of the CSP, as per OPSS 421 and OPSD 802.014. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

Preparation of the culvert subgrade should include removal of any organic soils or other unsuitable materials remaining after excavation to the subgrade level. In the event that subexcavation is required, the width of the subexcavation should be defined by a line extending from 0.3 m beyond the outside edge of the proposed culvert, outward and downward at 1H:1V. The subexcavated area should then be backfilled with granular material meeting OPSS.PROV 1010 Granular A or Granular B Type II requirements and compacted in accordance with OPSS.PROV 501.

The culvert should be designed to resist external loadings including lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

Foundation design for wing walls, if required, are discussed further in the report.

3.3 Frost Cover

The design depth of frost penetration at this site is 2.3 m. The base of all footings, if employed, must be provided with a minimum of 2.3 m of earth cover as protection against frost action. The frost cover requirement does not apply to the base of a box culvert or CSP. Frost treatment for a box culvert should be as per OPSD 803.010. For a CSP, a frost taper should be provided in accordance with OPSD 803.031.

4 CULVERT BACKFILL AND LATERAL EARTH PRESSURES

Culvert backfill should consist of granular material conforming to OPSS.PROV 1010 Granular A, Granular B Type II or Granular B Type III specifications. Granular backfill should be placed to the extents shown in OPSD 802.010 or OPSD 803.010. Backfilling to the culvert should be in accordance with OPSS 401 for a CSP or OPSS 902 for a box culvert.

Backfill should be placed and compacted in accordance with OPSS.PROV 501. The backfill must be placed in simultaneous equal lifts on both sides of the culvert, and the top of backfill elevation should be within 400 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert. Compaction equipment to be used adjacent to culverts should be restricted in accordance with OPSS.PROV 501.

Lateral earth pressures acting on the culvert walls may be assumed to be distributed triangularly and to be governed by the characteristics of the abutment backfill and the underlying soils. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

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

where	p_h	=	horizontal pressure on the wall at depth h (kPa)
	K	=	earth pressure coefficient (see table below)
	γ	=	bulk unit weight of retained soil (see table below)
	h	=	depth below top of fill where pressure is computed (m)
	q	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill to the retaining walls are dependent on the material used as backfill. Recommended values of the earth pressure coefficients are shown in Table 4.1.

Table 4.1 – Earth Pressure Coefficients, K

Wall Condition	Earth Pressure Coefficient, K			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ$; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ$; $\gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At rest (Restrained Wall)	0.43	-	0.47	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-

For rigid structures such as concrete box culverts, at-rest horizontal earth pressures should be used for design. Active pressures should be used for any unrestrained wall.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the culvert.

In accordance with Clause 6.12.3 of the CHBDC 2014, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I, or at a depth of 1.7 m for Granular A or Granular B Type II.

5 SEISMIC CONSIDERATIONS

Based on the undrained shear strength of the silty clay, Site Class D (stiff soil) should be assumed to evaluate the seismic site response, as per Table 4.1, Clause 4.4.3.2 of the CHBDC 2014.

The peak ground acceleration, PGA, for a 2% in 50 year probability of exceedance at this site is 0.038 as per the National Building Code of Canada (NBCC).

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 5.1 may be used:

Table 5.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I or Existing Sand Fill $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$
Active (K_{AE})*	0.28	0.32
Passive (K_{PE})	3.7	3.2
At Rest (K_{OE})**	0.45	0.50

- * After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
- ** After Woods

The stiff to very stiff silty clay underlying this site is not considered to be prone to liquefaction. In view of the soil conditions and the estimated peak ground acceleration, liquefaction is not a concern.

6 EMBANKMENT RESTORATION

The existing highway embankment is approximately 4 m in height at the culvert location, and the embankment slopes appear to be performing satisfactorily. Provided that the embankment is reconstructed at the same slope inclination as the existing embankment, but not steeper than 2H:1V, the restored embankment slope should remain stable.

As the roadway grade will not be raised, settlement of the embankment is not a concern. Any settlement due to changes in the culvert configuration is expected to be less than 25 mm.

Embankment restoration should be carried out in accordance with OPSS.PROV 206. In general, surface vegetation, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from within the embankment footprint prior to placement of fill.

7 EROSION CONTROL

Erosion protection must be provided along any soil surfaces that may be in contact with the stream flow. In general, this will involve placement of rock protection at the culvert inlet and outlet areas to prevent erosion and undermining of the culvert base.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

For a concrete box culvert, a concrete cut-off wall should be used to minimize the potential for erosion or piping around the culvert.

A clay seal may be used to minimize the potential for erosion near the inlet area. Where applicable, the clay seal should extend to the order of 0.3 m above the high water level and laterally for the width of the granular backfill material, and have a minimum thickness of 0.5m. The material requirements should be in accordance with OPSS 1205. A geosynthetic liner may be used as a clay seal.

8 EXCAVATION AND GROUNDWATER CONTROL

Excavation for culvert replacement will be carried out through the existing embankment fill and into the native silty clay extending below the water level.

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native silty clay and the embankment fill above the water level at this site are classified as Type 3 soils. Cohesionless fill and any soft/loose alluvial materials below the water level are classified as Type 4 soils.

The excavation and backfilling must be carried out in accordance with OPSS 401 for a CSP and OPSS 902 for a box culvert.

Installation of the culvert should be carried out in the dry. It is anticipated that excavation for culvert replacement will be carried out at or below the creek water level, and diversion of creek flow will be required. The underlying clay subgrade is relatively impermeable, however seepage should be anticipated from the embankment fill and any seams or sandy zones in the clay. Depending on the time of construction, a combination of cofferdam enclosures and creek diversion along with pumping from filtered sumps within the enclosure will be required to maintain dry excavations during the course of staged construction.

The design of the shoring and dewatering system that may be required is the responsibility of the Contractor and the Contract Documents must alert him to this responsibility and the need to engage a dewatering specialist. Unwatering must remain operational and effective until the culvert is installed and backfilled. Suggested wording for an NSSP in this regards is included in Appendix B.

Roadway protection will be required during construction staging. Roadway protection should be provided in accordance with OPSS.PROV 539 and designed for Performance Level 2. The design of roadway protection is the responsibility of the Contractor and all shoring should be designed by a Professional Engineer experienced in such designs.

9 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to the following:

- A suitable dewatering/unwatering system must be employed to enable construction in the dry and prevent sloughing and instability of the excavation walls.
- The thickness and depth to the base of the existing fill and any soft streambed deposits may vary at locations away from the boreholes.
- Cobbles or other obstructions may be present within the embankment fill. These materials may interfere with excavation or installation of roadway protection systems. The Contractor must be prepared to remove or otherwise penetrate these obstructions.
- The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary structures or fill (i.e., as a pad for crane support). Site conditions may limit the type of equipment suitable for use. The design and safety of any temporary works is the responsibility of the Contractor.

10 CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Ms. Anna Piascik, P.Eng., and Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.

Anna Piascik, P.Eng.
Senior Geotechnical Engineer



Murray Anderson, P.Eng., M.Eng.
Associate, Senior Geotechnical Engineer



P. K. Chatterji, P.Eng., Ph.D.
Review Principal, Designated MTO Contact

Appendix A

Record of Borehole Sheets and Borehole Location Plan

Geocres No. 52D-19

EXPLANATION OF TERMS USED IN REPORT

SPT 'N' VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE OF THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51 mm O.D. SPLIT BARREL SAMPLES TO PENETRATE 0.3 m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76 m. FOR PENETRATION OF LESS THAN 0.3 m 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 (DCPT): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51 mm 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 0.3 m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

TEXTURAL CLASSIFICATION OF SOILS

BOULDERS	COBBLES	GRAVEL	SAND	SILT	CLAY
GREATER THAN 200 mm	75 TO 200 mm	4.75 TO 75 mm	0.075 TO 4.75 mm	0.002 TO 0.075 mm	LESS THAN 0.002 mm

COARSE GRAIN SOIL DESCRIPTION (50% GREATER THAN 0.075 mm)

TERMINOLOGY	TRACE OR OCCASIONAL	SOME	WITH	ADJECTIVE (e.g. SILTY OR SANDY)	AND (e.g. SAND AND SILT)
	LESS THAN 10%	10 TO 20%	20 TO 30%	30 TO 40%	40 TO 60%

CONSISTENCY*: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (C_u) AND SPT 'N' VALUES AS FOLLOWS

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 - 100	100 - 200	> 200
N (BLOWS / 0.3 m)	<2	2 - 4	4 - 8	8 - 15	15 - 30	>30
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

N (BLOWS / 0.3 m)	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, 100 mm+ IN LENGTH EXPRESSED AS A PERCENTAGE 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

LEGEND OF RECORDS FOR BOREHOLES: SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS	SPLIT SPOON SAMPLE	WS	WASH SAMPLE
TW	THIN WALL SHELBY TUBE SAMPLE	AS	AUGER (GRAB) SAMPLE
PH	SAMPLER ADVANCED BY HYDRAULIC PRESSURE	TP	THIN WALL PISTON SAMPLE
WH	SAMPLER ADVANCED BY SELF STATIC WEIGHT	PM	SAMPLER ADVANCED BY MANUAL PRESSURE
SC	SOIL CORE	RC	ROCK CORE
	WATER LEVEL	$SENSITIVITY = \frac{UNDISTURBED\ SHEAR\ STRENGTH}{REMOLDED\ SHEAR\ STRENGTH}$	

*HIERARCHY OF SOIL STRENGTH PREDICTION: **1)** LABORATORY TRIAXIAL TESTING. **2)** FIELD INSITU VANE TESTING. **3)** LABORATORY VANE TESTING. **4)** SPT VALUES. **5)** POCKET PENETROMETER.

METRIC

DATUM Geodetic DATE - 5.2.14 CHECKED BY DB

DN MOT-HIGH VANES GS-TB-018735 DILKE CREEK LOGS.GPJ DST MIN.GDT 6/24/14

ENCLOSURE 1

RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. 6013-E-0023 LOCATION DILKE CREEK CULVERT - STA 20 + 343.5m, RT ORIGINATED BY Joe
 DIST HWY HWY 11 BOREHOLE TYPE HOLLOW STEM AUGER (80 mm ID) COMPILED BY MD
 DATUM Geodetic DATE - 5.2.14 CHECKED BY DB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
102.5	GROUND SURFACE							20	40	60	80	100				
102.5	ASPHALT - 75 mm		1	AS			102									
101.8	FILL - CRUSHED GRAVEL AND SAND, trace silt, brown															
101.8	FILL-SILT - trace clay, some sand, trace gravel, grey		2	SS	8		101									3 11 80 6
			3	SS	20											
100.0							100									
100.0	FILL-SAND - some gravel, some silt, brown		4	SS	46											
			5	SS	4		99									18 67 (15)
			6	SS	6		98									
97.9	CLAY - Silty, trace sand, trace gravel, trace organics, grey, stiff to very stiff		7	SS	4		97									
			8	SS	4											
			9	SS	5		96									
			10	SS	9		95									
							94									
			11	SS	8		93									
92.9	End of Borehole @ 9.6 m.															
9.6																

ON_MOT-HIGH VANES GS-TB-018735 DILKE CREEK LOGS.GPJ DST_MIN.GDT 6/24/14


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

RECORD OF BOREHOLE No BH3

1 OF 1

METRIC

W.P. 6013-E-0023 LOCATION DILKE CREEK CULVERT - STA 20 + 347 20m, LT ORIGINATED BY JM
 DIST HWY HWY 11 BOREHOLE TYPE HOLLOW STEM AUGER (80 mm ID) COMPILED BY MD
 DATUM Geodetic DATE - 5.2.14 CHECKED BY DB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
98.4	GROUND SURFACE							20 40 60 80 100							GR SA SI CL	
98.1	TOPSOIL							50 100 150 200 250							Water at surface	
0.3	Clay-Silty, some sand, trace to some organics, grey		1	AS			98									
			2	SS	4											
			3	SS	11			97								
			4	AS				96								
95.4															CPT 827 kPa	
3.0	End of Borehole @ 3.0 m.															

ON_MOT-HIGH VANES GS-TB-018735 DILKE CREEK LOGS.GPJ DST_MIN.GDT 6/24/14

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

ENCLOSURE 3

RECORD OF BOREHOLE No BH4

1 OF 1

METRIC

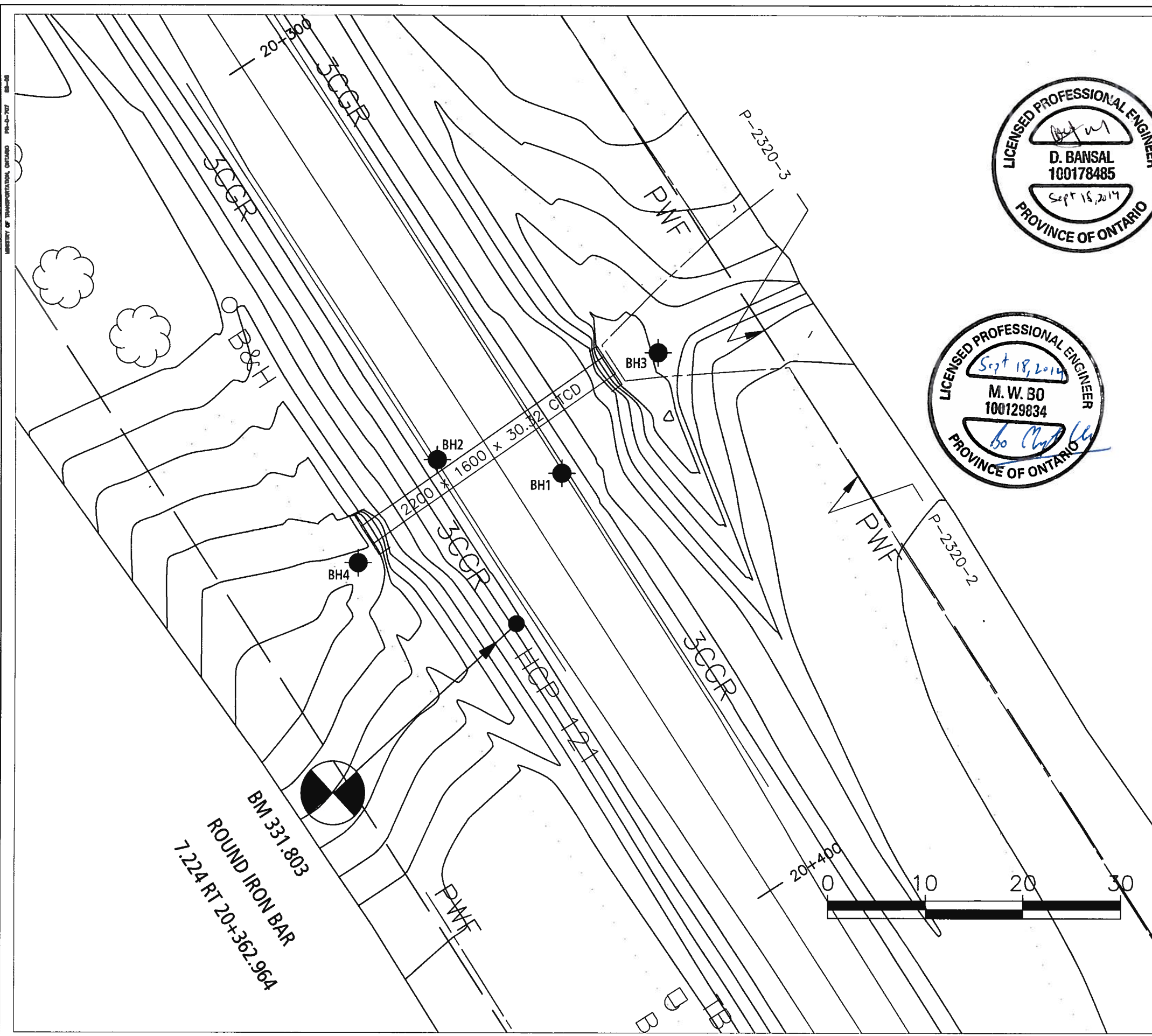
W.P. 6013-E-0023 LOCATION DILKE CREEK CULVERT - STA 20 + 347 17.5m, RT ORIGINATED BY JM
 DIST HWY HWY 11 BOREHOLE TYPE HOLLOW STEM AUGER (80 mm ID) COMPILED BY MD
 DATUM Geodetic DATE - 5.2.14 CHECKED BY DB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
98.1	GROUND SURFACE																
97.9	TOPSOIL																
0.3	CLAY - Sandy, with silt, trace gravel, grey		1	AS													
			2	AS													
			3	AS													
			4	AS													
95.0																	
3.1	End of borehole @ 3.1 m.																

ON_MOT-HIGH VANES GS-TB-018735 DILKE CREEK LOGS.GPJ DST_MIN.GDT 6/24/14

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

MINISTRY OF TRANSPORTATION, ONTARIO P-2320-3

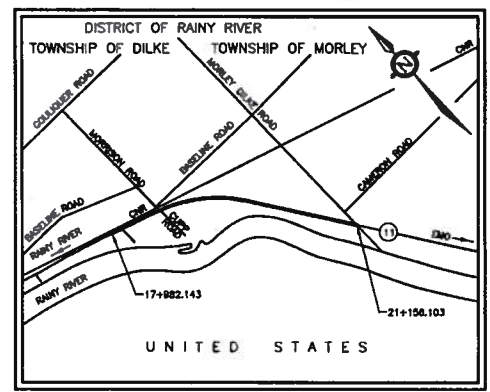


BM 331.803
ROUND IRON BAR
7.224 RT 20+362.964

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



CONT No 6013-E-0023	
WP No xxx-xx-xx	
SITE No 45-138/C	
GEOCREST No 52D-19	
CULVERT REPLACEMENT DILKE CREEK CULVERT	
STA 20+343 TO STA 20+351	SHEET
Survey 13-08 Revised	



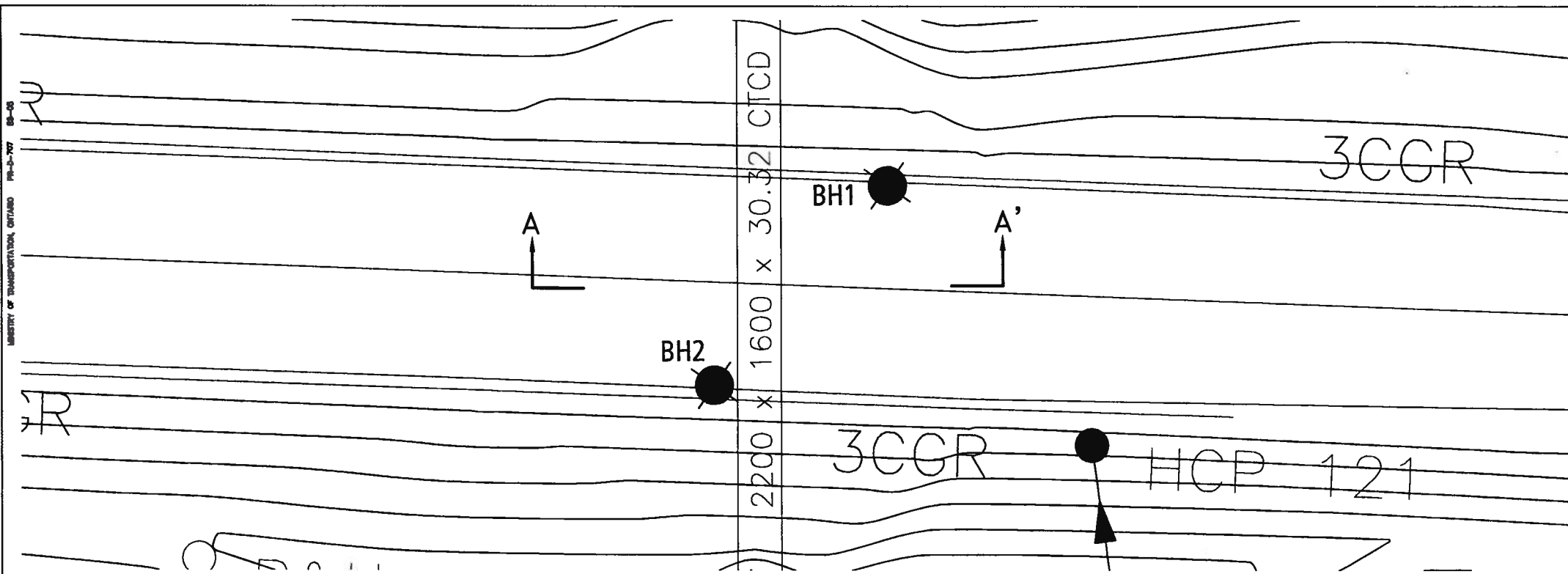
KEY PLAN
1.0 km 0 1.0 km
SCALE 1:50,000

LEGEND					
	Borehole		Borehole with CPT		Asphalt Core
	Rock Probe		Blows/0.3m (Std. Pen Test, 475 J/Blow)		Water level at time of investigation.
	Fill		Organics		Sand
	Topsoil		Silt		Clay
	Till		Sand & Gravel		Bedrock
	Boulders				
No.	Elevation	Northing	Eastings	Station	Offset
BH1	102.5	5396090 m N	212270 m E	20+351	5.0 m LT
BH2	102.5	5396092 m N	212257 m E	20+343	5.0 m RT
BH3	98.4	5396103 m N	212280 m E	20+347	20.0 m LT
BH4	98.1	5396081 m N	212249 m E	20+347	17.5 m RT

NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

DST
consulting engineers

DST Consulting Engineers Inc.
605 Hewitson Street
Thunder Bay, ON P7B 5V5
Ph: (807) 623-2829
Fx: (807) 623-1792
Email: thunderbay@dsgroup.com

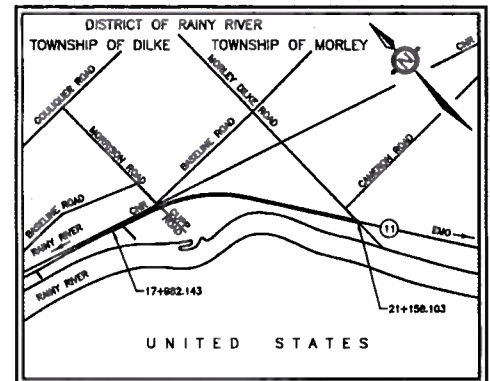


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METERS

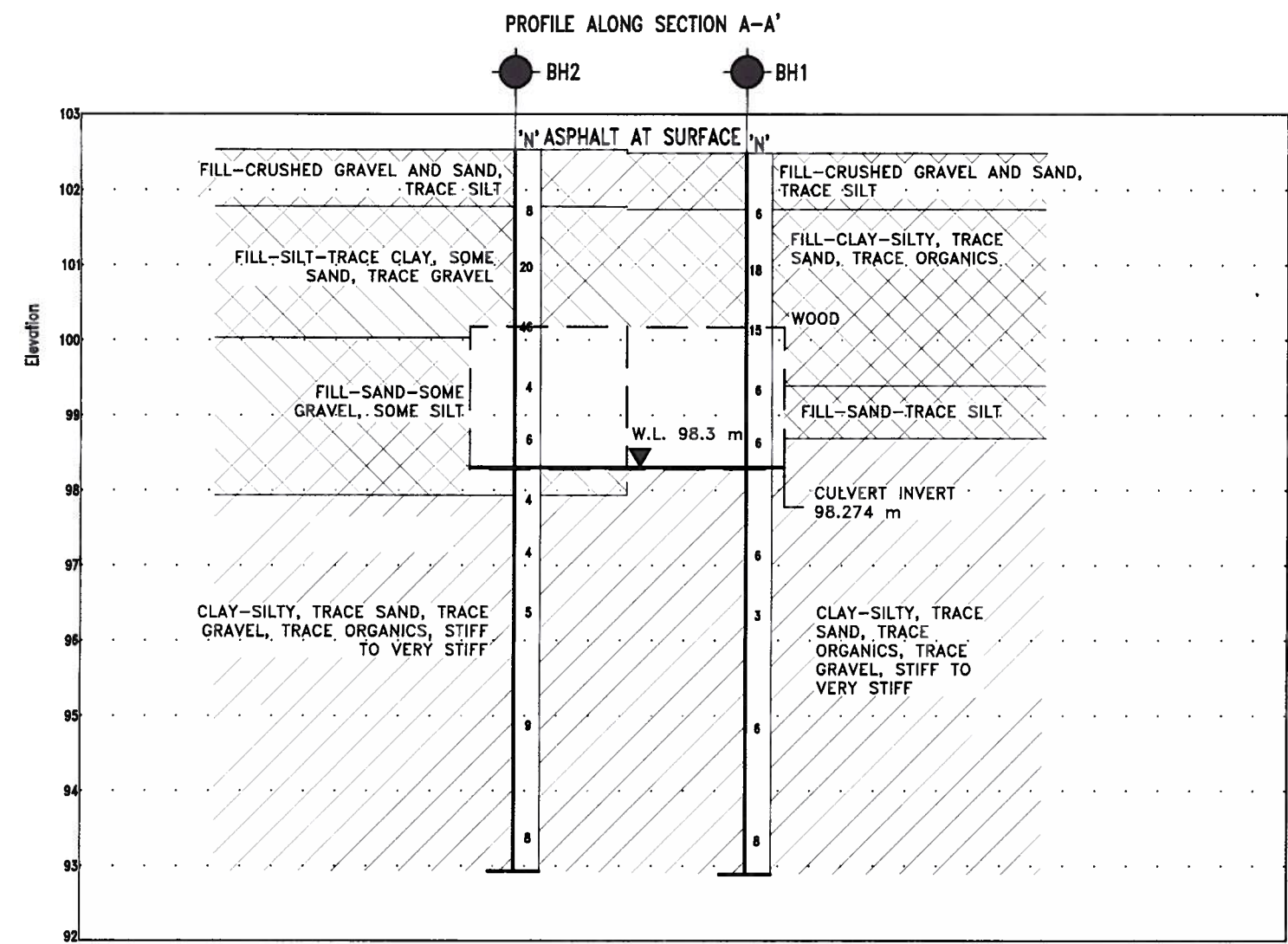
CONT	No 6013-E-0023
WP	No xxx-xx-xx
SITE	No 45-138/C
GEOCRES	No 52D-19
CULVERT REPLACEMENT DILKE CREEK CULVERT	
STA 20+343	TO STA 20+351
Survey	13-08 Revised



SHEET



KEY PLAN
1.0 km 0 1.0 km
SCALE 1:50,000

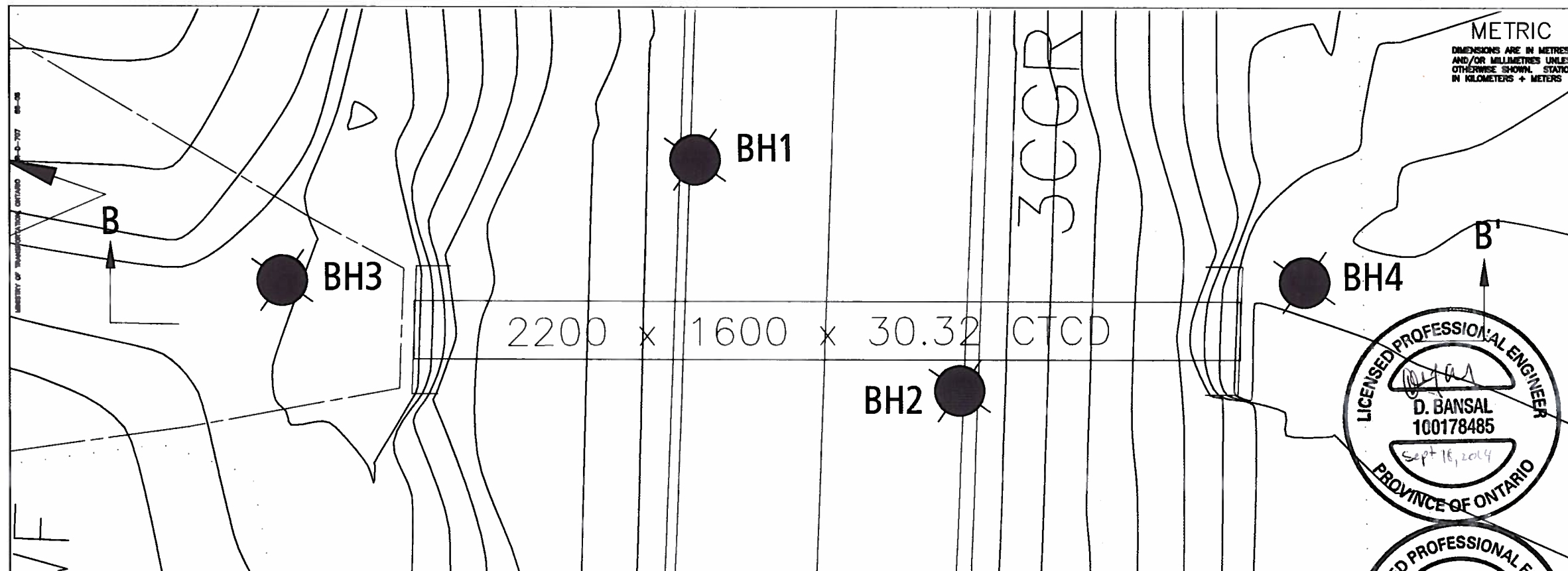


LEGEND					
	Borehole		Borehole with CPT		Asphalt Core
	Rock Probe		Blows/0.3m (Std. Pen Test, 475 J/Blow)		Water level at time of investigation
	Fill		Sand		Silt
	Organics		Clay		Sand & Gravel
	Topsoil		Bedrock		Boulders
	Till				

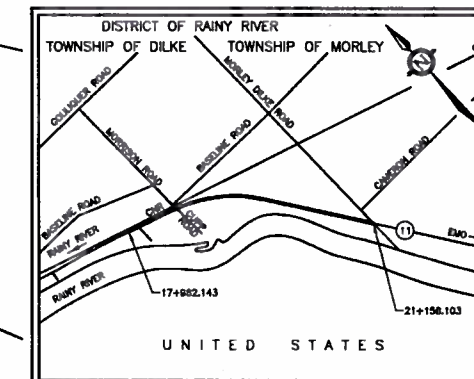
No.	Elevation	Northing	Easting	Station	Offset
BH1	102.5	5398090 m N	212270 m E	20+351	5.0 m LT
BH2	102.5	5398092 m N	212257 m E	20+343	5.0 m RT
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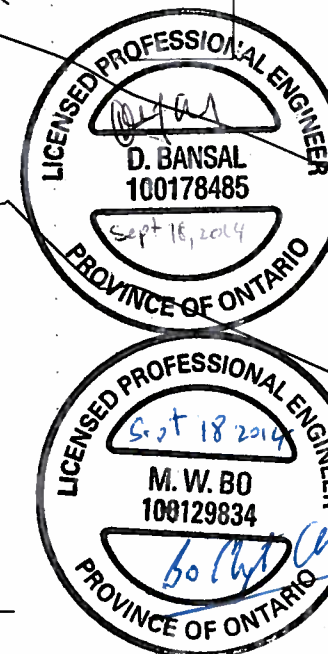
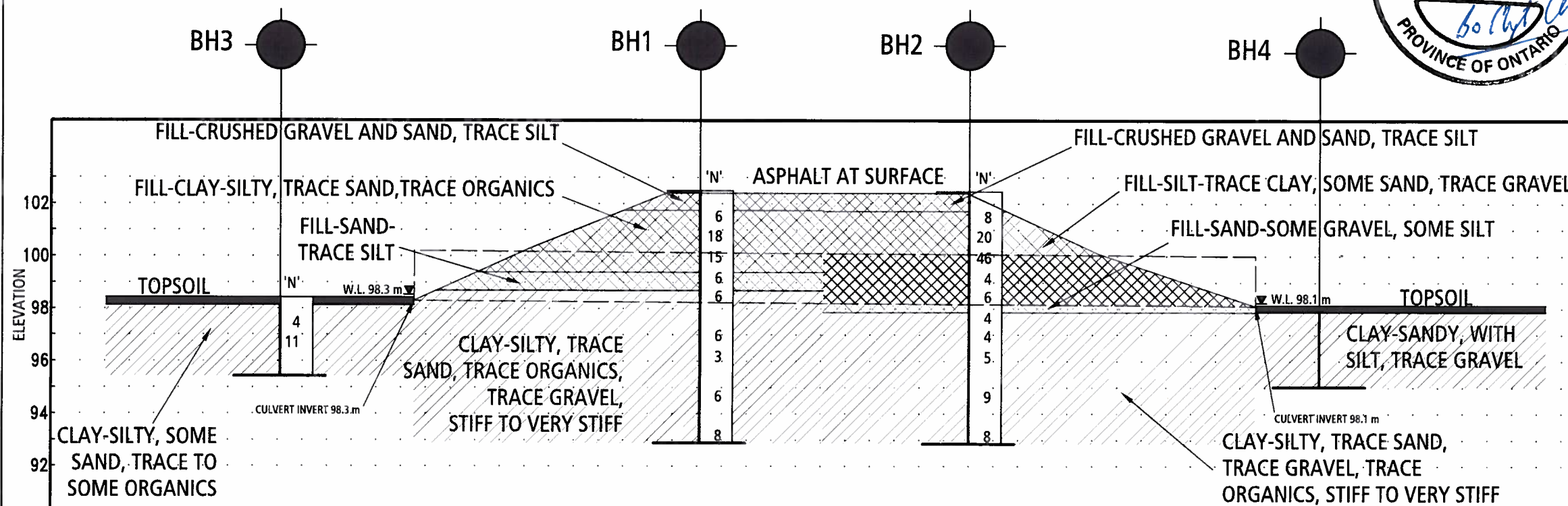


CONT No	6013-E-0023
WP No	xxx-xx-xx
SITE No	45-138/C
GEOCREST No	52D-19
CULVERT REPLACEMENT DILKE CREEK CULVERT	
STA 20+343 TO STA 20+351	
Survey	13-06 Revised
SHEET	



KEY PLAN
1.0 km 0 1.0 km
SCALE 1:50,000

PROFILE ALONG SECTION B-B'



LEGEND					
◆	Borehole	◆	Organics	◆	Sand
●	Borehole with CPT	◆	Topsoil	◆	Silt
◆	Asphalt Core	◆	Till	◆	Clay
●	Rock Probe	◆	Bedrock	◆	Sand & Gravel
'N'	Blows/0.3m (Std. Pen Test, 475 J/Blow)	◆		◆	Boulders
▽	Water level at time of investigation.				
No.	Elevation	Northing	Eastings	Station	Offset
BH1	102.5	5396090 m N	212270 m E	20+351	5.0 m LT
BH2	102.5	5396092 m N	212257 m E	20+343	5.0 m RT
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Appendix B

List of OPSSs and OPSDs and Suggested Wording for NSSP

1. List of OPSS and OPSD Documents Relevant to this Project

- OPSS.PROV 206
- OPSS 401
- OPSS 421
- OPSS 422
- OPSS.PROV 501
- OPSS.PROV 804
- OPSS 902
- OPSS.PROV 1010
- OPSS 1205
- OPSS.PROV 539
- OPSD 802.010
- OPSD 803.010
- OPSD 803.014
- OPSD 803.031

2. Suggested Wording for NSSP on Dewatering

Dewatering shall be provided by the Contractor during structure excavation, bedding placement and backfilling to allow the work to proceed in the dry. Excavation below the creek and groundwater level may lead to instability and sloughing of the cohesionless embankment fill and upper stiff silty clay. The dewatering system must remain operational and effective until the culvert is installed and backfilled.