Project No. 20-5-5236

Magnetawan Culvert No. 11

Geotechnical Report

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December 11, 2020

The Greer Galloway Group Inc.
640 Cataraqui Woods Dr, Unit 2A
Kingston, Ontario
K7P 2Y5

Re: Magnetawan Culvert No. 11
Project Number 20-5-5236

General Data
The project is identified as Magnetawan Culvert No. 11.
The culvert is located at the south end of the Poverty Bay watercourse.
The site is on West Poverty Bay Road, just east of the intersection at Magnet Road.
The existing culvert is a large-diameter steel multi-plate culvert, constructed in 1970.
The thickness of the multiplate steel was approximately 4mm.
The span of the culvert is 6.5m. The height of the culvert is 3.6m, with 0.8m of granular fill and surface treatment placed over the culvert which serves as the roadway structure. The present culvert invert is at an approximate depth of 4.5m below existing road surface. It is anticipated that the old culvert will be replaced with a similar culvert.

The physiography of the site is identified as shallow till and rock ridges. The overburden soils generally consist of sand or silty sand. The bedrock typically consists of granitic rock such as sillimanite-garnet-biotite-gneiss. The frost penetration treatment depth for this location is 1.8m below finished grade.

Investigation
Exploratory boreholes were placed on site on December 7, 2020. Two boreholes were placed using a tractor-mounted drilling rig, with 130mm solid stem augers. Soil types and depths were recorded, and selected samples of the subsoil materials were collected for laboratory analysis. Soil laboratory testing consisted of moisture content determination and grain size analysis. The borehole logs and laboratory testing data have been appended to this report.

The typical subsoil layers encountered on site were as follows:

surface treatment
sand & gravel
fine sand with silt
silty sand
silty sand trace clay

The subsoils above the groundwater elevation consisted of sandy materials in a moist and compact condition.

Groundwater was encountered at a typical elevation of 3m below existing road surface.

The soils below the water elevation were in a very loose to loose condition. The drill rig was able to penetrate the soils using downforce pressure alone, often without rotation of the auger. N values per foot were estimated based on the downforce pressure required to cause settlement of the soil. The typical N value was 4 blows per foot, which is classified as loose.

Auger refusal was encountered at significant depth, typically 13 to 15m below road surface. The refusal was inferred to be due to underlying bedrock. No rock coring was undertaken to prove bedrock.

Recommendations

Foundations

It is suspected that this culvert was originally built by conducting minimal dewatering and placing sand fill into the proposed culvert location. As such, the condition of the sand is loose rather than compact, and the sand is saturated. The bearing capacity of the silty sand subgrade is estimated as follows:

Factored ULS bearing capacity:	105 kPa
SLS allowable bearing capacity:	70 kPa

Since the bearing capacity is low, a culvert design that utilizes conventional footings is not recommended, due to the potential for settlement. The wide bottom of the existing multi-plate culvert helps to spread the load onto the bearing soil, and this shape provides some simplification with respect to placement of the bedding soil for a new culvert. Given the soil conditions, it is recommended that a new replacement culvert very similar to the old multi-plate culvert be installed at this location. The culvert installation depth will be very close to existing, which is approximately 4.5m below existing road Centre Line.

Stipulate in the contract that the soil below the existing culvert must be left in an undisturbed state. Placement of a high-strength biaxial geogrid such as Terrafix TBX3000 would be beneficial to help disperse the load from the new culvert and the surrounding backfill on each side of the culvert. The geogrid would be placed in longitudinal rolls (parallel to the road), and overlapped 1m at each grid edge. Allow for this overlap when calculating the geogrid quantities. A bedding layer of sand or gravel can be placed over the geogrid. For wet soil conditions, a 300mm depth of clear stone wrapped in a geotextile cloth is an alternative.

Culvert Backfill and Re-use of Soils

The soils within the existing embankment over the culvert consisted of fill materials such as fine sand with silt. The dry subgrade soils from the embankment, down to a depth of 1.5m, can be re-used as general subgrade backfill for road construction. These soils were identified as:
sand & gravel
fine sand with silt

Backfill to multi-plate culverts requires a free draining granular material such as OPSS 1010 Granular B Type 1. The following geotechnical parameters for B Type 1 are suggested:

<u>typical imported sandy Granular B Type 1 backfill</u>
internal friction angle = 32^{o}
Ka = 0.31, Ko = 0.47, Kp = 3.25
Moist unit weight = 22.3 kN/m3

Roadway frost tapers should be constructed for the new culvert, with a frost treatment depth of k = 1.8m. For a CSP culvert installation, the frost penetration line will be above the bedding grade, as per OPSD 803.031. Roadway taper material for the culvert should consist of a granular material such as Granular B Type 1. It was noted that there is a commercial sand and gravel quarry located near to the site on Old Highway Road.

Excavation and Dewatering

A significant continuous dewatering operation is expected to be required for this project.
The subsoils above the water table were classified as OHSA Type 3 soils. It is anticipated that all soils at and below the groundwater elevation will require treatment as a Type 4 collapsing soils. It is anticipated that a sheet piling system will be required to assist with groundwater removal and to hold back the Type 4 subsoils. The toe of the sheet piling may be driven into the underlying soil below the culvert elevation, however, it should be noted in the contract that the lateral support from these soils is weak.

It is anticipated that an Environmental Activity and Sector Registry (EASR) registration will be a suitable option for this project, depending on the daily volume of water that will require removal. An EASR allows for taking of groundwater and stormwater for construction dewatering purposes that total less than 400,000 L/day. Contractors bidding on this work should be advised to consult a hydrogeologist or other dewatering expert to assess the water quantities to be removed, and the viability of using an EASR registration for the dewatering operations on site.

The construction contract should stipulate that the integrity of all soil bearing surfaces must be preserved at all times. Therefore, all excavations on site must be protected from high moisture levels due to rainfall or accumulating groundwater, using appropriate dewatering techniques for the encountered site conditions. Stipulate in the contract that the contractor will be wholly responsible for the dewatering operation, and submit a detailed plan for the dewatering operation, to be reviewed by the Contract Administrator.

Pavement Design
For reinstatement of the roadway, construct earth grading for roadways as per OPSD 200.01. Replace the road surface over the new culvert with the following granular structure:

150mm Granular A
450mm Granular B Type 1
(over approved fill as required)

Apply double surface treatment to the road as per current Magnetawan standards. It may be prudent to wait one year prior to placing the surface treatment. This delay will facilitate the correction of the granular road surface in the case that small settlements of the culvert and backfill occur.

Compaction Requirements
Compaction requirements for all subgrade fill and granular materials should conform with OPSS 501, Subsection 501.08.02 - Method A, utilizing a minimum compaction standard of 98% of Standard Proctor Maximum Dry Density.

Statement of Limitations
This report is intended for the guidance of the project design team. From a construction standpoint, contractors must make their own assessment of the soil, rock, and groundwater conditions and how these will affect their proposed construction techniques and schedules.

The recommendations in this report are based on information determined at the test hole locations. Soils and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations and conditions may become apparent during construction that could not be detected or anticipated at the time of the soils investigation. If this occurs, we recommend that Terraspec be recalled to the site for further consultation, testing, and analysis.

We also recommend that Terraspec be retained to ensure that all subgrade preparation requirements are met, and to confirm that the soil conditions do not deviate materially from those encountered in test holes. In cases where any of our recommendations are not followed, the company's responsibility is limited to interpreting the information from the test hole data.

This report is applicable only to this specific project, constructed substantially in accordance with details of alignment and elevations quoted in the text. Elevations quoted in the document are approximate. Original ground elevations for project design purposes should be obtained from an experienced topographical survey consultant.

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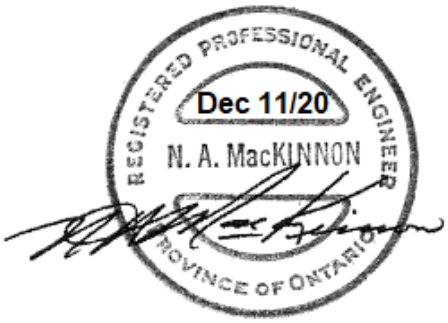
TERRASPEC ENGINEERING INC.
GEOTECHNICAL ENGINEERS



Shane Galloway, B.A.
Manager

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Senior Engineer

Borehole Data
Culvert #11
West Poverty Bay Road
December 7, 2020

Notes

1. Soil types, strata, and groundwater conditions have been established only at test hole locations.
2. Soils are described according to the MTO Soils Classification System and OPSD 100.06.
3. Dimensions are in millimetres up to 1 metre, then in metres thereafter.

Abbreviations

asph	-	asphalt	&	-	and
blds	-	boulders	w	-	with
blk	-	black	so	-	some
br	-	brown	tr	-	trace
BR	-	bedrock			
cl	-	clay(ey)	S	-	soil sample
cob	-	cobbles	Su	-	vane shear strength (kPa)
conc	-	concrete	N	-	estimated blow counts per 0.3m
cr	-	crushed			
f	-	fine			
gr	-	gravel(ly)			
gry	-	grey			
med	-	medium			
NFP	-	no further progress			
org	-	organics			
RF	-	rock fill			
sa	-	sand(y)			
si	-	silt(y)			
tps	-	topsoil			

1 2.5m N of Road CL, 4.2m E of culvert CL

0	-	20	surf treat	
20	-	170	br sa & gr -dry, compact	
170	-	400	br f sa w si -moist, compact	
400	-	1.50	br f sa w si -moist, compact	S1 at 1.0m
1.50	-	7.01	br si sa -moist, compact	
-saturated, loose after 3.1m				
7.01	-	10.06	gry/br si sa -sat, loose	S2 at 4.8m
10.06	-	13.11	gry si sa tr cl -sat, loose	
-so cob at 12.8m				
13.11			NFP, refusal due to BR inferred	

-water at 3.10m

at 4.27m	N=3
at 4.6m	N=3
at 5.49m	N=5
at 6.40m	N=6
at 7.92m	N=4
at 9.45m	N=4
at 10.97m	N=5
at 12.49m	N=5
at 13.11m	NFP, refusal

2 2.4m S of Road CL, 4.3m W of culvert CL

0	-	20	surf treat	
20	-	200	gry sa & gr -dry, compact	
200	-	400	br f sa w si -moist, compact	
400	-	1.50	br f sa w si -moist, compact	
1.50	-	7.11	br si sa -moist, compact	S3 at 5.8m

-saturated, loose after 3.1m

7.11	-	10.52	gry/br si sa -sat, loose	
10.52	-	15.09	gry si sa tr cl -sat, loose	S4 at 11.0m

-so cob at 14.8m

15.09 NFP, refusal due to BR inferred

-water at 3.05m

at 1.52m	N=10
at 3.05m	N=5
at 4.27m	N=5
at 4.6m	N=5
at 5.49m	N=4
at 6.40m	N=3
at 7.92m	N=5
at 9.45m	N=4
at 10.97m	N=4
at 12.49m	N=5
at 14.33m	N=6
at 14.94m	N=10
at 15.09m	NFP, refusal

Laboratory Test Data

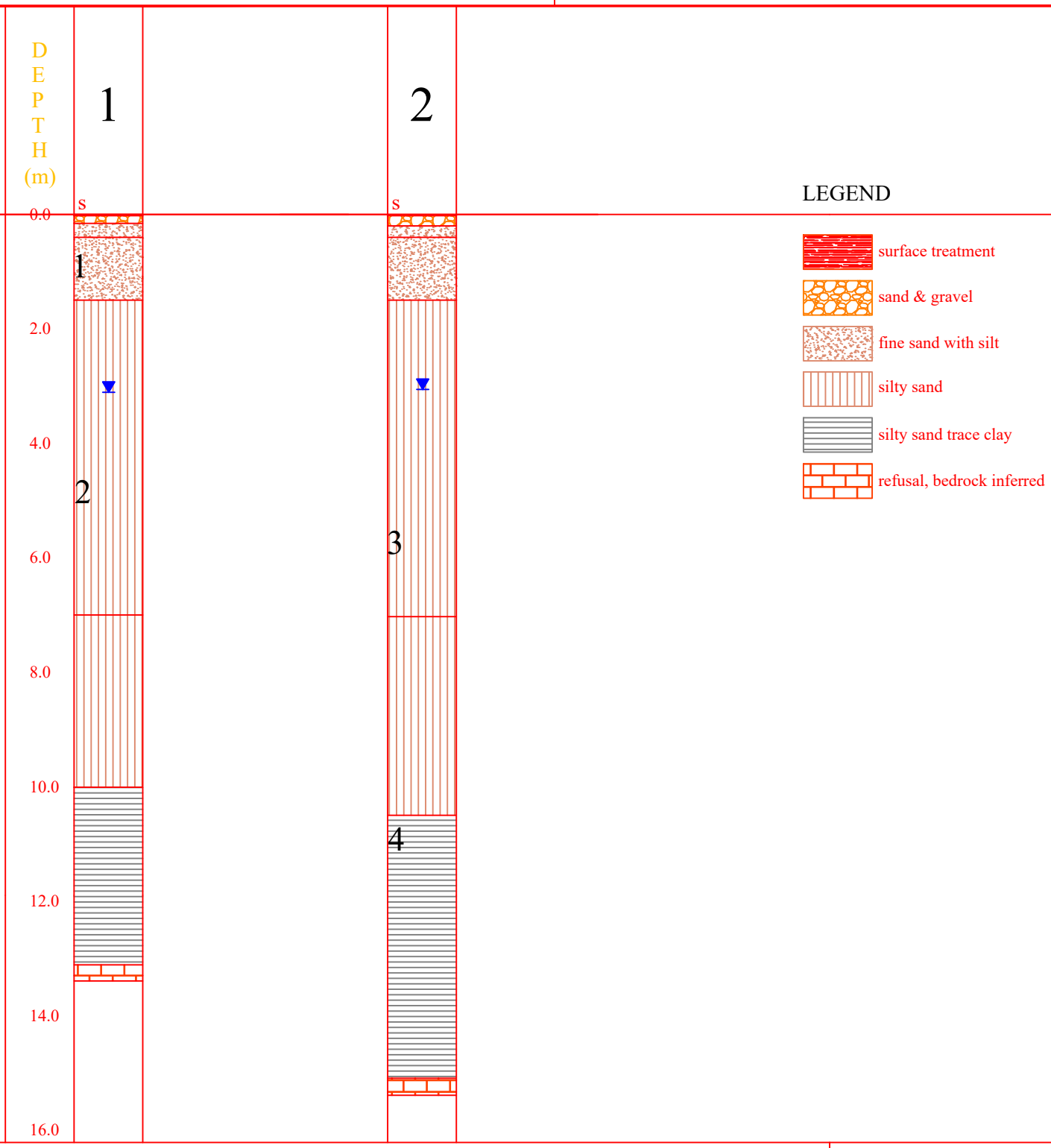
Soil Sample	**S1**	**S2**	**S3**	**S4**	
Sieve	**% Passing**				
13.2mm	100	100	100	100	grain size
9.50mm	100	100	98.5	100	
4.75mm	97.2	98.4	95.4	100	
2.36mm	94.5	96.5	92.3	99.8	
1.18mm	90.9	92.6	87.6	99.4	
600um	81.8	83.9	78.8	96.1	
300um	60.6	67.2	62.5	84.9	
150um	26.7	42.1	34.9	56.2	
75um	11.5	23.8	19.6	37.8	
ASTM	SP-SM	SM	SM	SM	soil classification
frost rating	Low	Low	Low	Low	susceptibility to frost heave
W	8.7	20.9	22.6	21.5	field moisture content

BOREHOLE LOG DATA

PROJECT No.: 20-5-5236
CLIENT: Municipality of Magnetawan
PROJECT: Culvert No. 11
DATE: December 7, 2020

SOIL DATA
METHOD: 130mm Solid Stem Auger
s = sample

▼ encountered water elevation



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Culvert 11
December 7, 2020
Borehole Locations

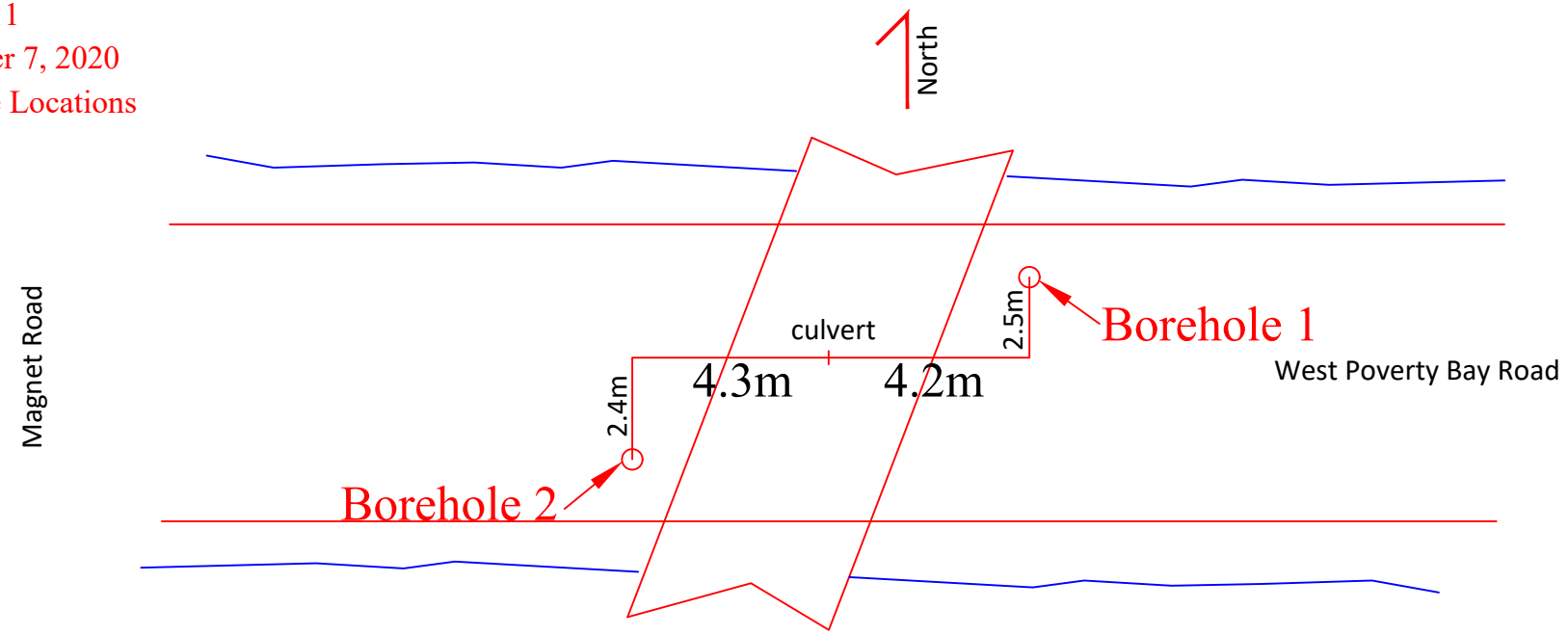

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Photo 1, North End

Photo 2, South End

Photo 3, South End

Photo 4, Inside View

Photo 5, Looking East