



Stantec

**CATEGORY 3 PERMIT TO TAKE
WATER APPLICATION
HYDROGEOLOGIC ASSESSMENT
HIGHWAY 12 WIDENING FROM
HIGHWAY 48 TO
REGIONAL ROAD 48
(WP 611-89-00)**

Prepared for
Ministry of Transportation Ontario

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WP 611-89-00, GEOCRES NUMBER 31D-538**

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1.0 Introduction

On behalf of the Ontario Ministry of Transportation (MTO), Stantec Consulting Ltd. (Stantec) has completed a hydrogeologic and hydrologic assessment in support of surface water diversion and groundwater dewatering required as part of the proposed culvert replacement/extension along Highways 12 and 48 in the Township of Brock near Beaverton, Ontario. The proposed culvert installations are located along approximately a 13 km section of Highways 12 and 48, located east of Lake Simcoe (Figures 1 and 2 – Appendix A).

It is anticipated that culvert installations will commence in July 2013 and be completed over a period of approximately four (4) months ending in October 2013. Based on a review of available reports and field observations, it is expected that the proposed culvert installation may require temporary groundwater dewatering and/or surface water diversion.

The following hydrogeologic and hydrologic assessment was completed to support a Ministry of the Environment (MOE) Category 3 Permit to Take Water (PTTW) application for construction dewatering and has the following main objectives:

- Estimate aquifer parameters in the vicinity of the six (6) proposed culvert replacement/extensions;
- Estimate surface water flows to the six (6) culverts
- Outline the proposed construction and de-watering strategy, as available;
- Assess potential impacts due to the proposed water taking and diversion; and
- Develop mitigation measures and contingency plans.

The following report is arranged in eight (8) sections, including this introduction. Section 2 presents available background information. Section 3 presents the geology and hydrogeology. Section 4 presents the hydrology. Section 5 presents the groundwater dewatering and surface water diversion requirements for construction, while Section 6 presents the impact assessment and mitigation measures. The study conclusions and references are presented in Sections 7 and 8. All figures and tables referenced in the report are presented in Appendix A and B, respectively. Appendices C and D present the borehole logs and hydraulic response testing, respectively. Appendix E includes the hydrologic modelling for the site.

2.0 Background

The MTO is planning to widen a section of Highway 12 between the south and north junctions of Highway 48. In support of the proposed highways widening, six (6) culverts need to be extended or replaced (Figures 1 and 2). Table 1 details the proposed culvert replacements.

The proposed culvert installations range in width from 1.2 m to 3.0 m and range in length from 6 m to 41 m long depending on the location. Based on construction details, it is understood that the installation may require excavation up to 2 m below ground surface (BGS).

It is expected that the exact location/depth of some of these culverts may be adjusted during final design and/or construction. The current locations are considered a best estimate of culvert location. Any potential changes to this design are not expected to affect dewatering estimates or impacts.

The MTO memo dated March 30, 2004 provides clearance for the proposed project. The memo indicates that the MTO has secured the required environmental approvals. Approvals under the federal Navigable Waters Protection Act was obtained in December 2003 and under the federal Fisheries Act was obtained in October 2004. The review process included a 30-day public review period during this time there were no objections.

2.1 CONSTRUCTION DETAILS

During the replacement of Culvert 48 at Station 21+067 on Highway 12, single lane detours around the areas of construction will be in effect. The replacement of Culvert 48 will take approximately one (1) month to complete; however, it may extend over a longer period depending on the final schedule. For culvert extensions, Highways 12 and 48 will remain open during construction, and the culvert work will be completed in approximately one (1) week. There will be a maximum of up to 60 separate days of pumping for the culvert replacement and 15 days for the culvert extensions at each culvert spread over a period of approximately 4 months. Culvert construction details are provided in Table 1.

With respect to the proposed culvert works, the following sequence of events is envisioned during construction:

- An impervious check dam (rock and polyethylene barrier, pea stone bags, etc.) will be placed across the narrow portion of the channel entering the upstream end of the culvert. Watercourse flows will be pumped around the work area to discharge into the existing channel downstream of the culvert. The pump intake will be screened and the outlet will be placed to prevent erosion
- Given the gradient of the existing culvert and the channel downstream of the road crossings, the requirement for a second downstream check dam is not anticipated. A downstream

check dam may be required however; if water is found to back up into the downstream end of the culvert

- Once bypass flow operations have begun, the channel length contained within the work area will be surveyed for fish. Any stranded fish will be removed from the work area and placed in the downstream channel
- Following completion of the culvert work, the upstream check dam will be removed slowly to allow flow to enter the new channel section as gently as possible. Bypass pumping will continue to alleviate some flow pressure on the new channel during check dam removal
- Following removal of the check dam, the bypass pumping will be stopped and the pump removed from the watercourse channel

Generally speaking, it is considered unlikely that the Construction Dewatering Program proposed within the current application will result in a negative impact on water quality for a number of reasons, including:

- The source water taking and discharge locations are generally equivalent, inherently minimizing the potential for concerns associated with inter-basin transfer or input of non-native characteristics to the receiving system
- The dam and pump method is essentially a closed system, minimizing the potential for negative thermal impacts (warming) through solar radiation or ambient heating
- No new water is to be discharged other than what would exist normally and the area has a proven ability to “manage” these flows / volumes

Erosion control / energy dissipation measures will be implemented at the proposed discharge location to disperse flows across a broad area minimizing the potential for scour and erosion, minimizing the potential for sediment transport and deposition within the watercourse

3.0 Geology and Hydrogeology

The section of Highway 12 between the south and north junctions of Highway 48 including the proposed culvert installations extends across the physiographic regions referred to by Chapman and Putnam (1984) as the Simcoe Lowlands and the Peterborough Drumlin Field. The Simcoe Lowlands were mapped directly adjacent to Lake Simcoe with clay plains mapped on land along the existing shoreline with the sand plains mapped to the east. Culverts 36, 44, 48 and 55 are located within the Simcoe Lowlands with Culvert 12 located at the southern extent of the lowlands. Culverts 1 and 12 are located within or partially within the Peterborough Drumlin Field which is described as a rolling till plain.

The Ontario Geological Society (OGS) geological mapping indicates that surficial deposits in the vicinity of Culverts 1 and 12 consist of silty to sandy till material (Figure 3) which is consistent with the description based on the physiographic region. Deposits in the vicinity of Culvert 36 are described by the OGS mapping as massive well-laminated deposits. It is interpreted that these deposits are part of the Simcoe Lowland clay plains. Deposits in the vicinity of Culverts 44, 48 and 55 are described as foreshore-basinal deposits. It is interpreted that these deposits would be coarser than the clay plains and may be composed of silt and fine sand material.

A detailed review of available geotechnical boreholes (Shaheen and Peaker, 2003), adjacent MOE water well records (WWR) and hydraulic testing is presented below for each of the six (6) culvert locations. Copies of the borehole logs are included in Appendix C with results of hydraulic testing included in Appendix D.

3.1 CULVERT 1

The 2003 geotechnical investigation included drilling of one (1) borehole in the vicinity of Culvert 1. The borehole log indicated peat material extending from ground surface (245.3 m above mean sea level (AMSL)) to 2.4 m BGS (242.9 m AMSL) and underlain by silty clay, silty clay till and silty sand till to 5.5 m BGS (239.8 m AMSL), which is interpreted as the top of bedrock. Nearby MOE WWR did not indicate any peat deposits and described the overburden as clay with stones/gravel extending from ground surface to 3.0 m BGS to 10.7 m BGS and underlain by limestone bedrock.

Monitoring Well C9 was installed within the sandy silt till at a total depth of 5.5 m BGS (239.8 m AMSL). Water level data from June 2001 following well installation and July 2002 indicated static water levels of 244.7 m AMSL and 245.2 m AMSL, respectively.

Stantec completed a Site inspection in February 2012 and noted that the well casing at C9 was likely blocked and accurate hydraulic testing and water level monitoring could not be completed.

The proposed culvert installation will require excavation within the peat deposits. Based on literature values, the hydraulic conductivity of peat material is estimated at 10^{-5} m/s to 10^{-7} m/s (Mitsch and Gosselink, 2000) while highly decomposed or compacted peat will have a lower hydraulic conductivity.

3.2 CULVERT 12

The 2003 geotechnical investigation included one (1) borehole in the vicinity of Culvert 12. The borehole log indicated silty clay till material extending from ground surface (248.9 m AMSL) to the top of bedrock at 2.0 m BGS (246.9 m AMSL). This description is consistent with nearby MOE WWR that indicated shallow deposits of clay with stones extending to 0.3 m to 3.0 m BGS and underlain by limestone bedrock.

Monitoring Well C8 was installed within the bedrock at a total depth of 3.5 m BGS (245.4 m AMSL). Water level data from June 2001 following well installation and July 2002 indicated static water levels of 247.8 m AMSL. Monitoring at C8 in February 2012 indicated a static groundwater level of 247.9 m AMSL.

Stantec completed a Site inspection in February 15, 2012 and completed hydraulic response testing at monitoring well C8. The hydraulic response testing was completed by adding 1 L of water to the water column, and monitoring the water levels as they decreased back to static (falling head test). The well response was monitored using manual water level measurements.

The results of the response testing were analyzed with the Aqtesolv™ software package using the Bouwer and Rice solution (1976) to determine the horizontal hydraulic conductivity of the formation within the immediate vicinity of the monitoring well screen. The hydraulic conductivity estimate for bedrock was 2×10^{-7} m/s. The detailed analyses are shown in Appendix D.

The proposed culvert installation will require excavation within the silty clay till material. Literature values suggest a hydraulic conductivity for clay till material of approximately 10^{-8} m/s (Fetter, 1994).

3.3 CULVERT 36

The 2003 geotechnical investigation included one (1) borehole in the vicinity of Culvert 36. The borehole log indicated silty clay and silty clay till material extending from ground surface (234.5 m AMSL) to 3.0 m BGS (231.6 m AMSL) and underlain by clayey silt till to 4.0 m BGS (230.6 m AMSL) and silty sand till to 4.4 m BGS (230.2 m AMSL), which is interpreted as the top of bedrock. Nearby MOE WWR typically indicated clay and clay with stone from ground surface to 8.8 m BGS to 13.4 m BGS and underlain by limestone bedrock. Sand deposits were noted at ground surface at some locations, extending up to 1.8 m BGS.

Monitoring Well C7 was installed within the clayey silt till / silty sand till at a total depth of 4.3 m BGS (230.3 m AMSL). Water level data from June 2001 following well installation and July 2002 indicated static water levels of 232.6 m AMSL and 233.4 m AMSL, respectively. Monitoring at C7 in February 2012 indicated a static groundwater level of 233.9 m AMSL.

Hydraulic response testing including a falling head slug test was performed by Stantec on February 15, 2012 at C7. The hydraulic testing and analysis was completed as described above at Culvert 12. The hydraulic conductivity estimate for till material at C7 was 1×10^{-8} m/s. The detailed analyses are shown in Appendix D.

The proposed culvert installation will require excavation within the silty clay material. Literature values suggest a hydraulic conductivity for clay of up to 10^{-8} m/s (Fetter, 1994).

3.4 CULVERT 44

The 2003 geotechnical investigation included one (1) borehole in the vicinity of Culvert 44. The borehole log indicated gravelly silty sand till at ground surface (232.0 m AMSL) extending to 2.3 m BGS (229.7 m AMSL). These surficial deposits were underlain by dense sand and gravel with some silt to 5.2 m BGS (226.8 m AMSL), which is interpreted as the top of bedrock. MOE WWR near Culvert 44 and 48 typically indicated clay and clay with stone extending from ground surface to 3.0 m BGS to 11.2 m BGS and underlain by limestone bedrock.

Monitoring Well C5 was installed within the dense gravelly sand at a total depth of 4.0 m BGS (228.0 m AMSL). Water level data from June 2001 following well installation indicated a groundwater level of 230.5 m AMSL. Stantec completed a Site inspection in February 2012 but could not locate C5 for additional testing.

The proposed culvert installation will require excavation within the silty sand till material. Literature values suggest a hydraulic conductivity for till material of 10^{-8} m/s to 10^{-6} m/s (Fetter, 1994).

3.5 CULVERT 48

The 2003 geotechnical investigation included three (3) boreholes in the vicinity of Culvert 48. The C1 borehole log indicated 1.8 m of fill material at ground surface, which was associated with the road embankment. All three (3) boreholes indicated that the native overburden began at 228.5 m AMSL to 229.1 m AMSL and consisted of approximately 3 m of silty clay material underlain by up to 0.5 m of sand and silt till material. The top of bedrock was inferred at 3.7 m BGS to 5.3 m BGS (225.4 m AMSL to 225.5 m AMSL). MOE WWR near Culvert 44 and 48 typically indicated clay and clay with stone extending from ground surface to 3.0 m BGS to 11.2 m BGS and underlain by limestone bedrock.

Monitoring Wells C1 and C4 were installed within silt till at total depth of 5.2 m BGS (225.6 m AMSL) and 3.7 m BGS (225.4 m AMSL), respectively. Water level data from June 2001 following well installation at C1 and C4 indicated static groundwater levels of 230.1 m AMSL and 228.6 m AMSL, respectively. Monitoring at C4 in February 2012 indicated a static groundwater level of 228.6 m AMSL.

Hydraulic response testing including a falling head slug test was performed by Stantec on February 15, 2012 at C4. The hydraulic testing and analysis was completed as described above at Culvert 12. Monitoring well C1 was not located during the 2012 field investigation. The hydraulic conductivity estimate for the sand and silt till material at C4 was $< 1 \times 10^{-8}$ m/s. The detailed analyses are shown in Appendix D. This conductivity estimate was slightly lower than the literature values for till material of 10^{-8} m/s to 10^{-6} m/s (Fetter, 1994).

The proposed culvert installation will require excavation within the silty clay material. Literature values suggest a hydraulic conductivity for clay of up to 10^{-8} m/s (Fetter, 1994).

3.6 CULVERT 55

The 2003 geotechnical investigation included one (1) borehole in the vicinity of Culvert 55. The borehole log indicated silty clay material extending from ground surface (220.1 m AMSL) to 10.8 m BGS (209.6 m AMSL) underlain by sand and silt material to 15.2 m BGS (205.2 m AMSL) and sand and silt till material to 18.3 m BGS (202.1 m AMSL). Nearby MOE WWR indicated clay material extending from ground surface at least 9.5m BGS.

Monitoring Well C2 was installed within the sand and silt till at a total depth of 16.8 m BGS (203.6 m AMSL). Water level data from June 2001 following well installation and July 2002 indicated static groundwater levels of 219.8 m AMSL.

Stantec completed a Site inspection in February 2012 and noted that the well casing at C2 was blocked at ground surface. Hydraulic testing and water level monitoring could not be completed.

The proposed culvert installation will require excavation within the silty clay material. Literature values suggest a hydraulic conductivity for clay of up to 10^{-8} m/s (Fetter, 1994).

4.0 Hydrology

Previous hydrologic work for the site is documented in the Highway 12 Preliminary Design Report (Totten Sims Hubicki, 1999) and the Hydrology and Stormwater Management Report (SNC-Lavalin, 2003). The Highway 12 corridor runs north-south within the study area and is located within the former Geographic Townships of Brock and Thorah. The area draining to Highways 12 and 48 is primarily agricultural land. Land use was assessed using information obtained during the field inspection and the Hydrology and Stormwater Report (SNC-Lavalin, 2003). The study area is generally characterized as mild to moderately sloping topography. Stormwater generally drains from east to west across Highway 12 towards Lake Simcoe through various tributaries. Catchment areas were delineated based on Ontario Base Mapping and the Hydrology and Stormwater Report (SNC-Lavalin, 2003). The site topography is shown on Figures 1 and 2.

Soil data was determined based on the Soil Survey of Ontario County – Soil Survey Report No. 23 (Canada Department of Agriculture, 1950) and the Soil Survey of Victoria County – Soil Survey Report No. 25 (Canada Department of Agriculture, 1957). Site soils are generally described as loams, sandy loams, and clay loams.

Under PTTW Regulations, a permit for surface water taking is required for the subject application given that the proposed means of maintaining a dry work area includes the installation of flow barriers and diversion of surface flows around the construction area by means of a “closed” diversion system. This surface water diversion is considered to represent a “taking and return to a nearby point with no significant change to water quantity or quality.”

A detailed surface water assessment has been completed to quantify surface drainage characteristics of lands contributing drainage through the subject culverts in order to assess the required pumping rates for the PTTW. Hydrologic event modeling was used to quantify the peak flow rates upstream of each culvert during the 5-year event. To assess the drainage system, the area was modeled using precipitation parameters for Lindsay and the SCS 6-hour storm distribution. Flows were modeled using the hydrologic model SWMHYMO. Detailed modeling has been included in Appendix E for reference.

Fish habitat has been considered within the proposed design and construction activities. In accordance with the MTO/DFO/MNR Fisheries Protocol, it was concluded that *Fisheries Act* implications can be avoided at this crossing provided that standard mitigation measures, described herein, are employed.

5.0 Predicted Groundwater Dewatering and Surface Water Diversion

Based on proposed construction activity, interpreted groundwater and surface water levels, groundwater dewatering and surface water diversion will be required for the installation of culverts along Highway 12.

As detailed in Section 3, it is interpreted that construction will be completed over a 4 month period with groundwater dewatering and/or surface water diversion required for various times during the construction period. The attached PTTW requests up to 4 months of pumping of groundwater and/or surface water along Highways 12 and 48 to account for any delays in construction and/or unforeseen circumstances.

The proposed method for the control of groundwater seepage into the excavation is dewatering on an as-required basis using submersible pumps, trash pumps, or equivalent. The proposed work will involve surface water diversions using dams and surface water pumping to isolate select work areas. It is the Contractor's responsibility to determine the location and extent of the groundwater dewatering and surface water diversion.

While it is proposed that dewatering and surface water diversion would be completed on an as-required basis, the MOE PTTW application requires that a maximum pumping rate per day and typical (average) pumping rate per day be determined. The rationale/methodology used to calculate these pumping rates is presented below.

5.1 AVERAGE PUMPING RATE PER DAY

GROUNDWATER DEWATERING

The average groundwater dewatering rate at each culvert location was estimated using the Cooper-Jacob (1946) Non-equilibrium Flow Equation. The equation assumes that the aquifer is homogeneous, isotropic with horizontal flow. Dewatering calculations are expected to provide a conservative dewatering estimate. The flow equation and parameters are detailed below:

$$s = \frac{2.303 Q}{4\pi T} \log\left(\frac{2.25Tt}{r^2 S}\right)$$

Where, s = drawdown (m)
 Q = pumping rate (m³/s)
 T = transmissivity (m²/s)
 t = time (s)
 r = radial distance (m)
 S = storativity (unitless)

Values used in the calculations for each culvert location are presented in Table 1 along with calculated average day dewatering rate.

After 30 days of pumping, the combined dewatering rate is estimated at 17,150 L/day. Based on the uncertainty of the calculations, the dewatering rate is increased by a factor of 2 to 34,300 L/day.

SURFACE WATER DIVERSION

Average pumping rates were estimated based on the watershed characteristics, baseflow observations made during the site visit, and a combination of a 4 inch (40 L/s) and 6 inch (100 L/s) pumps typically used during the construction dewatering process.

5.2 MAXIMUM PUMPING RATE PER DAY

GROUNDWATER DEWATERING

The maximum day groundwater dewatering rate at each culvert location was estimated using the same method described above. Values used in the calculations for each culvert location are presented in Table 1 along with calculated maximum day dewatering rate. In most cases, the calculations indicated that complete dewatering was not feasible after 24 hours of pumping due to the low conductivity of the overburden material. Complete dewatering after 24 hours of pumping was only predicted at Culverts 1 and 44.

The combined maximum day dewatering rate was estimated at 39,000 L/day. Based on the uncertainty of the calculations, the dewatering rate is increased by a factor of 2 to 78,000 L/day.

SURFACE WATER DIVERSION – NON CONSUMPTIVE USAGE

In accordance with the 2006 Draft MOE-MTO Memorandum of Understanding, a “draft estimate of the maximum or worst-case water-taking rate” has been provided within the current application with the expectation that it can be reduced as part of final construction preparation and Permit application process.

The maximum water taking rates requested within this Permit are based on the 5-year rainfall event. Flows were calculated based on a hydrologic model of the watersheds using known physical characteristics (slope, land use, soil properties). In the event that larger flows are encountered, it is expected that no work would take place and that any excessive flows would be conveyed through the work area relatively quickly.

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Predicted Groundwater Dewatering and Surface Water Diversion

April 23, 2012

SURFACE WATER DIVERSION – CONSUMPTIVE USAGE

With respect to any water requirements for grading, compaction, dust suppression and hydro seeding, it is anticipated that less than 50,000 L/day would be required and therefore would not require a PTTW. This condition will be stipulated in the contract documents but should the contractor determine that a greater amount of water is required, they will advise the MOE and provide the required documentation.

5.3 PTTW RATES

Depending on construction requirements, the system layout for the surface water diversion and groundwater dewatering may not allow the Contractor to evaluate the potential different sources of this water, such as surface water diversion and groundwater seepage. The Contractor may only be able to monitor and record total pumping volumes at the Site.

Based on the estimated rates presented above for average and maximum day pumping rates for both groundwater and surface water pumping, the following estimates are presented for the project as a whole. Surface water pumping rates assume that pumping is occurring at all six (6) sites simultaneously.

	Maximum Day Pumping Rate		Average Day Pumping Rate	
	L/day	L/min	L/day	L/min
Groundwater Dewatering	78,000	-	34,300	-
Surface Water Diversion	460,771,200	-	51,840,000	-
Total Combined Dewatering	460,849,200	320,034	51,874,300	36,024

The attached permit requests pumping/diversion with the excavation at a maximum rate of 320,034 L/min with a maximum daily volume of 460,849,200 L/day for up to a 4 month (120 day) period.

6.0 Impact Assessment and Mitigation Measures

The following section focuses on potential impacts due to the temporary surface water diversion and groundwater dewatering and details any mitigation measures to be completed during construction.

6.1 MANAGEMENT OF DISCHARGE

As described above, groundwater dewatering within the excavation will be completed on an as-required basis, while surface water diversion is anticipated at all sites.

The exact mitigation measures required will be determined by the Contractor throughout the dewatering activities. The proposed primary discharge location will vary depending on location but in all cases, any groundwater dewatering will be discharged to a downgradient low-lying vegetated area to promote infiltration. At no point will groundwater be discharged directly to a surface water feature. Due to the relatively low volumes of groundwater that will be dewatered during average day pumping, it is anticipated that the majority of the water discharged as part of culvert installation will infiltrate and recharge the groundwater system.

Typically during construction dewatering, the major water quality concern is the potential discharge of sediment laden water. To minimize sediment transport, the following mitigation measures are proposed as deemed necessary:

- The inlet pump head for the groundwater dewatering pumps will be wrapped in filter fabric, clear stone or equivalent; and
- All groundwater discharge water will be directed through a filter bag or straw bale/filter fabric device or equivalent to reduce suspended solids. The number and size of the sediment control bags or equivalent filter will be dependent on the extent and location of the required dewatering;

Surface water diversion will consist of flow barriers and diversion of surface flows around the construction area by means of a “closed” diversion system (i.e. a pump) considered to represent a “taking and return to a nearby point with no significant change to water quantity or quality.

Contamination Minimization

Various mitigation techniques will be employed during construction to reduce the risk of impacts to natural environment features. Mitigation measures for sediment and erosion control will be implemented to prevent sediment from entering aquatic resources.

The primary principles associated with sedimentation and erosion protection measures are to:

- (1) Minimize the duration of soil exposure;

- (2) Retain existing vegetation, where feasible;
- (3) Encourage re-vegetation;
- (4) Divert runoff away from exposed soils;
- (5) Keep runoff velocities low;
- (6) Trap sediment as close to the source as possible; and
- (7) Isolate work areas where in-water works are required.

To address these principles, the following mitigation measures are proposed:

- Work is proposed outside of all relevant fisheries timing restriction windows to protect sensitive life periods of fish identified in the area
- Equipment is not permitted to enter any aquatic resources during construction (work area not considered “aquatic resources” when dewatered)
- Silt fencing will be used along all construction areas adjacent to aquatic resources and the boundaries of the site
- All excavated materials requiring stockpiling (fill, topsoil, etc.) should be stabilized and kept a safe distance from any aquatic resources or sensitive natural features. The perimeter of the stockpiles should be encircled with silt fencing
- All exposed soil areas will be stabilized and re-vegetated, through the placement of native vegetation (i.e., seeding, mulching, sodding), upon completion of construction activities
- Refueling of equipment will be carried out away from any aquatic resources or sensitive natural features to avoid potential impacts, in the event that an accidental spill occurs
- In addition to the specified requirements, additional silt fence, turbidity curtain, and filter bags should be maintained on-site throughout operations to provide a contingency supply in the case of an emergency
- All sediment and erosion controls should be monitored and properly maintained as required. Controls are to be removed only after the soils of the construction area have been stabilized and adequately re-vegetated
- All in-stream work will be completed in the dry by de-watering the work area and diverting and/or pumping flows around cofferdams placed at the limits of the work area;
 - Existing stream flows will be maintained downstream of the de-watered work area without interruption, during all stages of work. There shall be no increase in water levels upstream of the work area
 - Fish shall be removed from the work area prior to and during dewatering and released immediately upstream or downstream

- Flow dissipaters and/or filter bags, or equivalent, shall be placed at water discharge points to prevent erosion and sediment release
- Silt or debris that has accumulated around the temporary cofferdams shall be removed prior to their withdrawal
- Any “sandbags” used for cofferdam construction will be filled with clean sand, free of fine particulates
- Upon project completion, all sandbags will be removed from the water

6.2 GROUNDWATER WELLS

A review of MOE WWR indicated that private wells were located within 500 m of each of the proposed culvert installations. The locations of the wells are shown on Figures 1 and 2. A description of the well use and construction details are summarized below for each culvert:

Culvert 1

- One (1) domestic well installed within gravel overburden at a total depth of 11.3 m BGS;

Culvert 12

- One (1) domestic well installed within the limestone bedrock at a total depth of 16.8 m BGS;
- One (1) shallow observation well;
- One (1) bedrock well installed within the limestone bedrock at a total depth of 14.3 m BGS. This well was installed in 1963 as a public supply well. Based on a well abandonment record from 2008, it is interpreted that this well is not in use and has been abandoned. The Site is currently a transmission station;

Culvert 36

- Three (3) domestic wells installed within the limestone bedrock at total depths of 7 m BGS to 38 m BGS;
- One (1) domestic well installed within gravel overburden at a total depth of 10 m BGS;

Culvert 44 and 48

- Five (5) domestic wells and one (1) livestock well installed within the limestone bedrock at total depths of 10 m BGS to 36 m BGS;
- Two (2) domestic wells installed within gravel overburden at total depths of 9 m BGS to 10 m BGS; and

Culvert 55

- One (1) domestic well installed within gravel overburden at a total depth of 22.5 m BGS.

Groundwater dewatering will only be completed on an as required basis at each culvert installation. The extent of groundwater drawdown due to groundwater dewatering is expected to be minimal based on the short duration of pumping and estimated low dewatering rate. Using the Cooper-Jacob (1946) Non-equilibrium Flow Equation, the extent of drawdown at Culvert 1 was estimated based on the requested maximum day pumping rate of 78,000 L/day and assuming dewatering was completed for a 30 day period; however, this maximum day pumping rate was not considered sustainable over a 30 day period. To allow dewatering calculations, the hydraulic conductivity was increased from 10^{-5} m/s to 10^{-4} m/s. With this higher conductivity estimate, complete drawdown of 2 m is predicted within the excavation over a 30 day period with drawdown extending approximately 100 m from the culvert.

Based on aerial photography and proposed culvert location, it is not expected that any of the nearby private wells are located within 100 m of the potential groundwater dewatering. Based on the limited lateral extent of drawdown, low dewatering rate and well construction details, no private well interference is expected due to the proposed dewatering.

Stantec**CATEGORY 3 PERMIT TO TAKE WATER APPLICATION
HYDROGEOLOGIC ASSESSMENT
HIGHWAY 12 WIDENING FROM HIGHWAY 48 TO REGIONAL ROAD 48
WP 611-89-00, GEOCREs NUMBER 31D-538****7.0 Conclusions and Recommendations**

Based on the above, the following conclusions and recommendations are provided:

- The groundwater and surface water dewatering program can be completed without causing any long-term impact to groundwater or surface water conditions. Any potential short-term impacts can be effectively mitigated with the contingency plans proposed herein; and,
- The PTTW requests permission to complete combined dewatering/diversion at a maximum instantaneous rate of 320,034 L/min and a maximum day pumping rate of 460,849,200 L/day. It is requested that pumping/diversion be permitted for 24 hours per day provided the maximum daily rate is not exceeded. It is anticipated that the construction will be completed between July 2013 and October 2013. To account for unforeseen delays in construction, it is requested that the PTTW be valid for 120 days between July 2013 and October 2014.

We trust that this information is suitable for the PTTW application. Please do not hesitate to contact the undersigned should you have any questions or concerns or if you require additional information.

All of which is respectfully submitted

STANTEC CONSULTING LTD.



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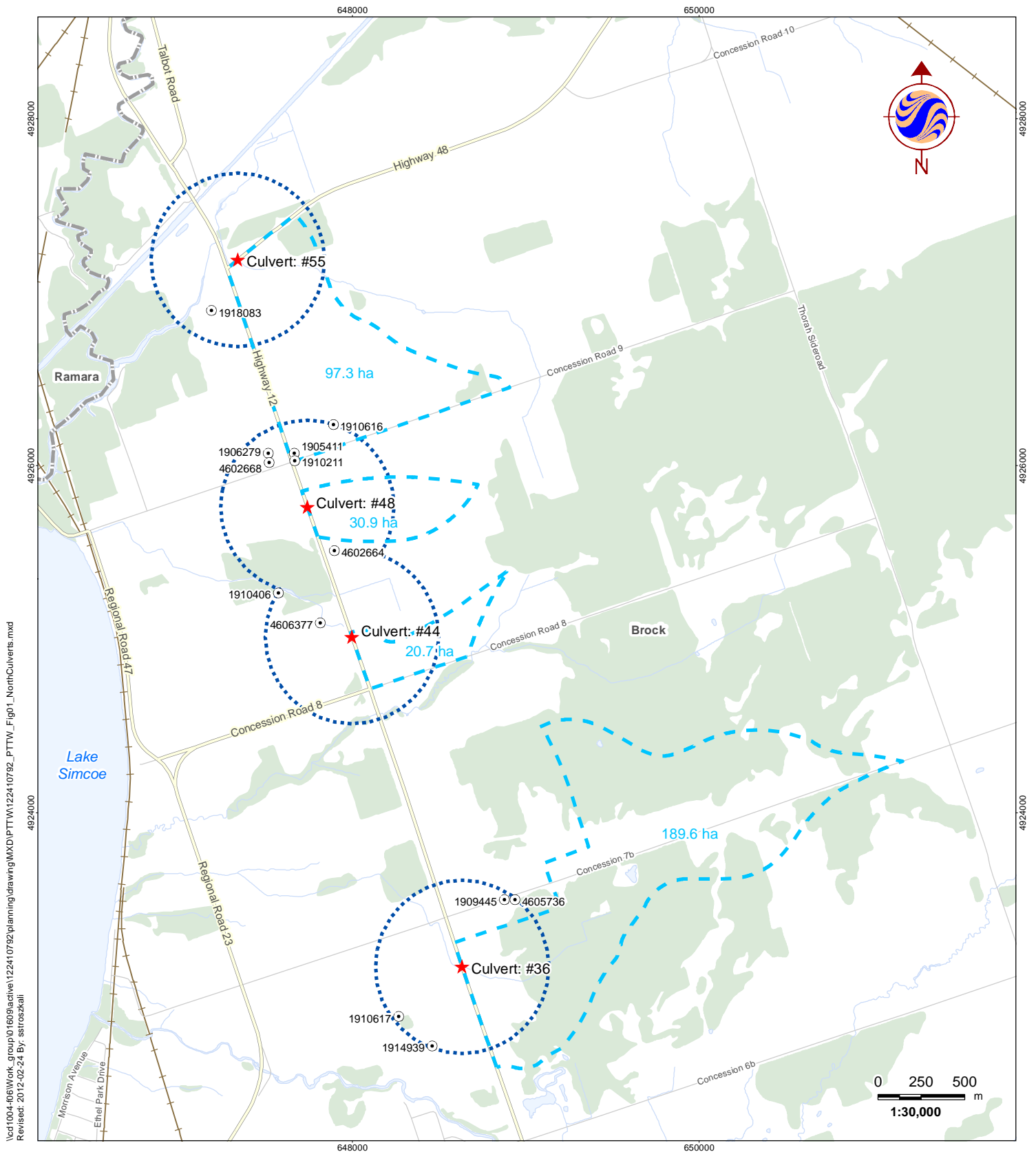


8.0 References

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APPENDIX A

FIGURES



I:\d1004-06\Work_group\01609\active\122410792\planning\drawing\MXD\PTTW\122410792_PTTW_Fig01_NorthCulverts.mxd
 Revised: 2012-02-24 By: astroszkali

February 2012
122410792



Legend

- | | | |
|-------------------------|---------------------------|---------------|
| ● MOE Water Well Record | ▭ Lower Tier Municipality | — Watercourse |
| ★ Culvert Location | — Major Road | — Waterbody |
| ⊙ 500 m Buffer | — Local Road | ■ Wooded Area |
| ▭ Drainage Catchment | — Railroad Line | |

Notes

- Coordinate System: NAD 1983 UTM Zone 17N
- Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2012.
- Catchments based on Highway 12 Drainage and Hydrology Report, W.G. Clarke, 2003.

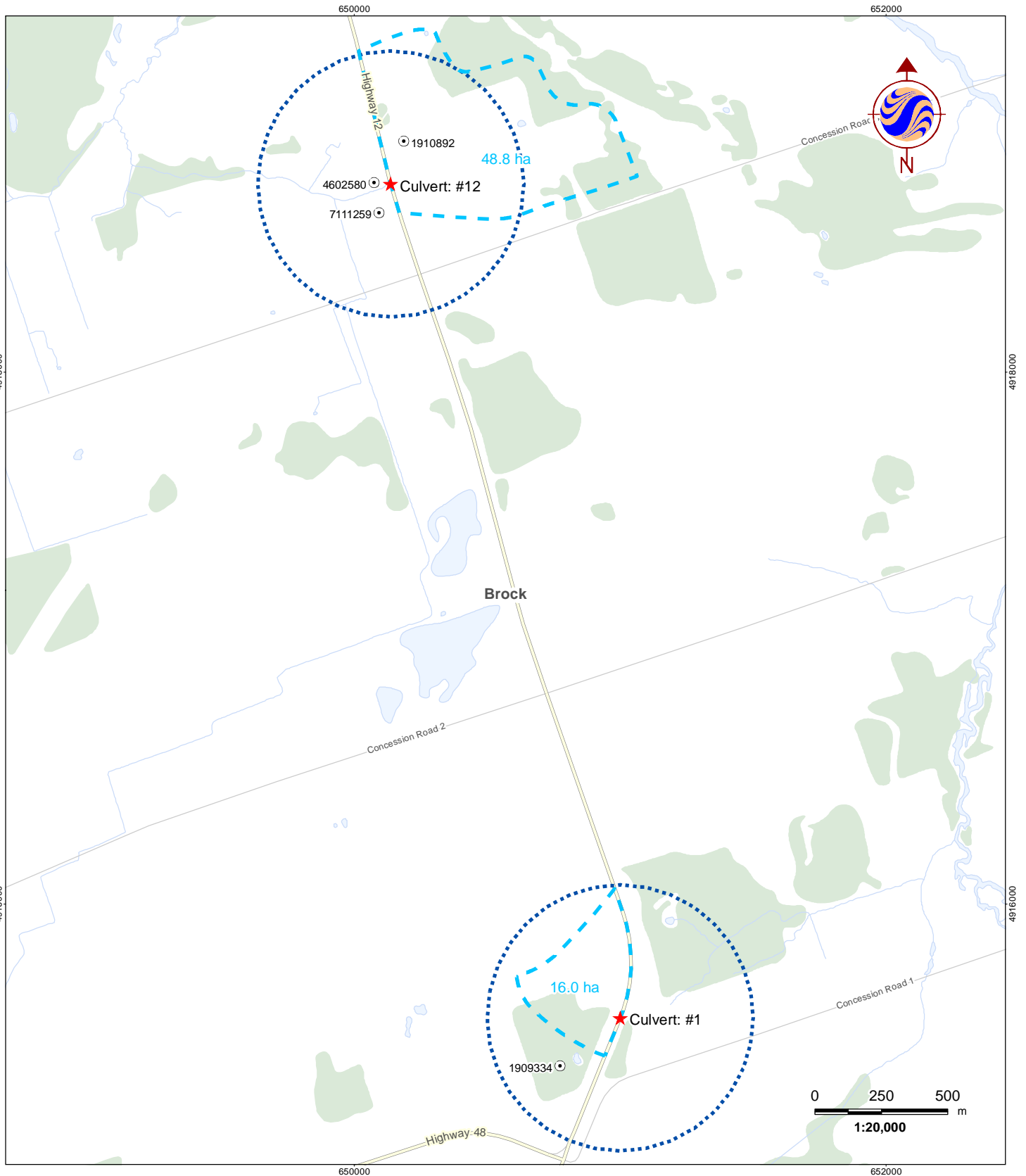
Client/Project
 Ontario Ministry of Transportation (MTO)
 Permit to Take Water
 Hwy 12 from Hwy 48 to RR 48

Figure No.
 1

Title

**Site Location
 (Northern Culverts)**

\\cd1004-06\Work_group\01609\active\122410792\planning\drawing\MXD\PTTW\122410792_PTTW_Fig02_SouthCulverts.mxd
Revised: 2012-02-24 By: astroszkali



February 2012
122410792



Legend

- MOE Water Well Record
- Culvert Location
- 500 m Buffer
- Drainage Catchment
- Major Road
- Local Road
- Watercourse
- Waterbody
- Wooded Area

Notes

- Coordinate System: NAD 1983 UTM Zone 17N
- Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2012.
- Catchments based on Highway 12 Drainage and Hydrology Report, W.G. Clarke, 2003.

Client/Project
Ontario Ministry of Transportation (MTO)
Permit to Take Water
Hwy 12 from Hwy 48 to RR 48

Figure No.
2

Title

**Site Location
(Southern Culverts)**

APPENDIX B

TABLES

Table 1
Summary of Culvert Installations
Hydrogeologic Assessment
Highway 12 (WP 611-89-00)

Hwy	Station	Culvert ID	Installation	Material	Shape	Culvert Dimensions		Ground Surface	Groundwater	Bottom of Excavation	Dewatering Depth ¹	Width of Excavation ²	Description of Excavation			Estimated Hydraulic Conductivity		Average Day Dewatering Rate ⁵	Maximum Day Dewatering Rate ⁶
						Length	Width and Height						Material	Aquifer Thickness ³	Storativity ⁴	(m/s)	Source		
						(m)	(mm)	(m AMSL)	(m AMSL)	(m BGS)	(m)	(m)		(m)	(-)			(L/day)	(L/day)
12	29+848	1	Extension	Concrete	Box	7	2440 x 1200	245.3	245.2	1.6	2.0	5	peat	2.4	0.1	1.0E-05	Literature	11,000	37,000
12	13+573	12	Extension	Concrete	Box	41	3050 x 1220	248.9	247.9	1.6	1.1	6	silty clay till	2	0.01	1.0E-08	Literature	-	-
12	18+231	36	Extension	Concrete	Box	12	1830 x 1520	234.5	233.9	1.6	1.5	4	silty clay	5	0.01	1.0E-08	Hydraulic Testing Literature	130	-
12	20+283	44	Extension	Concrete	Box	12	1220 x 610	232.0	230.5	1.6	0.6	5	silty sand till	5.2	0.01	1.0E-06	Literature	700	2,000
12	21+067	48	Replacement	Concrete	Box	12	2400 x 1200	228.5 to 229.1	228.6 to 230.1	1.6	2.1	6	silty clay	4	0.01	1.0E-08	Hydraulic Testing Literature	5,200	-
48	10+092	55	Extension	Concrete	Box	6	1830 x 910	220.1	219.8	1.6	1.8	6	silty clay	10	0.01	1.0E-08	Literature	120	-
TOTAL																		17,150	39,000

Notes:

¹ Dewatering depth is based on the elevation of the bottom of the excavation, the groundwater elevation across the Site, and includes a 0.5m safety factor of additional water at each location.

² Width of excavation estimated assuming approxiamtely a 1:1 slope ratio

³ Aquifer thickness based on thickness of excavation unit according to borehole log

⁴ Storativity for unconfined units expected to range from 0.01 to 0.3 (Driscoll, 1986) with higher values for coarse grained material.

⁵ Average Day dewatering estimated based on 30 days of consecutive pumping to achieve the required drawdown within the excavation.

⁶ Maximum Day dewatering estimated based on 24 hours of pumping to achieve the required drawdown within the excavation.

* Maximum Day dewatering estiamted based on 0.5 m of water pooling within the excavation following a period of prolonged shutdown.

- insignificant dewatering expected

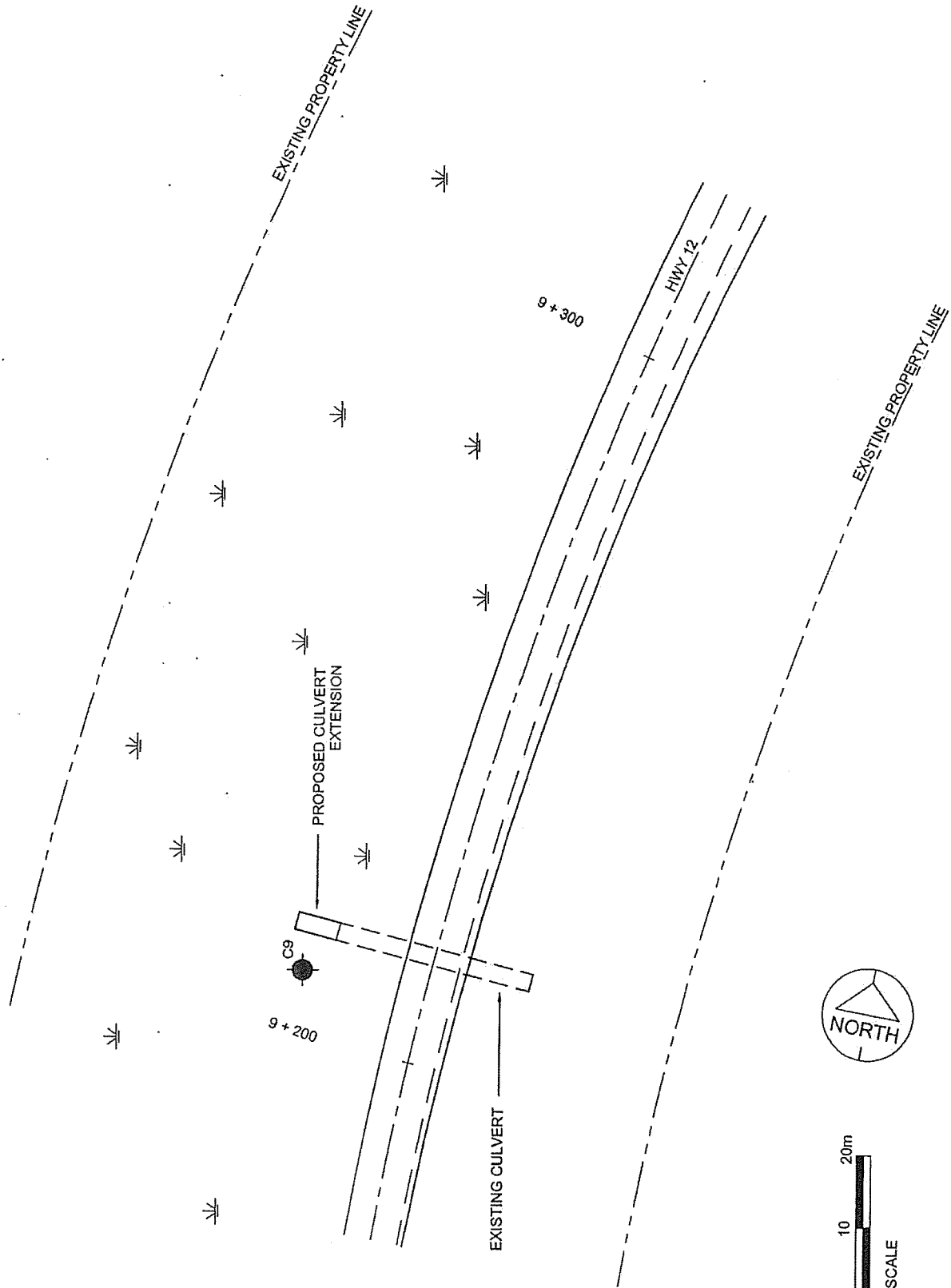
APPENDIX C

BOREHOLE LOGS

CULVERT 1

W.P. 611-89-00
Drawing No. 7
August, 2002

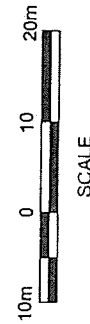
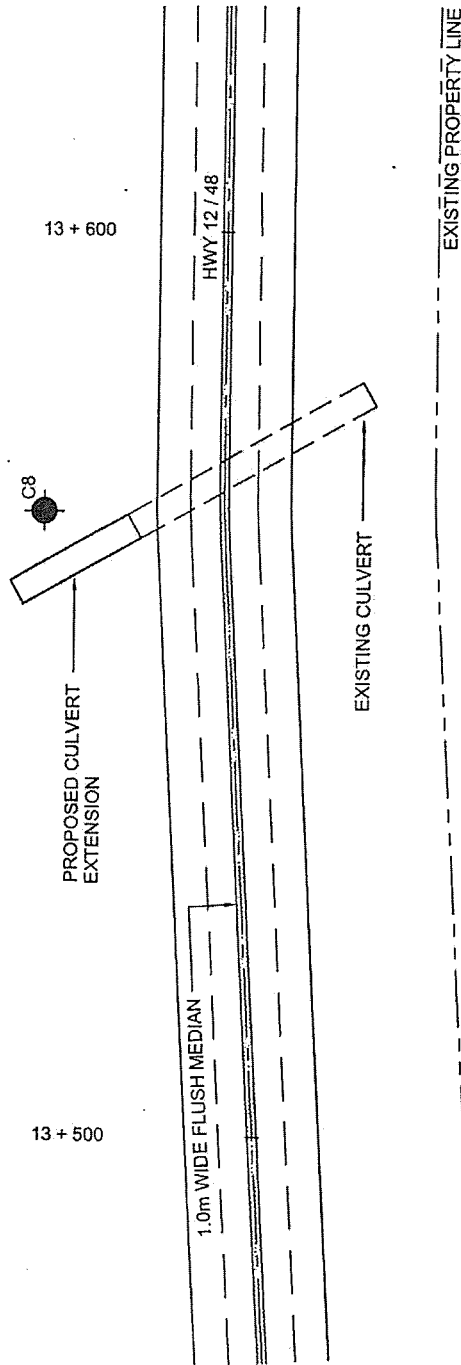
HIGHWAY 12 WIDENING PROPOSED CULVERT EXTENSION AT STN 9+215.0 BOREHOLE LOCATION PLAN



RECORD OF BOREHOLE No C9										1 OF 1		METRIC		
W.P. 611-89-00		LOCATION From South Junction of Hwy 48 to North Junction of Hwy 48, ON - Coords: N 4 914 361 4; E 335 934 2						ORIGINATED BY P.D.						
DIST 7 HWY 12		BOREHOLE TYPE Solid Stem Augering						COMPILED BY JS						
DATUM Geodetic		DATE 13.6.01						CHECKED BY J.G.						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
245.3	Ground Surface													
0.0	PEAT fibrous black very soft		1	SS	1									
			2	SS	1									
			3	SS	1									
242.9														
2.4	SANDY SILTY CLAY occ sand seams grey, firm		4	SS	5									0 35 28 37
242.2														
3.1	SILTY CLAY (Glacial Till) trace of sand and gravel grey, stiff		5	SS	14									
			6	SS	11									
240.6														
4.7	SILTY SAND (Glacial Till) some clay grey, compact		7	SS	20									
239.8														
5.5	END OF BOREHOLE Refusal to augering at 5.5m Possibly on bedrock * Water level at 4.3 m (not stabilized) upon completion ** Piezometer installed to 5.5 m Water Level Record Date WL, EL. (m) 22/06/01 244.7 29/07/02 245.2													

SPT 1024C SPT 1024C GPJ ON MOT.GDT 8/11/02

EXISTING PROPERTY LINE



HIGHWAY 12 WIDENING
PROPOSED CULVERT EXTENSION AT STN 13+573.8
BOREHOLE LOCATION PLAN

W.P. 611-89-00
Drawing No. 6
August, 2002

RECORD OF BOREHOLE No C8

1 OF 1

METRIC

W.P. 611-89-00 LOCATION From South Junction of Hwy 48 to North Junction of Hwy 48, ON - Coords: N 4 918 520.4; E 335 484.2 ORIGINATED BY P.D.
 DIST 7 HWY 12 BOREHOLE TYPE Solid Stem Augering & NQ Rock Core COMPILED BY J.S.
 DATUM Geodetic DATE 13.6.01 CHECKED BY J.G.

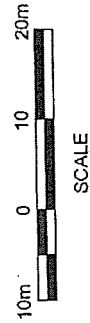
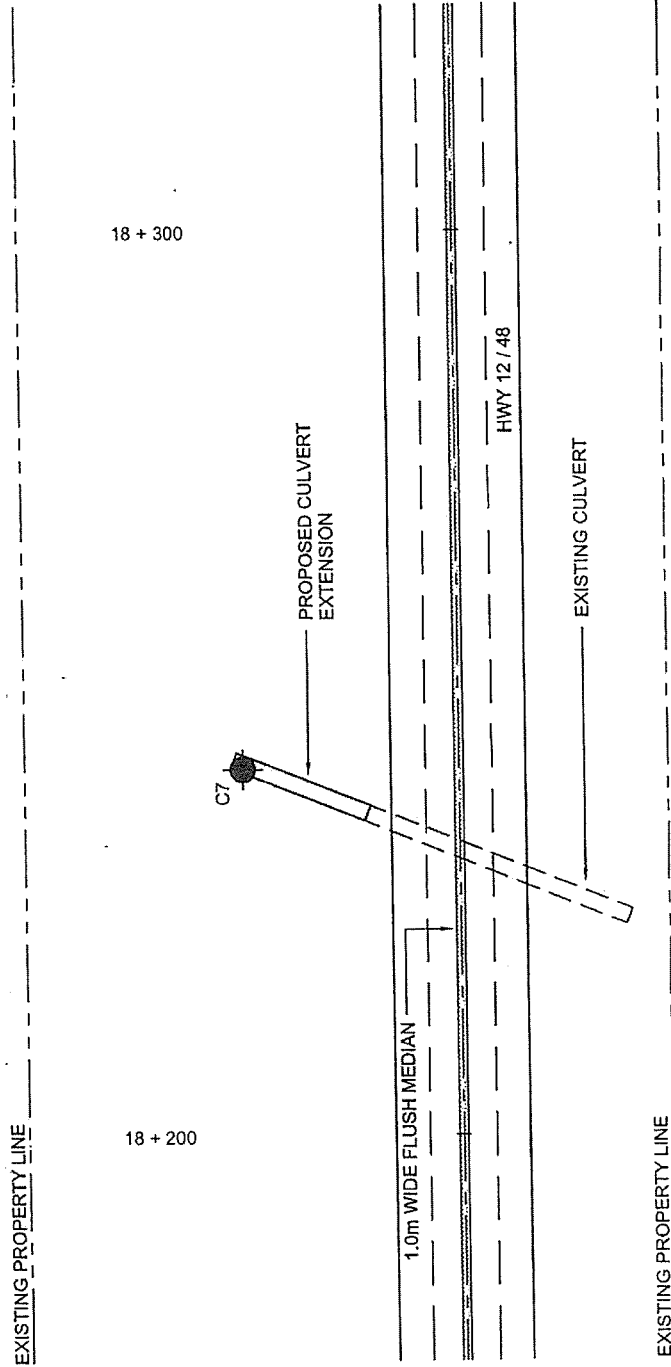
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
248.9 0.0	Ground Surface 460mm TOPSOIL		1	SS	12		248									
248.4 0.5	SILTY CLAY (Glacial Till) trace of sand, high plasticity grey to brown stiff		2	SS	11											
247.2 1.7	SILTY SAND (Glacial Till) some clay and gravel, grey/brown very dense		3	SS	100/ 25mm											
246.9 2.0	LIMESTONE light to medium grey with dark grey shaley partings and shale layers up to 100 mm in thickness		4	RC	RQD 42%											
245.4 3.5	fresh with slight weathering along discontinuities and shaley partings medium strong to very strong, shaley partings are weak to medium strong END OF BOREHOLE * Water level at 3.5 m (not stabilized) upon completion ** Piezometer installed to 3.5 m Water Level Record Date WL, El. (m) 22/06/01 247.8 29/07/02 247.8															

+ 3 X 3 Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

W.P. 611-89-00
Drawing No. 5
August, 2002

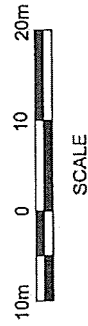
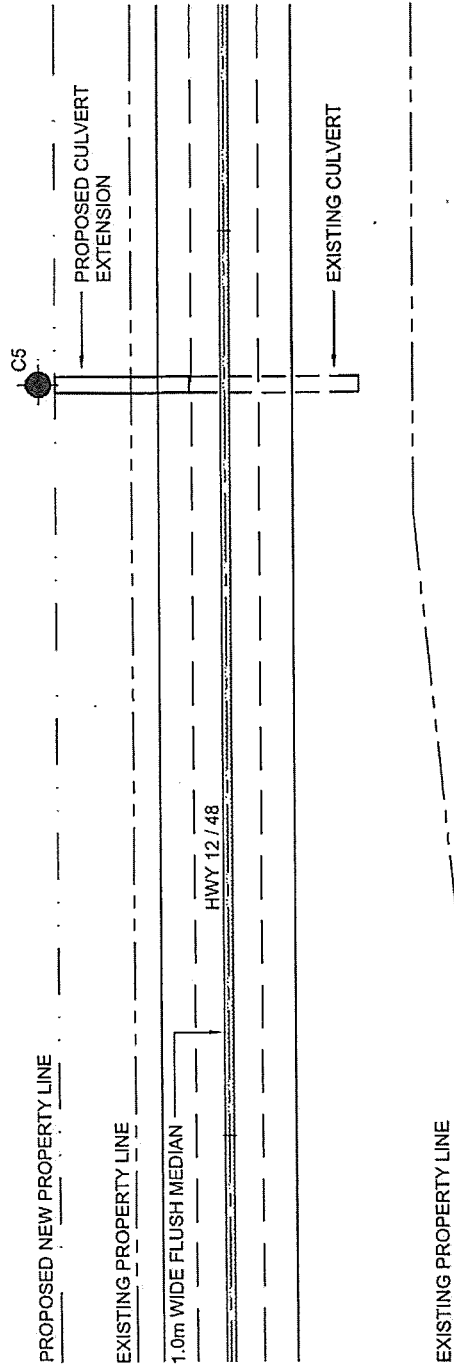
HIGHWAY 12 WIDENING
PROPOSED CULVERT EXTENSION AT STN 18+233.0
RORFHOLE LOCATION PLAN



RECORD OF BOREHOLE No C7										1 OF 1		METRIC				
W.P. 611-89-00		LOCATION From South Junction of Hwy 48 to North Junction of Hwy 48, ON - Coords: N 4 922 995.5, E 334 052.5				ORIGINATED BY P.D.										
DIST 7 HWY 12		BOREHOLE TYPE Solid Stem Augering				COMPILED BY J.S.										
DATUM Geodetic		DATE 8.8.01				CHECKED BY J.G.										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W		
234.6	Ground Surface															
0.0	500mm TOPSOIL		1	SS	5											
234.1			2	SS	5											
0.5	SILTY CLAY brown, firm															
232.9			3	SS	8											
1.7	SILTY CLAY (Glacial Till) some sand, trace of gravel grey, suff		4	SS	10											
231.6			5	SS	6											
3.0	GRAVELLY CLAYEY SILT (Glacial Till) grey, firm		6	SS	62/ 150mm											
230.6																
4.0	GRAVELLY SILTY SAND (Glacial Till)															
230.2	some clay, grey, very dense															
4.4	END OF BOREHOLE Refusal to augering at 4.4m															
	* Water level at 2.2 m (not stabilized) upon completion															
	** Piezometer installed to 4.3 m															
	Water Level Record Date WL, El. (m) 13/06/01 231.1 22/06/01 232.6 29/07/02 233.4															

SPT 1024C SPT 1024C GPJ ON MOT GDT 8/11/02

20 + 300



W.P. 611-89-00
Drawing No. 3
August, 2002

HIGHWAY 12 WIDENING
PROPOSED CULVERT EXTENSION AT STN 20+283.3
BOREHOLE LOCATION PLAN

RECORD OF BOREHOLE No C5

1 OF 1

METRIC

W.P. 611-89-00 LOCATION From South Junction of Hwy 48 to North Junction of Hwy 48, ON - Coords: N 4 924 913 2, E 333 443 7
DIST 7 HWY 12 BOREHOLE TYPE Solid Stem Augering
DATUM Geodetic DATE 12.6.01

ORIGINATED BY P.D.

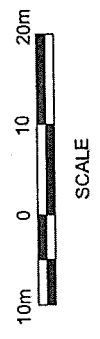
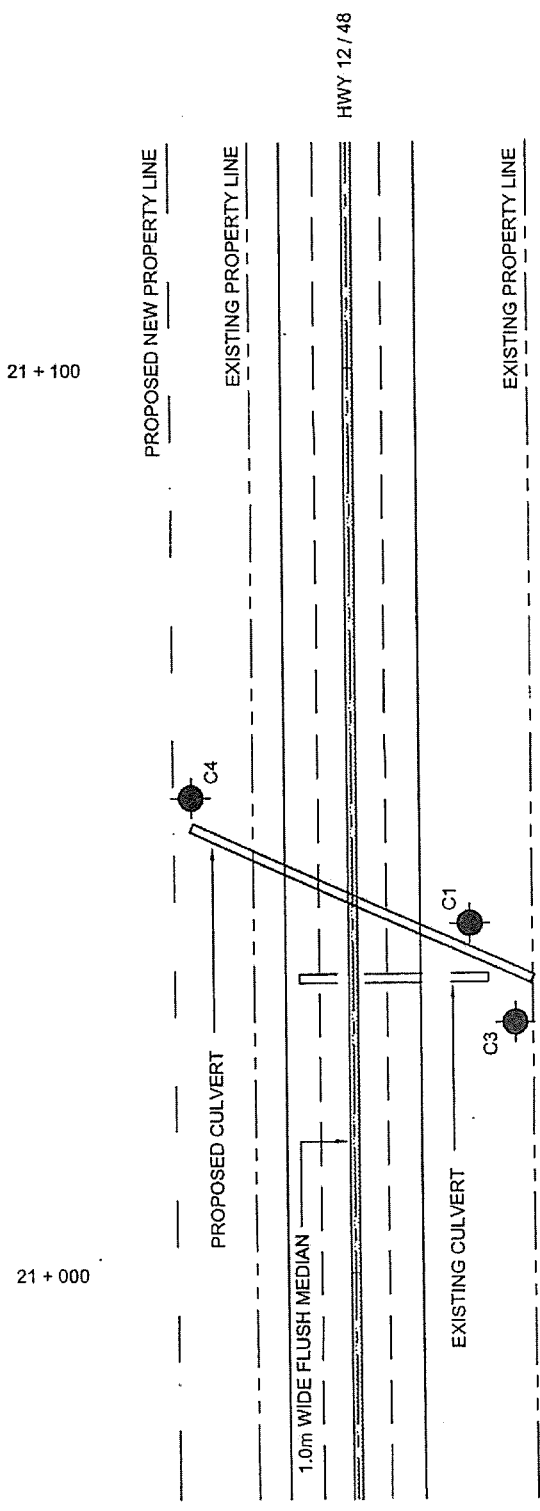
COMPILED BY J.S.

CHECKED BY J.G.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100					
232.01	Ground Surface															
0.01	TOPSOIL		1	SS	8											
231.61																
0.4	GRAVELLY SILTY SAND (Glacial Till) some clay gray to brown compact		2	SS	18											29 26 32 13
230.51																
1.5	SILTY SAND, trace of gravel brown, very dense		3	SS	64											12 57 26 5
230.2																
1.8	SILTY SAND (Glacial Till) trace of clay, some gravel brown, very dense															
229.7																
2.3	GRAVELLY SAND some silt brown, very dense		4	SS	51											
			5	SS	54											31 56 (13)
228.2																
3.8	SAND and GRAVEL some silt dense to very dense		6	SS	41											47 42 (11)
			7	SS	121/ 250mm											
226.81																
5.2	END OF BOREHOLE Refusal to augering at 5.2m Presumed bedrock * Water level at 1.5 m (not stabilized) upon completion ** Piezometer installed to 4.0 m Water Level Record Date WL, El. (m) 13/06/01 229.9 22/06/01 230.5															

SPT 1024C SPT 1024C GPJ ON MOT GDT 8/11/02

CULVERT 48



W.P. 611-89-00
Drawing No. 2
August, 2002

HIGHWAY 12 WIDENING
PROPOSED CULVERT EXTENSION AT STN 21+066.0
BOREHOLE LOCATION PLAN

RECORD OF BOREHOLE No C1										1 OF 1		METRIC	
W.P. 611-89-00		LOCATION From South Junction of Hwy 48 to North Junction of Hwy 48, ON - Coords: N 4 925 663.5; E 333 233.1						ORIGINATED BY P.D.					
DIST 7 HWY 12		BOREHOLE TYPE Solid Stem Augering						COMPILED BY J.S.					
DATUM Geodetic		DATE 11.6.01						CHECKED BY J.G.					

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
						○ UNCONFINED + FIELD VANE ■ QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%)						
						20	40	60	80	100	10	20	30	kN/m ³	GR SA SI CL	
230.8	Ground Surface															
0.0	355 mm GRAVELLY SAND		1	SS	10											
230.4																
0.4	FILL mixture of sand and clayey silt occ. clay lumps, trace of gravel brown, loose or firm		2	SS	8										4 51 (45)	
229.0			3	SS	8											
1.8	SILTY CLAY brown to grey, firm to very stiff		4	SS	7										0 3 69 28	
226.2			5	SS	4											
4.9			6	AS	-											
225.8	SANDY CLAYEY SILT (Glacial Till) some gravel, brown, hard		7	SS	98/150mm											
4.9	SILTY SAND some gravel, trace of clay grey, very dense															
225.5	END OF BOREHOLE Refusal to augering at 5.3m Presumed bedrock															
5.3																
* Water level at 4.0 m (not stabilized) upon completion ** Piezometer installed to 5.2 m Water Level Record Date W.L. El. (m) 12/08/01 228.8 13/06/01 228.7 22/06/01 230.1																

ON MOT SPT 1024C.GPJ ON MOT.GDT 22/11/02

RECORD OF BOREHOLE No C3

1 OF 1

METRIC

W.P. 611-89-00 LOCATION From South Junction of Hwy 48 to North Junction of Hwy 48, ON - Coords: N 4 925 881.1 E 333 238.8 ORIGINATED BY P.D.
DIST 7 HWY 12 BOREHOLE TYPE Hand Augering COMPILED BY J.S.
DATUM Geodetic DATE 11.6.01 CHECKED BY J.G.

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	NUMBER	TYPE			"N" VALUES	20 40 60 80 100					
228.5	Ground Surface											
228.2	300mm TOPSOIL	1	AS	-								
0.3	SILTY CLAY organic stained with rootlets to 1.2 m brown-black to grey inferred to be soft to firm	2	AS	-								
		3	AS	-								
		4	AS	-								
		5	AS	-								
226.7	END OF BOREHOLE	6	AS	-								
1.8	* Water level at 0.4 m (not stabilized) upon completion											

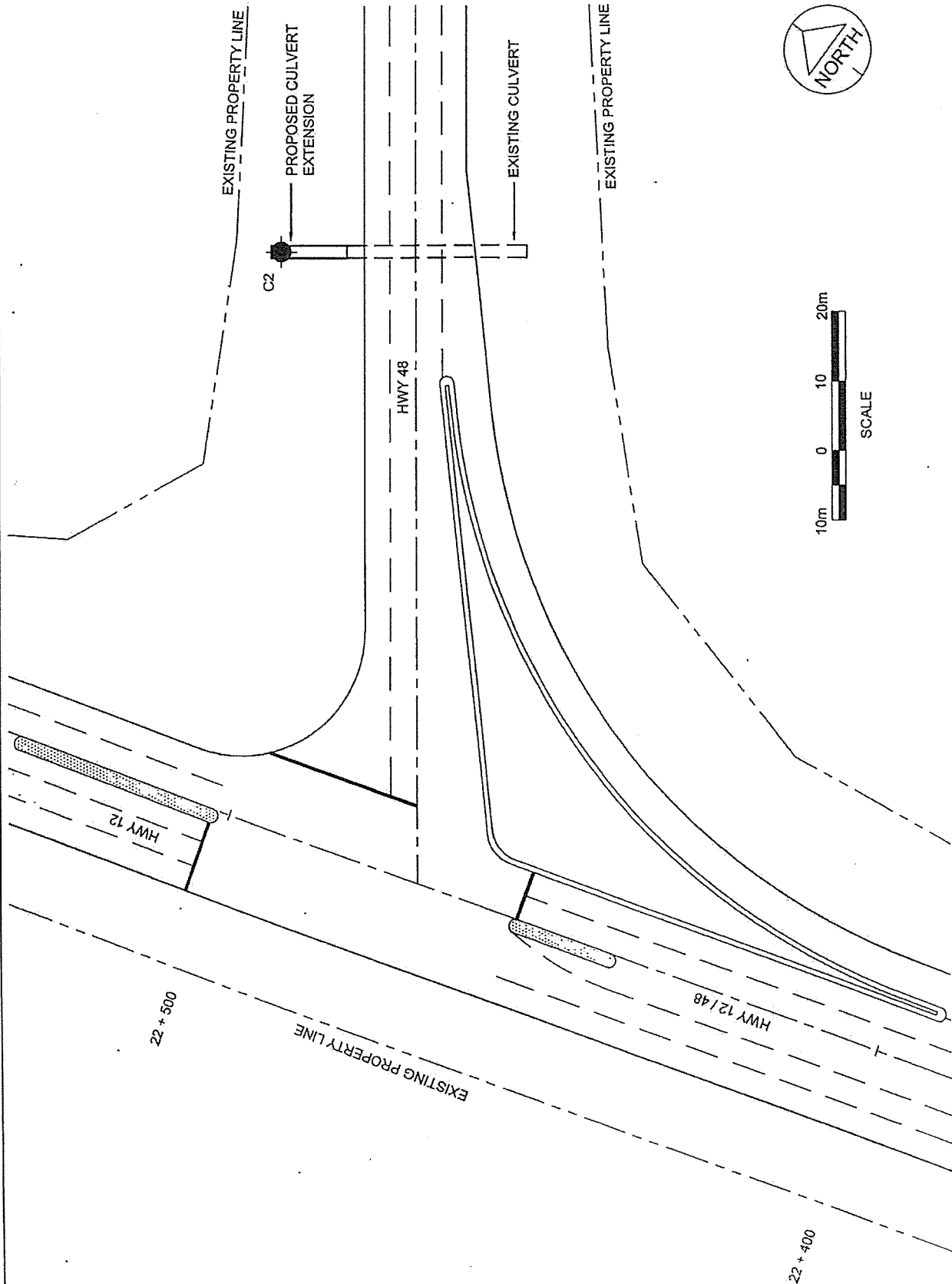
SPT 1024C SPT 1024C GPJ ON MOT GDT B71102

RECORD OF BOREHOLE No C4										1 OF 1		METRIC		
W.P. 611-89-00		LOCATION From South Junction of Hwy 48 to North Junction of Hwy 48, ON - Coords: N 4 925 672.4; E 333 198.8				ORIGINATED BY P.D.								
DIST 7 HWY 12		BOREHOLE TYPE Solid Stem Augering				COMPILED BY J.S.								
DATUM Geodetic		DATE 12.6.01				CHECKED BY J.G.								
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						
229.1	Ground Surface													
0.0	750mm TOPSOIL		1	SS	7									
228.3	SILTY CLAY brown firm		2	SS	7									
0.8			3	SS	5									
			4	SS	6									
			5	SS	6									
225.9	SAND and SILT (Glacial Till) some gravel and clay grey loose													
3.2														
225.4														
3.7	END OF BOREHOLE Refusal to augering at 3.7m Presumed bedrock													
	* Water level at 1.3 m (not stabilized) upon completion ** Piezometer installed to 3.7 m Water Level Record Date WL, El. (m) 13/06/01 227.1 22/06/01 228.8 29/07/02 228.6													

SPT 1024C SPT 1024C.GPJ ON MOT.GDT 8/1/02

W.P. 611-89-00
Drawing No. 1
August, 2002

HIGHWAY 12 WIDENING PROPOSED CULVERT EXTENSION AT HWY 48, NORTH, 91m EAST OF HWY 12 BOREHOLE LOCATION PLAN





RECORD OF BOREHOLE No C2

1 OF 2

METRIC

W.P. 611-89-00

LOCATION From South Junction of Hwy 48 to North Junction of Hwy 48, ON - Coords: N 4 927 074 7: E 332 683.4

ORIGINATED BY P.D.

DIST 7 HWY 12

BOREHOLE TYPE Solid Stem Augering

COMPILED BY J.S.

DATUM Geodetic

DATE 11.6.01

CHECKED BY J.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
220.4	Ground Surface												
0.0	450mm TOPSOIL		1	SS	5		220						
219.9			2	SS	1		219						
0.5	SILTY CLAY trace of sand firm to stiff		3	SS	2		218	7.3					0 6 68 26
			4	SS	5		217	5.5					
			5	TW	PH		216	5.3					
			6	SS	2		215	8.0					0 0 52 48
			7	SS	1		214	4.0					
			8	SS	1		213	2.5					
			9	SS	0		212	2.4					
			10	SS	0		211						
			11	SS	0		210						
209.6			12	SS	19		209						
10.8	SAND and SILT some clay with silty clay seams grey compact to dense		13	SS	21		208						
			14	SS	31		207						0 40 49 11
							206						

SPT 1024C SPT 1024C GPJ ON MOT GDT B11102

Continued Next Page

3 × 3 Numbers refer to Sensitivity

3% STRAIN AT FAILURE

CHIRCO

RECORD OF BOREHOLE No C2										2 OF 2		METRIC								
W.P. 511-89-00		LOCATION From South Junction of Hwy 48 to North Junction of Hwy 48, DN - Coords: N 4 927 074.7; E 332 863.4								ORIGINATED BY P.D.										
DIST 7 HWY 12		BOREHOLE TYPE Solid Stem Augering								COMPILED BY J.S.										
DATUM Geodetic		DATE 11.6.01								CHECKED BY J.G.										
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			20	40	60						80	100	20	40	60
205.2	SAND and SILT (Glacial Till) some clay, trace of gravel grey compact to dense	[Strat Plot]	15	SS	14	[Ground Water Conditions]	205													
202.1	SAND and SILT trace of clay grey very dense	[Strat Plot]	16	SS	34	[Ground Water Conditions]	204													
202.1	SAND and SILT trace of clay grey very dense	[Strat Plot]	17	SS	110	[Ground Water Conditions]	203													
200.4	END OF BOREHOLE	[Strat Plot]	18	SS	108/50mm	[Ground Water Conditions]	202													
20.0	END OF BOREHOLE	[Strat Plot]				[Ground Water Conditions]	201													
* Water level at 0.9 m (not stabilized) upon completion ** Piezometer installed to 16.8 m Water Level Record Date W.L. El.(m) 12/06/01 208.9 13/06/01 211.9 22/06/01 219.7 29/07/02 219.9																				

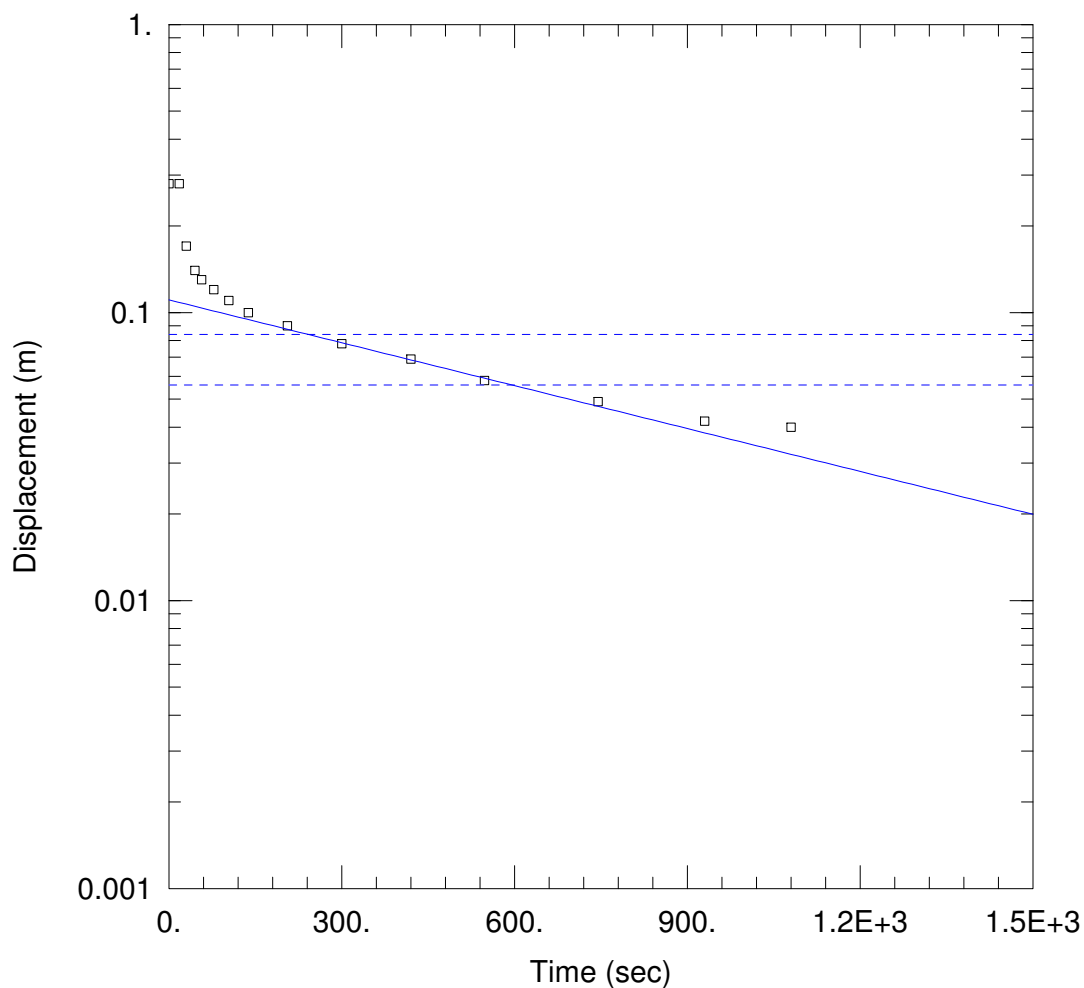
+ 3 . x 3. Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

SPT 1024C SPT 1024C GPJ ON MOT GDT 8/11/02

APPENDIX D

HYDRAULIC TESTING



CULVERT 12

Data Set: C:\...\culvert12.aqt

Date: 02/16/12

Time: 11:33:10

PROJECT INFORMATION

Company: Stantec

Client: MTO

Project: 122410792

Test Well: Culvert 12

Test Date: Feb 15, 2012

AQUIFER DATA

Saturated Thickness: 0.9144 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (Culvert 12)

Initial Displacement: 0.28 m

Static Water Column Height: 0.9144 m

Total Well Penetration Depth: 0.9144 m

Screen Length: 0.9144 m

Casing Radius: 0.009525 m

Well Radius: 0.009525 m

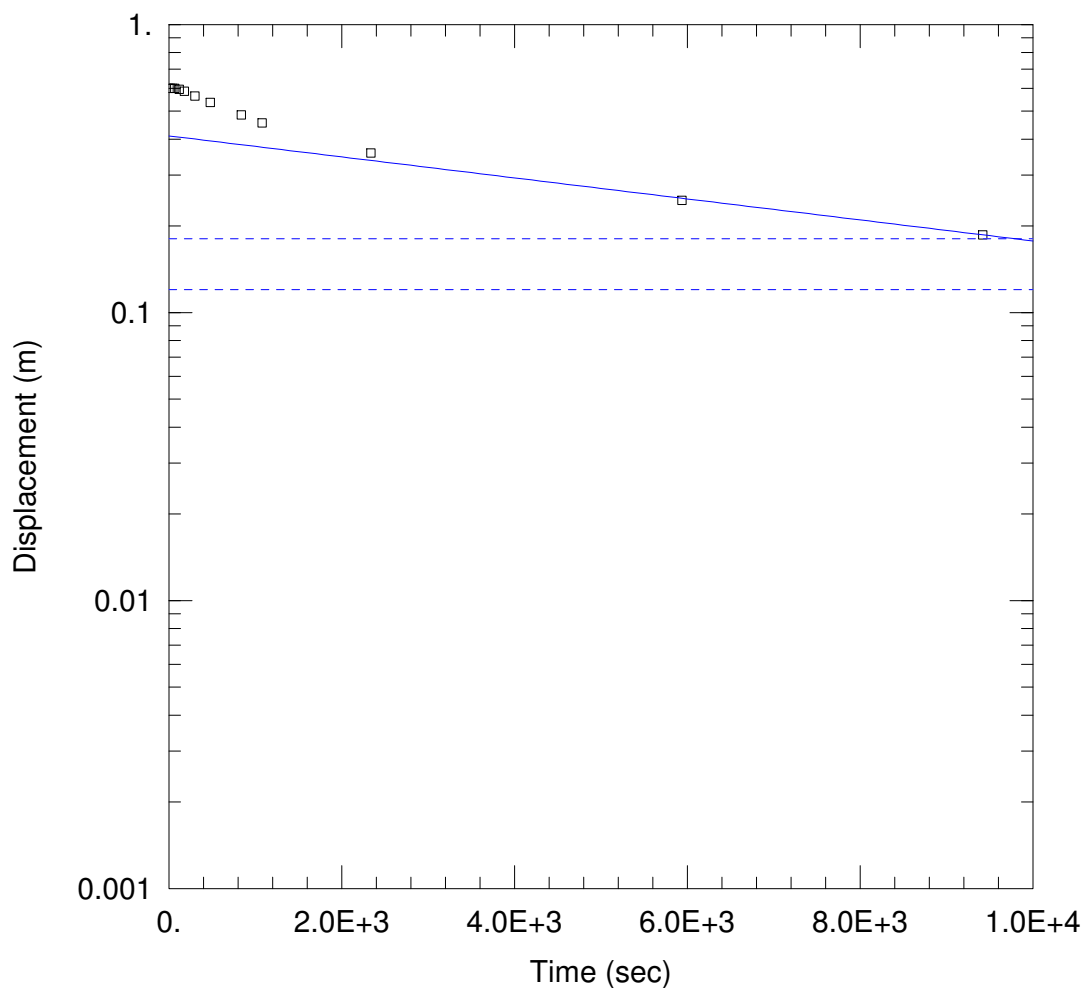
SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 1.991E-7$ m/sec

$y_0 = 0.1106$ m



CULVERT 36

Data Set: C:\...\culvert36.aqt

Date: 02/16/12

Time: 12:45:02

PROJECT INFORMATION

Company: Stantec

Client: MTO

Project: 122410792

Test Well: Culvert 36

Test Date: Feb 15, 2012

AQUIFER DATA

Saturated Thickness: 0.9144 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (Culvert 36)

Initial Displacement: 0.601 m

Static Water Column Height: 0.9144 m

Total Well Penetration Depth: 0.9144 m

Screen Length: 0.9144 m

Casing Radius: 0.009525 m

Well Radius: 0.009525 m

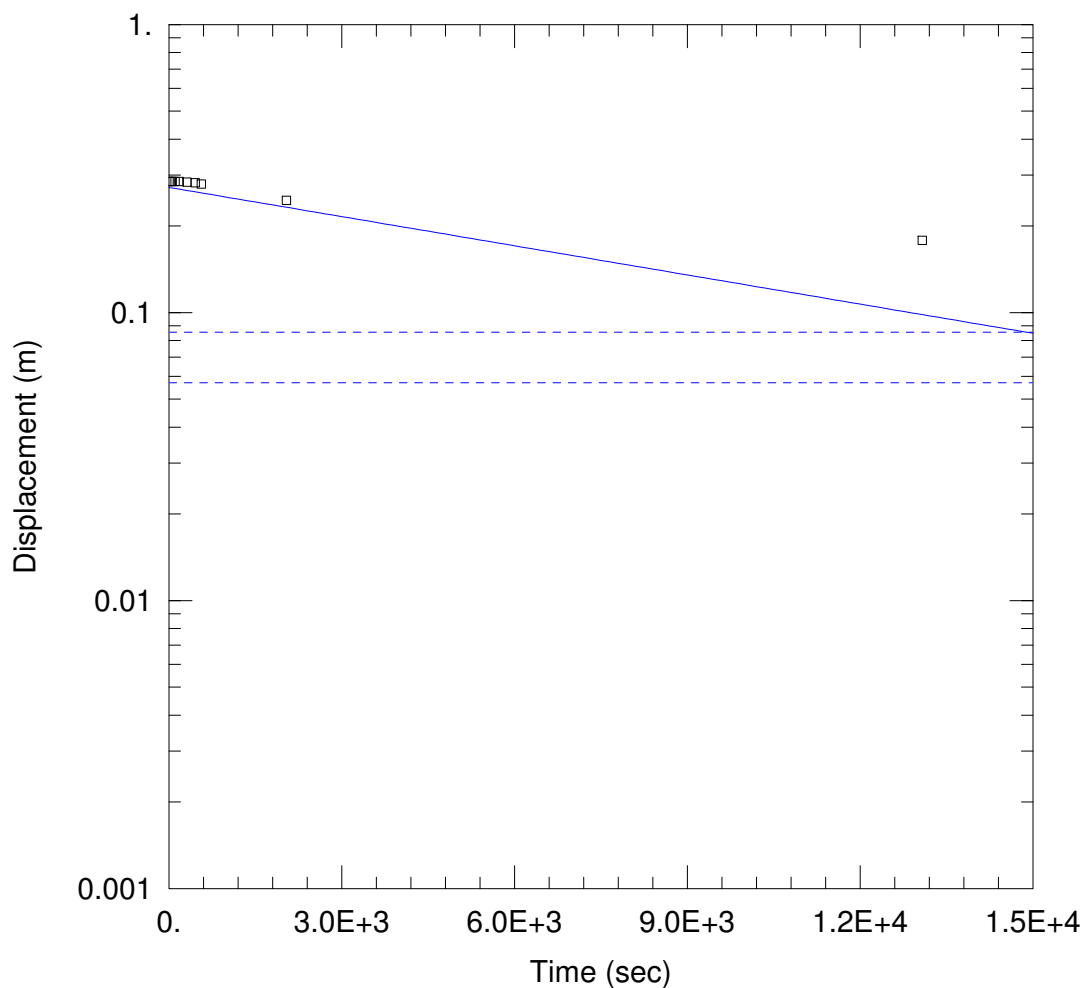
SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 1.463E-8$ m/sec

$y_0 = 0.4104$ m



CULVERT 48

Data Set: C:\...\culvert48.aqt

Date: 02/16/12

Time: 12:45:33

PROJECT INFORMATION

Company: Stantec

Client: MTO

Project: 122410792

Test Well: Culvert 48

Test Date: Feb 15, 2012

AQUIFER DATA

Saturated Thickness: 0.9144 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (Culvert 48)

Initial Displacement: 0.285 m

Static Water Column Height: 0.9144 m

Total Well Penetration Depth: 0.9144 m

Screen Length: 0.9144 m

Casing Radius: 0.009525 m

Well Radius: 0.009525 m

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 1.355E-8$ m/sec

$y_0 = 0.2719$ m

APPENDIX E

HYDROLOGY

```
00001> 2      Metric units
00002> *#*****
00003> *# Project Name: [HWY 12 PTTW] Project Number:[1224-10792]
00004> *# Date       : 24-2-2012
00005> *# Company    : Stantec Consulting Ltd. (Kitchener)
00006> *# Modeller   : George Golding, EIT
00007> *# License #   : 4730904
00008> *#*****
00009> *# HWY9: EXISTING CONDITONS MODEL
00010> *# 5-YEAR 6HR SCS STORMS (LINDSEY FILTRATION PLANT IDF)
00011> *# NOTE: HYDROLOGY PARAMETERS BASED ON W.G.CLARKE REPORT
00012> *#*****
00013> START          TZERO=[0.0], METOUT=[2], NSTORM=[1], NRUN=[1]
00014> *%             ["6HSCS5Y.STM"] <--storm filename, one per line for NSTORM t
00015> *%-----|-----|
00016> READ STORM      STORM_FILENAME=["STORM.001"]
00017> *#-----|-----|
00018> *#             CULVERT NO. 1
00019> *#-----|-----|
00020> DESIGN NASHYD    ID=[1], NHYD=["C1"], DT=[1]min, AREA=[16] (ha),
00021>                 DWF=[0] (cms), CN/C=[77.8], TP=[0.68]hrs,
00022>                 RAINFALL=[ , , , ] (mm/hr), END=-1
00023> *#-----|-----|
00024> *#             CULVERT NO. 12
00025> *#-----|-----|
00026> DESIGN NASHYD    ID=[2], NHYD=["C12"], DT=[1]min, AREA=[48.8] (ha),
00027>                 DWF=[0] (cms), CN/C=[67.1], TP=[0.47]hrs,
00028>                 RAINFALL=[ , , , ] (mm/hr), END=-1
00029> *#-----|-----|
00030> *#             CULVERT NO. 36
00031> *#-----|-----|
00032> DESIGN NASHYD    ID=[3], NHYD=["C36"], DT=[1]min, AREA=[189.6] (ha),
00033>                 DWF=[0] (cms), CN/C=[48.2], TP=[1.42]hrs,
00034>                 RAINFALL=[ , , , ] (mm/hr), END=-1
00035> *#-----|-----|
00036> *#             CULVERT NO. 44
00037> *#-----|-----|
00038> DESIGN NASHYD    ID=[4], NHYD=["C44"], DT=[1]min, AREA=[20.7] (ha),
00039>                 DWF=[0] (cms), CN/C=[66.7], TP=[1.29]hrs,
00040>                 RAINFALL=[ , , , ] (mm/hr), END=-1
00041> *#-----|-----|
00042> *#             CULVERT NO. 48
00043> *#-----|-----|
00044> DESIGN NASHYD    ID=[5], NHYD=["C48"], DT=[1]min, AREA=[30.9] (ha),
00045>                 DWF=[0] (cms), CN/C=[69.0], TP=[0.53]hrs,
00046>                 RAINFALL=[ , , , ] (mm/hr), END=-1
00047> *#-----|-----|
00048> *#             CULVERT NO. 55
00049> *#-----|-----|
00050> DESIGN NASHYD    ID=[6], NHYD=["C55"], DT=[1]min, AREA=[97.3] (ha),
00051>                 DWF=[0] (cms), CN/C=[75.7], TP=[1.52]hrs,
00052>                 RAINFALL=[ , , , ] (mm/hr), END=-1
00053> *#-----|-----|
00054> FINISH
00055>
```



```
00001> =====
00002>
00003> SSSSS W W M M H H Y Y M M OOO 999 999 =====
00004> S W W W MM MM H H Y Y MM MM O O 9 9 9 9
00005> SSSSS W W W M M M HHHHH Y M M M O O ## 9 9 9 9 Ver. 4.02
00006> S W W M M H H Y M M O O 9999 9999 July 1999
00007> SSSSS W W M M H H Y M M OOO 9 9 =====
00008> 9 9 9 9 # 4730904
00009> StormWater Management HYdrologic Model 999 999 =====
00010>
00011> *****
00012> ***** SWMHYMO-99 Ver/4.02 *****
00013> ***** A single event and continuous hydrologic simulation model *****
00014> ***** based on the principles of HYMO and its successors *****
00015> ***** OTTHYMO-83 and OTTHYMO-89. *****
00016> *****
00017> ***** Distributed by: J.F. Sabourin and Associates Inc. *****
00018> ***** Ottawa, Ontario: (613) 727-5199 *****
00019> ***** Gatineau, Quebec: (819) 243-6858 *****
00020> ***** E-Mail: swmhymo@jfsa.Com *****
00021> *****
00022>
00023> ++++++
00024> ++++++ Licensed user: Stantec Consulting Ltd. (Kitchener) ++++++
00025> ++++++ Kitchener SERIAL#:4730904 ++++++
00026> ++++++
00027>
00028> *****
00029> ***** ++++++ PROGRAM ARRAY DIMENSIONS ++++++ *****
00030> ***** Maximum value for ID numbers : 10 *****
00031> ***** Max. number of rainfall points: 15000 *****
00032> ***** Max. number of flow points : 15000 *****
00033> *****
00034>
00035> *** DESCRIPTION SUMMARY TABLE HEADERS (units depend on METOUT in START) ***
00036> ***-----***
00037> *** ID: Hydrograph IDentification numbers, (1-10). ***
00038> *** NYHD: Hydrograph reference numbers, (6 digits or characters). ***
00039> *** AREA: Drainage area associated with hydrograph, (ac.) or (ha.). ***
00040> *** QPEAK: Peak flow of simulated hydrograph, (ft^3/s) or (m^3/s). ***
00041> *** TpeakDate_hh:mm is the date and time of the peak flow. ***
00042> *** R.V.: Runoff Volume of simulated hydrograph, (in) or (mm). ***
00043> *** R.C.: Runoff Coefficient of simulated hydrograph, (ratio). ***
00044> *** *: see WARNING or NOTE message printed at end of run. ***
00045> *** **: see ERROR message printed at end of run. ***
00046> *****
00047> *****
00048>
00049> ::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
00050>
00051> *****
00052>
00053> ***** S U M M A R Y O U T P U T *****
00054> *****
00055> * DATE: 2012-02-24 TIME: 10:27:01 RUN COUNTER: 000821 *
00056> *****
00057> * Input filename: C:\SWMHYMO\122410~1\Hwy_12.dat *
00058> * Output filename: C:\SWMHYMO\122410~1\Hwy_12.out *
00059> * Summary filename: C:\SWMHYMO\122410~1\Hwy_12.sum *
00060> * User comments: *
00061> * 1:_____ *
00062> * 2:_____ *
00063> * 3:_____ *
00064> *****
00065>
```

```
00066>
00067> #*****
00068> #   Project Name: [HWY 12 PTTW] Project Number:[1224-10792]
00069> #   Date       : 24-2-2012
00070> #   Company    : Stantec Consulting Ltd. (Kitchener)
00071> #   Modeller   : George Golding, EIT
00072> #   License #  : 4730904
00073> #*****
00074> #   HWY9: EXISTING CONDITONS MODEL
00075> #   5-YEAR 6HR SCS STORMS (LINDSEY FILTRATION PLANT IDF)
00076> #   NOTE: HYDROLOGY PARAMETERS BASED ON W.G.CLARKE REPORT
00077> #*****
00078> RUN:COMMAND#
00079> 001:0001-----
00080>     START
00081>     [TZERO =    .00 hrs on        0]
00082>     [METOUT=    2      (1=imperial, 2=metric output)]
00083>     [NSTORM=    1 ]
00084>     [NRUN  =    1 ]
00085> 001:0002-----
00086>     READ STORM
00087>     Filename = STORM.001
00088>     Comment  = SCS-II 6H 5 year LINDSEY
00089>     [SDT=15.00:SDUR=    6.00:PTOT=  50.80]
00090> #-----|-----
00091> #           CULVERT NO. 1
00092> #-----|-----
00093> 001:0003-----ID:NHYD-----AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.
00094>     DESIGN NASHYD      01:C1      16.00      .462 No_date    3:40    19.96 .393
00095>     [CN= 77.8: N= 3.00]
00096>     [Tp=  .68:DT= 1.00]
00097> #-----|-----
00098> #           CULVERT NO. 12
00099> #-----|-----
00100> 001:0004-----ID:NHYD-----AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.
00101>     DESIGN NASHYD      02:C12     48.80     1.256 No_date    3:25    13.98 .275
00102>     [CN= 67.1: N= 3.00]
00103>     [Tp=  .47:DT= 1.00]
00104> #-----|-----
00105> #           CULVERT NO. 36
00106> #-----|-----
00107> 001:0005-----ID:NHYD-----AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.
00108>     DESIGN NASHYD      03:C36    189.60     1.161 No_date    4:38     7.54 .148
00109>     [CN= 48.2: N= 3.00]
00110>     [Tp= 1.42:DT= 1.00]
00111> #-----|-----
00112> #           CULVERT NO. 44
00113> #-----|-----
00114> 001:0006-----ID:NHYD-----AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.
00115>     DESIGN NASHYD      04:C44     20.70      .252 No_date    4:26    13.80 .272
00116>     [CN= 66.7: N= 3.00]
00117>     [Tp= 1.29:DT= 1.00]
00118> #-----|-----
00119> #           CULVERT NO. 48
00120> #-----|-----
00121> 001:0007-----ID:NHYD-----AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.
00122>     DESIGN NASHYD      05:C48     30.90      .781 No_date    3:30    14.87 .293
00123>     [CN= 69.0: N= 3.00]
00124>     [Tp=  .53:DT= 1.00]
00125> #-----|-----
00126> #           CULVERT NO. 55
00127> #-----|-----
00128> 001:0008-----ID:NHYD-----AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.
00129>     DESIGN NASHYD      06:C55     97.30     1.421 No_date    4:42    18.58 .366
00130>     [CN= 75.7: N= 3.00]
```

```
00131> [Tp= 1.52:DT= 1.00]
00132> #-----|-----
00133> 001:0009-----
00134> FINISH
00135> -----
00136> *****
00137> WARNINGS / ERRORS / NOTES
00138> -----
00139> Simulation ended on 2012-02-24 at 10:27:01
00140> =====
00141>
00142>
```