



THURBER ENGINEERING LTD.

Preliminary Hydrogeological Investigation Report

**North Halton Coordinated Municipal Class Environmental Assessment Study,
Halton Regional Road 25 from 5 Side Road to 10 Side Road,
Town of Halton Hills, Regional Municipality of Halton, Ontario**

Client: HDR Inc.

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1. INTRODUCTION

This report presents the results of a preliminary hydrogeological investigation completed for the proposed improvements and localized widening of Halton Regional Road 25 between 5 Side Road and 10 Side Road in the Town of Halton Hills as part of the North Halton Coordinated Municipal Class Environmental Assessment (MCEA) Study, initiated by the Regional Municipality of Halton (Halton Region).

Regional Road 25 is a major north-south two-lane arterial rural road in Halton Region. In order to support future travel demand and a transportation system that is safe, continuous, connected, and coordinated for all users and abilities, the recommended solution for Regional Road 25 involves improving active transportation facilities, improving traffic operations at intersections through physical and operational modifications, and widening Regional Road 25 to provide additional travel lanes and opportunities for transit supportive infrastructure.

The purpose of the hydrogeological investigation is to establish baseline hydrogeological conditions within the site, assess groundwater conditions, evaluate construction dewatering requirements, assess the potential impacts that the proposed construction works may have on the local groundwater quantity and quality, and determine preliminary water taking permit requirements.

Thurber Engineering Ltd. (Thurber) carried out the investigation as a sub-consultant to HDR Inc. (HDR) who is conducting the MCEA Study for the Halton Region.

A preliminary geotechnical investigation report was completed concurrently for this project under separate cover by Thurber and should be read in conjunction with this report.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. BACKGROUND REVIEW

2.1 Site and Project Description

Regional Road 25 is a major north-south two-lane arterial rural road. The project area is an approximately 3.0 km long portion of Regional Road 25 between 5 Side Road and 10 Side Road in the Town of Halton Hills, Ontario (the Site). The study area for the hydrogeological investigation was defined as 500 m around the Site and is located in the Towns of Halton Hills and Milton (Study Area). The locations of the Site and Study Area are shown on Figure 1.

Based on a review of the official plans of the Town of Halton Hills (Schedules A1 and A2), Town of Milton (Schedule B), and Halton Region (Maps 1 and 1A), the land uses adjacent to the Site and within the Study Area consist of Niagara Escarpment Plan area, protected countryside area, industrial area, business park area, agricultural area, urban Area, Greenbelt plan, and natural heritage system (Town of Halton Hills, 2020; Town of Milton, 2023; Halton Region, 2022). In general, the land use surrounding the Site consists of vacant, agricultural/farmland, woodlot, houses, and commercial golf courses. To the south of the Site and around 5 Side Road, the land use consists primarily of commercial/industrial properties.

2.2 Topography and Drainage

The Site is located within the Sixteen Mile Creek watershed and falls under the jurisdiction of the Conservation Halton (CH). The watershed includes parts of the Town of Halton Hills, Town of Milton, Town of Oakville, and the City of Mississauga. The total watershed area is 377 square kilometres. The Sixteen Mile Creek includes three (3) main branches: East, Middle, and West branches, with a total length of approximately 150 kilometres. The watershed drains from its headwaters near Highway 7 in a southeasterly direction to its outlet south of Lakeshore Road into Lake Ontario (Gore & Storrie Ltd. and Ecoplans Ltd., 1996).

The regional topography slopes downward in a southeasterly direction. The topography at the Site varies from approximate elevations of 245 m near 10 Side Road to 230 m near 5 Side Road (Figure 2). Overland flow is expected to be influenced by existing topography and local surface water features. It is anticipated that overland flow follows the existing topography in the southeast direction.

2.3 Physiography

A review of the Physiographic Regions of Southern Ontario indicated that the Site is located primarily within the Physiographic Region of the South Slope. The South Slope is typically a drumlinized area consisting of areas of thin (<1 m) aeolian sand deposits underlain by glacial deposits (Chapman and Putnam, 1984). The Physiographic Region of the Niagara Escarpment is observed in the north and west portions of the Study Area. The Niagara Escarpment extends from the Niagara River to the northern tip of the Bruce Peninsula and continues through the Manitoulin Islands. The escarpment represents the greatest topographic break produced by differential erosion of harder and softer rock in Ontario. The Niagara Escarpment is typically characterized by grey, carbonate rock cliffs overlooking long slopes carved in red shale, standing in sharp contrast to the gentler glaciated landscapes of the plains that flank it at both upper and lower levels (Chapman and Putnam, 1984). The Physiographic Region of the Peel Plain is also

observed to the south of the Study Area. A physiographic region map of the Site and surrounding area is shown on Figure 3.

2.4 Regional Geology and Hydrogeology Settings

Geological and hydrogeological conditions were based on publicly available information obtained from the Ontario Geological Survey (OGS), and York, Peel, Durham, Toronto and the Conservation Authorities Moraine Coalition (YPDT-CAMC) Oak Ridges Moraine Groundwater Program (ORMGP).

The surficial geology of the Site consists mainly of till consisting of clay to silt-textured till (derived from glaciolacustrine deposits or shale). Ice-contact stratified deposits of sand and gravel, with minor silt, clay, and till are observed partially along the north portion of the Site. Additionally, modern alluvial deposits of clay, silt, sand, and gravel are also reported partially along the creeks. Organic deposits of peat, muck, and marl are also reported in the small area within the central portion of the Site. Figure 4 illustrates the mapped surficial geology of the Site.

The bedrock underlying the Site consists of red shale of the Queenston Formation, consisting of shale and siltstone with minor limestone and sandstone. A bedrock geology map is presented on Figure 5.

A regional north to south geological cross section using the ORMGP's mapping tools along the Site is provided on Figure 6. Based on a review of the regional geological cross section, the following units overlie the bedrock from youngest to oldest:

- Undifferentiated Upper Sediments;
- Halton Till (Aquitard);
- Oak Ridges Moraine (Aquifer);
- Newmarket Till (Aquitard);
- Thorncliffe Formation (Aquifer); and,
- Scarborough Formation (Aquifer).

A description of each hydrostratigraphic unit is provided below:

- Undifferentiated Upper Sediments – These deposits vary from near shore sand and gravel beach deposits of the Lake Iroquois shoreline to the fine sands, silts, and clays of glaciolacustrine pondings that occur north of the Lake Iroquois shoreline. Based on the regional cross section, the thickness of this unit in the vicinity of the Site ranged from absent/thin to 5 m.

- Halton Till – The Halton Till comprises of sandy silt to clayey silt till interbedded with silt, sand and gravel, with clay-rich deposits encountered in some areas. This unit's thickness in the vicinity of the Site ranged from approximately 6 m to 18 m.
- Oak Ridges Moraine (ORM) – The uppermost aquifer underlying the Site is the ORM, which consists of sediments that includes discontinuous sands and gravels. Based on the regional cross section, the ORM is absent/thin to the north of the Site and is approximately up to 9 m thick to the south of the Site.
- Newmarket Till – The Newmarket Till consists of a massive, stony, and consistently dense silty sand. It acts as a regional aquitard separating the ORM from the underlying Thorncliffe formation. This unit's thickness in the vicinity of the Site ranged from absent/thin to the south of the Site up to 17 m in the north portion of the Site.
- Thorncliffe Formation – The Thorncliffe Formation consist of glaciofluvial deposits of sand and silty sand within pre-existing valleys. The Thorncliffe formation is typically considered an aquifer, and its thickness ranged from absent/thin to approximately 8 m in the vicinity of the Site.
- Scarborough Formation – The Scarborough Formation is deposited as part of a large fluvial deltaic system fed by large, braided melt-water rivers draining from an ice sheet, flowing from Georgian Bay to Lake Ontario over an approximate area of 200 km². Scarborough Formation is mostly found to the north of the Site with an approximate thickness of up to 6 m.

Based on the regional geologic cross section, the bedrock surface elevations in the Site ranged approximately from 216 m (north portion of the Site) to 203 m (south of the Site).

Information obtained from the ORMGP mapping shows that groundwater flows southeasterly toward tributaries of Sixteen Mile Creek, and ultimately to Lake Ontario.

2.5 MECP Water Well Records Review

A search of the Ministry of Environment, Conservation and Parks (MECP) well records database conducted for a 500 m radius around the Site returned a total of 112 records (Figure 7). Based on the MECP well records, the use of the well records was reported as observation, test hole, abandoned, and unknown. Seventy-four water supply wells were also found within the Study area, most of which were installed between the 1950s and 2010s (only one well was installed in 2021). A summary of the MECP's water well record database is provided in Appendix A.

2.6 Existing Water Taking Permits

A search of permitted water takers within the Study Area was conducted in June 2024. The search returned no active Permit to Take Water (PTTW) and no active Environmental Activity and Sector Registry (EASR) for construction dewatering within the Study Area.

2.7 Environmental Features

Based on the regional-scale source protection information Atlas mapping, the Site is not located within Wellhead Protection Areas (WHPAs), or Highly Vulnerable Aquifers (HVAs). However, the north portion of the Site is located within the Significant Groundwater Recharge Areas (SGRAs). Based on the Conservation Halton online mapping (planning and permits), the Site is partially located within the regulated limits.

A search on the Ministry of Natural Resources and Forestry (MNRF) online mapping in June 2024 indicated that there are a number of woodlands, watercourses, wetlands, natural heritage systems, Niagara Escarpment areas, and Greenbelt protected countryside within the Study Area. A number of tributaries of Middle Sixteen Mile Creek are located within the Site and Study Area. The roadway crosses over two (2) tributaries of Middle Sixteen Mile Creek located approximately 1.1 and 1.6 km north of 5 Side Road. One (1) pond was also found near Chudleigh's Farm to the northwest of Regional Road 25 and Northern Spy Way.

The nearby natural features and source water protection are illustrated on Figure 8 and Figure 9, respectively.

3. INVESTIGATION PROCEDURES

3.1 Geotechnical Investigation and Subsurface Drilling

Thurber conducted a geotechnical investigation for this project between September 11 and 14, 2023 with a total of 12 boreholes (RR25-01 to RR25-10, RR25-CULV-01, and RR25-CULV-02) advanced to depths ranging from 2.1 m to 11.3 m below ground surface.

The geotechnical borehole logs were used to understand the local geology of the Site. The locations of the boreholes and monitoring wells are shown in Appendix B, and respective records of borehole logs are presented in Appendix C.

Based on the borehole logs, the subsurface stratigraphy encountered at the Site generally consisted of a pavement structure (asphalt over granular) encountered at the ground surface, which extended to depths ranging from 0.5 m to 1.8 m below ground surface. The pavement

structure was underlain by silty clay fill in boreholes RR25-02, RR25-07, RR25-CULV-01, and RR25-CULV-02, and extended to depths ranging from 1.8 m to 3.0 m below ground surface. Locally, in borehole RR25-CULV-02, alluvial deposits of silt and gravel were contacted below fill at a depth of 2.2 m and penetrated at a depth of 4.1 m. Below pavement structure or fill, native cohesive deposits of silty clay to clayey silt and cohesionless deposits of silt to silt and sand were encountered. A deposit of till (silty clay to clayey silt till) was encountered below the granular material and fill in boreholes RR25-05 and RR25-CULV-01, and below the native silty clay and silt and sand deposits in boreholes RR25-03 and RR25-08. The boreholes were terminated in till deposits at depths of 2.1 m to 9.8 m.

3.2 Hydrogeological Investigation and Monitoring Wells Installation

To support the hydrogeological investigation, Thurber installed a total of three (3) monitoring wells in selected boreholes. Monitoring wells were constructed with 50 mm diameter PVC pipes to depths ranging between approximately 4.6 m and 9.9 m below the ground surface. The monitoring wells were screened in clayey silt till, sand, and sand and silt.

The monitoring wells were used to measure groundwater levels, collect samples for groundwater quality analyses, and estimate the hydraulic conductivity of the screened units. Monitoring well details are summarized in Table 3-1, and the locations of monitoring wells are provided on Figure 10.

Table 3-1: Monitoring Well Installation Details

Monitoring Well No.	Ground Elev. (m)	Well Depth (m)	Screened Interval Elev. (m)	Screened Geologic Unit(s)
RR25-09	249.1	4.6	244.5 – 246.0	Sand
RR25-CULV-01	231.4	8.8	222.6 – 225.7	Clayey Silt Till
RR25-CULV-02	226.7	9.9	216.8 – 219.8	Silty Sand / Sand and Silt

3.3 Single Well Response Tests

Rising head single well response tests (slug tests) were conducted on two (2) monitoring wells. Monitoring well RR25-09 was found to be dry. The tests were completed using the following method:



- In advance of conducting the slug tests, the monitoring wells (if not dried) were developed by withdrawing a minimum of three (3) well volumes of groundwater to remove excess sediment and to improve the transmissivity of the sand pack and well screen;
- Once the water level returned to a stabilized level, the static water level was measured and recorded. A datalogger was inserted into the well slightly above the bottom of the well. The datalogger was set to record water levels every 0.125 seconds to 30 seconds, depending on the anticipated rate of recovery of a well;
- A slug (or a known volume) of groundwater was removed from the well (rising head) to induce a change in the hydraulic head;
- Manual and electronic measurements of the water level were recorded until the water level in the well recovered sufficiently; and,
- Manual measurements were compared to electronic measurements for data quality control.

3.4 Groundwater Sampling

Groundwater quality samples were collected from two (2) monitoring wells (RR25-CULV-01 and RR25-CULV-02) for the purpose of considering disposal options and potential treatment needs at a preliminary level.

The monitoring wells were developed on October 26, 2023, prior to any sampling, by purging at least three (3) well volumes. The purpose of purging was to remove excess sediment that may have entered the well during installation and increase the representativeness of the natural groundwater in the well. Well development was assessed to be completed based on the number of well volumes purged, stabilization of general chemistry parameters of the purged groundwater (pH, temperature, electrical conductivity) over time, and qualitative observations such as a decrease in turbidity of the purged water.

Groundwater quality samples were collected on November 1, 2023. The collected samples were submitted to SGS Canada Inc. (SGS) for testing against the Provincial Water Quality Objectives (PWQO) limits for metals, inorganics, and general chemistry parameters. In addition to the unfiltered samples, field filtered samples for select metals were submitted for comparison to PWQO as a preliminary measurement of dissolved metal parameters.

4. INVESTIGATION FINDINGS AND ANALYSIS RESULTS

4.1 Groundwater Levels

Groundwater levels at monitoring wells were measured manually between October 11, 2023 and December 21, 2023. A summary of the water levels recorded in the monitoring wells is summarized in Appendix D.

The water level elevations for monitoring wells screened within the overburden ranged from 225.1 m to 228.7 m. The highest water level elevation (Elev. 228.7 m, depth 2.8 m) was measured in monitoring well RR25-CULV-01. Monitoring well RR25-09 was found to be dry during all monitoring events.

It should be noted that the groundwater levels, listed in Appendix D, are short-term readings and groundwater levels are expected to fluctuate seasonally. Higher groundwater levels may be expected during wet periods of the year such as spring or after periods of significant or prolonged precipitation. Perched water may be present in the fill material and/or more pervious sand pockets within the native soils.

4.2 Hydraulic Conductivity

Single well response tests (SWRTs) were initiated in two (2) monitoring wells on November 1, 2023, and December 12, 2023. The groundwater analysis software *AquiferTest Pro* was used for analyzing the slug tests, and hydraulic conductivity (K) estimates were obtained using the Hvorslev method (1951). Hydraulic conductivity estimates are presented in Table 4-1, and plots of the slug test results are presented in Appendix E.

Table 4-1: Estimated Hydraulic Conductivity Values

Monitoring Well No.	Well Screen Bottom Elev. (m)	Well Screen Top Elev. (m)	Screened Geologic Unit(s)	Hydraulic Conductivity (K) (m/s)	Test Type
RR25-CULV-01	222.6	225.7	Clayey Silt Till	4.3×10^{-9}	Rising Head
RR25-CULV-02	216.8	219.8	Silty Sand / Sand and Silt	7.3×10^{-6}	Rising Head

The hydraulic conductivity value for the clayey silt till was estimated to be 4.3×10^{-9} m/s, and the hydraulic conductivity of the sand and silt was estimated to be 7.3×10^{-6} m/s.

4.3 Groundwater Quality

The groundwater samples collected from monitoring wells RR25-CULV-01 and RR25-CULV-02 were tested against the PWQO limits for general chemistry, selected metals, and inorganic parameters. In addition to the unfiltered samples, field filtered samples were collected and tested for select metals analysis. The certificates of analysis are provided in Appendix F.

A review of the analytical results indicated that total iron exceeded the PWQO limit, and multiple parameters (total cobalt, dissolved cobalt, total phosphorous, total uranium, dissolved uranium, and total zinc) exceeded the interim PWQO limits. The exceedances of the PWQO limit and interim PWQO are summarized in Table 4-2.

Table 4-2: Summary of Exceedances to the PWQO and Interim PWQO Limits

Sample ID	Parameter	Unit	Measured Concentration	PWQO Limit Interim PWQO Limit
RR25-CULV-01	Total Cobalt	mg/L	0.00294	- 0.0009
	Dissolved Cobalt	mg/L	0.00276	- 0.0009
	Total Phosphorus	mg/L	0.02	- 0.01
	Total Uranium	mg/L	0.00826	- 0.005
	Dissolved Uranium	mg/L	0.00793	- 0.005
RR25-CULV-02	Total Iron	mg/L	0.393	0.3 -
	Total Phosphorus	mg/L	0.016	- 0.01
	Total Zinc	mg/L	0.023	0.03 0.02

Based on a review of the results of the filtered (dissolved) groundwater samples for metal parameters, filtering lowered some parameter concentrations below the PWQO and interim PWQO limits, except for dissolved cobalt and dissolved uranium at monitoring well RR25-CULV-01.

Groundwater of the quality that was observed herein could not be discharged to the natural environment without pre-treatment.

5. DEWATERING ASSESSMENT

5.1 Construction Dewatering

Groundwater taking for construction dewatering is governed by the Ontario Water Resources Act (OWRA), Environmental Protection Act (EPA) and the Water Taking and Transfer Regulation 387/04, a regulation under the OWRA.

If the water taking rate will be greater than 50,000 L/day and less than 400,000 L/day, registration on the EASR is required. If the water taking rate will be greater than 400,000 L/day, a Category 3 PTTW is required.

A preliminary assessment of the need for a Category 3 PTTW or registration on the EASR is provided, based on dewatering estimates presented in this report; however, the final assessment will need to be determined during detailed design and investigation. For the purpose of water taking permitting, the estimated withdrawal rates are conservatively assessed in order to reduce the likelihood that actual pumping rates might exceed the permitted allowance thereby stopping work and delaying the project.

Regional Road 25 crosses over two (2) tributaries of Middle Sixteen Mile Creek. It is anticipated that the existing concrete pipe culvert and concrete box culvert, located approximately 1.1 km and 1.6 km north of 5 Side Road, will require replacement and/or extension as part of the roadway widening. Proposed design details for the extension and/or replacement were not provided at the time of preparing this report.

5.1.1 South Culvert (Culvert D)

The south culvert is located approximately 1.1 km north of 5 Side Road. Based on the borehole information (borehole RR25-CULV-01) drilled at the south culvert, the subsurface stratigraphy consisted of a pavement structure and silty clay embankment fill over very stiff to hard silty clay till encountered at 3.0 m depth (Elev. 228.5 m). Based on Thurber's geotechnical investigation report, pipe culvert extensions or a replacement pipe or box culvert should be placed on the very stiff to hard silty clay till below the level of the fill at or below Elev. 228.5 m. A minimum 300 mm thick layer of Granular A bedding material should be provided under the base of the culvert (Thurber, 2024). Therefore, it is anticipated that excavation would extend into silty clay till at Elev. 228.2 m.

The highest groundwater level measured in monitoring well RR25-CULV-01 was at a depth of 2.8 m (Elev. 228.7 m). A hydraulic conductivity of 4.3×10^{-9} m/s estimated in monitoring well RR25-CULV-01 was used in assessing dewatering requirements. Design information was not available

at the time of preparing this report; therefore, the excavation area was assumed to be approximately 4 m x 30 m.

5.1.2 North Culvert (Culvert C-2)

The north culvert is located approximately 1.6 km north of 5 Side Road. Based on the borehole information (borehole RR25-CULV-02) drilled at the north culvert, the subsurface stratigraphy consisted of a pavement structure and silty clay embankment fill overlying silt and gravel alluvial deposits underlain by compact silty sand encountered at 4.1 m depth (Elev. 222.6 m). Based on Thurber's geotechnical investigation report, extensions or a replacement concrete box culvert should be founded on the compact sand below the level of the fill and alluvial soils at or below Elev. 222.6 m. A minimum 300 mm thick layer of Granular A bedding material should be provided under the base of the box culvert (Thurber, 2024). Therefore, it is expected that excavation would extend into silty sand at Elev. 222.3 m.

The highest groundwater level measured in monitoring well RR25-CULV-02 was at a depth of 1.5 m (Elev. 225.2 m). A hydraulic conductivity of 7.3×10^{-6} m/s estimated in monitoring well RR25-CULV-02 was used in assessing dewatering requirements. Design information was not available at the time of preparing this report; therefore, the excavation area was assumed to be approximately 6 m x 30 m

5.2 Dewatering Estimates

The following approach was used to estimate the budgeted peak water taking rate for the construction of proposed structures:

- A base groundwater extraction flow rate was estimated, and a factor of safety of three was applied to the base flow rate to provide an allowance for removal of water from soil storage, variation in hydraulic conductivity values, actual excavation dimensions and geometry, and fluctuations of groundwater levels due to seasonality or other factors;
- An allowance for removal of rainfall into the excavation was included, assuming 24 hours is used to remove 50 mm of rainfall; and,
- Lowering groundwater to about 1 m below the excavation base to facilitate a dry and stable work area was assumed.

Dewatering rates were estimated using the Dupuit analytical solution provided in Powers et al. (2007). The zone of influence (ZOI) was estimated using the Sichardt equation.

For the purpose of estimating water taking flow rates, it is assumed that all excavations would be open cut and support of excavation would not be watertight. Surface water in the vicinity of the

proposed excavations should be managed separately and directed away from the excavation. Temporary stream diversion measures should be provided to divert surface water runoff and stream flow away from excavations during construction.

The estimated maximum construction dewatering pump rates and zone of influence for the analyzed excavations are summarized in Table 5-1. The calculations and equations for the peak flow rate and zone of influence are provided in Appendix G. Figure 11 shows the extent of the estimated zone of influence.

Table 5-1: Estimated Construction Dewatering Volumes

Construction Element	Base Groundwater Flow (L/day)	Groundwater Flow with a Safety Factor of 3 (L/day)	Stormwater Allowance (L/day)	Estimated Peak Flow Rate (L/day)	Approx. Zone of Influence (m)
South Culvert (Culvert D)	< 1,000	< 3,000	6,000	9,000	1
North Culvert (Culvert C-2)	52,000	156,000	9,000	165,000	32

The total peak water taking rate for the south culvert including a safety factor of three on the base groundwater flow and a rainfall removal allowance of 50 mm in 24 hours is approximately 9,000 L/day. The total peak water taking rate for the north culvert including a safety factor of three on the base groundwater flow and a rainfall removal allowance of 50 mm in 24 hours is approximately 165,000 L/day.

6. IMPACT ASSESSMENT

Within the construction dewatering zone of influence, potential impacts such as ground subsidence and reduction in groundwater flow to groundwater users and watercourses must be considered. The potential impacts and mitigation measures are discussed herein.

6.1 Geotechnical Impacts

Dewatering of open excavations for the installation of the culverts would be within the fill materials, alluvial soils, silty clay till, and silty sand with an approximate drawdown of the water table up to 4 m and a maximum estimated zone of influence of 32 m from the edge of the excavation at the north culvert.

In general, the potential for ground settlement resulting from construction dewatering is greatest where the estimated drawdown is significant and compressible soils are located within the zone of influence of the dewatering. Structures or other infrastructure located within this zone may potentially be impacted by the ground settlement depending upon the magnitude of settlement and the sensitivity of the facility. The estimated maximum surface settlement values occur at the ground surface at the edge of the excavation. At distances away from the edge of the excavation, the estimated settlement decreases to almost zero at the outer limit of the respective zone of influence.

For the dewatering conditions assessed in this report, the magnitude of the drawdown is relatively low (approximately 1.5 m for the south culvert and less than 4 m for the north culvert), and the drawdown occurs primarily in plastic till for the south culvert, and in alluvial deposits and silty sand for the north culvert. The silty clay till was very stiff to hard, and alluvial deposits and silty sand were compact. Under these conditions, settlement of the surrounding ground surface within the zone of influence as a result of dewatering is expected to be negligible (<10 mm).

A preconstruction survey of all structures and utilities within the zone of influence should be considered prior to dewatering activities, and a survey and periodic visual inspections should be considered during dewatering to assess if any undesirable deformation has occurred. As noted above, based on the site conditions, it is anticipated that the settlement of the overburden deposits will be negligible, however, consideration should be provided for the continuation of the settlement monitoring post construction. A settlement monitoring program will need to be designed and implemented in accordance with the applicable requirements. The settlement monitoring program should be reviewed and approved by the responsible authorities.

If significant sediment and fines are removed during the dewatering due to improperly filtered extraction wells, then ground loss and settlement beyond that described above could occur.

6.2 Impacts to Surface Water and Natural Environment

Lowering the shallow groundwater level due to construction dewatering could potentially reduce the groundwater input into nearby environmental features. In addition, dewatering discharge that may be directed to nearby watercourses could potentially alter the physical, chemical and thermal regime of the receiving streams. A tributary of Middle Sixteen Mile Creek is anticipated to be located within the estimated zone of influence at the north culvert. The magnitude of the impact is not expected to be significant due to the limited drawdown. Reduction in groundwater discharge to surface water flow, to some extent, may occur due to groundwater extraction.

Mitigation measures to minimize potential impacts from a reduction of baseflow to nearby watercourses due to construction dewatering could include directing dewatering discharge into the watercourses to provide baseflow supplementation. Directing dewatering discharge to the streams will require approval from CH. Erosion and sediment control measures (e.g., silt fences) will be required around the construction site to minimize potential sediment loading to the watercourses. A monitoring plan should also be prepared and implemented during dewatering to mitigate potential impacts to nearby potential receptors. Temporary stream diversion measures should be provided to divert surface water runoff and stream flow away from excavations during construction.

The groundwater of the quality that was discussed in Section 4.3 cannot be discharged to the natural environment without pre-treatment due to exceedances of the PWQO limits based on the samples that were collected and analyzed. If discharge occurs to the natural environment or within 30 m of a surface water body, the discharge quality must be tested and routinely monitored to ensure that it meets the PWQO and interim PWQO requirements. Erosion and sediment control plans must also be implemented to ensure that there is no excess sediment being stirred up or into the surface water and to ensure that no erosion occurs. If discharging to land surface more than 30 m from a watercourse, the discharge must be monitored to ensure that the discharge does not reach a stream (unless it also meets the PWQOs).

6.3 Impacts to Water Well Users

The MECP well records review, as documented in Section 2.5, indicated 74 water supply wells were identified within the Study Area. Water supply wells appear to be located out of the estimated construction dewatering zone of influence of the north culvert, except one water supply record Well ID # 2810646 with 11.0 m depth that was completed in 2006. No water supply well is located within the estimated construction dewatering zone of influence of the south culvert.

It is recommended that a private well survey be conducted in advance of construction to identify potential well users in the area and to establish baseline water levels and water quality prior to, during, and following construction.

6.4 Other Potential Impacts

With prolonged dewatering activities, there can be potential for inorganic or organic chemical compounds present within the zone of influence to migrate and enter open excavations where sufficient flow rate and time permit. Commercial and industrial land uses are found to the south of the Site and around 5 Side Road which may have the potential to impact groundwater, however, they are not near the culvert locations. If any contaminated groundwater is collected from the

dewatering operations, it must be treated to meet any discharge criteria or disposed of at a facility licensed to handle such materials.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Water Taking Permit

The total peak dewatering rate for the construction elements discussed in Section 5.1 including a three (3) times safety factor on the base groundwater flow and a rainfall removal allowance of 50 mm in 24 hours was estimated to range approximately between 9,000 L/day and 165,000 L/day. Since the estimated peak water taking rate is greater than 50,000 L/day for the north culvert, an EASR registration will be required for the construction of the north culvert. The estimated peak water taking rate is less than 50,000 L/day for the south culvert, which is under the EASR limit.

For each excavation, the water taking rate is expected to be highest at the beginning of dewatering when the water table is being actively lowered and during large rainfall events. The means and methods of sequencing of excavations will be primarily determined by the contractor.

For construction dewatering purposes, a qualified dewatering engineer retained by the contractor must complete an independent assessment based on their own assumptions and requirements (e.g., overall analysis, assumptions, predicted dewatering rates, etc.) using the final design specifications and the contractor's proposed construction methodologies. The design and operation of the dewatering activities is the sole responsibility of the contractor, to ensure the EASR limit is not exceeded. The excavation and dewatering methods that will be used in the field will be determined by the selected contractor in accordance with the construction contract documents.

7.2 Discharge of Groundwater

Groundwater of the quality that was observed herein could not be discharged to the natural environment without pre-treatment due to exceedances of the PWQO and interim PWQO limits for various parameters including total iron, total cobalt, total phosphorous, total uranium, and total zinc. Based on a review of the results of the filtered groundwater samples for metal parameters, filtering lowered some parameter concentrations below the PWQO and interim PWQO limits, except for dissolved cobalt and dissolved uranium. If considering discharge to the natural environment, additional treatment beyond sediment control is anticipated to be required. Also, approvals from external agencies such as CH, MNRF, and Fisheries and Oceans Canada (DFO) may be required.

The results obtained herein were representative of the water sampled from the selected wells at the time of sampling and provided a general understanding of groundwater quality under those conditions; however, the water quality may vary significantly from the results obtained based on location, time, meteorological conditions, and in particular based on construction and dewatering methods. The contractor would need to consult with its dewatering and water treatment specialists to develop methods and means to meet the applicable limits based on the results presented herein and on any additional testing taken by the contractor and/or its consultant during detailed design. An experienced dewatering contractor and water treatment contractor are recommended to be retained to design and operate dewatering and/or treatment operations as required.

The extent of suspended solids in the groundwater or in water that is collected during construction dewatering (for example from a sump in an open excavation) will significantly affect the concentrations of many parameters that may be regulated based on a discharge location. The value of testing groundwater quality during the investigation is primarily to identify the types of contaminants that may need to be managed, and the presence of anthropogenic contaminants that are listed in the given discharge criteria that may require specific treatment.

7.3 Control of Impacts and Monitoring Program

The following measures are recommended to mitigate the potential for the dewatering activities to cause negative impacts as assessed previously:

- If discharge to the natural environment is proposed, treatment of groundwater to meet acceptable levels is required. Suitable treatment would likely include measures to address suspended sediments and associated metals. The operation and monitoring of discharge facilities should be carried out by an experienced dewatering contractor and water treatment contractor familiar with fisheries and water quality requirements.
- Where discharge is to land surface, the discharge must be at least 30 m away from any water bodies including streams. Temporary erosion control measures should also be developed and installed to control erosion at the discharge points. If discharging near Sixteen Mile Creek tributaries is considered, it is recommended to develop a monitoring plan to identify, minimize, and mitigate potential impacts to the tributaries during the detailed design stage. As north and south culverts are located within regulated areas, approvals/permits from external agencies may be required if discharging to the tributaries is considered.
- During the detailed design stage, it will be necessary to refine the analysis of the hydrogeological conditions to estimate dewatering rates and zone of influence. These

findings will be used to confirm the water takings requirements and the appropriate approvals from the MECP prior to the commencement of construction.

- A door-to-door well survey was not included for the scope of the hydrogeological investigation. It is recommended that a private well survey be conducted in advance of construction to identify potential well users in the area and to establish baseline water levels and water quality prior to, during, and following construction.
- Additional monitoring and terms and conditions will apply as determined by the water taking permits, by any discharge agreement or permit, and by other regulatory or jurisdictional bodies.



THURBER ENGINEERING LTD.

8. SIGNATURES/CLOSURE

We trust this report provides the information you require at this time. If you have any questions, please contact the undersigned at your convenience.



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File: 35477



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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.