Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report, Hydro One - Clarington Transformer Station

FINAL REPORT

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Sign-off Sheet

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Introduction

The Clarington Transformer Station is to be constructed on a 63 ha Hydro One owned property located within the Regional Municipality of Durham, in the Municipality of Clarington, bordering the east side of the City of Oshawa, northeast of Concession Road 7 and Townline Road North.

The 11 ha Station Site is to include a drainage system to collect precipitation that falls within the Station Site in order to maintain dry ground and safe operating conditions. The drainage system will be constructed on an area to be graded within the Station Site limits.

A draft Environmental Study Report (ESR) was made available for a 30-day public review and comment period starting on November 15, 2012. During this period comments and issues were received from stakeholders and the public regarding the project. Part II Orders requesting the Ministry of Environment (now the Ministry of Environment and Climate Change (MOECC)) elevate the project to an Individual Environmental Assessment (EA) were also received. Responses were prepared for all issues received. In a letter dated January 2, 2014, the Minister of the Environment informed Hydro One that an Individual EA was not required, and provided six (6) conditions to be undertaken during the detailed design and construction of the Clarington TS. The final ESR was submitted to the MOECC on January 16, 2014 (Hydro One, 2014).

The first condition was to submit a Groundwater Monitoring Plan to the MOECC Regional Director for review and approval. The approved Groundwater and Surface Water Monitoring Program (Monitoring Program) includes installation of new groundwater monitoring wells, decommissioning of previously existing geotechnical monitoring wells, implementation of groundwater, surface water, and private well monitoring programs, and annual reporting. The results of the Monitoring Program will allow for confirmation of the findings presented in the ESR, and refinement of the understanding of the hydrogeologic conditions within the Project Area. The Monitoring Program objectives include defining the hydraulic conductivity of geologic units, documenting pre-station construction hydrogeologic conditions within the Project Area, and establishing pre-station construction conditions in private wells within 1,200 m of the Station Site.

Site Setting

The Project Area is predominantly within the Oak Ridges Moraine planning boundary and falls within the Black/Harmony/Farewell Creek Watershed. Two (2) wetlands (Wetland Area 1 and 2) are partially located within the Project Area and have been determined to not be of suitable quality to be classified as Provincially Significant Wetlands.

The Oak Ridges Moraine consists of the following five (5) general units, from oldest to youngest, including:

- Lower Deposits
- Newmarket Till
- Tunnel Channels
- Oak Ridges Moraine (ORM) Sediments
- Halton Till

In the vicinity of the Project Area, the Newmarket Till is mapped as being present at ground surface with discontinuous areas of Halton Till present.

Local Geology and Hydrogeology

Since December 2013, a total of twelve (12) monitoring wells were installed at seven (7) locations throughout the Project Area as part of the Groundwater and Surface Water Monitoring Program. These boreholes were in addition to the twenty-nine (29) geotechnical boreholes that were completed within the Project Area in 2012 by exp (2012) and Inspec-Sol (2013).

A local conceptual hydrostratigraphic framework was developed based on the boreholes within the Project Area, and compared to the York, Peel, Durham, Toronto and the Conservation Authorities Moraine Coalition (YPDT-CAMC) Extended Core Model, surficial geology mapping, and the MOECC Water Well Database.

The surficial overburden material observed across the Project Area is composed of thin, discontinuous, loose silty sand overlying a compact to very dense silty sand to sandy silt till. The silty sand was identified in the northern and southern portions of the Project Area, and was generally absent in the western, central, and eastern portions of the Project Area.

The origin of the underlying dense silty sand to sandy silt till is difficult to determine, and may correspond to Halton Till, as mapped in the YPDT-CAMC Model, or potentially to a more weathered upper portion of the Newmarket Till, as identified in the Ontario Geological Survey OGS (2003) surficial quaternary geology mapping within the Project Area. Given the similarity in composition of the Halton and Newmarket Tills at the Station Site, these units are interpreted to behave as a single aquitard unit; with predominantly vertical leakage occurring through to the underlying Thorncliffe Aquifer.

No evidence of the Oak Ridges Moraine sediments were noted in any of the boreholes advanced as part of this Monitoring Program, indicating that this unit is not present beneath the Project Area to a depth of 40 m below ground surface (BGS) (212 m above mean sea level (AMSL).

From a hydrostratigraphic framework, the following aquifer and aquitard units are interpreted to be present beneath the Station Site. This framework further refines the understanding of the local hydrostratigraphy that was established in the ESR submitted to the MOECC in January 2014, and the Hydrogeologic and Hydrologic Assessment Report (Stantec, 2014).

- **Surficial Silty Sand** – A thin discontinuous silty sand that varies in thickness between less than 0.2 m to 3.1 m across the Project Area. It was found to be thickest in the northern and southern portions of the Project Area, and absent in the western, central, and eastern portions of the Project Area. Groundwater flow within this unit, where present, is predominantly to the south and southwest, with downward groundwater flow limited by the underlying very dense Upper Aquitard;

- **Upper Aquitard (Halton Till/Newmarket Till)** – Silty sand to sandy silt till was found to underlie the surficial silty sand, when present, or was present at ground surface. The upper portion of this till may correspond to Halton Till or weathered Newmarket Till. At depth this till becomes very dense and is interpreted to correspond to Newmarket Till; and,
- **Thorncliffe Aquifer** - is interpreted to underlie the Project Area at a depth of approximately 70 to 80 m BGS (top of aquifer), or an elevation of approximately 180 m to 185 m AMSL and represents a regional aquifer system within the Oak Ridges Moraine.

The hydraulic conductivity of the silty sand to sandy silt till of the Upper Aquitard ranges from $2x10^{-7}$ m/s to $7x10^{-9}$ m/s across the Project Area, with a geometric mean of $6x10^{-8}$ m/s and is consistent with hydraulic conductivity estimates for the Newmarket Till. At MW4-13S and MW5-14S, the shallow monitoring wells or sand packs are partially installed or connected to the overlying sand unit and as a result have hydraulic conductivities in the range of $1x10^{-5}$ m/s, typical of silty sand.

Within the Project Area, shallow groundwater flows to the northwest, west, and southwest towards the tributary of Harmony Creek and its associated branches. At the eastern extent of the Project Area, groundwater flow within the Farewell Creek Sub-watershed is to the southeast towards Farewell Creek, and is consistent with the overall ground surface topography and regional interpretations of shallow groundwater flow conditions. Seasonally, groundwater levels in the upper silty and sand unit decrease by up to 2.0 m through the summer as the upper sand unit is interpreted to drain with rapid water level fluctuations of 1.0 to 1.5 m in response to precipitation events. Water levels within the Upper Aquitard are at or near ground surface in spring, decreasing by 1 to 1.5 m over the summer, followed by a recovery in the fall in response to increased precipitation with decreasing effects of precipitation noted at depth.

The tributaries located within the Project Area provide intermittent flow during spring snow melt and following heavy precipitation events, indicating that they are supported primarily by surface water runoff. Vertical gradients within the surficial silty sand and the upper portion of the Upper Aquitard suggest that upward vertical flow may occur seasonally along the low lying valley associated with the tributary of Harmony Creek. Due to the limited thickness and discontinuous nature of the surficial silty sand and the low permeability of the Upper Aquitard, limited groundwater discharge to surface water features occurs across the Project Area. This is consistent with observed groundwater flow conditions that indicate the surface water features within the Project Area are predominantly sustained by surface water runoff.

A downward vertical gradient is interpreted from the shallow overburden within the proposed Project Area to the underlying Thorncliffe Aquifer. A downward flux or recharge to the Thorncliffe Aquifer of 18 mm/yr is estimated; corresponding to a vertical groundwater velocity of about 0.06 m/yr and a travel time to the top of the Thorncliffe Aquifer (185 m AMSL) of over 700 years.

Monthly water balance calculations were completed for the Project Area under pre-Station construction conditions, and indicate groundwater recharge rates of 112 to 144 mm/year. Accounting for a downward recharge through the Newmarket Till of 18 mm/yr, the total infiltration potentially from the Station Site contributing to baseflow in the tributary of Harmony Creek is estimated to be approximately 0.3 L/s.

Surface Water Quality

As part of the Monitoring Program, water quality monitoring was completed within surface water features from December 2013 to October 2014. Shallow groundwater flow contours suggested flow from adjacent fields towards Wetland Area 1 and South Branch tributary of Harmony Creek. The surface water quality monitoring data indicates that water quality is generally good with low concentrations of sodium, chloride, and nitrate and all parameters generally within the Provincial Water Quality Objectives (PWQO). The detection of elevated metals above the PWQO is attributed to elevated sediment concentrations within the samples. To evaluate the effects of sediment on water quality, future samples should include both dissolved and total metals analyses.

Shallow Groundwater Quality

Monitoring wells installed in support of the groundwater monitoring program on the Station Site were monitored from December 2013 to October 2014 for general inorganic chemistry, total metals, petroleum hydrocarbons (PHCs) (F1 to F4) and benzene, toluene, ethylbenzene and xylene (BTEX) compounds, polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOC) and volatile organic compounds (VOC) parameters.

Groundwater quality met the Ontario Drinking Water Standards (ODWS) for all health related parameters with the exception of nitrate in two (2) monitoring wells which is attributed to agricultural fertilizer and benzo(a)pyrene. Benzo(a)pyrene is a polycyclic aromatic hydrocarbon (PAH) that is found in coal tar and residuals from the combustion of organic material and was detected on at least one (1) occasion within monitoring wells MW1-13D, MW2-13S, MW3-13S/D and MW4-13S/D above the ODWS maximum acceptable concentration (MAC).

In addition to benzo(a)pyrene, phthalate compounds and several PAHs were detected at concentrations above the Ontario Regulation 153/04 (O.Reg.153/04) Table 6 and/or Table 8 Site Condition Standards. The detection of phthalate compounds may be related to plastics from the well itself, sampling tubing and/or bailer, or sample bottles as the highest concentrations were often found in the slowest recovering wells. Detections of PAHs, including benzo(a)pyrene can be biased high due to the presence of sediment within the sample. The total suspended solids (TSS) and turbidity results confirm high sediment levels within these same samples. No known sources of phthalate or PAHs exist or have existed within the Project Area; and as a result, further evaluation is required to confirm the effects of sampling equipment, well development and sediment concentrations on the detection of these parameters. Hydro One has committed to conducting further evaluation of these detections. Additional details are included in Section 6.3.2 of this report.

Private Well Water Quality

Stantec completed groundwater quality sampling at private supply wells that signed on to the program in July/August 2014 and October 2014 for general inorganic chemistry, total metals, PHCs (F1 to F4) and BTEX compounds, PCBs, SVOC and VOC, and bacteriological water quality. Well owner consent was obtained from the owners of 23 private wells (22 well owners) as of October 2014.

Bacteriological water quality was generally poor within the shallow private wells with 10 of the 12 wells (83%) having total coliforms present and 3 of 12 samples (25%) having E.coli present. Water quality for wells completed within the Thorncliffe Formation had only 1 (11%) detection of total coliforms and no detections of E.coli. The total coliform and E.coli detections within the shallow dug wells are interpreted to be related to local sources associated agricultural activities (manure storage and animal feedlots), septic systems, or potential surface influences and water well construction.

Inorganic and organic water quality from the private wells generally met the ODWS-MAC for all parameters with the exception of nitrate in one (1) shallow well and lead in another shallow well during the August 2014 sampling round. Concentrations in these wells were below the ODWS-MAC in the October 2014 sampling round. Benzo(a)pyrene was the only parameter detected above the ODWS-MAC in the initial sample from a well completed in the Thorncliffe Formation. The well owner pumped the well for an extended period of time and changed the sediment filter on the treatment system with the concentration decreasing below the method detection limit and ODWS-MAC criteria.

Conclusions and Recommendations

Based on the results presented in this Groundwater and Surface Water Baseline Conditions Report, the following conclusions are provided:

- The findings of the Baseline Conditions Report, including the conceptual hydrostratigraphic model interpreted for the Project Area, are consistent with the findings presented in the ESR that were submitted to the MOECC in January 2014;

- The Groundwater and Surface Water Monitoring Program, initiated in December 2013, and completed through October 2014, allowed for a refinement of hydrogeologic characterization within the Project Area, including shallow and deep groundwater flow directions and gradients, seasonal groundwater level and groundwater quality monitoring, and hydraulic conductivity estimates; and,

- The Groundwater and Surface Water Monitoring Program established baseline geologic and hydrogeologic conditions across the Project Area, and collected pre-Station construction water quality data for 23 private wells within 1,200 m of the Station Site.

The following recommendations are provided:

- Water level and water quality monitoring should continue semi-annually during station construction and post-station construction, as detailed in the Groundwater and Surface Water Monitoring Program;
- Further evaluation into the potential source of the phthalate and PAH detections in the Project Area monitoring wells should be conducted. The potential for sampling equipment and/or sediment to have biased the analytical results should be reviewed. Hydro One is in the process of completing additional groundwater sampling for Project Area monitoring wells. Sampling procedures will be modified to evaluate potential impacts from sampling equipment and to reduce entrained sediment. The evaluation will include a comparison of filtered and non-filtered water quality samples. Water quality results will be reviewed and, based on the results, changes to monitoring well sampling protocols may be recommended. Hydro One has committed to providing the findings of this evaluation, once completed, in a Baseline Conditions Report Addendum;
- It is recommended that MW5-14S/I, MW6-14 and MW7-14 be added to the monitoring program for 2015 to further document groundwater quality. The need for additional monitoring at these locations should be reviewed at the end of 2015;
- The monitoring wells within the Project Area should be left in place throughout construction and operation. When no longer being used for groundwater monitoring, the monitoring wells should be decommissioned in accordance with O.Reg.903; and,
- The condition of the drive-point piezometers should be inspected as part of the regular Monitoring Program and upgrades/replacement completed as necessary. At DP2-14 and DP3-14, it is recommended that a second drive-point piezometer be installed to evaluate the lack of response observed to precipitation events.

Abbreviations

AMSL	above mean sea level
BGS	below ground surface
BTEX	benzene, toluene, ethylbenzene and xylene
BTOC	below top of casing
Class EA	Class Environmental Assessment
CLOCA	Central Lake Ontario Conservation Authority
EA	Environmental Assessment
ECA	Environmental Compliance Approval
ESR	Environmental Study Report
GTA	Greater Toronto Area
ha	hectares
HDPE	high-density polyethylene
HHAR	Hydrogeology and Hydrology Assessment Report
Hydro One	Hydro One Networks Inc.
ID	Inner diameter
Lotowater	Lotowater Technical Services Inc.
Maxxam	Maxxam Analytics Inc.
MAC	Maximum Acceptable Concentration
Monitoring Program	Groundwater and Surface Water Monitoring Program
MNRF	Ministry of Natural Resources and Forestry
MOECC	Ontario Ministry of Environment and Climate Change

OCS	Oshawa WPCP Climate Station
OD	outer diameter
ODWS	Ontario Drinking Water Standards
OGS	Ontario Geological Survey
O. Reg. 153/04	Ontario Regulation 153/04
O. Reg. 903	Ontario Regulation 903
OWRA	Ontario Water Resources Act
PCBs	polychlorinated biphenyls
PHCs	petroleum hydrocarbons
Project Area	lands owned by Hydro One in the vicinity of the Clarington TS
PWQO	Provincial Water Quality Objectives
PSW	Provincially Significant Wetlands
PVC	polyvinyl chloride
Stantec	Stantec Consulting Ltd.
Station Site	Land area of the Clarington transformer station
SVOCs	semi-volatile organic compounds
TS	Transformer Station
TSS	Total suspended solids
VOCs	volatile organic compounds
WWR	Water Well Record
YPDT-CAMC	York, Peel, Durham, Toronto and the Conservation Authorities Moraine Coalition

1.0 INTRODUCTION

In 2014, Hydro One Networks Inc. (Hydro One, 2014) completed a Class Environmental Assessment for Minor Transmission Facilities (Class EA) to support the construction of the Clarington Transformer Station (TS). The Clarington TS is required to facilitate the delivery of power to the eastern portion of the Greater Toronto Area (GTA) as a result of the shutdown of the Pickering Nuclear Generating Station and to reinforce the regional reliability of power supply. The Clarington TS will be constructed on Hydro One owned property located in the Regional Municipality of Durham, in the Municipality of Clarington, bordering the east side of the City of Oshawa, northeast of Concession Road 7 and Townline Road North (Figure 1; Appendix A).

1.1 BACKGROUND

A draft Environmental Study Report (ESR) was made available for a 30-day public review and comment period starting on November 15, 2012. During this period comments and issues were received from stakeholders and the public regarding the project. Part II Orders requesting the Ministry of Environment (now the Ministry of Environment and Climate Change (MOECC)) elevate the project to an Individual Environmental Assessment (EA) were also received. Responses were prepared for all issues received. In a letter dated January 2, 2014, the Minister of the Environment informed Hydro One that an Individual EA was not required, and provided six (6) conditions to be undertaken during the detailed design and construction of the Clarington TS. The final ESR was submitted to the MOECC on January 16, 2014 (Hydro One, 2014).

Condition 1) of the MOECC letter required the submission of a Groundwater Monitoring Plan to the Regional Director in Central Region for review and approval. The Groundwater Monitoring Plan was to include water level and quality monitoring from wells located within the Project Area and adjacent private wells to document pre- and post-station construction conditions and to confirm no adverse effects are associated with the Clarington TS. To satisfy Condition 1), Stantec Consulting Ltd. (Stantec) was retained by Hydro One to prepare the monitoring plan. A proposed monitoring program was submitted in March 2014 for review by the MOECC Central Region. Following a comprehensive review and consultation period, the final monitoring program was submitted to the MOECC on June 13, 2014 (Appendix C). The objectives of the monitoring plan were to:

- Implement a pre-, during-, and post- transformer station construction groundwater and surface water monitoring program;
- Refine the understanding of the physical and chemical characteristics of the shallow and intermediate depth groundwater systems for the Project Area; and,

- Establish a pre-station construction baseline of groundwater conditions; including, seasonal variations in groundwater quality, quantity, and surface water / groundwater interaction.

Approval of the Groundwater and Surface Water Monitoring Program (Monitoring Program) was received from Ms. Dolly Goyette, Director Central Region MOECC, on June 24, 2014 (Appendix C). The approval included the following points related to the monitoring program:

- The MOECC would be notified in advance of the groundwater sampling in order for the Ministry to have the opportunity to observe Monitoring Program sampling events;
- Hydro One agreed that the Monitoring Program would be adaptive, and changes may be implemented at the advice of Hydro One's expert hydrogeology consultant, subsequent to approval by the Central Region Director and technical staff;
- Hydro One has committed to providing funding to the Municipality of Clarington for the hiring of a third-party consultant for the purposes of supporting residents in their review and interpretation of the data and results of the Monitoring Program; and,
- Hydro One will expand the private well monitoring program to include private water wells within 1,200 m of the Clarington TS.

1.2 REPORT OUTLINE

The following Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report presents the results of the Monitoring Program for the Clarington TS. This report is arranged into eight (8) sections, including this introduction. Section 2 presents an overview of the infrastructure and construction schedule for the Station Site. Section 3 presents a summary of the groundwater and surface water monitoring program. A review of the site setting and background information is presented in Section 4. Section 5 presents the study methods, and Section 6 presents the results of the baseline monitoring. Section 7 presents conclusions and recommendations, and Section 8 presents report references.

All Figures and Tables referenced throughout the report are presented in Appendices A and B, respectively. Appendix C contains a copy of the approved Groundwater and Surface Water Monitoring Program, associated correspondence from the MOECC and well owner notification letters. Appendices D to H include Test Pit, Borehole, and Monitoring Well Logs; Grain Size and Hydraulic Conductivity Analyses; Private Well Hydrographs; Laboratory Certificate of Analysis and Water Balance Calculations, respectively.

2.0 CLARINGTON TRANSFORMER STATION

2.1 OVERVIEW

The Clarington TS will be constructed on Hydro One owned property located within the Regional Municipality of Durham, in the Municipality of Clarington, bordering the east side of the City of Oshawa, northeast of Concession Road 7 and Townline Road North (Figure 1). For the purposes of this report, the lands owned by Hydro One in the vicinity of the Clarington TS are referred to as the Project Area, within which the transformer station area itself is referred to as the Station Site. The Station Site represents approximately 11 ha of the total 63 ha Project Area (Figure 2).

The Clarington TS will transform electricity voltages from 500 kV to 230 kV by connecting to two (2) of four (4) existing 500 kV circuits and to all five (5) of the existing 230 kV circuits located on or adjacent to the proposed Station Site. The Clarington TS will consist of two (2) 500/230 kV transformers, a 500 kV switchyard, a 230 kV switchyard, two relay buildings, one (1) electrical panel building, the associated buswork and equipment.

The existing 230 kV wood pole lines located on the property have been recently relocated and replaced with new 230 kV steel structures. Associated tapping structures have been erected to connect the existing 230 kV lines and the station. A temporary bypass has been installed to facilitate the construction of the new line structures. All necessary line work would be undertaken within the Project Area. An access road off Townline Road North is being constructed on the western edge of the Project Area. The access road is located at the municipal boundary between the Municipality of Clarington and the City of Oshawa. A municipal resolution has been passed, providing a permanent easement to these lands with a condition to install a deep monitoring well on or near the Project Area, and is to be screened within the underlying Thorncliffe Formation aquifer.

The Station Site will include a drainage system to collect precipitation that falls within the station in order to maintain dry ground and safe operating conditions. According to the design specifications provided by Hydro One, the drainage system consists of a series 150 mm diameter perforated high density polyethylene drainage (HDPE) pipes connected to one (1) of two (2) north-south header pipes which convey flows to the north, converging at MH7, and ultimately discharging to the tributary just north of the Station Site (Figure 2). The perforated drainage pipe inverts range from 253.3 m to 252.1 m above mean sea level (AMSL) with the inverts at MH7 from the south and east header pipes are 251.7 m and 251.3 m AMSL, respectively. The discharge invert from the drainage system is located at an elevation of 250.99 m AMSL. In the event of a release of mineral insulating oil from a transformer, a spill containment system has been included in the transformer station design to prevent the loss of transformer mineral insulating oil from entering the surrounding environment. The drainage and containment system are subject to an Environmental Compliance Approval (ECA) for Industrial Sewage Works under the Ontario Water Resources Act (OWRA).

2.2 CURRENT STATION SITE CONSTRUCTION STAGING

Prior to construction of the Clarington TS, site preparation and 230 kV tower construction activities are required to relocate the existing 230 kV lines to the north and west of the proposed Clarington TS. The following provides a summary of the construction staging schedule for the Clarington TS:

Spring 2014 – Fall 2014	Relocation of 230 kV transmission lines and construction of an access road.
Fall 2014 – Winter 2014	Construct 500 kV Tower Foundations
Winter 2014 – Winter 2016	Clarington TS Construction
Winter 2014 – Spring 2015	Relocation of 500 kV lines
Winter 2016 – Spring 2017	230 kV & 500 kV Connections and Commissioning
Spring 2017	Clarington TS - In-Service
Fall 2015 – Spring 2018	Habitat Creation and Visual Screening

Beginning the week of July 7, 2014, Hydro One crews initiated the construction of temporary access roads for trucks and equipment to enter and exit the Project Area, as well as service roads to allow access to existing and future towers that will be constructed within the Project Area during the initial stages of construction. Construction within the Project Area portion of the permanent access road was initiated in September 2014 and will be completed upon receipt of the finalized easement agreements between with the Municipality of Clarington and the City of Oshawa.

In August 2014, construction of the by-pass line and new 230 kV tower foundations was initiated. The 230 kV tower foundations were completed in October 2014, with the tower installations and stringing of the conductor lines on going. In October 2014, field crews have initiated the installation of the new 500 kV tower foundations as well as the construction of the permanent access road in the southwest corner of the Project Area.

3.0 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

The approved Groundwater and Surface Water Monitoring Program is included in Appendix C along with the approval letter for the program from the MOECC Central Region Director. The monitoring program consists of the following main components:

- Installation of new groundwater monitoring wells;
- Decommissioning of existing geotechnical monitoring wells;
- Implementation of a private well monitoring program;
- Surface water and groundwater monitoring; and,
- Annual reporting.

Groundwater and surface water data collected prior to Station construction has been used to define the relationship between the shallow and intermediate groundwater systems within the Project Area, and provide a baseline to which monitoring data collected during- and post-construction will be compared to evaluate potential impacts. Specifically, the objectives of the Monitoring Program are to:

- Refine our understanding of the geology within the Station Site;
- Define shallow and intermediate depth hydraulic conductivity of geologic units;
- Document seasonal shallow and intermediate groundwater levels within monitoring wells and private wells, including vertical gradients between shallow and intermediate groundwater systems and surface water features within the Project Area;
- Document seasonal groundwater quality of the shallow and intermediate groundwater system within the Project Area; and
- Document the potential change in shallow groundwater levels due to planned Station Site grading and drainage activities, including the potential radius of influence and potential for impact to adjacent private wells.

The following sections provide a summary of the specific monitoring requirements, including any changes to the Monitoring Program that have been implemented since the program was approved in June 2014.

3.1 MONITORING WELL INSTALLATIONS

Monitoring well installations MW1-13 to MW4-13 were completed in the late fall of 2013 (Figure 3). Based on the results of the borehole and monitoring well drilling, four (4) additional monitoring wells were installed in 2014 and were added to the monitoring program. These include MW5-14S/I, located just beyond the southwest corner of the Station Site, and MW6-14 and

MW7-14 located along the northeastern boundary of the Project Area (Figure 3). Details related to the monitoring installations are described in Section 5.0 with copies of the borehole and monitoring well logs and installation details provided in Appendix D and in Table 1. Grain size analyses completed to characterize subsurface soils are provided in Appendix E.

All wells have been developed and hydraulic testing has been completed to estimate the hydraulic conductivity of the surrounding soils (Appendix E), with the exception of MW3-13D and MW4-13D where limited water was available to complete the hydraulic testing.

3.2 WELL DECOMMISSIONING

A total of four (4) monitoring wells (BH7A, BH2-12, BH4-12, and BH11-12) were installed as part of previous geotechnical investigations within the Project Area (exp, 2012; Inspec-Sol, 2013). As these monitoring wells were installed either within the Station Site, or were located where hydro tower foundation footings were to be built, they needed to be decommissioned. The monitoring wells were decommissioned in the fall of 2013 by a licensed well drilling contractor in accordance with the requirements under Ontario Regulation 903 (O. Reg. 903).

3.3 PRIVATE WELL MONITORING

The Private Well Monitoring Program included the completion of door to door visits to property (well) owners within 1,200 m of the Station Site (Figure 3). Three (3) attempts were made to contact the well owners directly to discuss the program and offer the opportunity to have their well monitored. For those well owners that were home at the time of the visits, the program was discussed and a copy of the notification letter and consent form for the well monitoring program was provided. For well owners that were not home at the time of the visits, a copy of the notification letter and consent form for the well monitoring program was left at the residence and followed up by sending another copy by registered mail.

Registered mail letters were sent to all residences notifying the home owners of the program, and providing contact information for Stantec and Hydro One. A copy of the notification letter and blank consent form is included in Appendix C. Any interested well owner within 1,200 m of the Station Site was included in the monitoring program, once a signed consent letter was provided to Hydro One. Well owner consent was obtained from the owners of 23 private wells (22 well owners) as of October 2014.

For private well owners that agreed to participate in the Monitoring Program, the following was completed:

- A voluntary well questionnaire to collect any relevant information about the private well; specifically type of well, total depth, water quality and quantity history;
- For wells that were accessible for water level monitoring, an automated pressure transducer was installed by a licensed water well contractor to provide 'continuous' water level measurements from the pre-station construction through to post-construction monitoring period;

- Water quality samples were collected twice prior to station construction. Water quality samples will continue to be collected semi-annually over the course of the station construction period (2014-2017) and the post-construction period (2018-2019). Private well samples were analyzed for general chemistry, turbidity, metals, petroleum hydrocarbons (PHCs)(F1-F4), benzene, toluene, ethylbenzene, and xylene (BTEX), and bacteriological analyses; and,
- Following each monitoring event, a letter is sent to each of the well owners presenting the results of their individual monitoring. To maintain confidentiality, we have included the results of the private well monitoring in this report but have not included the well identifications.

3.4 SURFACE WATER AND GROUNDWATER MONITORING

The surface water monitoring program within the Project Area consisted of the following monitoring:

- Completion of a field visit annually by a terrestrial ecologist to identify notable indicator species or areas of direct seepage within the Project Area; and,
- Collection of surface water levels and water quality from three (3) locations (SW2 to SW4) adjacent to drive-point piezometers DP2-14, DP3-14 and DP4-13. The samples are to be analyzed for general chemistry, metals, PHCs (F1-F4) and BTEX compounds with temperature, conductivity, and pH collected in the field at the time of sampling.

The groundwater monitoring program within the Project Area consisted of the following:

- Groundwater level monitoring at monitoring wells MW1-13S/D, MW2-13S/D, MW3-13S/D, MW4-13S/D, and drive-point piezometers DP2-14, DP3-14 and DP4-13 using automated pressure transducers to allow a continuous record of groundwater level variations; and,
- Groundwater quality samples from monitoring wells MW1-13S/D, MW2-13S/D, MW3-13S/D, MW4-13-S/D for general chemistry, metals, PHCs (F1-F4) and BTEX compounds with temperature, conductivity, and pH collected in the field at the time of sampling.

The monitoring program was completed quarterly during the pre-station construction period in 2014, and will be completed semi-annually during the station construction period (2015-2017), and post-station construction monitoring period (2018-2019).

Following installation of monitoring wells MW5-14S/I, MW6-14, and MW7-14 in October 2014, water level monitoring and water quality sampling was completed seasonally. An evaluation of the need to include these wells in the monitoring program is included within this report (Section 7.0).

3.5 ANNUAL REPORTING

The first annual report to be prepared under the program is this Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report. The report is intended to present data collected between late fall 2013 and the fall of 2014 prior to station construction, and provide a refined understanding of the geology and hydrogeology, including documentation of seasonal variations in groundwater levels and water quality within the Project Area. This report also includes a summary of private well monitoring data collected pre-station construction.

Subsequent annual reports will be prepared following the annual fall monitoring event during the station construction and post-station construction monitoring period to document potential changes in groundwater and surface water quantity and quality, and to confirm if station construction has adversely affected the groundwater and surface water systems.

4.0 SITE SETTING

4.1 LAND USE

The Project Area is located within the Region of Durham and the Municipality of Clarington, Part Lots 33, 34, and 35, Concession 7 (Figure 1). The Station Site where the Clarington TS will be constructed is approximately 11 ha of the total Project Area (63 Ha).

The primary industries within the Municipality of Clarington include agriculture and agriculture services, aggregate excavation and cement, tourism, manufacturing, utilities, retail, and construction. The lands surrounding the Project Area are rural with farming representing the primary land use with a number of non-farming residences and hobby farms in the area.

The Project Area is predominantly within the Oak Ridges Moraine planning boundary with portions of the area identified as Countryside Area and Natural Linkage Area and Natural Heritage Systems as per the Oak Ridges Moraine Conservation Plan (MMAH, 2002) and the Greenbelt Plan (MMAH, 2005) (Figure 1). The lands within the Project Area are identified as Prime Agricultural Land and have been leased to local farmers by Hydro One, dating back to 1978 when the property was acquired. The subject property is designated "Utility" in the Municipality of Clarington Official Plan 1996 (Hydro One, 2014).

An existing 230 kV transmission right-of-way runs through the Project Area in a north-east direction, and a 500 kV transmission right-of-way runs east-west through the south side of the Project Area (Figure 2). The eastern extension of Highway 407 will pass south of the Project Area, just north of Concession Road 6, with construction proposed to start in 2017.

Ontario Hydro installed the first 230 kV circuit in the Project Area in 1928, with three (3) additional circuits installed in 1929, and the fifth 230 kV circuit installed in 1932. The property was later expropriated in 1978 for the purpose of installing the four (4) 500 kV circuits and a future transformer station.

4.2 PHYSIOGRAPHY

The Project Area is occupied by the physiographic region defined by Chapman and Putnam (1984) as the *South Slope*, characterized by till plains with long, thin drumlins pointing upslope. The southern edge of the Oak Ridges Moraine administrative planning boundary (Figure 1) extends just past the southern boundary of the Project Area. This boundary is defined by the 245 m ground surface elevation under the Oak Ridges Moraine Conservation Act, 2001, rather than by site-specific geologic or hydrogeologic characteristics.

Local topography for the Project Area was available based on 5 m contours from the Ministry of Natural Resources and Forestry (MNRF) 2006 Digital Elevation Model. The ground surface is hilly and generally decreases from north to south from 280 m AMSL just north of the Project Area to approximately 220 m AMSL along the southern boundary of the Project Area (Figure 3).

4.3 SURFACE WATER FEATURES

The Project Area falls within the Black/Harmony/Farewell Creek Watershed and is located within the jurisdiction of the Central Lake Ontario Conservation Authority (CLOCA).

The watershed divide between the Harmony and Farewell Creek Watershed is located along the topographic high that runs north-south through the eastern portion of the Project Area (Figure 3). Precipitation and runoff from the northern portion of the Project Area drains to the woodlot and wetland area (Wetland Area 1) north of the Project Area and to the tributary of Harmony Creek that flows west of the Project Area within the valley lands (Figure 3). In the southern portion of the Project Area, drainage flows overland to a surficial drainage feature with no defined channel. During spring freshet and following precipitation events, this drainage feature flows south across Concession Road 7 and discharges to the tributary of Harmony Creek that originates west of the Project Area. The eastern portion of the Project Area drains to Wetland Area 2 and then to the tributary of Farewell Creek that flows just west of Langmaid Road. Downstream of the Project Area, Harmony and Farewell Creeks join together prior to discharging to Lake Ontario.

Two (2) wetlands (Wetland Area 1 and 2) extend within the Project Area and have been determined to not be of suitable quality to be classified as Provincially Significant Wetlands (PSWs) (Hydro One, 2014). Wetland Area 1 is approximately 2 ha in size and located adjacent to the forest in the northwest portion of the Project Area (Figure 3). It is composed primarily of a large, dry, low-diversity reed-canary grass meadow marsh with a smaller edge inclusion of red-osier dogwood mineral thicket swamp to the west and a small interior inclusion of cattail meadow marsh. Wetland Area 2 is approximately 0.7 ha in size and is located along the eastern boundary of the Project Area adjacent to the Farewell Creek tributary (Figure 3). It is comprised of three (3) contiguous wetland communities consisting of a dry reed-canary grass meadow marsh, abutted to the north by smaller willow mineral deciduous swamp with a ground layer similar to the marsh communities, largely of reed-canary grass. These wetlands are seasonally wet/moist and move toward dryer conditions in a relatively short time as observed during field visits. The wetlands are observed to offer limited storage capacity.

Based on observations and monitoring during the Class EA (Hydro One, 2014) and during the pre-station construction monitoring program as discussed in this report, the surface water tributaries of Harmony Creek and the drainage channel within the Project Area are interpreted to be intermittent, with flow observed only during the spring and following significant precipitation events. No apparent groundwater seepage areas have been identified within or adjacent to the Project Area, suggesting these tributaries are supported primarily by overland flow.

Aquatic habitat assessments were completed in the Harmony Creek and Farewell Creek tributaries as part of the Class EA (Hydro One, 2014). During the assessments, water levels were low, and in some cases, the channels were dry with no fish observed; however, portions of the channels do appear to be favorable, seasonally for direct fish habitat.

4.4 REGIONAL GEOLOGY

The following sections provide an overview of the regional geology of the Project Area.

4.4.1 Overburden Stratigraphy

The Oak Ridges Moraine covers an area of 1,900 km^2 and extends from approximately Caledon in the west to Peterborough in the east and forms a regional topographic high. The Oak Ridges Moraine consists of quaternary deposits up to 200 m thick, grouped into the following five (5) general classifications as described by Geological Survey of Canada (2001) from oldest to youngest:

- ***Lower Deposits*** - directly overly the bedrock, and consist of interbedded layers of sand, silt, clay and till material. These deposits include the Thorncliffe Formation, Sunnybrook/Port Hope Till, Scarborough Formation, Don Formation, York Till and lower sediments;
- ***Newmarket Till*** - is described as a dense, stony, silty sand till extending up to 60 m in thickness, and has been traced lithologically beneath the moraine (Sharpe et al., 1998);
- ***Tunnel Channels*** - A regional unconformity that forms the upper drumlinized and channelized surface of the Newmarket Till. Tunnel channels oriented in a north–northeast to south-southwest direction extend through the Newmarket Till and may extend to the bedrock. The channels primarily contain sandy sediments related to the Oak Ridges Moraine sediment but may also contain gravel material;
- ***Oak Ridges Moraine (ORM) Sediments*** - Described as interbedded silt and fine sand with local sandy gravel material; and,
- ***Halton Till*** - The most recent stratigraphic unit that overlies portions of the Oak Ridges Moraine, and is predominantly composed of fine textured, low stone content clayey silt to silt till with interbedded sand and silt material.

Based on Ontario Geological Survey (OGS) surficial geological mapping for the Project Area (OGS, 2003), the surficial deposits are mapped as Newmarket Till. The Halton Till is mapped as a more continuous surficial layer further north of the Project Area, with localized lobes of Halton Till mapped to the south and east of the Project Area (Figure 4). This interpretation is consistent with mapping of Halton Till by Sharpe et al. (1999) that indicates the Halton Till is often overestimated east of the Humber Watershed and occurs as thin, narrow sequences overlying ORM Sediments or directly overlying Newmarket Till at the southern extent of the Oak Ridges Moraine. Surficial modern alluvial deposits associated with local watercourses are mapped within the Tributary of Harmony Creek within the west and north portion of the Project Area, and are indicated to be present to the east and south of the Project Area.

Figure 1 presents the location of a regional geological cross-section created from the York Peel Durham Toronto Region – Conservation Authority Moraine Coalition (YPDT-CAMC) Extended Core Model (YPDT-CAMC Model). The model surfaces are presented on Figure 5 and suggest the Halton Till as a continuous layer south of the Oak Ridges Moraine with a thin discontinuous sequence of ORM Sediments present at an elevation of approximately 210 to 220 m AMSL. This interpretation is not consistent with the mapping completed by OGS (2003) or Shape et al.

(1999), who both indicate the Halton Till to be much more discontinuous in the vicinity of the Project Area. Figure 5 indicates ORM Sediments to be underlain by a thick Newmarket Till layer to an elevation of approximately 180 to 185 m AMSL. The Newmarket Till is shown to extend beneath the entire moraine, serving as a regional aquitard to the underlying regional aquifer, the Thorncliffe Formation (Figure 5). The Thorncliffe Formation is estimated to be 35 to 40 m thick beneath the Project Area and is underlain by 10 to 15 m of Lower Sediments. Bedrock is estimated to occur at an elevation of 135 m to 140 m AMSL.

4.4.2 Bedrock

The bedrock underlying the Project Area consists of the Upper Ordovician Blue Mountain Formation (OGS, 1991) composed of blue grey non-calcareous shales. The top of bedrock occurs at an elevation of approximately 60 m to 70 m AMSL at the Lake Ontario shoreline increasing to 150 m AMSL at the topographic highs of the Oak Ridges Moraine (Singer et al., 2003). In the vicinity of the Project Area, the bedrock surface is estimated at 135 m to 140 m AMSL (Figure 5).

4.5 REGIONAL HYDROGEOLOGY

In the vicinity of the Project Area, the Newmarket Till is mapped as being present at ground surface with discontinuous areas of Halton Till present (Figure 4). These surficial till deposits are characterized as aquitard units with low hydraulic conductivities. Shallow horizontal groundwater flow systems within the upper weathered portions of these tills occur and are predominantly controlled by ground surface topography. Deeper groundwater flow within the till units is predominantly vertical in the form of leakage to the underlying aquifer systems.

The Newmarket Till is a regional aquitard within the Oak Ridges Moraine, limiting groundwater recharge through leakage to the underlying Thorncliffe Formation. Gerber and Howard (2002) estimate a leakage rate of 35 to 40 mm/yr for the Duffins Creek Watershed. In areas where tunnel channels have cut through the Newmarket Till, increased recharge to the underlying Thorncliffe Aquifer can occur (Sharpe et al., 1996).

As part of the source water assessment, CLOCA (2012) presented water level and groundwater flow conditions within the various hydrostratigraphic units in the vicinity of the Project Area. Figure 6 presents the regional water table surface based on wells less than 20 m deep and indicates the water table generally mimics ground surface topography, decreasing from over 250 m AMSL north of the Project Area to 200 m AMSL in the vicinity of Concession Road 6, located immediately south of the Project Area with downward vertical gradients between the shallow groundwater system and the underlying Thorncliffe Formation.

Regional mapping of water levels from wells interpreted to be completed within the Thorncliffe Formation indicates groundwater flows in a southerly direction across the Project Area towards Lake Ontario (Figure 7). The mapped potentiometric surface decreases from approximately 225 m AMSL in the vicinity of Regional Road 3 to the north of the Project Area, to approximately 200 m AMSL in the vicinity of Concession Road 6 to the south of the Project Area (CLOCA, 2012).

5.0 METHODS

The Groundwater and Surface Water Monitoring Program pre-station construction monitoring included the following components:

- Monitoring Well Installation;
- Drive-point Piezometer Installation;
- Elevation Surveying;
- Test Pit Excavation;
- Hydraulic Response Testing;
- Groundwater and Surface Water Level Monitoring; and,
- Groundwater and Surface Water Quality Monitoring.

The following sections present a summary of the study methodology for each of the above components.

5.1 MONITORING WELL INSTALLATION

Since December 2013, a total of twelve (12) monitoring wells (MW1-13S/D, MW2-13S/D, MW3-13S/D, MW4-13S/D, MW5-14S/I, MW6-14 and MW7-14) were installed at seven (7) locations throughout the Project Area in order to monitor groundwater and improve the understanding of the local geology and hydrogeology. The monitoring well locations are presented on Figure 3.

Monitoring wells were installed by Aardvark Drilling Inc. (Aardvark) between December 2 and 12, 2013 and October 1 and 8, 2014 under the observation of Stantec personnel. Boreholes were completed using a CME 75 track-mounted drill rig. Aardvark used 210 mm outside diameter (OD) / 108 mm inside diameter (ID) hollow stem augers for drilling at all boreholes. In addition, a 127 mm OD / 103 mm ID Christianson wireline PQ continuous coring system was used to complete the borehole at MW5-14I below 2.7 m below ground surface (BGS). Drilling mud was used during PQ coring at MW5-14I to stabilize the borehole. The drilling mud was mixed using water supplied by Aardvark. No water or drilling mud was used during completion of the auger drilling.

During auger drilling soil samples were collected with 0.45 m to 0.6 m long 50 mm diameter split spoon samplers at 0.76 m intervals for the initial 4.6 m of drilling, followed by 1.5 m to 3.0 m intervals for the remainder of the deep boreholes. Sampling was not completed during advancement of the shallow boreholes, as they were installed immediately adjacent to deeper boreholes.

Soil samples were classified by Stantec personnel using the ASTM guideline for visual-manual description and identification of soils. Borehole logs were prepared for each borehole and contain descriptions of soil type, texture, colour, structure, moisture content, and other observations.

A total of nine (9) soil samples from MW5-14I (4.7 m BGS, 12.9 m BGS, 24.1 m BGS, 27.4 m BGS and 38.1 m BGS), MW6-14 (6.2 m BGS and 7.0 m BGS) and MW7-14 (6.3 m BGS and 7.1 m BGS) were submitted for grain size analysis. The grain size results are included in Appendix E.

All monitoring wells were constructed using 51 mm ID Schedule 40 polyvinyl chloride (PVC) well casing. The wells were constructed with No. 10 slot (0.01 inch slot) PVC well screens 3.05 m in length, with the exception of MW6-14 and MW7-14, which were constructed of 1.52 m length screens. The annular space between the well and the formation was backfilled with No.3 grade silica sand surrounding the screen and extending 0.3 m to 0.6 m above the screen. The remainder of the annular space was filled with bentonite holeplug (chips) and/or bentonite grout to ground surface. The bentonite grout was installed using positive displacement methods. The surface seal consisted of bentonite holeplug to 0.3 m BGS with cement grout to ground surface. All wells were constructed with individual lockable steel protective casings. To further prevent any potential hydraulic connection between the shallow and deep monitoring locations, any nested monitoring wells were installed in separate boreholes. All monitoring wells constructed as part of this investigation were completed in accordance with O. Reg. 903.

Soil samples were collected at each location to confirm disposal requirements. Soil quality results are presented on Table G1 in Appendix G. Results did not indicate any exceedances of Ontario Regulation 153/04 (O. Reg. 153/04) Table 1 criterion. As a result, all soil cuttings generated during drilling were spread on the ground surface adjacent to each location.

The monitoring wells were developed using 16 mm diameter HDPE tubing connected to a Waterra® foot valve. Well development was completed by Hydro One technical staff with assistance from Stantec. At each well, a minimum of three (3) well volumes was removed due to the slow recovery at most locations. At MW1-13S, MW3-13D, MW4-13D, and MW5-14I, the wells were purged dry and due to the slow recovery no additional development was completed between sampling events. Monitoring well installation details are summarized in Table 1 and presented on the borehole logs in Appendix D.

5.2 DRIVE-POINT PIEZOMETER INSTALLATION

Three (3) drive-point piezometers (DP2-14, DP3-14 and DP4-13) were installed within the Project Area to provide an indication of groundwater levels and vertical gradients beneath the surface water features. A drive-point piezometer was not installed adjacent to MW1-13 as there is no directly adjacent surface water feature. Drive-point piezometer locations are presented on Figure 3. The drive-point piezometers consisted of a 19 mm diameter, 0.43 m long steel drive-point piezometer screen connected to 25 mm diameter galvanized steel risers. The drive-point piezometers were installed by hand driving methods. In 2014, Stantec replaced the drive-point at DP2, as the initial drive-point was installed at an angle due to difficult ground conditions and it was difficult to obtain accurate water level readings. Installation details are summarized in Table 1.

5.3 ELEVATION SURVEYING

Ground surface and top of casing elevations and spatial coordinates at all drive-point piezometers (DP2-14, DP3-14, DP4-13) and newly install monitoring wells (MW1-13S/D, MW2-13S/D, MW3-13S/D, MW4-13S/D, MW5-14S/I, and MW6-14 to MW7-14) were surveyed by Hydro One using a total station survey unit. All elevations and UTM coordinates are provided in Tables 1 and 2 along with the details of the source.

5.4 TEST PIT EXCAVATION

In October 2014, a total of three (3) test pits (TP1-14 to TP3-14) were completed at the eastern extent of the Station Site to document surficial soil conditions (Figure 3). The excavated soils were classified by Stantec personnel using the ASTM guideline for visual-manual description and identification of soils. Logs were prepared for each test pit location containing descriptions (where relevant and possible) of soil type, texture, colour, structure, moisture content, and other observations. Copies of the test pit logs are provided in Appendix D. Excavated soil was used to backfill the test pits to return each location to its original condition.

A soil sample was collected near the base of each test pit and submitted for grain size analysis. The grain size results are included in Appendix E.

5.5 HYDRAULIC RESPONSE TESTING

To estimate the hydraulic conductivity of the soil in the vicinity of the monitoring wells, Stantec performed in-situ hydraulic response testing within the shallow and deep monitoring wells.

At MW1-13D, MW4-13S and MW5-14S the testing consisted of a rising head slug test completed by rapidly removing a known volume of water from the well using a bailer, followed by recording the time taken for the water level to return to static conditions. This process was repeated 2 or 3 times, depending on the location and recovery period. Due to the minimal column of water within the wells at MW3-13D or MW4-13D, hydraulic conductivity testing was not completed. At the remaining monitoring well locations, due to the slow recovery, the testing consisted of purging a volume of water from the well and allowing it to recover. Based on the slow recovery, only one (1) test was completed at these locations.

The results were analyzed using the Bouwer and Rice (1976) solution provided in the software package AQTESOLV™ to determine the hydraulic conductivity of the overburden material within the immediate vicinity of the well screen. The results of hydraulic response testing are summarized in Table 1 with the AQTESOLV solutions presented in Appendix E.

5.6 GROUNDWATER AND SURFACE WATER LEVEL MONITORING

Surface water level monitoring was completed using manual techniques, while groundwater monitoring was completed using a combination of manual and automated techniques. Monitoring wells and drive-point piezometers were instrumented by Stantec with Solinst® LT

Leveloggers® and were set to record at 1-hour intervals. The Leveloggers® are not vented to the atmosphere and therefore record total pressure. As a result, data obtained from the Leveloggers® was corrected for atmospheric pressure to obtain the actual height of water above the sensor. The atmospheric corrections were made using data collected from a Solinst Barologger®, which was located at MW1-13S. For the period of time from December 2013 to May 2014, the Barologger malfunctioned and atmospheric corrections were completed using data from the Oshawa climate station.

Manual water level measurements were collected at all wells using a battery operated probe and calibrated tape. Water depths were recorded in metres below the top of the well casing (BTOC). Water level hydrographs for the monitoring wells and drivepoints within the Project Area are presented in Figures 12 and 13, respectively.

5.7 GROUNDWATER AND SURFACE WATER QUALITY MONITORING

5.7.1 Surface Water

No surface water was present adjacent to MW1-13, and therefore, no sampling could be completed. Surface water was only present at SW4 (adjacent to DP4-13) at the time of drive-point installation. This location was dry during all other field visits and therefore no surface water quality samples were collected from SW4.

Hydro One technicians, under the direction of Stantec field staff, completed surface water quality sampling within the nearby surface water features including the South Branch of the Tributary of Harmony Creek at SW2 (adjacent to DP2-14) and the Tributary of Harmony Creek at SW3 (adjacent to DP3-14). Surface water sampling at SW2 and SW3 was attempted in December 2013, May 2014, August 2014 and October 2014. Sampling could not be completed at SW3 in December 2013 as the creek was frozen.

Surface water samples were collected directly from the creek into laboratory provided sample containers. The samples were not field filtered. Field measurements of specific conductivity, temperature and pH were recorded using a YSI Quattro Pro meter or Hanna pH pen, depending on the sampling date. These meters were calibrated prior to use according to the manufacturers' specifications with the appropriate calibration standards.

All samples collected were packed into sample coolers, which were refrigerated using ice packs, and delivered to Maxxam Analytics Inc. for laboratory analyses. All surface water samples were analyzed for general inorganic chemistry, total metals, PHCs (F1 to F4) and BTEX compounds. The lab also analyzed for dissolved calcium, magnesium, potassium and sodium as part of ion balance calculations. Chain of custody forms were completed and included with the sample submissions. The results of the surface water quality testing are presented in Table 3 with copies of the Laboratory Certificates of Analysis provided in Appendix G.

5.7.2 Groundwater Monitoring Wells

Hydro One technicians, under the direction of Stantec staff, completed the groundwater quality sampling within the shallow and deep monitoring wells at MW1-13S/D to MW4-13S/D in December 2013, March 2014, May 2014, August 2014 and October 2014 and at MW5-14S/I, MW6-14 and MW7-14 in October 2014.

Groundwater samples were primarily collected using dedicated inertial lift Waterra™ sampling pumps in all wells, except MW1-13S, MW3-13D and MW4-13D, where manual methods were used. The use of dedicated equipment reduced the possibility of cross contamination of samples between sampling locations. The Waterra™ sampling pumps were constructed of 16 mm diameter HDPE tubing connected to a Waterra™ Delrin foot valve. For the deep monitoring well at MW5-14I, initial development was completed by hand using Waterra™ sampling pumps, with a hydrolift used during sampling to facilitate sample collection. Prior to sampling, efforts were made to purge three (3) well volumes prior to sample collection. At MW1-13S, MW3-13D and MW4-13D, the wells are slow to recover with minimal water within each well. At MW1-13S, 2 to 5 L was purged prior to sample collection. At MW3-13D and MW4-13D the wells were purged dry initially and allowed to recover, with each sample collected with a disposable bailer.

Field measurements of specific conductivity, temperature and pH were recorded using a YSI Quattro Pro meter or Hanna pH pen, depending on the sampling date. These meters were calibrated prior to use according to the manufacturers' specifications with the appropriate calibration standards. Field parameters were monitored during purging.

Following purging, groundwater samples were collected directly from the HDPE tubing or bailers into the sample containers. Groundwater samples for metals analysis were collected in unpreserved sample bottles and filtered by Maxxam in the laboratory.

All groundwater samples collected were packed into sample coolers, which were refrigerated using ice packs, and delivered to Maxxam for laboratory analyses. Groundwater samples were analyzed for general inorganic chemistry, dissolved metals, PHCs (F1 to F4), BTEX compounds, PCBs, VOCs and SVOCs. Chain of custody forms were completed and included with the sample submissions. The results of the groundwater quality testing at the monitoring wells are presented in Table 4 with a copy of the Laboratory Certificates of Analysis being provided in Appendix G.

Maxxam followed internal QA/QC protocols, which included internal replicates, process blanks, process recovery, and matrix spike analyses. Maxxam reported that the results for their internal QA/QC were within acceptable limits, and these results were considered acceptable for use in the report. The results of the lab replicates are not presented in Table 4, but included in the detailed laboratory certificates of analyses in Appendix G.

5.8 PRIVATE WELL MONITORING

Details of the private well survey, notification of the project and monitoring program and details of the private well monitoring were presented in Section 3.3. The following sections present the 2014 monitoring details.

5.8.1 Water Level Monitoring

Lotowater Technical Services Inc. (Lotowater), a licensed well contractor, completed water level monitoring, hydraulic testing, Levelogger® installation and downloading within the private wells. All equipment was disinfected prior to installing within any of the private wells.

Construction details for the private wells are presented on Table 2 with individual private well hydrographs included in Appendix F.

5.8.2 Water Quality Monitoring

Stantec completed groundwater quality sampling within the private supply wells in July/August 2014 and October 2014. The sampling was completed to document baseline conditions prior to station construction.

Stantec attempted to collect water quality samples from a raw water tap; however, this was not always feasible. Based on water quality results, it was confirmed that water samples from several locations were collected following treatment by a water softener. At these locations, further attempts will be made to locate a raw water tap with the well owner during future sampling events.

The sample location was typically an outdoor tap or a kitchen faucet, depending on the availability. Prior to sample collection, the tap was disinfected with a dilute bleach solution and allowed to run for approximately 10 minutes or until water quality stabilized. Water samples were collected directly into laboratory supplied containers. The samples were not filtered, and results represent total concentrations.

All groundwater samples collected were packed into sample coolers, which were refrigerated using ice packs, and delivered to Maxxam for laboratory analyses. Groundwater samples from private wells were analyzed for microbiological analysis, general inorganic chemistry, total metals, petroleum hydrocarbons and BTEX compounds, PCBs, VOCs and SVOCs. During the first round of sampling, not all wells were sampled for bacteriological analyses due to a miscommunication. The well owners affected by this omission have been notified, and a second round of bacteriological water quality analyses will be completed for private wells that were missed during the initial sampling round. Chain of custody forms were completed and included with the samples.

The results of the groundwater quality testing at the private wells are presented in Table 5 with a copy of the Laboratory Certificates of Analysis being provided in Appendix G.

Maxxam followed internal QA/QC protocols, which included internal replicates, process blanks, process recovery, and matrix spike analyses. Maxxam reported that the results for their internal QA/QC were within acceptable limits, and these results were considered acceptable for use in the report. The results of the lab replicates are not presented in Table 5, but included in the detailed laboratory certificates of analyses in Appendix G.

6.0 RESULTS

The following sections present the results of the pre-station construction baseline monitoring program based on data collected as part of the approved program, plus additional investigations that were completed to support the station construction.

6.1 LOCAL GEOLOGY AND HYDROSTRATIGRAPHY

A total of twenty-nine (29) geotechnical boreholes were completed within the Project Area by exp (2012) and Inspec-Sol (2013) in 2012. Stantec advanced twelve (12) boreholes as part of the Groundwater and Surface Water Monitoring Program in 2013 and 2014. The following provides a summary of the Project Area geology based on the borehole drilling results. The location of the Project Area boreholes and monitoring wells are shown on Figures 2 and 3.

6.1.1 Continuous Cored Borehole – MW5-14

A continuous core borehole MW5-14 was advanced immediately southwest of the Station Site at an elevation of 252.6 m AMSL. Two (2) monitoring wells were installed in separate boreholes to depths of 6.1 m BGS (MW5-14S) and 40.1 m BGS (MW5-14I). The purpose of this deeper well was to confirm the deeper groundwater level observed in MW3-13D and MW4-13D. At the time of this report, a deeper borehole and monitoring well to be completed to at least the Thorncliffe Formation is being planned, and was a condition of the access road easement agreement with the Municipality of Clarington.

The borehole at MW5-14 encountered a thin (0.20 m) layer of topsoil, underlain by fine sand to a depth of 2.7 m BGS (249.9 m AMSL). The sand transitioned from loose near surface to dense at depth, and is underlain by a dense to very dense silty sand to sandy silt till to 5.1 m BGS (247.5 m AMSL), potentially corresponding to Halton Till. Below 5.1 m BGS (247.5 m AMSL), a very dense silty sand till with some clay was encountered to the bottom of the borehole, and is interpreted to be Newmarket Till. Increased gravel content was observed in thin zones between 20.3 m to 21.8 m, 26.4 to 27.9 m BGS, and increased cobble content in thin zones between 29.4 m to 31.0 m, 32.5 to 34 m, and 38.6 to 40.1 m BGS. This borehole did not intersect ORM Sediments at the elevations estimated by the YPDT Model, indicating a refinement of the core model layers may be required. This is consistent with drilling results completed to the south of the Project Area as part of the eastern extension of Highway 407 (Gartner Lee, 2009).

Soil samples were selected from intervals of interest for grain size analysis and are summarized below.

Borehole	Sample	Median Depth (m)	Description	Gravel %	Sand %	Silt %	Clay %
MW5-15-I	CC6	4.7	silty SAND, some gravel, little clay (Silty Sand Till)	15	51	25	10
MW5-15-I	CC12	12.9	silty gravelly SAND, little clay (Gravelly Silty Sand Till)	26	31	25	18
MW5-15-I	CC19	24.1	silty clay SAND, little gravel (Silty Clayey Sand Till)	7	37	34	21
MW5-15-I	CC22	27.4	silty SAND, some clay, little gravel (Silty Sand Till)	10	43	29	18
MW5-15-I	CC28	38.1	Silty SAND, some clay, some gravel (Silty Sand Till)	12	38	34	16

Grain size distribution results based on Unified Classification System (ASTM D422)

All soil samples from MW5-14-I contain predominantly fine sand and silt with matrix supported coarse sand and fine to coarse gravel, typical of a till unit. The grain size distribution analyses were consistent with the field descriptions noted at the time of drilling. The results of the grain size distribution analyses are included in Appendix E.

6.1.2 East Side of Project Area – MW1-13, MW6-14, and MW7-14

Boreholes MW1-13, MW6-14, and MW7-14 were advanced along the eastern boundary of the Project Area. The ground surface elevation at these locations varies from 261 to 263 m AMSL. At MW1-13 a pair of shallow (S) and deep (D) groundwater monitoring wells were installed in December 2013 as part of the Monitoring Program. Monitoring wells MW6-14 and MW7-14 were installed in October 2014 to provide further characterization of shallow soils and input for determining construction dewatering requirements anticipated within this portion of the Project Area.

Near the center of the eastern boundary of the Project Area at MW1-13, a thin (0.20 m) layer of topsoil was encountered followed by a thin layer of sand to 0.8 m BGS (261.8 m AMSL). The sand is underlain by sand till consisting of fine grained sand with some silt to a depth of 3.05 m BGS (259.5 m AMSL). The sand till was underlain by very dense brown silty sand till, interpreted to be Newmarket Till to the bottom of the borehole. The upper sand till may potentially correspond to the Halton Till.

At MW6-14, a compact to dense silt till was encountered directly underlying the topsoil layer and extended to 6.1 m BGS (254.70 m AMSL) and was underlain by a very dense silty sand to sandy silt till interpreted to be the Newmarket Till. At MW7-14, silty sand to sandy silt till was encountered from beneath the topsoil and extended to the full depth of the borehole. Based on the change in colour from brown to grey and difficult drilling conditions, the Newmarket Till was interpreted at 6.1 m BGS (258.1 m AMSL).

Soil samples were selected from intervals of interest for grain size analysis and are summarized below.

Borehole	Sample	Median Depth (m)	Description	Gravel %	Sand %	Silt %	Clay %
MW6-14	SS9	6.2	SAND and SILT, some gravel, some clay (Silty Sand Till)	18	38	30	14
MW6-14	SS10	7.0	SAND and SILT, some clay, little gravel (Silty Sand Till)	8	41	34	16
MW7-14	SS9	6.3	SAND and SILT, little clay, little gravel (Silty Sand Till)	8	42	40	10
MW7-14	SS10	7.1	SAND and SILT, some clay, little gravel (Silty Sand Till)	9	43	34	14

Grain size distribution results based on Unified Classification System (ASTM D422)

All soil samples from MW6-14 and MW7-14 contain predominantly fine sand and silt with matrix supported coarse sand and fine to coarse gravel. The grain size analyses were consistent with the field descriptions noted at the time of drilling. The results of the grain size distribution analyses are included in Appendix E.

Three (3) test pits were excavated on the eastern side of the Project Area to evaluate the upper soils in the vicinity of the proposed grading where construction dewatering is anticipated (Figure 2). Grab samples collected from the bottom of the test pits were selected for grain size distribution analyses. The results of these tests are summarized in the table below.

Borehole	Sample	Median Depth (m)	Description	Gravel %	Sand %	Silt %	Clay %
TP-1	SA2	4.9	SAND and SILT, some gravel, some clay (Silty Sand Till)	16	39	32	13
TP-2	SA2	4.6	sandy silty GRAVEL, little clay (Gravelly Silty Sand Till)	43	25	23	9
TP-3	SA2	3.7	sandy silty GRAVEL, little clay (Gravelly Silty Sand Till)	37	29	25	9

Grain size distribution results based on Unified Classification System (ASTM D422)

The grain size distribution analyses from TP-1 indicate sand and silt (Silty Sand Till), and correlates with that observed in the closest borehole, MW7-14. The samples from TP-2 and TP-3 were specifically selected at a depth interval where increased gravel content and slight groundwater seepage was noted within the side of the test pit. The test pit logs and grain size distribution results indicate soils are a silty fine sand till with increased gravel content. The grain size distribution curves are included in Appendix E.

6.1.3 North Side of Project Area – MW2-13

MW2-13 is located at an elevation of 250.4 m AMSL along the north side of the Station Site adjacent to Wetland Area 1. The deep borehole at MW2-13 was advanced to a depth of 15.2 m BGS (MW2-13-D), with a shallow borehole advanced beside it to a depth of 4.6 m BGS (MW2-13-S).

A thin (0.20 m) layer of topsoil underlain by loose fine grained sand with some silt to a depth of 1.2 m BGS (249.2 m AMSL). The sand was underlain by dense brown silty sand till that transitioned to grey, very dense silty sand till at 4.6 m BGS (245.8 m AMSL). From 4.6 m BGS to the bottom of the borehole at 15.2 m BGS (235.2 m AMSL), the borehole encountered predominantly very dense silty sand till interpreted to be Newmarket Till.

6.1.4 West Side of Project Area – MW3-13

Monitoring Well MW3-13 is located between the west side of the Station Site and a tributary of Harmony Creek at an elevation of 244.0 m AMSL. The deep borehole at MW3-13 was advanced to a depth of 15.2 m BGS (MW3-13-D), with a shallow borehole advanced beside it to a depth of 6.7 m BGS (MW3-13-S). A thin (0.20 m) layer of loose silty fine grained sand was present to a depth of 0.8 m BGS (243.3 m AMSL), below which a very dense, silty sand till, interpreted to be Newmarket Till, was present to the base of borehole at 15.2 m BGS.

6.1.5 South Side of Project Area – MW4-13

Located south of the Station Site and near the southern Project Area boundary at an elevation of 238.7 m AMSL, the deep borehole at MW4-13 was advanced to a depth of 15.2 m BGS (MW4-13-D), with a shallow borehole advanced beside it to a depth of 4.6 m BGS (MW3-13-S).

A thin (0.13 m) layer of topsoil with organics was underlain by loose to very loose brown sand with some silt and trace to little clay to a depth of 3.0 m BGS (235.7 m AMSL). Below the sand, a thin (0.15 m) layer of silt till was encountered and was underlain by very dense silty sand till, interpreted to be Newmarket Till, to the bottom of the borehole.

6.1.6 Conceptual Hydrostratigraphic Framework

A local conceptual hydrostratigraphic framework was developed based on the detailed investigations within the Project Area and a comparison with available information, including the YPDT-CAMC Model, surficial geology mapping, and the MOECC Water Well Database. The location of the Project Area boreholes and monitoring wells and surrounding water wells identified in the MOECC WWR are presented in Figure 3 along with the location of select geologic cross-sections (Figures 8 to 10) through the Project Area.

The surficial overburden material observed across the Project Area is composed of a thin layer of discontinuous, loose silty sand overlying a compact to dense silty sand to sandy silt till. The silty sand was identified in the northern and southern portions of the Project Area, and was generally absent in the western, central, and eastern portions of the Project Area. In the northern portion of the Project Area, the silty sand ranges from 0.8 to 1.5 m thick (BH2, BH9-12, BH10-12, BH11-12 and BH12-12), and was found to be between 0.7 and 3.1 m thick in the southern (MW5-14, MW4-13, BH2-12, BH9, and BH10) portion of the Project Area. In the areas where the silty sand was absent, a thin (0.2 to 1.5 m thick) surficial layer of sandy clayey silt fill (agriculturally tilled soil) was identified.

The elevation of the underlying dense silty sand to sandy silt till generally mimics ground surface topography, decreasing from approximately 262 m AMSL along the eastern Project Area boundary, to 243 m AMSL in the west, and 235 m AMSL to the south of the Project Area (Figures 8 and 9). The origin of this dense silty sand to sandy silt till is difficult to determine and may correspond to Halton Till, as mapped in the YPDT-CAMC Model, or potentially to a more weathered upper portion of the Newmarket Till, as identified in the OGS (2003) surficial quaternary geology mapping within the Project Area. With increasing depth, this silty sand to sandy silt till becomes very dense and difficult to drill, with cores from MW5-14 observed to have expanded by 5 to 10% upon recovery, indicating this till is highly over-consolidated, typical of the Newmarket Till.

No evidence of the ORM Sediments was noted in any of the boreholes advanced as part of this Monitoring Program, indicating that this unit is not present beneath the Project Area. Further to the east of the Project Area, ORM Sediments may be present as discrete finger-like deposits within the Farewell Creek Sub-watershed at elevations of 225 m AMSL to 235 m AMSL and to the west at elevations of 210 m AMSL to 230 m AMSL (Figure 10).

From a hydrostratigraphic framework, the following aquifer and aquitard units are interpreted to be present beneath the Station Site:

- **Surficial Silty Sand** – A thin discontinuous silty sand that varies in thickness between less than 0.2 m to 3.1 m across the Project Area. It was found to be thickest in the northern and southern portions of the Project Area, and absent in the western, central, and eastern portions of the Project Area. Groundwater flow within this unit, where present, is predominantly to the south and southwest, with downward groundwater flow limited by the underlying very dense Upper Aquitard;
- **Upper Aquitard (Halton Till/Newmarket Till)** – Silty sand to sandy silt till was found to underlie the surficial silty sand, when present, or was present at ground surface. The upper portion of this till may correspond to Halton Till or weathered Newmarket Till. At depth this till becomes very dense and is interpreted to correspond to Newmarket Till. No evidence of ORM Sediments was identified at the Station Site. Given the similarity in composition of the Halton and Newmarket Tills at the Station Site these units are interpreted to behave as a single aquitard unit with predominantly vertical leakage occurring through to the underlying Thorncliffe Aquifer; and,
- **Thorncliffe Aquifer** - is interpreted to underlie the Project Area at a depth of approximately 70 to 80 m BGS (top of aquifer), or an elevation of approximately 180 m to 185 m AMSL and represents a regional aquifer system within the Oak Ridges Moraine.

6.2 LOCAL HYDROGEOLOGY

Hydraulic conductivity testing and groundwater and surface water level monitoring were completed within the Project Area from December 2013 to October 2014 to define the aquifer/aquitard properties and the direction and variation in groundwater flow. The data consists of eight (8) hydraulic conductivity estimates, water level measurements from three (3) drive-point piezometers, twelve (12) monitoring wells and twenty-three (23) private wells (Figure 11). The following sections detail the hydraulic conductivity analysis, groundwater levels, flow and gradients within the Project Area.

6.2.1 Hydraulic Conductivity Analysis

Hydraulic testing was completed on all monitoring wells with the exception of MW3-13D and MW4-13D due to the limited water available within the wells. Results of the hydraulic conductivity analyses are presented in Appendix E and summarized in Table 1.

The hydraulic conductivity of the silty sand to sandy silt till of the Upper Aquitard ranges from $2x10^{-7}$ m/s to $7x10^{-9}$ m/s across the Project Area with a geometric mean of $6x10^{-8}$ m/s and is consistent with hydraulic conductivity estimates for the Newmarket Till (Gartner Lee, 2009 and Gerber and Howard, 2002). At MW4-13S and MW5-14S, the shallow monitoring wells or sand packs are partially installed or connected to the overlying silty sand unit and as a result have hydraulic conductivities in the range of 1x10^{-5} m/s, typical of silty sand (Freeze and Cherry, 1979). These hydraulic conductivities are interpreted to correspond to the surficial silt and sand unit at the Station Site.

Due to the slowly recovering water level in the monitoring well at MW5-14I following installation and purging, hydraulic testing results for this well were completed prior to the well reaching static conditions. In order to estimate hydraulic conductivity, the water level recovery was plotted over time, and the recovery curve was extrapolated to an assumed static level of 18.5 m BGS. Based on the available data, a hydraulic conductivity of 1x10^{-9} m/s was estimated.

6.2.2 Shallow Groundwater Flow – Surficial Soils / Upper Aquitard

Shallow groundwater level measurements within the Project Area have been obtained from late fall 2013 through to fall 2014 from groundwater monitoring wells (MW1-13 to MW4-13) installed within the Upper Aquifer/Aquitard.

MW4-13S is the only well that provides an indication of groundwater flow conditions in the upper silty and sand unit within the Project Area. Water levels are near ground surface in the spring of 2014 and decrease by up to 2.0 m through the summer as the upper sand unit is interpreted to drain. Rapid water level increases of 1.0 to 1.5 m followed by rapid declines are evident throughout the summer and fall in response to precipitation events (Figure 12).

Water level data from wells completed in the Upper Aquitard indicate shallow groundwater conditions at or near ground surface in spring, decreasing by 1 to 1.5 m over the summer, followed by a recovery in the fall in response to increased precipitation (Figure 12). Monitoring wells MW1-13 to MW3-13 are all installed within the Upper Aquitard unit and show responses to individual precipitation events. At MW1-13, vertical gradients remain downward both seasonally and during precipitation events indicating groundwater recharge conditions and downward groundwater flow. At MW2-13, downward gradients exist over the majority of the year; however, immediately following a significant precipitation a reversal in gradient occurs temporarily due to a lag in the response of the shallow monitoring well (Figure 12). As MW2-13 is located at a lower elevation and near Wetland Area 1, this reversal in gradient is interpreted to correspond to shallow upward flow and possible short term discharge conditions.

At monitoring well MW3-14 and MW4-14, the water levels within the deeper monitoring wells are approximately 15 m below the shallow water levels, indicating a strong downward vertical gradient. The water levels within the deeper monitoring wells are consistent with water levels in the Newmarket Till at lower elevations suggesting that these water levels may be controlled by more regional topographic lows.

Shallow groundwater level data were also available from nearby private wells installed at depths of less than 16 m BGS. These wells are interpreted to be screened within thin sand layers within the Halton Till or the underlying Newmarket Till. Water level data from the shallow private wells show effects due to pumping of the well, which was characterized by rapid, regular drawdown and recovery that ranged from 0.2 m up to 1.0 m (Appendix F). The extent of water level fluctuation over the monitoring period was generally consistent within any given well and available data did not suggest any change in well performance over the monitoring period. At private wells installed to depths of less than 5 m BGS, precipitation impacts were more clearly evident, similar to what was observed within the shallow monitoring wells within the Project Area.

Shallow groundwater levels and available surface water levels within the Project Area are presented on Figure 14. Water level data are presented for October 1, 2014, following a period of minimal precipitation, and for private wells during non-pumping conditions. Within the Station Site, shallow groundwater flows to the southwest, west and south towards the tributary of Harmony Creek and its associated branches. At the eastern extend of the Project Area, groundwater flow within the Farewell Creek Sub-watershed is to the southeast toward Farewell Creek and is consistent with the overall ground surface topography. The horizontal gradient across the Station Site on October 1, 2014 ranges between 0.03 m/m (MW1-13S to MW3-13S) to 0.05 (MW6-14 to MW4S-13). The shallow groundwater flow conditions observed at the Project Area are consistent with regional interpretations of shallow groundwater flow (CLOCA, 2012).

Using the geometric mean hydraulic conductivity estimate for the upper silty sand layer encountered at MW4-13S and MW5-14S ($1x10^{-5}$ m/s), a gradient of 0.03, and a porosity of 0.30, an average horizontal groundwater velocity of 32 m/yr is estimated for the upper silty sand layer. In the Upper Aquitard, groundwater velocities are substantially lower, estimated at 0.2 m/yr based on the geometric mean hydraulic conductivity of $6x10^{-8}$ m/s.

6.2.3 Groundwater / Surface Water Interaction

Drive-point piezometers were installed at three (3) locations throughout the Project Area to evaluate groundwater / surface water interaction in the immediate vicinity of the surface water features associated with the tributary of Harmony Creek. Observations at each location are discussed below with respect to the groundwater contours.

6.2.3.1 South Branch of the Tributary of Harmony Creek

Groundwater contours, as shown on Figure 14, indicate shallow groundwater flows toward the South Branch of the tributary of Harmony Creek and Wetland Area 1 from the northern portion of the Project Area. During the spring, summer and fall monitoring events in 2014, brief periods of upward vertical gradients were observed between the shallow and deep monitoring wells at MW2-13 (Figure 12).

At DP2-14, groundwater levels did not respond to precipitation events and were consistently lower than the surface water levels (Figure 13) indicating downward vertical flow and groundwater recharge conditions. A possible explanation for the lack of water level response in DP2-14 is that during installation there was smearing of the fine material within the well screen at this location.

The absence of vertical gradients and discharge conditions at DP2-14 is consistent with surface water flow observations suggesting that this tributary and Wetland Area 1 are predominantly supported by surface water runoff.

6.2.3.2 Tributary of Harmony Creek

Shallow groundwater contours shown on Figure 14 indicate shallow groundwater flows from the east across the majority of the Station Site towards the tributary of Harmony Creek on the west side of the Project Area. Water levels indicate downward gradients beneath the creek and DP3-14 (Figure 13); however, it is noted that the groundwater level in DP3-14 is very close to ground surface, suggesting that it is possible that groundwater discharge occurs seasonally where the channel elevation approaches the shallow groundwater table. Similarly to DP2-14, the lack of response to precipitation at DP3-14 may be due to smearing of the fine material within the well screen at this location.

6.2.3.3 Drainage Swale

To the south of the Station Site, DP4-13 was installed within a mapped drainage swale in December 2013. At that time, there was some surface water drainage noted due to recent snow melt; however, no surface water was present at this location during any other field visit. The groundwater level at DP4-14 is consistently below ground surface suggesting the drainage swale is not maintained by groundwater discharge (Figure 13).

6.2.3.4 Summary

The water level data and interpreted vertical groundwater flow conditions are consistent with observed surface water flow. The tributaries on the Project Area provide intermittent flow during spring snow melt and following heavy precipitation events indicating that they are supported primarily by surface water runoff. Vertical gradients within the surficial silty sand and the upper portion of the Upper Aquitard suggest that seasonal upward vertical gradients may occur along the low lying valley associated with the tributary of Harmony Creek. Due to the limited thickness and discontinuous nature of the surficial silty sand and low permeability of the Upper Aquitard, limited groundwater discharge occurs across the Project Area to sustain baseflow conditions. This is consistent with observed flow conditions that indicate the surface water features within the Project Area are predominantly sustained by surface water runoff.

6.2.4 Thorncliffe Aquifer

There are no monitoring wells within the proposed Project Area completed within the Thorncliffe Formation; however, a number of nearby private wells are interpreted to be installed within this regional aquifer unit (Figure 10). Continuous water level data were obtained at eight (8) nearby private wells completed within the Thorncliffe Aquifer (Figure 15).

Water level data from the deep private wells typically indicated pumping impacts due to operation of the private well pump, which was characterized by rapid, regular drawdown and recovery (Appendix F). Effects due to pumping were more clearly visible in these drilled wells due to the smaller well diameter than the shallow dug wells previously discussed. Fluctuations due to private well pumping within the deep wells ranged from approximately 0.5 m up to 14 m (Appendix F). The extent of water level fluctuation due to private well pumping was generally consistent within any given well over the monitoring period and available data did not suggest any change in well performance over the monitoring period.

Static groundwater levels within the Thorncliffe Aquifer through the Project Area are presented on Figure 15. Water level data are presented for October 1, 2014 following a period of minimal precipitation and data was selected for non-pumping conditions. Groundwater levels range from 208.4 m AMSL to 214.9 m AMSL with an overall southerly groundwater flow direction which is consistent with regional mapping that indicates flow to the southeast across the Project Area (CLOCA, 2012).

A downward vertical gradient is interpreted from the Upper Aquitard within the proposed Project Area to the underlying Thorncliffe Aquifer. Assuming a shallow groundwater level of 250 m AMSL within the Station Site in the vicinity of MW5-14S, a groundwater level of 210 m AMSL within the Thorncliffe Aquifer, a downward hydraulic gradient of 0.6 m/m is estimated. Using a hydraulic conductivity of 1×10^{-9} m/s from MW5-14I, downward flux or recharge to the Thorncliffe Aquifer of 18 mm/yr is estimated, which is approximately 50% lower than the estimates from Gerber and Howard (2002). This would correspond to a vertical groundwater velocity of about 0.06 m/yr and a travel time to the top of the Thorncliffe Aquifer (185 m AMSL) of over 700 years.

6.2.5 Water Balance

Monthly water balance calculations were completed for the Project Area under pre-station construction conditions based on the method of Thornthwaite and Mather (1955). The Thornthwaite and Mather model is essentially an accounting procedure that analyzes the allocation of water among various components of the hydrologic system and can be simplified in the following equation:

$$P = ET + S + R + I$$

where:

P	= precipitation
ET	= evapotranspiration
S	=change in groundwater storage
R	=runoff
I	=infiltration

The above equation can be further simplified by ignoring change in groundwater storage, which trends over time to zero. The various elements of the water balance are estimated through methods of measurement and calculations based on a number of simplifying assumptions.

Precipitation (P) is a measured value, with the historical monthly averages (1981-2010) for the region being obtained from the Environment Canada website for the Oshawa WPCP Climate Station (OCS). The OCS is located approximately 8 km southwest of the Project Area. The monthly average precipitation (rainfall plus snowmelt) and temperature data collected at the

OCS is assumed to be reflective of the precipitation and temperature trends that have historically occurred at the Project Area.

The key component of the water balance is evapotranspiration (ET). The Thornthwaite and Mather model assumes that different soil textures have a characteristic capacity to hold water. Any deficit to the soil holding capacity must be met before water can infiltrate. Potential evapotranspiration, the rate at which evapotranspiration would occur for a given area presented with an unlimited supply of water, is calculated based on temperature, heat index, and an adjusting factor for latitude. The actual evapotranspiration is calculated using the input precipitation, potential evapotranspiration and change in soil moisture storage.

A total of four (4) drainage catchments occupy the Project Area (i.e., Catchments 100 to 103) and these catchments were divided into a series of sub-areas for the purposes of the water balance assessment. These sub-areas were categorized based on soil type, land cover and topography (Figure 16) and assigned corresponding soil moisture capacities as presented in the MOECC (2003) Stormwater Management Planning and Design Manual.

The water surplus, presented as an annual depth of water reported in millimetres (mm), available for infiltration (I) and runoff (R) in a given sub-area was determined by subtracting monthly values of actual evapotranspiration from corresponding precipitation averages. This calculation assumes that no surplus water is available during those months where water losses from actual evapotranspiration exceed precipitation inputs. An infiltration factor, determined for a given sub-area based on MOECC (2003) published values associated with the soil type, land cover and topographic characteristics assigned to that sub-area, was then applied to the monthly water surpluses to produce a corresponding infiltration depth of water, with the runoff being calculated by subtracting this resulting infiltration value from the surplus. These infiltration and runoff rates were then converted to total volumes by sub-areas to provide an overall infiltration volume for a given drainage catchment and, ultimately, the Project Area.

Pre-Station Construction – Project Area

The surficial overburden material present throughout the Project Area is generally a thin layer of sand to silty sand or where absent a silty sand to sandy silt till exists at ground surface. As a result soil characteristics for s silt-textured soil were used. The topography of the Project Area is hilly and characterized by vegetation cover consisting predominantly shallow-rooted corn and soybean crops (~76% of the Project Area), cultural thicket and meadow species (~13% of the Project Area), deciduous forest (~6% of the Project Area) and swamp thicket and meadow marsh vegetation (~5% of the Project Area). Table 6 provides a summary of the annual actual evapotranspiration, runoff and infiltration rates for the four (4) drainage catchments that intercept the Project Area, with these rates having been largely determined based on the soil type / moisture capacity, land cover and topographic characteristics of the delineated sub-areas present within these catchments (Figure 16).

The calculated infiltration rates occurring within the sub-areas of the Project Area ranged from 112 to 144 mm/year, with these values falling within the range of groundwater recharge rates published by the MOECC (1995) for silt-textured based soils and are consistent with estimates for the Halton Till (100 to 250 mm/year) as reported in Gerber and Howard (2002). The remaining 144 to 208 mm of surplus water is expected to occur as runoff. Overall, a total water volume of 74,554 m^3 is expected to annually infiltrate to the subsurface of the Project Area under the pre-station construction conditions (Table 6), with the majority of the infiltration occurring in Catchment 103 (34%), followed by Catchment 101 (25%), Catchment 100 (24%) and Catchment 102 (17%).

Pre-Station Construction -Station Site

Using the same water balance methodology applied to the Project Area, calculations indicate a total water volume of 12,504 m^3 is expected to annually infiltrate to the subsurface within the Station Site under the pre-station construction condition (Table 6), representing only 17% of the total infiltration (74,554 m^3) occurring throughout the Project Area. The majority of the infiltration occurs in Catchment 103 (54%), followed by Catchment 100 (37%) and Catchment 101 (9%). Catchment 102 does not intercept the Station Site.

Accounting for a downward recharge through the Newmarket Till of 18 mm/yr, the total infiltration potentially from the Station Site contributing to baseflow in the tributary of Harmony Creek is estimated to be approximately 0.3 L/s.

6.3 GROUNDWATER AND SURFACE WATER QUALITY

As part of the Monitoring Program, water quality monitoring was completed within surface water and groundwater monitoring wells from the Project Area from December 2013 to October 2014. Private supply wells were sampled twice between July and October 2014 with a second round of water quality sampling for residential wells that only had one (1) bacteriological sample collected planned for November 2014. Surface water quality data are presented in Table 3 with groundwater quality data from the monitoring wells presented in Table 4 and from the private wells in Table 5. To maintain confidentiality for the private well results, we have removed the well identification in Table 5. Laboratory certificates of analysis for all water quality sampling are included in Appendix G. The following section presents a review of the available water quality data.

6.3.1 Surface Water Quality

Surface water quality data are presented in Table 3 with results compared to Provincial Water Quality Objectives (PWQO), which are the applicable regulatory criteria for surface water within the Project Area. Water quality results are discussed below for each monitoring location.

As previously discussed, surface water was only present at SW4 (adjacent to DP4-13) at the time of drive-point installation. This location was noted as dry during all other field visits, and therefore, no surface water quality samples were collected from SW4.

The south branch of the tributary of Harmony Creek flows through Wetland Area 1, and is approximately 0.2 m wide at SW2. During the field visits, surface water was consistently noted at SW2 (adjacent to DP2-14), ranging from 0.02 m to 0.08 m in depth; however, minimal flow was observed. Due to the limited amount of water present, it was difficult to collect samples without allowing some sediment to enter the bottles and as result the sample results for metals are not considered representative of dissolved phase water quality.

Water quality at this location was characterized by:

- Due to the presence of sediment within the sample, the water quality results exceeded the PWQO criteria for aluminum, iron, and total phosphorous in the August 2014 and October 2014 samples; and cobalt in the October 2014 sample (Table 3). All other parameters were below the PWQO in the May, August, and October 2014 sampling rounds;
- In December 2013, aluminum, arsenic, cadmium, chromium, copper, lead, iron, nickel, silver, thallium, vanadium, total phosphorus, and zinc were above the PWQO. This sample had a high turbidity (27 NTU) and Total Organic Carbon (54 mg/L) suggesting that the elevated metal concentrations were related to sediment within the samples and are not reflective of dissolved phase water quality. Construction activity had not commenced at the time of sample collection in December 2013 and as a result we are not aware of activity within the Project Area during December 2013 that would explain these concentrations. The absence of these metals in subsequent samples suggests that this sample is not representative of background water quality at this location; and
- Chloride and sodium ranged from 8 to 14 mg/L and 3 to 4 mg/L, respectively; while nitrate ranged from non-detect up to 0.6 mg/L. Low levels of nitrate (up to 0.6 mg/L) suggest minimal influence from the adjacent agricultural activities.

The surface water sample at SW3 was collected from the tributary of Harmony Creek along the western Project Area boundary. At this location, the creek ranged from 0.5 to 1.0 m in width, with the actual channel being approximately 1.5 m wide. Surface water was flowing at SW3 during the three (3) field visits in 2014, with a creek depth of up to 0.10 m. A water quality sample could not be collected in December 2013, as the creek was frozen. Water quality at this location was characterized by:

- Zinc concentrations ranging from 5 to 28 µg/L with the October 2014 sample above the PWQO criteria of 20 µg/L. This sample had elevated turbidity and as a result the zinc concentrations are attributed to sediment within the samples. All other parameters were below the PWQO at SW3; and
- Chloride and sodium concentrations ranged from 12 to 17 mg/L and 4 to 6 mg/L, respectively; while nitrate ranged from1 to 3 mg/L. The higher nitrate levels suggest some influence from agriculture fertilizer may be occurring.

The surface water quality monitoring data indicates that water quality is generally characterized by low concentrations of sodium, chloride, and nitrate and all parameters generally within the

PWQO. The detection of elevated metals above the PWQO is attributed to elevated sediment concentrations within the samples. To evaluate the effects of sediment on water quality, future samples should include both dissolved and total metals analyses.

6.3.2 Monitoring Well Water Quality

Water quality sampling of the groundwater monitoring wells was completed in December 2013, March 2014, May 2014, August 2014, and October 2014 at MW1-13S/D to MW4-13S/D. The initial water quality samples from MW1-13S/D to MW4-13S/D from December 2013 were collected to evaluate the completion of well development within each well, and the results generally indicate that water quality was still stabilizing at this time. As a result, only the 2014 results are discussed below with respect to inorganic and organic parameters, as the 2013 water quality data are not believed to be characteristic of formation water quality. Monitoring wells MW5-14 S/I to MW7-14 were installed in October 2014 as part of the adaptive nature of the Monitoring Program, and as recommended by Stantec. These recently installed monitoring wells were sampled in October 2014 and will continue to be sampled in 2015 to further evaluate water quality.

The 2013 and 2014 results are presented in Table 4 and compared to the ODWS. For a number of SVOC and VOC there are no criteria in the ODWS and as a result the results were also compared to applicable criterion under O.Reg. 153/04. Tables 6 and 8 of the Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, dated April 15, 2011 (henceforth the SCS) were selected as the applicable criterion for the Project Area as the Station Site is located within 30 m of tributaries of Harmony Creek, has a shallow groundwater table, and is situated in an area in which groundwater is used as a potable source. Criteria for coarse grained material were used, as more than 33% of material is sand or coarser, even though the matrix is till.

6.3.2.1 Inorganic Water Quality

Groundwater quality from the Project Area monitoring wells met the ODWS for all health related parameters (ODWS-MAC) with the exception of nitrate which was detected at MW1-13S (11 to 18 mg/L) and MW5-14S (15 mg/L) above the ODWS-MAC of 10 mg/L. The elevated nitrate concentrations at these locations are attributed to agricultural fertilizer. The following parameters were detected above the ODWS-AO or ODWS-OG guidelines on at least one (1) occasion:

- Aluminum (100 μg/L OG) within MW5-14I;
- DOC (5 mg/ L AO) within MW1-13D, MW2-13D, MW3-13D;
- Hardness (80 to 100 mg/L OG) within all monitoring wells;
- Manganese (50 μg/L AO) within MW3-13D;
- Sodium (20 mg/L MOH) within MW3-13D and MW5-14I;
- Sulphate (500 mg/L AO) within MW3-13D;

- Total Dissolved Solids (TDS) (500 mg/L AO) within MW1-13S, MW3-13S/D, MW4-13D, MW5-14I; and,
- Turbidity (5 NTU AO) within all monitoring wells.

To visually compare water quality results, inorganic water quality data from the monitoring wells are presented as a piper plot on Figure 17. Results indicated very similar characteristics within the shallow monitoring wells and MW1-13D, with the water characterized as calcium and magnesium bicarbonate water. The deep monitoring wells indicate greater variation in water quality, primarily due to differences in sulphate and sodium concentrations. The water quality results indicate elevated sulphate levels with higher calcium concentrations suggesting that elevated sulphate concentrations may be partially related to dissolution of gypsum minerals within the aquitard units.

6.3.2.2 Organic Water Quality

Groundwater samples from the monitoring wells were also analyzed for petroleum hydrocarbons, BTEX compounds, PBCs, VOCs and SVOCs and compared to ODWS (Table 4). The only parameter detected above the ODWS was benzo(a)pyrene, a polycyclic aromatic hydrocarbon (PAH) that is found in coal tar and residuals from the combustion of organic material. Benzo(a)pyrene was detected on at least one (1) occasion within MW1-13D, MW2-13S, MW3-13S/D and MW4-13S/D with all detections exceeding the ODWS-MAC. Benzo(a)pyrene adsorbs to soil particles and it is expected that these detections are associated with the sediment within the sample. For samples with benzo(a)pyrene detections, total suspended solid concentration and turbidity levels ranged from 230 to 29,000 mg/L and 76 to 1900 NTU, respectively.

In addition to benzo(a)pyrene, a number of other VOCs and SVOCs parameters were detected on multiple sample dates within the monitoring wells and were either below the ODWS criteria or there were no applicable ODWS criteria. The following provides a summary of these parameters and a comparison with respect to the SCS criteria.

Water Quality – Upgradient of Station Site

Monitoring Wells MW1-13S/D, MW6-14 and MW7-14 are located upgradient (East) of the Station Site and indicated the following water quality results:

- No PCBs were detected within any of the samples;
- No PHCs were detected within any of the samples; however, low level BTEX concentrations were detected in MW1-13D, MW6-14 and MW7-14 but below the ODWS and SCS criteria;
- Detection of phthalate compounds within MW1-13S/D and MW7-14 with an exceedance of the SCS criteria for DEHP within one (1) sample from MW1-13D and two (2) samples from MW1-13S;

- Low level detections of PAHs within MW1-13S/D and MW6-14 with an exceedance in MW1-13S/D for benzo(a)pyrene in three (3) samples, benzo(b/j)fluoranthene in one (1) sample, and chrysene in one (1) sample.

At MW1-13S/D, concentrations of phthalates and PAHs decrease over the sampling period from March to October 2014 with only benzo(a)pyrene above ODWS and SCS criteria in August 2014 at MW1-13S. In October 2014, the method detection limits were above the applicable criteria in MW1-13S due to matrix interference possibly associated with the high sediment concentrations in the sample.

Water Quality – North of Station Site

Monitoring Wells MW2-13S/D are located at the northern extent of the Station Site and indicated the following water quality results:

- No PCBs were detected within any of the samples;
- No PHCs were detected within any of the samples; however, BTEX compounds were detected at low levels within both wells and benzene exceeded the SCS criteria in December 2013 and May 2014 with concentrations decreasing below the SCS criteria in August and October 2014;
- Detection of phthalate compounds within both wells with an exceedance of DEHP in MW2-13S in May 2014 with subsequent concentrations below the SCS criteria; and,
- Low level detections of PAHs within both wells with all concentrations below the ODWS and SCS criteria;

Similar to MW1-13S/D, concentrations of phthalate and PAHs decrease over the sampling period at MW2-13S/D with no parameters above the ODWS and SCS criteria in the August and October 2014 sampling round.

Water Quality – Southwest of Station Site

Monitoring Wells MW3-13S/D, MW4-13S/D and MW5-14S/I are located downgradient of the Station Site and indicated the following water quality results:

- No PCBs were detected within any of the samples;
- No PHCs were detected within any of the samples; however, BTEX compounds were detected at low levels within MW3-13D, MW4-13D, MW5-14S with all concentrations below the ODWS and SCS criteria;
- Detection of phthalate compounds within all wells with exceedance of DEHP within two (2) samples from MW3-13D, one (1) sample from MW3-13S and three (3) samples from MW4-13D; and,
- Low level detections of PAHs within MW3-13D, MW4-13D, MW5-14S with an exceedance of the ODWS and SCS criteria for benzo(a)pyrene within two (2) samples from MW3-13D, three (3) samples from MW3-13S, two (2) samples from MW4-13D, one (1) sample from

MW4-13S, benzo(b/j)fluoranthene and chrysene within one (1) sample from MW3-13D, one (1) sample from MW3-13S and two (2) samples from MW4-13D, and fluoranthene and phenanthrene within two (2) samples from MW4-13D.

Unlike monitoring wells MW1-13S/D and MW2-13S/D where concentrations decrease over the monitoring period suggesting improvements with increased development and sampling, water quality from monitoring wells MW3-13S/D and MW4-13S/D was variable, with a number of samples having method detection limits above the ODWS and SCS criteria during all sampling events. The detection of phthalates in the majority of wells, both upgradient and downgradient of the Station Site throughout the monitoring period may be related to plastics from the well itself, sampling tubing and/or bailer, or sample bottles as the highest concentrations were often found in the slowest recovering wells where development and sampling is difficult. Further evaluation is required to confirm the potential source.

Detections of PAHs can be biased high due to the presence of sediment within the sample, as these compounds can adsorb to sediment particles. For the samples with PAH exceedances, total suspended solid (TSS) concentration ranged from 230 to 29,000 mg/L, with typical concentrations of approximately 1,000 to 3,000 mg/L. For these same samples, turbidity levels ranged from 76 to 34,000 NTU, with typical levels of approximately 100 to 500 NTU. The TSS and turbidity results confirm high sediment levels within these samples. Further evaluation is required to confirm the effects of well development and sediment concentrations on PAH concentrations.

Hydro One is in the process of completing additional groundwater sampling for Project Area monitoring wells. Sampling procedures will be modified to evaluate potential impacts from sampling equipment and to reduce entrained sediment. The evaluation will include a comparison of filtered and non-filtered water quality samples. Water quality results will be reviewed and, based on the results, changes to monitoring well sampling protocols may be recommended. Hydro One has committed to providing the findings of this evaluation, once completed, in a Baseline Conditions Report Addendum.

6.3.3 Private Well Water Quality

Water quality monitoring was completed within the private wells from July to October 2014, with two (2) samples collected at each location. During sampling collection, Stantec attempted to collect a raw water quality (untreated) sample at each residence; however, based on water quality results, it was concluded that treated samples were collected at select locations on at least one (1) occasion. Water quality results are presented on Table 5 and compared to the ODWS which are the applicable criterion for drinking water in Ontario. For privacy reasons, sample identifications are not given and the samples are labelled based on aquifer unit and either raw or treated, as appropriate.

Following receipt of the water quality results, Stantec notified individual well owners of any health related exceedances within their water sample. A follow-up letter was provided to each well owner detailing the full water quality results. The sections below summarize key raw water quality characteristics only.

6.3.3.1 Bacteriological Water Quality

Water quality trends for shallow private wells that were installed to a maximum depth of 16 m BGS typically had elevated total coliform concentrations with 10 of the 12 wells (83%) sampled during the October 2014 round having total coliforms present. In the initial sampling round during August/ September bacteriological samples were only collected from three (3) of the wells due to a miscommunication with regards to the sampling parameters. Of the three (3) wells sampled for bacteriological analyses, two (2) had detections of total coliforms. No detection of E.coli was reported for the August/September 2014 sampling round in the three (3) wells that were sampled. E.coli was detected in three (3) of 12 samples (25%) in October 2014.

Of the nine (9) wells that are completed within the Thorncliffe Formation, only one (1) (11%) had detections of total coliform in the October 2014 sampling round. This same well had total coliform present during the August sampling round. Only one (1) other well had total coliforms present in August/September. E.coli was not detected in any of the samples from August/September and October 2014.

A greater number of total coliform detections were noted within the shallow dug wells compared to the drilled wells installed within the Lower Thorncliffe Formation. The total coliform and E.coli detections within the shallows dug wells are interpreted to be related to local sources associated agricultural activities (manure storage and animal feedlots), septic systems, or potential surface influences and well construction. All residents were notified by phone of the bacteriological results and directed to follow any recommendations from the Durham Region Health Unit regarding sampling, treatment of the well and well maintenance.

6.3.3.2 Inorganic Water Quality

Shallow water quality from the nine (9) wells sampled generally met the ODWS-MAC for all parameters with the exception of nitrate in one (1) well and lead in another during the August sampling round. Concentrations at both wells decreased below the ODWS-MAC in the October 2014 sampling round. Hardness was above the ODWS-OG in all wells, which is typical for groundwater quality from southern Ontario. The following parameters were detected above the ODWS-AO guidelines on at least one (1) occasion:

- Sodium exceeded the MOH guideline of 20 mg/L in 9 wells with water quality results from two (2) wells also exceeding ODWS-AO of 200 mg/L AO. Chloride exceeded the ODWS-AO guideline of 250 mg/L in the same two (2) wells that have sodium concentrations above the ODWS-AO, suggesting that the source is associated with winter road salting; and
- Total Dissolved Solids (TDS) (500 mg/L AO) in six (6) wells with concentrations of up to 1,010 mg/L associated with wells impacted by winter road salting.

Water quality for wells completed in the Thorncliffe Formation meets the ODWS-MAC for all parameters. Hardness was above the ODWS-OG in all wells (except for those from treated water), which is typical for groundwater quality from southern Ontario. Iron exceeded the ODWS-AO in six (6) wells with concentrations up to 2.7 mg/L and appears to have resulted in elevated turbidity at each of these wells due to precipitation in the unpreserved sample bottles. Sodium was above the ODWS-MOH guideline in the two (2) wells that corresponded to treated water.

6.3.3.3 Organic Water Quality

Water quality samples from private wells were tested for VOCs, SVOCs, PHCs and PCBs and results compared to ODWS. A summary of results is detailed below with the data presented in Table 5.

Benzo(a)pyrene was detected in the initial sample at one (1) well completed in the Thorncliffe Formation and exceeded the ODWS MAC. Once notified of the detection, the well owner pumped the well for an extended period of time and changed the sediment filter on the treatment system. Subsequent sampling revealed no detection of the parameter. No other VOC or SVOC parameters were detected above the ODWS.

Trihalomethanes (THMs) including bromoform, bromodichloromethane, dibromochloromethane and chloroform were detected within at least one (1) sample from nine (9) private wells with the highest concentration (Total THMs = 0.022 mg/L) well below the ODWS-MAC of 100 mg/L. These compounds are by-product of disinfection and are created by the reaction of chlorine with organic carbon within the groundwater. Discussions with well owners indicated that prior to the October 2014 sampling, at least two (2) well owners had recently disinfected their well to address bacteriological detections.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results presented in this Groundwater and Surface Water Baseline Conditions Report, the following conclusions are provided:

- The findings of the Baseline Conditions Report, including the hydrostratigraphic framework, further refines the understanding of the local hydrostratigraphy that was established in the ESR submitted to the MOECC in January 2014, and the Hydrogeologic and Hydrologic Assessment Report (Stantec, 2014);
- The Groundwater and Surface Water Monitoring Program, initiated in December 2013, and completed through October 2014, allowed for a refinement of groundwater characterization within the Project Area, including shallow and deep groundwater flow directions and gradients, seasonal groundwater level and groundwater quality monitoring, and hydraulic conductivity estimates;
- The Groundwater and Surface Water Monitoring Program established baseline geologic and hydrogeologic conditions across the Project Area, and collected pre-station construction water quality data for private wells within 1,200 m of the Station Site;
- Borehole drilling within the Project Area encountered a thin discontinuous silt and sand layer at surface that was found to be thickest in the northern and southern portions of the Project Area, and absent in the western, central, and eastern portions of the Project Area. The surficial silt and sand is underlain by a compact to dense silty sand to sandy silt that is considered representative of Newmarket Till. No deposits of the Oak Ridges Moraine Sediments were noted within the Project Area to the depth of the borehole drilling completed within the Project Area;
- Groundwater levels within the shallow overburden are controlled by topography with groundwater flow to the southwest, west and south towards the tributary of Harmony Creek and its associated branches. Groundwater levels from wells completed within the Thorncliffe Formation in the Project Area indicated a southerly flow direction consistent with regional mapping. Downward gradients were consistently present from the Upper Aquitard to the Thorncliffe Formation indicating downward flow in the form of leakage at rates of approximately 18 mm/yr which corresponds to a vertical groundwater velocity of about 0.06 m/yr and a travel time to the top of the Thorncliffe Aquifer (185 m AMSL) of over 700 years;
- Tributaries of Harmony Creek represent the main surface water features within the Project Area and extend along the northern and western boundary of the Project Area. Due to the limited thickness and discontinuous nature of the surficial silty sand and low permeability of the Upper Aquitard, limited groundwater discharge occurs across the Project Area to sustain baseflow conditions. This is consistent with observed flow

conditions that indicate the surface water features within the Project Area are predominantly sustained by surface water runoff;

- The surface water was sampled for general inorganic chemistry, total metals, PHCs (F1 to F4) and BTEX compounds with parameters generally below PWQO. Where elevated metals above PWQO were noted, they are attributed to elevated sediment concentrations within the samples;

- Groundwater quality from the Project Area monitoring wells were analyzed for general inorganic chemistry, dissolved metals, PHCs (F1 to F4) and BTEX compounds, PCBs, and SVOC and VOC parameters. Groundwater quality met the ODWS for all health related parameters with the exception of nitrate in two (2) monitoring wells, which is attributed to agricultural fertilizer, and benzo(a)pyrene. Benzo(a)pyrene is a PAH that is found in coal tar and residuals from the combustion of organic material and was detected on at least one (1) occasion within MW1-13D, MW2-13S, MW3-13S/D and MW4-13S/D above the ODWS-MAC. In addition to benzo(a)pyrene, phthalate compounds and several PAHs were detected at concentrations above the O.Reg.153/04 Table 6 and/or Table 8 Site Condition Standards. The detection of phthalate compounds may be related to plastics from the well itself, sampling tubing and/or bailer, or sample bottles as the highest concentrations were often found in the slowest recovering wells. Detections of PAHs, including benzo(a)pyrene can be biased high due to the presence of sediment within the sample. The TSS and turbidity results confirm high sediment levels within these same samples. No known sources of phthalate or PAHs exist on the site and as a result further evaluation is required to confirm the effects of well development and sediment concentrations on the detection of these parameters;

- Private water quality monitoring was completed within the private wells from July to October 2014, with 2 samples collected at each location and submitted for general inorganic chemistry, total metals, PHCs (F1 to F4) and BTEX compounds, PCBs, and SVOC and VOC, and bacteriological water quality. Bacteriological water quality was generally poor within the shallow private wells with 10 of the 12 wells (83%) having total coliforms present and 3 of 12 samples (25%) having E.coli present. Water quality for wells completed within the Thorncliffe Formation had only 1 (11%) detection of total coliform and no detections of E.coli. The total coliform and E.coli detections within the shallow dug wells are interpreted to be related to local sources associated agricultural activities (manure storage and animal feedlots), septic systems, or potential surface influences and well construction; and,

- Inorganic and organic water quality from the private wells generally met the ODWS-MAC for all parameters with the exception of nitrate in one (1) shallow well and lead in another shallow well during the August 2014 sampling round. Concentrations in these wells were below the ODWS-MAC in the October 2014 sampling round. Benzo(a)pyrene was the only parameter detected above the ODWS-MAC in the initial sample from a well completed in the Thorncliffe Formation. The well owner pumped the well for an extended period of time and changed the sediment filter on the treatment system with the concentration decreasing below the method detection limit and ODWS-MAC criteria.

The following recommendations are provided:

- Water level and water quality monitoring should continue semi-annually during station construction and post-station construction, as detailed in the Groundwater and Surface Water Monitoring Program;
- Further evaluation into the potential source of the phthalate and PAH detections in the Project Area monitoring wells should be conducted. The potential for sampling equipment and/or sediment to have biased the analytical results should be reviewed. Hydro One is in the process of completing additional groundwater sampling for Project Area monitoring wells. Sampling procedures will be modified to evaluate potential impacts from sampling equipment and to reduce entrained sediment. The evaluation will include a comparison of filtered and non-filtered water quality samples. Water quality results will be reviewed and, based on the results, changes to monitoring well sampling protocols may be recommended. Hydro One has committed to providing the findings of this evaluation, once completed, in a Baseline Conditions Report Addendum;
- It is recommended that MW5-14S/I, MW6-14 and MW7-14 be added to the monitoring program for 2015 to further document water quality. The need for additional monitoring at these locations should be reviewed at the end of 2015;
- The monitoring wells within the Project Area should be left in place throughout construction and operation. When no longer being used for groundwater monitoring, the monitoring wells should be decommissioned in accordance with O.Reg.903; and,
- The condition of the drive-point piezometers should be inspected as part of the regular Monitoring Program and upgrades/replacement completed as necessary. At DP2-14 and DP3-14, it is recommended that a second drive-point piezometer be installed to evaluate the lack of response observed to precipitation events.

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