Clarington Transformer Station
2016 Annual Monitoring Report

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Sign-off Sheet

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Executive Summary

This 2016 Annual Monitoring Report presents data collected during the Spring and Fall semi-annual sampling events completed in April and October-November, 2016. This report includes a summary of Project Area groundwater monitoring well and private well monitoring data collected during these semi-annual monitoring events, discusses adaptive changes made to the Groundwater and Surface Water Monitoring Program, and presents analyses, conclusions, and recommendations based on these data.

Introduction

The Clarington Transformer Station is currently under construction on a 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 includes a shallow stormwater management (SWM) system to collect precipitation that falls within the Station Site in order to maintain dry ground and safe operating conditions. The shallow SWM system was constructed within the graded area within the Station Site limits.

The MOECC approved Groundwater and Surface Water Monitoring Program (Monitoring Program) for the Clarington TS included installation of groundwater monitoring wells, implementation of groundwater, surface water, and private well monitoring programs, and annual reporting. The Monitoring Program objectives include defining the hydraulic conductivity of geologic units, documenting pre-station construction hydrogeologic conditions within the Project Area, and continued monitoring of the hydrogeologic conditions within the Project Area and for private wells within 1,200 m of the Station Site during and following station construction.

As of January 2017, the majority of the Clarington TS facility has been successfully constructed, with the delivery and installation of the primary power transformers, transformer foundations/spill containment system, relay buildings, shallow SWM system, and internal station buswork and equipment (circuit breakers, switches etc.) all being completed in 2016.

Local Hydrogeology

Since issuing the Baseline Conditions Report in November 2014, additional monitoring wells were installed in 2014, which included MW5-14S(2), and MW5-14D as a condition of the municipal resolution to provide a permanent easement for the Clarington TS access road. Monitoring well MW4-13D was replaced by MW4-15D in 2015; however, no new monitoring wells were installed in 2016. The drilling, monitoring well installation, and hydraulic testing associated with the borehole and monitoring well installations completed since November 2014 have been provided in the

Clarington Transformer Station Baseline Conditions - Addendum 2 Report (Stantec, 2015b), which was submitted to the MOECC and is publicly available on Hydro One's project website along with the 2015 Clarington Transformer Station Annual Monitoring Report (Stantec, 2015c).

Within the Project Area, shallow groundwater flows to the west and southwest towards the Harmony Creek tributaries and their associated branches. East of the Station Site, a shallow groundwater divide extends from north to south, dividing shallow groundwater lateral flow between the Harmony Creek and the Farewell Creek sub-watersheds. At the eastern extent 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 recorded water level elevation fluctuations indicate the monitoring wells have responded to seasonal changes, consistent with the findings presented in the Baseline Conditions Report (Stantec, 2014) and the 2015 Clarington Transformer Station Annual Monitoring Report (2015c). Environment Canada and local conservation authority climate data indicate seasonal climate changes were characterized by lower than normal precipitation for late spring and early summer, as well as the fall months; resulting in lower groundwater levels and dry creek tributaries at SW2 and SW4. Project Area monitoring wells MW1-13S, MW6-14, and MW7-14 showed the greatest change in shallow water level elevation in 2016 as compared to 2014; lowering 3.3 m, 2.7 m, and 3.0 m in MW1-13S, MW6-14, and MW7-14, respectively. Given the proximity of these shallow monitoring wells to the side of the graded slope, a greater localized lowering of the water level within these wells was anticipated following grading of the Station Site. These levels will continue to be monitored through completion of Station construction, and for two years afterward.

Site observations and recorded water level elevations at drivepoint piezometers within nearby surface water features and adjacent monitoring wells indicated that the Harmony Creek tributaries flowed intermittently, and were supported primarily by surface water runoff with seasonal spring groundwater discharge.

No shallow private wells are located downgradient of the Station Site. All shallow private wells in the vicinity of the Clarington TS participating in the Private Well Monitoring Program are located in the Oshawa Creek Watershed and Farewell Creek sub-watershed, with the exception of two (2) private wells located north and upgradient of the Station Site. Monitoring wells at MW2-13, MW3-13, MW4-13, and MW5-14 are well positioned to serve as downgradient shallow groundwater monitoring wells for the Station Site.

Recorded October 2016 groundwater level elevations from pairs of shallow and intermediate depth wells were used to calculate vertical hydraulic gradients at monitoring well locations MW1, MW2, and MW5. The vertical hydraulic gradient within the shallow overburden across the Project Area in 2016 ranged from 0.0 m/m to 0.02 m/m (downward). Gradients at MW3 and MW4 could not be determined due to very slow deep well recovery from sampling events.

A downward vertical hydraulic gradient is interpreted between the surficial sand and weathered till units within the proposed Project Area to the underlying Thorncliffe Aquifer. The difference in recorded water levels in both deeper wells MW5-14I and MW5-14D, in conjunction with the stratigraphic model understanding for the Site, indicates these wells have little to no direct hydraulic connection to each other or the shallow groundwater system.

Thorncliffe Aquifer monitoring wells indicate deeper groundwater levels decreased in 2016, ranging from 207.6 m AMSL to 210.7 m AMSL in October, with an overall southerly groundwater flow direction consistent with monitoring results from 2014 and 2015, and consistent with regional mapping CLOCA (2012) that indicates deep groundwater flow to the southeast across the Project Area.

Surface Water Quality

As part of the Monitoring Program, water quality monitoring was completed semi-annually in April and October-November, 2016. Surface water level elevations and water quality was monitored at three (3) locations on the Site (SW2, SW3 and SW4) in 2016. Hydro One technicians, under the direction of Stantec staff, completed surface water quality sampling within the nearby surface water features including the South Branch of the Tributary of Harmony Creek at SW2 , the Tributary of Harmony Creek at SW3 (adjacent to DP3-14), and at a drainage swale located south of the Station Site at SW4.

The surface water quality monitoring data in 2016 indicates that water quality is generally characterized by low concentrations of sodium, chloride, and nitrate, with all parameters generally within the PWQO, with the following exceptions. Elevated concentrations of aluminum (SW4), boron (SW3), iron (SW2), and phosphorous (SW2 and SW4) were detected in at least one (1) sample above the PWQO in 2016.

Shallow Groundwater Quality

Since December 2013, a total of sixteen (16) Project Area groundwater monitoring wells (MW1-13S/D, MW2-13S/D, MW3-13S/D, MW4-13S/D, MW4-15D, MW5-14S(2)/S/I/D, MW6-14, MW7-14, and temporary well MW8-15 (now decommissioned)) were installed at seven (7) locations throughout the Project Area in order improve the understanding of the local geology and hydrogeology prior to construction, and to monitor groundwater and surface water during and following construction of the Clarington TS.

During Spring and Fall 2016 monitoring events, all monitoring wells were sampled as part of the semi-annual Monitoring Program, with the exception of MW4-13D, as it was replaced by MW4-15D; and MW8-15 in October 2015, as this well was decommissioned in May 2015.

Groundwater quality samples from the Project Area monitoring wells were analyzed 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 Quality Standards (ODWQS) for all health related parameters with the exception of nitrate in one (1) monitoring well, which is attributed to agricultural fertilizer; and fluoride in one (1) monitoring well. Low level detection of phthalate compounds and several PAHs were detected at concentrations well below the SCS with the exception of benzo(a)pyrene which was detected in a Spring 2016 sample from MW4-15D (0.02 µg/L) and a Fall 2016 sample from MW3-13D (0.06 µg/L), in which turbidity and some suspended sediments were noted during sampling.

Historically in 2014, benzo(a)pyrene had been detected within some monitoring wells above the ODWQS. As presented in the Addendum Report (Stantec, 2015a), this compound adsorbs to soil particles and it was concluded that these detections are associated with the sediment collected within the sample. Stantec (2015a) recommended that water quality sampling protocols be amended to include low-flow sampling. This sampling protocol was adopted in 2015 and continued through 2016 sampling events.

The elevated benzo(a)pyrene detections in 2016 are interpreted to be due to the effect of sediment entrained within the samples from MW3-13D and MW4-15D, as the lab-filtered samples for the same monitoring locations during the same monitoring events did not detect the compound. These detections are generally consistent with 2013/2014 results and do not indicate any significant change in groundwater quality in 2016 through the start of construction of the Clarington TS.

Limited phthalate, PAH, and VOC compounds were detected at low concentrations that remained below the ODWQS and Ontario Regulation 153/04 (O.Reg.153/04) Table 6 and/or Table 8 Site Condition Standards. The number of detections and the concentration of detections of PAH and VOC compounds remained very low in 2016, as compared to 2014, as a result of further well development and continued implementation of low-flow sampling methods. These results are consistent with the understanding that historic PAHs detections were associated with the sediment and not representative of dissolved groundwater concentrations.

Private Well Water Quality

Stantec completed semi-annual groundwater quality sampling at private wells that participated in the program in April and October-November 2016 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 24 private wells (23 well owners) as of October 2016.

Bacteriological water quality was generally poor within the raw (un-treated) shallow private well samples, with 12 of the 14 wells (86%) having total coliforms present, and 5 of 14 samples (36%) having E.coli present on at least one occasion. Water quality within wells completed deeper than 50 m had only 2 (20%) detection of total coliforms, and no detections of E.coli. in 2016. The total coliform and E.coli detections within the shallow dug wells are interpreted to be related to local sources associated with agricultural activities (fertilizer, manure storage, and animal feedlots), septic systems, or potential surface influences.

Shallow private well inorganic water quality monitoring detected the following parameters above the ODWQS Aesthetic Objective (AO) or ODWQS Medical Officer of Health (MOH) guidelines on at least one occasion: iron in eight (8) wells, total dissolved solids in nine (9) wells, turbidity in six (6) wells, and sodium in three (3) wells.

Hardness was above the ODWQS Operational Guideline (OG) in the raw water from all deeper wells, which is common in groundwater quality from southern Ontario. Deep private well inorganic water quality monitoring detected the following parameters above the ODWQS-AO or ODWQS-MOH on at least one occasion: sodium in eleven (11) wells (3 well samples following a water softener), chloride in two (2) wells, total dissolved solids in one (1) intermediate depth well, and aluminum and iron in one (1) well each.

Conclusions and Recommendations

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

- The Groundwater and Surface Water Monitoring Program, initiated in December 2013, and completed through October-November 2016, allowed for annual characterization and monitoring of groundwater and surface water conditions within the Project Area.
- The Monitoring Program continues to monitor water levels continuously and water quality data semi-annually for private wells within 1,200 m of the Station Site.
- Groundwater levels within the shallow overburden mimic topography, with the shallow groundwater flow direction within the Station Site to the west and southwest towards the tributary of Harmony Creek and its associated branches. Monitoring wells at MW2-13, MW3-13, MW4-13, and MW5-14 are well positioned to serve as downgradient shallow groundwater monitoring wells for the Station Site. No shallow private wells are located immediately downgradient of the Station Site.
- Precipitation totals in the Oshawa area for a six-month period between May to November 2016 was lower than normal; only 57% of what was recorded during that same period in 2015, and only 67% of historic climate normals. Environment Canada temperature data for the same Oshawa Airport climate station indicates that there was an overall temperature increase over the six-month period of May to October from 15.8°C in 2014, to 16.1°C in 2015, and a 1.6°C increase to 17.4°C in 2016.
- Groundwater and surface water level elevation and water quality monitoring through to October-November 2016 indicates no adverse effects on the shallow groundwater system or in shallow or deep private wells as a result of Station Site grading and construction of the Clarington TS.

The following recommendations are provided:

- Continuous water level and semi-annual water quality monitoring should continue during station construction and post-station construction, as detailed in the Monitoring Program.
- Sampling procedures for Project Area wells should continue with low-flow sampling protocols, as recommended in the Baseline Conditions Report Addendum.
- Further water volume and water quality results should be analyzed to determine whether both deep wells at MW4 will be required to collect semi-annual samples for all analytical parameters, or whether one of the wells may be decommissioned.
- The need for removing or adding monitoring wells to the Monitoring Program should be reviewed annually.
- The condition of all monitoring wells and drive-point piezometers should be inspected as part of the regular Monitoring Program with upgrades/replacement completed, as necessary.

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
Hydro One	Hydro One Networks Inc.
ID	Inner diameter
LDPE	Low Density Polyethylene
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
ODWQS	Ontario Drinking Water Quality Standards
OGS	Ontario Geological Survey

O. Reg. 153/04	Ontario Regulation 153/04
O. Reg. 903	Ontario Regulation 903
OWRA	Ontario Water Resources Act
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	polychlorinated biphenyls
PHCs	petroleum hydrocarbons
Project Area	lands owned by Hydro One in the vicinity of the Clarington TS
PTTW	Permit to Take Water
PWQO	Provincial Water Quality Objectives
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

1.0 INTRODUCTION

In 2014, Hydro One Networks Inc. (Hydro One, 2014) completed a Class Environmental Assessment for Minor Transmission Facilities (Class EA) for the construction of the Clarington Transformer Station (TS). The Clarington TS is required to ensure an adequate and reliable supply 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 is currently being 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

In a letter dated January 2, 2014, the Minister of the Environment informed Hydro One that an Individual Environmental Assessment was not required, and provided six (6) conditions to be undertaken during the detailed design and construction of the Clarington TS.

A condition of the MOECC letter required the submission of a Groundwater Monitoring Plan to the MOECC Central Region Director for review and approval. The Groundwater Monitoring Plan was to include water level and water 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 this condition, Stantec Consulting Ltd. (Stantec) was retained by Hydro One to prepare the monitoring plan. The Groundwater and Surface Water Monitoring Program (Monitoring Program) was submitted to the MOECC on June 13, 2014 (Appendix C).

Approval of the Monitoring Program was received from the MOECC Central Region Director on June 24, 2014 (Appendix C).

The first monitoring report to be prepared under the Monitoring Program was the Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report (Baseline Conditions Report, Stantec, 2014). As per one of the recommendations of the Baseline Conditions Report, additional assessment of sampling methodology and the role of sediment in water quality results was completed, with the findings presented in an Addendum Report (Stantec, 2015a). Subsequent to the Baseline Conditions Report, additional drilling and installation of monitoring wells, hydraulic testing, and soil sampling were completed; with the findings of these investigations presented in an Addendum 2 Report (Stantec, 2015b).

The 2015 Annual Groundwater and Surface Water Monitoring Report (Stantec, 2015c) was completed and issued in November 2015. Following completion of Station Site grading and associated temporary water taking, a Clarington Transformer Station Permit to Take Water

Monitoring Report was submitted to the MOECC in April 2016. All of the above reports are available on Hydro One's Clarington TS Project Website.

This 2016 Annual Monitoring Report presents data collected during the Spring and Fall semi-annual sampling events completed in April and October-November 2016. This report includes a summary of Project Area groundwater monitoring well and private well monitoring data collected during these semi-annual monitoring events.

1.2 REPORT OUTLINE

The following 2016 Annual Groundwater and Surface Water Monitoring Report presents the results of the Monitoring Program for the Clarington TS. This report is arranged into seven (7) sections, including this introduction. Section 2 presents an overview and schedule of the infrastructure and construction tasks for the Project Area. Section 3 presents a summary of the Groundwater and Surface Water Monitoring Program. Section 4 presents the study methods, and Section 5 presents the results of the baseline monitoring. Section 6 presents conclusions and recommendations, and Section 7 presents report references.

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 and E include Private Well Hydrographs and Laboratory Certificate of Analyses, respectively. Appendix F includes a CD with historic monitoring data for the Site from 2013 through to 2016.

2.0 CLARINGTON TRANSFORMER STATION

The following Clarington TS overview and summary of construction staging is provided by Hydro One.

2.1 OVERVIEW

The Clarington TS is currently being constructed on Hydro One owned property located at 2745 Townline Road North, Oshawa 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 area that will be occupied by the transformer station itself is referred to as the Station Site. The Station Site represents approximately 11 ha of the total 63 ha Project Area (Figure 2), and lies within the Harmony Creek sub-watershed (Figure 3).

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 (2) relay buildings, one (1) electrical panel building, and associated buswork and equipment.

The 230 kV wood pole structures originally located on the property have been relocated and replaced with new 230 kV steel structures. An access road off Townline Road North has been 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. The Station Site includes a shallow stormwater management (SWM) system to collect precipitation that falls within the Station Site in order to maintain dry ground and safe operating conditions. In the unlikely event of a release of mineral insulating oil from a transformer, a spill containment system and oil-water separator have been included in the transformer station design to prevent the loss of transformer mineral insulating oil from entering the surrounding natural environment. The shallow SWM system and spill containment system have received *Environmental Compliance Approval* (ECA) for Industrial Sewage Works, as per 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 were 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:

Complete	Relocation of 230 kV transmission lines and construction of the access road.
Complete	Construct 500 kV Tower Foundations
Complete	Relocation of 500 kV lines
June 2015	Construction on the Clarington TS initiated
Complete	Grading (cut/fill) of the Station Site (completed December 2015)
Complete	Delivery and Assembly of Two (2) 500/230 kV Transformers
Complete	Installation of Two (2) Relay Buildings
Complete	Installation of 500 and 230 kV Switchyards and Equipment
Complete	Installation of Shallow Stormwater Management (SWM) System
Fall 2017 – Spring 2018	230 kV & 500 kV Connections and Commissioning
Spring 2018	Clarington TS - In-Service
2017 – 2018	Habitat Creation and Visual Screening

As of February 2017, the majority of the Clarington TS facility has been successfully constructed, with the delivery and installation of the primary power transformers, transformer foundations/spill containment system, relay buildings, shallow SWM system, and internal station buswork and equipment (circuit breakers, switches etc.) all being completed in 2016.

Work planned for 2017 includes completion of the station perimeter fence, finished grade topdressing, and commissioning of the telecommunications equipment housed within the relay buildings. Construction of the remaining transmission line structures and line connection points, located just outside the Station Site, is also underway in order to facilitate the Clarington TS' 2018 planned in-service date.

3.0 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

The approved Groundwater and Surface Water Monitoring Program (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, development, and hydraulic testing of new groundwater 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 have been used to define the relationship between the shallow and intermediate groundwater systems within the Project Area. The data also provide a baseline to which monitoring data collected during and post construction will be compared in order to evaluate potential effects of station construction on the natural environment and surrounding private wells. Specifically, the objectives of the Monitoring Program are to:

- Define our understanding of the geology within the Station Site prior to construction of the Clarington TS.
- 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 hydraulic 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.
- Document the shallow groundwater conditions during planned Station Site grading and shallow SWM system installation 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 WELLS

Monitoring well installations MW1-13 to MW4-13 were completed in the late fall of 2013 (Figure 4). 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 wells 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 4). Details of the drilling, monitoring well installation, and hydraulic testing associated with these twelve (12) wells were provided in the Baseline Conditions Report (Stantec, 2014).

Since issuing the Baseline Conditions Report in November 2014, two additional Project Area monitoring wells were added to the Monitoring Program: MW5-14S(2) was installed in December 2014 as part of the adaptive nature of the Monitoring Program, and MW5-14D was installed as part of an agreement between Hydro One and the Municipality of Clarington. A deep bedrock depth well at MW5-14D(2) was installed as part of a separate agreement between Hydro One and the Municipality of Clarington, and is not part of the Monitoring Program for the Clarington TS. CLOCA assumed ownership of this bedrock depth monitoring well in 2016.

In 2015, monitoring well MW4-15D was installed to verify the low groundwater level and slow recovery recorded in MW4-13D. Temporary monitoring well MW8-15 was installed to confirm the borehole log results of the geotechnical borehole BH7D, and borehole BH9-15 was drilled to confirm geologic conditions at the location of the Clarington TS planned oil/water separator location.

The drilling, monitoring well installation, and hydraulic testing associated with the borehole and monitoring well installations completed since November 2014 have been provided in the Clarington Transformer Station - Addendum 2 Report (Stantec, 2015b), which was submitted to the MOECC and is publicly available on Hydro One's project website. Monitoring well details related to all Project Area monitoring installations, are provided in Table 1 of this report.

The only change to the Monitoring Program in 2016 was at the request of the MOECC; to complete Fall monitoring approximately one month later in early November, 2016. Subsequent Fall monitoring events will be completed in early November or later, in an effort to better record the typical fall seasonal recharge of groundwater conditions. As a result, the Annual Monitoring Reports will be completed and presented in January – February of the following year. Project Area groundwater and surface water monitoring will continue semi-annually over the course of the station construction period (2014-2017) and the post-construction period (2018-2019).

3.2 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). Details of the initial notification were presented by Stantec in the Baseline Conditions Report (Stantec, 2014). By October 2014, well owner consent was obtained from the owners of 23 private wells (22 well owners). Two (2) additional private well owners provided their consent to be added to the Monitoring Program in 2015. One well owner elected to no longer participate in the Monitoring Program in 2016; leaving 24 participating private wells.

For private well owners that agreed to participate in the Monitoring Program, the following was completed in 2016:

- Automatic pressure transducers were accessed in Spring and Fall 2016 by a licensed water well contractor to retrieve recorded continuous (hourly) water level measurements.
- Water quality samples were collected semi-annually in 2016 (Spring and Fall).
- Following each Spring and Fall monitoring event, a letter was sent to each of the well owners presenting their individual well monitoring results. To maintain confidentiality, we have included the results of the private well monitoring in this report but have not included the well identifications.

Private well monitoring will continue semi-annually over the course of the station construction period (2014-2017) and the post-construction period (2018-2019).

3.3 REPORTING

As noted above, the first monitoring report to be prepared under the Monitoring Program was the Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report (Stantec, 2014). The findings of a subsequent assessment of sampling methodology and the role of sediment in water quality results were presented in an Addendum Report (Stantec, 2015a). An Addendum 2 Report (Stantec, 2015b) presents a summary of additional drilling and installation of groundwater monitoring wells, hydraulic testing, and soil sampling complete since issuing the Baseline Conditions Report. The 2015 Annual Monitoring Report was issued in November 2015.

This 2016 Annual Monitoring Report presents data collected during the Spring and Fall semi-annual sampling events completed in April and October-November 2016. This report includes a summary of private well monitoring data collected during these semi-annual monitoring events.

Subsequent annual monitoring reports will continue to 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 assess potential effects on the groundwater and surface water systems that may be related to station construction.

4.0 METHODS

The Monitoring Program included the following components in 2016:

- Groundwater and Surface Water Level Monitoring;
- Groundwater and Surface Water Quality Monitoring, and
- Private Well Monitoring; and
- Climate Monitoring

Methodologies employed during borehole drilling, well installations, and hydraulic testing completed following the Baseline Conditions Report (Stantec, 2014) are presented in the Addendum 2 Report (Stantec, 2015b). The following sections present a summary of the study methodology for water level and water quality monitoring.

4.1 MONITORING WELL INSTALLATION

Since December 2013, a total of sixteen (16) monitoring wells (MW1-13S/D, MW2-13S/D, MW3-13S/D, MW4-13S/D, MW4-15D, MW5-14S(2)/S/I/D, MW6-14, MW7-14, and temporary well MW8-15 (now decommissioned) were installed at eight (8) locations throughout the Project Area in order refine the understanding of the local geology and hydrogeology prior to construction and to monitor groundwater and surface water during and following construction of the Clarington TS.

Monitoring wells MW1-13S/D, MW2-13S/D, MW3-13S/D, and MW4-13S/D were installed in December 2013. Monitoring wells MW5-14 S/I, MW6-14, and MW7-14 were installed in October 2014, MW5-14 S(2)/D in December 2014, and MW4-15D and MW8-15 (temporary) were installed and added to the Monitoring Program in 2015 as part of the adaptive nature of the Monitoring Program.

No changes to the on-Site groundwater monitoring locations occurred in 2016. The monitoring well locations are presented on Figure 4. Well completion details are presented in Table 1.

4.2 DRIVE-POINT PIEZOMETER INSTALLATION

Three (3) drive-point piezometers (DP2-14, DP3-14 and DP4-13) were installed within surface water features / drainage swales within the Project Area to provide an indication of groundwater levels and vertical hydraulic 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. The drive-point piezometer locations are presented on Figure 4.

In April 2015, Stantec replaced the drive-point at SW2 (DP2-14 replaced by DP2-15), 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. In April 2015, Stantec also replaced the drive point piezometer at SW3 (DP3-14 replaced by DP3-15), as this monitor was found to be within a dry creek bed in 2014. No changes to the on-Site surface water monitoring locations occurred in 2016. The surface water monitoring locations are shown on Figure 4. Installation details are summarized in Table 1.

4.3 GROUNDWATER AND SURFACE WATER LEVEL MONITORING

Groundwater level monitoring was completed using a combination of manual and automated techniques, while surface water level monitoring was completed using manual techniques alone. 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® were 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 MW1-13D. For the period of time from December 2013 to May 2014, the Barologger malfunctioned, and atmospheric corrections were completed using data from Environment Canada's Oshawa Climate Station located at the Oshawa Airport.

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) and later corrected for well stick-up. Water level hydrographs for the monitoring wells and surface water drive-point piezometers within the Project Area are presented in Figures 5, 7, and 9.

4.4 GROUNDWATER AND SURFACE WATER QUALITY MONITORING

4.4.1 Surface Water

Surface water quality was monitored at three (3) locations on Site (SW2, SW3 and SW4) in 2016. Hydro One technicians, under the direction of Stantec 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), the Tributary of Harmony Creek at SW3 (adjacent to DP3-14), and at a drainage swale located south of the Station Site (SW4). Spring (April) 2016 surface water sampling was completed at SW2, SW3 and SW4. Despite Fall 2016 monitoring occurring during and after a precipitation event, both SW2 and SW4 monitoring locations were dry during the Fall 2016 (October / November) sampling event. As a result, surface water was only able to be sampled at SW3 during the Fall 2016 sampling event.

Surface water samples were collected directly from the creek into laboratory-provided sample containers. Sample containers for mercury were field-filtered. All other samples collected were not field-filtered. Field measurements of specific conductivity, temperature and pH were recorded using a YSI 556 multi-parameter meter. The meters were calibrated prior to use according to the manufacturers' specifications with the appropriate calibration standards. Following sampling, a bottle was filled for field analysis of dissolved oxygen.

All samples collected were packed into sample coolers, which were refrigerated using ice, and delivered to Maxxam Analytics Inc. (Maxxam) 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 E.

4.4.2 Groundwater Monitoring Wells

Hydro One technicians, under the direction of Stantec staff, completed groundwater quality sampling within the shallow and deep monitoring wells within the Project Area. Results of previous water level and water quality monitoring were detailed by Stantec (2014, 2015a, 2015b).

Water quality samples were collected at all Project Area monitoring wells as part of the Monitoring Program during semi-annual monitoring events, with two exceptions. First, in Spring 2016, MW4-13D was not sampled because it had insufficient water volume from which to collect a full suite of samples and MW4-15D had a larger groundwater volume from which to collect the laboratory required sample volumes. Second, in Fall 2016, MW4-15D was not sampled because it had insufficient water volume and MW4-13D had a larger water volume from which to collect laboratory samples. Both MW4-13D and MW4-15D have had extremely slow groundwater recovery since installation. Screened at a greater depth, MW4-15D only recovers slightly faster than MW4-13D, but both have demonstrated similar water quality. Further water volume and water quality results will be analyzed to determine whether both deep wells at MW4 will be required to collect semi-annual samples for all analytical parameters, or whether one of the wells may be decommissioned.

For the Spring and Fall 2016 monitoring events, and prior to sampling Project Area monitoring wells MW1-13S/D, MW2-13S, MW4-13S, MW5-14S MW5-14S(2), MW5-14S, MW5-14D, MW6-14 and MW7-14, pre-purging occurred where between one (1) and three (3) volumes of water were removed using the Waterra™ inertial lift system, depending on rate of well recovery. Well sampling was completed after pre-purging using a GeoTech Bladder Pump for low flow sampling with Teflon-lined, bonded low-density polyethylene (LDPE) tubing. Where well water level recovery was extremely slow, sampling was completed immediately with no prior purging (MW2-13D, MW3-13S/D, MW4-14S, and MW4-15D (spring 2016 only), MW4-13D (fall 2016 only), and MW5-14I). A bailer was used to sample low yield wells MW4-13D and MW4-15D.

Field measurements of specific conductivity, temperature, and pH were recorded using a YSI 556 multi-parameter meter. Meters were calibrated prior to use according to the manufacturers' specifications with the appropriate calibration standards. Field parameters were monitored during purging and following sampling. A laboratory sample bottle was filled for field analysis of dissolved oxygen.

Following purging, groundwater samples were collected directly from the Teflon-lined LDPE tubing, or bailers into the sample containers. Groundwater samples for metals were field filtered and preserved.

All collected groundwater samples were packed into sample coolers, which were refrigerated using ice, 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 E.

4.4.3 Quality Control Protocol

During the 2016 semi-annual groundwater sampling events, QA/QC sampling was completed and included one or more field duplicates, field blanks, and/or trip blanks to evaluate potential sources of error during sample collection. The following QA/QC samples were completed:

- Field blank for VOCs, SVOCs, BTEX and PHCs parameters for Spring and Fall 2016; and
- Trip blank for VOCs, SVOCs, BTEX and F1 parameters for Spring and Fall 2016.

Field duplicate samples for groundwater were also collected at a frequency of one (1) field duplicate per ten (10) samples during each sampling event. For surface water samples, field duplicates were collected during the Spring and Fall 2016 sampling events. The analytical results for the field and trip blanks are included in Table 4.

Maxxam followed internal QA/QC protocols, which included internal replicates, process blanks, process recovery, and matrix spike analyses. A surrogate spike was added for the SVOC analysis to document recovery within lab filtered samples. 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 1; however, they are included in the detailed laboratory certificates of analyses in Appendix E.

4.5 PRIVATE WELL MONITORING

The following sections present the details of the 2016 Private Well Monitoring Program completed semi-annually in Spring (April) and Fall (October/November) 2016.

4.5.1 Water Level Monitoring

Lotowater Technical Services Inc. (Lotowater), a licensed well contractor, completed water level monitoring, data logger (Solinst Levelogger®) installation and downloading within the private wells. All equipment was disinfected prior to use within each of the private wells.

All data loggers were downloaded during the Spring and Fall monitoring events in 2016, with the exception of the data logger installed in PW-17. The data logger in PW-17 was removed for pump repair between June and November 2016 at the request of the well owner. Groundwater levels dropped below the level of data loggers in PW-23 and PW-25 in the fall of 2016. One resident was not available during Fall 2016 monitoring to schedule logger download and sampling, but is expected to be available in Spring 2017. No data for these locations is available during these periods.

Construction details for the private wells are presented in Table 2, with private well hydrographs included in Appendix D.

4.5.2 Water Quality Monitoring

The Private Well Monitoring Program was initiated in 2014, with sampling completed to document conditions prior to, and during Station Site construction. In 2016, Stantec completed semi-annual groundwater quality sampling in the spring (April) and fall (October / November) from the private wells participating in the Monitoring Program.

All private wells were sampled during the Spring and Fall 2016 sampling events, with the exception of PW-09 (Spring 2016), PW-23 (Fall 2016) and PW-25 (Fall 2016). A suitable sampling time could not be scheduled for PW-09 during the spring sampling event. Both PW-23 and PW-25 were dry, and no sample could be collected during the Fall 2016 sampling event.

Stantec attempted to collect water quality samples from a raw water tap; however, this was not always feasible. Based on water quality results, it is concluded that water samples from some locations were collected following treatment (sediment filter, water softener, and / or ultra-violet).

The sample location was typically an outdoor tap or a kitchen faucet, depending on accessibility. Prior to sample collection, the tap was disinfected with a dilute 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 private well water 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 bacteriological analyses, general inorganic chemistry, total metals, petroleum hydrocarbons and BTEX compounds, PCBs, VOCs and SVOCs. 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 E.

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 E.

4.5.3 Well Interference Response Plan

Initiated in 2014, the Clarington TS Well Interference Response Plan (WIRP) continued to be implemented in 2016. The WIRP fulfills Hydro One's commitment to private well owners within 1,200 metres of the Clarington Transformer Station to respond to and assess the nature of well-related complaints. The WIRP was reviewed at the end of 2016, with no recommended changes to the process, implementation, or contact information.

4.6 CLIMATE MONITORING

Seasonal fluctuations in groundwater elevations are expected; typically with water levels rising during the spring freshet due to increased precipitation and warmer temperatures resulting in snow melt, followed by lowering of water levels during drier and warmer summer months. Water levels then generally increase again in the cooler and wetter fall months, and then lower again during the winter due to freezing ground conditions.

Environment Canada's Oshawa Climate Station data were used to represent precipitation and temperature at the Clarington TS. Occasionally, the Oshawa climate station is missing daily precipitation totals on specific days. In the event daily precipitation totals were not available, the Oshawa climate station data were supplemented on those days with data from the next closest Environment Canada stations at Blackstock and Oshawa WPCP stations, respectively.

5.0 RESULTS

The following sections present the results of the Monitoring Program based on data collected from 2016 monitoring activities as part of the approved program.

5.1 LOCAL HYDROGEOLOGY

Groundwater and surface water level monitoring continued in 2016, with the following presenting results of groundwater and surface water monitoring completed within the Project Area from Fall 2015 to Fall 2016 as part of the Monitoring Program. The groundwater elevation data consist of water level measurements from three (3) drive-point piezometers, fifteen (15) monitoring wells, and twenty-two (22) available private wells (2 private wells were inaccessible and one private well owner is no longer participating in the Monitoring Program) as presented on Figure 4.

The following sections present the groundwater and surface water level data. Hydrographs of the data are shown on Figure 5, 7, and 9. Shallow groundwater contours and an interpretation of shallow groundwater flow is provided on Figure 10, with Thorncliffe depth well water level elevations shown on Figure 11.

5.1.1 Shallow Groundwater Level Monitoring

5.1.1.1 Shallow Monitoring Wells

Shallow groundwater level elevations within the Project Area were obtained from the date of well completion through to Fall 2016 from eight (8) groundwater monitoring wells installed within the Upper Aquifer/Aquitard (MW1-13S, MW2-13S, MW3-13S, MW4-13S, MW5-14S/S(2), MW6-14, and MW7-14).

Overall, water level elevations were observed to increase in all shallow monitoring wells in the spring of 2016; rising to elevations that were equal to or greater than observed in the spring of 2015, in response to snow melt and increased precipitation (Figures 5, 7, and 9). Water levels were also observed to begin to decrease at the end of April, coinciding with significantly reduced precipitation and warmer temperatures in May and June. Water levels continued to decline throughout the summer and fall months, as a result of continued warmer temperatures and lower than normal precipitation for the months of September, October, and November.

The following discussion reflects shallow groundwater level elevation observations recorded in October 2016 and compares them with comparable observations from October 2015. An average water level elevation from data recorded within each monitoring well over a two-week period from October 1st to October 14th, was used for the purpose of evaluating changes in water level elevations between October 2014, October 2015, and October 2016.

Shallow Well Hydrographs

Shallow monitoring wells MW1-13S, MW6-14, and MW7-14 are located approximately 20 m upgradient of the graded slope on the east side of the Station Site, and showed similar groundwater level trends in response to seasonal changes and lower than normal precipitation. Within Project Area monitoring wells, the most significant decrease in water level elevation in 2016 as compared to 2015 was recorded at monitoring well MW7, with a 1.8 m decrease. Water level elevations from 2014 to 2016 were observed to be lower in monitoring wells MW1-13S, MW6-14, and MW7-14 with changes of 3.3 m, 2.7 m, and 3.0 m respectively (Figure 5).

Given the proximity of these shallow monitoring wells to the side of the graded slope, a greater localized decrease of the water level within these wells was anticipated following grading of the Station Site. The observed lower ground water levels in 2016 within the monitoring wells along the eastern edge of the grade slope are interpreted to be due to both Station Site grading, as predicted, and continued lower than normal precipitation recorded this year. Notwithstanding very low precipitation in 2016, water levels recorded in the eastern shallow wells remained higher than conservatively predicted after 523 days (158 days of water taking, plus 365 days) of approximately 4.1 m (Figure 6). Using the same model as presented in the PTTW report (based on Edelman, 1947), the predicted radius of influence after 523 days for a 10 cm drawdown is 80 m from the graded slope of the Station Site. The closest shallow private well is located approximately 430 m east of the Station Site.

MW2-13S is located on the north side of the Station Site, within Wetland Area 1 and beside the South Branch of the Tributary of Harmony Creek. Shallow water level elevations recorded within this monitoring well remained close to ground surface for most of 2016, fluctuating up to 1.1 m over the course of the entire year. The decrease in water levels at this well was 0.4 m when compared between October 2014 and October 2016 (Figure 7).

MW3-13S is located west of the Station Site and on the top of the eastern bank of the Tributary of Harmony Creek. MW4-13S is located south of the Station Site in a drainage swale that has intermittent flow during spring snow melt and during periods of significant precipitation, but is otherwise dry for most of the year. Both MW3-13S and MW4-13S had lower October 2016 water levels compared to October 2014 of 0.2 m and 1.9 m, respectively (Figure 7).

Shallow monitoring wells MW5-14S and MW5-14S(2) are installed immediately adjacent to the southwest corner of the Station Site. Shallow water level elevations in these two wells responded similarly to other shallow wells installed across the Project Area since their installation in late 2014 and early 2015, respectively. Similarly to other shallow monitoring wells across the site, these wells responded to seasonal changes, and showed a decrease in water levels as a response to low precipitation in the warm and dry summer and fall months of 2016 (Figure 8). Maximum fluctuations at MW5-14S(2) and MW5-14S were 0.9 m and 1.0 m, respectively in response to precipitation events and decreases during periods of reduced precipitation. Compared to October 2015 water levels, MW5-14S(2) and MW5-14S were approximately 0.4 m and 0.6 m lower, respectively as a result of continued lower than normal precipitation.

Shallow Well Hydraulic Gradients

Recorded water level elevations from pairs of shallow and intermediate or deep wells were used to calculate vertical hydraulic gradients at monitoring well nest locations MW1, MW2, MW3, MW4, and MW5.

Predominantly neutral to weak downward vertical hydraulic gradients were calculated at monitoring well pairs MW1-13S/D and MW2-13S/D, ranging from 0.0 m/m (MW2-13) to 0.02 m/m (MW1-13). A downward vertical hydraulic gradient of 0.2 m/m was noted at shallow monitoring wells MW5-14S(2)/S. Vertical gradients could not be calculated at MW3-13S/D and MW4-13S/D, because the deeper wells at MW3 and MW4 are installed within a dense till, slowing the well's recovery following installation and subsequent sampling events. At the time of Fall 2016 monitoring, the deep wells were still recovering from the Spring 2016 sampling event.

The difference in recorded water levels in both deeper wells, MW5-14I (237.0 m AMSL) and MW5-14D (211.6 m AMSL), in conjunction with the stratigraphic model understanding for the Site indicates these wells have little to no direct hydraulic connection with each other.

The overall downward vertical hydraulic gradients observed within shallow wells across the Project Area in 2015 are consistent with those presented in the Baseline Conditions Report (Stantec, 2014). The vertical hydraulic gradients in all wells will continue to be monitored as the construction of the Clarington TS progresses.

The horizontal hydraulic gradients across the Station Site calculated from average water elevations recorded between October 1 and October 14, 2016 are 0.025 m/m (MW6 to MW2-13S), 0.029 m/m (MW1-13S to MW3-13S), and 0.048 m/m (MW7-14 to MW4S-13), and remain consistent with horizontal hydraulic gradients measured in 2014 and 2015, which ranged from 0.03 m/m to 0.05 m/m.

5.1.2 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.

5.1.2.1 Tributary of Harmony Creek

Drive-point piezometers were installed at surface water monitoring locations within the South Branch of the Tributary to Harmony Creek at SW2, and within the Tributary to Harmony Creek at SW3 (Figure4). Hydrographs for DP2 and DP3 are presented on Figure 9.

There are two (2) drive-point piezometers installed within Wetland Area 1 at SW2, DP2-14 and DP2-15. DP2-15 is a replacement to DP2-14 due to a partially plugged screen which affected its response to seasonal changes. Since the installation of DP2-15, groundwater levels were consistently higher at DP2-15 as compared to DP2-14, and groundwater levels within both drive-point piezometers were higher than ground surface elevation in the spring following a warm and wet winter season, with a steady downward trend from May 2016 onward. DP2-15 does not respond quickly to seasonal or individual precipitation events, indicating it is installed within fine-grained soil within the wetland. This decreasing trend is consistent with observations of shallow monitoring wells and private wells. The decrease in water level is a clear response to lower than normal precipitation throughout the late spring / early summer and fall months in 2016 (Figure 9).

There are two (2) drive-point piezometers installed within the Tributary of Harmony Creek at SW3, DP3-14 and DP3-15. DP3-15 is a replacement to DP3-14 due to a partially plugged screen which affected its response to seasonal changes. During the monitoring period of 2016, groundwater levels were consistently higher at DP3-14 compared to DP3-15 and groundwater levels in both drive-point piezometers were lower than surface water elevation in early November, 2016 indicating groundwater recharge conditions.

Water level elevations recorded within the newly replaced DP2-15 and DP3-15 are very close to and above ground surface; however, manual measurements during Spring and Fall 2016 monitoring events indicated surface water elevations remained above those in the shallow monitors and are evidence of downward vertical hydraulic gradients within the surface water features.

5.1.2.2 Drainage Swale

A drive-point piezometer was installed within a mapped drainage swale to the south of the Project Area at SW4. At the time of installation in December 2013, there was some surface water drainage noted due to recent snow melt; however, surface water was not present at this location during further field visits in 2014. In both 2015 and 2016, surface water was only present in the Spring, but not in the Fall. The groundwater level elevation at DP4-14 remained predominantly below ground surface and responds quickly to precipitation events, indicating the drainage swale receives surface water runoff during spring snow melt and precipitation events (Figure 9) and is an area of groundwater recharge.

Site observations and recorded water level elevations at nearby drive-points and monitoring wells indicated that Harmony Creek tributaries were supported primarily by surface water runoff, with the potential for seasonal groundwater discharge in the wetland near SW2. Shallow water levels recorded within the surficial silty sand and the upper portion of the weathered till indicated predominantly downward vertical hydraulic gradient with the potential for short term seasonal upward vertical hydraulic gradients occurring within the low-lying valley associated with the tributary of Harmony Creek on the north side of the Project Area. Due to the limited thickness and discontinuous nature of the surficial silty sand and low permeability of the underlying weathered till, limited groundwater discharge occurs in surface water features within the Project Area sufficient to sustain consistent baseflow conditions. This is consistent with the findings presented in the Baseline Conditions Report (Stantec, 2014).

5.1.3 Shallow Private Wells

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 surficial sand or the underlying weathered to compact Newmarket Till. Water level data from the shallow private wells show effects due to regular daily well use, which was characterized by rapid, regular drawdown and recovery (Appendix D). Similar to onsite monitoring wells, private wells showed an increase in water levels at the end of October 2015 which recovered in the spring of 2016 to levels as high as or higher than previously recorded in these wells. A decrease in water levels from May 2016 to the end of the monitoring season is attributed to lower than normal precipitation and higher temperatures as previously discussed in section 5.1.1.

The greatest change in well water level was a decrease from May to October 2016 of approximately 9 m measured in a private well located north and upgradient of the station. From Fall 2015 to Fall, 2016, this well recorded a water level decrease of approximately 7 m. Similarly, there were several private wells located upgradient of the Project Area that ultimately were dry at the time of Fall 2016 monitoring, or shortly thereafter. These shallow private wells located between 900 m and 1,600 m north and northwest of the Project Area (well beyond the radius of influence of 80 m), are upgradient and at a higher elevation than most of the on-Site monitoring wells, and have a smaller catchment area which results in reduced groundwater recharge from infiltration of precipitation. As noted above, water levels within MW2 monitoring wells, located between the Station Site and the private wells much further away to the north and northwest, experienced a change in water level of only 0.3 to 0.4 m. As a result, and considering the significant reduction in precipitation in 2016, changes observed in shallow private wells are interpreted to be as a result of seasonal temperature and precipitation fluctuations, and not due to station construction activities.

5.1.4 Shallow Groundwater Flow

Shallow groundwater level elevations within the Project Area are presented on Figure 10. Water level data are presented for October, 2016 using an average of hourly recorded water level elevations from October 1st to 14th, 2016.

Within the Station Site, shallow groundwater flows to the west and southwest towards the tributary of Harmony Creek and its associated branches. East of the Station Site, a shallow groundwater divide shown as a dashed line on Figure 10 extends from north to south, dividing shallow groundwater lateral flow between the Harmony Creek and the Farewell Creek sub-watersheds. The shallow groundwater flow direction observed in 2016, remained consistent with observations in 2015, and prior to Station Construction in 2014.

Water levels recorded in shallow private wells closest to the Project Area are located within the Farewell Creek watershed (Figure 10) and indicate a general lowering of the water level of 0.2 m to 1.6 m, with the exception of one well (not closest to the Station Site) that recorded a lowering of 3.9 m from the previous year.

As noted above, shallow private wells within the Harmony Creek watershed and located upgradient of the Project Area recorded a more significant lowering of water levels recorded in October 2016 as compared to October 2015. These wells are also located further upgradient of the Project Area, with a smaller catchment available to provide water to the wells. Overall, there was a general reduction of water levels within shallow wells in the area due to seasonal and climate effects that were significantly drier and warmer than climate normals (discussed further in Section 5.3).

Based on the shallow groundwater contours and surface water features, the area downgradient of the Station Site is shaded in light blue (Figure 10). Monitoring wells at MW2-13, MW3-13, MW4-13, and MW5-14 are well positioned to serve as downgradient shallow groundwater monitoring wells for the Station Site. Notably, there are no shallow private wells located downgradient of the Station Site, with only one deep private well located downgradient (Figure 10).

All shallow private wells in the vicinity of the Clarington TS participating in the Private Well Monitoring Program are located in the Farewell Creek Watershed, with the exception of two (2) wells located north and upgradient of the Station Site. Two (2) additional wells are located in the Oshawa Creek watershed to the west of the Harmony Creek sub-watershed. At the eastern extent 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.

5.1.5 Thorncliffe Aquifer

In December 2014, monitoring well MW5-14I and MW5-14 D were added to the Monitoring Program, allowing for water levels within the Newmarket Till (MW5-14I) and a deeper sandy aquifer unit within a transition between the Newmarket Till and the Thorncliffe Aquifer (MW5-14D) to be monitored. In addition, a number of nearby private wells are interpreted to be installed within the Thorncliffe Aquifer (Figure 11). Continuous water level data were obtained at eight (8) nearby private wells completed at a depth greater than 50 m. One of the private wells located north east of the site had the levelogger removed for well repairs and therefore continuous water level data for this well are not available after June, 2016 (logger re-installed during Fall monitoring). Another well was not able to be downloaded due to scheduling with the well owner; however, the water level data are expected to be available after Spring 2017 monitoring.

Water level elevation data from the deep private wells typically indicated well use effects due to operation of the private well pump, which was characterized by rapid, regular drawdown and recovery (Appendix D). Effects due to water use were more clearly visible in these drilled wells due to the smaller well diameter as compared to shallow dug wells. Fluctuations due to deep private well use ranged from approximately 0.5 m up to 20 m (Appendix D). The extent of water level fluctuation due to well use was generally consistent within each deeper private well over the monitoring period, and available data did not suggest any change in well performance since monitoring began. Water level trends in the deep private wells are characterized by muted responses to individual precipitation events, and a steady decrease in water level from early May through to November, 2016 in response to lower than normal precipitation.

Interpreted static groundwater levels within the Thorncliffe Aquifer through the Project Area are presented on Figure 11. Average static water level data are presented for early October, 2016, following a period of minimal precipitation. Groundwater levels range from 207.6 m AMSL to 210.7 m AMSL, with an overall south to south to southeasterly groundwater flow direction that is consistent with monitoring results from 2014 and 2015, and is consistent with regional mapping CLOCA (2012) that indicates groundwater flow to the southeast across the Project Area.

A downward vertical hydraulic gradient is interpreted from water level elevations recorded in the surficial sand and weathered till units within the proposed Project Area to the underlying Thorncliffe Aquifer. Assuming a shallow groundwater level of 249.1 m AMSL within the Station Site in the vicinity of MW5-14S (Figure 10) and a groundwater level of 211.6 m AMSL from MW5-14D (Figure 11); the difference in recorded water levels in these monitoring wells, in conjunction with the stratigraphic model understanding for the Site, indicates these wells have little to no direct hydraulic connection.

5.2 GROUNDWATER AND SURFACE WATER QUALITY

As part of the Monitoring Program, water quality monitoring has been completed within surface water and groundwater monitoring wells from the Project Area since December 2013. In 2016, water quality was monitored semi-annually in the Spring and Fall both onsite and in private water wells. Surface water quality data are presented in Table 3, with groundwater quality data from Project Area monitoring wells presented in Table 4, and water quality data 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 E. The following section presents a review of the available water quality data.

5.2.1 Surface Water Quality

Surface water quality data are discussed below and 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.

The South Branch of the Tributary of Harmony Creek flows through Wetland Area 1, and is approximately 0.2 to 0.3 m wide at SW2. During the field visits, surface water at SW2 (adjacent to DP2-14/DP2-15), ranged in depth from 0.07 m in the Spring to being dry in the Fall, 2016. Due to the limited amount of water present, it is challenging to collect samples without allowing some sediment to enter the bottles. As a result, the field sample results for metals are considered representative of total metals water quality and not the dissolved phase. Laboratory filtered samples are representative of the dissolved phase.

Surface water quality at SW2 in 2016 was characterized by:

- The water quality results exceeded the PWQO criteria for aluminum in Spring, 2016;
- Low level detection of sodium of less than 10 mg/L with no other detection of dissolved metals above PWQO in Spring, 2016 samples;
- All other parameters were found to be below the PWQO criteria in Spring, 2016; and
- No detection of PHC or BTEX compounds in both rounds of sampling in 2016.

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 two (2) sampling rounds in 2016, with a creek depth ranging from 0.08 m in Spring to 0.19 m in Fall; noting that Fall 2016 monitoring occurred immediate following and during a precipitation event. Surface water quality at SW3 in 2016 was characterized by:

- The water quality results exceeded the PWQO criteria for aluminum in Spring and Fall, 2016 and total phosphorous, iron and boron exceeded the PWQO criteria in Fall, 2016;
- Low level detection of sodium (up to 86 mg/L in April, 2016); and
- No detection of PHC or BTEX compounds in both rounds of sampling in 2016.

Surface water was present at SW4 (within surficial drainage swale adjacent to DP4-13) at the time of drive-point installation in 2013; however, it was noted as being dry during all sampling visits in 2014. Surface water was flowing in Spring, 2016 with a surficial drainage depth of 0.01 m, but dry again in the Fall, similar to conditions observed in 2015. Surface water quality at SW4 in Spring, 2016 was characterized by:

- The water quality results exceeded the PWQO criteria for aluminum, total phosphorous, copper and iron in the Spring 2016 samples. All other tested parameters were below the PWQO criteria;
- Low level detection of sodium (up to 16 mg/L) with no other detection of dissolved metals above PWQO in the Spring 2016 sample; and
- No detection of PHC or BTEX compounds in the Spring 2016 sampling event.

Surface water quality monitoring data indicates that water quality is generally characterized by low concentrations of sodium (up to 8.4 mg/L at SW2, 86 mg/L at SW3 and 16 mg/L at SW4), chloride (up to 21 mg/L at SW2, 46 mg/L at SW3 and 41 mg/L at SW4), and nitrate (< 4 mg/L) and all tested parameters generally below the PWQO. The detection of aluminum, iron, copper, phosphorous, and boron above the PWQO is attributed to sediment within the samples.

5.2.2 Monitoring Well Water Quality

Semi-annual groundwater quality sampling of the on-Site groundwater monitoring wells was completed in Spring and Fall 2016 sampling events. The following presents the results from semi-annual monitoring completed in April and October-November, 2016.

Groundwater quality results from 2016 are presented in Table 4, and are compared to the ODWQS. Historical data from 2013 through to and including 2016 are provided in the accompanying CD-ROM of the report in Appendix F. For a number of SVOC and VOC there are no criteria in the ODWQS; 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.

5.2.2.1 Inorganic Water Quality

Groundwater quality from the Project Area monitoring wells in 2016 met the ODWQS maximum acceptable concentration (MAC) for all health related inorganic parameters with the exception of nitrate which was detected at MW1-13S (16.7 mg/L in Spring 2016), and fluoride at MW5-14I (1.6 mg/L in Spring, 2016). The elevated nitrate concentrations at these locations are attributed to agricultural fertilizer and consistent with previous results.

Nitrate in groundwater is common in agricultural communities, with potential sources including nitrate from fertilizers, septic system leaching, and the natural decaying process of vegetation and animal matter. As reported in the 2015 Annual Monitoring Report, nitrate concentrations in shallow the groundwater system decreased from east to west and southwest across the Project Area. The same trend was observed in the 2016 shallow groundwater quality data. Though shallow groundwater upgradient of the Station Site was found to have nitrate concentrations above the ODWQS of 10 mg/L in Fall 2016 monitoring, shallow groundwater leaving the Project Area remained well below 10 mg/L. In each of the shallow monitoring wells, nitrate concentrations were lower in Fall 2016 results as compared to Fall 2015.

Fluoride in groundwater is naturally found in groundwater from the weathering of rock and soil. At low concentrations, fluoride is known to reduce the risk of dental cavities, and is added to many municipal water supplies. Concentrations of fluoride in the intermediate and deep Project Area monitoring wells MW5-14I and MW5-14D have historically been detected near the ODWQS – MAC, ranging from 1.0 to 1.6 mg/L. However, shallow well concentrations of fluoride monitoring wells MW5-14S and MW5-14S(2) remained below detectable limits of 0.1 mg/L.

The following inorganic parameters were detected above the ODWQS aesthetic objective (AO), ODWQS operational guideline (OG) or ODWQS Medical Officer of Health (MOH) guidelines on at least one (1) occasion in 2016:

- Hardness (80 to 100 mg/L OG) within all monitoring wells;
- Sodium (20 mg/L MOH) within MW2-13D, MW3-13S/D, MW4-13 S/D, MW4-15D, MW5-14I, and MW5-14D;
- Sulphate (500 mg/L AO) within MW3-13D;
- Total Dissolved Solids (TDS) (500 mg/L AO) within MW3-13D, MW4-13S/D and MW5-14D; and
- Turbidity (5 NTU AO) within all monitoring wells with the exception of MW2-13D, MW5-14S and MW7-14.

These 2016 detections are generally consistent with previous 2013 to 2015 results, and do not indicate any significant change in groundwater quality in 2016 through the start of construction of the Clarington TS.

To visually compare 2016 water quality results, inorganic water quality data from the monitoring wells are presented as a piper plot on Figure 10 and include results from Fall 2016 sampling. The water quality distribution within the piper plot is consistent with the results from 2014 presented in the Baseline Conditions Report (Stantec, 2014) and the 2015 Annual Groundwater and Surface Water Monitoring Report (Stantec, 2015). Results indicated that water quality at MW6-14 and MW7-14 was similar to other shallow monitoring wells, 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. Results indicated similar groundwater chemistry at deeper monitoring wells MW4-15D, and MW5-14I.

5.2.2.2 Organic Water Quality

Groundwater samples from the monitoring wells were also analyzed for petroleum hydrocarbons, BTEX compounds, PBCs, VOCs and SVOCs and compared to ODWQS (Table 4). Historically in 2014, benzo(a)pyrene has been detected above the ODWQS. As presented in the Addendum Report (Stantec, 2015a), this compound adsorbs to soil particles and it was concluded that these detections are associated with the sediment collected within the sample. The Addendum Report recommended that water quality sampling protocols be amended to include low-flow sampling. This sampling protocol was adopted in the 2015 and 2016 Spring and Fall sampling rounds. In 2015, no detections of benzo(a)pyrene were noted in any of the Project Area monitoring wells. However, benzo(a)pyrene was detected in a Spring 2016 sample from MW4-15D (0.02 µg/L) and a Fall 2016 sample from MW3-13D (0.06 µg/L), in which turbidity and some suspended sediments were noted during sampling. The elevated benzo(a)pyrene is likely due to the effect of sediment entrained within the samples from MW3-13D and MW4-15D, as the lab-filtered samples for the same monitoring locations during the same monitoring events did not detect benzo(a)pyrene.

Certain other VOC and SVOC compounds were detected within the monitoring wells in Spring and/or Fall 2016 sampling in low concentrations either below the ODWQS criteria, or there were no applicable ODWQS criteria. The following provides a summary of these organic 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 groundwater quality results for 2016:

- No PCBs were detected within any of the samples;
- No PHCs were detected within any of the samples;
- No phthalate compounds were detected within any of the samples;
- No PAH compounds were detected within any of the samples; and
- No VOC compounds were detected within any of the samples.

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 groundwater 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 MW2-13D in Fall 2016 samples, with concentrations below the SCS criteria. Overall, the concentration of BTEX compounds show a decrease from those observed between 2013 and 2015;
- Low level detection of phthalate compounds within MW2-13S in Fall 2016 samples, with concentrations remaining below the SCS criteria;
- No PAH compounds were detected within either wells in 2016; and
- No VOC compounds were detected within any of the samples.

Water Quality – Southwest of Station Site

Monitoring Wells MW3-13S/D, MW4-13S, and MW4-15D (replacing MW4-14D) 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 or BTEX compounds were detected within any of the samples;
- Low level detection of phthalate compounds within MW3-13D, MW4-13D and MW4-15D, with concentrations remaining below the ODWQS and SCS criteria in both the Spring and Fall 2016 sampling rounds;
- Benzo(a)pyrene exceeded the ODWQS and SCS MAC criteria (0.01 µg/L) within a Spring sample at MW4-15D (0.02 µg/L) and a Fall sample at MW3-13D (0.06 µg/L). Additional low level detections of PAHs within MW4-15D were detected, with concentrations remaining below the ODWQS and SCS criteria in both the Spring and Fall, 2016 sampling rounds; and

- No VOC compounds were detected within any of the samples.

Water Quality – Adjacent to Station Site

The four monitoring wells at MW5 (MW5-14S(2)/S/I/D are located immediately on the southwest side of the Station Site and generally central to the Project Area. Water quality results indicated the following water quality results:

- No PCBs were detected within any of the samples;
- No PHCs or BTEX compounds were detected within any of the samples;
- Low level detection of phthalate compounds within MW5-14S, MW5-14I and MW5-14D, with concentrations remaining below the ODWQS and SCS criteria in both the Spring and Fall, 2016 sampling rounds;
- Low level detections of a PAH compound (phenanthrene) within MW5-14D in the Fall, 2016 sampling round, with concentrations remaining below the ODWQS and SCS criteria in both the Spring and Fall, 2016 sampling rounds; and
- No VOC compounds were detected within any of the samples.

Summary

The organic water quality results for on-site monitoring wells continued to show a general decrease in detections and concentrations. The 2016 results did not indicate any exceedances of the ODWQS or SCS criteria, with the exception of benzo(a)pyrene in MW4-15D and MW3-13D which is considered to be the result of sediments captured within the samples, as lab-filtered samples did not detect the compound.

5.2.3 Private Well Water Quality

Water quality monitoring was completed at private wells participating in the Monitoring Program in the Spring and Fall of 2016. During sample collection, Stantec attempted to collect a raw water quality (untreated) sample at each residence; however, based on discussions with well owners and water quality results, it is evident that treated samples were collected at select locations. Water quality results are presented in Table 5 and compared to the ODWQS, which are the applicable criterion for drinking water in Ontario. For privacy reasons, sample identifications are not given and the samples are labeled 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 following each monitoring event detailing the full water quality results. The sections below summarize key raw water quality characteristics only.

5.2.3.1 Bacteriological Water Quality

Water quality trends for shallow private wells that were installed to a maximum depth of 16 m BGS indicated that 12 of the 14 wells (86%) sampled during the Spring and Fall 2016 rounds had total coliforms present on at least one occasion. E. Coli was detected in five (5) of 14 wells (36%) on at least one occasion in 2016. Comparatively, total coliforms were detected in 73% of 15 shallow wells sampled in 2015, with E. Coli. detected in 33% of 15 shallow wells.

Of the ten (10) drilled wells completed at depths below 50 m BGS, including one drilled well completed at intermediate depth over 16 m BGS, only two (2) wells (20%) had detections of total coliform in 2016. E.coli was not detected in any of these samples collected in 2016. These results are consistent with results from 2015, when only one deep private well was found to have total coliforms and there were no detections of E.coli.

A greater number of total coliform detections were noted within shallow dug wells when compared to drilled wells completed at depths greater than 50 m. The total coliform and E.coli detections within the shallows dug wells are interpreted to be related to local sources associated agricultural activities (fertilizer, manure storage, and animal feedlots), septic systems, or potential surface influences. All residents were notified by phone of positive detection of bacteriological results and directed to follow any recommendations from the Durham Region Health Unit regarding water and well treatment, follow-up sampling, and well maintenance.

Of note, some laboratory bacteriological results were identified as *no data due to bacterial overgrowth*. This result indicates the target bacterial growth (total coliform and E. Coli) on the laboratory petri plate could not be counted due to excessive growth of either non-target bacteria (NDOGN), or excessive growth of the target bacteria, E. Coli. or total coliforms (NDOGT), thereby preventing the target bacteria cultures to be counted. Results of NDOGT are considered a positive detection, and NDOGN are considered as a potential positive result. Well owners were notified of these results and directed to follow recommendations from the Durham Region Health Unit.

5.2.3.2 Inorganic Water Quality

Water quality from the fifteen (15) shallow private wells participating in the Monitoring Program did not exceed the ODWQS-MAC for any tested inorganic parameter in both the Spring and Fall 2016 sampling rounds. Hardness was above the ODWQS-OG in all shallow wells, which is common in groundwater quality from southern Ontario. The following parameters were detected above the ODWQS-AO or ODWQS-MOH on at least one (1) occasion within shallow private wells:

- Sodium exceeded the ODWQS - MOH of 20 mg/L in eleven (11) wells, with water quality results from one (1) well also exceeding the ODWQS-AO of 200 mg/L, with three (3) of these wells reported as treated by a water softener;

- Chloride exceeded the ODWQS-AO guideline of 250 mg/L in two (2) wells;
- Total Dissolved Solids (TDS) (500 mg/L ODWQS-AO) in nine (9) wells with concentrations of up to 1,070 mg/L;
- Aluminum exceeded the ODWQS-OG of 0.1 mg/L in one (1) well; and
- Iron exceeded the ODWQS-AO (0.3 mg/L) in one (1) well.

Water quality for all ten (10) deeper wells completed below 50 m BGS, including one well completed at an intermediate depth of 18.9 m, BGS did not exceed the ODWQS-MAC for any tested inorganic parameter in both the Spring and Fall 2016 sampling rounds. Hardness was above the ODWQS-OG in the raw water from all deeper wells, which is common in groundwater quality from southern Ontario. The following parameters were detected above the ODWQS-AO or ODWQS-MOH on at least one (1) occasion in 2016 sampling within the deeper private wells:

- Iron exceeded the ODWQS-AO (0.3 mg/L) in eight (8) wells with concentrations up to 2.2 mg/L. Elevated iron is common in Thorncliffe-derived water in many areas in Southern Ontario, including within the Harmony Creek watershed (CLOCA, 2011).
- Total Dissolved Solids (TDS) (500 mg/L ODWQS-AO) in one (1) well of intermediate depth with a concentration of 512 mg/L;
- Turbidity exceeded the ODWQS-AO (5 NTU) in six (6) of 10 deeper wells; and
- Sodium was above the ODWQS-MOH guideline in the three (3) deeper wells two (2) of which correspond to treated water (softener).

5.2.3.3 Organic Water Quality

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

Low level concentrations of trihalomethanes (THMs) including bromoform, bromodichloromethane, dibromochloromethane and chloroform were detected within at least one (1) sample from seven (7) shallow private wells and one (1) deep private well, with the highest concentrations well below the ODWQS-MAC. These compounds are commonly 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 sampling, at least one (1) well owner had recently disinfected their well to address bacteriological detections. In addition, a low level concentration at the laboratory detection limit of bis(2-Ethylhexyl)phthalate (DEHP) was detected in one private well during the Spring 2016 sampling round. Subsequent water quality sampling in the Fall 2016 monitoring event did not detect the compound.

5.2.4 Well Interference Responses

Hydro One received four (4) complaints in 2016 from private well owners participating in the Private Well Monitoring Program. Three (3) complaints were related to shallow well water supply, with low water levels in the wells, to wells becoming dry later in the year; and one (1) was related to shallow well water quality. For each individual response, the WIRP was implemented by contacting the well owner within 24 hours in order to assess the nature of the well owner's concern, as part of the WIRP *Initial Assessment* process. In each case, the conclusion of the *Initial Assessment* found the well owner's concern to be unrelated to Clarington TS construction activities. None of the assessments required additional investigation, referred to as the *Secondary Assessment* process in the WIRP. The well owners were provided with individual written responses acknowledging their concern and providing the technical details related to the findings of *Initial Assessment*.

5.3 CLIMATE MONITORING

Summer months in Southern Ontario are typically warmer drier months; however, despite a month of July with above-normal precipitation, precipitation totals in the Oshawa area for a six-month period between May to November 2016 was extremely low and only 57% of what was recorded during that same period in 2015, and only 67% of climate normals.

The Central Lake Ontario Conservation Authority (CLOCA) manage their own climate monitoring stations which are separate from Environment Canada's stations and include many more monitoring stations within the Oshawa area. At Stantec's request, CLOCA provided their climate data for comparison to Environment Canada's climate station data. The six-month precipitation totals recorded for May to November 2016 from CLOCA's monitoring station was only 66% of climate normals, and notably consistent with Environment Canada's data.

Groundwater recharge relies on precipitation to infiltrate into the shallow groundwater system, and eventually provide recharge to deeper groundwater systems. While a number of factors influence groundwater recharge, available recharge from precipitation and evapotranspiration are two important factors. Increased summer temperatures will typically increase evapotranspiration, and therefore, reduce the amount of water available for infiltration into the shallow groundwater system. Environment Canada temperature data for the same Oshawa Airport climate station indicates that there was an overall mean daily temperature increase over the six-month period of May to October from 15.8°C in 2014, to 16.1°C in 2015, and a notable increase to 17.4°C in 2016.

The combination of significantly reduced precipitation and increased temperature have been noted by CLOCA and the four Low Water Condition advisories they issued in July, August, November, and December 2016. CLOCA notes that low water levels in surface water features and dry wells have been reported throughout the watersheds under their jurisdiction in the Oshawa, Ajax, and Clarington area. While this Monitoring Program is limited to the monitoring wells on-Site and surrounding private wells, low water levels have been observed throughout the region and are not limited to the Clarington TS.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results presented in this 2016 Groundwater and Surface Monitoring Report, the following conclusions are provided:

- The Groundwater and Surface Water Monitoring Program, initiated in December 2013, and completed through October 2016, allowed for annual characterization and monitoring of groundwater and surface water conditions within the Project Area.
- The Monitoring Program continues to monitor water levels and water quality data for participating private wells within 1,200 m of the Station Site.
- Site observations and recorded water level elevations at surface water monitoring locations SW2, SW3, and SW4 and nearby monitoring wells indicate that Harmony Creek tributaries are supported primarily by surface water runoff. Due to the limited thickness and discontinuous nature of the surficial silty sand and low permeability of the underlying weathered till, limited groundwater discharge occurred in surface water features within the Project Area sufficient to sustain continuous baseflow conditions, which was consistent with the findings presented in the Baseline Conditions Report (Stantec, 2014) and 2015 Annual Monitoring Report (Stantec, 2015c).
- Groundwater levels within the shallow overburden mimic topography, with shallow groundwater flow direction within the Station Site to the west and southwest towards the tributary of Harmony Creek and its associated branches. Monitoring wells at MW2-13, MW3-13, MW4-13, and MW5-14 are well positioned to serve as downgradient shallow groundwater monitoring wells for the Station Site.
- No shallow private wells are located immediately downgradient of the Station Site, as all shallow wells in the vicinity of the Clarington TS participating in the Private Well Monitoring Program are located in the Farewell Creek Watershed, with the exception of two (2) wells located north and upgradient of the Station Site, and two wells located in the adjacent Oshawa Creek watershed.
- Recorded October 2016 groundwater level elevations from pairs of shallow and intermediate depth wells were used to calculate vertical hydraulic gradients at monitoring well locations MW1, MW2, and MW5. The neutral to downward vertical hydraulic gradient within the shallow overburden across the Project Area in 2016 ranges from 0.0 m/m to 0.02 m/m. Vertical hydraulic gradients at MW3 and MW4 could not be determined due to very slow deep well recovery from sampling events. Neutral to downward vertical hydraulic gradients were consistently present within the shallow and deep pairs of monitoring wells within the surficial sand and underlying weathered till.
- Groundwater levels from private wells and Project Area wells completed within the Thorncliffe Formation indicate a southerly flow direction consistent with regional mapping by CLOCA (2012).
- The surface water quality monitoring data in 2016 indicates that water quality is generally characterized by low concentrations of sodium, chloride, and nitrate, with all parameters generally within the PWQO, with the following exceptions: elevated concentrations of

aluminum (SW4), boron (SW3), iron (SW2), and phosphorous (SW2 and SW4) were detected in at least one (1) sample above the PWQO in 2016.

- 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 ODWQS for all health related parameters (ODWQS-MOH) with the exception of nitrate in one (1) monitoring well, which is attributed to agricultural fertilizer; and fluoride in one (1) monitoring well.
- The source of nitrate within the Project Area is interpreted to be former land use prior to construction, and potential existing fertilizer use on farmed lands immediately upgradient of the Project Area. In each of the shallow monitoring wells, nitrate concentrations were lower in Fall 2016 results as compared to Fall 2015. Further, monitoring data indicates that Station Site construction and land use within the Project Area have not contributed, and will not contribute to increasing nitrate concentrations in the shallow groundwater system.
- Fluoride in groundwater is naturally found in groundwater from the weathering of rock and soil. Concentrations of fluoride in the intermediate and deep Project Area monitoring wells MW5-14I and MW5-14D have historically been detected near the ODWQS – MAC, ranging from 1.0 to 1.6 mg/L. However, shallow well concentrations of fluoride at the MW5 monitoring well nest remained below detectable limits of 0.1 mg/L.
- Low level detection of phthalate compounds and several PAHs were detected at concentrations well below the SCS with the exception of benzo(a)pyrene which was detected in a Spring 2016 sample from MW4-15D (0.02 µg/L) and a Fall 2016 sample from MW3-13D (0.06 µg/L), in which turbidity and some suspended sediments were noted during sampling. The elevated benzo(a)pyrene is interpreted to be due to the effect of sediment entrained within the samples from MW3-13D and MW4-15D, as the lab-filtered samples for the same monitoring locations during the same monitoring events did not detect the compound.
- Historically in 2014, benzo(a)pyrene has been detected within some monitoring wells above the ODWQS. As presented in the Addendum Report (Stantec, 2015a), this compound adsorbs to soil particles and it was concluded that these detections are associated with the sediment collected within the sample. Stantec (2015a) recommended that water quality sampling protocols be amended to include low-flow sampling. This sampling protocol was adopted in 2015 and continued through 2016 sampling events.
- Private well water quality monitoring was completed within the private wells in Spring and Fall 2016, with 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 raw shallow private well samples with 12 of the 14 wells (86%) having total coliforms present and 5 of 14 samples (36%) having E.coli present on at least one occasion. Water quality for wells completed within wells deeper than 50 m had only 2 (20%) 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 (fertilizer, manure storage, and animal feedlots), septic systems, or potential surface influences.

- Shallow private well inorganic water quality monitoring detected the following parameters above the ODWQS-AO or ODWQS-MOH on at least one occasion: iron in eight (8) wells, total dissolved solids in nine (9) wells, turbidity in six (6) wells, and sodium in three (3) wells.
- Deep private well inorganic water quality monitoring detected the following parameters above the ODWQS-AO or ODWQS-MOH on at least one occasion: sodium in eleven (11) wells (3 well samples following a water softener), chloride in two (2) wells, total dissolved solids in one (1) intermediate depth well, and aluminum and iron in one (1) well each.
- Precipitation totals in the Oshawa area for a six-month period between May to November 2016 was lower than normal; only 57% of what was recorded during that same period in 2015, and only 67% of historic 30-year climate normals.
- Environment Canada temperature data for the same Oshawa Airport climate station indicates that there was an overall temperature increase over the six-month period of May to October from 15.8°C in 2014, to 16.1°C in 2015, and a 1.6°C increase to 17.4°C in 2016.
- The combination of significantly reduced precipitation and increased temperature have been noted by CLOCA and the four Low Water Condition advisories they issued in July, August, November, and December 2016. CLOCA notes that low water levels in surface water features and dry wells have been reported throughout the watersheds under their jurisdiction in the Oshawa, Ajax, and Clarington area. While this Monitoring Program is limited to the monitoring wells on-Site and surrounding private wells, CLOCA have noted that low water levels have been observed throughout the region and are not limited to the Clarington TS.
- Water level and water quality monitoring through to October-November 2016 indicates no adverse effects on the shallow groundwater system or in shallow or deep private wells as a result of Station Site grading and construction of the Clarington TS.

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 Monitoring Program.
- Sampling procedures for Project Area well should continue with low-flow sampling protocols, as recommended in the Baseline Conditions Report Addendum.
- The water level in both MW4-13D and MW4-15D were very slow to recover from semi-annual well development, resulting in insufficient water with which to complete water quality sampling for all analytical parameters, and has been replaced by MW4-15D. Further water volume and water quality results will be assessed to determine whether both deep wells at MW4 will continue to be required to collect semi-annual samples, or whether one of the wells may be decommissioned in accordance with O.Reg.903.
- The condition of all monitoring wells and drive-point piezometers should be inspected as part of the regular Monitoring Program and upgrades/replacement completed, as necessary.

7.0 REFERENCES

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