REPORT

2016 GROUNDWATER AND LANDFILL PERFORMANCE MONITORING PROGRAM

CLEAN HARBORS LAMBTON FACILITY LANDFILL

RWDI #1600331
March 8, 2017

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VERSION HISTORY

Index	Date	Pages	Author
0	March 7, 2017	All	Peter-James Mauro

DECLARATION AND REPORT SIGNATURES

We, the undersigned, hereby declare that to the best of my knowledge, the information contained herein and the information in support of this submission is complete and accurate in accordance with our obligations under the Professional Engineers Act, R.S.O., 1990, as amended, and its regulations or the Professional Geoscientists Act, as amended and its regulations.

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1 INTRODUCTION

This document, the 2016 Groundwater Monitoring Report, Clean Harbors Canada, Inc. Lambton Facility Landfill, Corunna Ontario prepared by RWDI, presents the groundwater data and interpretive analysis for the period commencing on January 1, 2016 and ending on December 31, 2016. The groundwater report is prepared as part of the permitting specifications (see Section 2) issued by the Ministry of Environment and Climate Change is herein referred to as the MOECC).

The report is divided into seven sections and five supporting appendices. Section 2 provides an overview of the groundwater sampling program and includes a description of the sampling methods and the interpretive analysis employed. The principal findings for the monitoring period are provided in Section 3. Section 4 presents a summary and discussion of the findings. Section 5 provides recommendations, Section 6 is the Declaration of authorship and Section 7 lists References. Information supporting this annual summary of groundwater conditions is provided in appendices. Starting with this report, the appendices are provided electronically on a thumb drive included in a pocket at the back of this report. Additional clarifying guidance is provided in each appendix to facilitate access to the content.

The contents of the five appendices follow:

- **APPENDIX H-1: EXISTING CONDITIONS.** This appendix contains a description of the site's physical setting (including topography and drainage, geology, hydrogeology, groundwater chemistry, and local groundwater use); the site development history and the current limits of waste disposal; and summary of the leachate chemistry. This summary is from the existing conditions report generated during the Environmental Assessment completed for the landfill expansion (RWDI, 2014a).

- **APPENDIX H-2: GROUNDWATER MONITORING NETWORK**. This appendix contains information on the monitoring well network installed at the Clean Harbors Lambton Facility. Included are a summary of the status of individual wells, a description of the programs under which the wells were installed, figures showing well locations, borehole logs and well completion/decommissioning records.

- **APPENDIX H-3: STANDARD OPERATING PROCEDURES FOR GROUNDWATER MONITORING PROGRAM & LABORATORY ACCREDITATION**. Prescribed protocols and procedures that are employed during well sampling are provided in this appendix. In addition, copies of the laboratories Certificates of Accreditation issued by the Canadian Association for Laboratory Accreditation are provided.

- **APPENDIX H-4: MONITORING RESULTS AND ANALYSIS PRODUCTS.** Included in this appendix are: summary information on the various sampling programs; Quality Assurance/Quality Control and data validation procedures; the analysis results for 2016 and prior years; and the products of the statistical analysis of the chemistry data.

- **APPENDIX H-5: CORRESPONDENCE.** This appendix presents correspondence received from the Walpole Island First Nations (Neegan Burnside Ltd., Review of 2015 Annual Landfill Report, Project No. FEN020264.1601, August 5, 2016) on the 2015 Groundwater Monitoring Report and RWDI's response dated September 28, 2016. Also included are the chemical analysis results for 'split' samples collected by MOECC staff during the sampling events.

The locations of the Clean Harbors Canada, Inc. (Clean Harbors) Lambton Facility in southwestern Ontario and other properties acquired by Clean Harbors in the vicinity of the Facility are shown in **FIGURE 1**.

The facility entrance is located at:

Coordinate System	Zone	Easting (m)	Northing (m)	Horizontal Accuracy
NAD83	17	393,726	4,748,167	± 3 m

Note: Facility entrance coordinates obtained with a Garmin GPSMap 60Cx GPS unit.

Contact information for the site owner's representatives is as follows:

Facility Contact Information:

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Lambton Facility Landfill
4090 Telfer Road, Corunna, Ontario N0N 1G0
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The Competent Environmental Practitioners (CEPs) who prepared the 2016 Groundwater Monitoring Report are identified below:

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2 GROUNDWATER AND LANDFILL PERFORMANCE MONITORING PROGRAM

The site currently operates under Provisional Certificate of Approval [CofA] No. A031806, amended by CofA A031806 Notice 6 dated September 23, 2008, Amendment to Environmental Compliance Approval [ECA] No. A031806, Notice 8 dated May 3, 2013, and Amendment to Environmental Compliance Approval Number A031806, Notice No. 9, October 19, 2015.

The Lambton Facility Landfill undertook a Landfill Expansion Environmental Assessment which commenced in March 2011. A Notice of Approval to Proceed with the Undertaking was received on July 15, 2015.

The 2016 groundwater and landfill performance monitoring program is based on the document "***Final Draft – Groundwater and Landfill Performance Monitoring Programs***", prepared by RWDI (December 9, 2015) which formed part of the document titled "***Design and Operations Report-Lambton Landfill Expansion, Clean Harbors Canada, Inc., 4090 Telfer Road, St. Clair Township, Ontario***", prepared by Tetra Tech WEI Inc., (October 8, 2015). These documents were submitted to the MOECC as part of the Lambton Facility Landfill Expansion approval process.

In October, 2015, the MOECC agreed to change the reporting period for the monitoring program to coincide with the calendar year. As such, this report reflects the revised monitoring period of January 1, 2016 through December 31, 2016. The submission date for the Annual Landfill Report was also altered to April 1 from November 31 of the previous year.

The CofA for the Lambton Facility Landfill can be downloaded from the Clean Harbors Canada, Lambton Facility Online Information Resource Center:

http://www.cleanharbors.com/locations/canada/lambton-facility/facility-information-resource-centre

A copy of the Notice of Approval to Proceed with the Undertaking (construction of new landfill cells) is available from the Clean Harbors Canada, Lambton Facility Online Environmental Assessment Process Document Library:

http://www.cleanharbors.com/locations/canada/lambton-facility

The Groundwater and Landfill Performance Monitoring Programs document is subdivided into five Sections:

1) Groundwater Monitoring Along Perimeter of Facility

2) Monitoring Program to Assess Effectiveness of Sub-cell 3 Mitigation

3) Performance Monitoring of Engineered Landfill System

4) Purge Wells for Groundwater Control, and

5) Monitoring Well Installation, Maintenance and Decommissioning.

A brief summary of the work undertaken in 2016 follows.

2.1 Groundwater Monitoring Along Perimeter of Facility

The perimeter monitoring program involves the completion of two monitoring events per calendar year at a network of monitoring wells installed on and in the vicinity of the Clean Harbors' property. Monitoring involves the measurement of groundwater levels, and the collection and analysis of groundwater samples.

The groundwater level and chemistry data are compiled, examined in the context of previous monitoring results and summarized annually for inclusion in the Annual Groundwater Monitoring Report. This Report forms part of the Annual Landfill Report generated for the Facility.

The Facility's Surface Water Quality Monitoring Program is described in a separate report that is prepared by the surface water consultant retained by Clean Harbors.

2.1.1 Network of Monitoring Wells

The perimeter groundwater monitoring well network in 2016 included a total of 55 wells (installed between 1992 and 2013). The well network consists of wells that have been installed to monitor groundwater levels and water quality in the two hydraulically active geologic units that underlie the Facility property. These are described below:

- **WEATHERED/FRACTURED ZONE OF THE OVERBURDEN (REFERRED TO AS THE ACTIVE AQUITARD).** There are 31 shallow wells. This includes 19 wells located within the Facility property and 13 wells located on neighboring property that is owned by Clean Harbors. Six of the wells located on Facility property are installed in the northern perimeter berm. Six of the off-property wells are installed in/adjacent to the southern perimeter berm.

- **INTERFACE AQUIFER**. The Interface Aquifer straddles the lower metre or so of the overburden (locally consist of a thin granular layer of till or sand and gravel) and bedrock interface There are 24 monitoring wells that are installed in the Interface Aquifer. This includes 20 wells located within the Facility property and 4 wells located on neighboring property that is owned by Clean Harbors. Three of the wells located on the Facility property are installed through the northern perimeter berm.

Although not part of the annual monitoring program, existing wells (TW32-94-I, TW38-94-I and TW42-99D) screened deeper in the Kettle Point Formation (i.e. below the upper, more hydraulically active portion of the Formation which constitutes part of the Interface Aquifer) have been sampled on a regular basis.

This monitoring has been conducted to identify any change in the vertical hydraulic gradient between the Interface Aquifer and the underlying shale; and to collect water quality data to enhance the chemical database for groundwater in contact with the Kettle Point Formation shale.

[Note: The Kettle Point Formation (shale bedrock) was deposited in a marine environment and salt is present in the matrix/pores. The shale also contains bitumen, which is a potential hydrocarbon source. Samples collected from these three wells are mineralized and hydrocarbon compounds (e.g., benzene and toluene) have been detected.]

Well TW38-94-I, which was located within the footprint of the expansion area, was decommissioned in 2016 (see **Appendix H-2.4**). The remaining two deep wells (TW32-94-I and TW42-99D) are located along the perimeter of the property and have been retained for future monitoring. TW32-94-I and TW42-99D were last sampled during the 2015 monitoring period and the next scheduled monitoring event will occur in spring 2017.

Table 1 presents summary information on each well including: the wells location relative to site features (i.e. landfill, perimeter berm, and property boundary); the well's depth, the zone against which the well is screened; and the hydraulic conductivity estimated from slug tests.

The location of the various perimeter monitoring program wells installed at the Lambton Facility are shown in **Figure 2** (Active Aquitard) and **Figure 3** (Interface Aquifer and Kettle Point Formation shale). Information on the various monitoring wells is provided in **Appendix H-2**. Included are photographs of the well installations, location coordinates, borehole logs and well construction details.

There are several older wells on the Lambton Facility property that were installed in the 1980s and 1990s and are not in use. A program to decommission these older installations was initiated in 2013, with 12 wells decommissioned in 2013; 19 wells decommissioned in May/June 2014 and 2 shallow wells decommissioned in June 2016. In addition, monitoring wells OW1-92, TW38-94-I, TW33-94-I and existing test well PW4-03, which were located within the footprint of areas to be developed (i.e., new waste reception area and the path of the leachate trench/header), were decommissioned with MOECC concurrence, in June 2016. The decommissioning record for this well is provided in **Appendix H-2.4**.

2.1.2 Methodology

2.1.2.1 Groundwater Level Monitoring

Water level monitoring is undertaken to establish the water table in the upper weathered/fractured portion of the clay aquitard (i.e., Active Aquitard) and the hydraulic head potential at the overburden/bedrock contact (i.e., Interface Aquifer). Measurement of the water levels is conducted manually using a water level meter. These measurements are typically collected on a single day prior to any disturbance of the wells (i.e. purging or sampling).

As indicated in **Table 2**, several wells installed in the Interface Aquifer are currently equipped with pressure transducers and data loggers. As part of the monitoring to be conducted for the landfill expansion, existing monitoring wells, which are incorporated into the performance monitoring program (Section 2.3), are also equipped with pressure transducers and data loggers.

Table 1. Summary Information on the Compliance Monitoring Wells at the Lambton Facility

Monitor	Well Location	Screened Against	Ground Surface Elevation (masl)	Intake Interval (mbgs)		Intake Interval Elevation (masl)		Hydraulic Conductivity (m/s)
				top	bottom	top	bottom	
Deep Wells (Interface Aquifer) - Compliance Monitoring Network								
TW47-00D	Along northern property boundary, north of Cell 18 and perimeter berm, on west side	clayey silt till/shale	199.59	36.60	40.05	162.99	159.54	3.20E-07
TW40-99D	Along northern property boundary, north of Cell 18 and perimeter berm, central	gravelly sandy silt till/shale	198.78	39.70	41.38	159.08	157.40	7.80E-07
TW32-94-II	Along northern property boundary,, north of Cell 18 and Perimeter Berm, east side	clayey silt till/shale	198.09	40.00	43.00	158.09	155.09	2.00E-08
TW39-99D	Internal to Licensed Property, northwest corner of Cell 18, installed through berm	clayey silt till, gravelly sandy silt till/shale	211.92	49.50	51.50	162.42	160.42	4.70E-08
TW46-99D	Internal to Licensed Property, northeast corner of Cell 18, installed through berm	shale	212.02	55.50	57.38	156.52	154.64	8.40E-07
TW22-99D	Along western property boundary, west of Cell 18 and perimeter berm	silty till, gravely sandy silt till/shale	200.65	39.60	41.76	161.05	158.89	3.20E-07
TW45-99D	Along western property boundary, west of Plant Process area	shale	201.45	41.60	47.72	159.85	153.73	3.70E-09
TW33-94-I	Internal to Licensed Property, west of Pre-1986 landfill	sandy clayey silt till	201.85	41.40	41.96	160.45	159.89	3.00E-06
TW48-00D	Along western property boundary, west of Pre-1986 landfill	clayey silt till/shale	200.80	40.00	43.40	160.80	157.40	8.10E-10
TW41-99D	Along southern property boundary, south of East Reservoir and woodlot, southeast of Pre-1986 Landf	shale	200.42	42.80	44.35	157.62	156.07	7.20E-05
TW30-99D	Along eastern property boundary, east of East Reservoir and woodlot, east of Pre-1986 Landfill	sandy gravely silt till/shale	200.62	42.10	43.36	158.52	157.26	6.80E-05
OW32-90D	Along eastern property boundary, east of Cell 16 and perimeter berm	silt clay till/shale	200.25	41.70	43.54	158.55	156.71	8.00E-10
OW35-05D	Along eastern property boundary, east of Cell 18 and perimeter berm	clayey silt till with sand and gravel/shale	198.58	40.30	43.50	158.28	155.08	1.40E-06
TW53-03D	Along eastern property boundary, east of Cell 17 and perimeter berm	clayey silt till/shale	200.40	40.50	44.40	159.90	156.00	7.20E-06
TW34-94-I	Internal to Licensed Property, east of Pre-1986 Landfill, southwest of perimeter berm	sand, sand silt clay till/shale	201.57	41.50	43.89	160.07	157.68	2.00E-07
TW54-09D	Internal to Licensed Property, south of Cell 18	silty clay/shale	202.42	40.43	43.59	161.99	158.83	1.01E-08
TW43-99D	South of Licensed property, south of Pre-1986 Landfill and perimeter berm	silty clay till/shale	200.21	38.40	42.52	161.81	157.69	3.20E-06
TW49-00D	South of Licensed property, south of Pre-1986 Landfill and perimeter berm	clayey silt till, clayeysilt till some gravel/shale	200.02	39.50	42.90	159.99	157.12	1.40E-09
TW55-09D	South of Licensed property, south of Pre-1986 Landfill and perimeter berm	silty clay till/shale	198.66	43.60	46.84	155.38	151.82	8.64E-08
TW56-11D	East of Licensed property,	silty clay till/shale	197.51	40.77	43.41	156.74	154.10	1.20E-05
TW57-11D	East of Licensed property,	silty clay till/shale	200.38	41.30	43.89	159.08	156.49	1.30E-06
TW59-13D	West of Licensed property,	silty clay till/shale	201.35	46.13	47.65	155.22	153.70	1.10E-04
TW60-13D	Along western property boundary, west of Cell 18 and perimeter berm	silty clay till/shale	200.55	40.54	42.06	160.01	158.49	8.34E-06
TW61-13D	Internal to Licensed Property, west of Cell 18, installed through berm	silty clay till/shale	209.68	49.51	51.02	160.17	158.66	2.81E-10
Shallow Wells (Active Aquitard) - Compliance Monitoring Network								
TW21-94-II	Along northern property boundary, north of Cell 18 and perimeter berm, on west side	silty clay till	199.30	1.00	4.42	198.30	194.88	-
TW40-99S	Along northern property boundary, north of Cell 18 and perimeter berm, central	clayey silt till	198.77	1.30	4.55	197.47	194.22	1.20E-09
TW32-94-IV	Along northern property boundary,, north of Cell 18 and Perimeter Berm, east side	clayey silt till	198.04	1.30	5.40	196.74	192.64	-
TW39-99I	Internal to Licensed Property, northwest corner of Cell 18, installed through berm into native soil	clayey silt till (native)	211.89	12.00	15.37	199.89	196.52	1.00E-10
TW39-99S	Internal to Licensed Property, northwest corner of Cell 18, installed within berm	berm fill (clayey silt till)	211.84	8.40	11.68	203.44	200.16	3.20E-10
TW46-99I	Internal to Licensed Property, northeast corner of Cell 18, installed through berm into native soil	clayey silt till (native)	211.95	14.70	17.93	197.25	194.02	7.70E-10
TW46-99S	Internal to Licensed Property, northeast corner of Cell 18, installed within berm	berm fill (clayey silt till)	212.04	10.00	13.33	202.04	198.71	3.90E-10
TW22-94	Along western property boundary, west of Cell 18 and perimeter berm	clayey silt till	200.51	1.20	4.75	199.31	195.76	-
TW53-03S	Along eastern property boundary, east of Cell 17 and perimeter berm	clayey silt till, silty clay till	200.37	1.50	5.30	198.87	195.07	1.20E-09
OW32-90S	Along eastern property boundary, east of Cell 16 and perimeter berm	silty clay till	202.25	1.20	6.13	201.05	196.12	-
OW35-90S	Along eastern property boundary, east of Cell 18 and perimeter berm	silty clay till	198.42	1.20	6.12	197.22	192.30	-
TW45-99S	Along western property boundary, west of Plant Process area	clayey silt till	201.38	1.30	5.02	200.08	196.36	7.10E-09
TW44-99S	Along western property boundary, west of West Reservoir and woodlot, west of Pre-1986 Landfill	clayey silt till	200.81	1.50	4.98	199.31	195.83	1.00E-10
TW30-94	Along eastern property boundary, east of East Reservoir and woodlot	clayey silt till	200.51	1.60	4.75	198.91	195.76	-
TW41-99S	Along southern property boundary, south of East Reservoir and woodlot, southeast of Pre-1986 Landf	clayey silt till	200.34	1.30	4.62	199.04	195.72	4.10E-10
TW42-99S	South of Licensed property, south of Pre-1986 Landfill and perimeter berm	clayey silt till	199.93	1.20	4.60	198.73	195.33	1.00E-10
TW43-99S	South of Licensed property, south of Pre-1986 Landfill and perimeter berm	clayey silt till	200.03	1.20	4.70	198.83	195.33	2.20E-10
TW55-09S	South of Licensed property, south of Pre-1986 Landfill and perimeter berm	clayey silt till	198.57	2.13	5.78	196.44	192.79	1.42E-08
TW56-11S	East of Licensed property,	clayey silt till	197.53	1.85	6.22	195.68	191.31	2.60E-10
TW57-11S	East of Licensed property,	clayey silt till	197.83	1.83	5.31	196.00	192.52	2.60E-08
TW58-11S	East of Licensed property,	clayey silt till	197.83	1.83	5.31	196.00	192.52	4.80E-10
TW59-13S	West of Licensed property,	clayey silt till	201.36	2.74	5.79	198.62	195.57	4.80E-10
TW61-13I	Internal to Licensed Property, west of Cell 18, installed through berm into native soil	clayey silt till (native)	209.69	9.75	12.83	199.94	196.86	1.49E-08
TW61-13S	Internal to Licensed Property, west of Cell 18, installed within berm	berm fill (clayey silt till)	209.72	5.79	8.84	203.93	200.88	5.68E-10
TW62-13S	Internal to Licensed Property, west of Operations area	clayey silt till	201.47	2.44	5.49	199.03	195.98	-
TW63-13S	Internal to Licensed Property, west of Operations area	clayey silt till	201.54	2.51	5.56	199.03	195.98	-
TW48-16S	Along western property boundary, west of West Reservoir and woodlot, west of Pre-1986 Landfill	clayey silt till	200.71	1.90	4.95	198.81	195.76	-
Deep Shale Wells - Supplemental Monitoring Program								
TW32-94-I	Along northern property boundary,, north of Cell 18 and Perimeter Berm, east side	shale	198.04	45.40	46.80	152.64	151.24	-
TW42-99D	South of Licensed property, south of Pre-1986 Landfill and perimeter berm	shale	199.90	44.65	71.91	155.25	127.99	2.20E-09
South Berm Monitoring Wells								
TW52-02B	South of Licensed property, south of Pre-1986 Landfill, north slope perimeter berm	clayey silt till (below berm)	203.29	4.40	8.10	198.89	195.19	1.89E-09
TW52-02A	South of Licensed property, south of Pre-1986 Landfill, within perimeter berm	clayey silt till (toe of berm)	200.48	1.20	4.90	199.28	195.58	1.43E-09
TW51-02A	South of Licensed property, south of Pre-1986 Landfill, north slope perimeter berm	clayey silt till (toe of berm)	200.50	1.20	4.90	199.30	195.60	6.35E-10
TW51-02B	South of Licensed property, south of Pre-1986 Landfill, within perimeter berm	clayey silt till (below berm)	202.93	4.30	7.90	198.63	195.03	2.00E-09
TW50-02B	South of Licensed property, south of Pre-1986 Landfill, north slope perimeter berm	clayey silt till (below berm)	203.00	4.30	7.40	198.70	195.60	3.44E-09
TW50-02A	South of Licensed property, south of Pre-1986 Landfill, within perimeter berm	clayey silt till (toe of berm)	200.50	1.20	4.90	199.30	195.60	1.18E-08
Sub-cell 3 Monitoring Well Network								
PW2-S(R11)	Internal to Licensed property, Sub-Cell 3 Interface Aquifer Monitoring Well, south of Cell 18	silt till some gravel/shale	202.52	37.44	40.70	165.08	161.82	5.00E-06
PW1-N	Internal to Licensed property, Sub-Cell 3 Interface Aquifer Monitoring Well, north of Cell 18	clayey silt till some sand and gravel/shale	201.00	39.00	42.11	162.00	158.89	-
EW1a-01	Internal to Licensed property, Sub-Cell 3 North HCL Pumping Wells	North hydraulic control layer	201.53	20.95	24.48	180.58	177.05	-
EW2a-01	Internal to Licensed property, Sub-Cell 3 South HCL Pumping Wells	South hydraulic control layer	201.27	21.08	23.95	180.19	177.32	-
EW1b-13	Internal to Licensed property, Sub-Cell 3 North HCL Pumping Wells	North hydraulic control layer	201.57	24.22	25.74	177.35	175.83	-
EW2b-13	Internal to Licensed property, Sub-Cell 3 South HCL Pumping Wells	South hydraulic control layer	201.54	21.92	23.44	179.62	178.10	-
EW1c-13	Internal to Licensed property, Sub-Cell 3 North HCL Pumping Wells	North hydraulic control layer	201.57	23.56	25.08	178.01	176.49	-
EW2c-13	Internal to Licensed property, Sub-Cell 3 South HCL Pumping Wells	South hydraulic control layer	201.57	23.06	24.58	178.51	176.99	-

Table 2. Wells Monitored During the 2016 Monitoring Period and Monitoring Methodology

Monitor	Spring 2016 Sampling Event						Fall 2016 Sampling Event					
	Water Level		Continuous Volume Sampling	Low Flow Sampling	Discreet Interval Sampler	Discharge Sampling	Water Level		Continuous Volume Sampling	Low Flow Sampling	Discreet Interval Sampler	Discharge Sampling
	Manual Measurement	Pressure Transducer					Manual Measurement	Pressure Transducer				
Monitoring Network - Deep Wells												
OW1-92		√		√			*Decommisioned in June 2016*					
OW32-90D	√		√				√		√			
OW35-05D		√		√				√		√		
TW22-99D		√		√				√		√		
TW30-99D		√		√				√		√		
TW32-94-II		√		√				√		√		
TW33-94-I	√			√			*Decommisioned in June 2016*					
TW34-94-I	*Decommisioned in January 2016*											
TW39-99D		√		√				√		√		
TW40-99D		√		√				√		√		
TW41-99D	√			√			√			√		
TW43-99D	√			√			√			√		
TW45-99D	√				√		√		√		√	
TW46-99D		√		√				√		√		
TW47-00D		√		√				√		√		
TW48-00D		√			√			√			√	
TW49-00D		√			√			√			√	
TW53-03D		√		√				√		√		
TW54-09D		√		√				√		√		
TW55-09D	√			√			√			√		
TW56-11D	√			√			√			√		
TW57-11D	√			√			√			√		
TW59-13D	√			√			√			√		
TW60-13D		√		√				√		√		
TW61-13D		√			√			√			√	
Monitoring Network - Shallow Wells												
OW32-90S	√		√				√		√			
OW35-90S		√	√					√	√			
TW21-94-II	√		√				√		√			
TW22-94		√	√					√	√			
TW30-94		√	√					√	√			
TW32-94-IV	√		√				√		√			
TW39-99I		√	√					√	√			
TW39-99S	√		√				√		√			
TW40-99S	√		√				√		√			
TW41-99S	√		√				√		√			
TW42-99S		√	√					√	√			
TW43-99S	√		√				√		√			
TW44-99S	*Decommisioned in January 2016*											
TW45-99S	√		√				√		√			
TW46-99I	√		√				√		√			
TW46-99S	√		√				√		√			
TW48-16S	√		√				√		√			
TW53-03S	√		√				√		√			
TW55-09S	√		√				√		√			
TW56-11S	√		√				√		√			
TW57-11S	√		√				√		√			
TW58-11S	√		√				√		√			
TW59-13S	√		√				√		√			
TW61-13I		√	√					√	√			
TW61-13S	√		√				√		√			
TW62-13S	√		√				√		√			
TW63-13S	√		√				√		√			
TW50-02A	√		√				√		√			
TW50-02B	√		√				√		√			
TW51-02A	√		√				√		√			
TW51-02B	√		√				√		√			
TW52-02A	√		√				√		√			
TW52-02B	√		√				√		√			
Deep Shale Wells												
TW32-94-I	√		√				√					
TW38-94-I	√		√				*Decommisioned in June 2016*					
TW42-99D	√		√				√					

Notes:	Manual water level measurements collected semi-annually
	Continuous water level measurements collected hourly. Dataloggers downloaded quarterly.

The transducer/data loggers are set to collect a water level reading at a frequency of once per hour. The transducers are downloaded quarterly. Manual measurements of the water level are taken during each download.

Atmospheric pressure data are also obtained from a barometric pressure logger during each event. The data obtained from the pressure transducers are synchronized with that from the barometric pressure logger and subsequent processed using software supplied by the equipment supplier to compensate each reading for atmospheric pressure.

Hydrographs are prepared for each well installation to identify any trend in groundwater level elevations. The hydrographs are included in **APPENDIX H-4.1**.

Water level data for the monitoring wells (both existing wells and decommissioned wells) are provided in a database file (**APPENDIX H-4.4**). The database file can be accessed using Microsoft™ Access 2016 (or newer).

2.1.2.2 Sampling Methodology

Two groundwater sampling events were completed during the 2016 monitoring period. The first was conducted between May 2 and May 16, 2016, and the second between November 7 and November 11, 2016. The wells sampled during each sampling event are listed in Table 2.

Groundwater sampling of monitoring wells at the Lambton Facility has employed the following methodologies, referred to as: 1) the low flow purging and sampling method, which utilizes specialized pumping equipment to minimize drawdown; 2) the continuous volume method (CV Method) that involves the conventional drawdown and recovery of the water level; and 3) a no purge sampling method using a discrete interval sampler. The methodology applied at the individual wells is identified in **TABLE 2** and described in greater detail below:

> **LOW FLOW PURGING/SAMPLING METHOD:** The low flow method (USEPA, 2010) is the preferred methodology at the Lambton Facility for purging/sampling of the wells, as it minimizes the drawdown at the well thereby reducing the hydraulic gradient across the well screen. Samples collected by this method are considered to be more representative of formation water. Specifically, there is lower exposure of the water column to oxidation and there is less potential for particulate disturbance, which can be induced by turbulent flow through the screen during purging.
>
> The low flow method is not practical for wells screened against geologic units with a hydraulic conductivity lower than about 1E-9 m/s because of the extended time required to purge and sample these wells due to their low yield. Wells with low hydraulic conductivity (including the shallow wells installed in the clay overburden) will be sampled by the CV Method described below, or in cases where the hydraulic conductivity is extremely low (<5E-9 m/s) an interval sampler may be employed.
>
> The majority of the monitoring wells installed in the Interface Aquifer, with the exceptions identified in **TABLE 2**, are equipped with low flow samplers.

CV Method: The continuous volume method (or CV Method involves) purging of the wells by the repeated drawdown and recovery of the water level for an extended period of time prior to sampling to extract 'stagnant' groundwater and replace it with 'fresher' formation water. The CV Method was introduced in the 1980s and was the standardized practice at the Facility (per Section 6.2.1 of the 2010 Design and Operations Report) until the low flow method was introduced in 2009/2010.

Wells at which this method has been used are equipped with dedicated tubing and inertial pumps (essentially a one-way foot valve). The inertial pump is manually operated by alternately moving the tubing up/down rapidly. The oscillating action allows water to enter through the foot valve where it moves up the tubing to discharge. In collecting samples for VOC analysis, a narrow gauge tube is inserted into the tube of the inertial lift apparatus and the water column is drained by gravity into a VOC vial.

Discreet Interval Sampler (HydraSleeve®): CV and low flow methods were determined to be ineffective at some of the Interface Aquifer wells (TW32-90D, TW45-99D, TW48-00D, TW49-00D, and TW61-13D) because of the slow rate of recovery following purging.

These wells (TW32-90D, TW45-99D, TW48-00D, and TW49-00D, and TW61-13D) are sampled using a HydraSleeve® sampler. The sampler is lowered to the bottom of the well about two weeks prior to the sampling event. Water from the screened interval of the well enters the HydraSleeve®. When the sampler is retrieved, the reed valve of the sampler closes retaining the water sample.

2.1.2.3 Sample Handling and Transport

The samples are collected into pre-labeled containers that are supplied by the chemical laboratory. Following collection, the samples are placed in ice chests containing ice packs and returned to the Lambton Facility's laboratory where they were placed in refrigerated coolers. Samples collected for metals analysis were either field filtered using 45-micron inline field filters are where filtered in the laboratory. The samples are then inventoried, and shipped, under Chain of Custody, to the receiving laboratory that undertakes the analyses.

2.1.2.4 Quality Assurance and Quality Control

The quality assurance and quality control [QA/QC] component of the groundwater sampling program includes the analysis of field replicate samples, laboratory replicate samples, laboratory method blanks and spikes, and travel blanks. The following QA/QC samples were submitted to the laboratory in 2016:

	Trip Blanks	Field Replicate Samples
Spring 2016	1238323 (2016-05-02);1239052 (2016-05-05); 1238618 (2016-05-05)	OW200 (TW53-03D); OW201 (TW30-94); OW202 (TW40-99S); OW203 (TW32-94-II); OW204 (TW43-99D); OW205 (TW55-09S)
Fall 2016	1269854 (2016-11-07)	OW200 (TW59-13D); OW201 (TW22-94); OW202 (TW46-99I); OW203 (TW47-00D); OW204 (TW62-13S); OW205 (TW30-99D)

The Trip Blanks were analyzed for VOCs. The fall 2016 Field Replicate Samples were submitted for inorganic parameter analysis and the spring 2016 field replicate samples were submitted for inorganic, and VOC analysis. The analytical results are included in the database and within the tables in this report.

In 2016, the MOECC requested that split samples for VOC analysis during the fall 2016 sampling event. The MOECC did not request samples for the spring 2016 sampling event. Split samples were obtained from wells OW35-05D, TW22-99D, TW39-99D, TW47-00D and TW60-13D during the fall 2016 sampling event. These samples were sent to the MOECC laboratory for analysis (results are included in **Appendix H-5.1**).

Sample splits were also obtained from 14 wells in June 2016 to assess if there are any concentration differences resulting from the handling of the samples. Specifically, this sampling focused on whether there were any differences in iron, barium, bromide, and nickel concentrations between samples that were field filtered versus laboratory filtered. The collected samples were submitted to the following laboratories:

Well	Parameters	Exova (Primary Laboratory)		Maxxam (Secondary Laboratory)	
		Sample Submitted		Sample Submitted	
		Field Filtered	Lab Filtered	Field Filtered	Lab Filtered
OW35-90S	Fe	✓	✓	✓	
OW35-05D	Fe	✓		✓	
TW30-99D	Fe	✓		✓	
TW47-00D	Fe	✓	✓	✓	
TW60-13D	Fe, Ni	✓	✓	✓	
TW59-13D	Fe	✓		✓	
TW46-99D	Fe	✓	✓	✓	
TW32-94-II	Ba	✓		✓	
PW2-S(R11)	Fe	✓	✓	✓	
TW39-99I	Fe	✓		✓	
TW54-09D	Fe	✓	✓		
TW42-99S	B	✓	✓	✓	
TW61-13D	Fe, F		✓		✓
TW45-99D	Fe		✓		✓

An unfiltered split sample obtained from TW50-02A was also submitted to both Exova and Maxxam for chloride analysis as a measure of inter-laboratory precision. A discussion of the results of the sample split results is provided in **APPENDIX H-4.3**.

2.1.2.5 Chemical Parameter List and Sampling Frequency

The samples are collected and submitted to an independent commercial laboratory for analysis of the parameters listed in Table 2-3 of the Draft Monitoring Program [RWDI, 2015]. The list is reproduced below:

Parameter Grouping		Parameter
General Indicators		pH, Conductivity, TDS
Major Ions	***Anions***	Alkalinity, Chloride, Sulphate
	Cations	Calcium, Magnesium, Potassium, Sodium
Minor Ions	***Nutrients***	Ammonia (shallow wells only), Nitrite, Nitrate
	Miscellaneous	Bromide, Cyanide, Fluoride
Metals		Arsenic, Barium, Boron, Cadmium, Chromium, Iron, Lead, Nickel, Mercury, Zinc
Volatile Organic Compounds **Volatile Organic Compounds (continued)**		Benzene, Bromodichloromethane, Bromoform, Bromomethane, Carbon Tetrachloride,Chlorobenzene, Chloroethane, Chloroform, Chloromethane, Cis-1,2-Dichloroethylene, Cis-1,3-Dichloropropylene, Dibromochloromethane, Dichlorodifluromethane, Ethylbenzene,Methylene Chloride, o- Xylene, m-Xylene, p-Xylene, Styrene, Tetrachloroethylene, Toluene, Trans-1,2-Dichloroethylene,Trans-1,3-Dichloropropylene, Trichloroethylene, Trichlorofluoromethane, Vinyl Chloride, Total Xylene, 1,1,1,2-Tetrachloroethane,1,1,1-Trichloroethane, 1,1,2,2-Tetrachloroethane, 1,1,2-Trichloroethane,1,1-Dichloroethane, 1,1 –Dichloroethylene, 1,2-Dibromoethane, 1,2-Dichlorobenzene,1,2-Dichloroethane, 1,2-Dichloropropane, 1,3,5-Trimethylbenzene, 1,3-Dichlorobenzene, 1,4- Dichlorobenzene

The sampling frequency for is provided in Table 2-4 of the Draft Monitoring Program [RWDI, 2015]. The list is reproduced below:

Wells	Parameter Grouping	Frequency of Sample Collection and Analysis
Shallow Wells	General Indicators, Major & Minor Ions	Semi-Annual Frequency
	Metals	Annual Frequency
	Volatile Organic Compounds	Biennial Frequency
Interface Aquifer Wells	General Indicators, Major & Minor Ions	Semi-Annual Frequency
	Metals	Annual Frequency
	Volatile Organic Compounds	Annual Frequency
Kettle Point Shale Wells	General Indicators, Major & Minor Ions	Biennial Frequency
	Metals	
	Volatile Organic Compounds	

The sampling program outlined in Draft Monitoring Program [RWDI, 2015] indicates that samples are to be submitted for analysis of VOCs in the shallow wells and samples from the Kettle Point Shale Wells submitted for general indicators, major and minor ions, metals and VOCs on a biennial basis. These samples were last collected in spring 2015. As such, they were not collected in 2016 (next scheduled to be collected during the spring 2017 sampling event).

Although the Draft Monitoring Program [RWDI, 2015] requirements are focused on a short list of VOCs (per table above), the laboratory is required to provide the full list of VOC parameters within the analytical 'suite'.

The full VOC suite, which is listed in the following table, is included within the site analytical database contained in **APPENDIX H-4.4**.

Volatile Organic Compounds
Benzene, Bromodichloromethane, Bromoform, Bromomethane, Carbon Tetrachloride, Chlorobenzene, Chloroethane, Chloroform, Chloromethane, Cis-1,2-Dichloroethylene, Cis-1,3-Dichloropropylene, Dibromochloromethane, Dichlorodifluromethane, Ethylbenzene, Methylene Chloride, o- Xylene, m-Xylene, p-Xylene, Styrene, Tetrachloroethylene, Toluene, Trans-1,2-Dichloroethylene, Trans-1,3-Dichloropropylene, Trichloroethylene, Trichlorofluoromethane, Vinyl Chloride, Total Xylene, 1,1,1,2-Tetrachloroethane, 1,1,1-Trichloroethane, 1,1,2,2-Tetrachloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1 –Dichloroethylene, 1,2-Dibromoethane, 1,2-Dichlorobenzene, 1,2-Dichloroethane, 1,2-Dichloropropane, 1,3,5-Trimethylbenzene, 1,3-Dichlorobenzene, 1,4- Dichlorobenzene

The discussion and interpretation presented in this report encompasses this larger list of VOCs.

2.1.2.6 Analytical Laboratories

Exova Laboratories, Ottawa, Ontario was retained by Clean Harbors for the 2016 monitoring year to provide the primary analytical services for the spring and fall sampling events. As noted, sample splits collected from a subset of wells were submitted to Maxxam Analytics, Mississauga, Ontario. A statement of laboratory accreditation for Exova and Maxxam are provided in **APPENDIX H-3.3**. The wells that were resamples and parameters that were assessed are listed in **APPENDIX H-4.3**.

2.1.3 Data Analysis, Interpretation and Reporting

The perimeter groundwater monitoring program provides for the ongoing characterization of the groundwater quality at the Lambton Facility.

The interpretive analysis of the groundwater data for the Lambton Facility, as presented herein, is based on the approach initially developed in 1991 with MOECC involvement. The approach has been enhanced over the last two decades (also with MOECC involvement) and is currently conducted in accordance with the data processing and analysis procedures that are described in this section.

2.1.3.1 Groundwater Level Data

The manual water level measurements and the compensated water level data from the pressure transducers for each well installation are plotted against time to produce hydrographs. The water level data are also plotted on property plans/maps to show the hydraulic head distribution across the Facility property within the Active Aquitard and Interface Aquifer. The hydrographs and head distribution plots are reviewed to identify any emerging trends in groundwater level elevations.

Hydrographs for each well are provided in **APPENDIX H-4.1**.

The water level data for the monitoring wells are added annually to the Lambton Facility database file. The database file is included in **APPENDIX H-4.4**.

2.1.3.2 Groundwater Chemistry Data

Data Pre-processing

On receiving the chemical analysis results from the laboratory, the data undergoes a preliminary review to ensure that the samples were properly labeled, the analyses requested were completed and the laboratory holding-times for the individual parameters were achieved. The next step involves a well-by-well review of the data, which considers location relative to site features and operations, and the geologic unit against which the well screen is installed. Unusual or anomalous chemistry results are flagged and efforts are taken to investigate the source of the anomaly.

These efforts involve a more detailed assessment of the analytical data. During this assessment the laboratory data for each well is compared with the historical mean for the same well. If the concentration of a parameter is within a 20% range of the historical mean or is consistent with an increasing/decreasing trend evident from the database, the value is considered to be valid and is carried forward in the analysis.

Under circumstances where the parameter concentration falls outside the 20% variance from the historical mean or shows an inconsistent trend, the value is flagged and treated as anomalous. These chemical anomalies are brought to the attention of the laboratory. The laboratory review of flagged anomalies involves an initial examination of the data to establish whether the anomaly was caused by a transcription or calculation error. If the anomaly cannot be explained, the laboratory is asked to re-analyze the sample. Upon receipt of the re-analyzed data, the concentration data is compared to: (a) the original results; and, (b) the historic range and mean for the anomalous parameter(s) at the well.

Where it is determined that the analytical results for a specific well are anomalous because the data do not fit any apparent trend (e.g., concentration decreases, whereas the longer-term trend clearly suggests that the concentration should be upward), the well will be re-sampled to resolve the anomaly. Verification of the anomaly can entail re-analysis of the second well sample by the primary laboratory and possibly the analysis of a sample aliquot by a second laboratory.

An evaluation of the laboratory's intra-laboratory precision by comparison with the analytical results for QC samples submitted to the laboratory during each sampling event is also be completed. The results of the assessment of intra-laboratory precision is presented in **APPENDIX H-4.3**.

Once the data for each sampling event have been validated, copies of the analytical reports from the laboratory are forwarded to the MOECC Sarnia District Office. The chemistry data for the sampling event is then added to the Facility chemical database file. [Note: Groundwater analytical data predating June 1999 are archived. These older analytical data are available in spreadsheet files included on computer disks that are appended to the 1998 Annual Landfill Report and older reports. The files are accessible using software compatible with LOTUS 1-2-3, Version 5 or newer.]

Copies of the Analytical Certificates of Analysis are provided in **APPENDIX H-4.2**. The full analytical database file for the monitoring wells is provided in **APPENDIX H-4.4**.

Monitoring Well Groupings by Location and Depth of Well

For the purposes of analysis and presentation of the data, the monitoring wells are grouped by: the water-bearing zone against which the individual wells are screened (i.e. Active Aquitard and Interface Aquifer); and the well's location relative to site features and operations. The well groupings are listed in the following table:

Active Aquitard	Shallow wells located off the Facility property (wells removed from the Facility’s influence – Background Wells)	TW55-09S, TW56-11S, TW57-11S, TW58-11S, TW59-13S
	Shallow wells installed in the northern perimeter berm	TW39-99S, TW39-99I, TW46-99S, TW46-99I, TW61-13I, TW61-13S
	Shallow wells along the property Boundary (point of compliance), located downgradient of the North Perimeter Berm	OW35-90S, OW32-90S, TW21-94-II, TW22-94, TW32-94-IV, TW40-99S, TW53-03S
	Shallow wells along the property Boundary (point of compliance), removed from the North Berm	TW30-94S, TW41-99S, TW42-99S, TW43-99S, TW45-99S, TW62-13S
	Shallow Wells Internal to the property that are influenced by Facility operations	TW63-13S
Interface Aquifer	Deep wells located off the Facility property (wells removed from the Facility’s influence – Background Wells	TW55-09D, TW56-11D, TW57-11D, TW59-13D
	Deep wells internal to the property	TW34-94-I, TW39-99D, TW46-99D, TW54-09D, TW61-13D
	Deep wells along the property boundary (point of compliance	OW32-90D, OW35-05D, TW22-99D, TW30-99D, TW32-94-II, TW40-99D, TW41-99D, TW43-99D, TW45-99D, TW47-00D, TW48-00D, TW48-00D, TW53-03D, TW60-13D

Note: The reader is directed to Appendix H-1 for a general discussion of the geology, hydrogeology and groundwater quality at the Lambton Facility.

Subdividing the well data in this manner allows for the examination of a wider range of influences specific to the location of the well (i.e. near older landfill cells, within Central Waste Processing Area, adjacent to and in the perimeter berm, adjacent to public roadways and adjacent to cultivated agricultural land.)

Data Interpretation

The interpretation of the chemistry data, involves the following series of steps:

COMPARISON WITH HISTORICAL DATA: The chemical data for the current year’s monitoring events are compared with parameter concentration ranges for individual wells and with the concentration ranges established for other wells within each of the designated well groupings.

It has been established that the concentration data for eight parameters (chloride, sodium, sulphate, potassium, fluoride, barium, bromide and boron) are particularly useful in identifying the potential source of the groundwater (i.e., shallow overburden or bedrock), as the parameter concentrations and ratios differ significantly for each of these water sources. These parameters are referred to as ‘indicator parameters’ and are the focus of the analytical comparisons that are conducted during the annual review of the groundwater quality data.

Table 3 is provided for information purposes. Included in this table are chemical data compiled from Jagger Hims Limited (1996) for wells that were installed in areas of the Lambton Facility property that were undisturbed by landfilling activities at the time the samples were collected. Per the concentration distribution presented in **TABLE 3**, chloride and sodium concentrations become enriched with depth, whereas sulphate concentrations decrease.

Table 3: Indicator Parameter Concentrations – Natural Groundwater Sources

		Active Aquitard	Inactive Aquitard	Interface Aquifer	Shale Aquitard
Chloride	*Range [mg/L]*	4 to 34	32 to 146	89.5 to 389	5,850 to 20,000
	Average [mg/L]	16	84	260.2	12,925
Sodium	*Range [mg/L]*	20.9 to 98	80.9 to 220.1	139 to 530	5,324 to 11,002
	Average [mg/L]	58.9	127.8	254.1	8,163
	Concentration as a Ratio of Chloride	3.68	1.52	0.96	0.63
Sulphate	*Range [mg/L]*	*55.3 to 1,140*	*35 to 77*	*<5 to 15*	*<5 to 7*
	Average [mg/L]	*389*	*53*	*3.70*	*4.8*
	Concentration as a Ratio of Chloride	*23*	*0.63*	*0.014*	*3.7E-4*
Potassium	*Range [mg/L]*	2 to 5	1.5 to 10.1	1 to 3.7	15.4 to 20
	Average [mg/L]	3.5	4.2	2.35	17.68
	Concentration as a Ratio of Chloride	0.22	0.05	3.8E-3	1.4E-3

		Active Aquitard	Inactive Aquitard	Interface Aquifer	Shale Aquitard
Fluoride	*Range [mg/L]*	<0.05 to 2.1	0.72 to 1.79	0.93 to 1.38	0.64 to 0.65
	Average [mg/L]	0.9	1.22	1.16	0.645
	Concentration as a Ratio of Chloride	0.056	0.014	4.4E-3	5.0E-3
Barium	*Range [mg/L]*	<0.002 to 0.117	0.25 to 1.26	0.113 to 0.593	1.76 to 6.24
	Average [mg/L]	0.047	0.61	0.20	4.0
	Concentration as a Ratio of Chloride	2.9E-3	7.3E-3	7.7E-4	3.1E-4
Bromide	*Range [mg/L]*	<0.5	<0.5	<0.5	<5
	Average [mg/L]	<0.5	<0.5	<0.5	<5
	Concentration as a Ratio of Chloride	<0.03	<5.9E-3	<1.9E-3	<3.9E-4
Boron	*Range [mg/L]*	<0.03 to 0.130	0.6 to 75.4	0.71 to 7.66	<0.5 to 10.14
	Average [mg/L]	0.022	19.5	1.42	5.19
	Concentration as a Ratio of Chloride	1.4E-3	0.23	5.5E-3	4.0E-4

Notes: Data are from Appendix D Chemical Data, specifically Table D.1-4, Table D.1-8, Table D.1-9 and D.1-10 Jagger Hims Limited (1996). The chloride ratios are calculated from the reported average parameter concentrations.

Potassium, barium and boron concentrations are comparatively elevated in samples from wells installed in the Kettle Point Formation shale. The high average boron concentration listed in **TABLE 3** for the Inactive Aquitard is based on data from a single well.

Various contaminant sources (i.e., landfill leachate, solutes from deicing chemical usage and wastewater) also have characteristic chemical ‘fingerprints’ and the comparison of the eight parameters helps flag whether water quality is influenced by chemical movement from the landfill or some other Facility operation has impacted groundwater quality. The indicator parameter concentrations for leachate samples collected in 2012 from monitoring wells installed in the waste cells are listed in **Table 4**.

With the exception of barium and boron, the concentrations of the indicator parameters in the leachate [**Table 4**] are one to several orders of magnitude higher than that observed for groundwater [**Table 3**]. The average barium and boron concentrations in groundwater and leachate samples are not significantly different.

The assessment of the analytical data has involved the use of visual aids including graphs showing concentration with time, Trilinear Diagrams and scatter plots. The Trilinear diagrams are graphs that depict the relative concentrations of the major cations (calcium, magnesium, sodium and potassium) and anions (chloride, bicarbonate (calculated), and sulphate) in a water sample. Scatter plots are graphs that show the concentration of one parameter plotted on the ‘X’ axis with the concentration of a second parameter plotted on the ‘Y’ axis.

Table 4: Indicator Parameter Concentrations – Leachate Sources (2012 Data)

		Pre-1986 Landfill Area	Cell 16 Landfill Area	Cell 17 Landfill Area	Cell 18 Landfill Area
Chloride	Range [mg/L]	7,680 to 15,200	16,640 to 94,900	20,600 to 34,100	28,200 to 43,900
	Average [mg/L]	11,497	38,710	27,150	33,700
Sodium	Range [mg/L]	4,690 to 12,2000	14,000 to 20,500	20,600 to 25,000	21,000 to 42,600
	Average [mg/L]	8,290	17,275	22,875	28,540
	Concentration as a Ratio of Chloride	0.72	0.44	0.84	0.85
Sulphate	Range [mg/L]	23 to 1,910	1,070 to 10,600	4,420 to 8,470	3,580 to 23,040
	Average [mg/L]	779	5,508	6,433	10,708
	Concentration as a Ratio of Chloride	0.07	0.14	0.24	0.32
Potassium	Range [mg/L]	152 to 439	909 to 10,000	5,160 to 6,930	3,940 to 8,580
	Average [mg/L]	252	4,867	6,398	6,206
	Concentration as a Ratio of Chloride	0.02	0.13	0.24	0.18
Fluoride	Range [mg/L]	1.36 to 61.7	5.26 to 15.7	4.3 to 15	5.4 to 95
	Average [mg/L]	17.9	9.0	10.1	31.1
	Concentration as a Ratio of Chloride	0.002	2.3E-4	3.7E-4	9.2E-4
Barium	Range [mg/L]	0.02 to 0.5	0.1 to 0.5	<0.5	<0.5 to 2.3
	Average [mg/L]	0.14	0.40	<0.5	2.3
	Concentration as a Ratio of Chloride	1.2E-5	1.0E-5	<1.8E-5	6.8E-5
Bromide	Range [mg/L]	2.5 to 252	67.7 to 815	483 to 692	323 to 1,940
	Average [mg/L]	73.2	462	587	1,243
	Concentration as a Ratio of Chloride	0.006	0.011	0.022	0.37
Boron	Range [mg/L]	0.2 to 450	2 to 10	8 to 27	8 to 100
	Average [mg/L]	0.39	11.3	16.8	31
	Concentration as a Ratio of Chloride	3.2E-5	2.9E-4	6.2E-4	9.2E-4

Note: Concentration data are for samples collected from monitoring wells installed in waste cells as part of the field work conducted for the Environmental Assessment for landfill expansion that is currently under review.

The analytical data are also assessed statistically. This includes the use of Shewhart derived Upper Control Limits or UCLs (Starks, 1989) and trend analysis that applies a linear regression approach as outlined in the USEPA guidance document entitled, "***Methods for Evaluating the Attainment of Clean-up Standards." Volume 2: Ground Water [USEPA, 1992]***. This trend analysis is conducted to determine whether any changes in parameter concentrations are statistically significant.

The statistical analysis is completed for the sampling events conducted over the most recent five-year period. This encompasses ten (10) events for bromide, chloride, fluoride, potassium, sodium and sulphate, which are analyzed twice a year and five (5) events for boron and barium which are analyzed once per year.

The statistical analysis is conducted in two steps, with an initial assessment of statistically significant trends in the averaged parameter concentrations with time for each well group, followed by an assessment of the trend in the parameter concentrations for individual wells. The trends are identified as increasing, decreasing or no trend. The results are presented in **APPENDIX H-4-6** and, where applicable to the discussion of the analytical results, are highlighted in **SECTIONS 3.1.2 AND 3.1.3**.

Two sets of graphs presenting parameter concentrations with time for the eight indicator parameters (chloride, sodium, sulphate, potassium, fluoride, barium, bromide and boron) have been generated to assist with the interpretation of the chemical data.

The first set of graphs presents the event-specific average concentrations for the eight parameters as determined for each sub-group of the wells listed above. The period encompassed in the graphs extends from June 1991 to December 2016.

The chemistry data are presented either by a continuous line (i.e., averaged parameter concentrations) or by individual data points (i.e., 'squares') representing isolated sampling events that are either preceded or followed by gaps in data. Solitary diamond-shaped markers are used to identify sampling events where the data are limited to a single well because property access was denied or because the other wells in the group were 'dry' and therefore not sampled. The graphs are used to flag trends in parameter concentrations that are endemic to the individual groups and to visually illustrate differences between the well groups. The graphs for the sub-groups of wells installed in the Active Aquitard are included in **APPENDIX H-4.5-1**. The graphs for the wells installed in the Interface Aquifer are presented in **APPENDIX H-4.5-2**.

Graphs showing the concentration of the indicator parameter with time were also generated for the individual wells. The graphs for the wells that are screened within the Active Aquitard are presented in **APPENDIX H-4.5-3** and graphs for wells in the Interface Aquifer are included in **APPENDIX H-4.5-4**.

Imposed on the concentration time graphs for the individual Interface Aquifer wells, are Shewhart derived Upper Control Limits or UCLs [Starks, 1989]. The UCLs are calculated from the following equation:

$$UCL = \mu + ZS$$

where: μ is the mean background concentration of the parameter;

Z is a constant [a value of three (3) standard deviations has historically been used at the Lambton Facility in preparing the control charts]; and

S is the standard deviation of the sample set.

Using a Z constant of three (3), the probability of a random sample (i.e., spurious value) exceeding the UCL is not greater than [$\frac{1}{(3)2}\, x\ 100\%$] or 11%.

The parameter specific UCLs are calculated using the mean parameter concentration and standard deviation derived from the initial eight (8) sampling events completed for each individual well. The early time data (i.e., first eight events) are representative of background water quality, as the monitoring wells in the Interface Aquifer, at the time of their installation, are not expected to be affected by Facility operations including landfilling.

Upper Control Limits [UCLs] are applied to the graphed chemical data for individual wells to distinguish between long-term trends in parameter concentrations and any short-term concentration spikes that occasionally occur in a data set. The trend analysis is conducted to determine whether the identified trend is statistically significant.

Comparison with Ontario Drinking Water Standards, Guideline B-7 Criteria and Provincial Water Quality Objectives:

Since the initiation of monitoring in the 1970s, the groundwater quality data for the monitoring wells have been compared with applicable regulatory objectives/standards, which since 2006 are the "***Ontario Drinking Water Standards" [ODWS]***. Although the area is municipally serviced, some residents in the general vicinity of the Facility continue to extract water from shallow dug/bored wells and wells installed at the overburden/bedrock contact to supplement the municipal supply. The water is used for non-potable purposes such as lawn/garden watering, vehicle washing or watering/washing livestock. The protection of groundwater quality therefore continues to be of prime importance.

The ODWS comparison is presented in the tables included within **Section 3.1.2** for the individual well groupings for the Active Aquitard and **Section 3.1.3** for the well groupings established for the Interface Aquifer. Any parameter concentrations exceeding the ODWS are highlighted in the tables within these sections.

The groundwater quality data for wells along the Facility property boundary are also compared with criteria calculated per the approach presented in the document titled "***Guideline B-7: Incorporation of the Reasonable Use Concept into MOEE Groundwater Management Activities***". Guideline B-7 was established by the MOECC as a mechanism to evaluate whether the concentrations of chemical parameters moving outward from a waste disposal site through the groundwater have the potential to affect its use for supply purposes.

Under Guideline B-7, water quality is considered to have been impaired where:

- The concentration of a specific water quality parameter, which currently exceeds the applicable ODWS, has increased;
- The concentration of a specific water quality parameter, which is currently lower than the applicable non-health related ODWS, has increased by an amount in excess of 50 percent of the difference between the background concentration and the applicable ODWS; and

- The concentration of a specific water quality parameter, which is currently lower than the applicable health related ODWS, has increased by an amount in excess of 25 percent of the difference between the background concentration and the applicable ODWS.

The calculation for the maximum acceptable parameter concentration at the property boundary as specified in Guideline B-7 is as follows:

$$C_m = C_b + X\,(C_r - C_b)$$

where: C_m is the maximum concentration of the contaminant considered by MOECC as acceptable in the groundwater beneath the property boundary;

C_b is the background concentration;

X is a constant that reduces the level of contaminant concentration. X = 0.25 for a health related parameter, X = 0.50 for a non-health related parameter; and

C_r is the maximum concentration allowable in groundwater (i.e., ODWS).

The Guideline B-7 comparative analysis only considers those parameters that have ODWS.

The analysis is undertaken in three steps:

STEP 1: The Background Concentration (C_b) is represented by the arithmetic mean concentration calculated using the 2016 dataset for designated background wells.

For the Active Aquitard, this involved most of the 2016 dataset for shallow monitoring wells (TW55-09S, TW56-11S, TW57-11S and TW59-13S), which are located off-site.

For the Interface Aquifer, C_b was calculated using the arithmetic means for the 2016 dataset for monitoring wells (TW55-09D, TW56-11D, TW57-11D and TW59-13D), which are located off-site.

STEP 2: The maximum acceptable concentration (C_m) was calculated using the Guideline B-7 equation and the value of C_b calculated in Step 1.

With regard to the Interface Aquifer, some of the parameters are naturally elevated and occasionally exceed the applicable ODWS. Where this occurs, the maximum acceptable concentration (Cm) is set as the ODWS for the parameter.

STEP 3: The assessment of Guideline B-7 compliance is based on a comparison of the observed parameter concentrations for each event for the wells located between the landfill and the property boundary, and the C_m value calculated in Step 2.

Guideline B-7 compliance is achieved where the parameter concentrations are less than the derived maximum acceptable concentration (C_m criteria).

Under the circumstances where the parameter concentrations exceed the C_m criteria, the historic database for the well parameter is reviewed to determine if the reported value is: a) caused by an increasing concentration trend at the well; b) a spurious spike in the data; or, c) reflective of naturally elevated concentrations.

The comparison of the concentration data for individual wells with Guideline B-7 criteria is presented in **APPENDIX H.4.7**. The results of this comparison are summarized in **SECTION 3.1.2** and **SECTION 3.1.3**.

The chemistry data for samples from shallow monitoring wells are compared with ***"Provincial Water Quality Objectives" [PWQO].*** This is because shallow groundwater along the outside perimeter of the Lambton Facility property discharges to drainage swales, roadside ditches and tile drains in adjoining agricultural fields. The tile drains in turn convey flow to roadside ditches. Comparison with the PWQO identifies whether the shallow groundwater has the potential to impact surface water quality. [Note: The groundwater samples submitted for metals analysis are filtered as the ODWS criteria are applied to dissolved metals. The PWQO criteria consider total metals (unfiltered metals).]

The PWQO comparison is presented in the tables included within **SECTION 3.1.2**. Any parameter concentrations exceeding the PWQO are highlighted in the tables within this section.

2.1.4 Compliance Triggers

The interpretive approach outlined above has been applied to flag parameters in samples collected from the wells installed internal to the Facility property where the concentration change exceeds prescriptive standards (namely, OWDS, Guideline B-7 and PWQO). The concentration data for individual wells are also reviewed in the context of whether there is an emerging trend that is statistically significant.

An assessment of the data will be triggered under circumstances where one or more of the following are observed:

1. a parameter is detected in a sample at a concentration that is anomalous, as defined by historical parameter concentrations from the same well;
2. the parameter is not naturally occurring (e.g., VOC);
3. the parameter concentration exceeds a prescriptive standard; and
4. the parameter concentration exhibits an increasing trend.

The assessment may involve one or more of the following actions:

- resampling of the well(s) to confirm the parameter(s) concentration;
- inspection of the well to determine if the integrity of the well is compromised;
- collection of samples for environmental isotope analysis (deep wells only); and

- sampling of other wells in the immediate vicinity and analysis for subject parameter(s).

If the parameter(s) continues to be observed at concentrations of potential concern Clean Harbors is committed to inform the MOECC immediately. An investigation work plan will then be prepared and submitted to the MOECC for information/feedback, and once the plan is approved, the investigation will be implemented. The investigation may involve the installation of additional wells and sampling of these wells. The data collected and findings would be presented in the Annual Landfill Report for the period covered.

2.2 Monitoring Program to Assess Effectiveness of Sub-cell 3 Mitigation

2.2.1 Description of Monitoring Program

As part of future operations, there is an ongoing need to continue to operate the two pumping wells that are installed in the HCLs within Sub-cell 3. Pumping is conducted to maintain the water levels in the HCLs below the potentiometric surface in the Interface Aquifer. The control of the water level in the HCLs produces a hydraulic gradient into the HCL and therefore prevents downward seepage from Sub-cell 3 through the cracks/fissures that developed below this sub-cell. The monitoring program developed to assess the performance of the remedial structure is conducted both to verify/confirm that the hydraulic gradient is maintained and to assess the quality of the effluent that is extracted from the HCLs to determine how it is to be managed.

2.2.2 Network of Monitoring Wells

The monitoring well network used to verify that the inward gradient is being maintained, includes the two extraction wells [EW1a-01 and EW2a-01] and four monitoring wells [EW1b-13, EW1c-13, EW2b-13 and EW2c-13] installed in the gravel layers of the HCLs, and two monitoring wells [PW1-N and PW2-S(R11)] installed in the Interface Aquifer. The locations of the wells are shown in **FIGURE 4**.

Wells EW1a-01 and EW2a-01 are equipped with float-activated pneumatic pumps and pressure transducers. The pumps are supplied with air from a compressor that is housed in a building located north of the wells. Airlines have been installed between the wells/pumps and the compressor. The discharge lines from the pumps direct flow a short distance away from the wells. The airlines and the discharge lines are heat traced for operation during winter months.

Pump activation is triggered by a 1 m rise in the water level at each well. The float cycle, at EW1a-01 bottoms at an elevation of about 188 mASL and tops at an elevation 189 mASL. The float cycle at EW2a-01, bottoms at an elevation 187 mASL and tops at an elevation 189 mASL.

Construction details for the referenced wells are provided in **APPENDIX H-2.2** and summarized in **TABLE 5**. Monitoring well PW2-S(R11) lies within the footprint of proposed Cell 21-2 and would need to be decommissioned and replaced with a new well at a suitable location prior to the construction of the cell.

Table 5. Sub-cell 3 Wells Monitored During the 2016 Monitoring Period and Monitoring Methodology

Monitor	Spring 2016 Sampling Event						Fall 2016 Sampling Event					
	Water Level		Continuous Volume Sampling	Low Flow Sampling	Discreet Interval Sampler	Discharge Sampling	Water Level		Continuous Volume Sampling	Low Flow Sampling	Discreet Interval Sampler	Discharge Sampling
	Manual Measurem	Pressure Transducer					Manual Measurem	Pressure Transducer				
Sub-cell 3 Performance Monitoring Network												
PW1-N		√				√		√				√
PW2-S(R11)		√				√		√				√
EW1a-01		√				√		√				√
EW1b-13		√	√					√	√			
EW1c-13		√	√					√	√			
EW2a-01		√				√		√				√
EW2b-13		√	√					√	√			
EW2c-13		√	√					√	√			

Notes:	Manual water level measurements collected semi-annually
	Continuous water level measurements collected hourly. Dataloggers downloaded quarterly.

2.2.3 Groundwater Monitoring Program and Methods

2.2.3.1 Groundwater Level Monitoring

Monitoring of water levels at the wells installed in the HCLs [EW1a-01, EW2a-01, EW1b-13, EW1c-13, EW2b-13 and EW2c-13] and in the Interface Aquifer [PW1-N and PW2-S(R11)] is conducted using data logging pressure transducers installed in the wells. The transducers are set to record water levels at a frequency of at least once every six hours. The water levels at the wells are measured manually each time the loggers are downloaded. Downloading of the pressure transducers and the barometric pressure loggers are conducted at a quarterly frequency.

The data obtained from the pressure transducers are adjusted for barometric pressure [**SECTION 2.1.2.1**].

2.2.3.2 Pumping Volumes

The pneumatic pumps installed in the two extraction wells [EW1a-01 and EW2a-01] have cycle counters that record the number of pump cycles per quarterly monitoring interval. As the volume of water pumped per cycle is known, the cycle count is used to estimate the total flow volume. [Note: Pump discharge volumes are checked on a semi-annual basis as part of routine maintenance of the Sub-cell 3 system. This is accomplished by collecting the effluent from each pump into a calibrated bucket and comparing the volume obtained with the 'pump stroke volume' provided by the manufacturer (QED). In addition, the pumps are removed from each well and inspected/cleaned once every three years, or as necessary if necessary between inspections.]

2.2.3.3 Sampling Methodology

The water samples from the two extraction wells [EW1a-01 and EW2a 01] are collected from the pump discharge line directly into sample containers supplied by the laboratory. Care is taken to minimize the introduction of air into the sample during collection.

The monitoring wells [EW1b-13, EW1c-13, EW2b-13, EW2c-13, PW1-N and PW2-S(R11)] are sampled by the CV Method described in **SECTION 2.1.2.2**. Wells PW1-N and PW2-S(R11) were equipped with low flow samplers prior to the spring 2016 sampling event and are currently sampled by this method [**SECTION 2.1.2.2**].

2.2.3.4 Sampling Handling and Transport

The samples will be handled and transported in accordance with the procedure outlined in **SECTION 2.1.2.3**.

2.2.3.5 Chemical Parameter List and Sampling Frequency

Samples collected from the wells are to be analyzed for the parameters listed in Table 2-3 at the frequency specified in Table 2-4 of Draft Monitoring Program [RWDI, 2015]. Sampling is conducted to coincide with the perimeter groundwater monitoring program.

2.2.4 Data Analysis, Interpretation and Reporting

2.2.4.1 Groundwater Level Data

The water level data collected at the wells installed in each of the two HCLs are initially plotted in hydrographs and reviewed to determine that the water level in the individual HCLs is similar indicating good hydraulic connectivity within the HCL.

The data collected at the two wells installed in the Interface Aquifer [PW1-N and PW2-S(R11)] are next added to the hydrographs. This is to illustrate that an upward hydraulic gradient is maintained between the individual monitoring wells in the HCLs and the wells installed in the Interface Aquifer.

The water level data for the wells are added to the Lambton Facility database file [**APPENDIX H-4.4**]. The file is accessible using Microsoft™ ACCESS 2016 or newer.

2.2.4.2 Groundwater Chemistry Data

The analytical data collected for the current year's monitoring events from the eight wells are compared with the parameter concentration ranges for the individual wells. This comparison is conducted to flag any outliers or anomalies in the current year's data. Actions triggered by this review may include re-analysis of the sample by the primary laboratory or resampling/analysis at a secondary laboratory.

The assessment of the analytical data has involved the use of visual aids including summary tables of chemistry and graphs showing concentration with time. Imposed on the graphs are UCLs to distinguish between long-term trends in parameter concentrations and any short-term concentration spikes that occasionally occur in a data set [see **SECTION 2.1.3.2**]. A trend analysis that applies a linear regression approach is also conducted to determine whether an identified trend is statistically significant.

The quality of the pumping discharge will also dictate whether the discharge can be released to the internal surface water drainage system or needs to be collected and retained for disposal either as process water or alternatively as leachate. Currently this water is managed through the surface water drainage system.

2.2.4.3 Compliance Triggers

Compliance is interpreted as the ability of the Sub-cell 3 remedial system to maintain an upward hydraulic gradient between the Hydraulic Control Layers (HCLs) and the Interface Aquifer.

The upward gradient is produced by pumping of the wells installed in the HCLs, which draws the water level in the HCL downward to a level below that in the underlying Interface Aquifer.

The potentiometric head in the Interface Aquifer in the vicinity of Sub-cell 3 as measured at wells PW1-N and PW2-S(R11) is at an elevation between 196 mASL and 198 mASL, but has been steadily increasing. The pumps in the HCLs are set at a target elevation below 189 mASL. The water level recovery in the HCLs is very slow and it takes 3+ months for the water level in the HCLs to recover to a level equivalent to that in the Interface Aquifer. Therefore, the extraction system can be off-line for a short period of time without compromising compliance.

WATER LEVEL TRIGGERS AND CONTINGENCY: The pumping system has failed on numerous occasions in the past. The primary causes of failure are problems with the air compressor that drives the pneumatic pumps and freezing/rupturing of the air and discharge lines that extends overland to the pumps during the winter.

It is also possible in the future that system failure could occur as a result of:

- normal pump wear, which would be addressed through routine maintenance and replacement of the pumps; and
- plugging of the screens of the extraction wells as a result of precipitation of carbonates and iron bacteria fouling (evaluated by sampling and review of the pumping records).

System upgrades were implemented in 2015, which included replacement and heat tracing of the air and discharge lines, installation of a new high capacity air compressor and provision of a new shed to house the equipment. A 'warning system', which triggers the activation of a light, was installed to identify when the airlines are depressurized such as would occur if the air compressor is not operating.

Although these upgrades will address concerns with regards to the power supply, the warning system does not provide notification of system failure if it is due to a frozen discharge pipe or airline because the air pressure in the line would be maintained. To address this deficiency, Clean Harbors will install water level alarm sensors in the two pumping wells [EW1a-01 and EW2a-01] located within HCLs. The sensors will be activated when the water level at the wells increases to an elevation of 190 mASL (which is 1 metre above the operating level of the pumps in the HCL extraction wells). The sensors will trigger a 'high water level' alarm, which in turn will activate a bright light to be installed at the individual wells.

Should the alarm be triggered, manual efforts will be taken to pump the water level down in the HCLs. This may require redirection of water discharge flow through temporary lines. Alternative, the two monitoring wells that are installed in each of the HCLs can be equipped with pumps to draw the water level down if the two extraction wells are not accessible.

GROUNDWATER QUALITY TRIGGERS AND CONTINGENCY: The 'quality' of the discharge from the extraction pumps will determine if the water needs to be contained. This would be triggered where a parameter that is not naturally occurring (e.g., VOC) is detected. The discharge lines for the extraction wells would be directed to portable tanks. The contents of the tanks would be transferred to the leachate management system.

2.3 Performance Monitoring of Engineered Landfill System

2.3.1 Description of Monitoring Program

With reference to the Design and Operations Report [Tetra Tech, 2015], construction of the vertical landfill expansion will progress in a step-like manner starting along the west side of the Pre-1986 Landfill. The initial construction activity involved the installation of a perimeter leachate collection trench along the western and southern edge of the existing landfill (distance of about 500 m). Four sumps were installed along this segment of the trench.

The trench has an average depth of 6 m below the ground surface (approximate elevation of 195 mASL) at each of the sumps and rises to an elevation of about 196 mASL at the mid-point between sumps.

A perforated pipe has been installed at the base of the trench. The pipe consists of a perforated 200 mm nominal diameter SDR 11 HDPE pipe with fused joints and large radius bends to vertical cleanouts located adjacent to each of the pump sumps. The trench has been backfilled with clear drainage stone (primarily igneous and metamorphic rock).

The sumps were installed to a depth approximately 3 m below the bottom of the trench (about 192 mASL). Each sump is equipped with a high-head, low-flow pump. Leachate and groundwater accumulating in the trench gravity drains to the sumps and is then extracted and pumped through pipeline headers to a leachate pumping station and then onto holding tanks near the existing incinerator building.

Once the perimeter trench was installed, waste cell 19-1 was constructed above the existing landfill. This involved, placement of shallow berms to delineate the cells and to segregate clean and contaminated runoff, re-grading of the existing landfill cover and placement of a gravel drainage layer over the graded surface. The drainage layer was keyed into the underlying waste (through the cap) using shallow trenches that were backfilled with gravel, and extend outward to the perimeter trench. Waste was then placed above the drainage blanket. As the capacity of each cell is achieved, the waste has been covered with an interim clay cap. Construction of the final engineered cover system (which will incorporate the interim cap) will proceed once final grades are achieved.

The above sequence of development will be repeated until the landfill expansion reaches full capacity. At this point in time, the perimeter trench will be about 4,700 m in length and will have a total of 17 leachate extraction sumps.

The extraction of effluent from the sumps along the perimeter hydraulic control trench will influence the level of leachate in the waste cells. The goal is to maintain a liquid level in the perimeter trench at an average elevation of about 196 mASL, and through hydraulic connection, below an elevation of 198 mASL in the waste cells.

The average elevation of the water table in the surrounding shallow overburden and the potentiometric surface in the Interface Aquifer is 198 mASL. The water level differential will produce an inward hydraulic gradient that is into the landfill and the perimeter collection system.

By achieving this goal, the collection system is expected to provide hydraulic control/containment of the leachate within the landfill. The potential for solute movement away from the landfill will therefore be small.

Performance monitoring of the engineered systems focuses on the liquid level in the perimeter collection trench, the leachate head in the waste, the water table in the surrounding overburden and the potentiometric head with depth in the overburden and in the underlying Interface Aquifer. This requires that monitoring wells and instrumentation suitable for measuring and recording levels/pressures, be installed.

The discussion focus on the monitoring program to be implemented for Cell 19-1.

2.3.2 Network of Monitoring Wells

Water level monitoring is to be conducted using existing monitoring wells located along the perimeter of the Facility Property and new wells installed along the perimeter collection trench that are screened against the stone placed in the trench and at locations adjacent to the perimeter trench. Additional wells are to be installed in the waste following placement of the interim cap. These new wells will be installed along transects extending out from the landfill. A description of the wells for monitoring the groundwater response to construction of Cell 19-1 follows.

2.3.2.1 Wells installed Adjacent to the Perimeter Collection Trench

Monitoring of liquid levels in the perimeter trench is conducted at the individual sumps and at standpipes/wells installed at the mid-point of the trench between sums. The initial four wells (LCS OW1-15, LCS OW2-15, LCS OW3-15 and LCS OW4-15) were installed in January 2016 along the initial 500 m length of the trench that was constructed around the perimeter of Cell 19-1. The well locations are shown in **FIGURE 5**.

Installation involved drilling boreholes into the stone backfill of the collection trench using hollow stem augers to a depth of slightly above the crown of the perforated pipe that is placed at the base of the trench (above an elevation of 196.3 mASL) to avoid damaging the pipe. The wells were then constructed through the hollow stem augers. The annular space around the pipe/screen was backfilled with pea gravel as the augers were removed from the boreholes.

The wells consist of 102 mm inside diameter (ID) stainless steel pipe and screen. The screen interval of the well is 3 m in length and extends upwards from the base of the borehole.

2.3.2.2 Well Transects

Monitoring of the groundwater response extending outward from the initial waste cell (Cell 19-1) was conducted using wells installed at different depths along a transect that extended from the landfill outward to the Facility property boundary. The initial transect, along the west side of the Cell 19-1.

This transect currently includes a well installed within the gravel backfill of the perimeter LCS (LSC OW2-16); a nest of wells installed at a location west of the perimeter trench (TW64-16-I [Inactive Aquitard, depth of ~25.2 mbgs], TW64-16-II [Inactive Aquitard, depth of ~14.9 mbgs], TW64-16-III [Inactive Aquitard, depth of ~10.3 mbgs], and TW64-15-IV [Active Aquitard, depth of ~ 5.0 mbgs]) and perimeter monitoring wells TW48-00D [Interface Aquifer] and TW48-16S [Active Aquitard] along the west boundary of the Facility property [**FIGURE 5**]. Data collected at this initial transect will be used to determine the configuration (i.e. spacing and depth) of wells to be installed in the future at transects at the additional locations around the perimeter of the landfill.

2.3.3 Groundwater Level Monitoring

2.3.3.1 Perimeter Collection Trench

Water level monitoring along the initial 500 m length of the trench was conducted at four sumps and the four wells installed within the trench backfill.

The four sumps are equipped with hydrostatic level instruments that are connected by fiber optic cable to a Programmable Logic Controller (PLC). The controller starts and stops the sump pumps based on trigger levels that are set by the operator, and monitors and records the water level at the sump. A control panel with a power indicator light is installed at each sump so that an interruption in power can be observed by personnel on site.

The following settings have been established by Clean Harbors:

- pump activation when the liquid level in the sump reaches an elevation of 196.5 mASL; and
- pump shut off at 195.5 mASL.

These settings are selected to minimize turbulent flow into the trench and the possible induced displacement of fines into the gravel in the trench, and to ensure that the volume of leachate pumped can be actively managed with the available storage. A 'low' level control has been set above the pump intake to prevent the pumps from running dry. A 'high' level warning system, triggered when the water level reaches 197.5 mASL, has been set as a backup to the activation level for the pumps at each sump. It is expected that the pump shut off setting will be adjusted downward as the landfill slowly dewaters and experience with the systems operations is gained.

The liquid level in the four wells installed in the trench at the mid-point between sumps is monitored using pressure transducers. The transducers are set to record water levels at a frequency of once every 12 hours. The water levels at the wells are measured manually, on a quarterly basis, each time the loggers are downloaded.

The data obtained from the pressure transducers are adjusted for barometric pressure [**SECTION 2.1.2.1**].

2.3.3.2 Well Transects

Monitoring of water levels at the new and existing wells located along the initial transect is also being conducted using pressure transducers. The methodology and frequency of monitoring is similar to that conducted for the wells installed in the trench.

2.3.4 Data Analysis and Interpretation

2.3.4.1 Water level Data

The water level data recorded at the PLC, and the pressure transducers and the barometric pressure loggers are downloaded at a quarterly frequency. Following each quarterly download of the water level data, the data are graphed to produce a set of hydrographs for the individual wells. The data obtained from the quarterly manual measurements, once verified with the data from the PLC and transducers are to be plotted in cross section.

The hydrographs and cross sections visually illustrate the water level response to the operation of the perimeter leachate collection trench. The cross section plots are annotated to highlight the direction of the hydraulic response and the evolving gradient.

Copies of the hydrographs and cross sections will be maintained at the Lambton Facility and made available to the MOECC on request. The content of the hydrographs and quarterly cross sections that are produced are summarized and discussed in **SECTION 3.3** of this report.

Any manual water level data for the wells has been added to the Lambton Facility database file. The database file is included in **APPENDIX H-4.4** and is accessible using Microsoft™ ACCESS 2016 or newer.

2.3.4.2 Compliance Triggers

The performance of the engineered landfill components is evaluated through two programs.

The first program, referred to as the "**PERIMETER TRENCH PERFORMANCE MONITORING PROGRAM**", focuses on the ongoing operation and effectiveness of the perimeter trench at drawing down the water level along the perimeter of the landfill to a prescriptive level.

The second program, described below under "**PERFORMANCE OF ENGINEERED LANDFILL SYSTEM**", is intended to provide the information needed to assess the overall effectiveness of the engineered landfill components at controlling/preventing leachate from moving outward from the landfill. As noted, this is conducted by reducing the leachate head along the perimeter of the landfill and in the waste to a level that is lower than that in the surrounding overburden and the underlying Interface Aquifer.

The monitoring program contained herein focuses on the **PERFORMANCE OF ENGINEERED LANDFILL SYSTEM** component of the program.

The overall goal of the landfill design is to achieve sufficient drawdown of the leachate head in the landfill to induce and maintain an inward gradient onto the landfill. An inward gradient is generated where the liquid level in the landfill remains below a target elevation of 198 mASL.

As of December 31, 2016, the Cell 19-1 interim cap has not been constructed, consequently the monitoring wells that are to be installed in waste have not been installed.

2.4 Purge Wells for Groundwater Control

The Purge Well for Groundwater Control program is described in the Draft Monitoring Program [RWDI, 2015]. The program involves the installation of wells in the Interface Aquifer and active pumping of the wells to depress the hydraulic pressure head in the Interface Aquifer at the pumping well in order to produce a drawdown cone that extends outward from each well. This alteration of the hydraulic gradient draws groundwater towards the well.

Applying a model developed as part of the Environmental Assessment to identify a feasible purge well system, it was determined that two purge wells, one located along the north property boundary about 300 m east of Telfer Road pumping at a rate of 4 L/min. and a second about 250 m south of the northeast corner of the property pumping at a rate of 2 L/min. would provide complete hydraulic containment in the Interface Aquifer below the footprint of the vertical landfill expansion. The approximate locations are shown in **FIGURE 6**.

It is anticipated that the new purge wells will be installed during the 2017 monitoring period. The initial demonstration testing of the new purge wells will likely be carried out in early 2018.

2.5 First Nations' Comments

The Annual Landfill Reports are posted on the Clean Harbors' website and copies of the reports are sent out to the MOECC as well as the Walpole Island First Nations, and Aamjiwnaang First Nations.

Comments, received from the First Nations and their groundwater consultant (Neegan Burnside Limited) on the 2015 Groundwater Monitoring Report are included in **APPENDIX H-5.2**.

3 MONITORING RESULTS

3.1 Perimeter Groundwater Monitoring Program

3.1.1 Groundwater Level Data

3.1.1.1 Shallow Wells – Active Aquitard

Groundwater levels (expressed as elevations) for the shallow wells installed in the Active Aquitard measured on March 15, 2016 and September 19, 2016 are presented in **FIGURE 7** and **FIGURE 8**, respectively. The groundwater elevations generally mirror the local ground surface topography. The water level is mounded below topographic highs (i.e., perimeter screening berms and the Pre-1986 Landfill Area) and depressed in the vicinity of drainage trenches and retention ponds.

Hydrographs for the individual shallow monitoring wells are included in **APPENDIX H-4.1**. Depending on the well's location, depth and the local geology, the water level at individual wells fluctuate between 2 m and 4 m, showing seasonal variation (i.e., high water levels in the spring and lower levels in the fall).

Two figures (**FIGURE 9** and **FIGURE 10**) were prepared showing the hydrographs for wells located within and adjacent to the North Berm and the South Berm, respectively, to highlight the influence of the berm topography on groundwater levels and shallow flow.

FIGURE 9 presents the water level elevations for wells (TW39-99S, TW46-99S and TW61-13S) installed in the fill within the North Berm; wells (TW39-99I, TW46-99I and TW61-13I) installed in the native overburden immediately below the berm; and wells (TW21-94-II, TW22-94, TW32-94-IV and OW35-90) installed in the native overburden adjacent to the berm [Note: The locations of the wells are shown in **FIGURE 2**].

With reference to **FIGURE 9**, the water levels recorded at shallow wells (TW39-99I, TW46-99I and TW61-13I) are generally 1 m to 3 m higher than wells (TW21-94-II, TW22-94, TW32-94-IV and TW35-90) installed at similar depths exterior to the berm. The height of this berm is between 10 m and 12 m above the original ground surface.

FIGURE 10 presents the hydrographs for three pairs of wells installed along the South Berm. This berm, which extends along the south boundary of the property adjacent to the Pre-1986 Landfill area, is about 4 m to 4.5 m above the original ground surface. Wells TW50-02B, TW51-02B and TW52-02B are installed in the weathered/fractured clay overburden immediately below the fill and wells TW50-02A, TW51-02A and TW52-02A are installed immediately north of the berm at similar depths. [The locations of the wells are shown in **FIGURE 2**].

The water level differential between the wells installed below the berm and those located along the toe of the slope north of the berm, ranges between a few centimeters [TW51-02] and a few meters [TW50-02].

Shallow groundwater movement in the area south of the Pre-1986 Landfill is influenced by three factors, mounding within the South Berm, the surface water stage in the adjacent perimeter ditch and the recently installed leachate collection system [LCS]. The ditch at its west end has an invert elevation of 197.5 mASL and top of bank elevation of 200.5 mASL. At the east end, the invert elevation is 198.5 mASL and the top of bank elevation is 201 mASL.

On occasion, the spring water levels at TW50-02B and TW52-02B, which are installed in the native overburden through the berm, spike upward. These spikes appear to coincide with snow melt events. [Note the top of the berm was constructed with a slight depression to enhance recharge. Ponding can occur during spring melt and following significant precipitation events.]

Under normal conditions when the ditch is only partially filled, mounding in the berm results in flow from the berm northward to the ditch. Following a storm event that generates a rapid increase in the water level in the ditch, the level at the wells along the toe of the berm adjacent to the ditch can increase temporarily above that observed at the wells in the berm. This phenomenon is evident in the hydrograph for well nest TW52-02A and TW52-02B, where the level measured at the toe of the berm (TW52-02A) is occasional higher than that at TW52-02B. This will result in a temporary reversal in the hydraulic gradient between the two wells with groundwater flow potentially southward below the berm.

The LCS was installed along the south side of the Pre-1986 Landfill. At this time, only the western end of the LCS is equipped with sumps. As noted in Section 2.3, the trench of the LCS was installed to an approximate elevation of 195 mASL at each sump and 196 mASL at the midpoint of the trench between sumps. Pumps installed in the sumps are activated when the leachate level in the sump raises to 196.5 mASL and shut down when the level drops to 195.5 mASL.

3.1.1.2 Deep Wells – Interface Aquifer

Pattern of Groundwater Movement: The deep wells of the monitoring well network are installed such that the well screen either straddles the overburden/bedrock contact if the Basal Till (sandy/silty till) is encountered, or if absent, the screen is set within the upper 1 m to 2 m of the Kettle Point Formation shale. This contact zone, which has historically been exploited as a source of water, is referred to as the Interface Aquifer (see **Appendix H-1.3** for discussion of the hydrostratigraphic units).

Contoured groundwater hydraulic head elevations within the Interface Aquifer for March 15, 2016 and September 19, 2016 are presented in **Figure 7** and **Figure 8**, respectively.

The groundwater elevation contours indicate flow within the Interface Aquifer to be outward from a groundwater high (potentiometric high) that extends to the southeast from well TW39-99D past TW22-99D, TW60-13D, TW61-13D and TW54-09D to TW33-94-I. Wells TW22-99D and TW60-13D are under artesian conditions and the water level is within the well casing above ground surface.

Wells PW1-N and PW2-S(R11) were pumped intermittently during the 2014/2015 monitoring period. This pumping was undertaken to extract surface water introduced into the aquifer as a result of flooding that occurred in 2011 in the vicinity of Sub-cell 3. Pumping was discontinued with MOECC approval in July 2015 to allow for the recovery of the Interface Aquifer to static conditions. This action was taken to eliminate one of the variables influencing the pattern of groundwater movement within the Interface Aquifer at the Facility property.

[Note: An inspection of PW1-N conducted in 2014 with a pipe camera, indicates seepage may be entering the well at near surface well joints under conditions where there is ponded water in the vicinity of the well. The upper casing was repaired and clay was placed around the casing in spring 2015 to fill a surface depression adjacent to the well. Pumping of the well was generating an inward gradient across the casing joint. It was anticipated that the water level would recover to near ground surface when pumping was discontinued, which would in turn reverse the gradient.]

The partial recovery of the water levels after pumping of PW1-N and PW2-S(R11) is evident in **FIGURE 7** and **FIGURE 8** in comparison to Figure 6 and 7 of the 2015 Groundwater Monitoring Report [RWDI, 2016].

Water levels in the Interface Aquifer have recovered by ~ 5m at PW1-N and PW2-S(R11) and ~2.5 m at TW47-00D which is located a short distance northwest of PW1-N and installed in the same highly productive zone as PW1-N.

A number of the Interface Aquifer monitoring wells (**TABLE 2**) that are located in the northern portion of the Facility property are equipped with pressure transducers. The transducers are downloaded quarterly and the water level data for the individual wells are plotted in hydrograph format. A sub-sample of the water level data is selected at a quarterly interval and used to produce a series of potentiometric surface maps. The hydrographs and the potentiometric surface maps are included in **APPENDIX H-4.1-2**.

GROUNDWATER FLUCTUATIONS IN DEEP WELLS: Hydrographs for all deep monitoring wells are provided in **APPENDIX H-4.1-2**. The hydrographs for representative Interface Aquifer wells OW1-92, TW32-94-II, OW35-05D and TW40-99D are provided in **FIGURE 11** and for wells TW49-00D, TW56-11D, TW57-11D and TW59-13D in **FIGURE 12**.

The downward response observed in the hydrographs generated for TW40-99D and OW1-92 over the interval between 1999 and 2002 is attributed to three events: 1) pressure release of groundwater and natural gas through stress fractures that formed in the base of Sub-Cell 3; 2) depressurization pumping from the Interface Aquifer that was subsequently undertaken during implementation of remedial measures at Sub-cell 3 in 2001 and 2002; and 3) a test program involving two wells (OW1-92 and PW1-N) that was conducted in 2001 to assess the viability of using purge wells to control groundwater movement in the Interface Aquifer.

The drawdown response to these events is shown in **FIGURE 11**. Specifically, the water level data at the pumping well OW1-92 and at well TW40-99D, which is located about 120 m north of PW1-N, declined and it took several years for the water levels at the two wells to recover to pre-1999 water levels.

In spring 2012, pumping was initiated at PW1-N and PW2-S(R11) to remove surface water that had been entered PW2-S(R11) as a result of flooding that occurred in 2011. The response to pumping is evident in the hydrograph for well TW40-99D and possibly for well OW1-92 (**FIGURE 11**).

The water levels measured at wells TW32-94-II and OW35-05D located at the northeast corner of the Facility property (**FIGURE 11**) and at wells TW56-11D and TW59-11D located to the east and west of the site (**FIGURE 12**) exhibit a near continuous rising trend but in recent years the recovery has stabilized. The increase in the water levels at these wells is attributed to the reduction/discontinuation of groundwater extraction from wells for supply purposes at the residences and farms along Petrolia Line following the extension of the West Lambton Water Supply System into the area in the early 1990s. With the resulting availability of a ready source of high quality water, the use of private wells subsequently declined.

The hydrograph for well TW57-11D (which replaced TW37-94-I because of access problems) provided in **FIGURE 12**, also shows a rising trend although the response is more muted. These wells are located east of the Facility property and about 1 km south of Petrolia Line. The water level in this area is expected to be less influenced by the water takings at the residential/farm wells along Petrolia Line.

The general rise in the potentiometric surface in the Interface Aquifer is consistent with commentary in Weaver (1994) and Husain (1996). Both observed that, as the aquifer readjusts to the declining water taking, the regional pattern of groundwater flow and the hydraulic gradients in the area will change.

This adjustment was predicted to result in an increased hydraulic head in the Interface Aquifer, which in turn would lead to a flattening of the vertical and horizontal gradients.

The early portion of the hydrograph for well TW49-00D (**FIGURE 12**) exhibits the effects of prolonged development of the well to remove drilling mud and improve its hydraulic properties. The well is a poor producer as indicated by the slow water level recovery between sampling events. The seasonal fluctuations (1 m to 3 m) evident in the hydrograph are most likely the remnant effects of purging/sampling of the well.

3.1.1.3 Vertical Hydraulic Gradients between the Active Aquitard and Interface Aquifer

Groundwater movement across the intact/unfractured clay between the two hydraulically active units (i.e., Active Aquitard and Interface Aquifer) is very slow, being influenced by the low hydraulic conductivity of the intact clay with the direction of movement dependent on the vertical hydraulic gradient that develops between the overlying Active Aquitard and the underlying Interface Aquifer. The vertical hydraulic gradient across the Inactive Aquitard is calculated as the water level elevation differential for nested shallow and deep monitoring wells divided by the midpoint elevation of the well screen for the same nested wells.

The calculated gradients for 2016 are listed in **TABLE 6** along with the averaged vertical gradients calculated for the same wells for the current year. The distribution of the vertical gradients in the vicinity of the Facility Property is shown in **FIGURE 13**. A negative value indicates an upward hydraulic gradient at the referenced location.

With reference to **TABLE 6** and **FIGURES 13,** well TW22-99D and neighboring well TW60-13D are under artesian conditions and groundwater levels have consistently been above ground surface.

Table 6: Hydraulic Gradients Calculated for Shallow and Deep Pairs

Well Nest	Vertical Hydraulic Gradients		
	March 2016	September 2016	2014/2015 Average*
Northern Area			
Off-Property to West			
TW59-13 (S/D)	0.09	0.05	0.07
Lambton Facility Property – Northwest Corner			
TW22-94/TW22-99D	N/A	-0.04	N/A
TW22-94/TW60-13D	N/A	-0.04	N/A
TW61-13 (I/D)	-0.06	0.01	-0.02
TW39-99 (I/D)	-0.01	-0.02	-0.015
Lambton Facility Property – Central, Northern Boundary			
TW40-99 (S/D)	0.02	-0.02	0.00
Lambton Facility Property – Northeast Corner			
TW32-94 (II/IV)	0.06	0.03	0.05
TW46-99 (I/D)	0.10	0.10	0.10
OW35-90S/OW35-05D	0.06	0.04	0.05
Off-Property to East			
TW56-99 (S/D)	0.03	0.03	0.03
Southern Area			
Lambton Facility Property – West of Property Boundary			
TW45-99* (S/D)	1.10	1.08	1.09
TW48-16S/TW48-00D	0.07	0.05	0.06
Lambton Facility Property – East of Property Boundary			
OW32-90 (S/D)	0.05	0.03	0..04
TW30-94/TW30-99D	0.04	-0.01	0.01
TW41-99 (S/D)	0.05	0.05	0.05
TW53-03 (S/D)	0.07	0.04	0.06
Off-Property to East			
TW57-11 (S/D)	0.07	0.04	0.06
Off-Property to South			
TW42-99S/TW49-00D	-0.01	-0.03	-0.02
TW43-99 (S/D)	0.00	-0.02	-0.01
TW55-09 (S/D)	0.05	0.04	0.045

Notes: (#) Average of spring and fall monitoring events for current monitoring period. N/A – packer installed in deep well (water level not obtained);
(*) Exhibits the effects of slow recovery at bedrock wells TW45-99(D) and TW61-13D between sampling events.

The hydraulic gradient was also upward at well pairs TW61-13D/TW61-13I (spring 2015); TW42-99S/TW49-00D and TW39-99D/TW39-99I (both monitoring events); and, at TW43-99D/TW43-99S, TW30-99D/TW30-94S, and TW40-99D/TW40-99S (fall 2016 event).

As discussed in the previous section, the vertical gradient below the site has been evolving as a result of changes in the potentiometric head in the Interface Aquifer. The increase in the potentiometric water level has been most pronounced at wells in the general vicinity of Petrolia Line and smaller in wells further to the south.

To illustrate the effects of this increase on the vertical gradients, the calculated gradients for nested shallow and deep monitoring wells located in the general vicinity of Petrolia Line and for installations further from Petrolia Line were graphed. The two sets of graphs are presented in **FIGURE 14**. The uppermost graph in **FIGURE 14** includes the hydraulic gradients calculated for a sub-set of the wells located along the northern boundary of the Lambton Facility, whereas the lower graph is for representative well nests along the southern boundary of the property that are further removed from Petrolia Line.

With reference to the uppermost graph in **FIGURE 14**, the hydraulic gradient at well nest TW22-94/TW22-99D has been consistently upward. The gradient at well nest TW39-99 has been relatively flat, fluctuating between slightly upward and downward. [Note: The gradient at well nest TW39-99 is calculated using the water level data observed at the intermediate depth well TW39-99I (installed in the native clay unit below the berm) and the data for deep well TW39-99D at this location.]

With the initiation of pumping at PW1-N and PW2-S(R11) in 2012, the hydraulic gradient reversed again to downward and with termination of this pumping, the magnitude of the downward gradient is decreasing. The magnitude of the downward hydraulic gradients at nests TW32-94-II/IV, TW35-94S/D/TW59-13S/D and TW46-99S/D have decreased slightly as a result of the general recovery in the water levels at the deeper well installations.

Per **FIGURE 14**, the hydraulic gradients at TW41-99(S&D), OW32-90(S&D), TW32-94S/TW30-99D, TW42-99S/TW49-00D and TW43-99(S&D) fluctuate on a seasonal basis, and in some instances [e.g., TW43-99(S&D)], the fluctuations result in a reversal of the gradient from downward to upward. The hydraulic gradient at TW42-99S/TW49-00D is consistently downward, although the magnitude of the gradient changes seasonally. [Note: TW49-00D is a poor producer and the water level is slow to recover. The downward gradient may be an artifact of purging/sampling and not the actual condition.]

A discussion of the vertical and horizontal hydraulic gradients and the possible influence on the evolution of the chemistry observed along the northern boundary of the Facility is provided in **SECTION 4.4.1** of this report.

3.1.2 Groundwater Chemistry Data – Shallow Wells (Active Aquitard)

This section presents the results of the chemical analyses conducted on groundwater samples collected from wells installed in the Active Aquitard (i.e., shallow overburden) during the 2016 reporting period.

The water quality database, which is accessible by Microsoft ACCESS 2016, is located in **APPENDIX H-4.4**. The locations of the various wells are shown in **FIGURE 2**.

3.1.2.1.1 Inorganic Chemistry Results

Inorganic parameters concentrations in samples collected from wells installed in the Active Aquitard are spatially variable, being influenced both by the chemical alteration of the parent soil material as a result of weathering and by the effects of activities occurring in the vicinity of the well. In comparison with the groundwater quality of the Interface Aquifer, samples from wells installed in the Active Aquitard, at locations removed from the Facility property and therefore not impacted by Facility operations, are enriched in sulphate, calcium and magnesium, and depleted in chloride, sodium and potassium.

A description of Existing Conditions in the vicinity of the Facility property, including a discussion of groundwater chemistry in the key stratigraphic units, is provided for information purposes in **APPENDIX H-1**.

The inorganic chemistry results are organized by the well groupings listed in **SECTION 2.1.3.2**, and discussed in the context of applicable regulatory standards/criteria, historical chemistry data for the individual wells and any water quality changes observed during the monitoring period.

Shallow Wells Located Off the Facility Property

Five of the existing shallow wells (TW55-09S, TW56-11S, TW57-11S, TW58-13S and TW59-13S) are installed at locations removed from the Lambton Facility property. The well locations are shown in **FIGURE 2**.

TW56-11S is located approximately 200 m east of the Facility property and about 10 metres south of the drainage ditch along Petrolia Line. Groundwater flow at this location is expected to be northward towards the roadside drainage ditch.

Based on the annual review of the data from historical well TW36-94S (which was replaced by TW56-11S in 2011), it was observed that the chloride and sodium concentrations in samples collected at this location were increasing. It was postulated that the source of the increase was deicing salt usage along Petrolia Line. To further investigate this source, a shallow well (TW58-11S) was installed in 2011 at a location between well TW56-11S and the roadside ditch.

TW57-11S is located about 600 m east of the southeast corner of the Facility property along a tree line adjacent to a cultivated field. The direction of shallow groundwater flow in the vicinity of this well is not known but could be influenced by tile drainage in the field.

TW59-13S is located on private property about 440 m west of the Lambton Facility and about 800 m south of Petrolia Line. This well is located at the upper end of a sub-watershed that drains towards the northeast to the Petrolia Line roadside ditch (AECOM, 2013). The pattern of shallow groundwater flow at this location is unknown but it is possible that it is locally influenced by the tile drainage in the adjacent farm fields.

TW55-09S is on adjacent property owned by Clean Harbors at a location about 380 m south of the Lambton Facility and about 900 m east of Telfer Road. The well is located along a fence line adjacent to a cultivated field. The field is tile drained with the drains running north to south towards discharge at the roadside ditch along Rokeby Line. Shallow groundwater flow at this location is expected to be influenced by the tile drainage.

The samples from the five wells within this well grouping provide information on local changes to groundwater chemistry, if any, which might be caused by activities not attributed to the Facility. The historical range in parameter concentrations for all five well s and the analytical results for samples collected in 2016 from these wells are presented in **TABLE 7**.

The concentrations of the major ions and metals at well TW59-13S (located west of the Facility property) have remained low in comparison with the other four wells. With reference to **FIGURE 2**, well TW59-13S is immediately north of a large woodlot and therefore isolated from common influencing factors including residential land use, winter maintenance on roadways, (i.e., deicing salt use) and agricultural practices (i.e., cultivation and fertilizer use). The chemistry of samples from TW59-13S is considered to be the most representative of pre-development shallow groundwater quality.

The chemistry for wells TW56-11S and TW58-11S (located near Petrolia Line east of the Facility property) shows greater variability than would be expected considering the wells are within 10 m of each other. The concentrations of major ions (alkalinity, chloride, calcium, magnesium, potassium and sodium) and TDS are elevated at TW58-11S in comparison with available data for TW56-11S.

The sulphate concentration at TW57-11S has been moderately elevated (462 mg/L to 907 mg/L) since the well was installed.

The concentrations of most parameters at TW55-09S, with the exception of sulphate, are low. The sulphate concentrations in recent samples are 416 mg/L (spring 2016) and 432 mg/L (fall 2016).

GRAPHS PRESENTING PARAMETER CONCENTRATION DATA WITH TIME: Graphs showing the average indicator parameter concentrations for the wells in this group [TW55-09S, TW56-11S TW57-11S, TW58-11S and TW59-13S] are provided in **FIGURE H-4.5-1.1**, **APPENDIX H-4.5**. The concentration averages have been calculated for different sets of wells, as follows:

- prior to fall 2009, the averages included the database for wells TW35-94-II, TW36-94-II, TW37-94-II;
- between the fall 2009 and fall 2011, wells TW36-94-II and TW37-94-II were not accessible and the data are limited to the analysis results for samples collected from well TW35-94-II and TW55-09S);
- between spring 2012 and fall 2012 the averages were calculated using data for wells TW35-94-II, TW36-94-II, TW37-94-II, TW55-09S, TW56-11S and TW57-11S;
- the spring 2013 concentrations exclude TW35-94-II, which was decommissioned in March 2013, but include replacement well TW59-13S, which was installed approximately 150 m west of TW35-94-II; and

- between the fall 2013 and the present, the averages were calculated using the database for TW55-09S, TW56-11S, TW57-11S and TW59-13S, as access to wells TW36-94-II and TW37-94-II was withheld.

Table 7. Shallow Wells Located Off the Facility Property

	Regulatory Criteria			Monitoring Wells Located Off-Site on Adjacent Property												Monitoring Wells on Adjacent Property to the East Known to be Impacted by Road Salt		
				TW59-13S			TW55-09S			TW56-11S			TW57-11S			TW58-11S		
Parameter	ODWS		PWQO	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators																		
pH [unitless]	6.50 - 8.50	(OG)	6.50 - 8.50	7.82 - 8.22	7.98	7.92	8.00 - 8.29	*7.95*	*7.81*	7.77 - 8.13	7.96	*7.69*	7.68 - 8.06	7.88	*7.58*	7.64 - 8.03	7.84	7.69
Conductivity [µS/cm]	-		-	855 - 971	884	911	1310 - 1440	*1290*	1340	2130 - 2390	2140	*2090*	1560 - 2230	*1290*	*2240*	3200 - 3430	3270	3200
Total Dissolved Solids	500	(AO)	-	550 - 631	**575**	**592**	317 - 1080	**903**	**938**	1400 - 2050	**1710**	**1670**	1090 - 1780	***838***	***1790***	2080 - 3250	**2130**	**2560**
Minor Ions – Anions																		
Alkalinity	30 - 500	(OG)	-	358 - 392	391	*400*	272 - 322	319	*324*	262 - 344	323	326	459 - 506	472	**506**	487 - 544	**537**	488
Chloride	250	(AO)	-	11 - 13	13	13	14 - 16	15	15	58 - 64	58	*56*	23 - 31	24	31	278 - 350	**312**	**302**
Sulphate	500	(AO)	-	103 - 164	122	116	430 - 521	*416*	432	907 - 1050	**926**	***845***	462 - 907	*267*	***912***	992 - 1160	***935***	**1150**
Major Ions – Cations																		
Calcium	-		-	91 - 102	101	*104*	148 - 170	160	170	251 - 336	296	284	181 - 306	*152*	*319*	302 - 385	343	364
Magnesium	-		-	48 - 57	52	55	70 - 87	75	77	128 - 161	135	132	109 - 174	*86*	165	218 - 280	256	248
Potassium	-		-	2.0 - 3.0	2	2	3	3	3	3 - 4	4	4	4 - 5	*3*	5	5 - 7	5	7
Sodium	200	(AO)	-	28 - 52	31	32	41 - 59	50	55	79 - 90	84	87	39 - 68	40	*69*	106 - 138	120	137
Major Ions – Nutrients																		
Ammonia	-		-	0.02 - 0.41	<0.025	0.12	<0.02 - 0.09	<0.025	<0.05	<0.02 - 0.32	<0.025	0.06	0.02 - 0.23	<0.025	0.08	<0.025 - 0.069	<0.025	<0.05
Nitrate	10	(MAC)	-	<0.1 - 1.26	0.36	0.76	<0.1 - 0.54	<0.1	<0.1	<0.1 - 0.37	0.23	<0.1	<0.1 - 0.15	<0.1	<0.1	0.10 - 0.21	<0.1	<0.1
Nitrite	1	(MAC)	-	<0.1 - 1.5	<0.1	<0.1	<0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Major Ions – Miscellaneous																		
Bromide	-		-	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25 - 0.43	<0.25	<0.25
Cyanide (Free)	0.2	(MAC)	0.005	<0.002 - <0.005	<0.005	<0.005	<0.002 - <0.01	<0.005	<0.005	<0.002 - <0.005	<0.005	<0.005	<0.002 - <0.01	<0.005	<0.005	<0.002 - <0.005	<0.005	<0.005
Fluoride	1.5	(MAC)	-	0.91 - 1.13	*0.63*	1.08	0.73 - 1.00	*0.62*	0.87	0.73 - 0.95	*0.56*	0.75	0.91 - 1.48	*0.53*	1.15	0.83 - 1.06	*0.55*	0.94
Metals																		
Arsenic	0.025	(MAC)	0.100	<0.001	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-
Barium	1	(MAC)	-	0.06 - 0.08	0.04	-	0.02 - 0.05	0.02	-	0.01 - 0.04	0.01	-	0.02 - 0.03	0.02	-	0.02 - 0.05	*0.01*	-
Boron	5	(IMAC)	0.2	0.1 - 0.14	*0.15*	-	0.17 - 0.42	0.29	-	0.32 - 0.39	*0.43*	-	0.16 - 0.25	*0.13*	-	0.20 - 0.30	*0.32*	-
Cadmium	0.005	(MAC)	0.0002	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-
Chromium (Total)	0.05	(MAC)	-	<0.001 - 0.003	<0.001	-	<0.001 - <0.005	<0.001	-	<0.001 - 0.002	<0.001	-	<0.001 - <0.005	<0.001	-	0.003 - <0.005	<0.001	-
Iron	0.3	(AO)	0.3	<0.03	<0.03	-	<0.03	<0.03	-	<0.03	<0.03	-	<0.03	<0.03	-	<0.03	<0.03	-
Lead	0.01	(MAC)	0.005	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-
Mercury	0.001	(MAC)	0.0002	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-
Nickel	-		0.025	<0.005	<0.005	-	<0.005 - 0.01	<0.005	-	<0.005 - 0.015	<0.005	-	<0.005	<0.005	-	0.007 - 0.014	<0.005	-
Zinc	5	(AO)	0.02	0.01	<0.01	-	<0.01 - 0.02	<0.01	-	<0.01 - 0.04	<0.01	-	<0.01 - <0.02	<0.01	-	0.01 - 0.02	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS).

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration.

Blue Shading – Indicates value exceeds Policy and Guidelines – Provincial Water Quality Objectives, The Ontario Ministry of the Environment and Energy, July 1994 (PWQO).

With the exception of Mercury, the PWQO criteria for metals apply to unfiltered sample. Protocol requires that all groundwater samples were filtered, and this factor should be recognized when reviewing the findings.

Italicized – Analytical result outside of historical concentration range for the parameter.

N/A - TW36-94-II and TW37-94-II were inaccessible during the Spring 2016 and Fall 2016 groundwater sampling events due to property access issues.

Unless otherwise stated, all units are reported in mg/L.

The chloride and sodium concentrations at TW58-11S are elevated, adding to the evidence supporting the interpretation that the shallow groundwater in the vicinity of TW56-11S and TW58-11S is under the influence of deicing salt use along Petrolia Line. The chemical data for well TW58-11S are not included in the group averages (**FIGURE H-4.5-1.1, APPENDIX H-4.5**) as its inclusion would skew the averages. The long term trends for the group of wells by indicator parameter are provided in the following table:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	No Trend	Increasing	Increasing	Increasing	Increasing	Decreasing	No Trend	Increasing

With reference to **FIGURE H-4.5-1.1** and the above table, the average concentration for sodium, potassium, sulphate, boron and fluoride for this group of wells is increasing. This increase is in part caused by the inclusion of data for wells installed in 2011, namely TW56-11S (which has a comparatively elevated chloride, potassium, sodium, sulphate and fluoride concentrations) and TW57-11S (elevated sulphate and fluoride concentrations). Barium has been decreasing over the period of record for this group of wells.

The concentration verses time graphs for the individual wells within the group are provided in **APPENDIX H-4.5-3**. Observations with regards to these graphs are summarized below:

Well	Concentration Trend for the Full Period of Record for Group[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW55-09S	No Trend	Increasing	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend
TW56-11S	Decreasing	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend
TW57-11S	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW58-11S	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW59-13S	Increasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	Increasing

Notes: The boron and barium concentration trend observations for well TW55-09S are based on seven sampling events, that for wells TW56-11S, TW57-11S and TW58-11S on six sampling events and for well TW59-13S on five events.

COMPARISON OF THE CURRENT YEARS ANALYTICAL RESULTS WITH APPLICABLE REGULATORY STANDARDS/CRITERIA: The standards/criteria considered are listed in **TABLE 7**. Parameters detected in samples from wells TW55-09S, TW56-11S, TW57-11S, TW58-11S and TW59-13S at concentrations that are equal to or exceed either the ODWS or the PWQO are listed in the table that follows:

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
TDS (500 mg/L)	TW55-09S (903 mg/L) TW56-11S (1,710 mg/L) TW57-11S (838 mg/L) TW58-11S (2,130 mg/L) TW59-13S (575 mg/L)	TW55-09S (938 mg/L) TW56-11S (1,670 mg/L) TW57-11S (1,790 mg/L) TW58-11S (2,560 mg/L) TW59-13S (592 mg/L)
Alkalinity (30 to 500 mg/L)	TW58-11S (537 mg/L)	TW57-11S (506 mg/L)
Sulphate (500 mg/L)	TW56-11S (926 mg/L) TW58-11S (935 mg/L)	TW56-11S (845 mg/L) TW57-11S (912 mg/L) TW58-11S (1,150 mg/L)

PWQO	Well at which PWQO is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
Boron (0.2 mg/L)	TW55-09S (0.29 mg/L) TW56-11S (0.43 mg/L) TW58-11S (0.32 mg/L)	Not analyzed

STATISTICAL ANALYSIS FOR WELL GROUP AND INDIVIDUAL WELLS: The statistical analysis for this group of wells is included in **APPENDIX H-4.6-1**. As noted in **SECTION 2.1.3.2**, the statistical analysis is completed for the sampling events conducted over the most recent five-year period and therefore encompasses a total of 10 events for bromide, chloride, fluoride, potassium, sodium and sulphate, which are analyzed twice a year and a total of 5 events for boron and barium, which are analyzed once a year). For wells TW56-11S, TW57-11S and TW59-13S the analysis encompasses the limited database for the interval between spring 2012 and fall 2016. The data for well TW58-11S was also excluded as this well is known to be affected by deicing salt use along Petrolia Line and the inclusion of the elevated concentration data would skew the statistical results.

Graphs showing the average indicator concentrations for this group of wells are provided in **FIGURE H-4.6-1.1**, **APPENDIX H-4.6**, with the results summarized in the table that follows:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	Decreasing	No Trend	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend

Notes: (1) The database for the individual wells and parameters on which the trend analysis is based varies.

Decreasing trends were identified for chloride, potassium and sulphate.

The trend analysis for the individual wells is presented in **Appendix H-4.6-2** and is summarized in the following Table:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW55-09S	No Trend	Increasing*	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend
TW56-11S	Decreasing	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend
TW57-11S	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW58-11S	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW59-13S	Increasing*	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend

Notes: (1) The database for the individual wells and parameters on which the trend analysis is based varies. (*) 2016 concentration below the maximum value previously observed at well.

Shallow Wells Installed in the North Berm

This well group includes three well nests, TW39-99 located at the northwest corner of the northern perimeter berm, TW46-99 at the northeast corner of the berm, and TW61-13 on the west leg of the berm. Each nest of three wells includes a well installed in the fill used to construct the berm (suffix "S") and a deeper well (suffix "I") installed in the underlying native overburden and a well installed at the overburden/bedrock interface (Interface Aquifer). Groundwater samples collected from the deeper Interface Aquifer monitoring wells are described in **Section 3.1.3**.

Well nest TW61-13 was installed in June 2013 as part of the investigation into the detection of Trichloroethylene at Interface Aquifer monitoring well TW22-99D. The well nest was subsequently added to the compliance monitoring program. The analytical database for this well nest (TW61-13) is limited to seven sampling events.

From observed water levels, the water table is mounded within the berm at all three locations (TW39-99, TW46-99 and TW61-13). Specifically, the water levels in TW39-99S, TW46-99S, and TW61-13S are at least one meter higher than their respective companion wells (TW39-99I, TW46-99I and TW61-13I), and several meters higher than the water levels observed in the monitoring wells located between the berm and the property boundary.

Because of the mounding, groundwater flow is expected to be downward through the berm fill and outward through the native overburden from the berm either to the drainage ditch that is present to the north along Petrolia Line and west to Telfer Road, or to the internal surface water drainage ditch located between the berm and the landfill cells.

The analytical results for this well group are presented in **Table 8**. The chemistry of samples from the six wells is influenced by the weathering and leaching of the clay fill used to construct the berm. The fill is a mixture of excavated material obtained during construction of the landfill cells. Based on regional and local studies, the chloride and sodium observed in the clay overburden originates primarily from the upward diffusion of these parameters into the overburden from the underlying bedrock.

The chloride and sodium concentrations increase with depth below ground surface. As the excavated clay from the landfill cells is a mixture of the strata encountered from surface to a depth as great as 24.4 m, the fill in the berms will have chloride and sodium concentrations representative of both the shallow overburden and the deeper clay. This clay is also known to contain sulphur-enriched minerals such as pyrite. The exposure/disturbance of the sulphide minerals to weathering/oxidation following excavation results in elevated sulphate concentrations in the groundwater producing a weak acid, which is buffered by the dissolution of carbonate minerals, specifically releasing calcium, magnesium and alkalinity, and inducing ion exchange thereby releasing sodium into solution. This phenomenon is described in Abbot (1987) and was considered to be the primary source of the sulphate-rich, shallow groundwater observed throughout the St. Clair Clay Plain.

As a group, most of the major ions observed in samples from the six shallow wells are elevated in comparison to wells that are located off the Facility property. On an individual well basis, the concentrations of most of the parameters in samples from the four older wells (TW39-99S, TW39-99I, TW46-99S and TW46-99I) have remained stable (i.e., lie within the historical concentration ranges for these parameters established at the wells) or have decreased. The exceptions during the 2016 monitoring interval [**Table 8**] follow:

- iron (spring 2016) exceeds the historical concentration range at TW39-99I;
- alkalinity (spring 2016 and fall 2016), conductivity (fall 2016), and calcium (fall 2016) exceeded the historical concentration range at TW46-99I;
- calcium (fall 2016) exceeded the historical concentration range for these parameters at TW46-99S;
- chloride (spring and fall 2016), sulphate (spring 2016), fluoride (spring and fall 2016) were below the historical concentration range at TW61-13I; and,
- calcium (spring and fall 2016) exceeded the historical calcium concentration range while pH (fall 2016), nitrate (spring and fall 2016), bromide (spring 2016) and fluoride (spring 2016) were below the historical concentration range at TW61-13S.

Table 8. Shallow Wells Installed in the North Berm

	Regulatory Criteria			Monitoring Wells Installed in the North Perimeter Berm								
				TW39-99I			TW39-99S			TW46-99I		
Parameter	ODWS		PWQO	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators												
pH [unitless]	6.50 - 8.50	(OG)	6.50 - 8.50	7.50 - 8.33	7.84	7.82	7.50 - 8.24	7.82	7.91	7.30 - 8.20	7.68	7.88
Conductivity [µS/cm]	-		-	1100 - 1700	1440	1440	1080 - 1500	1280	1280	1060 - 1410	1400	*1420*
Total Dissolved Solids	500	(AO)	-	868 - 1340	**936**	**936**	770 - 1420	**832**	**832**	772 - 1130	**910**	**994**
Minor Ions – Anions												
Alkalinity	30 - 500	(OG)	-	410 - 598	**579**	**550**	357 - 476	*487*	466	332 - 396	*408*	*417*
Chloride	250	(AO)	-	17 - 28.8	18	18	17.5 - 24	21	22	28.6 - 41	39	40
Sulphate	500	(AO)	-	287 - 389	292	295	257 - 477	270	258	213 - 390	380	383
Major Ions – Cations												
Calcium	-		-	82 - 123	112	118	100 - 128	121	128	121 - 163	162	*173*
Magnesium	-		-	89.7 - 124	116	118	62 - 90	87	83	66.4 - 97	92	92
Potassium	-		-	0.5 - 2.2	1	2	0.5 - 3.0	1	2	1.0 - 3.0	2	2
Sodium	200	(AO)	-	65 - 94	75	77	50 - 88.0	63	80	37.6 - 57	54	54
Major Ions – Nutrients												
Ammonia	-		-	<0.02 - 1.35	0.182	<0.05	<0.02 - 0.09	<0.025	<0.05	0.02 - 0.28	<0.025	0.06
Nitrate	10	(MAC)	-	0.074 - 0.5	<0.1	<0.1	0.12 - 0.53	0.19	*0.11*	<0.01 - 0.26	<0.1	<0.1
Nitrite	1	(MAC)	-	<0.01 - 0.12	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.02	<0.1	<0.1
Major Ions – Miscellaneous												
Bromide	-		-	0.18 - <3.5	0.3	0.28	<0.35 - <3.5	0.39	*<0.25*	0.025 - 0.36	<0.25	<0.25
Cyanide (Free)	0.2	(MAC)	0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005
Fluoride	1.5	(MAC)	-	0.57 - 1.5	0.61	0.92	0.6 - 1.3	*0.52*	0.71	0.3 - 1.2	0.45	0.51
Metals												
Arsenic	0.025	(MAC)	0.100	<0.001 - <0.01	0.002	-	<0.001 - <0.002	<0.001	-	<0.001 - <0.002	<0.001	-
Barium	1	(MAC)	-	0.04 - 0.07	0.04	-	0.03 - 0.05	0.03	-	0.03 - 0.08	0.04	-
Boron	5	(IMAC)	0.2	0.04 - 0.18	*0.19*	-	0.19 - 0.37	0.33	-	0.087 - 0.16	0.12	-
Cadmium	0.005	(MAC)	0.0002	<0.0001 - 0.004	<0.0001	-	<0.0001 - <0.003	<0.0001	-	<0.0001 - <0.003	<0.0001	-
Chromium (Total)	0.05	(MAC)	-	<0.001 - <0.005	<0.001	-	<0.001 - 0.006	<0.001	-	<0.0003 - 0.03	<0.001	-
Iron	0.3	(AO)	0.3	0.0025 - 0.23	***1.52***	-	<0.03 - 0.04	<0.03	-	<0.005 - 0.042	<0.03	-
Lead	0.01	(MAC)	0.005	<0.0001 - <0.002	<0.001	-	<0.0001 - <0.002	<0.001	-	<0.0001 - 0.002	<0.001	-
Mercury	0.001	(MAC)	0.0002	<0.0001 - 0.0003	<0.0001	-	<0.0001 - 0.0008	<0.0001	-	<0.0001 - <0.001	<0.0001	-
Nickel	-		0.025	<0.001 - <0.01	<0.005	-	<0.001 - <0.01	<0.005	-	<0.001 - <0.01	<0.005	-
Zinc	5	(AO)	0.02	<0.01 - 0.084	<0.01	-	<0.005 - 0.031	<0.01	-	<0.005 - 0.024	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS).

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration.

Blue Shading – Indicates value exceeds Policy and Guidelines – Provincial Water Quality Objectives, The Ontario Ministry of the Environment and Energy, July 1994 (PWQO).

With the exception of Mercury, the PWQO criteria for metals apply to unfiltered sample. Protocol requires that all groundwater samples were filtered, and this factor should be recognized when reviewing the findings.

Italicized – Analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.

Table 8 continued …

	Regulatory Criteria			Monitoring Wells Installed in the North Perimeter Berm								
				TW46-99S			TW61-13I			TW61-13S		
Parameter	**ODWS**		**PWQO**	**Historical Range**	**Spring 2016**	**Fall 2016**	**Historical Range**	**Spring 2016**	**Fall 2016**	**Historical Range**	**Spring 2016**	**Fall 2016**
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators												
pH [unitless]	6.50 - 8.50	(OG)	6.50 - 8.50	7.30 - 8.21	7.73	7.86	8.02 - 8.27	*7.93*	*7.7*	8.02 - 8.25	8.02	*7.64*
Conductivity [µS/cm]	-		-	1310 - 2400	1970	1900	971 - 1000	980	*965*	1200 - 1250	*1260*	1240
Total Dissolved Solids	500	(AO)	-	917 - 1980	**1280**	**1520**	631 - 660	**637**	***627***	786 - 890	**819**	**806**
Minor Ions – Anions												
Alkalinity	30 - 500	(OG)	-	270 - 375	318	300	329 - 372	347	341	368 - 457	420	428
Chloride	250	(AO)	-	23 - 100	40	29	23 - 24	*22*	*22*	20 - 21	20	20
Sulphate	500	(AO)	-	356 - 949	**779**	**783**	190 - 203	*189*	190	263 - 313	299	279
Major Ions – Cations												
Calcium	-		-	78 - 240	233	*243*	119 - 128	122	124	125 - 137	*140*	*140*
Magnesium	-		-	33 - 110	99	98	55 - 63	58	57	63 - 74	70	69
Potassium	-		-	5.0 - 19.0	9	11	<1.0 - 1.0	1	<1	3	3	3
Sodium	200	(AO)	-	89 - 220	131	115	23 - 30	25	27	63 - 68	65	66
Major Ions – Nutrients												
Ammonia	-		-	<0.02 - 0.36	<0.025	<0.05	<0.02 - 0.1	<0.025	0.06	<0.025 - 0.05	<0.025	<0.05
Nitrate	10	(MAC)	-	<0.1 - 0.88	0.27	0.32	<0.1 - 0.13	<0.1	<0.1	0.18 - 0.89	*0.11*	*0.14*
Nitrite	1	(MAC)	-	<0.01 - 0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Major Ions – Miscellaneous												
Bromide	-		-	0.12 - 0.9	0.26	<0.25	0.25	<0.25	<0.25	0.56 - 0.62	*0.55*	0.62
Cyanide (Free)	0.2	(MAC)	0.005	<0.002 - <0.02	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoride	1.5	(MAC)	-	<0.05 - 1.5	0.57	0.67	0.39 - 0.48	*0.31*	*0.38*	0.85 - 0.99	*0.56*	0.89
Metals												
Arsenic	0.025	(MAC)	0.100	<0.001 - <0.01	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-
Barium	1	(MAC)	-	0.019 - 0.068	0.02	-	0.06 - 0.07	0.07	-	0.07 - 0.08	*0.04*	-
Boron	5	(IMAC)	0.2	0.81 - 31	4.6	-	0.09 - 0.44	*0.08*	-	0.34 - 0.4	0.37	-
Cadmium	0.005	(MAC)	0.0002	<0.0001 - <0.003	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-
Chromium (Total)	0.05	(MAC)	-	<0.0003 - 0.004	<0.001	-	<0.001 - 0.003	<0.001	-	<0.001 - 0.004	<0.001	-
Iron	0.3	(AO)	0.3	<0.005 - 0.044	<0.03	-	<0.03	<0.03	-	<0.03	<0.03	-
Lead	0.01	(MAC)	0.005	<0.0005 - <0.002	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-
Mercury	0.001	(MAC)	0.0002	<0.0001 - <0.001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-
Nickel	-		0.025	<0.005 - 0.012	<0.005	-	<0.005	<0.005	-	<0.005 - 0.006	<0.005	-
Zinc	5	(AO)	0.02	<0.003 - 0.04	<0.01	-	<0.01 - 0.03	<0.01	-	<0.01 - 0.01	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS).

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration.

Blue Shading – Indicates value exceeds Policy and Guidelines – Provincial Water Quality Objectives, The Ontario Ministry of the Environment and Energy, July 1994 (PWQO).

With the exception of Mercury, the PWQO criteria for metals apply to unfiltered sample. Protocol requires that all groundwater samples were filtered, and this factor should be recognized when reviewing the findings.

Italicized – Analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.

PARAMETER CONCENTRATION WITH TIME GRAPHS: Graphs showing the averaged parameter concentrations for this group of wells and the concentrations for the individual wells on a sampling event basis are presented in the figures included in **APPENDIX H-4.5-1** and **APPENDIX H-4.5-3**, respectively. The long-term average concentration trends for the group are identified in the following table:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	Decreasing	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend

With reference to **FIGURE H-4.5-1.2**, the average parameter concentrations at the wells (TW39-99S, TW39-99I, TW46-99S, TW46-99I, TW61-13S and TW61-13I) exhibit significant variability between sampling events, with occasional spikes evident in the data.

The long-term concentration trends for individual wells are identified in the following table:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW39-99I	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW39-99S	Increasing	No Trend	No Trend	Decreasing	Increasing	No Trend	No Trend	No Trend
TW46-99I	Increasing	Increasing	No Trend	Increasing	No Trend	No Trend	No Trend	No Trend
TW46-99S	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend
TW61-13I	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing
TW61-13S	No Trend	Increasing	No Trend	Increasing	No Trend	Decreasing	No Trend	No Trend

COMPARISON OF THE CURRENT YEAR'S ANALYTICAL RESULTS WITH APPLICABLE REGULATORY STANDARDS/CRITERIA: With reference to **TABLE 8**, parameter concentrations at the individual wells that exceed either the ODWS or the PWQO are listed in the following table:

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
TDS (500 mg/L)	TW39-99I (936 mg/L) TW39-99S (832 mg/L) TW46-99I (910 mg/L) TW46-99S (1,280 mg/L) TW61-13I (637 mg/L)	TW39-99I (936 mg/L) TW39-99S (832 mg/L) TW46-99I (994 mg/L) TW46-99S (1,520 mg/L) TW61-13I (627 mg/L)

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	**Fall 2016**
	TW61-13S (819 mg/L)	TW61-13S (806 mg/L)
Alkalinity (30 to 500 mg/L)	TW39-99I (579 mg/L)	TW39-99I (550 mg/L)
Sulphate (500 mg/L)	TW46-99S (779 mg/L)	TW46-99S (783 mg/L)
Iron (0.3 mg/L)	TW39-99I (1.52 mg/L)	Not analyzed

PWQO	Well at which PWQO is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
Boron (0.2 mg/L)	TW46-99S (4.6 mg/L) TW61-13S (0.37 mg/L)	Not analyzed
Iron (0.3 mg/L)	TW39-99I (1.52 mg/L)	Not analyzed

The wells are located internal to the Facility property and by definition the data for these wells were not compared to the Guideline B-7 criteria.

STATISTICAL ANALYSIS FOR WELL GROUP AND INDIVIDUAL WELLS: The graphs presenting the results of the statistical analysis for this group of wells and the individual wells within the group are presented in **APPENDIX H-4.6**. The analysis encompasses data collected for the six wells over the interval between spring 2012 and fall 2016. The following tables summarized the content in the graphs for the group of wells and the individual wells:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	**Sodium**	**Potassium**	**Sulphate**	**Boron**	**Barium**	**Bromide**	**Fluoride**
Trend for Group	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	No Trend	Decreasing

Notes: (1) The database for the individual wells and parameters on which the trend analysis is based varies.

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW39-99I	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW39-99S	No Trend	Increasing*	No Trend	No Trend	Increasing *	No Trend	Decreasing	No Trend
TW46-99I	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW46-99S	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend
TW61-13I	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing
TW61-13S	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend

Notes: (1) The database for the individual wells and parameters on which the trend analysis is based varies. (*) 2016 concentration below the maximum value previously observed at well.

Shallow Wells Along Perimeter of Facility Property, Downgradient of North Berm

Seven (7) shallow wells (OW32-90S, OW35-90S, TW21-94-II, TW22-94, TW32-94-IV, TW40-99S and TW53-03S) are located between the perimeter berm that encompasses the northern portion of the Lambton Facility and the Facility property boundary (**FIGURE 2**). These wells are hydraulically downgradient of the northern perimeter berm. Shallow groundwater flow in the vicinity of the wells is expected to be outward from the berm towards the roadside drainage ditches along Petrolia Line (to the north) and Telfer Road (to the west), and to a shallow swale between the berm and the farm field to the east.

The analytical results for samples collected from these seven wells are presented in **TABLE 9**. The groundwater chemistry is expected to be influenced by groundwater contact with the clay used in construction of the berm (immediately upgradient from the wells).

In addition, four of the wells in the group (TW21-94-II, TW22-94, TW32-94-IV and TW40-99S) are relatively close to (<20 m) of Petrolia Line and Telfer Road and could be influenced by deicing salt use along the roadways. Chloride and sodium concentrations at three of these wells (TW22-94, TW32-94-IV and TW40-99S) are elevated in comparison to the wells in the group that are further removed from the roadways.

Well TW22-94 is located adjacent to wells TW22-99D and TW60-13D, which are installed in the Interface Aquifer. Both deep wells are under artesian conditions and overflow the casings. The external surface casings at the two deep wells are perforated to allow water that accumulates within the casing to discharge to the ground surface at the well head. The groundwater in the Interface Aquifer at TW22-99D and TW60-13D is mineralized and its discharge may be a secondary source of the chloride and sodium concentrations detected at TW22-94.

Table 9. Shallow Wells along Perimeter of Facility Property, Downgradient of North Berm

	Regulatory Criteria			Monitoring Wells along the Property Boundary, Downgradient of Nothern Perimeter Berm											
				OW32-90S			OW35-90S			TW21-94-II			TW22-94		
Parameter	ODWS		PWQO	Historical Range	Spring 2015	Fall 2015	Historical Range	Spring 2015	Fall 2015	Historical Range	Spring 2015	Fall 2015	Historical Range	Spring 2015	Fall 2015
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators															
pH [unitless]	6.50 - 8.50	(OG)	6.50 - 8.50	7.20 - 8.18	7.91	8.04	7.50 - 8.33	7.82	7.99	7.49 - 8.22	7.85	7.86	7.48 - 8.20	7.77	7.6
Conductivity [μS/cm]	-		-	933 - 1300	1150	1030	804 - 1500	1220	1030	742 - 1400	1080	1090	1029 - 1780	1690	1760
Total Dissolved Solids	500	(AO)	-	578 - 1100	**805**	**670**	631 - 1100	**854**	**721**	400 - 900	**702**	**708**	692 - 1520	**1100**	**1320**
Minor Ions – Anions															
Alkalinity	30 - 500	(OG)	-	200 - 347	290	286	200 - 321	260	261	210 - 489	320	415	340 - 458	434	444
Chloride	250	(AO)	-	10 - 45.1	15	16	8 - 36.6	10	7	6 - 16	9	10	30 - 73	56	73
Sulphate	500	(AO)	-	235 - 495	371	283	152 - 499	428	327	85 - 422	307	223	282 - 537	489	***550***
Major Ions – Cations															
Calcium	-		-	110 - 191	178	154	21.7 - 178	176	150	71.6 - 191	172	186	102 - 168	162	*178*
Magnesium	-		-	38.3 - 71	61	52	8 - 84	70	55	36 - 68	53	51	73.3 - 121	107	116
Potassium	-		-	2.0 - 6.0	2	3	0.8 - 5.4	3	3	<1 - 3.2	<1	<1	2.0 - 4.4	2	3
Sodium	200	(AO)	-	23 - 69.1	25	26	40 - 306	*36*	*33*	21 - 46	22	25	58.7 - 105	*109*	97
Major Ions – Nutrients															
Ammonia	-		-	<0.02 - 0.26	<0.025	<0.05	<0.02 - 0.44	<0.025	0.14	<0.02 - 0.24	<0.025	<0.05	<0.02 - 0.14	<0.025	0.09
Nitrate	10	(MAC)	-	<0.03 - 2.63	<0.1	0.12	<0.03 - 1.02	<0.1	<0.1	0.043 - <5	<0.1	<0.1	<0.01 - <2	<0.1	<0.1
Nitrite	1	(MAC)	-	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1
Major Ions – Miscellaneous															
Bromide	-		-	<0.05 - 0.9	<0.25	<0.25	<0.02 - 0.25	<0.25	<0.25	<0.02 - <3.5	<0.25	<0.25	<0.05 - <3.5	<0.25	<0.25
Cyanide (Free)	0.2	(MAC)	0.005	<0.002 - <0.02	<0.005	<0.005	0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005
Fluoride	1.5	(MAC)	-	0.026 - 0.9	0.37	0.47	0.4 - 1	0.47	0.47	0.29 - 1	*0.22*	*0.22*	0.78 - 1.3	*0.71*	1.09
Metals															
Arsenic	0.025	(MAC)	0.100	<0.001 - <0.06	<0.001	-	<0.001 - <0.06	<0.001	-	<0.001 - <0.06	<0.001	-	<0.001 - <0.06	<0.001	-
Barium	1	(MAC)	-	0.02 - 0.06	0.03	-	0.02 - 0.29	0.03	-	0.04 - 0.073	0.04	-	<0.002 - 0.058	0.02	-
Boron	5	(IMAC)	0.2	0.25 - 3.71	*0.21*	-	0.27 - 2.46	*0.25*	-	<0.03 - 0.309	0.08	-	<0.03 - 0.295	0.19	-
Cadmium	0.005	(MAC)	0.0002	<0.0001 - 0.004	<0.0001	-	<0.0001 - <0.005	<0.0001	-	<0.0001 - <0.005	<0.0001	-	<0.0001 - <0.005	<0.0001	-
Chromium (Total)	0.05	(MAC)	-	<0.001 - 0.007	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - 0.004	<0.001	-
Iron	0.3	(AO)	0.3	<0.005 - 0.05	<0.03	-	<0.005 - 0.06	*0.17*	-	<0.005 - 0.062	<0.03	-	<0.005 - 0.46	<0.03	-
Lead	0.01	(MAC)	0.005	<0.0005 - <0.05	<0.001	-	<0.0005 - <0.05	<0.001	-	<0.0005 - <0.025	<0.001	-	<0.0005 - <0.025	<0.001	-
Mercury	0.001	(MAC)	0.0002	<0.0001 - 0.00018	<0.0001	-	<0.0001 - 0.00016	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-
Nickel	-		0.025	<0.001 - 0.01	<0.005	-	<0.005 - <0.01	<0.005	-	0.001 - 0.006	<0.005	-	<0.001 - <0.01	<0.005	-
Zinc	5	(AO)	0.02	<0.003 - 0.05	<0.01	-	<0.005 - 0.09	<0.01	-	<0.005 - 0.045	<0.01	-	<0.003 - 0.097	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS).

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration.

Blue Shading – Indicates value exceeds Policy and Guidelines – Provincial Water Quality Objectives, The Ontario Ministry of the Environment and Energy, July 1994 (PWQO).

With the exception of Mercury, the PWQO criteria for metals apply to unfiltered sample. Protocol requires that all groundwater samples were filtered, and this factor should be recognized when reviewing the findings.

Italicized – Analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.

Table 9 continued...

Parameter	Regulatory Criteria			Monitoring Wells along the Property Boundary, Downgradient of Nothern Perimeter Berm								
				TW32-94-IV			TW40-99S			TW53-03S		
	ODWS		PWQO	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators												
pH [unitless]	6.50 - 8.50	(OG)	6.50 - 8.50	7.65 - 8.33	7.99	7.63	7.60 - 8.27	7.91	7.83	7.70 - 8.21	7.82	7.77
Conductivity [µS/cm]	-		-	915 - 1600	994	1170	780 - 1170	1020	1080	860 - 1480	1240	*1550*
Total Dissolved Solids	500	(AO)	-	595 - 1200	**646**	**760**	533 - 955	**663**	**702**	2.5 - 1110	**868**	**1080**
Minor Ions – Anions												
Alkalinity	30 - 500	(OG)	-	279 - 406	339	*412*	334 - 422	394	403	299 - 442	307	*449*
Chloride	250	(AO)	-	17.2 - 32	25	26	17 - 26	19	19	7 - 13	7	10
Sulphate	500	(AO)	-	148 - 564	192	236	126 - 215	213	199	173 - 516	426	476
Major Ions – Cations												
Calcium	-		-	72 - 195	99	121	77.7 - 106	100	106	100 - 225	195	*258*
Magnesium	-		-	40 - 88.5	55	70	52.5 - 74	68	70	40 - 84	67	*85*
Potassium	-		-	1.0 - 4.0	1	1	2.0 - 3.0	3	3	<1.0 - 3.0	<1	1
Sodium	200	(AO)	-	56 - 101	60	75	40 - 54.9	52	53	24 - 90	24	33
Major Ions – Nutrients												
Ammonia	-		-	<0.02 - 0.4	<0.025	0.1	<0.02 - 0.16	<0.025	<0.05	<0.02 - 0.28	<0.025	<0.05
Nitrate	10	(MAC)	-	<0.01 - <2	<0.1	<0.1	<0.1 - 3.23	<0.1	<0.1	<0.1 - 0.44	<0.1	<0.1
Nitrite	1	(MAC)	-	<0.01 - 0.12	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - 0.14	<0.1	<0.1
Major Ions – Miscellaneous												
Bromide	-		-	<0.02 - <3.5	<0.25	<0.25	<0.05 - <3.5	<0.25	<0.25	<0.05 - <1.8	<0.25	<0.25
Cyanide (Free)	0.2	(MAC)	0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005
Fluoride	1.5	(MAC)	-	0.56 - 1.2	*0.39*	0.76	0.79 - 1.4	1.14	1.07	0.40 - 0.97	*0.36*	*0.38*
Metals												
Arsenic	0.025	(MAC)	0.100	<0.001 - <0.6	<0.001	-	<0.001 - <0.002	<0.001	-	<0.001	<0.001	-
Barium	1	(MAC)	-	0.01 - 0.04	0.01	-	0.03 - 0.06	0.03	-	0.03 - 0.068	0.03	-
Boron	5	(IMAC)	0.2	0.12 - 0.405	0.12	-	0.15 - 0.215	*0.23*	-	0.09 - 0.19	0.11	-
Cadmium	0.005	(MAC)	0.0002	<0.0001 - 0.004	<0.0001	-	<0.0001 - <0.001	<0.0001	-	<0.0001 - <0.001	<0.0001	-
Chromium (Total)	0.05	(MAC)	-	<0.001 - 0.004	<0.001	-	<0.001 - 0.004	<0.001	-	<0.001 - <0.01	<0.001	-
Iron	0.3	(AO)	0.3	<0.005 - 0.682	<0.03	-	<0.005 - 0.038	<0.03	-	<0.03 - 0.04	<0.03	-
Lead	0.01	(MAC)	0.005	<0.0005 - <0.025	<0.001	-	<0.0005 - <0.002	<0.001	-	<0.0005 - <0.001	<0.001	-
Mercury	0.001	(MAC)	0.0002	<0.0001 - 0.0005	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-
Nickel	-		0.025	<0.001 - 0.02	<0.005	-	<0.001 - <0.01	<0.005	-	<0.01 - <0.005	<0.005	-
Zinc	5	(AO)	0.02	<0.005 - 0.04	<0.01	-	<0.003 - 0.067	<0.01	-	<0.005 - 0.02	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS).

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration.

Blue Shading – Indicates value exceeds Policy and Guidelines – Provincial Water Quality Objectives, The Ontario Ministry of the Environment and Energy, July 1994 (PWQO).

With the exception of Mercury, the PWQO criteria for metals apply to unfiltered sample. Protocol requires that all groundwater samples were filtered, and this factor should be recognized when reviewing the findi

Italicized – Analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.

PARAMETER CONCENTRATION WITH TIME GRAPHS: The averaged parameter concentrations for the group of seven wells (OW32-90S, OW35-90S, TW21-94-II, TW22-94, TW32-94-IV, TW40-99S and TW53-03S) with time and for the seven individual wells are presented in **APPENDIX H-4.5**. The following table summarizes the content in the graphs for the group of wells.

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	Decreasing	No Trend	Decreasing	Increasing	Decreasing	No Trend	No Trend	Decreasing

The following table summarizes the content in the graphs for the individual wells:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
OW32-90S	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	No Trend	No Trend	No Trend
OW35-90S	Decreasing	No Trend	No Trend	Increasing	Decreasing	No Trend	No Trend	No Trend
TW21-94-II	No Trend	No Trend	No Trend	Increasing	No Trend	No Trend	No Trend	Decreasing
TW22-94	Increasing	Increasing	No Trend	Increasing	No Trend	No Trend	No Trend	No Trend
TW32-94-IV	Increasing	No Trend	No Trend	Decreasing	Decreasing	No Trend	No Trend	Decreasing
TW40-99S	No Trend	No Trend	No Trend	Increasing	No Trend	No Trend	No Trend	Increasing
TW53-03S	No Trend	Decreasing	No Trend	Increasing	Decreasing	No Trend	No Trend	Decreasing

COMPARISON OF THE CURRENT YEAR'S ANALYTICAL RESULTS WITH APPLICABLE REGULATORY STANDARDS/CRITERIA: Parameters detected at Concentrations at the individual wells that exceed the ODWS, Guideline B-7 or the PWQO are listed in the following tables:

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
TDS (500 mg/L)	OW32-90S (805), OW35-90S (854), TW21-94-II (702), TW22-94 (1,100), TW32-94-IV (646), TW40-99S (663), TW53-03S (868)	OW32-90S (670), OW35-90S (721), TW21-94-II (708), TW22-94 (1,320), TW32-94-IV (760), TW40-99S (702), TW53-03S (1,080)
Sulphate (500 mg/L)		TW22-94 (550 mg/L)

PWQO	Well at which PWQO is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
Boron (0.2 mg/L)	OW32-90S (0.21 mg/L)	Not analyzed

Guideline B-7 Value derived for Off-Site Wells	Well at which Guideline B-7 Criteria is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
Sulphate (spring 2016 - 446 mg/L, 500 fall 2016 - mg/L)	TW22-94 (489 mg/L)	TW22-94 (550 mg/L)
Iron (spring 2016 - 0.16 mg/L)	OW35-90S (0.17 mg/L)	

STATISTICAL ANALYSIS FOR WELL GROUP AND INDIVIDUAL WELLS: The statistical analysis for this group of wells and the individual wells within the group are presented in **APPENDIX H-4.6** and summarized in the following tables.

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
OW32-90S	No Trend	No Trend	No Trend	Increasing*	Decreasing	No Trend	No Trend	No Trend
OW35-90S	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing
TW21-94-II	Increasing*	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend
TW22-94	No Trend	Increasing**	No Trend	Increasing**	No Trend	No Trend	No Trend	No Trend
TW32-94-IV	No Trend	No Trend	No Trend	No Trend	Decreasing	Decreasing	No Trend	No Trend
TW40-99S	No Trend	Increasing*	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW53-03S	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend

Notes: (1) The database for the individual wells and parameters on which the trend analysis is based varies. (*) 2016 concentration below the maximum value previously observed at well. (**) 2016 concentration above the maximum value previously observed at well.

Shallow Wells Along the Perimeter of Facility Property, Removed from the North Berm

Seven wells (TW30-94, TW41-99S, TW42-99S, TW43-99S, TW45-99S, TW62-13S and TW48-16S) are assigned to this group.

Well TW30-94 is located along the eastern edge of a wooded area in the southeast corner of the property. The well (TW30-94) is about 80 m southeast of the perimeter berm and 35 m west of the Facility property boundary. The property east of the Facility is cultivated. Shallow groundwater flow in the vicinity of TW30-94 is poorly defined. The ground surface in the vicinity of the well slopes gently to the northwest to a shallow surface depression that lies at the toe of the berm. The depression does not appear to be drained except by overland flow during wet conditions. The water table under normal or averaged conditions is shallow and the vegetation is typical of marshy/swampy conditions.

Well TW41-99S is located south of this same wooded area at the southeast corner of the property. The well (TW41-99S) is about 125 m east of the Pre-1986 Landfill and perimeter drainage ditch, 75 m south of the East Reservoir and 25 m northeast of the South Berm. The ground surface in the well's vicinity slopes gently to the southwest and there are local depressions that pond surface water under wet conditions. Groundwater movement in the vicinity of TW41-99S is undefined but would be expected to be influenced by the water stage at the East Reservoir and perimeter ditch, and mounding of the water table within the South Berm and in the Pre-1986 Landfill.

Two of the wells (TW42-99S and TW43-99S) are installed south of the Facility property boundary, along a tree line adjacent to a cultivated farm field.

Shallow groundwater flow south of the Facility property has not been defined but is presumably influenced locally by surface topography and by tile drainage, which underlies the cultivated land.

Wells TW48-16S, TW45-99S and TW62-13S are located along the west side of the Lambton Facility property. Well TW48-16S is located between the West Reservoir and Telfer Road. Well TW45-99S is located between the Gate 1 and Gate 2 entrances to the Facility. Well TW62-13S was installed a part of an investigation conducted to assess the rising chloride concentrations at TW45-99S. TW62-13S is located adjacent to the raised wastewater tile bed that services the Facility office complex. Shallow groundwater flow in the vicinity of the three wells (TW48-16S, TW45-99S and TW62-13S) is expected to be westward towards the roadside ditch along Telfer Road.

The analytical data for the group of seven wells (TW30-94, TW41-99S, TW42-99S, TW43-99S, TW45-99S, TW62-13S and TW48-16S) are presented in **TABLE 10**.

Table 10. Shallow Wells along Perimeter of Facility Property, Removed from North Berm

Parameter	Regulatory Criteria			Monitoring Wells along the Property Boundary but Removed from the Berm											
				TW30-94			TW41-99S			TW42-99S			TW43-99S		
	ODWS		PWQO	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators															
pH [unitless]	6.50 - 8.50	(OG)	6.50 - 8.50	7.60 - 8.40	8.04	7.75	7.40 - 8.14	7.79	7.45	7.40 - 8.25	7.67	7.86	7.40 - 8.29	8.03	7.88
Conductivity [µS/cm]	-		-	711 - 980	788	964	1220 - 1700	1450	1560	724 - 2970	*2990*	*3000*	1 - 1350	637	997
Total Dissolved Solids	500	(AO)	-	510 - 630	**512**	**627**	793 - 1250	**1020**	**1010**	471 - 2460	**2390**	**2400**	350 - 995	414	**648**
Minor Ions – Anions															
Alkalinity	30 - 500	(OG)	-	360 - 444	*349*	407	388 - 539	468	***588***	183 - 429	371	355	269 - 363	*259*	330
Chloride	250	(AO)	-	4 - 6	6	6	7 - 52	41	*60*	3 - 57	27	19	8 - 16	9	13
Sulphate	500	(AO)	-	90 - 151	117	151	279 - 603	344	238	162 - 1680	**1590**	***1710***	64 - 455	85	218
Major Ions – Cations															
Calcium	-		-	78.6 - 100	82	*106*	151 - 210	198	*236*	68 - 462	*479*	*509*	0.001 - 172	80	121
Magnesium	-		-	49 - 62	51	59	46 - 100	77	75	24 - 207	*222*	*229*	23 - 77.6	27	52
Potassium	-		-	1.0 - 4.0	2	3	1.0 - 4.0	2	1	1.0 - 6.0	5	*8*	1.0 - 3.4	2	2
Sodium	200	(AO)	-	27 - 49	40	42	46.1 - 65	52	56	37.1 - 105	67	76	29.0 - 56	29	42
Major Ions – Nutrients															
Ammonia	-		-	<0.02 - 0.49	<0.025	0.06	<0.02 - 0.18	<0.025	0.05	<0.02 - 0.47	<0.025	-	<0.02 - 0.37	<0.025	0.08
Nitrate	10	(MAC)	-	<0.1 - 1.28	<0.1	0.12	<0.1 - 0.26	<0.1	<0.1	0.045 - 0.9	<0.1	0.14	<0.1 - 0.24	<0.1	<0.1
Nitrite	1	(MAC)	-	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - 0.1	<0.1	<0.1	<0.01 - 0.13	<0.1	<0.1
Major Ions – Miscellaneous															
Bromide	-		-	<0.05 - <0.35	<0.25	<0.25	<0.05 - 0.26	<0.25	*0.76*	<0.25 - 1.39	<0.25	<0.25	<0.05 - 36.5	<0.25	<0.25
Cyanide (Free)	0.2	(MAC)	0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	-	<0.002 - <0.01	<0.005	<0.005
Fluoride	1.5	(MAC)	-	1.0 - 1.7	0.89	1.5	0.34 - 1.3	0.52	0.49	0.41 - 1.16	0.61	0.75	<0.1 - 1.1	0.35	0.78
Metals															
Arsenic	0.025	(MAC)	0.100	<0.001 - <0.002	<0.001	-	<0.001 - <0.002	<0.001	-	<0.001 - <0.002	<0.01	-	<0.001 - <0.002	<0.001	-
Barium	1	(MAC)	-	0.029 - 0.058	0.03	-	0.018 - 0.05	0.02	-	0.02 - 0.058	<0.1	-	0.02 - 0.063	0.03	-
Boron	5	(IMAC)	0.2	<0.03 - 0.18	0.12	-	0.06 - 0.342	0.2	-	0.12 - 0.2	*0.3*	-	0.05 - 0.358	0.1	-
Cadmium	0.005	(MAC)	0.0002	<0.0001 - <0.005	<0.0001	-	<0.0001 - <0.003	<0.0001	-	<0.0001 - <0.003	<0.001	-	<0.0001 - 0.004	<0.0001	-
Chromium (Total)	0.05	(MAC)	-	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.01	-	<0.001 - <0.01	<0.001	-
Iron	0.3	(AO)	0.3	<0.005 - 0.304	<0.03	-	<0.005 - 0.043	<0.03	-	<0.005 - 0.23	<0.3	-	<0.005 - 0.051	<0.03	-
Lead	0.01	(MAC)	0.005	<0.0005 - <0.01	<0.001	-	<0.0005 - <0.002	<0.001	-	<0.001 - <0.05	<0.01	-	<0.001 - <0.05	<0.001	-
Mercury	0.001	(MAC)	0.0002	<0.0001	<0.0001	-	<0.0001 - 0.0004	<0.0001	-	<0.0001 - 0.0013	<0.0001	-	<0.0001	<0.0001	-
Nickel	-		0.025	<0.001 - <0.01	<0.005	-	<0.001 - <0.01	<0.005	-	<0.005 - 0.017	<0.05	-	<0.001 - <0.01	<0.005	-
Zinc	5	(AO)	0.02	<0.003 - 0.039	<0.01	-	<0.003 - 0.061	<0.01	-	<0.01 - 0.079	<0.1	-	0.007 - 0.039	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS).

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration.

Blue Shading – Indicates value exceeds Policy and Guidelines – Provincial Water Quality Objectives, The Ontario Ministry of the Environment and Energy, July 1994 (PWQO).

With the exception of Mercury, the PWQO criteria for metals apply to unfiltered sample. Protocol requires that all groundwater samples were filtered, and this factor should be recognized when reviewing the findings.

Italicized – Analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.

N/A Denotes well was insufficient volume for sample, the parameter is not analyzed.

* denotes newly installed well with no historical data avaliable

Table 10 continued...

	Regulatory Criteria			Monitoring Wells along the Property Boundary but Removed from the Berm								
				TW45-99S			TW62-13S			TW48-16S		
Parameter	ODWS [mg/L]		PWQO [mg/L]	Historical Range [mg/L]	Spring 2016 [mg/L]	Fall 2016 [mg/L]	Historical Range [mg/L]	Spring 2016 [mg/L]	Fall 2016 [mg/L]	Historical Range* [mg/L]	Spring 2016 [mg/L]	Fall 2016 [mg/L]
General Indicators												
pH [unitless]	6.50 - 8.50	(OG)	6.50 - 8.50	7.58 - 8.26	8.03	7.8	8.18 - 8.26	*8.12*	*7.92*	-	8.01	7.67
Conductivity [µS/cm]	-		-	618 - 1220	1080	1000	980 - 1020	994	995	-	1070	1050
Total Dissolved Solids	500	(AO)	-	430 - 830	**702**	**650**	637 - 690	**646**	**647**	-	**696**	**682**
Minor Ions – Anions												
Alkalinity	30 - 500	(OG)	-	260 - 542	327	369	315 - 355	331	332	-	405	398
Chloride	250	(AO)	-	10.9 - 121	70	54	25 - 27	*28*	*32*	-	19	20
Sulphate	500	(AO)	-	6 - 190	160	112	187 - 226	*181*	*178*	-	190	182
Major Ions – Cations												
Calcium	-		-	67.8 - 144	141	137	106 - 118	110	116	-	112	119
Magnesium	-		-	26.9 - 51	42	41	42 - 48	44	44	-	64	63
Potassium	-		-	1.0 - 3.0	3	3	2.0 - 4.0	2	3	-	3	3
Sodium	200	(AO)	-	32.4 - 74	44	41	52 - 66	58	63	-	50	48
Major Ions – Nutrients												
Ammonia	-		-	0.02 - 0.26	<0.025	0.05	<0.02 - 0.32	<0.025	0.1	-	<0.025	<0.05
Nitrate	10	(MAC)	-	<0.1 - 0.33	<0.1	<0.1	0.13 - 0.26	<0.1	<0.1	-	<0.1	<0.1
Nitrite	1	(MAC)	-	<0.01 - 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1
Major Ions – Miscellaneous												
Bromide	-		-	<0.05 - 0.36	<0.25	<0.25	<0.25	<0.25	<0.25	-	<0.25	<0.25
Cyanide (Free)	0.2	(MAC)	0.005	<0.002 - <0.02	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.005
Fluoride	1.5	(MAC)	-	0.41 - 1.3	*0.27*	0.43	0.84 - 0.92	*0.52*	0.85	-	0.68	1.2
Metals												
Arsenic	0.025	(MAC)	0.100	0.0005 - 0.007	<0.001	-	<0.0001 - <0.01	<0.001	-	-	<0.001	-
Barium	1	(MAC)	-	0.05 - 0.14	0.06	-	0.06 - 0.09	*0.04*	-	-	0.03	-
Boron	5	(IMAC)	0.2	0.05 - 0.206	0.06	-	0.12 - 0.18	0.16	-	-	0.3	-
Cadmium	0.005	(MAC)	0.0002	<0.0001 - 0.003	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	-	<0.0001	-
Chromium (Total)	0.05	(MAC)	-	<0.001 - <0.01	<0.001	-	<0.001 - 0.003	<0.001	-	-	<0.001	-
Iron	0.3	(AO)	0.3	<0.005 - 2.52	0.03	-	<0.03	<0.03	-	-	<0.03	-
Lead	0.01	(MAC)	0.005	<0.0005 - <0.002	<0.001	-	<0.001	<0.001	-	-	<0.001	-
Mercury	0.001	(MAC)	0.0002	<0.0001 - 0.0012	<0.0001	-	<0.0001	<0.0001	-	-	<0.0001	-
Nickel	-		0.025	<0.001 - <0.01	<0.005	-	<0.005	<0.005	-	-	<0.005	-
Zinc	5	(AO)	0.02	<0.003 - 0.037	<0.01	-	<0.01 - 0.02	<0.01	-	-	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS).

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration.

Blue Shading – Indicates value exceeds Policy and Guidelines – Provincial Water Quality Objectives, The Ontario Ministry of the Environment and Energy, July 1994 (PWQO).

With the exception of Mercury, the PWQO criteria for metals apply to unfiltered sample. Protocol requires that all groundwater samples were filtered, and this factor should be recognized when reviewing th

Italicized – Analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.

N/A Denotes well was insufficient volume for sample, the parameter is not analyzed.

* denotes newly installed well with no historical data avaliable

Well TW62-13S was installed just prior to the fall 2013 sampling event and the database is limited to the seven sampling events that have been completed. Well TW48-16S was installed in January 2016 and the database is limited to two sampling events that have been completed.

The chloride concentration at TW41-99S has been steadily increasing since spring 2010 from a concentration of 7 mg/L to a current concentration of 60 mg/L (fall 2016). Bromide was detected in the fall 2016 sample at 0.76 mg/L, which is above the previous high concentration (0.43 mg/L, fall 2015) for this well. The other parameters at this well while exhibiting variability in concentrations between sampling events have remained within the historical range established for the individual parameters.

The sulphate concentration at TW42-99S is elevated (1,590 mg/L in spring 2016 and 1,710 mg/L in fall 2016). The chloride concentration has fluctuated significantly with a value of about 25 mg/L immediately following installation of TW42-99S, to a peak 57 mg/L in spring 2006 and a low of 3 mg/L in the fall 2008. The spring 2016 and fall 2016 chloride concentrations at TW42-99S are 27 mg/L and 19 mg/L, respectively. Sodium, potassium and fluoride concentrations also exhibit some variability between sampling events. With the exception of bromide (a single concentration spike of 1.4 mg/L in spring 2009) and boron (a single concentration spike of 0.3 mg/L in spring 2016) the concentrations of the other parameters have remained fairly stable.

The concentrations of most of the major and minor ions at TW43-99S are comparatively low and stable. The sulphate concentration at this well shows seasonal variability being elevated in the fall and lower in the spring. This continues to be evident in the most recent data [i.e., 85 mg/L (spring 2016) and 218 mg/L (fall 2016)].

The chloride concentration at well TW45-99S peaked at 121 mg/L in the spring 2013, which was determined to be statistically significantly and triggered an investigation into the chloride source. It was determined that the elevated chloride concentration was caused by deicing salt use along the road ways adjacent to the well, which raised the 'salt' content in the roadside ditches. Flooding of the ditch along Telfer Road due to a blocked culvert, allowed salt laden runoff to infiltrate and mix with shallow groundwater near the well. The chloride concentrations at TW45-99S has since declined with values of 70 mg/L in spring 2016 and 54 mg/L in fall 2016.

The database for TW62-13S is limited to seven sampling events. Parameters concentrations in samples from this well exhibit only minor variability. The well is located adjacent to the tile bed for the septic system at the Facility and the discharge may be buffering (i.e., moderating) the parameter concentrations.

PARAMETER CONCENTRATION WITH TIME GRAPHS: Graphs showing the averaged parameter concentrations for this group of wells and the concentrations for the individual wells on a sampling event basis are presented in figures included in **APPENDIX H-4.5-1** and **APPENDIX H-4.5-3**, respectively. The long-term concentration trends for the group are identified in the following table:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	Increasing	No Trend	No Trend	Increasing	Decreasing	Increasing	No Trend	No Trend

An increase in the average chloride concentration is evident in FIGURE H-4.5-1.4. This increase is attributed to the inclusion of data from TW41-99S and TW45-99S. The increasing average sulphate concentration for this group is attributed to the data for well TW42-99S, while the increase in barium concentration for the group is attributed to the inclusion of the data for well TW45-99S.

The long-term concentration trends for the individual wells are identified in the following table:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW30-94	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	Increasing
TW41-99S	Increasing	No Trend	Decreasing	Decreasing	Decreasing	No Trend	No Trend	Decreasing
TW42-99S	No Trend	Increasing	Increasing	Increasing	No Trend	Decreasing	No Trend	No Trend
TW43-99S	No Trend	No Trend	No Trend	Decreasing	Decreasing	No Trend	No Trend	No Trend
TW45-99S	Increasing	No Trend	No Trend	No Trend	Decreasing	Increasing	No Trend	Decreasing
TW62-13S	Increasing	No Trend	No Trend	Decreasing	No Trend	Decreasing	No Trend	No Trend
TW48-16S	Analysis limited to two sampling events.							

COMPARISON OF THE CURRENT YEAR'S ANALYTICAL RESULTS WITH APPLICABLE REGULATORY STANDARDS/CRITERIA:

Parameters detected at concentrations at the individual wells that exceed the ODWS and the Guideline B-7 criteria are listed in the following table:

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
TDS (500 mg/L)	TW30-94 (512), TW41-99S (1,020), TW42-99S (2,390), TW45-99S (702), TW62-13S (646), TW48-16S (696)	TW30-94 (627), TW41-99S (1,010), TW42-99S (2,400), TW43-99S (648), TW45-99S (650), TW62-13S (647), TW48-16S (682)
Alkalinity (30 to 500 mg/L)		TW41-99S (588)

PWQO	Well at which PWQO is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
Boron (0.2 mg/L)	TW42-99S (0.30 mg/L)	Not analyzed

Guideline B-7 Value derived for Off-Site Wells	Well at which Guideline B-7 Criteria is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
Alkalinity (spring 2016 - 438 mg/L, fall 2016 - 445 mg/L)	TW41-99S (458 mg/L)	TW41-99S (588 mg/L)
Sulphate (spring 2016 - 446 mg/L, fall 2016 – 500 mg/L)	TW42-99S (1,590 mg/L)	TW42-99S (1,710 mg/L)
Fluoride (spring 2016 - 0.81 mg/L, fall 2016 – 1.10 mg/L)	TW30-94 (0.89 mg/L)	TW30-94 (1.5 mg/L)

Statistical Analysis for Well Group and Individual Wells: The statistical analyses for this group of wells and the individual wells within the group are presented in **Appendix H-4.6**.

The results for this group of wells and the individual wells are summarized in the tables, which follow:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW30-94	Increasing*	Increasing*	No Trend	Increasing*	No Trend	No Trend	No Trend	No Trend
TW41-99S	Increasing**	No Trend	No Trend	No Trend	No Trend	No Trend	Increasing**	No Trend
TW42-99S	No Trend	No Trend	Increasing**	No Trend	No Trend	No Trend	No Trend	No Trend
TW43-99S	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW45-99S	No Trend	No Trend	Increasing*	Increasing*	Decreasing	No Trend	Decreasing	Decreasing
TW62-13S	Increasing**	No Trend	No Trend	Decreasing	No Trend	Decreasing	No Trend	No Trend
TW48-16S	Analysis limited to two data points – Insufficient data to complete trend analysis							

Notes: (1) The database for the individual wells and parameters on which the trend analysis is based varies. (*) 2016 concentration below the maximum value previously observed at well. (**) 2016 concentration above the maximum value previously observed at well. The database for TW62-13S for chloride, sodium, potassium, sulphate, bromide and fluoride is limited to seven samples in total and that for boron and barium is limited to four samples. The database for TW48-16S for chloride, sodium, potassium, sulphate, bromide and fluoride is limited to two samples in total and that for boron and barium is limited to one samples.

On an individual well basis, the chloride concentration in samples from TW41-99S exhibits a statistically significant increasing trend. The fall 2016 concentrations (60 mg/L) exceed the previous historical maximum value for chloride of 52 mg/L.

A surface water sample collected on March 31, 2015 at the south perimeter ditch near the East Reservoir had a chloride concentration of 39 mg/L. The increasing trend in chloride may be related to the general influence of the reservoir (outward flow under conditions when the water stage in the reservoir is elevated.

TW48-16S was installed as a replacement well for TW44-99S, which was decommissioned to allow for the construction of an additional surface water reservoir. The database for TW48-16S is therefore limited to two sampling events.

South Berm Monitoring Wells

The monitoring wells TW50-02A, TW51-02A and TW52-02A are installed at the north toe of the south berm adjacent to the perimeter drainage ditch that lies between Cell 19-1 and the Pre-1986 Landfill and the berm. Monitoring Wells TW50-02B, TW51-02B and TW52-02B are installed through the fill of the berm into the underlying clay overburden. The locations of the wells are shown in **Figure 2**. The south berm wells were installed to assess the effectiveness of the berm as a barrier to southerly flowing groundwater from the Pre-1986 Landfill area. The program required that the wells only be sampled for chloride and sodium. As part of the landfill expansion, monitoring of these six wells was expanded to include the full parameters list (**Section 2.1.2.5)** on a semi-annual basis. As such, the database for most of the parameters at the south berm wells is currently limited to two sampling events.

The analytical results for this group of wells during the 2016 monitoring period are presented in **Table 11**.

Comparison of the Current Year's Analytical Results with Applicable Regulatory Standards/Criteria:
Parameters detected at concentrations at the individual wells that exceed the ODWS in 2016 are listed in the following table:

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
TDS (500 mg/L)	TW50-01A (1110), TW51-02A (715), TW52-02A (1030) TW50-01B (793), TW51-02B (1010), TW52-02B (631)	TW50-01A (1140), TW51-02A (805), TW52-02A (1220) TW50-01B (696), TW51-02B (1040), TW52-02B (806)
Alkalinity (30 - 500 mg/L)		TW52-02A (579)

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Table 11. Shallow Wells Installed Along South Berm

Parameter	Regulatory Criteria			Monitoring Wells Installed In North Toe of South Berm									Monitoring Wells Installed Through South Berm								
				TW50-02A			TW51-02A			TW52-02A			TW50-02B			TW51-02B			TW52-02B		
	ODWS		PWQO	Historical Range*	Spring 2016	Fall 2016	Historical Range*	Spring 2016	Fall 2016	Historical Range*	Spring 2016	Fall 2016	Historical Range*	Spring 2016	Fall 2016	Historical Range*	Spring 2016	Fall 2016	Historical Range*	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators																					
pH [unitless]	6.50 - 8.50	(OG)	6.50 - 8.50	-	8.09	7.78	-	7.83	7.93	-	7.73	7.85	-	7.85	7.85	-	7.73	7.91	-	7.71	7.88
Conductivity [µS/cm]	-		-	-	1590	1490	-	1100	1150	-	1470	1740	-	1220	1070	-	1440	1490	-	971	1240
Total Dissolved Solids	500	(AO)	-	-	**1110**	**1040**	-	**715**	**805**	-	**1030**	**1220**	-	**793**	**696**	-	**1010**	**1040**	-	**631**	**806**
Minor Ions – Anions																					
Alkalinity	30 - 500	(OG)	-	-	426	404	-	343	313	-	430	**579**	-	447	405	-	435	427	-	435	432
Chloride	250	(AO)	-	16 - 20.7	*21*	20	15 - 18.4	*14*	*14*	40 - 92.7	21	43	2 - 27.8	12	6	17 - 20	19	20	9 - 13	*5*	11
Sulphate	500	(AO)	-	-	488	437	-	298	319	-	453	426	-	259	227	-	401	418	-	150	258
Major Ions – Cations																					
Calcium	-		-	-	168	184	-	131	140	-	177	204	-	124	163	-	145	151	-	171	126
Magnesium	-		-	-	110	92	-	69	71	-	93	119	-	74	53	-	88	89	-	42	73
Potassium	-		-	-	2	3	-	2	2	-	3	2	-	3	3	-	4	3	-	2	3
Sodium	200	(AO)	-	52.0 - 64	*66*	57	28.0 - 37	*38*	36	56.0 - 77	58	69	12.0 - 126	72	27	71.0 - 90	90	*93*	64.0 - 74	*11*	73
Major Ions – Nutrients																					
Ammonia	-		-	-	<0.025	0.11	-	<0.025	0.18	-	<0.025	0.08	-	<0.025	0.23	-	<0.025	0.13	-	<0.025	0.07
Nitrate	10	(MAC)	-	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	0.24	-	<0.1	<0.1	-	<0.1	<0.1
Nitrite	1	(MAC)	-	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1
Major Ions – Miscellaneous																					
Bromide	-		-	-	<0.25	<0.25	-	<0.25	<0.25	-	<0.25	<0.25	-	<0.25	<0.25	-	<0.25	<0.25	-	<0.25	<0.25
Cyanide (Free)	0.2	(MAC)	0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005
Fluoride	1.5	(MAC)	-	-	0.52	1.11	-	0.78	0.9	-	0.83	0.6	-	1.23	0.32	-	0.9	1.07	-	0.17	1.15
Metals																					
Arsenic	0.025	(MAC)	0.100	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001	-
Barium	1	(MAC)	-	-	0.02	-	-	0.06	-	-	0.01	-	-	0.02	-	-	0.02	-	-	0.02	-
Boron	5	(IMAC)	0.2	-	0.22	-	-	0.16	-	-	0.32	-	-	0.3	-	-	0.39	-	-	0.09	-
Cadmium	0.005	(MAC)	0.0002	-	<0.0001	-	-	<0.0001	-	-	<0.0001	-	-	<0.0001	-	-	<0.0001	-	-	<0.0001	-
Chromium (Total)	0.05	(MAC)	-	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001	-
Iron	0.3	(AO)	0.3	-	<0.03	-	-	<0.03	-	-	<0.03	-	-	<0.03	-	-	<0.03	-	-	1.43	-
Lead	0.01	(MAC)	0.005	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001	-
Mercury	0.001	(MAC)	0.0002	-	<0.0001	-	-	<0.0001	-	-	<0.0001	-	-	<0.0001	-	-	<0.0001	-	-	<0.0001	-
Nickel	-		0.025	-	<0.005	-	-	<0.005	-	-	<0.005	-	-	<0.005	-	-	<0.005	-	-	<0.005	-
Zinc	5	(AO)	0.02	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS).

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration.

Blue Shading – Indicates value exceeds Policy and Guidelines – Provincial Water Quality Objectives, The Ontario Ministry of the Environment and Energy, July 1994 (PWQO).

With the exception of Mercury, the PWQO criteria for metals apply to unfiltered sample. Protocol requires that all groundwater samples were filtered, and this factor should be recognized when reviewing the findings.

Italicized – Analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.
N/A Denotes well was insufficient volume for sample, the parameter is not analyzed.

* Denotes historical range limited to 2 sampling events.

PWQO	Well at which PWQO is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
Boron (0.20 mg/L)	TW50-02A (0.22), TW52-02A (0.32) TW50-02B (0.30), TW51-02B (0.39)	Not analyzed

Shallow Wells Internal to the Facility Property Influenced by Waste Handling/Disposal

Well TW63-13S is located internal to the Facility property and the chemistry of samples from this wells is known to be affected by Facility operations.

Well TW63-13S was installed during the investigation of increasing chloride concentrations at TW45-99S (RWDI, 2014b). The well is located at the west edge of the vehicle maintenance compound, which has been in active use since the Facility was established in the 1960s. Groundwater movement in the vicinity of the well is expected to be influenced by a number of factors including: structures, pavement and buried services within the maintenance area; the Pre-1986 Landfill to the west and south; and the water stage in the drainage channel located immediately west of TW62-13S. The channel drains to a process water pond located adjacent to the Facility incinerator building. The water in the process pond is extracted when required for incineration purposes.

The 2016 chemistry results for well TW63-13S are included in **TABLE 12**, along with the historical ranges in the concentrations for the individual parameters.

The database for well TW63-13S is limited to seven sampling events, and a few additional chloride and sodium analyses conducted during the TW45-99S chloride investigation (RWDI, 2014b).

Table 12. Shallow Wells Internal to Facility Property Influenced by Waste Handling/Disposal

	Regulatory Criteria			Monitoring Wells Internal to Facility Property		
				TW63-13S		
Parameter	ODWS		PWQO	Historical Range*	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators						
pH [unitless]	6.50 - 8.50	(OG)	6.50 - 8.50	7.95 - 8.10	*7.8*	*7.58*
Conductivity [µS/cm]	-		-	2480 - 2840	2690	2580
Total Dissolved Solids	500	(AO)	-	1610 - 2250	**1750**	**1680**
Minor Ions – Anions						
Alkalinity	30 - 500	(OG)	-	389 - 415	*439*	*420*
Chloride	250	(AO)	-	552 - 668	**578**	**584**
Sulphate	500	(AO)	-	78 - 80	*66*	*64*
Major Ions – Cations						
Calcium	-		-	223 - 236	230	230
Magnesium	-		-	90 - 106	97	94
Potassium	-		-	4.0 - 5.0	*3*	4
Sodium	200	(AO)	-	166.0 - 196	191	194
Major Ions – Nutrients						
Ammonia	-		-	<0.02 - 0.11	<0.025	0.09
Nitrate	10	(MAC)	-	<0.01 - 0.16	<0.1	<0.1
Nitrite	1	(MAC)	-	<0.1	<0.1	<0.1
Major Ions – Miscellaneous						
Bromide	-		-	1.71 - 2.54	*0.94*	*1.43*
Cyanide (Free)	0.2	(MAC)	0.005	<0.005	<0.005	<0.005
Fluoride	1.5	(MAC)	-	0.61 - 0.76	*0.37*	0.75
Metals						
Arsenic	0.025	(MAC)	0.100	<0.001 - <0.1	<0.001	-
Barium	1	(MAC)	-	0.16 - 0.19	*0.14*	-
Boron	5	(IMAC)	0.2	0.2 - 0.38	0.28	-
Cadmium	0.005	(MAC)	0.0002	<0.0001 - 0.0001	<0.0001	-
Chromium (Total)	0.05	(MAC)	-	<0.001 - 0.004	<0.001	-
Iron	0.3	(AO)	0.3	<0.03	<0.03	-
Lead	0.01	(MAC)	0.005	<0.001	<0.001	-
Mercury	0.001	(MAC)	0.0002	<0.0001	<0.0001	-
Nickel	-		0.025	0.077 - 0.092	0.089	-
Zinc	5	(AO)	0.02	0.01 - 0.02	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS)

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration.

Blue Shading – Indicates value exceeds Policy and Guidelines – Provincial Water Quality Objectives, The Ontario Ministry of the Environment and Energy, July 1

With the exception of Mercury, the PWQO criteria for metals apply to unfiltered sample. Protocol requires that all groundwater samples were filtered, and this fa

Italicized – Analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.
N/A Denotes well was insufficient volume for sample, the parameter is not analyzed.

* Denotes historical range limited to 2 sampling events.

TDS, a number of major ions (calcium, magnesium, sodium and chloride), bromide, and some metals (barium, boron and nickel) are present in the samples at concentrations that are elevated with respect to wells installed off-property and along the property boundary.

PARAMETER CONCENTRATION WITH TIME GRAPHS: Graphs showing the averaged parameter concentrations for the individual wells on a sampling event basis are presented in figures included in **APPENDIX H-4.5-3** and the information is summarized below:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW63-13S	No Trend	Increasing	No Trend	Decreasing	No Trend	Decreasing	Decreasing	No Trend

Note: (1) The database for TW63-13S for chloride, sodium, potassium, sulphate, bromide and fluoride is limited to seven samples in total and that for boron and barium is limited to four samples.

COMPARISON OF THE CURRENT YEAR'S ANALYTICAL RESULTS WITH APPLICABLE REGULATORY STANDARDS/CRITERIA: Regulatory standards/criteria that are exceeded in samples collected at TW63-13S are listed in the following tables:

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
TDS (500 mg/L)	TW63-13S (1,750)	TW63-13S (1,680)
Chloride (250 mg/L)	TW63-13S (578)	TW63-13S (584)

PWQO	Well at which PWQO is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
Boron (0.20 mg/L)	TW63-13S (0.28)	Not analyzed
Nickel (0.025 mg/L)	TW63-13S (0.089)	Not Analyzed

STATISTICAL ANALYSIS OF INDIVIDUAL WELLS: The results of the statistical analysis for TW63-13S (**FIGURE H-4.6-2.27, APPENDIX H-4.6**), follows:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW63-13S	No Trend	Increasing*	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend

Notes: (*) 2016 concentration below the maximum value previously observed at well. The database for TW63-13S for chloride, sodium, potassium, sulphate, bromide and fluoride is limited to seven samples in total and that for boron and barium is limited to four samples.

3.1.2.1.2 Organic Groundwater Chemistry

The prescribed monitoring program requires samples to be collected from the monitoring wells and submitted for the organic compounds listed in **SECTION 2.1.2.5** every two years. The most recent event was completed in spring 2015. The next monitoring event is scheduled for spring 2017.

3.1.3 Groundwater Chemistry Data – Deep Wells (Interface Aquifer)

This section presents the results of the chemical analyses conducted on groundwater samples collected from wells installed in the Interface Aquifer (i.e., overburden/bedrock contact zone) during the 2016 reporting period. The water quality database, which is accessible by Microsoft ACCESS 2016 or newer, is located in **APPENDIX H-4.4**. The locations of the wells installed in the Interface Aquifer are shown in **FIGURE 3**.

3.1.3.1 Inorganic Groundwater Chemistry

Deep Wells Located Off the Facility Property

Wells TW55-09D, TW56-11D, TW57-11D and TW59-13D are located on adjacent property some distance removed from the Lambton Facility. Wells TW56-11D and TW57-11D were installed east of the Facility property on property owned by Clean Harbors. These two wells were installed in the general area of historical wells TW36-94-I and TW37-94-I.

TW55-09D is located on adjacent property owned by Clean Harbors at a location about 800 m south of the Lambton Facility. TW59-13D is installed on Clean Harbors owned property approximately 150 m to the west of an earlier well (TW35-94-I), which it replaced.

The analytical results for samples from these wells are presented in **TABLE 13**. The chemistry for these wells is considered to be representative of background conditions. The historical range for the individual parameters in samples collected at TW59-13D is limited to eight monitoring events.

Table 13. Deep Wells Located Off the Facility Property

Parameter	Regulatory Criteria		Interface Aquifer Wells on Adjacent Properties			Interface Aquifer Wells on Adjacent Properties								
			TW55-09D			TW56-11D			TW57-11D			TW59-13D		
	ODWS		Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators														
pH [unitless]	6.50 - 8.50	(OG)	8.32 - 8.53	*8.27*	*8.15*	8.12 - 8.42	8.36	8.25	7.84 - 8.44	8.25	8.03	8.13 - 8.37	8.14	8.22
Conductivity [µS/cm]	-		1720 - 1870	1780	1760	1550 - 1770	1570	1560	1530 - 2310	1930	2100	864 - 939	898	880
Total Dissolved Solids	500	(AO)	1030 - 1220	**1160**	**1140**	580 - 1150	**1020**	**1010**	690 - 1500	**1250**	**1360**	410 - 610	**584**	**572**
Minor Ions – Anions														
Alkalinity	30 - 500	(OG)	272 - 302	297	290	329 - 353	351	335	298 - 432	385	398	242 - 288	*293*	273
Chloride	250	(AO)	362 - 411	**383**	***344***	282 - 334	**282**	**285**	299 - 448	**371**	**440**	110 - 129	122	121
Sulphate	500	(AO)	2 - 27	*1*	*1*	1 - 7	*<1*	1	<1 - 4	<1	<1	2 - 15	*1*	*<1*
Major Ions – Cations														
Calcium	-		14 - 22	21	22	21 - 31	24	26	15 - 23	22	*24*	16 - 18	17	18
Magnesium	-		6 - 8	7	7	8 - 11	9	9	6 - 9	8	8	5 - 6	5	5
Potassium	-		2.0 - 4.0	3	3	1.0 - 3.0	3	3	1.0 - 3.0	2	2	1.0 - 3.0	2	2
Sodium	200	(AO)	316 - 385	**369**	**366**	283 - 366	**314**	**352**	291 - 474	**404**	**444**	170 - 191	*192*	176
Major Ions – Nutrients														
Nitrate	10	(MAC)	<0.1	<0.1	<0.1	<0.1	*0.11*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite	1	(MAC)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Major Ions – Miscellaneous														
Bromide	-		<0.25 - 2.96	<0.25	0.44	0.38 - 1.73	<0.25	0.46	0.38 - 4.11	<0.25	0.55	0.39 - 0.65	*0.28*	0.41
Cyanide (Free)	0.2	(MAC)	<0.002 - <0.01	<0.005	<0.005	<0.002 - 0.006	<0.005	<0.005	<0.002 - <0.005	<0.005	<0.005	<0.002 - <0.005	<0.005	<0.005
Fluoride	1.5	(MAC)	1.54 - 1.88	*1.18*	*1.25*	1.21 - 1.48	*0.84*	*1.13*	1.22 - 1.69	*0.95*	1.27	1.45 - 1.65	*1.13*	*1.4*
Metals														
Arsenic	0.025	(MAC)	<0.001 - <0.01	<0.001	-	0.001 - <0.01	<0.001	-	0.002 - <0.01	0.002	-	<0.01 - 0.002	<0.001	-
Barium	1	(MAC)	0.14 - 0.29	0.21	-	0.13 - 0.25	*0.12*	-	0.11 - 0.14	0.11	-	0.1 - 0.18	0.1	-
Boron	5	(IMAC)	1.3 - 1.9	1.8	-	2.2 - 2.5	2.2	-	1.6 - 2.4	2.2	-	1.2 - 1.4	1.4	-
Cadmium	0.005	(MAC)	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-
Chromium (Total)	0.05	(MAC)	<0.001 - 0.007	<0.001	-	<0.001 - 0.004	<0.001	-	0.002 - 0.037	<0.001	-	<0.001 - 0.003	<0.001	-
Iron	0.3	(AO)	<0.03 - 0.47	0.08	-	<0.03 - 0.59	0.24	-	0.23 - 7.5	**4.48**	-	<0.03 - 0.14	*0.3*	-
Lead	0.01	(MAC)	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-
Mercury	0.001	(MAC)	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-
Nickel	-		<0.005	0.006	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Zinc	5	(AO)	<0.005 - <0.01	<0.01	-	<0.01 - 0.03	<0.01	-	<0.01 - 0.02	<0.01	-	<0.01 - 0.03	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS);

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; and, IMAC = Interim Maximum Acceptable Concentration.

Italicized – analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.

N/A - TW36-94-I and TW37-94-I were inaccessible during the Spring 2016 and Fall 2016 groundwater sampling events due to property access issues.

GRAPHS PRESENTING PARAMETER CONCENTRATION DATA WITH TIME: Graphs, showing the average indicator parameter concentrations for the wells in this group [TW55-09D, TW56-11D TW57-11D and TW59-13D], are provided in **FIGURE H-4.5-2.1, APPENDIX H-4.5-2**.

The concentration averages have been calculated for different sets of wells, as follows:

- prior to fall 2009, the averages included the database for historical wells TW35-94-I, TW36-94-I, TW37-94-I;
- between the fall 2009 and fall 2011, wells TW36-94-I and TW37-94-I were not accessible and the data are limited to the analysis results for samples collected from well TW35-94-I and TW55-09D);
- between spring 2012 and fall 2012 the averages were calculated using data for wells TW35-94-I, TW36-94-I, TW37-94-I, TW55-09D, TW56-11D and TW57-11D;
- the spring 2013 concentrations exclude TW35-94-I, which was decommissioned in March 2013, but include replacement well TW59-13D, which was installed approximately 150 m west of TW35-94-I; and
- between fall 2013 and the present (fall 2015), the averages were calculated using the database for TW55-09D, TW56-11D, TW57-11D and TW59-13D, as access to wells TW36-94-I and TW37-94-I was withheld.

The long term trend for the group of wells is summarized by parameter in the following table:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	Increasing	Increasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend

With reference to **FIGURE H-4.5-2.1** and the above table, the average concentration for chloride and sodium for this group of wells have increased with time. This increase appears to be caused by the changes made to the network of monitoring wells starting in 2009, which added well (TW55-09D). The chloride and sodium concentrations at well TW55-09D are comparatively elevated. The effects of adding this well, are evident in **FIGURE H-4.5-2.1**. When the data are averaged into the data for other wells average chloride and sodium concentrations are increased. With the addition of the data for TW59-13D, which is generally less mineralized in comparison with the other three wells, the concentrations have either stabilized or declined.

Allowing for occasional 'spikes' the averaged boron, barium, bromide and fluoride concentrations are relatively stable. For bromide, the observed spike in the averaged bromide concentration is related to a single sample from TW57-11D (bromide concentration of 4.1 mg/L collected during the spring 2013 event). Bromide concentrations at TW57-11D have steadily declined [spring 2016 (<0.25 mg/L) and fall 2016 (0.55 mg/L)].

The concentration verses time graphs for the individual wells within the group are provided in **APPENDIX H-4.5-4**. Observations with regards to these graphs are summarized in the following table:

Well	Concentration Trend for the Full Period of Record for Group[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW55-09D	No Trend	No Trend	No Trend	Decreasing	No Trend	Increasing	Decreasing	Decreasing
TW56-11D	No Trend	No Trend	No Trend	Decreasing	No Trend	Decreasing	Decreasing	Decreasing
TW57-11D	Increasing	Increasing	No Trend	No Trend	Increasing	No Trend	Decreasing	Decreasing
TW59-13D	Increasing	No Trend	No Trend	Decreasing	Increasing	No Trend	Decreasing	Decreasing

Notes: (1) The concentration trend observations for the wells TW56-11D and TW57-11D are based on ten sampling events. The concentration trend observations for well TW59-13D is based on eight sampling events.

On an individual well basis, the sulphate concentration at TW55-09D following its installation in 2009 was elevated (>20 mg/L) in comparison with the sulphate concentration at other wells installed in the Interface Aquifer at off-property locations. It was initially postulated that the elevated sulphate concentration at TW55-09D was caused by the purging methodology (conventional drawdown and recovery) being employed (see discussion in 2014/2015 Groundwater Report [RWDI, 2016]).

Subsequent assessment determined that the elevated sulphate concentration in the wells is an artifact of their installation. Specifically, during the installation of these wells the bedrock was cored using municipal water that has a comparatively elevated sulphate concentration. Given the slow recovery of wells such as TW55-09D, it could take a substantial period of time until the residual drill water is either extracted through development/purging or has dispersed in the Interface Aquifer.

The sulphate concentrations at the four wells (TW55-09D, TW56-11D, TW57-11D and TW59-13D) in 2016 are <5 mg/L, which is representative of the sulphate concentration in the Interface Aquifer.

The intra-well Upper Control Limits (UCLs) were not calculated for the metals (boron and barium) at TW55-09D, TW56-11D, TW57-11D, or TW59-13D because the database includes less than the requisite eight (8) analyses required to determine the UCLs. There were no exceedances of the UCLs during 2016 for the individual wells within this well grouping.

Comparison of the Current Year's Analytical Results with Applicable Regulatory Standards/Criteria:

Parameters detected at concentrations at the individual wells that exceed the ODWS in 2016 are listed in the following table:

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
TDS (500 mg/L)	TW55-09D (1,160), TW56-11D (1,020), TW57-11D (1,260), TW59-13D (584)	TW55-09D (1,140), TW56-11D (1,010), TW57-11D (1,360), TW59-13D (5872
Chloride (250 mg/L)	TW55-09D (383), TW56-11D (282),	TW55-09D (344), TW56-11D (285),

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
	TW57-11D (371)	TW57-11D (440)
Sodium (200 mg/L)	TW55-09D (369), TW56-11D (314), TW57-11D (404)	TW55-09D (366), TW56-11D (352), TW57-11D (444)

Statistical Analysis for Well Group and Individual Wells: The statistical analysis for this group of wells is included in **Appendix H-4.6**. The analysis encompasses the database for wells TW55-09D, TW56-11D, TW57-11D and TW59-13D for the interval between spring 2012 and fall 2016.

Graphs showing the average indicator concentrations for this group of wells are provided in **Figure H-4.6-1-5, Appendix H-4.6**, with the results summarized in the table that follows:

The trend analysis for the individual wells is presented in **Figure H-4.6-3.1** through **Figure H-4.6-3.4**, **Appendix H-4.6-3** and is summarized in the following table:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	Decreasing	No Trend	No Trend	Decreasing	No Trend	Decreasing	Decreasing	Decreasing

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW55-09D	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	Decreasing
TW56-11D	Decreasing	No Trend	No Trend	Decreasing	No Trend	Decreasing	Decreasing	Decreasing
TW57-11D	Increasing*	Increasing*	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend
TW59-13D	Increasing*	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	Decreasing

Note: (1) The database considered in the trend analysis varies by well and parameter. * . (*) 2016 concentration below the maximum value previously observed at well.

Deep Wells Internal to the Facility Property

A number of wells (OW1-92, TW33-94-I, TW39-99D, TW46-99D, TW54-09D and TW61-13D) were installed internal to the Lambton Facility property (**Figure 3**) for various purposes in the past. Wells OW1-92, TW33-94-I and TW34-94-I, as discussed below, were decommissioned in 2016 with MOECC concurrence.

OW1-92, which was located in the central area of the property east of the Thermal Desorption Unit, was initially installed as a test well to evaluate the viability of using low capacity extraction wells for purging groundwater from the Interface Aquifer. OW1-92 was decommissioned in June 2016 to allow for the construction of the expanded landfills waste receiving pits. OW1-92 was sampled during the spring 2016 event and the data are included herein.

TW33-94-I was located at the south edge of the Central Processing Area and TW34-94-I was adjacent to the access road that extends north-south between Cell 16 and the Pre-1986 Landfill. The wells were installed to characterize groundwater conditions internal to the property immediately adjacent to the older waste cells. TW33-94-I was decommissioned in June 2016 to allow for the future installation of the leachate collection system headers through this portion of the site. TW33-94-I was sampled during the spring 2016 event and the data are included herein.

TW34-94-I was damaged in late December 2015 during construction of the new waste cell. This well was decommissioned in January 2016 and was not sampled in 2016.

TW39-99D, TW46-99D and TW61-13D have been installed through the north perimeter berm into the underlying Interface Aquifer. TW39-99D is at the northwest corner of the berm and TW46-99D is at the northeast corner of the berm. These two wells were installed to assess the influence of the berm on the potentiometric surface in the Interface Aquifer and on the vertical gradients between the fill of the berm and the Interface Aquifer.

Well TW61-13D was installed as part of investigations conducted to identify the source of the Trichloroethylene detected at TW22-99D (Section 2.6.1). The hydraulic conductivity of the Interface Aquifer at this location is very low and the well is slow to recover after purging/sampling.

Well TW54-09D was installed to replace well OW2-92 (a former test well used to evaluate the viability of using low capacity extraction wells for purging of the Interface Aquifer).

TW54-09D is located in the immediate vicinity of two former deep disposal wells that are on the property and the data collected have been used to determine whether there are any effects on the Interface Aquifer from the past disposal of liquid waste in deep underlying bedrock formations.

The analytical results for the spring 2016 and fall 2016 monitoring events for this group of wells are listed in **TABLE 14**.

GRAPHS PRESENTING PARAMETER CONCENTRATION DATA WITH TIME: GRAPHS, showing the average indicator parameter concentrations for the wells in this group are provided in **FIGURE H-4.5-2.2, APPENDIX H-4.5-2**.

The concentration averages up to fall 2009 included data for OW2-92, which was subsequently decommissioned and replaced with TW54-09D. The concentration averages up to fall 2015 included data for TW34-94-I. The averages up to spring 2016 include data for OW1-92 and TW33-94-I. The chemistry at TW61-13D is anomalous indicating the presence of residual drill water and the data have not been included in the calculation of average concentrations.

The long term trend for the group of wells is summarized by parameter in the following table:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	Decreasing	Decreasing	Decreasing	Increasing	No Trend	Decreasing	No Trend	Increasing

The averaged chloride, sodium and potassium concentrations for this group declined between 1991 and 2002 and have since stabilized. For the most part, the averaged concentrations for these three parameters are similar to the average concentrations observed for the off-property wells. The averaged sulphate and boron have remained relatively stable in comparison to the off-property wells.

The bromide concentrations for both the group and the off-property wells fluctuate between sampling events. As the bromide concentrations are low, the variability is more likely related to analytical sensitivity than a natural phenomenon. The average fluoride concentration for the group has increased over the last 5 years.

The concentration verses time graphs for the individual wells within the group are provided in **Appendix H-4.5-4**. Observations with regards to these graphs are summarized below:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
OW1-92[1]	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW33-94-I[1]	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW39-99D	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend
TW46-99D	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW54-09D	No Trend	No Trend	No Trend	Decreasing	No Trend	Decreasing	Decreasing	No Trend
TW61-13D	Well not fully developed. Chemistry suggests presence of residual drill water.							

Notes: (1) Well decommissioned in June 2016. Trend analysis includes data for spring 2016 only.

Table 14. Deep Wells Internal to the Facility Property (Interface Aquifer)

	Regulatory Criteria		Interface Aquifer Wells Internal to the Site									Interface Aquifer Wells Internal to the Site								
			OW1-92			TW54-09D			TW33-94-I			TW39-99D			TW46-99D			TW61-13D		
Parameter	ODWS		Historical Range	Spring 2016	Fall 2016*	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016*	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators																				
pH [unitless]	6.50 - 8.50	(OG)	7.80 - 8.43	8.15	-	8.26 - 8.64	*8.13*	*8.19*	7.65 - 8.65	8.22	-	7.87 - 8.54	7.91	*7.74*	7.80 - 8.71	7.82	7.68	8.20 - 8.53	8.3	8.31
Conductivity [µS/cm]	-		1030 - 2210	1400	-	880 - 954	908	915	653 - 1315	1100	-	1470 - 2400	1600	1570	1000 - 1400	1180	1190	939 - 1260	1060	*1320*
Total Dissolved Solids	500	(AO)	670 - 1240	**910**	-	520 - 620	**590**	**595**	413 - 820	**715**	-	810 - 1230	**1040**	**1020**	630 - 845	**767**	**774**	540 - 819	**689**	***858***
Minor Ions – Anions																				
Alkalinity	30 - 500	(OG)	285 - 461	388	-	245 - 281	271	281	214 - 736	313	-	312 - 421	352	346	300 - 356	323	316	226 - 300	267	*313*
Chloride	250	(AO)	194 - 518	220	-	116 - 144	123	132	95.6 - 344	166	-	274 - 460	**294**	**304**	153 - 265	186	197	128 - 207	154	*225*
Sulphate	500	(AO)	<0.5 - 100	1	-	<1 - 12	<1	<1	0.49 - 5	<1	-	0.49 - 5.9	<1	<1	0.47 - 4.7	<1	<1	17 - 67	24	*12*
Major Ions – Cations																				
Calcium	-		11 - 77	27	-	15 - 18	18	18	10 - 31	22	-	18 - 35.7	28	31	14 - 20	19	*23*	17 - 27	21	21
Magnesium	-		4 - 33	10	-	5 - 7	6	6	5.2 - 10	7	-	7 - 13.1	9	9	4.8 - 7.1	6	6	5 - 7	6	6
Potassium	-		0.4 - 3.3	2	-	2.0 - 3.0	2	2	1.0 - 3.0	2	-	1.0 - 2.1	2	2	1.0 - 4.0	2	2	1 - 2	2	1
Sodium	200	(AO)	223 - 438	**290**	-	161 - 196	185	193	131 - 270	**223**	-	262 - 415	**301**	**286**	216 - 290	**244**	**246**	187 - 246	**211**	***275***
Major Ions – Nutrients																				
Nitrate	10	(MAC)	<0.01 - <1	<0.1	-	<0.1 - 0.14	<0.1	<0.1	<0.01 - <5	<0.1	-	0.015 - <1	<0.1	<0.1	<0.021 - 0.46	<0.1	<0.1	<0.01 - 0.11	<0.1	<0.1
Nitrite	1	(MAC)	<0.01 - <0.2	<0.1	-	<0.10	<0.1	<0.1	<0.01 - <0.2	<0.1	-	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01	<0.1	<0.1
Major Ions – Miscellaneous																				
Bromide	-		<0.25 - <3.5	0.28	-	0.4 - 1.1	*0.28*	0.4	0.07 - 0.92	0.25	-	<0.25 - 0.98	<0.25	0.7	<0.35 - 1.62	*<0.25*	0.6	<0.25 - 0.64	0.31	0.49
Cyanide (Free)	0.2	(MAC)	<0.002 - <0.05	<0.005	-	<0.002 - <0.01	<0.005	<0.005	<0.002 - <0.05	<0.005	-	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoride	1.5	(MAC)	0.92 - 2	1.23	-	1.43 - 1.77	*1.01*	*1.33*	0.87 - 1.45	*0.84*	-	0.99 - 2	*0.93*	1.46	1 - 1.8	*0.97*	1.38	1.35 - 1.69	*0.9*	*1.22*
Metals																				
Arsenic	0.025	(MAC)	<0.0002 - <0.06	<0.001	-	<0.001 - <0.1	<0.001	-	<0.001 - <0.06	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - 0.002	<0.001	-	0.003 - 0.004	0.003	-
Barium	1	(MAC)	0.088 - 0.36	0.12	-	0.13 - 0.3	0.11	-	0.15 - 0.76	0.16	-	0.1 - 0.312	0.15	-	0.08 - 0.2	0.13	-	0.08 - 0.13	*0.05*	-
Boron	5	(IMAC)	<0.03 - 2.61	2.1	-	1.4 - 1.7	1.6	-	0.007 - 2.3	2	-	1.7 - 2.4	2	-	1.5 - 2.09	1.7	-	1.4 - 1.6	1.6	-
Cadmium	0.005	(MAC)	<0.0001 - 0.005	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.005	<0.0001	-	<0.0001 - 0.003	<0.0001	-	<0.0001 - 0.003	<0.0001	-	<0.0001 - <0.0004	<0.0001	-
Chromium (Total)	0.05	(MAC)	0.0002 - 0.008	<0.001	-	0.001 - 0.004	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - 0.008	<0.001	-	0.0003 - 0.007	<0.001	-	<0.001 - 0.002	<0.001	-
Iron	0.3	(AO)	0.003 - 1.87	**0.43**	-	<0.03 - 0.06	*0.17*	-	<0.005 - 0.3	0.11	-	0.008 - <0.05	<0.03	-	0.018 - 0.054	***0.59***	-	<0.03 - 0.04	*0.1*	-
Lead	0.01	(MAC)	<0.0005 - <0.06	<0.001	-	<0.001	<0.001	-	<0.0005 - <0.025	<0.001	-	<0.0005 - <0.002	<0.001	-	<0.0005 - <0.002	<0.001	-	<0.001	<0.001	-
Mercury	0.001	(MAC)	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001 - 0.0007	<0.0001	-	<0.0001 - 0.00048	<0.0001	-	<0.0001 - <0.001	<0.0001	-	<0.0001	<0.0001	-
Nickel	-		<0.001 - 0.02	<0.005	-	<0.005	<0.005	-	<0.001 - <0.01	<0.005	-	<0.001 - <0.01	0.005	-	<0.001 - <0.01	0.01	-	<0.005	<0.005	-
Zinc	5	(AO)	<0.001 - 0.05	<0.01	-	<0.01 - 0.04	<0.01	-	<0.003 - 0.07	<0.01	-	<0.005 - 0.096	<0.01	-	<0.003 - 0.19	<0.01	-	<0.01 - 0.02	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS);

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; and, IMAC = Interim Maximum Acceptable Concentration.

Italicized – analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.

* Well was decomissioned in Fall 2016

Sulphate was detected in a sample collected from OW1-92 during the spring 2014 event at a concentration (17 mg/L). This concentration was significantly elevated in comparison with the prior (fall 2013) sample (<1 mg/L) from the well and concentrations that are typically observed for the Interface Aquifer. The sulphate concentration in fall 2014 (10 mg/L) and spring 2015 (100 mg/L) samples from OW1-92 are also comparatively elevated. The well was resampled immediately following the spring 2015 event and the sulphate concentration in the sample (110 mg/L) confirmed the initial result. The sulphate concentration at OW1-92 in the fall 2015 sample subsequently declined to 9 mg/L. The well was resampled on December 3, 2015 with a sulphate concentration of 8 mg/L confirming this lower value. The spring 2016 sulphate concentration at OW1-92 subsequently declined further to 1 mg/L.

The elevated sulphate concentration at this well is attributed to the introduction of potable water used during the decommissioning of adjacent well TW38-94-II and the presence of residual drill water in the Interface Aquifer. This water was sourced from the municipal supply at the Facility and is known to have a sulphate concentration that is substantially higher then water in the Interface Aquifer. The decline in the suphate concentrations in the recent samples is attributed to the enhanced purging of the Interface Aquifer in the vicinity of OW1-92 via pumping from PW4-03, another nearby well of larger diameter. It appears that the drill water had dispersed prior to decommissioning of OW1-92 in June 2016.

No UCL exceedances were observed in this group of wells in 2016 (**APPENDIX H-4.5-4**).

COMPARISON OF THE CURRENT YEAR'S ANALYTICAL RESULTS WITH APPLICABLE REGULATORY STANDARDS/CRITERIA: Parameters detected at concentrations at the individual wells that exceed the ODWS in 2016 are listed in the following table:

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
TDS (500 mg/L)	OW1-92 (910), TW33-94-I (715), TW39-99D (1,040), TW46-99D (767), TW54-09D (590), TW61-13D (689)	TW39-99D (1,020), TW46-99D (774), TW54-09D (595), TW61-13D (858)
Chloride (250 mg/L)	TW39-99D (294)	TW39-99D (304)
Sodium (200 mg/L)	OW1-92 (290), TW33-94-I (223), TW39-99D (301), TW46-99D (244), TW61-13D (211)	TW39-99D (286), TW46-99D (246), TW61-13D (275)
Iron (0.3 mg/L)	OW1-92 (0.43), TW46-99D (0.59)	Not Analyzed

STATISTICAL ANALYSIS FOR WELL GROUP AND INDIVIDUAL WELLS: The statistical analysis for this group of wells is included in **APPENDIX H-4.6**.

Graphs showing the average indicator concentrations for this group of wells are provided in **FIGURE H-4.6-1-6, APPENDIX H-4.6**. The results of the statistical analysis are summarized in the table that follows:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	Decreasing	No Trend

The trend analysis for the individual wells is presented in **Figure H-4.6-3.5** through **Figure H-4.6-3.11**, **Appendix H-4.6-3** and is summarized in the following table:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
OW1-92[2]	No Trend	Decreasing	Increasing*	No Trend	No Trend	Decreasing	No Trend	No Trend
TW33-94-I[2]	Decreasing	No Trend	No Trend	Decreasing	No Trend	Decreasing	Decreasing	No Trend
TW39-99D	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend
TW46-99D	No Trend	No Trend	No Trend	Decreasing	Decreasing	No Trend	Decreasing	No Trend
TW54-09D	Decreasing	No Trend	No Trend	Decreasing	Decreasing	Decreasing	Decreasing	No Trend

Note: (1) The database considered in the trend analysis varies by well and parameter. (2) Well decommissioned in June 2016. Trend analysis includes data for spring 2016 only. (*) 2016 concentration below the maximum value previously observed at well.

A statistically significant increasing trend was identified for potassium at OW1-92 (**Figure H-4.6-3.5, Appendix H-4.6**), however the spring 2016 concentration remained below the historical maximum value observed at the well.

As noted, the chemistry at TW61-13D is anomalous indicating the presence of residual drill water. With purging, there has been a steady increase in the concentrations for chloride, sodium and potassium, whereas the sulphate concentration has been declining.

Deep Wells Along the Perimeter of the Facility Property

Fourteen (14) wells [OW32-90D, OW35-05D, TW22-99D, TW30-99D, TW32-94-II, TW40-99D, TW41-99D, TW43-99D, TW45-99D, TW47-00D, TW48-00D, TW49-00D, TW53-03D, and TW60-13D] are located around the perimeter of the Lambton Facility (**Figure 3**). These wells are used to monitor changes in chemistry with time at the Facility's point of compliance.

The analytical results for this group of wells during the 2016 monitoring period are presented in **Table 15**.

Table 15. Deep Wells along the Perimeter of the Facility Property (Interface Aquifer)

Parameter	Regulatory Criteria		Monitoring Wells along the Perimeter of the Site														
			OW32-90D			OW35-05D			TW22-99D			TW30-99D			TW32-94-II		
	ODWS		Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators																	
pH [unitless]	6.50 - 8.50	(OG)	7.61 - 8.40	8.14	8.07	7.60 - 8.43	8.13	8.16	7.60 - 8.48	8.05	7.94	7.80 - 8.57	8.18	8.12	7.60 - 8.52	8.45	8.24
Conductivity [µS/cm]	-		1200 - 1500	1380	1420	1240 - 1380	1300	1330	3400 - 5410	4520	4640	1200 - 1600	*1180*	*1190*	1190 - 3340	2410	2400
Total Dissolved Solids	500	(AO)	603 - 942	**897**	**923**	690 - 897	**845**	**864**	2300 - 3220	**2940**	**3020**	630 - 1010	**767**	**774**	309 - 2170	**1570**	**1560**
Minor Ions – Anions																	
Alkalinity	30 - 500	(OG)	210 - 263	254	246	255 - 334	275	275	600 - 766	**757**	**727**	243 - 312	274	245	234 - 300	264	254
Chloride	250	(AO)	190 - 400	**284**	**304**	234 - 266	244	**258**	932 - 1690	**1020**	**1170**	225 - 355	*208*	*208*	227 - 930	**597**	**644**
Sulphate	500	(AO)	<0.5 - 10.6	<1	<1	<0.5 - 3	<1	<1	<0.1 - 5	<1	<1	0.53 - 4	<1	<1	<1 - 7	<1	<1
Major Ions – Cations																	
Calcium	-		19.6 - 41	25	20	17 - 28	24	25	21 - 67	32	36	18 - 28	24	26	11.6 - 24	17	23
Magnesium	-		7 - 13	8	*6*	6 - 9	8	8	8 - 19.2	13	14	7 - 10	8	8	6 - 19	14	15
Potassium	-		1.5 - 5.2	3	2	2.0 - 2.4	2	2	2.0 - 4.0	3	4	<1 - 3.0	2	3	1.0 - 4.0	3	3
Sodium	200	(AO)	170 - 280	**278**	**248**	218 - 310	**243**	**231**	777 - 1250	**987**	**994**	195 - 320	**231**	**237**	220 - 631	**482**	**489**
Major Ions – Nutrients																	
Nitrate	10	(MAC)	<0.002 - 0.22	<0.1	<0.1	<0.1	<0.1	<0.1	0.018 - <1	<0.1	<0.1	<0.1 - <0.5	<0.1	<0.1	<0.01 - <5	<0.1	<0.1
Nitrite	1	(MAC)	<0.01 - <0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1
Major Ions – Miscellaneous																	
Bromide	-		0.16 - 2.3	<0.25	0.71	0.15 - 2.11	0.25	0.46	<0.2 - 4	<0.25	0.53	0.15 - 1.81	<0.25	0.47	0.15 - 0.82	0.26	0.56
Cyanide (Free)	0.2	(MAC)	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.05	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005
Fluoride	1.5	(MAC)	0.5 - 1.6	1.11	1.44	1.11 - 1.55	*1.01*	*1.04*	<0.05 - 3.2	0.56	0.74	1.1 - 1.62	1.13	1.47	0.76 - 1.7	0.82	1.17
Metals																	
Arsenic	0.025	(MAC)	<0.001 - <0.06	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.01	-	<0.001 - <0.002	<0.001	-	<0.001 - <0.06	<0.001	-
Barium	1	(MAC)	0.072 - 0.23	0.2	-	0.11 - 0.22	0.15	-	0.29 - 0.597	0.4	-	0.29 - 0.46	0.39	-	0.11 - 0.23	*0.38*	-
Boron	5	(IMAC)	0.97 - 2.1	1.6	-	1.4 - 1.9	1.8	-	3.09 - 5.36	***5.6***	-	1.4 - 2	1.9	-	1.6 - 3.83	2.6	-
Cadmium	0.005	(MAC)	<0.0001 - 0.005	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.003	<0.001	-	<0.0001 - <0.003	<0.0001	-	<0.0001 - <0.005	<0.0001	-
Chromium (Total)	0.05	(MAC)	<0.001 - <0.01	<0.001	-	<0.001 - 0.007	<0.001	-	<0.001 - <0.01	<0.01	-	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.001	-
Iron	0.3	(AO)	<0.005 - 0.57	**0.49**	-	<0.03 - 0.18	***0.66***	-	<0.005 - 2.66	<0.3	-	<0.013 - 0.05	*0.2*	-	<0.005 - <0.3	0.03	-
Lead	0.01	(MAC)	<0.0005 - <0.05	<0.001	-	<0.0005 - <0.001	<0.001	-	<0.0005 - <0.002	<0.01	-	<0.0005 - 0.003	<0.001	-	<0.0005 - <0.025	<0.001	-
Mercury	0.001	(MAC)	<0.0001 - 0.0013	<0.0001	-	<0.0001	<0.0001	-	<0.0001 - 0.0007	<0.0001	-	<0.0001	<0.0001	-	<0.0001 - 0.0003	<0.0001	-
Nickel	-		0.003 - <0.05	<0.005	-	<0.001 - <0.005	<0.005	-	<0.001 - 0.028	<0.05	-	<0.001 - <0.01	<0.005	-	<0.001 - <0.05	<0.005	-
Zinc	5	(AO)	<0.003 - 0.04	<0.01	-	0.009 - 0.06	<0.01	-	<0.003 - 0.06	<0.1	-	<0.003 - 0.05	<0.01	-	<0.003 - <0.1	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS);

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; and, IMAC = Interim Maximum Acceptable Concentration.

Italicized – analytical result outside of historical concentration range for the parameter.

Unless otherwise stated, all units are reported in mg/L.

Table 15 continued...

Parameter	Regulatory Criteria		Monitoring Wells along the Perimeter of the Site														
			TW40-99D			TW41-99D			TW43-99D			TW45-99D			TW47-00D		
	ODWS		Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators																	
pH [unitless]	6.50 - 8.50	(OG)	7.80 - 8.37	8	8.08	7.90 - 8.60	8.29	8.11	7.70 - 8.49	8.21	8.1	7.80 - 8.58	8.13	8.03	8.00 - 8.52	8	*7.75*
Conductivity [µS/cm]	-		1200 - 3340	1540	1460	1150 - 1400	1180	*1130*	1100 - 1300	1190	1170	1000 - 3790	3290	3760	1100 - 10900	*11000*	5930
Total Dissolved Solids	500	(AO)	690 - 2170	**1000**	**949**	540 - 895	**767**	**734**	580 - 833	**774**	**760**	580 - 2470	**2140**	**2440**	680 - 7930	**7150**	**3850**
Minor Ions – Anions																	
Alkalinity	30 - 500	(OG)	238 - 318	269	266	288 - 358	302	295	240 - 294	275	263	264 - 914	**881**	***935***	270 - 1240	***1360***	**689**
Chloride	250	(AO)	268 - 819	**330**	**298**	186 - 270	187	192	209 - 300	*204*	218	173 - 707	**463**	**704**	240 - 3150	**2870**	**1530**
Sulphate	500	(AO)	<1 - 6	<1	<1	0.95 - 6	<1	<1	0.14 - <5	<1	<1	<1 - 14	<1	<1	0.44 - <5	<5	<1
Major Ions – Cations																	
Calcium	-		26 - 59	35	34	12 - 19.7	17	18	19 - 33	29	29	4 - 30.8	9	7	17 - 92	*94*	*98*
Magnesium	-		9 - 22	12	11	5 - 7.2	6	6	7 - 11	10	10	1 - 10.9	2	3	<0.1 - 47	44	40
Potassium	-		1.9 - 4.0	3	2	1.0 - 3.3	2	2	1.0 - 3.0	2	2	1.0 - 3.0	2	2	1.3 - 10.0	7	6
Sodium	200	(AO)	227 - 406	**281**	**240**	208 - 269	**237**	**241**	197 - 259	**220**	**219**	217 - 1020	**761**	**900**	250 - 3040	**2420**	**1150**
Major Ions – Nutrients																	
Nitrate	10	(MAC)	<0.021 - <1	<0.1	<0.1	<0.01 - 0.3	<0.1	<0.1	0.016 - <1	<0.1	<0.1	0.023 - <0.5	<0.1	<0.1	0.011 - <1	<0.1	<0.1
Nitrite	1	(MAC)	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1
Major Ions – Miscellaneous																	
Bromide	-		0.1 - 0.87	<0.25	0.52	<0.25 - 1.8	<0.25	0.42	0.11 - <3.5	<0.25	0.48	<0.25 - 3.08	<0.25	<0.25	0.09 - 4.77	<1.25	1.88
Cyanide (Free)	0.2	(MAC)	<0.002 - <0.05	<0.005	<0.005	<0.002 - <0.05	<0.005	<0.005	<0.002 - <0.05	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005
Fluoride	1.5	(MAC)	0.88 - 1.41	1.1	1.1	0.3 - 1.55	0.97	1.41	0.18 - 1.6	0.87	1.09	0.37 - 1.5	*0.3*	0.59	0.67 - 1.5	*0.49*	0.8
Metals																	
Arsenic	0.025	(MAC)	<0.001 - <0.01	<0.001	-	<0.001 - 0.002	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - 0.006	0.01	-	<0.001 - 0.004	<0.01	-
Barium	1	(MAC)	0.19 - 0.37	0.25	-	0.077 - 0.93	0.09	-	0.19 - 0.3	*0.18*	-	0.069 - 0.32	0.15	-	0.2 - 3.0	***3.4***	-
Boron	5	(IMAC)	1.62 - 2.4	1.8	-	1.5 - 2.1	1.8	-	1.27 - 1.7	1.4	-	0.9 - 3.1	2.8	-	2.0 - 5.1	***6***	-
Cadmium	0.005	(MAC)	<0.0001 - 0.005	<0.0001	-	<0.0001 - 0.006	<0.0001	-	<0.0001 - <0.003	<0.0001	-	<0.0001 - 0.006	<0.0001	-	<0.0001 - <0.001	<0.001	-
Chromium (Total)	0.05	(MAC)	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - 0.003	<0.001	-	<0.001 - <0.01	<0.001	-	<0.0001 - <0.01	<0.01	-
Iron	0.3	(AO)	<0.013 - 1.87	**1.07**	-	<0.02 - 4.9	0.05	-	<0.013 - 0.26	***0.37***	-	<0.005 - <0.05	***3.39***	-	<0.019 - 1	***5.5***	-
Lead	0.01	(MAC)	<0.0005 - 0.002	<0.001	-	<0.0005 - 0.0073	<0.001	-	<0.0005 - <0.002	<0.001	-	<0.0005 - <0.002	<0.001	-	<0.0005 - <0.01	<0.01	-
Mercury	0.001	(MAC)	<0.0001 - 0.0001	<0.0001	-	<0.0001 - 0.00035	<0.0001	-	<0.0001	<0.0001	-	<0.0001 - 0.0007	<0.0001	-	<0.0001 - 0.0001	<0.0001	-
Nickel	-		<0.001 - <0.01	<0.005	-	<0.001 - <0.01	<0.005	-	<0.001 - <0.01	<0.005	-	<0.001 - <0.01	<0.005	-	<0.001 - <0.05	<0.05	-
Zinc	5	(AO)	<0.005 - 0.516	<0.01	-	<0.005 - 0.53	<0.01	-	0.004 - 0.06	<0.01	-	<0.003 - 0.036	<0.01	-	<0.005 - 0.2	<0.1	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS);

OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; and, IMAC = Interim Maximum Acceptable Concentration.

Italicized – analytical result outside of historical concentration range for the parameter.

* Denotes historical range limited to 2 sampling events.

Unless otherwise stated, all units are reported in mg/L.

Table 15 continued...

Parameter	Regulatory Criteria		Monitoring Wells along the Perimeter of the Site											
			TW48-00D			TW49-00D			TW53-03D			TW60-13D		
	ODWS		Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators														
pH [unitless]	6.50 - 8.50	(OG)	7.80 - 8.54	8.21	8.06	7.87 - 8.57	8.03	7.87	7.90 - 8.53	8.15	8	8.15 - 8.26	8.03	*7.92*
Conductivity [µS/cm]	-		1900 - 2670	2190	*1880*	600 - 847	757	778	1300 - 4920	1720	1670	4150 - 4630	4340	4300
Total Dissolved Solids	500	(AO)	1100 - 1600	**1420**	**1220**	360 - 551	492	**506**	810 - 3200	**1120**	**1090**	2360 - 3010	**2820**	**2800**
Minor Ions – Anions														
Alkalinity	30 - 500	(OG)	254 - 472	444	408	206 - 252	*253*	*267*	259 - 607	318	297	615 - 746	**742**	**730**
Chloride	250	(AO)	371 - 610	**431**	***357***	83 - 94	85	90	262 - 1210	**342**	**360**	929 - 1120	**988**	**992**
Sulphate	500	(AO)	0.65 - 4	<1	<1	<1 - 43.4	<1	<1	0.45 - 5	<1	<1	<1 - <2	<1	<1
Major Ions – Cations														
Calcium	-		12 - 34.9	26	32	9 - 28.9	27	28	20 - 65	31	31	24 - 39	35	39
Magnesium	-		7 - 14.8	9	9	3.7 - 7.6	5	5	7 - 25	11	11	10 - 14	13	14
Potassium	-		2.0 - 4.0	3	2	1.0 - 2.0	2	2	2.0 - 4.0	2	2	3 - 4	3	4
Sodium	200	(AO)	391 - 510	**460**	***384***	124 - 166	143	146	246 - 853	**338**	**344**	951 - 1010	**962**	***889***
Major Ions – Nutrients														
Nitrate	10	(MAC)	0.012 - 0.35	<0.1	<0.1	<0.01 - 0.14	<0.1	<0.1	<0.05 - <1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite	1	(MAC)	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.2	<0.1	<0.1	<0.01 - <0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Major Ions – Miscellaneous														
Bromide	-		0.17 - 3.2	<0.25	0.46	0.08 - 0.8	0.37	0.44	0.19 - 1.03	<0.25	0.83	<0.25 - 1.52	<0.25	1.34
Cyanide (Free)	0.2	(MAC)	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.05	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoride	1.5	(MAC)	0.91 - 1.89	1.05	**1.64**	<0.01 - 1.7	0.96	1.45	1 - 1.54	1.11	1.36	0.72 - 0.91	*0.58*	0.79
Metals														
Arsenic	0.025	(MAC)	0.001 - <0.01	0.001	-	0.001 - <0.01	0.001	-	<0.001 - 0.002	<0.001	-	<0.001 - 0.003	<0.01	-
Barium	1	(MAC)	0.16 - 0.63	0.19	-	0.06 - 0.48	0.08	-	0.19 - 0.4	0.24	-	0.36 - 0.49	0.4	-
Boron	5	(IMAC)	0.3 - 3.5	2.7	-	0.9 - 1.5	1.2	-	1.6 - 2.2	2.1	-	4.7	***5.6***	-
Cadmium	0.005	(MAC)	<0.0001 - <0.001	<0.0001	-	<0.0001 - <0.001	<0.0001	-	<0.0001 - <0.001	<0.0001	-	<0.0001 - <0.0004	<0.001	-
Chromium (Total)	0.05	(MAC)	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.001	-	<0.001 - <0.005	<0.01	-
Iron	0.3	(AO)	0.014 - 0.37	0.14	-	<0.03 - 1.2	<0.03	-	0.025 - 0.58	**0.46**	-	0.04 - 0.22	***1.6***	-
Lead	0.01	(MAC)	<0.0005 - <0.001	<0.001	-	<0.0005 - <0.001	<0.001	-	<0.0005 - <0.001	<0.001	-	<0.001	<0.01	-
Mercury	0.001	(MAC)	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-
Nickel	-		<0.001 - <0.01	<0.005	-	<0.001 - <0.01	<0.005	-	<0.001 - <0.01	<0.005	-	<0.005	0.05	-
Zinc	5	(AO)	<0.01 - 0.042	<0.01	-	<0.005 - 0.08	<0.01	-	<0.005 - 0.12	<0.01	-	<0.01 - 0.03	<0.1	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS);
OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; and, IMAC = Interim Maximum Acceptable Concentration.
Italicized – analytical result outside of historical concentration range for the parameter.
Denotes historical range limited to 2 sampling events.
Unless otherwise stated, all units are reported in mg/L.

Graphs Presenting Parameter Concentration Data with Time: Graphs, showing the average indicator parameter concentrations for the wells in this group are provided in Figure H-4.5-2.3, Appendix H-4.5-2. The long term trend for the group of wells is summarized by parameter in the following table:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	Increasing	Increasing	No Trend	Decreasing	Increasing	Increasing	No Trend	Decreasing

The average chloride, sodium, boron and barium concentrations show an increasing concentration trend. The chloride and sodium concentrations for the group remained relatively stable until 2009, after which the concentrations of both parameters started to rise. Boron and barium concentrations have increased gradually over the full period of record.

The increases in the averaged chloride and sodium concentrations are primarily attributed to the inclusion of data from TW40-99D, TW45-99D and TW47-00D. The upward trend in the chloride and sodium concentrations at TW45-99D started in 2004 and at TW47-00D in 2010. An increase in chloride and sodium concentrations at TW40-99D was first observed in the spring 2012 sample from this well.

The concentration verses time graphs for the individual wells within the group are provided in Appendix H-4.5-4. Observations with regards to these graphs are summarized in the table that follows:

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
OW32-90D	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
OW35-05D	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW22-99D	Increasing	Increasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW30-99D	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW32-94-II	No Trend	No Trend	No Trend	No Trend	No Trend	Increasing	No Trend	No Trend
TW40-99D	No Trend	No Trend	No Trend	No Trend	Increasing	No Trend	No Trend	No Trend
TW41-99D	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW43-99D	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW45-99D	Increasing	Increasing	No Trend	No Trend	Increasing	No Trend	No Trend	Decreasing
TW47-00D	Increasing	Increasing	Increasing	No Trend	Increasing	Increasing	No Trend	Decreasing
TW48-00D	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	Increasing
TW49-00D	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
TW53-03D	Increasing	Increasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
TW60-13D	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend

Wells TW40-99D and TW47-00D are located in the northwestern corner of the Lambton Facility property and TW45-99D is along the west property boundary south of the entrance to the Facility. The chloride and sodium concentrations at TW40-99D peaked in the fall 2013 sample at 819 mg/L and 572 mg/L, respectively and subsequently declined to 515 mg/L and 374 mg/L, respectively in spring 2014. Chloride concentrations in the most recent samples are 330 mg/L (spring 2016) and 298 mg/L (fall 2016). Sodium concentrations in the most recent samples are 281 mg/L (spring 2016) and 240 mg/L (fall 2016).

The chloride and sodium concentrations also peaked at TW47-00D in the fall 2013 at 3,150 mg/L (chloride) and 3,040 mg/L (sodium), before declining in spring 2014 to 2,970 mg/L and 2,410 mg/L, respectively. The concentrations in the spring 2016 sample are 2,870 mg/L (chloride) and 2,420 mg/L (sodium), and the concentrations in the fall 2016 sample are 1,530 mg/L (chloride) and 1,150 mg/L (sodium).

The cause of the fluctuations in the chloride and sodium concentrations at TW40-99D and TW47-00D are not currently known but may be related to pumping of wells PW1-N and PW2-S(R11) located to the southwest near Sub-cell 3. Pumping at these two wells has been intermittent, which would affect the potentiometric surface and pattern of groundwater flow in the northwest corner of the property.

Pumping of wells PW1-N and PW2-S(R11) was discontinued in June 2015 in order to allow the potentiometric surface of the Interface Aquifer to fully recover, thereby eliminating this potential influence. Chloride and sodium concentrations have been declining in both TW40-99D and TW47-00D since pumping at PW1-N and PW2-S(R11) was discontinued.

Chloride and sodium concentrations at TW45-99D peaked at 707 mg/L and 1,020 mg/L respectively in fall 2012 and declined in the spring 2014 sample to 562 mg/L and 792 mg/L, respectively. The chloride and sodium concentrations in the spring 2016 sample are to 463 mg/L and 761 mg/L, respectively. The chloride and sodium concentrations in the fall 2016 sample are 704 mg/L and 900 mg/L, respectively.

Sulphate and the volatile organic compound chloroform have been detected on occasion at TW45-99D. It was postulated that shallow water could be entering the well from a joint in the casing. In response to this observation, the well was inspected in early spring 2015 using a downhole pipeline camera. The casing appears to be sound to a depth of at least 15 m (limits of the equipment) as there was no evidence of damage or staining at the casing joints.

The performance of the well (i.e., slow recovery after purging/sampling) deteriorated significantly a few years after the well was installed. The deterioration of well performance could be related to fine-particulates plugging the sand pack around the screen or alternatively the growth of iron bacteria.

In an effort to enhance recovery, the well was redeveloped during the 2015 monitoring period. This involved the addition of chlorinated water, active surging of the water level and pumping to remove the water. The process was subsequently repeated. The lower chloride and sodium concentrations in the spring 2015 sample and the detection of sulphate at 3 mg/L, and the VOCs chloroform and chloromethane indicates presence of chlorinated water in the well. Additional purging was conducted and the chloride and sodium concentrations have increased (per fall 2015 data). Both chloride and sodium concentrations remained elevated at this well during the 2016 monitoring period.

The intra-well Upper Control Limits (UCLs) calculated using the early time data for the individual wells in the group are presented in the concentration time graphs in Appendix H-4.5-4. Wells at which the intra-well UCLs were exceeded in 2016 are listed in the following table:

Well	2016 Parameter Concentration Exceeding Upper Control Limits (Calculated UCL Value)	
	Spring 2016	Fall 2016
OW35-05D	Boron - 1.80 mg/L (1.78 mg/L)	
TW32-94-II	Chloride – 597 mg/L (467.7 mg/L) Sodium – 482 mg/L (315.6 mg/L) Barium – 0.38 mg/L (0.22 mg/L)	Chloride – 644 mg/L (467.7 mg/L) Sodium – 489 mg/L (315.6 mg/L)
TW45-99D	Sodium 761 mg/L (365.4 mg/L)	Chloride – 704 mg/L (474.7 mg/L) Sodium - 900 mg/L (365.4 mg/L)
TW47-00D	Chloride – 2,870 mg/L (383.3 mg/L) Sodium – 2,420 mg/L (333.5 mg/L) Potassium – 7 mg/L (2.5 mg/L) Boron – 6 mg/L (3.07 mg/L) Barium – 3.4 mg/L (0.75 mg/L)	Chloride – 1,530 mg/L (383.3 mg/L) Sodium – 1,150 mg/L (333.5 mg/L) Potassium – 6 mg/L (2.5 mg/L)

Comparison of the Current Year's Analytical Results with Applicable Regulatory Standards/Criteria:

Parameters detected at concentrations at the individual wells that exceed the ODWS and the Guideline B-7 calculated criteria in 2016 are listed in the following table:

ODWS	Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
TDS (500 mg/L)	OW32-90D (897), OW35-05D (845), TW22-99D (2,940), TW30-99D (767), TW32-94-II (1,570), TW40-99D (1,000), TW41-99D (767), TW43-99D (774), TW45-99D (2,140), TW47-00D (7,150),	OW32-90D (923), OW35-05D (864), TW22-99D (3,020), TW30-99D (774), TW32-94-II (1,560), TW40-99D (949), TW41-99D (734), TW43-99D (760),

ODWS	**Well at which ODWS is exceeded (Concentration Triggering Exceedance in mg/L)**	
	Spring 2016	**Fall 2016**
	TW48-00D (1,420), TW53-03D (1,120), TW60-13D (2,820)	TW45-99D (2,440), TW47-00D (3,850), TW48-00D (1,220), TW49-00D (506) TW53-03D (1,090), TW60-13D (2,800)
Alkalinity (30 to 500 mg/L)	TW22-99D (757), TW45-99D (881), TW47-00D (1,360), TW60-13D (742)	TW22-99D (727), TW45-99D (935), TW47-00D (689), TW60-13D (730)
Chloride (250 mg/L)	OW32-90D (284), TW22-99D (1,020), TW32-94-II (597), TW40-99D (330), TW45-99D (463) TW47-00D (2,870), TW48-00D (431), TW53-03D (342), TW60-13D (988)	OW32-90D (304), OW35-05D (258), TW22-99D (1,170), TW32-94-II (644), TW40-99D (298), TW45-99D (704), TW47-00D (1,530), TW48-00D (357), TW53-03D (360), TW60-13D (992)
Sodium (200 mg/L)	OW32-90D (278), OW35-05D (243), TW22-99D (987), TW30-94 (231), TW32-94-II (482), TW40-99D (281), TW41-99D (237), TW43-99D (220), TW45-99D (761) TW47-00D (2,420), TW48-00D (460), TW53-03D (338), TW60-13D (962)	OW32-90D (248), OW35-05D (231) TW22-99D (994), TW30-94 (237), TW32-94-II (489), TW40-99D (240), TW41-99D (241), TW43-99D (219) TW45-99D (900) TW47-00D (1,150), TW48-00D (384), TW53-03D (344), TW60-13D (889)
Fluoride (1.5 mg/L)		TW48-00D (1.64)
Barium (1.0 mg/L)	TW47-00D (3.4)	Not Analyzed
Boron (5 mg/L)	TW22-99D (5.6), TW47-00D (6), TW60-13 D (5.6)	Not Analyzed
Iron (0.30 mg/L)	TW32-90D (0.49), OW35-05D (0.66), TW40-99D (1.07), TW43-99D (0.37), TW45-99D (3.39), TW47-00D (5.5), TW53-09D (0.46), TW60-13D (1.6)	Not Analyzed

Parameter (Guideline B-7 Value derived for Off-Site Wells)	Well at which Guideline B-7 Criteria is Exceeded (Concentration Triggering Exceedance in mg/L)	
	Spring 2016	Fall 2016
Alkalinity (spring 2016 - 416 mg/L fall 2016 – 412 mg/L)	TW22-99D (757), TW45-99D (881), TW47-00D (1,360), TW48-00D (444), TW60-13D (742)	TW22-99D (727), TW45-99D (935), TW47-00D (689), TW60-13D (730)
Chloride (spring 2016 - 250 mg/L, fall 2016 – 250 mg/L)	OW32-90D (284), TW22-99D (1,020), TW32-94-II (597), TW40-99D (330), TW45-99D (463) TW47-00D (2,870), TW48-00D (431), TW53-03D (342), TW60-13D (988)	OW32-90D (304), OW35-05D (258), TW22-99D (1,170), TW32-94-II (644), TW40-99D (298), TW45-99D (704), TW47-00D (1,530), TW48-00D (357), TW53-03D (360), TW60-13D (992)
Sodium (spring 2016 - 200 mg/L, Fall 2016 – 200 mg/L)	OW32-90D (278), OW35-05D (243), TW22-99D (987), TW30-94 (231), TW32-94-II (482), TW40-99D (281), TW41-99D (237), TW43-99D (220), TW45-99D (761) TW47-00D (2,420), TW48-00D (460), TW53-03D (338), TW60-13D (962)	OW32-90D (248), OW35-05D (231) TW22-99D (994), TW30-94 (237), TW32-94-II (489), TW40-99D (240), TW41-99D (241), TW43-99D (219) TW45-99D (900) TW47-00D (1,150), TW48-00D (384), TW53-03D (344), TW60-13D (889)
Fluoride (fall 2016 - 1.32 mg/L)		TW48-00D (1.64)
Barium (spring 2016 - 0.35 mg/L)	TW47-00D (3.4)	Not Analyzed
Boron (spring 2016 – 2.68 mg/L)	TW22-99D (5.6), TW47-00D (6), TW60-13 D (5.6)	Not Analyzed
Iron (spring 2016 - 0.30 mg/L)	OW32-90D (0.49), OW35-05D (0.66), TW40-99D (1.07), TW43-99D (0.37), TW45-99D (3.39), TW47-00D (5.5), TW53-09D (0.46), TW60-13D (1.6)	Not Analyzed

STATISTICAL ANALYSIS FOR WELL GROUP AND INDIVIDUAL WELLS: The statistical analysis for this group of wells is included in FIGURE H-4.6-1.7, APPENDIX H-4.6. The results of the analysis for this group of wells follow:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Group	No Trend	No Trend	No Trend	Decreasing	No Trend	Increasing	Decreasing	No Trend

Note: (1) The statistical analysis for the metals (boron and barium) is limited to five sampling events.

The results of the analysis for the individual wells are summarized below:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
OW32-90D	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend
OW35-05D	Decreasing	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	Decreasing
TW22-99D	No Trend	No Trend	Increasing*	Decreasing	Increasing**	Decreasing	No Trend	No Trend
TW30-99D	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend
TW32-94-II	No Trend	No Trend	No Trend	Decreasing	No Trend	Increasing**	Decreasing	No Trend
TW40-99D	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	Increasing*
TW41-99D	Decreasing	No Trend	Increasing*	Decreasing	No Trend	No Trend	Decreasing	No Trend
TW43-99D	Decreasing	No Trend	Increasing*	No Trend	No Trend	No Trend	Decreasing	No Trend
TW45-99D	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	Decreasing
TW47-00D	No Trend	No Trend	No Trend	No Trend	Increasing**	Increasing**	No Trend	No Trend
TW48-00D	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend
TW49-00D	No Trend	No Trend	Increasing*	Decreasing	Increasing*	No Trend	Decreasing	No Trend
TW53-03D	No Trend	Increasing*	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend
TW60-13D	Insufficient Data to Complete Trend Analysis							

Notes: (1) The database considered in the trend analysis varies by well and parameter. Specifically, the statistical analysis for metals (boron and barium) completed for the wells, excepting TW60-13D, is limited to five sampling events. The major ion chemistry database for TW60-13D is limited to seven sampling events and the boron and barium database of the same well is limited to two and three sampling events, respectively. (*) 2016 concentration below the maximum value previously observed at well. (**) 2016 concentration above the maximum value previously observed at well.

3.1.3.2 Organic Groundwater Chemistry

Groundwater samples are collected from the monitoring wells installed in the Interface Aquifer and submitted for analysis of the volatile organic compounds (VOCs) listed in **Section 2.1.2.5** on an annual basis. The most recent site-wide event was completed in spring 2016.

In addition to this site-wide program, additional samples for VOC analysis were collected as part of the various supplemental programs described in Section 2.6.

The MOECC obtained samples (sample splits) from OW35-05D, TW22-99D, TW39-99D, TW47-00D, and TW60-13D during the site-wide monitoring program on November 8th, 2016. In addition, a sample was collected from TW46-99D.

The VOC analytical results for 2016 monitoring year (including the results of sample splits analyzed by the MOECC and the secondary lab) are included in the laboratory analytical reports in **APPENDIX H-4.2**.

Positive detections are summarized in **TABLE 16** and reviewed on a parameter/well basis in this section.

In 2016, the Guideline B-7 value for benzene is exceeded at one or more samples collected from TW22-99D, TW60-13D and TW61-13D located on the Facility property and at TW57-11D and TW59-13D located off-property.

Trichloroethylene (TCE) has been detected at TW22-99D since 2007, with other VOCs including Methylene Chloride (DCM), cis-1,2-Dichloroethylene (cis-1,2-DCE), trans-1,2-Dichloroethylene (trans-1,2-DCE), Tetrachloroethylene (PCE) and Benzene detected in one or more samples from in the same well.

TCE and cis-1,2-DCE remain isolated to samples collected from well TW22-99D. Specifically, this parameter has not been detected in the adjacent well (TW60-13D), which was installed within the same water bearing zone, nor has TCE been detected in samples from any other monitoring wells installed in the Interface Aquifer.

Table 16: Summary of VOC Detections in 2016 at Deep Wells

Well	Volatile Organic Compound Detections (expressed in µg/L)									
	TCE	Cis-1,2-DCE	Trans-1,2-DCE	Benzene	Ethyl-benzene	Toluene	Total Xylene	Chloro-form	Bromo-form	Chloro-methane
ODWS	5			5	2.4	24	300	100[1]	100[1]	
Guideline B-7 Value	1.5			1.6	1.45	12,25	150.2	25.2	25.2	
TW22-99D (well at northwest corner of Facility Property)										
Nov. 4, 2014	3.3 (3.5*)	1.6 (2.1*)		1.9 (2.3*)						
Mar. 30, 2015	5.2 (4.2**)	2.1 (2.2**)	0.5 (0.43**)	2.8 (2.8**)						
May 6, 2015	4.9 (4.4*)	0.8 (2.0*)	<0.5 (0.4*)	1.1 (2.4*)						
Jun. 23, 2015	0.9***									
Jun. 24, 2015	0.9***									
Nov. 4, 2015				3.8						
Dec. 4, 2015	3.8 (2.5*)	<0.4(1.8*)		<0.5(1.3*)						
May 3, 2016	1.6									
Nov. 8, 2016	3.4 (3.6*)	2.0 (3.0*)	<0.4 (0.4*)	1.7 (3.4*)						
TW39-99D (well at northwest corner of Facility Property)										
May 13, 2003								0.7		0.32
Jun. 1, 2005									0.4	
May 16, 2007										
May 4, 2016						0.6				
Nov. 9, 2016						0.5				
TW46-99D (well installed at northeast corner of Facility Property)										
Nov. 10, 2015				2.1						0.41
May 31, 2005								0.1	0.4	
May 4, 2016						1.2				
Nov. 9, 2016						0.9				
TW45-99D (well along west side of Facility Property)										
Nov. 5, 2014								2.7		
May 15, 2015								8.8		6.0
Nov. 11, 2015				1.8						
May 6, 2016				1.5						
TW56-11D (well located off Facility Property to east)										
May 11, 2014				0.7						
May 6, 2016				0.6						
TW57-11D (well located off Facility property to east)										
May 15, 2015				5.1						
May 6, 2014				6.9						
May 6, 2016				8.1						
TW59-13D (well located off Facility property to west)										
May 5, 2014				<0.5 (3.8*)						
May 4, 2016				3.6						

Notes: (1) The ODWS specified is for trihalomethanes. (*) result from sample split analyzed at the MOECC laboratory. (**) results for sample split analyzed at second laboratory (MAXXAM). (***) samples recovered from upper portion of casing during packer testing.

Table 16 continued …

Well	Volatile Organic Compound Detections (expressed in µg/L)									
	TCE	Cis-1,2-DCE	Trans-1,2-DCE	Benzene	Ethyl-benzene	Toluene	Total Xylene	Chloro-form	Bromo-form	Chloro-methane
ODWS	5			5	2.4	24	300	100[1]	100[1]	
Guideline B-7 Value	1.5			1.6	1.45	12,25	150.2	25.2	25.2	
TW60-13D (well at northwest corner of Facility Property)										
Nov. 4, 2014				5.3 (5.7*)		1.1 (1.1*)				
Mar. 30, 2015				9.5 (7.3**)	0.15	0.8 (0.69**)	0.46**			
May 6, 2015				<0.5 (6.2*)		<0.5 (0.7*)	<0.5 (0.5*)			
Nov. 4, 2015				6.1						
Nov. 8, 2016				7.0 (6.4*)		<0.5 (0.2*)	<0.5 (0.2*)			
TW61-13D (well installed Along West Side of Facility Property)										
Nov. 7, 2013				3.8		0.8				
May 21, 2014				1.4						
Nov. 4, 2014				1.4						
Nov. 4, 2015				2.3						
May 6, 2016				5.6						

Notes: (1) The ODWS specified is for trihalomethanes. (*) result from sample split analyzed at the MOECC laboratory. (**) results for sample split analyzed at second laboratory (MAXXAM). (***) samples recovered from upper portion of casing during packer testing.

3.2 Monitoring Program to Assess Effectiveness of Sub-cell 3 Mitigation

Performance effectiveness of the remedial mitigation implemented at Sub-cell 3 is assessed on the basis of the ability to maintain the hydraulic pressure head elevation in the Hydraulic Control Layers (HCLs) installed at the base of Sub-cell 3 at a lower level (188 to 192 mASL) than the hydraulic pressure head in the Interface Aquifer (approximately 196 to 198 mASL). The water level differential creates an upward/inward gradient across the clay till that separates the base of Sub-cell 3 and the Interface Aquifer and prevents water within Sub-cell 3 from moving downward through the stress fractures that were produced below the Sub-cell.

Water levels are monitored in the HCLs and the Interface Aquifer using pressure transducers. Extraction well EW1a-01, and monitoring wells EW1b-13 and EW1c-13 are installed in the northern HCL. Extraction Well EW2a-01 and monitoring wells EW2b-13 and EW2c-13 are installed in the southern HCL.

Wells PW1-N and PW2-S(R11) are installed in the Interface Aquifer north and south respectively of the Sub-cell 3 footprint. The well locations are shown in **FIGURE 4**.

Water samples are collected at a biannual frequency from the HCL extraction wells (EW1a-01 and EW2a 01), the HCL monitoring wells (EW1b-13, EW1c-13, EW2b-13 and EW2c-13) and monitoring wells PW1-N and PW2-S(R11). The samples are analyzed for the list of parameters in **SECTION 2.1.2.5**. The specific gravity of HCL water samples is determined during each sampling event. A bottom opening bailer is used to determine whether precipitate is accumulating at the bottom of the extraction wells.

3.2.1 Water Level Monitoring

Figure 15 is a graph of the water levels measured at HCL extraction and monitoring wells (EW1a-01, EW1b-13 and EW1c-13 in the northern HCL and EW2a-01, EW2b-13 and EW2c-13 in the southern HCL) and Interface Aquifer monitoring wells PW1-N and PW2-S(R11). The water levels in HCL extraction wells EW1a-01 and EW2a-01 were maintained below 192.7 mASL. With the exception of short-term purging responses in preparation for sampling of the wells, the water levels in Interface Aquifer monitoring wells PW1-N and PW2-S(R11) were maintained above 197.6 mASL. An upward hydraulic gradient between the water level in the HCLs and the Interface Aquifer existed throughout the 2016 monitoring period.

Periods were the water level increased in the HCLs and at PW1-N and PW2-S(R11) (per **Figure 15**) correspond to intervals when the air compressor that powers the pumps was off-line. Compressor failure was caused by two factors:

1) short-term electrical outages (evident as upward spikes in the water levels); and

2) frozen airlines/blockage of discharge piping (May and December 2016).

Pumping at PW1-N and PW2-S(R11) was discontinued in June 2015. This was conducted after reviewing the volumes extracted and the chemistry of samples collected from the pump discharge. The review concluded that pumping had removed the surface water/shallow groundwater that had been introduced into the Interface Aquifer (RWDI, 2016).

Quarterly potentiometric surfaces for the northern portion of the Facility property are provided in **Appendix H-4.8-1**. Specifically, potentiometric surfaces dated March 30, 2016, June 9, 2016, September 12, 2016 and December 31, 2016 evidence the continued recovery of the Interface Aquifer in the vicinity of Sub-cell 3 following discontinuation of pumping from PW1-N in July 2015.

3.2.2 Volume of Water Extracted

The total volume of water extracted from the northern and southern HCLs over the period extending between December 3, 2015 and January 18, 2017 is estimated as 41.84 m^3 and 13.81 m^3, respectively (**Table H-4.8-1.1**, **Appendix H-4.8**). This corresponds to an average extraction rate of 101.6 L/day from the northern HCL and 33.5 L/day from the southern HCL.

3.2.3 Water Chemistry

The water chemistry data collected from the various wells installed to monitor Sub-cell 3 performance are included in the laboratory analytical reports in **Appendix H-4.2** and discussed below:

3.2.3.1 Inorganic Chemistry

The chemical analysis results for samples collected in 2016 are presented in **Table 17**. A compilation of the results for the indicators pH, conductivity, TDS and specific gravity, and the major ions chloride, sulphate, alkalinity, sodium, potassium and magnesium for samples collected from the wells from the date of installation is provided in **Table 18**.

Data for Wells within the HCLs: The water quality as determined for the wells installed in the northern HCL is stable. Samples from the northern HCL have consistently been more mineralized than those from the southern HCL. [Note: the extraction rate from the southern HCL is only a 1/3 of the rate extracted from the northern HCL, which would indicate less water from the bedrock is moving upward into the southern HCL. This likely influences the overall degree of mineralization in the water in the southern HCL.]

Over recent years the degree of mineralization as evident in the TDS content in the samples from the southern HCL has been declining. On an individual parameter basis, the decrease is most evident in in the sulphate concentration in samples from the southern HCL, which has declined from >100 mg/L in June 2006 to 13 mg/L in May 2016 and 39 mg/L in November 2016. In contrast, the alkalinity has increased from 194 mg/L (June 2006) to 227 mg/L in May 2016 and 238 mg/L in November 2016.

The change in water quality in samples from the southern HCL would suggest a water contribution from a low mineralized water source. Ponded water over portions of the cap on the southern HCL has been observed on occasion during site visits. The hydraulic gradient across the cap over the southern HCL is therefore likely to be higher than that over the northern HCL, and the rate of infiltration through the cap would be correspondingly higher. This may be the primary basis for the decrease in the mineralization of the water extracted from the southern HCL.

Data for Wells in the Underlying Interface Aquifer: Since pumping was initiated at PW1-N, the chemistry of the samples from this well has fluctuated. This is most evident with sulphate, where the concentration at PW1-N has fluctuated between values that are representative of groundwater in the Interface Aquifer (<5 mg/L) and concentrations (>5 mg/L) that suggest a mixture of deep and shallow groundwater. This was attributed to a breach in the casing at PW1-N, which was subsequently repaired (see the discussion in the 2014/2015 Groundwater Report [RWDI, 2016]). With regards to the 2016 data, there is a noticeable change in conductivity, TDS and the concentration of the major ions between the spring 2016 sample and the fall 2016 sample at well PN1-N. Specifically, the conductivity, TDS and the chloride and sodium concentrations decreased, whereas the sulphate concentration increased slightly from <1 mg/L to 2 mg/L.

Table 17. Wells Located in Sub-Cell 3, Cell 18

	Regulatory Criteria		Interface Aquifer Wells Located in Sub-Cell 3, Cell 18							HCL Extraction Wells Located in Sub-Cell 3, Cell 18					
			PW1-N			PW2-S*	PW2-S(R11)			EW1a-01			EW2a-01		
Parameter	ODWS		Historical Range	Spring 2016	Fall 2016	Historical Range	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators															
pH [unitless]	6.50 - 8.50	(OG)	8.00 - 8.54	8.22	*7.99*	7.45 - 8.54	8.34 - 8.72	8.34	*8.23*	7.56 - 8.42	7.78	7.89	7.41 - 8.35	7.88	7.92
Conductivity [µS/cm]	-		1.4 - 1920	1840	1660	1.4 - 3930	1590 - 2770	2060	1880	1700 - 2130	1770	1750	1 - 1200	747	806
Total Dissolved Solids	500	(AO)	830 - 1250	**1200**	**1080**	850 - 2550	980 - 1800	**1340**	**1220**	1090 - 1380	**1150**	**1140**	346 - 719	486	**524**
Minor Ions – Anions															
Alkalinity	30 - 500	(OG)	290 - 355	338	315	317 - 450	373 - 454	437	396	262 - 347	299	308	119 - 290	227	238
Chloride	250	(AO)	340 - 408	**375**	**341**	273 - 1000	277 - 600	**393**	**361**	292 - 402	**325**	**324**	62 - 220	100	98
Sulphate	500	(AO)	<1 - 31	<1	2	0.88 - 65	<1 - 24	<1	<1	67 - 179	133	129	47 - 150	*13*	*39*
Major Ions – Cations															
Calcium	-		21 - 41	30	30	14 - 28	14 - 33	24	23	52 - 129	101	103	33 - 78	41	47
Magnesium	-		7.4 - 16	10	9	6.6 - 18	6 - 16	10	10	26 - 78	55	55	13 - 46	17	20
Potassium	-		<1 - 3.0	2	2	1.6 - 5.0	2 - 23	2	2	3.7 - 8	6	5	2 - 8.1	3	3
Sodium	200	(AO)	300 - 391	**364**	**348**	300 - 761	341 - 579	**401**	**408**	171 - 300	200	**206**	61 - 114	103	111
Major Ions – Nutrients															
Nitrate	10	(MAC)	0.065 - <1	<0.1	<0.1	0.069 - <1	<0.1 - <0.1	<0.1	<0.1	0.1 - <1	<0.1	<0.1	0.056 - 1.2	<0.1	<0.1
Nitrite	1	(MAC)	<0.01 - <0.1	<0.1	<0.1	<0.01 - <0.1	<0.1 - <0.1	<0.1	<0.1	0.013 - <0.1	<0.1	<0.1	<0.01 - 0.11	<0.1	<0.1
Major Ions – Miscellaneous															
Bromide	-		0.2 - 3.15	<0.25	0.44	0.16 - <3.5	<0.25 - 2.37	<0.25	0.38	0.96 - 9.28	2.11	2.33	0.66 - 3.38	0.84	0.9
Cyanide (Free)	0.2	(MAC)	<0.002 - <0.02	<0.005	<0.005	<0.002 - <0.02	<0.002 - <0.01	<0.005	<0.005	<0.002 - <0.01	<0.005	<0.005	<0.002 - <0.01	<0.005	<0.005
Fluoride	1.5	(MAC)	0.84 - 1.42	*0.77*	1.13	0.98 - 1.4	0.94 - 1.44	*0.77*	1.2	1.18 - 2	1.24	1.4	0.67 - 1.38	1.15	*1.41*
Metals															
Arsenic	0.025	(MAC)	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.001 - <0.01	<0.001	-	<0.001 - <0.1	<0.001	-	0.001 - <0.01	<0.001	-
Barium	1	(MAC)	0.25 - 0.44	*0.45*	-	0.2 - 0.46	0.17 - 0.41	0.21	-	0.07 - 0.11	*0.06*	-	0.08 - 0.11	*0.21*	-
Boron	5	(IMAC)	1.6 - 2.7	2.3	-	1.9 - 4.1	2.1 - 3.6	2.6	-	1 - 1.9	1.3	-	0.83 - 1.3	1.2	-
Cadmium	0.005	(MAC)	<0.0001 - <0.001	<0.0001	-	<0.0001 - <0.001	<0.0001 - <0.0001	<0.0001	-	<0.0001 - <0.0001	<0.0001	-	<0.0001 - <0.001	<0.0001	-
Chromium (Total)	0.05	(MAC)	<0.001 - <0.01	<0.001	-	<0.001 - <0.01	<0.001 - 0.01	<0.001	-	<0.001 - 0.009	<0.001	-	<0.001 - <0.01	<0.001	-
Iron	0.3	(AO)	<0.019 - 0.2	<0.03	-	<0.019 - 0.059	<0.01 - <0.03	*0.2*	-	<0.03 - 0.23	0.2	-	<0.019 - 0.16	0.14	-
Lead	0.01	(MAC)	<0.0005 - <0.001	<0.001	-	<0.0005 - <0.001	<0.001 - <0.001	<0.001	-	<0.001 - <0.001	<0.001	-	<0.001 - <0.001	<0.001	-
Mercury	0.001	(MAC)	<0.0001	<0.0001	-	<0.0001	<0.0001 - <0.0001	<0.0001	-	<0.0001 - <0.0001	<0.0001	-	<0.0001 <0.0001	<0.0001	-
Nickel	-		<0.001 - <0.01	<0.005	-	<0.001 - 0.014	<0.005 - <0.005	<0.005	-	<0.005 - <0.005	<0.005	-	<0.005 - <0.01	<0.005	-
Zinc	5	(AO)	<0.005 - 0.05	0.03	-	<0.005 - 0.02	<0.01 - 0.03	<0.01	-	<0.01 - <0.05	<0.01	-	<0.005 - 0.01	*0.02*	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS);
OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; and, IMAC = Interim Maximum Acceptable Concentration.
Italicized – analytical result outside of historical concentration range for the parameter.
Unless otherwise stated, all units are reported in mg/L.
** PW2-S historical range is from Spring 2002 to Spring 2011 and was replaced by PW2-S(R11) in February 2011. PW2-S historical range data is shown for reference only.*

Table 17 continued …

Parameter	Regulatory Criteria		HCL Observation Wells Located in Sub-Cell 3, Cell 18											
			EW1b-13			EW1c-13			EW2b-13			EW2c-13		
	ODWS		Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016	Historical Range	Spring 2016	Fall 2016
	[mg/L]		[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
General Indicators														
pH [unitless]	6.50 - 8.50	(OG)	8.19 - 8.23	8.03	*7.89*	8.19 - 8.22	*8.02*	*7.82*	8.26 - 8.37	*8.18*	*8.05*	8.2 - 8.28	*8.16*	*8.04*
Conductivity [µS/cm]	-		1820 - 1880	*1770*	*1740*	1790 - 1820	*1730*	*1680*	785 - 847	*760*	*729*	809 - 859	*778*	*737*
Total Dissolved Solids	500	(AO)	1160 - 1230	***1150***	***1130***	1080 - 1180	**1120**	**1090**	430 - 521	494	474	470 - 540	**506**	479
Minor Ions – Anions														
Alkalinity	30 - 500	(OG)	296 - 321	303	*279*	283 - 326	298	287	226 - 257	238	*225*	212 - 248	230	227
Chloride	250	(AO)	316 - 345	***311***	***302***	306 - 329	***296***	***281***	100 - 104	*95*	*98*	99 - 109	*92*	*95*
Sulphate	500	(AO)	143 - 147	*139*	*129*	131 - 165	*130*	*121*	17 - 52	*12*	*7*	39 - 72	*30*	*16*
Major Ions – Cations														
Calcium	-		101 - 109	102	104	100 - 108	101	102	43 - 51	*42*	*42*	46 - 54	*45*	*44*
Magnesium	-		54 - 65	56	*53*	52 - 57	54	52	17 - 21	17	17	18 - 22	18	*17*
Potassium	-		5 - 5	5	5	5 - 6	5	5	3 - 3	3	3	3	3	3
Sodium	200	(AO)	195 - 211	**205**	198	187 - 202	199	195	98 - 106	100	103	97 - 102	100	*103*
Major Ions – Nutrients														
Nitrate	10	(MAC)	<0.1 - 0.1	<0.1	<0.1	0.1 - <0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite	1	(MAC)	<0.1 - 0.1	<0.1	<0.1	0.1 - <0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Major Ions – Miscellaneous														
Bromide	-		2.76 - 2.98	*1.86*	*2.31*	2.44 - 2.96	*1.93*	*2.15*	0.94 - 1.18	*0.76*	*0.92*	0.9 - 1.03	*0.73*	*0.86*
Cyanide (Free)	0.2	(MAC)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoride	1.5	(MAC)	1.4 - 1.51	*0.94*	1.45	1.34 - 1.54	*0.91*	1.41	1.25 - 1.36	*0.81*	1.34	1.28 - 1.45	*0.84*	1.34
Metals														
Arsenic	0.025	(MAC)	<0.001 - <0.005	<0.001	-	0.002 - <0.005	0.002	-	<0.001	<0.001	-	<0.001	<0.001	-
Barium	1	(MAC)	0.07	*0.05*	-	0.06	*0.05*	-	0.12 - 0.14	0.14	-	0.12	*0.11*	-
Boron	5	(IMAC)	1.2 - 1.4	1.3	-	1.1 - 1.4	1.4	-	1.1 - 1.3	1.3	-	1.1 - 1.2	1.2	-
Cadmium	0.005	(MAC)	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-	<0.0001 - <0.0004	<0.0001	-
Chromium (Total)	0.05	(MAC)	<0.001 - <0.005	<0.001	-	<0.001 - <0.005	<0.001	-	<0.001 - <0.005	<0.001	-	<0.001 - <0.005	<0.001	-
Iron	0.3	(AO)	0.11 - 0.2	*0.67*	-	0.04 - 0.11	***0.54***	-	<0.03	*0.08*	-	<0.03	*0.22*	-
Lead	0.01	(MAC)	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-
Mercury	0.001	(MAC)	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-	<0.0001	<0.0001	-
Nickel	-		<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Zinc	5	(AO)	<0.01 - 0.01	<0.01	-	0.01	*<0.01*	-	<0.01	<0.01	-	<0.01 - 0.01	<0.01	-

Notes: **BOLD** – Indicates value exceeds Ontario Drinking Water Standards, Objectives and Guidelines, Ontario Ministry of the Environment, as revised June 2006 (ODWS);
OG = Operational Guideline; AO = Aesthetic Objective; MAC = Maximum Acceptable Concentration; and, IMAC = Interim Maximum Acceptable Concentration.
Italicized – analytical result outside of historical concentration range for the parameter.
Unless otherwise stated, all units are reported in mg/L.
** PW2-S historical range is from Spring 2002 to Spring 2011 and was replaced by PW2-S(R11) in February 2011. PW2-S historical range data is shown for reference only.*

Table 18. Indicator Parameter Concentrations in Samples from the Sub-cell 3 Monitoring Wells

Sample Date	pH	Conductivity (mS/cm)	Total Dissolved Solids (mg/L)	Specific Gravity (-)	Chloride (mg/L)	Sulphate (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Alkalinity (mg/L)
Monthly and Performance Monitoring Groundwater Samples Collected from **EW1a-01** Northern HCL Extraction Well)											
3-Nov-04	7.97	1.70	1100	1.0*	340	67	280	3.7	52	26	340
2-Jun-05	8.38	1.73	1090	1.0*	364	85	300	4.3	62	31	347
2-Nov-05	7.56	1.74	1130	1.0*	319	111	266	4.0	63	32	346
7-Jun-06	8.24	1.87	1220	1.0*	331	118	255	5.0	70	36	331
7-Nov-06	8.22	1.89	1230	1.0*	306	121	270	8.0	72	38	342
7-Jun-07	8.12	1.94	1260	1.0*	334	132	268	5.0	76	40	342
22-Oct-07	8.06	1.92	1250	1.0*	318	128	242	6.0	81	44	336
13-May-08	8.22	1.90	1230	1.0*	323	136	252	5.0	80	42	335
22-Oct-08	8.15	2.09	1360	1.0*	381	156	268	7.0	105	62	334
26-Aug-09$^{\#\#}$	8.03	2.03	1280	1.0*	352	156	237	6.0	96	55	325
3-Nov-09	8.00	1.94	1260	1.0*	338	152	243	5.0	89	49	324
27-May-10	8.16	2.09	1360	1.0*	396	179	234	6.0	108	62	295
7-Dec-10	8.09	2.13	1380	1.0*	402	175	225	7.0	109	65	302
11-Jul-11$^{\#\#}$	8.09	1.92	1250	1.0*	333	170	196	6.0	102	59	286
6-Dec-11	8.05	1.75	1140	1.0*	293	171	199	5.0	101	48	262
11-Jun-12	8.22	1.83	1190	1.0*	310	163	195	5.0	88	47	284
16-Nov-12	8.42	2.05	1330	1.0*	370	150	192	6.0	120	58	317
23-May-13$^{\#\#}$	8.11	1.93	1250	1.0*	369	140	246	7.0	129	78	227
5-Nov-13	8.01	1.98	1290	1.0*	362	149	207	6.0	111	62	291
15-May-14	8.25	1.95	1190	1.0*	361	143	209	6.0	112	64	329
12-Nov-14	8.21	1.91	1150	1.0*	351	141	213	7.0	107	65	293
13-May-15$^{\#\#}$	8.15	1.89	1230	1.0*	348	137	206	6.0	104	62	292
11-Nov-15	8.22	1.87	1220	1.0*	326	131	200	6.0	103	55	303
6-Jun-16$^{\#\#}$	7.78	1.77	1150	1.0*	325	133	133	6.0	101	55	299
10-Nov-16	7.89	1.75	1140	1.0*	324	129	206	5.0	103	55	308
Performance Monitoring Groundwater Samples Collected from **EW1b-13** (Northern HCL Monitoring Well)											
15-May-14	8.22	1.88	1230	1.0*	345	143	204	5.0	109	60	321
12-Nov-14	8.23	1.85	1160	1.0*	340	144	211	6.0	103	62	296
13-May-15$^{\#\#}$	8.19	1.85	1200	1.0*	331	147	200	6.0	102	58	300
11-Nov-15	8.18	1.82	1180	1.0*	316	143	195	5.0	101	54	305
4-May-16$^{\#\#}$	8.03	1.77	1150	1.0*	311	139	205	5.0	102	56	303
10-Nov-16	7.89	1.74	1740	1.0*	302	129	198	5.0	104	53	279
Performance Monitoring Groundwater Samples Collected from **EW1c-13** (Northern HCL Monitoring Well)											
15-May-14	8.22	1.80	1130	1.0*	306	165	202	5.0	108	55	326
12-Nov-14	8.2	1.81	1080	1.0*	318	152	200	5.0	102	56	292
13-May-15$^{\#\#}$	8.21	1.82	1180	1.0*	329	139	195	6.0	102	57	283
11-Nov-15	8.19	1.79	1160	1.0*	311	131	187	5.0	100	52	291
4-May-16$^{\#\#}$	8..02	1.73	1120	1.0*	296	130	199	5.0	101	54	298
10-Nov-16	7.82	1.68	1090	1.0*	281	121	195	5.0	102	52	287
Monthly and Performance Monitoring Groundwater Samples Collected from **EW2a-01** (Southern HCL Extraction Well)											
3-Feb-03	7.39	0.97	NA	NA	150	140	98	5.1	NA	NA	NA
13-Mar-03	7.55	0.75	NA	NA	158	146	104	5.3	NA	NA	NA
15-Apr-03	7.65	0.90	NA	NA	140	130	95	4.8	NA	NA	NA
13-May-03$^{\#\#}$	7.8	1.00	650	1.0*	160	140	96	4.5	68	36	180
15-May-03	7.55	0.99	NA	NA	138	123	97	4.7	NA	NA	NA
18-Jun-03	8.05	1.03	NA	NA	150	130	95	4.8	NA	NA	NA
17-Jul-03	7.56	1.07	NA	NA	140	130	103	4.4	NA	NA	NA
27-Aug-03	7.35	0.87	NA	NA	130	120	95	4.8	NA	NA	NA
18-Sept-03	7.47	0.94	NA	NA	140	129	80	3.8	NA	NA	NA
29-Oct-03	7.8	0.96	620	1.0*	150	130	95	3.9	66	32	180
4-Dec-03	7.63	0.82	NA	NA	140	120	97	4.3	NA	NA	NA
2-Feb-04	7.03	1.01	NA	NA	123	107	94	4.3	NA	NA	NA
6-Apr-04	7.49	1.06	NA	NA	120	180	120	4.6	NA	NA	NA
7-May-04	7.63	0.97	NA	NA	115	132	80	4.26	NA	NA	NA
18-May-04	7.9	1.20	580	1.0*	130	140	100	4.3	69	33	180
30-Jun-04	7.51	1.15	NA	NA	129	139	90	3.7	NA	NA	NA
26-Jul-04	7.59	1.10	NA	NA	130	150	90	3.7	NA	NA	NA
3-Nov-04	7.83	0.97	640	1.0*	130	110	94	3.9	64	29	190
2-Jun-05	8.06	0.95	719	1.0*	129	111	100	3.7	62	28	196
2-Nov-05	7.41	0.93	603	1.0*	125	109	97	3.0	60	25	194
7-Jun-06	8.28	0.97	629	1.0*	126	106	99	4.0	57	24	194
7-Nov-06	8.23	0.96	623	1.0*	116	104	107	3.0	63	27	198
15-May-07	8.18	0.94	611	1.0*	112	98	101	3.0	60	25	200
22-Oct-07	8.11	0.94	608	1.0*	119	98	101	4.0	58	24	195
13-May-08	8.25	0.94	611	1.0*	111	87	104	3.0	57	23	206
22-Oct-08	8.21	0.93	602	1.0*	107	98	98	3.0	52	21	202
26-Aug-09$^{\#\#}$	8.13	0.91	592	1.0*	109	91	101	3.0	52	22	204
3-Nov-09	7.95	0.92	601	1.0*	120	94	104	3.0	51	21	205
16-Jun-10	8.24	0.91	590	1.0*	109	87	101	3.0	52	21	197
7-Dec-10	8.19	0.90	585	1.0*	113	83	102	3.0	48	19	205
11-Jul-11$^{\#\#}$	8.2	0.89	575	1.0*	98	77	94	3.0	43	19	205
6-Dec-11	8.05	0.53	346	1.0*	62	48	61	2.0	33	13	119
11-Jun-12	8.31	0.88	572	1.0*	106	78	97	3.0	45	18	200
16-Nov-12	8.32	0.96	622	1.0*	107	78	97	3.0	56	19	206
23-May-13$^{\#\#}$	8.33	0.83	541	1.0*	106	59	106	3.0	48	20	200
5-Nov-13	8.12	0.94	608	1.0*	106	63	114	4.0	56	23	230
15-May-14	8.35	0.84	470	1.0*	103	47	105	3.0	51	20	263
12-Nov-14	8.25	0.81	460	1.0*	102	38	107	3.0	47	20	223
13-May-15$^{\#\#}$	8.34	0.80	523	1.0*	100	20	102	3.0	43	19	231
11-Nov-15	8.25	0.78	510	1.0*	99	14	95	3.0	42	17	241
7-Jun-16$^{\#\#}$	7.88	747.00	486	1.0*	100	13	103	3.0	41	17	227
10-Nov-16	7.92	0.81	524	1.0*	98	39	111	3.0	47	20	238
Performance Monitoring Groundwater Samples Collected from **EW2b-13** (Southern HCL Extraction Well)											
15-May-14	8.37	0.85	430	1.0*	104	52	105	3.0	51	21	257
12-Nov-14	8.27	0.82	440	1.0*	101	43	106	3.0	49	21	237
13-May-15$^{\#\#}$	8.26	0.80	521	1.0*	102	28	102	3.0	45	20	226
11-Nov-15	8.27	0.79	510	1.0*	100	17	98	3.0	43	17	233
5-May-16$^{\#\#}$	8.18	0.76	494	1.0*	95	12	100	3.0	42	17	238
10-Nov-16	8.05	0.73	474	1.0*	98	7	103	3.0	42	17	225
Performance Monitoring Groundwater Samples Collected from **EW2c-13** (Southern HCL Extraction Well)											
15-May-14	8.28	0.86	470	1.0*	102	72	102	3.0	54	22	248
12-Nov-14	8.2	0.84	540	1.0*	109	68	102	3.0	51	21	208
13-May-15$^{\#\#}$	8.23	0.82	532	1.0*	101	52	102	3.0	48	20	212
11-Nov-15	8.28	0.81	526	1.0*	99	39	97	3.0	46	18	224
5-May-16$^{\#\#}$	8.16	0.78	506	1.0*	92	30	100	3.0	45	18	230
10-Nov-16	8.04	0.74	479	1.0*	95	16	103	3.0	44	17	227

Notes:

*NA : Not Analyzed; * - calculated based on total dissolved solids concentration.*

$^{\#\#}$ *- VOC analysis conducted*

Table 18 (Continued)

Sample Date	pH	Conductivity (mS/cm)	Total Dissolved Solids (mg/L)	Specific Gravity (-)	Chloride (mg/L)	Sulphate (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Alkalinity (mg/L)
Performance Monitoring Groundwater Samples Collected from **PW1-N** (Interface Aquifer Monitoring Well)											
2-Jan-03	7.75	1.50	NA	NA	311	<1	343	2.1	NA	NA	NA
3-Feb-03	7.68	1.40	NA	NA	340	<1	337	2.0	NA	NA	NA
17-Feb-03##	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13-Mar-03	7.74	1.11	NA	NA	363	<1	338	2.1	NA	NA	NA
15-Apr-03**	8.16	1.40	NA	NA	330	5.3	322	2.5	NA	NA	NA
13-May-03##	8.1	1.50	860	NA	340	<1	320	1.7	22	7.9	300
15-May-03##**	7.7	1.51	NA	NA	306	<1	323	2.1	NA	NA	NA
18-Jun-03	8.39	1.53	NA	NA	340	<1	324	2.1	NA	NA	NA
17-July-03**	7.76	1.63	NA	NA	330	<1	328	2.3	NA	NA	NA
27-Aug-03**	7.79	1.33	NA	NA	304	3	309	2.1	NA	NA	NA
18-Sept-03**	7.6	1.39	NA	NA	330	<1	229	1.4	NA	NA	NA
29-Oct-03##**	8	1.40	860	NA	350	1.4	300	2.0	21	7.4	290
4-Dec-03	7.55	1.30	NA	NA	319	<1	310	1.9	NA	NA	NA
7-May-04**	7.78	1.52	NA	NA	327	1	280	1.9	NA	NA	NA
18-May-04	8.1	1.90	900	NA	380	<1	320	2.0	24	8.3	300
30-Jun-04**	7.44	1.85	NA	NA	368	<1	300	1.8	NA	NA	NA
26-Jul-04**	7.78	1.74	NA	NA	350	2	280	1.8	NA	NA	NA
3-Nov-04##	8.06	1.60	960	NA	350	1.3	300	2.7	24	8.2	300
2-June-05##	8.53	1.58	1010	NA	388	< 5	350	2.1	26	8.8	306
2-Nov-05	8.23	1.62	1050	NA	343	2	306	2.0	24	8	310
7-Jun-06	8.27	1.68	1090	NA	354	2	305	2.0	24	8	306
8-Nov-06	8.24	1.69	1100	NA	341	1	352	2.0	23	9	304
15-May-07	8.17	1.78	1160	NA	357	2	309	2.0	29	10	318
24-Oct-07	8.29	1.71	1110	NA	351	4	313	2.0	26	9	303
13-May-08	8.37	1.74	1130	NA	358	3	317	2.0	27	9	311
21-Oct-08	8.33	1.73	1120	NA	355	3	324	2.0	24	8	314
20-May-09##	8,28	1.72	1120	NA	346	2	315	2.0	23	8	312
3-Nov-09	8.22	1.71	1110	NA	365	4	348	2.0	25	9	313
17-May-10	8.29	1.84	1200	NA	400	4	358	2.0	22	9	301
30-Nov-10##	8.32	1.79	1160	NA	357	6	345	2.0	26	12	316
7-Jun-11##	8.33	1.78	1160	NA	375	21	332	3.0	23	12	307
6-Dec-11##	8.31	1.92	1250	NA	405	29	374	3.0	28	16	303
9-Apr-12	8.12	1.79	1160	NA	382	<1	294	2.0	26	10	311
9-May-12	-	-	-	NA	389.1	<0.1	350	2.2	-	-	-
6-Jun-12##	8.32	1.78	1160	NA	387	< 3	341	2.0	23	8	307
10-Jul-12	-	-	-	NA	394.78	<0.1	360	2.2	-	-	-
28-Aug-12	-	-	-	NA	378.87	0.36	360	2.2	-	-	-
19-Sep-12	8.28	1.80	1170	NA	353	49	265	3.0	51	15	296
25-Oct-12	-	-	-	NA	345.3	145.4	310	3.7	-	-	-
16-Nov-12##	8.54	1.86	1210	NA	365	31	382	3.0	41	11	323
20-Dec-12	-	-	-	NA	393.9	26.8	360	2.5	-	-	-
1-Apr-13	8.11	1.84	1200	NA	393	19	336	3.0	35	12	314
16-May-13##	8.3	1.89	1230	NA	404	2	391	2.0	25	10	304
25-Sep-13	8.03	1.90	1240	NA	420	7	352	3.0	33	11	322
5-Nov-13##	8.27	1.90	1240	NA	399	9	386	3.0	34	11	304
19-Dec-13	8.23	1.90	1240	NA	396	8	382	2.0	26	9	313
18-Mar-14	8.1	1.82	980	NA	395	6	352	3.0	29	11	317
21-May-14##	8.37	1.84	920	NA	378	< 1	388	< 1	24	9	355
5-Nov-14##	8.24	1.64	750	NA	354	49	337	2.0	26	12	322
6-May-15##	8.34	1.91	1240	NA	408	<1	352	3.0	32	10	318
11-Oct-15	8.3	1.88	1220	NA	379	<1	324	3.0	30	10	339
4-May-16##	8.22	1.84	1200	NA	375	<1	364	2.0	30	10	338
10-Nov-16	7.99	1.66	1080	NA	341	2	348	2.0	30	9	315
Performance Monitoring Groundwater Samples Collected from **PW2-S** (Interface Aquifer Monitoring Well)											
13-May-03##	8	1.50	870	NA	330	< 1	320	1.6	18	6.6	320
29-Oct-03##	8.2	1.50	930	NA	350	1.6	320	1.9	21	7	320
18-May-04	8.2	1.80	890	NA	340	1.8	330	2.1	21	7.7	320
3-Nov-04##	8.28	1.60	1000	NA	340	0.88	300	1.9	20	7.1	330
2-June-05##	8.32	1.60	1070	NA	363	< 5	340	1.9	23	8	321
2-Nov-05	8.32	1.60	1040	NA	329	2	307	2.0	20	7	326
6-Jun-06	8.3	1.80	1180	NA	379	2	333	2.0	23	9	340
8-Nov-06	8.31	1.80	1150	NA	355	1	322	2.0	20	8	325
15-May-07	8.32	1.88	1220	NA	389	< 1	320	2.0	28	11	334
23-Oct-07	8.24	1.87	1220	NA	383	4	334	2.0	24	9	330
13-May-08	8.38	1.90	1230	NA	402	2	345	2.0	25	9	336
21-Oct-08	8.38	1.90	1200	NA	379	3	359	2.0	23	8	338
20-May-09##	7.45	1.97	1280	NA	408	2	344	2.0	22	9	344
3-Nov-09	8.29	2.03	1320	NA	452	< 1	384	2.0	23	9	348
18-May-10	8.54	3.93	2550	NA	1000	< 1	733	3.0	14	11	447
30-Nov-10	8.35	3.80	2470	NA	916	65	706	5.0	27	18	450
16-Jun-11##	8.33	3.32	2160	NA	814	52	761	4.0	22	14	428
Performance Monitoring Groundwater Samples Collected from **PW2-S(R11)** (Interface Aquifer Monitoring Well)											
6-Dec-11	8.63	2.77	1800	NA	600	20	579	23.0	14	14	438
10-Apr-12	8.28	2.15	1400	NA	430	3	353	4.0	20	9	429
9-May-12	-	-	-	NA	504.6	1.6	460	2.6	-	-	-
6-Jun-12†##	8.35	2.30	1500	NA	473	5	419	2.0	26	9	444
10-Jul-12	-	-	-	NA	455.09	3.67	450	2.3	-	-	-
28-Aug-12	-	-	-	NA	383.46	1.72	420	2.1	-	-	-
19-Sep-12	8.47	1.90	1240	NA	348	3	368	2.0	23	8	422
25-Oct-12	-	-	-	NA	363.5	0.75	390	2.2	-	-	-
16-Nov-12†##	8.72	1.85	1200	NA	316	< 3	341	2.0	23	7	454
20-Dec-12	-	-	-	NA	309.2	0.4	380	2.0	-	-	-
1-Apr-13	8.33	1.69	1100	NA	299	<3	353	2.0	20	6	430
15-May-13†##	8.49	1.70	1100	NA	297	< 1	380	2.0	20	7	405
25-Sep-13	8.33	15.58	1030	NA	273	1	324	2.0	16	6	396
05-Nov-13†##	8.4	1.59	1030	NA	277	< 1	354	2.0	17	6	373
19-Dec-13	8.37	1.57	1020	NA	265	<1	343	2.0	13	5	372
18-Mar-14	8.21	1.53	860	NA	268	<1	333	2.0	16	6	386
15-May-14†##	8.48	2.07	1180	NA	411	< 1	438	2.0	30	10	445
05-Nov-14##	8.34	1.74	980	NA	327	<1	398	2.0	23	7	427
06-May-15##	8.42	1.96	1270	NA	373	<1	387	2.0	23	8	417
11-Nov-15	8.42	2.13	1380	NA	403	<1	432	3.0	30	10	435
5-May-16##	8.34	2.06	1340	NA	393	<1	401	2.0	24	10	437
10-Nov-16	8.23	1.88	1220	NA	361	<1	408	2.0	23	10	396

Notes:

*NA : Not Analyzed; * - calculated based on total dissolved solids concentration.*

- VOC analysis conducted

*** - VOC analysis also conducted on post-treated water from PW1-N prior to injection into northern HCL - all VOC compliance monitoring analytes were below 1 ug/L.*

The chemistry of samples collected at PW2-S(R11) has undergone change since it was initially installed to replace PW2-S (at which the casing was breached allowed shallow water to enter the well). Shortly after its installation, extensive flooding in the vicinity of Sub-cell 3 allowed surface water to enter PW2-S(R11). The well has been actively pumped to extract the introduced water. The water quality of samples from PW2-S(R11) has undergone change and is now similar to that for the wells located off the Facility property.

Graphs Presenting Parameter Concentration Data with Time: Concentration verses time graphs for the two extraction wells and the two Interface Aquifer monitoring wells in the vicinity of Sub-cell 3, are provided in **Appendix H-4.8** (**Figures H-4.8-1 through H-4.8-4**).

Well	Concentration Trend for the Full Period of Record for Group							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Sub-cell 3 Interface Aquifer Wells								
PW1-N	No Trend	Increasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
PW2-S(R11)	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend
Northern HCL Extraction/Observation Wells								
EW1a-01	No Trend	Decreasing	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend
EW1b-13	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend
EW1c-13	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend
Southern HCL Extraction/Observation Wells								
EW2a-01	Decreasing	Increasing	No Trend	Decreasing	No Trend	Increasing	Decreasing	No Trend
EW2b-13	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend
EW2c-13	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend

Wells at which the intra-well UCLs (calculated using the initial eight data points from the subject well) were exceeded in 2016 are listed in the following table:

Well	2016 Parameter Concentration Exceeding Upper Control Limits (Calculated UCL Value)	
	Spring 2016	Fall 2016
PW1-N	Sodium - 364 mg/L (362.4 mg/L) Barium - 0.45 mg/L (0.36 mg/L)	
PW2-S(R11)	Sodium – 401 mg/L (360.6 mg/L) Boron – 2.6 mg/L (2.86 mg/L)	Sodium – 408 mg/L (360.6 mg/L)
EW1a-01		Bromide – 2.33 mg/L (2.28 mg/L)

Well	2016 Parameter Concentration Exceeding Upper Control Limits (Calculated UCL Value)	
	Spring 2016	Fall 2016
EW2a-01	Barium – 0.21 mg/L (0.12 mg/L)	Sodium – 111 mg/L (108.8 mg/L)

Statistical Analysis for Individual Wells: The statistical analysis for two extraction wells [EW1a-01 and EW2a-01] and the two Interface Aquifer monitoring wells [PW1-N and PW2-S(R11)] as a group and as individual wells is included in **Appendix H-4.6-4** and the results are summarized in the tables that follow:

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Trend for Extraction Wells	Decreasing	No Trend	No Trend	Decreasing	No Trend	Increasing	Decreasing	No Trend
Trend for Interface Aquifer Monitoring Wells	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend

Well	Statistically Significant Concentration Trend for Data Collected Between Spring 2012 and Fall 2016[1]							
	Chloride	Sodium	Potassium	Sulphate	Boron	Barium	Bromide	Fluoride
Extraction Wells								
EW1a-01	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	Increasing*
EW2a-01	Decreasing	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	Increasing**
Interface Aquifer Monitoring Wells								
PW1-N	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	Decreasing
PW2-S(R11)	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend

Notes: (1) The database considered in the trend analysis varies by well and parameter. Specifically, the statistical analysis for metals (boron and barium) completed for wells EW1a-01 and EW2a-01 is limited to four sampling events. The metals database for PW1-N is limited to nine sampling events. The major ion chemistry database for PW2-S(R11) is limited to nine sampling events and the metals database of the same well is limited to eight sampling events. (*) 2016 concentration below the maximum value previously observed at well. (**) 2016 concentration above the maximum value previously observed at well.

3.2.3.2 Organic Chemistry

VOC content analyses were conducted on samples collected in spring 2016 from PW1-N and PW2-S(R11) installed in the Interface Aquifer, extraction wells EW1a-01 and EW2a-01 and the four monitoring wells (EW1b-13, EW1c-13, EW2b-13 and EW2c-13) installed in the HCLs. The analysis results are incorporated into the database (**Appendix H-4.4**). VOCs were not detected in any of the samples.

3.3 Performance Monitoring of Engineered Landfill System

3.3.1 Perimeter Collection Trench Monitoring Results

Figures H-4.9-1 through **H-4.9-4** (**Appendix H-4.9**) present hydrographs for the LCS Observation Wells and corresponding sumps in closest proximity to each Observation Well. As discussed in **Section 2.3** the wells were installed near the midpoint of the trench between sumps. LCS Observation Well locations are presented in **Figure 5**. Borehole logs are located in **Appendix H-2.3**. Monitoring results are summarized in the following table:

LCS Observation Well		Pumping Sump Location	
Well	**Observed Leachate Level Range [mASL]**	**Sump**	**Observed Leachate Level Range [mASL]**
LCS OW1-15	196.59 to 201.10 (197.70)	PTS-01	193.08 to 201.34 (197.58)
LCS OW2-15	<196.47 to 201.06 (197.79)	PTS-02	192.66 to 200.79 (197.45)
LCS OW3-15	<197.32 to 201.00 (198.40)	PTS-03	192.72 to 200.27 (197.11)
LCS OW4-15	<197.07 to 200.86 (198.06)	PTS-04	192.59 to 200.39 (197.12)

__Notes:__ () bracketed values represent the average leachate level over the 2016 monitoring period. "<" leachate level was below the pressure transducer sensor elevation.

Figures H-4.9-5 through **H-4.9-8** present cross sections through the LCS trench for March 30, 2016 (**Figure H-4.9-5**), June 9, 2016 (**Figure H-4.9-6**), September 12, 2016 (**Figure H-4.9-7**) and December 31, 2016 (**Figure H-4.9-8**)

3.3.2 Well Transect Monitoring Results

Continuous hydrographs for each of the six wells within the initial transect constructed along the western extent of Cell 19-1 are presented in **Figure H-4.9-9** (**Appendix H-4.9**). A continuous hydrograph for LCS OW2-16 is presented in **Figure H-4.9-2**. The location of the transect is provided in **Figure 5**.

Cross-sections through the transect were prepared for March 30, 2016 (**Figure H-4.9-10**), June 9, 2016 (**Figure H-4.9-11**), September 12, 2016 (**Figure H-4.9-12**) and December 31, 2016 (**Figure H-4.9-13**) are provided in **Appendix H-4.9**.

Table H-4.9-1 (**Appendix H-4.9**) presents the calculated vertical hydraulic gradient between the wells that comprise the transect.

4 SUMMARY AND DISCUSSION OF FINDINGS

4.1 Perimeter Monitoring Program

4.1.1 Groundwater Levels

4.1.1.1 *Shallow Wells (Active Aquitard)*

The hydraulic head distribution in 2016, as observed in the shallow monitoring wells, is consistent with that observed and reported in previous years. The shallow groundwater flow pathways are short, with recharge occurring over topographically elevated areas and discharge occurring in adjacent lows. The shallow groundwater catchment is generally coincident with the surface water catchment areas, the limits of which are delineated by topography.

At the Lambton Facility, the areas where waste is handled/treated/disposed is internal to features along the perimeter of the property such as large perimeter berms (below which the water table is mounded) and retention reservoirs and drainage ditches that act as groundwater 'sinks' under low stage conditions. The shallow groundwater that is collected in the ditches is treated prior to release from the Facility property

In the northern area of the Facility property, shallow flow is outward from a groundwater mound that has developed within the northern berm towards the property boundary (i.e., drainage ditches along Petrolia Line and Telfer Road). Surface water flow along Petrolia Line is eastward towards Perch Creek, which in turn drains to Lake Huron. A component of flow is also expected to be inward from the berm towards the Facility's internal storm water management system.

In the area south of the Pre-1986 Landfill, shallow groundwater movement is influenced by three factors: mounding within the South Berm; the surface water stage in the East and West Reservoirs and the deep drainage channel installed between the landfill (Pre-1986 Landfill) and the South Berm; and the active extraction of leachate from the Cell 19-1 LCS.

Under normal conditions when the reservoirs and ditch are only partially filled, mounding in the South Berm results in flow from the berm northward to the ditch. The mounding therefore acts to contain the leachate plume that exists along the edges of the landfill. Following a storm event that generates a rapid increase in the water level in the ditch, the hydraulic gradient can reverse resulting in the potential for southward groundwater flow below the berm.

Internal to the property, runoff from the landfill and adjacent areas and shallow interflow will be collected within the various drainage ditches, and be conveyed to two ponds (East and West Reservoirs). Water from the West Reservoir is treated prior to being released from the Facility property.

With approval of the expansion of the landfill a leachate collection trench [LCR] was constructed along the west and south perimeter of the Pre-1986 Landfill Area. As such, the collection trench is expected to alter groundwater flow and intercept leachate moving outward from the landfill.

The influence of the LCS on groundwater flow adjacent to and beyond the perimeter trench is discussed in **SECTION 4.3**.

4.1.1.2 *Vertical Hydraulic Gradient across the Inactive Aquitard*

The principal direction of groundwater movement as determined from vertical hydraulic gradient (calculated using water levels measured in adjacent shallow and deep wells) has been downward across most of the Facility property. There has however been a steady increase in the potentiometric surface in the Interface Aquifer, primarily along the northern boundary of the property, since monitoring was initiated in the 1970s.

This increase has been attributed to the expansion of municipal supplies into the area and the general reduction in the volume of water extracted from the Interface Aquifer for residential/farming use. Upward gradients across the clay aquitard are developed over portions of the property (see discussion in **SECTION 3.1.1.3**).

The installation of a leachate collection trench along perimeter of the landfill as part of the landfill expansion, started in the fall of 2015, and is expected to alter the vertical gradients across the clay aquitard below and immediately adjacent to the landfill, and induce an inward hydraulic gradient towards the trench. A discussion with respect to any observed changes in vertical hydraulic gradient related to the LCT is provided in **SECTION 4.3** of this report.

4.1.1.3 *Deep Wells (Interface Aquifer)*

The Facility is located on a regional high, which is reflected in the water level measured at wells installed in the Interface Aquifer. Groundwater flow is outward from this high. As noted above, the potentiometric head observed in many of the wells installed along the northern boundary of the Lambton Facility property and to the east and west of the property have been rising. This is evident in most of the hydrographs prepared for wells located near Petrolia Line, where the past water taking was most pronounced (i.e., residential/farm well supplies) [see **FIGURE 11**].

Past and ongoing activities at the Facility, which have involved pumping from the Interface Aquifer, have depressed the potentiometric surface below the property for extended periods of time. This in turn has influenced the pattern of groundwater flow in the Aquifer below the Facility Property. Most recently (starting in early 2012) pumping from PW1-N and PW2-S(R11) to purge water from the Interface Aquifer (described in Section 2.6.2) has generated a drawdown cone centred on the two wells [PW1-N and PW2-S(R11)] where extraction occurred. The drawdown influence extends outwards from the pumping wells and encompasses much of the north central area of the property.

Pumping at the two wells, which was intermittent because of problems with air compressor, frozen airlines and equipment failure [i.e., pump at PW2-S(R11)], was discontinued in June 2015. The water level in the Aquifer in the vicinity of the wells has been slowly rising in response to the discontinuation of pumping.

4.1.2 Inorganic Chemistry in Shallow Wells (Active Aquitard)

The majority of the shallow monitoring wells installed at the Facility property are located along the property boundary. This well network is supplemented with wells that are located in areas where groundwater quality is known to be affected by site operations. The data from the perimeter and internal wells are used to monitor changes in chemical composition in groundwater quality with time. The shallow monitoring wells that make up the monitoring network at the Lambton Facility have, for purposes of discussion and data interpretation, been grouped according to their location relative to site features.

The chemistry data for the individual wells are compared with the Ontario Drinking Water Standards (ODWS), Guideline B-7 criterion where applicable, and are also reviewed in the context of Provincial Water Quality Objectives (PWQO) as the shallow groundwater along the Facility perimeter is expected to discharge to surface drainage channels and mix with surface runoff. Trends in the parameter concentrations are identified and assessed statistically to determine their significance.

4.1.2.1 Shallow Wells Located Off the Facility Property

The principal findings in 2016 (i.e., parameters that are detected at concentrations that exceed ODWS and PWQO, and emerging trends as defined for the full period of record and through statistical analysis for the last 10 sampling events) observed for the shallow wells located on adjacent property are summarized in **TABLE 19**.

Well TW59-13S is located adjacent to a woodlot west of the Lambton Facility property and is removed from activities such as deicing salt usage and agricultural practices (cultivation and fertilization) that could influence water quality. Although the database for this well is limited, parameter concentrations in samples from this well are substantially lower than the concentrations observed in the other wells that make up the group.

Wells TW56-11S and TW58-11S are located east of the Facility property near Petrolia Line. The chloride and sodium concentrations are elevated in comparison to well TW59-13S. It is postulated that the shallow groundwater quality in the vicinity of the two wells is influenced by deicing salt use (wind drift/spray from Petrolia Line and the subsequent mobilization of salt by infiltrating precipitation). [Note: Well TW58-11S, which is included in this ‘group’, was intentionally installed at a location east of the Facility near the Petrolia Line roadside ditch to characterize groundwater quality immediately adjacent to the roadway.]

Well TW57-13S is located about 500 m east of the Facility property and well TW55-09S is located about 380 m south of the Facility boundary. Both wells are adjacent to a cultivate fields.

Table 19: Summary of Chemistry – Shallow Wells Located Off the Facility Property

Well	Exceeds OWDS	Exceeds PWQO	Increasing Concentration Trend for Full Well Record	Statistically Significant Increasing Trend for Last 10 Sampling Events
Monitoring Wells Located on Adjacent Property to East and West of Facility				
TW56-11S	TDS (spring and fall 2016) Sulphate (spring and fall 2016)	Boron (spring 2016)	Sodium	
TW57-11S	TDS (spring and fall 2016) Alkalinity (fall 2016) Sulphate (fall 2016)			
TW58-11S	TDS (spring and fall 2016) Alkalinity (spring 2016) Sulphate (spring and fall 2016)		Barium	
TW59-13S	TDS (spring and fall 2016)		Chloride, Fluoride	Chloride*
Monitoring Well Located on Adjacent Property (Owned by Clean Harbors) to South of the Facility				
TW55-09S	TDS (spring and fall 2016)	Boron (spring 2016)	Sodium	Sodium*

Notes: (1) Database for the individual wells on which the trend analysis is based varies. (*) 2016 concentration below the maximum value previously observed at well.

The parameter concentrations for TDS (all wells), sulphate (TW56-11S, TW57-11S and TW58-11S), and alkalinity (TW57-11S and TW58-11S), exceeded their respective ODWS criteria in one or more samples collected in 2016. The boron concentration in the spring 2016 sample from TW55-09S and TW56-11S exceeded the PWQO criterion for boron.

With reference to the average parameter concentration verses time graphs for this group of wells (FIGURE H-4.5-1.1, APPENDIX H-4.5), sodium, potassium, sulphate, boron and fluoride concentrations exhibit an increasing trend. On an individual basis, as highlighted in TABLE 19, sodium concentration at TW56-11S, barium concentration at TW58-44S, the chloride and fluoride concentration at TW59-13S, and sodium at TW55-09S are increasing (see graphs in APPENDIX H-4.5-3). Chloride, sodium, potassium, sulphate and bromide concentrations at TW58-11S are comparatively elevated but are stable.

With reference to the statistically significant average parameter concentration verses time graphs for this group of wells (FIGURE H-4.6-1-1, APPENDIX H-4.6), chloride, potassium, and sulphate exhibits a decreasing trend. On an individual well basis, statistically significant increasing trends are identified at TW59-13S (chloride) and at TW55-09S (sodium) however concentrations remain below the historical maximum value observed at these wells. The database for TW56-11S, TW57-11S, TW58-11S and TW59-13S is limited and it is reasonable to conclude that the full range in the concentrations remains undefined.

4.1.2.2 Shallow Wells Located Internal to Facility Property

Table 20 lists the principal findings (i.e., parameter concentrations that regulatory standards and objectives, and emerging trends) for the shallow wells located internal to the Facility property. The chemistry of the individual wells is described in the following discussion.

Table 20: Summary of Chemistry – Shallow Wells Internal to Facility Property

Well	Exceeds OWDS	Exceeds PWQO	Increasing Concentration Trend for Full Well Record	Statistically Significant Increasing Trend for Last 10 Sampling Events
Monitoring Well Installed Internal to the Facility Property that is Influenced by Facility Operations				
TW63-13S	TDS (spring and fall 2016) Chloride (spring and fall 2016)	Boron (spring 2016) Nickel (spring 2016)		
Monitoring Well Installed Internal to Facility Property in Clay Fill of North Berm				
TW39-99S	TDS (spring and fall 2016)		Chloride, Boron, Bromide	Sodium*, Boron*
TW46-99S	TDS (spring and fall 2016) Sulphate (spring and fall 2016)	Boron (spring 2016)		
TW61-13S	TDS (spring and fall 2016)	Boron (spring 2016)	Sodium, Sulphate	
Monitoring Wells Installed Internal to the Facility Property in Underlying Native Clay below North berm				
TW39-99I	TDS (spring and fall 2016) Alkalinity (spring and fall 2016) Iron (spring 2016)	Iron (spring 2016)		
TW46-99I	TDS (spring and fall 2016)		Chloride, Sodium, Sulphate	
TW61-13I	TDS (spring and fall 2016)			

Notes: (1) Database for the individual wells on which the trend analysis is based varies. (*) 2016 concentration below the maximum value previously observed at well.

Shallow Wells Internal to Property that is Influenced by Facility Operations: Well TW63-13S, which is located within the Facility vehicle maintenance staging area, was installed as part of the investigation conducted to identify the source of the elevated chloride concentration at TW45-99S.

Many of the indicator parameters (chloride, sodium, potassium, barium, boron and bromide) are elevated at TW63-13S in comparison to samples collected from the other wells internal to the property (**TABLE 12**). Further, TDS and chloride exceed their respective ODWS. Nickel and boron exceeded the PWQO. [Note: There is substantial use of deicing salt within the Facility vehicle maintenance staging area.

Further, the maintenance area has also been in active use for over 50 years and it is not possible to rule out water quality impact from minor spills from the past handling of waste and vehicle servicing.]

SHALLOW WELLS INTERNAL TO PROPERTY THAT ARE INSTALLED IN THE NORTH BERM: This group of six wells includes three shallow wells (TW39-99S, TW46-99S and TW61-13S) installed in the fill used to construct the berms and three deeper wells (TW39-99I, TW46-99I, and TW61-13I) installed in native overburden below the fill. The wells are installed as part of three well nests that include deep wells completed in the Interface Aquifer.

The water table is mounded in the North Berm and shallow groundwater movement is downward and outward from the berm. The intermediate wells (TW39-99I, TW46-99I, and TW61-13I) are therefore downgradient of the shallow wells (TW39-99S, TW46-99S and TW61-13S) and are expected to exhibit chemistry that is generally similar to the shallow wells.

The ODWS criterion for TDS was exceeded at all six wells in 2016. The ODWS range for alkalinity and iron was exceeded at TW39-99I and the ODWS for sulphate was exceeded at TW46-99S during both sampling events. The PWQO for boron was exceeded at TW46-99S and TW61-13S, and the PWQO for iron was exceeded at TW61-13I during the spring 2016 sampling event. As a group, the indicator parameters (chloride, sodium, potassium and sulphate) in samples from the six wells in this group are elevated in concentration in comparison to the wells located off-property.

On an individual well basis, statistically significant increasing trends were observed for: sodium and boron at TW39-99S, however, concentrations were below the maximum concentrations previously observed at this wells.

4.1.2.3 Shallow Wells Located Along the Perimeter of the Facility Property

Regulatory compliance at the Facility is assessed through a comparison of the analytical results for samples collected from individual shallow wells installed along the Facility property boundary with ODWS and Guideline B-7 criteria derived from chemistry data for wells located off-property. A comparison with the PWQO is also provided to flag parameters of potential concern from a surface water quality perspective.

The principal findings (i.e., parameter concentrations that regulatory standards and objectives, and emerging trends) for the shallow wells located along the perimeter of the Facility property are summarized in **TABLE 21**. The interpretation is divided based on the wells' location relative to the North Berm.

Shallow Wells along Property Boundary, Downgradient of the North Berm: Seven (7) shallow wells (OW32-90S, OW35-90S, TW21-94-II, TW22-94, TW32-94-IV, TW40-99S and TW53-03S) are located between the North Berm and the Facility property boundary.

Shallow groundwater flow in this area is expected to be outward from the North Berm towards roadside ditches along Petrolia Line (north) and Telfer Road (west), and to the drainage swale between the berm and the adjacent farm field to the east. The chemical analysis results for this group of wells are provided in **TABLE 8**. Observations specific to these results are summarized in **TABLE 21**.

The ODWS for TDS was exceeded at all of the wells within this group. The ODWS for sulphate was exceeded at TW22-94 in the fall 2016 sample. Guideline B-7 criteria were exceeded for: iron at OW35-90S in the spring 2016 sample, and sulphate at TW22-94 during both the spring and fall 2016 events. The PWQO for boron (0.2 mg/L) was exceeded at OW32-90S during the spring 2016 event.

For the group as a whole, there has been a significant decreasing trend in the average boron concentration. On an individual well basis statistically significant increasing trends are observed for chloride at OW32-90S; sodium and sulphate at TW22-94; chloride and sulphate at TW32-94-IV; and sodium at TW40-99S. Sodium and sulphate concentrations at TW22-94 were above the historical maximum concentrations observed at the wells on one or more occasion.

Table 21: Summary of Chemistry – Shallow Wells along Perimeter of Facility Property

Well	Exceeds ODWS	Exceeds Guideline B-7 Vaule1	Exceeds PWQO	Increasing Concentration Trend for Full Period of Record	Statistically Significant Increasing Trend for Last 10 Sampling Events
Monitoring Wells Installed along the Property Boundary, Downgradient of the North Berm					
OW32-90S	TDS (spring and fall 2016)		Boron (spring 2016)		Sulphate*
OW35-90S	TDS (spring and fall 2016)	Iron (spring 2016)		Sulphate	
TW21-94-II	TDS (spring and fall 2016)			Sulphate	
TW22-94	TDS (spring and fall 2016) Sulphate (fall 2016)	Sulphate (spring and fall 2016)		Chloride, Sodium, & Sulphate	Sodium** & Sulphate**
TW32-94-IV	TDS (spring and fall 2016)			Chloride	
TW40-99S	TDS (spring and fall 2016)			Sulphate & Fluoride	Sodium*
TW53-03S	TDS (spring and fall 2016)			Sulphate	
Monitoring Wells Installed along the Property Boundary, Removed from the North Berm					
TW30-94	TDS (spring and fall 2016)	Fluoride (spring and fall 2016)		Fluoride	Chloride*, Sodium* & Sulphate*
TW41-99S	TDS (spring and fall 2016) Alkalinity (fall 2016)	Alkalinity (spring and fall 2016)		Chloride	Chloride** & Bromide**
TW42-99S	TDS (spring and fall 2016) Sulphate (spring and fall 2016)	Sulphate (spring and fall 2016)	Boron (spring 2016)	Sodium, Potassium, & Sulphate	Potassium**
TW43-99S	TDS (fall 2016)				

Well	Exceeds ODWS	Exceeds Guideline B-7 Vaule1	Exceeds PWQO	Increasing Concentration Trend for Full Period of Record	Statistically Significant Increasing Trend for Last 10 Sampling Events
TW45-99S				Chloride & Barium	Potassium* & Sulphate*
TW62-13S	TDS (spring and fall 2016)			Sodium & Sulphate	Chloride**
TW48-16S	TDS (spring and fall 2016)			Analysis Limited to two sampling events.	

Notes: (1) Background concentrations used in Guideline B-7 calculation were determined using the average concentration data for the off-site wells (TW55—09S, TW56-11S, TW57-11S and TW59-09). (*) 2016 concentration below the maximum value previously observed at well. (**) 2016 concentration above the maximum value previously observed at well.

Shallow Wells along Property Boundary, Removed from the North Berm: The chemical analysis results for the seven wells (TW30-94, TW41-99S, TW42-99S, TW43-99S, TW45-99S, TW62-13S and TW48-16S) assigned to this group, are provided in **Table 10**. Observations specific to these results are summarized in **Table 21**.

The ODWS for TDS was exceeded in one or more samples for all of the wells in this group except TW45-99S in 2016. The ODWS for alkalinity was exceeded at TW41-99S during the fall 2016 sampling event.

Guideline B-7 criteria were exceeded for: fluoride at TW30-94 (spring and fall 2016); alkalinity at TW41-99S (spring and fall 2016); and sulphate at TW42-99S (spring and fall 2016).

The PWQO criteria for boron was exceeded at TW42-99S during the spring 2016 sampling event.

As a group, the long-term average concentration of boron has decreased. Chloride, sulphate and barium exhibit statistically significant increasing trends. The increasing sulphate trend is attributed primarily to the sulphate concentration at TW42-99S, which has increased steadily between when the well was installed in 1999 (200 mg/L), peaking in May 2014 at 1,600 mg/L. The current sulphate concentration at this well is 1,590 mg/L (spring 2016) and 1,710 mg/L (fall 2016).

Statistically significant increasing trends are evident during the last 10 sampling events for: chloride, sodium and sulphate at TW30-94; chloride and bromide at TW41-99S; potassium at TW42-99S; potassium and sulphate at TW45-99S and chloride at TW62-13S (**Figures H-4.6-2.19 through H-4.6-2.25, Appendix H-4.6**).

The chloride and bromide concentrations at TW41-99S, potassium concentration at TW42-99S, and chloride concentration at TW62-13S in one or more samples in 2016 were above the historical maximum concentrations observed at the wells.

Wells Installed Along the South Berm: The chemical analysis results for the six wells (TW50-02A, TW51-02A, TW52-02A, TW50-02B, TW51-02B and TW52-02B) within this group, are provided in **Table 11**. Observations specific to these results are summarized in **Table 22**.

Table 22: Summary of Chemistry – Wells Installed along the South Berm

Well	Exceeds OWDS	Exceeds PWQO	Increasing Concentration Trend for Full Well Record	Statistically Significant Increasing Trend for Last 10 Sampling Events
Monitoring Well Installed along north toe of the South Berm				
TW50-02A	TDS (spring and fall 2016)	Boron (spring 2016)	No Trend in Chloride or Sodium. All other parameters limited to two sampling events.	No Trend in Chloride or Sodium. All other parameters limited to two sampling events.
TW51-02A	TDS (spring and fall 2016)			
TW52-02A	TDS (spring and fall 2016)	Boron (spring 2016)		
Monitoring Wells Installed in Center of the South berm				
TW50-02B	TDS (spring and fall 2016)	Boron (spring 2016)	No Trend in Chloride or Sodium. All other parameters limited to two sampling events.	No Trend in Chloride or Sodium. All other parameters limited to two sampling events.
TW51-02B	TDS (spring and fall 2016)	Boron (spring 2016)		
TW52-02B	TDS (spring and fall 2016)			

The ODWS for TDS was exceeded in all the wells within this group during both the spring and fall 2016 sampling events.

The PWQO criteria for boron was exceeded at TW50-02A, TW52-02A, TW50-02B and TW52-02B during the spring 2016 sampling event.

There was no discernible trend in chloride or sodium concentrations for the full well record of each well in this group. The analytical database for all other parameters is limited to two sampling events (spring and fall 2016).

4.1.3 Discussion of Shallow Groundwater Chemistry

4.1.3.1 Sources/Activities that can Impact on Shallow Groundwater Chemistry

The interpretation of the chemistry data collected from the shallow monitoring wells over the last several years has identified three contributing sources/activities that have the potential to alter water quality in the vicinity of the wells. These include: the excavation and displacement of clay to construct perimeter berms; use of deicing salt on roadways and parking areas both internal to the Facility property and along Petrolia Line and Telfer Road; and mobilization of chemical constituents in the waste managed at the Facility property.

Shallow monitoring wells have been installed to collect information on the groundwater quality within the 'sphere of influence' of each of these contributing sources. Summary information on each of these influencing sources was presented in the 2014/2015 Groundwater Report [RWDI, 2016]. Referring to the 2014/2015 Groundwater Report, the chemistry data obtained for shallow wells that are considered representative of groundwater in contact with these sources are presented in Table 8 (clay fill), Table 23 (deicing salt and sand/salt mixtures) and Table H-1.7 (Appendix H-1.7) and Table 4 (leachate chemistry).

4.1.3.2 Shallow Wells Located Off Facility Property

SUMMARY COMPARISON OF ANALYTICAL DATA: TABLE 23 presents a summary of the inorganic parameter chemistry for wells that are located off-property (background chemistry) and the chemistry for the potential contaminant sources that are identified in **SECTION 4.1.3.1**.

The background chemistry in **TABLE 23** is represented by the 2016 data for wells TW55-09S, TW56-11S, TW57-11S and TW59-13S (summarized from **TABLE 7**). The chemistry data for groundwater in contact with clay fill is compiled from the 2016 data for wells TW39-99S, TW46-99S and TW61-13S (**TABLE 8**). The deicing sand/salt analysis results are from a summary evaluation presented in Table 22 of RWDI, 2016 and the leachate chemistry is reproduced from **TABLE 4**.

The parameter averages in **TABLE 23** for the off-site wells are skewed because of the inclusion of data for well TW56-11S in the average. This well is located near Petrolia Line and the chloride and sodium concentrations in samples from this well (61 - 62 mg/L and 80 - 89 mg/L, respectively) are elevated in comparison with samples from TW59-13S (11 - 13 mg/L and 28 – 52 mg/L, respectively). Well TW59-13S is some distance removed from any anthropogenic influence and the data for this well (**TABLE 7**) are most representative of background water quality.

Table 23: Comparison of Chemistry for Shallow Off-Property Wells and Contaminant Sources

Parameter	Off-Site	Wells Installed in North Berm	Deicing Salt Analysis	Leachate Chemistry
Alkalinity	319 to 506 (382)	300 to 487 (403)	24 to 82 (44)	430 to 22,083 (7,727)
Barium	0.01 to 0.04 (0.02)	0.02 to 0.04 (0.03)	NA	<0.5 to <5.0 (0.69)
Boron	0.13 to 0.43 (0.25)	0.33 to 4.60 (1.77)	<0.5 (<0.5)	0.2 to 450 (54)
Bromide	<0.25 (<0.25)	<0.25 to 0.62 (0.35)	<0.1 to <5.0 (5.1)	2.5 to 1,911 (495)
Calcium	101 to 319 (198)	121 to 243 (167)	58 to 169 (106)	34 to 1,160 (447)
Chloride	13 to 58 (28)	20 to 40 (25)	22,770 to 26,673 (24,648)	7,680 to 94,900 (26,262)
Fluoride	0.53 to 1.15 (0.77)	0.52 to 0.89 (0.65)	NA	1.36 to 61.7* (13.6)
Iron	<0.03 (<0.03)	<0.03 (<0.03)	NA	0.4 to 127* (16.0)
Magnesium	52 to 165 (97)	69 to 99 (84)	2.7 to 5 (3.9)	0.5 to 304* (47.8)
Potassium	2 to 5 (3.5)	1 to 11 (4.8)	2.9 to 12 (8.6)	152 to 10,000 (4,023)
Sodium	31 to 87 (56)	63 to 131 (87)	14,600 to 18,700 (16,266)	4,690 to 42,600 (18,308)
Sulphate	116 to 926 (504)	258 to 783 (445)	86 to 420 (223)	23 to 23,040 (5,467)
Zinc	<0.01 (<0.01)	<0.01 (<0.01)	NA	<0.5 to 98 (14.1)

Notes: Concentration values expressed in mg/L, NA refers to analysis not being available for the indicated parameter. < refers to less than Method Reporting Limit. Bracketed value is averaged concentration. Where the concentration is below the method detection limit, a value of 50% of non-detect value was applied in calculating the average.

The anion concentrations for one of the leachate monitoring wells (LM8-11) are anomalously low, which was inferred to be caused by matrix interference. The data for this well were discounted and have been removed from the ranges and averages presented in Table 23.

The average concentrations for boron, bromide, potassium and sodium in samples collected from the three wells installed in the North Berm are slightly elevated in comparison with the data for the off-site wells. The remaining parameters are at similar or lower concentrations in the samples from wells installed in the berm.

With regards to the deicing sand/salt analysis results, chloride, potassium and sodium are present at concentrations that are significantly higher than concentrations in the water samples from both the wells located off-site and the wells installed within the clay fill of the berm. Alkalinity, magnesium and sulphate concentrations in the analysis data for deicing sand/salt samples are lower than concentrations in the water samples from the off-site and berm wells.

Although concentration ranges for the parameters present in samples from the wells installed in the waste are large, most parameters were detected at concentrations that are elevated in comparison to the parameter concentrations in samples from the wells located off-site and the berm wells. The exception is magnesium, which is present at a higher concentration in the wells located off-site and the berm wells.

The averaged parameter concentrations for alkalinity, calcium, potassium, and sulphate exhibit the most pronounced differences (i.e., concentration differences of 10x or larger) between the leachate and deicing sand/salt samples.

Bromide concentrations are elevated in the leachate. The average bromide concentration in the deicing sand/salt mixture is also elevated. However, this value is artificially induced by the method used to calculate the averages. Specifically, the bromide concentration in the sand/salt mixture is reported as below the method reporting limits (MRL) and a value of 50% of the MRL is assigned in calculating the averages.

GRAPHIC PRESENTATION OF CHEMISTRY DATA: Trilinear diagrams (also referred to as Piper Plots) and scatter plots (graphs) were prepared as visual aids to highlight the differences between the background chemistry and the identified three contributing sources/activities that have the potential to alter shallow groundwater quality. The graphs (Trilinear Diagrams and scatter plots) are also commonly employed to flag 'mixtures' of water from different sources (i.e., when two water types mix, the chemistry is altered and the data for a parameter, when graphed, will plot between the data fields for the two water types).

TRIANGULAR DIAGRAMS: The Trilinear Diagram is a plot of the relative concentrations of the major cations (calcium, magnesium, sodium and potassium) and anions (chloride, bicarbonate (calculated) and sulphate). In preparation of the Trilinear Diagrams, the sample results, expressed in mg/L, are initially converted to milliequivalents per litre (meq/L). The meq/L concentrations for the cations and anions are then added together, and individual cation and anion percentages are calculated based on the total meq/L for each sample.

FIGURE 16 presents the major ion chemistry for the off-property wells TW55-09S, TW56-11S, TW57-11S and TW59-13S (subsequently referred to as background wells) and compares the chemistry for these wells with the chemical analysis results for:

- wells that are installed in the clay fill of the North Berm (wells TW39-99S, TW46-99S and TW61-13S);
- wells installed within waste cells at the landfill (2012 data for 10 wells); and
- samples of sand/salt mixtures.

Data field boundaries are drawn around the collection of data points that have a 'similar' origin.

The boundary that encompass the data for the three wells (TW39-99S, TW46-99S and TW61-13S) installed in the clay fill of the berm, overlaps with the data field boundary generated for the background wells (TW55-09S, TW56-11S, TW57-11S and TW59-13S). There is only a subtle difference between the chemistry for the two sets of wells. With reference to the cation triangle in **FIGURE 16**, the water quality at the three berm wells is slightly enriched in sodium and depleted in calcium.

The chemistry for both the leachate samples and salt source samples plot against the far right of the composite diagram (diamond) indicating calcium, magnesium and bicarbonate alkalinity concentrations are low in comparison with sodium, potassium, chloride and sulphate concentrations. The leachate and salt source samples also both plot in the lower right hand corners of the anion and cation triangles. In comparison with the leachate samples, the salt source samples are depleted in sulphate.

FIGURE 17 was prepared using **FIGURE 16** as a base with the data field boundaries for the off-property wells and the three contributing sources/activities highlighted. Superimposed in **FIGURE 17** are the groundwater quality data for the following wells:

- wells installed in the native clay overburden immediately below the North Berm (TW39-99I, TW46-99I and TW61-13I);
- well TW63-13S located within the Facility vehicle maintenance yard [Note: the maintenance yard has been part of the Facility's core operational area since the 1960s. Groundwater quality at TW63-13S is thought to be impacted by a combination of factors including minor spills from waste handling activities and the use of deicing salt within the maintenance yard.]; and
- well TW58-11S, which is located east of the Facility property near Petrolia Line and is known to be impacted by deicing salt use along Petrolia Line.

The data for wells TW46-99I and TW61-13I in **FIGURE 17** cluster with the data fields for the off-site wells and the data for TW39-99I with the data field for wells installed in the clay fill of the North Berm. Samples fromTW39-99I are enriched in magnesium and slightly depleted in calcium (cation triangle).

The water samples from TW63-13S are enriched in chloride (per anion triangle) and sodium (cation triangle in **FIGURE 17**). The data for this well plot within the data field boundary for leachate in the anion triangular. With reference to the central diamond in **FIGURE 17**, the data for TW63-13S plot to the right of the data fields for the off-site wells and the wells installed in the clay fill towards the leachate and salt envelopes indicating potential 'mixing' of water from one or both of these sources.

The data for well TW58-11S in the diamond in **FIGURE 17** plot within the data field for the off-site wells, but lie to the right of the data field for the background wells in the anion triangle. This indicates that the water quality is comparatively enriched in chloride.

CONCENTRATION GRAPHS (SCATTER PLOTS): Scatter plots were prepared using the concentration data for background wells, wells installed in the Northern Berm (clay fill) and the waste cells (leachate), and the sand/salt mixtures to highlight the differences between background groundwater chemistry and these contaminating sources/activities (see **FIGURE 18**). The data for the parameters alkalinity, boron, bromide, calcium, chloride, fluoride, magnesium, potassium and sulphate were assigned to the "Y" axis in the graphs and sodium was assigned to the "X" axis. Sodium was assigned to the "X" axis because the concentration differs significantly between the background wells and the three contributing sources/activities, allowing for a wider distribution of the data points in the graphs. [Note: it was initially intended that the barium concentration (one of the indicator parameters) be graphed, however the leachate and salt concentrations are low and the inclusion of the parameter did not contribute to the analysis. Magnesium, which shows some variability in concentration between the background wells and the three contributing sources/activities, was included instead on the "Y" axis.]

Similar to the Triangular Diagram (**FIGURE 16**), the data points for the background wells, the leachate and the sand/salt mixtures presented in the scatter plots (**FIGURE 18**) group into distinctive clusters. The leachate and salt data cluster towards the right side of the graphs, which is consistent with the elevated sodium parameter concentrations in leachate. As is apparent by the position of the data points, alkalinity, boron, potassium and sulphate concentrations are elevated in the leachate samples in comparison with the salt data.

The data for the background wells and wells installed in clay fill of the berm cluster towards the left central portion of the graphs.

The data fields for most of the parameters in samples from the background wells and wells installed in clay fill of the berm overlap. This indicates that there are only minor differences in the concentration of these parameters. The exception is sodium, which is enriched in samples from the wells installed in the clay fill of the North Berm.

FIGURE 19 was prepared using **FIGURE 18** as a base. Superimposed in the figure, are the groundwater quality data for the same set of wells used in generating Trilinear Diagram **FIGURE 17** (i.e., TW39-99I, TW46-99I and TW61-13I; TW15-94 and TW63-13S, and TW58-11S)

For the most part, the data for wells TW39-99I, TW46-99I and TW61-13I in **FIGURE 19** lie within the data field for the background wells. The parameters alkalinity, bromide, fluoride, magnesium and sodium at TW39-99I are slightly enriched and the data points for these parameters in the scatter plots lie within the data field for the wells installed in the clay fill of the berm.

The data for the water samples collected from TW58-11S and TW63-13S in **FIGURE 19** generally lie outside the data field for both the background wells and the wells installed in the North Berm. This is because of the higher calcium, chloride, potassium and sodium concentrations (all three wells), bromide (TW63-13S) and magnesium (TW58-11S).

4.1.3.3 Shallow Wells Along the Perimeter of the Facility Property

Shallow wells that are located along the Facility property boundary that are considered in the assessment of site compliance include:

- OW32-90S, OW35-90S, TW21-94-II, TW22-94, TW32-94-IV, TW40-99S and TW53-03S (located in the northern portion of the Facility property down gradient from the North Berm); and
- TW30-94, TW41-99S, TW42-99S, TW43-99S, TW45-99S, TW62-13S and TW48-16S (located in the southern portion of the Facility property and therefore removed from berm).

Refer to **FIGURE 2** for well locations. The discussion below is organized by these two groups of wells and is followed by summary observations related to site compliance on a parameter-specific basis.

SHALLOW WELLS ALONG PROPERTY BOUNDARY, DOWNGRADIENT OF THE NORTH BERM: With reference to **TABLE 21**, the ODWS for TDS (all wells) and sulphate (TW22-94) were exceeded in one or more samples collected in 2016.

Guideline B-7 criterion were exceeded for: iron at OW35-90S in the spring 2016 sample; and sulphate at TW22-94 in both the spring and fall 2016 samples. The PWQO for boron (0.2 mg/L) was exceeded at wells OW32-90S during the spring 2016.

Statistically significant increasing concentration trends were identified at: OW32-90S (sulphate); TW22-94 (sodium and sulphate); and TW40-99S (sodium). The sodium and sulphate concentrations at TW22-94 exceeded the historical maximum concentration at this location.

FIGURE 20 (Trilinear Diagrams) and **FIGURE 21** (scatter plots) were generated using **FIGURE 16** and **FIGURE 17** respectively. Superimposed in these figures are: the datasets for wells OW32-90S, OW35-90S, TW21-94-II, TW22-94, TW32-94-IV, TW40-99S and TW53-03S. The findings are discussed in the text that follows:

Per the central diamond in **FIGURE 20**, the chemistry for OW32-90S, OW35-90S, TW22-94 and TW53-03S lie within the data field envelop for the background well, whereas the data for TW32-94-IV and TW40-99S lie within the data field envelop for the berm wells. As previously observed the samples from wells in the clay fill of the North Berm are enriched in sodium, which is consistent with the higher sodium concentrations observed in samples from TW32-94-IV and TW40-99S.

Well TW21-94-II is an outlier. With reference to the anion and cation triangles, the concentrations of most of the major ions are comparatively low in the samples from TW21-94-II, which is reflected in the position of the data points.

With reference to **FIGURE 21**, there is no clear differentiation in parameter concentrations for these boundary wells when compared with either the background wells or the wells installed in the clay fill of the North Berm. The data for TW22-94 skew towards the upper right of the data fields for the wells installed in the clay fill of the berm indicating slight enrichment in sodium, chloride, fluoride, magnesium. The data for TW21-94-II either lie below or to the left of the data fields for the background wells.

SHALLOW WELLS ALONG PROPERTY BOUNDARY, REMOVED FROM THE NORTH BERM: These monitoring wells are located along the southern perimeter of the property along the east, south and west boundaries. Per **TABLE 21**, ODWS for TDS (all wells except TW45-99S) and alkalinity (TW41-99S) was exceeded in one or more samples in 2016. The calculated Guideline B-7 criteria were exceeded for alkalinity (TW41-99S), fluoride (TW30-94) and sulphate (TW42-99S). Boron exceeded the PWQO criteria at TW43-99S during the spring 2016 sampling event.

Statistically significant increasing concentration trends were identified for chloride, sodium and sulphate at TW30-94; chloride and bromide at TW41-99S; potassium at TW42-99S; potassium and sulphate at TW45-99S; and, chloride at TW62-13S.

FIGURE 22 (Trilinear Diagram) and **FIGURE 23** (scatter plots) were generated using **FIGURE 20** and **FIGURE 22** respectively as bases. Superimposed in these figures are: the datasets for wells TW30-94, TW41-99S, TW42-99S, TW43-99S, TW45-99S, TW62-13S, and TW48-16S.

With reference to **FIGURE 22** (anion triangle) the data for TW30-94, and TW41-99S lie adjacent to the data field for the background wells, indicating alkalinity and sulphate enrichment and comparatively low chloride concentrations. Wells TW62-13S, and TW48-16S cluster with the data for the wells installed in the clay fill of the North Berm.

The concentrations of the major ions in samples from well TW43-99S show variability between sampling events (i.e., TDS range of 414 mg/L in spring 2016, and 648 mg/L in fall 2016), which explains the scatter in the data for this well. This variability is most evident in the sulphate concentration (85 mg/L in spring 2016 and 218 mg/L in fall 2016) and to a lesser extent in calcium (80 mg/L in spring 2016 and 121 mg/L in fall 2016) and magnesium (27 mg/L in spring 2016 and 52 mg/L in fall 2016).

The anion data for TW45-99S skew towards the chloride apex indicating chloride enrichment. For TW42-99S, the data in the central diamond and anion triangle skew towards the sulphate apex indicating sulphate enrichment.

For the most part, there is no clear differentiation in the concentration graphs (**FIGURE 23**) between the data for the seven wells (TW30-94, TW41-99S, TW42-99S, TW43-99S, TW45-99S, TW62-13S, and TW48-16S) and the data fields for the background wells. The exceptions are: alkalinity concentrations at TW43-99S; and the sulphate concentration at TW42-99S, which lie outside the data fields for these parameters.

Observations Regarding Compliance with Regulations

The following summary discussion is focused on those parameters that have been detected in samples from the shallow wells at concentrations that either exceed one or more of the regulatory criteria or where the parameter concentration exhibits a statistically increasing trend.

TOTAL DISSOLVED SOLIDS (TDS): The ODWS for this parameter is an aesthetic objective applicable to drinking water. TDS refers to the dissolved inorganic components of the water.

TDS is elevated in most of the shallow monitoring wells installed at the Facility property. With the exception of TW45-99S, the ODWS criteria for TDS was exceeded at all of the perimeter wells (see **TABLE 21**) and at the monitoring wells installed off the Facility property (**TABLE 19**).

The TDS values for individual wells along the boundary of the property fall within the historical concentration ranges for these wells.

BORON: The ODWS for boron (5 mg/L) has not been exceeded in the wells along the perimeter of the property.

The lower PWQO criterion for boron (0.2 mg/L) is exceeded at several wells. The boron concentrations OW32-90S and TW42-99S in samples collected in spring 2016 (0.21 mg/L and 0.30 mg/L, respectively) are at the low end of the historical range established for the two wells.

OW32-90S is located between the north perimeter berm and the east property boundary. TW42-99S is located south of the south perimeter berm near the southern property boundary. The north berm was constructed using clay fill excavated during advancement of waste cells 16 and 17, while the south berm was constructed using clay fill excavated during the advancement of cell 18. Shallow groundwater flow in the vicinity of OW32-90S is outward from the berm to the east, while shallow groundwater flow in the vicinity of TW42-99S is expected to be outward from the south berm towards the south. In the vicinity of OW32-90S, a drainage swale located close to the property line would likely intercept a portion of the flow where it would mix with surface runoff and be channeled northward towards discharge at the south ditch along Petrolia Line. The ditch flows from west to east and outlets to Perch Creek northeast of the property.

Boron was also detected at concentrations above the PWQO criteria value at south berm wells TW50-02A (0.22 mg/L), TW52-02A (0.32 mg/L), TW50-02B (0.30 mg/L), and TW51.02B (0.39 mg/L).

Boron was detected at TW55-09S located west of the facility property (off-site) in the spring 2016 sample at a concentration of 0.29 mg/L and at TW56-11S located east of the Facility property near Petrolia Line in the spring 2016 sample at a concentration of 0.43 mg/L. The historical range for boron at these wells is between 0.17 and 0.42 mg/L, and 0.32 and 0.39 mg/L, respectively.

Boron has been consistently detected at elevated concentrations in samples from well TW46-99S, a shallow well that is screened in the clay fill used to construct the berm. The boron concentration at TW46-99S peaked at 31 mg/L in the May 2004 sample and has declined steadily to 3.9 mg/L (May 2015). The boron concentration at TW46-99S during the spring 2016 sampling event was 4.6 mg/L.

Boron has also been observed at concentrations exceeding the PWQO in samples from three other wells located internal to the property, specifically TW39-99I (north berm in north west corner of Facility property), TW61-13S (north berm along west leg) and TW63-13S located within the Facility vehicle maintenance yard east of Telfer Road. The boron concentrations in the spring 2016 samples from wells TW36-99I, TW61-13S and TW63-13S are 1.52 mg/L, 0.37 mg/L and 0.28 mg/L, respectively.

The source of the boron has not been identified. Plausible explanations are that the boron was introduced during berm construction or that the boron is naturally occurring. With regards to the latter, Jagger Hims Limited (1996) reported elevated boron concentrations in groundwater samples collected from wells installed in the clay aquitard (to 75.4 mg/L), Interface Aquifer (to 7.66 mg/L) and underlying shale aquitard (to 10.14 mg/L). The boron concentration in the near surface Active Aquitard at wells located in areas that were not disturbed was reported as low (<0.13 mg/L).

CHLORIDE AND SODIUM: The ODWS for chloride (250 mg/L) and sodium (200 mg/L) are aesthetic objectives for drinking water. These parameters are considered as ‘indicators’ of potential contamination from two sources (i.e., waste leachate moving outward from the landfill and deicing salt applied to local roadways and on roads/parking lots and walkways within the Facility property). Therefore, a statistically significant, increasing trend in the chloride and/or sodium concentrations in samples from a well located along the property boundary may be indicative of the groundwater in the vicinity of the well being influenced by one or possibly both of these contaminating sources.

The ODWS and Guideline B-7 criteria for chloride and sodium were not exceeded in any of the boundary wells in 2016, however statistically significant trends in chloride and sodium were observed in samples from several wells. These include: TW22-94 (sodium); TW40-99S (sodium); TW30-94 (chloride and sodium), TW41-99S (chloride), and TW62-13S (chloride). Well locations are shown in **FIGURE 2**.

The sodium concentrations at wells TW22-94 have been consistently elevated in comparison with most other monitoring wells. The sodium concentration (109 mg/L) in spring 2016 sample from TW22-94 exceeded its historical range. The source of the elevated concentrations is not known.

TW22-94 is located relatively close to (<20 m) Telfer Road where deicing salt is applied. TW22-94 is also within a few metres of two deep wells (TW22-99D and TW60-13D) installed within the Interface Aquifer. These two deep wells are under artesian conditions and the water level under static conditions is above the top of the well casing.

The water is allowed to discharge to the ground surface adjacent to the wells through holes drilled into the exterior protective casing. TDS, conductivity, alkalinity, chloride and sodium concentrations are elevated in water samples from TW22-99D and TW60-13D (**TABLE 15**).

A statistically significant increasing trend in both chloride and sodium was identified at TW30-94. TW30-94 is located along the edge of a wooded area to the east of the south-east retention pond. The chloride concentrations (6 mg/L during both the spring and fall 2016 sampling events) at this well is marginally higher then concentrations observed prior to the fall 2013 sampling event (4 to 5 mg/L).

TW40-99S is downgradient of the North Berm. The sodium concentration at TW40-99S has been increasing since spring 2010 (40 mg/L) with spring 2016 and fall 2016 concentrations being 52 mg/L and 53 mg/L respectively.

A statistically significant increasing trend in chloride was identified at TW41-99S. TW41-99S is located within a wooded area at the southeast corner of the property within about 100 m of the East Retention Reservoir and 125 m of the Pre-1986 Landfill Area. The chloride concentration (41 – 60 mg/L) at this well in 2016, while below the ODWS and Guideline B-7 criterion, is at a level exceeding its historical range.

The source of the chloride at TW41-99S has not been established. Possible sources are: leachate movement outward from the Pre-1986 Landfill Area (per studies conducted by Balfour, 1991; Dames and Moore, Canada, 1992 and 1993; Jagger Hims Limited,1996b; and McKay et al., 1998); and the infiltration/movement of water from the East Reservoir under high water stage conditions. A study was completed in 2015 where samples were collected from the perimeter ditch immediately south of the Pre-1986 Landfill. The study concluded that it was not possible to differentiate between either impacted groundwater moving outward from the Pre-1986 Landfill area or surface water infiltration from the East Reservoir [RWDI, 2016].

Elevated chloride concentrations were observed at well TW62-13S, which is located west of the Central Processing Area of the Facility near the property boundary adjacent to Telfer Road (**FIGURE 2**). The chloride concentration in samples from TW62-13S peaked at 32 mg/L in the fall 2016 sample.

TW62-13S was installed as part of an investigation focused around establishing the source of elevated chloride concentrations observed at TW45-99S (located adjacent to TW62-13S).

The source of the elevated chloride at TW45-99S was established to be attributed to surface infiltration of runoff containing deicing salt that was applied along Telfer Road and at the main entrance to the Lambton Facility.

FLUORIDE: The ODWS for fluoride (1.5 mg/L) is a maximum acceptable concentration (MAC) for drinking water. The fluoride ODWS and Guideline B-7 criterion have been sporadically exceeded at various shallow and deep wells located on and off the Facility property.

In 2016, the Guideline B-7 criterion for fluoride was exceeded at wells TW30-94. An increasing trend in fluoride was observed for the full record period for wells TW40-99S and TW30-94, however, the increasing fluoride trends were not considered to be statistically significant.

Fluoride is a natural constituent in groundwater in Lambton County and the concentration is quite variable. Dillion Consulting Limited in association with Golder Associates (2004) referencing Mellary and Kilburn (1969) reports that 35% of the 23 wells sampled had fluoride concentrations exceed 1.2 mg/L.

SULPHATE: The ODWS for sulphate (500 mg/L), an aesthetic objective applicable to drinking water, was exceeded at TW22-94 and TW42-99S. The sulphate concentration observed at TW22-94 is 550 mg/L (fall 2016 sample) and at TW42-99S is 1,590 mg/L (spring 2016) and 1,710 mg/L (fall 2016). The Guideline B-7 criterion for sulphate was exceeded at the same two wells (TW22-94 and TW42-99S). Statistically significant increasing trends in sulphate were observed at several wells (OW32-90S, TW22-94, TW30-94, TW45-99S and TW42-99S).

With reference to **TABLE 7**, sulphate is present at concentrations exceeding the ODWS (500 mg/L) in samples collected from three (TW56-11S, TW57-11S and TW58-11S) of the five shallow monitoring wells located off-property.

Review of the literature on sulphate concentrations in groundwater in Lambton County identified a reference (Abbott, 1987) that provides an indication of the likely source of the sulphate. Abbott's thesis is directed at the identification of the potential geochemical origin of the elevated sulphate concentrations (to 9,600 mg/L) that have been observed by various researchers in shallow groundwater samples collected in the St. Clair Clay Plain in the Sarnia Area. The research study involved extensive sampling and analysis of soil and shallow groundwater at several sites throughout Lambton County. It was concluded by Abbott that the elevated sulphate is from the dissolution of sulphate minerals and oxidation of reduced forms of sulphur in the clay till.

The till contains abundant fragments of Kettle Point shale, with the average sulphur content of the shale established to be 2.3%, with 84% of the sulphur occurring as pyrite. Groundwater samples collected below the active weathered zone contains hydrogen sulphate, which is a product of sulphate reduction.

It is assumed that the elevated sulphate concentrations in samples from the wells located off property and the wells located downgradient from the berms is related to the disturbance of the clay either through cultivation of the soil or construction of the berms. The comparatively low concentration of sulphate at TW59-13S (103 mg/L to 164 mg/L), a well that is removed from anthropogenic influences (soil disturbance) lends support to this assumption).

An investigation was conducted in 2014/2015 to identify the source of the elevated sulphate concentration at TW42-99S. The study report is included in Appendix H-5.1 of RWDI, 2015. Potential sources for the elevated sulphate concentrations that were considered are: leachate movement southward from Pre-1986 Landfill Area; weathering/oxidation of naturally occurring pyrite in the native overburden at the well site and in the fill used to construct the South Berm located to the north; and the periodic application of fertilizer (containing sulphur) on the field to the south.

The investigation involved sampling of shallow wells in the vicinity of TW42-99S, including two south berm wells TW52-02A and TW52-02B (located to the north of TW42-99S), the collection of surface water samples and soil/bentonite backfill samples adjacent to TW42-99S.

In evaluating the potential leachate source, it would be expected that chloride, bromide, and sodium, which are present in the leachate at elevated concentrations and are mobile in groundwater, would be detected at elevated concentrations at TW42-99S and at the two wells (TW52-02A and TW52-02B) installed between TW42-99S and the landfill. This has not been the case. There does not appears to be direct correlation between the high sulphate concentration at TW42-99S and movement of leachate from the landfill.

TDS, calcium, magnesium and potassium concentrations in samples from TW42-99S (**TABLE 10**) are also comparatively elevated. The higher concentrations of these parameters are consistent with observations presented in Abbott (1987) regarding weathering/oxidation of sulphide minerals in the groundwater.

BROMIDE: Bromide, which does not have an ODWS or a PWQO, was detected at TW41-99S at a statistically increasing concentration. Bromide is known to be elevated in samples collected from wells installed in the landfill and has been observed at an elevated concentration at historical well TW15-94 which was located at the south toe of the Pre-1986 Landfill. It is not currently known whether the source of the elevated bromide at TW41-99S is the leachate plume along the perimeter of the Pre-1986 Landfill or surface water infiltration from the East Reservoir. Surface water samples at the Facility property are not analyzed for bromide and no information is available on its presence/concentration in the surface water on the Facility Property.

4.1.4 Inorganic Chemistry in Deep Wells (Interface Aquifer)

Parameters including alkalinity, chloride, sodium and fluoride are frequently detected in samples collected from the deep monitoring wells screened against the Interface Aquifer located both off-property and within the Facility property at concentrations which exceed the ODWS, the derived Guideline B-7 values or both.

Barium, boron and iron are also occasionally observed in samples from these wells at elevated concentrations. These parameters occur naturally and their presence at elevated concentrations is documented in past monitoring reports for the Facility property and published papers that described the hydrogeology and geochemistry in Lambton County.

The chemistry results for deep wells installed on neighbouring properties and within the Facility property are summarized herein and the findings are presented by well group and on a well-by-well basis, where applicable.

4.1.4.1 Deep Wells Located Off the Facility Property

The chemistry for the deep wells located on neighbouring properties is summarized in **TABLE 24**.

The ODWS for TDS, chloride and sodium were exceeded in all of the samples collected in 2016 at TW55-09D, TW56-11D and TW57-11D. The ODWS for TDS was exceeded in the spring 2016 and fall 2016 samples at TW59-13D only.

Statistically significant increasing trends were identified for chloride (TW57-11D and TW59-13D), and sodium (TW57-11D). Parameter concentrations are within or lower than the historical concentration ranges that were established for the individual wells.

Table 24: Summary of Chemistry – Deep Wells Located Off the Facility Property

Well	Exceeds ODWS	Exceeds Derived Guideline B-7 Criteria[1]	Calculated UCL Exceeded[2]	Statistically Significant Increasing Trend for Last 10 Sampling Events[2]
Monitoring Wells Located on Adjacent Property to East and West of the Facility				
TW56-11D	TDS (spring and fall 2016) Chloride (spring and fall 2016) Sodium (spring and fall 2016)	Not Applicable	UCL Not Exceeded	
TW57-11D	TDS (spring and fall 2016) Chloride (spring and fall 2016) Sodium (spring and fall 2016)		UCL Not Exceeded	Chloride* and Sodium*
TW59-13D	TDS (spring and fall 2016)		UCL Not Exceeded	Chloride*
Monitoring Wells Located on Adjacent Property to the South of the Facility				
TW55-09D	TDS (spring and fall 2016) Chloride (spring and fall 2016) Sodium (spring and fall 2016)	Not Applicable	UCL Not Exceeded	

Notes: (1) Guideline B-7 only applied to wells located along perimeter of the Facility property. (2) Trend analysis for the four wells is based on very limited data. (*) 2016 concentration below the maximum value previously observed at well.

4.1.4.2 *Deep Wells Internal to the Facility Property*

The chemistry results for the deep wells installed in the Interface Aquifer at locations on the Facility property are summarized in **TABLE 25**. The average concentrations of the indicator parameters in samples collected in 2016 from this group of wells remained consistent both within the group and on a well-by-well basis.

Table 25: Summary of Chemistry – Deep Wells Installed Internal to Facility Property

Well	Exceeds ODWS	Exceeds Derived Guideline B-7 Criteria[1]	Calculated UCL Exceeded[2]	Statistically Significant Increasing Trend for Last 10 Sampling Events[2]
OW1-92[3]	TDS (spring 2016) Sodium (spring 2016) Iron (spring 2016)	Not Applicable		Potassium*
TW33-94-I[3]	TDS (spring 2016) Sodium (spring 2016)			
TW39-99D	TDS (spring and fall 2016) Chloride (spring and fall 2016) Sodium (spring and fall 2016)			

Well	Exceeds ODWS	Exceeds Derived Guideline B-7 Criteria[1]	Calculated UCL Exceeded[2]	Statistically Significant Increasing Trend for Last 10 Sampling Events[2]
TW46-99D	TDS (spring and fall 2016) Sodium (spring and fall 2016) Iron (spring 2016)	Not Applicable		
TW54-09D	TDS (spring and fall 2016)			
TW61-13D	TDS (spring and fall 2016) Sodium (spring and fall 2016)			

Notes: (1) Guideline B-7 only applied to wells located along perimeter of the Facility property. (2) TW61-13D is slow to recover following purging/sampling, the chemistry suggests the presence of residual drill water. (*) 2016 concentration below the maximum value previously observed at well. (**) 2016 concentration above the maximum value previously observed at well. (3) Well Decommissioned in June 2016. Trend analysis includes data for spring 2016 only.

As in the past, TDS concentrations at all of the wells within this group exceeded the ODWS for TDS. The ODWS for sodium was exceeded at wells OW1-92, TW33-94-I, TW39-99D, TW46-99D and TW61-13D; and the ODWS for iron at OW1-92.

There were no exceedances of the intra-well UCLs.

A statistically significant increasing trend in potassium was identified at OW1-92, however the spring 2016 concentration (2 mg/L) remained below the historical maximum value observed at this well (3.3 mg/L).

4.1.4.3 Deep Wells along the Perimeter or the Facility Property

The chemistry results for the fourteen (14) deep wells [OW32-90D, OW35-05D, TW22-99D, TW30-99D, TW32-94-II, TW40-99D, TW41-99D, TW43-99D, TW45-99D, TW47-00D, TW48-00D, TW49-00D, TW53-03D and TW60-13D] installed in the Interface Aquifer at locations along the Lambton Facility property boundary are summarized in **TABLE 26.** Groundwater quality data for these wells are used to monitor changes in chemistry with time at the Facility's point of compliance.

Table 26: Summary of Chemistry – Deep Wells Installed Along Perimeter of Facility Property

Well	Exceeds ODWS	Exceeds Derived Guideline B-7 Criteria[1]	Calculated UCL Exceeded[2]	Statistically Significant Increasing Trend for Last 10 Sampling Events[2]
OW32-90D	TDS (Spring/Fall 2016) Sodium (Spring/Fall 2016)	Alkalinity (fall 2016) Chloride (fall 2016) Sodium (spring/fall 2016)		
OW35-05D	TDS (Spring/Fall 2016)	Alkalinity (fall 2016)	Boron (spring 2016)	

Well	Exceeds ODWS	Exceeds Derived Guideline B-7 Criteria[1]	Calculated UCL Exceeded[2]	Statistically Significant Increasing Trend for Last 10 Sampling Events[2]
	Sodium (Spring/Fall 2016) Iron (spring 2016)	Chloride (fall 2016) Sodium (spring/fall 2016) Iron (spring 2016)		
TW22-99D	TDS (Spring/Fall 2016) Alkalinity (Spring/Fall 2016) Sodium (Spring/Fall 2016) Boron (spring 2016)	Alkalinity (spring/fall 2016) Chloride (spring/fall 2016) Sodium (spring/fall 2016) Boron (spring 2016)		Potassium*, Boron**,
TW30-99D	TDS (Spring/Fall 2016) Sodium (Spring/Fall 2016)	Alkalinity (fall 2016) Sodium (spring/fall 2016)		
TW32-94-II	TDS (spring/Fall 2016) Sodium (spring/Fall 2016)	Alkalinity (fall 2016) Chloride (spring/fall 2016) Sodium (spring/fall 2016)	Chloride (spring and fall 2016) Sodium (spring and fall 2016) Barium (spring 2016)	Barium**
TW40-99D	TDS (spring/Fall 2016) Sodium (spring/Fall 2016) Iron (spring 2016)	Alkalinity (fall 2016) Chloride (spring/fall 2016) Sodium (spring/fall 2016) Iron (spring 2016)		Fluoride*
TW41-99D	TDS (spring/Fall 2016) Sodium (spring/Fall 2016)	Alkalinity (fall 2016) Sodium (spring/fall 2016)		Potassium*
TW43-99D	TDS (spring/Fall 2016) Sodium (spring/Fall 2016) Iron (spring 2016)	Alkalinity (fall 2016) Sodium (spring/fall 2016) Iron (spring 2016)		Potassium*
TW45-99D	TDS (Spring/Fall 2016) Alkalinity (spring/Fall 2016) Sodium (spring/Fall 2016) Iron (spring 2016)	Alkalinity (fall 2016) Chloride (spring/fall 2016) Sodium (spring/fall 2016) Iron (spring 2016)	Chloride (fall 2016) Sodium (spring/fall 2016)	
TW47-00D	TDS (spring/Fall 2016) Alkalinity (spring/Fall 2016) Sodium (spring/Fall 2016) Barium (spring 2016) Boron (spring 2016) Iron (spring 2016)	Alkalinity (spring/fall 2016) Chloride (spring/fall 2016) Sodium (spring/fall 2016) Barium (spring 2016) Boron (spring 2016) Iron (spring 2016)	Chloride (spring/fall 2016) Sodium (spring/fall 2016) Potassium (spring/fall 2016) Boron (spring 2016) Barium (spring 2016)	Boron**, Barium**
TW48-00D	TDS (spring/Fall 2016)	Alkalinity (spring/fall 2016)		

Well	Exceeds ODWS	Exceeds Derived Guideline B-7 Criteria[1]	Calculated UCL Exceeded[2]	Statistically Significant Increasing Trend for Last 10 Sampling Events[2]
	Fluoride (fall 2016)	Chloride (spring/fall 2016) Sodium (spring/fall 2016) Fluoride (fall 2016)		
TW49-00D	TDS (spring/Fall 2016)			Potassium*, boron*
TW53-03D	TDS (spring/Fall 2016) Alkalinity (spring/Fall 2016) Sodium (spring/Fall 2016) Iron (spring 2016)	Alkalinity (fall 2016) Chloride (spring/fall 2016) Sodium (spring/fall 2016) Iron (spring 2016)		Sodium*
TW60-13D	TDS (spring/Fall 2016) Alkalinity (spring/Fall 2016) Sodium (spring/Fall 2016) Boron (spring 2016) Iron (spring 2016)	Alkalinity (spring/fall 2016) Chloride (spring/fall 2016) Sodium (spring/fall 2016) Boron (spring 2016) Iron (spring 2016)		Insufficient data to complete trend analysis

Notes: (1) Guideline B-7 only applied to wells located along perimeter of the Facility property. (2) TW61-13D is slow to recover following purging/sampling, the chemistry suggests the presence of residual drill water. (*) 2016 concentration below the maximum value previously observed at well. (**) 2016 concentration above the maximum value previously observed at well.

Based on the average parameter concentrations for the group as a whole, the water quality is becoming more mineralized. Specifically, the average concentrations of several parameters including conductivity, TDS, chloride, sodium, barium and boron show an increasing concentration trend. As noted in **SECTION 3.3.1.3**, the chloride and sodium concentrations for the group remained relatively stable until 2009, after which the concentrations of both parameters started to increase. The concentrations of boron and barium have increased gradually over this same interval.

The increase in average chloride and sodium concentrations are primarily attributed to the inclusion of data from TW40-99D and TW47-00D. The upward trends in the chloride and sodium concentrations at TW47-00D first became apparent in 2010. This was followed by an increase in chloride and sodium concentrations at TW40-99D in the spring 2012 sample from this well. Both wells are at the northwest corner of the property.

With reference to **TABLE 26**, the ODWS (for TDS, alkalinity, sodium, barium, boron, fluoride, and iron) and the derived Guideline B-7 criteria (for alkalinity, chloride, sodium, fluoride, barium, boron, and iron), were exceeded in one or more samples collected in 2016 from the 14 wells in the group.

The Upper Control Limits (UCLs) were exceeded at: OW35-05D (boron); TW32-94-II (chloride, sodium and barium); TW45-99D (chloride and sodium); and TW47-00D (chloride, sodium potassium, boron and barium).

Statistically significant increases were observed for: sodium (TW53-03D); potassium (TW22-99D, TW41-99D, TW43-99D, and TW49-00D); fluoride (TW40-99D); barium (TW32-94-II, TW47-00D and TW48-00D); and boron (TW22-99D, TW47-00D, and TW49-0D).

4.1.5 Discussion of Deep Groundwater Chemistry

4.1.5.1 Characterization of Sources/Activities that can Impact on Groundwater Chemistry in the Interface Aquifer

Two contributing sources/activities have been identified that can alter the chemistry of the groundwater in the Interface Aquifer. The first is the presence or formation of a 'conduit' that would allow shallow groundwater or leachate from the landfill to move downward through the thick clay deposit to the Interface Aquifer. The second is the natural mineralization of the groundwater resulting from an alteration of the volume of groundwater flow through the bedrock (shale of the Kettle Point Formation) component of the Interface Aquifer. A thorough discussion of these two factors is presented in the 2014/2015 Annual Monitoring Report [RWDI, 2016] and the reader is referred to this report for details (http://www.cleanharbors.com/locations/canada/lambton-facility/landfill-report-pages/2015-landfill-report).

4.1.5.2 Comparison of Groundwater Chemistry – Interface Aquifer, Shallow Overburden, Shale Aquitard and Waste Leachate

SUMMARY COMPARISON OF ANALYTICAL DATA: A comparative assessment of the inorganic chemistry of samples collected from various wells located off and on the Lambton Facility property was completed to highlight the differences in the chemistry from the different water sources (Interface Aquifer, Shallow Overburden, Shale and Leachate).

The assessment approach is similar to that described for the shallow wells in **SECTION 4.1.3.2**, which involved the summary compilation of the recent data for the different water sources, and the use of visual aids (Trilinear diagrams and scatter plots) to highlight the differences.

The chemistry data for samples collected from the following sources are compiled in **TABLE 27**:

- off-property wells installed in the shallow overburden (TW55-09S, TW56-11S, TW57-11S and TW59-13S);
- off-property wells installed in the Interface Aquifer (TW55-09D, TW56-11D, TW57-11D and TW59-13D);
- wells installed in the Kettle Point Formation shale (TW32-94-I, TW38-94-I and TW42-99D); and
- wells installed in waste cells at the Facility in 2011 (2012 data compiled from Table H-1.7, Appendix H-1.7).

Table 27: Comparative Summary of Chemistry – Interface Aquifer and Other Water Sources

Parameter	2016 Off-Site Shallow Overburden Wells[1]	2016 Off-Site Wells in Interface Aquifer	2014/2015 Shale Wells	2012 Chemistry Data for Leachate Wells[1]
Alkalinity	319 to 506 (382)	273 to 398 (327.75)	753 to 2,120 (1,321)	430 to 22,083 (7,727)
Barium	0.01 to 0.04 (0.02)	0.10 to 0.21 (0.14)	0.9 to 5.8 (2.77)	<0.5 to <5.0 (0.69)
Boron	0.13 to 0.43 (0.25)	1.40 to 2.20 (1.90)	5 to 7 (5.87)	0.2 to 450 (54)
Bromide	<0.25 (<0.25)	0.13 to 0.55 (0.31)	0.58 to 3.45 (2.14)	2.5 to 1,911 (495)
Calcium	101 to 319 (198)	17 to 26 (21.75)	20 to 234 (92.6)	34 to 1,160 (447)
Chloride	13 to 58 (28)	121 to 440 (293.5)	2,150 to 17,300 (7,977)	7,680 to 94,900 (26,262)
Fluoride	0.53 to 1.15 (0.77)	0.84 to 1.40 (1.14)	0.66 to 0.81 (0.71)	1.36 to 61.7* (13.6)
Iron	<0.03 (<0.03)	0.08 to 4.48 (1.28)	<0.3	0.4 to 127* (16.0)
Magnesium	52 to 165 (97)	5 to 9 (7.25)	15 to 249 (102)	0.5 to 304* (47.8)
Potassium	2 to 5 (3.5)	2 to 3 (2.5)	5 to 42 (20)	152 to 10,000 (4,023)
Sodium	31 to 87 (56)	176 to 444 (327.13)	1,970 to 11,300 (5,678)	4,690 to 42,600 (18,308)
Sulphate	116 to 926 (504)	<1 to 1 (0.75)	1 to <10 (4.56)	23 to 23,040 (5,467)
Zinc	<0.01 (<0.01)	<0.01 (<0.01)	<0.1	<0.5 to 98 (14.1)

Notes: Concentration values expressed in mg/L, < refers to less than Method Detection Limit. Bracketed value is averaged concentration, 50% of non-detect value applied in calculating averages, (*) outlier values not considered in averages.
(1) Values carried forward from Table 23.

The following differences are evident in **Table 27** between the water sources:

- **Comparison of Chemistry between Shallow Overburden Wells and Wells in Interface Aquifer:** Most parameters, with the exception of alkalinity, calcium, magnesium and sulphate, are at higher average concentrations in the deep wells in comparison with the shallow wells. The average sulphate concentration in the shallow overburden is about 250x greater than the concentration observed in samples from the Interface Aquifer.

- **Comparison of Chemistry between Wells in Interface Aquifer and Wells Installed in the Waste:** Chemical parameter concentrations for samples collected from wells installed in the waste are substantially higher than samples collected from wells installed in the Interface Aquifer. The average sulphate concentration for samples from the waste is about 2,300x greater than the concentration observed in samples from the Interface Aquifer.

- **Comparison of Chemistry between Wells Installed in the Shale and Wells Installed in the Waste:** Most of the parameters, with the exception of barium and magnesium, are elevated in wells installed in the waste in comparison with samples collected from wells installed in the Kettle Point Formation shale.

Graphic Presentation of Chemistry Data: **Figure 24** is a Trilinear Diagram that shows the major ion chemistry data for the individual wells that are representative of the four water sources (shallow overburden, Interface Aquifer, Kettle Point Formation shale and waste). Data field boundaries are drawn around the collection of data points for samples of 'similar' origin/composition.

As illustrated in **Figure 24**, the data field for the overburden wells is distinct from the data fields for the Interface Aquifer, Kettle Point Formation shale and waste (which overlap). The primary differentiators are chloride and sodium, which are present at low concentrations in the shallow overburden, and are present at comparatively elevated concentrations in the Interface Aquifer, Kettle Point Formation shale and wells installed in the waste. In the cation triangle, samples from the overburden wells are enriched in magnesium and calcium in comparison with the other water sources.

Figure 25 presents concentration graphs (scatter plots) that were generated with the data for alkalinity, boron, bromide, calcium, chloride, fluoride, magnesium, potassium and sulphate assigned to the "Y" axis and sodium to the "X" axis. The data for the various sources plot in distinctive clusters reflecting the differing parameter concentrations. Of note, samples from the shallow wells have the lowest boron, bromide, chloride, potassium and sodium concentration and the samples from the waste have the highest concentrations of these parameters. The samples from the wells installed in the Interface Aquifer and the Kettle Point Formation shale lie between these two extremes, with the parameters boron, bromide, chloride, potassium and sodium present at higher concentrations in the shale wells.

The shallow overburden wells are enriched in calcium, magnesium and sulphide compared to samples collected for wells in Interface Aquifer and wells in the Kettle Point Formation shale. The fluoride concentrations are slightly elevated in the samples from the shallow overburden wells and wells in Interface Aquifer, compared to samples from wells in the Kettle Point Formation shale.

4.1.5.3 *Deep Wells Internal to the Facility Property*

Figure 26 (Trilinear Diagram) and **Figure 27** (Scatter Plots) were generated using **Figure 24** and **Figure 25** respectively, as bases. Superimposed on these figures are: the inorganic parameter datasets for monitoring wells installed in the Interface Aquifer internal to the Facility property (OW1-92, TW33-94-I, TW34-94-I, TW39-99D, TW46-99D, TW54-09D and TW61-13D).

Per **Figure 26**, the data for this group of wells cluster with that for the Interface Aquifer wells located off property.

Figure 27 presents the chemistry for this group (OW1-92, TW33-94-I, TW34-94-I, TW39-99D, TW46-99D, TW54-09D and TW61-13D) in concentration graphs. For the most part the chemistry data for these seven wells lie within the data field boundary for the Interface Aquifer wells. The outliers are evident in the sulphate graphs (data for TW61-13D). The anomalous chemistry at TW61-13D is indicative of the contribution from an alternative source (drill water from the Facility's municipal supply) which is likely still present given the slow recovery (low hydraulic conductivity) at this location.

4.1.5.4 *Deep Wells Along the Perimeter of the Facility Property*

The deep wells located along the perimeter Facility property are arbitrarily divided into two groups in order to accommodate the large volume of chemistry data in the preparation of the Trilinear Diagrams and scatter plots.

These two groups include the following wells:

- OW35-05D, TW22-99D, TW32-94-II, TW40-99D, TW47-99D, TW53-03D and TW60-13D installed in the Interface Aquifer along the northern perimeter of the Facility property; and
- OW32-90D, TW30-99D, TW41-99D, TW45-99D, TW48-00D and TW49-00D installed in the Interface Aquifer along the southern perimeter of the Facility property.

The well locations are shown in **FIGURE 3**. The discussion below is organized by these two groups of wells.

DEEP WELLS LOCATED ALONG THE NORTHERN PERIMETER OF THE PROPERTY: **FIGURE 28** (Trilinear Diagram) and **FIGURE 29** (Scatter Plots) were generated using **FIGURE 24** and **FIGURE 25** respectively, as bases. Superimposed on these figures are the inorganic parameter datasets for monitoring wells OW35-05D, TW22-99D, TW32-94-II, TW40-99D, TW47-99D, TW53-03D and TW60-13D, which are installed in the Interface Aquifer and are located along the northern perimeter of the Facility property (**FIGURE 3**).

With reference to the anion triangle plot in the Trilinear Diagram (**FIGURE 28**), the chemistry for the seven (7) boundary wells cluster with the data for the wells installed in the Interface Aquifer (at off-property locations) and the wells installed in the Kettle Point Formation shale.

The position of the data points (i.e., along the bottom of the triangle), reflects the low sulphate concentration in the samples from these wells. The dataset for these wells in the composite diamond (**FIGURE 28**) shows greater variance. Specifically, the samples from TW32-94-II and TW47-00D are comparatively enriched in chloride. The calcium and magnesium concentrations at TW40-99D are also proportionally higher.

The chemistry for OW35-05D, TW32-94-II, TW22-99D, TW53-03D and TW60-13D overlaps the data field for the Interface Aquifer wells (located off-property) indicating no significant differences in the major ion chemistry for the wells.

Per **FIGURE 29** the data for OW35-05D, TW32-94-II, TW40-99D and TW53-03D plot within the data field for the Interface Aquifer wells (located off-property) indicating the chemistry profile is similar. The data for wells TW22-99D, TW47-00D and TW60-13D skew towards the data field for the wells installed in the Kettle Point Formation. Samples from these three wells (**TABLE 15**) are enriched in alkalinity, boron, chloride and sodium, and depleted in sulphate and fluoride.

DEEP WELLS LOCATED ALONG THE SOUTHERN PERIMETER OF THE PROPERTY: **FIGURE 30** (Trilinear Diagram) and **FIGURES 31** (Scatter Plot) present the inorganic parameter datasets for the Interface Aquifer wells located along the southern perimeter of the Facility property. Included in these figures are the data for seven wells OW32-90D, TW30-99D, TW41-99D, TW43-99D, TW45-99D, TW48-00D and TW49-00D.

Per the central diamond and the cation triangle in the Trilinear diagram (**FIGURE 30**), the chemistry data for these perimeter wells cluster with that for the off-property wells installed in the Interface Aquifer.

With reference to **Figure 31**, the data points for the seven wells cluster with the data for the off-property wells installed in the Interface Aquifer. The two data points for TW45-99D in the various concentration graphs appear to be influenced by the Kettle Point Shale (indicated by how they plot between the Off-Site and shale well fields).

Observations Regarding Compliance with Regulations: The concentrations of various parameters including TDS, alkalinity, barium, boron, chloride, fluoride, iron, potassium and sodium, have been detected in samples from many of the monitoring wells installed in the Interface Aquifer along the perimeter of the Facility property at concentrations that exceed regulatory criteria (i.e., ODWO and the calculated Guideline B-7 criteria). These parameters (at the concentrations observed) have been detected in samples collected from both the Interface Aquifer deep wells located off the Facility property (**Table 13**), and the wells that are installed in the underlying Kettle Point Formation shale (**Table 28**), at elevated concentrations, and are therefore considered to be endemic to the groundwater in contact with the bedrock (Kettle Point Formation) in the general vicinity of the Lambton Facility property.

The trend towards increasing mineralization of the groundwater in the Interface Aquifer is most evident in samples from the wells (TW22-99D, TW40-99D, TW47-99D and TW60-13D) installed in the Interface Aquifer that are located in the northwestern portion of the Lambton Facility property.

The increasing mineralization is attributed to an increase in the water levels in the Interface Aquifer across the northern portion of the property and a readjustment of vertical and horizontal hydraulic gradients.

The resulting effect is that there is less groundwater flow through the Interface Aquifer and less recharge from the overlying clay, and therefore less water available to dilute the natural constituents present in the matrix of the shale that are released by solution/diffusion into the groundwater.

4.1.6 Monitoring Results – Organic Chemistry

4.1.6.1 *Summary Observations – Shallow Wells (Active Aquitard)*

Samples are collected for VOC analysis at a frequency of once every two years. The most recent sampling event was completed in May 2015. The next shallow biennial sampling event for VOCs is scheduled for spring 2017.

4.1.6.2 *Summary Observations – Deep Wells (Interface Aquifer)*

VOCs Detected at Well TW22-99D: As discussed in **Section 3.1.2.2**, Trichloroethylene (TCE) has been detected at TW22-99D since 2007, with other VOCs including Methylene Chloride (DCM), cis-1,2-Dichloroethylene (cis-1,2-DCE), trans-1,2-Dichloroethylene (trans-1,2-DCE), Tetrachloroethylene (PCE) and Benzene detected in one or more samples from in the same well. Well TW22-99D has been the focus of an ongoing investigation as to the potential source of these VOCs. The most recent information that has been collected is summarized in **Table 16**.

TCE and Cis-1,2-DCE remain isolated to samples collected from well TW22-99D. Specifically, these parameters have not been detected in the adjacent well (TW60-13D), which was installed within the same water bearing zone, nor has TCE been detected in samples from any other monitoring wells installed in the Interface Aquifer.

VOCs Detected at Other Wells In the Interface Aquifer: With reference to **Table 16**, the petroleum hydrocarbon constituents, Benzene and Toluene, were detected in one or more samples collected in 2016 from several wells installed in the Interface Aquifer located both on property (TW22-99D, TW39-99D, TW45-99D, TW46-99D, TW60-13D and TW61-13D) and off property (TW56-13D, TW57-13D and TW59-13D). Benzene and toluene has also historically been detected in the underlying Kettle Point Formation shale (TW32-94-I, TW38-94-I and TW42-99D) [RWDI, 2016]. The hydrocarbons appear to be endemic to groundwater in contact with the bitumen in the Kettle Point Formation and their occurrence at individual wells may be related to the sluggish water movement through the shale and extended groundwater/shale contact time.

4.2 Monitoring Program to Assess Effectiveness of Sub Cell 3 Mitigation

Water level monitoring at the wells installed in the HCLs of the remedial structures in Sub-cell 3 and within the underlying Interface Aquifer confirms that an inward hydraulic gradient is being maintained. The chemistry of the samples collected from wells installed in the northern HCL is stable, whereas the chemistry of samples from wells in the southern HCL is undergoing change (reduction in the degree of mineralization). The ground surface over this portion of Sub-cell 3 is depressed compared to the surrounding area and standing water is frequently observed following a significant precipitation event. The presence of standing water would create a larger downward hydraulic gradient across the clay cap above the HCL. The downward movement of surface water with a relatively low TDS content would dilute the groundwater entering the HCL from the surrounding and underlying clay overburden.

Sulphate was detected at well PW1-N in the fall 2014 at a concentration (49 mg/L) that is atypical of the Interface Aquifer. It was determined that seepage was entering the well at shallow casing joints (above a depth of 6 m). Repairs were subsequently made. The sulphate concentration in the spring 2016 and fall 2016 samples was below 2 mg/L (<1 mg/L in spring 2016 and 2 mg/L in fall 2016) indicating the repair was effective.

Quarterly potentiometric surfaces of the northern portion of Sub-cell 3 evidence the continued recovery of the Interface Aquifer in the vicinity of Sub-cell 3 following discontinuation of pumping from PW1-N in July 2015.

4.3 Performance Monitoring of Engineered Landfill System

4.3.1 Perimeter Collection Trench

As detailed in **Section 2.3.3.1**, water levels are collected from four sumps (PTS-01, PTS-02, PTS-03 and PTS-04) and four observation wells (LCS OW1-15, LCS OW2-15, LCS OW3-15 and LCS OW4-15) installed within the backfill of the initial 500 m length of the leachate collection trench. Well locations are provided in **Figure 5**. Observations follow:

LCS OW1-15: Figure H-4.9-1 (Appendix H-4.9) presents hydrographs for LCS OW1-15 and adjacent LCS sumps PTS-01 and PTS-02. The pressure transducer installed within LCS OW1-15 was found to be defective (leaky seal) during the June downloading event, and was subsequently replaced on June 8, 2016. Therefore, water level data from the date the transducer was installed (January 8, 2016) and June 8, 2016 was not recorded. With the exception of five spikes in water level (June 16 to 20, July 14, August 14, August 16 and December 25 to 29, 2016), water level elevations at this observation well were maintained between 198 mASL and 197 mASL.

The five spikes in water level elevation correlate to similar leachate level spikes recorded by the systems Programmable Logic Controller (PLC) at sumps PTS-01 and PTS-02. These in turn corresponds to precipitation events recorded at the Environment Canada, Sarnia, Chris Hadfield Airport Climate Station.

LCS OW2-15: Figure H-4.9-2 (Appendix H-4.9) presents hydrographs for LCS OW2-15 and adjacent LCS sumps PTS-02 and PTS-03. A rapid decrease in the leachate level was observed at LCS OW2-15 following initiation of pumping from sumps PTS-02 and PTS-03 on February 8, 2016. With the exception of a number of spikes in the leachate level (observed between March 25 to 26, between May 14 to 21, August 17 and December 27 to 28), levels were maintained below 198 mASL over the balance of the monitoring period. [Note: periods within the hydrograph where no data is presented indicate that the leachate level was below the pressure transducer sensor depth]. For the most part the spikes correspond to precipitation events recorded at the Environment Canada, Sarnia, Chris Hadfield Airport Climate Station.

LCS OW3-15: Figure H-4.9-3 (Appendix H-4.9) provides hydrographs for LCS OW3-15 and adjacent LCS sumps PTS-03 and PTS-04. A rapid decrease in the leachate level occurred at LCS OW3-15 following initiation of pumping from sumps PTS-01 and PTS-03 on February 8, 2016. With the exception of spikes in leachate level (observed between March 25 to 27, between May 14 to 29, August 14, August 17 and December 27 to 28), levels were maintained below 198 mASL over the balance of the monitoring period. For the most part spikes correspond to precipitation event recorded at the Environment Canada, Sarnia, Chris Hadfield Airport Climate Station.

LCS OW4-15: Figure H-4.9-4 (Appendix H-4.9) provides hydrographs for LCS OW4-15 and adjacent LCS sump PTS-04. A rapid decrease in leachate level occurred at LCS OW4-15 following initiation of pumping from sump PTS-04 on February 8, 2016. With the exception of spikes in leachate level (observed between March 25 to 27, between May 14 to June 21, August 14, August 17 and December 27 to 28), liquid levels were maintained below 198 mASL for the balance of the monitoring period. For the most part spikes correspond to precipitation event recorded at the Environment Canada, Sarnia, Chris Hadfield Airport Climate Station.

Cross-Sections Through The LCS: Figures H-4.9-5 through **H-4.9-8 (Appendix H-4.9)** show profiles of the leachate level recorded on March 30, 2016, June 9, 2016, September 12, 2016, and December 31, 2016, respectively. For the most part, the leachate level was flat along the length of the LCS. The exception occurred on December 31, 2016 where a horizontal gradient towards pumping stations PTS-01, PTS-03, and PTS-04 is evident. The horizontal gradient at PTS-02 was relatively flat in comparison to adjacent observation wells LCS OW1-15 and LCS OW2-15.

4.3.2 Well Transect Monitoring Program Results

The water levels observed at the various wells, which comprise the initial LCS monitoring transect along the west side of Cell 19-1, were compared to determine if an inward gradient exists towards the LCS.

Figure H-4.9.9 (**Appendix H-4.9**) presents hydrographs for each of the transect wells (TW64-16I, TW64-16-II, TW64-16III, TW64-16-IV, TW48-00D and TW48-16S. With the exception of early data (which reflects the recovery of water levels to static conditions following well installation), the water levels within the transect wells were generally flat throughout the monitoring period with responses to purging/sampling events evident at TW45-16S as well as precipitation recharge events evident within the active aquitard well TW64-16-IV.

Figures H-4.9-10 through **H-4.9-13** present cross-sections through the monitoring transect on March 30, 2016, June 9, 2016, September 12, 2016, and December 31, 2016, respectively. **Table H-4.9-1** (**Appendix H-4.9**) provides calculated vertical gradients between each of the transect wells on the above dates.

Horizontal Gradients: The horizontal gradient within the Active Aquitard (TW48-16S, TW64-16-IV and LCS OW2-15) is towards the LCS trench on each of the four monitoring events. Water levels within the Inactive Aquitard well installed below the base of the landfill (TW64-16-I) are relatively stable fluctuating up to 1.7 m throughout the year. Intermediate Active Aquitard wells TW64-16-II and TW64-16-III vary seasonally, fluctuating within 2.8 m and 1.3 m range respectively.

Vertical Gradients: As presented in **Table H-4.9-1** (**Appendix H-4.9**) a downward gradient exists between Active Aquitard and the Interface Aquifer at well nest TW48-00D/TW48-16S which is consistent throughout the monitoring period. Early groundwater level data indicates a downward vertical gradient between Inactive Aquitard well TW64-16-I (installed below the base of the Pre-1986 Landfill) and Active Aquitard Well TW64-16-IV, however an upward gradient develops between these two wells by September 12, 2016 becoming increasingly upward by December 31, 2016. A similar upward gradient has developed between Intermediate Inactive Aquitard wells TW64-16-II and TW64-16-III; and Inactive Aquitard Well TW64-16-II and Active Aquitard well TW64-16-IV.

As evident in the above analysis, the horizontal gradient within the Active Aquitard is towards the perimeter LSC; and an upward vertical hydraulic gradient is evident between the Inactive Aquitard wells towards the Active Aquitard within the transect well nest (TW64-16).

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Groundwater Monitoring Along Perimeter Monitoring Program

5.1.1 Monitoring Well Network

WELL DECOMMISSIONING: A number of redundant or unused wells exist at the Lambton Facility Landfill. Clean Harbors initiated a program to decommission the wells per the requirements of Ontario Regulation 903. The majority of the redundant wells have been removed in prior monitoring years. If access to the private property located east of the Facility is obtained, the two existing wells nests located on this property (TW35-94 and TW37-94) should be decommissioned. **FIGURE 2** and **FIGURE 3** show the locations of the referenced wells.

WELL INSTALLATION: It is intended that two large diameter wells be installed as part of the Performance testing of the Purge Well Pumping System (**SECTION 2.4**). The two wells would be installed in the Interface Aquifer at locations to be determined along the north and east boundary of the Facility property. This work should be conducted in accordance with the "**FINAL DRAFT GROUNDWATER AND LANDFILL PERFORMANCE MONITORING PROGRAMS**" [RWDI, 2015].

5.1.2 Monitoring Program

The groundwater and landfill performance monitoring program as outlined in the document "***Final Draft – Groundwater and Landfill Performance Monitoring Programs***", prepared by RWDI (December 9, 2015) should continue through 2017 with the following modifications:

- The inside diameter of OW32-90D does not allow for the installation of either low flow or discrete interval sampling apparatus. As such, this well should continue to be purged and sampled using cumulative volume sampling techniques, limiting the drawdown to a maximum depth of 5 m above the well screen.

5.1.3 Investigation into Anomalies Identified in the 2016 Analytical Results

TW42-99S: An investigation was conducted in 2014/2015 to determine the source/cause of the elevated sulphate concentration at TW42-99S. Although the results are inconclusive, it is apparent that the elevated sulphate concentration is limited to this well. Sulphate concentrations in the wells located closer to the Pre-1986 Landfill are substantially lower.

With the installation of the leachate collection system along the southern perimeter of the Pre-1986 Landfill, it is expected that the existing shallow groundwater flow pattern, which is outward from the landfill, will be altered. It is therefore recommended that Clean Harbors Canada, Inc. meet with the MOECC to determine what further action, if any, be taken to assess the sulphate concentrations at TW42-99S.

TW45-99D: The occurrence of sulphate at concentrations that are atypical of the Interface Aquifer and the historical sporadic detection of chloroform, which is associated with the chlorination of water, in samples from TW45-99D are suggestive that shallow groundwater may be moving downward to the screen of this well (possibly along the annulus of the well). This well is poorly productivity, and is very slow to recover between sampling events. The drawdown associated with purging/sampling induces a near continuous inward gradient towards the well. This would promote downward movement along the annulus of the well.

Well TW45-99D was inspected with a downhole camera in 2015 and the casing appeared to be sound down to the 15 m depth examined. The well was also redeveloped in an effort to improve its hydraulic response. Well's recovery continues to be poor.

It is not possible to assess the integrity of the annulus around the casing.

It is recommended that well TW45-99D be decommissioned and replaced with a new installation. The replacement well should be completed with Schedule 80 PVC pipe as opposed to the prior practice of using Schedule 40 PVC pipe.

TW22-99D: TCE and cis-1,2-DCE continue to be detected at TW22-99D at concentrations of concern. Although the source of the TCE (and associated daughter product, cis-1,2-DCE) has not been determined, the data collected to date indicate that TCE is not within the Interface Aquifer.

Specifically, TCE has not been detected in a well (TW60-13D), which was installed to the same depth immediately next to TW22-99D. The possibility exists that TCE may be entering the well at a shallower depth, possibly with seepage at a joint in the casing.

Downhole packer testing was attempted in 2014/2015 to determine if seepage was occurring and whether this seepage contained TCE (RWDI, 2015). Testing was limited to the upper 12 m of the well because of an obstruction in the well. The results were inconclusive.

The TCE and c is-1,2-DCE concentrations are stable. At this time, it is recommended that Clean Harbors continue to monitor TW22-99D for VOCs on a semi-annual basis to coincide with the routine groundwater monitoring events. Should the concentrations increase, Clean Harbors should inform the MOECC immediately to discuss what additional actions could be taken.

5.2 Monitoring Program to Assess Effectiveness of Sub Cell 3 Mitigation

The Sub-cell 3 Monitoring Program as outlined in the document "***Final Draft – Groundwater and Landfill Performance Monitoring Programs***", prepared by RWDI (December 9, 2015) should continue through the 2017 monitoring period.

In addition, Clean Harbors intends to install high level alarms in the two extraction wells (EW1a-01 and EW2a-01) to provide an additional level of warning should the pumping equipment stop operating. Installation of this equipment is to occur once Sub-cell 3 is accessible in the spring of 2017.

5.3 Performance Monitoring of Engineered Landfill System

The Engineered Landfill System Performance Monitoring Program as outlined in the document "***Final Draft – Groundwater and Landfill Performance Monitoring Programs***", prepared by RWDI (December 9, 2015) should continue through the 2017 monitoring period.

In accordance with the program established in the above document, additional wells should be installed in the waste along the initial transect that currently consists of wells LCS OW2-15, TW64-16 (I, II, III, and IV), TW48-00D and TW48-16S once the interim cap has been installed on Cell 19-1. These wells should be nested to allow for the determination of both the vertical and horizontal hydraulic gradients within the waste.

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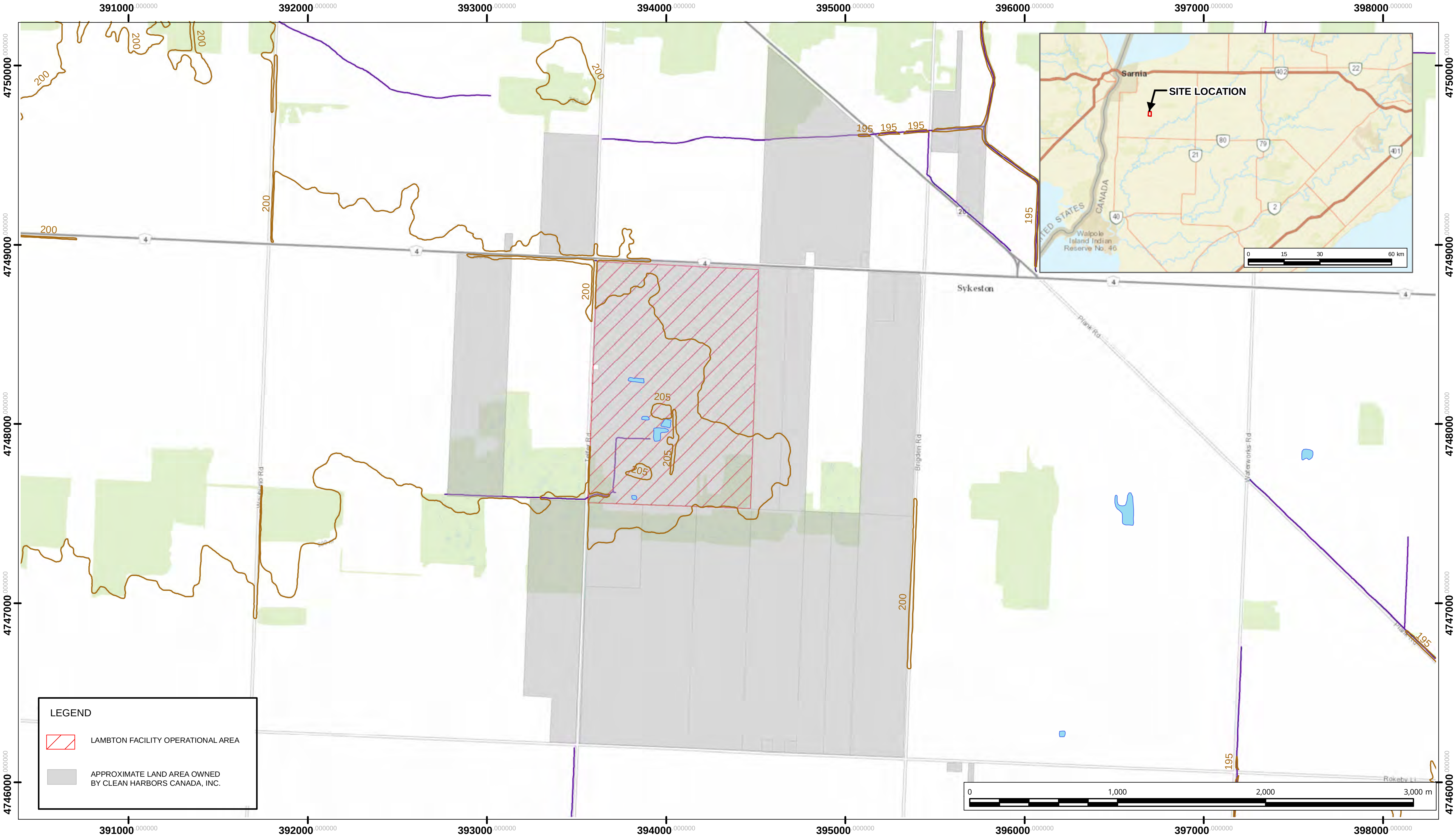
FIGURES



LEGEND

🟥 LAMBTON FACILITY OPERATIONAL AREA

⬜ APPROXIMATE LAND AREA OWNED BY CLEAN HARBORS CANADA, INC.

SITE LOCATION PLAN

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Coruuna, Ontario

Notes:
1. Basemap from Ontario Base Mapping.
2. Regional map from ESRI Community Mapping services (2017).

Map Projection: NAD 1983 UTM Zone 17N

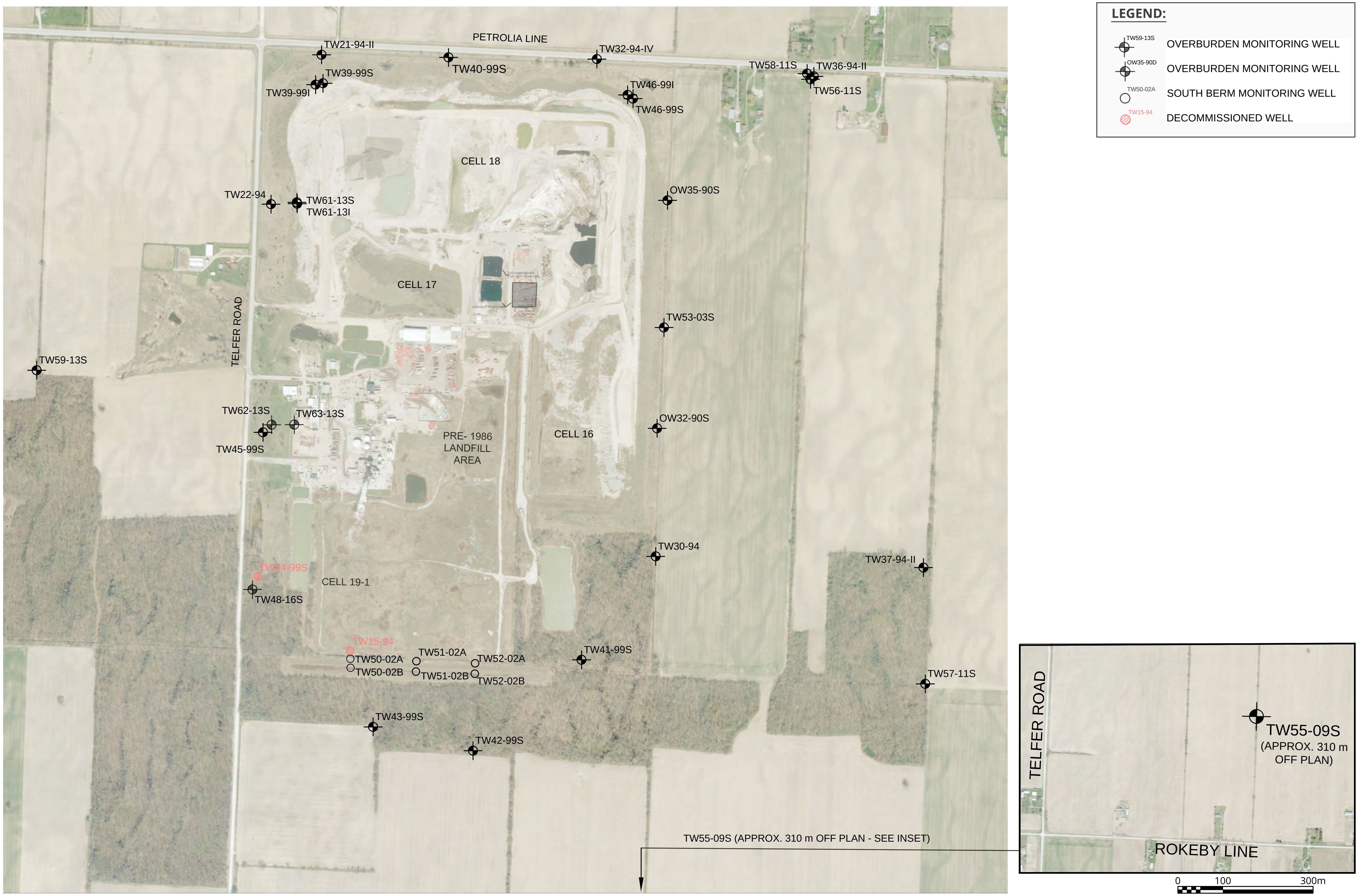
True North

Project #: 1600331

Drawn by: SSL	Figure: 1
Approx. Scale:	1:24,245
Date Revised:	Mar 1, 2017

DATE PLOTTED: March 1, 2017

Map Document: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\1600331_F01.mxd



WELL LOCATIONS FOR THE ACTIVE AQUITARD

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

Notes
1. ORTHOPHOTO PROVIDED BY FIRST BASE SOLUTIONS, (2010).

True North

Project #1600331

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Approx. Scale: 1:8,000	
Date Revised: Feb. 28, 2017	

FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\1600331_F02.dwg

DATE PLOTTED: February 28, 2017

LEGEND:

TW43-99D	INTERFACE AQUIFER MONITORING WELL
OW35-05D	INTERFACE AQUIFER MONITORING WELL
● TW42-99D	KETTLE POINT SHALE MONITORING WELL
⊗ PW1-N	INTERFACE AQUIFER MONITORING WELL (SUB-CELL 3 OPERATIONS AND MAINTENANCE PROGRAM)
◉ PW4-03	INTERFACE AQUIFER PUMPING WELL (DECOMMISSIONED)
▨ OW1-92	DECOMMISSIONED WELL

WELL LOCATIONS FOR THE INTERFACE AQUIFER AND KETTLE POINT FORMATION

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

Notes
1. ORTHOPHOTO PROVIDED BY FIRST BASE SOLUTIONS, (2010).

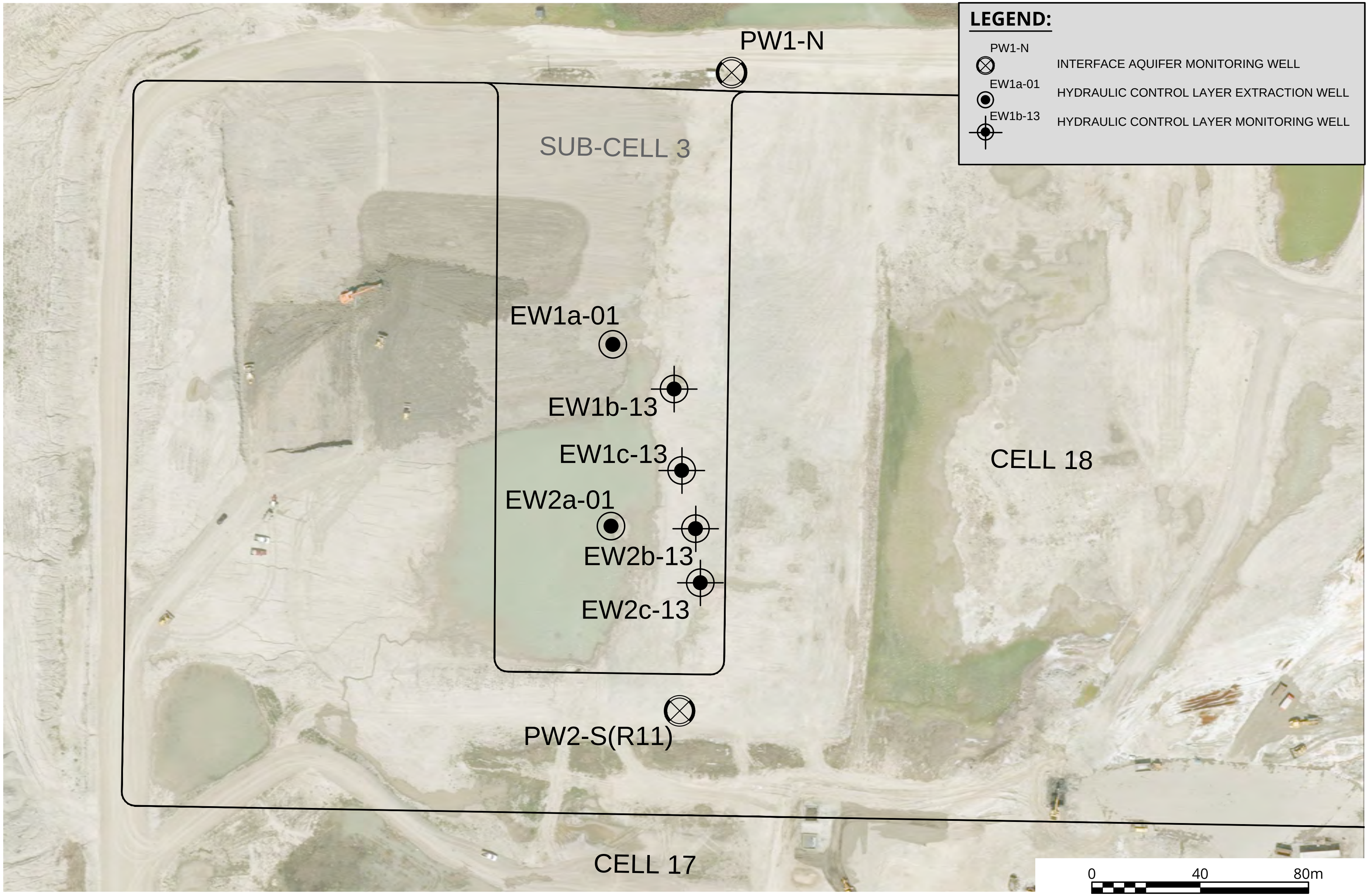
True North

Project #1600331

Drawn by: SSL
Figure: 3
Approx. Scale: 1:8,000
Date Revised: Feb. 28, 2017

FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\1600331_F03.dwg

DATE PLOTTED: February 28, 2017



SUB-CELL 3 MONITORING WELLS

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

Note:
1. ORTHOPHOTO PROVIDED BY FIRST BASE SOLUTIONS (2010).

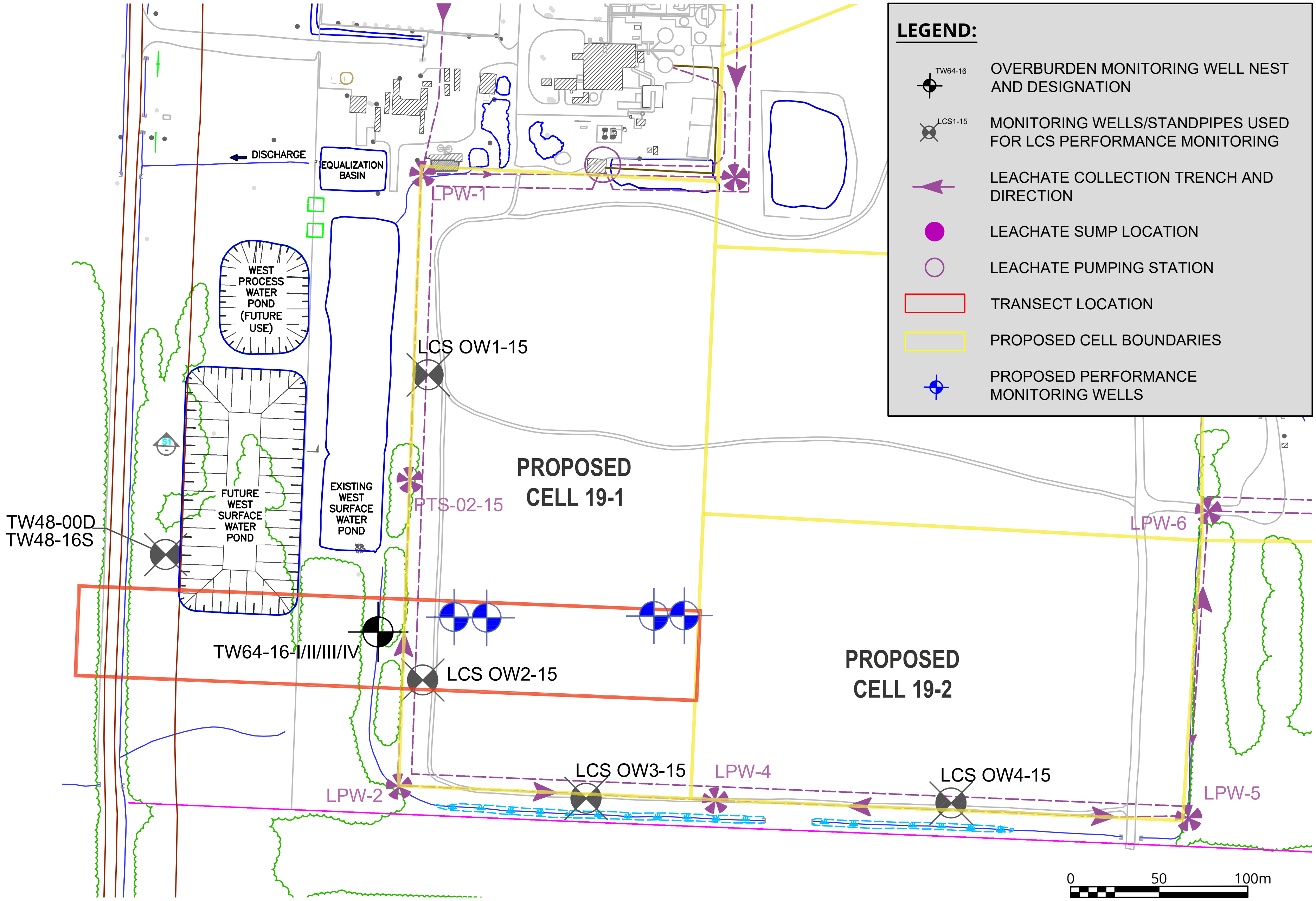
True North

Project #1600331

Drawn by: SSL	Figure: 4
Approx. Scale: 1:2,000	
Date Revised: Jan. 11, 2017	

FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\1600331_F04.dwg

DATE PLOTTED: March 1, 2017



ENGINEERED LANDFILL SYSTEM MONITORING WELLS

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

Note:
1. BASEMAP PROVIDED BY TETRATECH (2015).

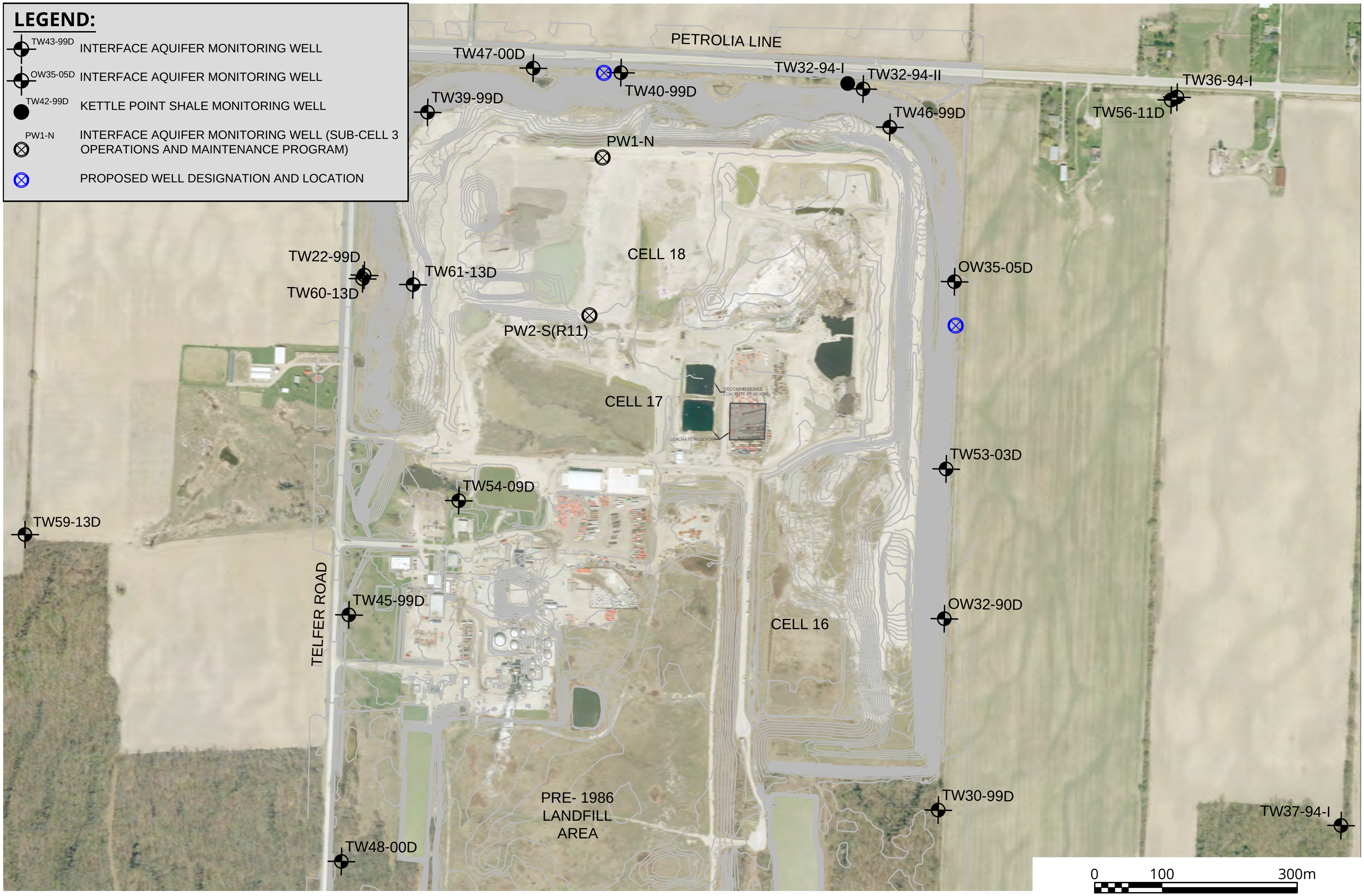
True North

Project #1600331

Drawn by: SSL	Figure: 5
Approx. Scale:	1:3,000
Date Revised:	Mar. 3, 2017

FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\1600331_F05_170123.dwg

DATE PLOTTED: March 3, 2017



PROPOSED PURGE WELL LOCATIONS

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

Note:
1. ORTHOPHOTO PROVIDED BY FIRST BASE SOLUTIONS (2010).NOTES:
2. BASEMAP PROVIDED BY INSPEC-SOL (2013) AND MONTEITH & SUTHERLAND LTD. (2015).

True North

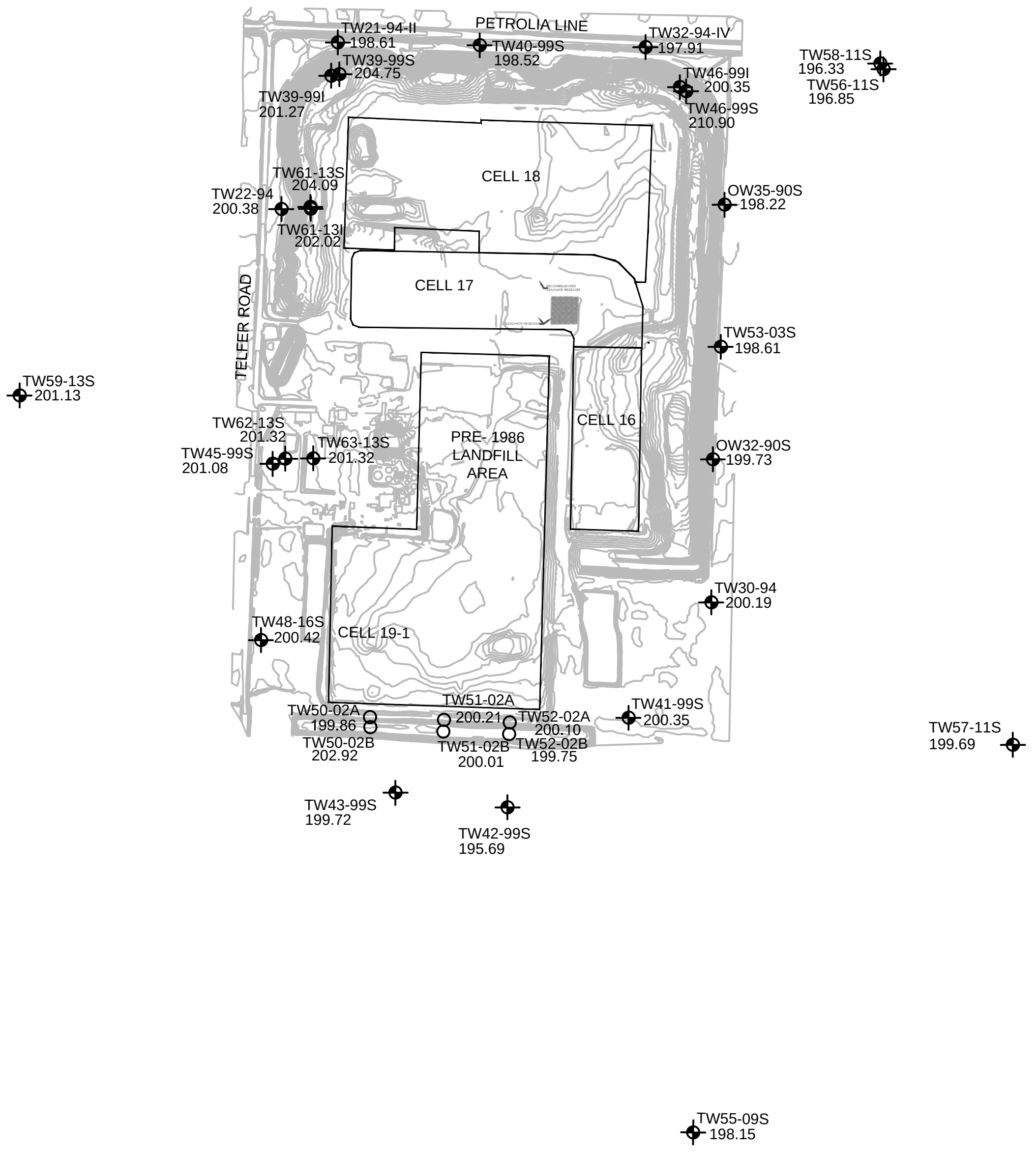
Project #1600331

Drawn by: SSL	Figure: 6
Approx. Scale:	1:2,000
Date Revised:	Mar. 2, 2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\1600331_F06_PWLoc.dwg

DATE PLOTTED: March 2, 2017

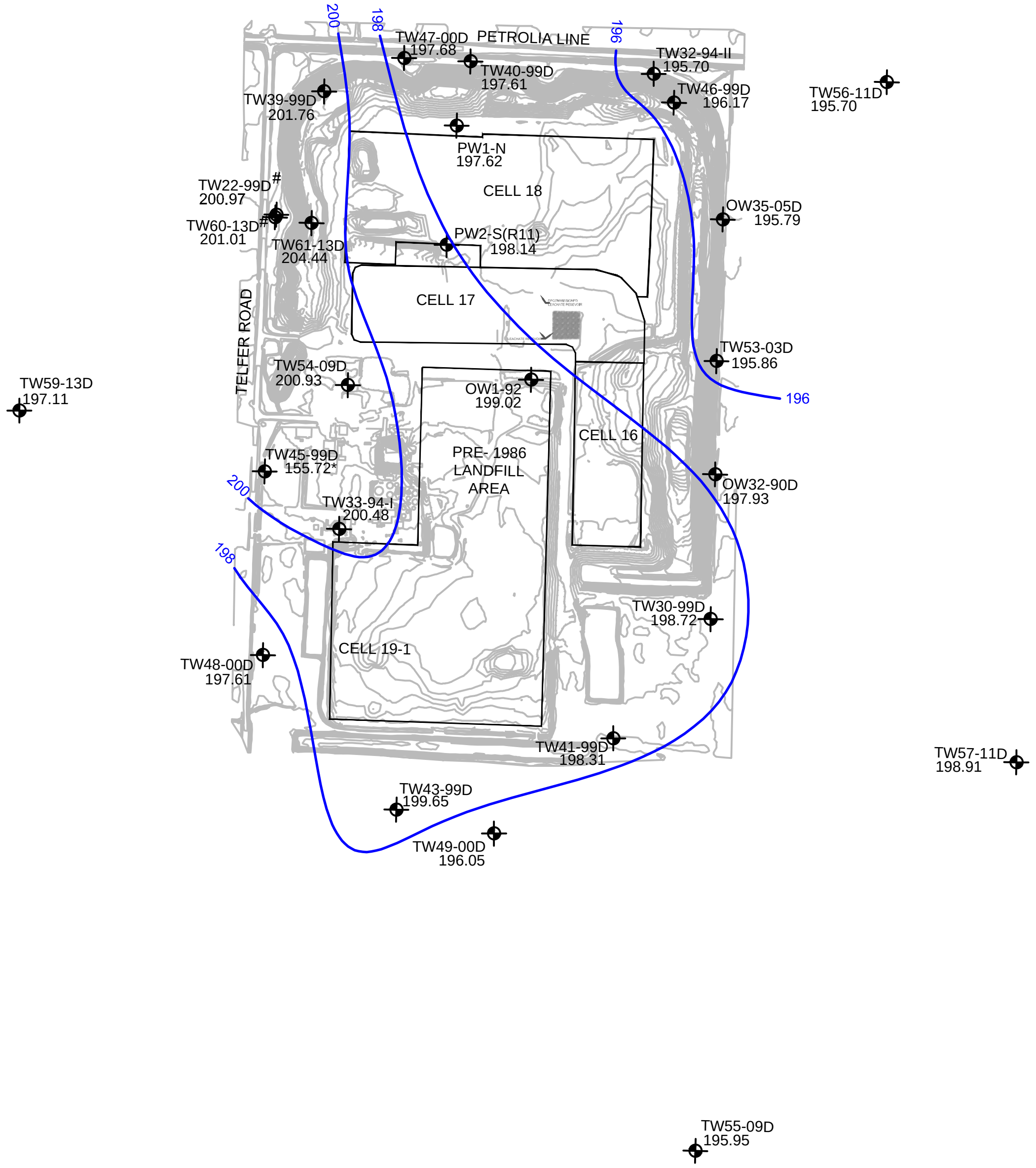
ACTIVE AQUITARD
SPRING 2016 (MARCH 15, 2016)



INTERFACE AQUIFER
SPRING 2016 (MARCH 15, 2016)

LEGEND:

TW59-13S 2013.13	MONITORING WELL LOCATION AND WATER LEVEL ELEVATION (mASL).
TW50-02A 199.86 ○	SOUTH BERM MONITORING WELL LOCATION AND WATER LEVEL ELEVATION (mASL).
200	POTENTIOMETRIC SURFACE



0 300 600m

GROUNDWATER ELEVATIONS (MARCH 2016)

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

Notes:
1. N/A DENOTES MONITORING WELL NOT ACCESSIBLE.
2. * DENOTES NOT STATIC WATER LEVEL - WELL EXHIBITS SLOW RECOVERY
3. # DENOTES WATER LEVEL TAKEN ON MARCH 30, 2016.
4. BASEMAP PROVIDED BY INSPEC-SOL INC. (2013) AND MONTEITH & SUTHERLAND LTD. (2015).

True North

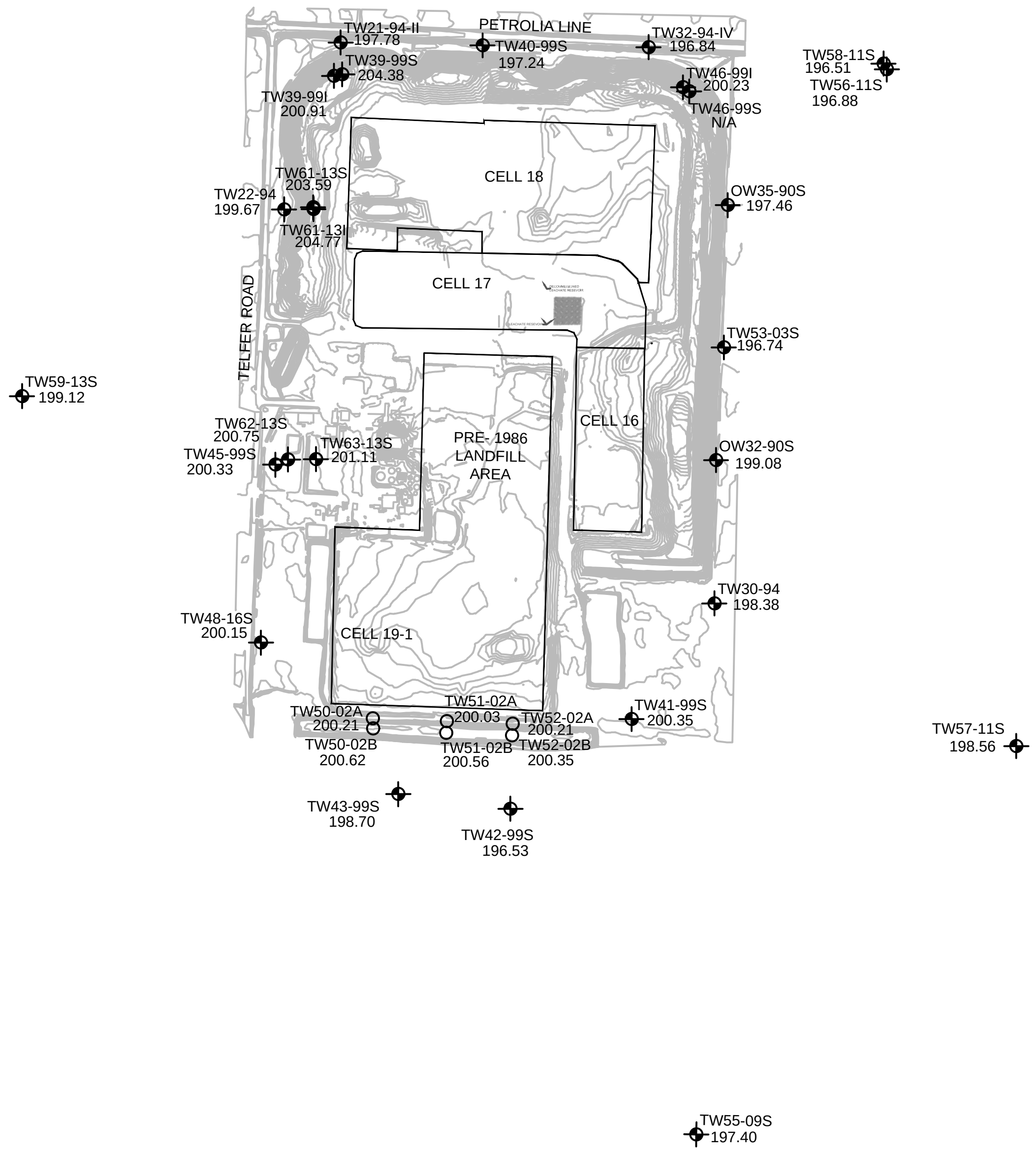
Project #1600331

Drawn by: SSL	Figure: 7
Approx. Scale: 1:4,500	
Date Revised: Jan. 24, 2017	

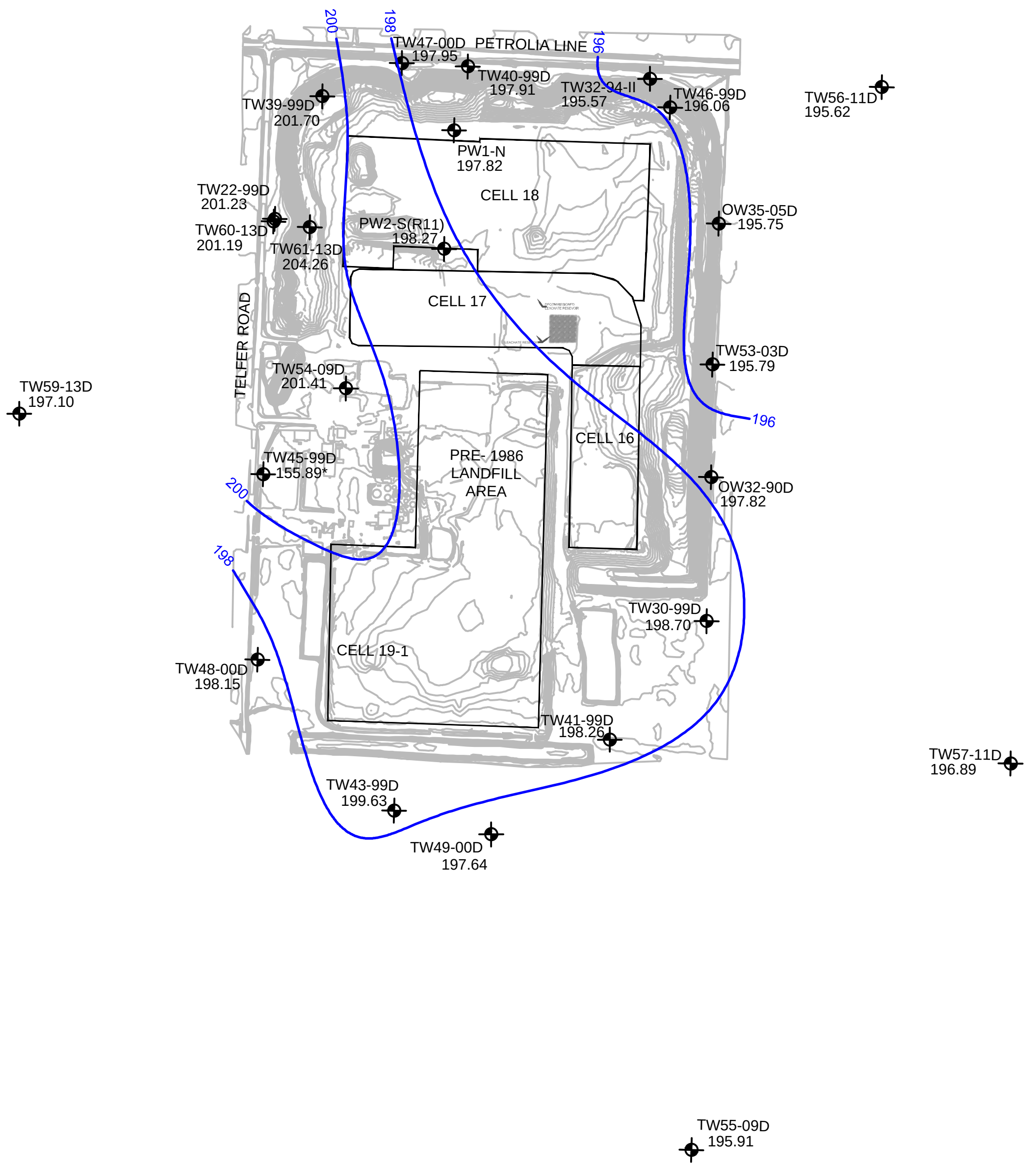
FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\1600331_F07_WL-S16_160422.dwg

DATE PLOTTED: March 1, 2017

ACTIVE AQUITARD
FALL 2016 (SEPTEMBER 19, 2016)



INTERFACE AQUIFER
FALL 2016 (SEPTEMBER 19, 2016)



LEGEND:

TW59-13S 201.31 ⊕	MONITORING WELL LOCATION AND WATER LEVEL ELEVATION (mASL).
TW50-02A 200.21 ○	SOUTH BERM MONITORING WELL LOCATION AND WATER LEVEL ELEVATION (mASL).
200 ——	POTENTIOMETRIC SURFACE

0 300 600m

GROUNDWATER ELEVATIONS (SEPTEMBER 2016)

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

Note:
1. N/A DENOTES MONITORING WELL NOT ACCESSIBLE.
2. * DENOTES NOT STATIC WATER LEVEL - WELL EXHIBITS SLOW RECOVERY
3. BASEMAP PROVIDED BY INSPEC-SOL INC. (2013) AND MONTEITH & SUTHERLAND LTD. (2015).

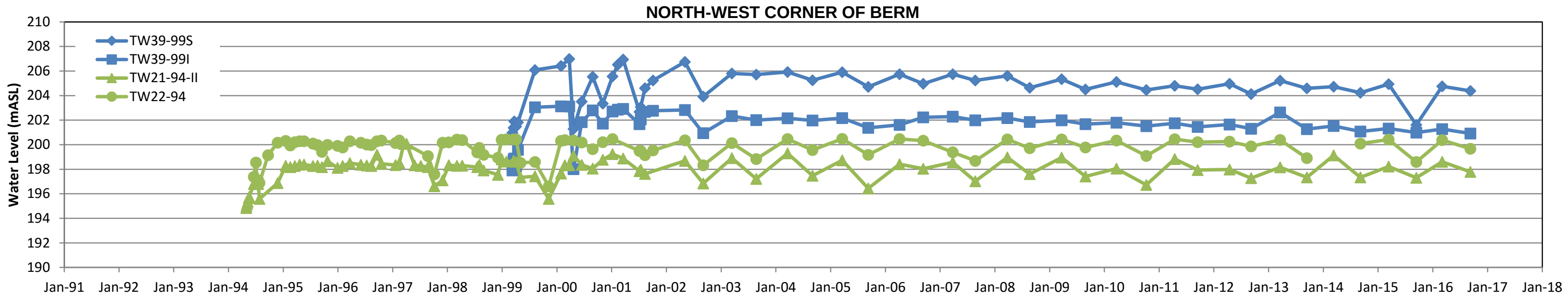
True North

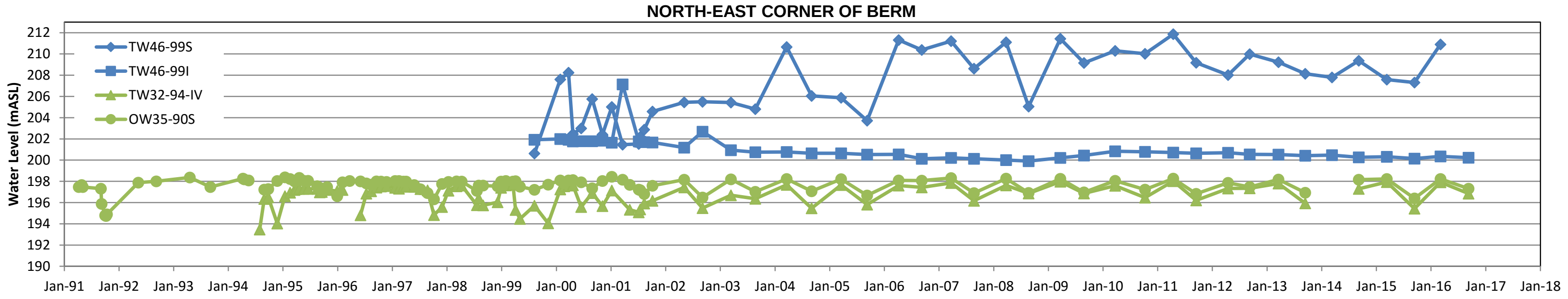
Project #1600331

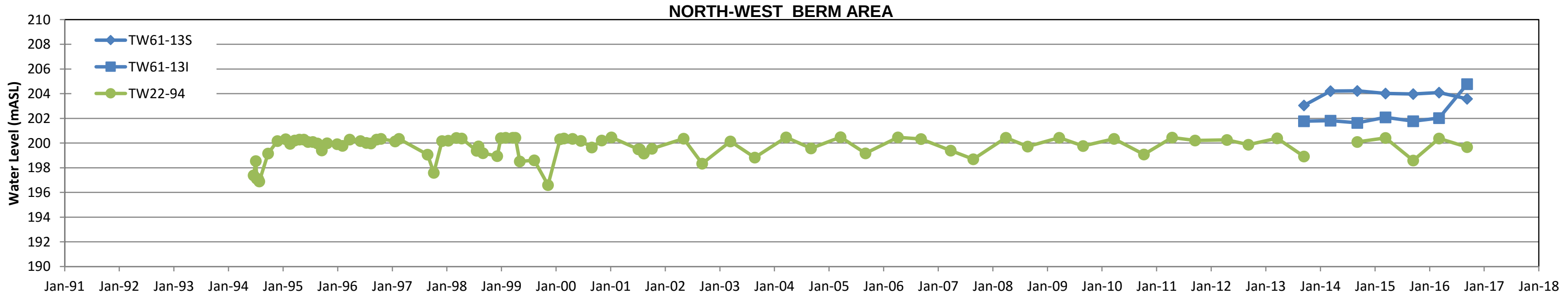
Drawn by: SSL	Figure: 8
Approx. Scale: 1:4,500	
Date Revised: Jan. 24, 2017	

FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\1600331_F08_WL-F16.dwg

DATE PLOTTED: January 24, 2017







Notes:

1. Water level data collected during Spring and Fall events on an annual basis. Gaps in data are due to the absence of measurements because of ice blockage.

HYDROGRAPHS FOR SHALLOW GROUNDWATER WELLS IN THE VICINITY OF THE NORTHERN BERM

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

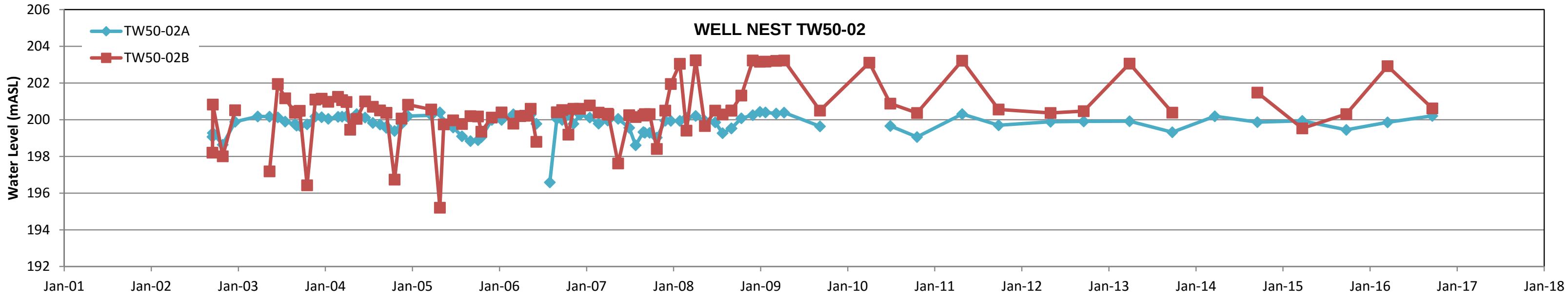
Project #: 1600331

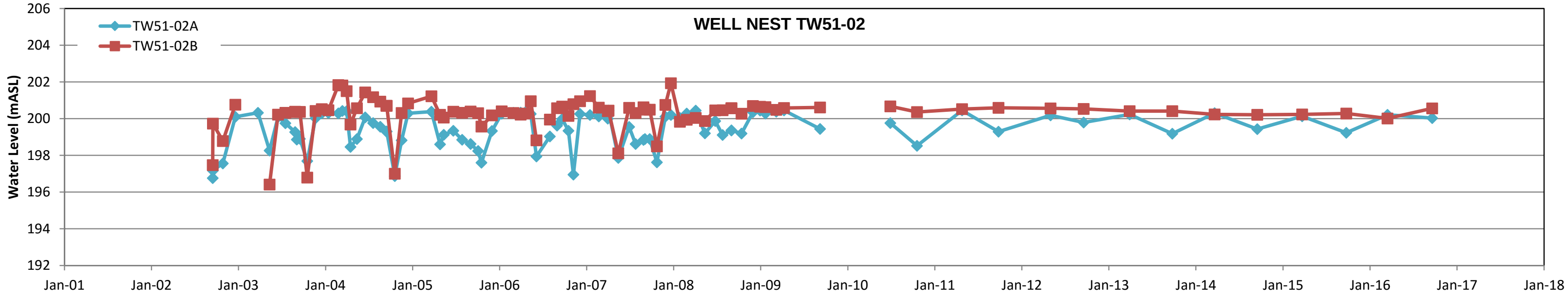
Figure No. **9**

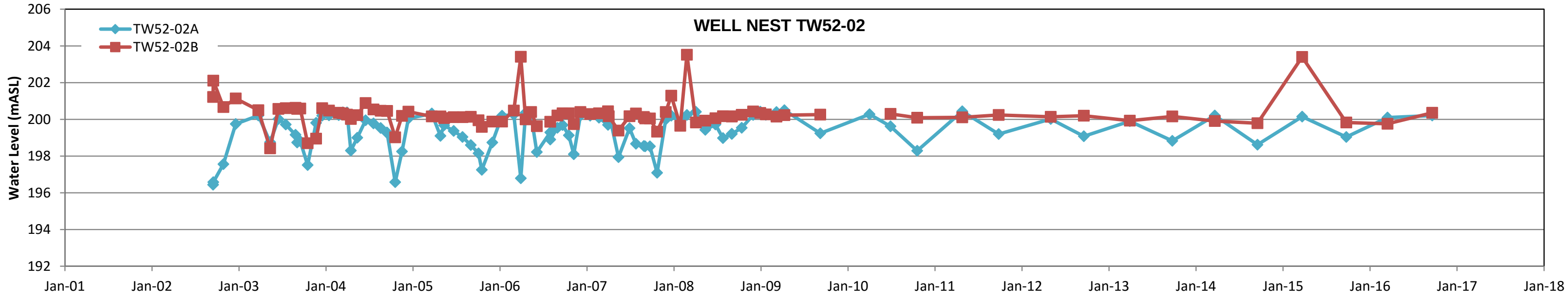
Date: 11/11/2016

FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\[1600331_F08-F09_SWLBerm.xlsx]F09

DATE PLOTTED: January 24, 2017







Notes:

1. Monitoring wells identified with the suffix 'A' were installed into native overburden at the north toe of the berm.
2. Monitoring wells identified with the suffix 'B' were installed into native overburbern below the berm
3. Water level data collected during Spring and Fall events on an annual basis. Gaps in data are due to the absence of measurements because of ice blockage.

HYDROGRAPHS FOR SHALLOW GROUNDWATER WELLS IN THE VICINITY OF THE SOUTHERN BERM

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

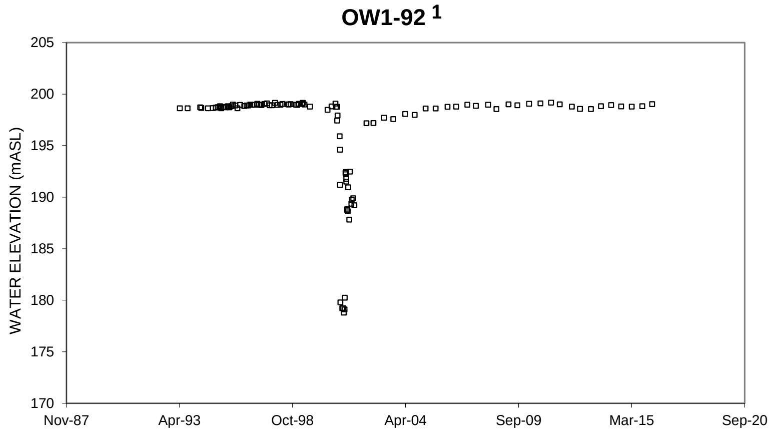
Project #: 1600331

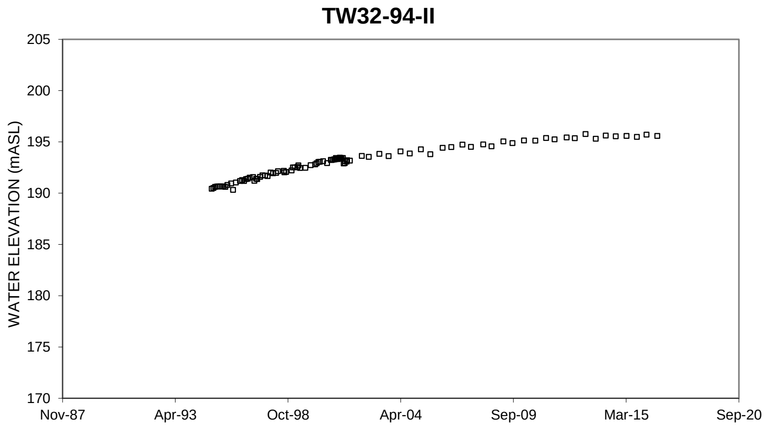
Figure No. 10

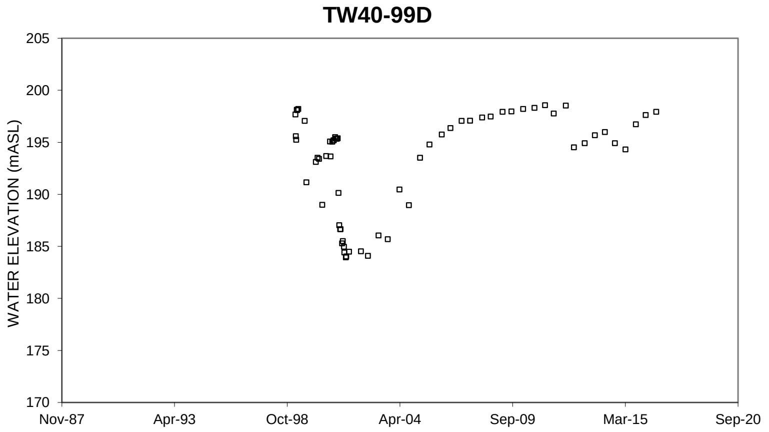
Date: 11/11/2016

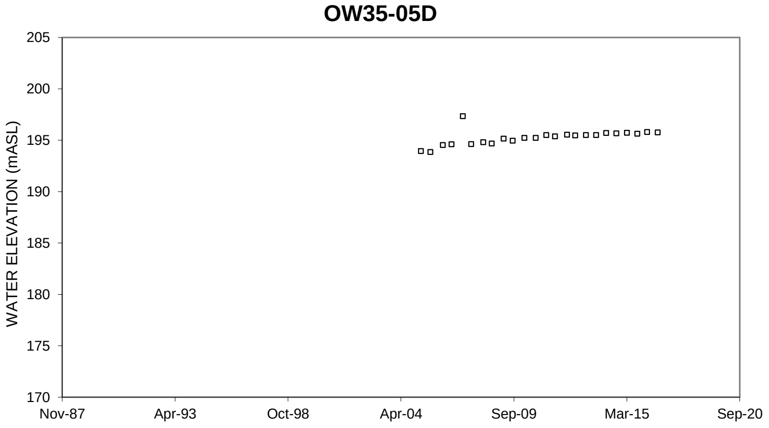
FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\[1600331_F08-F09_SWLBerm.xlsx]F09

DATE PLOTTED: January 24, 2017


OW1-92 [1]


TW32-94-II


TW40-99D


OW35-05D

Notes:
1. OW1-92 was decommissioned in June 2016.

SELECT GROUNDWATER HYDROGRAPHS - ON-SITE INTERFACE AQUIFER

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

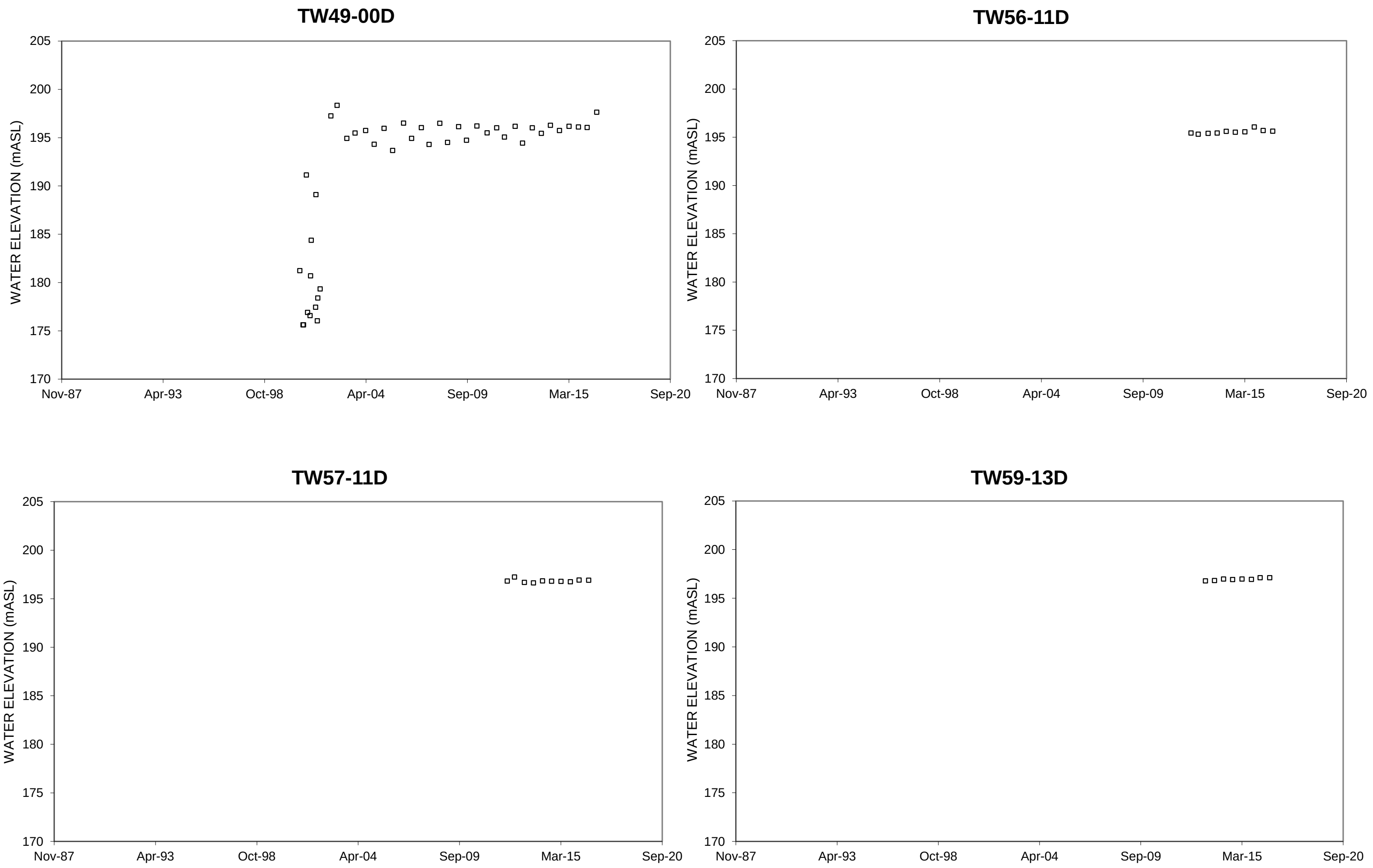
Project #: 1600331

Figure No. 11

Date: Jan. 24, 2017

FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\[1600331_F11_IAHydrograph1.xlsx]F11

DATE PLOTTED: January 24, 2017


TW49-00D

TW56-11D

TW57-11D

TW59-13D

SELECT GROUNDWATER HYDROGRAPHS - OFF-SITE INTERFACE AQUIFER

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

Project #: 1600331

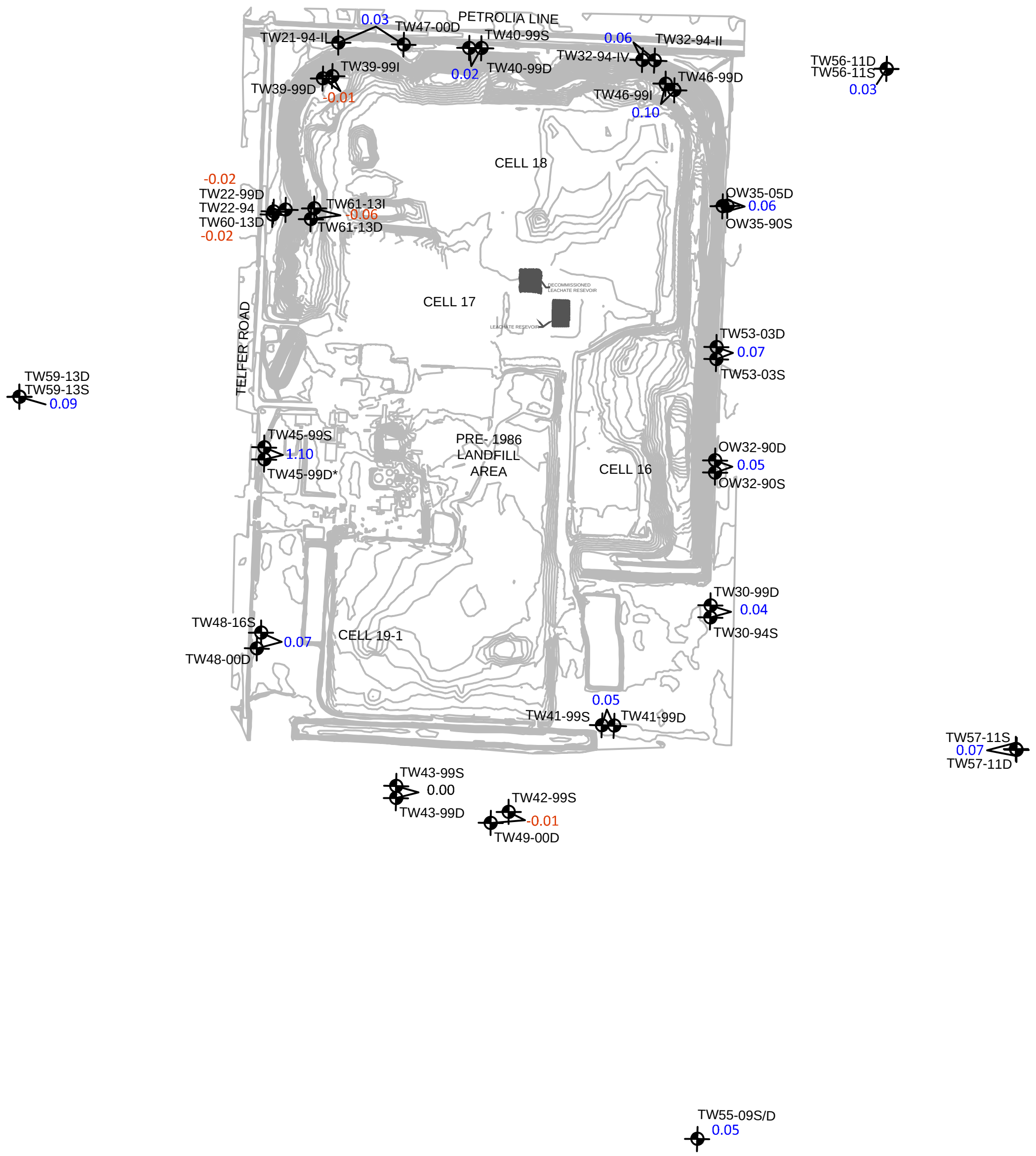
Figure No. 12

Date: Jan. 24, 2017

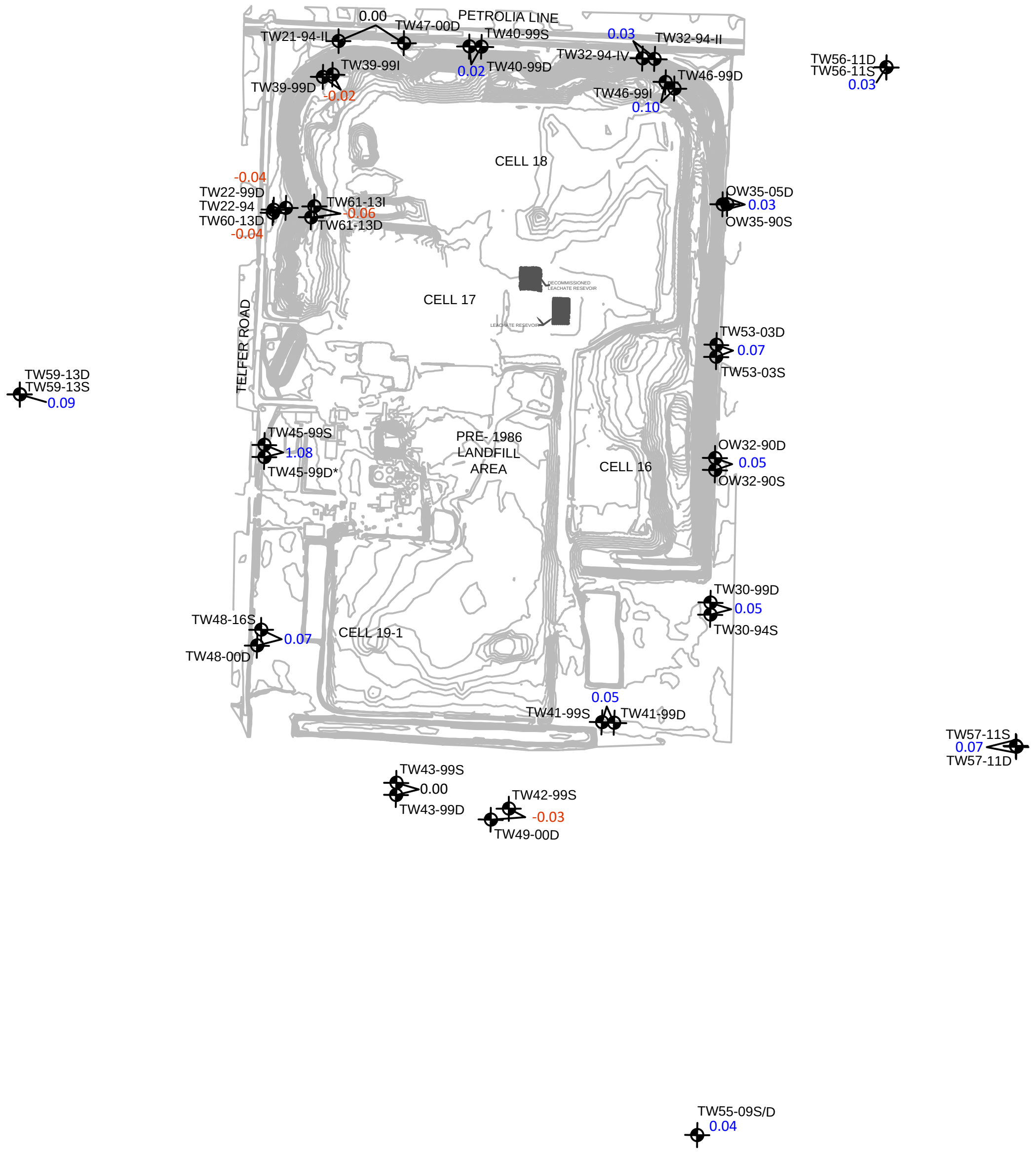
FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\[1600331_F12_IAHydrograph2.xlsx]F12

DATE PLOTTED: January 24, 2017

VERTICAL HYDRAULIC GRADIENT
MARCH 2016



VERTICAL HYDRAULIC GRADIENT
SEPTEMBER 2016



LEGEND:

⌖ TW59-13D	MONITORING WELL LOCATION
0.02	DOWNWARD HYDRAULIC GRADIENT
0.00	NO VERTICAL HYDRAULIC GRADIENT
-0.01	UPWARD HYDRAULIC GRADIENT

0 300 600m

DISTRIBUTION OF VERTICAL HYDRAULIC GRADIENTS (MARCH AND SEPTEMBER 2016)

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

Notes:
1. * DENOTES NOT STATIC WATER LEVEL - WELL EXHIBITS SLOW RECOVERY.
2. BASEMAP PROVIDED BY INSPEC-SOL INC. (2013) AND MONTEITH & SUTHERLAND LTD. (2015).

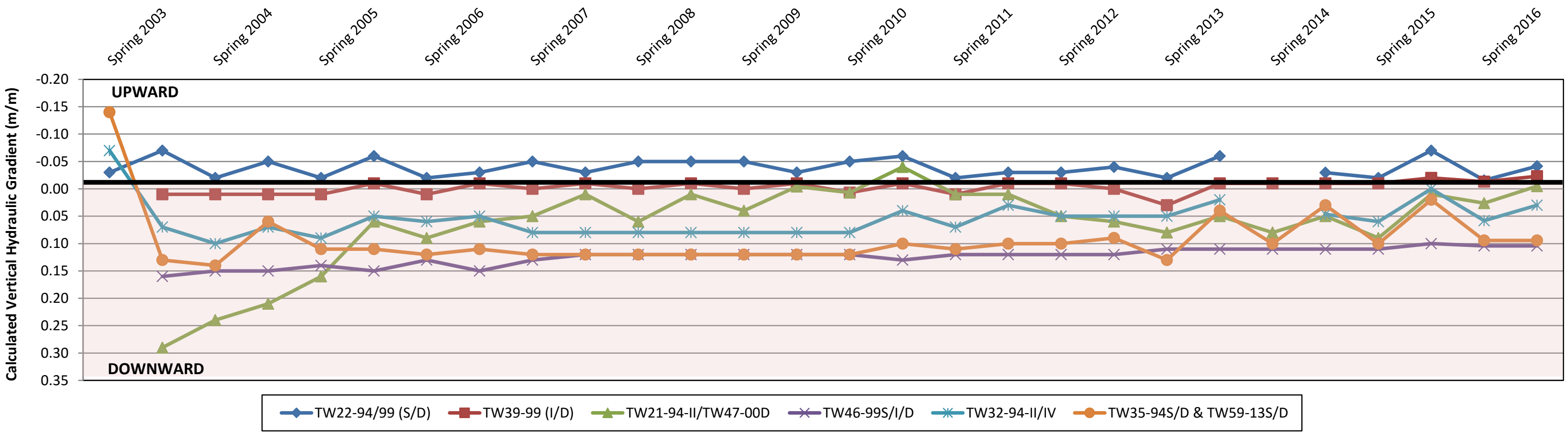
True North

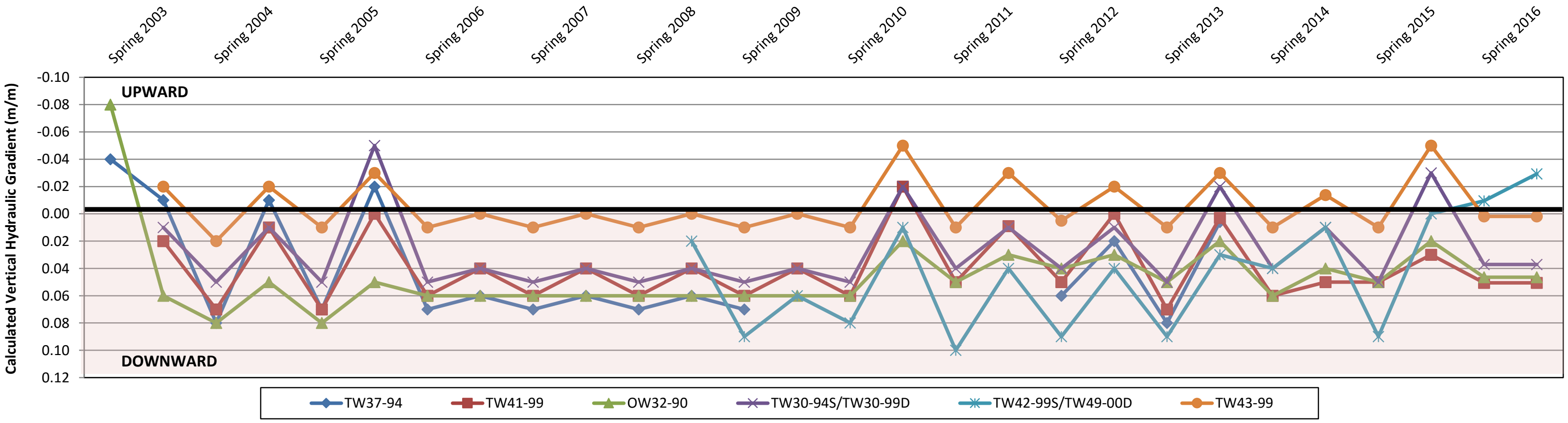
Project #1600331

Drawn by: SSL	Figure: 13
Approx. Scale:	1:4,500
Date Revised:	Mar. 1, 2017

FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\1600331_F13_VGradS16_160422.dwg

DATE PLOTTED: March 1, 2017





VERTICAL HYDRAULIC GRADIENT

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

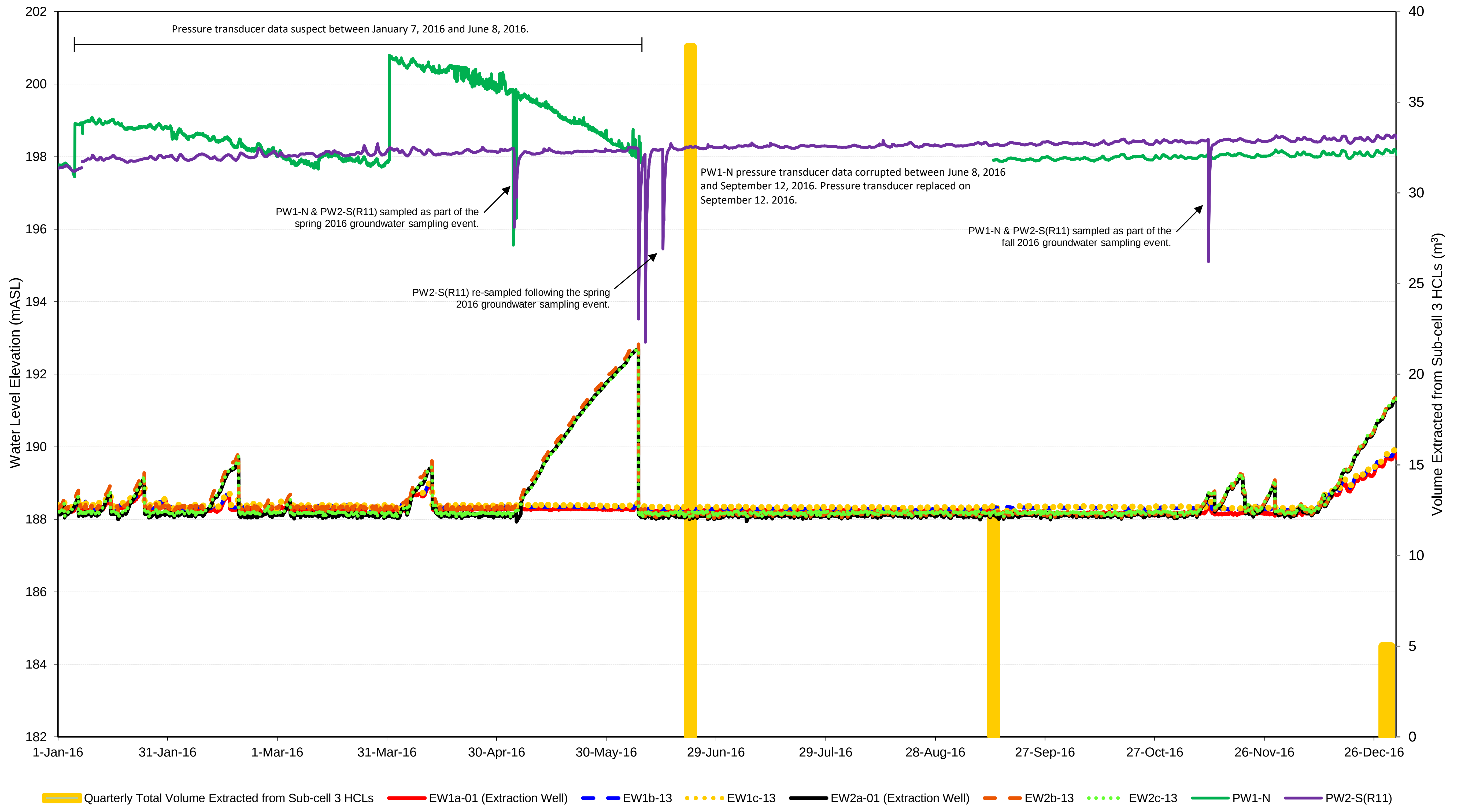
Project #: 1600331

Figure No. 14

Date: Mar. 1, 2017

FILE LOCATION: I:\1600331\6. Deliverables\2016 Monitoring Report\Figures\Working Files\[VertGrad2016.xlsx]Southern Portion of Site

DATE PLOTTED: March 1, 2017



NOTES:

1. Periods were the water level increased in the HCLs correspond to intervals when the air compressor that powers the pumps was off-line due to short-term electrical outages (evident as upward spikes in the water levels).
2. HCL extraction data from the first quarter of 2016 not available. Cycle counters could not be accessed due to ponded stormwater. Data presented during June 2016 represents extraction data from the first and second quarters of 2016.

SUB-CELL 3 PERFORMANCE MONITORING
WATER LEVEL RECORD

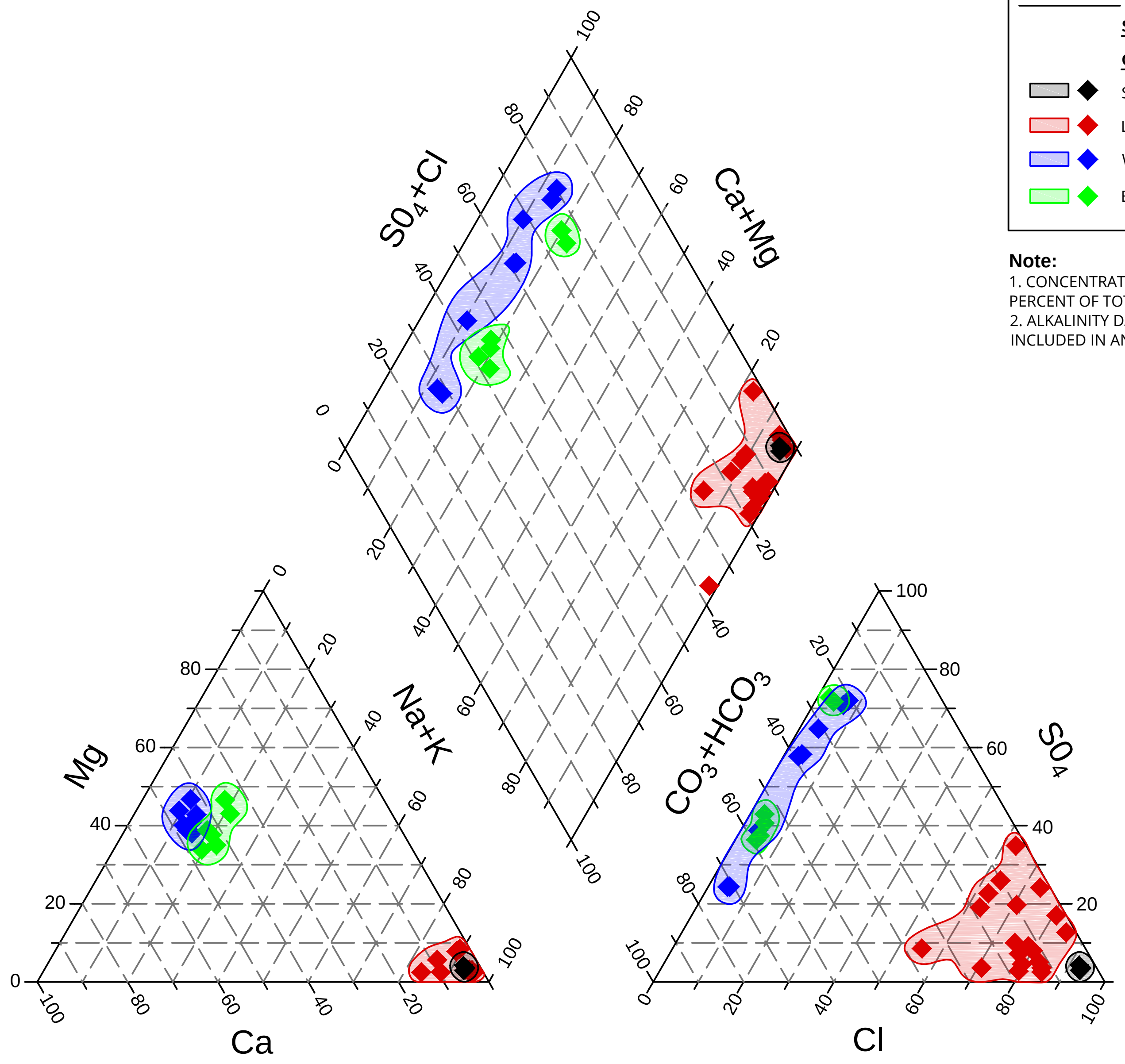
2016 COMPLIANCE MONITORING PROGRAM

CLEAN HARBORS CANADA, INC.,
LAMBTON FACILITY LANDFILL

FIGURE NUMBER	PROJECT NUMBER
15	**1600331**
APPROX. SCALE	DATE REVISED
NTS	**24/01/2017**

FILE LOCATION: I:\1600331\4. Analysis\[1600331_SC3 Levelogger Data 2016.xlsx]Annual RPT

DATE PLOTTED: March 3, 2017



LEGEND:

SOURCES / ACTIVITIES THAT INFLUENCE SHALLOW GROUNDWATER CHEMISTRY

⬜ ◆	SALT ANALYSIS (1994 & 2014)
🟥 ◆	LEACHATE WELLS (2012)
🟦 ◆	WELLS OFF THE FACILITY PROPERTY (2016)
🟩 ◆	BERM WELLS (2016)

Note:
1. CONCENTRATIONS OF CATIONS (OR ANIONS) ARE EXPRESSED AS PERCENT OF TOTAL MILLEQUIVALENTS PER LITER.
2. ALKALINITY DATA FROM LEACHATE WELL LM8-11 SUSPECT, NOT INCLUDED IN ANALYSES.

TRILINEAR DIAGRAM -
SOURCES / ACTIVITIES THAT INFLUENCE SHALLOW GROUNDWATER CHEMISTRY

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

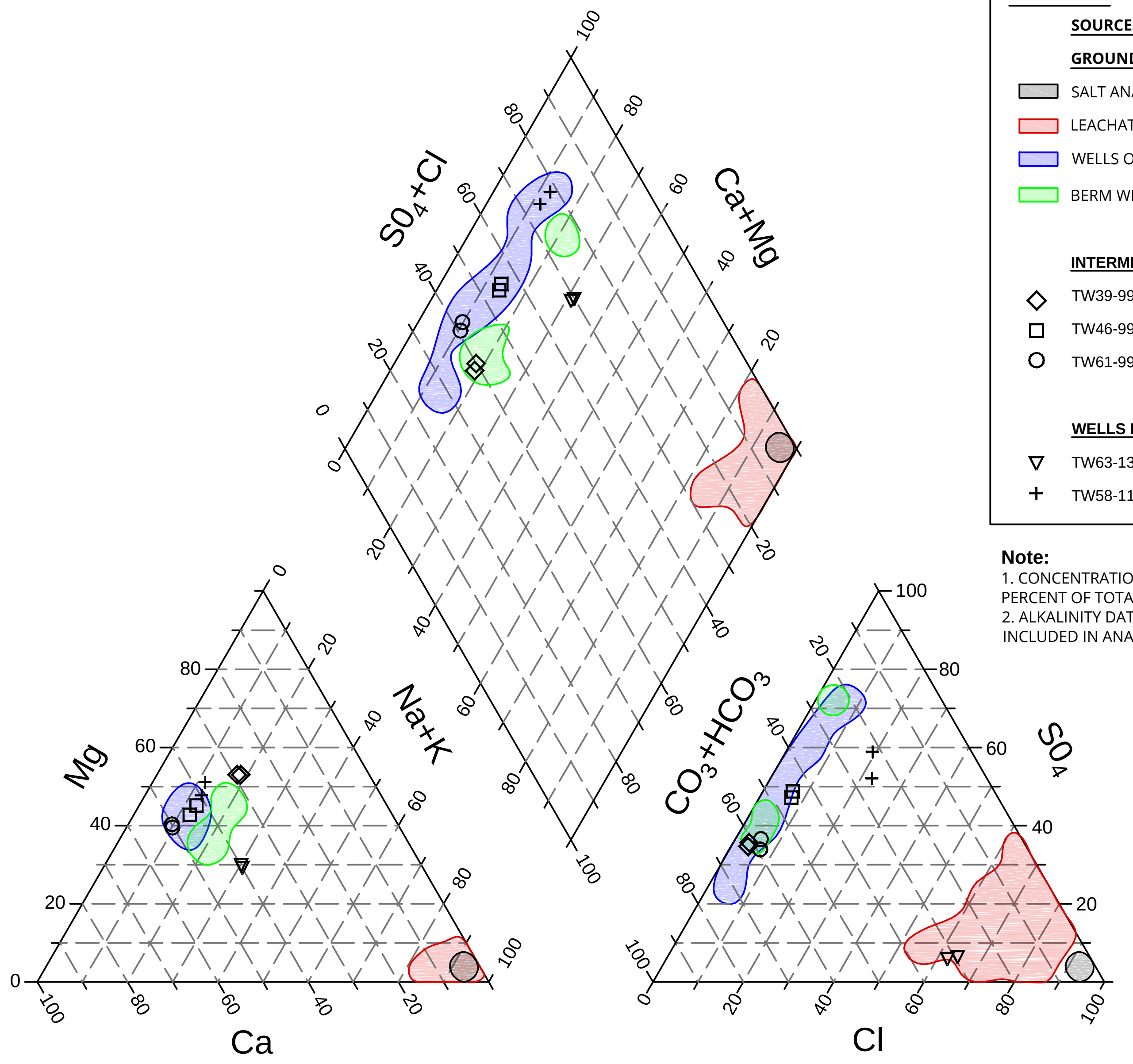
True North

Project #1600331

Drawn by: SSL	Figure: 16
Approx. Scale: NA	
Date Revised: Feb. 15, 2017	

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\1600331_F16_TriBGShal-S1_170214.dwg

DATE PLOTTED: March 1, 2017



LEGEND:

SOURCES / ACTIVITIES THAT INFLUENCE SHALLOW GROUNDWATER CHEMISTRY

- ▨ SALT ANALYSIS (1994 & 2014)
- 🟥 LEACHATE WELLS (2012)
- 🟦 WELLS OFF THE FACILITY PROPERTY (2016)
- 🟩 BERM WELLS (2016)

INTERMEDIATE WELLS INSTALLED IN THE NORTH BERM

- ◇ TW39-99I
- □ TW46-99I
- ○ TW61-99I

WELLS KNOWN TO BE IMPACTED

- ▽ TW63-13S
- + TW58-11S

Note:
1. CONCENTRATIONS OF CATIONS (OR ANIONS) ARE EXPRESSED AS PERCENT OF TOTAL MILLEQUIVALENTS PER LITER.
2. ALKALINITY DATA FROM LEACHATE WELL LM8-11 SUSPECT, NOT INCLUDED IN ANALYSES.

TRILINEAR DIAGRAM -
WELLS INSTALLED BELOW NORTH BERM & WELLS INFLUENCED BY CONTAMINANTS

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

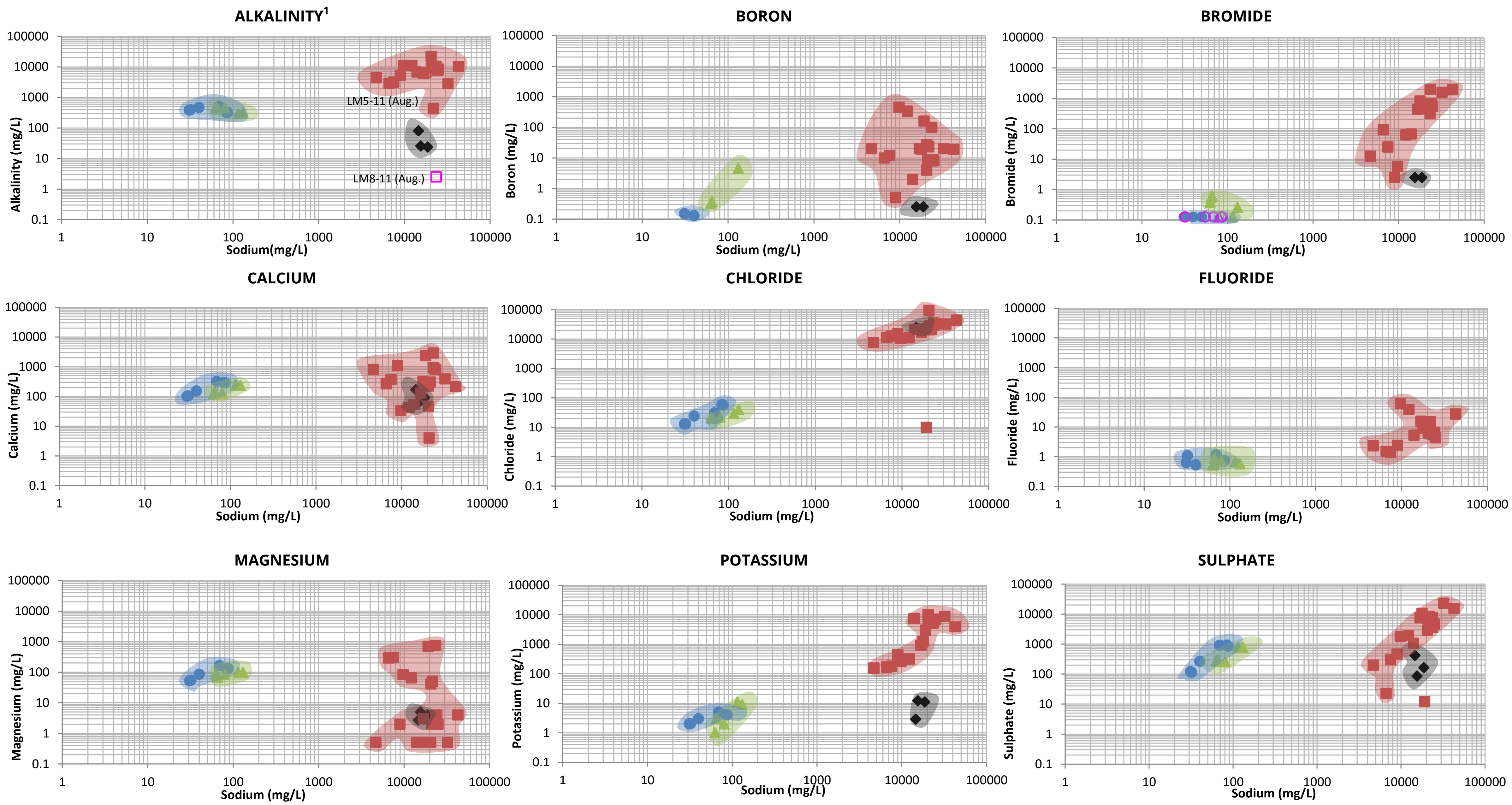
True North

Project #1600331

Drawn by: SSL	Figure: 17
Approx. Scale:	NA
Date Revised:	Feb. 15, 2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\1600331_F17_TrilntImpact-S6_170214.dwg

DATE PLOTTED: March 1, 2017



Notes:
1) Alkalinity data from Leachate Well LM5-11 (Aug. 2012) & LM8-11 (Aug. & Nov. 2012) suspect, identified on graph.

LEGEND:
◆ ▬ Salt Analysis
■ ▬ Leachate
● ▬ Wells off the Facility Property (TW55-09S, TW56-11S, TW57-11S, TW59-13S)
▲ ▬ Berm Wells (TW39-99S, TW46-99S, TW61-13S)
□ ○ △ Non-Detect (50% of MDL value)

CONCENTRATION GRAPHS -
SOURCES / ACTIVITIES THAT INFLUENCE SHALLOW GROUNDWATER CHEMISTRY

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

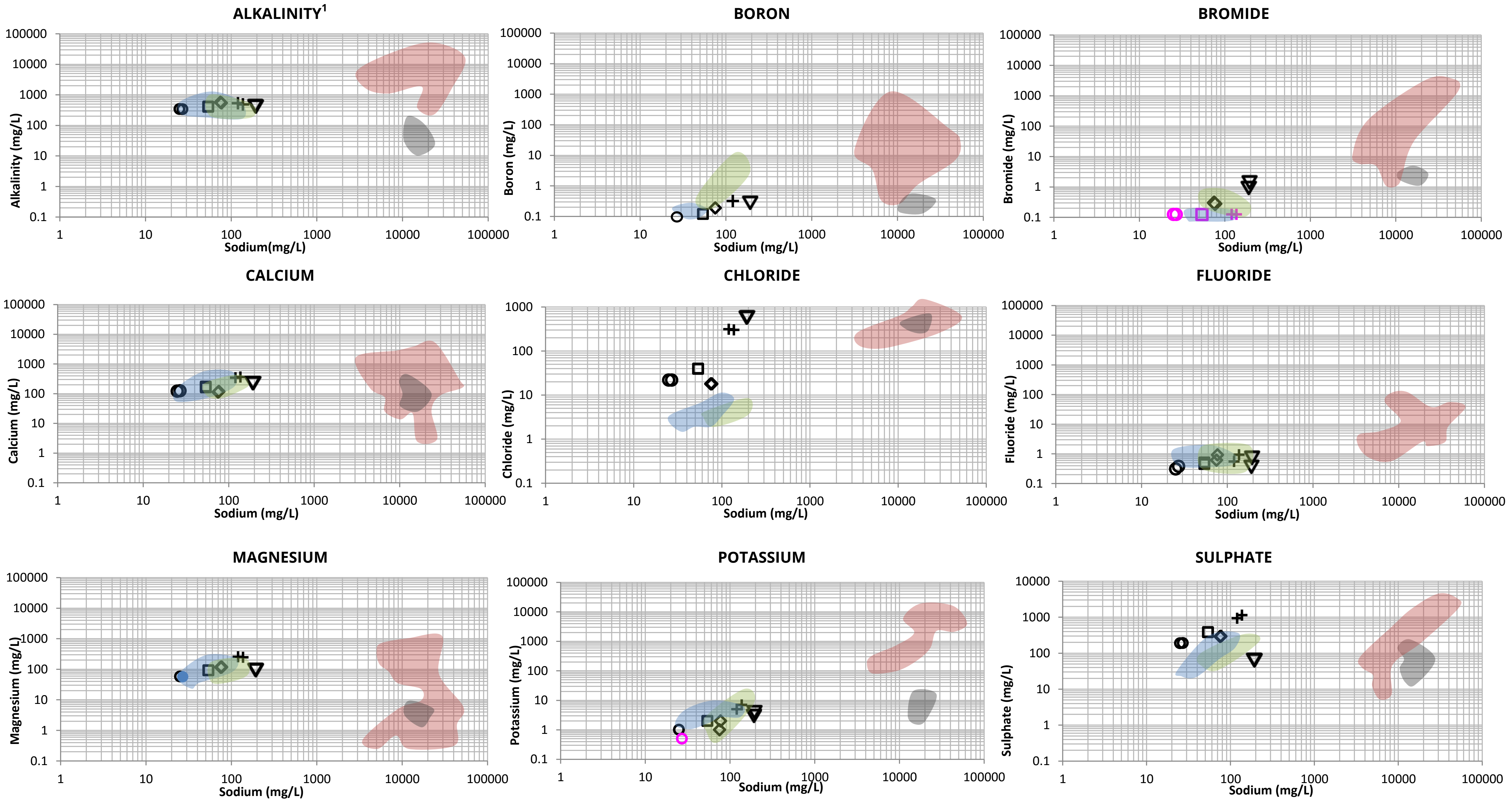
Project #: 1600331

Figure No. 18

Date: 15/2/2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\[1600331_F18-23_ConcGrpS_170214.xlsx]BG NA

DATE PLOTTED: March 1, 2017



Notes:
1) Alkalinity data from Leachate Well LM5-11 (Aug. 2012) & LM8-11 (Aug. & Nov. 2012) suspect, identified on graph.

LEGEND:

- ▬ Salt Analysis
- ▬ Leachate
- ▬ Wells off the Facility Property (TW55-09S, TW56-11S, TW57-11S, TW59-13S)
- ▬ Berm Wells (TW39-99S, TW46-99S, TW61-13S)
- □ ○ + Non-Detect (50% of MDL value)

Intermediate Wells Installed in Berm:
- ◇ TW39-99I
- □ TW46-99I
- ○ TW61-13I

Wells Known to be Impacted:
- ▽ TW63-13S
- + TW58-11S

CONCENTRATION GRAPHS -
WELLS INSTALLED BELOW NORTH BERM AND WELLS INFLUENCED BY CONTAMINANTS

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

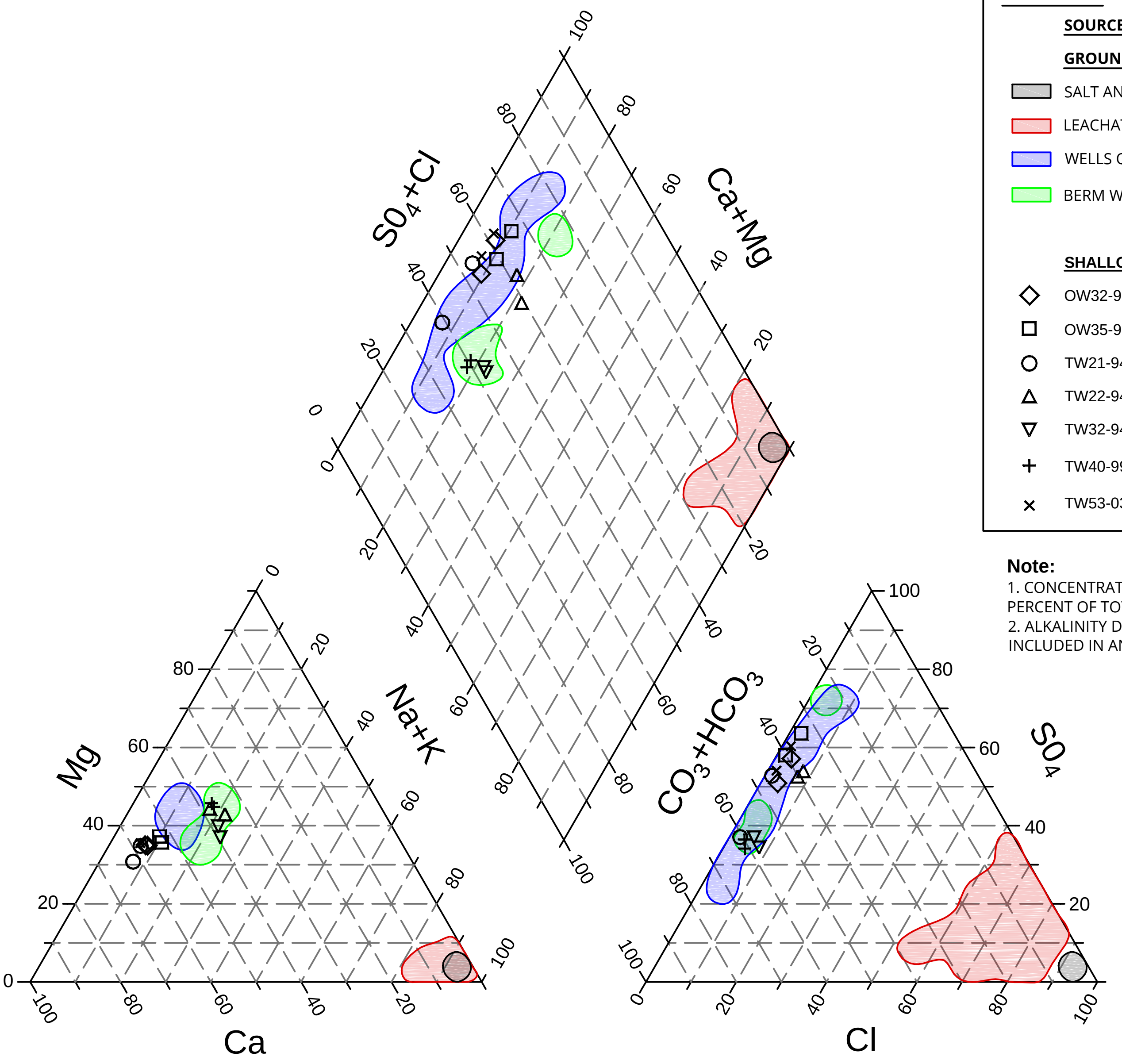
Figure No. 19

Project #: 1600331

Date: 20/2/2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\[1600331_F18-23_ConcGrpS_170214.xlsx]BG NA I

DATE PLOTTED: March 1, 2017



LEGEND:

SOURCES / ACTIVITIES THAT INFLUENCE SHALLOW GROUNDWATER CHEMISTRY

- ▨ SALT ANALYSIS (1994 & 2014)
- 🟥 LEACHATE WELLS (2012)
- 🟦 WELLS OFF THE FACILITY PROPERTY (2016)
- 🟩 BERM WELLS (2016)

SHALLOW WELLS DOWNGRADIENT OF NORTH BERM

- ◇ OW32-90S
- □ OW35-90S
- ○ TW21-94-II
- △ TW22-94
- ▽ TW32-94-IV
- \+ TW40-99S
- × TW53-03S

Note:

1. CONCENTRATIONS OF CATIONS (OR ANIONS) ARE EXPRESSED AS PERCENT OF TOTAL MILLEQUIVALENTS PER LITER.
2. ALKALINITY DATA FROM LEACHATE WELL LM8-11 SUSPECT, NOT INCLUDED IN ANALYSES.

TRILINEAR DIAGRAM -
SHALLOW WELLS ALONG PROPERTY BOUNDARY DOWNGRADIENT OF NORTH BERM

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

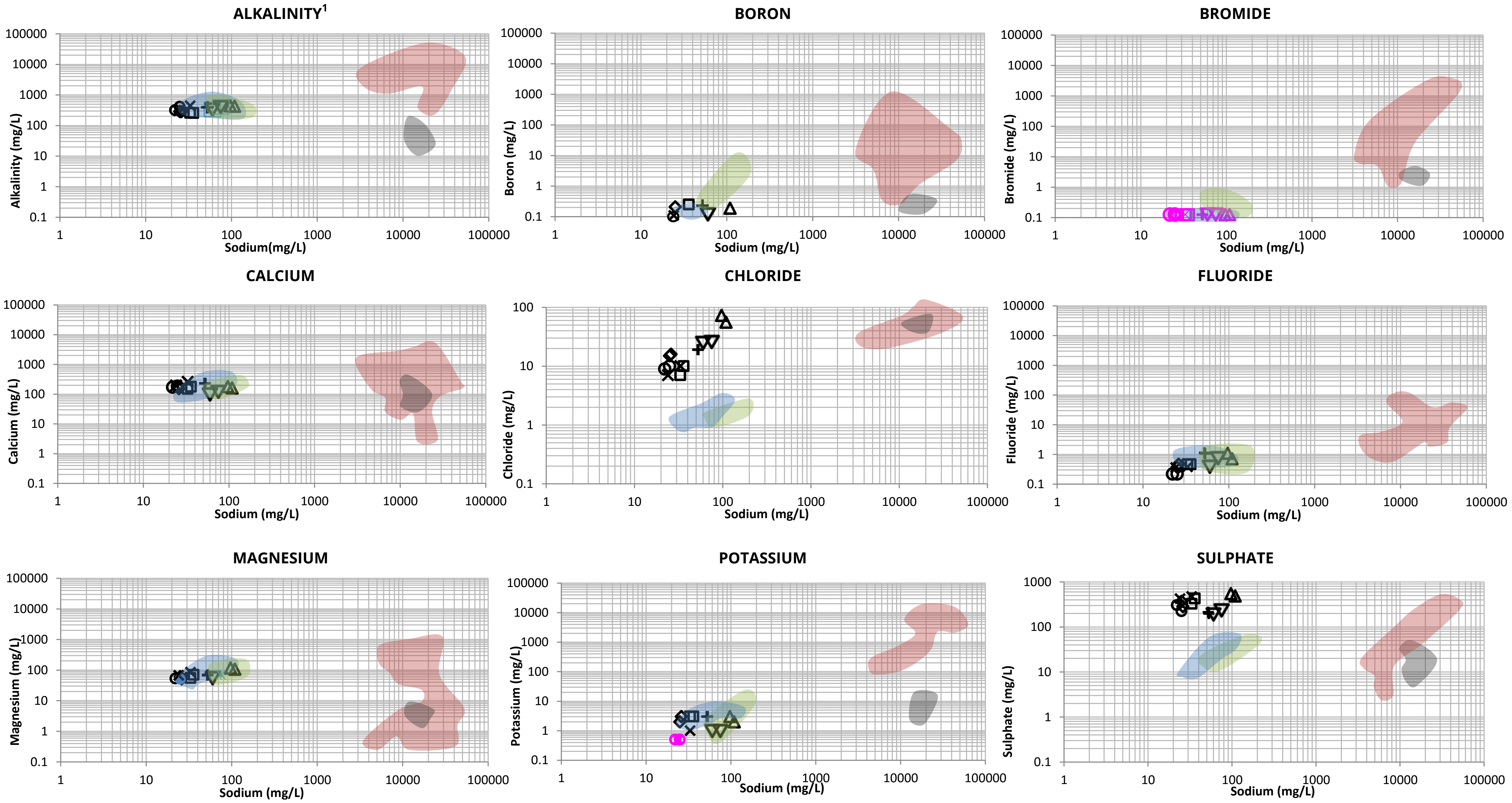
True North

Project #1600331

Drawn by: SSL	Figure: 20
Approx. Scale:	NA
Date Revised:	Feb. 15, 2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\1600331_F20_TriSdownGrad-S4_170214.dwg

DATE PLOTTED: March 1, 2017



Notes:
1) Alkalinity data from Leachate Well LM5-11 (Aug. 2012) & LM8-11 (Aug. & Nov. 2012) suspect, identified on graph.

LEGEND:

■ Salt Analysis
■ Leachate
■ Wells off the Facility Property
(TW55-09S, TW56-11S, TW57-11S, TW59-13S)
■ Berm Wells (TW39-99S, TW46-99S, TW61-13S)
□ ○ △ Non-Detect (50% of MDL value)

◇ OW32-90S
□ OW35-90S
○ TW21-94-II
△ TW22-94
▽ TW32-94-IV
+ TW40-99S
✖ TW53-03S

CONCENTRATION GRAPHS -
SHALLOW WELLS ALONG PROPERTY BOUNDARY DOWNGRADIENT OF NORTHERN BERM

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

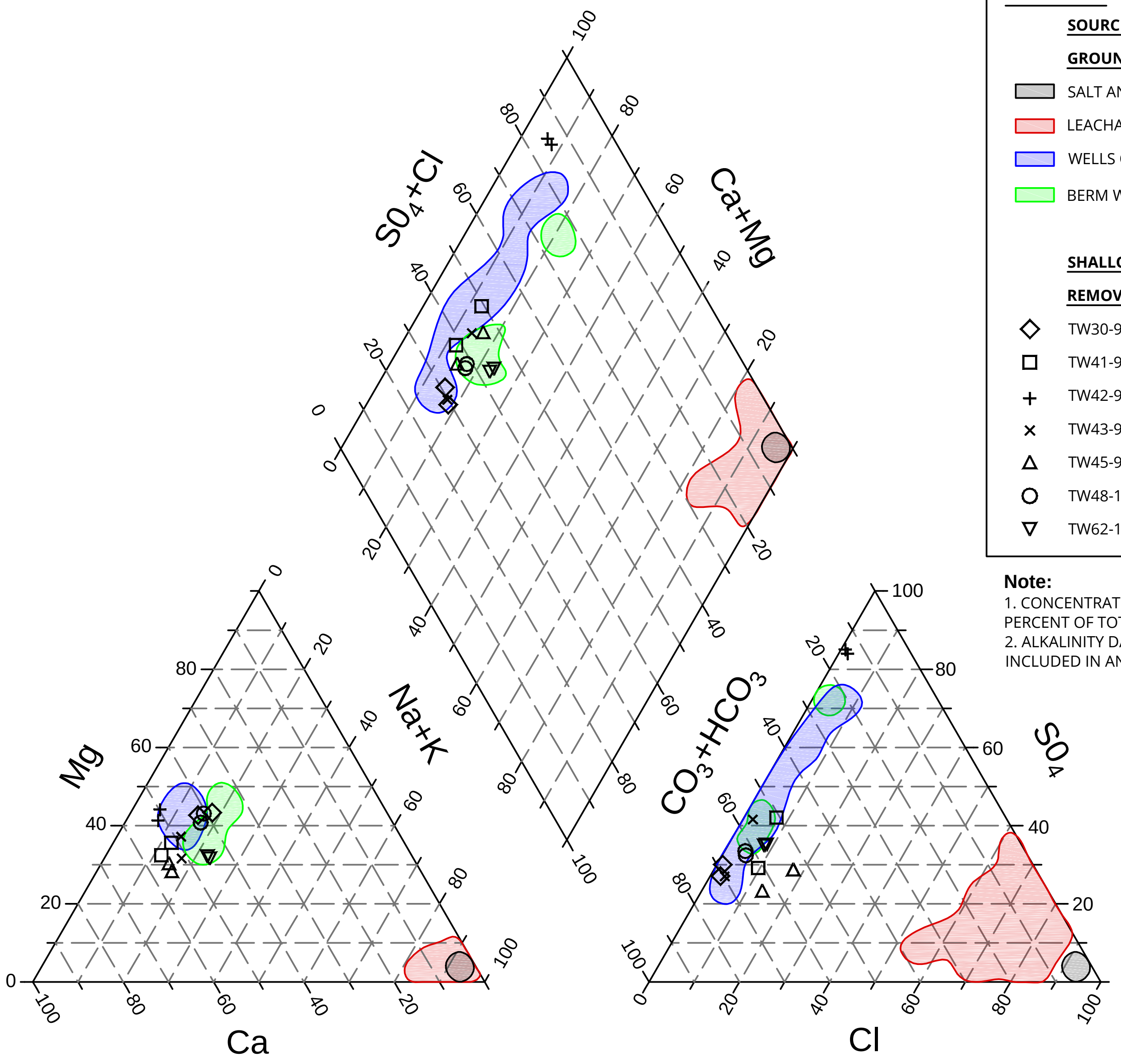
Project #: 1600331

Figure No. 21

Date: 21/2/2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\[1600331_F18-23_ConcGrpS_170214.xlsx]BG NA I

DATE PLOTTED: March 1, 2017



LEGEND:

SOURCES / ACTIVITIES THAT INFLUENCE SHALLOW GROUNDWATER CHEMISTRY

▨ SALT ANALYSIS (1994 & 2014)
🟥 LEACHATE WELLS (2012)
🟦 WELLS OFF THE FACILITY PROPERTY (2016)
🟩 BERM WELLS (2016)

SHALLOW WELLS ALONG PROPERTY BOUNDARY REMOVED FROM NORTH BERM

◇ TW30-94
□ TW41-99S
+ TW42-99S
× TW43-99S
△ TW45-99S
○ TW48-16S
▽ TW62-13S

Note:
1. CONCENTRATIONS OF CATIONS (OR ANIONS) ARE EXPRESSED AS PERCENT OF TOTAL MILLEQUIVALENTS PER LITER.
2. ALKALINITY DATA FROM LEACHATE WELL LM8-11 SUSPECT, NOT INCLUDED IN ANALYSES.

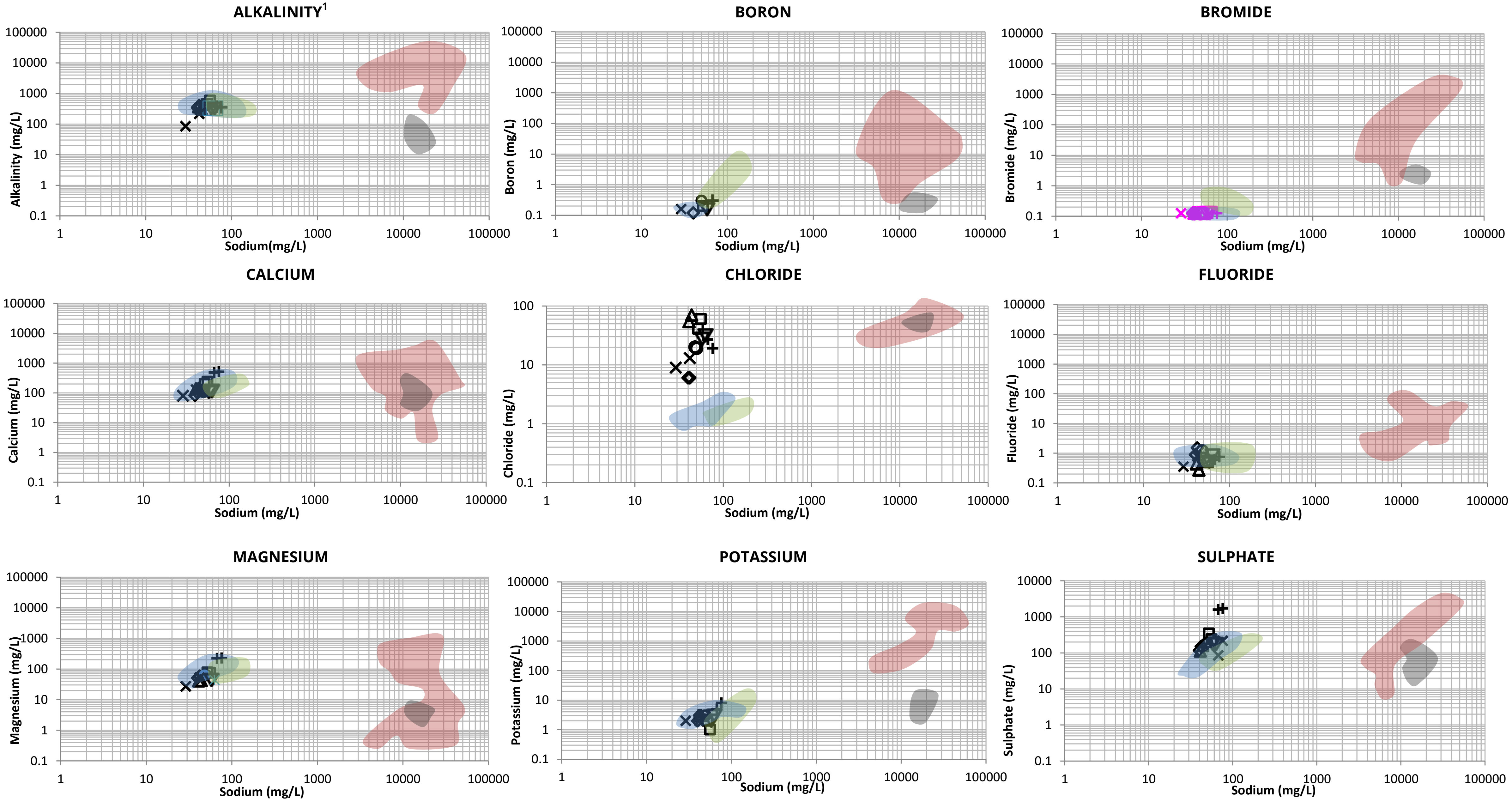
TRILINEAR DIAGRAM - SHALLOW WELLS ALONG PROPERTY BOUNDARY REMOVED FROM NORTH BERM

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

True North

Project #1600331

Drawn by: SSL	Figure: 22
Approx. Scale: NA	
Date Revised: Feb. 15, 2017	



Notes:
1) Alkalinity data from Leachate Well LM5-11 (Aug. 2012) & LM8-11 (Aug. & Nov. 2012) suspect, identified on graph.

LEGEND:

- ▬ Salt Analysis
- ▬ Leachate
- ▬ Wells off the Facility Property (TW55-09S, TW56-11S, TW57-11S, TW59-13S)
- ▬ Berm Wells (TW39-99S, TW46-99S, TW61-13S)
- □ ○ △ Non-Detect (50% of MDL value)

- ◇ TW30-94
- □ TW41-99S
- ○ TW48-16S
- △ TW45-99S
- ▽ TW62-13S
- + TW42-99S
- ✖ TW43-99S

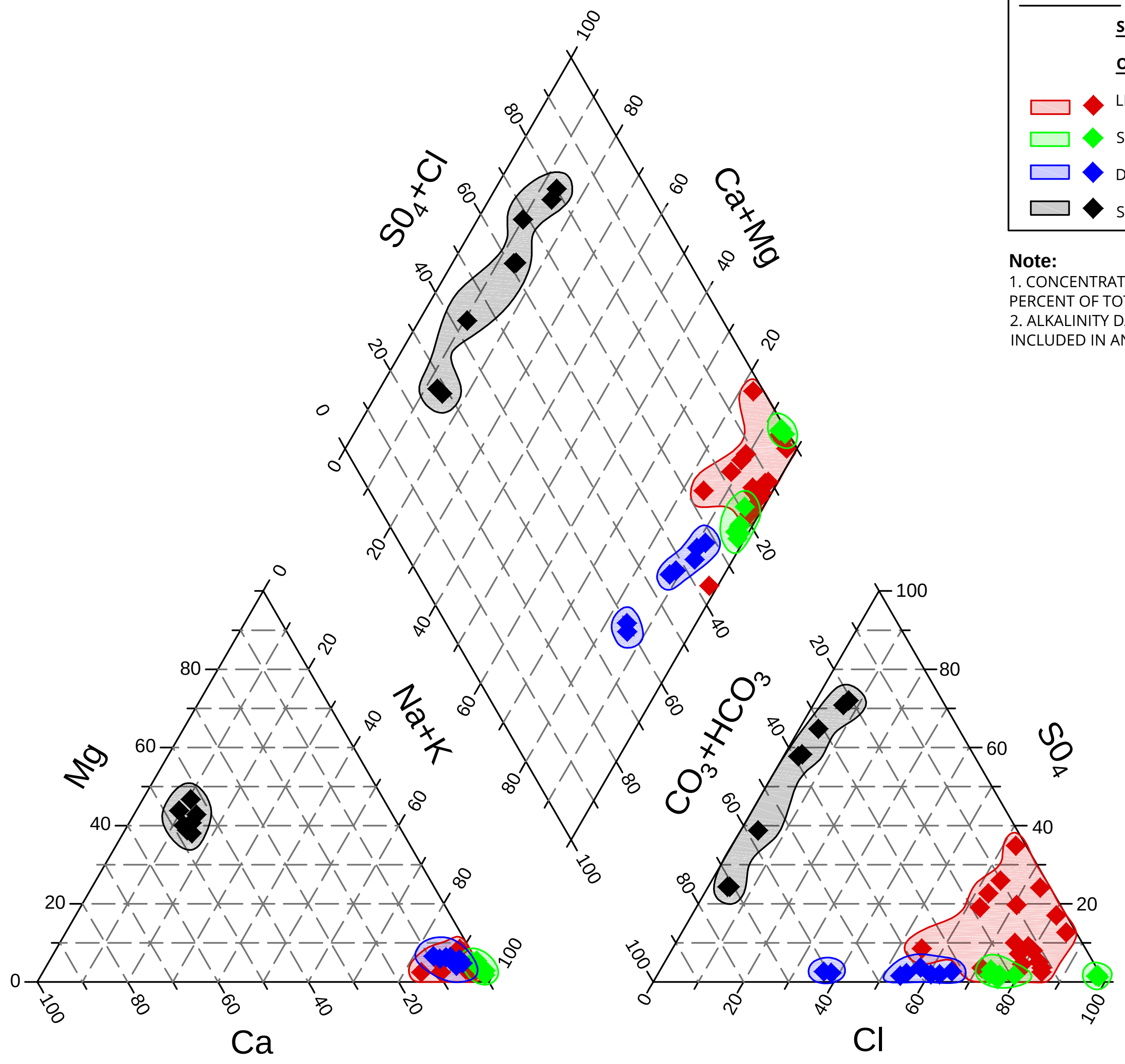
CONCENTRATION GRAPHS -
SHALLOW WELLS ALONG PROPERTY BOUNDARY REMOVED FROM NORTH BERM

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

Project #: 1600331

Figure No. 23

Date: 21/2/2017



LEGEND:

SOURCES / ACTIVITIES THAT INFLUENCE CHEMISTRY OF INTERFACE AQUIFER

- 🟥 ◆ LEACHATE WELLS
- 🟩 ◆ SHALE WELLS (2014/2015)
- 🟦 ◆ DEEP WELLS OFF THE FACILITY PROPERTY (2016)
- ⬛ ◆ SHALLOW WELLS OFF THE FACILITY PROPERTY (2016)

Note:

1. CONCENTRATIONS OF CATIONS (OR ANIONS) ARE EXPRESSED AS PERCENT OF TOTAL MILLEQUIVALENTS PER LITER.
2. ALKALINITY DATA FROM LEACHATE WELL LM8-11 SUSPECT, NOT INCLUDED IN ANALYSES.

TRILINEAR DIAGRAM - SOURCES / ACTIVITIES THAT INFLUENCE CHEMISTRY OF INTERFACE AQUIFER

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

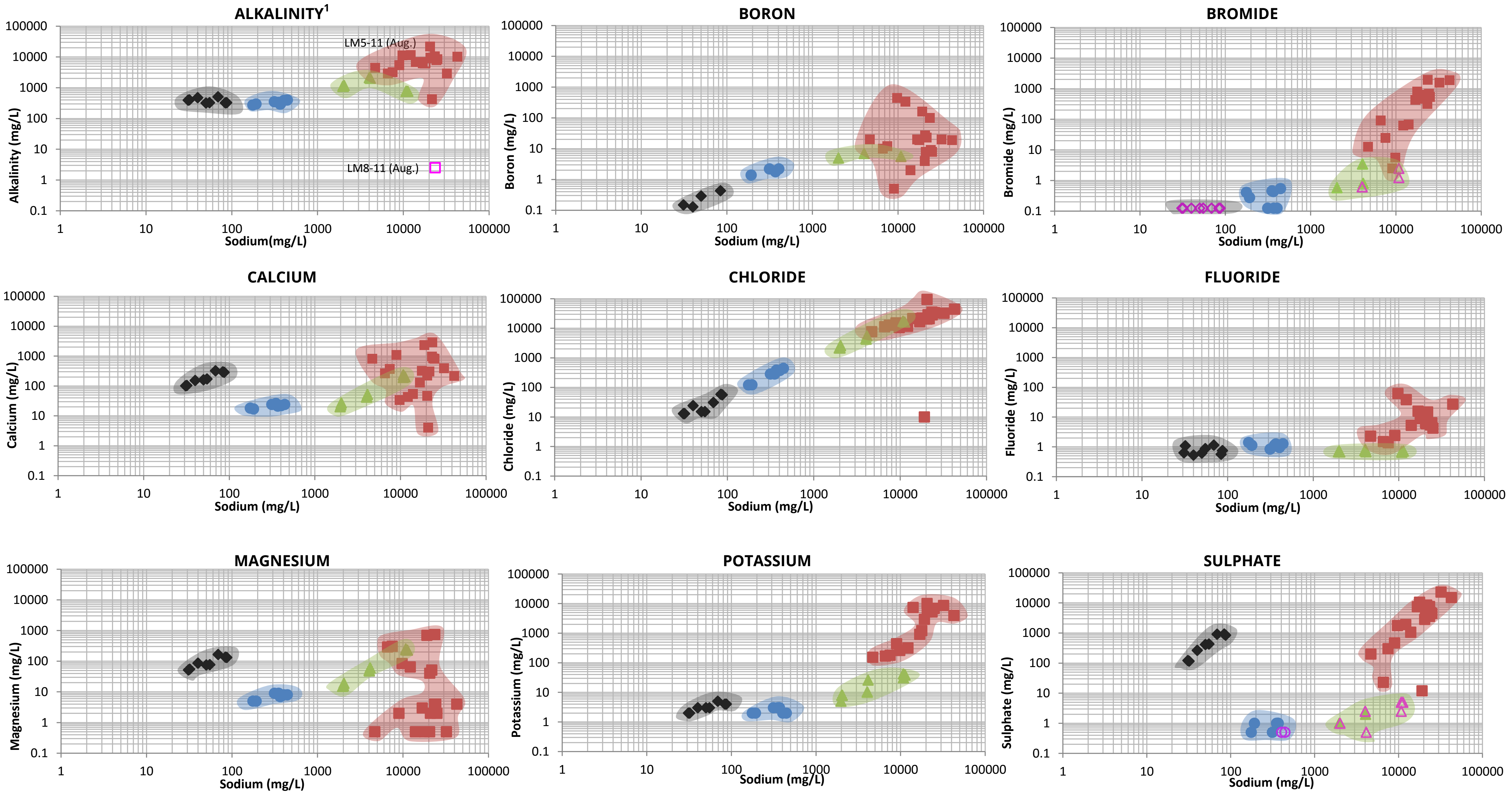
True North

Project #1600331

Drawn by: SSL	Figure: 24
Approx. Scale: NA	
Date Revised: Feb. 15, 2017	

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\1600331_F24_TriBGDeep-D1_170214.dwg

DATE PLOTTED: March 1, 2017



Notes:
1) Alkalinity data from Leachate Well LM5-11 (Aug. 2012) & LM8-11 (Aug. & Nov. 2012) suspect, identified on graph.

LEGEND:

◆ ▬ Shallow Wells off the Facility Property
(TW55-09S, TW56-11S, TW57-11S, TW59-13S)
■ ▬ Leachate
● ▬ Deep Wells off the Facility Property
(TW55-09D, TW56-11D, TW57-11D, TW59-13D)
▲ ▬ Shale Wells (TW32-94-I, TW38-94-I, TW42-99D)
□ ○ △ Non-Detect (50% of MDL value)

CONCENTRATION GRAPHS -
SOURCES / ACTIVITIES THAT INFLUENCE CHEMISTRY OF INTERFACE AQUIFER

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

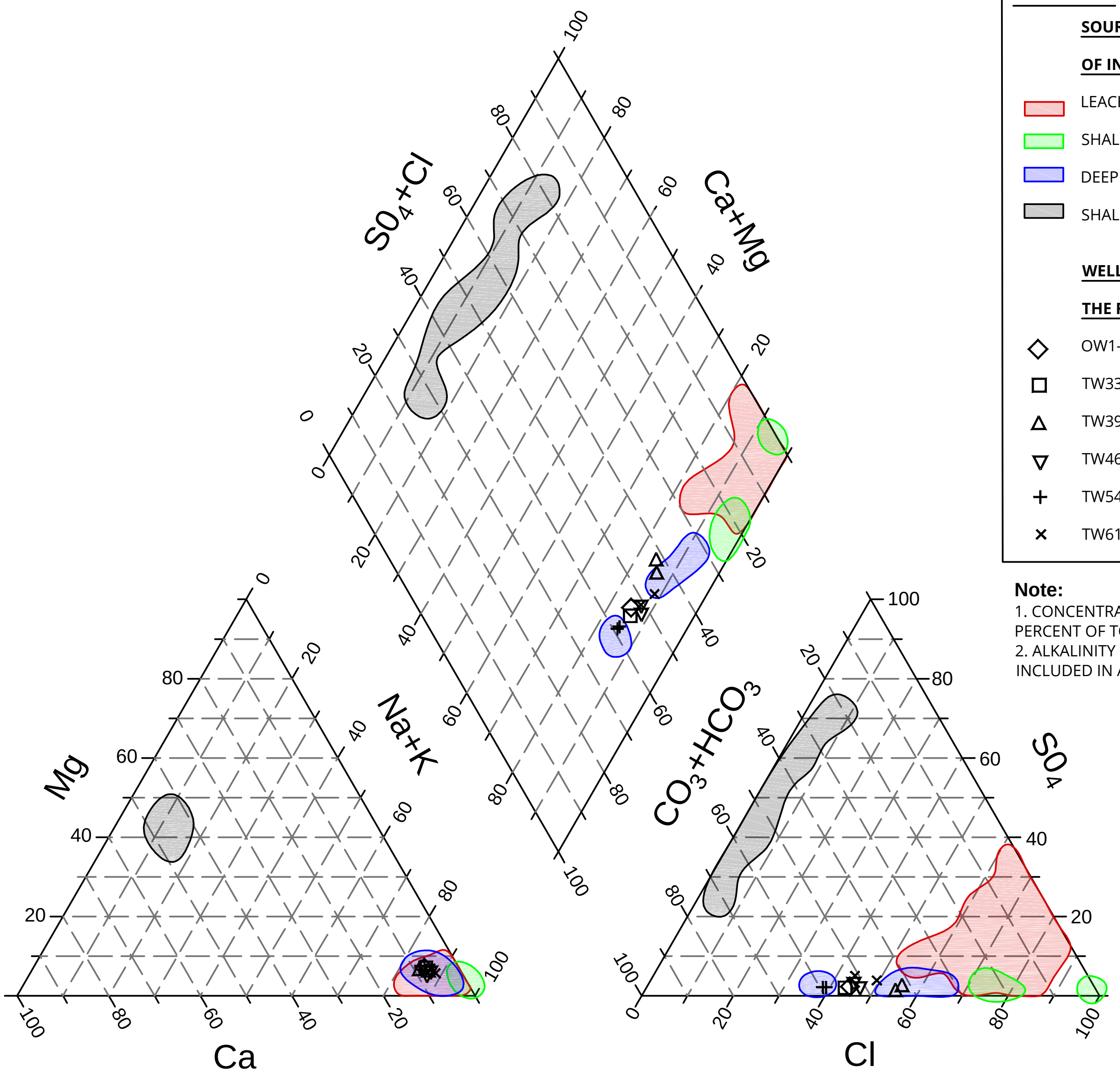
Project #: 1600331

Figure No. 25

Date: 21/2/2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\[1600331_F18-23_ConcGrpS_170214.xlsx]BG NA III

DATE PLOTTED: March 1, 2017



LEGEND:

SOURCES / ACTIVITIES THAT INFLUENCE CHEMISTRY OF INTERFACE AQUIFER

🟥 LEACHATE WELLS
🟩 SHALE WELLS (2014/2015)
🟦 DEEP WELLS OFF THE FACILITY PROPERTY (2016)
⬜ SHALLOW WELLS OFF THE FACILITY PROPERTY (2016)

WELLS IN INTERFACE AQUIFER LOCATED INTERNAL TO THE FACILITY PROPERTY

◇ OW1-92
□ TW33-94-I
△ TW39-99D
▽ TW46-99D
\+ TW54-09D
× TW61-13D

Note:
1. CONCENTRATIONS OF CATIONS (OR ANIONS) ARE EXPRESSED AS PERCENT OF TOTAL MILLEQUIVALENTS PER LITER.
2. ALKALINITY DATA FROM LEACHATE WELL LM8-11 SUSPECT, NOT INCLUDED IN ANALYSES.

TRILINEAR DIAGRAM - WELLS IN INTERFACE AQUIFER INTERNAL TO THE FACILITY PROPERTY

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

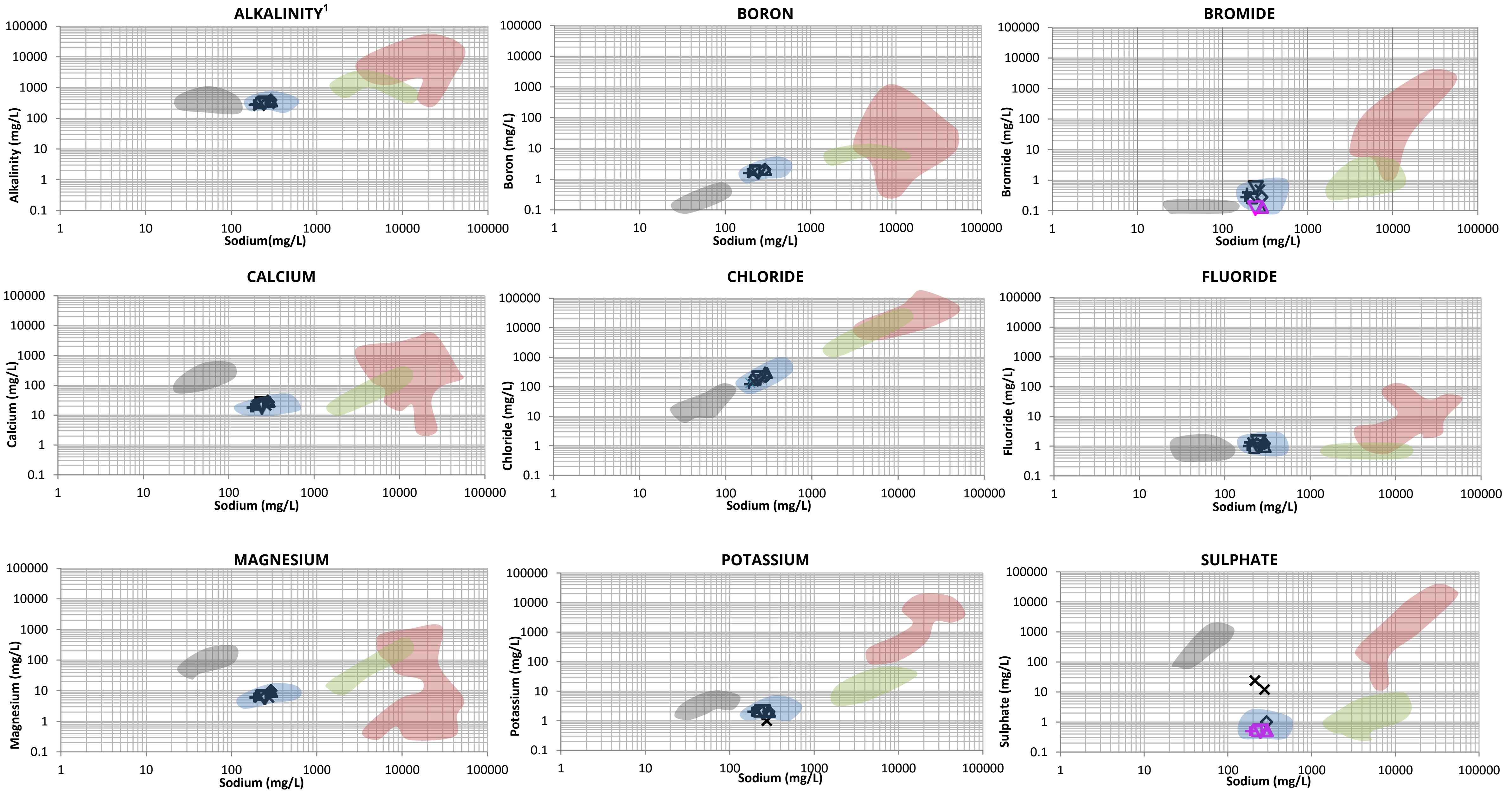
True North

Project #1600331

Drawn by: SSL
Figure: 26
Approx. Scale: NA
Date Revised: Feb. 15, 2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\1600331_F26_TrilnFacilityD-D2_170214.dwg

DATE PLOTTED: March 1, 2017



Notes:
1) Alkalinity data from Leachate Well LM5-11 (Aug. 2012) & LM8-11 (Aug. & Nov. 2012) suspect, identified on graph.
2) OW1-92 and TW33-94-I was decomissioned in Summer 2016.

LEGEND:

■ Shallow Wells off the Facility Property
(TW55-09S, TW56-11S, TW57-11S, TW59-13S)
■ Leachate
■ Deep Wells off the Facility Property
(TW55-09D, TW56-11D, TW57-11D, TW59-13D)
■ Shale Wells (TW32-94-I, TW38-94-I, TW42-99D)
□ ○ △ Non-Detect (50% of MDL value)

◇ OW1-92
□ TW33-94-I
△ TW39-99D
▽ TW46-99D
+ TW54-09D
✖ TW61-13D

CONCENTRATION GRAPHS -
INTERFACE AQUIFER WELLS INTERNAL TO THE FACILITY

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

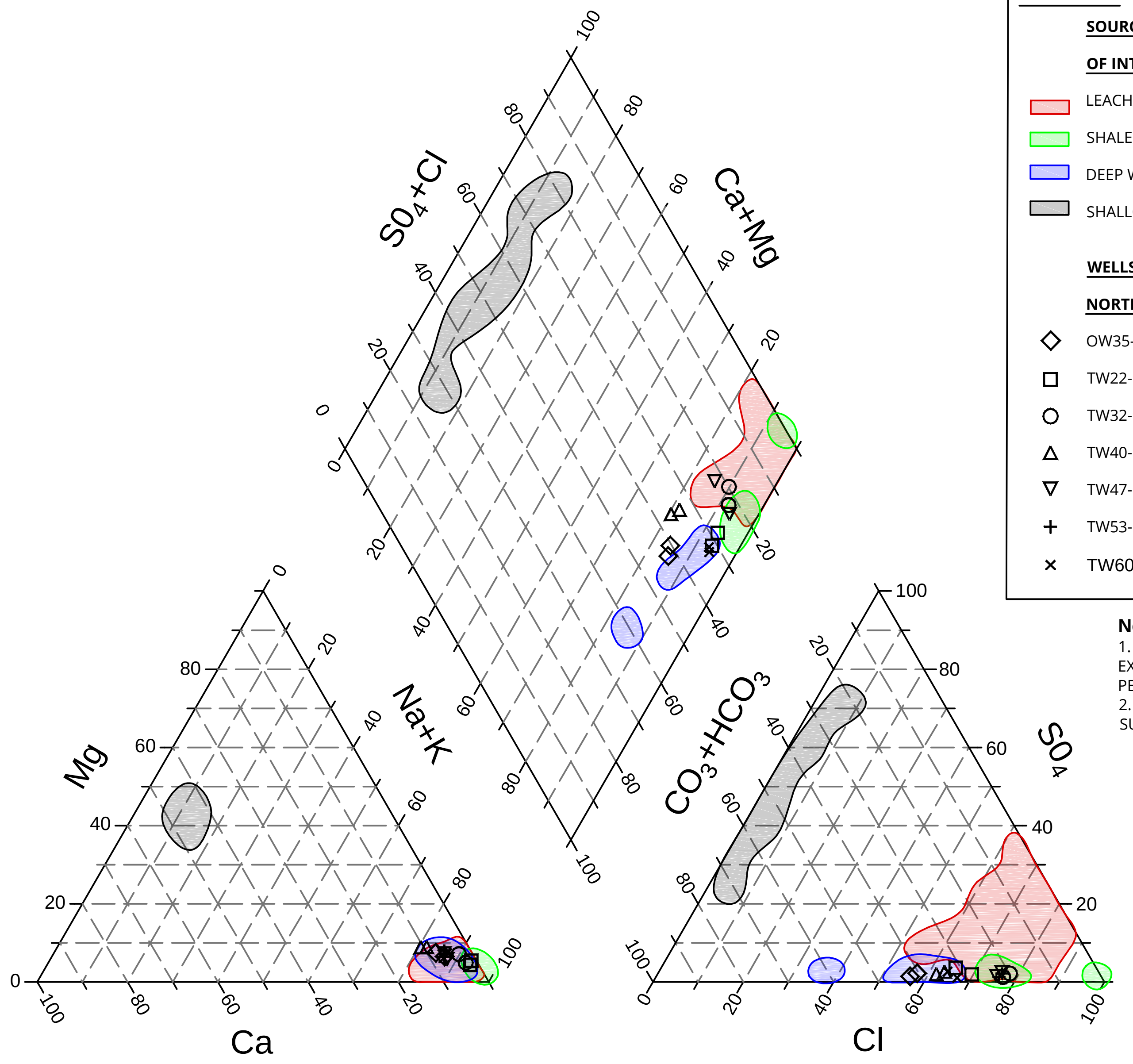
Project #: 1600331

Figure No. 27

Date: 21/2/2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\[1600331_F18-23_ConcGrpS_170214.xlsx]BG NA III

DATE PLOTTED: March 1, 2017



LEGEND:

SOURCES / ACTIVITIES THAT INFLUENCE CHEMISTRY OF INTERFACE AQUIFER

- 🟥 LEACHATE WELLS
- 🟩 SHALE WELLS (2014/2015)
- 🟦 DEEP WELLS OFF THE FACILITY PROPERTY (2016)
- ⬛ SHALLOW WELLS OFF THE FACILITY PROPERTY (2016)

WELLS IN INTERFACE AQUIFER LOCATED ALONG THE NORTH PERIMETER OF THE FACILITY PROPERTY

- ◇ OW35-05D
- □ TW22-99D
- ○ TW32-94-II
- △ TW40-99D
- ▽ TW47-00D
- + TW53-03D
- × TW60-13D

Note:

1. CONCENTRATIONS OF CATIONS (OR ANIONS) ARE EXPRESSED AS PERCENT OF TOTAL MILLEQUIVALENTS PER LITER.
2. ALKALINITY DATA FROM LEACHATE WELL LM8-11 SUSPECT, NOT INCLUDED IN ANALYSES.

TRILINEAR DIAGRAM - WELLS IN INTERFACE AQUIFER ALONG THE NORTHERN PERIMETER OF THE FACILITY PROPERTY

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

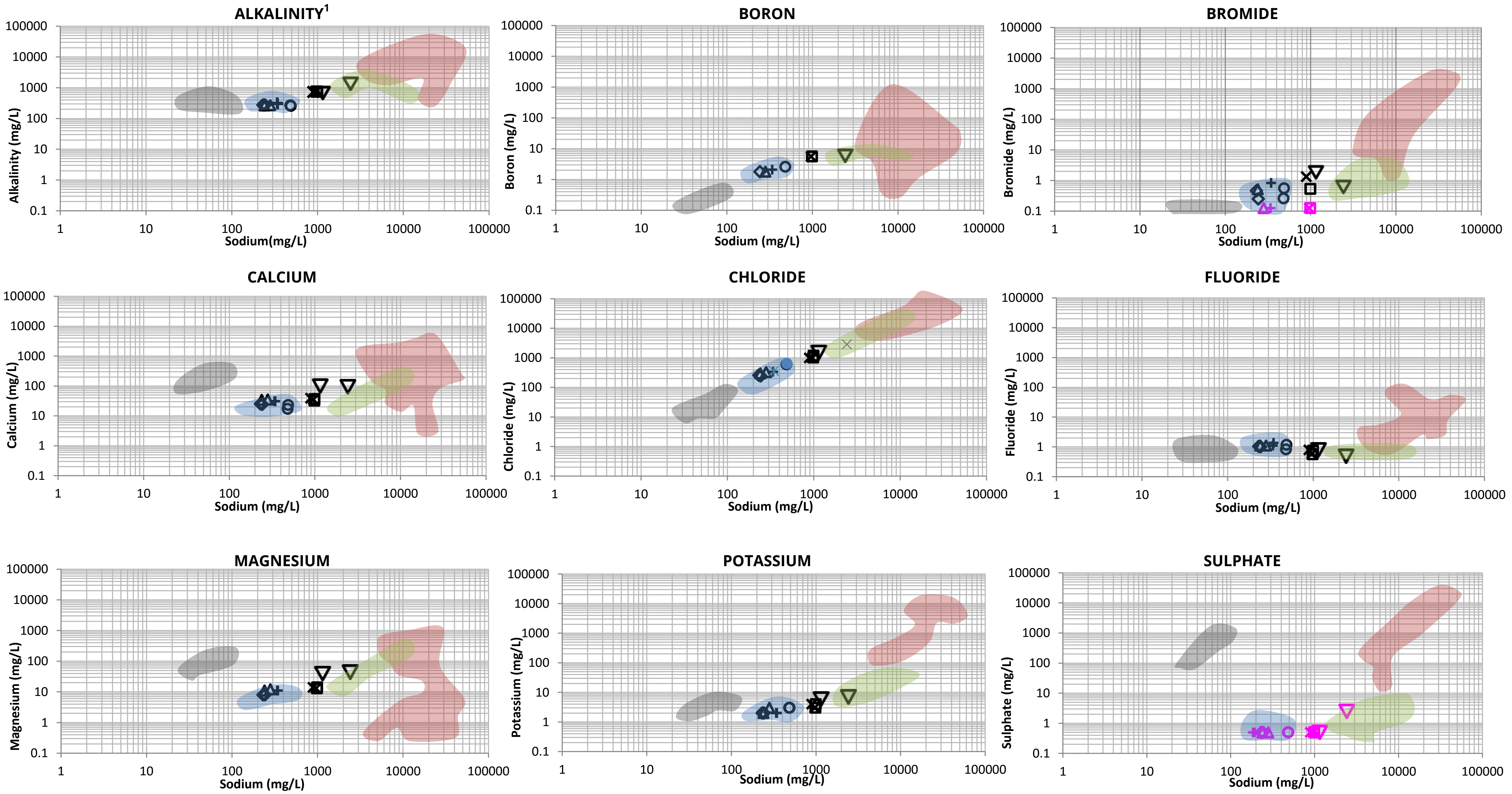
True North

Project #1600331

Drawn by: SSL
Figure: 28
Approx. Scale: NA
Date Revised: Feb. 15, 2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\1600331_F28_TriNPermD_170214.dwg

DATE PLOTTED: March 1, 2017



Notes:
1) Alkalinity data from Leachate Well LM5-11 (Aug. 2012) & LM8-11 (Aug. & Nov. 2012) suspect, identified on graph.
2) OW1-92 and TW33-94-I was decomissioned in Summer 2016.

LEGEND:

▬	Shallow Wells off the Facility Property (TW55-09S, TW56-11S, TW57-11S, TW59-13S)	◇	OW35-05D
🟥	Leachate	□	TW22-99D
🟦	Deep Wells off the Facility Property (TW55-09D, TW56-11D, TW57-11D, TW59-13D)	○	TW32-94-II
🟩	Shale Wells (TW32-94-I, TW38-94-I, TW42-99D)	△	TW40-99D
□ ○ △	Non-Detect (50% of MDL value)	▽	TW47-00D
		+	TW53-03D
		✖	TW60-13D

CONCENTRATION GRAPHS -
INTERFACE AQUIFER WELLS ALONG THE NORTHERN PERIMETER OF THE FACILITY

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

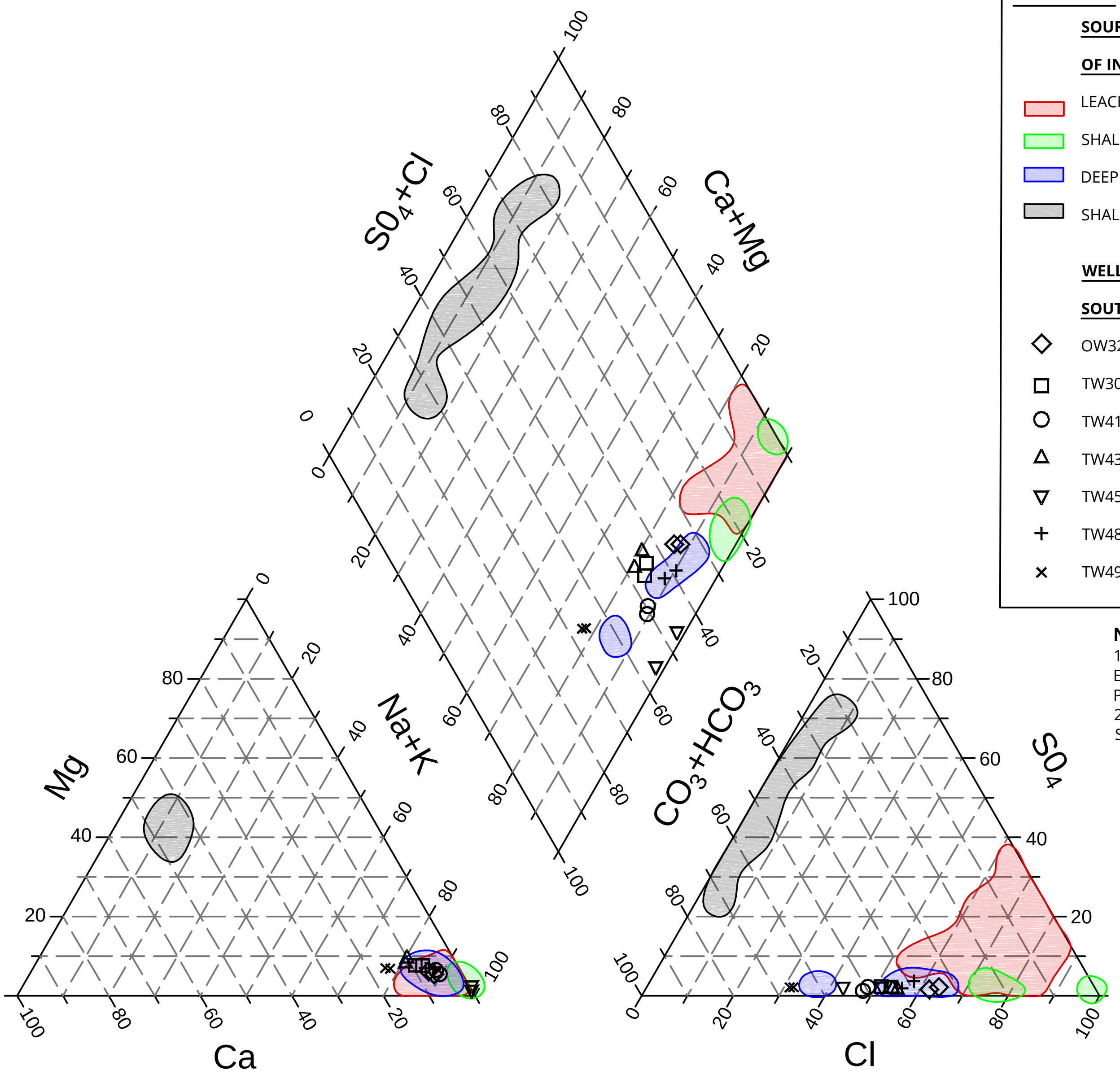
Project #: 1600331

Figure No. 29

Date: 21/2/2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\[1600331_F25-31-ConGrpD_170214.xlsx]BG NA I

DATE PLOTTED: March 1, 2017



LEGEND:

SOURCES / ACTIVITIES THAT INFLUENCE CHEMISTRY OF INTERFACE AQUIFER

- 🟥 LEACHATE WELLS
- 🟩 SHALE WELLS (2014/2015)
- 🟦 DEEP WELLS OFF THE FACILITY PROPERTY (2016)
- ▨ SHALLOW WELLS OFF THE FACILITY PROPERTY (2016)

WELLS IN INTERFACE AQUIFER LOCATED ALONG THE SOUTHERN PERIMETER OF FACILITY PROPERTY

- ◇ OW32-90D
- □ TW30-99D
- ○ TW41-99D
- △ TW43-99D
- ▽ TW45-99D
- \+ TW48-00D
- × TW49-00D

Note:

1. CONCENTRATIONS OF CATIONS (OR ANIONS) ARE EXPRESSED AS PERCENT OF TOTAL MILLEQUIVALENTS PER LITER.
2. ALKALINITY DATA FROM LEACHATE WELL LM8-11 SUSPECT, NOT INCLUDED IN ANALYSES.

TRILINEAR DIAGRAM - WELLS IN INTERFACE AQUIFER ALONG THE SOUTHERN PERIMETER OF THE FACILITY PROPERTY

2016 Groundwater Monitoring Report
Clean Harbors Canada, Inc., Lambton Facility Landfill

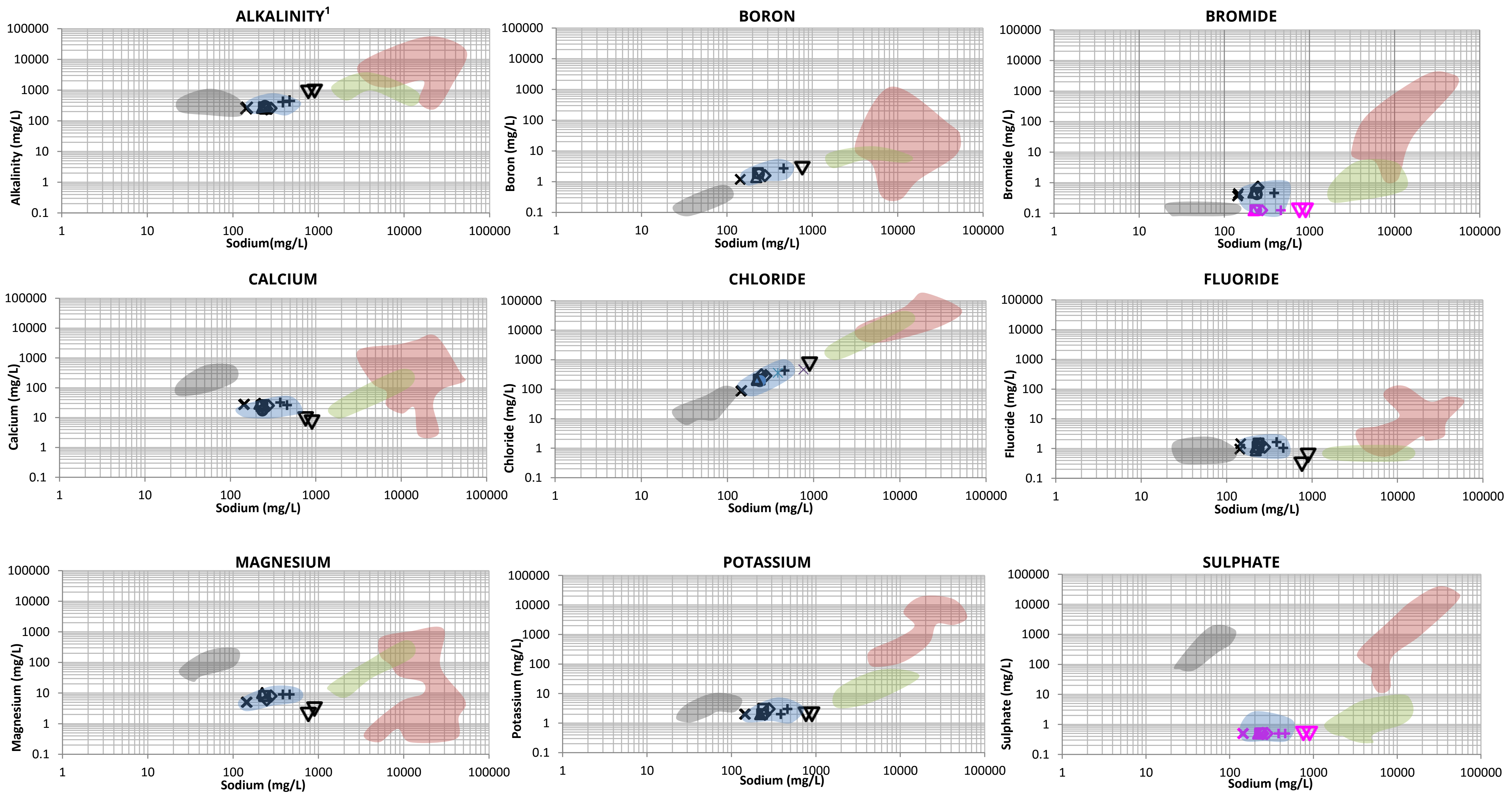
True North

Project #1600331

Drawn by: SSL	Figure: 30
Approx. Scale: NA	
Date Revised: Feb. 15, 2017	

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\1600331_F30_TriSPermD_170214.dwg

DATE PLOTTED: March 1, 2017



Notes:
1) Alkalinity data from Leachate Well LM5-11 (Aug. 2012) & LM8-11 (Aug. & Nov. 2012) suspect, identified on graph.
2) OW1-92 and TW33-94-I was decomissioned in Summer 2016.

LEGEND:

▬	Shallow Wells off the Facility Property (TW55-09S, TW56-11S, TW57-11S, TW59-13S)	◇	OW32-90D
▬	Leachate	□	TW30-99D
▬	Deep Wells off the Facility Property (TW55-09D, TW56-11D, TW57-11D, TW59-13D)	○	TW41-99D
▬	Shale Wells (TW32-94-I, TW38-94-I, TW42-99D)	△	TW43-99D
□ ○ △	Non-Detect (50% of MDL value)	▽	TW45-99D
		+	TW48-00D
		✖	TW49-00D

CONCENTRATION GRAPHS -
INTERFACE AQUIFER WELLS ALONG THE SOUTHERN PERIMETER OF THE FACILITY

2016 Groundwater Monitoring Report - Clean Harbors Canada, Inc.
Lambton Facility Landfill, Corunna, Ontario

Project #: 1600331

Figure No. **31**

Date: 21/2/2017

FILE LOCATION: C:\Users\ssl\Desktop\Lambton Landfill\1600331 - 2016 Annual Report\Figures\Working Files\Trilinear chem\[1600331_F25-31-ConGrpD_170214.xlsx]BG NA III

DATE PLOTTED: March 1, 2017