2016 Annual Report
Groundwater Monitoring and
Interim Action Performance Monitoring

Pasco Landfill NPL Site
Pasco, Washington

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1 INTRODUCTION

On behalf of the Industrial Waste Area Generators Group lll (IWAG), PBS Engineering and Environmental Inc. (PBS) has prepared this *2016 Annual Report Groundwater Monitoring and Interim Action Performance Monitoring* (2016 Annual Report) for the Pasco Landfill NPL Site (Site) in Pasco, Washington. This report is being submitted to the Washington State Department of Ecology (Ecology) in support of the ongoing obligations of the potentially liable persons (PLPs) under Agreed Order No. DE 9240 (Agreed Order).

This 2016 Annual Report summarizes the results of the groundwater monitoring and interim action performance monitoring activities conducted during 2016 and discusses the effectiveness of the various interim actions implemented at the Site.

This 2016 Annual Report contains the following enclosures:

- Attachment A contains the *Data Validation Report Pasco Sanitary Landfill Groundwater Monitoring October 2016 Sampling*, by Pyron Environmental, Inc., dated February 14, 2017.
- Attachment B contains laboratory data from waste characterization sampling, hazardous waste manifests for wastes generated and transported off site for treatment or disposal during 2016, and documentation for non-hazardous waste generated and transported off-site for treatment, reactivation, or disposal during 2016.
- Attachment C contains monthly inspection checklists for the Industrial Waste Area landfill covers, detention/evaporation basins, and perimeter fencing for Zones A, C/D, and E.
- Attachment D contains differential TIN surface maps from quarterly 3D laser scans of the Zone A landfill.
- Attachment E contains the *Technical Memorandum – Updated Cover Settlement Evaluation – Industrial Waste Area - Zone A Drum Disposal Area - Pasco Sanitary Landfill Site - March 2017*, prepared by SCS Engineers.
- Attachment F contains the 2016 East Pasco Plume Area Well Location Survey prepared by the City of Pasco and the Annual Institutional Controls Report for 2016 prepared by the Franklin County Planning and Building Department.
- Attachment G of the final paper copy of this report will contain an electronic data deliverable, on compact disk, with Site data generated during the fourth quarter 2016 sampling event. The file PLF-Report-4Q16.xlsx contains multiple worksheets, containing fourth quarter 2016 water level data, well stabilization parameters, and laboratory results from volatile organic compound (VOCs), semi-volatile organic compound (SVOCs), herbicide, chromium, natural attenuation, and landfill parameter analyses.

1.1 Site Location

The general location of the Site and the Pasco Sanitary Landfill (PSL) property are depicted on Figure 1. The PSL property is located approximately 1.5 miles northeast of the City of Pasco, in the southwest quarter of Section 15, the northeast quarter of Section 21, and the northwest quarter of Section 22, Township 9 North, Range 30 East, Willamette Meridian, located in Franklin County, Washington. The PSL property is located on Dietrich Road near the intersection of Pasco-Kahlotus Road and U.S. Highway 12.

The PSL property occupies an area of more than 250 acres consisting of rolling hills surrounded by irrigated cropland. The former municipal solid waste landfill (MSW Landfill), Balefill/Inert Waste Disposal Area, Industrial Waste Area (IWA), and the New Waste, Inc. (NWI) landfill are located within the PSL property. Figure 2 shows the locations of each waste area on the PSL property. Reporting requirements detailed in the Agreed Order for the MSW Landfill and Balefill/Inert Waste Disposal Areas are addressed in a separate report by the Landfill Group (LFG). The NWI landfill is a modern and fully lined solid waste landfill located to the north of the MSW Landfill that opened on May 31, 1993 and closed in 2002. The NWI landfill is not considered further in this report. Data and discussion related to Zone B is also presented in a separate report prepared by Bayer Crop Science (BCS).

The formal definition of the Site is presented in the Agreed Order. The Site boundary, as defined in the Agreed Order and illustrated in Exhibit A of the Order, encompasses both the PSL property, and the Groundwater Protection Area (GPA).

1.2 Background

The operational history and cleanup history of the Site has been documented extensively in numerous prior reports including the *Draft Focused Feasibility Study – Pasco Landfill National Priorities List Site* (FFS), dated September 3, 2014. The reviewer is directed to the FFS for information related to the Site background.

The following technical documents pertaining to groundwater monitoring and interim actions under the Agreed Order were submitted to Ecology during 2016:

- *Revised 2014 Annual Report – Groundwater Monitoring and Interim Action Performance Monitoring, dated January 7, 2016.*
- *2015 Annual Report - Groundwater Monitoring and Interim Action Performance Monitoring*, dated March 23, 2016.
- *Engineering Test Plan,* dated March 28, 2016.
- *Notice of Violation Docket No. 13240*, response letter to Ecology prepared by Landau Associates, dated April 28, 2016.
- *High Operating Values, Zone A, Pasco Sanitary Landfill, Pasco, Washington*, letter prepared by SCS Engineers, dated May 6, 2016.
- *Pasco Landfill: Update on RTO repair and testing,* email from Mike Riley, dated May 31, 2016.
- *First Quarter 2016 Groundwater Monitoring and Interim Action Performance Monitoring Report*, dated June 16, 2016.
- *Performance Test Plan: Engineering/Optimization and Compliance Tests at the Pasco Sanitary Landfill,* dated June 17, 2016.
- *Assessment of Pasco Sanitary Landfill RTO Performance*, dated June 24, 2016.
- *Proposed Modifications to the Existing Interim Actions Ground Water Monitoring Program*, dated June 24, 2016.
- *Revised Site-Wide Groundwater Performance and Protection Monitoring Operations and Maintenance Manual, dated June 27, 2016.*
- *Memorandum – Transmittal of As-Built Documentation and Specification One-way Air Intake Valves,* dated July 27, 2016
- *Addendum No. 1 to Volume 3 – As-Built Report for SVE System Upgrades – Attachment A – Sampling and Analysis Plan,* dated July 29, 2016

- *Second Quarter 2016 Groundwater Monitoring and Interim Action Performance Monitoring Report*, dated September 15, 2016.
- *Conceptual Combustion Evaluation Workplan,* dated September 26, 2016.
- *Detailed Work Plan to Evaluate Potential Combustion in Zone A*, dated October 31, 2016.
- *Revised Detailed Work Plan to Evaluate Potential Combustion in Zone A,* dated November 23, 2016.
- *Memorandum – GCE RTO Unit Repairs*, dated November 28, 2016.
- *Second Revised Detailed Work Plan to Evaluate Potential Combustion in Zone A*, dated December 9, 2016.
- *Third Quarter 2016 Groundwater Monitoring and Interim Action Performance Monitoring Report*, dated December 16, 2016.
- Twelve (12) Monthly Status Reports were submitted to Ecology during 2016. A memorandum was submitted during the first full week of each month summarizing activities and publications delivered to Ecology during the preceding month.

This report does not present information related to the Balefill Area combustion extinguishment actions or construction of the supplemental protection barrier, which were conducted in compliance with Enforcement Order DE 10651 (EO 10651). This work was presented in the following documents submitted to Ecology during 2016 as required by EO 10651:

- *Construction Summary Report for the Balefill Area Extinguishment and Supplemental Protection Barrier Project at the Pasco Landfill NPL Site*, dated April 18, 2016;
- *Revised Construction Summary Report for the Balefill Area Extinguishment and Supplemental Protection Barrier Project at the Pasco Landfill NPL Site*, dated October 31, 2016;
- *Draft Enforcement Order Task 2 Technical Memorandum – Pasco Sanitary Landfill National Priorities List Site*, dated April 18, 2016; and
- *Draft Enforcement Order Task 2 Technical Memorandum – Pasco Sanitary Landfill National Priorities List Site*, dated October 31, 2016.

2 OBJECTIVES

The specific objectives of the groundwater monitoring and interim action performance monitoring conducted at the Site include:

- Assessment of groundwater quality relative to the draft cleanup levels (dCULs) in the FFS;
- Evaluation of trends in groundwater quality;
- Evaluation of the performance and effectiveness of the SVE and thermal oxidation systems; and
- Evaluation of subsidence on the Zone A cap.

This report presents and evaluates data collected during 2016 under the Agreed Order and reports on groundwater monitoring, operations and maintenance activities completed in relation to the soil vapor extraction (SVE) system operating beneath and within the Zone A landfill, the thermal oxidation units used to treat SVE system effluent, waste management, landfill covers on waste Zones A, C/D, and E, and Institutional Controls at the Site.

2.1 Contaminants of Potential Concern

Contaminants of Potential Concern (COPCs) were defined in the Site *Risk Assessment/Cleanup Level Analysis* Report (PSC 1998) based upon the occurrence and quantification of compounds detected in soil and groundwater during the Site investigation.

The COPCs were defined as follows:

- Soil – acetone.
- Groundwater – acetone, benzene, hexavalent chromium, 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), tetrachloroethene (PCE), toluene, 1,1,1-trichloroethane (1,1,1-TCA), 1,1,2-trichloroethane (1,1,2-TCA), trichloroethene (TCE), and vinyl chloride (VC).

2.2 Draft Cleanup Levels

On May 14, 2013, Ecology presented dCULs for the Site, which were updated in the 2014 FFS. During the April 11, 2014 monthly meeting with the IWAG, Ecology agreed to allow the use of the dCULs for evaluation of groundwater monitoring results.

The following table summarizes the 2014 dCULs:

dCULs for Groundwater
in micrograms/liter (µg/l)

Compound	2014 dCUL
Benzene *	0.79
1,2-Dichloroethane *	0.38
1,1-Dichloroethene **	0.057
cis-1,2-Dichloroethene	16
Methylene Chloride *	5.0
Tetrachloroethene *	0.69
Toluene	615
1,1,1-Trichloroethane	200
Trichloroethene *	2.5
Vinyl Chloride *	0.069
Total Chromium	100

Notes:

* Known or suspected carcinogenic compound.

** No longer contributes additional cancer risk for the calculation of groundwater dCULs at the Site.

3 GROUNDWATER MONITORING

3.1 Methodology

3.1.1 Groundwater Monitoring Wells

Groundwater monitoring at the Site was conducted in accordance with schedules and field sampling methods presented in:

- *The Revised Site-Wide Groundwater Performance and Protection Monitoring Operations and Maintenance Manual – Pasco Landfill Site* (Groundwater O&M Manual), dated May 9, 2014, with October 10, 2014 Revisions.

As part of the quarterly groundwater monitoring activities during January, April, July and October 2016, groundwater levels were measured to the nearest 0.01-foot in wells throughout the Site. Figure 3 illustrates the location of each well in the groundwater monitoring well network. Groundwater levels were not measured in the residential wells because those wells were not constructed in a manner that allows such measurements.

Quarterly groundwater samples were collected during all four quarters. Semi-annual groundwater samples were collected in April and October. Table 1 summarizes the wells sampled and the specific chemical analyses requested for each quarterly and semi-annual sampling event.

Selective ion monitoring (SIM) is used along with full-scan VOC and SVOC laboratory analysis of groundwater samples in order to attain reporting limits less than the dCULs or MTCA Method B values for each compound analyzed. All laboratory data from groundwater samples collected at the Site during 2016 have been submitted to a third-party data validator for evaluation. Attachment A contains the data validation report for the fourth quarter sample analysis. Data validation reports for the first through third quarters were submitted with the quarterly reports.

3.1.2 Residential Wells

The target sampling frequency for residential wells in the Groundwater Protection Area (GPA) is presented in the *Groundwater O&M Manual*. At a minimum, all functional and safely accessible residential wells are sampled on a semi-annual basis during the second and fourth quarters. If any compound is detected in a residential well at a concentration that exceeds a dCUL, that well is moved to a quarterly sampling schedule. If all analytical results are below the dCULs in four consecutive quarterly samples, the well is moved back to a semi-annual sampling schedule.

At the start of 2016, none of the analytical data from the most recent four consecutive samples for any residential well contained a VOC concentration above a dCUL for the Site. Therefore, all residential wells were sampled semi-annually (i.e., second and fourth quarters).

The actual number of wells sampled during each semi-annual event in 2016 was dependent upon a number of factors including whether permission was granted by the property owner, the well was safely accessible, and the equipment or piping were functional. The IWAG does not control or maintain the residential wells and is not responsible for their upkeep or performance.

Residential wells are further described in Section 3.2.2.2.6.

3.2 Findings

3.2.1 Groundwater Elevation Data

Both horizontal and vertical hydraulic gradients for the monitoring well network were evaluated during 2016.

3.2.1.1 Horizontal Hydraulic Gradients

Groundwater elevation contours were developed using the site-wide groundwater elevation measurements from January, April, July, and October 2016. A summary of the groundwater elevation data for each quarterly groundwater monitoring event is presented in Table 2. Site-wide groundwater elevation contours for shallow wells are presented in Figures 4 through 7.

The piezometric contours indicate that the groundwater flow direction beneath Zone A and across the PSL property was consistently southwesterly throughout 2016. As measured between wells MW-52S in Zone A and MW-11S approximately 1,109 feet southwest at the downgradient property boundary, the hydraulic gradient averaged less than 0.002 feet/feet (ft/ft) during 2016.

The direction of groundwater flow shifts to a more southerly orientation downgradient of the property boundary and is best indicated by the historical orientation of the dissolved-phase contaminant plume. The hydraulic gradient south of the property boundary is less steep than on the property. As measured between wells MW-11S at the property boundary and MW-43S, which is located approximately 8,025 feet south of the property boundary along East A Street, the off-property hydraulic gradient averaged less than 0.001 ft/ft during 2016.

Hydraulic gradients measured in the shallow aquifer in 2016 were consistent throughout the year and were consistent with findings for prior years. The hydraulic gradient direction and slope at the Site are stable and are not expected to change in the future.

The direction of the groundwater gradient for the intermediate portion of the aquifer was consistent with the shallow portion of the aquifer throughout 2016. The hydraulic gradient for the intermediate portion of the aquifer on the PSL property, as measured between MW-47I and MW-11I (approximately 845 feet), averaged less than 0.001 ft/ft during 2016. As with the shallow portion of the aquifer, the gradient for the intermediate portion of the aquifer is less steep downgradient of the property and, as measured between MW-11I and MW-54I (approximately 11,107 feet), averaged less than 0.001 ft/ft during 2016.

As with the shallow aquifer, the hydraulic gradients in the intermediate portion of the aquifer were consistent throughout the year and were consistent with prior years. The hydraulic gradient direction for the intermediate portion of the aquifer is stable and is not expected to change in the future.

3.2.1.2 Vertical Hydraulic Gradients

Groupings of shallow, intermediate, and deep wells allow for the calculation of vertical hydraulic gradients throughout the full thickness of the aquifer. The gradients are calculated using groundwater elevations and the elevations of the centers of the intermediate and deep well screens. Due to the accuracy of the water level meter and survey instruments, the vertical gradients have been rounded to the nearest thousandth of a foot. Negative values reflect an upward vertical gradient. Table 3 summarizes vertical hydraulic gradients

calculated for well clusters on the landfill property near Zone A. Table 4 summarizes vertical hydraulic gradients calculated for wells at the Site downgradient of the landfill property.

Vertical hydraulic gradients near Zone A have been calculated for six clusters of three wells screened at the shallow, intermediate, and deep portions of the aquifer (#2R/I/D, MW-12S/I/D, MW-47S/I/D, MW-48S/I/D, MW-49S/I/D and NVM-01/I/D). During 2016, the vertical hydraulic gradients for the six Zone A well clusters ranged from 0.073 ft/ft to -0.091 ft/ft.

Four off-property well pairs are screened at the shallow and intermediate portions of the aquifer, and are located along the inferred longitudinal axis of the dissolved-phase plume (MW-11S/I, MW-29S/I, MW-38S/I, and MW-43S/I). During 2016 the vertical gradients for the downgradient off-property well pairs ranged from 0.006 ft/ft in to -0.006 ft/ft.

The vertical gradient data indicate that only very small vertical gradients exist at the Site and that these vertical gradients are unlikely to have a significant effect on the vertical migration of dissolved-phase compounds.

3.2.2 Groundwater Quality

Well stabilization parameters collected during well purging are summarized in Table 5. Laboratory analytical results from groundwater monitoring during 2016 are summarized in Tables 6 through 11. The data are evaluated by well groupings in Section 3.2.2.2 and by distribution of dissolved-phase contaminants in Section 3.2.2.3. Overall concentration trends for 2016 will also be discussed in relation to SVE System Performance Monitoring in Section 4.5 - Groundwater Quality Trends. The evaluation of groundwater quality at the Site is focused on compounds that were detected at concentrations exceeding a dCUL.

3.2.2.1 Well Stabilization Parameters

Well stabilization parameters are collected to evaluate steady-state conditions in each well prior to sampling. pH, conductivity, dissolved oxygen (DO), and turbidity are the primary parameters used to evaluate steady-state conditions prior to sample collection. During well purging, temperature and oxidation-reduction potential (ORP) are also stabilized and recorded. Well stabilization data are presented in Table 5.

3.2.2.2 Evaluation by Well Grouping

This section presents a discussion of the analytical results for the following groups of wells:

- Performance Monitoring Wells
    - MSW Landfill
    - Zone A
    - Zone B
    - Zones C and D
    - Zone E
- Sentinel Wells
- Property Boundary Wells

- Off-Property Downgradient Monitoring Wells
- Upgradient Wells
- Residential Wells

These well groupings are as presented in the *Groundwater O&M Manual*. Well locations are shown on Figure 3.

3.2.2.2.1 Performance Monitoring Wells

Performance monitoring wells are used to monitor the effectiveness of interim remedial measures and track changes in contaminant concentrations and distribution over time. They are located either directly under a waste zone or on the downgradient boundary of a zone. The performance monitoring wells are grouped into wells monitoring groundwater quality at the MSW landfill, Zone A, Zone B, Zones C/D, and Zone E. The wells associated with each landfill or zone are discussed below.

MSW Landfill Wells

The groundwater monitoring network for the MSW Landfill consists of wells 4R, MW-16S, and MW-17SR. Table 1 summarizes the wells sampled and analyses requested for each. Samples for VOC analysis were collected from wells 4R, MW-16S, and MW-17SR during all four quarters of 2016. VOC data for the MSW landfill wells are summarized in Table 6.

Landfill parameter samples were collected from wells 4R, MW-16S, and MW-17SR during the second and fourth quarters. The landfill parameters analyzed include nitrate, ammonia, sulfate, total dissolved solids, total alkalinity, bicarbonate, carbonate, hydroxide, chloride, total organic carbon, calcium, total iron, magnesium, manganese, potassium, and sodium. Landfill parameter data are summarized in Table 11.

Evaluation of MSW Landfill well data is provided in the 2016 Annual Report for the MSW Landfill as prepared by the LFG.

Zone A Wells

The groundwater monitoring network for Zone A consisted of nine wells during 2016. Wells EE-2, MW-13S, MW-47S, MW-50S, MW52S, MW-53S, and NVM-01 are completed in the shallow portion of the aquifer, and wells MW-47I and NVM-01I are completed in the intermediate portion of the aquifer. Both intermediate wells are paired with an adjacent shallow well. Table 1 summarizes the analyses requested for each Zone A Performance Monitoring well.

VOC analyses were performed on samples from six wells (MW-13S, MW-47S, MW-50S, MW52S, MW-53S, and NVM-01) on a quarterly basis during 2016. VOC analyses were performed on samples from three additional wells (EE-2, MW-47I, and NVM-01I) on a semi-annual basis during the second and fourth quarters.

Groundwater monitoring wells MW-52S and MW-53S are considered source zone wells as they are immediately beneath the Zone A wastes. During 2016, 19 different VOCs were detected in samples from MW-52S. Of those 19 compounds, PCE was detected at a concentration exceeding the dCUL during one quarter of 2016. TCE was detected at a concentration exceeding a dCUL during two quarters of 2016. Ten different VOCs were detected in samples from MW-53S, but none exceeded the respective dCUL.

The sample collected from MW-52S during the fourth quarter 2016 contained a concentration of TCE of 2.4 ug/l. The duplicate sample from MW-52S contained a concentration of TCE of 4.2 ug/l. Since the dCUL for TCE is 2.5 ug/l, the concentration reported in Table 6 is from the duplicate sample.

No other VOCs were detected at a concentration exceeding a dCUL in any of the other Zone A performance monitoring wells at any time during 2016. No compounds were detected in any sample from the two Zone A performance monitoring wells in the intermediate portion of the aquifer during 2016. Table 6 summarizes VOC data for the Zone A wells.

SVOC analyses were performed on samples from the two Zone A source wells (MW-52S and MW-53S) during the second and fourth quarters. Four SVOCs were detected in samples from MW-52S and MW-53S during 2016. SVOC data are summarized in Table 7. There are no Site specific dCULs for any of the detected SVOCs. For purposes of comparison only, concentrations of all of the detected SVOCs were below the Model Toxics Control Act (MTCA) Method B cleanup levels listed in the Ecology-maintained Cleanup Levels and Risk Calculation (CLARC) data tables as updated in August 2015.

Herbicide analyses were performed on samples from two Zone A wells (MW-52S and MW-53S) during the second and fourth quarters. No herbicides were detected in samples analyzed during 2016. Herbicide data are summarized in Table 8.

Total and hexavalent chromium analyses was performed on the sample from MW-13S during all four quarters of 2016. No hexavalent chromium was detected. Total chromium was detected at concentrations below the dCUL. Chromium data are summarized in Table 9.

Natural attenuation analyses were performed on samples from two Zone A wells (MW-47S and MW-50S) during the second and fourth quarters. The natural attenuation parameters analyzed include nitrate, nitrite, ammonia, sulfate, ferrous iron, manganese, chemical oxygen demand, total dissolved solids, methane, ethane, ethene, total alkalinity, bicarbonate, carbonate, hydroxide, chloride, and total organic carbon. Natural attenuation data are summarized in Table 10.

Zone B Well

The groundwater monitoring network for Zone B consisted of well MW-26SR during 2016. Well MW-26SR was sampled for VOCs, SVOCs and herbicides during all four quarters. Table 1 summarizes the analyses requested for this well.

During 2016, two VOCs were detected in the first quarter sample at a concentration below the dCUL. No other VOCs were detected in samples from MW-26SR at any time during 2016.

Two SVOCs were detected in the fourth quarter sample from MW-26SR. The concentrations detected were well below the MTCA Method B groundwater cleanup levels.

No herbicides were detected in any samples from MW-26SR during 2016.

VOC, SVOC, and herbicide data are summarized in Tables 6, 7, and 8.

Zone C/D Well

The groundwater monitoring network for Zones C and D consisted of well MW-55S in 2016. Well MW-55S was sampled for VOCs, and total and hexavalent chromium during all four quarters. Table 1 summarizes the analyses requested for the Zone C/D well.

TCE was detected only in the third quarter of 2016 and at a concentration below the dCUL. No other VOC concentrations were detected in samples from MW-55S any time during 2016.

Total chromium was detected in MW-55S during all four quarters of 2016 at concentrations below the dCUL. Hexavalent chromium was not detected in MW-55S in 2016.

VOC and chromium data are summarized in Tables 6 and 9, respectively.

Zone E Well

The groundwater monitoring network for Zone E consisted of well MW-27SR during 2016. Well MW-27SR was sampled for VOCs, and total and hexavalent chromium during all four quarters. Table 1 summarizes the analyses requested for the Zone E well.

No VOCs were detected during 2016 in samples from MW-27SR.

Total chromium was detected in the first three quarters of 2016, at concentrations below the dCUL. Hexavalent chromium was not detected in samples from MW-27SR in 2016.

VOC and total and hexavalent chromium data are summarized in Tables 6 and 9, respectively.

3.2.2.2.2 Sentinel Wells

Sentinel wells are located between a landfill or waste zone and the property boundary. The sentinel wells, in conjunction with the performance monitoring wells, provide a means of tracking changes in contaminant concentrations over the distance from each source area and over time. This information is used to estimate concentration attenuation with distance from each source area.

The sentinel well monitoring network consists of seven shallow wells (2R, MW-12S, MW-15S, MW-18S, MW-19S, MW-23S, and MW-49S) and three intermediate wells (2I, MW-12ID and MW-49I). Each of the intermediate depth wells is paired with an adjacent shallow zone well. Table 1 summarizes the analyses requested for each sentinel well.

All seven shallow wells were analyzed for VOCs on a quarterly basis. The three intermediate wells were analyzed for VOCs on a semi-annual basis in the second and fourth quarters. VOC concentrations detected in samples from the sentinel wells during 2016 were all below dCULs. VOC data are summarized in Table 6.

Wells MW-12S and MW-19S were sampled for total and hexavalent chromium during all four quarters. Total chromium concentrations in samples from both wells were below the dCUL in 2016. No hexavalent chromium was detected in samples from either well during 2016. Total and hexavalent chromium data are summarized in Table 9.

Wells 2R, MW-12S, and MW-49S were sampled for natural attenuation parameters on a semi-annual basis during the second and fourth quarters. Natural attenuation data are summarized in Table 10.

3.2.2.2.3 Property Boundary Wells

The property boundary groundwater monitoring network consists of five shallow wells (MW-10S, MW-11S, MW-22S, MW-24S, and MW-51S) and one intermediate depth well (MW-11I). Except for MW-22S, 24S, and 51S during the third quarter, samples from the five shallow wells were analyzed for VOCs on a quarterly basis and the sample from the intermediate depth well was analyzed for VOCs on a semi-annual basis in the second and fourth quarters. MW-22S, MW-24S and MW-51S were not sampled during the third quarter of 2016 since access to the wells was not granted by the property owner.

Samples from MW-22S, a MSW Landfill well, were analyzed for total and hexavalent chromium on a quarterly basis and for landfill parameters on a semi-annual basis during the second and fourth quarters. Table 1 summarizes the wells and analyses requested for the Property Boundary Wells.

No VOCs were detected in any property boundary monitoring wells in 2016 at a concentration exceeding a dCUL. Total chromium was detected at concentrations below the dCUL. Hexavalent chromium was not detected in samples from 2016.

VOC and total and hexavalent chromium data are summarized in Tables 6 and 9, respectively. Landfill parameter data are summarized in Table 11.

The monitoring data for well MW-22S will be discussed in the 2016 Annual Report for the MSW Landfill.

3.2.2.2.4 Downgradient Monitoring Wells

The off-property downgradient monitoring well network consists of 12 shallow wells (MW-29S, MW-31S, MW-34S, MW-37S, MW-38S, MW-40S, MW-41SR, MW-42S, MW-43S, MW-44S, MW-45S, and MW-46S) and four intermediate depth wells (MW-29I, MW-38I, MW-43I, and MW54I). All downgradient off-property wells were analyzed for VOCs during 2016. The shallow depth wells were sampled on a quarterly basis, except for MW-44S and MW-45S, which were sampled on a semi-annual basis. The intermediate depth wells, MW-43I and MW-54I were sampled on a quarterly basis, while MW-29I and MW-38I were sampled on a semi-annual basis. With the exception of MW-54I, the furthest downgradient well, each intermediate depth well is paired with an adjacent shallow depth well. Table 1 summarizes the wells and analyses requested for the off-property downgradient wells.

No VOCs were detected in any of the downgradient monitoring wells in 2016 at a concentration exceeding a dCUL. VOC data are summarized in Table 6.

3.2.2.2.5 Upgradient Wells

The upgradient monitoring well network consists of three shallow wells (NW-1, MW-20S, and MW-25SR). Table 1 summarizes the wells and analyses requested for the upgradient wells. Sampling of NW-1 is performed and reported as part of the New Waste landfill monitoring program. The data from samples from this well are discussed in the 2016 Annual Report for the MSW Landfill as prepared by the LFG.

No VOCs were detected in samples collected at any time during 2016 from the upgradient monitoring well MW-25SR. Total chromium was detected at concentrations below the dCUL in in both samples collected from MW-20S during 2016. Hexavalent chromium was not detected in MW-20S at any time in 2016.

VOC, chromium, natural attenuation and landfill parameter data are summarized in Tables 6, 9, 10 and 11, respectively.

3.2.2.2.6 Residential Wells

As outlined in the methodology section for residential wells, at the start of 2016, all residential wells in the GPA were scheduled for semi-annual VOC sampling and analysis. Groundwater samples were collected from nine residential wells in the second quarter and, due to access limitations, from seven wells in the fourth quarter. Table 1 summarizes residential well sampling and analysis.

VOCs detected in samples collected from the residential wells are summarized in Table 6. No VOCs were detected at a concentration exceeding a dCUL in any of the residential wells at any time during 2016.

Based on these data, all residential wells will remain on a semi-annual monitoring schedule at the start of 2017.

3.2.2.3 Contaminant Distribution

This section discusses the dissolved-phase distribution of the compounds for which dCULs have been established for the Site and for which observed concentrations exceeded a dCUL during 2016. Only PCE and TCE were detected at a concentration above a dCUL during 2016. The concentration of PCE exceeded the dCUL in only one sample collected from MW-52S and only during the first quarter of 2016. The concentration of TCE exceeded the dCUL only at MW-52S and only during the third and fourth quarters of 2016. No other COC concentrations exceeded a dCUL during 2016. Maps depicting concentrations for PCE during the first quarter and TCE during the third and fourth quarters, are presented in Figures 8 through 10.

3.2.2.4 Natural Attenuation and Landfill Parameters

Samples from wells 2R, MW-12S, MW-20S, MW-25SR, MW-47S, MW-49S, and MW-50S were analyzed for natural attenuation parameters during the second and fourth quarters of 2016. Table 1 summarizes the wells analyzed for natural attenuation monitoring. Natural attenuation parameter data are summarized in Table 10.

Due to the generally low concentrations and limited distribution of VOCs observed in groundwater at the Site, an evaluation of natural attenuation parameters provides insufficient information for a thorough evaluation of biochemical degradation processes occurring in groundwater beneath the Site. As such, no detailed evaluation or scoring of natural attenuation mechanisms has been performed for this report. As approved by Ecology in their December 29, 2016 email and subsequent discussions, natural attenuation parameter analysis will be suspended starting with the second quarter of 2017. Further discussion of changes in the groundwater monitoring program is presented in Section 3.3 below.

Samples from wells 4R, MW-16S, MW-17SR, MW-20S, MW-22S, and MW-25SR were analyzed for landfill parameters during the second and fourth quarters of 2016. Table 1 summarizes the wells and analyses for landfill parameter monitoring. Landfill parameter data are summarized in Table 11. Landfill parameter data will be discussed in the 2016 Annual Report for the MSW Landfill prepared by the LFG.

3.3 Revised Groundwater Monitoring Program

On June 24, 2016, the *Proposed Modifications to the Existing Interim Actions Ground Water Monitoring Program* was submitted to Ecology. In the light of decreasing groundwater concentrations throughout the Site, the document proposed several changes in the groundwater sampling and water level measurement program. Ecology responded via e-mail on December 29, 2016, with modifications to the proposal. The modifications were discussed in early 2017 and a revised sampling program began during the first quarter of 2017.

The changes include:

- VOC sampling in all property boundary and offsite wells, and at MW-17SR, MW-23S, and MW-26SR will be reduced to semi-annual (April & October).
- SVOC sampling will reduced to semi-annual at MW-26SR, but added to the semi-annual monitoring at MW -47S, MW-50S, and MW-25SR.
- Herbicide sampling will be reduced to semi-annual at MW-26SR, but added to the semi-annual monitoring at MW-25SR.
- Natural attenuation parameter sampling will be eliminated at all 7 wells.
- Landfill parameter sampling will be eliminated at MW-25SR but will be added at MW-23S, and MW-19S.
- Total and hexavalent chromium sampling will be eliminated at MW-12S and 13S, reduced to semi-annual at MW-19S, 22S, 27SR and 55S, and added at 4R, MW-16S, 47S, and 50S.

A revised Groundwater O&M Manual will be prepared and submitted to Ecology in 2017 to document the new program.

4 SVE SYSTEM PERFORMANCE MONITORING

4.1 SVE Operation

As part of Interim Actions at the Site, a soil vapor extraction (SVE) system has been in operation at Zone A of the IWA since May 1997. In March 2012, the system was upgraded and active extraction was switched over to six SVE wells (VEW-06S, VEW-06I, VEW-06D, VEW-07S, VEW-07I and VEW-07D) installed within the Zone A landfill. Until October 2015, effluent from the SVE system was conveyed through an underground pipeline to the MSW Landfill flare for treatment. In September 2015, a regenerative thermal oxidizer (RTO) was installed adjacent to the SVE skid as a replacement for the MSW Landfill flare. The RTO, from Gulf Coast Environmental Systems (GCE), was operational from October 2015 through mid-December 2016.

The GCE RTO was subject to the Ecology issued *Pasco Sanitary Landfill Approval Order No. 14AQ-E571* (Order 14AQ-E571), dated July 30, 2015. Both shallow and deep SVE wells ran continuously throughout 2016 except for short periods for required maintenance.

The GCE RTO did not operate as designed. Stack testing was conducted on January 13-15, 2016 by EPI and Montrose Environmental. Test results indicated that the measured GCE RTO mass emission rates for some parameters were above the permitted limits. On March 31 and April 1, 2016, with the approval of Ecology,

the IWAG conducted additional engineering testing to target performance issues. On April 4, Notice of Violation #13230 was issued to address the permit exceedances. On June 24, 2016, the IWAG issued the technical memorandum *Assessment of Pasco Sanitary Landfill RTO Performance*, which presented discussion of compliance testing and operational issues.

Efforts to resolve issues with the condensate injection system, emissions rates, destruction efficiency, and the damper valve were made through August 2016 when the IWAG and Ecology decided to replace the RTO with a new unit. As a new RTO could not be manufactured and installed prior to April 2017, the IWAG and Ecology's Air Quality Program determined that a rental unit would be needed in the interim. A rental thermal oxidizer (TO) from Anguil Environmental Systems, Inc. (Anguil) was installed in December 2016.

Anguil was on-site to supervise and direct commissioning of the TO, provide operator training, and to define and input initial system parameters. HiLine Engineering of Pasco, Washington provided additional technical assistance during tie-in to the electrical system, and interlock programming of the existing SVE system Programmable Logic Controller (PLC). SMK Tri-Cities provided mechanical support for installation of the process air piping to the TO unit. After assembly, the TO underwent a period of initial startup and basic functionality testing before being brought on line on December 13, 2016.

Operation of the TO system during 2016 was in accordance with Administrative Order Docket # 13922, dated November 29, 2016, which detailed operational parameters

A new Anguil RTO is in the design process and is scheduled to be installed in June 2017 with performance testing to follow. A revised operations and maintenance manual for the combined SVE and RTO system will be prepared after the final configuration and operation of the Anguil RTO has been established.

Shallow and deep SVE wells ran continuously throughout 2016, with the flow from all four wells totaling between 191 and 503 scfm.

4.2 SVE Monitoring and Vapor Treatment

Monitoring of the SVE system was performed using active and inactive vapor extraction wells (VEWs), vapor monitoring wells VMW-50S, VMW-51I, and VMW-51D, and vacuum monitoring points. Figure 11 illustrates the locations of these features.

Operation, monitoring and upgrades of the SVE system during 2016 were conducted in accordance with the following Ecology approved documents:

- *Proposed Flowrates for Upgraded Zone A SVE System and Communications Protocol*, dated December 4, 2012.
- *As-Built and Testing Reports with Operations and Maintenance Manual* (SVE System O&M Manual), dated February 25, 2013.
- *Addendum No. 1 – Volume 1 – As-Built Report for SVE System Upgrades*, dated February 20, 2014.
- *Engineering Design Report for SVE System with Regenerative Thermal Oxidation Upgrade*, dated May 27, 2015.
- *Addendum No. 2 – Volume 1 – As-Built Report for SVE System Upgrades, dated May 8, 2015.*

- Ecology issued *Pasco Sanitary Landfill Approval Order No. 14AQ-E571* (Order 14AQ-E571), dated July 30, 2015
- *Performance Testing Plan – Pasco Sanitary Landfill*, prepared by Landau Associates, Inc., dated October 9, 2015.
- *Addendum No. 1 – Volume 3 – As-Built Report for SVE System Upgrades As-Built and Testing Reports with Operations and Maintenance Manual Attachment A – Sampling and Analysis Plan, dated July 29, 2016.*
- *Administrative Order Docket # 13922*, dated November 29, 2016, and issued by Washington State Department of Ecology, Air Quality Program.

Numerous meetings and communications between the IWAG and Ecology also guided operation, monitoring and upgrades to the systems.

During 2016, routine SVE performance monitoring included both field observation and measurement, and laboratory analysis of the SVE system and effluent air stream.

SVE system operational parameters were measured and recorded on a weekly basis at the wellheads and at the SVE equipment compound. Parameters recorded included wellhead and skid vacuum and airflow, dilution airflow, wellhead temperature, carbon dioxide (CO_2), oxygen (O_2), total VOCs, and lower explosive limit (LEL). Field measurements were conducted using a photoionization detector (PID) to monitor total VOCs, and a GEM 2000 Landfill Gas Analyzer to monitor carbon dioxide, oxygen, and LEL. SVE parameter data are presented in Table 12.

Operational parameters presented were recorded at each of the extraction wells (VEW-06S/I/D and VEW-07S/I/D), VMW-51I, and VMW-50S. Flowrates and applied vacuum measurements from individual SVE system wells are presented in Figures 12 and 13 respectively. Active extraction of soil vapor from beneath Zone A during the period of September 2015 through mid-May 2016 was performed with airflows of approximately 73 to 165 scfm in the four shallow and deep wells. On approximately May 17, 2016 airflow within the deep extraction wells was increased to approximately 200 scfm and airflow within the shallow wells was decreased to approximately 30 scfm.

Vacuum monitoring was performed on a weekly basis during 2016 in order to confirm a negative pressure beneath the geomembrane and to assess radius of influence of the SVE system. In addition to the vacuum measurements included in Table 12, vacuum measurements were collected at the inactive SVE extraction wells VEW-04 and VEW-05, at vacuum monitoring wells VMW-50S, VMW-51I, VMW-51D, and at vacuum monitoring probes VMP-02, VMP-04, VMP-05, VMP-06, VMP-08, VMP-09, VMP-10, VMP-13S, VMP-13D, VMP-17, VMP-18, VMP-19, VMP-20, and VMP-21. Vacuum measurement data are presented in Table 13.

As mentioned above and illustrated in Figure 12, airflow in the deep extraction wells during the period of May through December 2016, was increased nearly 100 scfm and airflow in the shallow extraction wells was decreased by 50 to 100 scfm. In response to the adjustment in extraction well airflow, vacuum measured in other deep wells around Zone A increased (VEW-04, VEW-05, VMW-50S, and VEW-51D), the vacuum in VMW-51i and the shallow vacuum monitoring points beneath the Zone A cover (VMP-02, 04, 05, 06, 08, 09, and 10) decreased, and vacuum outside of the protective barrier wall (VMP-13S, 13D, 17, 18, 19, 20, and 21) remained stable. Average vacuum measurements for each location, before and after May 2016, and for the entire year

are shown on Table 13 These data illustrate that changes in vacuum and airflow at the shallow and deep SVE wells: affect all wells and probes set in the shallow, intermediate, and deep intervals beneath the Zone A cover system. Meanwhile, such changes do not affect vapor monitoring probes screened at the shallow interval outside the protective barrier wall.

The radius of influence of the SVE system encompasses all shallow, intermediate and deep intervals beneath the Zone A cover, and deep extraction wells beyond the cover, providing an effective means of contaminant source removal for the Zone A landfill.

The protective barrier wall installed in 2015 along the northern and northeastern boundaries of the Zone A landfill effectively limited air flow airflow between the SVE system and the Balefill Area during 2016. This is evidenced by vacuum measurements in shallow probes in the Balefill Area outside of the protective barrier wall being un-influenced by significant changes in SVE system airflow during 2016.

Vapor samples were collected at each active extraction well (VEW-06S & D, and VEW-07S & D) on a monthly basis through May 23 and on a weekly schedule thereafter. The change to weekly frequency was in response to the changes in airflow and to assist in evaluating performance of the GCE RTO. Additional vapor samples were collected from the combined SVE effluent line before thermal treatment at the RTO/TO (SV-BRTO). Samples were submitted for laboratory analysis of VOCs using a modified EPA Method 8260. SVE system laboratory data are presented in Table 14.

. The percentage of the top ten compounds contained in each sample of the SVE effluent collected during 2016 are summarized in Table 15. The ten compounds constitute 92.8 to 99.3 percent of the total VOCs detected in each sample.

A contaminant mass removal rate is calculated for each sample using the total VOC concentration and the measured flow rate. Figure 12 illustrates the average daily contaminant mass removal rates from the active SVE wells and for the combined SVE system effluent line from March 14, 2012 through the end of December 2016. Gaps in the graphed data series represent periods when wells were not operated.

Between January 11, 2016 and December 26, 2016, the sum of contaminant mass removal rates ranged from a low of 54 pounds/day (lb/day) on November 15, 2016 to the high of 142 lb/day on February 9, 2016. The SVE system recovered an estimated 49,066 pounds of VOCs during 2016, with an average combined SVE mass removal rate of 135 lb/day or 5.63 lb/hr.

Other calculations performed and discussed with Ecology during 2016 related to VOC emissions from the SVE and RTO systems indicate that the mass removal rate may have been 30 to 50% higher or approximately 189 to 203 lb/day. Analysis for Tentatively Identified Compounds (TICs), which was performed as part of RTO stack testing in April 2016, indicated that the extracted VOC mass could be higher than that calculated with 8260 target compounds. The April 2016 analysis indicated that the mass from TICs could be 40% of the total VOCs detected from 8260 analysis. Additional analysis for TICS is planned for 2017 and the potential additional extracted mass associated with TICs can be better identified with the additional planned data.

The SVE system has recovered a total of approximately 1,036,183 pounds of VOCs between May 1997 and December 26, 2016. The cumulative mass removal is illustrated in Figure 13. The dark blue circles on the figure represent the dates when significant changes were made to the active vapor extraction well configuration.

The ability of the SVE system to recover contaminant mass was limited throughout much of 2016 due to recurring operational issues with the GCE RTO. Even though the SVE system recovered approximately 49,000 pounds of total VOCs in 2016, that mass recovery is less than what SVE is capable of if the intermediate wells were active. The SVE system, as currently operated, is limited in its ability to remove VOCs from Zone A by a number of factors including temperature and gas-related limitations that would have been in place but for the RTO issue. With the installation and full operation of a new Anguil RTO in the Spring of 2017 and the design capability to treat higher mass loadings, maximizing the effectiveness of the SVE system will be a key objective of the IWAG's operation of the combined SVE/RTO system in 2017 and beyond. Maximizing SVE mass removal provides a demonstrated means for protection of groundwater quality.

4.3 Carbon Monoxide Monitoring

In response to a request from Ecology, routine carbon monoxide monitoring of Zone A wells began on July 25 2016. Carbon monoxide (CO) monitoring activities were performed in accordance with the following document:

- *Addendum No. 1 to Volume 3 – As-Built Report for SVE System Upgrades – Attachment A – Sampling and Analysis Plan,* dated July 29, 2016

The wells monitored included all six vapor extraction wells (VEW-06S/I/D and VEW-07S/I/D) and vapor monitoring well VMW-51I. Field measurements were made using a QRae3 and Tedlar bag samples were collected for laboratory analysis by modified EPA Method 25C. Field measurements are collected from each well.

Table 16 contains carbon monoxide monitoring data.

4.4 SVE System Repair Reporting

SVE system shutdowns occur both as planned events for routine system maintenance, system upgrades, and as unplanned shutdowns.

Intermittent shutdowns of the SVE system occurred during 2016. Details of each shutdown that occurred between January 1, 2016 and September 30, 2016 were included in the first, second, and third quarter reports. Shutdowns that occurred during the fourth quarter of 2016 are summarized in Table 17.

Work performed for installation of the Anguil RTO and integration of the RTO with the SVE system will be documented in the as-built and revised operations and maintenance reports for the revised system.

4.5 Groundwater Quality Trends

VOC data presented in quarterly and annual reports, including Phase I AIA studies reported in the 2008 and 2009 Annual Reports, illustrate that extraction of soil vapor and groundwater quality associated with Zone A appear to be closely linked, and contaminant transport through the vadose zone to the water table is likely the primary mechanism for contaminant migration from the Zone A wastes to groundwater.

As noted in Section 3 above, the only well that contained any VOCs at a concentration exceeding a dCUL in 2016 was MW-52S, which is located within Zone A. No other wells throughout the Site, including sentinel

wells immediately downgradient of Zone A, contained a dCUL exceedance of any VOCs at any time during 2016 (Table 6.)

Groundwater quality continues to comply with the dCULs both at the property boundary and at all locations downgradient of the property boundary. These data continue to indicate the effectiveness of the SVE system for groundwater protection.

Table 18 presents groundwater quality trend data for the Zone A source wells (MW-52S and 53S) since their installation in October 2010, and for the Zone A sentinel wells (MW-47S, 50S, NVM-01, and MW-12S) since January 2010. Groundwater trends since 2010 show that groundwater concentrations in MW-52S have continued to decrease since the recent peak in early 2015. While there were nine compounds exceeding a dCUL in April 2015, and five compounds exceeding a dCUL in October 2015, there were only two compounds exceeding a dCUL in all of 2016, and no exceedances in April 2016.

Groundwater quality at the Site has improved markedly over the last several years to the point at which only one well, the Zone A source monitoring well MW-52S, contained COCs at concentrations exceeding dCULs in 2016. The stability of groundwater quality throughout 2016 and the continued improvements in groundwater quality in MW-52S, supports a conclusion that SVE is an appropriate remedy for Zone A and is effective for protection of groundwater quality associated with releases from Zone A.

Due to the low concentrations and limited number of detected compounds in other wells at the Site, it is not practical to provide meaningful analysis of trends.

5 WASTE MANAGEMENT

Table 19 summarizes waste volumes disposed of or treated off-Site during 2016. Attachment B contains analytical data used for characterization and hazardous waste manifests and other documentation for materials transported off-Site during 2016.

5.1 Balefill Area Extinguishment Waste Management

Wastes generated during December 2015 from the Balefill area post-extinguishment monitoring network installation were transported off-site in 2016. These activities were conducted in accordance with the following Ecology approved documents:

- Final Technical Execution Plan for the Balefill Area Extinguishment and Supplemental Protection Barrier Project, dated August 6, 2015.

Seven drums of decontamination water from drilling and installation of monitoring locations was transported off site on February 3, 2016 for treatment at the Burlington Environmental, LLC Kent, Washington Facility. On March 10, 2016, fourteen drums of soil cuttings from the same activity were transported off-site as hazardous waste, carrying a D008 waste code for lead, to the US Ecology of Idaho, facility in Grand View, Idaho. Also on March 10, 2016, forty-six drums of non-hazardous soil cuttings were transported off-site for disposal at the CleanHarbors Grassy Mountain facility in Grantsville, Utah.

Table 19 summarizes volumes of soil cuttings and decontamination waste treated or disposed of off-Site during 2016. Attachment B contains analytical data used for characterization of soil and wastewater treated or disposed of off-Site during 2016.

5.2 SVE System Waste Storage, Characterization, and Management

During 2016, SVE system condensate was generated within the SVE system equipment compound and was stored in polyethylene tanks prior to treatment off-Site. Sampling and characterization of condensate is performed annually and as necessary to confirm the composition of the condensate and its consistency with the previously established waste profile. Condensate may also be sampled if there is a substantial change in SVE system operation or a change in the rate of condensate accumulation. Condensate sampling was performed during the first, second, and third quarters of 2016.

A total of 11,140 gallons of SVE condensate were generated in 2016. All SVE condensate generated at the Site during 2016 was designated as hazardous waste and transported to Burlington Environmental, LLC in Kent, Washington for treatment and disposal. The condensate was manifested as Dangerous Waste carrying waste codes for methyl ethyl ketone (D035) and TCE (D040).

Table 19 summarizes volumes of SVE system condensate treated off-Site during 2016. Attachment B contains analytical data used for characterization of condensate treated off-Site during 2016.

5.3 Granular Activated Carbon (GAC) Waste Management

On September 9, 2015, 10,000 pounds of vapor-phase activated carbon that remained on-site and had been used as the historical backup for SVE effluent treatment in the event of an extended MSW flare shutdown was sampled for characterization. In addition, four 2,000-lb vessels of activated carbon previously used for the treatment of NoVOCs^{TM} off-gas were sampled for characterization. The carbon was analyzed by Evoqua Water Technologies using the Zero Headspace Toxicity Characteristic Leaching Procedure (TCLP) analysis Method 1311 with the resulting extract analyzed for VOCs using EPA Method 8260B. The results were used to profile the carbon for reactivation and shipment off-site. On June 22, 2016, sixteen super-sack bags of spent carbon were sent off-site as non-hazardous waste to the Evoqua Reactivation Facility in Parker, Arizona.

5.4 Groundwater Monitoring Waste Storage, Characterization, and Management

Purge and decontamination water generated during routine sampling was stored, sampled and characterized prior to off-Site treatment. Polyethylene tanks were used for storage of purge water and decontamination water from routine monitoring. Water in each tank was sampled and characterized before off-Site treatment.

During 2016, 840 gallons of water from well purging was disposed of off-Site. This water was characterized as non-hazardous and transported to the City of Pasco Waste Water Treatment Plant for treatment.

Table 19 summarizes volumes of purge water and decontamination waste treated off-Site during 2016. Attachment B contains analytical data used for characterization of groundwater monitoring wastewater treated off-Site during 2016.

6 LANDFILL CAP PERFORMANCE MONITORING

Monitoring of the Zone A, C/D, and E landfill caps during 2016 was conducted in accordance with the following Ecology approved documents:

- *Operations and Maintenance Manual for Industrial Waste Area Caps – Zones A, C/D, and E – Pasco Landfill Site Pasco, Washington*, dated November 21, 2013.

- *Final Technical Execution Plan for the Balefill Area Extinguishment and Supplemental Protection Barrier Project* (TEP), dated August 6, 2015.

- Correspondence from Ecology on July 28, 2016 requesting quarterly reporting of bi-weekly or monthly vacuum and airflow measurements for the Zone A cover relief vents.

Monthly visual inspections are performed to monitor the condition of the Zone A, C/D, and E landfill covers, detention and evaporation basins, and perimeter fencing. Each monthly inspection is recorded on an inspection checklist. Monthly inspection checklists for Zones A, C/D, and E for the fourth quarter of 2016 are available in Attachment C.

Cover inspections include assessment of man-made, animal-made and other disturbances including vehicle traffic, burrowing, erosion, vegetation and settlement. The Zone A cover inspection also involves inspection of sumps and SVE piping. Sumps were installed in the areas of greatest settlement to inspect for potential surface water accumulation. SVE piping on the Zone A cover is monitored for settlement or other changes that may affect the flow of air or condensate within the pipes. Disturbances under evaluation or requiring repairs are noted on the checklist.

Detention and evaporation basins on each landfill cover are checked for disturbances including damage to the liner, staff gauge, or anchor trench along with levels of accumulated water, sediment or vegetation. Perimeter fencing for each landfill is inspected for disturbances such as damage from vehicles, burrowing under the fence line, vegetation accumulation, and fence posts leaning.

6.1 Zone A Landfill

The Zone A Landfill Cover, Detention/Evaporation Basin, and Fence Inspection Checklists for the fourth quarter of 2016 are presented in Attachment C. Settlement on the surface of the Zone A cover during 2016 is addressed below.

6.2 Zone A Settlement

Enhanced monitoring of differential settlement of the Zone A cap has been ongoing since May 2008.

Monitoring has included the installation and periodic surveying of settlement monitoring plates in 2008 and 2010. On December 15, 2011, a three-dimensional point cloud survey using a Light Distancing and Ranging (LIDAR) scanning method was performed on the Zone A cap.

In January 2013, an aerial survey of the Site was flown for the purpose of establishing a topographic survey for the entire Site.

New areas of differential settlement and associated cracks in the surface of the uppermost soil cover on the Zone A cap were noted during the first quarter of 2013. Starting in April 2013, LIDAR surveys have been performed on a quarterly basis to evaluate the progression of settlement first observed in early 2013. These areas of settlement and surface cracks were inspected by SCS Engineers and settlement related survey data were evaluated against yield point and break point values for the Zone A cover materials. The results of that evaluation are summarized in the *Technical Memorandum – Cover Settlement Evaluation Update – Zone A Drum Disposal Area – Pasco Sanitary Landfill Site*, dated September 13, 2013.

Since April 2013, settlement of the Zone A cap has been monitored quarterly using LIDAR surveys. Subsequent surveys were evaluated relative to the baseline LIDAR survey of December 2011, to evaluate total settlement and relative to the prior quarterly survey to assess incremental settlement. During December 2015, a new baseline scan was performed to capture changes on the Zone A cover following the construction activities and installation of the protective barrier wall. LIDAR surveys of the Zone A cover were performed in March, July and October of 2016. No January 2016 survey was made since the new baseline scan had been performed in the prior month.

In March 2016, SCS prepared an updated evaluation of the Zone A cover strain: *Technical Memorandum – Cover Settlement Evaluation Update – Zone A Drum Disposal Area – Pasco Sanitary Landfill Site*, dated March 7, 2016. The report presented an evaluation of cover system settlement and an assessment of strain on the Zone A high-density polyethylene (HDPE) geomembrane.

The first and third quarterly reports for 2016 contain differential surface maps from those quarters. Attachment D for this report contains differential surface maps for the fourth quarter of 2016, showing elevation changes between the October 2016 and previous surveys performed in July 2016, December 2015, and December 2011.

Each differential surface map shows the surface of Zone A color-coded to indicate areas of positive or negative changes in elevation between the dates of comparison. Portions of the map colored blue indicate areas of increasing elevation. Areas of increasing elevation include portions of the landfill where additional soil cover or gravel was added or vegetative growth occurred. Portions of the map that are colored green, yellow or red indicate areas of settlement.

Attachment E contains the *Technical Memorandum – Updated Cover Settlement Evaluation – Industrial Waste Area – Zone A – Pasco Sanitary Landfill Site*, dated March 2017, which was prepared for the IWAG by SCS Engineers. The memorandum provides an updated evaluation of settlement on the Zone A cover system.

The IWAG will continue to perform quarterly subsidence monitoring of the Zone A cap and evaluate settlement rates and total strain on the Zone A cover system.

6.3 Zone A Cover Vent Monitoring

Measurement of vacuum and pressure in the four Zone A cover vents began on July 27, 2016 in response to an email request from Ecology earlier that same day. The Zone A cover vents were installed through the Zone A cover along the inner side the Zone A protective barrier wall in 2015. One way valves in each vent allow ambient air to flow beneath the Zone A cover. The vent locations are illustrated on Figure 11. Table 20 contains vacuum and airflow measurements for the vents.

6.4 Zone A Fencing

The northeastern portion of the Zone A perimeter fencing was removed during 2015 as needed to perform Balefill extinguishment and barrier wall construction activities. A locked gate along Dietrich Road limits access to Zone A by the public. The fencing along Dietrich Road and along the boundary with the BDI transfer station to the south is in good condition. Installation of additional Zone A fencing will be performed in 2017.

6.5 Zones C/D and E Landfills

The Zone C/D and Zone E Landfill Cover, Detention/Evaporation Basin, and Fence Inspection Checklists for 2016 are presented in Attachment C. No conditions requiring maintenance or repair were observed on the Zone C/D or E caps, basins, or fencing in 2016.

7 INSTITUTIONAL CONTROLS

Institutional controls for the Site are presented in:

- *Pasco Landfill Site Updated Institutional Controls Plan – Revision 1*, dated October 7, 2013.

Institutional controls at the Site include Zone A, B, C/D, and E perimeter fencing and informational signage posted around the Site. As discussed above, perimeter fencing is inspected on a monthly basis. Informational signage is monitored during the monthly inspections as well as during operations and maintenance activities.

Other institutional controls at the Site include City of Pasco Ordinance No. 3469 and Municipal Code Section 16.06.040 and Franklin County Ordinance No. 2-99 and Code Chapter 17.56 both prohibiting installation of new drinking water wells within the Groundwater Protection Area (GPA). As part of the control measures, the City of Pasco and Franklin County monitor and control building and development permits within the GPA.

On November 18, 2016, representatives of the City of Pasco, Benton/Franklin County Health Department and PBS as a representative of the IWAG, performed the annual survey of the GPA including inspection of each known residential well. This annual well survey is a component of the institutional controls. The Franklin County *Annual Institutional Controls Report for 2016* and the City of Pasco *2016 – East Pasco Plume Area – Well Location Survey* are included in Attachment F.

8 SUMMARY

The following summarizes the primary findings and conclusions from the groundwater monitoring and the interim action operations and maintenance in 2016:

- Groundwater quality at the downgradient property boundary, and locations downgradient of the property boundary, continued to comply with the dCULs throughout 2016. No samples from property boundary wells or downgradient wells contained a COC at a concentration exceeding a dCUL at any time in 2016.
- The only location at the Site where groundwater quality exceeded a dCUL is well MW-52S, which is a source zone well installed inside of Zone A immediately below Zone A wastes. Groundwater quality at well MW-52S indicated continued improvement in comparison to 2015. Samples from

the other Zone A source well, MW-53S, did not contain COCs at a concentration exceeding a dCUL at any time in 2016.

- The current monitoring network is adequate to assess and evaluate ongoing groundwater quality at the Site.
- Current groundwater quality continues to indicate that the SVE system is a highly effective remedial technology and highly protective of groundwater quality for contamination associated with Zone A and the covers at Zones B, C/D, and E have been effective in protecting groundwater quality in these areas.
- The SVE system was operated below its maximum capacity in 2016 due to recurring performance issues with the GCE RTO. The approximately 49,000 pounds of total VOCs removed in 2016 is less than the mass removed in prior years, due to the lack of operation of the intermediate depth SVE wells during 2016 and the otherwise lower flowrates from the shallow and deep SVE wells due to operational limitations of the RTO and temperature and LEL related limitations. It is expected that the SVE system mass removal rate will increase in 2017 with the potential operation of the intermediate depth wells and the installation of a replacement RTO unit from Anguil Environmental.
- The radius of influence of the SVE system encompasses all shallow, intermediate and deep intervals beneath the Zone A cover, and deep extraction wells beyond the cover, providing an effective means of contaminant source removal for the Zone A landfill.
- The protective barrier wall installed in 2015 along the northern and northeastern boundaries of the Zone A landfill effectively limited air flow airflow between the SVE system and the Balefill Area during 2016. This is evidenced by vacuum measurements in shallow probes in the Balefill Area outside of the protective barrier wall being un-influenced by significant changes in SVE system airflow during 2016.
- Settlement of the Zone A cover continued during 2016 at significantly lower rates than in prior years. The total strain on the HDPE and GCL is less than the allowable strain of 10 percent. Differential settlement does not currently pose any threat to the Zone A cover system.

The following Ecology approved changes in operation and maintenance are expected at the Site during 2017:

- The groundwater monitoring program at the Site will be modified starting in the first quarter of 2017 and a revised groundwater O&M Manual will be prepared for submittal to Ecology.
- Installation and refinement of operation of an Anguil Environmental RTO will occur in mid-2017. Performance stack testing will be performed and a new O&M Manual will be prepared outlining operations and maintenance of the SVE and RTO systems.