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Second Quarter 2014 Progress Report for the Former Defense Supply Center Philadelphia Facility Philadelphia, PA

July 31, 2014

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LNAPL recovery operations for the Former DSCP facility and the Former Passyunk Homes area.

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1. Executive Summary

This Second Quarter of 2014 Progress Report (Progress Report) for the Former Defense Supply Center Philadelphia (DSCP) Site presents an update regarding remediation system operations and maintenance (O&M) data, remediation system optimization testing data, Site-wide liquid level and groundwater elevation gauging data, and a description of potential activities to be conducted in the Third Quarter of 2014. The activities described herein were conducted as required by the Administrative Order (Order), dated December 10, 1999 between the Commonwealth of Pennsylvania, Department of Environmental Protection (PADEP) and the Department of the Army and DSCP (collectively the Defense Logistics Agency, or "DLA") by ARCADIS U.S., Inc. (ARCADIS).

The Order requires that remediation be conducted as needed to remove as much petroleum Light Non-Aqueous Phase Liquid (LNAPL) as is practicable from beneath the Former DSCP property, including Quartermaster Plaza, and the following contiguous properties: the CSX railroad right of way, the Steen property, and the Former Passyunk Homes property (currently the Philadelphia Housing Authority [PHA] property and the Siena Place property). Collectively, these properties are defined in the Order as the "Affected Area", and the Affected Area is the "Site" as defined under the Pennsylvania Land Recycling and Environmental Remediation Standards Act (Land Recycling Act or Act 2).

During the Second Quarter of 2014, vapor phase petroleum hydrocarbon mass and LNAPL recovery continued via vacuum enhanced skimming (VES). O&M data were used to optimize VES system performance, specifically to enhance the rate of vapor and liquid phase petroleum hydrocarbon recovery. To track the removal of petroleum hydrocarbon mass via the VES system, analytical results from influent summa canister EPA Toxic Organic Chemical method TO-15 samples were evaluated.

Additional activities designed to enhance the conceptual Site model (CSM) and/or to evaluate the operation and performance of the Site's remediation systems were also conducted. These included a liquid level gauging event and a groundwater sampling event.

As discussed in previous reports, LNAPL recovery at the Former DSCP Site was initially very robust, and had been following a decreasing trend from 1999 to 2005 as groundwater elevations began to rise in the vicinity of the Site and the availability of easily recoverable LNAPL decreased. The 2005 addition of a VES system, which combined petroleum hydrocarbon vapor recovery with LNAPL recovery, temporarily halted this trend. By the end of 2006, the rate of LNAPL recovery again began to define a generally decreasing trend which continued until the Fourth Quarter 2011, when optimization efforts began (for a complete history, see Appendix F). As a result of the remediation system optimization efforts, the mass of petroleum hydrocarbons recovered as vapor since the Fourth Quarter of 2011 is now more than five times greater than the amount recovered since the start-up of the VES system in 2005 (e.g., 55,805 gallons from the Fourth Quarter 2011 to date versus 10,038 gallons from 2005 through the Third Quarter 2011). During the Second Quarter of 2014, 328 gallons of LNAPL were recovered by the fixed-skimming system and an additional 2,763 gallons of LNAPL (as vapor) was recovered by the VES system, for a total recovery of 3,091 gallons for the quarter. The new cumulative recovery of LNAPL as of March 31, 2014 is now 1,026,413 gallons.

The isotopic analysis of carbon dioxide (CO_2) collected from the VES system's influent vapor during the Second Quarter of 2014 demonstrates that approximately 81% of the CO_2 in site soil gas may be directly attributed to VES system-driven biodegradation. If the results of these isotopic samples of CO_2 from the VES system influent in the Second Quarter 2014 were applied to the entire quarter, the CO_2 concentration extrapolates to approximately 80,125 pounds (lbs) of organic compounds degraded in-situ on a quarterly basis. This yields another 13,516 gallons of LNAPL remediated in the Second Quarter of 2014 by in-situ biodegradation.

This Progress Report documents the state of the Site remediation optimization and Act 2 path-to-closure work conducted during the Second Quarter of 2014. The Order-required LNAPL remediation work described herein was implemented with the goal of improving the rate of LNAPL remediation via existing Site remediation equipment. This goal is being achieved despite naturally occurring constraints such as elevated groundwater levels and the resulting submerged LNAPL present in the water table aquifer beneath the Site.

Limited available Site characterization and remediation data from the adjacent former Sun Oil Company (Sunoco) refinery have been reviewed, but additional data needs remain, specifically on the current nature of remediation activities, groundwater flow, and petroleum hydrocarbon contaminant transport within the aquifer systems beneath the refinery. It is believed that the synchronization of aquifer sampling and monitoring activities, and the sharing and evaluation of data will be essential to the establishment of Site aquifer- specific cleanup goals under the Act 2 program. These include a Site Specific Standard (SSS) pathway elimination approach for LNAPL, and specific petroleum hydrocarbon Short List Constituents of Concern (COC) in the shallow aquifer zone. Regarding the deep aquifer, pursuit of a background standard approach as defined under Act 2 or attainment of a Site-specific Non-Use Aquifer Determination (NUAD) are potentially viable options. Data reported in this and prior reports since October 2011 continue to support pursuit of these potential Act 2 endpoints.

In addition to the summary of Second Quarter of 2014 activities completed, this report also presents activities tentatively planned for the Third Quarter of Calendar Year (CY) 2014. These activities will support continued refinement of the DLA's remediation strategy under the Order and provide a foundation for continued voluntary Site path-to-closure activities under Act 2.

2. Introduction

The Former DSCP property was closed under the 1993 Base Realignment and Closure (BRAC) program. In 2001, the US Army transferred the air and surface rights to the Philadelphia Authority for Industrial Development (PAID) for commercial development. A shopping center, known as Quartermaster Plaza, was constructed in 2004 on the northwestern portion of the Former DSCP property. It currently contains approximately 18 retail stores and 4 restaurants.

Between 2002 and 2008, residences at the former Passyunk Homes complex were razed, and a new Philadelphia Housing Authority (PHA) office and maintenance building was constructed in the southern portion of the Site (south of Interstate 76 [I-76], the Schuylkill Expressway) and on the northern portion of the Former Passyunk Homes property. The Former Passyunk Homes property was purchased by Penrose Park Associates and is being redeveloped for residential housing. This growing housing development and neighborhood is called Siena Place. The former Sunoco refinery boundary is located approximately 100 feet from the western edge of the Site, across a section of I-76 and west of the CSX Railroad, (as shown on Figures 1 through 3). The refinery is now jointly owned and operated by the Carlyle Group and Energy Transfer Partners L.P.

Petroleum hydrocarbon constituents and LNAPL are present in the shallow (i.e., water table) aquifer at the Site. The area impacted by LNAPL has been investigated by teams from the former Sunoco refinery, the Former DSCP, and the Defense Energy Support Center (DESC). Remediation began in 1996 using skimmer pumps installed to remove the petroleum LNAPL from the shallow aquifer, and a full-scale VES System has been in operation since 2005.

This Quarterly Progress Report is submitted in accordance with the terms in the Order dated December 10, 1999 and summarizes Site remedial progress and environmental monitoring results from the Second Quarter (April, May, and June) of 2014. Included in this Progress Report are:

- Monthly photo-ionization detector (PID), smoke tube, and lower explosive limit (LEL) meter monitoring data for two sanitary sewer manholes on the Packer Avenue Sewer (MH-C and MH-G, as shown in Figures 1-3), and three additional sanitary sewer locations selected by the DLA and the United States Army Corps of Engineers (USACE) (19^{th} and Moyamensing East, 19^{th} and Moyamensing West, Pollock and Moyamensing, and 19^{th} Street [near the cut through]);

- Site-wide groundwater elevation and LNAPL thickness gauging data from a liquid level measurement event beginning on May 12, 2014;

- Analytical data from a groundwater sampling event conducted May 13-23, 2014;

- Final version of data logs from direct-push investigations completed in February 2014;

- Remediation O&M data from the Site's fixed and modular LNAPL skimming units and VES System; and

- Data from Site remediation system optimization testing activities conducted during the quarter.

3. Vapor Measurements from the Packer Avenue Sewer

Two Packer Avenue sewer manholes (MH-C and MH-G), as seen in Figures 1 through 3, were monitored monthly with a PID, smoke tubes, and LEL meter. As previously reported, the intent of the monitoring was to evaluate the vacuum effect on the Packer Avenue sewer system imparted by the Sewer Vapor Extraction system located on the former Sunoco refinery. The Sewer Vapor Extraction System is managed and maintained by the operators of the former Sunoco refinery. The purpose of the Sewer Vapor Extraction system is to prevent a buildup of gasses (e.g., methane [CH_4] and petroleum hydrocarbon vapors) in the sewer system. The purpose of the reporting of readings in this report is to provide feedback on the operation of the system. A direct line of communication with the new ownership has not yet been established, but is recommended. Vapor measurements were collected on April 15, 2014, May 30, 2014, and June 16, 2014, and are shown in Table 1.

Smoke tubes were used to determine if air was moving into or out of the sewer manhole covers at the time of the monitoring event. The results of smoke tube testing indicated that air was flowing into manholes MH-C and MH-G during all testing events. Airflow was into the 19th and Moyamensing East and West manholes during the April and June testing events, and out during the May testing event. Following smoke tube testing, a PID equipped with a 10.6 electron-volt (eV) lamp, and a MSA Passport LEL/Oxygen (O_2) meter were used to monitor and gather measurements from ports in the two sewer manhole covers. PID readings ranged from 0.0 parts per million (ppm) to 7.6 ppm. LEL readings ranged from 0% to 12%. No readings above 100 ppm were recorded. Readings above 100 ppm are reported to the PADEP, former Sunoco refinery, the DLA, and the USACE Baltimore and Philadelphia District offices.

At the request of the USACE, readings were also collected at the following sanitary sewer manholes, each of which measured 0.0% LEL and ranged from 0 ppm to 0.3 ppm (via PID measurement): 19th and Moyamensing East, 19th and Moyamensing West, Pollock and Moyamensing, and 19th Street (near the cut through).

At the Pollock and Moyamensing location, airflow indications were not available because of the absence of manhole openings.

These observations are in line with previously reported sanitary sewer readings since October 2011.

4. Liquid Level Gauging and Groundwater Sampling

Site-wide liquid level gauging and groundwater sampling events were conducted during the Second Quarter of 2014. Like previous gauging events, and as required by the Order, all accessible wells within the Site's monitoring and recovery well network were included. The six comprehensive groundwater sampling events conducted during 2012, 2013, and the First and Second Quarters of 2014 included the entire Site monitoring and recovery well network, except for those wells not accessible at the times of the events.

Data from the most recent comprehensive event (Second Quarter 2014), along with that from previous sampling events, has provided the clearest view to date of the distribution of dissolved-phase petroleum hydrocarbon impacts in the shallow/intermediate and deep aquifer systems beneath the Site. Additionally, this information has been added to the Site's database, which includes laboratory analytical results from five partial groundwater sampling events conducted from 2010 to 2011. These events included only about one third (approximately 40 wells) of the Site's monitoring well network. The intent of continued data collection and integration with past groundwater gauging and sampling event data is ultimately to provide remediation performance feedback on the ongoing remediation of LNAPL, as defined under the Order, and to support eventual attainment demonstration under the Act 2 program.

4.1 Liquid Level Gauging – Second Quarter 2014

The VES system and pneumatic skimming system recovery wells were deactivated on May 9, 2014, and on May 12, 2014, liquid level gauging data from the Site's monitoring and recovery well network were collected. Table 2 contains the gauging event data.

4.1.1 Site Hydrographs

Hydrographs for Site monitoring wells selected previously for long term groundwater elevation trend monitoring have been updated . These hydrographs are included as Appendix A (for MW-29, MW-32, MW-35, MW-36, PH-14, PH-15, PH-18, and PH-20). With the exception of abandoned wells PH-15 and MW-35, the hydrographs show groundwater elevations during the Second Quarter of 2014 gauging event to have been toward the upper range of the elevations recorded since 2001. Over time, these oscillating groundwater elevations show an amplitude of approximately two feet, and are generally concomitant as indicated by similar trends on the hydrographs for MW-29, MW-32, MW-36, PH-14, PH-18 and PH-20. These hydrograph patterns therefore may be Site-wide in extent, and are likely affected by seasonal changes, precipitation, and leaking sewers.

The groundwater levels measured during the Second Quarter of 2014 continue to be well above (i.e., by approximately two feet) the drought -indicative groundwater elevations reported from late 2001 to the beginning of 2003, and slightly above normal pre-drought measured water levels. These higher water levels are likely in response to higher amounts of precipitation during the First and Second Quarters of 2014 compared to recent years. A chart showing recorded precipitation in Philadelphia per month is presented in Appendix A. The chart indicates the aforementioned increase in precipitation. For example, precipitation in April of 2014 was recorded as 6.69 inches, compared to 2.32 inches in 2013 and 2.55 inches in 2012. This likely corresponds to the increase in groundwater elevation shown in the Site hydrographs (Appendix A) over a similar time period. The data continue to support the underlying Site-wide trend towards higher groundwater elevations since the start of Site LNAPL remediation activities in the late 1990s.

4.1.2 Site Hydrographs and the Packer Avenue Sewer

During the Second Quarter of 2014 and consistent with previous observations, measureable LNAPL was not observed in the monitoring wells located south of the Packer Avenue sewer. In addition to quarterly hydrographs, Appendix A also contains figures depicting the elevation of the LNAPL, groundwater and the bottom of the sewer. Groundwater elevations in the wells in close proximity to the Packer Avenue sewer were higher than the bottom of the sewer and no measureable LNAPL was observed in wells located south of the sewer.

4.1.3 Potentiometric Surfaces and Groundwater Gradients

The gauging event included the monitoring and recovery wells on the Former DSCP property, the Former Passyunk Homes property (i.e., around the PHA building and Siena Place Homes property), the CSX property, the P. Agnes property, and the SEPTA property. Access to the Steen property was denied by the Steen property owner prior to the gauging event. Access issues are currently being negotiated between the USACE and the property owner. Therefore, the shallow and deep aquifer zone monitoring wells present on the Steen property were not gauged and have not been included in the potentiometric surface maps described below. Access to these wells was last available during the Third Quarter 2012 gauging event. The potentiometric maps provided in previous quarterly progress reports presented this data.

Groundwater elevations used to prepare the hydrographs (Appendix A) and the potentiometric surface maps shown in Figures 1 and 2 were determined by subtracting the depth to water from the elevation of the surveyed measuring point (the top of the inner well casing). In cases where LNAPL was measured in a well, the groundwater elevations were corrected by multiplying the apparent LNAPL thickness by a specific gravity of 0.77, and adding this value to the groundwater elevation. This value, used in previous calculations, is an average of the range of specific gravity values provided in the *Fourth Quarter of 1999 Progress Report* by IT Corp (specifically Appendix D of that report).

Corrected groundwater elevation data was used to create a potentiometric surface map for the shallow/water table aquifer zone beneath the Site (Figure 1). A few Site wells are screened in areas where the presence of near-surface silty clay units and/or the presence of extensive paved areas of the Site appear to impede infiltration of precipitation, creating isolated perched zones and sinks. Additionally, based on the continued observance of isolated potentiometric high points at discrete well locations, some wells appear to be influenced by other infiltration sources, such as leakage from the numerous sanitary and storm sewer laterals that underlie the Site. Regardless of the source, and as found during prior gauging events, anomalous elevation heads were measured in the wells listed below (i.e., with respect to levels measured in the majority of surrounding shallow aquifer zone wells). These monitoring wells excluded from the shallow aquifer zone potentiometric map include CSX-MW-1, CSX-MW-2, PH-MW-37, PH-MW-43, PH-RW-A, PH-RW-C, PH-RW-D, PH-RW-Q, PH-RW-S, PH-RW-I, and PH-RW-T.

Based on water level measurements and well construction details, several well screens were submerged at the time of the gauging event. Groundwater elevations for wells with submerged screens have been excluded from the shallow aquifer/water table potentiometric surface map. These wells include DSCP-MW-5, DSCP-MW-10, DSCP-MW-11, DSCP-MW-14, DSCP-MW-34, DSCP-MW-59, DSCP-RW-5/MW-25,DSCP-RW-7, DSCP-RW-10, EPH-MW-48, EPH-MW-49, EPH-MWS-5, EPH-PH-5, EPH-PH-7, PH-MW-58, PH-MW-60, PH-MWS-2A, PH-MWS-3, PH-MWS-4, PH-PH-6, PH-RW-F, and PH-RW-N. Exclusion of these wells, and the wells described above, does not materially affect the interpretation of the potentiometric surface for the gauging event.

As described above, the access agreement to the Steen property has lapsed. Access to the monitoring wells was denied by the Steen property owner; therefore the monitoring wells present on the Steen property were not gauged and have not been included in the contours shown in Figure 1 or Figure 2. Potentiometric contours in this area have been inferred.

The Figure 1 potentiometric surface map of the shallow/water table aquifer indicates that groundwater in the northern part of the Site flows down gradient from the northwest to the south and southeast starting near DSCP-MW-20 at an elevation of 4.80 feet (ft) above mean sea level (AMSL) to around 2.55 AMSL at DSCP-MW-27A. In the southeastern part of the Site a separate and distinct potentiometric high is observed with a flow gradient from southeast to northwest. The high point is located at EPH-MWS-10 at 5.07 AMSL, and elevations decrease to the northwest towards EPH-MW-50 (2.37 AMSL).

Outside of localized anomalies at the Site, groundwater flow generally follows the regional groundwater gradient in a southerly to south easterly direction. In the southern area of the Site, groundwater flows south from the PHA building to the southern portion of Siena Place Homes. In the midsection of the Site, a trough-like depression is oriented approximately east-west in the shallow aquifer potentiometric surface. This feature, which has also been regularly observed during prior quarterly gauging events, is most pronounced near the BJ's retail building and in an area extending southwest from the VES system building to the former PHA property.

Gauging data from the Site's eleven deep aquifer zone wells were used to create a deep aquifer zone potentiometric surface map, as shown on Figure 2. Previous deep aquifer zone potentiometric maps indicated a gradient oriented south to southeast, a direction generally concordant with the dip azimuth of the deep aquifer zone's hydrostratigraphic units. Figure 2 remains consistent in that it continues to show a southern groundwater flow direction, with a high point of 1.88 ft AMSL at DSCP-MW-20D and a low point of 0.91 ft AMSL at PH-DW-3. The figure depicts a depression at DSCP-DW-6 (1.60 ft AMSL). A similar depression at this well was observed during the First Quarter of 2014. As stated in previous quarterly reports, the absence of Steen property monitoring well gauging data affects the visual presentation of the potentiometric surface data.

Vertical gradients (i.e., head potentials) between the shallow and deep aquifer zone for the Second Quarter 2014 well gauging event are shown on Table 3. Gradients were calculated using measured groundwater elevations for wells within nested shallow and deep aquifer zone pairs. Well pairs included:

- CSX-DW-4 and CSX-MW-7;
- DSCP-DW-1 and DSCP-MW-23A;
- DSCP-DW-13 and DSCP-MW-11;
- DSCP-DW-6 and DSCP-MW-2B;
- PH-DW-10 and PH-MWS-1;
- PH-DW-11 and PH-PH-22;
- PH-DW-2 and PH-MWS-15;
- DSCP-MW-20D and DSCP-MW-20; and
- PH-DW-3 and EPH-PH-5.

All vertical gradients during the Second Quarter of 2014 well gauging event were found to be indicative of a broad downward groundwater flow potential throughout the midsection of the Site. The well pairs are generally coincident with the approximate reported extent of a "breach" in the base of the Site's shallow aquifer zone[1]. Additional discussion on COC and the results of direct push work conducted to help further evaluate aquifer features such as the previously reported "breach" are discussed in subsequent sections of this report.

Corrected groundwater elevation data were used to prepare an apparent LNAPL thickness map (Figure 3). The apparent LNAPL thickness contours are approximate and do not necessarily indicate consistent in-situ LNAPL saturation, volume, mobility or recoverability. However, the measurements are useful as a metric, to be used in context with other metrics such as constituent concentrations, to evaluate the progress of Site remediation through time. Measured LNAPL thickness is influenced spatially by various factors including: 1) the heterogeneous nature of the LNAPL (i.e., both type and degree of weathering – a range of light, middle, and heavy end distillates were identified via historic LNAPL forensic data), 2) hydrogeologic characteristics (aquifer heterogeneity- units of varying grain size over the screened interval of a given well), 3) well construction (screen type and interval, sand pack design), and 4) temporal changes (e.g., groundwater level fluctuations).

Compared with previous quarterly report data, the general trends of the LNAPL distribution remain the same, suggesting that the LNAPL body at the Site is stable and not laterally mobile. As shown on Figure 3, the distribution of LNAPL appears to be constrained within an elongated area, following an east-west trend. This distribution has been seen in previous gauging events and appears to roughly coincide with the recurring east-west "trough" in the shallow potentiometric surface (Figure 1).

While small LNAPL thickness increases and decreases in individual wells are observed, these superficial changes in thickness may be related to the focused vacuum and skimming approach to remediation system O&M that has been applied to date, and seasonal fluctuations in groundwater elevation.

[1] As defined by Ron Sloto, USGS, in meetings on September 17, 2010 and January 19, 2012.

No data from the concurrent groundwater/LNAPL gauging event conducted at the Sunoco refinery and adjacent Philadelphia Gas Works (PGW) property were available for the preparation of these figures.

4.2 Site Wide Groundwater Sampling Event – Second Quarter 2014

A groundwater sampling event was conducted at the Site from May 13, 2014 through May 23, 2014. The event was the second Site-wide groundwater sampling event of CY 2014, and the sixth comprehensive Site-wide groundwater sampling event since the Third Quarter of 2012. The event included all accessible wells within the Site's monitoring and recovery well network on the Former DSCP property, the Former Passyunk Homes property (the new PHA building and the Siena Place Homes), the CSX property, the P. Agnes property, and the SEPTA property. A total of 144 wells were sampled. Access to the Steen property was not available during this event due to access agreement issues.

Like the previous comprehensive Site-wide groundwater sampling events, the Second Quarter 2014 event included collection of samples for laboratory analysis of previously defined Short List COC[2] from all accessible monitoring and recovery wells. Laboratory analytical data from the Second Quarter 2014 sampling event will be combined with historic sampling data and future Site-wide sampling data to: 1) evaluate remedial performance, 2) determine the stability of Site LNAPL, and 3) present data in support of an Act 2 SSS closure approach for Site LNAPL.

The recovery wells connected to the VES System and the pneumatic system on the Former DSCP property and the Former Passyunk Homes property were deactivated on May 9, 2014. Site recovery wells were reactivated following completion of groundwater gauging and sampling activities on May 27, 2014.

After liquid level data were collected, accessible wells were sampled via low flow sampling techniques using QED bladder pumps. Groundwater sampling was conducted from the middle of the saturated screened interval of each groundwater monitoring well. Prior to sampling the well, pH, conductivity, temperature, dissolved oxygen, and turbidity readings were measured at regular five-minute intervals up to one hour as the well purged, to ensure that water quality parameters had stabilized

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[2] PADEP Short List for Petroleum Products- Leaded Gasoline, Aviation Gasoline, and Jet Fuel

prior to sampling. Groundwater sampling logs are included in Appendix B. For LNAPL-bearing wells, sample collection was accomplished using procedures designed to obtain representative groundwater samples free of LNAPL. These procedures are outlined in previous quarterly progress reports.

The language in the Order requires that remediation be conducted as needed to remove as much LNAPL as is practicable from beneath the Former DSCP property. The following COCs from the PADEP *Short List of Petroleum Products for Leaded Gasoline, Aviation Gasoline and Jet Fuel* were selected based on the reported approximate composition of LNAPL at the Site. The Short List of Petroleum Products includes:

- Benzene
- Toluene
- Ethyl Benzene
- Xylenes (Total)
- Cumene (Isopropylbenzene)
- Naphthalene
- Trimethyl benzene, 1,2,4- (Trimethyl benzene, 1,3,4-)
- Trimethyl benzene, 1,3,5-
- Dichloroethane, 1,2-
- Dibromoethane, 1,2-
- Lead (dissolved)

Due to Site history of arsenic detections and impacted soils, dissolved arsenic was also analyzed. Groundwater samples were analyzed for methyl tertiary-butyl ether (MTBE). To evaluate potential MTBE distribution and degradation, and groundwater flow paths in the hydraulically linked aquifer systems, samples were also analyzed for tertiary butyl alcohol (TBA), a known daughter product of anaerobic degradation of MTBE.

Samples from all 144 wells were analyzed using EPA 8260B for Volatile Organic Compounds (VOCs), EPA 8011 for Semi-Volatile Organic Compounds (SVOCs) and EPA 6020 A for dissolved lead and arsenic. Analytical data packages are located in Appendix C. Tabulated analytical results for VOCs and Metals are presented in Tables 4a and 4b. Results were compared to the PADEP Groundwater Medium Specific Concentrations (MSCs) for Non-Residential Used Aquifers with Total Dissolved Solids (TDS) less than or equal to (≤) 2,500 milligrams per liter (mg/L). Analytical results that exceed the Non-Residential Used Aquifer (TDS <2,500 mg/L) Groundwater MSCs are bolded and highlighted in yellow. If the detection limit for a reported result exceeds the

MSC, and the sample result is non-detect, the result is highlighted in gray. These standards have been selected for comparison purposes only and are not intended to be the target cleanup goals for Site groundwater. A Site Specific Standard pathway elimination and LNAPL stability approach to Site groundwater cleanup may be pursued for the shallow aquifer zone, as previously discussed with PADEP (e.g. meetings held on October 27, 2011, January 19, 2012, March 13, 2012, and March 6, 2013). For the deep aquifer zone, as discussed during the March 6, 2013 PADEP meeting, either a background standard approach or an area-wide Non-Use Aquifer Determination (NUAD) will be pursued.

Table 4a shows analytical results of the Site VOC COC, including MTBE and TBA, compared to the MSCs. Table 4a also shows the sum of all VOC COC. These results are shown on Figure 4 through Figure 13. Each figure shows a well location based on the total VOC COC concentration only for the respective aquifer zone. The figures are organized to summarize differing concentration ranges for both the shallow and deep aquifers, as follows:

- Figure 4 shows total VOC results for COC in the shallow aquifer that are greater than 10,000 micrograms per liter (ug/L);
- Figure 5 shows total VOC results for COC for the shallow aquifer that are between 3,000 ug/L and 10,000 ug/L;
- Figure 6 shows total VOC results for COC for the shallow aquifer that are between 1,000 ug/L and 3,000 ug/L;
- Figure 7 shows total VOC results for COC for the shallow aquifer that are between 100 ug/L and 1,000 ug/L;
- Figure 8 shows total VOC results for COC for the shallow aquifer that are between 1 ug/L and 100 ug/L;
- Figure 9 shows total VOC results for COC for the shallow aquifer that are less than 1 ug/L;
- Figure 10 shows total VOC results for COC in the deep aquifer that are greater than 1,000 ug/L; and
- Figure 11 shows total VOC results for COC in the deep aquifer that are less than 1,000 ug/L.
- Figure 12 shows MTBE and TBA results for the shallow/intermediate aquifer
- Figure 13 shows MTBE and TBA results for the deep aquifer

Site metals concentration in the groundwater for the shallow and intermediate aquifer zones are shown in Figures 14 and 15 while Site metals concentrations in the deep aquifer are shown in Figure 16. Each of these figures show the data compared to the

Non-Residential Used Aquifer (TDS <2,500 mg/L) Groundwater MSC. Arsenic and lead are the two diagnostic metals detected in groundwater at the Site that reportedly may have an association with the Order-defined petroleum hydrocarbon impacts. Tabulated metals values are given in Table 4b.

4.2.1 Site-Wide Groundwater Sampling Event Observations – Shallow and Deep Aquifer Zone

Volatile Organic Compound Constituents of Concern

A total of 15 shallow and intermediate wells yielded results where total VOC COC exceeded 10,000 ug/L (shown in blue on Figures 4-11, detail Figure 4). Most of these wells are clustered within the central portion of the Site, including the VES well network on the PHA property and the general vicinity of the VES building. Five wells on the Former DSCP property have total VOC COC greater than 10,000 ug/L. The northernmost of these wells is DSCP-MW-3A (total VOCs 14,652 ug/L), and the southernmost well is PH-MWS-2A (12,438 ug/L). The maximum total VOC concentration is 42,292 ug/L in DSCP-MW-65. Within the wells with high total VOCs, benzene is consistently the COC with the highest concentration. Benzene concentrations in this set of wells range from 4,530 ug/L in PH-MW-43 to 38,300 ug/L in PH-IW-10.

Overall, the highest reported groundwater VOC COC concentration data points generally cluster in the center of the Site and occupy an area with an elongated east to west axis, with points of lower VOC COC concentration surrounding the area. This spatial distribution of the high VOC wells coincides with the trough-like feature in the shallow aquifer zone potentiometric surface and measured LNAPL distribution.

While locations of high VOC COC and locations of greatest measured LNAPL thickness both lie in the trough feature in the center of the Site, a complete correlation between LNAPL thickness and groundwater VOC COC concentration was not observed. For example, DSCP-MW-3A showed a high concentration of total VOCs of 14,652 ug/L, but showed relatively small LNAPL thickness (0.2 ft). Areas of high measured LNAPL thickness, such as near DSCP-MW-33 (0.79ft.) and DSCP-RW-6 (0.66 ft.), do not contain total VOC COC levels greater than 10,000 ug/L. This may be an indication of the spatially variable composition of the Site's LNAPL, as previously reported, and specifically may indicate the presence of heavier or more weathered LNAPL in the vicinity of these wells. Through volatilization and in-situ biodegradation, the Site's VES system and naturally occurring indigenous microbes weather LNAPL via removal of the VOC COC components. Therefore, barring any new source addition, declining COC concentration trends and the continued observation of discordant LNAPL and VOC COC distributions are to be expected.

Surrounding the area of total VOC COC results greater than 10,000 ug/L are the greater than 1,000 to less than 10,000 ug/L wells, shown in yellow on Figures 4-11. Figures 5 and 6 show results between 1,000 ug/L and 10,000 ug/L. A total of 37 shallow wells yielded total VOC COC results in this category. For these wells, benzene was typically the COC with the highest concentration.

Generally toward the edges of the Site are wells with concentrations less than 1,000 ug/L, shown in green on Figures 4-11. A total of 92 shallow wells were placed in this category. In 34 of these locations, benzene still exceeds the Non-Residential Used Aquifer (TDS <2,500 mg/L) Groundwater MSC of 5 ug/L.

Total VOC COC concentrations above 1,000 ug/L were detected in deep wells PH-DW-3 and PH-DW-11, as shown in Figure 10. PH-DW-3, located south of the Site, showed a total VOC result of 8,311 ug/L and a benzene result of 7,830 ug/L. PH-DW-11 yielded a total VOC concentration of 4,862 ug/L and a benzene concentration of 4,780 ug/L. Of the remaining deep wells where total VOC COC were below 1,000 ug/L, 6 wells exceeded the Non-Residential Used Aquifer (TDS <2,500 mg/L) Groundwater MSC for at least one compound.

<u>MTBE and TBA</u>

Figures 12 and 13 show MTBE and TBA results in the shallow/intermediate and deep aquifer zones. During the Second Quarter of 2014, 14 MTBE detections were observed, including 8 of which were above the Non-Residential Used Aquifer (TDS <2,500 mg/L) Groundwater MSC. Observations regarding MTBE results include:

- 7 shallow/intermediate wells are shown with MTBE detections, maximum 21.8 ug/L at DSCP-MW-30. Four of these wells are in the center of the Site near areas of measureable LNAPL. The additional 3 wells are located on the western boundary and eastern portion of the Site.

- 7 deep wells are shown with MTBE detections, maximum 34.4 ug/L at PH-DW-10. Three of the seven wells are located along the western portion of the Site, north of the northern boundary of the breach. Within the breach, one well with a detection is found in the center of the Site, and another along the western edge. Two additional wells with detections are located south of the Site.

Since the Third Quarter 2013 event, samples have also been analyzed for TBA, a daughter product derived from the biodegradation of MTBE, or a precursor chemical compound in the manufacturing of MTBE. While TBA is not a PADEP regulated compound, it was sampled for to aid in understanding of the flux of groundwater and COC within the Site's aquifer systems. TBA was not tested for in sampling events prior to the Third Quarter of 2013, but as TBA data are collected from future events, trends in MTBE migration and degradation may become apparent. In the Second Quarter of 2014, 29 wells showed TBA detections.

Figures 12-13 show the following observations:

- 23 shallow/intermediate wells showed TBA detections, maximum 5,040 ug/L in PH-MW-43.

- 6 deep wells showed TBA detections, maximum 288 (lab-estimated value, above Limit of Detection [LOD] but below Limit of Quantitation [LOQ]) ug/L in PH-DW-3.

- The regions of highest TBA detections in the shallow/intermediate zones are located within the central portion of the Site, as well as along the western side of the Site, between the Steen and PHA properties.

- The highest deep aquifer TBA detection was observed in DSCP-DW-3, located in the southern part of the Site.

- Three wells in the shallow/intermediate zones show MTBE detections but not TBA detections. These wells include CSX-IW-5, andDSCP-IW-1. These wells are located in the central to northwestern portions of the Site, from the central Former DSCP property to the CSX property. In addition, one well located on the SEPTA property, SEPTA-SEPTAMW-3, showed MTBE detection but not TBA.

- Two wells in the deep zone show MTBE detections but not TBA detections. DSCP-MW-20D is located on the northwestern portion of the Site, and PH-DW-10 is located along the western edge of the Site, between the Steen and PHA properties.

Dissolved Metals

Table 4b and Figures 14, 15 and 16 show dissolved metals results for dissolved arsenic and lead in the shallow and deep aquifer. Dissolved lead concentrations are represented by larger circles, while arsenic is represented by small circles. Detections that exceed the Non-Residential Used Aquifer (TDS<2500 mg/L) Groundwater MSCs are highlighted in blue. The metals results for arsenic and lead in both the shallow and deep aquifers showed detections exceeding MSCs in the same areas of high VOC COC concentrations, where measureable LNAPL is located. In addition, results from several shallow and deep wells on the CSX property to the west of the Site showed levels of arsenic and lead that exceeded the MSCs.

Specific observations include:

- 96 shallow/intermediate wells are shown with arsenic detections, maximum 109 ug/L at DSCP-IW-12. 46 of these detections exceed the PADEP MSC.

- Shallow/intermediate arsenic impacts are observed throughout the Site, with the highest impact centered on the area of measureable LNAPL. Several wells along the western boundary of the Site, including CSX-MW-2, CSX-MW-8, and CSX-MW-9, yielded arsenic detections above the PADEP MSC.

- 6 deep wells are shown with arsenic detections, maximum 7.0 ug/L at CSX-DW-5. All of these detections were below the PADEP MSC.

- 20 shallow/intermediate wells are shown with lead detections, maximum 14.30 ug/L at CSX-MW-9. 3 of these detections exceed the PADEP MSC.

- One of the shallow/intermediate wells with lead exceedances is located along the western portion of the Site, on the CSX property. The remaining two wells with lead exceedances are located in the central portion of the Site.

- One lead detection was reported for the deep aquifer zone, at CSX-DW-5 with a concentration of 2.1 ug/L (lab-estimated value, above LOD but below LOQ). CSX-DW-5 is located in the northwestern portion of the Site.

4.2.2 Historical Site-Wide Groundwater Sampling Event Data Observations

Historical VOC COC data tables were compiled from Site-wide groundwater sampling events dating as far back as 1994. These tables are given in Appendix D, and may be read in conjunction with Figures 4-13, which show the most recent groundwater sampling data. The color coding used in these figures (blue for VOCs>10,000 ug/L, green for 1,000-10,000, and yellow for <1,000) has been applied to the well names in the historic data table for reference.

Wells with total VOCs >10,000 ug/L during the most recent sampling event, in general, have historically shown high levels of VOCs, including benzene and MTBE (where data available). The well with the highest benzene level for the most recent event, PH-IW-10, has shown benzene levels of over 15,000 ug/L since 2007, with a maximum level of 38,300 ug/L during the most recent event. This well is located on the western edge of the PHA property. The well with the highest total VOC concentration, DSCP-MW-65 at 42,292 ug/L, has returned high VOC levels since its installation in 2013, and is located in the central portion of the Site.

Results from the Second Quarter of 2014 compared to historic data show a few wells with notably increasing trends in VOC COC. These wells include DSCP-MW-30, DSCP-MW-3A, and PH-IW-10. These wells are located within the central and southern portions of the Site. Trends will continue to be monitored in future quarters. .

Comparison of recent and historical data also shows decreasing trends in some wells. Substantial decreases in VOC COC over time were noted in 20 wells, including CSX-MW-5, DSCP-DW-12, DSCP-MW-28, DSCP-MW-29, DSCP-RW-1A, DSCP-RW-3, DSCP-RW-4, DSCP-RW-5/MW-25, DSCP-RW-8, EPH-MW-39, EPH-MW-49, PH-MW-55, PH-MWS-1, PH-PH-1, PH-PH-16, PH-PH-20, PH-RW-A, PH-RW-D, PH-RW-I, and PH-RW-M. Trends in these well locations will continue to be monitored through the addition of future sampling results to the historical data table.

Though TBA data has only been available since the Third Quarter of 2013, it has been included in the historical data table, along with MTBE, so that with the addition of data from future sampling events, trends in TBA and MTBE concentrations may be observed. Based on the data since the Third Quarter of 2013 through current, Site locations with MTBE and TBA detections remain largely consistent, and include the central portion of the Site on the Former DSCP property, the western portion of the Site on PHA property, and the northwestern portion of the Site on CSX property. The following specific observations were noted:

- As reported above, three shallow/intermediate wells, including CSX-IW-5, DSCP-IW-1, and SEPTA-SEPTAMW-3, showed MTBE detections but not TBA detections. CSX-IW-5 and DSCP-IW-1 showed similar results in the Third and Fourth Quarters of 2013. These wells are located on the western and northwestern portions of the Site. MTBE was not detected in SEPTA-SEPTAMW-3 in the previous quarter, when the well was first sampled.

- Deep wells DSCP-MW-20D and PH-DW-10 showed MTBE detections but not TBA detections during this quarter, and also showed similar results during the three previous quarters. These wells are located within the northwestern portion of the Site.

Though metal concentration data have not been included in the historical data table in Appendix D, several observations were made comparing the Second Quarter of 2014 data with previous quarterly data:

- Generally, regions with arsenic and lead detections remained consistent over time. Arsenic impacts were observed throughout the Site, with the highest impact centered on the area of measureable LNAPL. Lead impacts were observed towards the eastern portion of the Site, as well as in wells along the western boundary of the Site on the CSX property.

- During the Third Quarter of 2013 and the First Quarter of 2014, one deep well, DSCP-MW-20D, showed lead detections that exceeded the PADEP MSC. However, no lead detections were identified in this well or any other deep well during the Second Quarter of 2014. This well, along with other deep wells, will be monitored for lead detections in future events.

The historical data table in Appendix D will be used as a database, and data from future groundwater sampling events will be added. This information will be used along with remediation O&M data to better define contaminant concentration and LNAPL thickness trends and to focus future Site remedial efforts.

4.2.3 Sample Reduction Statistical Analysis

After six comprehensive sampling events including all accessible wells at the Site, data show that some of the sampling locations provide no significant additional data to the project. Efforts are being planned to reduce the number of samples analyzed each quarter without reducing the value of the data provided by the sampling events. Statistical analyses are planned on the data to select groups of wells that no longer need to be sampled, groups that can be sampled less frequently, and groups of wells which provide similar information which may be sampled on a rotating basis. It is hoped that the results of the analysis will reduce the amount of resources expended on a given sampling event while continuing to add high quality data to the project database.

As the analysis of the data proceeds, decisions about changes to the sampling plan will be based on the following guiding principles:

- Trends: Wells with stable downward trends in contaminant concentrations will possibly be sampled less often; wells with stable upward trends that are above groundwater standards, or unstable trends will generally continue to be sampled regularly. The Mann-Kendall trend detection test will be used to quantify the type of trend. (See EPA QA/G-9S, *Data Quality Assessment: Statistical Methods for Practitioners*, February 2006)
- Groundwater Standards: Wells that have never had contaminant concentrations above the applicable groundwater standards (PADEP MSCs for Non-Residential Used Aquifers) can often be removed from the sampling plan or the sampling frequency can be reduced. Typically, wells that often exceed groundwater standards may have reduced sampling frequency based on other guiding principles listed here, but normally would not be entirely removed from sampling plans.
- Toxicity: Wells with significant concentrations of more toxic contaminants will remain in the sampling plan; wells with significant concentrations of only less toxic contaminants may be removed from the plan or be sampled at less frequent intervals.
- Sentinel wells: Some wells on the boundary of the site area will remain in the sampling plan if they are necessary to provide early warning of unexpected movement of contaminants out of the area of interest, or the arrival of contaminants from off-site, which may affect background level designations.
- Vicinity: Well data will be compared to that from nearby wells to ensure that data quality does not suffer from well removal. Nearby wells that provide no unique data may be removed or their sampling frequency may be reduced.
- Clusters: Wells in multi-level clusters may be kept in the sampling plan at the expense of single wells to provide vertical definition of variations in contaminant concentrations.
- Long-term Data: Since long-term trends can be important in analysis, sampling frequency will be reduced more often than complete removal from the dataset.

The next quarterly report (Third Quarter of 2014) will include a table of wells with information about the trends, contaminant levels, and nearby wells with a recommendation for future sampling frequency at each well.

5. Direct-Push Investigation

During the previous quarter, between February 18, 2014 and February 21, 2014, a subsurface direct-sensing investigation was completed on the SEPTA South Terminal property located to the east of 26th Street South. Details of the work, along with draft versions of the data logs, were provided in the First Quarter of 2014 progress report (ARCADIS 2014). Since the distribution of that report, finalized data logs were provided by the contractor. These logs are shown in Appendix E. The data in the finalized logs are consistent with the data shown in the draft logs in the previous quarter. For reference, a data results and discussion section similar to the previous reports is given below.

5.1 Data Results and Discussion

The logs included in Appendix E include the direct-push data for each location investigated at the SEPTA property. As shown, and as described above, zones of fine and coarse grained materials were observed, zones of low and high K were identified, and residual petroleum hydrocarbon impacts were observed (i.e. data indicative of LNAPL saturation were not observed). Attempts to measure and bail free product produced no recoverable LNAPL. The general stratigraphic sequence echoes that observed during extensive direct-push work conducted on the DSCP property, which was described in the Fourth Quarter 2012 and Calendar Year 2012 Summary Progress Report (ARCADIS, 2013). The geologic sequence is consistent with that of the Potomac Raritan Magothy formation as described by the USGS (Paulachok, 1991).

Additional data from future direct-push events will be used with the above results to better define Site stratigraphy and geologic features, in order to update the CSM.

6. VES System Operation and Maintenance

Remediation began at the Site in 1996 utilizing in-well skimmer pumps for removal of LNAPL. In March 1999, operation of an expanded LNAPL skimming system commenced. The expanded system included two separate fixed pneumatic LNAPL skimming systems at the Former DSCP property and the Former Passyunk Homes property (the PHA property). The current VES System, which began operations in

March 2005, was installed to enhance LNAPL recovery rates by inducing a pressure (i.e., vacuum) gradient that can help draw additional LNAPL to the recovery wells without depressing the groundwater table. The VES system also removes hydrocarbon mass via vapor phase recovery which can be expressed as LNAPL using a vapor mass to LNAPL volume conversion factor. For a complete history of Site remedial operations, please see Appendix F – Site History. This history reveals how the more recently adopted dynamic approach to O&M has allowed remediation efforts to evolve based on the needs of the system so that recovery is more effective. Below is a description of the performance of the mobile and VES systems and related remediation O&M observations during the Second Quarter of 2014.

6.1 Fixed Skimming System – Second Quarter 2014

The fixed LNAPL skimmer pumps are connected to a totalizer installed in each recovery well vault. Recovery well totalizers are used only to estimate the LNAPL recovered from each well during skimmer pump operation. This is because as a function of normal skimmer pump operation, some air passes through the totalizers along with the LNAPL, and/or totalizers can occasionally become stuck as a function of regular operation, resulting in inaccurate estimation of the quantity of LNAPL recovered at each well. The more accurate measurement of the volume of LNAPL recovered by skimming is obtained from tank charts that correlate storage tank volume and the depth of LNAPL measured in a given Site LNAPL storage tank (where the total volume of LNAPL recovered is monitored continuously and recorded weekly, at a minimum). This tank chart data is obtained via a volume-measuring probe installed in each of the Site's two LNAPL aboveground storage tanks (ASTs).

The fixed system LNAPL skimmer pumps located on the Former Passyunk Homes property (the current PHA property) are connected to a 5,200-gallon AST and the fixed system LNAPL skimmer pumps located on the Former DSCP property are connected to a 10,000-gallon AST. Tables 5 and 6 detail the estimated quantity of LNAPL recovered from each of the fixed system recovery wells, in addition to the total and cumulative LNAPL recovered by each fixed system based on the tank charts mentioned above. Table 5 contains the LNAPL recovered for the Former DSCP system and Table 6 contains the LNAPL recovered for the Former Passyunk Homes system.

During the Second Quarter of 2014, Former DSCP area fixed skimming system recovery well RW-9 recovered an estimated 85 gallons of LNAPL according to the totalizer in the recovery well vault (as shown in Table 5). However, as discussed above, recovery well totalizers are not the most accurate method of recording the amount of LNAPL recovered. Based on volume-measuring probe data and resultant tank chart readings, the AST on the Former DSCP property received approximately 328 gallons of LNAPL during the quarter. This results in a total approximate volume of LNAPL recovered by the Former DSCP area fixed system of 508,456 gallons through the end of the Second Quarter 2014.

During the Second Quarter of 2014, and according to the totalizers in each recovery well vault (as shown on Table 6), the Former Passyunk Homes property fixed skimming system recovered an estimated 16 gallons of LNAPL from RW-A and an estimated 6 gallons of LNAPL from PH-20. However, as of the end of the Second Quarter of 2014, no measureable LNAPL has collected in the AST. This indicates that the skimming system lines have not filled with a sufficient quantity of LNAPL to accumulate in the AST. The underground piping for this system has a capacity of approximately 500 gallons, which must fill prior to any LNAPL entering the AST. Approximately 167,558 gallons of LNAPL have been recovered by the Former Passyunk Homes fixed skimming system since it was started in March 1999. This total remains unchanged as of the end of the Second Quarter 2014.

Both fixed skimming systems were shut down from May 12, 2014 to May 23, 2014 for the quarterly groundwater gauging and sampling event. With the exception of this event, the skimmer system operated continuously during the quarter. Neither AST used for storing LNAPL was pumped out during this quarter. System O&M, pump cycling frequency and pump intakes were adjusted as necessary. Adjustments were made to optimize LNAPL recovery while maintaining enough LNAPL thickness in the wells to prevent pumping groundwater along with the recovered LNAPL.

As discussed in previous quarterly reports, the LNAPL recovery by skimmer pump from approximately 2006 to date continues to be lower than what was witnessed during the first 6 years of skimmer system operation. This general decrease in LNAPL recovered by skimmer is most likely the result of the following factors:

- The majority of the LNAPL that was recoverable by skimmer pump has been removed;

- A reduction in the regional pumping rates in the shallow aquifer over the years in the vicinity of the Site has resulted in higher groundwater elevations. As a result, much of the remaining LNAPL/ petroleum hydrocarbon mass at the Site is now most likely trapped below the water table. This change in the regional aquifer effectively reduced the amount of mobile LNAPL available for recovery by skimmer pump. The resulting increase in the groundwater level has also submerged the screened interval in some recovery wells thereby cutting off the recovery well from any mobile LNAPL and or hydrocarbon vapor that may be present adjacent to the well; and

- As evidenced by recent activities related to aquifer testing on the Site, there is likely some fouling in the screens and sand packs of the Site's wells, especially those that have been actively used for LNAPL and vapor recovery for several years. Fouling can occur due to biological activity (biofouling) or from extended periods of vapor recovery in LNAPL wells. In the case of vapor recovery, the lighter fraction of the LNAPL is volatilized, leaving behind the less volatile, heavier, and more viscous fraction. Fouling can reduce soil porosity in the formation adjacent to the recovery well, reducing the rate of recovery over time.

Because of the generally lower ability to recover LNAPL by skimmer pump, ARCADIS has been conducting optimization testing activities on the vapor recovery portion of the VES system as discussed in Section 6.3 below. Additionally, ARCADIS has also been conducting optimization of the operational strategy of the fixed skimmer systems including:

- Keeping skimmer pumps off in recovery wells that exhibit less than 0.3 ft of free LNAPL to prevent water from being pumped into the ASTs, and to reduce the amount of labor expended on tasks that do not yield significant LNAPL recovery. These recovery wells are checked periodically and the skimmers are turned on only when supervised to pump out accumulated LNAPL but not to pump water into the ASTs;

- Removing skimmer pumps from recovery wells that do not exhibit recoverable LNAPL to reduce costs associated with maintaining pumps in wells where no LNAPL is being recovered. These pumps are kept onsite and will be re-deployed when recoverable LNAPL is measured in these recovery wells;

- Operating sets of fixed skimming (recovery) wells at higher vacuum levels (i.e. between 20 and 30 inches of water [iw]) for extended periods of time, then periodically stopping the vacuum and using the skimmer pumps to pump out the LNAPL that has accumulated. This strategy, often referred to as "pulsing" the smear zone, is a dynamic approach to LNAPL recovery which can help mobilize LNAPL in the smear zone not otherwise effected by a more static VES strategy. Periodically stopping the vacuum in this strategy is necessary in some of the wells as the effectiveness of the skimmer pumps may be decreased by these higher vacuums. This pulsing of the aquifer is done by focusing LNAPL skimming at the VES wells being utilized in rotating groups, discussed in more detail in Section 6.3 below.

- Conducting an optimization test using the RW-A and PH-20 skimmers on the former Passyunk Homes Skimming System with a pump controller removed from one of the mobile systems. This strategy operates the skimmer on a timed schedule (three events per day, five minutes per event) in place of continuous operation if LNAPL is present. This allows the LNAPL to recover in the well between periods of pump operation. By allowing the LNAPL in wells to recover, the LNAPL in the well is not cut off from the surrounding LNAPL in the formation, and as a result of surface tension, more LNAPL can be drawn into the well. This strategy may have the added benefit of pumping less water into the storage tank. By adjusting the controller frequency, the pump is controlled to only pump when LNAPL is present. This test commenced in the Third Quarter of 2013, and is ongoing. The well totalizers on these wells had been showing an increase in the amount of LNAPL recovered in the previous two quarters. The LNAPL recovery from PH-20 decreased in the Second Quarter 2014; however recovery increased in RW-A in the Second Quarter 2014. This is most likely due to higher groundwater table as a result of high levels of precipitation during the quarter (discussed below). The results of this ongoing optimization test will be provided in future quarterly reports.

This optimized fixed-skimming system operational strategy appears to have contributed to a significant increase in the amount of LNAPL recovered by skimming from the Third Quarter 2012 through the Second Quarter of 2014. LNAPL recovery tables are provided in Appendix G.

6.2 Modular Skimming System – Second Quarter 2014

A modular LNAPL recovery system is currently also operating on the Former DSCP property, at well DSCP-MW-3A (installed October 25, 2004). The LNAPL recovery data for this modular system is included in Table 7. A graph showing the total LNAPL recovery per quarter over time by the modular systems is included in Appendix G. There was no LNAPL recovered by the modular system at DSCP-MW-3A during this quarter.

As discussed above, the ongoing optimization efforts involve testing the Site's LNAPL skimming methodology. The operational methodology being applied to the fixed skimming systems is also being applied to the modular skimming unit currently installed at DSCP-MW-3A. DSCP-MW-3A is operating on a pump controller that allows the unit to pump LNAPL on a timed frequency of twice per day for 5 minutes if LNAPL is present.

The rate of LNAPL recovery by the modular skimming system at DSCP-MW-3A remains low (i.e., results are in line with published recovery results since the fourth quarter of CY 2011). and as described above can likely be attributed to high groundwater elevations. DSCP-MW-3A was, however, the only location where recoverable LNAPL exists in a well that is not already connected to the fixed skimming systems and where a modular system can be securelydeployed. The low level of effort afforded by the use of the modular skimming system is the main reason why skimming has continued at this location. Evaluation of the feasibility of deploying modular units at other locations of the Site is ongoing.

6.3 VES System Operation and Optimization- Second Quarter 2014

As part of system improvement activities in 2004, the VES system was installed to enhance the recovery rate of the existing LNAPL skimming systems. As originally designed, the VES system allows the placement of vacuum on selected recovery wells to create a pressure (vacuum) gradient. Ideally, this gradient helps draw additional LNAPL to the recovery well. However, the applied vacuum also removes hydrocarbon mass via vapor phase recovery which can be expressed as gallons of LNAPL using a conversion factor. Additional details on the calculations were provided in previous quarterly reports and are discussed in Appendix F – Site History.

The well field optimization testing that commenced in the Fourth Quarter 2011 determined that the application of focused VES system-generated vacuum on a selected subset of recovery wells increased the overall rate and quantity of petroleum hydrocarbon mass recovery from the VES system. This focused vacuum strategy, as opposed to the equal application of VES vacuum to all Site recovery wells, has been continued through the Second Quarter 2014 with some minor changes to the subset of wells being used for continuous VES operation. Appendix H shows which VES system wells were operated during this quarter.

The subsets of the VES system wells in Appendix H have been grouped into primary, secondary and tertiary subsets of wells. In the current remedial strategy, wells from the primary, secondary, tertiary and wells not in a group (RW-W and MWS-2A) are utilized for continuous focused vacuum extraction due to consistent mass recovery yielded by these wells. These wells are only shut off briefly to periodically pump out the LNAPL that accumulates by skimmer pump or to address high water level issues (discussed further below). This strategy is done to generate a pulsing effect in portions of the plume, increasing the overall mass recovery of both LNAPL and as well as increasing the volume of extracted soil vapor. The VES system was operated during the Second Quarter of 2014 with the wells listed above at an applied vacuum of between 10 to 33 iw. The remaining recovery wells were not used due to lower potential mass recovery rates, but the wells are checked periodically to determine if they should be added to the well rotation. Recovery wells would typically be considered for addition to the network if they could increase mass recovery (determined by periodic liquid level gauging, and extracted soil vapor composition screening) or if LNAPL is consistently present in these wells.

A comprehensive optimization assessment including liquid level gauging, and extracted vapor composition screening of the primary and secondary well groups, as well as tertiary wells RW-E and RW-W, began on March 31, 2014. This was prompted by an observed reduction in vapor mass recovered by the VES system during the First Quarter of 2014. The initial review of the findings of this optimization assessment indicate that the mass recovery potential from most of our operating recovery wells has decreased due to rising groundwater levels.

High precipitation during the winter and spring of 2014 had caused increases in the groundwater level from February 2014 through May of 2014. This higher groundwater table has reduced the length of unsubmerged well screen available for vacuum extraction in the recovery wells in use from an average of 2.5 feet during the February 2014 Site-wide well gauging, to 1.8 feet by the beginning of May, with a few of the recovery wells having screens that are completely submerged. Appendix I illustrates key VES wells and their depth to water/depth to product elevations compared to the depth to screen interval. The reduction in unsubmerged screen in recovery wells during the first half of the Second Quarter 2014, lowered the amount of VOCs and methane being recovered by the VES system and therefore caused the VES system's thermal oxidizers to consume more propane makeup fuel than usual. To address the high propane usage caused by the high groundwater levels, the VES system was operated intermittently or pulsed "on", then shut off to concentrate on skimming and conserve fuel. The reduction in the screen available for vacuum extraction and resultant reduction in VES system uptime due to this pulsing strategy resulted in lower mass recovery in the beginning of the Second Quarter 2014. The groundwater levels decreased in the second half of the Second Quarter 2014 as rainfall amounts decreased, and thereby mass recovery increased.

The side effect of the higher focused vacuum recovery strategy that ARCADIS has implemented is that the groundwater becomes mounded in the recovery wells being operated. At normal groundwater levels, there is still enough exposed screen in recovery wells to allow us to pull significant amounts of VOCs from the formation. During times of high groundwater, this mounding of the water table during VES operation is likely completely submerging the well screens in most, if not all of the primary VES wells during operation. In addition to reducing the amount of VOCs recovered by the VES system, this mounding of the water table completely cuts off the recovery well from the surrounding LNAPL that is floating on the water table, thereby reducing the amount of LNAPL skimmed.

This reduction in the screen available for vacuum extraction resulted in lower mass recovery in the beginning of the Second Quarter 2014 because the VES system was turned off to conserve fuel. As the groundwater levels dropped later in the Second Quarter 2014, continuous operation of the VES system was resumed. If groundwater levels increase, the pulsing strategy will resume. Alternately, specific sets of wells may continue to be operated at lower vacuum to reduce mounding. Either of these strategies will allow the VES system to continue to recover LNAPL as vapor, while maximizing LNAPL recovery by skimming during periods of high groundwater level.

During the Second Quarter 2014, the VES system operated continuously from the wells listed above, with exceptions of the period from April 8 through April 22, 2014 due to high groundwater levels discussed above. The VES system was also off from April 30 through May 6, 2014 again due to high groundwater. The VES system was turned off between May 9, 2014 and May 27, 214 for liquid level gauging and groundwater sampling. The VES system was also down from June 6, 2014 through June 9, 2009 due to a low gas pressure alarm from low propane levels in the tank (propane ran low before subcontractor could refill the storage tank).

Monitoring of CH_4 (with and without carbon filter), LEL, carbon dioxide (CO_2), and O_2 were recorded periodically during the quarter. Mass recovery was calculated using PID data collected at the VES system manifold. However, high CH_4 results tend to negatively skew the PID data collected at the VES system manifold, therefore PID data was calibrated using TO-15 summa canister air sample data. The petroleum hydrocarbon mass recovery calculations for the focused VES system are based on a weighted average of the compounds detected in the TO-15 manifold combined influent vapor samples. These samples are collected twice-monthly, when possible, to allow better accuracy of the mass recovery calculations. During the Second Quarter of 2014, three of these samples were collected. The average molecular weights from the results of the TO-15 samples of the combined influent were calculated in grams per mole (g/mol) as follows:

- April 30, 2014 – 89.90 g/mol
- May 28, 2014 – 89.90 g/mol
- June 16, 2014 – 89.97 g/mol

The TO-15 summa canister vapor sample results can be found in Appendix J. Mass recovery calculations are presented in Appendix K.

During the Second Quarter 2014, the VES system operated in optimized/focused-vacuum mode yielding an average mass recovery of 5.51 pounds/hour (lbs/hr). This represents a decrease from the mass recovery rate observed during the First Quarter 2014 and is a function of the rising groundwater level in recovery wells discussed in greater detail above, as well as downtime associated with the low propane pressure issue. However, mass recovery remains higher utilizing the focused vacuum remedial strategy than it was prior to optimization.

During the Second Quarter 2014, the average CH_4 (with carbon filter) was 3.7%, less than the previous quarter (5.4%). The average CO_2 was 56.0%, up from 5.5% in the previous quarter, and the average O_2 was 10.3%, down from the 11.8% in the previous quarter. These changes may be the result of the VES well operational approach described above, specifically the periodic changing of the groups of VES wells on-line. Additionally, note that during preparation of this report only one set of isotopic VES influent gas sample results were available (for $CO_{2,}$ etc.). Hence, the values above may upon receipt of additional isotopic data fall in line with previously reported results for influent gases indicative of subsurface biochemical reaction.

Both thermal oxidizers (TX100 & TX200) can operate; however, only TX100 was used during the Second Quarter of 2014. One thermal oxidizer was adequate to treat the vapor from the VES system during this time period. The second oxidizer, TX200 was maintained on standby in the event of a problem with TX200.

The overall VOC recovery rate for the VES system from April 1, 2014 through June 30, 2014 was 15,989 pounds which correlates to approximately 2,763 gallons of LNAPL. This is calculated using the mean density of the compounds detected in the laboratory analytical results of the summa canister samples collected from the influent vapor stream at the VES system manifold. This mean density is calculated based on a weighted average of the molecular weights of the compounds detected. This conversion factor was calculated as follows during the Second Quarter 2014:

- 5.95 pounds (lbs)/gallon on April 30, 2014
- 5.90 lbs/gallon on May 28, 2014
- 5.95 lbs/gallon on June 16, 2014

A graph showing the cumulative mass recovery of the VES system per quarter is included in Appendix G. As shown on this graph, the mass recovered by the optimized VES system since the Fourth Quarter of 2011 is more than five times the total mass recovered by the VES system since its start-up in 2005 through the Fourth Quarter of 2011. In the Second Quarter of 2014, VES mass recovery was higher than the previous quarter despite the downtime associated with the low pressure alarm, propane leak, and the rising ground water table.

6.4 Methane and Carbon Dioxide Forensic Techniques

In addition to mass recovered as VOCs, the VES system also contributes to the in-situ degradation of hydrocarbon mass by way of aerobic microbial degradation. The effect of aerobic microbial degradation can be estimated using the concentration of CO_2 entering the VES system. As discussed in prior quarterly reports, the calculation of the aerobic microbial degradation had been previously based on a conservative estimate of 10% of the CO_2 recovered being attributed directly to in-situ aerobic degradation of VOCs. In order to determine a more accurate "weighting" factor to convert CO_2 and CH_4 to pounds of hydrocarbon mass degraded in situ, carbon isotopic analysis of the CO_2 and CH_4 from the headspace of recovery wells, as well as the VES-extracted soil vapor, commenced in the Third Quarter of 2013 and is ongoing into the Second Quarter of 2014. The analysis of the carbon isotopes present in these samples can be used to determine the portion of CO_2 and CH_4 attributed to degradation of a fossil fuel compared to the portion derived from more modern sources (such as human activities and the decay of peat in soils).

In the Second Quarter of 2014, samples for isotopic analysis of soil vapor were collected on the following dates at the same location (i.e., combined VES influent sampling port) :

- CO_2 from the VES combined influent on April 30, 2014;

- CO_2 from the VES combined influent on May 28, 2014; and
- CO_2 from the VES combined influent on June 25, 2014.

Analytical results of the April 30, 2014 sample only, as well as calculated results of the percent contribution from Petroleum Hydrocarbon Degradation are provided below and in Appendix L. Only the April 30, 2014 results were available for preparation of this report . The amount of the carbon 14 (^{14}C) isotope, expressed as percent modern carbon (pMC), in the CH_4 and CO_2 is used to determine the "age" of the CH_4, and CO_2, similar to age dating of organic material from archeological sites (i.e. CH_4 or CO_2 derived from degradation of petroleum hydrocarbons will have zero ^{14}C, while CH_4 or CO_2 derived from anthropogenic sources such as landfills may be up to 100 pMC). The analytical result of the CO_2 in the April 30, 2014 sample indicates that the carbon present in the CO_2 had a ^{14}C value of 6.2 pMC. The low value of ^{14}C in this sample indicates that the CO_2 is primarily derived from degradation of petroleum hydrocarbons (i.e. anaerobic degradation of the LNAPL plume).

The April 30, 2014 analytical result suggest that the relatively high levels of CH_4 present in the formation and extracted by the VES system are in large part the result of years of anaerobic LNAPL biodegradation. This process is occurring naturally, and is independent of the VES system operation. However, the CO_2 present in the formation and extracted soil vapor is increasingly being derived from aerobic in-situ biodegradation, which can be directly attributed to the operation of the VES system (i.e., as the VES system withdraws CO_2, CH_4 and VOC laden soil gas, the concurrent infiltration of atmospheric air supplies oxygen to the subsurface).

As discussed previously, the calculation of the aerobic microbial degradation had been based on a conservative estimate of 10% of the CO_2 recovered being attributed directly to in-situ aerobic degradation of VOCs. The isotopic analytical result of CO_2 in the soil vapor of the VES system combined influent conducted during the Second Quarter of 2014 yielded a value of 14 pMC. This demonstrates that an average of approximately 14% of the CO_2 recovered by the VES system during the Second Quarter 2014 is derived from modern or anthropogenic sources (i.e. not related to in-situ degradation of the VOCs). To determine how much of the remaining 86% of the CO_2 is then directly attributed to in-situ degradation of the VOCs, the percent derived from degradation of peat and organics in soil must be considered. As described in the Technical Memorandum included in Appendix L, the amount of ^{14}C in CO_2 derived from the degradation of peat is approximately 74 pMC. The percent contribution from petroleum hydrocarbon degradation is then expressed as:

$100 - \frac{100 \text{ x } 14 \text{ pMC (sample result)}}{74 \text{ pMC (contribution from peat)}}$ = 81% (from petroleum hydrocarbons)

The results of this analysis therefore demonstrates that the percent of the carbon dioxide recovered that may be directly attributed to the VES system operation is approximately 81%; much greater than the 10% that had been conservatively assumed in previous reports.

Updated results are provided in Appendix K, which includes a table that tracks the total mass degraded in-situ by aerobic degradation based on updated isotopic analysis data. However, if the results of these isotopic samples of CO_2 from the VES system influent in the Second Quarter 2014 were applied to the entire quarter, a total of 80,125 lbs of VOCs were degraded in-situ as measured by CO_2 recovered. This yields another 13,516 gallons of LNAPL remediated in the Second Quarter 2014 by in-situ degradation calculated using the same LNAPL densities discussed in Section 6.3 above. This total is not being added to the total mass recovery by the VES system at this time, but is presented separately in Appendix K.

7. Investigation Derived Waste

The approach to management of investigation derived waste (IDW) was outlined in the Draft Waste Management Plan (WMP; PARS, January 2014) submitted to USACE on January 28, 2014. An updated WMP is currently under review by USACE. The WMP was developed to be a “living” document, such that IDW from each phase of work would be addressed in an addendum to the WMP.

The following IDW was removed from the Site during the Second Quarter of 2014:

- Two 10-yard roll-offs, one each on April 4, 2014 and June 19, 2014, containing sampling event tubing, PPE, and other disposable equipment
- 1,000 gallons liquid waste (purge water from sampling events)

Waste manifests are provided in Appendix M.

8. Summary

8.1 Conceptual Site Model

The following bullets summarize the observations obtained during the Second Quarter of 2014 in the context of the current CSM:

- Figures 1 and 2 present the potentiometric surface data for the shallow/intermediate and deep aquifer zones during the Second Quarter of 2014 gauging event. With the exception of changes resulting from lack of access to the Steen property, the surfaces do not differ greatly from those published in previous quarterly progress reports. Regionally, horizontal gradients within each aquifer zone are oriented south to southeast. However, each shallow/intermediate aquifer map has revealed an elongated east-west oriented “trough” feature in the potentiometric surface beneath the midsection of the Site. This feature appears to be a persistent, localized zone of depressed groundwater elevations that differs from the regional pattern of groundwater flow.

- Vertical gradients, as measured by well pairs within and proximal to the “trough” are predominantly indicative of downward groundwater flow. This has been a constant observation across data from past quarterly gauging events.

- The “trough” approximately coincides spatially with the limits of the interpreted “breach” described as a geologic feature that allows hydraulic connection between the shallow/intermediate aquifer units and the underlying Cretaceous aquifer units.

- Figure 3 indicates the extent of measureable LNAPL in Site wells during the Second Quarter of 2014 gauging event. Viewed in context with previously published Site LNAPL thickness maps, Figure 3 reveals that the horizontal extent of Site LNAPL is generally constant through time, and is generally confined to the area of the “trough” above the “breach” mentioned above. A consistently observed downward gradient in that area, along with buoyant forces, have trapped LNAPL in the “trough” above the “breach.”

- As shown on Figures 4-9, the highest concentrations of PADEP Short List COC in the shallow/intermediate aquifer zones are generally observed in the center of the Site, coinciding with the location of the “trough/breach” and region of measureable LNAPL.

- In the deep aquifer zone, as shown in Figures 10-11, the well with the highest VOC COC concentration was found within the “breach.” The well with the second highest concentration was found south of the “breach.”

- MTBE and TBA Observations

  - As shown on Figures 12-13, TBA detections were reported in the shallow, intermediate, and deep aquifer zones more frequently than were MTBE detections, indicating that MTBE is likely degrading via anaerobic pathways. The spatial distribution of these detections is generally confined to the "trough/breach," but some notable differences are observed.

  - The locations of highest TBA detections are situated within the central and western sides of the Site between the PHA and Steen properties. While these areas are still within the approximate limits of the "trough/breach," they do not always coincide with areas of measureable LNAPL thickness, as shown on Figure 3.

  - MTBE detections were reported predominantly in the western and, to a lesser degree, central portions of the Site, as shown in Figures 12-13. Three of these detections in the shallow/intermediate zone and two in the deep zone do not coincide with TBA detections, and occur along the western and central portions of the Site.

- As shown on Figure 14-15, the majority of shallow/intermediate arsenic detections and MSC exceedances are generally located within the approximate limits of the "trough/breach," in the area of measureable LNAPL where anaerobic conditions predominate. However, some of the shallow/intermediate lead detections and MSC exceedances occur outside of the "trough/breach," and are found within the northwestern portion of the Site.

- On Figure 16, data reveal limited arsenic and lead impacts in the deep aquifer zone.

8.2 VES System Operation and Maintenance

The total LNAPL recovered from the start of LNAPL recovery operations in 1996 through the First Quarter 2014 was 1,023,322 gallons. During the Second Quarter of 2014, an additional 2,763 gallons of LNAPL was recovered by the VES system, and 328 gallons were recovered by the DSCP fixed skimming system, yielding a total of 3,091 gallons of LNAPL for the quarter. The following table illustrates the LNAPL recovered in gallons during the Fourth Quarter of 2013 and the Second Quarter of 2014.

Recovery System	Current Quarter LNAPL Recovered (Gallons)	Previous Quarter LNAPL Recovered (Gallons)	Change in LNAPL Recovered (Gallons)
Former DSCP Fixed System	328	60	268
Modular Units	0	0	0
Passyunk Homes System	0	0	0
VES System	2,763	1,359	1,131
Total	**3,091**	**1,419**	**1,672**

The above total mass recovered during the Second Quarter 2014 does not include the mass degraded by In-Situ biodegradation as measured by CO_2 recovered by the VES system and calculated based on Isotopic sampling of the VES system influent. As discussed in Section 6.4, the mass degraded In-Situ during the quarter equates to another 13,516 gallons of LNAPL remediated by the VES system via in-situ biodegradation.

The total cumulative LNAPL recovery through the end of the Second Quarter of 2014 is shown below. Total cumulative data shown is the sum of the recovery from the Fourth Quarter 2011 through the Second Quarter of 2014, added to the total cumulative LNAPL recovered as previously reported by TtEC in the Third Quarter of 2011 Progress Report. The cumulative recovery of LNAPL since the start of LNAPL recovery operations in 1996 through the end of the end of the Second Quarter of 2014 is now 1,026,413 gallons.

System	System Description	Dates	Gallons
Army Corps of Engineers	This value has been reported by the United States Army Corps of Engineers as the total removed during their initial recovery efforts at the Former DSCP.	1996 – 1999	153,350
Former Internal Combustion Engine	An internal combustion engine was used to perform a pilot test of vacuum enhanced skimming. This number represents the calculated volume of LNAPL removed as vapors from this event.	2002 – 2003	2,840
Former DSCP System	This value represents the volume of LNAPL removed utilizing the recovery system on the Former DSCP Property. See Section 5.1 for system details.	1999 - Current	508,456
Former Passyunk Homes System	This value represents the volume of product removed utilizing the recovery system on the Former Passyunk Homes Property. See Section 5.1 for system details.	1999 – Current	167,558
Mobile Units	This value represents the total volume of product removed utilizing the mobile recovery systems. See Section 5.2 for system details.	1999 – Current	136,427
VES System	The calculated volume of LNAPL removed as vapors from the existing VES system. See Section 6.3.	2005 – Current	57,672
VTE Testing	Estimated amount of liquid LNAPL Recovered during VTE testing.	June 2012	110
TOTAL		**1,026,413 Gallons**	

The results of remediation O&M and optimization testing conducted to date are summarized as follows:

- The majority of the mobile LNAPL (or LNAPL available for recovery) has been removed from the Site. However, petroleum mass is still available for recovery in the vapor phase. By increasing the vacuum on the VES system recovery wells, an increase of mass recovery has been observed, provided that the water table isn't mounded to the point where it obstructs the screens, or high due to excessive precipitation. Optimization testing also showed that some VES system recovery wells will not produce high mass recovery rates in the vapor phase, most likely due to submerged well screens or fouling issues.

- Optimization testing also showed that a "pulsing" operational strategy can increase recovery of LNAPL in the liquid phase by the skimmer pumps. To achieve the benefit of a pulsing remediation strategy and maintain high mass recovery, a strategy of operating a primary group of wells and rotating groups of secondary wells has been employed.

- An optimization test using a pump controller similar to those employed on the mobile units is being tested on recovery well RW-A, and is thus far yielding promising results. The controller may allow the skimmer to pump more LNAPL over time by not pumping all of the LNAPL out of the well (and thereby not cutting off the well from the LNAPL in the formation). This strategy also should prevent the skimmers from pumping water into the storage tanks as the pump frequency can be set such the pump only operates when its intake is fully immersed in LNAPL.

- This optimized operational strategy for the fixed skimming systems, appears to have contributed to a significant increase in the amount of LNAPL recovered by skimming from the Third Quarter 2012 through the First Quarter 2014. LNAPL recovery is lower in the Second Quarter 2014 due to high groundwater levels. However, even with this increase in the LNAPL recovery by skimming, a greater volume of mass can be recovered in the vapor phase than by skimming alone.

- The VES optimization efforts applied to the VES system have been successful. The mass recovered by the optimized VES system since the Fourth Quarter 2011 is more than five times the total mass recovered by the VES system since its start-up in 2005 through the end of the Fourth Quarter of 2011.

- In the Second Quarter of 2014, VES mass recovery was more than the previous quarter, and remains significantly higher than the average observed mass recovery prior to commencement of optimization efforts in the Fourth Quarter of 2011. High precipitation during the winter months has caused an increasing trend in the groundwater level from February 2014 through early May of 2014. This higher groundwater table has reduced the length of unsubmerged well screen available for vacuum extraction in the recovery wells. This reduction in the screen available for vacuum extraction has resulted in lower mass recovery during the first part of the quarter. Mass recovery did rebound after the temporary rise in groundwater level subsided in the Second Quarter 2014. The overall mass recovery was higher for the Second Quarter 2014 as a result.

- If high groundwater levels return, an intermittent or pulsed operational strategy may need to be implemented, where the VES system is operated for a few days a week, then is shut off to concentrate on skimming for the remainder of the week. Alternately, specific sets of wells may continue to be operated at lower vacuum to reduce mounding of the groundwater in VES system wells. Either of these strategies will allow the VES system to continue to recover LNAPL as vapor, while maximizing LNAPL recovery by skimming during periods of high groundwater level.

- In general, the high levels of CO_2 in the vapor stream of the VES system during the optimization testing indicate that in-situ degradation of petroleum hydrocarbon is actively occurring in the shallow aquifer. However, the presence of CH_4 and lack of O_2 in the vapor stream indicate that this process is largely anaerobic and that aerobic degradation (the faster of the two processes) is O_2 limited. As a result, the testing suggests that the Former DSCP Site may be amenable to a future bioventing / air injection strategy which can accelerate the process of in-situ degradation by providing O_2 to the subsurface.

- The optimization testing has suggested that a bioventing / air injection strategy would be best utilized in the fringes of the impacted area, and where the LNAPL is less degraded. The results of the LNAPL fingerprinting analysis suggests that the areas of the Site near RW-A and RW-2 are potential locations where bioventing may be implemented in the future.

- The result of the isotopic analysis of CO_2 from the VES system influent vapor conducted during the Second Quarter 2014 demonstrates that approximately 81% of the CO_2 may be directly attributed to the VES system operation. If the results of these isotopic samples of CO_2 from the VES system influent in the Second Quarter 2014 were applied to the entire quarter, a total of 80,125 lbs of VOCs would have been degraded in-situ as calculated from measured CO_2. This yields another 13,516 gallons of LNAPL remediated in the Second Quarter 2014 by in-situ degradation. The results of upcoming isotopic samples will be provided in subsequent quarterly reports.

The evaluation of these optimization testing activities is ongoing into the Third Quarter of 2014; the results of the testing will be provided to PADEP in the quarterly reports.

9. Future Activities

The following are a list of projected tentative activities planned or are under consideration for the Third Quarter of 2014. These include:

- Conducting a groundwater gauging and sampling event in August 2014.
- Installation of replacement VES system wells at select locations on the PHA property to improve recovery by utilizing wells with screened intervals above the water table.
- Evaluation, design, and construction of a bioventing system, based on a Basis of Design report and accompanying optimization test results (ARCADIS 2013). Findings will also support the future evaluation of the Former DSCP Site with regard to Act 2-based cleanup criteria.
- Continued evaluation of data from direct push/direct sensing activities. Data from these activities will be used to further enhance the CSM, specifically the extent of the “breach,” its impact on petroleum hydrocarbon distribution, and the pursuit of cleanup goals under Act 2.
- Continuation of soil gas/VES system vapor influent isotopic sampling from wells and the VES system that commenced in the Third Quarter 2013.

- Continued evaluation of groundwater COC concentration trends, especially in the wells that appear to show decreasing trends. These trends may be viewed in the context of areas of measureable LNAPL thickness, and also in the context of VES system operation. The purpose of evaluating COC data trends within wells that consistently show measureable LNAPL is to gather statistical and scientific evidence for the stability of Site LNAPL such that closure under an Act 2 SSS approach for the shallow aquifer could be pursued.

- Implementation of an intermittent or pulsed operational strategy where the VES system is operated for a few days a week, then is shut off to concentrate on skimming for the remainder of the week. This strategy will be implemented only when groundwater levels are too high to allow the VES system to operate without mounding the water so highly that the screens are submerged. Alternately, specific sets of wells may continue to be operated at lower vacuum to reduce mounding of the groundwater in VES system wells. Either of these strategies will allow the VES system to continue to recover LNAPL as vapor, while maximizing LNAPL recovery by skimming during periods of high groundwater level.

Finally, and as discussed with the PADEP during the meetings held on January 19 and March 13, 2012 and March 6, 2013, the overall goal of the ongoing optimization testing and related activities described above is to improve LNAPL remediation at the Former DSCP Site. As lessons are learned, data will continue to be applied and remediation O&M procedures modified as feasible using existing Site remediation infrastructure.