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Second Quarter 2013 Report for the Former Defense Supply Center Philadelphia Facility Philadelphia, PA

July 31, 2013

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Second Quarter 2013 Progress Report for the Former Defense Supply Center Philadelphia Facility Philadelphia, PA

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

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1. Executive Summary

This Second Quarter 2013 Progress Report (Progress Report) for the Former Defense Supply Center Philadelphia (DSCP) Site presents 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 2013. 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 2013, vapor phase petroleum hydrocarbon mass and LNAPL recovery continued via vacuum enhanced skimming (VES). A total of 9,429 gallons were recovered. 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 of influent summa canister TO-15 samples were evaluated.

Additional activities designed to enhance the Site conceptual model (SCM) and/or operation and control of the Site’s remediation systems were also conducted. These included a liquid level gauging event, and a 24-hour constant-rate pumping test (i.e., aquifer test). Details on the aquifer test, including test procedures and preliminary findings are provided in this report. Further analysis of test data in the context of the SCM and with an emphasis on possible future changes to the Site remediation approach, will be provided in future Administrative Order and/or Act 2-required reports.

As discussed in previous reports, LNAPL recovery at the Former DSCP Site 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 recoverable LNAPL decreased. For example, the reported quarterly LNAPL recovery total for the 4th quarter of 1999 was 155,938 gallons whereas the reported total for the 2nd quarter of 2005 was 5,244 gallons. The 2005 addition of a VES system, which combined petroleum hydrocarbon vapor recovery with LNAPL recovery, temporarily halted this trend. The reported quarterly LNAPL recovery total following startup of the VES system, which is also the highest recovery rate observed through the end of calendar year 2006 was 17,624 gallons. By the end of 2006, the rate of LNAPL recovery began to define a generally decreasing trend which continued through the Third Quarter of 2011 when only 704 gallons were recovered for the quarter.

Relatively high groundwater elevations within the Site's water table aquifer system continue to submerge petroleum hydrocarbon mass and limit the open interval of Site recovery wells. As such, LNAPL and hydrocarbon vapor recovery rates at the Site continue to be restricted with respect to historic levels. However, as a result of the remediation system optimization efforts that commenced during the Fourth Quarter of 2011, the mass of petroleum hydrocarbons recovered as vapor since the Fourth Quarter of 2011 is now more than four times the previous total mass recovered since the startup of the VES system in 2005 (e.g., 45,225 gallons from the Fourth Quarter 2011 to date versus 10,038 gallons from 2005 through the Third Quarter 2011). During the Second Quarter of 2013, 1,678 gallons of LNAPL were recovered by the fixed-skimming system, an additional 7,718 gallons of LNAPL (as vapor) were recovered by the VES system, and 33 gallons were recovered by the modular (mobile) skimming system for a total recovery of 9,429 gallons for the quarter. The new cumulative recovery of LNAPL as of June 30, 2013 is now 1,015,943 gallons.

This Progress Report documents the state of the Site remediation optimization and Act 2 path-to-closure work conducted during the Second Quarter of 2013. 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 seasonally elevated groundwater levels, and the resulting submerged LNAPL beneath the water table aquifer in portions of the Site.

Additional data needs remain however, specifically on the nature of groundwater flow and petroleum hydrocarbon contaminant transport within the contiguous aquifer systems beneath the Site and the adjacent former Sun Oil Company (Sunoco) 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 the shallow aquifer zone, and a similar SSS approach for the deep aquifer zone. Pursuit of a background standard approach as defined under Act 2 is also a potentially viable option. Data reported in this and prior reports since October 2011 continue to support pursuit of these potential cleanup goals.

In addition to the summary of Second Quarter 2013 activities completed, this report also presents activities tentatively planned for the Third Quarter of CY 2013. 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 four restaurants.

A new Philadelphia Housing Authority (PHA) building was constructed to house the PHA's maintenance operations 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 neighborhood is called Siena Place. The former Sunoco refinery is located to the west of the Site, across a section of I-76 and 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 reside in the shallow (i.e., water table) aquifer at the Site. The area impacted by LNAPL has been investigated by 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 2013. 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 conducted on June 18-20, 2013;

- A 24-hour constant-rate pumping test was conducted on recently installed DSCP-MW-65 to estimate hydraulic conductivity of the upper-water bearing zone and to evaluate well yield and efficiency. The pumping test was conducted at a rate of 25 gallons per minute (gpm) between April 24^{th} and April 25^{th}, 2013;

- 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. Vapor measurements were collected on April 29, May 13, and June 4, 2013 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. 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. Readings ranged from 0.0 parts per million (ppm) to 24.3 ppm and 0% LEL to 12% LEL. 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 49.9 ppm: 19th and Moyamensing East, 19th and Moyamensing West, and Pollock and Moyamensing.

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 observations and are believed to be affected by localized wind and or other weather phenomena.

4. Liquid Level Gauging

Site-wide liquid level gauging was conducted during the Second Quarter of 2013. Like previous gauging events, and as required by the Order, all accessible wells within the Site's monitoring and recovery well network work were included in these events.

The VES system and pneumatic skimming system recovery wells were deactivated on June 12, 2013, such that on June 18-20, 2013 liquid level gauging data from the Site's monitoring and recovery well network could be collected. Table 2 contains the gauging event data. Hydrographs for Site monitoring wells selected previously for long term groundwater elevation trend monitoring have been updated accordingly. These hydrographs are included as Appendix A (for MW-29, MW-32, MW-36, PH-14, PH-15, PH-18, and PH-20). With the exception of wells PH-15 and MW-35, the hydrographs show groundwater levels during the gauging event to have been at the low end of an approximately eight year long span of tightly constrained oscillating groundwater elevations, with the most recent Second Quarter 2013 data showing the beginning of the upward trending portion of the oscillation. With amplitude of approximately two feet, these oscillations were generally concurrent between wells and site-wide. The low end of this range continues to be above (i.e., approximately two feet) the drought - indicative groundwater elevations reported from late 2001 to the beginning of 2003.

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), and the CSX property. Access to the Steen property and the SEPTA property were denied by the respective property owners prior to the June 2013 gauging event. Therefore, the monitoring wells present on the Steen and SEPTA properties were not gauged and have not been included in the potentiometric surface maps described below. Access to the STEEN wells was last available during Third Quarter 2012 gauging event. Access to the SEPTA wells was last available during the First Quarter 2013 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 for the shallow and deep aquifers (Figures 1 and 2, respectively) 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-rich units and/or the presence of extensive paved areas of the Site appear to impede infiltration of precipitation. 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 potential leakage from the numerous sanitary and/or storm sewer laterals that underlie the Site. Anomalous elevation heads were measured in the wells listed below. The monitoring wells excluded from the shallow aquifer zone potentiometric map include DSCP-PREPACK-02, PH-MW-37, PH-MW-57, PH-RW-A, PH-RW-I, PH-RW-S, PH-RW-T, and PH-RW-V.

As described above, the access agreement to the Steen property, located southwest of the Site, 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. All contours in this area have been inferred.

The access agreement to the SEPTA property has lapsed, therefore access to the SEPTA property was denied for this gauging event. Monitoring wells present on the SEPTA property were not gauged and have not been included in the contours shown in Figure 1.

A few well screens were submerged at the time of the gauging event. Groundwater elevations for wells with submerged screens, including DSCP-MW-5, DSCP-MW-11, DSCP-MW-31, DSCP-MW-34, DSCP-MW-59, EPH-MWS-5, EPH-PH-5, PH-MWS-4, PH-PH-6, PH-RW-N, and PH-RW-V, have been excluded from the shallow aquifer/water table potentiometric surface map. Exclusion of these wells, and the wells described above, do not materially affect the interpretation of the potentiometric surface for the gauging event. The deep and intermediate zone wells were also excluded from Figure 1 because these wells are interpreted to be screened in hydrostratigraphic units below the shallow/water table aquifer.

Figure 1 shows the shallow/water table aquifer groundwater gradient at the site to be oriented in a largely north-northwesterly to south-southeasterly direction, starting near CSX-MW-1 at an elevation of 8.33 above mean sea level (AMSL) to PH-MSW-15 at 0.94 AMSL. A separate and distinct potentiometric high with a largely opposing gradient is noticeable in the southeastern portion of the Site. The high points are located at EPH-MWS-10 at 3.71 AMSL and EPH-PH-7 at 3.26 AMSL. The potentiometric surface slopes from these points westward towards EPH-PH-5 (0.65 AMSL), northwest towards EPH-MW-48 (0.89 AMSL), and northeast towards SEPTA-PH-8 (0.17 AMSL). A roughly east-west linear feature is observed, consisting of smaller regions of potentiometric highs and lows surrounded by an area of generally low groundwater elevation. This feature is shown on Figure 1, bound by the striped lines that indicate the limits of the “breach,” as described in prior reports as a geologic feature that allows hydraulic connection between the shallow aquifer units and the underlying Cretaceous aquifer units[1].

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

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

direction generally concordant with the dip azimuth of the deep aquifer zone's hydrostratigraphic units. Figure 2 shows a noticeably different potentiometric pattern and a gradient oriented in a more south direction. This apparent flow direction shift is likely due to the lack of Steen property monitoring well gauging data rather than an actual flow direction change. Figure 2 has inferred Steen property data. Changes in deep aquifer zone groundwater gradients are observed through comparison of the Second Quarter 2013 data with existing First Quarter 2013 and Fourth Quarter 2012 data. While the direction remains consistently to the south and southeast, the slope of the deep aquifer potentiometric surface varies across these datasets. These variations are assumed to be seasonally-induced.

Intermediate wells are screened in a zone reportedly distinct from the deep aquifer zone, and some intermediate wells have a head difference of more than a foot when compared to the deep wells. Thus, intermediate wells are not included in the deep well potentiometric surface map (Figure 2). Measured groundwater elevations are shown in Table 2.

Vertical gradients (i.e., head potentials) between the shallow and deep aquifer zone for well gauging events 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 DSCP-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.

With the exception of one location, vertical gradients during the Second Quarter 2013 well gauging event was found to be indicative of a broad downward groundwater flow potential throughout the general midsection of the Site. Monitoring wells PH-DW-10 and PH-MWS-1 comprised the only well pair to exhibit an upward gradient during the Second Quarter 2013 gauging event. Aside from two separate instances of upward groundwater flow (DSCP-DW-6 and DSCP-MW-2B in December 2012 and DSCP-DW-13 and DSCP-MW-11 in May 2012); this is also the only well pair to show an upward gradient in more recent gauging events. This well pair is located on the southwestern edge of the site, outside of the Site's primary LNAPL and dissolved-phase petroleum hydrocarbon constituent of concern (COC) impact areas. The balance of the wells, those with downward potentials, are generally located near or directly below the Site's primary LNAPL and COC impact areas. These wells are generally coincident with the approximate reported extent of a "breach" in the base of the Site's shallow aquifer zone (as previously described).

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. 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 fingerprinting data), 2) hydrogeologic characteristics (e.g. stratigraphic soil types over the screened interval of a given well and characteristics of a well), 3) well construction, 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. 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 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.

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

5. Liquid Levels and the Packer Avenue Sewer

During the Second Quarter of 2013, and consistent with previous observations, measureable LNAPL was not observed in the monitoring wells located south of the Packer Avenue sewer. Appendix B 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.

6. Aquifer Testing Activities

The First Quarter 2013 report outlined the installation of monitoring well DSCP-MW-65, for the purpose of conducting an aquifer test within the Site's shallow aquifer zone. The planned 24-hour constant-rate pumping test (i.e., aquifer test) would allow for the estimation of hydraulic conductivity of the upper-water bearing (shallow aquifer) zone and the yield and efficiency of a pumping well located within the "breach" as previously described.

Well DSCP-MW-65 was constructed on January 14, 2013 with 4-inch, schedule-40 PVC casing and screen within an 8-½-inch borehole drilled using hollow stem auger drilling techniques. The well is screened between 15 and 45 feet below ground surface (bgs) with 0.020-inch machine milled slots. Filter pack materials surrounding the well screen are #3 washed and graded Monterey-type silica sand sealed below approximately 2-feet of hydrated bentonite chips. Well development activities included pre-swabbing during filter-pack placement to ensure no bridging occurred, followed by pumping with a 3-inch electric submersible pump throughout the screened section at a rate of approximately 15 gpm until turbidity was minimized.

The well screen is positioned within both the Trenton Gravel and the Farrington Sand formations beneath the Site with approximately 20 feet of screen within the Trenton Gravel, and the remaining 10 feet in the underlying Farrington Sand. Between these formations, and at a depth of approximately 35 feet below ground surface, the presence of a thin (approximately two feet thick) silty sand to sandy clay-rich unit was interpreted from direct push borings installed proximal to MW-65 in September 2012 (MiHPT-10 and MiHPT-13). The interpreted presence of this unit is based on the response of the electrical conductivity and hydraulic profiling tools deployed during the course of the Fall 2012 direct push investigation. Boring logs for the monitoring wells (MW-30, -31 and -32) and recovery well (RW-1A) used for aquifer test water level monitoring suggest the presence of a sandy silt to silt-rich unit at approximately the same depth interval, and as such are interpreted to be farther out into the "breach" and in an area of greater vertical hydraulic connection, than MiHPT-10 and MiHPT-13. As indicated on Figures 1, 2 and 3, MW-65 and the surrounding recovery and shallow aquifer zone monitoring wells used for the collection of pumping test data (see Appendix C) collectively lie within the "breach", the area of the Site where the

Cretaceous clay-rich unit located at the base of the Site's shallow aquifer zone is thin to absent.

Of particular importance is the designation of the Trenton Gravel itself; while there are significant amounts of gravel within the formation, there are appreciable fines and iron-oxide cementation. These characteristics lead to a formation that generally yields less water than would be expected from a "gravel", and when coupled with the effects of partial well penetration (i.e., through the aforementioned silt to clay-rich unit and into the underlying Farrington Sand), has a significant effect on the apparent well efficiency and estimated transmissivity values.

The pumping test was conducted at a rate of 25 gpm between April 24th and April 25th, 2013. With no prior pumping tests of similar duration having been identified in Site literature, and with little site specific aquifer data available (e.g. hydraulic conductivity), the goals of the pumping test were to provide data for the continued evaluation of: 1) ongoing Site remediation practices and procedures (VES system operation and LNAPL skimming), 2) possible future remediation system enhancements, and 3) the Site groundwater flow models developed by Todd Kinkaid (Geohydros, LLC), Ron Sloto (USGS) and Robert Prucha (Integrated Hydro Systems, LLC). The use of pumping test data in support of the ongoing evaluation of the aforementioned groundwater flow models was discussed during the March 6, 2013 meeting with representatives from the PADEP, DLA, USACE, ARCADIS and Pars, Inc. Evaluation results will be the topic of a future meeting with the PADEP and will be provided in a future Order-required report.

Pumping was achieved using a Grundfos Model 22SQ 15C-220 electric submersible pump attached to 1-inch poly discharge tubing. The pump inlet was positioned at approximately 35 feet bgs (i.e., 10 feet from the bottom of the well) providing 15 feet of available drawdown. Pumped water from the well was containerized on site in two 21,000-gallon storage tanks and removed for treatment after the conclusion of the pumping test, as described below in Section 8.

Groundwater levels at DSCP-MW-65 and 4 observation wells (MW-31, RW-1A, Prepack-02 and MW-32; Figure C-1 in Appendix C) were measured manually with an interface probe and electronically using pre-programmed submerged pressure transducers. The submersible pressure transducers were Solinst Levelogger Gold® models specifically designed to measure water levels within water columns of less than 50 feet. The submerged pressure transducers were deployed approximately 1 week prior to the start of the pumping test to record background, pre-pumping groundwater levels at the Former DSCP Site so that any trends not related to pumping could be identified. To correct for barometric pressure and evaluate the local aquifer's response to changes in barometric pressure, one transducer was deployed above the water table.

6.1 Background Water Levels

Pre-pumping (background) groundwater levels were monitored beginning on April 15, 2013 and continued until pumping commenced on April 24, 2013 (Figure C-2 in Appendix C). Background water levels were recorded with pre-programmed pressure transducers submerged below the water table. The pressure transducers were programmed to collect pressure readings at an interval of once per minute. Transducer data were barometrically compensated using barometric data collected with a pressure transducer deployed above the water table at the Former DSCP Site, and Solinst's Levelogger 4.0.3 software.

The results of the background water level monitoring are presented graphically in Figure C-2. Minor fluctuations in groundwater levels were observed during the background monitoring period. The largest change in water level was observed at MW-31 on April 20, 2013. This change was not observed in other wells being monitored on this day and does not appear to have impacted the results of the pumping test. Background water levels monitored at RW-1A illustrate the operation of the existing VES system at the Site until the system was shut down on April 16, 2013. The graph of background water levels also illustrates the shallow aquifer's response to barometric pressure. As shown in Figure C-2, groundwater levels at the Site share an indirect relationship with barometric pressure and responses to changes in barometric pressure occur relatively quickly.

6.2 Pumping Water Levels

Drawdown in wells monitored during the 24-hour pumping test ranged from approximately 11 feet in the pumping well (DSCP-MW-65) to approximately 0.2 feet in Prepack-02 (Figure C-3). Atmospheric pressure logging at the Site indicates a high pressure weather pattern moved through the region during the course of the pumping test. The barometric pressure change occurred at approximately 600 minutes into the pumping test (Figure C-3 of Appendix C), and receded for the duration of the test. The effect of barometric pressure on water levels was observed as a transient increase in water levels at the 600 minute mark of the pumping test. In wells MW-31, RW-1A and Prepack-02 the pressure effect was great enough to counter the effects of pumping on drawdown, resulting in rising water levels near the latter portion of the pumping test (time greater than 600 minutes since pumping began).

Water level data collected from monitoring well MW-32 during pumping indicates this well was likely outside the radius of pumping influence during at least the early portion of the test. It is difficult to ascertain based on the water level data collected during the pumping test whether groundwater in MW-32 became influenced by pumping at DSCP-MW-65. Figure C-4 suggests the radius of pumping influence during the test probably does not extend much beyond 100 feet from the pumping well. MW-32 is approximately 220 feet from pumping well DSCP-MW-32. Prepack-02 is the second farthest monitoring well location from the pumping well (approximately 94 feet). Although pumping-induced drawdown was observed at Prepack-02 in the early stages of the pumping test (less than 100 minutes into the test), the barometric pressure effects offset the drawdown caused by pumping. The closest monitoring well to the pumping well was MW-31, which is approximately 30 feet from the pumping well. Drawdown in MW-31 was observed within approximately 20 minutes from the time pumping started. As shown in Figure C-3, drawdown at MW-31 remained consistent until approximately 350 minutes since pumping began. At approximately this time, drawdown caused by pumping was offset by the regional barometric pressure changes.

6.3 Calculated Average Transmissivities

Aquifer transmissivity values were calculated using the Cooper-Jacob method applied to drawdown data obtained from observation wells. Several assumptions are made when using this analytical method to calculate aquifer parameters, many of which are seldom realized during an actual test. Of the more important assumptions, and those that are most applicable to the Site, are: 1) that the aquifer being tested is assumed to be of infinite areal extent, 2) the pumping well fully penetrates the entire aquifer thickness, 3) the saturated thickness of the aquifer remains constant throughout the test, and 4) the pumping well is 100-percent efficient.

From previous work, it is known that the aquifer system in the vicinity of the pumping test lies within a highly stratified geologic framework. Proximal to the pumping test area, the system likely consists of a filled fluvial channel that cross-cuts underlying clay and sand units and has significant lateral and vertical non-homogeneity (i.e., the “breach”). Based on this hypothesis, the pumping well’s screen straddles the Trenton and Farrington Formations and partially penetrates the underlying Farrington. Due to the generally unconfined nature of the shallow (Trenton Gravel) aquifer system, aquifer saturated thickness will decrease with time with continued pumping decreasing the well's specific capacity. Finally, no well is 100-percent efficient, and there are varying methods for calculating that inefficiency. However, recognition of these departures helps define the limitations of the data set and provides a proper framework within which the data can be used to support conceptual site model (CSM) development.

The barometric influence on drawdown at MW-31, RW-1A and Prepack-02 was accounted for by subtracting the water level changes in MW-32 from the observed water levels in each of these wells. Water levels at MW-32 are interpreted to have been caused by barometric pressure, not pumping. This correction produces data with less fluctuation in drawdown, particularly in the early time data which is used for the calculation of aquifer transmissivity.

As shown in Figures C-5, C-6 and C-7 in Appendix C, time-drawdown analyses produced calculated average transmissivity values for MW-31, RW-1A and Prepack-02 are 2,200 ft^2/day, 5,900 ft^2/day, and 4,000 ft^2/day, respectively. Aquifer transmissivity was also calculated using a distance drawdown analysis – the distance drawdown method indicates a transmissivity value of 5,100 ft^2/day (Figure C-5 in Appendix C). Aquifer storativity values were calculated using the transmissivity values for MW-31, RW-1A and Prepack-02. Both transmissivity and storativity values are shown in Figures C-5 through C-7 in Appendix C.

The individual effect on transmissivity and storativity of the two screened geologic formations cannot be evaluated individually due to the position of the screened interval. Therefore, the results of this pumping test are interpreted to represent aggregate hydraulic properties of both the Trenton Gravel and Farrington Sand. In reality, the transmissivity values of the Trenton may be lower than calculated while the Farrington may have a higher value than calculated. These calculated values also may not be indicative of aquifer properties at locations outside the radius of pumping influence created from this test, as the nature of the aquifer systems at the Site are spatially variable (i.e., pumping tests conducted at similar depths but in Site wells located outside the interpreted limits of the "breach" where the thickness of the clay-rich unit that separates the Site's shallow and deep aquifer zone is considerably greater (greater than 10 feet), would be expected to produce significantly different aquifer responses and test results.

6.4 Pumping Well Efficiency

The efficiency of a pumped well can in some cases be estimated from the distance drawdown plot (Figure C-4 in Appendix C). Using the observation well drawdown values, a straight line is extended through the drawdown values at each observation well, at a selected time during the test, back to a distance that represents the casing of the pumping well. The intersection of the extended line with the radius of the pumping well will show the theoretical drawdown for a 100-percent efficient well that fully penetrates a confined aquifer. Any difference between the actual (observed) drawdown and the theoretical drawdown is assumed to represent well inefficiency as measured as a percentage. This method, however, is valid only in a confined aquifer when the full thickness saturated thickness of the aquifer is screened. Analytical methods are available to account for partially penetrating wells and those screened in unconfined aquifers.

As shown in Figure C-4 of Appendix C, the well efficiency of DSCP-MW-65 was calculated using drawdown data from monitoring wells at the same time. The time selected for the distance drawdown graph in Figure C-4 of Appendix C was 1,000.9 minutes. At 1,000.9 minutes, the recorded drawdown in wells DSCP-MW-65, MW-31, RW-1A and Prepack-02 were 10.81 feet, 0.25 feet, 0.16 feet and 0.12 feet, respectively. The line through the drawdown values at the observation wells and extended back to the pumping well suggests that there should have only been 1.1 feet of drawdown in well MW-65, yielding a well efficiency value of only 10-percent (1.1'/10.81' x 100). However, as discussed above, some assumptions associated with this type of evaluation are not applicable (i.e., partially penetrating well and dewatering in the unconfined aquifer). The actual efficiency of MW-65 is likely much higher. While difficult to quantify in terms of additional drawdown, a partially penetrating well imparts greater head losses which manifest as additional observed drawdown in the pumped well. Similarly, dewatering in an unconfined aquifer will lead to Increased observed drawdown then leads to a lower calculated well efficiency.

One way to estimate a corrected theoretical drawdown in this case is to apply correction factors to the observed drawdown when aquifer dewatering occurs. Driscoll (1986)[2] lists an equation for corrected theoretical drawdown:

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[2] Driscoll, F.G., 1986, Groundwater and wells (2d ed.): St. Paul, Minnesota, Johnson Filtration Systems, Inc., 1089 p.

$s_t = s_a - (s_a^2/2b)$, where s_t is the theoretical drawdown, s_a is the actual measured drawdown, and b is the aquifer thickness.

Applying various aquifer thickness values based on the Trenton thickness (13’), the screen length (30’), and an estimated Farrington thickness (45’), and using the measured drawdown of 10.81’, theoretical drawdown values range from 6.32’ to 9.51’. Recalculating well efficiency now suggests that the well is between 58 and 82 percent efficient. Recognizing the geologic framework of the “breach” and depths to which well MW-65, and the preexisting test observations wells (MW-30, -31, -32 and RW-1A) were installed, the cross-screening of two formations with varying stratigraphic and hydraulic properties and partial well penetration likely account for the additional inefficiency calculated using data from this test.

6.5 Pumping Test Conclusions

Average calculated aquifer transmissivity and storativity values based on the 24-hour pumping test are 4,300 ft^2/day and 0.05, respectively. The results of this pumping test indicate a shallow cone of depression in the upper-water bearing zone due to pumping at 25 gpm. The zone of pumping influence did not extend beyond approximately 100 feet during a 24-hour pumping period. At a pumping rate of 25 gpm in Well DSCP-MW-65, there was little available drawdown remaining in the well after 24 hours; setting the pump lower would have afforded additional available drawdown. Partial aquifer penetration, screening across two aquifer units, and dewatering of the unconfined aquifer led to increased drawdown and lower estimated well efficiency values (as indicated above).

Late-time drawdown (greater than 400 minutes since pumping began) in wells MW-31, RW-1A and Prepack-02 was affected by a change in barometric pressure in the region. The barometric effect shares an indirect relationship with groundwater levels at the Site. As barometric pressure decreased during the pumping test, the subsequent rise in water levels offset the drawdown caused by pumping in observation wells MW-31, RW-1A and Prepack-02. The data collected during the 24-hour pumping test are useable for the purposes of estimating transmissivity, which was between 2,200 and 5,900 ft^2/day.

The results of this pumping test have been evaluated against original Site monitoring and recovery well boring and well construction logs that were not available to the project team during the planning and execution phases of the pumping test conducted in MW-65. Data from original Site well logs is currently being integrated with the direct push-direct sensing hydrogeological conceptual site model information that was presented during the March 6, 2013 meeting with the PADEP. Direct push-direct sensing investigations are currently ongoing at the Site, and additional investigations have been tentatively planned for Fall 2013 (e.g., at the Steen property and the SEPTA garage). Once complete, the results of the pumping test described herein, as well as the results of other ongoing Site activities (e.g. VES system O&M activities) will be re-evaluated in the context of the refined conceptual site model that is anticipated following stratigraphic data integration. The following preliminary conclusions can be drawn from the pumping test results:

- Based on the reported design of the Site's shallow aquifer zone monitoring and recovery wells, particularly for those wells located within the estimated limits of the "breach", if there is a future need to hydraulically evaluate each of the aquifer units on-site, existing wells should be "packed-off" or new wells should be screened fully across a single aquifer unit. The test data illustrated the inferred differences in aquifer properties between the Trenton Gravel and the Farrington Sand. Water levels can be lowered significantly with relatively low pumping rates in wells constructed as MW-65.

- To improve well design, it would be advantageous to collect soil samples during drilling for sieve analysis such that a distribution of grain size can be evaluated for enhanced filter pack and screen design. More rigorous well development, including swab, surge, and bailing techniques will improve hydraulic communication with the aquifer.

7. 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 D – 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 2013.

7.1 Fixed Skimming System – Second Quarter 2013

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, resulting in the overestimation 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 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 4 and 5 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 4 contains the LNAPL recovered for the Former DSCP system and Table 5 contains the LNAPL recovered for the Former Passyunk Homes system.

During the Second Quarter 2013, Former DSCP area fixed skimming system recovery well RW-9 recovered an estimated 1,061 gallons of LNAPL according to the totalizer in the recovery well vault (as shown in Table 4). While the totalizers provide an assessment of which recovery wells are recovering LNAPL, the tank chart is used to record the actual amount of LNAPL recovered. Based on volume-measuring probe data and resultant tank chart readings, the AST on the Former DSCP property received approximately 1,678 gallons of LNAPL during the quarter. This results in a total approximate volume of LNAPL recovered by the Former DSCP area fixed system of 507,442 gallons through the end of the Second Quarter 2013.

During the Second Quarter 2013, the Former Passyunk Homes property fixed skimming system recovery well RW-A recovered an estimated 20 gallons of LNAPL, and PH-20 recovered an estimated 24 gallons of LNAPL, according to the totalizers in each recovery well vault (as shown on Table 5). As discussed in previous quarterly reports, the fixed skimming system on the Former Passyunk Homes property was down through August 8, 2011 due to construction activities related to the new PHA building and replacement of the former LNAPL storage UST with an AST. As of the end of the Second Quarter 2013, no LNAPL has collected in the AST, as the LNAPL 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 2013.

Both fixed skimming systems were shut down from April 16, 2013 through April 26, 2013 for the aquifer testing activities and again from June 16, 2013 through June 20, 2013 for the quarterly groundwater gauging event. With the exception of these events, 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 apparent LNAPL thickness in the wells to prevent pumping groundwater along with the recovered LNAPL.

As discussed in previous quarterly reports, the low LNAPL recovery by skimmer pump from 2006 through the Second Quarter of 2012 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 advanced fouling in the well screens and sand pack, especially those wells being 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 which volatizes the lighter fraction of the LNAPL and leaving the less volatile, heavier, and more viscous fraction in place which can clog the soil pours in the formation adjacent to the recovery well over time. This fouling is likely limiting some of the transmissivity of these wells to LNAPL and reducing the rate of recovery as well.

For a complete site history, please see Appendix D – Site History. 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 7.3 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 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 as the effectiveness of the skimmer pumps is 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 7.3 below.

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 2013. As shown in Appendix E, the amount of LNAPL recovered by skimmer pumps on the Former DSCP property during the First Quarter of 2013 by skimming remains higher than at any time since the First Quarter 2009. Optimization efforts will continue into the Third Quarter 2013, the results of which will be discussed in future quarterly reports.

7.2 Modular Skimming System – Second Quarter 2013

A modular LNAPL recovery system is currently also operating on the Former DSCP property, at well MW-3A (installed October 25, 2004). The LNAPL recovery data for this modular system is included in Table 6. A graph showing the total LNAPL recovery per quarter over time by the modular systems is included in Appendix E.

The amount of LNAPL recovered by the modular system at MW-3A increased to a total of approximately 33 gallons 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 MW-3A. 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.

LNAPL recovery by the modular skimming system at MW-3A remains low as there is not much apparent recoverable LNAPL in this location. It is, however, the only location where recoverable LNAPL thickness exists in a well that is not already connected to the fixed skimming systems. The low level of effort afforded by the use of the modular skimming system is the only major reason why skimming has continued to be conducted in this location.

Evaluation of the feasibility of deploying modular units at other locations of the site is ongoing. Lacking LNAPL bearing wells outside of the reach of the VES system; it was not necessary or practical to utilize the modular (mobile) skimming systems at any location other than MW-3A during the Second Quarter of 2013.

7.3 VES System Operation and Optimization Second Quarter 2013

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. For a complete site history, please see Appendix D – 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 2013 with some minor changes to the subset of wells being used for continuous VES operation. Appendix F shows which VES system wells were operated during this quarter.

The subsets of the VES system wells in Appendix F have been grouped into primary, secondary and tertiary subsets of wells. In the current remedial strategy, only the primary recovery wells are utilized for continuous focused vacuum extraction due to consistent mass recovery yielded by these wells. These primary wells are only shut off briefly to periodically pump out the LNAPL that accumulates by skimmer pump. The secondary wells, which do not yield as much consistent mass recovery as the primary wells, are operated (in addition to the primary wells) in rotating groups of 3 to 5 wells. This strategy of operating groups of secondary wells periodically is done to generate the pulsing effect in portions of the plume, increasing the overall mass recovery as both LNAPL and extracted vapor. The VES system was operated during the Second Quarter of 2013 using the primary wells, secondary group 1 and tertiary wells RW-E and RW-W at an applied vacuum of between 20 to 30 iw. The remainder of the recovery wells were not used due to lower potential mass recovery rates, but are checked periodically to determine if they should be added to the secondary well rotation to increase mass recovery on a temporary basis or if LNAPL is consistently present in these wells.

The VES system operated continuously with the exception of April 16, 2013 through April 26, 2013 for aquifer testing activities, June 12, 2013 through June 20, 2013 for the quarterly gauging event and June 24, 2013 through June 25, 2013 due to a combustion blower damper motor replacement. Mass recovery by vapor phase of the VES system is further presented in this section.

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 tends 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 2013, 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 1, 2013 – 90.15 g/mol
- May 7, 2013 – 92.03 g/mol
- June 27, 2013 – 88.94 g/mol

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

During the Second Quarter 2013, the VES system operated in optimized/focused-vacuum mode yielding an average mass recovery of 17.9 pounds/hour (lbs/hr). This represents an increase from the mass recovery rate observed during the First Quarter 2013 and is a function of the revised remedial strategy discussed above (i.e., application of focused vacuum over a greater number and varying combinations of recovery wells). Mass recovery remains higher utilizing the focused vacuum remedial strategy than it was prior to optimization. For a complete site history, please see Appendix D – Site History.

During the Second Quarter 2013, the average CH_4 (with carbon filter) was 7.5%, up from 2.3% in the previous quarter. The average CO_2 was 7.4%, up from 4.5% in the previous quarter, and the average O_2 was 7.8%, down from the 13.6% in the previous quarter. These changes are the result of modifications to the recovery wells being used for focused vacuum extraction during the reporting period (i.e., the primary and secondary groups of recovery wells).

Both thermal oxidizers (TX100 & TX200) can operate; however, only TX200 was used during the Second Quarter 2013. One thermal oxidizer was adequate to treat the vapor from the VES system during this time period. The second oxidizer, TX100 was maintained on standby in the event of a problem with TX200.

The overall VOC recovery rate for the VES system from April 1, 2013 through June 30, 2013 was 44,515 pounds which correlates to approximately 7,718 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. The 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 2013:

- 5.98 lbs/gallon on April 1, 2013
- 5.89 lbs/gallon on May 7, 2013
- 5.90 lbs/gallon on June 27, 2013

A graph showing the cumulative mass recovery of the VES system per quarter is included in Appendix E. As shown on this graph, the optimization efforts applied to the VES system since the Fourth Quarter 2011 have more than doubled the total mass recovered by the VES system since the start-up of the VES system in 2005. In the Second Quarter of 2013, VES mass recovery is higher than what was witnessed in the First Quarter of 2013, mainly due to changes to the primary and secondary well groups in use. The total mass recovered is lower than the all-time high in the Second Quarter of 2012 (when vacuum truck testing combined with lower groundwater levels lead to a spike in the mass recovery in that quarter) yet remains significantly higher than the average observed prior to the Fourth Quarter 2011 (prior to optimization). It is anticipated that the optimization efforts will maintain these higher mass recovery levels from the VES system.

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 amount of CO_2 captured. During VES system operation in the Second Quarter 2013, a total of 7,718 lbs of VOCs were degraded in-situ as measured by CO_2 recovered. This calculation is based on a conservative estimate of 10% of the CO_2 recovered being attributed directly to in-situ aerobic degradation of VOCs. This yields another 1,354 gallons of LNAPL removed in the Second Quarter 2013 by in-situ degradation. It is not clear how much of this CO_2 is being produced as a result in-situ degradation; therefore, this total is not added to the total mass recovery by the VES system at this time. However, isotopic analysis of CO_2 and CH_4 in VES system influent will begin in the Third Quarter 2013. This data will provide a more accurate "weighting" factor to convert CO_2 and CH_4 to lbs of hydrocarbon mass degraded in situ.

8. Investigation Derived Waste

The approach to management of investigation derived waste (IDW) was outlined in the Draft Waste Management Plan (WMP; PARS, 2012) submitted to USACE on August 21, 2012. 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.

IDW removed from the site during the Second Quarter 2013 consisted of the following:

- Approximately 39,350 gallons of aquifer testing purge water and water produced for cleaning the bulk storage tanks.

The bulk water was vacuumed from the bulk storage tanks removed from the Site between May 17, 2013 and June 1, 2013 by Lewis Environmental, Inc. and delivered to Monarch Environmental Recycling in Woodstown, NJ. All waste manifests are included in Appendix I.

9. Summary

The total LNAPL recovered from the start of LNAPL recovery operations in 1996 through the First Quarter 2013 was1,006,514 gallons. During the Second Quarter of 2013, an additional 7,718 gallons of LNAPL was recovered by the VES system, 1,678 gallons were recovered by the DSCP fixed skimming system and 33 gallons were recovered by the modular (mobile) skimming system, yielding a total of 9,429 gallons of LNAPL for the quarter. The following table illustrates the LNAPL recovered in gallons during the First and Second Quarters of 2013.

Recovery System	Current Quarter LNAPL Recovered (Gallons)	Previous Quarter LNAPL Recovered (Gallons)	Change in LNAPL Recovered (Gallons)
Former DSCP Fixed System	1,678	2,074	-400
Modular Units	33	17	+16
Passyunk Homes System	0	0	0
VES System	7,718	4,101	+3,617
Total	**9,429**	**6,192**	**+3,237**

The total cumulative LNAPL recovery through the end of the Second Quarter of 2013 is shown below. Total cumulative data shown is the sum of the recovery from the Fourth Quarter 2011 through the Second Quarter of 2013, 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 2013 is now 1,015,943 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	507,442
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	136,410
VES System	The calculated volume of LNAPL removed as vapors from the existing VES system. See sections 5.3 and 5.4	2005 – Current	48,233
VTE Testing	Estimated amount of liquid LNAPL Recovered during VTE testing.	June 2012	110
TOTAL		**1,015,943 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. 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.

- 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 Second Quarter 2013. However, even with this increase in the LNAPL recovery by skimming, it is likely that a greater volume of mass can be recovered in the vapor phase than by skimming with the current groundwater elevation.

- The VES optimization efforts applied to the VES system since the Fourth Quarter 2011 have more than doubled the mass recovered in the vapor phase since the start-up of the VES system in 2005.

- In the Second Quarter of 2013, VES mass recovery remained significantly higher than the average observed mass recovery prior to commencement of optimization efforts in the Fourth Quarter of 2011.

- 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 evaluation of these optimization testing activities is ongoing into the Third Quarter 2013, the results of the testing will be provided to PADEP in the quarterly reports.

10. Future Activities

The following are a list of projected tentative activities planned or are under consideration for the Third Quarter of 2013. These include:

- Conducting a groundwater gauging event in August 2013.

- Evaluation of bioventing and VES system optimization testing results in the context of the 24-hr pumping test data. These test findings may be used to modify existing remediation infrastructure and/or to enhance the conceptual site model. Findings will also support the future evaluation of the Former DSCP Site with regard to Act 2-based cleanup criteria.

- Performance of additional direct-push/direct-sensing activities. Data from these activities will be used to further enhance the conceptual site model, specifically the extent of the “breach,” its impact on petroleum hydrocarbon distribution, and the pursuit of cleanup goals under Act 2.

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.