2015 ANNUAL GROUNDWATER MONITORING REPORT

(JULY 2015 - JUNE 2016)

HAVERTOWN PCP SUPERFUND SITE
HAVERTOWN, HAVERTOWN TOWNSHIP,
DELAWARE COUNTY, PENNSYLVANIA

Contract No. SAP#4000019261
Task Order IRRSC7-1-303

JULY 2016

Pennsylvania Department of Environmental Protection
Hazardous Sites Cleanup Program
Southeast Regional Office
2 East Main Street
Norristown, Pennsylvania 19401

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Prepared for:

Pennsylvania Department of Environmental Protection
Hazardous Sites Cleanup Program
Southeast Regional Office
2 East Main Street
Norristown, Pennsylvania 19401

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ACRONYMS

ARAR	Applicable, Relevant, or Appropriate Requirement
bgs	Below Ground Surface
CCA	Chromium Copper Arsenate
COC	Contaminant of Concern
CTR	Collection Trench
CW	Cluster Well
CZA	Capture Zone Analyses
DEP	Pennsylvania Department of Environmental Protection
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency Region 3
ft	Feet
GES	Groundwater & Environmental Services, Inc.
gpm	Gallons per Minute
HAV	Havertown Well
IW	Injection Well
J	Estimated Data Qualifier Value
lb	Pound
LTRA	Long Term Response Action
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mV	Millivolts
MW	Monitoring Well
NA	Not Available
ND	Non-Detect
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NW	National Wood (Preservers) Well
NWP	National Wood Preservers
O&M	Operation and Maintenance
ORP	Oxidation Reduction Potential
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	Polynuclear Aromatic Hydrocarbon
PCG	Philadelphia Chewing Gum Company
PCP	Pentachlorophenol
PCRR	Penn Central Railroad
PDU	Peroxide Destruction Unit
PE	Polyethylene

ACRONYMS (Continued)

Pg/L	Picogram per Liter
PZ	Piezometer
RA	Remedial Action
RAO	Remedial Action Objective
RD	Remedial Design
RG	Remediation Goal
ROD	Record of Decision
ROS	Recreation and Open Space
RR ROW	Railroad Right-of-Way
RW	Recovery Well
SAP	Sampling and Analysis Plan
SMCL	Secondary Maximum Contaminant Level
SVOC	Semi-Volatile Organic Compound
TCE	Trichloroethene
TEQ	Toxicity Equivalent Quotient
µg/L	Micrograms per Liter
U	Non-Detected Laboratory Value
USACE	U.S. Army Corps of Engineers
VOC	Volatile Organic Compound
YMCA	Young Men's Christian Association

1.0 INTRODUCTIONS

Tetra Tech, Inc. (Tetra Tech) was tasked by the Pennsylvania Department of Environmental Protection (DEP), under Contract Number SAP#4000019261, to perform operation and maintenance (O&M) services under Operable Unit 2 (OU-2) and OU-3 for the groundwater treatment facility at the Havertown PCP Superfund Site located in Haverford Township, Pennsylvania.

Activities performed for OU-2 O&M are to operate and maintain the groundwater treatment facility, optimize the facility's performance, perform all required monitoring (groundwater and surface water discharge) associated with this facility, and maintain the cap in accordance with the selected remedy and Remedial Action Objectives (RAOs). Activities conducted for OU-3 O&M are to contain the contaminated deep groundwater plume that is migrating from the site in conjunction with the OU-2 remedy, operate and maintain the OU-3 extraction and monitoring wells in the Recreation and Open Space (ROS) Area, maintain the ROS pumping system through the Railroad Right-of-Way (RR ROW), and operate the in-situ flushing system in conjunction with the OU-2 groundwater treatment system.

This report covers the groundwater monitoring period from July 2015 to June 2016, which includes long-term performance monitoring for the OU-2 and OU-3 remedies. Analytical data collected during monitoring period were used to evaluate efficacy and capacity of the groundwater collection system; update the site-wide historical database; and present conclusions and recommendations regarding future groundwater sampling. The treatment system's operational performance (including plant discharge monitoring results) is presented in a separate report.

1.1 SITE BACKGROUND

The Havertown PCP Superfund Site (the Site) is located in southeastern Pennsylvania approximately 10 miles west of Philadelphia (Figure 1). Commercial establishments, industries, parks, schools, and residential homes surround the Site.

The Site covers approximately 12 to 15 acres and is defined by the extent of contamination attributable to the site. It is roughly delineated by Lawrence Road and Rittenhouse Circle to the south, the former Penn Central Railroad (PCRR) tracks to the north, and the fence on the Continental Motors property to the west, and Naylors Run to the east.

The Havertown PCP site is located in the Piedmont Uplands section of the Piedmont Physiographic Province. Consolidated rock in the vicinity of the site consists of metamorphic schist and gneiss of the Wissahickon Formation. Regionally the unconsolidated deposits that overlay the bedrock consist of saprolite (in-situ weathered bedrock), and occasional sand and gravel terrace deposits, and artificial fill. In the vicinity of the bed of Naylors Run, thicker unconsolidated gravel deposits have been identified above Wissahickon Schist. Groundwater at the Havertown site flows in a southeasterly direction and occurs in two major zones. The upper zone consists of surficial soils and saprolite (heavily weathered rock). The movement of water in the saprolite

zone is influenced by the degree of saprolite weathering, relict bedrock structures, compositional variations, and the thickness of the weathered zone. The lower zone consists of fractured schist bedrock, with water movement occurring along interconnected fractures. Vertical hydraulic gradients are small, suggesting that the aquifer at the site is well connected by porous/fracture flow.

Upward flow occurs within the saturated saprolite and presumably provides observed seepage/base flow to Naylors Run southeast of Rittenhouse Circle. The depth to groundwater below the site ranges from approximately 23 feet below ground surface in the vicinity of former Young's Produce Store to seepage as springs at ground surface in the ROS Area southeast of Rittenhouse Circle. These permeable zones are closely interconnected, and typically represent one aquifer. Semi-confining layers may locally reduce aquifer interconnection — but are not widespread.

Historically, the Site consisted of a number of distinct properties, including a former wood treatment facility owned by National Wood Preservers (NWP), a bubble gum manufacturing plant owned by the Philadelphia Chewing Gum Company (PCG), and neighboring residential and commercial areas. Former structures on the NWP property (lying north of the intersection of Eagle Road and Lawrence Road) consisted of a sheet metal building with multiple aboveground chemical storage tanks. The two-acre NWP property has since been capped and enclosed within a chain-link fence. The PCG facility consisted of a single, large former gum production building located due east of NWP (northeast of the intersection of Eagle Road and Lawrence Road). Residential areas bordering Rittenhouse Circle and Naylors Run comprise the remainder of the study area (Figure 2).

From approximately 1947 to 1963, the NWP property was used to treat wood products using pentachlorophenol (PCP) dissolved in diesel fuel. NWP allegedly disposed of waste materials into a well reportedly located in the vicinity of the former Young's Produce Market, at the corner of Lawrence and Eagle Road. However, the exact location of the well was not identified. In 1977, the NWP facility discontinued the use of PCP and oil to treat wood products and began treating wood using metal salts.

The metal salts consisted of chromium copper arsenate (CCA) in a 0.4% or 0.6% water solution. Other metals used included chromated zinc chloride (a fire retardant) and tributyl tin oxide (an anti-fouling compound). All three water-soluble chemicals were used in pressure treatment of wood products.

The Site was placed on the National Priorities List (NPL) in 1982. The Site was divided into three OUs. OU-1 addressed the discharge to Naylors Run and the on-site wastes at the NWP facility. OU-2 addressed shallow groundwater, and OU-3 addressed deep groundwater in the source area and the groundwater and soil contamination in the ROS Area.

Major contaminants attributable to the Site include volatile organic compounds (VOCs), PCP, polynuclear aromatic hydrocarbons (PAHs), and dioxins/furans.

EPA issued the first Record of Decision (ROD) for the Site in September 1989. The 1989 ROD for OU-1 included provisions for an interim remedial action. It called for the installation of an oil-water separator to address the

continued release of contaminants from the Site into the surface water of Naylors Run. In addition, this ROD called for the removal and disposal of the on-site waste.

During a soil investigation, EPA learned that the contamination on the NWP facility was more extensive than originally anticipated. The soil contamination was addressed in a 1996-1997 Superfund Removal Action, during which a synthetic geo-membrane cap was installed over three acres of the Site. The installation of the cap removed the potential for exposure to soils contaminated with arsenic and dioxins/furans by providing an impermeable synthetic barrier and 18 inches of soil cover over the areas of contamination. In the fall of 1997, EPA covered the capped area with an additional 4 feet of fill and planted the fill with a mixture of seed mulch and fertilizer.

EPA issued the ROD for OU-2 on September 30, 1991, which defined the interim remedy. The RAOs of the OU-2 remedy were as follows:

- Design and implement an interim remedial action to protect human health and the environment by removing free product and contaminated groundwater from the shallow groundwater aquifer.
- Collect data on the aquifer and contaminant response to remedial measures.

The primary purpose of the OU-2 ROD is to contain the entire contaminated shallow groundwater plume migrating from the Site under Eagle Road and to treat and discharge it into Naylors Run. The extraction/recovery wells are intended to reduce the size of the oil plume floating on the water table.

Tetra Tech completed the conceptual design for OU-2 (shallow groundwater) in 1994. The Remedial Design (RD) for OU-2 was completed during the period 1997-2000 by several contractors under direction from the U.S. Army Corps of Engineers (USACE). Treatment plant construction was completed in 2001, and the plant became fully operational in August 2001, with treated water being discharged to Naylors Run in accordance with National Pollutant Discharge Elimination System (NPDES) permit limits. Groundwater & Environmental Services, Inc. (GES) operated the plant on behalf of USACE until August 15, 2002. Between 2002 and 2013, Tetra Tech performed O&M activities at the plant on behalf of EPA.

EPA issued the ROD for OU-3 in April 2008. OU-3 was further divided into OU-3A and OU-3B. OU-3A addressed contamination related to deep groundwater in the source area, whereas OU-3B addressed contamination in Haverford Township's ROS Area, located below Rittenhouse Circle and adjacent to Washington Avenue in Havertown. The RAOs for the OU-3 remedy were as follows:

<u>Groundwater</u>

- Mitigate contamination to Applicable, Relevant or Appropriate Requirements (ARARs) and/or risk-based cleanup levels to protect human health and the environment.
- Discharge treated groundwater to surface water (Naylors Run) in concentrations that meet NPDES regulations.

- Prevent exposure to contaminated groundwater in the future.
- Prevent discharge of groundwater to surface water at concentrations of contaminants that would result in exceedances of water quality criteria.
- Contain the contamination plume in the source area and the ROS Area to prevent further off-site migration and to ensure that downgradient groundwater is not impacted.
- Restore groundwater quality at the Site.

Soils of ROS Area

- Eliminate current exposure of human and ecological receptors to contaminated soils.
- Prevent further migration of contaminants in soil to groundwater.
- Prevent transport of contaminants in surface soils via surface water runoff.
- Prevent potential future exposure to contaminants through ingestion and dermal contact by human and ecological receptors.

The purposes of the OU-3 remedy are to contain the contaminated deep groundwater plume migrating from the site in conjunction with the OU-2 remedy, operate and maintain the OU-3 shallow extraction and monitoring wells in the ROS, maintain the ROS pumping system through the RR ROW, and operate the in-situ flushing system in conjunction with the OU-2 groundwater treatment system. The OU-2 remedy was incorporated into the OU-3 as a final groundwater remedy. The OU-3 remedy consisted of the following elements:

- Installation of an additional groundwater recovery well and associated piping in the Source area of the site.
- Operate and maintain the existing groundwater treatment facility. Upgrade or retrofit the existing groundwater treatment facility to increase the capacity of the facility to process 60 to 70 gallons per minute (gpm) of contaminated water.
- Treat collected groundwater as necessary to meet discharge requirements.
- In-situ flushing in the Source area of the Site, with treated water from the groundwater treatment facility.
- Excavation of an area approximately 50 ft. by 50 ft. around wells SW-8 and SW-9 in the ROS Area, and a narrow zone along the abandoned sewer line about 200 ft. long and 20 ft. wide. The portion of the abandoned sewer line that has not been sealed will be removed. All excavated material will be properly disposed of off-site.

- Backfilling of the excavated area with clean fill, restoration of sidewalks, curbs, utilities, etc. and planting of appropriate vegetation.
- Installation of three groundwater recovery wells and associated piping in the ROS Area to extract groundwater and transport it to the site's groundwater treatment facility for remediation.
- Demonstrate recovery of benthic macroinvertebrate and fish communities, to examine the efficacy of the ROS Area excavation and groundwater treatment to reduce or eliminate the contaminant releases that are the major source of risk to aquatic organisms in Naylors Run.
- Perform groundwater monitoring.
- Implement institutional controls to protect the integrity of the remedy and to prevent the installation of groundwater wells, through groundwater use restrictions and notices for the site and surrounding area, as appropriate.

In November 2008, EPA began work to increase the capacity and optimize the existing groundwater treatment facility and to meet the 2008 OU-3 ROD requirements. EPA redesigned the pretreatment portion of the facility to increase the amount of water being treated. This portion of the Remedial Action (RA) was completed in February 2009 as part of the OU-2 long-term response action (LTRA). The facility currently treats 70 gpm of contaminated groundwater. From March through August 2010, the OU-3 remedy was implemented. Construction involved converting an existing monitoring well (CW-31D) to a deep recovery well (RW-7), adding three new shallow recovery wells (RW 8, RW-9, and RW-10) and three new monitoring wells (CW-32, CW-33, and CW-34) in the ROS Area, and converting three existing shallow recovery wells (RW-1, RW-2, and RW-4) into injection wells (IW-1, IW-2, and IW-3) with an associated pumping system as part of the in-situ flushing system. The treatment plant remained operational during construction.

The groundwater extraction and treatment system consists of six recovery wells, one collection trench (CTR), and an on-site treatment system. The CTR has been online since 2001; RW-5 and RW-6 have been online since February 2006; RW-7 was fully online in October 2010; and RW-8, RW-9, and RW-10 were online in August 2010. Four original recovery wells (RW-1, RW-2, RW-3, and RW-4) have been offline since February 2006. In 2010, the former RW-1, RW-2, and RW-4 were converted into injection wells (IW-1, IW-2, and IW-3) and placed into service in August 2010. Since IW-1, IW-2, and IW-3 started plugging, two additional wells, IW-4 (formerly CW-29D) and IW-5 (formerly CW-30D), were placed online in July and October 2011, respectively.

To restore contaminated groundwater to beneficial use, remediation implemented under the remedies will operate until remediation goals (RGs) or groundwater clean-up goals are achieved. The RGs for groundwater OU-2 and OU-3 are presented in Table 1.

1.2 GROUNDWATER WELL NETWORK DESCRIPTION

The groundwater well network consists of recovery wells, injection wells, monitoring wells, and the CTR. Well construction data is provided in Table 2. These wells are also located on Figure 2.

There are six active recovery wells currently including RW-5, RW-6, RW-7, RW-8, RW-9, and RW-10. Four original recovery wells RW-1, RW-2, RW-3, and RW-4 have been offline since February 2006.

There are five injection wells (IW-1 through IW-5) in or near the source area. The injection wells IW-1, IW-2, and IW-3 were placed into service in August 2010. The former monitoring well CW-29D was converted into injection well IW-4 and placed online in July 2011, and the former monitoring well CW-30D was converted into injection well IW-5 and placed online in October 2011.

After IW well redevelopment in June 2013, three IW wells (IW-1, IW-2, and IW-3) were shut down. The injection system remains active with IW-4 and IW-5.

Four piezometers (PZ-1 through PZ-4) are used to monitor water levels in the CTR.

1.3 MONITORING PROGRAM

Presently, there are 60 wells included in the O&M groundwater monitoring program. These wells can be classified as shallow wells above bedrock [about 5 ft. to 30 ft. below ground surface (bgs)] and deep wells in the bedrock (up to 120 ft. deep). In 2010 and 2011, six wells were deleted from the program but remain available. In mid-2012, due to construction of the Young Men's Christian Association (YMCA) building, four monitoring wells (HAV-02, CW-6S, CW-6I, and CW-6D) were abandoned.

The purpose of this sampling is to monitor treatment system performance and migration of the PCP plume. Sampling is performed per the revised Sampling and Analysis Plan (SAP) (Tetra Tech, 2015c). Groundwater samples are collected on periodic as follows:

- Quarterly sampling to determine recovery system water quality and extraction system's effectiveness.
- Semi-annual sampling to determine recovery well water quality and effectiveness.
- Bi-annual sampling to monitor the edge of the shallow contaminant capture zone.
- Annual sampling to update the historical database.

Groundwater samples are analyzed for VOCs, semi-volatile organic compounds (SVOCs), metals, and dioxin/furans. During well sampling, other parameters are also collected [e.g., pH, temperature, dissolved oxygen (DO), specific conductivity and oxidation-reduction potential (ORP)].

During the July 2015 to June 2016 period, all samples were sent to the DEP-designated laboratory for analysis.

2.0 GROUNDWATER MONITORING ACTIVITIES

2.1 SAMPLING METHODS

Groundwater samples were collected from the monitoring wells and injection wells through polyethylene (PE) tubing that was attached to a peristaltic pump with medical-grade flexible silicon tubing. The PE tubing was inserted down the well and set at the approximate midpoint of the screen. Geochemical parameters (DO, specific conductivity, pH, temperature, and ORP) were measured during purging using an YSI 556 water quality meter equipped with an in-line flow through cell. Turbidity was measured using a LaMotte 2020e turbidimeter during purging. The purging rate was set at between 0.1 to 0.4 liter/minute, and water levels were monitored to assure that the static water level was not drawn down into the well screen.

Purged water was monitored for pH, specific conductivity, temperature, turbidity, ORP, and dissolved oxygen (DO) every five minutes. When levels of these parameters stabilized, and a minimum of two saturated screen volumes had been removed from the well, the purging was considered complete and the groundwater samples were obtained. Parameter stabilization was defined as three successive readings (taken at least 5 minutes apart) within 0.1 unit for pH, 3% for specific conductivity, 10% for turbidity and DO, and 10 mV for ORP. All monitored parameter measurements (including time, water level, purge rate, temperature, pH, specific conductance, turbidity, DO, and ORP) were recorded on low-flow purge data sheets. Groundwater samples were collected in laboratory-supplied containers after three consistent readings of pH, specific conductivity, temperature, and turbidity (±10%), immediately placed on ice, and delivered under proper chain-of-custody protocol to ALS Environmental.

Groundwater samples of the recovery wells were collected from sampling ports located in the well vaults. After purging 5 gallons of the groundwater from sampling port, the groundwater sample was obtained. Temperature, pH, specific conductance, turbidity, DO and ORP, were measured and recorded on sampling logs.

2.2 GROUNDWATER SAMPLING EVENTS

A quarterly groundwater sampling event was performed on September 21 and 22, 2015. A total of 11 wells were sampled and analyzed for TCL VOCs and SVOCs. Recreation and Open Space (ROS) recovery wells (RW-8, RW-9, and RW-10) were also sampled and tested for herbicides. The analytical results are provided in Appendix A-1.

A quarterly groundwater sampling event was conducted on December 16, 2015. A total of 7 wells were sampled and analyzed for TCL VOCs and SVOCs. Recreation and Open Space (ROS) recovery wells (RW-8, RW-9, and RW-10) were also sampled and tested for herbicides. The analytical results are provided in Appendix A-2.

The annual groundwater sampling event was performed from March 21 through March 30, 2016. A total of 54 wells were sampled and analyzed for TCL VOCs and SVOCs. A total of 6 wells were sampled and analyzed for TAL metals. A total of 8 wells were sampled and analyzed for dioxins/furans. Injection wells IW-2 and IW-3 were

dry and were not sampled. Figure 2 presents sample locations. The analytical results are provided in Appendix A-3.

A quarterly groundwater sampling event was conducted on June 13 and 14, 2016. A total of 9 wells were sampled and analyzed for TCL VOCs and SVOCs. Recreation and Open Space (ROS) recovery wells (RW-8, RW-9, and RW-10) were also sampled and tested for herbicides. The analytical results are provided in Appendix A-4.

2.3 WATER-LEVEL MEASUREMENTS

Water-level measurements were collected from 77 wells on May 15, 2015. Elevation measurements were obtained during a day of no precipitation, and at least 48 hours after the conclusion of any precipitation event. Static water levels were measured in all available wells using an electronic water-level indicator and were recorded to the nearest 0.01 foot. The static water levels in the flowing artesian monitoring wells were obtained by extending the casing stick-up of the wells and measuring the height of the water above the reference point elevation. Groundwater level data are provided in Table 3.

Figure 3 shows groundwater contours for the shallow zone/overburden while the system was operational. Figure 4 displays groundwater contours for the deep zone/bedrock while the system was operational.

3.0 DATA EVALUATION

3.1 GROUNDWATER LEVELS

Table 3 presents water-level data. Figures 3 and 4 indicate a measurable drawdown near the RW wells and CTR. Pumping at recovery well RW-5 screened at 36 to 46 ft bgs continued to draw down water levels in surrounding deep wells CW-24, CW-26 and CW-16 S/I/D, and to impact the water level in downgradient wells CW 27D, and CW-4S/I/D. Pumping at RW-7 (screened from 90 to 120 ft bgs) draws down the water tables in surrounding wells CW-28, NW-1, CW-4S/I/D, and CW-17D, and impacts water levels in downgradient wells CW-3S/I/D, CW-5S/I/D, CW-18D, and CW-19D.

The pumping systems at the CTR (8 to 18 ft bgs) and RW-6 (screened from 25 to 35 ft bgs) continued to draw down water levels in nearby monitoring wells MW-1, MW-2, CW-9S/D, and downgradient wells HAV-07 and CW-21S/D. These two pumping systems also influenced water levels in upgradient wells HAV-04, HAV-05, and MW-3. The ROS Area recovery wells RW-8, RW-9, and RW-10 (all three screened from 7 to 18 ft bgs) drew down water levels in upgradient wells CW-32, CW-33, and CW-34.

3.2 GROUNDWATER CONTAMINANT CONCENTRATIONS AND TRENDS

The shallow aquifer source area encompasses groundwater contamination associated with wells CW-2S, R-2, CW-4S, CW-5S, HAV-02 (now B-1), and HAV-04 (Tetra Tech, 1991). The OU-3 ROD (EPA, 2008) further defined the deep aquifer source area as encompassing wells CW-17D, CW-25D (now RW-5) CW-2I, CW-2D, and CW-31D (now RW-7) by establishing the plume of deep free-product oil containing PCP. This area is considered to represent principal threat waste since it is a continuous source of groundwater contamination. The OU-3 ROD also considered well CW-16S to be representative of the shallow aquifer source area. The complete sets of analytical data generated during the reporting period are included in Appendix A. Table 4 summarizes the contaminants of concern (COCs) detected in well samples during the 2016 annual sampling event and compares them to groundwater remediation goals (RGs) (Table 1). Figures 5 and 6 present the PCP concentrations detected during 2016 annual sampling event as iso-concentration contour maps for shallow overburden and deep bedrock wells, respectively.

Historical trends were evaluated by comparing current PCP concentrations with those detected during previous sampling events. The historical PCP and dioxin concentrations are presented in Table 5 from September 2010 to June 2016. Appendix B graphically represent the historical trends of PCP concentrations during the period February 2008 through June 2016 in the source area wells (recovery wells, injection wells and surrounding wells); recovery trench area wells; plume perimeter wells; and ROS Area recovery wells and surrounding wells.

3.2.1 Recovery Well and Collection Trench PCP Concentrations and Trends

Generally, PCP concentrations in the recovery wells (RW) continued to decline as follows:

- RW-5 [varied from 5,200 micrograms per liter (µg/L) (March 2013) to 2,860 µg/L (April 2014) to 3,820 µg/L (April 2015) to 3,500 µg/L (March 2016)].
- RW-6 [varied from 700 µg/L (March 2013) to 306 µg/L (April 2014) to 498 µg/L (April 2015) to 418 µg/L (March 2016)].
- RW-7 [varied from 3,200 µg/L (March 2013) to 2,580 µg/L (April 2014) to 2,110 µg/L (April 2015) to 3,050 µg/L (March 2016)].

Operation of the three other ROS recovery wells (RW-8, RW-9, and RW-10) continued to contain the shallow plume in this area. Based on the 2015-2016 data, PCP concentrations of RW-8, RW-9 and RW-10 have continued to be non-detect (ND) or below the groundwater RG of 1 µg/L since December 2012. In March 2016, these wells were analyzed for SVOC using a reporting limit of 1 µg/L or lower based on a recent EPA and DEP's mutual agreement.

For CTR samples, PCP concentrations varied from 500 µg/L (March 2013) to 415 µg/L (April 2014) to 255 µg/L (April 2015) to 430 µg/L (March 2016). More detailed information may be found in Table 5.

3.2.2 Monitoring Well PCP Concentrations and Trends

Operation of deep recovery well RW-5 continued to decrease PCP concentrations in the source area deep groundwater (see Figures 7 and 8). During the period of 2013 to 2016, PCP concentrations decreased in deep wells near RW-5. Specifically:

- CW-24D [4,000 µg/L (March 2013) to 2,230 µg/L (April 2014) to 1,920 µg/L (April 2014) to 1,180 µg/L (March 2016)].

PCP concentrations in other adjacent wells near RW-5 fluctuated as follows:

- CW-16D [33 µg/L (March 2013) to 29.55 µg/L (April 2014) to 3.7 µg/L (April 2015) to 7.3 µg/L (March 2016)].
- CW-26D [1,300 µg/L (March 2013) to 3,560 µg/L (April 2014) to 4.1 µg/L (April 2015) to 3.6 µg/L (March 2016)].
- CW-27D [4,600 µg/L (March 2013) to 1,810 µg/L (April 2014) to 1,950 µg/L (April 2015) to 1,310 µg/L (March 2016)].
- CW-28D [1,800 µg/L (March 2013) to 6,830 µg/L (April 2014) to 3,230 µg/L (April 2015) to 219 µg/L (March 2016)].

Operation of deep extraction well RW-7 continued to affect PCP concentrations in deep wells near RW-7 (Figures 7, 8, 9, and 10). During the period of 2013 to 2016, PCP concentrations in adjacent wells near RW-7 fluctuated as follows:

- CW-3D [140 µg/L (March 2013) to 552 µg/L (April 2014) to 209 µg/L (April 2015) to 215 µg/L (March 2016)].
- CW-4D [1,700 µg/L (March 2013) to 1,180 µg/L (April 2014) to 1,260 µg/L (April 2015) to 2,030 µg/L (March 2016)].
- CW-5D [16 µg/L (March 2013) to ND (April 2014) to 6 µg/L (April 2015) to ND (March 2016)].
- CW-17D [1,800 µg/L (March 2013) to 3,780 µg/L (April 2014) to 1,300 µg/L (April 2015) to 2,800 µg/L (March 2016)].
- CW-18D [ND (March 2013) to 52.6 µg/L (April 2014) to 59.8 µg/L (April 2015) to ND (March 2016)].
- CW-19D [1,300 µg/L (March 2013) to 1,030 µg/L (April 2014) to 554 µg/L (April 2015) to 1,040 µg/L (March 2016)].
- CW-27D [4,600 µg/L (March 2013) to 1,810 µg/L (April 2014) to 1,950 µg/L (April 2015) to 1,450 µg/L (March 2016)].
- CW-28D [1,800 µg/L (March 2013) to 6,830 µg/L (April 2014) to 3,230 µg/L (April 2015) to 219 µg/L (March 2016)].

Due to YMCA building construction, wells HAV-02, CW-6D, CW-6I, and CW-6S were abandoned in mid-2012 and are no longer part of the groundwater monitoring program.

Operation of deep extraction well RW-6 and CTR continued to decrease in PCP concentrations in groundwater around the CTR area and downgradient wells (see Figure 9). Specifically:

- MW-3 [varied from 920 µg/L (March 2013) to 1,040 µg/L (April 2014) to 599 µg/L (April 2015) to 773 µg/L (March 2016)].
- CW-21S [varied from 1,300 µg/L (March 2013) to 833 µg/L (April 2014) to 892 µg/L (April 2015) to 523 µg/L (March 2016)].
- CW-21D [varied from 1,300 µg/L (March 2013) to 830 µg/L (April 2014) to 1030 µg/L (April 2015) to 827 µg/L (March 2016)].
- MW-1 [decreased from 2.4 µg/L (March 2013) to ND (April 2014) to ND (April 2015) to ND (March 2016)].
- MW-2 [varied from ND (March 2013) to 4.3 µg/L (April 2014) to 2.8 µg/L (April 2015) to 3 µg/L (March 2016)].

PCP concentrations for wells HAV-04 and HAV-05 were as follows:

- HAV-04 [varied from 2,900 µg/L (March 2013) to 3,290 µg/L (April 2014) to 4,180 µg/L (April 2015) to 5,910 µg/L (March 2016)].
- HAV-05 [varied from 3,600 µg/L (March 2013) to 2,020 µg/L (April 2014) to 3,490 µg/L (April 2015) to 502 µg/L (March 2016)].

Between the source area and ROS Area, PCP in two deep wells (CW-12D and CW-13D) located southeast of the main groundwater contaminant plume has been non-detect in April 2015 and March 2016 sampling. PCP in another deep well CW-10D, just north of CW-13D, was non-detect in 2014 and 2015 sampling while it was 6.2 µg/L in March 2016 sampling. The PCP concentrations reported for these wells since 2012 are as follows:

- CW-10D [ranged from 6.7 µg/L (September 2012) to ND (April 2014) to ND (April 2015) to 6.2 (March 2016)].
- CW-12D [ranged from 0.96 µg/L (September 2012) to 4 µg/L (April 2014) to ND (April 2015) to ND (March 2016)].
- CW-13D [fluctuated from 63 µg/L (September 2012) to ND (December 2012) to 115 µg/L (April 2014) to ND (April 2015) to ND (March 2016)].

Figure 10 presents the historical trends of PCP concentrations detected in plume perimeter wells.

3.2.3 In-Situ Flushing System PCP Concentrations and Trends

Operation of the in-situ flushing system continued to influence PCP concentrations in injection wells and deep wells near the injection system. IW-4 and IW-5 were both operational during the monitoring period from March 2013 to July 2016. IW-1, IW-2, and IW-3 were non-operational since June 2013. Figure 11 presents historical trends of PCP concentrations in the injection wells.

For injection wells IW-4 and IW-5, PCP concentrations were as follows:

- IW-4 [ranged from an average of 58 µg/L (2013) to 11 µg/L (April 2014) to 97.1 µg/L (April 2015) to 47.8 µg/L (March 2016)].
- IW-5 [varied from an average of 2 µg/L (2013) to 33.2 µg/L (April 2014) to 37.5 µg/L (April 2015) to 172 µg/L (March 2016)].

Between 2012 and 2016, PCP concentrations for non-operational wells IW-1, IW-2, and IW-3 were variable. Specifically:

- IW-1 [varied from ND (March 2013) to 358 µg/L (April 2014) to 981 µg/L (April 2015) to 1,060 µg/L (March 2016)].
- IW-2 [ranged from 4,800 µg/L (March 2013) to 4,750 µg/L (April 2014) to 11 µg/L (April 2015)].
- IW-3 [varied from 1,700 µg/L (March 2012) to 3,100 µg/L (June 2012) to 980 µg/L (April 2014)].

Between 2011 and 2016, PCP concentrations for three deep wells were reported as follows:

- CW-26D [results varied from 88+ µg/L (March 2011) to 3,560 µg/L (April 2014) to 4.1 µg/L (April 2015) to 3.7 µg/L (March 2016)].
- CW-27D [from 1,500+ µg/L (March 2011) to 4,600 µg/L (April 2014) to 1,950 µg/L (April 2015) to 1,450 µg/L (March 2016)].
- CW-28D [from 3,000+ µg/L (March 2011) to 6,830 µg/L (April 2014) to 3,230 µg/L (April 2015) to 219 µg/L (March 2016)].

These wells received the majority of injection flow during the period. To compensate for this, the injection pumping system was turned off prior to groundwater sampling events.

3.2.4 Other Groundwater Contaminants

Table 4 provides a summary of the groundwater concentrations detected during the 2016 annual sampling event. Trends for several other contaminants are discussed below.

Trichloroethene (TCE) and Vinyl Chloride: During the reporting period, TCE was detected above the groundwater RG of 5 µg/L only in wells CW-1S, CW-13D and RW-5 at concentrations of 401 µg/L, 7.3 µg/L and 9.5 µg/L, respectively.

TCE concentrations contained in well cluster CW-1 (upgradient of the site) were as follows:

- Shallow well CW-1S [varied from 430 µg/L (2013), 160 µg/L (2014), ND (2015), and 401 µg/L (March 2016)].
- Deep well CW-1D [ranged from 5.8 µg/L (2013), 1.7 µg/L (2014), 3.6 µg/L (2015), and 4.4 µg/L (March 2016)].

TCE was also contained in downgradient wells CW-10D, and HAV-04 and source area recovery wells RW-5 and RW-7 as reported below:

- CW-10D [results varied from 1.5 µg/L (2012), 5.8 µg/L (2014), and 2.9 µg/L (2015) to 2 µg/L (March 2016)].
- HAV-04 [varied from 6.1 µg/L (2013), 3.9 µg/L (2014), and 7.2 µg/L (2015) to 2.9 µg/L (March 2016)].
- RW-5 [ranged from 6.9 µg/L (2013), 10.5 µg/L (2014), and 7.6 µg/L (2015) to 9.5 µg/L (March 2016)].
- RW-7 [varied from 6.2 µg/L (2013), 4.5 µg/L (2014), and 3.8 µg/L (2015) to 2.2 µg/L (March 2016)].

Vinyl chloride was also detected above the groundwater RG of 5 µg/L in wells CW-1D and CW-1S at concentrations of 13.7 µg/L and 38.7 µg/L, respectively.

Benzene: Benzene was detected in wells CW-4D, CW-4I, CW-17D, CW-24D, CW-27D, and RW-5 at concentrations exceeding its RG of 5 µg/L. Benzene concentrations ranged from 6.6 µg/L contained in well CW-27D to 40.5 µg/L in well CW-4I.

2-Methyl-4,6-dinitrophenol was detected above the groundwater RG of 1.7 µg/L in well CW-4S at concentrations of 24.2 µg/L.

2-Methylnaphthalene was detected above the groundwater RG of 2 µg/L in wells CW-2D, CW-24D, HAV-04, RW-3, RW-5 and RW-7 at concentrations of 39.5 µg/L, 154 µg/L, 320 µg/L, 27.7 µg/L, 5.7 µg/L and 20.6 µg/L, respectively.

Benzo(a)pyrene was detected above the groundwater RG of 0.2 µg/L in wells CW-16S, CW-23D and HAV-04 at concentrations of 0.96 µg/L, 2.8 µg/L and 0.79 µg/L, respectively.

Dibenzofuran was detected above the groundwater RG of 4 µg/L in wells CW-24D, RW-3, RW-5 and RW-7 at concentrations of 6.9 µg/L, 4.2 µg/L, 4.8 µg/L and 4.4 µg/L, respectively.

Naphthalene: Naphthalene was detected above the groundwater RG of 3 µg/L in 10 wells. Concentrations were ranging from 3.4 µg/L for well HAV-05 to 546 µg/L for well CW-24D. These wells are part of the same source area and plume as associated with PCP concentrations.

In general, naphthalene concentrations continued to decline in most wells as follows:

- RW-5 [varied from 710 µg/L (2013) to 175 µg/L (2014) to 60.7 µg/L (2015) to 62 µg/L (March 2016)].
- RW-7 [varied from 255 µg/L (2013) to 147 µg/L (2014) to 78.6 µg/L (2015) to 89.4 µg/L (March 2016)].
- CW-4D [varied from 150 µg/L (2013) to 31.1 µg/L (2014) to 3.4 µg/L (2015) to 6.9 µg/L (March 2016)].
- CW-4S [varied from ND (2013) to ND (2014) to 4.2 µg/L (2015) to ND (March 2016)].
- CW-16S [decreased from 500 µg/L (2013) to 9.9 µg/L (2014) to ND (2015) to ND (March 2016)].
- CW-17D [varied from 24 µg/L (2013) to 99.9 µg/L (2014) to ND (2015) to 0.39 µg/L (March 2016)].
- CW-26D [varied from 110 µg/L (2013) to 5.9 µg/L (2014) to ND (2015) to 0.6 µg/L (March 2016)].
- CW-27D [varied from 720 µg/L (2013) to 4.2 µg/L (2014) to ND (2015) to 2.5 µg/L (March 2016)].
- CW-28D [varied from 180 µg/L (2013) to 698 µg/L (2014) to 127 µg/L (2015) to 5.3 µg/L (March 2016)].
- HAV-05 [varied from 52 µg/L (2013) to 123 µg/L (2014) to 310 µg/L (2015) to 3.4 µg/L (March 2016)].

However, more recent naphthalene concentrations increased in the following wells. Specifically:

- RW-3 [varied from 630 µg/L (2013) to 627 µg/L (2014) to 1.7 µg/L (2015) to 168 µg/L (March 2016)].
- CW-2D [varied from 6.9 µg/L (2013) to 53 µg/L (2014) to ND (2015) to 76.9 µg/L (March 2016)].

- CW-4I [varied from 35 µg/L (2013) to 2.7 µg/L (2014) to 1.5 µg/L (2015) to 9.7 µg/L (March 2016)].
- CW-24D [varied from 1,400 µg/L (2013) to 415 µg/L (2014) to 193 µg/L (2015) to 546 µg/L (March 2016)].
- HAV-04 [varied from 39 µg/L (2013) to ND (2014) to 12.4 µg/L (2015) to 216 µg/L (March 2016)].

Phenanthrene was detected above the groundwater RG of 41 µg/L in well HAV-04 at concentrations of 143 µg/L.

Dioxins/Furans: Total 2,3,7,8-TCDD, reported as Dioxin Toxicity Equivalent Quotient (TEQ), was detected only in well NW-1 at concentrations exceeding its RG of 30 pg/L. Specifically:

- NW-1 [results varied from 105 pg/L (2013) to 25 pg/L (2014) to 35 pg/L (2015) to 101 pg/L (March 2016)].

3.2.5 Conceptual Site Model (CSM)

Per the EPAs request, the Conceptual Site Model (CSM) for the site was updated to include the data from the March 2016 sampling event. The purpose of this updated CSM is to depict current site conditions and compare them with historical conditions. The current CSM is based on the original CSM generated in 2006 and modified back in 2014.

This updated CSM was generated using ArcGIS technology along with the most recent available aerial photograph as a background. It should be noted that site conditions have changed since this aerial was taken in 2010, and the former Gum Factory has been replaced with a new YMCA. Aerial photographs depicting the new YMCA were not available at the time this CSM update was performed.

New data was added to the map using the ESRI shapefile format for the groundwater levels, PCP concentration levels, and contours. The overhead view of the CSM is shown on **Figure 12**.

The three cross-section alignments generated during the 2014 update were updated with the March 2016 data as well. The alignment locations are shown on **Figure 12**. These cross-sections were generated in AutoCAD to depict the subsurface conditions at key locations and include the following:

- Parallel to the flow direction (cross-section A-A', **Figure 13**);
- Parallel to Eagle Road and perpendicular to the primary flow direction (cross-section B-B', **Figure 14**);
- Perpendicular to primary flow direction in the vicinity of historic groundwater discharge to the stream (cross-section C-C', **Figure 15**).

The electronic files of the surface map and the subsurface cross-sections constitutes the site CSM. Using this electronic resource, a variety of figures depicting different aspects of the CSM can be generated based on the requirements of the user.

Review of the data indicates that the primary contaminant demonstrating the extent of contamination is PCP. While other contaminants, such as naphthalene, are present at levels of concern, they do not have the overall

lateral extent nor the consistently high concentrations of PCP. Therefore for mapping and visual interpretation purposes, PCP is the most appropriate/conservative site chemical to depict the extent of contamination.

Historical CSM interpretation of the site is that that there are two distinct zones of contamination, a shallow zone and a deep zone. While it is possible to separate out the contamination into these zones, comparison of the two indicates that with the exception of the occasional hot spots, plume morphology between depths is very similar. This is a result of the local geology which includes overburden, weathered rock which transition to bedrock in a heterogeneous manner across the site. However, with this in mind for the purposes of the CSM, the deep plume (which is the larger of the two plumes) was utilized to depict the overall extent of the contamination. This is considered the most conservative approach to depicting the current conditions of the CSM.

Review of pump test and boring log data at RW-5, RW-6, and RW-7 indicated a zone of vertical fracturing near the area shown on **Figure 12**. At this time, the fracture zone has not been fully delineated, and the approximate alignment shown on the map is the area estimated to have an impact on the wells currently included in the O&M monitoring. Based on the alignment of Naylor's Run, the rocks observed in the creek, and the approximate alignment of the fractures on the historic Naylor's Run stream channel, it is probable that the fracture zone extends further north and south away from the approximate alignment shown on the map.

A review of the updated CSM indicates that the vast majority of the plume is currently being captured by the existing remediation system. While 100% capture may not always occur due to abnormal conditions (such as an excessively rainy season, or technical issues) the remediation system has reduced the overall size of the plume from the 2005 extent and appears to contain it. However, since the 2014 CSM update, there does not appear to have be a significant change in plume volume, though there has been a change in morphology, as seen by the extent of the 2016 plume when compared to the 2014 plume. At the time sampling was performed, the plume appears to have extend outside the capture zone. The cause for this is currently unknown.

Vertically, the extent of the plume is based on the groundwater model and analytical data, and the capture zone analysis indicates that groundwater capture extends below the bottom of the recovery wells. Cross-sections showing the estimated extent of vertical contamination are shown in **Figures 13, 14, and 15**. Overall, there has been little changed in the vertical profile of the plume when comparing the 2014 and 2016 plumes.

Review of the cross-sections B-B' and C-C' indicate that while the contamination is migrating primarily in a northwest to southeast orientation, there is some migration away from the inferred source areas perpendicular to the primary regional flow direction. The CZA indicates that most of this migration is captured by the treatment system.

3.3 DISCUSSION

Based upon a review of the groundwater data generated through June 2016, there has been contaminant reduction in both shallow and deep zones in general. Contaminant concentrations in some wells fluctuated over

the past three years and did not indicate a decreasing trend over time. Appendix B presents historical PCP concentrations in wells from February 2008 to June 2016.

No major contaminants have been detected in the shallow zone boundary wells (CW-3S, CW-9S, CW-12S, and R-4) since 2002; PCP concentrations in CW-3S, CW-7S, CW-7D, CW-8S, CW-8D, CW-9D, CW-11D, CW-12S, CW-13S, CW-15S, CW-20D, CW-22S, CW-22D, CW-23D, HAV-07, NW-01, and MW-1 continued to be non-detect. Free product was observed at well R-2; however, the floating product depth continued to be non-existent at those wells formerly containing product.

Operation of the three other ROS Area recovery wells (RW-8, RW-9, and RW-10) continued to contain the shallow plume in this area. Based on the 2012-2016 data, PCP concentrations for RW-8, RW-9, and RW-10 continued to be non-detect. In March 2016, these three wells were analyzed for SVOC using a reporting limit of 1 µg/L or lower based on a recent EPA and DEP's mutual agreement.

Between the source area and ROS Area, PCP in two deep wells (CW-12D and CW-13D) located southeast of the main groundwater contaminant plume has been non-detect in April 2015 and March 2016 sampling. PCP in another deep well CW-10D, just north of CW-13D, was non-detect in 2014 and 2015 sampling while it was 6.2 µg/L in March 2016 sampling.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The following conclusions have been made based on the analytical and hydrogeologic data collected over the monitoring period:

- Overall, there has been contaminant reduction in both shallow and deep groundwater zones since operation of the treatment plant began.
- The overall areal extent of the PCP plume based on 2016 data is smaller compared to 2015 based on PCP groundwater concentrations. Also, the magnitude of the plume is slightly lower.
- In general, historical trends of PCP concentrations in groundwater indicate a very gradual and uneven decrease in PCP concentrations.
- PCP concentrations for ROS Area recovery wells RW-8, RW-9, and RW-10 continued to be non-detect. Based on a recent EPA and DEP's mutual agreement, starting March 2016, RW-8 thru RW-10 will be sampled for SVOC for eight quarters using a reporting limit of 1 µg/L or lower.

4.2 RECOMMENDATIONS

The following recommendations are made with respect to the groundwater monitoring results:

- Continue evaluating analytical and hydrogeologic data to determine the long-term effects of the extraction system on reducing the extent of the contaminant plume and the removal of contaminants.
- Continue monitoring the ROS Area recovery wells and nearby monitoring wells as per recent EPA and DEP agreement.
- Consider the use of the Groundwater Statistics Tool (EPA, 2014a) to reduce the frequency of monitoring as well as the required analytical parameters for ROS area wells; modify the SAP as required.
- Assess the need for increased frequency of CW-10D sampling.
- Consider sampling of CW-9S and CW-10S to further evaluate shallow groundwater PCP concentrations in the vicinity of HAV-04.

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APPENDIX A

ANALYTICAL DATA

A-1 SEPTEMBER 2015 GROUNDWATER DATA

A-2 DECEMBER 2015 GROUNDWATER DATA

A-3 MARCH 2016 GROUNDWATER DATA

A-4 JUNE 2016 GROUNDWATER DATA

APPENDIX B

GRAPHS OF HISTORICAL CONTAMINANT CONCENTRATIONS IN MONITORING WELLS

TABLES

FIGURES