RECORD OF DECISION

Pohatcong Valley Groundwater Contamination Superfund Site

Operable Unit 3

Washington Borough and Washington Township

Warren County, New Jersey

United States Environmental Protection Agency
Region 2
New York, New York
September 2016

393186

DECLARATION STATEMENT
RECORD OF DECISION

SITE NAME AND LOCATION

Pohatcong Valley Groundwater Contamination Superfund Site (NJD981179047), Warren County, New Jersey. Operable Unit 03 – Source area soils.

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedy to address soil contamination at the Pohatcong Valley Groundwater Contamination Superfund Site (PVGWCS or Site) Operable Unit (OU) 3, in Warren County, New Jersey. The selected remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, and to the extent practicable the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record established for this Site.

The State of New Jersey concurs with the selected remedy, but does not concur with EPA's site-specific remediation goal for trichloroethene (TCE) in the soil (See Appendix IV).

ASSESSMENT OF THE SITE

The remedy selected in the Record of Decision (ROD) is necessary to protect public health or the environment from actual or threatened releases of hazardous substances from the Site into the environment.

DESCRIPTION OF THE SELECTED REMEDY

The selected remedy described in this document represents the third and final phase of three planned remedial phases, or operable units, for the PVGWCS.

Based on EPA's review of all comments received during the public comment period, EPA has determined that a more flexible approach to implementing EPA's selected remedy, Alternative 4, as described in the Feasibility Study Report (June 2016) and presented in the Proposed Plan, is appropriate. EPA's selected remedy for trichloroethene (TCE) contaminated soils is *in-situ* treatment of deep soils through soil vapor extraction (SVE) and/or thermal hot-spot treatment with flexibility in phasing the approach or using just one of the two treatment technologies; *in-situ* treatment of shallow soils through the existing SVE and sub-slab depressurization (SSD) systems; long-term groundwater and indoor air monitoring; and institutional controls.

The major components of the selected remedy include:

- The implementation of deep SVE and/or thermal treatment to address deep soil contamination underlying the former American National Can (ANC) building;

- Long-term operation and maintenance of the existing shallow SVE and SSD systems within the former ANC building;

- Long-term groundwater and indoor air monitoring in the OU3 Study Area will be performed over time to assess the remedy's effectiveness; and

- Institutional controls, including the existing deed notice, will remain in effect at the former ANC property and will be amended to reflect the components of the Selected Remedy for OU3 that will be implemented at the former ANC property. The institutional controls periodically will be verified as remaining in effect as part of the long-term monitoring effort.

DECLARATION OF STATUTORY DETERMINATIONS

Part 1: Statutory Requirements

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial actions, is cost effective, and utilizes permanent solutions and treatment technologies to the maximum extent practicable.

Part 2: Statutory Preference for Treatment

The selected remedy, which includes SVE and/or thermal treatment of shallow and deep soils underlying the former ANC building satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment).

Part 3: Five-Year Review Requirements

This remedy will leave hazardous substances, pollutants or contaminants on-site above levels that allow for unlimited use and unrestricted exposure. Therefore, CERCLA requires that the Site be reviewed every five years. If justified by the review, additional response actions may be implemented.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record for the Site.

- Chemicals of concern and their respective concentrations may be found in the "Site Characteristics" section.

- Baseline risk represented by the chemicals of concern may be found in the "Summary of Site Risks" section.

- A discussion of remediation goals may be found in the "Remedial Action Objectives" section.

- A discussion of source materials constituting principal threats may be found in the "Principal Threat Waste" section.

- Current and reasonably anticipated future land use assumptions are discussed in the "Current and Potential Future Site and Resource Uses" section.

- Estimated capital, annual operation and maintenance (O&M) and total present worth costs are discussed in the "Description of Alternatives" section.

- Key factors that led to selecting the remedy (i.e., how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision) may be found in the "Comparative Analysis of Alternatives" and "Statutory Determinations" sections.

September 30, 2016
Date

Walter E. Mugdan, Director
Emergency & Remedial Response Division
EPA – Region 2

DECISION SUMMARY

Pohatcong Valley Groundwater Contamination Superfund Site

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APPENDICES

SITE NAME, LOCATION, AND DESCRIPTION

The Pohatcong Valley Groundwater Contamination Site (PVGWCS or Site) is located in parts of Washington Borough, Washington Township, Franklin Township, and Greenwich Township in Warren County, New Jersey (see **Figure 1**). The PVGWCS includes a groundwater contaminant plume that is approximately 8.5 miles long and 1.5 miles wide. Groundwater contamination primarily consists of trichloroethene (TCE) and perchloroethylene (PCE). The TCE and PCE plumes join into a combined plume. Pohatcong Valley is a northeast-southwest trending valley that is part of the Delaware River watershed and is drained by Pohatcong Creek and associated tributaries.

Due to its size and complexity, EPA has divided the PVGWCS cleanup into three Operable Units (OUs), referred to as the OU1, OU2, and OU3 Study Areas.

The OU1 Study Area extends approximately 4.5 miles southward from the former American National Can (ANC) and the former Tung Sol Tubing facilities. It includes TCE and PCE contaminated groundwater within Washington Borough and parts of Washington and Franklin Townships.

The OU2 Study Area is immediately downgradient of OU1 and extends approximately 4 miles southward from there (*i.e.*, extending from approximately 4.5 to 8.5 miles from the former ANC property). OU2 includes TCE and PCE groundwater contamination located downgradient of OU1 within portions of Franklin and Greenwich Townships.

This ROD addresses OU3 of the PVGWCS. The OU3 Study Area is located in Washington Borough near Route 31 and includes the former ANC property and several adjacent downgradient properties: Area of Concern 1 (AC1), Warren Lumber Yard (WLY), and Vikon Tile Corporation (VTC). These four properties were identified in the OU1 RI as potentially contributing TCE to the Site-wide groundwater contamination associated with OU1 and OU2. Land use for the properties of the OU3 Study Area are mainly industrial. The former ANC property is currently an active industrial facility. AC1 and VTC are currently inactive facilities. WLY is currently an active industrial facility. See **Figure 1** for a layout of the three OU Study Areas. See **Figure 2** for a layout of the former ANC, AC1, WLY, and VTC properties.

The OU1 Remedial investigation (RI) indicated that there were elevated TCE concentrations in soil and groundwater in the OU3 Study Area requiring further delineation. TCE-contaminated soil in the OU3 Study Area provides a continuing source of contaminants to groundwater and indoor air. Soils contaminated with TCE were grouped into three areas related to TCE contamination in the OU3 Study Area. These potential TCE contamination source areas have been designated during the OU3 RI as Areas A, B and C described below:

- **Area A**: This area includes the soils beneath the southwestern portion of the former ANC building. Drain Lines (DL) DL-9 and DL-10, which connect to discharge structures on the down slope portions of the former ANC property, originate in this area of the former ANC building.

- **Area B:** This area is located at the DL-9 discharge point. Area B also includes areas down slope of DL-9, including a small portion of the former ANC property (west of the railroad spur) and the Warren Lumber Yard (WLY) ponded area that primarily lie in the railroad Right-of-Way (ROW).

- **Area C**: This area is located at the DL-10 discharge point and includes areas down slope of this discharge on the former ANC slope drainage area.

RI sampling focused on, but was not limited to these 3 areas. See **Figure 2** for a layout of Areas A, B, and C.

The U.S. Environmental Protection Agency (EPA) is the lead agency, and the New Jersey Department of Environmental Protection (NJDEP) is the support agency for this Site.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

VOCs, specifically TCE and PCE, were detected in groundwater from two public potable-water supply wells in Washington Borough in the late 1970s. The two potable-water supply wells, the Vannatta Street Well and the Dale Avenue Well, are owned and operated by New Jersey American Water Company.

After subsequent investigations conducted by the Warren County Department of Health and NJDEP, wellhead treatment systems were added to the public wells so groundwater is treated to meet drinking-water standards prior to distribution. NJDEP installed public water-supply connections to homes and businesses within contaminated areas of Washington Township in 1989. EPA included the PVGWCS on the National Priorities List (NPL) of Superfund sites in March 1989.

Regarding the OU1 Study Area, EPA initiated RI/FS activities to delineate the nature and extent of contaminated groundwater and to evaluate potential human health and ecological risks. The OU1 RI documented levels of TCE and PCE in groundwater above drinking water standards. OU1 was subdivided into the OU1-TCE plume (groundwater primarily contaminated with TCE from the former ANC facility) and the OU1-PCE plume (groundwater primarily contaminated with PCE from the former Tung-Sol Tubing facility). The TCE and PCE plumes join into a combined plume. The entire OU1 area covers Washington Borough, Washington Township, and the northern portion of Franklin Township. The OU1 PCE plume is significantly smaller than the OU1 TCE plume, and is encompassed solely within Washington Borough. The OU1 TCE plume extends from the former ANC facility approximately 4.5 miles southward to Asbury-Broadway Road. EPA completed the OU1 RI in 2005.

EPA selected a remedy for OU1 in 2006 that includes: 1) extraction of the most contaminated part of the TCE and PCE groundwater plumes near the downgradient edge of the suspected soils source areas; 2) treatment of the extracted water to meet New Jersey Groundwater Quality Standards (NJGWQS) of 1 ppb for TCE and 1 ppb for PCE using air stripping prior to reinjection into the regional aquifer; 3) long-term monitoring of natural attenuation in the downgradient portions of the OU1 TCE and PCE plumes to determine whether these contaminants are meeting the appropriate NJGWQSs, or the Maximum Contaminant Levels (MCLs), whichever is lower; and 4) institutional controls, such as the implementation of a Classification Exception Area (CEA), to further restrict the use of groundwater within the OU1 area until the aquifer is restored. Two groundwater treatment plants have been constructed and began operations in 2016. For further information regarding the OU1 remedy, refer to the July 2006 Record of Decision (ROD). This document can be found in the Administrative Record for the OU3 Study Area and at https://www.epa.gov/superfund/pohatcong-valley-groundwater. See **Figure 1** for a layout of the OU1 Study Area.

Regarding the OU2 Study Area, between 2006 and 2009, EPA conducted an RI to determine the nature and extent of contamination beyond the OU1 Study Area. The RI also included an assessment of the hydraulic gradient and hydrogeologic connection between the OU1 and the OU2 Study Areas, and an evaluation of potential human health and ecological risks based on the occurrence and distribution of Site-related contamination in sediment, surface water, residential wells, indoor air, and groundwater. OU2 includes TCE-contaminated groundwater resulting from the OU1-TCE plume and is located downgradient of the OU1 Study Area in portions of Franklin and Greenwich Townships. EPA selected a remedy for OU2 in September 2010. The OU2 remedy includes the following: 1) providing potable water to impacted and threatened properties through the construction of water mains and service connections; 2) monitored natural attenuation for the remediation of contaminated groundwater in the OU2 Study Area until cleanup goals are met; 3) establishing a CEA to minimize the potential for exposure to contaminated groundwater until cleanup goals are met; and 4) abandoning private potable wells. The engineering design of the OU2 remedy is anticipated to be completed in 2017. For further information, regarding the OU2 remedy refer to the September 2010 ROD. This document can be found in the Administrative Record for the OU3 Study Area at https://www.epa.gov/superfund/pohatcong-valley-groundwater. See **Figure 1** for a layout of the OU2 Study Area.

In 2011, EPA initiated OU 3 Study Area RI/FS activities to determine the nature and extent of contamination. The RI included an evaluation of potential human health and ecological risks based on Site-related contamination in soil, sediment, surface water and indoor air.

On March 11, 2015, the United States District Court of New Jersey entered a Consent Decree between the United States and seven private parties who are current or past owner-operators of the former ANC facility. With the exception of certain claims reserved by the United States, the settlement represents global resolution of the United States' claims in *United States v. Pechiney Plastic Packaging, Inc.*, 09-cv-05692, and *United States v. Bristol-Myers Squibb Company, et al.*, 13-cv-05798, for costs incurred and to be incurred and work to be performed in connection with the Site pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA).

Under the Consent Decree, Pechiney Plastic Packaging, Inc. (PPPI), the Primary Settling Defendant and former owner and operator of the former ANC property, has agreed to perform (1) the response actions as described in the RODs for the OU1 TCE plume and OU2, (2) the vapor intrusion removal action and associated operation and maintenance at the former ANC property, and (3) the response action to be selected for OU3 except for the performance of response actions for OU3 beyond the geographic boundaries of the former ANC property.

Under the Consent Decree, Albea Americas, Inc. (Albea) (formerly known as Twist Beauty Packaging US, Inc.), the current owner of the former ANC property, agreed to (1) provide access to the former ANC property, (2) impose deed restrictions on the former ANC property, and (3) provide an alternative water source for non-contact cooling water for production that does not use groundwater as a source of water supply and seal and abandon production wells (PW-3 and PW-5) and groundwater injection well (RW-1). Albea recorded a deed notice on April 9, 2015, and established an alternative water supply for its operations. Once Albea established an alternative water supply in December 2015, PPPI sealed and abandoned production wells PW-3 and PW-5 and groundwater injection wells RW-1. PPPI plans to convert groundwater injection well RW-2 to be used as an injection well for the OU1 remedy.

HIGHLIGHTS OF COMMUNITY PARTICIPATION

The 2016 FS Report and the Proposed Plan for OU3 of the Site were released to the public for comment on June 15, 2016. These documents were made available to the public at information repositories maintained at the Warren County Health Department in Oxford, New Jersey and the EPA Region 2 Office in New York City. The notice of availability for the above-referenced documents was published in the *Express Times* on June 15, 2016. The public comment period ran from June 15, 2016 to August 15, 2016. On June 21, 2016, EPA conducted a public meeting at the Washington Borough Municipal Building to inform local officials and interested citizens about the Superfund process, to present the Proposed Plan for the Site, including the preferred alternative, and to respond to questions and comments from the approximately 20 attendees. The original public comment period ended on July 15, 2016, but due to a request, EPA extended the public comment period to August 15, 2016. Responses to the questions and comments received at the public meeting and in writing during the public comment period are included in the Responsiveness Summary (see **Appendix V**).

SCOPE AND ROLE OF OPERABLE UNIT 3

OU 3, which is the subject of this ROD, will address the TCE- contaminated soils that constitute a source of contamination to groundwater and indoor air at the Site. The OU3 ROD is expected to be the final remedy selected for this Site.

The primary objectives of this action are to remediate the source soils that are contributing to groundwater and indoor air contamination at the Site and minimize potential future health and environmental impacts from site-related contaminants.

SITE CHARACTERISTICS

The data collected during the OU3 RI and other sampling efforts provided EPA with specifics related to Site characteristics, as well as information to perform a Risk Assessment. The results of the OU1 RI performed by EPA, as well as investigations performed by other parties, indicated that there were elevated TCE concentrations in soil and groundwater in the OU3 Study Area requiring further delineation.

The actions taken as a result of the OU1 ROD (2006) and OU2 ROD (2010) are currently addressing groundwater.

This ROD addresses the soil source area beneath the southwestern portion of the former ANC building, the characteristics of which are summarized in this section and the "Summary of Site Risks" section, below. The results of the vapor-intrusion investigation, conducted during the OU3 RI, are also detailed below.

Site Geology/Hydrogeology

The PVGWCS is located in the Highlands physiographic province of western New Jersey. The Pohatcong Valley trends northeast-southwest and is underlain by carbonate rocks. Glacial moraine deposits overlay the carbonate bedrock. The glacial deposits are comprised of a mix of glacio-fluvial deposits and till and are characterized as a poorly sorted mixture of sand, silt, and clay with larger clasts ranging from gravel to boulders. The moraine deposits range from 95 feet to greater than 140 feet thick at the OU3 Study Area. In general, the permeability of the glacial deposits is low.

The groundwater occurs in the carbonate bedrock aquifer below the overburden. This group of fractured carbonate rocks is part of the Leithsville Formation and is often referred to as the Kittatiny Aquifer System. Near the OU3 Study Area, the depth to groundwater is approximately 100 to 120 feet below ground surface (bgs). Groundwater flow is from the northeast to the southwest, down the axis of the valley.

Nature and Extent of Contamination

Investigations

The results of the OU1 RI performed by EPA, as well as investigations performed by other parties, indicated that there were elevated TCE concentrations in soil and groundwater in the OU3 Study Area requiring further delineation. Several investigations were completed between 2012 and 2015 to determine the nature and extent of contamination at the OU3 Study Area. These investigations included: soil investigations, a drainage pathway investigation, groundwater investigations, indoor and sub-slab air sampling investigations, and an ecological characterization.

Soil Investigations

Based on historical soil sampling results, EPA targeted soil investigations throughout the OU3 Study Area, including Areas A, B, and C. From 2012 to 2015, 71 borings were advanced to collect a total of 470 soil samples for chemical analysis to determine the extent of soil contamination. Sample locations are presented on **Figure 3**.

The highest concentrations and most frequent detections of TCE were beneath the southwestern corner of the former ANC building (Area A), where TCE degreasers are believed to have been located. Below the former ANC building, a total of 165 samples from 30 borings were collected between 2012 and 2015 to determine the extent of soil contamination directly below the former ANC building. Out of 28 soil samples collected in shallow soils (< 2 feet bgs) beneath the building slab, TCE was detected in 6 samples at levels ranging from .008 parts per million (ppm) to 2.8 ppm. The maximum concentration was detected under the southwestern corner of the building (Area A). Soil samples from the subsurface soils (soils > 2 feet bgs) showed TCE at levels ranging from non-detect to 120 ppm, with the maximum concentration again detected under the southwestern corner of the building (Area A).

Vertically, TCE is present in Area A throughout the overburden soils beneath the former ANC building and into the weathered bedrock zone to a depth of approximately 100 feet (bgs). Area A has the highest concentrations of TCE in soil at the OU3 Study Area with 21 out of 165 samples containing TCE above 1 ppm (the maximum TCE concentration detected was 120 ppm at a depth of 80 feet bgs). A hot-spot was identified within Area A at depths between 70 and 100 feet bgs (19 of the 56 soil samples collected from this area contained TCE above 1 ppm).

TCE detections in the groundwater (sampled by Environ, contractor to PPPI) directly under the former ANC building (Area A) ranged from 74 parts per billion (ppb) in December 2006 to as high as 120 ppb in July 2013. The NJGWQS for TCE is 1 ppb. Sampling of groundwater by Environ in 2006 found TCE at a concentration of 4,600 ppb in the groundwater 100 feet downgradient from this area, confirming that TCE beneath the former ANC building has migrated through the unsaturated overburden into the regional groundwater. The TCE remaining in the soils in Area A is an ongoing source of groundwater and indoor air contamination.

A total of 123 samples from 15 borings were collected outside the former ANC building footprint on the former ANC property during the OU3 RI, including in Areas B and C. Out of 123 soil samples, TCE was detected in 28 samples as high as 0.74 ppm. The maximum concentration was detected in deep soils (90 -92 feet bgs) downgradient of the DL-10 discharge point (Area C).

Soil samples were also taken on adjacent properties downgradient of the former ANC property, AC1, WLY, and VTC. On the WLY property, 58 samples were collected from 9 borings. TCE was found in 36 samples at a range of non-detect to 6.7 ppm, with the maximum concentration found 7 feet bgs in the WLY ponded area, near the DL-9 discharge (Area B). On the AC1 property, 92 soil samples were collected from 12 borings. The maximum TCE detection was 2 ppm in the surface soil downgradient from the DL-10 discharge (Area C). On the VTC property, 32 samples were collected from 5 borings and no TCE contamination was detected.

Soil samples were also analyzed for semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and metals within the OU3 Study Area. SVOCs, PCBs, pesticides, and metals were detected in soil throughout the OU3 Study Area. However, these detections were isolated occurrences, not found in widespread areas of the OU3 Study Area associated with the TCE contamination. The limited presence of SVOCs, PCBs, pesticides, and metals above guidance values are not Site-related because they are not associated with the TCE-contaminated groundwater. These results will be forwarded to the facility property owners as well as state and local authorities to address under other cleanup authorities, as appropriate.

Drainage Pathway Investigation

Surface water and sediment samples were obtained to determine the nature and extent of contamination in outfall areas, drainage pathways, and ponded water areas. A total of 13 surface water samples and 14 sediment samples were collected throughout the OU3 Study Area including in Areas B and C. It was not possible to collect surface water and sediment samples from Area A, since that area is under the former ANC building. Sample locations are presented on **Figure 4**.

Since there are no permanent surface-water features in the OU3 Study Area, samples were collected following a rain event to examine the impact of recharge at areas with soil contamination (*i.e.*, Areas B and C). Surface water and sediment samples were analyzed for VOCs, SVOCs, pesticides, PCBs and metals.

The data suggest that TCE entered the wastewater drainage network inside the Area A portion of the former ANC building and that TCE-contaminated water either infiltrated into the ground through cracked drain pipes under the facility or was directed through effluent pipes that then discharged to drainage areas on the eastern (DL-9) and western (DL-10) side of the former ANC railroad spur (Areas B and C, respectively).

Compared to the high TCE concentrations in soil underneath Area A of the former ANC building (Area A), substantially lower concentrations of TCE were identified throughout Areas B and C of the OU3 Study Area. Area C includes the former ANC slope drainage area east of the railroad spur down slope from the DL-10 outfall, which extends into the AC1 drainage basin through an eroded channel, and Area B in the WLY ponded area down slope from the DL-9 outfall on the western side of the former ANC property railroad spur. TCE was detected in 103 of 305 samples collected from the four OU3 Study Area properties (not including samples from below the former ANC building). TCE in Area C was observed in the surface water (up to 0.11 ppb) and sediment (up to .002 ppm). TCE in Area B was observed in surface water (up to 21 ppb) and sediment (up to .008 ppm).

Residual levels of TCE in subsurface soil throughout the drainage areas indicate likely disposal and transfer of TCE at the former ANC facility during historical operations. The data suggests that TCE migrated through overland flow and then infiltration in the drainage areas provided a mechanism for TCE in the surface water and sediment to mobilize from the discharge areas (DL-9 and DL-10), to redistribute to the lower portions of the drainage areas, and either migrate into groundwater and/or volatize into the air.

Surface water and sediment samples were also analyzed for SVOCs, pesticides, PCBs, and metals. SVOCs, PCBs, pesticides and metals were detected in surface water and sediment within the OU3 Study Area. The detections were isolated occurrences, not found in widespread areas of the OU3 Study Area associated with the TCE contamination. The limited presence of SVOCs, PCBs, pesticides, and metals above the guidance values are not Site-related and are not associated with the TCE-contaminated groundwater.

Groundwater Investigations

Based on EPA's OU1 and OU2 comprehensive RI studies, TCE forms a continuous 8.5 mile groundwater contaminant plume originating in the OU3 Study Area. Based on the extensive OU1 groundwater investigation, EPA concluded that TCE is by far the main groundwater contaminant throughout the PVGWCS and that the former ANC property constitutes the primary source of that TCE. Groundwater samples collected throughout the OU1 Study Area indicate that TCE has migrated down through unconsolidated soils from the former ANC property (Area A) into the regional aquifer.

The highest TCE concentration detected in groundwater sampled during the 2002 OU1 RI (2,100 ppb) was located immediately downgradient of the former ANC facility. Sampling results in the regional aquifer by Environ revealed that groundwater immediately downgradient of the former ANC facility is consistently highly contaminated with TCE, with concentrations as high as 4,600 ppb. In addition, a groundwater sample (PPP-SBD-40) collected during the OU3 RI detected TCE at 540 ppb in the southern portion of the former ANC property.

A total of 11 perched groundwater samples were collected in both deep and shallow soil borings in perched zones throughout the drainage areas of the OU3 Study Area. Perched water was encountered in small, discontinuous zones throughout the overburden. Perched water samples were analyzed for VOCs to determine the presence of TCE contamination. TCE levels in perched groundwater ranged from 0.4 ppb to 820 ppb with the maximum concentration detected in Area C near the base of the ANC slope, downgradient from the DL-10 discharge point. Sample locations are presented on **Figure 3**.

Indoor and Sub-Slab Air Sampling Investigations

In 2013, buildings throughout the OU3 Study Area were screened for potential vapor intrusion during the OU3 RI. The only building determined to have the potential for vapor intrusion was the former ANC building. In March 2013, a vapor intrusion investigation was completed within and under the former ANC building. Ten sub-slab and ten indoor air samples were collected.

Significantly elevated levels of VOC vapors were detected in both sub-slab and indoor air samples. The results indicated that concentrations of TCE in the sub-slab air were significantly above the NJDEP Non-Residential Soil Gas Screening Level (150 micrograms per cubic meter, or $\mu g/m^3$) and indoor air concentrations were well above the Site-specific indoor air health goal of 7 $\mu g/m^3$ developed by EPA and the Agency for Toxic Substances and Disease Registry (ATSDR). The highest level of TCE in the sub-slab was found to be 480,000 $\mu g/m^3$. This concentration was detected under the southwestern corner of the former ANC building. Indoor air TCE concentrations up to 180 $\mu g/m^3$ were also detected in the southwestern corner of the former ANC building.

Immediately upon analysis of the vapor data, during the summer of 2013, soil vapor extraction (SVE) and sub-slab depressurization (SSD) systems to mitigate exposure to TCE inside the building were installed by a potentially responsible party under EPA oversight. The systems treat the vapors associated with soils to a depth of approximately 5 feet below the building slab. Results of subsequent sampling show the systems have reduced concentrations in the indoor and sub-slab air significantly and indoor air levels are below the Site-specific indoor air health goal of 7 $\mu g/m^3$.

Ecological Characterization

OU3 Study Area habitats were characterized for the former ANC, AC1, VTC, and WLY properties. It was determined that no endangered, threatened or sensitive species were present within a quarter mile of the Site and that investigation and cleanup of the OU3 Study Area would have no effect on any federally listed threatened or endangered species or critical habitats.

Contamination Fate and Transport

A chemical's fate in the environment is a function of its physical and chemical properties and conditions at the study area. The potential for environmental transport is a function of the conditions at the study area, including geological and hydrogeological characteristics. The primary fate and transport aspects of the OU3 Study Area are summarized below.

- TCE, either in dissolved form or as pure liquid phase, has been released to soils from historic operations at the former ANC property and has migrated through the unconsolidated vadose zone and into groundwater. Some of the TCE mass was retained by capillary forces in the soil pores, with the highest concentrations remaining presently in the 60-to 100-foot interval underneath the former ANC building.

- The potential release of the TCE in soil is either through volatization to the vapor phase or through continuous dissolution of contaminants to percolating groundwater.

- TCE in soil and groundwater have migrated as vapor. Vapor intrusion is a concern for the former ANC building as it is located directly over soils contaminated with TCE. The results of the vapor intrusion investigation indicated that significantly elevated levels of

> TCE vapors were detected in both the sub-slab and indoor air samples. As noted previously, an immediate removal action was performed under EPA oversight and included the installation and operation of the SVE and SSD systems to mitigate exposure of TCE vapors inside the building.

The majority of the TCE detected in the OU3 Study Area was likely released at the former ANC property prior to the mid-1980s when the use of TCE at the ANC property reportedly ceased. Prior to that time, data suggests TCE entered the wastewater drainage network inside the former ANC building and that TCE-contaminated water either infiltrated into the ground through cracked drain pipes or was directed through effluent pipes to the downslope drainage areas. TCE containing water then migrated down through the 100-foot thick vadose zone and contaminated the regional groundwater aquifer.

The TCE remaining in soils and the limited perched groundwater zones continue to act as a source of contamination, impacting water that infiltrates through the contaminated overburden soils, continually discharging additional TCE mass to the regional groundwater TCE plume. TCE remaining in soils below the former ANC building will also continue to act as a source of indoor air contamination, impacting human receptors if the SVE and SSD systems are not in operation. **Figure 5** depicts the current conceptual Site model[1].

CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

Land Use

The OU3 Study Area and surrounding area is comprised of a mix of commercial, industrial, and residential properties. Immediately southwest of the OU3 Study Area lies the Borough of Washington, made up primarily of residential areas and small businesses. Southeast of the OU3 Study Area is farmland with small pockets of residential and industrial areas. The area directly north of the OU3 Study Area, along Route 31, is mostly rural with small pockets of commercial properties.

The former ANC property occupies 19.6 acres on the eastern slope of the Pohatcong Valley and is zoned industrial on the latest tax maps. While the property is flat, the former ANC building is built into the west side of a hill. To the west of the former ANC property is an unused railroad right of way. The majority of the former ANC property is paved and developed, with small grassy areas toward the north and east walls of the ANC building. A vegetated area is located toward the southwest of the former ANC property.

At the base of the hill south of the former ANC property are the AC1, VTC, and WLY properties. These properties are all zoned industrial.

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[1] A conceptual site model illustrates contaminant sources, release mechanisms, exposure pathways, migration routes, and potential human and ecological receptors.

The AC1 property (9.3 acres) consists primarily of several large structures, including a large, unused dilapidated building, a cellular telephone tower, and a large drainage basin. The remaining areas of the property are unused and covered with grass except for a gravel road north of the building.

The VTC property is predominantly paved or gravel covered, with several abandoned buildings and garages. The property has been abandoned since 2003.

The WLY property is predominately paved or gravel covered, with several large buildings surrounding a large central parking lot. Only a portion of the former lumberyard is currently in use. The abandoned Erie-Lackawanna railroad to the northeast of the property fenceline is predominately grass covered.

The former ANC property is an active industrial facility and is expected to remain zoned for industrial use. The adjacent downgradient properties (AC1, WLY, and Vikon) are also expected to remain zoned for industrial use. The existing institutional controls (2015 deed notice) on the former ANC property provides, among others things, restriction of groundwater use, and restrictions of land use in areas deemed necessary for remediation activities, as well as, areas that would interfere with the protectiveness of the selected remedy.

Groundwater Use

Groundwater in the Pohatcong Valley occurs mainly in the sedimentary limestone and dolomite (carbonate) rocks underlying the valley. Karstic development in these carbonate rocks increases the porosity and permeability of the aquifer beneath the Valley. The groundwater in the Valley is used by residential and commercial properties as a source of potable drinking water and by industrial facilities.

New Jersey American Water Company owns and operates two groundwater production wells in the Pohatcong Valley and one groundwater production well in the adjacent Musconetcong Valley. These production wells represent the sole source of drinking water for Washington Borough residents and for numerous people throughout the valley. The Vannatta Street and Dale Avenue production wells in the Pohatcong Valley have wellhead treatment due to impacts from the PVGWCS.

SUMMARY OF SITE RISKS

As part of the RI/FS, EPA conducted a baseline risk assessment to estimate the current and future effects of contaminants on human health and the environment. A baseline risk assessment is an analysis of the potential adverse human health and ecological effects of releases of hazardous substances from a site in the absence of any actions or controls to mitigate such releases, under current and future land and groundwater uses. The baseline risk assessment includes a human health risk assessment and an ecological risk assessment. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment for the site.

Human Health Risk Assessment

A four-step process is utilized for assessing site-related human health risks for a reasonable maximum exposure scenario:

- *Hazard Identification* – uses the analytical data collected to identify the contaminants of potential concern at the site for each medium, with consideration of a number of factors explained below;

- *Exposure Assessment* - estimates the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures, and the pathways (e.g., ingesting contaminated well-water) by which humans are potentially exposed;

- *Toxicity Assessment* - determines the types of adverse health effects associated with chemical exposures, and the relationship between magnitude of exposure (dose) and severity of adverse effects (response); and

- *Risk Characterization* - summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site-related risks. The risk characterization also identifies contamination with concentrations which exceed acceptable levels, defined by the National Contingency Plan (NCP) as an excess lifetime cancer risk greater than 1×10^{-6} – 1×10^{-4}, an excess of lifetime cancer risk greater than 1×10^{-6} (i.e., point of departure) combined with site-specific circumstances, or a Hazard Index (HI) greater than 1.0; contaminants at these concentrations are considered chemicals of concern (COCs) and are typically those that will require remediation at the site. Also included in this section is a discussion of the uncertainties associated with these risks.

Hazard Identification

In this step, the chemicals of potential concern (COPCs) in each medium were identified based on such factors as toxicity, frequency of occurrence, fate and transport of the contaminants in the environment, concentrations, mobility, persistence and bioaccumulation. The risk assessment for OU3 focused on surface soil and subsurface soil contaminants related to the PVGWCS which may pose significant risk to human health. Analytical information that was collected to determine the nature and extent of contamination revealed the presence of VOCs in the soil gas and indoor air at concentrations of potential concern. As a result, groundwater (a focus of the OU1 BHHRA) was also assessed.

This ROD focuses on the 42-acre facility area which consists of the ANC property and adjacent properties, including WLY, AC1 and VTC. The contaminated media, concentrations detected and concentrations utilized to estimate potential risks and hazards for the COCs at the Site are presented in **Table 1**. The only COC requiring remediation at the Site is TCE; soil vapors and groundwater were the only media that contained TCE at levels of concern. A comprehensive list of all COPCs identified in soils, sediment and surface water can be found in the BHHRA, entitled “Revised Final Human Health Risk Assessment – Pohatcong Valley Groundwater Contamination Site, OU3” – September 2015. A comprehensive list of groundwater COPCs can be found in the BHHRA, entitled “Human Health Risk Assessment – Pohatcong Valley Groundwater Contamination Site, OU1” – June 2005. The analysis of soil gas and indoor air concentrations in the ANC building prior to the sub-slab depressurization system installation can be found in the “Final Vapor Intrusion Sampling Technical Memorandum – Pohatcong Valley Groundwater Contamination Site, OU3” – June 2013. These documents are available in the Administrative Record file.

Exposure Assessment

Consistent with Superfund policy and guidance, the exposure assessment assumes no remediation or institutional controls to mitigate or remove hazardous substance releases. Cancer risks and noncancer hazard indices were calculated based on an estimate of the reasonable maximum exposure (RME) expected to occur under current and future conditions at the Site. The RME is defined as the highest exposure that is reasonably expected to occur at a site.

The baseline human health risk assessment (BHHRA) evaluated potential risks to populations associated with both current and potential future land uses. The primary land use in the OU3 Study Area is industrial. Exposure pathways were identified for each potentially exposed population and each potential exposure scenario for exposure to surface soil, subsurface soil, surface water, sediment, groundwater, and indoor air.

A summary of exposure pathways assessed in the BHHRA are presented in **Table 2** and included future exposure to residents and current and future exposure to trespassers, site workers and construction workers exposed through incidental ingestion, dermal contact and inhalation from contaminated media on the Site. Typically, exposures are evaluated using a statistical estimate of the exposure point concentration, which is usually an upper-bound estimate of the average concentration for each contaminant, but in some cases may be the maximum detected concentration. The exposure point concentration for TCE in groundwater can be found in **Table 1**, while a comprehensive list of the exposure point concentrations for all COPCs can be found in the BHHRA. There were no site-related COCs identified for surface soil, subsurface soil, surface water, or sediment.

Toxicity Assessment

In this step, the types of adverse health effects associated with contaminant exposures and the relationship between magnitude of exposure and severity of adverse health effects were determined. Potential health effects are contaminant-specific and may include the risk of developing cancer over a lifetime or other noncancer health effects, such as changes in the normal functions of organs within the body (*e.g.,* changes in the effectiveness of the immune system). Some contaminants are capable of causing both cancer and noncancer health effects.

Under current EPA guidelines, the likelihood of carcinogenic risks and noncancer hazards due to exposure to site chemicals are considered separately. Consistent with current EPA policy, it was assumed that the toxic effects of the site-related chemicals would be additive. Thus, cancer and noncancer risks associated with exposures to individual COPCs were summed to indicate the potential risks and hazards associated with mixtures of potential carcinogens and noncarcinogens, respectively.

Toxicity data for the human health risk assessment were provided by the Integrated Risk Information System (IRIS) database, the Provisional Peer Reviewed Toxicity Database (PPRTV), or another source that is identified as an appropriate reference for toxicity values consistent with EPA's directive on toxicity values. This information for the site-related COCs is presented in **Table 3** (noncancer toxicity data summary) and **Table 4** (cancer toxicity data summary). Additional toxicity information for all COPCs is presented in the OU1 and OU3 BHHRAs.

Toxicity values for the COC TCE have been updated since the OU1 BHHRA was conducted in 2005. The new toxicity values do not impact the groundwater cleanup levels or remedy selection since the exposure point concentration of TCE exceeds the MCL. While TCE was detected at low levels in surface and subsurface soils during the OU3 investigation, it is not a COC for direct human exposure to soils since the levels are not high enough to contribute to unacceptable direct contact risks or hazards from the Site.

Risk Characterization

Noncarcinogenic risks were assessed using a HI approach, based on a comparison of expected contaminant intakes and benchmark comparison levels of intake (reference doses, reference concentrations). Reference doses (RfDs) and reference concentrations (RfCs) are estimates of daily exposure levels for humans (including sensitive individuals) which are thought to be safe over a lifetime of exposure. The estimated intake of chemicals identified in environmental media (*e.g.,* the amount of a chemical ingested from contaminated drinking water) is compared to the RfD or the RfC to derive the hazard quotient (HQ) for the contaminant in the particular medium. The HI is obtained by adding the hazard quotients for all compounds within a particular medium that impacts a particular receptor population.

The HQ for oral and dermal exposures is calculated as below. The HQ for inhalation exposures is calculated using a similar model that incorporates the RfC, rather than the RfD.

HQ = Intake/RfD

Where: HQ = hazard quotient
Intake = estimated intake for a chemical (mg/kg-day)

RfD = reference dose (mg/kg-day)

The intake and the RfD will represent the same exposure period (i.e., chronic, subchronic, or acute).

As previously stated, the HI is calculated by summing the HQs for all chemicals for likely exposure scenarios for a specific population. An HI greater than 1.0 indicates that the potential exists for noncarcinogenic health effects to occur as a result of site-related exposures, with the potential for health effects increasing as the HI increases. When the HI calculated for all chemicals for a specific population exceeds 1.0, separate HI values are then calculated for those chemicals which are known to act on the same target organ. These discrete HI values are then compared to the acceptable limit of 1.0 to evaluate the potential for noncancer health effects on a specific target organ. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media. A summary of the noncarcinogenic hazards associated with these chemicals for each exposure pathway is contained in **Table 5**.

Table 5 shows that the HI for noncancer effects is elevated for future residential exposure to groundwater through tap water and shower vapors due to concentrations of TCE. The HI for noncancer effects from COCs is below the threshold of 1 for direct contact exposure to surface and subsurface soils.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a carcinogen, using the cancer slope factor (SF) for oral and dermal exposures and the inhalation unit risk (IUR) for inhalation exposures. Excess lifetime cancer risk for oral and dermal exposures is calculated from the following equation, while the equation for inhalation exposures uses the IUR, rather than the SF:

Risk = LADD x SF

Where: Risk = a unitless probability (1×10^{-6}) of an individual developing cancer
LADD = lifetime average daily dose averaged over 70 years (mg/kg-day)
SF = cancer slope factor, expressed as [1/(mg/kg-day)]

These risks are probabilities that are usually expressed in scientific notation (such as 1×10^{-4}). An excess lifetime cancer risk of 1×10^{-4} indicates that one additional incidence of cancer may occur in a population of 10,000 people who are exposed under the conditions identified in the assessment. Again, as stated in the NCP, the point of departure is 10^{-6} and the acceptable risk range for site-related exposure is 10^{-6} to 10^{-4}.

A summary of the estimated cancer risks is presented in **Table 6**. The results indicated that the cancer risks exceeded the acceptable risk range for residential exposure to tap water and shower vapors due to groundwater concentrations of TCE. The cancer risk from COCs is below the acceptable risk range for direct contact exposure to surface and subsurface soils.

The qualitative soil vapor intrusion screening level evaluation indicated that the potential for vapor intrusion exists at OU3. EPA conducted vapor intrusion sampling at the ANC building in March 2013 which revealed the presence of high levels of TCE in both sub-slab and indoor air samples. Soil vapor extraction and sub-slab depressurization systems were installed in the summer of 2013 which prevent current exposure to soil gas vapors, however the potential for exposure to TCE exists in the absence of functioning mitigation systems. Prior to the operation of the SVE/SDS to treat indoor air, concentrations of TCE detected in sub-slab and indoor air samples exceeded EPA's risk-based vapor intrusion screening levels (VISLs). A comparison of the vapor intrusion sampling results with the VISLs can be found in **Table 7**. Further discussion of the VI results and sub-slab depressurization system can be found in Section 6.4 of the OU3 BHHRA.

Ecological Risk Assessment

A screening-level ecological risk assessment (SLERA) was conducted to evaluate the potential for ecological risks from the presence of contaminants in surface soil, sediment and surface water. The SLERA focused on evaluating the potential for impacts to sensitive ecological receptors to site-related constituents of concern through exposure to soil, sediment and surface water on the combined properties (ANC, WLY, and AC1/VTC). Concentrations in the media listed above were compared to ecological screening values as an indicator of the potential for adverse effects to ecological receptors. A complete summary of all exposure scenarios can be found in the SLERA.

There is not a potential for adverse effects to ecological receptors (invertebrates, reptiles, amphibians, birds and mammals) from exposure to contaminated soil, sediment and surface water. Detected concentrations for all site-related chemicals in all media were below the ecological screening criteria, which resulted in HIs below the acceptable threshold of 1. There were no COCs identified for ecological receptors. In addition, there is limited habitat present in the site for ecological receptors.

Based on the results of the SLERA, there are no unacceptable risks or hazards associated with site-related contamination for ecological receptors.

Uncertainties

The procedures and inputs used to assess risks in this evaluation, as in all such assessments, are subject to a wide variety of uncertainties. In general, the main sources of uncertainty include:

- environmental data
- exposure parameter estimation
- exposure point concentrations
- toxicity values

- risk characterization

Two of the primary sources of uncertainty identified in the HHRA were associated with exposure parameters and toxicological data. Uncertainty in exposure parameters was related to many of the parameters being associated with default values since site-specific values were not available. This would provide a conservative estimate of potential risk and hazards.

Another important source of uncertainty was toxicological data. The toxicity factors used in the quantitative evaluation of potential risks and hazards were primarily selected from the Integrated Risk Information System (IRIS). For many chemicals, there is a lack of appropriate information on effects in humans (i.e., epidemiologic studies). Therefore, animal studies are generally used to develop toxicity values in human health risk assessments, which may under- or over-estimate potential risks and hazards.

More specific information concerning uncertainty in the health risks is presented in the baseline human health risk assessment report.

Risk Assessment Summary

While evaluated as part of the OU3 investigations, no OU3-related human health and ecological risks were found on the adjacent AC1, VTC, or WLY properties; please refer to the OU3 RI Report and OU3 BHHRA for further detail on the results of these investigations. Further, based on the results of the OU3 human-health and ecological risk assessments it has been concluded that no Site-related risks are attributable to Areas B & C. However, based on the results of the OU1 and OU3 human-health risk assessments, there are unacceptable risks associated with Site-related contamination in indoor air and groundwater. TCE in soils beneath the ANC building (Area A) will need to be addressed in order to ensure continued protection of human health and the environment.

Basis for Action

Based upon the quantitative human-health risk assessment and ecological evaluation, EPA has determined that actual or threatened releases of hazardous substances from the Site, if not addressed by the response action selected in this ROD, may present a current or potential threat to human health and the environment.

REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are specific goals to protect human health and the environment. These objectives are based on available information and standards, such as applicable or relevant and appropriate requirements (ARARs), to-be-considered guidance, and Site-specific risk-based levels.

RAOs have been developed to focus on reducing the impact from the contaminated vadose zone soils (unsaturated zone of soil and rock above the water table) to the groundwater quality and the indoor air. The RAOs for the OU3 Study Area are:

For contaminated soil:

- Reduce contaminant mass in the vadose-zone soil to minimize the impact to groundwater quality.
- Reduce contaminant mass in the vadose-zone soil to minimize the potential human-health risks from vapor intrusion.

For soil vapor:

- Mitigate impacts to public health resulting from existing, or potential, soil vapor intrusion into buildings.

To achieve these RAOs, remediation goals for contaminated soil and soil vapor at the Site were identified.

This site provides an unusual situation for the evaluation of impact to groundwater because 1) the highest level of vadose zone soil contamination is located beneath a large building, and the building slab is acting as a cap; 2) the infiltration of rain water is significantly reduced but cannot be confirmed to be zero; 3) the highest contaminant concentrations are located at depth (70 to 100 feet bgs); and 4) contaminants have migrated into the fractured bedrock aquifer. There is no promulgated federal soil cleanup standard for impact to groundwater. The methodologies established by NJDEP for calculating impact-to-groundwater soil remediation standards are To- Be-Considered (TBC) guidance and are not strictly applicable for contamination under a cap and with the presence of a fractured bedrock aquifer. Even though any models used to develop cleanup standards under this unusual situation will have significant limitations, the SESOIL/AT123D model was used to provide an estimate of contaminants that may release into the groundwater from the vadose zone soil. Modeled calculations demonstrate that a TCE soil concentration of 1 ppm would result in minimal impact to TCE concentrations in groundwater at the OU1 groundwater treatment plant extraction wells, thus, would be protective of groundwater at this Site. Therefore, a Site-specific remediation goal of 1 ppm has been established for TCE in the vadose-zone soil.

The Site-specific indoor air health goal of 7 $\mu g/m^3$ developed by EPA and ATSDR is a TBC criterion. Using collected sub-slab and indoor air concentrations, a Site-specific attenuation factor from sub-slab vapor to indoor air was developed. Using the Johnson & Ettinger Model for Subsurface Vapor Intrusion into Building, a soil cleanup value of 1 ppm for TCE was determined to be protective of human-health.

The cleanup levels for soil and indoor air and their basis are presented in **Table 8.**

DESCRIPTION OF REMEDIAL ALTERNATIVES

CERCLA Section 121(b)(1), 42 U.S.C. § 9621(b)(1), mandates that remedial actions must be protective of human health and the environment, be cost-effective, comply with ARARs, and utilize permanent solutions, alternative treatment technologies, and resource recovery alternatives to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions which employ, as a principal element, treatment to permanently and significantly reduce the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants at a site. CERCLA §121(d), 42 U.S.C. § 9621(d), further specifies that a remedial action must attain a level or standard of control of the hazardous substances, pollutants, and contaminants that at least attains federal and state ARARs, unless a waiver can be justified pursuant to CERCLA Section 121(d)(4), 42 U.S.C. § 9621(d)(4).

Potential applicable technologies were identified and screened in the FS using effectiveness, implementability, and cost as the criteria, with emphasis on the effectiveness of the remedial action. The retained technologies were combined into four remedial alternatives. A brief summary of the remedial alternatives for the Site is provided below.

The construction time for each alternative reflects only the time required to construct or implement the remedy and does not include the time required to design the remedy, or procure contracts for design and construction. Because Alternatives 3 & 4 would leave hazardous substances, pollutants or contaminants on-site above levels that allow for unlimited use and unrestricted exposure, CERCLA requires that the Site be reviewed every five years (five year reviews.) If justified by the review, additional response actions may be implemented.

With the exception of the No Action alternative, all alternatives would include the following common elements: modifications to the existing deed notice to ensure non-interference with all components of the OU3 remedy; operation, maintenance and monitoring of the existing shallow soil vapor extraction (SVE) and sub-slab depressurization (SSD) systems; and five-year reviews.

Detailed descriptions of the remedial alternatives for the OU3 Study Area can be found in the FS report.

The alternatives are:

Alternative 1: No Action

Capital Cost:	$0
Annual O&M Costs:	$0
Present-Worth Cost:	$0
Construction Time:	0 months
Timeframe to reach RAOs	>100 years

The No Action Alternative was retained, as required by the NCP, and provides a baseline for comparison with other Site remedial alternatives. No remedial actions would be implemented to address the TCE-contaminated soil as part of the No Action Alternative.

Under the No Action alternative, the former ANC building acts as an impermeable cap, which reduces the infiltration beneath the former ANC building; significantly slows down contaminant migration into groundwater; and prolongs the existence of contamination in the vadose zone.

Under this alternative, the shallow SVE and SSD systems, which are currently operating in order to address indoor air TCE contamination, are assumed not to be in operation. No remedial action or monitoring would be performed. Additionally, this option does not include the continuation of any existing institutional controls, such as the existing deed notice, nor the implementation of any new institutional controls.

Alternative 2: Limited Action

Capital Cost:	$0
Annual O&M Costs:	$185,000
Present-Worth Cost:	$2.37 million
Construction Time:	0 years
Timeframe to reach RAOs	>100 years

Under this alternative, the existing shallow SVE and SSD systems would be operated and maintained. The shallow SVE and SSD systems create a negative pressure through a series of extraction wells. The extraction wells are used to collect the contaminated air, which is then treated to remove contaminants through the use of granular activated carbon. The operation of the shallow SVE and SSD systems provides protection of human health from vapor intrusion. The shallow SVE and SSD systems treat contaminated soil vapor in the sub-slab down to approximately 5 feet under the slab. TCE concentrations in the most recent indoor air sampling event ranged from non-detect to 1 $\mu g/m^3$, which meet the Site-specific indoor air health goal and demonstrate that the system is effective.

System construction was completed in 2013. The existing deed notice restricts groundwater use, states that PPPI must operate the SVE and SSD systems until EPA deems it is no longer necessary, and restricts land use in areas deemed necessary for remediation activities.

Because this alternative would leave hazardous substances, pollutants or contaminants on-site above levels that allow for unlimited use and unrestricted exposure, CERCLA requires that the Site be reviewed every five years. If justified by the review, additional response actions may be implemented.

Alternative 3: In-Situ Chemical Oxidation

Capital Cost:	$10.3 million
Annual O&M Costs:	$185,000
Present-Worth Cost:	$12.6 million
Construction Time:	3 years
Timeframe to reach RAOs	>30 years

Under this alternative, *in-situ* chemical oxidation (ISCO), in conjunction with the shallow SVE and SSD systems, would be implemented to remediate the contaminated area beneath the former ANC building. The shallow SVE and the SSD systems would be operated as described in Alternative 2. The ISCO treatment would involve injecting an oxidant or oxidant releasing compounds into the target treatment zone containing TCE at levels of greater than 1 ppm in the soil. The oxidant would mix with the contaminants and cause them to decompose. When the process is complete, only water and innocuous breakdown products would be left in the treated area. Monitoring would be required to determine the effectiveness of the treatment. For the ISCO treatment, the chemical distribution would require enhancement by environmental hydraulic fracturing, which involves the injection of an amendment under moderate pressure to create flow paths to enhance oxidant distribution. For this alternative, permanganate is assumed as the representative oxidant for alternative development and estimating costs. During the remedial design (RD), other process options would be evaluated based on bench-study and pilot study results to select the most effective oxidant to treat the Site.

For the remedial action, environmental hydraulic fracturing would be conducted followed by the delivery of chemicals (*e.g.*, permanganate solution) using a network of injection wells. Multiple applications of treatment agents are anticipated as the injected chemical would infiltrate into a deeper depth by gravity. A monitoring well screened at the groundwater table would be installed at the downgradient edge of the injection area to monitor the migration of contaminants and /or oxidant into the aquifer.

After completion of multiple rounds of ISCO treatment, soil borings would be installed within the treatment zone to evaluate the effectiveness of treatment. Data from soil sampling and analysis and groundwater samples below the treatment zone could also be used to evaluate the mass reduction. Due to the challenges in ensuring adequate distribution of oxidant in vadose zone soils, it is estimated that approximately 50 percent mass removal could be achieved within the treatment zone based on prior experience at other sites. The remaining soil contamination left in place would migrate to the building sub-slab as soil gas and be extracted by the shallow SVE and SSD systems or migrate to groundwater and be addressed under the OU1 remedy. It is estimated that construction related to this effort would be completed in three years.

The existing deed notice restricts groundwater use, states that PPPI must operate the SVE and SSD systems until EPA deems it is no longer necessary, and restricts land use in areas deemed necessary for remediation activities. The deed notice will be modified to assure the implementation of all aspects of the OU3 remedy.

This remedy will leave hazardous substances, pollutants or contaminants on-site above levels that allow for unlimited use and unrestricted exposure. Therefore, CERCLA requires that the Site be reviewed every five years. If justified by the review, additional response actions may be implemented.

Alternative 4: Deep SVE with Optional In-Situ Thermal Hot-Spot Treatment

Deep SVE without *in-situ* Thermal Treatment

Capital Cost:	$3.5 million
Annual O&M Costs:	$609,000
Present-Worth Cost:	$7.8 million
Construction Time:	2.5 years
Timeframe to reach RAOs	10 years

Deep SVE with *in-situ* Thermal Treatment

Capital Cost:	$9.2 million
Annual O&M Costs:	$410,000
Present-Worth Cost:	$12.7 million
Construction Time:	4 years
Timeframe to reach RAOs	10 years

Under this alternative, the shallow SVE and the SSD systems would be operated as described in Alternative 2. A deep SVE system would be installed from 30 to 100 feet bgs to remediate the deep vadose zone contamination beneath the former ANC building to meet the Site-specific remediation goal. The deep SVE system would operate by the same principles as the shallow SVE system, except it would be located in a deeper interval. The shallow SVE system has been successfully remediating the shallow soil. The lithology in the deeper soils is similar to the shallow soils, indicating that it is likely that the deep SVE system would be effective in treating the deeper soils. During the RD, a pilot study would be performed to obtain additional design parameters and also to determine the full effectiveness of a deep SVE system. If, due to Site specific conditions (such as excess moisture in the deep zone), the deep SVE system could not effectively achieve the remediation goal in a reasonable timeframe, this alternative includes the option to implement *in-situ* thermal treatment. *In-situ* thermal treatment would be used if necessary to remediate the most contaminated zone (hot-spot) where contamination may persist, in addition to the deep SVE system. *In-situ* thermal treatment entails heating the treatment zone soils to a high temperature that can volatilize TCE into soil gas, which would then be captured by the deep SVE system.

Alternative 4 includes the long-term operation and maintenance of the existing shallow SVE/SSD systems, which are successfully remediating shallow soils under the building and protecting indoor air within the ANC building, as well as the installation of a deep SVE system.

The deep SVE system will be installed to a depth of approximately 100 feet bgs beneath the ANC building in Area A, to remediate the deep vadose zone contamination. If it is determined by EPA during remedial design or remedial action that the deep SVE system alone will not be sufficient to meet RAOs in a reasonable timeframe, then *in-situ* thermal treatment to remediate the hot-spot area, located within Area A approximately 70 to 100 feet below the building will be implemented. The determination as to whether to implement the *in-situ* thermal treatment in the hot-spot area would be made by EPA either during the remedial design or during the operation of the deep SVE system based on data collected. Groundwater monitoring in the OU3 Study Area will be performed over time to assess the remedy's effectiveness in protecting groundwater.

After the first few years (approximately 3 to 5 years) of operation of the deep SVE system, as TCE concentrations in the extracted vapor reach the asymptotic level, the operation of the SVE system would likely become intermittent. The mass removal rate and the TCE concentration rebound (especially at the hot-spot) during the deep SVE system shutdown period would be evaluated. Options for optimizing the system would be evaluated. Soil samples may also be collected and compared to the Site-specific remediation goal for TCE. The option of implementing *in-situ* thermal hot-spot treatment would be evaluated as one of the optimization options for the deep SVE system in order to meet the remediation goal in a reasonable timeframe.

If *in-situ* thermal treatment is implemented, it is anticipated to be conducted between 60 and 100 feet bgs at the hot-spot under the ANC building. *In-situ* thermal treatment involves the installation of closely spaced heater wells, vapor extraction wells, temperature and vapor monitoring points, above ground power distribution system and an ex situ vapor/water treatment system. Hot-spot treatment is estimated to operate for 6 months. After the completion of *in-situ* thermal treatment, soil samples would be collected from the treatment zone to evaluate the treatment effectiveness.

If the remedy solely included SVE for deep soils, approximately 90 percent mass removal of TCE is anticipated. If *in-situ* thermal treatment is implemented, it is likely to result in 98 percent mass removal in the hot-spot.

It is estimated that construction related to this effort would be completed in 2.5 years (if only SVE/SDS is needed to meet RAOs) or 4 years (if thermal treatment is also needed in addition to the SVE/SDS treatment).

The existing deed notice restricts groundwater use, states that PPPI must operate the SVE and SSD systems until EPA deems it is no longer necessary, and restricts land use in areas deemed necessary for remediation activities. The deed notice will be modified to assure the implementation of all aspects of the OU3 remedy.

This remedy will leave hazardous substances, pollutants or contaminants on-site above levels that allow for unlimited use and unrestricted exposure. Therefore, CERCLA requires that the

Site be reviewed every five years. If justified by the review, additional response actions may be implemented.

COMPARATIVE ANALYSIS OF ALTERNATIVES

In selecting a remedy, EPA considered the factors set out in CERCLA Section121, 42 U.S.C. § 9621, by conducting a detailed analysis of the viable remedial response measures pursuant to the NCP, 40 CFR §300.430(e)(9) and OSWER Directive 9355.3-01. The detailed analysis consisted of an assessment of each of the individual response measures per remedy component against each of nine evaluation criteria and a comparative analysis focusing upon the relative performance of each response measure against the criteria.

***Threshold Criteria** – The first two criteria are known as "threshold criteria" because they are the minimum requirements that each response measure must meet in order to be eligible for selection as a remedy.*

1. Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

With the exception of Alternative 1, all the alternatives provide protection to human health. For the OU3 Study Area, human health risks and ecological risks associated with Site-related contaminants from direct contact with soils are within EPA's acceptable range. However, human health risks from exposure to elevated levels of TCE in the indoor air are above the EPA's acceptable range. Under Alternative 1, human health would not be protected, since the shallow SVE and SSD systems would not be in place to mitigate vapor intrusion. Under Alternatives 2, 3 and 4, vapor intrusion at the former ANC building would be effectively mitigated by the operation of the shallow SVE and SSD systems and human health would be protected from vapor intrusion. Therefore, Alternatives 2, 3 and 4 would meet the RAO for soil vapor.

Under both Alternatives 1 and 2, no or very limited reduction of deep vadose zone TCE soil contamination would occur. Contamination beneath the former ANC building would serve as a continuous source for vapor intrusion and groundwater contamination. The RAOs for soil would not be met. Alternatives 3 and 4 would achieve the RAOs. Alternative 3 would remove some contaminants (approximately 50 % mass removal is expected) in deep vadose zone soils, which would shorten the operation of the shallow SVE and SSD systems and groundwater pump and treat system under OU1 compared to Alternatives 1 and 2. Therefore Alternative 3 provides some protection of the environment. Alternative 4 would have the highest removal of contamination underneath the former ANC building (approximately 90% mass removal is expected) and offers the highest degree of protectiveness of all of the alternatives. The vadose zone soil would no longer serve as a source for groundwater contamination.

The use of institutional controls, specifically the modified deed notice would mitigate potential risks from exposure to indoor air and groundwater.

2. Compliance with applicable or relevant and appropriate requirements (ARARs)

Section 121(d) of CERCLA and NCP §300.430(f) (ii) (B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner, and are more stringent than Federal requirements, may be relevant and appropriate.

Compliance with ARARs address whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for invoking a waiver.

There are no promulgated federal chemical-specific ARARs which apply to Site soils and indoor air, the two media of concern for this operable unit. Site contaminant concentrations of TCE in surface and shallow subsurface soil did not exceed the promulgated state chemical-specific ARARs for direct contact with soils, the NJDEP Non-Residential Direct Contact Soil Remediation Standard (NRDCSRS). For TCE, a Site-specific impact to groundwater soil remediation goal and a Site-specific health goal for vapor intrusion were developed for this Site. Alternative 1 would not meet the soil Site-specific remediation goal (1 ppm) and the Site-specific indoor air health goal (7 µg/m^3). Alternatives 2, 3, and 4 would be in compliance with the Site-specific indoor air health goal due to the effective operation of the existing shallow SVE and SSD systems. Alternative 2 would not meet the soil remediation goal for TCE. Alternatives 3 and 4 are expected to meet the soil Site-specific remediation goal for TCE. While both Alternatives 3 and 4 may potentially reach ARARs, Alternative 4, would likely attain ARARs much more expeditiously than Alternative 3, as it is expected to remove more mass through active treatment.

Alternatives 3 and 4 would be conducted in accordance with NJDEP permit equivalency requirements. A Discharge to Ground Water permit equivalency would be required for the injection of chemical oxidants for Alternative 3. An air permit equivalent and a condensate discharge-permit equivalency (if necessary) would be required for Alternative 4. Both Alternatives 3 and 4 would meet action-specific ARARs.

Other location-specific ARARs relevant to Alternatives 3 and 4 include the Endangered Species Act (40 CFR 400), Fish and Wildlife Conservation Act (16 USC 2901 et seq), and the National Historic Preservation Act. Both Alternatives 3 and 4 would meet location-specific ARARs. A complete list of ARARs can be found in **Tables 9a, 9b, and 9c** in Appendix II.

***Primary Balancing Criteria** – The next five criteria, criteria 3 through 7, are known as "primary balancing criteria." These criteria are factors by which tradeoffs between response measures are assessed so that the best options will be chosen, given site-specific data and conditions.*

3. Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain on-site following remediation and the adequacy and reliability of controls.

The highest degree of permanence and long term effectiveness is achieved for those alternatives that result in the greatest removal of contaminants from the Site.

Under Alternative 1, soil contamination would not be remediated and would continue to serve as the source for groundwater contamination and for vapor intrusion. Human health would be at risk from vapor intrusion. Therefore, Alternative 1 does not provide long-term effectiveness and permanence. For Alternative 2, contamination would be removed from the shallow depth, to a depth of about 5 feet below the former ANC building. However, the removal of contamination from the deep vadose zone would be minimal. The deep soil contamination would continue to serve as the source for groundwater contamination and for potential vapor intrusion. Alternative 2 would result in the operation of the existing shallow SVE and SSD systems and the OU1 pump and treat system for a long time, possibly hundreds of years. Alternative 3 is expected to remove approximately 50 percent of deep soil contamination and would result in the operation of the existing shallow SVE and SSD systems and the OU1 pump and treat system for more than 30 years. The remaining contamination in the deep vadose zone would continue serving as the source for groundwater contamination and for potential vapor intrusion. The required duration for the operation of the existing shallow SVE and SSD systems and the OU1 pump and treat system would be shortened compared to Alternatives 1 and 2. Alternative 4 would remove approximately 90 percent or more of the contaminant mass within the treatment zone, and the contamination beneath the former ANC building would no longer serve as a significant source for groundwater contamination or vapor intrusion. The operation of the existing shallow SVE and SSD system would also be significantly shortened (to 10 years) compared to Alternatives 1, 2, and 3. A few years after the completion of Alternative 4 remediation, shutting down the shallow SVE system may be evaluated and operation of the SSDS alone may be sufficient to mitigate the remaining potential of vapor intrusion.

Residual soil contamination remaining after implementation of Alternatives 2 or 3 would be addressed by the OU1 groundwater remedy. While the OU1 groundwater remedy is considered an adequate and reliable control measure for residual groundwater contaminant sources, it will do little to address the remaining soil contamination. Alternative 4 would be protective of groundwater by removing the source of contamination.

The use of institutional controls, specifically the modified deed notice would mitigate potential risks from exposure to indoor air and groundwater.

4. Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternative 1 would provide no reduction of toxicity, mobility and volume (T/M/V). Alternative 2 is expected to have very limited reduction of T/M/V since the soil contamination deeper than 5 feet below the former ANC building would not be directly targeted for treatment. Alternative 4 would have the highest reduction (more than 90 percent) of contaminant mass from the treatment zone, followed by Alternative 3 (estimated at 50 percent mass reduction). Under Alternative 4, the deep SVE system would extract soil gas, which would contain TCE, from the subsurface soil. The extracted soil gas would then be treated prior to discharge to the atmosphere using vapor phase carbon which would remove TCE from the soil gas through a process called adsorption. Periodically, the carbon would need to be regenerated as the TCE adsorption capacity is exhausted. The adsorbed TCE would then be treated (destroyed) during the carbon regeneration process. Therefore, Alternative 4 would have the highest degree of reduction of T/M/V. Alternative 3 would destroy (oxidize) the contaminants *in-situ,* but results in less reduction of T/M/V than Alternative 4 because only approximately 50 percent of the contaminant mass would be treated due to the limitations in distributing oxidant in soils under Alternative 3 versus more than 90 percent reduction of contaminant mass under Alternative 4. If thermal treatment is implemented in the hot-spot area as part of Alternative 4, it is estimated that up to 98 percent of contaminant mass could be removed through this technology.

5. Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

Alternative 1 would have no short-term impact to the workers, communities, and the environment since no additional remedial action would be conducted. Alternative 2 would have minimal short-term impact to workers, communities, and the environment, since the installation has been completed and the routine operation and maintenance of the shallow SVE and SSD systems is established.

Alternatives 3 and 4 would have greater short-term impacts to the current operation of the facility as compared to Alternatives 1 or 2. The potential impacts may include physical hazards, noise, dust, heavy equipment construction and operations, and emissions. Noise and dust control measures could be implemented to minimize the impacts.

Additional significant short-term risks would be present under Alternative 3, as this alternative would involve the handling and temporary storage of a large quantity of high concentration oxidants, which present potential health and fire hazards in an active facility. Special health and safety measures would need to be developed and followed to prevent direct contact to the oxidant by Site workers and to prevent fire and explosion. Environmental hydraulic fracturing would be required to facilitate the delivery of the oxidant to the contaminated soil, likely resulting in the release of some oxidants into the fractured bedrock aquifer. Additional measures would need to be taken to prevent the oxidants from reaching the OU1 groundwater treatment system, which is not equipped to treat the oxidant and would possibly need to be temporarily shut down.

Alternative 4 involves the installation of deep SVE wells and piping inside the facility. However, this would be manageable as demonstrated by the shallow SVE/SSD system already in place. The carbon treatment system would be located outside of the building. If *in-situ* thermal treatment is implemented, additional closely spaced wells and monitoring points would need to be installed. Additionally, high voltage and current electrical cables would be connected to the heating wells. Electrical safety measures would need to be developed and implemented for *in-situ* thermal treatment. Access to the treatment area would need to be restricted for the protection and safety of Site workers.

Both Alternatives 3 and 4 would pose significant short-term impact to the current facility operation. Alternative 3 has much higher short-term impact to the current facility operation and the operation of the OU1 groundwater remedy than Alternative 4 because of the concerns about:

- Storage and handling of a large quantity of oxidants;
- Hydraulic fracturing; and
- Potential impact to OU1 operations.

EPA would work with the facility management to minimize the impacts of construction and operation of the remedy to the extent practicable.

The construction period for Alternative 3 is expected to be 3 years. However, it would take more than 30 years to reach the Site-specific remediation goal (1 ppm). The time frame to reach the Site-specific remediation goals for Alternative 4 with or without *in-situ* thermal treatment is expected to be 10 years.

6. Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, *administrative feasibility, and coordination with other governmental entities are also considered.*

Alternative 1 is the easiest to implement since no action would be taken. Alternative 2 would be the second easiest to implement since the shallow SVE and SSD systems are already in operation. Alternatives 3 and 4 are both implementable, but with both logistic and technical challenges. The implementation of Alternatives 3 and 4 would take up space in the building and would generate dust and noise that would affect the operation of the facility to different degrees. This is manageable since the remediation would be conducted outside the main production area and engineering controls are available to mitigate these challenges. Impacts to the current operations can be minimized through coordination with facility representatives.

Implementing Alternative 3 is technically more challenging than Alternative 4. Distributing oxidants through the heterogeneous, low-permeability formation via flow pathways created by environmental hydraulic fracturing would be much more challenging and less effective than drawing air through the formation under Alternative 4. The shallow SVE/SSD system has been successfully distributing air similar to the deep stratigraphy. Additionally, both environmental hydraulic fracturing and *in-situ* chemical treatment in a vadose zone are innovative technologies with less well-established track records of performance. Environmental hydraulic fracturing would need to be properly planned and executed by an experienced vendor to prevent potential adverse impacts to the building. The extent of improvement using hydraulic fracturing to enhance chemical distribution within the vadose zone soil is uncertain. As treatment will only occur in the aqueous phase, the ability to keep the vadose zone soil flooded with oxidant solution for treatment while minimizing oxidant migration into the bedrock aquifer is also uncertain.

Implementing Alternative 4 without *in-situ* thermal treatment would be much easier than Alternative 3. No significant installation and operation issues would be anticipated for the deep SVE system, as the shallow SVE/SSD system has been installed without issue and is successfully operating. The addition of *in-situ* thermal treatment into Alternative 4 would increase the implementability issues, but these issues are manageable and would be comparatively easier to manage than Alternative 3. Implementing *in-situ* thermal treatment would likely require additional power supply, would require the establishment of an exclusion zone to handle the electrical hazard, and would require more space both inside and outside of the former ANC building for the large quantity of wells, piping, and the above ground treatment system.

7. Cost

Includes estimated capital and O&M costs, and net present worth value of capital and O&M costs.

The cost of <u>Alternative 1</u> is $0. This Alternative provides no protection of human health or the environment.

The estimated present worth cost of Alternative 2 is $2,400,000, which includes O&M costs over a 30-year period.

The estimated present worth cost of Alternative 3 is $12,600,000, which includes O&M costs over a 30-year period.

The estimated present worth cost of Alternative 4 (no thermal) is $7,800,000, which includes O&M costs over a 30-year period.

The estimated present worth cost of Alternative 4 (with thermal) is $12,700,000, which includes O&M costs over a 30-year period.

The cost estimates for each alternative are order-of-magnitude estimates with an accuracy range of plus 50 to minus 30 percent. The final costs of the selected remedy will depend on actual labor and material costs, competitive market conditions, final project scope, the implementation schedule, and other variables. The specific details of the selected remedial alternative and the corresponding cost estimate will be refined during the remedial design phase of the project.

***Modifying Criteria** – The final two evaluation criteria, criteria 8 and 9, are called "modifying criteria" because new information or comments from the state or the community on the Proposed Plan may modify the preferred response measure or cause another response measure to be considered.*

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8. State Acceptance

Indicates whether based on its review of the RI/FS reports and the Proposed Plan, the state supports, opposes, and/or has identified any reservations with the selected response measure.

The State of New Jersey concurs with the selected remedy, but does not concur with EPA's site-specific remediation goal for trichloroethene (TCE) in the soil. See NJDEP letter attached (**Appendix IV**) for details.

9. Community Acceptance

Summarizes the public's general response to the response measures described in the Proposed Plan and the RI/FS reports. This assessment includes determining which of the response measures the community supports, opposes, and/or has reservations about.

EPA solicited input from the community on the remedial response measures proposed for the Site. Oral comments presented at the public meeting were recorded, and EPA received written comments during the public comment period. The Responsiveness Summary (**Appendix V**) addresses all public comments received by EPA during the public comment period. Overall, the community members, elected officials, and stakeholders were in favor of EPA's recommended alternative. Comments on certain technical aspects of the preferred alternative were submitted by the responsible parties and are addressed by EPA in the Responsiveness Summary and in the *Documentation of Significant Changes* section of the ROD.

PRINCIPAL THREAT WASTE

The “principal threat” concept is applied to the characterization of “source materials” at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for the migration of contamination to groundwater, surface water, or air, or act as a source for direct exposure. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur. The decision to treat these wastes is made on a site-specific basis through a detailed analysis of alternatives, using the remedy-selection criteria which are described below. This analysis provides a basis for making a statutory finding that the remedy employs treatment as a principal element.

Soils with elevated levels of TCE in the vadose zone underlying the former ANC building (Area A) are considered principal threat wastes. Addressing these contaminated soils by the selected remedy will have a positive impact on the ongoing groundwater remediation, as they are an ongoing source of contamination to groundwater. In addition, they are a source to indoor air contamination at this Site.

While Alternative 3 would address the contaminated source soils in Area A through chemical oxidation treatment over an estimated 30 years, Alternative 4 would address the source soils constituting principal threats through treatment in significantly less time. Alternatives 3 and 4 both meet the statutory preference for treatment of principal threat waste.

SELECTED REMEDY

Based upon consideration of the results of the Site investigations, the requirements of CERCLA, the detailed analysis of the response measures, and public comments, EPA has determined that a more flexible approach to implementing EPA’s selected remedy, Alternative 4, as described in the Feasibility Study Report (June 2016) and presented in the Proposed Plan, is appropriate. The remedy best satisfies the requirements of CERCLA Section 121 and the NCP’s nine evaluation criteria for remedial alternatives, 40 CFR § 300.430(e)(9). EPA’s selected remedy for trichloroethene (TCE) contaminated soils is *in-situ* treatment of deep soils through soil vapor extraction (SVE) and/or thermal hot-spot treatment with flexibility in phasing the approach or using just one of the two treatment technologies; *in-situ* treatment of shallow soils through the existing SVE and sub-slab depressurization (SSD) systems; long-term groundwater and indoor air monitoring; and institutional controls.

The major components of the selected remedy include:

- The implementation of deep soil vapor extraction (SVE) and/or thermal treatment to address deep TCE-contaminated soils underlying the former ANC building;

- Long-term operation and maintenance of the existing shallow SVE and sub-slab depressurization (SSD) systems;

- Long-term groundwater monitoring in the OU3 Study Area will be performed over time to assess the remedy's effectiveness. Long-term indoor air monitoring will be performed in the former ANC building to assess the remedy's effectiveness; and

- Institutional controls, including the existing deed notice, will remain in effect at the former ANC property and will be amended to reflect the components of the Selected Remedy for OU3 that will be implemented at the former ANC property. The institutional controls periodically will be verified as remaining in effect as part of the long-term monitoring effort.

As discussed, Alternative 4, with some adjustment, is the best remedial alternative to address OU3 Site contamination. This includes the option of performing thermal hot-spot treatment of deep soils first, and eliminating the deep SVE portion of the remedy if EPA deems that RAOs have been sufficiently met by thermal hot-spot treatment alone. Final determination of how best to employ the two technologies to meet RAOs would be determined in remedial design. In the event that *in-situ* thermal treatment of the hot-spot alone does not meet RAOs, then deep SVE would be implemented. Deep SVE treatment throughout Area A and/or *in-situ* thermal treatment to remediate the hot-spot area, located within Area A approximately 70 to 100 feet below the former ANC building, will be implemented. See *Documentation of Significant Changes* section below for further information.

On April 9, 2015, Albea recorded a deed notice on the former ANC property which provides a description of the real property and provides notice to all successors-in-title that this property is part of the PVGWC site, that EPA has selected a remedy for OU1 and OU2 and intends to select a remedy for OU3, and that the defendants have entered into a Consent Decree requiring implementation of the remedies. The deed notice also provides restriction of groundwater use, states that PPPI must operate the SVE and SSD systems until EPA deems it is no longer necessary, and restricts land use in areas deemed necessary for remediation activities.

The current deed notice will be amended to reflect the Selected Remedy for OU3 that will be implemented at the former ANC property. The institutional controls periodically will be verified as remaining in effect as part of the long-term monitoring effort.

This remedy will leave hazardous substances, pollutants or contaminants on-site above levels that allow for unlimited use and unrestricted exposure. Therefore, CERCLA requires that the Site be reviewed every five years. If justified by the review, additional response actions may be implemented.

The estimated capital, annual O&M, and total present-worth costs (using the federal standard 7% discount rate) for the selected remedy without thermal treatment are $3.5 million, $185,000 to $609,000 and $7.8 million, respectively. The estimated capital, annual O&M, and total present-worth costs (using the federal standard 7% discount rate) for the selected remedy with thermal treatment are $9.8 million, $185,000 to $410,000 and $12.7 million, respectively. The estimated capital, total O&M, and total present-worth costs (using the federal standard 7% discount rate) for thermal treatment alone are $5.7 million, $2.5 million, and $8.2 million, respectively. **Tables 10a, 10b, and 10c** provide the basis for these cost estimates.

The cost estimates are based on the best available information regarding the anticipated scope of the overall remedy. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedy. These are order-of-magnitude engineering cost estimates that are expected to be within plus 50 to minus 30 percent of the actual project costs.

Based on the information available at this time, EPA believes the selected remedy provides the best balance of trade-offs among the response measures with respect to the nine evaluation criteria. EPA believes that the selected remedy will be protective of human health and the environment, will comply with ARARs, will be cost effective, and will utilize permanent solutions and alternative treatment technologies to the maximum extent practicable.

Summary of the Rationale for the Selected Remedy

The selected remedy is believed to provide the best balance of trade-offs among the alternatives with respect to the evaluation criteria. EPA has determined that the selected remedy will be protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, is cost-effective, and will utilize permanent solutions and treatment technologies to the maximum extent practicable.

Green Remediation

Consistent with EPA Region 2's Clean and Green policy, EPA will evaluate the use of sustainable technologies and practices with respect to implementation of all components of the selected remedy.

STATUTORY DETERMINATIONS

As was previously noted, CERCLA Section 121(b)(1), 42 U.S.C. § 9621(b)(1) mandates that remedial actions must be protective of human health and the environment, cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. CERCLA Section 121(b)(1) also establishes a preference for remedial actions which employ treatment to permanently and significantly reduce the volume, toxicity or mobility of the hazardous substances, pollutants, or contaminants at a site. CERCLA Section 121(d) further specifies that a remedial action must attain a degree of cleanup that satisfies ARARs under federal and state laws, unless a waiver can be justified pursuant to §121(d)(4), 42 U.S.C. § 9621(d)(4)

Protection of Human Health and the Environment

Based on the results of the OU1 and OU3 human-health risk assessments, there are unacceptable risks associated with Site-related contamination in indoor air and groundwater. TCE in soils beneath the former ANC building (Area A) will need to be addressed in order to ensure continued protection of human health and the environment. The results of the OU3 risk assessment indicate that, if no action is taken, the hypothetical future exposure to the indoor air at the Site will pose an unacceptable increased future cancer risk and an unacceptable non-cancer hazard risk to human health. The selected remedy will be protective of human health and the environment in that it will address the soil contamination beneath the former ANC building that is contributing to the groundwater and indoor air contamination. Combined with existing institutional controls for the former ANC property, and implementation of the OU1 Remedy, the selected remedy will provide protectiveness of human health and the environment over both the short and long-term.

Compliance with ARARs

The selected remedy for TCE contaminated soil will comply with ARARs.

A summary of key ARARs which will be complied with during implementation of the selected remedy is presented below.

Key chemical-specific ARARs:
NJDEP Soil Remediation Standards (N.J.A.C. 7:26D) – Non-Residential Direct Contact Soil Cleanup Criteria

Key action-specific ARARs:
Clean Air Act - National Ambient Air Quality Standards (NAAQs) (40 CFR 50)
New Jersey Air Pollution Control Act (N.J.A.C. 7:27)

Location-specific ARARs include the Endangered Species Act (40 CFR 400), Fish and Wildlife Conservation Act (16 USC 2901 et seq), and the National Historic Preservation Act.

A comprehensive ARAR discussion is included in the Feasibility Study and a complete listing of ARARs and to-be-considered (TBC) criteria are provided in **Tables 9a, 9b, and 9c**.

Cost-Effectiveness

EPA has determined that the selected remedy is cost-effective and represents a reasonable value. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." (NCP §300.430 (f) (1) (ii) (D)). EPA evaluated the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR-compliant).

Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of the selected remedy was determined to be proportional to costs and hence, this alternative represents a reasonable value for the money to be spent.

The selected remedy is cost effective as it has been determined to provide the greatest overall protectiveness for its present worth costs.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

EPA has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the Site. Of those alternatives that are protective of human health and the environment and comply with ARARs, EPA has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and State and community acceptance.

The selected remedy will provide adequate long-term control of risks to human health and the environment through treatment of the TCE-contaminated soil, long-term monitoring and institutional controls (deed notice). The selected remedy will provide a permanent remedy to reduce the toxicity, mobility, and volume of the contaminants in the soil. The selected remedy employs innovative technologies that have proved successful at other sites having TCE-contaminated soil.

Preference for Treatment as a Principal Element

The statutory preference for remedies that employ treatment as a principal element is satisfied under the selected remedy in that the contaminated soils will be treated, and treatment will be used to reduce the toxicity, mobility, and volume of contamination and achieve cleanup levels.

Five-Year Review Requirements

This remedy will leave hazardous substances, pollutants or contaminants on site above levels that allow for unlimited use and unrestricted exposure. Therefore, CERCLA requires that the Site be reviewed every five years. If justified by the review, additional response actions may be implemented.

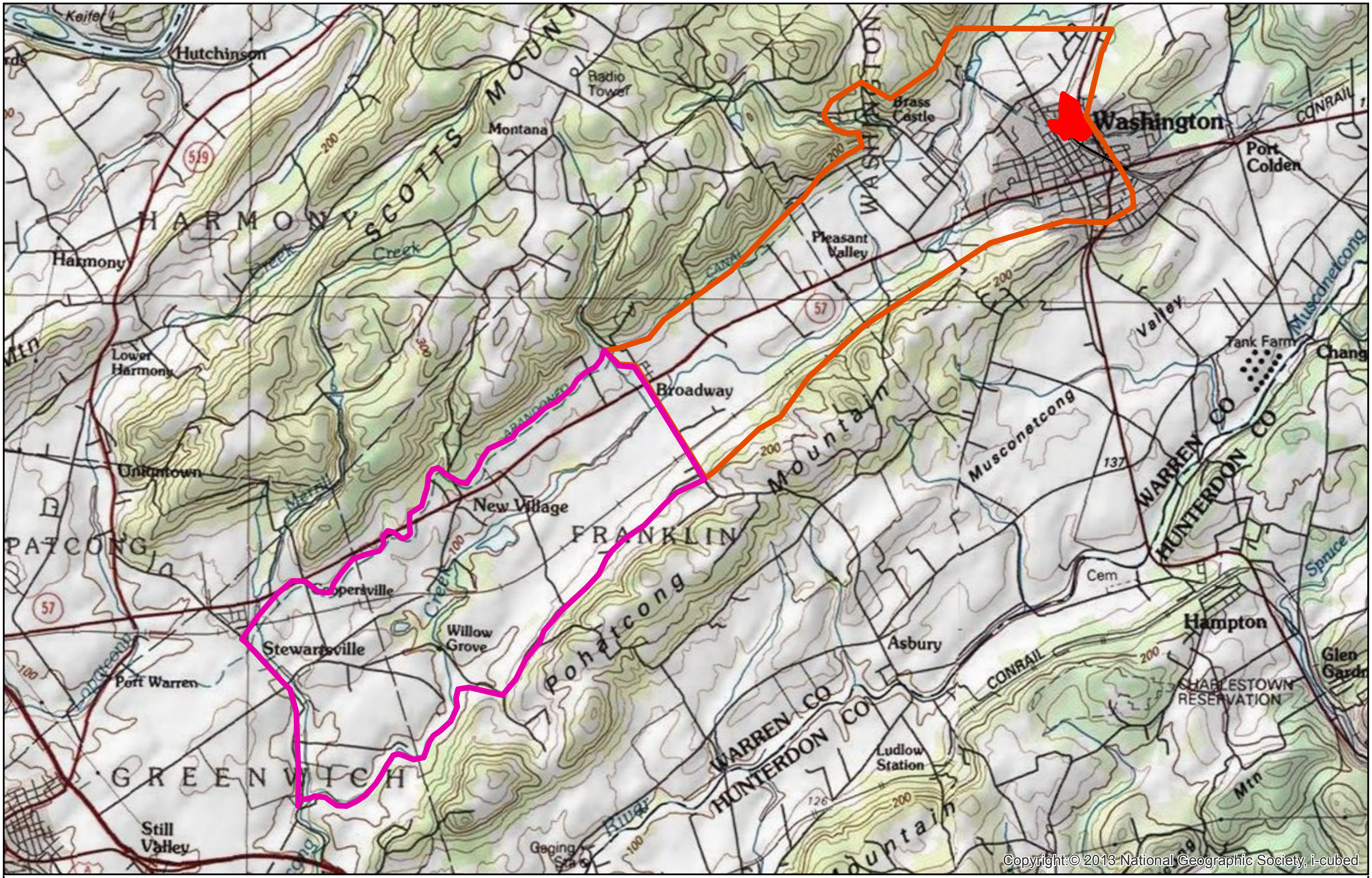
DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for OU3 of the Site was released for public comment on June 15, 2016. The comment period closed on August 15, 2016. The Proposed Plan identified Alternative 4 (Deep

SVE with Optional *In-Situ* Thermal Hot-Spot Treatment) as the preferred alternative to address TCE-contaminated soil at the Site. Implementation of this alternative (as described in the Feasibility Study Report (June 2016)) included the treatment of contaminated deep soils under the ANC building by SVE first, and based on the level of success of this treatment in removing TCE from deep soils, later treatment of hot-spot area soils using thermal treatment technology, if necessary.

Based on EPA's thorough review of all comments received during the public comment period (see **Appendix V** - Responsiveness Summary), EPA believes that while Alternative 4 remains the best remedial alternative to address OU3 Site contamination, it is appropriate to allow a more flexible approach to implementing Alternative 4 through the use of both or just one of the two technologies included in this alternative (SVE and thermal treatment). This would include the option of performing thermal hot-spot treatment of soils first, and eliminating the deep SVE portion of the remedy if EPA deems that RAOs have been sufficiently met by thermal treatment alone. Final determination of how best to employ the two technologies to meet RAOs would be determined in remedial design. Due to its long-term effectiveness, less obtrusive nature, and superior mass reduction capabilities, EPA believes performing *in-situ* hot-spot thermal treatment first, may be as effective at meeting the RAOs compared to the use of SVE throughout the deep soils of Area A. In the event that *in-situ* thermal treatment of the hot-spot alone does not meet RAOs, then deep SVE would be implemented.

APPENDIX I: Figures



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☐ OU1 Study Area (approximate)

☐ OU2 Study Area (approximate)

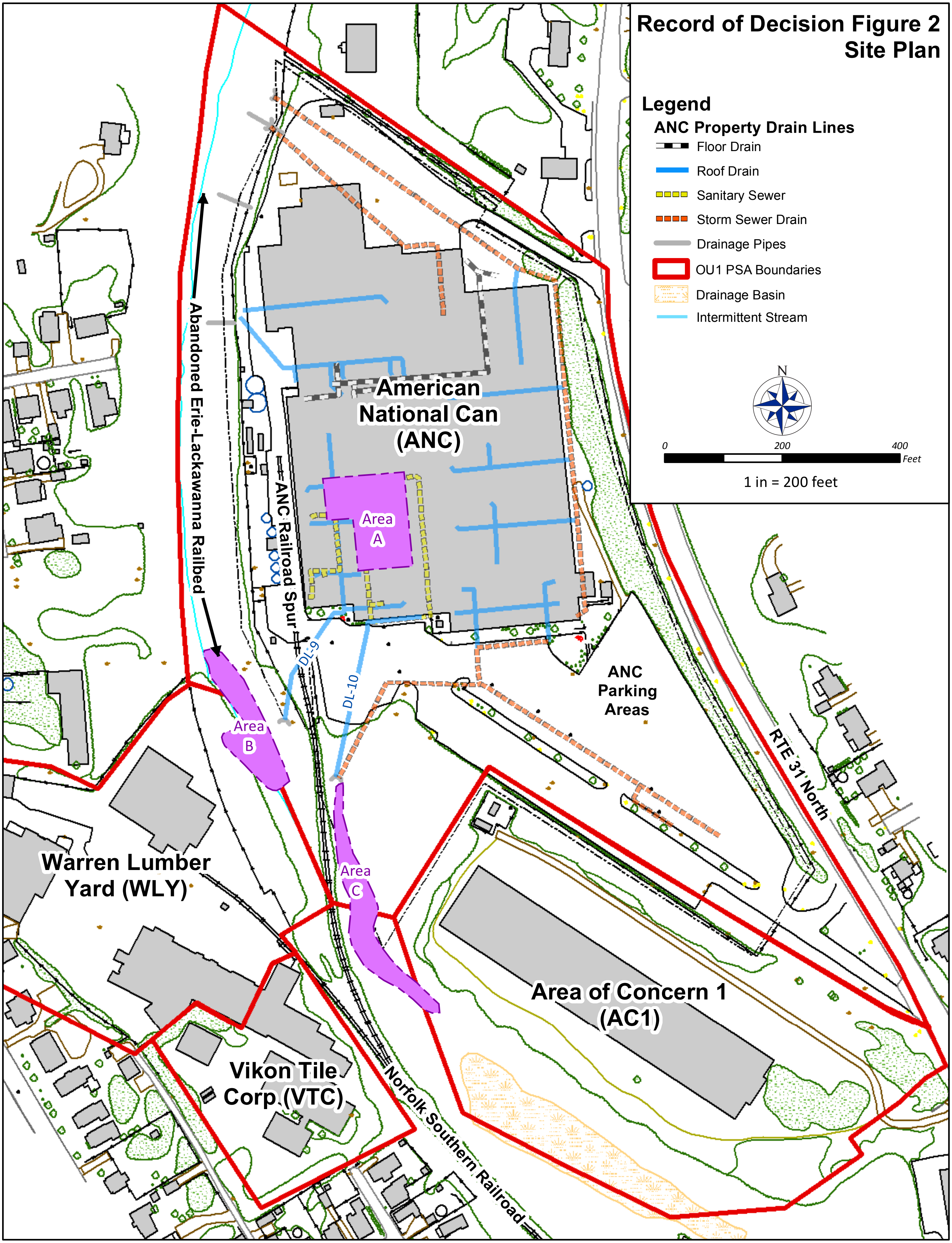
■ OU3 Study Area (approximate)

N

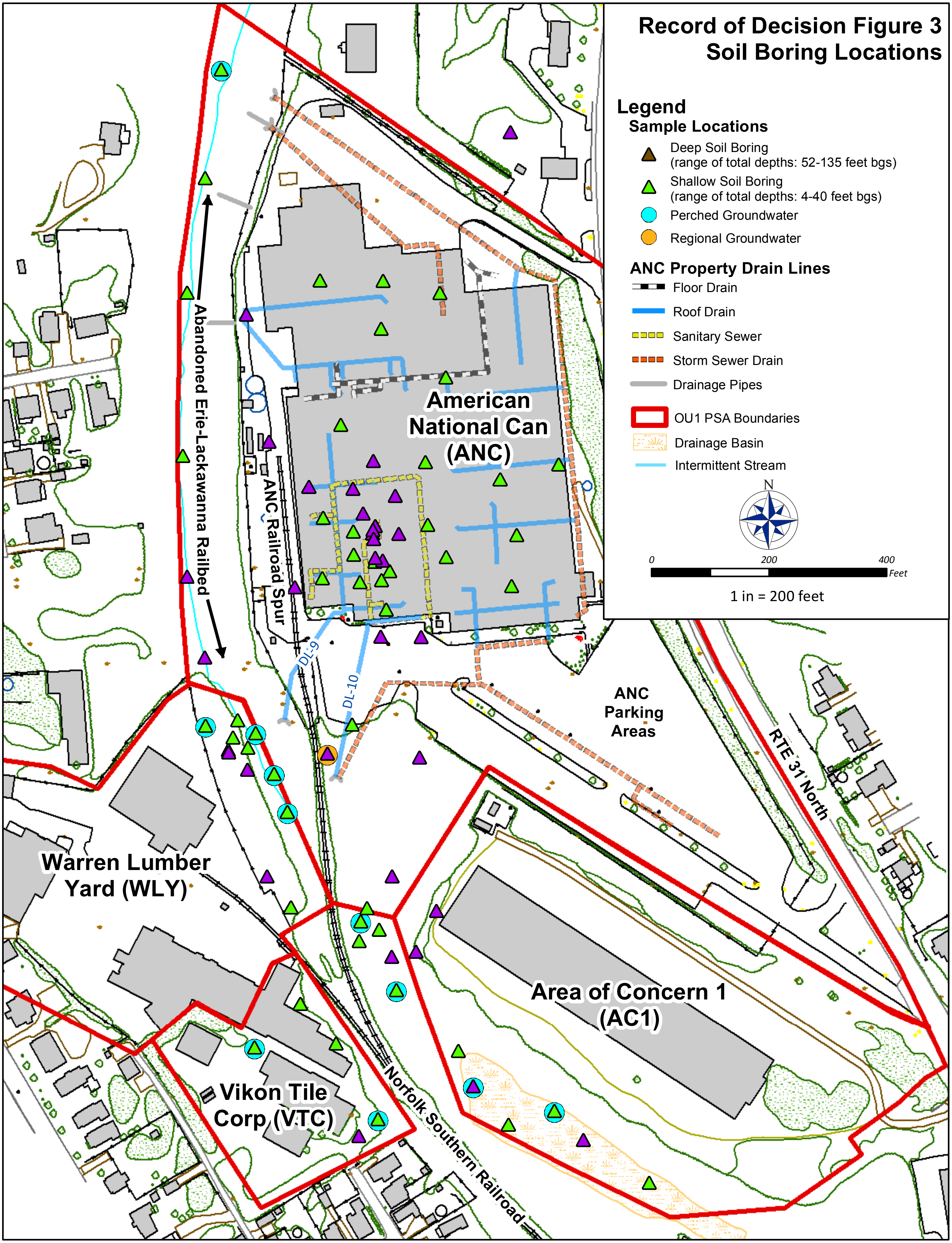
0 6,000 12,000 Feet

1 in = 6,000 feet

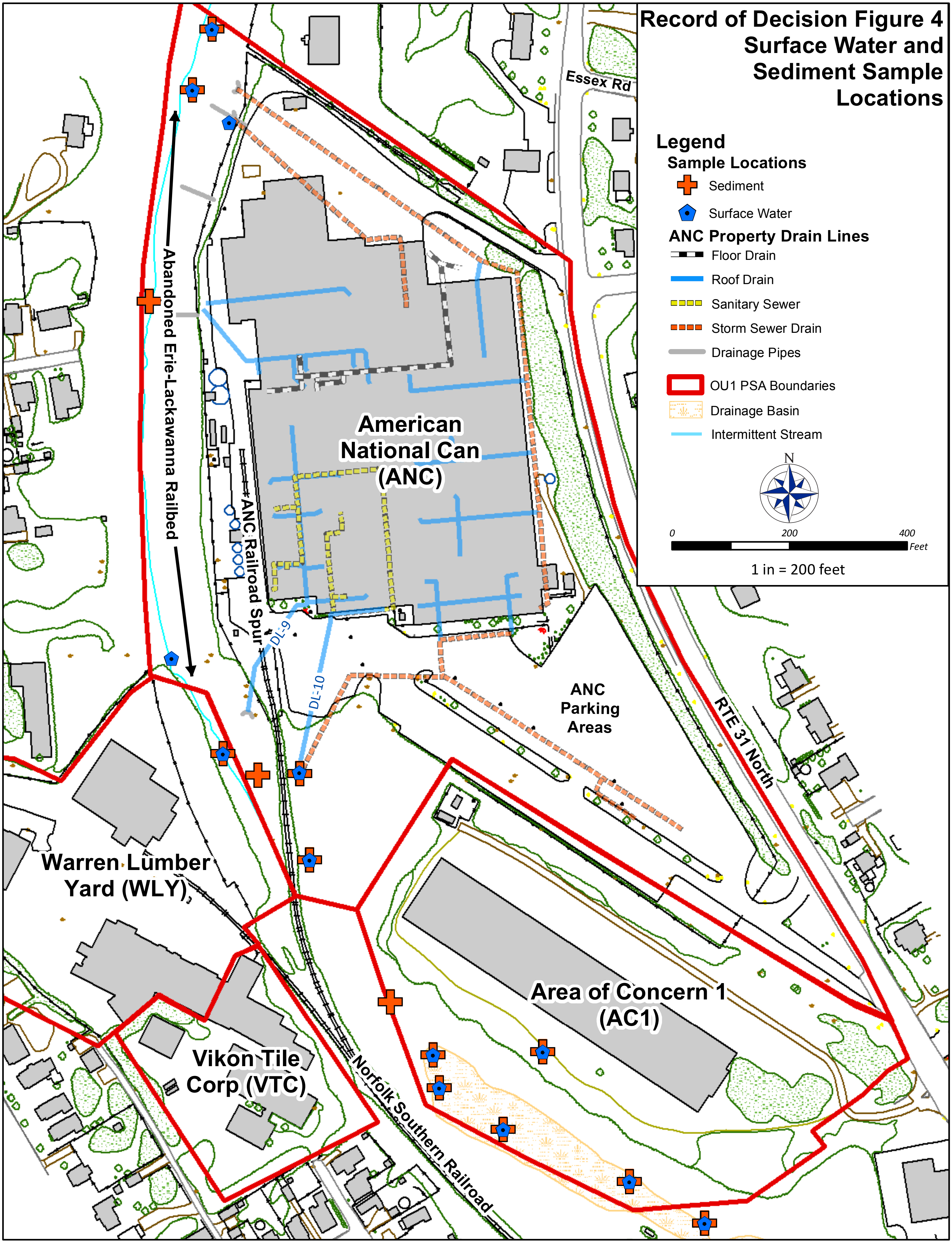
Record of Decision Figure 1
Site Location Map



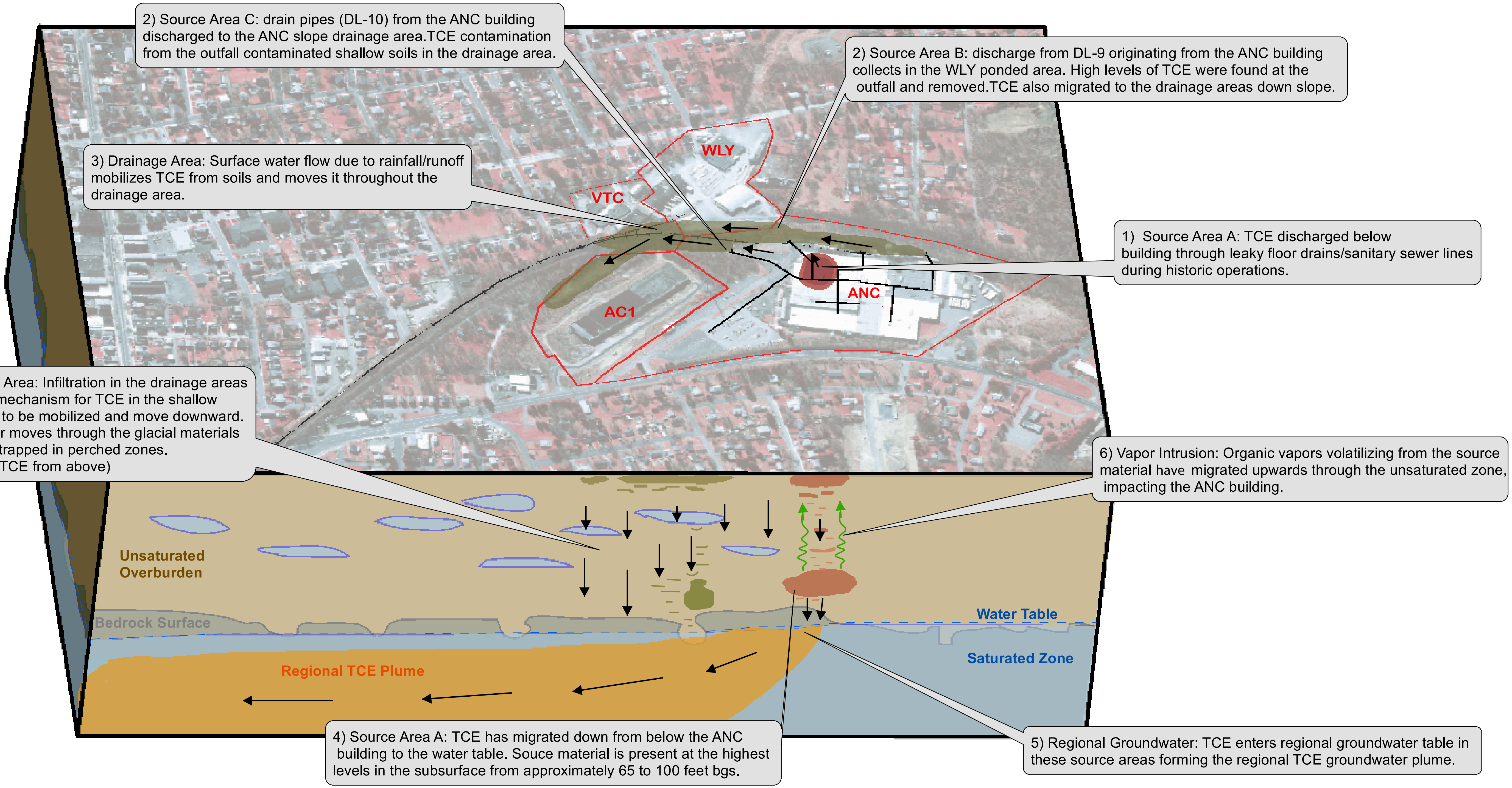
Record of Decision Figure 2
Site Plan



Record of Decision Figure 3
Soil Boring Locations



Record of Decision Figure 4 Surface Water and Sediment Sample Locations



2) Source Area C: drain pipes (DL-10) from the ANC building discharged to the ANC slope drainage area.TCE contamination from the outfall contaminated shallow soils in the drainage area.

2) Source Area B: discharge from DL-9 originating from the ANC building collects in the WLY ponded area. High levels of TCE were found at the outfall and removed.TCE also migrated to the drainage areas down slope.

3) Drainage Area: Surface water flow due to rainfall/runoff mobilizes TCE from soils and moves it throughout the drainage area.

1) Source Area A: TCE discharged below building through leaky floor drains/sanitary sewer lines during historic operations.

4) Drainage Area: Infiltration in the drainage areas provides a mechanism for TCE in the shallow surface soil to be mobilized and move downward. As the water moves through the glacial materials it becomes trapped in perched zones. (containing TCE from above)

6) Vapor Intrusion: Organic vapors volatilizing from the source material have migrated upwards through the unsaturated zone, impacting the ANC building.

4) Source Area A: TCE has migrated down from below the ANC building to the water table. Souce material is present at the highest levels in the subsurface from approximately 65 to 100 feet bgs.

5) Regional Groundwater: TCE enters regional groundwater table in these source areas forming the regional TCE groundwater plume.

Legend

🟩 Drainage Area
🟥 TCE Source Material
🟧 Regional TCE Plume
🟫 Overburden: Heterogeneous Glacial Till
⬛ Bedrock: Karstic Dolostone
⌐ Facility Drain Pipes

OU3 Study Area Properties

ANC: American National Can
AC1: Area of Concern 1
VTC: Vikon Tile Corp.
WLY: Warren Lumber Yard

Note: Cross-section view is projected to the edge of block. It represents the sub-surface below the ANC building and the drainage areas.

Record of Decision Figure 5
Conceptual Site Model

APPENDIX II: Tables

TABLE 1
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration (EPC)	EPC Units	Statistical Measure
		Min	Max					
PVGCS Area Regional Groundwater Plume	Trichloroethylene	1	2,100	ug/kg	49/53	422	ug/kg	97.5% Chebyshev UCL

97.5% Chebyshev-UCL – 97.5% upper confidence limit, Chebyshev statistic (mean, STD)

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

This table presents the chemicals of concern (COCs) and exposure point concentrations (EPCs) for the COCs in groundwater. The table includes the range of concentrations detected for TCE, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the EPC and how it was derived. TCE was not detected at levels of concern in surface and subsurface soils, sediment or surface water at the site.

TABLE 2. Selection of Exposure Scenarios

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis
Current/Future	Soil	Surface soil	ANC Property	Site worker	Adult	Ing/Der/Inh	Quantitative
			WLY Property				
			AC1/VTC/Railroad Property	Trespasser	Adolescent (12 to <18 yrs)	Ing/Der/Inh	Quantitative
	Surface Water	Surface water	AC1/VTC/Railroad Property	Trespasser	Adolescent (12 to < 18 yrs)	Ing/Der	Qualitative
	Sediment	Sediment			Adolescent (12 to < 18 yrs)	Ing/Der	Quantitative
Future	Soil	Surface soil	ANC Property	Site worker	Adult	Ing/Der/Inh	Quantitative
			WLY Property				
			AC1/VTC/Railroad Property				
			ANC Property	Resident	Adult and Child (birth to <6 yrs)	Ing/Der/Inh	Quantitative
			WLY Property				
			AC1/VTC/Railroad Property				
		Surface and Subsurface soil	ANC Property	Construction worker	Adult	Ing/Der/Inh	Quantitative
			WLY Property				
			AC1/VTC/Railroad Property				
	Groundwater	Indoor Air	ANC Property	Site worker	Adult	Inh	Qualitative
				Resident	Adult and Child (birth to <6 yrs)	Inh	Qualitative
		Tap Water[1]	PVGCS Area Regional Groundwater Plume (Tap Water/Shower Head)	Resident	Adult and Child (birth to <6 yrs)	Ing/Der/Inh	Quantitative

Ing – Ingestion

Der – Dermal

Inh – Inhalation

[1] Pathway was evaluated as part of the OU1 Human Health Risk Assessment conducted in 2005.

Summary of Selection of Exposure Pathways

This table describes the exposure pathways that were evaluated for the risk assessment. Exposure media, exposure points, and characteristics of receptor populations are included.

TABLE 3

Non-Cancer Toxicity Data Summary

Pathway: Oral/Dermal

Chemical of Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Absorp. Efficiency (Dermal)	Adjusted RfD (Dermal)	Adj. Dermal RfD Units	Primary Target Organ	Combined Uncertainty /Modifying Factors	Sources of RfD: Target Organ	Dates of RfD:
Trichloroethylene	Chronic	3.0E-04	mg/kg-day	1	3.0E-04	mg/kg-day	Liver, Kidney	3000	NCEA	08/01/01

Pathway: Inhalation

Chemical of Concern	Chronic/ Subchronic	Inhalation RfC	Inhalation RfC Units	Inhalation RfD	Inhalation RfD Units	Primary Target Organ	Combined Uncertainty /Modifying Factors	Sources of RfD: Target Organ	Dates:
Trichloroethylene	Chronic	4.0E-02	mg/m^3	1.0E-02	mg/kg/day	CNS, Liver	1000	NCEA	08/01/01

Key

-----: No information available
CNS: Central Nervous System
NCEA: National Center for Environmental Assessment, US EPA

Summary of Toxicity Assessment

This table provides non-carcinogenic risk information which is relevant to the contaminants of concern. When available, the chronic toxicity data have been used to develop oral reference doses (RfDs) and inhalation reference doses (RfDs).

TABLE 4

Cancer Toxicity Data Summary

Pathway: Oral/Dermal

Chemical of Concern	Oral Cancer Slope Factor	Units	Adjusted Cancer Slope Factor (for Dermal)	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Trichloroethylene	4.0E-01	mg/kg-day	4.0E-01	mg/kg-day	B1	NCEA	08/01/01

Pathway: Inhalation

Chemical of Concern	Unit Risk	Units	Inhalation Slope Factor	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Trichloroethylene	1.1E-04	$(ug/m^3)^{-1}$	4.0E-01	mg/kg-day	B1	NCEA	08/01/01

Key:

B1: Probable Human Carcinogen – indicates that limited human data are available
-----: No information available
NCEA: National Center for Environmental Assessment, US EPA

Summary of Toxicity Assessment

This table provides carcinogenic risk information which is relevant to the contaminants of concern. Toxicity data are provided for both the oral and inhalation routes of exposure.

TABLE 5

Risk Characterization Summary - Noncarcinogens

Scenario Timeframe: Future
Receptor Population: Site Resident
Receptor Age: Adult

Medium	**Exposure Medium**	**Exposure Point**	**Chemical of Concern**	**Primary Target Organ**	**Non-Carcinogenic Risk**			
					Ingestion	**Dermal**	**Inhalation**	**Exposure Routes Total**
Groundwater	PVGCS Area Regional Groundwater Plume	Tap water	Trichloroethylene	Liver, Kidney, Fetus	2.9	0.5		3.4
							Hazard Index Total=	**3**
		Shower vapors	Trichloroethylene	CNS, Liver, Endocrine system			73	73
							Hazard Index Total=	**73**

Scenario Timeframe: Future
Receptor Population: Site Resident
Receptor Age: Child

Medium	**Exposure Medium**	**Exposure Point**	**Chemical of Concern**	**Primary Target Organ**	**Non-Carcinogenic Risk**			
					Ingestion	**Dermal**	**Inhalation**	**Exposure Routes Total**
Groundwater	PVGCS Area Regional Groundwater Plume	Tap water	Trichloroethylene	Liver, Kidney, Fetus	6.7	1.1		7.9
							Hazard Index Total=	**8**
		Shower vapors	Trichloroethylene	CNS, Liver, Endocrine system			160	160
							Hazard Index Total	**160**

Summary of Risk Characterization - Non-Carcinogens

The table presents hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for exposure to groundwater containing site-related chemicals. The Risk Assessment Guidance for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse non-cancer effects.

TABLE 6

Risk Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Site Resident
Receptor Age: Lifetime (Adult/child)

Medium	**Exposure Medium**	**Exposure Point**	**Chemical of Concern**	**Carcinogenic Risk**			
				Ingestion	**Dermal**	**Inhalation**	**Exposure Routes Total**
Groundwater	PVGCS Area Regional Groundwater Plume	Tap Water	Trichloroethylene	2.5E-03	4.3E-04		2.9E-03
						Total Risk =	**3E-03**
		Shower Head	Trichloroethylene			3.5E-02	3.5E-02
						Total Risk =	**4E-02**

Summary of Risk Characterization – Carcinogens

The table presents site-related cancer risks for groundwater exposure. As stated in the National Contingency Plan, the point of departure is 10^{-6} and the acceptable risk range for site-related exposure is 10^{-6} to 10^{-4}. The cancer risk from trichloroethylene in groundwater exceeds the acceptable risk range, indicating an unacceptable risk from exposure to groundwater.

TABLE 7

Risk Screening Summary – Vapor Intrusion

Chemical of Concern	Unit	Soil Gas VISL[1]	ANC Building Sub-Slab Results	Indoor Air VISL[1]	ANC Building Indoor Air Results
Trichloroethylene	µg/m^3	16	5 J – 480,000 J	0.48	4 J – 180 J

J: data qualifier indicating estimated value

[1] **VISLs –**EPA **v**apor intrusion screening levels for soil gas and indoor air are based on future residential exposure at a target risk of 10-6 for carcinogens and target hazard quotient of 1 for noncarcinogens, and calculated using the VISL calculator version 3.5.1 (May 2016).

Summary of Risk Screening – Vapor Intrusion

The table presents the results of the vapor intrusion sampling investigation which was conducted in and around the ANC building prior to the installation of soil vapor extraction and sub-slab depressurization systems.

Table 8
Record of Decision
Preliminary Remediation Goals for Soil
Pohatcong Valley Superfund Site - OU3
Washington, Warren County, New Jersey

Contaminants of Concern	NJDEP Non-Residential Direct Contact Health Based Soil Remediation Standard[1]	Site-Specific Soil Criterion from EPA Indoor Air VISL[2]	Impact to Groundwater Soil Criterion [3]	PRG	Maximum Detected Concentrations[4]
	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Volatile Organic Compounds*					
Trichloroethene (TCE)	20,000	880	1,000	1000	120,000

Notes:

1. NJDEP 2009. Non-Residential Direct Contact Health Based Criteria and Soil Remediation Standards (Last Revised 11/2009); http://www.nj.gov/dep/srp/regs/rs/, downloaded January 24, 2011.
2. EPA and NJDOH site-specific indoor air health goal of 7 µg/m^3 was used to calculate a soil cleanup criterion using site-specific attenuation factor. See Appendix A and B of the Final FS Report (CDM Smith 2016) for NJDOH letter and calculations, respectively.
3. SEVIEW model results indicate that TCE concentration at 1 mg/kg would be protective of groundwater with consideration of natural attenuation. See Appendix C of the Final FS Report (CDM Smith 2016) for additional details.
4. The maximum concentrations detected at the Site during the Remedial Investigation.

*PRGs were only calculated for TCE as it is the predominant contaminant of concern. PCE, cis-1,2-DCE, and vinyl chloride were only detected sporadically and are expected to be remediated together with TCE.

Acronyms:

µg/kg - microgram per kilogram
µg/m^3 - microgram per cubic meter
PRG - Preliminary Remediation Goal

NJDOH - New Jersey Department of Health
PCE - tetrachloroethene
cis-1,2-DCE - cis-1,2-dichloroethene

Table 9a
Record of Decision
Chemical-specific ARARs, Criteria, and Guidance
Pohatcong Valley Superfund Site - OU3
Washington, Warren County, New Jersey

Regulatory Level	Authority/Source	Status	Requirement Synopsis	Comments
Federal	EPA Regional Screening Level (RSL) for industrial soil	To Be Considered	Establishes health-based standards for soil cleanups.	The RSL were considered in the development of the Preliminary Remediation Goals (PRGs) where there are no applicable standards.
State	NJDEP Impact to Groundwater Remediation Standards Guidance (N.J.A.C. 7:26D)	To Be Considered	Guidance for soil cleanups that may potentially be considered.	Guidance was considered during development of the PRGs.
Federal	OSWER Vapor Intrusion Assessment: Vapor Intrusion Screening Level (VISL) Calculator Version 3.4, June 2015 RSLs	To Be Considered	Provides generally recommended screening level concentrations for groundwater, soil gas (exterior to buildings and sub-slab), and indoor	The standards were used to develop screening criteria for vapor intrusion.
State	NJDEP Vapor Intrusion Guidance	To Be Considered	Provides generally recommended screening level concentrations for groundwater, soil gas, and indoor air for default target risk levels and exposure scenarios	The standards were used to develop screening criteria for vapor intrusion.

Table 9b
Record of Decision
Location-specific ARARs, Criteria, and Guidance
Pohatcong Valley Superfund Site - OU3
Washington, Warren County, New Jersey

Regulatory Level	Authority/Source	Status	Requirement Synopsis	Comments
Federal	Endangered Species Act (16 USC 1531 et seq.; 40 CFR 400)	Potentially Applicable	This act protects endangered species from extinction.	Applicable to any action during implementation of the Remedial Design/Remedial Action (RD/RA) that
Federal	Fish and Wildlife Conservation Act (16 USC 2901 et seq.)	Potentially Applicable	This act protects and conserves nongame fish and wildlife.	Applicable to any action during implementation of the RD/RA that may have an impact on the Fish and Wildlife
Federal	Fish and Wildlife Coordination Act (16 USC 661)	Potentially Applicable	This act maintains and coordinates wildlife conservation.	Applicable to any action during implementation of the RD/RA that may have an impact on the Fish and Wildlife
Federal	National Historic Preservation Act (40 CFR 6.301)	Potentially Applicable	This requirement establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.	Applicable to any action during implementation of the RD/RA that may have an impact on the National Preservation Act.
State	New Jersey Endangered and Nongame Species Conservation Act (N.J.S.A. 23:2A-1 - 15)	Potentially Applicable	This act protects and conserves endangered and nongame species.	Applicable to any action during implementation of the RD/RA that may have an imact on the New Jersey Endangered and Nongame Species Conservation Act. NJDEP record review indicates that state-listed
State	New Jersey Endangered Plant Species List Act (N.J.A.C. 7:5B)	Potentially Applicable	This act protects endangered plant species.	Applicable to any action during implemenation of the RD/RA that may have an impact on the New Jersey Endangered Plant Species List Act.

Table 9c
Record of Decision
Action-specific ARARs, Criteria, and Guidance
Pohatcong Valley Superfund Site - OU3
Washington, Warren County, New Jersey

Regulatory Level	Authority/Source	Status	Requirement Synopsis	Comments
General Site Remediation				
Federal	RCRA Identification and Listing of Hazardous Wastes (40 CFR 261)	Applicable - ARAR	This regulation describes methods for identifying hazardous wastes and lists known hazardous wastes.	This regulation is applicable to the identification of hazardous wastes that are generated, treated, stored, or disposed during remedial activities.
Federal	RCRA Standards Applicable to Generators of Hazardous Wastes (40 CFR 262)	Applicable - ARAR	This regulation describes standards applicable to generators of hazardous wastes.	Standards will be followed if any hazardous waste is generated onsite.
Federal	RCRA Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities – General Facility Standards (40 CFR	Relevant and Appropriate	This regulation lists general facility requirements including general waste analysis, security measures, inspections, and training requirements.	Facility will be designed, constructed, and operated in accordance with this regulation. All workers will be properly trained.
Federal	RCRA Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities – Preparedness and Prevention (40 CFR	Relevant and Appropriate	This regulation outlines the requirements for safety equipment and spill control.	Safety and communication equipment will be installed at the site. Local authorities will be familiarized with the site.
Federal	RCRA Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal	Relevant and Appropriate	This regulation outlines the requirements for emergency procedures to be used following	Emergency Procedure Plans will be developed and implemented during remedial action. Copies of the plans
State	New Jersey Technical Requirements for Site Remediation (N.J.A.C. 7:26E)	Relevant and Appropriate	Establishes technical requirements for investigation and remediation processes under New Jersey cleanup programs.	The substantive requirements of this regulation will be applied to any hazardous waste operation during remediation of the site.

Table 9c
Record of Decision
Action-specific ARARs, Criteria, and Guidance
Pohatcong Valley Superfund Site - OU3
Washington, Warren County, New Jersey

Regulatory Level	Authority/Source	Status	Requirement Synopsis	Comments
State	New Jersey Hazardous Waste Regulations - Identification and Listing of Hazardous Waste (N.J.A.C. 7:26G-5)	Applicable - ARAR	This regulation describes methods for identifying hazardous wastes and lists known hazardous wastes.	The substantive requirements of this regulation will be applicable to the identification of hazardous wastes that are generated, treated, stored, or disposed during remedial activities.
State	New Jersey Soil Erosion and Sediment Control Act (N.J.A.C. 2:90)	Applicable - ARAR	This act outlines the requirements for soil erosion and sediment control measures.	The substantive requirements of this Act will be applied to any remediation activities performed at the site.
State	New Jersey Ambient Air Quality Standards (N.J.A.C. 7:27-13)	Applicable - ARAR	This standard provides the requirement for ambient air quality control.	The substantive requirements of this regulation will be applied to any remediation activities performed at the site.
State	New Jersey Noise Control (N.J.A.C. 7:29)	Applicable - ARAR	This standard provides the requirement for noise control.	The substantive requirments of this regulation will be applied to any remediation activities performed at the
Waste Transportation				
Federal	Department of Transportation (DOT) Rules for Transportation of Hazardous Materials (49 CFR Parts 107, 171, 172, 177 to 179)	Applicable - ARAR	This regulation outlines procedures for the packaging, labeling, manifesting, and transporting hazardous materials.	Any company contracted to transport hazardous material from the site will be required to comply with this regulation.
Federal	RCRA Standards Applicable to Transporters of Hazardous Waste (40 CFR 263)	Applicable - ARAR	Establishes standards for hazardous waste transporters.	Any company contracted to transport hazardous material from the site will be required to comply with this
State	Transportation of Hazardous Materials (N.J.A.C. 16:49)	Applicable - ARAR	Establishes record keeping requirements and standards related to the manifest system for hazardous	Any company contracted to transport hazardous material from the site will be required to comply with this
Waste Disposal				

Table 9c
Record of Decision
Action-specific ARARs, Criteria, and Guidance
Pohatcong Valley Superfund Site - OU3
Washington, Warren County, New Jersey

Regulatory Level	Authority/Source	Status	Requirement Synopsis	Comments
Federal	RCRA Land Disposal Restrictions (40 CFR 268)	Relevant and Appropriate	This regulation identifies hazardous wastes restricted for land disposal and provides treatment standards for land disposal.	Hazardous wastes will be treated to meet disposal requirements.
State	Land Disposal Restrictions (N.J.A.C. 7:26G-11)	Relevant and Appropriate	These regulations establish standards for treatment and disposal of hazardous wastes.	Hazardous wastes will comply with the treatment and disposal standards.
Water Discharge or Subsurface Injection				
Federal	National Pollutant Discharge Elimination System (NPDES) (40 CFR 100 et seq.)	Applicable - ARAR	NPDES permit requirements for point source discharges must be met, including the NPDES Best Management Practice Program. These regulations include, but are not limited to, requirements for compliance with water quality standards, a discharge monitoring system, and records maintenance	Project will meet NPDES permit requirements for point source discharges.
Federal	Safe Drinking Water Act – Underground Injection Control Program (40 CFR 144, 146)	Relevant and Appropriate	Establish performance standards, well requirements, and permitting requirements for groundwater re-injection wells.	For alternatives that include injection of reagent, project will evaluate the requirement for injection of reagent for in situ treatment.
State	The New Jersey Pollutant Discharge Elimination System (N.J.A.C. 7:14A)	Applicable - ARAR	This permit governs the discharge of any wastes into or adjacent to State waters that may alter the physical, chemical, or biological properties of	For alternatives that include injection of reagent, project will meet NPDES permit requirements for surface discharges or groundwater discharge

Table 9c
Record of Decision
Action-specific ARARs, Criteria, and Guidance
Pohatcong Valley Superfund Site - OU3
Washington, Warren County, New Jersey

Regulatory Level	Authority/Source	Status	Requirement Synopsis	Comments
Off-Gas Management				
Federal	Clean Air Act (CAA)—National Ambient Air Quality Standards (NAAQs) (40 CFR 50)	Applicable - ARAR	These provide air quality standards for particulate matter, lead, NO_2, SO_2, CO, and volatile organic matter.	During excavation, treatment, and/or stabilization, air emissions will be properly controlled and monitored to comply with these standards.
Federal	Standards of Performance for New Stationary Sources (40 CFR 60)	Applicable - ARAR	Set the general requirements for air quality.	During excavation, treatment, and/or stabilization, air emissions will be properly controlled and monitored to comply with these standards.
Federal	National Emission Standards for Hazardous Air Pollutants (40 CFR 61)	Applicable - ARAR	These provide air quality standards for hazardous air pollutants.	During excavation, treatment, and/or stabilization, air emissions will be properly controlled and monitored to comply with these standards.

Table 9c
Record of Decision
Action-specific ARARs, Criteria, and Guidance
Pohatcong Valley Superfund Site - OU3
Washington, Warren County, New Jersey

Regulatory Level	Authority/Source	Status	Requirement Synopsis	Comments
State	New Jersey Air Pollution Control Act (N.J.A.C. 7:27)	Applicable - ARAR	Describes requirements and procedures for obtaining air permits and certificates; rules that govern the emission of contaminants into the ambient atmosphere.	During excavation, treatment, and/or stabilization, air emissions will be properly controlled and monitored to comply with these standards.
Federal	Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway for Subsurface Vapor Sources to Indoor Air (OSWER Publication 9200.2-154)	To Be Considered	Presents current techncial recommendations of EPA in assessing the vapor intrusion pathway, conducting vapor intrusion investigation, and conducting	Technical guidance on operation, monitoirng, and maintenace of the shallow soil vapor extraction and sub-slab depressurization system.
State	Site Remediation Program: Vapor Instruction Technical Guidance (March 2013)	To Be Considered	presents guidance on vapor intrusion investigation, mitigation, monitoring and ultimately termination	Technical guidance on operation, monitoirng, and maintenace of the shallow soil vapor extraction and sub-slab depressurization system.

10a
Record of Decision
Cost Estimate for Deep Soil Vapor Extraction without In Situ Thermal Hot Spot Treatment
Pohatcong Valley Contaminated Groundwater Superfund Site, OU3 Study Area
Washington, New Jersey

No.	Description	Cost
	Remedial action	
01	General requirements	$988,000
02	Deep Soil Vapor Extraction Construction and Startup	$1,138,000
03	First Year Deep Soil Vapor Extraction Operation and Maintenance	$363,320
	Subtotal	$2,489,320
	General Contractor Markup (profit, insurance etc) 20%	$497,864
	Contingency 20%	$497,864
	Total Remedial Action Capital Costs	**$3,486,000**
	OPERATION AND MAINTENANCE COSTS	
04	Annual Operation and Maintenance for the Deep SVE System (Year 2 and 3)	$424,000
04	Annual Operation and Maintenance for the Deep SVE System (Year 4-10)	$225,000
	Annual Operation and Maintenance for the Shallow SVE and SSD Systems	$185,000
05	Performance Evaluation and Site Restoration (Year 10)	$511,200
06	EPA Five Year Reviews	$12,000
	PRESENT WORTH	
	Total Capital Cost	**$3,486,000**
	Present Worth for Deep SVE (Years 2 to 10)	$1,707,000
	Present Worth for Performance Evaluation and Site Restoration	$260,000
	Present Worth for Operation, Monitoring and Maintenance of Shallow SVE and SSD Systems (Years 1 to 30)	$2,296,000
	Total O&M Cost	**$4,263,000**
	Total Present Worth of Five Year Review Costs	**$30,000**
	Total Present Worth	**$7,779,000**

Note: The project cost presented herein are prepared to facilitate alternative comparison. Between alternatives for feasibility study level evaluation Subject to change pending the results of the pre-design investigation, which is intended to collect sufficient data to assist in the development of remedial design and associated detailed cost estimate. Expected accuracy range of the cost

Table 10b
Record of Decision
Cost Estimate for Deep Soil Vapor Extraction with In Situ Thermal Hot Spot Treatment
Pohatcong Valley Contaminated Groundwater Superfund Site, OU3 Study Area
Washington, New Jersey

No.	Description	Cost
	Remedial action	
01	General requirements	$2,173,000
02	Soil Vapor Extraction Construction and Startup	$1,138,000
03	Deep Soil Vapor Extraction Operation and Maintenance during Construction	$726,640
04	In Situ Thermal Treatment (including detailed design)	$2,281,000
05	Performance Evaluation after In Situ Thermal Treatment (year 3)	$225,000
	Subtotal	**$6,543,640**
	General Contractor Markup (insurance, bonds, fees etc.) 20%	$1,308,728
	Contingency 20%	$1,308,728
	Total Remedial Action Capital Costs	**$9,162,000**
	OPERATION AND MAINTENANCE COSTS	
06	Annual Operation and Maintenance (Year 3 to 10)	$225,000
	Annual Operation and Maintenance for the Shallow SVE and SSD Systems	$185,000
07	Performance Evaluation and Site Restoration (Year 10)	$511,200
08	EPA Five Year Reviews	$12,000
	PRESENT WORTH	
	Total Capital Cost (up to 5 years)	**$9,162,000**
	Present Worth for Deep SVE Operation and Maintenance (Years 3 to 10)	$989,835
	Present Worth for Performance Evaluation and Site Restoration (year 10)	$260,000
	Present Worth for Operation, Monitoring and Maintenance of Shallow SVE and SSD Systems (Years 1 to 30)	$2,295,672.62
	Total O&M Cost	**$3,546,000**
	Total Present Worth of Five Year Review Costs	**$30,000**
	Total Present Worth	**$12,738,000**

Note: The project cost presented herein are prepared to facilitate alternative comparison. Between alternatives for feasibility study level evaluation Subject to change pending the results of the pre-design investigation, which is intended to collect sufficient data to assist in the development of remedial design and associated detailed cost estimate. Expected accuracy range of the cost

Table 10c
Record of Decision
Cost Estimate for In Situ Thermal Hot Spot Treatment
Pohatcong Valley Contaminated Groundwater Superfund Site, OU3 Study Area
Washington, New Jersey

No.	Description	Cost
	Remedial action	
01	General requirements	$1,318,000
02	In Situ Thermal Treatment (including detailed design)	$2,281,000
03	Performance Evaluation after In Situ Thermal Treatment	$225,000
	Subtotal	**$3,824,000**
	General Contractor Markup (insurance, bonds, fees etc.) 20%	$764,800
	Contingency 30%	$1,147,200
	Total Remedial Action Capital Costs	**$5,736,000**
	OPERATION AND MAINTENANCE COSTS	
04	Annual Operation and Maintenance for the Shallow SVE and SSD Systems	$185,000
05	Final Vadose Zone Contamination Evaluation (Year 10)	$395,000
06	EPA Five Year Reviews	$12,000
	PRESENT WORTH	
	Total Capital Cost (2-3 years)	**$5,736,000**
	Present Worth for Operation, Monitoring and Maintenance of Shallow SVE and SSD Systems (Years 1 to 30)	$2,296,000
	Present Worth for the Second Vadose Zone Contamination Evaluation (year 10)	$201,000
	Total O&M Cost	**$2,497,000**
	Total Present Worth of Five Year Review Costs	**$30,000**
	Total Present Worth	**$8,263,000**

Note: The project cost presented herein are prepared to facilitate alternative comparison. Between alternatives for feasibility study level evaluation Subject to change pending the results of the pre-design investigation, which is intended to collect sufficient data to assist in the development of remedial design and associated detailed cost estimate. Expected accuracy range of the cost estimate is -30% to +50%.

APPENDIX III: Administrative Record Index

ADMINISTRATIVE RECORD INDEX OF DOCUMENTS

FINAL

09/27/2016

REGION ID: 02

Site Name: POHATCONG VALLEY GROUND WATER CONTAMINATION
CERCLIS ID: NJD981179047
OUID: 03
SSID: 023J
Action:

DocID:	Doc Date:	Title:	Image Count:	Doc Type:	Addressee Name/Organization:	Author Name/Organization:
395880	9/27/2016	ADMINISTRATIVE RECORD INDEX FOR OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	5	ARI / Administrative Record Index		R02: (US ENVIRONMENTAL PROTECTION AGENCY)
124191	1/26/2016	COMPREHENSIVE ADMINISTRATIVE RECORD INDEX FOR OU1 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	4	ARI / Administrative Record Index		R02: (US ENVIRONMENTAL PROTECTION AGENCY)
128127	1/26/2016	COMPREHENSIVE ADMINISTRATIVE RECORD INDEX FOR OU2 FOR THE POHATCONG VALLEY GROUNDWATER CONTAMINATION SITE	3	ARI / Administrative Record Index		R02: (US ENVIRONMENTAL PROTECTION AGENCY)
123766	7/1/2010	FINAL REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN FOR OU 3 FOR THE POHATCONG VALLEY GROUNDWATER CONTAMINATION SITE	130	RPT / Report		R02: (CDM)
268317	9/21/2012	PATHWAY ANALYSIS REPORT FOR OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	404	RPT / Report	R02: Granger, Michelle (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Leonard, Edward (CDM)
268310	3/22/2013	FINAL REMEDIAL INVESTIGATION / FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN REVISED ADDENDUM NO. 1 VAPOR INTRUSION FOR OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	178	RPT / Report	R02: Granger, Michelle (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Leonard, Edward (CDM)
268312	4/16/2013	FINAL SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT FOR OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	59	RPT / Report	R02: Granger, Michelle (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Leonard, Edward (CDM)
268326	6/11/2013	FINAL VAPOR INTRUSION SAMPLING TECHNICAL MEMORANDUM FOR OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	28	RPT / Report	R02: Granger, Michelle (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Leonard, Edward (CDM)

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268321	6/12/2013	FINAL TECHNICAL MEMORANDUM - HUMAN HEALTH RISK ASSESSMENT FOR FUTURE RESIDENTS FOR OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	37	RPT / Report	R02: Granger, Michelle (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Leonard, Edward (CDM)
413357	2/12/2014	DRAFT REMEDIAL INVESTIGATION / FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN ADDENDUM NO. 2 FACILITY SUPPLEMENTAL SOIL INVESTIGATION OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	33	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: (CDM FEDERAL PROGRAMS CORPORATION)
413359	11/12/2014	REVISED DRAFT REMEDIAL INVESTIGATION / FEASIBILITY STUDY QUALITY ASSURANCE PROJECT PLAN ADDENDUM NO. 3 REVISED REMEDIAL INVESTIGATION OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	59	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: (CDM FEDERAL PROGRAMS CORPORATION)
335927	4/10/2015	DEED NOTICE APPROVED BY THE US EPA FOR OU1, OU2 AND OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	11	LTR / Letter	R02: (US ENVIRONMENTAL PROTECTION AGENCY), R02: (US DEPT OF JUSTICE)	R02: White, Bruce (BARNES & THORNBURG)
413424	4/10/2015	MONTHLY PROGRESS REPORT NO. 1 FOR THE PERIOD 03/01/2015 - 03/31/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	3	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413425	5/8/2015	MONTHLY PROGRESS REPORT NO. 2 FOR THE PERIOD 04/01/2015 - 04/30/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	3	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413426	6/6/2015	MONTHLY PROGRESS REPORT NO. 3 FOR THE PERIOD 05/01/2015 - 05/31/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	4	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413427	7/9/2015	MONTHLY PROGRESS REPORT NO. 4 FOR THE PERIOD 06/01/2015 - 06/30/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	4	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)

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413421	7/28/2015	REVISED FINAL SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	68	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: (CDM FEDERAL PROGRAMS CORPORATION)
413428	8/10/2015	MONTHLY PROGRESS REPORT NO. 5 FOR THE PERIOD 07/01/2015 - 07/31/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	19	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413429	9/10/2015	MONTHLY PROGRESS REPORT NO. 6 FOR THE PERIOD 08/01/2015 - 08/31/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	5	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413423	9/18/2015	REVISED FINAL HUMAN HEALTH RISK ASSESSMENT OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	510	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: (CDM FEDERAL PROGRAMS CORPORATION)
413394	10/1/2015	FINAL DESIGN REPORT FOR THE SOIL VAPOR EXTRACTION AND MITIGATION SYSTEM, VOLUME 1 OF 2 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	848	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY), R02: (PECHINEY PLASTIC PACKAGING INCORPORATED)	R02: (RAMBOLL ENVIRON CORPORATION)
413395	10/1/2015	FINAL DESIGN REPORT FOR THE SOIL VAPOR EXTRACTION AND MITIGATION SYSTEM, VOLUME 2 OF 2, APPENDIX A OPERATION, MAINTENANCE, AND MONITORING PLAN FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	2242	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY), R02: (PECHINEY PLASTIC PACKAGING INCORPORATED)	R02: (RAMBOLL ENVIRON CORPORATION)
413430	10/9/2015	MONTHLY PROGRESS REPORT NO. 7 FOR THE PERIOD 09/01/2015 - 09/30/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	5	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413431	11/9/2015	MONTHLY PROGRESS REPORT NO. 8 FOR THE PERIOD 10/01/2015 - 10/31/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	5	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)

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413432	12/10/2015	MONTHLY PROGRESS REPORT NO. 9 FOR THE PERIOD 11/01/2015 - 11/30/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	5	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413433	1/10/2016	MONTHLY PROGRESS REPORT NO. 10 FOR THE PERIOD 12/01/2015 - 12/31/2015 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	5	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413434	2/10/2016	MONTHLY PROGRESS REPORT NO. 11 FOR THE PERIOD 01/01/2016 - 01/31/2016 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	10	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413435	3/10/2016	MONTHLY PROGRESS REPORT NO. 12 FOR THE PERIOD 02/01/2016 - 02/29/2016 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	5	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413436	4/8/2016	MONTHLY PROGRESS REPORT NO. 13 FOR THE PERIOD 03/01/2016 - 03/31/2016 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	5	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413437	5/10/2016	MONTHLY PROGRESS REPORT NO. 14 FOR THE PERIOD 04/01/2016 - 04/30/2016 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	5	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: Kennington, Bruce (ENVIRON INTERNATIONAL CORPORATION)
413397	5/11/2016	FINAL REMEDIAL INVESTIGATION REPORT, VOLUME 1 OF 5, TEXT FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	217	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: (CDM SMITH)
413398	5/11/2016	FINAL REMEDIAL INVESTIGATION REPORT, VOLUME 2 OF 5, APPENDIX A - HISTORICAL REPORTS FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	4849	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: (CDM SMITH)
413399	5/11/2016	FINAL REMEDIAL INVESTIGATION REPORT, VOLUME 3 OF 5, APPENDIX B - FIELD CHANGE NOTIFICATIONS AND APPENDIX C - SOIL BORING LOGS FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	278	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: (CDM SMITH)

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413400	5/11/2016	FINAL REMEDIAL INVESTIGATION REPORT, VOLUME 4 OF 5, APPENDIX D - VAPOR INTRUSION REPORTS FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	3192	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: (CDM SMITH)
413401	5/11/2016	FINAL REMEDIAL INVESTIGATION REPORT, VOLUME 5 OF 5, APPENDIX E-ECOLOGICAL CHARACTERIZATION, APPENDIX F-TOPOGRAPHIC SURVEY, APPENDIX G-DATA QUALITY ASSURANCE, APPENDIX H-ANALYTICAL DATA TABLES FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	624	RPT / Report	R02: (US ENVIRONMENTAL PROTECTION AGENCY)	R02: (CDM SMITH)
395904	6/10/2016	FEASIBILITY STUDY FOR OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	261	RPT / Report		R02: (CDM SMITH)
395905	6/13/2016	PROPOSED PLAN FOR OU3 FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	22	WP / Work Plan		R02: (US ENVIRONMENTAL PROTECTION AGENCY)
123708	8/1/2007	REMEDIAL INVESTIGATION REPORT PECHINEY PLASTICS PACKAGING, INCORPORATION (FORMERLY AMERICAN NATIONAL CAN COMPANY) FOR THE POHATCONG VALLEY GROUND WATER CONTAMINATION SITE VOLUME I and II	549	RPT / Report	R02: (PECHINEY PLASTIC PACKAGING INCORPORATED)	R02: (ENVIRON CORPORATION)
447169	7/1/2012	SITE INVESTIGATION REPORT OU3 FOR POHATCONG VALLEY GROUND WATER CONTAMINATION SITE	129	RPT / Report	R02: (PECHINEY PLASTIC PACKAGING INCORPORATED)	R02: (ENVIRON INTERNATIONAL CORPORATION)

APPENDIX IV: State Concurrence Letter

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
SITE REMEDIATION AND WASTE MANAGEMENT PROGRAM
Mail Code 401-05M
P. O. Box 420
Trenton, New Jersey 08625-0420
Tel. #: 609-292-1251
Fax. #: 609-777-1914

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

September 28, 2016

Mr. Walter Mugdan, Director
Emergency and Remedial Response Division
U.S. Environmental Protection Agency
Region II
290 Broadway
New York, NY 10007-1866

Re: Pohatcong Valley Groundwater Contamination Superfund Site
Record of Decision Operable Unit 3
EPA ID# NJD981179047
DEP PI# G000005662

Dear Mr. Mugdan:

The New Jersey Department of Environmental Protection (DEP) has completed its review of the "Record of Decision, Pohatcong Valley Groundwater Contamination Superfund Site, Operable Unit 3, Warren County, New Jersey" prepared by the U.S. Environmental Protection Agency (EPA) Region II in September 2016 and concurs with the selected remedy to enable use of in-situ thermal treatment and soil vapor extraction (SVE) to clean up contaminated soils under the former American National Can building. However, DEP disagrees with the site-specific remediation goal for trichloroethene (TCE) in the vadose-zone soil and requests that EPA and the responsible parties required to implement the action develop a more appropriate cleanup goal for soil under the building, now occupied by the Albea company, during the remedial design phase for the selected remedy.

The major component of the selected remedy includes:

- Implementation of deep SVE and/or thermal treatment to address deep soil contamination underlying the former American National Can building. This would include the option of performing thermal hot-spot treatment of soils first, and eliminating the deep SVE portion of the remedy if EPA deems that remedial action objectives have been sufficiently met by thermal treatment alone. In the event that in-situ thermal treatment of the hot-spot does not meet remedial objectives, then deep SVE would be implemented.

It is important to note for this component of the selected remedy that the ability of the soil action to arrest groundwater impacts at source areas should guide development of a performance standard and remedial design for the in-situ thermal treatment work. Groundwater remediation must be evaluated and demonstrated at the Operable Unit 3 source areas. DEP requests that EPA and responsible parties submit a model of the proposed remedy using a site-specific remediation goal that demonstrates timely achievement of the DEP's Ground Water Quality Standard at both the downgradient edge of Area A and near the limits of Operable Unit 3 (downgradient of Areas B and C), for review and comment during remedial design.

The Remediation Standards rules, N.J.A.C. 7:26D-1.1, and the Technical Requirements for Site Remediation, N.J.A.C. 7:26E-1.3, require the person responsible for conducting the remediation to develop site-specific soil remediation standards that are protective of groundwater. DEP has identified several methods that may be used to develop site-specific impact to groundwater remediation standards, including the use of default Impact to Ground Water Soil Remediation Standards. DEP's default Impact to Ground Water Soil Remediation Standard for TCE is 0.01 part per million (ppm) and is a "to be considered" criteria that should be used unless a site-specific number is developed in accordance with the DEP's various guidance documents.

The site-specific remediation goal selected by EPA of 1 ppm for TCE in soil was not developed in accordance with DEP guidance. Specifically, the SESOIL/AT123D model is not applicable for developing standards for soils beneath the former American National Can building. The reason the model is not applicable for use in deriving site-specific impact to groundwater soil remediation standards for soils beneath a building is limited infiltration. EPA has acknowledged the limitations of using the model for this reason, hence a site-specific goal that is developed and applied in accordance with DEP guidance is recommended.

The other major components of the selected remedy include:

- Long-term operation and maintenance of the existing shallow SVE and Sub-slab Depressurization systems within the former American National Can building;

- Long-term groundwater and indoor air monitoring in the OU3 Study Area will be performed over time to assess the remedy's effectiveness; and,

- Institutional controls, including the existing deed notice, will remain in effect at the former American National Can property and will be amended to reflect the components of the selected remedy for Operable Unit 3 that will be implemented at the former American National Can property. The institutional controls will be periodically verified by EPA as part of the long-term monitoring effort.

DEP appreciates the opportunity to participate in the decision making process to select an appropriate remedy for this site. Further, DEP is looking forward to future cooperation with EPA in remedial actions to ensure a full cleanup at all areas impacted by this site.

If you have any questions, please call me at 609-292-1251.

Sincerely,

Kenneth J. Kloo, Director
Division of Remediation Management

C: Mark J. Pedersen, Assistant Commissioner,
Site Remediation & Waste Management Program
Edward W. Putnam, Assistant Director, Publicly Funded Response Element, DEP
Carole Petersen, Chief, New Jersey Remediation Branch, EPA Region II

APPENDIX V: Responsiveness Summary

APPENDIX V

RESPONSIVENESS SUMMARY
Pohatcong Valley Groundwater Contamination Superfund Site
Operable Unit 3
Washington Borough and Washington Township, Warren County, New Jersey

INTRODUCTION

This Responsiveness Summary provides a summary of the public's comments and concerns regarding the Proposed Plan for the Operable Unit 3 (OU3) portion of the Pohatcong Valley Groundwater Contamination Superfund Site (Site), and EPA's responses to those comments, in accordance with the requirements set forth in 40 CFR 300.430(f)(3). All comments summarized in this document have been considered in EPA's final decision in selecting a remedy for the OU3 portion of the Site.

This Responsiveness Summary is divided into the following sections:

I. BACKGROUND OF COMMUNITY INVOLVEMENT AND CONCERNS: This section provides the history of community involvement and interests regarding the Site.

II. COMPREHENSIVE SUMMARY OF MAJOR QUESTIONS, COMMENTS, CONCERNS AND RESPONSES
This section contains summaries of oral comments received by EPA at the public meeting, EPA's responses to these comments, as well as responses to written comments received during the public comment period.

The last section of the Responsiveness Summary includes attachments, which document public participation in the remedy selection process for this Site. They are as follows:

Attachment A contains the Proposed Plan that was distributed to the public for review and comment;

Attachment B contains the public notices that appeared in the *Express Times* newspaper;

Attachment C contains the transcript of the public meeting; and

Attachment D contains the written comments received by EPA during the public comment period.

I. BACKGROUND ON COMMUNITY INVOLVEMENT AND CONCERNS

EPA has worked closely with local residents, public officials, and other interested members of the community throughout site-wide investigations and remedial actions. On June 15, 2016, EPA released the Proposed Plan and supporting documentation for the OU3 proposed remedy to address source contamination at the Site to the public for comment. EPA made these documents available to the public electronically at the following website:
https://www.epa.gov/superfund/pohatcong-valley-groundwater

and in the administrative record repositories maintained at EPA's Region 2 office (290 Broadway, New York, New York) and at the Warren County Health Department (700 Oxford Road, Oxford, New Jersey).

EPA published a notice of availability of these documents in the *Express Times* newspaper on June 15, 2016 as well as on the Washington Borough website. EPA opened a public comment period which ran from June 15, 2016 through July 15, 2016. On June 21, 2016, EPA held a public meeting at the Washington Borough Municipal Building in Washington Borough, New Jersey to inform local officials and interested residents about the Superfund process, to present the preferred remedial alternative for OU3 of the Site, solicit oral comments, and respond to questions from area residents and other interested parties. On July 6, 2016, a party requested a 30 day extension of the public comment period. This request was granted and the public comment period was extended to August 15, 2016. Notice of the extension of the public comment period was published in the *Express Times* newspaper on July 15, 2016.

II. COMPREHENSIVE SUMMARY OF MAJOR QUESTIONS, COMMENTS, CONCERNS AND RESPONSES

PART 1: Verbal Comments

This section summarizes comments received from the public during the public comment period, along with EPA's responses.

A. SUMMARY OF QUESTIONS AND EPA'S RESPONSES FROM THE PUBLIC MEETING CONCERNING OU3 OF THE POHATCONG VALLEY GROUNDWATER CONTAMINATION SITE – JUNE 21, 2016

A public meeting was held on June 21, 2016 at 6:30 p.m. in the Washington Borough Municipal Building, Washington Borough, New Jersey. In addition to a brief presentation of the investigation findings, EPA presented the Proposed Plan and preferred alternatives for the Site, received comments from meeting participants, and responded to questions regarding the remedial alternatives under consideration. **Attachment C** includes the entire transcript of the public meeting.

A summary of comments raised by the public following EPA's presentation is presented below:

Comments on the Proposed Remedy

> **Comment 1:** *Were any early actions taken at the facility to address risks when it was determined that pipes under the former American Can facility were leaking?*
>
> **EPA Response:** EPA's investigations of soils in the OU3 Study Area were initiated in 2011. The results of those studies are being presented tonight and are summarized in EPA's Proposed Plan. In the Proposed Plan, EPA presents a cleanup plan to address the contaminated soils under the former American National Can (ANC) facility. The primary contaminant of concern in soils and groundwater at the Site is TCE. TCE was used historically at the former ANC facility, but has not likely been used or disposed of at the former ANC facility since the 1980's or earlier. There is no direct human exposure to

contaminated soils directly under the building, however, in 2013, as a result of soil vapor data collected by EPA, elevated levels of TCE were detected in indoor air at the former ANC facility. Based on this data, an immediate action was taken to address unacceptable levels of TCE in indoor air in the facility. A sub-slab depressurization system and soil vapor extraction system were installed on an expedited basis and now all indoor air criteria are being met at the facility.

Comment 2: *With respect to the indoor air mitigation system, how many monitoring points are there in the Albea building?*

EPA Response: We do not know the exact number of indoor air monitoring points. The current subslab depressurization and soil vapor extraction system has been demonstrated to protect workers and people inside the building from exposure to elevated levels of contaminants in the indoor air.

Note: After the public meeting, EPA reviewed the site file and determined that there are 42 indoor air monitoring points in the Albea building.

Comment 3: *Would EPA's estimate removal of 90 percent of contamination through the implementation of Alternative 4 in soils under the building include contamination in the identified hot-spot?*

EPA Response: Yes, 90 percent of existing mass of TCE is predicted to be removed through Alternative 4, Soil Vapor Extraction with Optional *In-Situ* Thermal Hot-Spot Treatment. This would include impacted soils under the building both within and outside of the hot-spot.

Comment 4: *What is the depth of groundwater?*

EPA Response: The depth to groundwater throughout the Site varies. At the portion of the Site near the Park Hill Apartments, contaminated groundwater is at about 40 feet below the ground surface. At the former ANC facility, the depth to groundwater is about 110 feet.

Comment 5: *Once you implement the cleanup under the former American Can facility, how does this ultimately affect the downgradient part of the plume?*

EPA Response: The goal of the proposed remedy is to remove the remaining source of groundwater contamination in the soils underlying the former ANC facility. There are currently two groundwater treatment systems extracting and treating groundwater from two areas of the Site. One is at the current former ANC facility and it is extracting and treating approximately 400 gallons per minute of contaminated groundwater. The other treatment system is near the Park Hill Apartments and it is extracting and treating about 45 gallons per minute of contaminated groundwater. The overall site remedy includes extracting from these two most highly contaminated areas of groundwater contamination and also removing any remaining contaminated soils which are acting as a source of groundwater contamination. The OU3 Remedial Investigation identified the soil under the building at the Albea facility to be contributing to the groundwater contamination associated with OU1 and OU2. The lesser contaminated areas of groundwater contamination not addressed by the extraction and treatment plants will be allowed to naturally attenuate.

Comment 6: *Explain what you mean by allowing the groundwater to attenuate. Is the plume continuing to migrate? How is the plume defined?*

EPA Response: When the source of groundwater contamination is addressed, and the groundwater is pumped and reinjected in the most contaminated areas, it will allow the areas that have lesser levels of contamination to attenuate, in this case primarily through dilution. This will be a long-term process. Long-term monitoring will be performed to ensure that natural attenuation is occurring in areas that we expect it to. We do not believe that the downgradient edge of the plume is continuing to migrate appreciably. The extent of the plume is stable and we will continue to monitor to confirm this over time.

The contaminant plume is defined as the area where TCE is greater than 1 part per billion, which is the drinking water standard.

Comment 7: *Will the cleanup of the plume involve fracking anywhere along the valley?*

EPA Response: No.

Comment 8: *Are you anticipating to go down 100 feet to clean and strip the water?*

EPA Response: Groundwater from below 100 feet at the Site in the highest area of contamination is being extracted, sent through a treatment plant where it is treated to remove TCE, and then the clean water is being reinjected.

Comment 9: *When will work start for the OU3 remedy?*

EPA Response: EPA expects to issue a Record of Decision, which will finalize the proposed remedy in September 2016. An enforcement agreement is in place through which private parties will implement the selected OU3 remedy. It will take them approximately a year to perform an engineering design of the selected remedy. During the design, a construction schedule will be developed.

Comment 10: *Who is paying for the cleanup?*

EPA Response: EPA has entered into a settlement with a number of private parties related to past operations at the Site who will fund the OU3 cleanup work.

Comment 11: *Is the Site still considered a Superfund Site?*

EPA Response: Yes, the Site is a federal Superfund Site. This allows federal funds to be spent on site investigation and cleanup, if necessary. Early on, federal money was used to investigate the Site prior to potentially responsible parties being identified. At this time, parties have been identified and have settled with EPA to fund and/or perform certain cleanup work at the Site. One area of the Site, the groundwater cleanup for PCE contamination at the Park Hills Apartments, is being performed and funded by the government because no viable responsible parties were identified.

Comments Regarding Vapor Intrusion Work

Comment 12: *How often is vapor monitored? Is there a place online where people can look up the results of EPA's ongoing vapor investigation results*?

EPA Response: EPA has performed vapor intrusion sampling throughout all areas of the Site and has addressed problems discovered in some structures. EPA has gained a good understanding of groundwater contamination and associated vapor intrusion issues. EPA's highest priority is the protection of public health and EPA has installed or overseen the installation of several vapor mitigation systems in buildings located above the Site's groundwater plume. Since the groundwater plume is relatively stable, EPA does not expect to see significant increases in the need for vapor mitigation systems, however, EPA will continue to perform periodic monitoring for vapor intrusion related to this Site. EPA's workplans for the performance of vapor sampling as well as sampling results are available to the public upon request. EPA has three project managers working on different aspects of this site and their contact information will be provided to you.

Comment 13: *Is there a vapor removal system at an elementary school on Asbury Broadway Road? Please explain why that system is needed.*

EPA Response: Yes, EPA installed a vapor treatment system at a school. The contaminant plume comprised of volatile organic compounds associated with the Site is about 8 miles long. Because these contaminants can volatilize from groundwater and migrate under buildings, we sampled a number of buildings throughout the valley that overlie the plume including schools, daycare centers and residences. The indoor air in the school had some slightly elevated levels of TCE, and based on that, EPA installed a treatment system which allows gases from below the building slab to vent to the outside of the building.

Comment 14: *Several residents of Taylor Street indicated that they never received a letter from EPA requesting permission to sample for vapor in their homes. They wanted to know which residents received letters offering vapor sampling.*

EPA Response: EPA contacted a number of residents of Taylor Street, as well as surrounding streets to request permission to perform vapor investigation prior to 2006, and again in 2013, and received a very limited number of responses. There were several residences on or in close proximity of Taylor Street that were sampled. The results indicated that no elevated levels of contaminants were detected in indoor air or subslab air.

Based on these results and the depth of groundwater in the vicinity of Taylor Street, which is approximately 60 to 80 feet below ground surface, there is a low likelihood of vapor intrusion of contaminants into homes in that area. Periodic vapor sampling, every few years, is being performed at the Site and interested residents can be included in future sampling events.

Comment 15: *Was Taylor Street School ever sampled for indoor air contamination? It is so close to the source area and yet Franklin Elementary School is much further away and required an indoor air mitigation system.*

EPA Response: The topography changes throughout the valley and so there are related water table changes. The groundwater is over 100 feet below ground surface near the former ANC facility and Taylor Street. Groundwater is about 40 feet below ground surface in the area near Franklin Elementary School. There is believed to be a fault near the Pohatcong Creek. The higher level of groundwater to the surface as well as the fault may be the reasons that some elevated levels of TCE contamination in indoor air were observed at and near the Franklin Elementary School.

Comments Regarding Communication

Comment 16: *One resident indicated that she did not get information about the public meeting.*

EPA Response: EPA published a notice of this public meeting in the local newspaper, the *Express Times*. EPA also notified the local officials in Washington Borough, who posted a notice of the meeting on the Borough's website.

Comment 17: *Have the Freeholders been updated on Site activities?*

EPA Response: No, however, EPA provides regular Site updates and coordinates cleanup activities at this Site with Christine Blanchard, the Township Manager for Washington Borough. We have not reached out specifically to the county Freeholders, but we have widely advertised our activities at the Site, including posting notices in the newspaper regarding this meeting tonight. We have also coordinated Site activities through the years with Kevin Cavotta of the Warren County Health Department.

Comments Related to Aspects of the Pohatcong Valley Superfund Site other than Operable Unit 3, Source Areas

Comment 18: *Does the Site area being referred to include the former Tungsol Tubing property?*

EPA Response: The former Tungsol Tubing facility is part of the Pohatcong Valley Superfund Site, however, a groundwater cleanup is underway there which is not the subject of EPA's proposed plan being presented tonight. The meeting tonight is to present information about EPA's proposed cleanup plan for source areas of groundwater contamination at the Albea facility.

Comment 19: *A resident requested an update on the status of air quality testing recently performed at the Park Hill Apartments, as well as the status of the recently constructed groundwater treatment system located on and adjacent to the Park Hill Apartments.*

EPA Response: Although the ongoing groundwater remediation at the Park Hills Apartments is not the subject of the meeting tonight, it is one of the aspects of the overall Site cleanup. This newly constructed groundwater extraction and treatment system began operating to treat contaminated groundwater two weeks ago. In addition, periodic vapor monitoring is performed at the Park Hill Apartments and other structures in the area. Another EPA project manager is managing that aspect of the project and her contact information will be provided so that you can speak to her in detail about these activities.

Comment 20: *A resident of the Park Hill Apartments asked about the ramifications of the Proposed Plan, since it does not appear to directly impact residents of the Park Hill Apartments. Both areas of the Site have different contaminants, PCE and TCE.*

EPA Response: The Park Hill Apartments are primarily impacted by the ongoing groundwater cleanup that has just begun at the property and adjacent properties. A small groundwater treatment plant is operating in a corner of the parking lot for those apartments. The primary contaminant of concern at that portion of the Site is PCE in groundwater. In the OU3 Study Area, in the vicinity of the former ANC facility, the primary contaminant of concern in soils and groundwater is TCE.

Comment 21: *I do not understand where the groundwater plume is and how it affects the Park Hill Apartments?*

EPA Response: EPA showed the resident the location of groundwater contamination throughout the Site on a map.

Comment 22: *Are the Park Hill Apartments located on your map?*

EPA Response: No, the map we are discussing shows the features of Operable Unit 3, the area we are discussing tonight. The Park Hill Apartments are also on the Site and are located about a quarter of a mile south on Route 31.

Comment 23: *Several residents that live in close proximity to areas of recent construction of a groundwater extraction and treatment system at the Site complained of wet basements and a sewage-like stench in their basements which has occurred recently, concurrent with EPA's construction activities. They further indicated that their basements have water in them after rain events.*

EPA Response: Water in local basements after rain events is highly unlikely to be contaminated groundwater related to the Site since the depth to groundwater in the area is approximately 70 feet deep. So water in basements after rain evens is more likely due to localized drainage problems. It is likely that runoff from rainfall collected and has migrated to basements. It was pointed out that surface soil at the Site does not contain any levels of contaminants that pose a significant risk to human health or the environment, so local runoff does not contain Site contaminants.

Comment 24: *A resident indicated that environmental sampling at the Taylor Street School was observed by them recently and despite their efforts to get information about the purpose of this sampling, they could not get any additional information.*

EPA Response: EPA did not perform or oversee any sampling event regarding the Taylor Street School as part of OU3 Site activities. This sampling event that you witnessed recently is unrelated to EPA's work at the Site. You may want to contact your local officials to get more information about the work at the Taylor Street School.

Part 2: Written Comments

This section provides a summary of written comments received from the public during the public comment period and EPA's responses.

B. COMMENTS FROM ALICIA LYDING (via email):

Comment 1: *In the WLY Ponded Area TCE was detected in surface water, how is surface water being addressed as part of this ROD?*

EPA Response: Low levels of TCE were detected in surface water in the WLY Ponded Area. This area is typically dry, however, water intermittently ponds in this area during storm events, but does not migrate out of the area. The ponded water either evaporates or infiltrates into the ground surface within a few days. This area also has low levels of TCE detected in the soils directly in contact with the ponded water most likely causing the low levels of TCE in the ponded water. The small areas of contamination within the WLY ponded area does not pose unacceptable risks to human health. The surface water contamination will be allowed to attenuate under natural conditions.

Comment 2: *Remedial Action Objectives assume that the land use will remain industrial, what controls will be required as part of the ROD to ensure that the land use does not change?*

EPA Response: A deed notice for the former ANC property is in place which requires the land use of this property to be restricted. The owner must refrain from using the property in any manner that may adversely affect the implementation, integrity, or protectiveness of any portion of the remediation. The deed notice also requires the owner to provide written notice to EPA on any land use changes.

Comment 3: *A site-specific indoor air health goal is proposed that is higher than the NJDEP Indoor Air Screening Level for Nonresidential. What was the basis for this alternative standard?*

EPA Response: This site specific indoor air goal of 7 $\mu g/m^3$ for TCE was developed by the New Jersey Department of Health and the federal Agency for Toxic Substances and Disease Registry. The health goal was calculated based on employees working 12 hour shifts for 4 days per week and the USEPA Reference Concentration of 2 $\mu g/m^3$.

Comment 4: *A Preliminary Remediation Goal (PRG) was established for TCE within the vadose zone, however no PRGs were established for any of TCE daughter products (such as Vinyl Chloride). How will generation of daughter products due to the remediation be monitored? Without PRGs for the daughter products how can you ensure the remediation is completely removing/addressing the daughter products that may be generated during remedial actions?*

EPA Response: The contamination in the vadose zone below the former ANC building is not conductive to anaerobic biodegradation processes, which can generate TCE daughter products, such as vinyl chloride. A very limited amount of daughters products were detected beneath the building. No vinyl chloride was detected, but cis-dichloroethene was detected at concentrations up to 9.6 ppb in about 10% of the samples. The remedial technologies proposed uses physical treatment or oxidation mechanisms that will not generate vinyl chloride. Furthermore, as remediation occurs, extracted contaminated vapors will be monitored and treated as part of the vapor monitoring program.

Comment 5: *Alternative 3 proposes the injection of an oxidant from approximately 60 to 100 feet. How would this injection potentially impact the groundwater aquifer located directly below this zone? Would this have a potential impact on the local drinking water? What would be the proposed additional treatment required for the aquifer if the contaminants and oxidant migrate to the aquifer?*

EPA Response: The potential for an oxidant to impact groundwater was evaluated and was one of the reasons Alternative 3 was not selected as the preferred treatment.

Comment 6: *Due to the extremely high levels of TCE in the sub-slab soil gas, will the exhaust stack of the SVE and SSD systems be tested to ensure ambient air concentrations are below appropriate levels? Was an air permit required to operate the existing systems?*

EPA Response: Soil gas with high levels of contaminants, such as TCE, will be treated through vapor phase granular activated carbon prior to be released to the atmosphere. Routine sampling of air from of the vapor phase granular activated carbon treatment units will be performed to ensure the contaminants are not released to ambient air above levels of concern. An air permit equivalency from the NJDEP is required.

Comment 7: *As part of Alternative 4, will monitoring of the sub slab and indoor air at surrounding residents be conducted to ensure that soil gas levels do not become elevated due to the remedial action?*

EPA Response: The treatment as presented in Alternative 4 will draw/collect contaminated air below the sub-slab of the former ANC building through a designed treatment system, away from the surrounding areas. It will not create additional soil vapors, nor cause existing contaminated vapor to migrate away from the former ANC building. Therefore, it will not result in any increase of contaminated soil gas level to residents located at a much lower elevation than the facility. Based on this, the risk of exposure to people through vapor intrusion will decrease after the system begins to operate. Currently, even without the operation of a soil treatment system at the Site, vapor intrusion into nearby homes has not been demonstrated. However, EPA will continue to perform periodic subslab sampling in buildings located over the plume until the plume has been remediated.

C. COMMENTS RECEIVED FROM ALBEA AMERICAS, INC. (VIA EMAIL)

Comment 1: *Albea would like to point out that Section 25 of the Consent Decree commits US EPA to "coordinate access activities with [Albea] in an effort to minimize adverse impacts on Washington Facility plant operations".*

EPA Response: EPA performed a multi-phased remedial investigation in the former ANC facility and is well aware of the issues concerning impacts to the ongoing operations at the Albea Americas facility. The RI included the installation of approximately 12 deep and 31 shallow borings through the building slab and was done in close coordination with plant officials and in a manner to minimize the disruption of work at the facility. Further approaches to minimize impact of remediation to ongoing operations will be evaluated and addressed in the remedial design. Significant soil contamination remains under the building slab at depth and must be addressed. This will involve some impacts on current operations, however, as stated above, procedures will be developed in the remedial design to minimize the impacts.

Comment 2: *Albea supports PPPI's alternative and requests that US EPA move forward with that approach.*

EPA Response: Comment noted. See all responses to PPPI comments below in Section D below.

D. COMMENTS RECEIVED FROM RIO TINTO ON BEHALF OF PECHINEY PLASTIC PACKAGING, INC. (PPPI) (VIA EMAIL AND MAIL)

Set 1 – Prepared for PPPI by Ramboll Environ US Corporation

General Comments

Comment 1*: The USEPA's proposed remedy, Alternative 4 - Deep SVE (with optional In-Situ Thermal Remediation) will not be able to achieve the remedial action goals of 1 mg/kg in soil within the targeted remediation area. Specifically, in the third paragraph on page 13 of the USEPA OU3 PRAP, the USEPA states that deep SVE if employed also with In-Situ Thermal Remediation (ISTR) will be able to achieve 90% removal of TCE in soil within the target remedial area. Concentrations of TCE in soils within Area A of OU3 have exhibited concentrations in excess of 120 mg/kg in the soils beneath Area A during the USEPA OU3 activities and 9,500 mg/kg during the remedial investigation activities undertaken by PPPI in the former Molding area (within the USEPA's Area A) prior to 2007.*

*Page ES-13 of the 2016 RI Report, states, "Directly underneath the ANC building, TCE detections in soil are concentrated around the sanitary sewer lines and floor drains in the former Blak-Sol operations area, in the southwestern corner of the building, where TCE degreasers are believed to have been located. During the OU3 RI, TCE exceeded the OU3 RI screening criterion (10 µg/kg) in 58 of the 165 soil samples collected below the ANC building. Vertically, TCE is present above 1,000 µg/kg throughout the overburden and into the weathered bedrock zone to a depth of approximately 100 feet bgs. This area has the highest concentrations of TCE in soil at the OU3 Study Area (**as high as 120,000 µg/kg TCE during the OU3 RI and as high as 9,500,000 µg/kg during the 2007 PPPI RI**)." [emphasis added in **bold**]*

For soils with TCE concentrations in excess of 10,000 µg/kg, (or 10 mg/kg), 90% removal would result in TCE remaining at concentrations in excess of 1 mg/kg. In the case of the detections of TCE in soils during the OU3 RI in excess of 100,000 µg/kg, such treatment would result in soil concentrations remaining after treatment in excess of 10,000 µg/kg (or 10 mg/kg), an order of magnitude above the USEPA's proposed soil remedial goal.

EPA Response: The Feasibility Study states that Alternative 4 is estimated to achieve 90% mass removal of TCE in soil within the target remedial area. The commenter indicated that Alternative 4 will not be able to achieve the Site specific soil remediation goal of 1 mg/kg and supported this statement by providing examples such as soils with TCE concentrations in excess of 10 mg/kg remaining at concentrations in excess of 1 mg/kg even after treatment resulting in 90% removal. The example cited by the commenter implies the commenter misunderstood how EPA applies the estimate of 90% mass removal in the FS report. The estimate of 90% mass removal applies to the overall reduction of contaminant mass in soil by Alternative 4, and it is not a removal rate for contaminant concentrations in soil at any given location.

EPA believes that Alternative 4 – which includes deep SVE with optional *in-situ* thermal remediation (ISTR) is capable of achieving the soil remediation goal of 1 mg/kg within the treatment zone. A pilot study would be required during the remedial design to determine with a higher degree of confidence if adequate air flow through the contaminated soils can be achieved and if a reasonable well spacing and mass removal rate can be achieved. Additionally, various enhancement technologies could be utilized to enhance the performance of a deep SVE system if necessary, such as injection of heated air or pneumatic fracturing. If the pilot study or pre-design investigations indicate that contaminant removal will require very closely spaced wells and may not be effective for the highly contaminated zone, *in-situ* thermal remediation alone can be implemented at the hot-spot. The extent of the hot-spot will be determined in remedial design, based on additional sampling. *In-situ* thermal remediation is capable of reducing soil TCE concentrations to below 1 mg/kg in the hot-spot area. Through the use of SVE and/or *in-situ* thermal remediation, EPA believes that implementation of Alternative 4 will reduce contaminant mass sufficiently to achieve the remedial action objectives (RAOs).

Comment 2: *Based on the current understanding of the deep soils within Area A of OU3, deep SVE will not be for treatment of soils to achieve the stated remedial objectives. As provided in Specific Comment No. 19 on the 2016 FS Report and Specific Comment No. 21 on the USEPA OU3 PRAP that follow, given the low permeability of the soil within the deep soils of Area A, the use of deep SVE with installation of vertical extraction wells is not practicable due to the high density of wells through the building slab (more than twice that presented in the 2016 FS Report) and the associated piping (even if routed vertically to run to the overhead of the ceiling of the former Molding area). The space required for these remedial components would effectively preclude access for use of the plant floor for facility operations by Albéa Americas, the current owner of the facility. Additionally, given the low permeabilities of the deep soils present (the 2016 RI Report presented soil hydraulic conductivity values ranging from approximately 2E-6 centimeters per second (cm/s) to 8E-8 cm/s for these soils) the use of SVE for remediation of TCE is not likely to be effective. SVE is typically more applicable for cases where unsaturated soils are relatively permeable (i.e., hydraulic conductivities in excess of 1E-3 cm/s to 1E-2 cm/s) (USEPA, Feb 1991). Removal of contaminants from fine grain soils consisting of silts and clays with permeabilities ranging from 1E-3 to 1E-6 has been demonstrated, however the effective treatment of* *such soils is limited (Parsons, 2001) (USEPA 2001) (USACE, 2002). Based on the logs of soil borings conducted through Area A of OU3 boring logs, boulders and cobbles were encountered throughout, along with layers of more highly permeable sands. Impermeable features such as bolder and cobbles would impede the ability to ventilate soils where present, and create "shadows" where movement of air through soil venting would be impeded leaving areas where soil treatment would be incomplete. The presence of permeable sand layers or veins in between fine grained soils of low permeability would create short-circuiting and incomplete venting of soils that would impede the treatment of the finer grained, less permeable soils. Both of these factors would result in incomplete treatment of the subsurface soils. Accordingly, the effectiveness of SVE in the deep soils of Area A at the Washington plant is highly questionable in the long term under the USEPA's nine evaluation criteria and without results of pilot or treatability study to support its evaluation, deep SVE should have been eliminated from consideration as a remedial technology in the 2016 FS Report and the USEPA OU3 PRAP.*

EPA Response: The commenter indicated that SVE is not suitable for the low permeability soil at this site and air flows through boulders, cobbles and sandy layers could impede the treatment of finer grained, less permeable soils. EPA understands the listed concerns, however, the referenced documents listed in the comment do not indicate that SVE should be precluded as an alternative based on the Site's deep soil permeability. For example, in the Final Guidance on Soil Vapor Extraction Optimization (Parsons, 2001), it is stated that "Generally, silt/clay soils with a median grain size of less than 0.075 mm (No. 200 sieve) and a moisture greater than 50 percent of field capacity will be unlikely candidates for successful SVE". Grain size distribution of samples collected from underneath the ANC building indicated that the median grain size of site soil was not less than 0.075 mm. Available soil moisture data indicated that the soil underneath the ANC building was low which is amenable to SVE. The commenter stated that contaminant removal from fine grained materials next to boulders and cobbles or sandy layers would be diffusion controlled. However, review of the boring logs from the remedial investigation indicates the presence of primarily clayey silt, silt, sandy silt and silty sand with trace to little gravel and cobbles in the majority of soil volume below the ANC building. Additionally, boring logs describing soils located under the Molding Area of the ANC building indicate that the lithology of the shallow soils which are being successfully treated by SVE now, and deep soils was similar. Based on all of these factors, EPA believes that deep SVE is an appropriate technology for the Site in both the shallow and deep soils underlying the ANC building. EPA indicated in the Proposed Plan that a pilot test is required to be able to determine the effectiveness of SVE throughout the vadose zone with greater confidence, and to design an effective SVE system. For further discussion of this issue, please see responses to Comment Nos. 19 and 21 below**.**

The commenter also stated that the space required for the Alternative 4 remedial action components would effectively preclude access for use of the plant floor for facility operations. However, the OU3 RI work, which is similar in nature to the work to be performed under Alternative 4, has been successfully completed within the molding area of the Washington plant in the past in a manner minimizing the disruption of work activities at the facility. The FS conceptually describes how the remedial technologies can be implemented for cost estimating purpose only. Details regarding the implementation of the selected remedy will be developed as part of the remedial design process and the remedy can be designed in a manner to minimize impacts to the operations within the facility.

Comment 3: *Given the above that a remedial objective of 1 mg/kg for remediation of TCE in soils is not practicably achievable using Deep SVE with in-situ thermal remediation (ISTR), Ramboll Environ performed a more detailed evaluation of the available data for TCE in soils within the target treatment zone of Area A within the Washington plant. The results of this evaluation are discussed further in Comment No. 7 and Comment No. 23 that follow and are included in Attachment A to these comments ("Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building"). The purpose of this evaluation was to determine the minimum extent to which soil below the ANC building would have to be treated (or removed) in order to ensure that indoor worker soil vapor intrusion exposure would not result in unacceptable risk in the absence of engineering controls. This analysis is more refined than the approach used by CDM-Smith in deriving the TCE soil cleanup level of 1 mg/kg in the 2016 FS Report in that (1) it accounts for the fact that the bulk of the soil contamination was identified at depths at least 60 ft. below ground surface (bgs) and (2) it uses a mass flux approach to identify the minimum extent of remediation needed to ensure acceptable indoor worker risks.*

The analysis demonstrates that not all soil below the ANC building with a concentration above 1 mg/kg would need to be treated in order to ensure acceptable risks in the absence of engineering controls. USEPA's targeted soil treatment volume below the ANC building is approximately 41,000 yd^3, as depicted in Figure B-1 of Attachment B to these comments. This analysis demonstrates that only approximately 1,000 yd^3 of deep soil and approximately 70 yd^3 of shallow soil below the ANC building would warrant treatment in order to achieve the remedial objective. Further, and as presented in Specific Comment No. 20 on the 2016 FS Report discussed below, Ramboll Environ has assessed that treatment of the same volume of soil as is shown to be protective for vapor intrusion exposure would also be protective with consideration for leaching to groundwater. The target locations for treatment of the necessary volume of soils based on actual soil analytical results as necessary to address the vapor intrusion risks are shown in Figure A-4 of the Ramboll Environ Technical Memorandum provided in Attachment A to these comments.

EPA Response: The commenter performed its own evaluation to determine the minimum extent of soil contamination below the ANC building that would require treatment, in order to protect the human health of indoor workers in the absence of engineering controls, and compared its results to EPA's evaluations. The commenter also calculated the mass of TCE in soils and modeled the calculated source to demonstrate its protectiveness to groundwater. The commenter's evaluations resulted in significantly less estimated mass of TCE in soils compared to EPA's estimates and proposed significantly less contaminated soils be addressed under the remedial alternative. Additional details of these evaluations were included in Comments Nos.20, 23 and Attachment A, and EPA's responses to those details are provided below.

EPA reviewed the evaluations included and generally found that the commenter's approach used assumptions that were insufficiently conservative compared to EPA's approach to modeling vapor intrusion, calculating the mass of TCE below the ANC building, delineating the source area hot-spot, and modeling the potential impact to groundwater. EPA disagrees with the conclusions drawn from these analyses because of the specific deficiencies found in the analyses as discussed below:

<u>Remedial Goals</u>: The commenter's approach was to determine the minimum extent of soil contamination that would require treatment to be protective of indoor air and groundwater. The FS shows that the cleanup goal of 1 mg/kg EPA developed for TCE meets the RAOs and results in the reduction of the contaminant mass to significantly shorten the period of operation of the shallow SVE system and the groundwater pump and treat system.

<u>Modeling Vapor Intrusion</u> – In Attachment A, the commenter used soil results from both shallow borings and deep borings, assigned a polygon (an area) to each soil boring, and assumed that the soil contamination within each polygon underneath the building will only contribute mass flux to indoor air within that area of the polygon. This method is not acceptable as it has the potential to significantly underestimate the total mass flux to indoor air, because: 1) contaminated soil gas will migrate following preferential pathways in accordance with the concentration gradient and pressure gradient, which can include lateral migration in addition to upward migration; and 2) a large number of *shallow* soil borings are used in developing the Thiessen Polygons. The level of soil contamination at shallow depth (many borings were sampled only to approximately 10 feet bgs and found trace or no contamination) does not represent the level of contamination of the entire vertical soil column. Elevated soil contamination, more than 1 mg/kg, could be present beneath the shallow soil samples, which would result in an estimated total mass flux to the indoor area to be bias low. Accordingly, the resulting minimum volume of soil contamination that would require treatment to be protective of human health would be biased low by this method. This is addressed in more detail in response to Comment No. 23.

<u>Calculating the Mass of TCE in Soil</u> – Comment No. 20 states the overall mass of TCE in the soil underlying the ANC building, according to the modeling the commenter performed, is in the range of 50 to 70 kg. In the FS, EPA utilized various methods (3D modeling, concentration averaging, etc.) to estimate TCE mass in the vadose zone. The resulting estimated mass calculated varied greatly and ranged from 100 kg to greater than 1,000 kg of TCE, depending on the method used. For the purpose of evaluating remedial alternatives in the FS, EPA selected NJDEP's approach to calculating mass in the source area as defined in the NJDEP SESOIL/AT123D Guidance Document (NJDEP 2014). This method resulted in a total estimated TCE mass in soils of 519 kg. EPA believes this is an appropriately conservative mass estimate for use in the selection of a remedy. It is

appropriate to be conservative due to the uncertainty in estimating mass which results from having a fairly limited number of samples collected during the RI and the somewhat sporadic and variable nature of the TCE concentrations distributed in vadose zone soils. During the remedial design phase of the project, further evaluations may be performed to refine the TCE mass estimate in soils. This issue is addressed in more detail in the response to Comment Nos. 7 and 20.

Delineating the Source Area Hot-Spot – The commenter indicates that approximately 1,000 yd^3 of deep soil and approximately 70 yd^3 of shallow soil below the ANC building would warrant treatment in order to achieve the remedial objectives. The treatment volume was determined by the commenter using the current data set (in Attachment A) with minimal consideration for uncertainties. This is not an appropriate approach as the TCE contamination has been observed to be unevenly distributed even in small lateral and vertical areas, and the areas with the highest TCE concentrations at depth are not known to be as limited laterally as the commenter's modeling suggests. EPA chose an appropriately conservative approach in estimating the hot-spot area and the area exceeding the preliminary remediation goal of 1 mg/kg, which takes into consideration the uncertainties in the data results due to sample spacing and variable nature of TCE distribution in the vadose zone soils. EPA's estimate of hot-spot soils requiring treatment is 5,333 yd^3 as compared to the commenter's estimate of 1,000 yd^3. The FS specifies a pre-design investigation to be conducted to better define the source area, including the hot-spot to be treated by *in-situ* thermal remediation. This is addressed in more detail in response to Comment Nos. 7, 20 and 23.

Modeling Potential Impact to Groundwater – As described in more detail in the response to Comment No. 20 below, the commenter utilized the SEVIEW model to demonstrate their modeled treatment zone would be protective of the groundwater aquifer. EPA did not utilize the SEVIEW model in this manner, but rather used the SEVIEW model to compare various remedial alternatives and the impact they would have on groundwater reaching the OU1 groundwater extraction and treatment system. EPA presented the results of the model because the SEVIEW modeling, when utilized with conservative inputs, provided a reasonable evaluation for a feasibility study level assessment. There are limitations in the SEVIEW model's use based on conditions at this Site, such as the fractured bedrock aquifer and the fact that the contamination is capped by the building slab. Based on this, attempting to use the model in the manner that the commenter did is not appropriate.

Comment 4: *It is recognized that with the low permeability soil and, the presence of cobbles and boulders likely to be encountered within the target soil volume to be treated, in-situ chemical oxidation (ISCO) technology, evaluated as Alternative 3 in the 2016 FS Report, would not be expected to reasonably achieve these treatment efficiencies (i.e., in excess of 90% removal of TCE in soils). As discussed in General Comment No. 2 above regarding the limited effectiveness of SVE in the deep, low permeability soils of Area A, and the impracticality of alternatives such as excavation beneath the operational areas of the Washington plant production areas, the only reasonable alternative for OU3 is suggested to be ISTR.*

EPA Response: As discussed in the response to Comment No. 2, above, EPA does not believe that the soil permeability or the presence of cobbles and boulders will prevent successful implementation of SVE to address both shallow and deep soils contamination below the ANC building. However, the permeability characteristics of Site soils, and other factors (such as being in the vadose zone and short or lack of contact time between soils and the oxidants) are likely to prevent the success of the ISCO technology to treat deep soils. EPA agrees that soil excavation is not a practical alternative at this Site. With respect to the *in-situ* thermal remediation technology, EPA believes that this technology will be effective. EPA will allow *in-situ* thermal remediation to be implemented either 1) as a contingency option for hot-spot soils if the deep SVE technology proves to be ineffective, or 2) to address hot-spot soils in lieu of SVE treatment. The final determination of the use of the SVE and/or *in-situ* thermal remediation technologies and the extent of the area requiring treatment will be determined in the remedial design phase.

Comment 5*: In the evaluation of the various remedial alternatives presented in the 2016 FS Report, the USEPA did not consider the feasibility of vertical installation of the various remedial components indoors and within the existing Albéa America's operational areas of the facility, nor the cost implications of such. Depending upon the remedial alternative, installation of such components and maintenance and monitoring activities will have varying durations that have the potential to disrupt or to preclude operations at the facility. The potential impact of such installations and operations within the existing operational areas of the facility was not fully evaluated by USEPA.*

EPA Response: EPA performed a multi-phased remedial investigation in the former ANC facility and is well aware of the issues concerning impacts to the ongoing operations at the Albea Americas facility. The RI included the installation of approximately 12 deep and 31 shallow borings through the building slab and was done in close coordination with plant officials and in a manner to minimize the disruption of work at the facility. Further approaches to minimize impact of remediation to ongoing operations will be evaluated and addressed in the remedial design. Significant soil contamination remains under the building slab at depth and must be addressed. This will involve some impacts on current operations, however, as stated above, procedures can be developed in the remedial design to minimize the impacts.

Comment 6: Pages 2-1 and 2-2 – *It is stated that, "After completing the 2012 field investigation, EPA determined that some of the VOCs, SVOCs, pesticides, and PCBs analytical results from soil, sediment, groundwater, and surface water samples were of unknown quality; these results are not reported or used in this report….In order to replace the data from the 2012 investigation that was unusable, CDM Smith conducted additional sampling of soil, groundwater, sediments, and surface water from the same locations from December 2014 to March 2015 (2015 field investigation)." Figures 2-1 and 2-3 show the soil boring locations from the 2012 and 2015 investigations, respectively. It appears that some of the locations from 2012 for which VOCs, SVOCs,* *pesticides, and PCB data were not reported were resampled in 2015 in approximately the same locations (e.g., 2015 locations VTC-SBS-220 through VTC- SBS-224 appear to be in approximately the same locations as 2012 locations VTC-SBS-20 through VTC-SBS-24). However, some of the ANC building interior boring locations appear to have been adjusted between the 2012 and 2015 investigations. For example, VOCs, SVOCs, pesticides, and PCB data were not reported for the soil borings advanced at locations PPP-SBI-01 through PPP-SBI-04 in 2012. Additional soil borings (such as PPP-SBI-250 through PPP-SBI-253) were advanced in 2015 and analyzed for VOCs, SVOCs, pesticides and PCBs, however, these do not appear to be located in the same locations as the 2012 borings. See for example Figure 1-4, which includes both 2012 and 2015 boring locations. Section 2 does not include an explanation of why the 2015 boring locations are different than the 2012 boring locations. Please note that the locations identified in this comment are not meant to be a comprehensive list of the 2015 locations that are different than the 2012 locations but rather representative examples.*

EPA Response: As indicated in the 2016 RI Report, a subset of organic analyses collected during the EPA 2012 RI Field Investigation were subsequently deemed of unknown quality by EPA. Most of the samples were re-collected during the EPA 2015 RI Field Investigation. Specific to the comment, the analytical results from four of the locations inside the facility (SBI-01 to SBI-04) were deemed unusable. The laboratory analytical results from SBI-01 to SBI-04 are invalid, however, the field measurements of organic vapors using a PID on the soil core from those locations provided some qualitative information regarding the general amount of contamination present at those locations. This information allowed EPA to adjust the locations of those four borings to better delineate the hot-spot underneath the facility.

Specific Comments

Comment 7: Page 2-8 (Section 2.3.2) – *The USEPA indicated that treatment would target the area that exceeds 1 milligram per kilogram (mg/kg) of trichloroethylene (TCE), as shown on Figure 2-2 of the 2016 FS Report. Section 4.2.5.1 subsequently indicated that the recommended deep soil vapor extraction (SVE) system would be installed from 30 to 100 feet below ground surface (bgs). Based on the approximate 16,000 square feet area identified on Figure 2-2 of the 2016 FS Report and the target treatment zone thickness identified of 70 feet, this results in a USEPA target treatment volume of approximately 41,000 yd^3. The 2016 FS Report did not provide an evaluation of site soil data to demonstrate that treatment of this volume (41,000 yd^3) is necessary in order to achieve 1 mg/kg TCE. To assess a reasonable extent for treatment of soils beneath the building in Area A, Ramboll Environ performed an evaluation of the available soil data. The results of this evaluation are included in Attachment A to these comments ("Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building"). The purpose of this evaluation was to determine the minimum extent to which soil below the ANC building would have to be treated (or removed) in order to ensure that indoor worker soil vapor intrusion exposure would not result in unacceptable risk in the absence of engineering controls. This analysis is more refined than the approach used by CDM-Smith in deriving the TCE soil* *cleanup level of 1 mg/kg in the 2016 FS Report in that (1) it accounts for the fact that the bulk of the soil contamination was identified at depths at least 60 ft. below ground surface (bgs) and (2) it uses a mass flux approach to identify the minimum extent of remediation needed to ensure acceptable indoor worker risks.*

The analysis demonstrates that not all soil below the ANC building with a concentration above 1 mg/kg would need to be treated in order to ensure acceptable risks in the absence of engineering controls. USEPA's targeted soil treatment volume below the ANC building is approximately 41,000 yd^3. This analysis demonstrates that only approximately 1,000 yd^3 of deep soil and approximately 70 yd^3 of shallow soil below the ANC building would warrant treatment in order to achieve the USEPA's remedial action objective.

EPA Response: The commenter stated that EPA's targeted soil treatment volume below the ANC building is approximately 41,000 yd^3. The commenter indicates that the FS Report did not provide an evaluation of site soil data to demonstrate that treatment of this volume (41,000 yd^3) is necessary in order to achieve 1 mg/kg TCE. The commenter performed an analysis to demonstrate that only approximately 1,000 yd^3 of deep soil and approximately 70 yd^3 of shallow soil below the ANC building would warrant treatment in order to achieve EPA's remedial action objectives. EPA disagrees with this analysis as discussed below.

The remedial approach presented in the 2016 FS presented a general remediation area of 13,500 square feet (approximately 40,000 yd^3) that encompassed most of the locations where TCE contamination was detected above 1 mg/kg in Area A beneath a portion of the ANC building. It is a more conservative approach than the commenter's approach presented above and in Attachment A. An additional targeted hot-spot treatment area was identified to encompass the most highly contaminated volume of soil under the building. This treatment volume is approximately 3,600 square feet between 60-100 feet bgs (5,333 yd^3 of soil). In the development of both of these treatment areas EPA took into consideration the uncertainties in the data results due to sample spacing. The FS specifies that a pre-design investigation will be conducted to collect additional soil data to refine the treatment volume during the remedial design. The treatment volumes developed were for the purposes of developing remedial alternatives and estimating costs for the remedy selection process. EPA believes the soil volume estimates generated are reasonably conservative and supports the FS estimates of soil requiring treatment. The commenter's estimates are likely underestimated.

The approach presented in Attachment A is to meet only one of the remedial action objectives: protecting human health from contaminated indoor air, instead of achieving the remediation goal of 1 mg/kg. EPA has determined that the cleanup goal of 1 mg/kg is necessary to protect indoor air *and* groundwater. EPA has evaluated the analysis in Attachment A, even though it does not address all RAOs. EPA finds the analysis presented by the commenter unacceptable as stated in the response to General Comment No. 3, as EPA believes the approach presented in Attachment A is inappropriately biased to provide a low estimate of soil to be addressed to meet ROAs. Contaminated soil gas with elevated TCE concentrations from soil contamination within a given polygon can impact a larger area than that polygon. Using shallow soil data with low or trace contaminant concentration can lead to underestimating the contaminant flux within those polygons where elevated soil contamination exists at depth. EPA highlighted the polygons with data from the full depth of the vadose zone in Figure A-1 and this is presented as Exhibit 1 of this response. The area represented by soil data from the full depth of the vadose zone appears to be less than half of the total area in Figure A-1, which demonstrates that the approach used by the commenter can underestimate the total mass flux migrating into indoor air. See responses to Comment No. 3 and Comment Nos. 20 and 23 for further discussions.

Comment 8: Page 2-14 (Section 2.5.7.1*)* – *The USEPA indicated that thermal technologies require "little to no O&M." It should be noted that, during the typical approximate 6-month operational timeframe of thermal remediation technologies, the following O&M activities are often conducted:*

- *Conduct regular site visits to view site conditions and collect performance data (air flow rates, vapor contaminant concentrations at various locations in soil vapor extraction/treatment systems, air samples for discharge compliance testing, and water samples for discharge compliance testing).*
- *Perform soil vapor extraction and treatment system optimization.*
- *Monitor the respective remedial systems' performance via dial-up connections.*
- *Perform routine soil vapor extraction/treatment system maintenance and repairs.*

EPA Response: EPA agrees that there will be O&M activities required for thermal treatment, including the activities listed in the comment above. However, the O&M period is likely to be very short, possibly as short as 6 months for the thermal treatment technology. Therefore, in the FS report these O&M activities were included as part of the construction period activities. The O&M activity in the context of the FS report refers to long-term O&M activities after completion of the construction.

Comment 9: Page 2-14 (Section 2.5.7.1.1, third paragraph) – *The USEPA indicated that "ERH electrodes and SVE capture wells would be installed through the ANC building slab." However, alternate geometries for installation were not discussed. In review of potential installation options with qualified ISTR vendors, numerous cases exist and adequate performance has been demonstrated for horizontal and angled borings for installation of electrodes or heating elements along with vapor extraction points (i.e., for removal of vapors and steam from soil heating). Although the complexity and cost of drilling and installation would increase significantly compared to vertical installations, such alternate installation geometry would significantly reduce the potential disruption of Albéa America's production operation activities within Area A of the Washington plant.*

EPA Response: The FS includes a preliminary conceptual design to provide a proof of concept and a means for cost estimation. The configuration of the selected remediation system will be determined during the remedial design. Angled borings can be proposed in the remedial design and will be evaluated at that time. Also see response to Comment No. 5 for further discussion. It should be noted that for *in-situ* thermal treatment, the heater wells may be spaced 15 to 18 feet apart, plus there will be a need to install SVE wells and thermal and vapor monitoring points. Using angled drilling or horizontal drilling to install heating wells, soil vapor extraction wells and all the necessary temperature and pressure monitoring probes to 70 plus feet bgs will be costly and very challenging.

Comment 10: Page 2-15 (Section 2.5.7.1.2, third paragraph) – *The USEPA indicated that "TCH heating wells and SVE wells can be installed through the ANC building slab." Similar to ERH, TCH heating wells and extraction wells can be angled or horizontal such that they could be installed outside of the building slab, but the complexity and cost of drilling and installation also increases significantly compared to vertical installations.*

EPA Response: The exact configuration of a remediation system will be determined during the remedial design. An evaluation of whether vertical or horizontally placed wells are most appropriate can be evaluated in the remedial design phase. See responses to Comment No. 5 and Comment No. 9.

Comment 11: Page 2-16 (Section 2.5.7.3.1, first paragraph) – *The USEPA states that "Hydraulic fracturing is a technology in which pressurized water or a slurry of chemical reagents is injected into the subsurface to increase permeability." Hydraulic fracturing does not affect formation permeability; the process simply emplaces a high permeability lens through the formation, the permeability of which remains the same.*

EPA Response: Comment noted.

Comment 12: Page 2-16 (Section 2.5.7.3.1, first paragraph) – *The USEPA states that "The typical distance of fracture propagation in silt and clay is 40 to 50 feet beyond the injection point." Based on information contained in Suthersan (1999), the radius of influence for a fracture well in unconsolidated materials is limited to 20 to 35 feet. Pages 3 and 4 of Appendix G identify an assumed hydraulic fracture radius of influence of 11 feet within the target treatment zone, rather than the 40 to 50 feet referenced on page 2-16.*

EPA Response: Comment noted. The distance of fracture propagation presented in the FS report Section 2.5.7.3.1 was based on vendor's information for a typical site. The approach used for the cost estimate of Alternative 3, 11 feet, is relatively conservative, less than the 20 to 35 feet in Suthersan (1999), and based on vendor information and CDM Smith's past experience**.**

Comment 13: Pages 2-22 and 2-23 (Section 2.5.8.2*)* – *The USEPA indicated that if contaminated soil exceeds TCLP criteria, it would be disposed of in a RCRA Subtitle C* *landfill or treated to meet the Universal Treatment Standards (UTS) at a hazardous waste treatment facility prior to disposal. The first complete sentence on page 2-23 states that "For contaminated soil with TCLP results of TCE exceeding 1 mg/L, treatment is required." The basis for the 1 mg/L TCLP value referenced above is unclear. 40 CFR Part 268 identifies hazardous wastes that are restricted from land disposal without prior treatment to UTS. Hazardous remediation wastes that are managed off-site are subject to the Land Disposal Restrictions (LDR) UTS for wastewater (liquid) or non-wastewater (solid). Hazardous soils must be treated to 90% reduction in concentration capped at 10 times the UTS for principal hazardous constituents. For TCE, 10 times the UTS equates to 60 mg/kg.*

EPA Response: The first complete sentence on Page 2-23 of the FS Report should be revised to state "For contaminated soil with TCLP results of TCE exceeding 0.5 mg/kg, treatment may be required to meet LDR Universal Treatment Standards (UTS) prior to disposal." The treatment is to remove the hazardous characteristic and to meet LDR requirements. To comply with 40 CFR 268.49 – Alternative LDR Treatment Standards for Contaminated Soil, the treatment must attain 90% reduction or 10 times the UTS, whichever is higher. Note that if treatment of soil is to only 10 times the UTS (i.e., 60 mg/kg) as suggested by the commenter, the soil will fail TCLP (i.e., the soil is still hazardous) and would still need to be disposed in a Subtitle C landfill.

Comment 14: Page 3-4, second complete paragraph – *The USEPA states that "If implemented, it is anticipated that the in-situ thermal treatment alternative would be conducted from 60 to 100 feet bgs at the hot-spot beneath the former molding area." No evaluation of site soil data is provided to support selection of this identified treatment depth interval.*

EPA Response: The intent of the FS was to provide a conceptual area and volume for *in-situ* thermal treatment. The soil samples collected from OU3 RI borings PPP-SBI-05, PPP-SBI-06, PPP-SBI-07, PPP-SBI-08, and PPP-SBI-250 had elevated concentrations of TCE at 70-100 feet bgs. Soil samples were not collected between 62 to 70 feet bgs. Therefore, to be conservative, the vertical treatment zone is estimated to be from 60 to 100 feet bgs. The actual *in-situ* thermal treatment volume will be determined during the remedial design.

Comment 15: Page 3-4, third complete paragraph – *The USEPA states "More than 90 percent mass removal is anticipated for this alternative." It is unclear if this estimated mass removal would result from implementation of SVE alone, or SVE in conjunction with thermal treatment of the identified subset of the SVE treatment area. Moreover, no literature or case study citations are provided to support this estimated 90 percent mass removal value.*

EPA Response: Vadose zone SVE has been documented to achieve more than 90% mass removal in case studies. The estimated 90% mass removal for Alternative 4 was for SVE alone. Thermal treatment would be implemented, if needed, to reach the remediation goal of 1 mg/kg within the hot-spot. Thermal treatment is documented to be able to achieve approximately 97% contaminant mass removal (Interstate Technology &

Regulatory Council [ITRC], Integrated DNAPL Site Strategy, November 2011).

Comment 16: Page 4-11, first full paragraph – *Section 4.2.4.1 provided a description of implementation of Alternative 3, in-situ chemical oxidation using sodium permanganate as the selected oxidant, to achieve remedial action objectives for the impacted site soils. The sodium permanganate solution would be diluted to 10 percent strength for injection. Based on an assumed initial soil oxidant demand of 4 grams of permanganate per kilogram of soil, Appendix G identifies injection of 273,200 gallons of 10 percent sodium permanganate solution as part of an initial injection event, and 140,000 gallons of 6.53 percent sodium permanganate solution as part of a second injection event. Injection of such quantities of sodium permanganate solution represents 14 percent of the treatment zone pore volume as part of the initial injection event, and 19 percent of a reduced treatment zone pore volume as part of the second injection event. Based on Ramboll Environ's experience with regard to injection of liquid reagents into low permeability fine-grained soils, injection of such large percentages of target treatment zone pore volumes is unlikely to be achievable. Moreover, if the results of bench-scale testing indicate a soil oxidant demand that exceeds 4 grams of permanganate per kilogram of soil, even greater quantities of oxidant would need to be injected (with an even lower likelihood of success).*

EPA Response: Comment noted. The FS provided a conceptual approach for implementing the ISCO technology. The estimated volume of oxidant required was developed for cost estimating purpose only. Based on past experience, injecting the estimated amount of oxidant solution is achievable. The concerns the commenter raised regarding the difficulty of injecting large quantity of chemical solution and the potential of higher soil oxidant demand are uncertainties in implementing ISCO treatment and are usually tested during the remedial design. EPA agrees that the uncertainties of using ISCO are great in this case, and this is one of the reasons that EPA did not select this technology at this Site**.**

Comment 17: Page 4-13, second paragraph – *The USEPA states "Due to difficulty in evenly delivering oxidants to treat contaminants in the clayey silty soil and in the deep vadose zone, the overall effectiveness of this alternative is estimated to be 50 percent within the treatment zone." No literature or case study citations are provided to support this estimated 50 percent effectiveness value.*

EPA Response: Effectiveness of ISCO treatment in terms of mass removal rate depends on many factors at any given site. The effectiveness of ISCO treatment documented in the ITRC document "Integrated DNAPL Site Strategy" (ITRC 2011) ranged from -55% to 100%, with a median reduction of 72% in one survey. Achieving high mass reduction in a vadose zone provides extra challenge. The 50 percent effectiveness value was selected to illustrate the limited effectiveness of ISCO in achieving the RAOs and cleanup goal of 1 ppm of TCE in vadose zone soils.

Comment 18: Page 4-18, first paragraph – *The USEPA OU3 PRAP indicates that the Preferred Alternative for achieving remedial action objectives for the impacted site* *soils is Alternative 4, Deep SVE with Optional In-Situ Thermal Hot-Spot Treatment. As stated, the determination as to whether to implement the in-situ thermal treatment in the hot-spot area would be made by USEPA during the remedial design (based on SVE pilot study results) or during the operation of the deep SVE system based on SVE performance data. On page 4-18 (first sentence), the USEPA indicated that, based on potential impact of low soil moisture content on the effectiveness of electrical resistance heating (ERH), thermal conductive heating (TCH) is selected as the thermal process option. A primary factor that can limit the effectiveness of heating using ERH is moisture loss. Moisture loss is a concern because electrical resistance increases (electrical conductivity decreases) as soil moisture decreases, thereby resulting in reduced energy delivery to drier portions of the target treatment zone. ERH systems therefore often incorporate wetting systems around the electrodes and in the targeted treatment area to maintain a specified amount of soil moisture within the vadose zone (Kueper et. al., 2014). As such, implementation of ERH should be evaluated against implementation of TCH with respect to cost.*

EPA Response: The FS used TCH as a representative process option for cost estimating purpose. The actual technology to be used for thermal treatment will be determined during remedial design. All *in-situ* thermal treatment technologies could be considered and evaluated during the remedial design.

Comment 19: Figure 4-2 of the Feasibility Study - *Conceptual Layout for Alternative 4, and Appendix G-3a of the Feasibility Study - Cost Estimate for Alternative 4 - Deep Soil Vapor Extraction without In-Situ Thermal Hot-spot Treatment. The estimated number of SVE wells for treatment of the source zone soil in Area A presented in the 2016 FS Report is a total of 14 wells and assumes each SVE well will have a radius of influence of about 18 to 20 feet. Based on the approximate 16,000 square feet area identified on Figure 2-2 of the 2016 FS Report, this is approximately equivalent to one SVE well per 1,000 square feet (ft2) to 1,200 ft2 of treatment area. There is no supporting information presented in the 2016 FS Report on which this radius of influence is based. In consideration of the design recommendations provided in the USACE Engineering Design Manual for Soil Vapor Extraction and Bioventing (USACE, 2002), it is desirable to achieve pore-gas velocities in the treatment zone such that the maximum travel time is between 2 and 4 days from the edge of the treatment zone to the extraction wells (USACE, 2002). It is also recommended that a minimum pore-gas velocity throughout the treatment zone should be between 0.001 cm/s, (about 3 ft./day) and 0.01 cm/s (about 30 ft./day) (USACE, 2002). In general, for SVE to be effective in reducing contaminant mass in a reasonable period of time requires at least 10 pore volume exchanges per day across the treatment zone (USACE, 2002). Based on these design recommendations and considering the USEPA's treatment volume and the estimated radius of influence of 18 to 20 feet per SVE well, USEPA's target treatment depth of 30 to 100 feet below ground surface, and an estimated soil air-filled porosity of 0.2, the approximate air extraction flow rate would need to be on the order of 100 cubic feet per minute (cfm) to 120 cfm per SVE well. This high air flow rate at the SVE well is not likely to be achieved within the subsurface soil in the OU3 area given the low values of intrinsic air permeability as discussed in Specific Comment No. 21 on the USEPA*

OU3 PRAP below. To accomplish the required minimum number of pore-volume exchanges would require a significant increase in the number of SVE wells to be installed within the treatment area. An estimate of the required SVE well spacing to achieve the recommended design of 10 pore volume exchange rates per day using an air flow extraction rate of 40 cfm per SVE well (based on the performance of the existing SVE/SSDS system) is approximately 11 feet. This results in approximately 30 SVE well locations within the defined treatment area. This is more than twice the number of SVE wells proposed in the 2016 FS Report. Consequently, doubling the number of wells will result in significant increases in remedy implementation cost and implementation issues as access to the identified areas for soil treatment within Area A inside the existing operating facility is limited and would result in significant disruption of manufacturing operations at the facility.

EPA Response: The commenter estimated that for an adequate SVE system, well spacing would need to be 11 feet and 30 SVE well locations would be needed within the defined treatment area. This is significantly higher than the 14 SVE well locations EPA estimated would be required, and would result in increased costs. It should be noted that the FS report provided a conceptual layout for order of magnitude cost estimating. The cost estimate included well clusters (3 individual wells per cluster screened at different target depths) for each of the 14 locations shown on Figure 4-2. Each SVE well will only need to pull one-third of the estimated flow rate to achieve the design parameters estimated by the commenter. Therefore, the FS did not significantly underestimate the costs compared to the commenter's analysis. The actual SVE well spacing for implementing the full scale remedy would be determined based on the results from a pilot study during the remedial design and the remedial action costs would be adjusted as new site-specific data become available.

Comment 20: Appendix C – Development of a PRG for Groundwater - *Regarding the development of a preliminary remedial goal (PRG) protective of groundwater, the following is provided in review of the methodology and calculations presented in Appendix C of the 2016 FS Report.*

A. Ramboll Environ was unable to reproduce the results obtained and reported in Appendix C of the 2016 FS Report. Using the inputs provided in the text, one arrives at a maximum concentration at Point of Compliance 2 that is about 25% lower than the value reported in the graphical output of the modelling results. It would be helpful to have the actual SEVIEW input files to determine why there is a discrepancy.

B. The results presented in Appendix C of the 2016 FS Report are presented for two points of compliance, one on the downgradient edge of the suspected source area within Area A beneath the former Molding Room of the Washington plant, and the other at 950 feet downgradient of this suspected source area, corresponding to the location of the extraction wells POHPT1 and POHPT3 for the existing Groundwater Extraction and Treatment System for OU1 (TCE). As this location is *not a source of drinking water, an alternative point of compliance is proposed, such as at a location where the groundwater would be reasonably assumed to be used for drinking water purposes. Accordingly, the existing Dale Avenue production well located approximately 6,200 feet from the suspected source area at the former ANC plant is proposed as a logical point of compliance downgradient of the suspected source area for use in calculations to determine a preliminary remediation goal.*

C. *Appendix C of the 2016 FS Report presents a scenario that estimates the total mass of TCE in soils of 519 mg/kg used in the calculation of impacts to groundwater and is overly conservative. Specifically, Appendix C states, "TCE Loading – Concentrations of TCE for each sub-layer of the model were developed by taking the* ***maximum concentration*** *observed in each layer within the source zone. This modeled source likely represents a greater mass of TCE than is actually present. This method is the accepted method in the NJDEP guidance and provides a conservative estimate of TCE source. Using this method, SESOIL calculated the source to be 519 kg of TCE." [emphasis added in* ***BOLD****] (Appendix C Page C-5)*

The lateral dimensions for the source term used in the model are 50 meters by 25 meters. The mass is then computed as a layered block of soil about 120-foot thick. This results in a total soil volume in this scenario of 1.6 million cubic feet (see Figure B-1 of Attachment B to these comments). From the results of TCE detected presented in the 2016 RI Report, the actual geometry of contaminated soils in this area is much different than this. In addition, the actual mass present is significantly different from that used in the calculation of Appendix C. As a conservative estimate of potential impact to groundwater, Ramboll Environ produced a 3-dimensional model of the soil concentrations based on all sampling results reported to date, including the results of soil samples obtained pre-2006 from the results of the RI activities conducted under the oversight of the NJDEP along with the results reported in the 2016 RI Report. The computed volume of soil with TCE concentration above 1 mg/kg is 0.2 million cubic feet (0.8 million cubic feet for soil with TCE concentration above 0.2 mg/kg). Using these combined results, the computed total TCE mass in soil above 1 mg/kg is about 55 kg (70 kg for soil with TCE concentration above 0.2 mg/kg). This estimated mass is significantly lower than the mass used in the calculations performed for development of a preliminary remediation goal as presented in the calculations of Appendix C in the 2016 FS Report.

These conservative assumptions regarding the source to groundwater impacts from TCE in soils have led to significant over-estimates of impact to groundwater.

D. *As provided in the calculations of Appendix C of the 2016 FS Report, the use of SEVIEW to develop a preliminary remediation goal ignores the fact that the discharge of the contaminants occurred a very long time ago and that it has been demonstrated that concentrations in downgradient wells are either stable or decreasing (Ramboll Environ, November 2015). The USEPA uses SEVIEW to* *estimate the peak concentration for TCE expected in the future for groundwater near the source area or at an assumed compliance point. The statistical evaluation of results of groundwater monitoring performed at the Site to date at groundwater monitoring wells located downgradient of the OU3 suspected source area have demonstrated concentrations of TCE in groundwater to be stable or decreasing (Ramboll Environ, 2015). Accordingly, the use of a model that projects future concentrations to be on the rise and selection of modelled "peak" concentrations that may have already passed is an exceedingly conservative use of the model.*

E. *The adjustment of the infiltration rate through the soils beneath a slab of the building of the Washington plant is not supported. To create a pathway for migration of TCE in soils to groundwater, the use of infiltration to model the transport of TCE to the water table is logical, however the method employed, where the data at MW-13 is plotted to justify the value selected and concentrations from the simulations are somehow projected backwards to a value the model did not itself predict (purposefully ignoring the value the model did predict) lacks justification and is not technically supported.*

F. *The inputs used by USEPA in its soil leaching to groundwater calculations as presented in Appendix C of the 2016 FS Report were overly conservative, and led to an unwarranted conclusion that remediation of a significant volume of soil to a high degree would be necessary to achieve RAO's.*

To develop a proposed, revised preliminary remedial goal for protection of groundwater, Ramboll Environ employed the same method and tools as presented in the 2016 FS Report, but modified inputs to be more representative of actual site conditions instead of the overly conservative values employed by USEPA. Areas near high concentration locations were removed sequentially from the simulations to reduce the maximum concentration in a SEVIEW model sublayer. The modelling demonstrates that the volume requiring treatment to achieve the goal of 1 µg/L in groundwater at a modified point of compliance is the same treatment volume required to be protective of indoor air (see Figure A-4 of Attachment A, "Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building"), except that one area requires treatment to remove additional contaminant mass. This is a much smaller volume of soil that would be targeted for treatment as compared to the volume calculated by USEPA and depicted in Figure B-1 of Attachment B to these comments. The SEVIEW input parameter values were set to be the same as described in Appendix C, except that:

- *The hydraulic gradient value used in the AT123D simulation was updated to 0.015 and is consistent with the value reported in the OU1 Remedial Investigation Report (CH2M HILL, 2005);*
- *The point of compliance was set as the Dale Avenue Well at a distance of 6,200 feet downgradient of the suspected source area at the former ANC plant, and is a down gradient location from which groundwater might be used for drinking water purposes;*
- *The vertical contaminant profile was computed using all measured*

concentrations and using a spatially weighted average concentration for the model layer intervals.

Three simulations are shown:

- *Base-case – no soil treatment;*
- *Case-1 - recommended treatment to be protective of indoor air;*
- *Case-2 – additional treatment beyond Case-1 necessary to achieve the groundwater PRG.*

A summary of updated sublayer loads in the simulated scenarios is provided below in ***Table 1****. The simulated TCE concentration in groundwater at the modified point of compliance associated with each scenario is compared to the 1 µg/L remediation goal for groundwater and shown below in* ***Figure 2****.*

As shown in Table 1, the only difference between Case-1 and Case-2 is the lowering of the average concentration in Sublayer 3-10. The simulations show that to reach the preliminary remedial goal for groundwater, the soil concentration in Sublayer 3-10 needs to be lowered beyond what is necessary to be protective of indoor air. In order to lower the average concentration in that layer it is necessary to further reduce the soil concentration in the area represented by BS11 at a depth of 76 feet. That location had a measured concentration of 9,500 mg/kg during the 2006 sampling. To be protective of indoor air it is proposed to reduce the concentration at that location to 190 mg/kg. To meet the proposed remedial goal for groundwater the soil concentration in that area should be further reduced to 60 mg/kg.

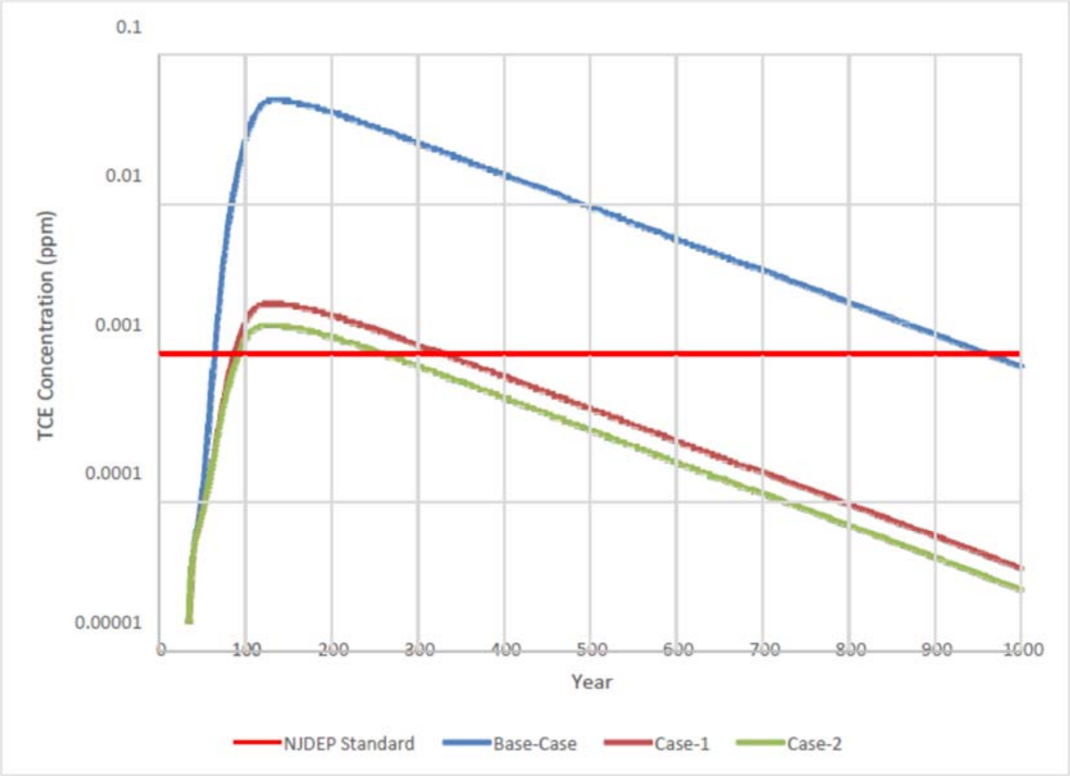
The SEVIEW simulations indicate that the soil treatment proposed to be protective of indoor air is nearly sufficient to be protective of groundwater (resulting in a TCE groundwater concentration of 1.4µg/L at the modified point of compliance). To meet the remediation goal of 1 µg/L, the treatment volumes are the same. The only additional effort required to achieve the proposed remedial goal for groundwater is additional treatment as necessary to reduce contaminant mass at the location represented by the highest measured concentration of 9,500 mg/kg (during the pre-2007 remedial investigation activities performed by PPPI) at a depth of 76 feet.

<u>Table 1</u>. Summary of Changes in Sublayer Load in SESOIL Simulations

Sublayer	Sublayer Top (feet)	Sublayer Bottom (feet)	Base-Case - No Soil Treatment TCE Concentration (mg/kg)	Case 1 – Post Treatment TCE Concentration (mg/kg)	Case 2 – TCE Concentration with Additional Treatment (mg/kg)
1-	0.0	1.1	1.63	0.42	0.42
2-	1.1	5.0	6.40	0.23	0.23

Sublayer	Sublayer Top (feet)	Sublayer Bottom (feet)	Base-Case - No Soil Treatment TCE Concentration (mg/kg)	Case 1 – Post Treatment TCE Concentration (mg/kg)	Case 2 – TCE Concentration with Additional Treatment (mg/kg)
2-	5.0	9.0	0.10	0.10	0.10
2-	9.0	12.9	0.22	0.22	0.22
2-	12.9	16.8	0.61	0.61	0.61
2-	16.8	20.8	0.12	0.12	0.12
2-	20.8	24.7	0.15	0.15	0.15
2-	24.7	28.6	0.73	0.73	0.73
2-	28.6	32.6	0.24	0.24	0.24
2-	32.6	36.5	0.86	0.86	0.86
2-10	36.5	40.4	0.18	0.18	0.18
3-	40.4	44.4	0.12	0.12	0.12
3-	44.4	48.3	0.00	0.00	0.00
3-	48.3	52.3	0.07	0.07	0.07
3-	52.3	56.2	0.09	0.09	0.09
3-	56.2	60.1	0.73	0.73	0.73
3-	60.1	64.1	1.17	1.17	1.17
3-	64.1	68.0	6.71	3.88	3.88
3-	68.0	71.9	3.05	1.50	1.50
3-	71.9	75.9	21.35	1.88	1.88
3-10	75.9	79.8	961.11	21.84	8.80
4-	79.8	83.7	12.39	2.25	2.25
4-	83.7	87.7	11.56	4.77	4.77
4-	87.7	91.6	1.66	1.66	1.66
4-	91.6	95.5	2.00	2.00	2.00
4-	95.5	99.5	2.16	0.53	0.53
4-	99.5	103.4	0.94	0.94	0.94
4-	103.4	107.4	0.01	0.01	0.01
4-	107.4	111.3	0.01	0.01	0.01
4-	111.3	115.2	0.20	0.20	0.20
4-	115.2	119.2	0.12	0.12	0.12

<u>Figure 2</u>. Simulated TCE Concentration in Groundwater over time at proposed Point of Compliance (6,200 feet downgradient of Area A)



EPA Response: The commenter utilized the SEVIEW model to demonstrate their modeled treatment zone would be protective of the groundwater aquifer. EPA reviewed the limited results of the modeling presented in Comment 20, including Table 1 (which presents the modeled TCE mass in each sublayer) and Figure 2 (which presents the results of the SEVIEW modeling at a point of compliance located 6,200 feet from the source area). EPA disagrees with this analysis as discussed below. As noted in Appendix C of the FS Report, the SEVIEW software was selected by EPA to support the remediation goal of 1 mg/kg of TCE and to compare various remedial alternatives and the impact they would have on groundwater reaching the OU1 groundwater extraction and treatment system. The SEVIEW modeling was not intended to generate a NJDEP Site-Specific Impact to Ground Water Soil Remediation Standard as defined by NJDEP Remediation Standard Rules (N.J.A.C. 7:26D-1.1) and the NJDEP Technical Requirements for Site Remediation (N.J.A.C. 7:26E-1.3). The SEVIEW model presented by both the commenter and Appendix C of the FS Report does not meet all the requirements in the NJDEP guidance for generating site-specific remediation goals, mostly because the model is not intended for use when a site is capped or when groundwater flows in a fractured bedrock aquifer, as is the case at the Site.

This site provides an unusual situation for the evaluation of impact to groundwater because 1) the highest level of vadose zone soil contamination is located beneath a large building, and the building slab is acting as a cap; 2) the infiltration of rain water is significantly reduced but cannot be confirmed to be zero; 3) the highest contaminant concentrations are located at depth (70 to 100 feet bgs); and 4) contaminants have migrated into the fractured bedrock aquifer. There is no promulgated federal soil cleanup standard for impact to groundwater. The methodologies established by NJDEP for calculating impact-to-groundwater soil remediation standards are To-Be-Considered (TBC) guidance and are not strictly applicable for contamination under a cap and with the presence of a fractured bedrock aquifer. Even though any models used to develop cleanup standards under this unusual situation will have some limitations, the SESOIL/AT123D model was used by EPA to provide an estimate of contaminants that may release into the groundwater from the vadose zone soil. Modeled calculations demonstrate that a TCE soil concentration of 1 mg/kg would result in minimal impact to TCE concentrations in groundwater at the OU1 groundwater treatment plant extraction wells, and thus, would be protective of groundwater at this Site. Therefore, a Site-specific remediation goal of 1 ppm has been established for TCE in the vadose-zone soil. EPA took the model limitations into consideration and utilized the results of the SEVIEW modeling because when designed with conservative inputs, it provides a reasonable evaluation of potential impact to groundwater quality.

Due to the limitations in the use of the SEVIEW model, attempting to use the model in a less conservative manner, as the commenter did, is problematic. Specific responses to Comment No. 20 sub-comments are provided below:

A) Without the commenter's SEVIEW files, which were not included in the submittal, EPA is unable to determine why the commenter was unable to reproduce the results EPA provided in Appendix C of the FS Report. It possibly is due to the incorrectly stated hydraulic gradient in the bedrock aquifer (see response 20.F, below).

B) The point of compliance selected for use in the model does not need to be the closest drinking water source as indicated in the comment. In fact, use of the Dale Avenue Wellfield as the point of compliance is inappropriate and not consistent with the remediation goals set for this Site. For this Site, EPA has determined that the contaminated aquifer must be restored to meet drinking water standards as it is a Class II-A New Jersey aquifer. This goal applies to the entire impacted aquifer, not just at the potable wellfield located downgradient of the ANC facility source area. This objective will be achieved by the combination of soil remediation (OU3), the extraction and treatment of the most contaminated groundwater at the Site (OU1), and Monitored Natural Attenuation. EPA believes that using the compliance point at the OU1 groundwater extraction wells in order to develop an appropriately protective soil remediation goal is most appropriate in this case and is consistent with the RAOs of both OU1 and OU3. Note that one of the goals of remediation of the soils below the building is to minimize the impact to groundwater quality at the Site.

C) EPA reviewed the evaluation included and generally found that the commenter's approach was much less conservative than EPA's approach to delineating the source area and calculating the mass of TCE. Specifically, EPA found the following:

   <u>Delineating the Modeled Source</u> - EPA modeled a source area in SEVIEW consisting of 50 x 25 meters (~13,500 square feet) that encompassed most of the locations where

TCE contamination was detected above 1 mg/kg. The commenter suggests that this approach is overly conservative. It should be noted that the TCE source has been observed to be unevenly distributed even in small lateral and vertical areas and the areas with the highest TCE concentrations are not known to be as laterally limited as the commenter's modeling suggests. EPA chose an appropriately conservative conceptual source area that takes into consideration the uncertainties in the data results due to sample spacing and varied distribution of TCE in vadose zone soils. The existing data set is sufficient for the purposes of selecting a remedy, however, pre-design investigations will be necessary to more specifically define the source area to prepare an engineering design.

Modeling the mass of TCE in Soil – The commenter states the overall mass of TCE in the soils according to the 3-dimensional modeling they performed (using data collected prior to the installation of the shallow SVE system) is in the range of 70 kg, much lower than EPA's calculated mass of 519 kg. For the purposes of the SEVIEW modeling effort, EPA selected NJDEP's approach to modeling mass in the source area as defined in the NJDEP SESOIL/AT123D Guidance Document (NJDEP 2014) which is shown in Appendix C of the 2016 FS Report.

In order to verify that the mass estimate presented in Appendix C of the FS Report is conservative, yet reasonable, EPA has utilized various methods (3D modeling, concentration averaging, etc.) to estimate TCE mass in the vadose zone. The resulting estimated mass ranged from 100 kg to over 1,100 kg of TCE. Tables 1 and 2 below show two similar results (1,100 and 1,182 kg of TCE) obtained by averaging concentrations in various discrete layers. Both estimates also break the source area into zones separating the larger source area (over 1 mg/kg TCE) from the hot-spot (elevated TCE found between 60-100 feet bgs). Based on the various methods used, the NJDEP method which resulted in an estimated mass of 519 kg is a reasonable and appropriate number to use for the purposes of remedy selection. Furthermore, it must be noted that the commenter's 2015 submittal titled " Final Design for the Shallow Soil Vapor Extraction and Mitigation System", estimated a total TCE mass in soils of approximately 3,000 kg. The commenter also provided EPA with the monitoring data of the shallow SVE system and estimated that approximately 370 kg of TCE has been removed from the shallow soils. Therefore, the 70 kg of TCE estimated by the commenter is an underestimate. The 70 kg of TCE the commenter estimated in soil with TCE concentrations above 0.2 mg/kg throughout the vadose zone underneath the ANC building is inconsistent with the much higher 2015 estimate of 3,000 kg and appears to be inaccurate when compared to the 370 kg of TCE removed from the shallow soils.

In summary, any calculation of TCE mass in this vadose zone source area must be considered a rough estimate, as the results are biased due to sample spacing. EPA chose the NJDEP method for the SEVIEW modeling which resulted in an estimated

519 kg of TCE mass and believes its approach to estimating TCE mass in the vadose zone is appropriately conservative due to the uncertainty in mass calculation as a result of sample spacing. EPA does not agree with the commenter's approach.

Table 1 (Basic Spacing)

Area Designation	Area (sq. feet)	Depth Range (ft. bgs)	Volume of Soil (cu. Yds.)	Mean TCE Concentration (mg/kg)	Mass of TCE (kg)
Hot Spot (top)	3,600	0-60 ft.	8,000	2.1	23
Hot Spot (bottom)	3,600	60-100 ft.	5,333	124.8	906
Outside Hot Spot (top)	9,900	0-60 ft.	22,000	4.9	149
Outside Hot Spot (bottom)	9,900	60-100 ft.	14,677	1.1	22
				Total TCE (kg)	**1,100**

Table 2 (10-ft Spacing)

Area Designation	Area (sq. feet)	Depth Range (ft. bgs)	Volume of Soil (cu. Yds.)	Mean TCE Concentration (mg/kg)	Mass of TCE (kg)
Hot Spot (top)	3,600	0-10	1,333	6.3	11
Hot Spot (top)	3,600	10-20	1,333	0.7	1
Hot Spot (top)	3,600	20-30	1,333	0.7	1
Hot Spot (top)	3,600	30-40	1,333	0.5	1
Hot Spot (top)	3,600	40-50	1,333	0.3	0
Hot Spot (top)	3,600	50-60	1,333	0.8	2
Hot Spot (bottom)	3,600	60-70	1,333	5.0	9
Hot Spot (bottom)	3,600	70-80	1,333	544.3	987
Hot Spot (bottom)	3,600	80-90	1,333	23.8	43
Hot Spot (bottom)	3,600	90-100	1,333	4.8	9
Outside Hot Spot (top)	9,900	0-10	3,667	18.1	90
Outside Hot Spot (top)	9,900	10-20	3,667	0.1	0
Outside Hot Spot (top)	9,900	20-30	3,667	0.1	1
Outside Hot Spot (top)	9,900	30-40	3,667	0.03	0
Outside Hot Spot (top)	9,900	40-50	3,667	0.2	1
Outside Hot Spot (top)	9,900	50-60	3,667	0.2	1
Outside Hot Spot (bottom)	9,900	60-70	3,667	0.5	2
Outside Hot Spot (bottom)	9,900	70-80	3,667	2.5	13
Outside Hot Spot (bottom)	9,900	80-90	3,667	1.7	9

Outside Hot Spot (bottom)	9,900	90-100	3,667	0.2	1
				Total TCE (kg)	**1,182**

D) See General Response to this comment above (Comment No. 20) on the intended use of the SEVIEW model. EPA understands that the TCE remaining in the source area under the building, while still at significant levels, is likely remaining mass from a much larger discharge that occurred many years ago. The model only used data collected after 2003 to look at the current state of contamination in the vadose zone and compared how potential soil remediation scenarios may reduce future impact to the groundwater. Current concentrations in the bedrock groundwater system were not evaluated in this modeling. In addition, the volume of groundwater data collected in the vicinity of OU3 is not robust enough to support the conclusions that the commenter made regarding declining levels of TCE in groundwater. EPA believes that the assumptions made in the SEVIEW model were appropriately conservative for conditions and the data set generated at the Site.

E) EPA believes that reducing infiltration in the SEVIEW model to account for the presence of the ANC building above the vadose zone soil contamination is reasonable. EPA modeled several scenarios with different infiltration rates controlled by the permeability of the upper foot of the models altered to simulate the concrete slab of the building. EPA chose to present the scenarios showing 1 inch and 3 inches of infiltration to estimate leaching of TCE from the vadose zone soils to the regional groundwater system. EPA compared the results of the 1-inch infiltration and 3-inch infiltration modeling to the current groundwater concentrations at MW-13 (immediately downgradient of the source area) and found the simulation results similar to what has been detected in this well. This comparison indicated that the estimates of infiltration are reasonable.

F) EPA reviewed the evaluation including Table 1 and Figure 2 and generally found that the commenter's approach was much less conservative than EPA's approach. See General Response to this comment above on the intended use of the model. EPA does not agree with the less conservative assumptions presented by the commenter describing the design of the SEVIEW model, including the estimate of the source area size (see response to Comment 20.C above) and the use of a point of compliance 6,200 feet downgradient from the source area (see response to Comment 20.B above). Therefore, the modeling presented in Table 1 and Figure 2 is not a valid approach to model the contaminant source. Specific responses to the bullet items are provided below:

   a. The hydraulic gradient used in the SEVIEW model was 0.015, the listed value of 0.15 was a typographical error in Appendix C of the 2016 FS.
   b. Using the Dale Avenue Well as a downgradient point of compliance is not acceptable to EPA for reasons described in the response to Comment No. 20.B above.
   c. See response to Comment No. 20.C above. In addition, the spatially weighted method ignores the intrinsic biases the sample spacing of RI borings within the Molding Area of the ANC building creates. The TCE source is unevenly distributed even in small lateral and vertical areas. The areas with the highest TCE concentrations are not

known to be as laterally limited as the Commenter's modeling suggests. EPA appropriately chose a more conservative estimate of source mass. The final estimate of the mass of TCE within the source zone will be determined during the remedial design based on additional sampling results.

Comment 21: Page 4, 1st paragraph - *The USEPA's Proposed Plan states "the glacial deposits are comprised of a mix of glacio-fluvial deposits and till and are characterized as a poorly sorted mixture of sand, silt, and clay, with larger clasts ranging from gravel to boulders. The moraine deposits range from 95 feet to greater than 140 feet thick at the OU3 Study Area. In general, the permeability of the glacial deposits is low."*

Laboratory geotechnical testing results from soil samples collected in the OU3 study area, as shown in Tables H1 through H-4 of Appendix H of the 2016 RI Report, document soil hydraulic conductivity values ranging from approximately 2E-6 centimeters per second (cm/s) to 8E-8 cm/s. Given this range of hydraulic conductivity, the equivalent intrinsic permeability of the soil based on methods used for calculating intrinsic permeability in soil as described in the U.S. Army Corps of Engineers Engineering Design Manual EM 1110-1-4001 for Soil Vapor Extraction and Bioventing, Section D-2 in Appendix D (USACE, 2002), is approximately $3x10^{-7}$ cm^2 *to* $1x10^{-8}$ cm^2*. Assuming an effective water saturation content of 6% (based on a conservatively low soil moisture of 12% documented at boring PPP-SBI-04 from the laboratory test results for soil beneath the facility presented in the 2016 RI Report), the resulting intrinsic air permeability of the soil in the area targeted for SVE is estimated to be on the order of* $2x10^{-7}$ cm^2 *to* $9x10^{-9}$ cm^2*. These data confirm that the permeability of the soil in the OU3 area is extremely low. The permeabilities of the deep soils within Area A of OU3 are below those where SVE technology is likely to be effective (USEPA, 1991). Accordingly, without additional information (e.g., soil testing or pilot testing) the selection of SVE as a remedial technology for OU3 is not supported.*

EPA Response: On Figure 3-10 Technology Screening Decision Tree of the U.S. Army Corps of Engineers Engineering Design Manual EM 1110-1-4001 for Soil Vapor Extraction and Bioventing, it shows that for air permeability higher than 10^{-10} cm^2, SVE is considered and evaluated. The calculations presented in the comment indicate that air permeability at the site is higher than 10^{-10} cm^2. Furthermore, the hydraulic conductivity measurements were performed on a soil core, which measures the vertical hydraulic conductivity instead of lateral hydraulic conductivity. The vertical hydraulic conductivity is typically ten times lower than the horizontal hydraulic conductivity. The lithology logs and the grain size analysis indicated that the formation primarily consists of a heterogeneous mixture of silt, sand, and trace clay. Based on the above, SVE is an acceptable technology for use on deep soils at this Site. Alternative 4 was developed to include a pilot study first, so additional information regarding the effectiveness of SVE can be collected for the engineering design. Alternative 4 includes some flexibility in the use and phasing of deep SVE and *in-situ* thermal treatment. The design will allow for further evaluation of SVE and thermal treatment for deep soils and the flexibility to implement either or both of these technologies after further testing and evaluations during the remedial design.

Comment 22: Page 7 – *On page 7 of the Proposed Plan, USEPA indicates that soil underlying the ANC building is being considered "Principal Threat" material. However, the specific basis for classifying this material as a Principal Threat is not explained. Providing a clear basis for this classification is important because an incorrect classification may preclude the evaluation and selection of remedial alternatives that meet the CERCLA remedy selection criteria (e.g., a remedy that is protective, implementable, and cost- effective).*

Principal Threat materials are those "considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur" (USEPA, 1991b). Also, as a general rule of thumb USEPA considers as a "principal threat those source materials with toxicity and mobility characteristics that combine to pose a potential risk several orders of magnitude greater than the risk level that is acceptable for the current or reasonably anticipated future land use, given realistic exposure scenarios." (USEPA, 1997).

Section 6.1 of the 2016 RI Report explains that under current and future land use the estimated risks for receptors exposed to site-related chemicals in soil, surface water and sediment at all exposure areas are below USEPA's risk management limits. The 2016 RI Report also explains that, prior to the installation and activation of the soil vapor extraction system/subslab depressurization system (SVE/SSDS) at the ANC building, indoor air concentrations of TCE were above the NJDOH's site-specific health goal of 7 µg/m^3 *for workers. More specifically, on Page 6 the Proposed Plan explains that indoor air TCE concentrations were as high as 180 µg/. Site-specific exposure of workers in the ANC building to this air concentration would result in an incremental excess cancer risk of approximately 8 x* 10^{-5} *and noncancer HQ of approximately 30. These risk levels would not be consistent with USEPA's general rule of thumb for identifying Principal Threat material (i.e., "several orders of magnitude greater" than the acceptable risk level).*

Also, the USEPA OU3 PRAP explains that the SVE/SSDS systems "have reduced concentrations in the indoor and subslab air significantly" (Page 6), that "with the vapor mitigation systems operational, the vapor intrusion exposure is incomplete" (Page 9), that the "operation of the shallow SVE and SSD systems provides protection of human health from vapor intrusion" (Page 12), and that recent sampling "demonstrate that the system is effective." (Page 12) These conclusions also indicate that the soil contamination below the ANC building does not represent Principal Threat material since it is being "reliably contained" via the SVE/SSDS system.

EPA Response: For this site, the area with the highest contamination, referred to as the hot-spot, is located beneath the former molding area of the ANC building. The level of contaminant concentrations within the hot-spot is significantly higher than levels seen throughout the rest of the site. The highest historic TCE concentration of 9,500 mg/kg was found in the hot-spot location at approximately 76 feet bgs in 2005. This

concentration is significantly above the saturation point of TCE in the soil matrix, indicating that dense non-aqueous phase liquid (DNAPL) was released in the past and possibly still exists in the soil matrix. The highest TCE concentration found during the OU3 RI was 120 mg/kg. Even though the contaminated vadose zone soil does not pose direct contact risks to human health and ecological receptors, it acts as a continuous source for both the groundwater contamination and vapor intrusion to the indoor air of the ANC building. Both vapor intrusion and contaminated groundwater pose unacceptable human health risks (above the VI screening level and MCL). There is a TCE groundwater contaminant plume emanating from the ANC facility that is eight and a half miles long. TCE levels of up to 2,400 ppb in groundwater within this plume have been detected recently (in 2016) near the ANC building. The contaminated soil within the hot-spot area continues to act as a source to this groundwater plume and is considered principal threat waste. Treatment of contaminated soils, including soils in the hot-spot area, wherever practicable, will be in compliance with the NCP.
The commenter stated that Site specific exposure of workers in the ANC building to indoor air concentrations of TCE (without operation of the shallow SVE/SDS system which is part of the selected remedy) would result in an incremental excess cancer risk of approximately 8×10^{-5} and a non-cancer HQ of approximately 30. The commenter further states that the soil contamination below the ANC building does not represent Principal Threat material since it is being "reliably contained" via the SVE/SSDS system. EPA believes this conclusion is misguided. EPA's acceptable risk range for non-cancer risk is a HQ of less than 1. A non-cancer vapor intrusion HQ of 30 is significantly above EPA's acceptable risk range. Additionally, the operation of the shallow SVE/SDS has provided protection of human health from vapor intrusion; however, the operation of the shallow SVE/SDS will not address the deep TCE soil contamination, which will continue to pose an unacceptable risk to human health for the foreseeable future.

Comment 23: Page 11 – *On Page 11 of the Proposed Plan, USEPA notes that a TCE soil cleanup level of 1 ppm (rounded up from 880 µg/kg) has been determined to be protective for human exposure via vapor intrusion exposure to subsurface soil contamination under the ANC building. This value was determined utilizing a site-specific attenuation factor estimated from subslab and indoor air sampling data in order to model potential indoor exposure risk.*

Appendix B of the 2016 FS Report provides the supporting information for derivation of the cleanup level of 880 µg/kg. In doing so, CDM-Smith utilized site-specific subslab soil gas and indoor air data in order to develop a site-specific subslab-to-indoor air attenuation factor (α) in order to model indoor air exposure risk from subslab soil gas concentrations. The site-specific subslab to indoor air attenuation factor of 0.000019 utilized by CDM-Smith appears to be a reasonable value considering the degree of attenuation identified across the entire ANC building slab during the Removal Action sampling performed in 2013 prior to the installation and activation of the SVE/SSDS. However, based upon a review of the subslab and indoor air concentrations observed in June 2016 from sampling locations where the bulk of the soil contamination has been identified (i.e., within the Molding Area), this underestimates the actual degree of attenuation. As explained in Attachment A ("Tech Memo: Basis for Alternative Soil

Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building"), Ramboll Environ has utilized a subslab-to-indoor air attenuation factor of 0.000045 in modelling the migration of shallow soil contamination into the ANC building.

The cleanup level proposed by CDM-Smith in the 2016 FS Report of 880 µg/kg is based upon the assumption that soil contamination is present at these levels immediately below the ANC building slab. It does not take into account the fact that the bulk of the TCE soil contamination was identified at depths 60 ft. below ground surface (bgs) or greater. It also does not take into account that shallow (0-5 ft. bgs) soil concentrations below the ANC building have very likely been significantly reduced due to the operation of the existing shallow SVE/SSDS system. As noted on Page 17 of the USEPA OU3 PRAP, the existing shallow SVE/SSDS systems "are successfully remediating shallow soils under the building." In determining the extent to which soil would warrant cleanup under the ANC building, USEPA should consider the degree to which clean shallower soil (e.g., from 0 to 60 ft. bgs) would help to attenuate soil vapor intrusion potential.

Also, the remedial action objective would be better stated as, "to reduce soil TCE concentrations below the ANC building as necessary to ensure that indoor worker soil vapor intrusion exposure would not result in unacceptable risk in the absence of engineering controls". Achieving this objective would achieve the same protection but would not necessarily require the treatment of all soils beneath the former ANC building with a concentration above 1 mg/kg. Instead, it would allow the treatment of a volume of TCE-contaminated soil below the ANC building as necessary to reduce the total vapor flux of TCE into the building in order to achieve acceptable risks for the site-specific worker population (in the absence of engineering controls). As presented in Attachment A to these comments ("Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building"), Ramboll Environ has performed an analysis to determine the extent to which soil below the ANC building would have to be treated (or removed) in order to achieve this objective. This analysis (1) accounts for the attenuation due to the presence of clean soil from 10 to 60 ft. bgs and (2) determines what soil would warrant treatment in order to reduce the total TCE vapor flux from contaminated soil below the building and achieve a condition of acceptable risk within the ANC building in the absence of engineering controls.

EPA Response: The commenter has developed an attenuation factor of 0.000045 for shallow soil contamination in their Attachment A. The commenter used this attenuation factor (0.000045) for soil contamination shallower than 60 feet bgs, then used the attenuation factor developed by EPA for the entire soil column of 0.000019 for soil contamination at and deeper than 60 feet bgs. Since the majority of samples detected with TCE concentrations greater than 1 mg/kg in OU3 RI were collected deeper than 60 feet, the attenuation factor of 0.000045 used in Attachment A has little effect on vapor intrusion results.

The commenter stated that the cleanup level proposed by EPA of 1 mg/kg of TCE in soils is based upon the assumption that soil contamination is present immediately below the ANC building slab and has not accounted for "the degree to which clean shallower soil (e.g. from 0 to 60 feet bgs) would help to attenuate soil vapor intrusion potential." However, the commenter did not provide or support any attenuation mechanism. The only consideration of impact of depth on vapor intrusion presented in Attachment A is to change the attenuation factor for soil shallower than 60 feet to 0.000045 and used the attenuation factor of 0.000019 for soil at or deeper than 60 feet. Therefore, in terms of consideration on impact of depth of contamination on vapor intrusion, the calculation presented in Attachment A is essentially the same as what CDM Smith presented in the FS Report.

The major changes presented in Attachment A by the commenter compared to EPA's approach for calculating vapor intrusion risks are: 1) the commenter indicates that the soil contamination within a polygon would only contribute mass flux to indoor air within that area of the polygon and the total mass flux into indoor air is estimated by adding mass flux from each individual area. As shown in Exhibit 1, the contaminated vapor from elevated soil contamination is assumed to only migrate to the area outlined in red: and 2) a large number of shallow soil boring results were used for developing the Thiessen polygons and the total mass flux estimate. EPA believes this methodology is not appropriate and may significantly underestimate the total mass flux to indoor air because: 1) contaminated soil gas will migrate following preferential paths in accordance with concentration gradient and pressure gradient, not necessarily directly upward. Assigning a high mass flux (from a high soil concentration) only to a small area could underestimate the potential of vapor intrusion; and 2) the large number of shallow soil samples with trace and low TCE concentration does not represent the contamination at depth. More than half of the area defined as "Exposure Area" in Figure A-1 is represented by the shallow soil data with TCE concentrations less than 1 mg/kg (shown in blue color in Exhibit 1). Based on available data, it is reasonable to assume that there is elevated soil contamination at depth within these areas which will contribute to vapor intrusion and is not accounted for in the commenter's assessment. The commenter's evaluation of attenuation is not acceptable and will underestimate the mass flux for vapor intrusion.

In conclusion, EPA disagrees with the analysis presented in Attachment A. After evaluating this comment, EPA believes the assumptions it used in developing a soil cleanup goal of 1 mg/kg of TCE are appropriately conservative.

Comment 24: Page 13, 1st Paragraph – *The USEPA's Proposed Plan states that the shallow SVE system has been successfully remediating the shallow soil and the lithology in the deeper soils is similar to the shallow soils. Therefore, it is likely that the deep SVE would be effective in treating the deep vadose zone soil contamination. In addition, page 4-21, paragraph 4 of the Feasibility Study Report states that "The existing shallow SVE system indicates that the heterogeneous low permeable soil beneath the building can achieve a significant radius of influence and air exchange rate under natural conditions."*

The assumption USEPA makes regarding the effectiveness of the shallow SVE/ SSDS being similar to how a deep SVE system will perform is not accurate. First, the primary objective of the shallow SVE system is to reduce the indoor air concentrations of TCE in *the Albéa facility by 1) mitigating the sub slab concentrations of TCE; and, 2) maintaining a negative pressure in the subsurface immediately beneath the building floor slab. Although contaminant mass is being removed from the shallow soils by the system, its primary objective is to solely address the vapor migration pathway. Second, the zone of influence of the shallow SVE system is much greater than what would be expected by a deep SVE system due to the zone of higher permeability between the floor slab and the subsurface soil (void space that is present immediately beneath a floor slab and the presence of permeable, granular fill materials consisting of sand and gravel were observed to be present when installing the shallow SVE well points for this system). As vacuum measurements for the shallow SVE system are taken from within the permeable zone just beneath the slab, the resulting vacuum influence of the SVE/SSDS system will be significantly greater than what would be expected in the deeper native soil beneath the building. As provided in Specific Comment No. 21 on the USEPA OU3 PRAP above, the deep soils within Area A at the Washington plant are orders of magnitude less permeable than the shallow, granular subgrade materials present beneath the building slab. Therefore, selection of the deep SVE alternative based on the assumption that it will perform similar to the shallow SVE system installed for mitigation of vapors beneath the building is inappropriate.*

EPA Response: The commenter states that the assumption EPA makes regarding the effectiveness of the shallow SVE/SSDS being similar to how a deep SVE system will perform is not accurate. Further, the commenter concluded that the selection of the deep SVE alternative based on the assumption that it will perform similar to the shallow SVE system installed for mitigation of vapors beneath the building is inappropriate. Review of boring logs collected under the Molding Area of the ANC building shows similar lithology for shallow soils and deep soils. Review of the guidance document cited by the commenter against site-specific information does not preclude the use of SVE. See response to Comment Nos. 2, 19 and 21 above for further discussion. Alternative 4 includes a pilot study which will further evaluate the effectiveness of the deep SVE and also collect site-specific design parameters, including the radius of vacuum influence, for the design of a deep SVE system. Alternative 4 also includes the implementation of *in-situ* thermal treatment as an option in order to achieve the remediation goals. It is important to note that *in-situ* thermal treatment also requires the support of a SVE system (thermal SVE system) to ensure all the contaminated vapor generated from the *in-situ* thermal treatment is captured and appropriately treated, even though the thermal SVE system for *in-situ* thermal treatment would be installed at a shallower depth than the deep SVE system targeting the most contaminated soils. EPA believes that the deep SVE is likely to be very effective, even though enhancement technologies and closer well spacing than currently shown in the FS report may be necessary, based on additional data to be collected during a pilot study.

Based on EPA's thorough review of all comments received during the public comment period, EPA believes that while Alternative 4 remains the best remedial alternative to address OU3 Site contamination, it is appropriate to allow a more flexible approach than described in the FS Report in implementing Alternative 4 through the use of both or just one of the two technologies included in this alternative (SVE and thermal treatment). This would include the option of performing thermal hot-spot treatment of soils first, and eliminating the deep SVE portion of the remedy if EPA deems that RAOs have been sufficiently met by thermal treatment alone. Final determination of how best to employ the two technologies to meet RAOs would be determined in remedial design. Due to its long-term effectiveness, less obtrusive nature, and superior mass reduction capabilities, EPA believes performing *in-situ* hot-spot thermal treatment first may be as effective at meeting the RAOs compared to the use of SVE throughout the deep soils of Area A. In the event that *in-situ* thermal treatment of the hot-spot alone does not meet RAOs, then deep SVE would be implemented for areas outside the hot-spot.

Comment 25: Page 15 - *The USEPA's Proposed Plan states that "Alternative 4 would remove approximately 90 percent or more of the contaminant mass within the treatment zone, and the contamination beneath the ANC building would no longer serve as a significant source for groundwater contamination or vapor intrusion." There is no supporting information provided in the Feasibility Study Report or USEPA's Proposed Plan on how the estimate of 90% mass removal was derived for the deep SVE alternative. Based on the low values of soil air permeability discussed in Specific Comment No. 21 on the USEPA OU3 PRAP above and given the heterogeneous nature of the unsaturated soil in the OU3 area, it is unlikely that a high enough pore-gas velocity can be achieved throughout the treatment area given the number and spacing of proposed SVE wells to effectively reduce the contaminant mass by 90% or greater, and within the 10-year timeframe that USEPA indicates is required to reach the Site-specific remediation goal of 1 mg/kg TCE. Furthermore, as SVE is a rate-limited mass transfer process and contaminant mass reduction depends greatly on achieving a sufficient pore-gas velocity throughout the treatment zone, any fine-grained soil zones having TCE concentrations above the remediation goal may not be subjected to the required amount of air flow or pore-volume exchanges. This is further complicated based on the presence of obstruction to vapor flow identified within soil borings conducted within Area A that include boulders and cobbles. Consequently, the alternative of using SVE alone is prone to failure at the onset and would necessitate the need for applying the thermal enhancement option at significantly higher costs.*

EPA Response: The issues raised in this comment have been raised in previous comments and are responded to in EPA's response to Comment Nos. 1, 2, 15 and 21. After considering these and all other comments received, EPA has determined that the deep SVE system can be effective if properly designed since TCE is highly volatile, the soil contains primarily silt and sand with low moisture content, and the permeability of deep soils does not preclude the use of SVE. EPA acknowledges that the time required for a remedy using deep SVE system will be much longer than using *in-situ* thermal remediation, and further acknowledges that data collected during a pilot study would be needed to determine with certainty how many wells would be required and other important aspects of the SVE system. As stated in the response to Comment No. 24, above, after fully evaluating all of the comments received during the public comment period, EPA has also determined that it is appropriate to allow a more flexible approach than presented in the description of Alternative 4 in the FS Report for addressing Site soils. This would include the option of performing thermal hot-spot treatment of soils first, and eliminating the deep SVE portion of the remedy if EPA deems that RAOs have been sufficiently met by thermal treatment alone. Final determination of how best to employ the two technologies to meet RAOs would be determined in remedial design. Due to its long-term effectiveness, less obtrusive nature, and superior mass reduction capabilities, EPA believes performing *in-situ* hot-spot thermal treatment first, may be as effective at meeting the RAOs compared to the use of SVE throughout the deep soils of Area A. In the event that *in-situ* thermal treatment of the hot-spot alone does not meet RAOs, then deep SVE would be implemented for areas outside the hot-spot.

Comment 26: Page 16 – *In the second paragraph, USEPA states, "Alternative 4 involves the installation of deep SVE wells and piping inside the facility. However, this would be manageable as demonstrated by the shallow SVE system." This statement is incorrect and assumes that the number and location of deep SVE wells would be the same as for the existing vapor extraction points for the shallow vapor mitigation system. In review of the conceptual installation of the deep SVE system as provided in Specific Comment No. 19 on the 2016 FS Report above, the number of SVE wells that would be needed would be at least twice (over 30) that of the shallow SVE points installed for the existing vapor mitigation system located within Area A of the former ANC plant. This number of extraction wells and the associated piping would be a significant impediment and would likely make it impracticable for the facility to conduct operations in this area of the plant for many years.*

EPA Response: Please see the response to Comment No. 2 and No. 19 regarding the number of SVE wells. EPA understands the concerns expressed regarding the potential impact to the operations at the facility by the installation of a large number of wells and piping and the desire to complete the remediation within a short period of time. Note that similar work has been successfully completed within the Molding Area of the ANC building in the past without impeding the operations at the facility. The FS conceptually describes how the remedial technologies can be implemented for cost estimating purpose only. Details on how the remedial technology will be implemented to minimize impacts to the ongoing operations within the facility, to the extent possible, and whether SVE or *in-situ* thermal remediation should to be used first in order to achieve the remediation goals within the shortest period of time will be addressed during the remedial design.

Comment 27: **Page 17** - *The USEPA's Proposed Plan states that "No significant installation and/or operation issues are anticipated for the deep SVE system, as the currently operating shallow SVE system was installed in 2013 and is currently successfully operating at the Site in Area A." As shown in Figure 4-2 of the Feasibility Study - Conceptual Layout for Alternative 4, fourteen SVE well locations are proposed. The fourteen deep well installations would require the use of roto-sonic drilling equipment due to the presence of cobbles and boulders, and roto-sonic drilling equipment requires a considerable amount of open space and ceiling clearance to install the wells. The SVE/SSDS extraction points are installed to a depth of 2 and 5 feet only* *and could be installed using hand augers and small-scale soil boring equipment. The use of large-scale roto-sonic drilling equipment within the interior of the building will have significant effects on facility operations, implementation challenges, and cost. USEPA's assessment that installation of a deep SVE system is comparable to the installation of the shallow SVE/SSDS system warrants further evaluation.*

EPA Response: Deep borings have been installed inside the ANC building using roto-sonic drilling methods during the OU3 RI and it is feasible to install more. Review of soil boring logs indicated that cobbles and boulders were encountered, but the majority of subsurface soil borings contain trace to little gravel. Alternative approaches that can minimize impact on facility operations will be evaluated and developed during the remedial design. Please see the response to Comment No. 5.

Comment 28: **Page 17** – *The Proposed Plan notes that after "treatment, post-remediation sampling will be performed to confirm that remediation goals have been met." This is consistent with language in the 2016 FS Report that explains that after "the completion of deep SVE treatment and in-situ thermal treatment, if implemented, soil samples would be collected to evaluate the treatment effectiveness." As a remedial action objective is reduction of vapor intrusion to be protective of indoor air, it is suggested that a more effective and practical means for evaluating the effectiveness of treatment will be to utilize soil vapor probes and to sample subslab soil gas to determine if subslab concentrations have been reduced, in the absence of engineering controls, to a concentration that at a level not be expected to result in an unacceptable vapor intrusion risk (e.g., a concentration approximately 400,000 µg/m^3 consistent with that presented in Appendix B of the 2016 FS Report). It is noted that confirmation sampling by means of soils borings through Area A within the building would be highly disruptive to facility operations, would only represent a small volume as compared to the overall volume of the soils to be treated (i.e., may not be fully representative), and significant variability of concentrations (i.e., ability to reproduce results) could result from soils samples even if collected within a short distance from one another.*

EPA Response: Contaminant data collected using soil vapor probes and from sampling sub-slab soil gas could not be directly co-related to the level of soil contamination at depth and cannot be used to determine if the remediation goal is met. EPA developed the remediation goal of 1 mg/kg for TCE and determined that TCE at this level would be protective to both indoor air and groundwater. Post remediation soil sampling will be required to evaluate the effectiveness of the remedy in meeting the remediation goal. However, the details of the monitoring requirements will be developed during the remedial design.

Set 2 – Prepared for PPPI by Arcadis

Comment 29: *Focusing first on the site characterization work, Arcadis believes the site characterization work and Site Conceptual Model reasonably represents the Site conditions. The reports document that the vadose zone soils are glacial till and consist of mostly silt and clay, which have low permeability. The reports document that most of the*

TCE with concentrations greater than 1 mg/kg (the vadose zone soil remediation goal) is present below the ANC building at a depth of between 70 and 100 ft. bgs. The reports also properly documented that the TCE mass likely migrated to the deeper soils, through a portion of the heterogeneous glacial till soils that were more permeable, but also diffused into the less permeable silts and clays that make up most of the vadose zone soils.

Arcadis also agrees that the shallow SVE and SSD system is meeting the design objective of reducing the subslab vapor concentrations and applying a negative pressure to the subsurface, but Arcadis questions the EPA's conclusions that the design principals of the shallow SVE system would be appropriate for the deeper SVE system for the following reasons:

EPA General Response: Regarding Design Principles of the Shallow and Deep SVE Systems: EPA understands the commenter's concern that the deep SVE wells will function differently than the shallow SVE wells. EPA's selected remedy addresses this concern by including a pilot study during the Remedial Design phase to determine the actual radius of influence in the deep soils. EPA disagrees that the shallow SVE system design and the difference in the composition of shallow soils as compared to the deep soils indicates that the Deep SVE system will not function. Specific responses follow.

A. The analytical data documented that TCE was not detected in shallow soils at concentrations greater than 1 mg/kg.

EPA Response: It appears the commenter only reviewed the results of the EPA 2012 and 2015 investigations. These investigations were designed to supplement and confirm the data set collected under the building by Environ (Environ, 2007) under NJDEP oversight prior to 2006. Environ detected TCE above 1 mg/kg at several locations within the shallow soils, including two locations above 100 mg/kg. However, the infrequent detection of high TCE concentrations in shallow soils during the OU3 RI, even around the sanitary sewer lines and floor drains in the former Blak-Sol operations area, indicates that much of the TCE has migrated to deeper intervals or volatilized into soil gas. If the soil had very low permeability and high moisture content, it would have retained the high TCE contamination.

B. The shallow SVE system well screens are between 1 to 4 ft. bgs. The design of these SVE wells will allow the vacuum to short circuit to directly beneath the concrete slab. The vacuum and airflow will be transmitted through the interface of the concrete and the soil. The design basis of a SVE radius of influence (ROI) of 45 ft. is based on the vacuum and air traveling between the soil and concrete and not directly through the soil. The shallow SVE system is collecting vapors that diffuse beneath the concrete slab. The shallow SVE system is not extracting TCE from the clay and silt soils. This idea is reinforced by the EPA reference to one of their own publications:

"Impacted areas that are not in direct contact with the advective air flow will rely on diffusion of VOCs toward zones of enhanced air flow. Diffusion is a slow, rate-limiting process compared to advection (USACE, 2002)."

EPA Response: EPA agrees that a portion of the vacuum and air flow may transmit through the interface of the concrete and soil, which could result in a larger radius of influence compared to vacuum and air flow only through soils. However, EPA disagrees with the statement that "The shallow SVE system is collecting vapors that diffuse beneath the concrete slab. The shallow SVE system is not extracting TCE from the clay and silt soils". If what the commenter suggested is true, then it should not take the shallow SVE system long (only one or two pore volumes) to remove the accumulated contaminants in the void between the building slab and soil. The fact that the shallow SVE system removed more than 800 pounds of TCE from the shallow soil by June 2015 (Ramboll Environ's Monthly Progress Report No. 5, Reporting Period July 1 2015 to July 31 2015) in less than two years of operation suggests that the TCE mass was also removed from the soils, not just from the gap between the soil and concrete floor.

The fact that high TCE concentrations were not detected frequently in shallow soil in EPA's OU3 RI may indicate two possible conditions: 1) the shallow soil is relatively permeable to air and 2) TCE retained in soil has volatilized over the years; and/or TCE has migrated down to deeper intervals by gravity, as the data showed. Both of these conditions suggest that the soil may not be as impermeable as the commenter suggested.

EPA understands that the deep SVE wells will function differently than the shallow SVE wells, and EPA selected remedy includes a pilot study during the Remedial Design phase to determine the actual radius of influence in the deep soils.

C. *Comparing the information presented on the **Attachment 5** cross section (RI Report) to the ANC interior (**Attachment 1**) and exterior (**Attachment 6**; FS Report) summaries Arcadis generated, the **Attachment 5** cross section does not appear to reflect the heterogeneities of glacial till. Key boring logs from the RI and Shallow SVE reports are included in **Attachments 1, 3** and **6**. Comparison of the RI and SVE logs clearly shows the SVE logs are mostly sand, while the deeper soils containing elevated TCE concentrations (the RI soil boring logs) are mostly clayey-silt with some pockets of sand, cobbles, and boulders. Furthermore, comparing the two shallow SVE boring log summaries in **Attachment 3** that Arcadis generated, shows that even the shallow borings are heterogeneous.*

EPA Response: EPA disagrees with the statement that "Comparison of the RI and SVE logs clearly shows the SVE logs are mostly sand." There are 13 SVE logs in the molding area. Three SVE logs (SVE-1, SVE-2 and SVE-4) showed well-graded sand with silt to one foot bgs without deeper soil being logged. Two SVE logs (SVE-8 and SVE-11) showed silt with gravel. Eight SVE logs showed primarily silt. Clay is not documented at any significant presence. In addition, some SVE wells are constructed in borings up to 6 feet bgs. Both the shallow SVE logs and the interior OU3 RI soil logs indicate that silt is the dominant soil type for shallow soil and as the OU3 RI logs show silt is also the dominant soil type for deep soil.

Comment 30: *As for the site-specific remediation goal of 1 mg/kg of TCE in vadose zone soils, this value may be too conservative and therefore Arcadis suggests further evaluation of its technical basis. Arcadis reviewed the groundwater fate and transport modeling and vapor intrusion evaluation presented in the RI and FS Reports. A summary of Arcadis' review and some considerations for further evaluation are as follows:*

A. *Fate and transport modeling*
In general, Arcadis agrees with the overall conceptualization: less infiltration leads to longer residual mass residence time in the vadose zone and overall longer times to reach a target remediation goal. However, the report tended to be vague on multiple inputs, as well as unclear in other areas, and did not tend to tie field data to model results. In addition, the report did not seem to include a calibration although it appears that sufficient field data exist for such a calibration.

EPA Response: Please see EPA's response to Comment No. 20 in regard to the EPA's intended use of the SEVIEW model. EPA's use of the SEVIEW model was limited to modeling the future impact leachate leaving the source area would have on groundwater. The model was designed to compare the impact that various degrees of soil remediation would have on future groundwater reaching the extraction and treatment system downgradient of the source area. Current groundwater concentrations were not input into the model and therefore calibration of the model using groundwater sampling results downgradient from the source area was not necessary.

Specific items that warrant further consideration are as follows:

a. *Model Construction*
   i. *Model layering seems more dense than presented via field soil concentrations at various depth intervals.*

   EPA Response: EPA built the model to include the results from all 8 deep borings sampled during the 2012 and 2015 OU3 Remedial Investigations as well as the 9 deep borings installed by Environ during the 2005 Environ RI. There is adequate data to support the approximately 4-foot vertical spacing selected in the SEVIEW model. It appears the commenter only reviewed the results of the EPA 2012 and 2015 investigations.

   ii. *Individual layer-simulated lithology (silt, sand or clay) within overburden till not described.*

   EPA Response: EPA reviewed the boring logs throughout the entire source area and found that the till as described was a heterogeneous mixture of silts, sands and clays with lesser amounts of gravel and occasional cobbles and boulders. The lack of noted layering led EPA to select a bulk intrinsic permeability for the entire modeled overburden, with the exception of the upper foot, which was modeled to represent the concrete floor of the facility.

   iii. *No figure presenting alignment between subsurface geology or impacts via* *characterization program to understand chosen sub-layering.*

EPA Response: See responses above to 30.A.a.i. and 30.A.a.ii. above. EPA chose the model spacing to represent the bulk geology encountered and to represent the data collected.

iv. *Post vadose zone transport, groundwater flow is simulated within a weathered carbonate bedrock aquifer. Report states model is not suitable for a fractured bedrock environment and the estimate provided is only a potential value. However, no potentiometric surface map was presented, nor a discussion on an equivalent porous medium.*

EPA Response: EPA understands that the SEVIEW model (specifically the AT123D portion of the model) was not intended for modeling contaminant fate and transport within a fractured bedrock environment. EPA took these model limitations into consideration and utilized the results of the SEVIEW modeling because when designed with conservative inputs, it provided a reasonable evaluation of potential impact to groundwater quality for a feasibility study level assessment. EPA selected model inputs for the carbonate bedrock aquifer from the OU1 Remedial Investigation Report (CH2M HILL, 2005) (including the hydraulic gradient) in order to compare the impact various degrees of soil remediation would have on future groundwater reaching the extraction and treatment system downgradient of the site.

b. *Parameters*

i. *Initialized TCE concentrations not clear within individual sub-layers. Report states TCE from average concentrations derived from model without any table of initial values, only simulated.*

EPA Response: Table 1 of Appendix C of EPA's FS Report presents the initial TCE concentration in soil for each sublayer. As described in Appendix C of the 2016 FS, the TCE concentrations selected for each layer of the SEVIEW model were selected from the highest concentration observed in each sublayer. This method was selected by EPA based on the NJDEP SESOIL/AT123D Guidance Document (NJDEP 2014).

ii. *Report tends to be vague on input parameters for both the SESOIL and AT123D models.*

EPA Response: All site specific input parameters were included within Appendix C of the FS Report. Any additional parameters that were not specifically listed in the memorandum were based on chemical type, weather station or other general inputs that are standardized within the SEVIEW software.

iii. *Report states the effective porosity was calculated from Site data using a* *geomean, with a value 2/3 of total porosity for SESOIL. However, for AT123D the effective porosity is set with the same value, but referenced (without source) to a median literature lookup value for karst.*

EPA Response: The AT123D input for effective porosity refers to the value for the carbonate bedrock aquifer. The reference for the effective porosity of 0.22 (22%) for karst limestone was mistakenly left out of Appendix C of the FS Report. The correct reference is USGS 1967. Summary of Hydrologic and Physical Properties of Rock and Soil Materials, as analyzed by the Hydrologic Laboratory of the U.S. Geological Survey, 1948-1960.

iv. *Report does not mention the use/non-use of degradation during dissolved phase transport.*

EPA Response: As stated on page C-2 of Appendix C of the FS Report, AT123D (the dissolved phase transport model) simulates advection, dispersion, sorption and biological decay (degradation)**.**

c. *Outputs*

i. *Report states that the 15 simulations of groundwater concentrations versus time are shown. However, only 12 simulations were presented.*

EPA Response: A total of 15 simulations were run of the model (3 modeled infiltration rates x 5 modeled contaminant loads) as shown on Table 2 in Appendix C of the FS Report. However, the results of only 12 of the runs were shown on Figure 2, which the commenter is likely referencing. The purpose of Figure 2 is to demonstrate the impacts to groundwater at different infiltration rates. The 3 simulation results related to the ISCO treatment alternative were within the ranges demonstrated by the 12 simulations and the total number of simulations were considered unnecessary to be presented on Figure 2.

ii. *Report states low infiltration simulations reasonably match what current groundwater concentrations should be. However, no mention of a direct comparison to field data was discussed.*

EPA Response: Please see the General Response to Fate and Transport Modeling Comment above (Comment 30A). As shown on Page C-7 of Appendix C of the FS Report, EPA compared the Point of Compliance 1 (groundwater leaving source area) results from the 1-inch infiltration and 3-inch infiltration modeling to the current groundwater concentrations at a monitoring well located approximately 100 feet downgradient of the source area (MW-13) and found the simulation results within the range of what had been detected in this well. This comparison, although simplified, indicates that the estimates of infiltration are reasonable.

B. Vapor intrusion modeling/evaluation

Further evaluation of the Site-specific attenuation of soil vapor concentrations *through the vadose zone seems warranted*.

EPA Response: EPA agrees. Further evaluation of site-specific attenuation of soil vapor concentration through vadose zone soil will be conducted during the remedial design. However, the existing data set is deemed sufficient for remedy selection purposes.

Comment 31: A*rcadis is concerned that Alternatives 1 and 2 do not address the source area*.

EPA Response: Comment noted, Alternatives 1 and 2 were not selected. Alternative 1, No Action, is required by the National Contingency Plan to be developed for comparison purposes with other alternatives**.**

Comment 31: *Arcadis agrees that Alternative 3 should not be considered, but Arcadis does not agree that 50% of the TCE in the vadose zone would be addressed by using hydraulic fracturing to distribute a chemical oxidant (and we would like to understand the basis for the 50% destruction assumed). Arcadis believes that hydraulic fracturing will enhance the permeability of the permeable zones and will not enhance the permeability of the clays and silts.*

EPA Response: Effectiveness of ISCO treatment in term of mass removal rate depends on many factors. The effectiveness of ISCO treatment documented in the ITRC document "Integrated DNAPL Site Strategy" (ITRC 2011) ranged from -55% to 100%, with median reduction 72% in one survey. Achieving high mass reduction in a vadose zone poses extra challenges. The 50 percent effectiveness value was selected to illustrate the limited effectiveness of ISCO in achieving the RAOs and PRG. See response to Comment No. 17 for further discussion.

EPA agrees that hydraulic fracturing will create preferential pathways within the low permeability soils dependent on soils encountered. This will facilitate oxidant distribution, but will not ensure all TCE mass is addressed. This was taken into consideration when selecting the 50% effectiveness value for ISCO.

Comment 32: *As for Alternative 4, the preferred alternative, Arcadis recommends forgoing the deep SVE remediation because most of the TCE mass is present in diffusion-limited clays and silts, and because of the heterogeneous nature of Site soils. As per the abundance of published SVE design information available in the literature, SVE is applicable for remediation of soils with high air permeabilities, and much less applicable or even impracticable for the low-permeability silts and clays found at the Site. The issues and limitations of applying SVE in heterogeneous soils, where mass removal rates will be limited by diffusion from low permeability zones has been well understood and studied for many years. Researcher such as M. Truex, G. Beckett, D, Benson, and D. Digiulio have evaluated and documented the effect of diffusion limited mass transfer on the performance of SVE system and the difficulties of attempting to implement SVE systems for heterogeneous sites. The following figures from Suthersan, et al. sum up this* *problem (Suthan Suthersan, "Soil Vapor Extraction", Remediation Engineering: Design Concepts, Boca Raton, CRC Press LLC, 1999):*

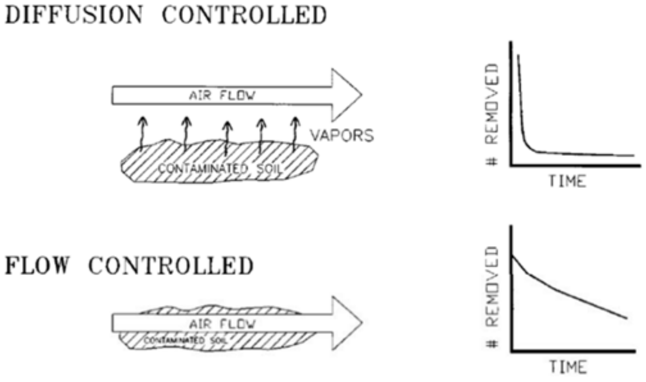


Figure 3.4 Decline in vapor concentrations under diffusion and flow-controlled regimes.

EPA Response: The commenter recommends forgoing the deep SVE remediation because most of the TCE mass is present in diffusion-limited clays and silts, the heterogeneous nature of Site soils, and mass removal rates will be limited by diffusion from low permeability zones. Review of site boring logs underneath the ANC building indicated the presence of clayey silt, sandy silt and silty sand with trace clay, trace to little gravel and cobbles in the majority of soil volume. Evaluation of grain size distribution indicated that the median grain size is greater than 0.075mm and SVE should be considered. Even though cobble or gravel or sand layers were encountered, they were only found in limited portions of the borings and mostly at depths shallower than 60 feet. Based on the data collected during the RI, EPA believes that the deep SVE system will be effective if properly designed, although it is possible that enhancement technologies may be required. See response to Comment Nos. 2 and 21 for further discussions. A pilot study will be required during the remedial design phase. The pilot study will collect site specific parameters needed for the successful engineering design of a deep SVE treatment system. See response to Comment No. 24 for further discussions.

Comment 33: *Based on Arcadis' experience in northern New Jersey and glacial till, Arcadis believes that if SVE is utilized, a more reasonable ROI would be about 10 to 15 ft. (not the 45 ft. presented in the Proposed Plan) when an airflow of 30 cfm at 15"Hg is applied. However, given the additional cost associated with the installation of the extra SVE wells and the larger treatment system, Arcadis believes that applying thermal remediation alone from the start will allow for the achievement of the soil remediation goal in a more timely and cost effective manner than SVE alone or SVE operating for 10 years and then applying thermal to address the residual TCE mass.*

EPA Response: The optimal well spacing for SVE would be determined in the remedial design phase of the project, after the collection of additional data from a pilot study. Even with the well spacing presented by the commenter, the construction of a deep SVE system would be less expensive than the construction of an *in-situ* thermal remediation system when treating the same volume of soil contamination. EPA agrees that applying *in-situ* thermal remediation from the start will allow the achievement of soil remediation goals sooner than by employing deep SVE alone. Based on EPA's thorough review of all comments received during the public comment period, EPA believes that while Alternative 4 remains the best remedial alternative to address OU3 Site contamination, it is appropriate to allow a more flexible approach than described in the FS Report in implementing Alternative 4 through the use of both or just one of the two technologies included in this alternative (SVE and thermal treatment). This would include the option of performing thermal hot-spot treatment of soils first, and eliminating the deep SVE portion of the remedy if EPA deems that RAOs have been sufficiently met by thermal treatment alone. Final determination of how best to employ the two technologies to meet RAOs would be determined in remedial design. Due to its long-term effectiveness, less obtrusive nature, and superior mass reduction capabilities, EPA believes performing *in-situ* hot-spot thermal treatment first may be as effective at meeting the RAOs compared to the use of SVE throughout the deep soils of Area A. In the event that *in-situ* thermal treatment of the hot-spot alone does not meet RAOs, then deep SVE would be implemented for areas outside the hot-spot. See response to Comment Nos. 19 and 24 for further discussions.

Comment 34: *As discussed above, SVE for deep soils will not be effective in meeting the remedial objectives for deep soil treatment, due to the higher moisture contents and resulting lower relative air permeabilities of the deep soil and the likely presence of the majority of the mass in the low permeability silts and clays as a result of dense non-aqueous phase liquid (DNAPL) dissolution and forward diffusion into these soils. SVE in the deep soils may initially be effective at sweeping out the readily accessible mass present in the more permeable zones, but removal of the majority of the mass that is present in the low permeability soils will be limited by the slow process of cross diffusion and likely will take decades. To overcome the diffusion-limited mass transfer rates and effectively remediate the deep soils in an efficient and timely manner, the best remedial approach is to use an appropriate in-situ thermal technology to thoroughly heat the deep soils to approximately 100 degrees Celsius (°C) in combination with effective pneumatic and hydraulic capture and off-gas treatment systems. Heating the impacted deep soil zones to 100° C will result in boiling and steam/vapor formation within the pores of the low permeable silts and clays. The increased volatility of the target constituents of concern (COCs) at 100°C, in combination with the formation of a vapor phase within the pores, will result in volatilization and stream stripping of the dissolved and sorbed COCs and any DNAPL, if present. The buoyancy and increased pore pressure generated as a result of steam bubble formation drives the COC mass laden vapors upwards where they can be intercepted and removed by the vapor extraction system for treatment.*

EPA Response: The soil moisture content in deep soil is low underneath the ANC building which results in higher relative air permeability. EPA believes that SVE in the deep soil zone would be effective. A pilot study during the remedial design would gather additional information to support this. EPA agrees that *in-situ* thermal remediation can overcome the diffusion-limited mass transfer issue, if properly implemented. As noted in EPA's response to the previous comment, EPA's selected remedy provides for the flexibility of using both or just one of the two technologies included in this alternative

(SVE and thermal treatment). Final determination of how best to employ the two technologies to meet RAOs would be determined during the remedial design phase based on additional design studies to be performed. See response to Comment Nos. 24 and 33 for further discussions**.**

Comment 35: Attachment 7*, authored by Dr. Eva Davis of USEPA's Office of Research and Development, National Risk Management Research Lab, Groundwater and Ecological Restoration Research Laboratory in Ada, Oklahoma, outlines how implementing SVE and/or pump and treat in heterogeneous soils with diffusion limited mass transfer can lead to incomplete removal, rebound, and failure to achieve the remedial objectives. The paper also discusses how in-situ thermal remediation (ISTR) overcomes these constraints due to changes in physical properties of the COCs that leads to much more favorable removal mechanisms (i.e., increased volatilization and stream stripping). Dr. Davis is USEPA's lead technical person for thermal remediation projects and provides support activities including: characterization for remediation purposes; evaluation of the applicability of thermal methods for a particular site; overview of design, construction, and operation; and performance assessments.*

EPA Response: EPA understands the technical difficulties of implementing deep SVE and thermal at this Site and has thoroughly evaluated all appropriate Site specific conditions in considering both of these technologies. The final determination on the use of deep SVE and/or thermal treatment for soils and the extent of the treatment area will be made in the remedial design phase based on additional design studies to be performed. See response to Comment Nos. 2, 21, and 24 for further discussions.

Comment 36: *Attempting to implement SVE for the deep soils first, with the provision to possibly then implement ISTR technology if (when) the deep SVE system is unable to sufficiently remove COC mass, is problematic for the following reasons:*

a. *It is well understood that for these types of geologic settings and contaminant distributions, SVE has a very low probability of being successful due to diffusion limited mass transfer.*
b. *Any SVE system installed for the impacted deep soils will have to be substantially upgraded and/or removed in order to allow installation of an ISTR system:*
    i. *To be compatible with ISTR, the SVE wells would need to be constructed of materials suitable for 100°C (e.g., stainless steel, fiberglass, etc.).*
    ii. *The SVE well layout may not be compatible with the ISTR wellfield layout and some or most of the SVE wells may need to be abandoned.*
    iii. *To allow efficient installation of the ISTR wellfield, the SVE manifold piping system will have to be disassembled and removed.*
    iv. *In addition, the SVE manifold system will likely have to be replaced with suitably sized piping for the increased flow rates associated with ISTR and that is also compatible with temperatures of approximately 100 ^{o}C (e.g., fiberglass, carbon steel, etc.).*
    v. *The extraction (i.e., blowers) and treatment system will also have to be substantially upgraded and/or replaced to be able to handle the steam load,*

increased COC removal rates, increased temperatures, and liquid condensate/groundwater treatment rates.

EPA Response: EPA is aware of the concerns listed. Whether to implement a deep SVE at the start of the remedial action or *in-situ* thermal remediation at the hot-spot first will be determined during the remedial design after the pilot study is conducted.

a. The Site soil has low moisture content and trace clay in the majority of the targeted treatment volume. The shallow SVE system is believed to be removing TCE from the shallow soils. The effectiveness of a deep SVE system will be determined based on the pilot study results. See response to Comment Nos. 2, 21, and 29 for further discussions.

b. The commenter listed the items that will require substantial upgrade if a deep SVE system is designed and implemented first and then *in-situ* thermal remediation is implemented. All these items can be further considered when a determination of whether to treat deep soils within Area A through an SVE technology or to treat hot-spot soils through *in-situ* thermal remediation is made. This determination will be made in remedial design pending collection of additional information and analysis. Part of that analysis can include a cost-benefit analysis to help determine the best application of SVE and *in-situ* thermal remediation technologies at this Site.

Comment 37: *For these reasons, the best approach with regards to probability of success in: 1) meeting the performance objectives; 2) meeting the performance objectives within a predictable and efficient schedule (e.g., 1 year from construction, through operation, to completion); and 3) achieving the desired results in the most cost effective manner is to by-pass attempting to use SVE for the deep soils and directly implement ISTR.*

EPA Response: The decision on whether or not to implement *in-situ* thermal remediation from the start of the remedial action will be determined during the remedial design. The option of forgoing SVE in deep soils and using *in-situ* thermal remediation for hot-spot soils is available and will be evaluated in remedial design. See response to Comment Nos. 24, 25, and 33 for further discussions.

Comment 38: *With respect to ISTR technologies, the FS is generally on target that the most suitable approach would be to use Thermal Conduction Heating (TCH) due to uncertainty in maintaining sufficient moisture content to enable effective implementation of Electrical Resistance Heating (ERH) approaches. However, for these depths, there is currently only one TCH technology (electrically powered TCH) and associated vendor (TerraTherm/Cascade) capable of bidding and performing the work. To address this limitation, the following provides our recommendations to identify the best technology and approach and ensure competitive bids/pricing (or at the very least, more than one bid):*

c. Collect representative soil samples of the various geologic strata at 2-3 locations within the identified treatment area (a total of 10 to 12) for laboratory characterization of static and dynamic soil resistivity.

d. If the resistivity testing indicates that the deep soils may be suitable for ERH, then *prepare a Request for Proposal (RFP) for either electrically powered TCH or ERH and solicit proposals/bids.*

e. *Identify the "Best Value" proposal based on: health and safety, robustness and flexibility of the heating design, probability of success in achieving the remedial objectives, probability of success in meeting the objectives on time, robustness and flexibility of the pneumatic and hydraulic control and treatment systems, and price.*

EPA Response: The recommendations provided by the commenter will be considered in the pre-design investigation and remedial design. These considerations are not applicable to remedy selection.

Comment 39: *If a thermal remedy is implemented for the Site, the heating and vapor capture systems must be designed to ensure minimal adverse impacts to the existing shallow SVE and SSD system. This will require careful evaluation and potential testing of vapor flow properties and conditions above and in the vicinity of the thermal treatment area. Testing could include installation of deep vapor extraction wells and operation of the wells to determine the anisotropy of the vapor permeability of the soils (kh:kv) and the potential connection between vapor extraction from the deep soils (e.g., 50 to 90 feet) and the operation of the shallow SVE and SSD system. Potential adverse impacts would be escape of COC and steam vapors from the deep thermal treatment interval up to the shallow soils and capture of the COC and steam vapors by the shallow soil systems. This could result in exceeding the COC loading and treatment rates of the shallow systems and/or the temperature rating of the wells, manifold piping, and equipment.*

EPA Response: EPA agrees with the commenter that a pilot study should be conducted for the design of an *in-situ* thermal remediation system to ensure that the contaminants and steam vapors can be fully captured immediately above the heated soils. Escape of contaminants to shallower depths can result in contamination of shallow soils, over-loading the shallow SVE system and increasing the potential for vapor intrusion.

Comment 40: *Due to significant access constraints within the ANC building, the thermal remedy would need to install the wells and manifold piping from outside the treatment area footprint and/or outside the building using angled and/or directional drilling techniques. The engineering and design details for installing the wells using angled and/or directional drilling techniques would need to be carefully evaluated and established during the final remedy design process.*

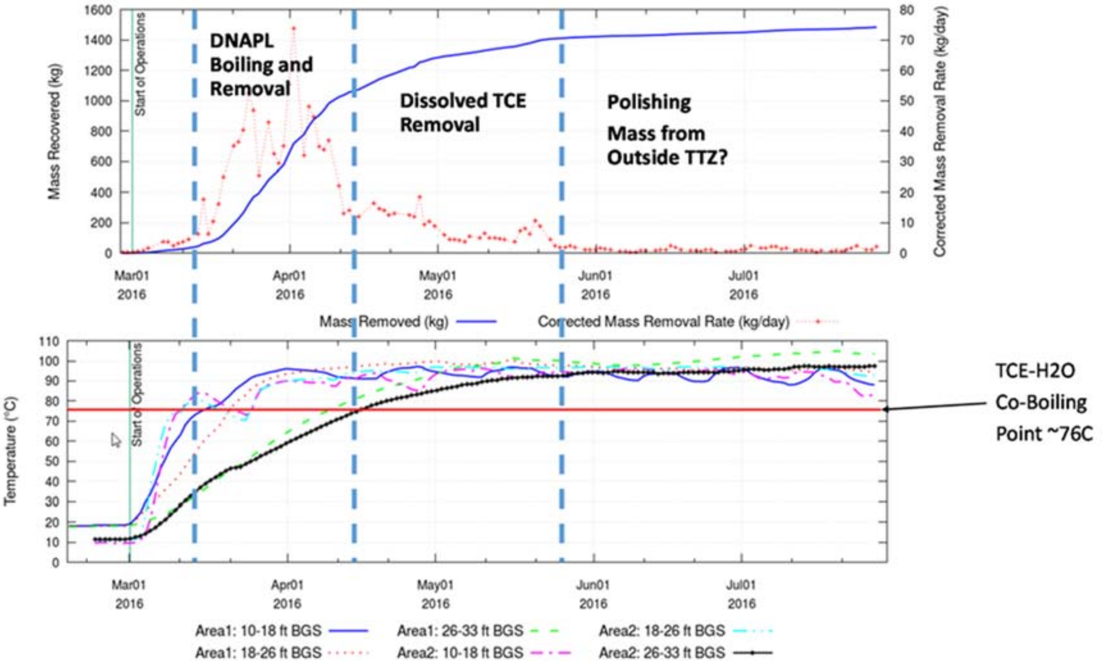
EPA Response: The OU3 RI field work, which is similar in nature to the work to be performed under Alternative 4, has been successfully completed within the Molding Area of the former ANC building in the past in a manner that caused minimal disruption of work activities at the facility. The configuration of the remediation system will be evaluated as part of the remedial design process and can be designed to minimize impacts to the ongoing operation within the facility. See response to Comment Nos. 2, 9, and 10 for further discussions.

Comment 40: *Also, for any thermal remedy implemented for the Site, the performance of* *the system should be evaluated with respect to the following lines of evidence. Because collection of confirmatory soil samples at the Site would be very difficult due to access constraints within the ANC building, the following two lines of evidence would be relied upon for evaluation of ISTR treatment system performance:*

f. Heat-up and thoroughness or uniformity of heating within the targeted treatment zone (e.g., 90% of the temperature sensors within the treatment zone achieve 90^{o}C).

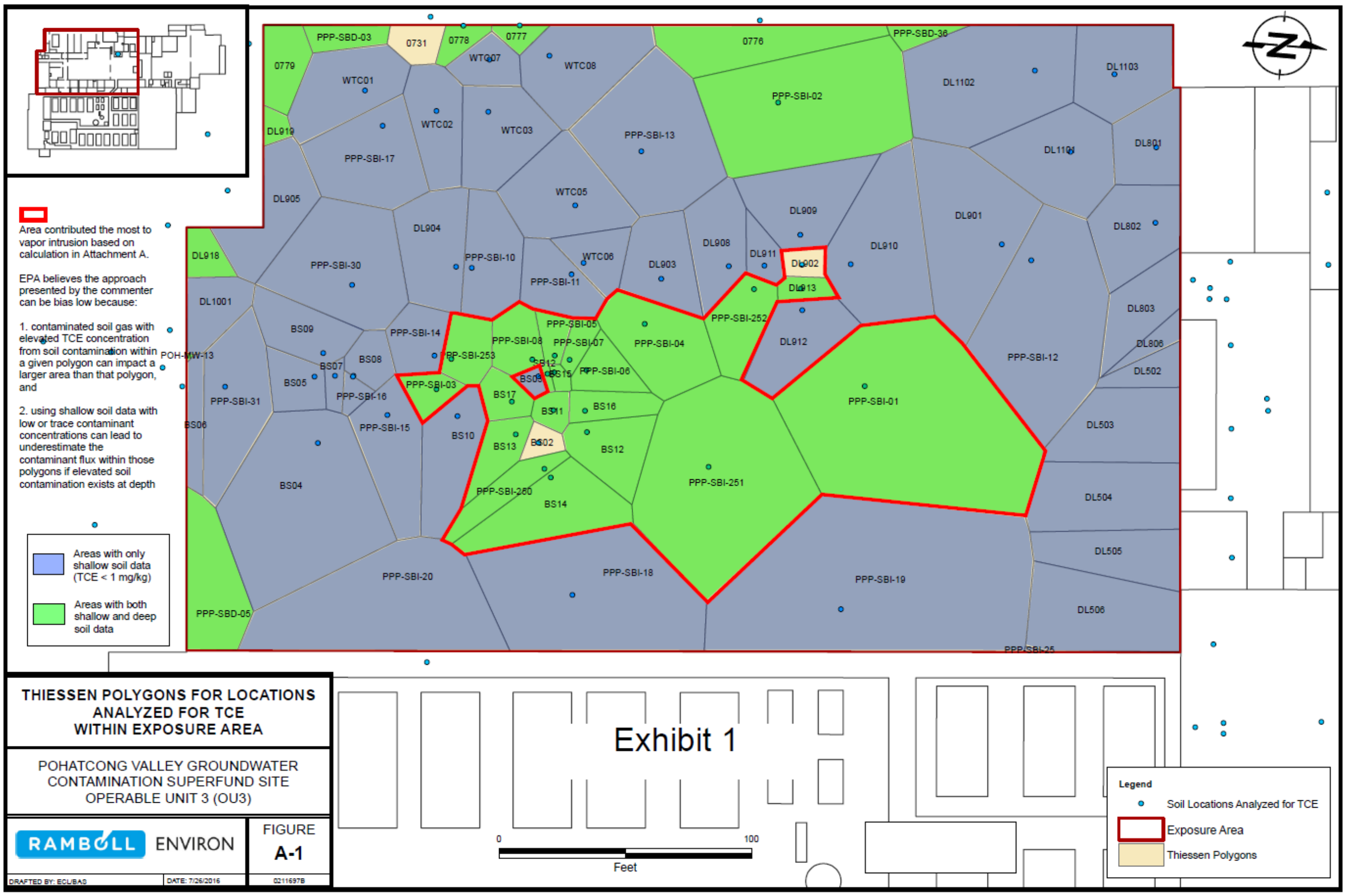
g. Mass removal rates and cumulative mass removed over time. Typically ISTR projects demonstrate a rapid and significant increase in removal rates (e.g., lbs./day of COCs) as significant portions of the site attain critical temperatures such as the co-boiling point of TCE and water (~76 ^{o}C at 1 atmosphere (ATM)) and the boiling point of water (100 ^{o}C at 1 ATM), followed by a pronounced decline in removal rates after two to three months of continued heating until the temperature performance criteria are met.

The following figures illustrate the concepts of how the temperature and COC removal lines of evidence are compared to evaluate performance of an ISTR system.



EPA Response: The recommended monitoring can be conducted during the implementation of *in-situ* thermal remediation to monitor the treatment progress, but cannot be used to determine if the remediation goals are met. Post remediation soil sampling will be required to evaluate the effectiveness of the remedy in meeting remediation goals. However, the details of the monitoring requirements will be developed during the remedial design. See response to Comment No. 28 for further discussions.

EXHIBIT 1



Area contributed the most to vapor intrusion based on calculation in Attachment A.

EPA believes the approach presented by the commenter can be bias low because:

1. contaminated soil gas with elevated TCE concentration from soil contamination within a given polygon can impact a larger area than that polygon, and

2. using shallow soil data with low or trace contaminant concentrations can lead to underestimate the contaminant flux within those polygons if elevated soil contamination exists at depth

🟦 Areas with only shallow soil data (TCE < 1 mg/kg)

🟩 Areas with both shallow and deep soil data

Exhibit 1

Legend

- ● Soil Locations Analyzed for TCE
- 🟥 Exposure Area
- ▨ Thiessen Polygons

THIESSEN POLYGONS FOR LOCATIONS ANALYZED FOR TCE WITHIN EXPOSURE AREA

POHATCONG VALLEY GROUNDWATER
CONTAMINATION SUPERFUND SITE
OPERABLE UNIT 3 (OU3)

RAMBOLL ENVIRON

FIGURE
A-1

DRAFTED BY: ECL/BAS
DATE: 7/26/2016
0211697B

Attachment A: Proposed Plan

Superfund Program Proposed Plan for Operable Unit 3

Pohatcong Valley Groundwater Contamination Site

Warren County, New Jersey

June 2016

EPA ANNOUNCES PROPOSED PLAN

This Proposed Plan identifies the Preferred Alternative to address soil contamination at the Pohatcong Valley Groundwater Contamination Site (PVGWCS) Operable Unit (OU) 3 located in Warren County, New Jersey (the Site), and provides the rationale for this preference. Alternatives have been developed to address soil contaminated with the volatile organic compound (VOC) trichloroethene (TCE).

The U.S. Environmental Protection Agency's (EPA's) Preferred Alternative to address soil contamination in OU3 is Alternative 4: the construction of a deep Soil Vapor Extraction (SVE) system, with optional *in-situ* thermal hot-spot treatment to enhance mass removal.

This Proposed Plan includes a summary of all cleanup alternatives evaluated for OU3. This document is issued by EPA, the lead agency for Site activities, and New Jersey Department of Environmental Protection (NJDEP), the support agency. EPA, in consultation with NJDEP, will select the final remedy for OU3 after reviewing and considering all information submitted during a 30-day public comment period. EPA, in consultation with NJDEP, may modify the preferred alternative or select another response action presented in this Proposed Plan based on new information or public comments. Therefore, the public is encouraged to review and comment on all of the alternatives presented in this document.

EPA is issuing this Proposed Plan for OU3 as part of its public participation responsibilities under Section 117(a) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, or Superfund). This Proposed Plan summarizes information that can be found in greater detail in the OU3 Remedial Investigation (RI) and Feasibility Study (FS) reports and other documents contained in the Administrative Record for the Site.

Mark Your Calendar

June 15, 2016 – July 15, 2016: Public Comment Period on the Proposed Plan.

June 21, 2016, at 6:30p.m.: The EPA will hold a Public Meeting to explain the Proposed Plan, at the Washington Borough Municipal building, 100 Belvidere Avenue, Washington, NJ 07882
Telephone: (908) 689-3600

For more information, see the Administrative Record file (which includes the Proposed Plan and supporting documents), available at the following locations:

Warren County Health Department
700 Oxford Road
Oxford New Jersey, 07863
Telephone: (908) 475-7960
Fax: (908) 475-7964
Website: http://www.co.warren.nj.us/healthdept/
Hours: Monday-Friday: 8:30 am – 4:30 pm

And USEPA-Region II
Superfund Records Center
290 Broadway, 18th Floor
New York, New York 10007-1866
(212) 637-4308 Monday-Friday, 9:00 a.m. - 5:00 p.m.

EPA's website for the Pohatcong Valley Groundwater Contamination Site:
https://www.epa.gov/superfund/pohatcong-valley-groundwater

Written comments on this Proposed Plan should be addressed to:

Michelle Granger
Remedial Project Manager
Southern New Jersey Remediation Section
U.S. Environmental Protection Agency
290 Broadway, 19th Floor
New York, New York 10007-1866
Telephone: (212) 637-4975
Email address: granger.michelle@epa.gov

or

Pat Seppi,
Community Involvement Coordinator
290 Broadway, 26th Floor
New York, New York 10007-1866
Telephone: 212-637-3679
Email address: seppi.pat@epa.gov

SITE DESCRIPTION

The PVGWCS is located in parts of Washington Borough, Washington Township, Franklin Township, and Greenwich Township in Warren County, New Jersey (see **Figure 1**). The PVGWCS includes a groundwater contaminant plume that is approximately 8.5 miles long and 1.5 miles wide. Groundwater contamination primarily consists of TCE and perchloroethylene (PCE). The TCE and PCE plumes join into a combined plume. Pohatcong Valley is a northeast-southwest trending valley that is part of the Delaware River watershed and is drained by Pohatcong Creek and associated tributaries.

Due to its size and complexity, EPA has divided the PVGWCS cleanup into three OUs, referred to as the OU1, OU2, and OU3 Study Areas.

The OU1 Study Area extends approximately 4.5 miles southward from the former American National Can (ANC) facility. It includes TCE and PCE contaminated groundwater within Washington Borough and parts of Washington and Franklin Townships.

The OU2 Study Area is immediately downgradient of OU1 and extends approximately 4 miles southward from there (*i.e.*, extending from approximately 4.5 to 8.5 miles from the former ANC facility). OU2 includes TCE and PCE groundwater contamination located downgradient of OU1 within portions of Franklin and Greenwich Townships.

The OU3 Study Area is located in Washington Borough near Route 31 and includes the former ANC property and several adjacent downgradient properties: Area of Concern 1 (AC1), Warren Lumber Yard (WLY), and Vikon Tile Corporation (VTC)**.** The former ANC property is currently an active industrial facility. Land use for the properties of the OU3 Study Area are mainly commercial and industrial. These properties were identified in the OU1 RI as potentially contributing TCE to the Site-wide groundwater plume. See **Figure 2** for a layout of the ANC, AC1, WLY, and VTC properties.

This Proposed Plan addresses OU3 of the PVGWCS. The OU3 Study Area includes the four properties identified in the OU1 RI that have potentially contributed TCE to the groundwater contamination associated with OU1 and OU2. See **Figure 1** for a layout of the three OU Study Areas.

The OU1 RI indicated that there were elevated TCE concentrations in soil and groundwater in the OU3 Study Area requiring further delineation. PCE was not identified as a contaminant of concern for OU3. TCE-contaminated soil in the OU3 Study Area provides a continuing source of contaminants to groundwater and indoor air. Soils contaminated with TCE were grouped into three areas related to TCE contamination in the OU3 Study Area. These potential TCE contamination source areas have been designated during the OU3 RI as Areas A, B and C described below:

- **Area A**: This area includes the soils beneath the southwestern portion of the ANC building. Drain Lines (DL) DL-9 and DL-10, which connect to discharge structures on the down slope portions of the ANC property, originate in this area of the ANC building.

- **Area B:** This area is located at the DL-9 discharge point. Area B also includes areas down slope of DL-9, including a small portion of the ANC property (west of the railroad spur) and the Warren Lumber Yard (WLY) ponded area that primarily lie in the railroad Right-of-Way (ROW).

- **Area C**: This area is located at the DL-10 discharge point and includes areas down slope of this discharge on the ANC slope drainage area.

RI sampling focused on, but was not limited to these 3 areas. See **Figure 2** for a layout of Areas A, B, and C.

SITE HISTORY

VOCs, specifically TCE and PCE, were detected in groundwater from two public potable-water supply wells in Washington Borough in the late 1970s. The two potable-water supply wells, the Vannatta Street Well and the Dale Avenue Well, are owned and operated by New Jersey American Water Company.

After subsequent investigations conducted by the Warren County Department of Health and NJDEP, NJDEP installed public water-supply connections to homes and businesses within contaminated areas of Washington Township in 1989. Wellhead treatment systems were added to the public wells so groundwater is treated to meet drinking-water standards prior to distribution. EPA included the PVGWCS on the National Priorities List (NPL) of Superfund sites in March 1989.

Regarding the OU1 Study Area, EPA initiated RI/FS activities to delineate the nature and extent of contaminated groundwater and to evaluate potential human health and ecological risks. The OU1 RI documented levels of TCE and PCE in groundwater above drinking water standards. OU1 was subdivided into the OU1-TCE plume (groundwater primarily contaminated with TCE from the former ANC facility) and the OU1-PCE plume (groundwater primarily contaminated with PCE from the former Tung-Sol Tubing facility). The entire OU1 area covers Washington Borough, Washington Township, and the northern portion of Franklin Township. The OU1 PCE plume is significantly smaller than the OU1 TCE plume, and is encompassed solely within Washington Borough. The OU1 TCE plume extends from the former ANC facility approximately 4.5 miles southward to Asbury-Broadway Road. EPA completed the OU1 RI in 2005.

EPA selected a remedy for OU1 in 2006 that includes: 1) the extraction, treatment and reinjection of TCE and PCE contaminated water in the most contaminated areas; 2) monitored natural attenuation for the remediation of contaminated groundwater until cleanup goals are met; and 3) establishing a Classification Exception Area (CEA), to minimize the potential for exposure to contaminated groundwater until the groundwater meets cleanup goals. The groundwater treatment plants have been constructed and are anticipated to be operational in 2016. For further information regarding the OU1 remedy, refer to the July 2006 Record of Decision (ROD). This document can be found in the Administrative Record for the OU3 Study Area and at https://www.epa.gov/superfund/pohatcong-valley-groundwater. See Figure 1 for a layout of the OU1 Study Area.

Regarding the OU2 Study Area, between 2006 and 2009, EPA conducted an RI to determine the nature and extent of contamination beyond the OU1 Study Area. The RI also included an assessment of the hydraulic gradient and hydrogeologic connection between the OU1 and the OU2 Study Areas, and an evaluation of potential human health and ecological risks based on the occurrence and distribution of Site-related contamination in sediment, surface water, residential wells, indoor air, and groundwater. OU2 includes TCE-contaminated groundwater resulting from the OU1-TCE Plume and is located downgradient of the OU1 Study Area in portions of Franklin and Greenwich Townships. EPA selected a remedy for OU2 in September 2010. The OU2 remedy includes the following: 1) providing potable water to impacted and threatened properties through the construction of water mains and service connections; 2) monitored natural attenuation for the remediation of contaminated groundwater until cleanup goals are met; 3) establishing a CEA, to minimize the potential for exposure to contaminated groundwater until cleanup goals are met; and 4) abandoning private potable wells. The engineering design of the OU2 remedy is anticipated to be completed in 2017. For further information, regarding the OU2 remedy refer to the September 2010 ROD. This document can be found in the Administrative Record for the OU3 Study Area at https://www.epa.gov/superfund/pohatcong-valley-groundwater. See Figure 1 for a layout of the OU2 Study Area.

Regarding the OU3 Study Area, in 2011, EPA initiated RI/FS activities to determine the nature and extent of contamination. The RI included an evaluation of potential human health and ecological risks based on Site-related contamination in soil, sediment, surface water and indoor air.

SITE CHARACTERISTICS

Geology/ Hydrology

The PVGWCS is located in the Highlands physiographic province of western New Jersey. The Pohatcong Valley trends northeast-southwest and is underlain by carbonate rocks. Glacial moraine deposits overlay the carbonate bedrock. The glacial deposits are comprised of a mix of glacio-fluvial deposits and till and are characterized as a poorly sorted mixture of sand, silt, and clay with larger clasts ranging from gravel to boulders. The moraine deposits range from 95 feet to greater than 140 feet thick at the OU3 Study Area. In general the permeability of the glacial deposits is low.

The groundwater occurs in the carbonate bedrock aquifer below the overburden. This group of fractured carbonate rocks is part of the Leithsville Formation and is often referred to as the Kittatiny Aquifer System. Near the OU3 Study Area, the depth to groundwater is approximately 100 to 120 feet below ground surface (bgs). Groundwater flow is from the northeast to the southwest, down the axis of the valley.

Investigations

The results of the OU1 RI performed by EPA, as well as investigations performed by other parties, indicated that there were elevated TCE concentrations in soil and groundwater in the OU3 Study Area requiring further delineation. Several investigations were completed between 2012 and 2015 to determine the nature and extent of contamination at the OU3 Study Area. These investigations included: soil investigations, a drainage pathway investigation, groundwater investigations, indoor and sub-slab air sampling investigations, and an ecological characterization.

Soil Investigations

Based on historical soil sampling results, EPA targeted soil investigations throughout the OU3 Study Area, including Areas A, B, and C. From 2012 to 2015, 71 borings were advanced to collect a total of 470 soil samples for chemical analysis to determine the extent of soil contamination. Sample locations are presented on **Figure 3**.

The highest concentrations and most frequent detections of TCE were beneath the southwestern corner of the ANC building (Area A), where TCE degreasers are believed to have been located. Below the ANC building, a total of 165 samples from 30 borings were collected between 2012 and 2015 to determine the extent of soil contamination directly below the ANC building. Out of 28 soil samples collected in shallow soils (< 2 feet bgs) beneath the building slab, TCE was detected in 6 samples at levels ranging from .008 parts per million (ppm) to 2.8 ppm. The maximum concentration was detected under the southwestern corner of the building (Area A). Soil samples from the subsurface soils (soils > 2 feet bgs) showed TCE at levels ranging from non-detect to 120 ppm, with the maximum concentration again detected under the southwestern corner of the building (Area A).

Vertically, TCE is present above 1 ppm throughout the overburden beneath the ANC building and into the weathered bedrock zone to a depth of approximately 100 feet (bgs). Area A has the highest concentrations of TCE in soil at the OU3 Study Area (as high as 120 ppm at a depth of 80 feet bgs). Throughout the vadose zone soils under the building, levels of TCE were above 1 ppm, however a hotspot was identified within Area A at depths between 70 and 100 feet bgs. TCE detections in the groundwater directly under the ANC building (Area A) ranged from 74 parts per billion (ppb) to as high as 120 ppb. The New Jersey Groundwater Quality Standard (NJGWQS) for TCE is 1 ppb. TCE detections were as high as 4,600 ppb in the groundwater 100 feet downgradient from this area, confirming that TCE beneath the ANC building has migrated through the unsaturated overburden into the regional groundwater. The TCE remaining in the soils in Area A is an ongoing source of groundwater and indoor air contamination.

A total of 123 samples from 15 borings were collected outside the ANC building footprint on the ANC property during the OU3 RI, including in Areas B and C. Out of 123 soil samples, TCE was detected in 28 samples as high as 0.74 ppm. The maximum concentration was detected in deep soils downgradient of the DL-10 discharge point (Area C).

Soil samples were also taken on adjacent properties downgradient of the ANC property, AC1, WLY, and VTC. On the WLY property, 58 samples were collected from 9 borings. TCE was found in 36 samples at a range of non-detect to 6.7 ppm, with the maximum concentration found 7 feet bgs in the WLY ponded area, near the DL-9 discharge (Area B). On the AC1 property, 92 soil samples were collected from 12 borings. The maximum TCE detection was 2 ppm in the surface soil downgradient from the DL-10 discharge (Area C). On the VTC property, 32 samples were collected from 5 borings and no TCE contamination was detected.

Soil samples were also analyzed for semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and metals within the OU3 Study Area. SVOCs, PCBs, pesticides, and metals were detected in soil throughout the OU3 Study Area. These detections were isolated occurrences, not found in widespread areas of the OU3 Study Area associated with the TCE contamination. The limited presence of SVOCs, PCBs, pesticides, and metals above guidance values are not Site-related because they are not associated with the TCE-contaminated groundwater. These results will be forwarded to the facility property owner as well as state and local authorities to address under other cleanup authorities, as appropriate.

Drainage Pathway Investigation

Surface water and sediment samples were obtained to determine the nature and extent of contamination in outfall areas, drainage pathways, and ponded water areas. A total of 13 surface water samples and 14 sediment samples were collected throughout the OU3 Study Area including in Areas B and C. It was not possible to collect surface water and sediment samples from Area A, since that area is under the ANC building. Sample locations are presented on **Figure 4**.

Since there are no permanent surface-water features in the OU3 Study Area, samples were collected following a rain event to examine the impact of recharge at areas with soil contamination (*i.e.*, Areas B and C). Surface water and sediment samples were analyzed for VOCs, SVOCs, pesticides, PCBs and metals.

The data suggest that TCE entered the wastewater drainage network inside the Area A portion of the ANC building and that TCE-contaminated water either infiltrated into the ground through cracked drain pipes under the facility or was directed through effluent pipes that then discharged to drainage areas on the eastern (DL-9) and western (DL-10) side of the ANC railroad spur (Areas B and C, respectively).

Compared to the high TCE concentrations in soil underneath Area A of the ANC building (Area A), substantially lower concentrations of TCE were identified throughout Areas B and C of the OU3 Study Area. Area C includes the ANC slope drainage area east of the railroad spur down slope from the DL-10 outfall, which extends into the AC1 drainage basin through an eroded channel, and Area B in the WLY ponded area down slope from the DL-9 outfall on the western side of the ANC property railroad spur. TCE was detected in 103 of 305 samples collected from the four OU3 Study Area properties (not including samples from below the ANC building). TCE in Area C was observed in the surface water (up to 0.11 ppb) and sediment (up to .002 ppm). TCE in Area B was observed in surface water (up to 21 ppb) and sediment (up to .008 ppm).

Residual levels of TCE in subsurface soil throughout the drainage areas indicate likely disposal and transfer of TCE at the ANC facility during historical operations. The data suggests that TCE migrated through overland flow and then infiltration in the drainage areas provided a mechanism for TCE in the surface water and sediment to mobilize from the discharge areas (DL-9 and DL-10), redistribute to the lower portions of the drainage areas, and either migrate into groundwater and/or volatize into the air.

Surface water and sediment samples were also analyzed for SVOCs, pesticides, PCBs, and metals. SVOCs, PCBs, pesticides and metals were detected in surface water and sediment within the OU3 Study Area. The detections were isolated occurrences, not found in widespread areas of the OU3 Study Area associated with the TCE contamination. The limited presence of SVOCs, PCBs, pesticides, and metals above the guidance values are not Site-related and are not associated with the TCE-contaminated groundwater.

Groundwater Investigations

Based on EPA’s OU1 and OU2 comprehensive RI studies, it has been concluded that TCE forms a continuous 8.5 mile groundwater contaminant plume originating in the OU3 Study Area. The extensive OU1 groundwater investigation concluded that TCE is by far the main groundwater contaminant throughout the PVGWCS and the ANC property constitutes the primary source of that TCE. Groundwater samples collected throughout the OU1 Study Area indicate that TCE has migrated down through unconsolidated soils from the ANC property (Area A) into the regional aquifer.

The highest TCE concentration detected in groundwater sampled during the OU1 RI (2,100 ppb) was located immediately downgradient of the ANC facility. Sampling results in the regional aquifer revealed that groundwater underlying the ANC facility is consistently highly contaminated with TCE, with concentrations as high as 4,600 ppb. In addition, a groundwater sample (PPP-SBD-40) collected during the OU3 RI detected TCE at 540 ppb in the southern portion of the ANC property.

A total of 11 perched groundwater samples were collected in both deep and shallow soil borings in perched zones throughout the drainage areas of the OU3 Study Area. Perched water samples were analyzed for VOCs to determine the presence of TCE contamination. TCE levels in perched groundwater ranged from .4 ppb to 820 ppb with the maximum concentration detected in Area C near the base of the AC1 slope, downgradient from the DL-10 discharge point. Sample locations are presented on Figure **3**.

Indoor and Sub-Slab Air Sampling Investigations

Buildings throughout the OU3 Study Area were screened for potential vapor intrusion during the OU3 RI. The only building that had the potential for vapor intrusion was the ANC building. In March 2013, a vapor intrusion investigation was completed within and under the ANC building. Ten sub-slab and ten indoor air samples were collected. Significantly elevated levels of VOC vapors were detected in both sub-slab and indoor air samples. The results indicated that concentrations of TCE in the sub-slab air were significantly above the NJDEP Non-Residential Soil Gas Screening Level (150 micrograms per cubic meter, or $\mu g/m^3$) and indoor air concentrations were well above the Site-specific indoor air health goal of 7 $\mu g/m^3$ developed by EPA and the Agency for Toxic Substances and Disease Registry (ATSDR). The highest level of TCE in the sub-slab was found to be 480,000 ug/m^3. This concentration was detected under Area A. Indoor air TCE concentrations up to 180 ug/m^3 were also detected in Area A.

During the summer of 2013, soil vapor extraction (SVE) and sub-slab depressurization (SSD) systems to mitigate exposure to TCE inside the building were installed. The systems treat the soils to a depth of approximately 5 feet below the building slab. Results of subsequent sampling show the systems have reduced concentrations in the indoor and sub-slab air significantly and indoor air levels are below the Site-specific indoor air health goal of 7 $\mu g/m^3$.

Ecological Characterization

OU3 Study Area habitats were characterized for the ANC, AC1, VTC, and WLY properties. It was determined that no endangered, threatened or sensitive species were present within ¼ mile of the Site and that investigation and cleanup of the OU3 Study Area would have no effect on any federally listed threatened or endangered species or critical habitats.

SCOPE AND ROLE OF THE ACTION

EPA has addressed the cleanup of this Site by implementing both immediate and long-term cleanup actions.

With respect to immediate actions taken in the OU3 Study Area, in 2013 an action was performed which included the installation of SVE and SSD systems to mitigate exposure to TCE in the indoor air of the building. As noted above, results of subsequent sampling show the systems have reduced concentrations in the indoor air below levels of concern. The SVE/SSD systems continue to operate at the ANC building.

The long-term cleanup at the Site is being conducted in three phases, or operable units.

- OU1, which was the subject of a 2006 ROD, provides for the implementation of a remedy to address groundwater contamination, including: 1) the extraction, treatment and reinjection of TCE and PCE contaminated water in the most contaminated areas; 2) monitored natural attenuation for the remediation of contaminated groundwater until cleanup goals are met; and 3) establishing a CEA, to minimize the potential for exposure to contaminated groundwater until the groundwater meets cleanup goals.

- OU2, which was the subject of a 2010 ROD, provides for the implementation of a remedy to address groundwater contamination, including: 1) providing potable water through the construction of water mains and service connections; 2) monitored natural attenuation for the remediation of contaminated groundwater until cleanup goals are met; 3) establishing a CEA, to minimize the potential for exposure to contaminated groundwater until the groundwater meets cleanup goals; and 4) abandoning private potable wells.

- OU3, which is the subject of this Proposed Plan, will address the TCE contaminated soils that constitute a source of contamination to groundwater and indoor air at the Site. The OU3 ROD is expected to be the final remedy selected for this Site.

Principal Threats

Soils with elevated levels of TCE in the vadose zone underlying the ANC building are considered principal threat wastes. Addressing these contaminated soils will have a positive impact on the planned groundwater remediation, as they are an ongoing source of contamination to groundwater and indoor air at this Site (see inset box).

WHAT IS A "PRINCIPAL THREAT"?

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP Section 300.430(a)(1)(iii)(A)). The "principal threat" concept is applied to the characterization of "source materials" at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, surface water or air, or acts as a source for direct exposure. Contaminated groundwater generally is not considered to be a source material; however, Non-Aqueous Phase Liquids (NAPLs) in groundwater may be viewed as source material. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur. The decision to treat these wastes is made on a site-specific basis through a detailed analysis of the alternatives using the nine remedy selection criteria This analysis provides a basis for making a statutory finding that the remedy employs treatment as a principal element.

WHAT IS RISK AND HOW IS IT CALCULATED?

A Superfund baseline human health risk assessment is an analysis of the potential adverse health effects caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these under current- and future-land uses. A four-step process is utilized to assess site-related human health risks for reasonable maximum exposure scenarios.

Hazard Identification: In this step, the chemicals of potential concern (COPCs) at a site in various media (*i.e.*, soil, groundwater, surface water, and air) are identified based on such factors as toxicity, frequency of occurrence, and fate and transport of the contaminants in the environment, concentrations of the contaminants in specific media, mobility, persistence, and bioaccumulation.

Exposure Assessment: In this step, the different exposure pathways through which people might be exposed to the contaminants identified in the previous step are evaluated. Examples of exposure pathways include incidental ingestion of contaminated groundwater. Factors relating to the exposure assessment include, but are not limited to, the concentrations that people might be exposed to and the potential frequency and duration of exposure. Using these factors, a reasonable maximum exposure scenario, which portrays the highest level of human exposure that could reasonably be expected to occur, is calculated.

***Toxicity Assessment**:* In this step, the types of adverse health effects associated with chemical exposures and the relationship between magnitude of exposure and severity of adverse effects are determined. Potential health effects are chemical-specific and may include the risk of developing cancer over a lifetime or other noncancer health effects, such as changes in the normal functions of organs within the body (*e.g.*, changes in the effectiveness of the immune system). Some chemicals are capable of causing both cancer and noncancer health effects.

Risk Characterization: This step summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site risks. Exposures are evaluated based on the potential risk of developing cancer and the potential for non-cancer health hazards. The likelihood of an individual developing cancer is expressed as a probability. For example, a 10^{-4} cancer risk means a one-in-ten-thousand excess cancer risk; or one additional cancer may be seen in a population of 10,000 people as a result of exposure to site contaminants under the conditions explained in the Exposure Assessment. Current guidelines for acceptable exposures are an individual lifetime excess cancer risk in the range of 10^{-4} to 10^{-6} (corresponding to a one-in-ten-thousand to a one-in-a-million excess cancer risk) with 10^{-6} being the point of departure. For noncancer health effects, a hazard index (HI) is calculated. An HI represents the sum of the individual exposure levels compared to their corresponding reference doses. The key concept for a non-cancer HI is that a threshold level (measured as an HI of less than 1) exists below which non-cancer health effects are not expected to occur.

RISK SUMMARY

The purpose of the risk assessment is to identify potential cancer risks and noncancer health hazards at the Site assuming that no further remedial action is taken. A baseline human-health risk assessment was performed to evaluate current and future cancer risks and noncancer health hazards based on the results of the RI. A screening-level ecological risk assessment was also conducted to assess the risk posed to ecological receptors due to Site-related contamination.

Human-Health Risk Assessment

As part of the RI/FS, a baseline human-health risk assessment (BHHRA) was conducted to estimate the risks and hazards associated with the current and future effects of contaminants on human health and the environment. A baseline human-health risk assessment is an analysis of the potential adverse human-health effects caused by hazardous-substance exposure in the absence of any actions to control or mitigate these under current and future land uses.

A four-step human-health risk assessment process was used for assessing Site-related cancer risks and noncancer health hazards (see inset box "What is Risk and How is it Calculated"). The four-step process is comprised of: Hazard Identification of Chemicals of Potential Concern (COPCs), Exposure Assessment, Toxicity Assessment, and Risk Characterization.

The BHHRA began with selecting COPCs in the various media (*i.e.*, soil, subsurface soil, etc.) that could potentially cause adverse health effects in exposed populations. The current and future land use scenarios included the following exposure pathways and populations:

- Site Workers (adult): current/future ingestion, dermal contact and inhalation of soil particles and vapors related to surface soil from the ANC and WLY properties. In addition, the AC1/VTC/railroad property was evaluated for future exposures.
- Trespassers (adolescent): current ingestion, dermal contact and inhalation of soil particles and vapors related to surface soil and ingestion and dermal contact from surface water and sediment from the AC1/VTC/railroad property.
- Construction Workers (adult): future ingestion, dermal contact and inhalation of soil particles and vapors from both surface and subsurface soil related to ANC, WLY, and AC1/VTC/railroad properties.
- Residents (child/adult): future hypothetical ingestion, dermal contact and inhalation of soil particles and vapors related to surface soil from the ANC, WLY and AC1/VTC/railroad properties.

In this assessment, exposure point concentrations were estimated using either the maximum detected concentration of a contaminant or the 95 percent upper-confidence limit (UCL) of the average concentration. Chronic daily intakes were calculated based on the reasonable maximum exposure (RME), which is the highest exposure reasonably anticipated to occur at the Site. The RME is intended to estimate a conservative exposure scenario that is still within the range of possible exposures. Central tendency exposure (CTE) assumptions, which represent typical average exposures, were also developed. A complete summary of all exposure scenarios can be found in the baseline human-health risk assessment.

In addition, indoor air and groundwater are also considered as part of assessing risk at the OU3 Study Area.

Surface Soil

Risks and hazards were evaluated for current and future exposure to surface soil. The populations of interest included adult Site workers, adolescent trespassers and adult/child residents. The cancer risks for all of the receptor populations evaluated were within or below the acceptable EPA risk range of 1 x 10^{-6} to 1 x 10^{-4} with the exception of the adult/child resident for ANC and AC1/VTC/Railroad properties, which were above the acceptable cancer risk range. The hazard indexes for all of the receptor populations evaluated were below the EPA acceptable value of 1 with the exception of the adult/child resident for all properties. The primary contaminants associated with the elevated risks and hazards were arsenic, chromium, vanadium, and PCBs. The risks and hazards for TCE and the breakdown products, all which are Site-related contaminants, were all below or within EPA acceptable ranges.

Since the contaminants that are associated with the cancer risk and noncancer hazards above acceptable EPA criteria are not considered to be Site-related contaminants, there were no contaminants of concern (COCs) identified for surface soil.

Surface and Subsurface Soil

Risks and hazards were evaluated for the potential future exposure to surface and subsurface soil. The population of interest included adult construction workers. The cancer risks were below or within the EPA acceptable ranges. The non-cancer hazards were below the EPA acceptable value of 1, with the exception of the construction worker for the AC1/VTC/Railroad property. There were no Site-related COCs identified in the surface/subsurface soil.

Since the contaminants that are associated with the cancer risk and noncancer hazards above acceptable EPA criteria are not considered to be Site-related contaminants, there were no COCs identified for surface and subsurface soil.

Sediment and Surface Water

Risks and hazards were evaluated for the potential current exposure to sediment and surface water. The population of interest included adolescent trespassers at the AC1/VTC/Railroad property. The surface water is intermittent as it is associated with rainfall and standing water in low lying areas. Due to the lack of a consistent surface water body, the surface water was not evaluated quantitatively in the risk assessment. The cancer risks calculated for sediment exposure exceeded the EPA acceptable ranges. The non-cancer hazards for sediment exposure also exceeded the EPA acceptable value of 1. The primary contaminants associated with the elevated sediment risks are PCBs. There were no Site-related COCs identified in the sediment or surface water.

Since the contaminants that are associated with the cancer risk and noncancer hazards above acceptable EPA criteria are not considered to be Site-related contaminants, there were no COCs identified for surface soil.

Vapor Intrusion

Risks and hazards were evaluated for the potential exposure of workers at the ANC building to TCE by the intrusion of vapors from contaminated soils and groundwater. Sub-slab soil vapor concentrations of TCE beneath the ANC building continue to exceed the 10^{-6} screening criteria. Indoor air vapor concentrations of TCE exceeded the 10^{-6} screening criteria by several orders of magnitude. Indoor air vapor concentrations are currently below the screening criteria due to the ongoing operation of the SVE and SSD systems, which were installed in 2013. With the vapor mitigation systems operational, the vapor intrusion exposure pathway is incomplete.

Groundwater

As noted above, TCE is the main OU1 groundwater contaminant and the ANC property (OU3) constitutes the primary source of that TCE. With TCE as the primary COC in the groundwater, and since groundwater in the regional aquifer within the OU1 Study Area is used as a potable water supply, the OU1 risk assessment evaluated the risks associated with exposures to the groundwater in the OU1 Study Area for industrial/commercial and residential use. The results of the OU1 baseline risk assessment indicate that the TCE-contaminated groundwater within OU1 poses an unacceptable risk to human health. The hazards and risks associated with exposure to the regional groundwater within the OU1 Study Area, which begins in the OU3 Study Area, result in risks above EPA's target risk levels for both industrial and residential scenarios.

Although other contaminants were detected in groundwater and contribute to risk, TCE by far presents the most concern. In contrast to the TCE groundwater contamination, other contaminants identified are limited in extent, and are localized inside and outside the TCE plume. As noted above, the TCE plume extends approximately 8.5 miles from the OU3 Study Area.

Human Health Risk Assessment Summary

Based on the results of the OU1 and OU3 human-health risk assessments, there are unacceptable risks associated with Site-related contamination in indoor air and groundwater.

Ecological Risk Assessment

A screening-level ecological risk assessment (SLERA) was conducted to evaluate the potential for ecological risks from the presence of contaminants in surface soil, sediments and surface water. The SLERA focused on evaluating the potential for impacts to sensitive ecological receptors to Site-related constituents of concern through exposure to soil, sediments and surface water on the combined properties (ANC, WLY and ACI/VTC/Railroad). Surface soil, sediment and surface water concentrations were compared to ecological screening values as an indicator of the potential for adverse effects to ecological receptors. A complete summary of all exposure scenarios can be found in the SLERA.

Surface Soil

The surface soil screening criteria were exceeded for metals (antimony, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, selenium, vanadium, and zinc), pesticides (aldrin and dieldrin), SVOCs, (benzo[a]anthracene, fluoranthene, and pyrene), and PCBs (*i.e.*, Aroclor 1248), which resulted in HIs greater than the acceptable value of 1. None of these compounds are considered to be Site-related.

Sediment

The sediment screening criteria were exceeded for metals (antimony, arsenic, cadmium, chromium, copper, cyanide, iron, lead, manganese, mercury, nickel, and zinc), pesticides (4,4'-DDE, 4,4'-DDT, aldrin, dieldrin, endosulfan, endosulfan sulfate, endrin, gamma-chlordane, and heptachlor), SVOCs (2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k] fluoranthene, chrysene, dibenzo[a,h]anthracene, fluoranthene, hexachlorobenzene, indeno[1,2,3-cd] pyrene, phenanthrene, and pyrene), and PCBs (*i.e.*, Aroclor 1248), which resulted in HIs greater than the acceptable value of 1. None of these compounds are considered to be Site-related.

Surface Water

The surface water screening criteria were exceeded for metals (aluminum, cadmium, chromium, copper, iron, lead, manganese, nickel, and zine) and PCBs (*i.e.*, Aroclor 1248), which resulted in HIs greater than the acceptable value of 1. None of these compounds are considered to be Site-related.

Ecological Risk Assessment Summary

No concentrations of Site-related chemicals (*i.e.*, TCE) were detected at concentrations above ecological screening criteria, therefore there were no ecological COCs identified for the Site. In addition, there is limited habitat present on the Site for ecological receptors. Based on the results of the SLERA there are no unacceptable risks or hazards associated with Site-related contamination.

Conclusion of the Risk Assessment

While evaluated as part of the OU3 investigations, no OU3-related risks were found on the adjacent AC1, VTC, Railroad or WLY properties; please refer to the OU3 RI Report and OU3 BHHRA for further detail on the results of these investigations. Further, based on the results of the OU3 human-health and ecological risk assessments it has been concluded that no Site-related risks are attributable to Areas B & C. Based on the results of the OU1 and OU3 human-health risk assessments, there are unacceptable risks associated with Site-related contamination in indoor air and groundwater. TCE in soils beneath the ANC building (Area A) will need to be addressed in order to ensure continued protection of human health and the environment. In addition, TCE contamination in soil under the ANC building poses a risk to the groundwater as it acts as a continuing source of contamination.

REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) are specific goals to protect human health and the environment. These objectives are based on available information and standards, such as applicable or relevant and appropriate requirements (ARARs), to-be-considered (TBC) guidance, and Site-specific risk-based levels.

RAOs have been developed to focus on reducing the impact from the contaminated vadose zone soils (unsaturated zone of soil and rock above the water table) to the groundwater quality and the indoor air. The RAOs for the OU3 Study Area are:

For contaminated soil:

- Reduce contaminant mass in the vadose-zone soil to minimize the impact to groundwater quality.
- Reduce contaminant mass in the vadose-zone soil to minimize the potential human-health risks from vapor intrusion.

For soil vapor:

- Mitigate impacts to public health resulting from existing, or the potential for, soil vapor intrusion into buildings.

To achieve these RAOs, remediation goals for contaminated soil and soil vapor at the Site were identified.

Modeled calculations demonstrate that a TCE soil concentration of 1 ppm would result in minimal impact to TCE concentrations in groundwater at the OU1 groundwater treatment plant extraction wells, thus, would be protective of groundwater at this Site. Therefore, a Site-specific remediation goal of 1 ppm has been established for TCE in the vadose-zone soil.

The Site-specific indoor air health goal of 7 $\mu g/m^3$ developed by EPA and ATSDR is a TBC criterion. Using collected sub-slab and indoor air concentrations, a Site-specific attenuation factor from sub-slab vapor to indoor air was developed. Using the Johnson & Ettinger Model for Subsurface Vapor Intrusion into Building, a soil cleanup value of 1 ppm for TCE was determined to be protective of human-health.

SUMMARY OF REMEDIAL ALTERNATIVES

CERCLA Section 121(b)(1), 42 U.S.C. Section 9621(b)(1), mandates that remedial actions must be protective of human health and the environment, cost-effective, comply with ARARs, and utilize permanent solutions and alternative treatment technologies and resource recovery alternatives to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions which employ, as a principal element, treatment to permanently and significantly reduce the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants at a Site.

Potential applicable technologies were identified and screened in the FS using effectiveness, implementability, and cost as the criteria, with emphasis on the effectiveness of the remedial action. The retained technologies were combined into four remedial alternatives. A brief summary of the remedial alternatives for the Site is provided below.

The timeframes for implementation of alternatives do not include the time for designing the remedy or the time to procure necessary contracts. Because each of the action alternatives are expected to take longer than five years to reach cleanup criteria, a Site review will be conducted every five years (five-year reviews) until remedial goals are achieved.

With the exception of the No Action alternative, all alternatives would include the following common elements: a deed notice which will assure the implementation of all aspects of the OU3 remedy; operation, maintenance and monitoring of the existing shallow soil vapor extraction (SVE) and sub-slab depressurization (SSD) systems; and five-year reviews.

Detailed descriptions of the remedial alternatives for the OU3 Study Area can be found in the FS report.

Alternative 1 – No Action

The No Action Alternative was retained, as required by the National Oil and Hazardous Substances Contingency Plan (NCP), and provides a baseline for comparison with other Site remedial alternatives. No remedial actions would be implemented to address the TCE-contaminated soil as part of the No Action Alternative.

Under the No Action alternative, the ANC building acts as an impermeable cap, which reduces the infiltration beneath the ANC building; significantly slows down contaminant migration into groundwater; and prolongs the existence of contamination in the vadose zone.

Under this alternative, the shallow SVE and SSD systems, which are currently operating in order to address indoor air TCE contamination, are assumed to be not in operation. No remedial action or monitoring would be performed.

Capital Cost:	$0
Annual O&M Cost:	$0
Present-Worth Cost	$0
Construction Timeframe:	0 years
Timeframe to reach RAOs	> 100 years

Alternative 2 – Limited Action

Under this alternative, the existing shallow SVE and SSD systems would be operated and maintained. The shallow SVE and SSD systems create a negative pressure through a series of extraction wells. The extraction wells are used to collect the contaminated air, which is then treated to remove contaminants through the use of granular activated carbon. The operation of the shallow SVE and SSD systems provides protection of human health from vapor intrusion. The shallow SVE and SSD systems treat contaminated soil vapor in the sub-slab down to approximately 5 feet under the slab. TCE concentrations in the most recent indoor air sampling event ranged from non-detect to 1 µg/m^3, which meet the Site-specific indoor air health goal and demonstrate that the system is effective.

Capital Cost:	$0
Annual O&M Cost:	$185,000
Present-Worth Cost:	$2,370,000
Construction Timeframe:	0 years
Timeframe to reach RAOs	>100 years

Alternative 3 – *In-Situ* Chemical Oxidation

Under this alternative, *in-situ* chemical oxidation (ISCO), in conjunction with the shallow SVE and SSD systems, would be implemented to remediate the contaminated area beneath the ANC building. The shallow SVE and the SSD systems would be operated as described in Alternative 2. The ISCO treatment would involve injecting an oxidant or oxidant releasing compounds into the target treatment zone containing TCE at levels of greater than 1 ppm in the soil. The oxidant would mix with the contaminants and cause them to decompose. When the process is complete, only water and innocuous breakdown products would be left in the treated area. Monitoring would be required to determine the effectiveness of the treatment. For the ISCO treatment, the chemical distribution would require enhancement by environmental hydraulic fracturing, which involves the injection of an amendment under a moderate pressure to create flow paths to enhance oxidant distribution. For this alternative, permanganate is assumed as the representative oxidant for alternative development and estimating costs. During the remedial design (RD), other process options would be evaluated based on bench-study and pilot study results to select the most effective oxidant to treat the Site.

For the remedial action, environmental hydraulic fracturing would be conducted followed by the delivery of chemicals (*e.g.*, permanganate solution) using a network of injection wells. Multiple applications of treatment agents are anticipated as the injected chemical would infiltrate into a deeper depth by gravity. A monitoring well screened at the groundwater table would be installed at the downgradient edge of the injection area to monitor the migration of contaminants and /or oxidant into the aquifer.

After completion of multiple rounds of ISCO treatment, soil borings would be installed within the treatment zone to evaluate the effectiveness of treatment. Data from soil sampling and analysis and groundwater samples below the treatment zone could also be used to evaluate the mass reduction. Due to the challenges in adequate distribution of oxidant in vadose zone soils, it is estimated that approximately 50 percent mass removal could be achieved within the treatment zone based on prior experience. The remaining soil contamination left in place would migrate to the building sub-slab as soil gas and be extracted by the shallow SVE and SSD systems or migrate to groundwater and be addressed under the OU1 remedy.

Capital Cost:	$10,300,000
Annual O&M Cost:	$185,000
Present-Worth Cost:	$12,600,000
Construction Timeframe:	3 years
Timeframe to reach RAOs	> 30 years

Alternative 4 – Deep SVE with Optional *In-Situ* Thermal Hot-Spot Treatment

Under this alternative, the shallow SVE and the SSD systems would be operated as described in Alternative 2. A deep SVE system would be installed from 30 to 100 feet bgs to remediate the deep vadose zone contamination beneath the ANC building to meet the Site-specific remediation goal. The deep SVE would operate by the same principles as the shallow SVE, except it would be located in a deeper interval. The shallow SVE system has been successfully remediating the shallow soil. The lithology in the deeper soils is similar to the shallow soils, indicating that it is likely that the deep SVE would be effective in treating the deeper soils. During the RD, a pilot study would be performed to obtain additional design parameters and also to determine the full effectiveness of a deep SVE system. If, due to Site specific conditions (such as excess moisture in the deep zone), the deep SVE could not effectively achieve the remediation goal in a reasonable timeframe, this alternative includes the option to implement *in-situ* thermal treatment. *In-situ* thermal treatment would be used if necessary to remediate the most contaminated zone (hot-spot) where contamination would likely persist, in addition to the deep SVE system. EPA would evaluate the necessity of implementing *in-situ* thermal treatment during the remedial design and/or during the operation of the deep SVE system. *In-situ* thermal treatment entails heating the treatment zone soils to a high temperature that can volatilize TCE into soil gas, which would then be captured by the deep SVE system.

After the first few years (approximately 3 to 5 years) of operation of the deep SVE system, as TCE concentrations in the extracted vapor reach the asymptotic level, the operation of the SVE system would likely become intermittent. The mass removal rate and the TCE concentration rebound (especially at the hot-spot) during the deep SVE system shutdown period would be evaluated. Options for optimizing the system would be evaluated. Soil samples may also be collected and compared to the Site-specific remediation goal for TCE. The option of implementing *in-situ* thermal hot-spot treatment would be evaluated as one of the optimization options for the deep SVE system in order to meet the remediation goal in a reasonable timeframe.

If *in-situ* thermal treatment is implemented, it is anticipated to be conducted between 60 and 100 feet bgs at the hot-spot under the ANC building. *In-situ* thermal hot-spot treatment is estimated to operate for 6 months. After the completion of *in-situ* thermal treatment, soil samples would be collected from the treatment zone to evaluate the treatment effectiveness. More than 90 percent mass removal of TCE is anticipated for this alternative.

Deep SVE without *in-situ* Thermal Treatment:

Capital Cost:	$3,500,000
Annual O&M Cost:	$609,000
Present-Worth Cost:	$7,800,000
Construction Timeframe:	2.5 years
Timeframe to reach RAOs	10 years

Deep SVE with *In-Situ* Thermal Treatment

Capital Cost:	$9,200,000
Annual O&M Cost:	$410,000
Present-Worth Cost:	$12,700,000
Construction Timeframe:	4 years
Timeframe to reach RAOs	10 years

EVALUATION OF ALTERNATIVES

Nine criteria are used to evaluate the different remedial alternatives individually and against each other in order to select the best alternative. This section of the Proposed Plan profiles the relative performance of each alternative against the nine criteria, noting how it compares to the other alternatives under consideration. The nine evaluation criteria are discussed below. A more detailed analysis of the presented alternatives can be found in the FS.

Overall Protection of Human Health and the Environment

With the exception of Alternative 1, all the alternatives provide protection to human health. For the OU3 Study Area, human health risks and ecological risks associated with Site-related contaminants from direct contact with soils are within EPA's acceptable range. However, human health risks from exposure to elevated levels of TCE in the indoor air are above the EPA's acceptable range. Under Alternative 1, human health would not be protected, since the shallow SVE and SSD systems would not be in place to mitigate vapor intrusion. Under Alternatives 2, 3 and 4, vapor intrusion at the ANC building would be effectively mitigated by the operation of the shallow SVE and SSD systems and human health would be protected from vapor intrusion. Therefore, Alternatives 2, 3 and 4 would meet the RAO for soil vapor.

THE NINE SUPERFUND EVALUATION CRITERIA

1. **Overall Protectiveness of Human Health and the Environment** evaluates whether and how an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment.

2. **Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)** evaluates whether the alternative meets federal and state environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified.

3. **Long-term Effectiveness and Permanence** considers the ability of an alternative to maintain protection of human health and the environment over time.

4. **Reduction of Toxicity, Mobility, or Volume (TMV) of Contaminants through Treatment** evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.

5. **Short-term Effectiveness** considers the length of time needed to implement an alternative and the risks the alternative poses to workers, the community, and the environment during implementation.

6. **Implementability** considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.

7. **Cost** includes estimated capital and annual operations and maintenance costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

8. **State/Support Agency Acceptance** considers whether the State agrees with the EPA's analyses and recommendations, as described in the RI/FS and Proposed Plan.

9. **Community Acceptance** considers whether the local community agrees with EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

Under both Alternatives 1 and 2, no or very limited reduction of deep vadose zone TCE soil contamination would occur. Contamination beneath the ANC building would serve as a continuous source for vapor intrusion and groundwater contamination. The RAOs for soil would not be met. Alternative 3 would remove some contaminants in deep vadose zone soils, which would shorten the operation of the shallow SVE and SSD systems and groundwater pump and treat system under OU1 compared to Alternatives 1 and 2. Therefore Alternative 3 provides some protection of the environment. Alternative 4 would have the highest removal of contamination underneath the ANC building and offer the highest degree of protectiveness of all of the alternatives. The vadose zone soil would no longer serve as a source for groundwater contamination. Alternatives 3 and 4 would achieve the RAOs.

Compliance with ARARs

There are no promulgated federal chemical-specific ARARs which apply to Site soils and indoor air, the two media of concern for this operable unit. Site contaminant concentrations of TCE in surface and shallow subsurface soil did not exceed the promulgated state chemical-specific ARARs for direct contact with soils, the NJDEP Non-Residential Direct Contact Soil Remediation Standard (NRDCSRS). For TCE, a Site-specific impact to groundwater soil remediation goal and a Site-specific health goal for vapor intrusion were developed for this Site. Alternative 1 would not meet the soil Site-specific remediation goal (1 ppm) and the Site-specific indoor air health goal (7 ug/m^3). Alternatives 2, 3, and 4 would be in compliance with the Site-specific indoor air health goal due to the effective operation of the existing shallow SVE and SSD systems. Alternatives 2 and 3 would not meet the soil remediation goal for TCE. Alternative 4 is expected to meet the soil Site-specific remediation goal for TCE.

Long-Term Effectiveness and Permanence

The highest degree of permanence and long term effectiveness is achieved for those alternatives that result in the greatest removal of contaminants from the Site.

Under Alternative 1, soil contamination would not be remediated and would continue to serve as the source for groundwater contamination and for vapor intrusion. Human health would be at risk from vapor intrusion. Therefore, Alternative 1 does not provide long-term effectiveness and permanence. For Alternative 2, contamination would be removed from the shallow depth, to a depth of about 5 feet below the ANC building. However, the removal of contamination from the deep vadose zone would be minimal. The deep soil contamination would continue to serve as the source for groundwater contamination and for potential vapor intrusion. Alternative 2 would result in the operation of the existing shallow SVE and SSD systems and the OU1 pump and treat system for a long time, possibly hundreds of years. Alternative 3 is expected to remove approximately 50 percent of deep soil contamination and would result in the operation of the existing shallow SVE and SSD systems and the OU1 pump and treat system for more than 30 years. The remaining contamination in the deep vadose zone would continue serving as the source for groundwater contamination and for potential vapor intrusion. The required duration for the operation of the existing shallow SVE and SSD systems and the OU1 pump and treat system would be shortened compared to Alternatives 1 and 2. Alternative 4 would remove approximately 90 percent or more of the contaminant mass within the treatment zone, and the contamination beneath the ANC building would no longer serve as a significant source for groundwater contamination or vapor intrusion. The operation of the existing shallow SVE and SSD system would also be significantly shortened (to 10 years) compared to Alternatives 1, 2, and 3. A few years after the completion of Alternative 4 remediation, the possibility of shutting down the shallow SVE system may be evaluated and the SSDS may be sufficient to mitigate the remaining potential of vapor intrusion.

Residual soil contamination remaining after implementation of Alternatives 2 or 3 would be addressed by the OU1 groundwater remedy. While the OU1 groundwater remedy is considered an adequate and reliable control measure for residual groundwater contaminant sources, it will do little to address the remaining soil contamination. Alternative 4 would be protective of groundwater by removing the source of contamination.

Reduction in Toxicity, Mobility or Volume

Alternative 1 would provide no reduction of toxicity, mobility and volume (T/M/V). Alternative 2 is expected to have very limited reduction of T/M/V since the soil contamination deeper than 5 feet below the ANC building would not be directly targeted for treatment. Alternative 4 would have the highest reduction (more than 90 percent) of contaminant mass from the treatment zone, followed by Alternative 3 (estimated at 50 percent mass reduction). Under Alternative 4, the deep SVE system would extract soil gas, which would contain TCE, from the subsurface soil. The extracted soil gas would then be treated prior to discharge to the atmosphere using vapor phase carbon which would remove TCE from the soil gas through a process called adsorption. Periodically, the carbon would need to be regenerated as the TCE adsorption capacity is exhausted. The adsorbed TCE would then be treated (destroyed) during the carbon regeneration process. Therefore, Alternative 4 would have the highest degree of reduction of T/M/V. Alternative 3 would destroy (oxidize) the contaminants in situ, but results in less reduction of T/M/V than Alternative 4 because only approximately 50 percent of the contaminant would be treated due to the limitations in distributing oxidant in soils under Alternative 3 versus more than 90 percent treatment under Alternative 4.

Short-Term Effectiveness

Alternative 1 would have no short-term impact to the workers, communities, and the environment since no additional remedial action would be conducted. Alternative 2 would have minimal short-term impact to workers, communities, and the environment, since the installation has been completed and the routine operation and maintenance of the shallow SVE and SSD systems is established.

Alternatives 3 and 4 would have greater short-term impacts to the current operation of the facility as compared to Alternatives 1 or 2. The potential impacts may include physical hazards, noise, dust, heavy equipment construction and operations, and emissions Noise and dust control measures could be implemented to minimize the impacts.

Additional significant short-term risks would be present under Alternative 3, as this alternative would involve the handling and temporary storage of a large quantity of high concentration oxidants, which present potential health and fire hazards in an active facility. Special health and safety measures would need to be developed and followed to prevent direct contact to the oxidant by Site workers and to prevent fire and explosion. Environmental hydraulic fracturing would be required to facilitate the delivery of the oxidant to the contaminated soil, likely resulting in the release of some oxidants into the fractured bedrock aquifer. Additional measures would need to be taken to prevent the oxidants from reaching the OU1 groundwater treatment system, which is not equipped to treat the oxidant and would possibly need to be shut down.

Alternative 4 involves the installation of deep SVE wells and piping inside the facility. However, this would be manageable as demonstrated by the shallow SVE system. The carbon treatment system would be located outside of the building. If *in-situ* thermal treatment is implemented, additional closely spaced wells and monitoring points would need to be installed. Additionally, high voltage and current electrical cables would be connected to the heating wells. Electrical safety measures would need to be developed and implemented for in-situ thermal treatment. Access to the treatment area would need to be restricted for the protection and safety of Site workers.

Both Alternatives 3 and 4 would pose significant short-term impact to the current facility operation. Alternative 3 has much higher short-term impact to the current facility operation and the OU1 remedy than Alternative 4 because of the concerns about:

- Storage and handling of a large quantity of oxidants;
- Hydraulic fracturing; and
- Potential impact to OU1 operations.

.

The construction period for Alternative 3 is expected to be 3 years. However, it would take more than 30 years to reach the Site-specific remediation goal (1 ppm). The time frame to reach the Site-specific remediation goal for Alternative 4 with or without *in-situ* thermal treatment is expected to be 10 years.

Implementability

Alternative 1 is the easiest to implement since no action would be taken. Alternative 2 would be the second easiest to implement since the shallow SVE and SSD systems are already in operation. Alternatives 3 and 4 are both implementable, but with both logistic and technical challenges. The implementation of Alternatives 3 and 4 would take up space in the building and would generate dust and noise that would affect the operation of the facility to different degrees. This is manageable since the remediation would be conducted outside the main production area and engineering controls are available to mitigate these challenges. Impacts to the current operations can be minimized through coordination with facility representatives.

Implementing Alternative 3 is technically more challenging than Alternative 4. Distributing oxidants through the heterogeneous, low-permeability formation via flow pathways created by environmental hydraulic fracturing would be much more challenging and less effective than drawing air through the formation under Alternative 4. The shallow SVE system has been successfully distributing air similar to the deep stratigraphy. Additionally, both environmental hydraulic fracturing and *in-situ* chemical treatment in a vadose zone are innovative technologies with less well-established track records of performance. Environmental hydraulic fracturing would need to be properly planned and executed by an experienced vendor to prevent potential adverse impacts to the building. The extent of improvement using hydraulic fracturing to enhance chemical distribution within the vadose zone soil is uncertain. As treatment will only occur in the aqueous phase, the ability to keep the vadose zone soil flooded with oxidant solution for treatment while minimizing oxidant migration into the bedrock aquifer is also uncertain.

Implementing Alternative 4 without *in-situ* thermal treatment would be much easier than Alternative 3. No significant installation and operation issues would be anticipated for the deep SVE system, as the shallow SVE system has been installed without issue and is successfully operating. The addition of *in-situ* thermal treatment into Alternative 4 would increase the implementability issues, but these issues are manageable and would be comparatively easier to manage than Alternative 3. Implementing *in-situ* thermal treatment would likely require additional power supply, would require the establishment of an exclusion zone to handle the electrical hazard, and would require more space both inside and outside of the ANC building for the large quantity of wells, piping, and the above ground treatment system.

Cost

Table 1: Cost Comparison for Alternatives

Remedial Alternative	Capital Cost	Annual Cost	Present Worth
1	0	0	0
2	0	185,000	2.4 million
3	10.3 million	185,000	12.6 million
4 no thermal	3.5 million	185,000 to 609,000	7.8 million
4 w/ thermal	9.8 million	185,000 to 410,000	12.7 million

The estimated capital, annual O&M, and present-worth costs for each of the alternatives are presented in Table 1. The present-worth costs for each alternative were calculated for a period of 30 years based on EPA guidance.

State Acceptance

EPA's Preferred Alternative as presented in this Proposed Plan is under review by the State of New Jersey.

Community Acceptance

Community acceptance of the Preferred Alternative will be evaluated after the public comment period ends and will be described in the Record of Decision. Based on public comment, the preferred alternative could be modified from the version presented in this proposed plan. The Record of Decision is the document that formalizes the selection of the remedy for a Site.

PREFERRED ALTERNATIVE

The Preferred Alternative for achieving remedial action objectives for the soils impacted by Site-related contamination is Alternative 4, Deep Soil Vapor Extraction with Optional *In-Situ* Thermal Hot-Spot Treatment.

Alternative 4 includes the long-term operation and maintenance of the existing shallow SVE/SSD systems, which are successfully remediating shallow soils under the building and protecting indoor air within the ANC building, as well as the installation of a deep SVE system. The deep SVE system will be installed to a depth of approximately 100 feet bgs beneath the ANC building in Area A, to remediate the deep vadose zone contamination. If it is determined by EPA during remedial design or remedial action that the deep SVE system alone will not be sufficient to meet RAOs in a reasonable timeframe, then *in-situ* thermal treatment to remediate the hot-spot area, located within Area A approximately 70 to 100 feet below the building will be implemented. The determination as to whether to implement the *in-situ* thermal treatment in the hot-spot area would be made by EPA either during the remedial design or during the operation of the deep SVE system based on data collected. Groundwater monitoring in the OU3 Study Area will be performed over time to assess the remedy's effectiveness in protecting groundwater.

No significant installation and/or operation issues are anticipated for the deep SVE system, as the currently operating shallow SVE system was installed in 2013 and is currently successfully operating at the Site in Area A. The lithology in the deep zone is similar to that of the shallow zone, and therefore it is believed that SVE alone may be sufficient to meet cleanup goals. However, as stated above, hot-spot remediation by thermal treatment will be employed if needed. After treatment, post-remediation sampling will be performed to confirm that remediation goals have been met. SVE is an established technology, widely employed to treat soils contaminated with volatile organic contaminants, such as this Site.

The Preferred Alternative, Alternative 4, provides the best balance of trade-offs among the alternatives with respect to the evaluation criteria. The Preferred Alternative will be protective of human health and the environment, comply with ARARs, and is expected to meet the RAOs for the Site.

Consistent with EPA policy, five-year reviews will be conducted until remediation goals are achieved. In addition, the existing deed notice will be modified, as appropriate, to include any additional restrictions in order to assure the implementation of all aspects of the OU3 remedy.

Consistent with EPA Region 2's Clean and Green policy, EPA will evaluate the use of sustainable technologies and practices with respect to implementation of the selected remedy.

Based on information currently available, EPA believes that Alternative 4 will achieve RAOs by reducing the impact from the contaminated vadose zone soils to the groundwater and indoor air.

COMMUNITY PARTICIPATION

EPA provided information to the public regarding the cleanup of the OU3 portion of the Pohatcong Valley Groundwater Contamination Superfund Site through public meetings, the Administrative Record file for the Site and announcements published in the Express Times. EPA encourages the public to gain a more comprehensive understanding of the Site and the Superfund activities.

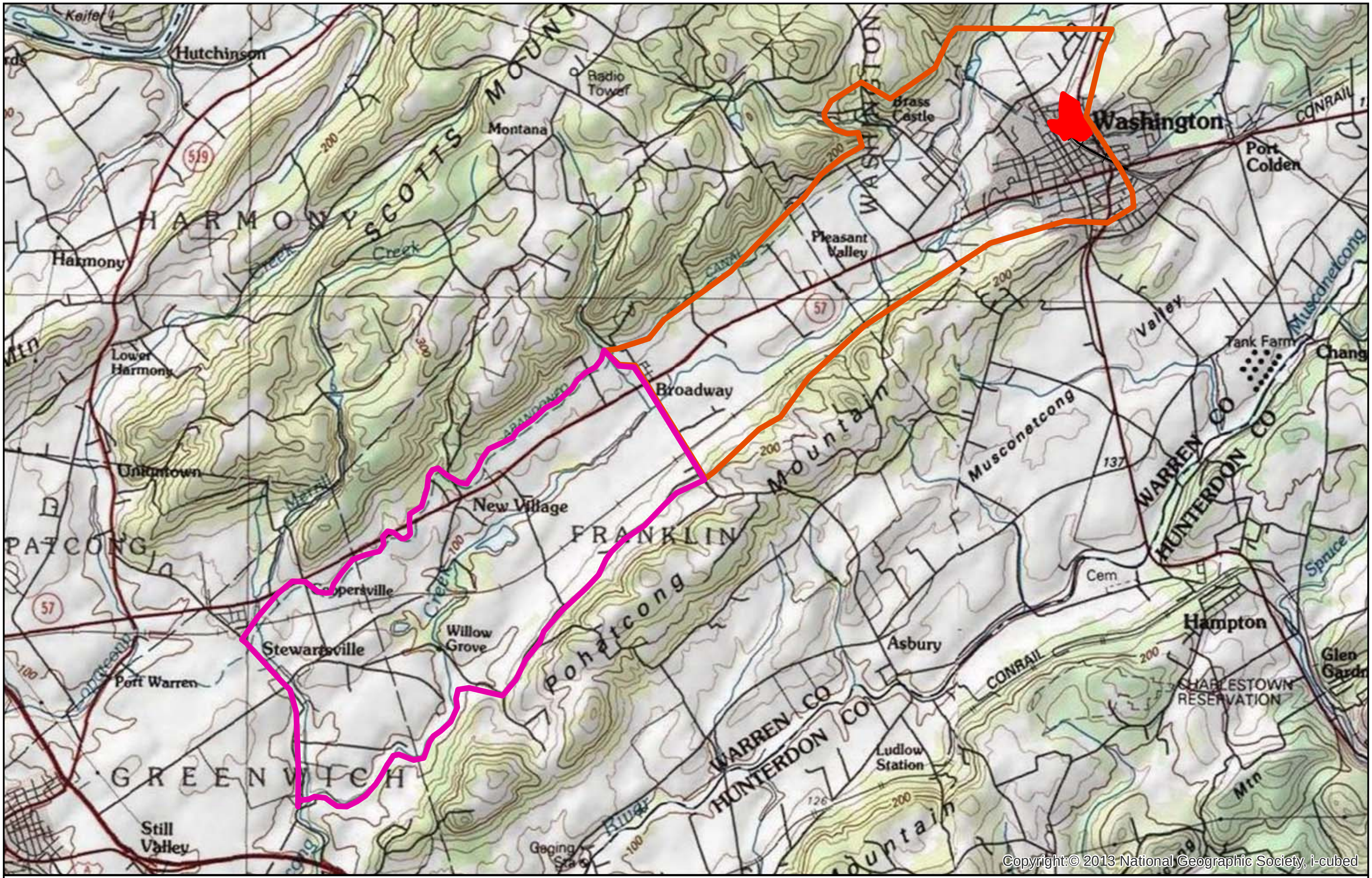
The dates for the public comment period, the date, the locations and time of the public meeting, and the locations of the Administrative Record files, are provided on the front page of this Proposed Plan.

For further information on EPA's Preferred Alternative for the OU3 portion of the Pohatcong Valley Groundwater Contamination Superfund Site, please contact:

Michelle Granger
Remedial Project Manager
(212) 637-4975

Patricia Seppi
Community Relations
(212) 637-3679

U.S. EPA
290 Broadway, 19th Floor
New York, New York 10007-1866



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🟧 OU1 Study Area (approximate)

🟪 OU2 Study Area (approximate)

🟥 OU3 Study Area (approximate)

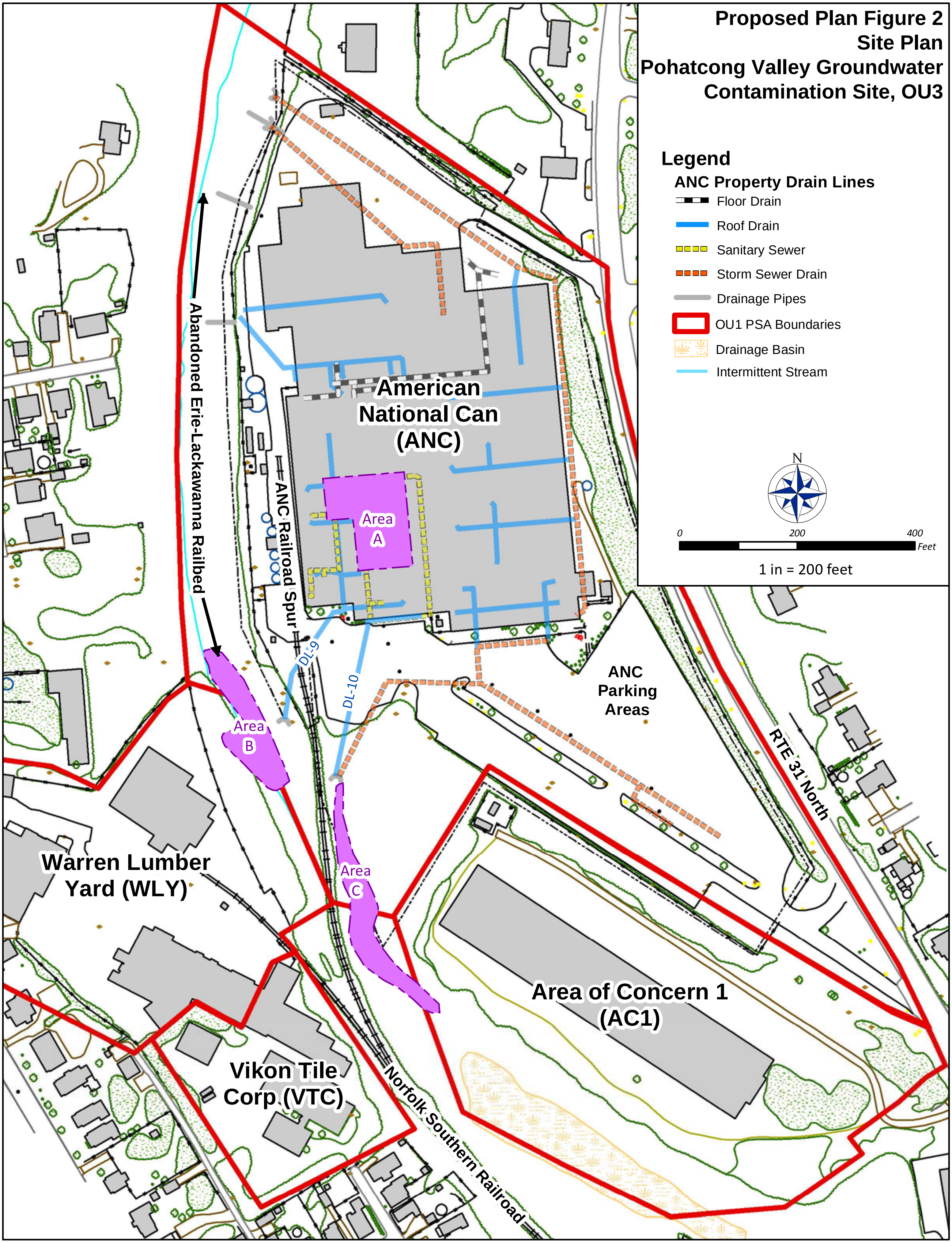
N

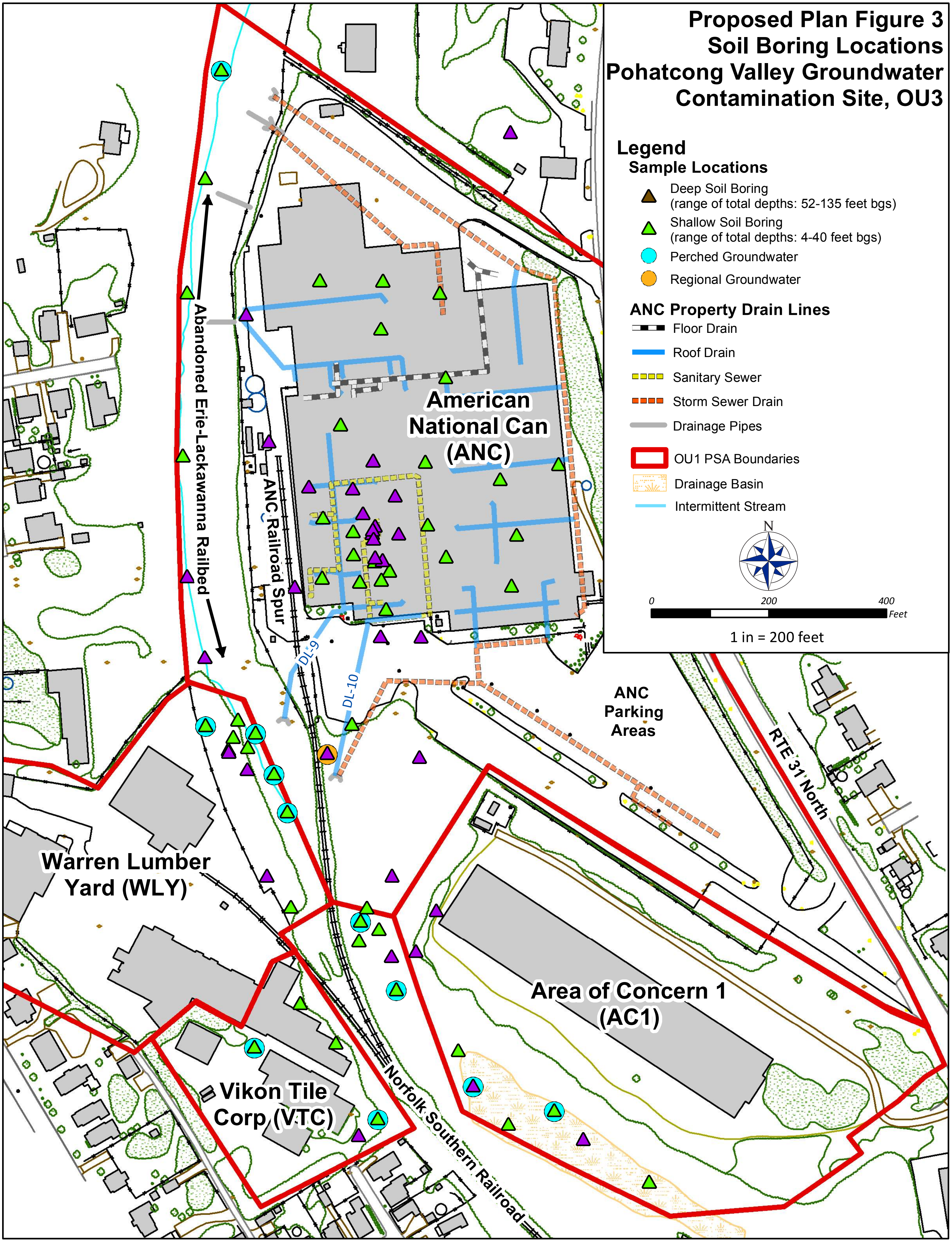
0 6,000 12,000 Feet

1 in = 6,000 feet

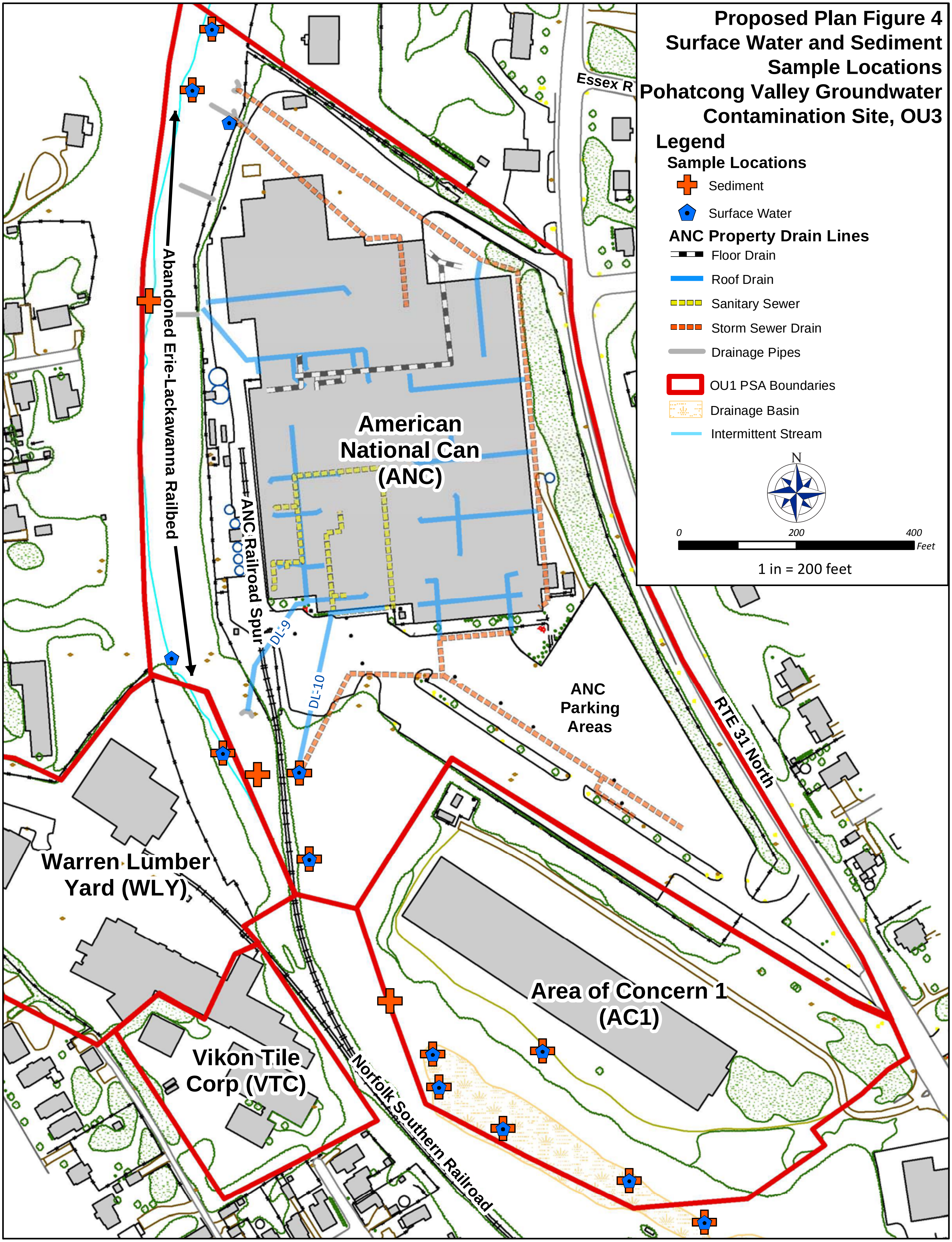
Proposed Plan Figure 1
Site Location Map
Pohatcong Valley Groundwater Contamination Site, OU3

Proposed Plan Figure 2
Site Plan
Pohatcong Valley Groundwater Contamination Site, OU3





Proposed Plan Figure 3 Soil Boring Locations Pohatcong Valley Groundwater Contamination Site, OU3



Proposed Plan Figure 4
Surface Water and Sediment Sample Locations
Pohatcong Valley Groundwater Contamination Site, OU3

Attachment B: Public Notice

Obituaries

Mark W. Tickle

Lopatcong Twp., NJ

Mark W. Tickle, 29, of Lopatcong Twp., NJ, passed away in an auto accident, in Warren Twp., NJ, on June 12, 2016.

Born in Phillipsburg, NJ on May 6, 1987, Mark was the son of William and Pamela Tickle of Lopatcong Twp., NJ.

Mark was employed as a purchasing manager for Elgen Capital Hardware Supply Co. of Closter, NJ. He was a great fan of the NY Mets, Jets and Rangers, and he was the Founder of the Tickle Stadium Wiffleball League.

In addition to his parents, Mark is survived by Brian, Kathy and Samantha Tickle; Glen, Stephanie and Amelia Tickle; Kristin, Anthony and Nicholas Sansosti; Keith Tickle and Victoria Mizzer. Mark's girlfriend is Alexa Rubino. He is also survived by his godparents, Linda Schaller and Charles Gensheimer, and many aunts, uncles, cousins and friends.

Viewing hours will be held on Thursday June 16, 2016, from 5 pm to 9 pm at The Finegan Funeral Home, 302 Heckman Street, Phillipsburg, NJ. A Memorial Picnic Celebration will be held on Friday June 17, 2016 at his parent's home beginning at 12 noon.

In lieu of flowers, donations may be made to Special Olympics Polar Bear Plunge 'Team Todd' at www.specialolympics.org or to Walk MS Lake Como 'Team Fitz' at www.nationalmssociety.org

Susan J. Huxley

Easton, PA

Susan J. Huxley, 55 of Easton, PA died Saturday, June 11, 2016 at home. Born April 18, 1961 in Victoria, British Columbia, Canada she was a daughter of Glen Huxley of British Columbia, Canada and Dorothy (Gill) Smith of Wetaskiwin, Alberta, Canada.

She was the Creative Director and Owner of Huxley Communications/ Sew'n Tell Studio . Prior to that she had been employed by Rodale, Inc. She was also an editor and writer for Bale Communications, one of Canada's National Daily Newspapers and managing editor for Crafts Plus Magazine. Susan was a member of the Crochet Guild of America; the Lehigh Valley Couturiere Society and the Arts Community of Easton (ACE) and was responsible for organizing the "Chase the Chill" project where scarves are handcrafted and hung from trees around neighborhoods for people in need of warmth to take.

She is survived by her parents; her husband of 15 years: Robert Gerheart and her sister: Jane Hlewka of Edmunton, Alberta, Canada.

A calling period will be held from 3 to 5:30 PM Thursday in the Ashton Funeral Home, 1337 Northampton St., Easton.

Memorial contributions may be made to the Center for Animal Health and Wellness, 1165 Island Park Road, Easton, PA 18042. Offer online condolences at www.AshtonFuneralHome.com.

Ashton Funeral Home, Inc.
1337 Northampton Street
Easton, PA 610-253-4678

Jean B. LaDuca

Easton, PA

Jean B. LaDuca, 80, passed away Monday, June 13, 2016, in Easton. Her husband of 46 years, Joseph F. LaDuca, died in 2003.

Born in Freemansburg, she was a daughter of the late Fred G. and Irene (Keiper) Berger.

Jean was the office manager for Bethlehem Township for 17 years, and later worked for RT Schaller, Easton before retiring in 1995.

She was a member of St. Stephen's Lutheran Church, Bethlehem.

Survivors: Sons, Charles, and wife Kathy of Syracuse and David, and companion Cindy Duarte of Phillipsburg; sisters, Ruth Gilbert of Hanover Township and Darlene "Dolly" Ackerman of Bethlehem; grandsons, Ken LaDuca, Esq. and Jeff LaDuca.

Services: 11:30 p.m. Friday, June 17, in the church, 67 W. Washington Avenue, Bethlehem. Family and friends may call 12:30 - 1:30 p.m. Friday in church.

Memorials: May be made to the American Diabetes Association, P. O. Box4383, Bethlehem, PA 18018-0383. Online condolences may be sent to www.pearsonfh.com

Pearson Funeral Home, Inc.
1901 LInden Street
Bethlehem, Pennsylvania
(610) 866-1031
pearsonfh.com

Frances C. Blessing

Largo, FL

Frances Blessing, 86, of Largo, Florida formerly of Phillipsburg, NJ passed away Friday June 10 after a brief illness. She and her husband, Kenneth, had been married for 57 years. Kenneth died in October of 2008.

Surviving is a son, Kenneth and his wife Beverly of Pinellas Park Florida, two daughters Cathy Beers and her husband Daniel of Nazareth, and Shelley Sciabarassi and her husband Mike of Easton, PA, five grandchildren Charissa Fredriksson, Tommy Blessing, Anthony Sciabarassi, Kent Beers, and Gina Sciabarassi, and two great-grandchildren Lexus Blessing and Giuliana Sciabarassi, sisters-in-law Joan Rush and her husband Bob and Carolyn Angst.

Services will be held in Florida at the convenience of the family.

Dorothy E. Leopold

formerly of Easton, PA

Dorothy E. Leopold, 101, of Plantation, Florida, formerly of Easton, died Monday, June 13, 2016 in Broward Health North, Deerfield Beach, Florida.

Born September 2, 1914 in Mauch Chunk, she was the daughter of the late Frederick and Emma (Miller) Frederickson.

Dorothy was a secretary at Lafayette College and was a member of Good Shepherd Lutheran Church, Wilson Borough.

Surviving are her daughter, Barbara Fogarty with whom she resided, a granddaughter, Adrienne Fraser and her husband, Thomas and two great grandchildren, Katie and T. J. Her husband, Willard Leopold, died earlier.

Private graveside services will be held in Easton Cemetery. The Ashton Funeral Home, Easton is handling the arrangements. Offer online condolences at www.AshtonFuneralHome.com.

Ashton Funeral Home, Inc.
1337 Northampton Street
Easton, PA 610-253-4678

SOUTH WHITEHALL TWP.

Black bear tranquilized near Rt. 22

A black bear found its way into a residential neighborhood of South Whitehall Township, before being tranquilized and transplanted Tuesday morning, township police report.

Officers responded shortly after 7 a.m. to the report of a black bear walking through the area of North 18th and Frankenfield streets, across Mauch Chunk Road from Rothrock Motors and just west of the 15th Street interchange of Route 22.

Police kept the bear in a small wooded area until help arrived from the Pennsylvania Game Commission.

An officer with the Game Commission tranquilized the bear, estimated to be 2 to 2½ years old and weigh about 240 pounds, police said on the department's Facebook page.

The bear was safely removed to be released in a suitable area by the Game Commission.

The encounter follows the trapping of a bear last week in the area of fast-food restaurants in Wind Gap.

South Whitehall police did not indicate whether Tuesday's bear was male or female.

Adult female black bears generally weigh between 150 and 250 pounds and adult male black bears, between 350 and 500 pounds, though a male may reach more than 600 pounds, according to the Penn State Cooperative Extension.

The American black bear, scientific name Ursa americana Pallas, is the smallest and most common of the three bear species that are found in North America.

"Black bears are very adaptable and live quite well in areas populated by humans," the extension says.

— Kurt Bresswein

PUBLIC NOTICE

In compliance with Subchapter 9-9.10 of the NJ Pesticide Control Code (N.J.A.C. Title 7, Chapter 30), notice is hereby given that the Warren County Mosquito Extermination Commission, PO Box 388, 2 Furnace Street, Oxford, NJ 07863, will be applying Duet Dual- Action (active ingredients –Prallethrin, Sumithrin, Piperonyl Butoxide) Scourge (active ingredients - Resmethrin and Piperonyl Butoxide), Zenivex (active ingredients-Etofenprox) or Fyfanon (active ingredient Malathion) by truck mounted ULV (Ultra Low Volume) sprayer or by aircraft for the control of adult mosquito populations on an area wide basis, as needed, throughout the County of Warren, during the period from May 11, 2016 through October 28, 2016. The pesticides used will be those recommended by the New Jersey Agricultural Experiment Station (NJAES) for the control of adult mosquitoes. For additional information on adulticiding activities contact Jennifer Gruener, Superintendent (pesticide applicator license #25339B) at 908-453-3585. Call the NJ Poison Information & Education System 800-222-1222 for emergencies, the National Pesticide Information Center 800-858-7378 for routine health inquiries and to obtain information about signs and symptoms of pesticide exposure. Call NJ Pesticide Control Program 609-984-6507 for pesticide regulation information, pesticide complaints and health referrals. Upon request, the pesticide applicator or applicator business shall provide a resident with notification at least 12 hours prior to the application, except for Quarantine and Disease Vector Control only, when conditions necessitate pesticide applications sooner than that time. The Commission's website, www.warrencountymosquito.org provides updated information on time and location of application(s).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY INVITES PUBLIC COMMENT ON THE PROPOSED PLAN FOR THE POHATCONG VALLEY GROUNDWATER CONTAMINATION SITE – OPERABLE UNIT 3 WARREN COUNTY, NEW JERSEY

The U.S. Environmental Protection Agency (EPA) announces the opening of a 30-day comment period on the preferred plan to address the soil contaminated with tricholoroethene (TCE), a volatile organic compound at the Pohatcong Valley Groundwater Contamination Site Operable Unit 3 (OU3) in Warren County, New Jersey. The preferred remedy and other alternatives are identified in the Proposed Plan.

The comment period begins on June 15, 2016 and ends on July 15, 2016. As part of the public comment period, EPA will hold a public meeting on June 21, 2016 at 6:30 pm at the Washington Boro Municipal Building, 100 Belvidere Ave., Washington NJ 07882.

The Proposed Plan is available electronically at the following address:

https://www.epa.gov/superfund/pohatcong-valley-groundwater

Written comments on the Proposed Plan, postmarked no later than close of business July 15, 2016, may be emailed to granger.michelle@epa.gov or mailed to Michelle Granger, US EPA, 290 Broadway, 19th Floor, New York, NY 10007-1866.

The Administrative Record files are available for public review at the following information repositories:

The Warren County Health Department, 700 Oxford Rd., Oxford, NJ 07863 or at the USEPA – Region 2, Superfund Records Center, 290 Broadway, 19th Floor, New York, NY 10007-1866.

For more information, please contact Pat Seppi, EPA's Community Liaison, at 646.369.0068 or seppi.pat@epa.gov

NOTICE TO CUSTOMERS OF JERSEY CENTRAL POWER & LIGHT COMPANY WITH TRANSMISSION RIGHT-OF-WAY ACROSS THEIR PROPERTY

Jersey Central Power & Light Company (JCP&L) has contracted professional tree care companies for the purpose of conducting vegetation management on electric transmission rights-of-way in parts of Warren and Hunterdon Counties. JCP&L will be performing vegetation maintenance by removing and pruning trees, mowing vegetation, selectively applying herbicides and manually controlling tall growing incompatible trees that can cause power outages or inhibit access or inspection within the transmission rights-of-way. The goal of vegetation treatments is to promote low growing compatible vegetation which is consistent with safe and reliable operation of the electric facilities and can improve wildlife habitat for native species. Both the selection of the herbicide and the application method are specified by JCP&L. The herbicides are registered and approved for this use by the U. S. Environmental Protection Agency.

Vegetation management will be performed on electric line rights-of-way commencing 7 - 45 days from the date of publication of this notice. Prior to commencing vegetation maintenance, JCP&L will also provide an additional notice to municipalities, and to customers and property owners residing on the property scheduled for vegetation maintenance.

Requests for additional information should be directed to: Jersey Central Power & Light Company, 300 Madison Ave. Morristown, NJ 07962-1911, 1-800-662-3115.

Jersey Central Power & Light
A FirstEnergy Company

Local News

BELMAR

Pair of plumbers take top prize

The winner of the 30th annual New Jersey Sandcastle Contest on Wednesday was definitely a first — this year's "Best on the Beach" award went to a toilet and a sink. The sand sculptures were created by a pair of friends from Monmouth County — Andrew Guarrera and Chris Kirsten, who are plumbers. The contest included dozens of other creations, such as large cartoon turtles, an elephant, a lifeguard Hello Kitty, an interactive horse-drawn chariot and intricate sandcastles.
Rob Spahr/NJ Advance Media

WILSON BOROUGH

More charges for man accused of fleeing

Pamela Sroka-Holzmann *For The Express-Times*

A 27-year-old Catasauqua man is facing additional charges after allegedly fleeing from police for two nights straight in May.

Sheldon Shiller, of the 1100 block of Front Street, at 9:07 p.m. May 11 was seen in the 700 block of Washington Street by a Wilson Borough police officer. Police said there was an active warrant against Shiller since May 10, when he led police in a car chase that ended due to safety reasons.

Once Shiller saw the officer on May 11, he allegedly ran around the corner of a home and waited for the officer to follow him before jumping out and pushing the officer, police said. Wilson Officer Dan Dieter used a stun gun on Shiller and he was arrested and searched, according to police.

The incident with Shiller began in the evening May 10 when someone had stopped at the police station to report being followed by a car, Wilson Police Chief Steven Parkansky said.

In that incident Shiller is charged with fleeing or attempting to elude police, making terroristic threats, recklessly endangering others, reckless driving, driving without lights, driving at unsafe speeds, and going through two red lights.

Shiller in the May 11 incident is charged with simple assault, resisting arrest, marijuana possession and possession of drug paraphernalia.

Devin Dowd

Sydney Solimani

PHILLIPSBURG HIGH

Two seniors awarded Lawrence scholarships

Two Phillipsburg High School seniors were awarded $1,000 each for the PHS Class of 1960/Bruce E. Lawrence Scholarship.

Devin Dowd, a member of the National Honor Society and a soccer scholar athlete, will be attending Wake Forest University majoring in business management; and Sydney Solimani, a member of the National Honor Society and captain of the girl's soccer team, will be attending John Jay College Criminal Justice, majoring in forensic science.

Maj. Bruce Lawrence, an Air Force pilot, was shot down in Dong Hoi, North Vietnam, on July 5, 1968. After 43 years his remains were repatriated on Sept. 23, 2011, and he is buried in Raubsville cemetery.

The PHS class of 1960 holds a fundraiser five-class picnic each year to raise money. This year the picnic will be at Flynn's In the Glen Oct. 1.

SALISBURY TWP.

State audit hits charter school for 2 violations

Sara K. Satullo *For The Express-Times*

The board at a Salisbury Township charter school failed to properly file financial disclosure forms and didn't inform the public of special board meetings, a state audit has found.

Auditor General Eugene DePasquale announced Thursday that over the three-year period covered by the audit the Arts Academy Charter School largely complied but the review turned up two violations.

Members of the charter schools board of trustees and an administrator did not file, filed later or filed incomplete statements of financial interest, he said.

The forms must be filed annually by May 1 in compliance with the public official and employee ethics act. Failing to file the report opens officials up to fines.

"When a public official does not file or fully complete a required (statement of financial interest), the public cannot examine the statement's disclosures in order to determine whether conflicts of interest exist," the audit states. "This in turn erodes the public's trust."

The disclosures must be filed while someone holds the position and for a year after leaving the position. That seems to be where the charter middle school got hung up — school staff did not realize that board members who resigned needed to file by May 1, the audit states.

The board of trustees properly advertised its regular board meetings in accordance with the Sunshine Act but did not let the public know it was holding special meetings once in 2012 and twice in 2013. The school opened during the 2012-13 school year.

In its response, the charter schools lays out a plan for ensuring that members of the board complete the forms when they first become available.

And it lays out a protocol to be followed if they aren't completed properly.

The school acknowledged it erred in not properly advertising the special meetings and promised to do so in the future.

Sara K. Satullo, NJ advance Media, ssatullo@njadvancemedia.com

Attachment C: Public Meeting Transcript

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 3 .

- -X

SUPERFUND PROGRAM PROPOSED PLAN FOR OPERABLE UNIT 3

POHATCONG VALLEY GROUNDWATER CONTAMINATION SITE

PUBLIC MEETING

- X

Washington Borough Municipal Building
100 Belvidere Avenue
Washington, New Jersey 07882

June 21, 2016
6:30 p.m.

PRESENTERS:

KIM O'CONNELL,
EPA Section Chief

MICHELLE GRANGER,
EPA Project Manager

EDWARD LEONARD,
Site Manager/CDM Smith

ADDITIONAL GOVERNMENT REPRESENTATIVES:

JERRY BURKE,
EPA Attorney

CHUCK NACE,
EPA Risk Assessor

ABBEY STATES,
EPA Risk Assessor

FRED A. MUMFORD,
NJDEP Superfund Coordinator & Section Chief

GRACE CHEN,
FS Task Lead, CDM Smith

JOSEPH BUTTON,
RI Task Lead, CDM Smith

MS. O'CONNELL: I would like to welcome you here on behalf of the EPA. My name is Kim O'Connell. I'm the supervisory engineer at EPA. We're in the Superfund Program on the Pohatcong Valley Groundwater Contamination Site, and that's the purpose of this meeting. The EPA has completed its study of the 3rd phase of this Superfund project, which investigated the nature and extent of the contamination in the soils, and that's the soil contamination that was the source of the groundwater contamination.

This is our 3rd phase. We have already selected cleanup actions for groundwater in the 1st phase, OU1, and the 2nd phase, OU2. We have 2 groundwater extraction treatment plants that have recently just began operating to remove contamination from groundwater within Washington Borough. Again, this phase addresses the soil contamination.

There will be some presentations tonight where we are going to summarize the results of our studies and our analysis of what we found and how we developed different cleanup alternatives, and we're also going to present the agency's preferred alternative.

This meeting is part of our community relations requirements under Superfund. When we come out to propose a remedy we come out to the communities, we like to hear what people say. We open a comment period, and all of the comments that we receive during the comment period will be considered before a final remedy is selected for the site.

So, the public commentary for this project has opened up. It opened up on June 15th, and our public commentary goes from June 15th to July 15th. So, tonight, you can provide comments, of course. People came to ask questions and provide comments. Comments can also be called into the agency. You can send us a written letter. You can send us an email. All comments received in any of those fashions before July 15th will be considered by the agency in part of the formal record. And, again, we will probably select a remedy for this site, probably around September, after we receive all the public comments and consider them. If you have not signed in, we have a sign-up sheet here, and if you put your number in the contact information on that, we would be able to contact you regarding any site updates.

We have a stenographer here tonight. This meeting is being recorded. There will be a transcript generated. So, after our presentations, you know, we're going to open up the floor for questions. We have a fairly small group here. So, I think everybody will have plenty of time to answer everybody's questions and allow them to provide any comments they want, but you'll need to stand up and state your name for the stenographer, for the record, and there will be a transcript generated eventually for this.

So, I am just going to introduce the EPA folks that are here. We have some in the audience. We have some making presentations here. So you know who everybody is and then I'm going to turn the meeting over to Michelle for our presentation. We try to keep the presentations short so we ask you to hold your questions until after.

We have Michelle Granger, who is EPA's New York project manager in charge of managing the cleanup at this portion of the site. We have Grace Chen, who is the project engineer working on this project with CDM Smith, the government's consultants for this. Also with CDM Smith we have Joe Button, who is the project geologist, and we have Ed Leonard, who is our site manager for CDM Smith. We have Chuck Nace over here who is EPA's risk assessor for the site, evaluating all the risks, you know, based on the data collected here. We also have Abbey States, another risk assessor with EPA here. We have Fred Mumford from the New Jersey Department of Environmental Protection. He is the section chief and a Superfund coordinator and has worked with us on this project for quite sometime, and we have Jerry Burke, who is EPA's attorney, who will be working on all the legal aspects of this project.

I think I hit everybody. So, now I'm going to turn it over to Michelle, who is going to give you a summary of the site.

MS. GRANGER: So, I will do an overview of the Superfund process. Several well-publicized toxic waste disposal disasters in the late 1970's shocked the nation and highlighted the fact that past waste disposal practices were not safe. In 1980 congress responded with the creation of the Comprehensive Environmental Response Compensation and Liability Act, more commonly known as Superfund.

The Superfund law provided a federal fund to be used in the clean-up of uncontrolled and abandoned hazardous waste sites, and for responding to emergencies involving hazardous substances.

In addition, EPA was empowered to compel those parties that are responsible for these sites to pay for or to conduct the necessary response actions.

The Superfund remedial process. The work to remediate a site is usually very complex and takes place in a number of stages. Once a site is discovered an inspection further identifies the hazards and contaminants. A determination is then made whether to include the site on the Superfund national priorities list, a list of the nations worst hazardous waste sites. Sites are placed on the national priorities list primarily on the basis of their scores obtained from the hazard ranking system, which evaluates the threat posed by a site. Only sites on the national priorities list are eligible for remedial work financed by Superfund.

The selection of a remedy for a

Superfund site is based on 2 studies: A remedial investigation and feasibility study. The purpose of the remedial investigation is to determine the nature and extent of the contamination at and emanating from the site and the associate threat to public health and the environment.

The purpose of the feasibility study is to identify and evaluate ways to clean up the site.

Public participation is a key feature of the Superfund process. The public is invited to participate in the decisions that will be made at a site through the community relations program. Public meetings such as this one are held, as necessary, to keep the public informed about what has happened and what is planned for a site. The public is also given an opportunity to ask questions about the results of the investigation and studies conducted at the site and to comment on the proposed remedy.

After considering public comments on the proposed remedy, a record of decision is signed. A record of decision documents why a particular remedy was chosen.

The site then enters the design

phase where the plans associated with the implementation of the selected remedy are developed. The remedial action is the actual hands-on work associated with cleaning up the site. Following the completion of the remedial action the site is monitored if necessary. Once the site no longer poses a threat to public health or the environment, it can be deleted from the Superfund national priorities list. Removal actions may be undertaken at any time during this process to address any immediate threat to public health, welfare or the environment.

Next we'll go on to the overview of site history. The site was discovered in the late 1970's when trichloroethylene, TCE, and perchloroethylene, PCE, were detected in two Washington Borough public wells. These wells are the Vannatta Street and Dale Avenue wells. After subsequent investigations the State of New Jersey NJDEP installed public water connections and wellhead treatment. The site was then listed on the NPL March of 1989. Due to its large size and complexity, EPA divided the site cleanup into 3 operable units or OU's; referred to as the OU1, OU2 and OU3 study areas.

The OU1 study area extends approximately 4 1/2 miles southward from the former American National Can facility, which is currently operating as Albea's American Incorporated.

The OU1 remedial investigation documented levels of TCE and PCE in the groundwater, above drinking water standards. EPA selected a remedy for OU1 in 2006 that addresses contaminated groundwater in the OU1 study area. A component of the OU1 remedy is the extraction, treatment, and reinjection of TCE and PCE contaminated water in the most contaminated areas.

The current status of this is that we now have 2 groundwater treatment plants that have been constructed and are currently in operation.

So, now we're at the site location map, and I'll point out the OU1 study area. The OU1 study area is this red outline here. It extends 4 1/2 miles south of the ANC facility, which is inside of this red filled in space here, and it goes southward 4 1/2 miles to the Asbury Broadway Road. This is Route 57 here and Route 31 in here.

So, the OU2 study area is immediately down-gradient of the OU1 study area. It extends 4 miles southward into portions of Franklin and Greenwich Townships. OU2 includes TCE contaminated groundwater resulting from the OU1 TCE plume. EPA selected a remedy for OU2 in September 2010 that addressed contaminated groundwater down-gradient of the OU1 study area. One component of the OU2 remedy is providing potable water to impacted and threatened properties through the construction of water mains and service connections. The current status of this is that we are working on an engineering design that is anticipated to be completed in 2017.

Back to our site location map, I will show you OU2 study area, which is this here. So, this is the Asbury Broadway Road, and the OU2 study area starts at the Asbury Broadway Road and extends 4 miles down into portions of Franklin and Greenwich Township. This is the Route 57, once again.

The OU3 study area includes soil source areas identified in the OU1-RI that have potentially contributed TCE into the groundwater contamination associated with OU1 and OU2. It is located in Washington Borough near Route 31 and it includes the former ANC property and several adjacent down-gradient properties. The remedial investigation and feasibility studies have been completed and a record of decision is expected in 2016.

Go back to our site location map. So, this area, this red filled in area here is the OU3 study area. It's in Washington Borough near Route 31. It's the focus of tonight's meeting. I'll show you a closeup of that next.

So, these are the 4 properties that were identified in the OU1-RI. This is the American National Can, formally American National Can, which is now being operated as Albea, the Warren Lumber Yard, Vikon Tile Corporation, and area concern 1. These are the 4 properties that are the focus of our study for finding the source of the 8 1/2 mile groundwater plume that makes up OU1 and OU2.

THE PUBLIC: Does area 1 include where the former Tung Sol Tubing?

MS. O'CONNELL: Former Tung Sol Tubing.

THE PUBLIC: That's the Park Hill apartments.

MS. O'CONNELL: No.

THE PUBLIC: What area is that?

MS. O'CONNELL: That's part of the site but it's a groundwater clean-up that's happening separately. The groundwater clean-up is ongoing there. It's part of our phase 1. We have two groundwater treatment plants operating as part of phase 1. That's not part of the source area study that's being presented tonight.

MS. GRANGER: So, the focus of tonight's meeting is the OU3 study area, which is right here. I'll hand the floor now over to Ed Leonard of CDM Smith, EPA's consultant, who will present the technical discussion related to the OU3 study area.

MR. LEONARD: Thank you, Ms. Granger.

MS. GRANGER: You're welcome.

MR. LEONARD: So, I'll finish up the presentation. I'll be talking about the remedial investigation of the sampling that was done out in OU3. I'll give a summary of the risk assessments that were done, both to human health and the ecological, and then we'll discuss some key points in the feasibility study or the engineering study.

How do we go about cleaning it up? So, the remedial investigation, as you can see, we took a lot of samples. We took well over 500 samples out there. Primarily the soils. Again, this is an investigation for contaminant sources in soils. The events, there were 4 of them held between 2012 and 2015, and based on historical data and sampling results throughout the area, and we don't have a sample here, but throughout this whole area is how we determined where samples went.

Samples were analyzed for volatile organic compounds, semi volatile organic compounds, pesticides, PCB's and metals and polychlorinated biphenyls.

An ecological characterization was also performed out there where we did habitat studies, and within a quarter of a mile of the study area no threatened endangered or sensitive species had been identified. So, over the next few slides we'll go through all the different sampling programs that we did. Again, the soils, the groundwater, the drainage pathway and the airs. We're going to focus on TCE, which is the contaminant of concern for the groundwater issue.

Again, if you remember, this is a source area for the large groundwater issue that we have here in the valley. So, our focus is really going to be on those contaminates, and discuss those results.

So, first thing we'll talk about is the soils and groundwater. So, hundreds of soil samples were collected throughout the area, including underneath the former ANC building, which is American National Can. Again, this is the former National Can. As you can see, all the different locations where all the borings were put in, TCE detected throughout the whole area, with the highest concentrations underneath the American National Can, particularly in this southwest corner where there was some work done with TCE, which was used as a cleaner underneath some of the former processes.

Contaminants were found at depth in a hot zone, primarily between 70 and 100 feet at levels from non-detect up to 120 ppm. So, those were the highest concentrations. And the most frequent were in the southwest corner of the building. In addition, throughout the site, there were levels of TCE detected in many of these other borings outside the building, ranging anywhere from non detection, or 0, all the way up to 6.7ppm.

So, as Michelle mentioned, there was an extensive groundwater study, as previously had been done under the first 2 phases, and an extensive amount of groundwater sampling was done. As part of this investigation, if groundwater was encountered, we collected it, but we didn't go out of our way to collect groundwater samples.

The majority of the groundwater that was sampled is perched groundwater, and perch groundwater are layers or pockets of groundwater between the surface and your groundwater aquifer, which is in this area about 100 feet down. They were encountered. Little pockets or lenses that may be sitting in the soil. As we hit those while we were drilling we sampled those.

Eleven of those samples were collected. They were primarily along the drainage pathway, and we'll talk about that in a second, but the drainage pathway is down along the western side of the American National Can into the area of concern 1, and then there is another one down on the eastern side of the railway right-of-way.

This drainage pathway, for many of you who have grown up around here, is the old Erie Lackawanna rail line. The groundwater levels of TCE range from .4 PPB to 820 PPB in these perched groundwater samples.

Next investigation is the drainage pathway. So, again, as we said, there are 2 major pathways for storm water or surface water. One is down along the eastern side -- excuse me, the western side of the former American National Can, and then it ran under the railroad spur here and into a ponded area here by the area concern 1, and the 2nd is another drainage pathway that came off the former National -- American National Can property and down into this drainage basin here.

The sampling was done to perform a nature and extent of contaminates in the outfalls drainage pathway and ponded waters. So, there are several storm water outfalls along the western side of American National Can. There are 2 old drain lines here for roof runoff that go into this drainage pathway. The ponded areas, there is one here by area of concern 1, and there is also another ponded area over here by Warren Lumber Yard. There's no permanent surface water structures out there. So, as ponded areas fill up during a rain event, as things dry out, those ponded areas will dry up and evaporate. So, the sampling was done after rain events in order to make sure we could get surface water or runoff after a rain event and make sure we could collect that.

TCE range from non-detect to 21 parts per billion in the surface water and that was the ponded area over here by Warren Lumber Yard. The sediments ranged from non-detect, also to 15 parts per billion in the sediments, and the highest one there was in the drainage pathway coming down off the American National Can into area of concern 1.

And the last sampling program were indoor air and sub-slab air. Indoor air would be the air such as in the building here. Sub-slab would be the floor slab of the building underneath it before you hit the soil.

This is the American National Can. That's north. Route 31 is here. So, the buildings in the OU1, OU2 and OU3 study area, which were these 4 properties, again, Warren Lumber, Vikon Tile, area of concern 1, and National Can went through all of screen process up front to determine if vapor samples should be collected. And, based on history, depth of groundwater, what's currently going on at the different facilities, only one building came up that was necessary to sample for vapors, and that was the American National -- the former American National Can building.

Also should be noted that there were previous samplings done for residential areas immediately around the former American National Can facility, and there were no detection of indoor vapors for those residential areas or buildings.

So, the indoor air and sub-slab air samples were collected from the building. Again, indoor air would have been canisters in the building itself. Sub-slab, they drill through the floor slab, the concrete floor slab, and were sampling from beneath that. There were detections of vapors, specifically TCE's, at significant levels.

The current facility operator,

Albea, was notified of it, and they immediately took some actions, including putting a vapor extractor or vapor removal system in to remove the vapors that were both immediately below the slab and within the top 5 feet of the soil, and they were able to abate the issue and stop any other vapors from coming inside the building, and that system is still running today.

So, what do we do with all this information; we take all this information and it feeds into a couple of different things. One is the conceptual site model, which we'll talk about here in a moment. The other is the risk assessments, which we'll talk about soon, and then eventually into the engineering study, feasibility study.

So, what is a conceptual site model; you take all the information you've gathered, whether it's historic information, current information, just sampling information, activities you know that are going on at the site, and you try to come up with a scenario or a visual summary of what's happened over time and currently.

So, with this, again, we do know that at the former National Can, American National

Can, there was use of TCE as part of the production for cans, and that continued up until the early 1980's when that stopped. During that time, TCE, as part of waste water, entered part of the drainage systems which were underneath the building, or floor slabs, and that waste water did a couple of different things; 1. It discharged out along some drainage lines to the drainage pathway we talked about before, but the other was many of these pipes leaked, as pipes still do today, and that waste water drained out of those pipes and down through the soils and into the regional groundwater aquifer, which is about 100 feet deep. So, with that there was large amounts of TCE that went with it and was discharged. The water that went into the drainage pathway, that TCE was washed into the drainage pathway. Storm events, rain events came through and washed it further down the drainage pathway, and that TCE did 1 of 2 things; either it soaked into the ground or volatilized off back into the air. And, as we said, we still have remnants of low levels of TCE throughout the drainage pathway. So, we do know that happened.

The second is that the TCE itself

discharged underneath the building and down through the soils, and when a large amount of waste water, that we had through those pipes leaked, it flushed down into the aquifer, and that continued, again, for 25, 30 years, and washed down into the groundwater aquifer and then straight down the valley, which shows over here where you have your plumes.

And then the 3rd piece to this is that after 30 years they stopped using TCE back in the early '80's. A lot of that TCE did flush out into the groundwater, that once sub-surfaced below the building, but some of it stayed there. So, we still do have some residual levels of TCE that are acting as a source and doing 1 of 2 things; they either continue to feed the groundwater plume, or they're actually volatilizing up and underneath the building, which is the reason they found the very high elevated levels of TCE underneath the sub-slab and inside the building.

So, that completes the overview of the remedial investigation. And a little clip on the CSM, conceptual site model, of what we believe has happened out there.

So, now what do we do with all this

data; so, one of the things we do is feed it into a couple of risk assessments. Both the human health and ecological. And I guess, in summary, the easiest things to say for the ecological, the OU3 study area has no unacceptable ecological risks or hazards associated with the site for site related contaminants, which is a good thing. Again, though there is a limited amount of habitat out there within the OU3 study area, it's mostly commercial and industrial. So, you got limited ecological exposure, but there is some.

The 2nd and more important thing is the human health. Again, there's no direct contact risk from the contaminants. Go out and touch the soil, there is no issue. The concern becomes particularly underneath the building where the TCE is discharged is you'll end up with 2 things; again, either the TCE is volatilizing up and back into the building and exposing the people inside the building or it's being washed down into the aquifer, into the groundwater, and then you have potential exposure and groundwater contamination from the TCE. So, those are the primary risks in the site.

THE PUBLIC: So, there is risk,

human health issues, because it is in the plume?

MR. LEONARD: Yes, ma'am. Two things though, there is currently an SVE system running inside the building, or underneath the building, and that's removing those vapors. So nobody is currently being exposed in the building, and then, as part of OU1 and OU2 there are groundwater treatment systems that are up and running to treat that.

THE PUBLIC: Well, when they found out that there is contamination and obviously there is ongoing plumbing there, did anybody jump in there and try to secure some of this so it didn't go into the aquifer and go into the storm drains through the piping?

MR. LEONARD: Initially when they -- well, again, that stopped back in the early '80's. Initially when they realized that the groundwater was contaminated they assessed 100 different sites in the area trying to determine it. It took several years to figure out where it was actually coming from.

THE PUBLIC: Well, that I know, but I'm just saying, you brought up a good point that some of those pipe systems were broken and that caused either more of a compounded issue. Did anybody go back in there and try to prevent further leakage and drainage on that part of it?

MR. LEONARD: Based on the history we have of the site, most of those -- most of that usage and those pipes were shut off. A lot of it had to do with septic systems and discharges off the site. Most of that over the years has been corrected.

MS. O'CONNELL: I'm sorry, could you state your name for the record because we are recording this.

THE PUBLIC: Okay, it's Marsha Marasco, M-A-R-A-S-C-O. My concern is when you have contamination like this, is, the longer you wait the more risks are at hand, not only for people surrounding the area but the chain of it going wherever, either in the air or in the plume, or ground contamination, which costs more, becomes more expensive and out of control. So, if it took several years to start shutting down water systems, that to me doesn't make sense, if it was diagnosed that it was unhealthy situation I would think that would have been one of the first things to do within the first year or two. Not ten to twenty years.

MS. O'CONNELL: I think I can answer that.

MR. LEONARD: Go ahead.

MS. O'CONNELL: This is an old industrial facility. It had different operators. It was, we call it, former American Can operated there for many years, and there were other companies that operated since then. The TCE, the contaminant of concern, the trichloroethylene was disposed of historically. It hasn't been used since probably -- it's also hard to figure out exactly what was used and when, but it's not likely to have been used since before the '80's. So, the disposal is old. It's not recent. By the time the site went on the Superfund list and -- well, that site didn't go on the Superfund list. The groundwater contamination went on the Superfund list and then we were charged with looking throughout the whole valley to see the source or sources were.

THE PUBLIC: Which has proven that it didn't spread over a period of time. We all know that.

MS. O'CONNELL: It was first

detected in the groundwater. The groundwater plume is approximately, at this point we know it's 8.5 miles. Starts at the American Can facility, down into Greenwich. So we know that now after years of study but when we started investigating the site all we knew was that there was contamination at the public supply wells. They reported it. They sampled regularly. They put treatment on it. So, right away, as soon as it was detected in the public supply wells, treatment was put on the groundwater before it was distributed. So, that immediate concern was addressed. And then we needed to -- we looked at about 45 different facilities up in and around Washington Borough, old industry facilities, old dry cleaners, large factories, any place that could have potentially been a source, and at the end of the day we found, for TCE, the source was the former American Can facility. It's an old source and the pipes underground were no longer being operated. There still remains some contamination.

THE PUBLIC: But once you found that out what year was that?

MS. O'CONNELL: The first sampling

under the building that showed I think was done in about 2006, and our study followed up on it. We have been sampling from about 2010 or '11.

MR. LEONARD: Eleven.

MS. O'CONNELL: Through last year.

THE PUBLIC: During that 6 year period was there any remediation done at all conducted?

MS. O'CONNELL: The remediation that was done was the remediation of the indoor air. During our investigation we discovered that there was elevated levels of TCE in the building.

THE PUBLIC: But not in the ground? There wasn't any remediation in the ground?

MS. O'CONNELL: There is some contamination in the ground and that's what this plan is about. This is our proposed plan.

THE PUBLIC: What I'm saying is no one conducted remediation in the ground during that 6 year-period.

MS. O'CONNELL: No, the remediation plan is being presented tonight. The remediation that's been done in that period is the immediate remediation of indoor air to prevent any exposure to the indoor air. There's not any exposure to the soil directly from the soil under the building. The health concern was that the contamination to soil had spread into the indoor air. So, an immediate action was taken in 2013 to address the indoor contamination. So, that source was cutoff and indoor air levels are sampled regularly and they meet criterion now. So, that was done. And we are here to present our plan for addressing deeper contamination in the soil to address that to make sure that it's cutoff from either adding to the indoor air problem or moving down and contributing to the groundwater problem.

THE PUBLIC: Okay. Thank you.

THE PUBLIC: I have a question.

MS. O'CONNELL: Okay. State your name.

THE PUBLIC: Cara Crisafi, C-R-I-S-A-F-I. You mentioned you checked the air quality at American Can. Isn't there a vapor removal system at an elementary school on Asbury Broadway Road?

MS. O'CONNELL: Yes.

THE PUBLIC: And at an apartment building locally?

MS. O'CONNELL: Yes.

THE PUBLIC: So, what's the story with that?

MS. O'CONNELL: Okay. So basically there are sort of -- they're related but they're a little bit different. Basically when groundwater is contaminated with volatile contamination the contaminates volatilize and a building is on top of that groundwater. You know, it might be 30 or 40 feet above the groundwater. The vapors can volatilize out of the groundwater and they can move up through the soil and they can collect underneath the basement slab or a building slab. Then if there's cracks in the slab, or based on the construction, sometimes those vapors can find their way into the building or the basement usually and that's what we call indoor air. That's vapor intrusion or that's indoor air contamination that's actually coming from the groundwater. So, since we have an 8 mile groundwater plume that's comprised of volatile organic chemicals, mostly TCE and PCE, we sampled buildings throughout the valley. We've sampled all the daycares. We've sampled most of the schools. We sampled some residence throughout the valley to see if the groundwater contamination had potentially impacted indoor air.

We found one school that the levels were pretty low, but since it was a school we put a system in. They had some levels in the indoor air.

THE PUBLIC: Is that the Franklin Elementary School?

MS. O'CONNELL: That's on Asbury Broadway, right. The levels were pretty low, but it was kind of a conservative move when we decided to put a system in there. The system is like a radon system. It just vents the gases instead of going into the building. Any gases collected under the building through a fan would just be vented out the side. It's not a complicated system. Some homebuilders put the systems in automatically for purposes of radon.

THE PUBLIC: Right.

MS. O'CONNELL: So, there were 2 homes next to the school. There is groundwater contamination there. We also sampled a bunch of homes further down from there. We didn't find any levels of concern. We sampled a number of homes in Washington Borough. Private homes over here.

In Washington Borough the groundwater is 100 feet or between 100 and 120 feet below the ground surface. It would take a lot of contamination to come up to get into the building that distance. When you get down by Asbury Broadway Road I think the water is at maybe 40 feet below ground surface. It's just, you know, 4 miles down. So, the closer the contaminated water is to the home the more potential. So, we sampled throughout the valley and we found some limited problems.

The Park Hill apartments is the former Tung Sol Tubing site. That's a separate source. There's PCE contamination that's not related to American Can that was related from that factory's operations there. We have put a system in one part of that building. The other parts of the building weren't showing contamination. So one of the buildings there, there are several buildings there, has indoor air treatment.

Over at American Can it's a little different. The disposal of the TCE happened directly underneath the building. It leaked down the pipe. It didn't come out from the groundwater. It was disposed of and it moved down 120 feet into the groundwater and then down the valley. Some of it was caught up in the soil and then it vaporized under there. That was the source. There was likely very, very high lots of very high levels disposed there for a number of years. That's what we think is most likely. You know, it's hard to say. We can still see even though a lot of the contamination has already vaporized or washed into the soil. We can see there's still some contamination there and that's the subject of our plan. Everybody wants to talk. Okay. Let's do it. Yes.

MS. BRUEN: Yes, I'm Gail Ann Bruen. I would like an update in terms of 2 things. I understand there was a recent air quality test for the Park Hill apartments. And, secondly, although we have a treatment site on the property, I don't know if it's really running. Okay. So, I would like to know if it is and what the current status of --

MS. O'CONNELL: I can answer your questions. That's not the subject of this meeting. So, I can answer your questions.

MS. BRUEN: I understand that.

MS. O'CONNELL: The system has been running for 2 weeks now. Approximately 2 weeks.

So, groundwater is being extracted and treated and sent to the POTW, sent to the sewage treatment plant.

MS. BRUEN: It's been running for 2 weeks?

MS. O'CONNELL: Several weeks now, yes.

MS. BRUEN: Is or is not?

MS. O'CONNELL: It is running. It is running now, yes.

MS. BRUEN: Because it hadn't been.

MS. O'CONNELL: Very recently started operations.

MS. BRUEN: Because I understand there were other things found, you know, some additional chemical found, and I understand it's not the focus of tonight's meeting, but, you know, as a resident there for 3 years I am very concerned, and I have breathing problems to begin with. So, you know, I would really like an update in terms of --

MS. O'CONNELL: We periodically monitor vapor throughout the valley --

MS. BRUEN: The last time I talked to you was 2013.

MS. O'CONNELL: Theresa Wilka is the project manager for that aspect of the project. I think you know her. I remember meeting you at a previous session.

MS. BRUEN: Yes. Yes.

MS. O'CONNELL: We do periodic vapor monitoring in that area. So, since there has been some impact to one part of the building, and I believe there was vapor investigations done there this winter, I don't know if it was February or March. So, the results should be in, or almost in, and I can have you contact Theresa to get the details.

MS. BRUEN: Okay. I would appreciate that.

MS. MARASCO: Because you're saying "periodically" that could be 3 months. That could be 6 months. That could be a year for, you know, monitoring wells, vapor, everything. So, is there somewhere to go online to look up when they're being conducted and what the results are?

MS. O'CONNELL: We have some work plan that talk about the frequency of sampling. The frequency of sampling, you know, we modify it as needed, as we go along. We have a very good handle.

MS. MARASCO: When you're saying "we" --

MS. O'CONNELL: The EPA. The EPA. We have a very good handle on the groundwater plume. We have, you know, dozens of wells throughout the valley and it's monitored regularly. More wells may need to be put in over time. Some will be closed. Our highest priority is the protection of public health. We do not have a very large indoor air problem related to this plume. We have certainly had a large problem inside the building that's been dealt with. We've had a few -- a little bit of vapor intrusion into other buildings. The plume is pretty stable. So, if the levels of the plume start increasing anywhere that would be a reason why we would want to maybe increase vapor sampling in that area, but if the plume -- remember, it's an older plume. It's been around a long time. If the contamination decreases in the plume or stays stable, we may still periodically check for vapor intrusion in some select areas but it would just be a spot check. There would be no reason to believe that there was going to become a vapor problem unless new information showed it to be. So, the plume is relatively stable.

MS. MARASCO: Are you doing it now, a schedule of any of this? Like when I have something done on a private property that's worked with the EPA, we get a schedule through the technicians and they tell us when they're going to come and do some of the testing. Sometimes it changes. Sometimes it doesn't, based on the prior records of the checking. But there is still a schedule that is designed to be able to be expected to have done, and then the information is sent to the board members and then the board members dispatch it publicly. I'm not hearing that here. I'm hearing there's inconsistency based on your records of the last recorded testing and that doesn't reassure a lot of people to know how long of a stretch this is taking. Because this Superfund has been going on for 2 decades. And to hear now people are doing this testing, I'm saying, well, what's happened at the beginning of when it was discovered because the EPA has been around since the 70's. So, I have been here for 17 years and I have never seen a place I could go online and get the results of the testing that's been done for the Superfund. And yet when I go into the superfund.org I can print up 130 pages of it from all of them in New Jersey. That's not what I'm looking for. I'm looking to know what is being done and when and what the results are for Washington Borough.

MS. O'CONNELL: Well, we do have work plans. Some of our plans are available online. They're certainly all available if you would contact the project managers for the site. We sample as needed. We need to have flexibility to increase and decrease sampling. Except for inside the building, we don't see the need for other than periodic vapor sampling, which means likely every 2 to 3 years. If the situation in the groundwater plume changes we could increase that. So, we don't have a full schedule for that or we've modified our schedule. We also have, you know, we have to look at our resources, and when we can, schedule these things. So, there isn't a schedule. We obviously schedule with the property owner before coming to sample. Obviously they're inside their home.

MS. MARASCO: So, who should we contact through the town to find out? Because there is always a technician that's in charge of each contaminated property. So, who here -- when we walk out this door tonight we should have an address or contact person who we can talk to on a periodic basis that is going to view it as the representative of the EPA.

MS. O'CONNELL: You can contact EPA directly, and I have -- there's 3 project managers that work on 3 different aspects of this site, and we can give you their names and their emails.

MS. MARASCO: Okay. So, you're going to give that to all of us before --

MS. O'CONNELL: Sure. Michelle is available in the presentation, but I have 2 other project managers that are working. One is working on the Park Hill apartments, the old Tung Sol Tubing groundwater treatment system. She's also working on the design of a waterline that's going to be constructed in Franklin and Greenwich Township as part of the OU2 or the phase 2, and then Stephen Cipot is the other project manager working on the groundwater pump and treatment system that's being operated right now at they Albea facility. So, I can give you that contact information and you can contact them by phone or by email and ask for a periodic update.

MS. MARASCO: Thank you.

MS. WILSON: Tauneah Wilson. I live right here on Taylor Street, and we are a little outside of your area of concern 1, but literally probably about 5 houses from Vikon Tile.

MS. O'CONNELL: Okay.

MS. WILSON: Now, you were saying that several homes in the borough have been sampled. You have 3 residents on Taylor Street here and none of our houses have ever been sampled.

MS. O'CONNELL: For vapor? Can you put that map up for the OU2 study area. So, this is the street that -- I don't have the addresses of the homes that have been sampled, but we did, back in OU1 we sampled -- we sent out a lot of letters. We had very little response but we sampled about 3 homes in that area. I don't know if they were right on Taylor Street, but we sampled about 3 homes in that area. I can get you all of that data. There was no problem. The reason why we don't think there was a problem with the indoor air there is because the groundwater is about 120 feet deep there. The groundwater is contaminated underlying that area, but it's deep. It's over 100 feet below the surface, which doesn't mean there is not a problem.

MR. LEONARD: I was going to say it's probably a little shallower there. Maybe about 60 to 80 feet.

MS. O'CONNELL: Oh, it is. Okay. So, the groundwater in that area is 60 to 70 feet deep then. I guess it starts to come up, and we did sample about 3 homes in the area. One of them had a dirt floor, and we, you know, sampled the 1st floor, the downstairs. Last year -- not last year; in 2013 when we found the indoor air problem inside the American Can facility we also did an outreach to the town and we tried to get people to agree to let us come and sample. We sent out maybe 20 letters and we only had 3 people respond and they would allow us to come and sample. We did that sampling in 2013. It showed no elevated vapors.

MS. WILSON: I'm a little concerned now because, like I said, where my house is, if you look at Vikon Tile, my backyard is the Norfolk Southern Railroad. My family lived in this town for several generations. So, I'm no stranger to

Washington at all. However, I think perhaps you did not get the response you were looking for because no one understands what's going on. I just found out about this meeting probably 20 minutes before it happened. So, welcome to good old Washington Borough where, you know, I pay my taxes, I'm a homeowner, I raise my children here, but somehow I don't seem to get the information that I need. Additionally, like I said, several homeowners I've spoken to on my street, we haven't had anything sampled. How would we go about doing that at this point?

MS. O'CONNELL: Well --

MS. WILSON: -- because right now -- let me finish. I'm sorry.

MS. O'CONNELL: Okay.

MS. WILSON: -- there is a stench in my home that smells like sewage, to something died, rotten food, to sulfur, where I have to leave my home for hours, whether it rains, whether it's a hot day, even to the point where I yelled at my children, who are teenagers, thinking they did something, and it wasn't. We get water in our basement. So, you cannot honestly tell me that there is not something wrong.

MS. O'CONNELL: Well --

MS. WILSON: And before, whatever is going on at Vikon Tile and the area of concern 1, whatever issues people are doing, it happened after that. Additionally, when there are people on my street, when they were taking, I guess, samples in the field, which is part of Taylor Street school field, and you would ask what is going on, we're not given any information. I had personally gone and said, excuse me, what are you doing. You get nothing. Like I'm not even a person. Don't speak to me, don't say hello, don't give me a card. I think that's unacceptable.

MS. O'CONNELL: Where is this? In a school?

MS. WILSON: In the school field. So, if you're looking at area of concern 1, bring your pointer down. Probably right around there.

MS. O'CONNELL: That wasn't part of our study. I don't know what that was. I mean there may be something going on there. I mean you might have to contact your local official. That wasn't part of the Superfund study.

MS. WILSON: Oh, I have, which is pointless.

MS. O'CONNELL: Kevin Cavotta at the Warren County health department. We work with him on a regular basis. That wasn't -- I don't know, I can't speak to that because I don't know what that is. That wasn't part of our study. It looks close by. It might have been some kind of local work done. Our work was, the samples we took were on those 4 properties which are in the vicinity of your home. I can tell you one thing, there was no contaminants on the surface that was posing any human health risk or direct contact risk. So, the shallow soil samples were not heavily contaminated at this point in time. The highest contamination we found was in the soil below the American Can building, of our concern, which is Tung Sol Tubing.

MS. WILSON: How do we get, if we prefer, now at this point, to get tested?

MS. O'CONNELL: Well, what I would like to do is to get your address from you, and we can look to see which homes were sampled in the vicinity. There may have been a home sampled in the vicinity of your home, or not. We had a very low response rate when we sent letters out to request indoor air sampling. Maybe people don't understand it, but we tried to explain it, and we request permission, and we did not find a large problem there, but we can look. I think the first thing to do would be to look to see where your residence is located with respect to the samples we already took to see if that's helpful or not. As I said before, we do do periodic vapor sampling. We're not doing it every year because we don't feel the situation warrants it, based on the sampling that we've done so far. So, we are doing periodic sampling. It's possible we can add your home on to the next round of sampling, and I can't tell you when that would be. It may not be immediate. I don't -- you know, I can't say the problems in your home, what they are. There could be a whole bunch of things. We dealt with people who, you know, a lot of times there's just not proper drainage around their homes. Just these localized issues that's really caused a lot of --

MS. WILSON: It's not just myself. There's several, but, you know, a lot of people, like I said, I just got notice so --

MS. O'CONNELL: Right. Do you think there's drainage problems around your home with like the rain runoff? Is it by the railroad tracks?

MS. WILSON: I don't know because we get water in our basement.

MR. STONE: I have a sump pump because every time it drizzles we get our basement flooded. So, the water table is a lot closer than I think you guys are saying. I have a radon set up also, due to the gases, but I still am 4 houses from her, and I have the same smell comes out of my basement. I am literally pumping it from my basement right into my driveway because that's where I put it. You can't put it in the street because of the DEP, and I still have this. Not too long ago I was asking my wife what is that smell. I couldn't figure it out. I walked into the basement, nothing in my house smells in the basement, but the smell is just horrendous.

MS. O'CONNELL: It would be highly unlikely for groundwater, there is contaminated groundwater down at 60 feet, to be flooding your basement during a rain event. It's more likely that it's some kind of runoff issue or drainage issue. I mean groundwater does not come up 60 feet in a rain event. I believe you. It's just very unlikely that that's contaminated groundwater.

MR. STONE: A cistern, how would that work?

MR. BUTTON: A drywell?

MR. STONE: It's almost like a drywell. They used to use it back in the old days to store water to use the water.

MR. BUTTON: A drywell is the same thing. It's collecting runoff from rainfall and then basically injecting it into the ground. The regional groundwater table is deep, but everything, if I remember right, Taylor Street is the one that dead ends on Vikon Tile. So, you have --

MR. STONE: See, it runs right alongside the tracks.

MS. WILSON: So, we're almost cutoff.

MR. BUTTON: Yeah, I think I know where you are. You're basically right in here, right?

MS. WILSON: Correct. Yes.

MR. BUTTON: So, you have low areas. You know, the site here, this is the lower area on this side of the tracks. Vikon Tile is kind of a little higher than you there, I think, right? What it sounds like you're talking about is, you know, runoff and other, basically rainfall, you know, collecting and flooding into the area, but as far as the smells and the odors you're saying, that's a new thing?

MR. STONE: It started when everything was happening. And you guys are saying you guys weren't responsible for drilling, but the same company though drilling up the tracks, it was the same exact company made the path to the tracks. Same exact company they made their own path to the tracks.

MS. O'CONNELL: Right. Vikon Tile, because that was probably the construction of the groundwater treatment plant that's located right -- no, the groundwater treatment plant is up in there, and the extraction wells are on Vikon Tile property. That's where the groundwater is pulled up and it's piped back, I guess under the tracks and into a treatment plant that has just begun operating in March. That's the construction you seen there.

MR. STONE: But that's what she was saying though like when people were drilling the field you ask them what they were drilling for, they looked at you like you had 10 heads and turned their back and walked away. The same company that was drilling those holes in the field is the same company drilling the holes up on the tracks.

MS. O'CONNELL: I don't know. These are the only properties that we operated on, and there were contractors out there, and maybe subcontractors out there doing the work. You know, when people asked them questions they usually don't answer, but they usually provide you a contact of somebody who can, who is managing the project you can answer to. So, I don't know what that was about.

MS. MARASCO: When you sent out the letters I'm assuming you're referring to contacting the residents over there by the area of concern, and you had to do it by so many feet on the residents that are closest near that, but if Vikon residents over in that area were not considered a concern then they probably weren't notified at the time to do any sampling, right?

MS. O'CONNELL: You know what, it might be misleading, the reason that's called an area of concern, it was just a name given to that --

MS. MARASCO: No, I'm asking where did you send those letters?

MS. O'CONNELL: To all residents around that area. Even across the street from the entrance to American Can --

MS. MARASCO: My lot is 260 feet. So, it went on both sides of the tracks?

MS. O'CONNELL: We went all around to try to see who would let us come in. We knew there was a problem in the American Can facility. We thought it was unique. We thought it was because it was disposed of right there, but we wanted to go around and see if we could get several residents from all sides as close to the plant as possible to let us sample, and we were only, even though I believe we reached out to about 20 residents, only 3 gave us permission. It would have been 2013 I think.

MS. MARASCO: I mean that's pretty significant, if I was a resident and I got a EPA notice and from the health department and borough I would remember that.

MS. O'CONNELL: It's not usual for

us to get, you know, less than 50 percent --

MS. MARASCO: I believe people that are now complaining, if your concerns were within this radius, no matter how much footage it was going either way, then all of them should have received that same letter back in 2013, and either they approached you back then or they should have been here tonight. But these two residents, I'm hearing about, are saying this is something that just developed new, and it may be because there has been some disruption on the testing, and now I think, as a hygienist, as a tech, that has to be related, and they need to go back, and they need to reinvent a letter to that area there and see if they can have an idea of --

MS. O'CONNELL: We have sampled in that area. We have sampled for vapor, for indoor air contamination in that area. We have several samples. I can't tell you how many. We may have 3 to 5 samples in that area, and we'll go back and look. We'll go back and look, because we took samples in 2013, but even before that we reached out, before 2006, because that was when we wrote our ROD. You know, in the 2000's we reached out and we did some sampling really throughout the whole valley, including this area. I told you we also targeted schools and daycares. We did some samples in the middle of the valley where the contamination was a little lower. We did some at the end of the contamination. We wanted to kind of see if we could see a trend. So, there was at least 2 rounds of sampling in that area, and, as I said, we found no indoor air contamination in any of the buildings other than the American Can building itself. And, based on the depth of the groundwater contamination, and the fact that we didn't find any vapor contamination in several rounds of sampling, makes it a low risk of there being vapor contamination. This issue with the drainage and the flooding is a different issue than indoor air contamination. That sounds like a different issue.

MS. MARASCO: It could be both because it's incapsulated in the basement. That would be vapors in the basement. Because there's no circulation and she stipulated it didn't matter if it was a rainy day or a dry day. Now she's smelling something, which is vapor, and that could be from water or it could be from air pollution, and that's something that needs to be explored and they should be contacted I think.

MS. O'CONNELL: Well, we will go back and we will get the results of sampling that's been done on your street, and we can see -- we can follow up with you on that and see where it is and whether additional sampling is warranted.

So, we are going to let Ed finish his presentation. I think he's in the last leg of it and then we'll open it up again for questions.

MR. LEONARD: So, the last piece is the feasibility study, which is an engineering study. So, we are going to hit some of the key aspects of the feasibility study. The first is you have to define the remedial objectives. Basically why are you doing this study. And there were 2 basic objectives. One was to reduce the contaminant mass, which is the TCE, under the building in the soil to minimize impact to the groundwater, which is below the building and impact to the human health inside the building above the TCE. And then the 2nd thing was to mitigate impacts to the public health, again, from the vapors. So, it's basically try to minimize what's in the soil and try to stop what is in the soil from going into the building.

Then we developed site specific remediation goals. So, with that we took all the information from the risk assessments, from the remedial investigation, and took all that information and came up with the site specific remediation goal. That was developed as 1 milligram per kilogram for TCE in the soil. We are looking at both to protect the groundwater itself and human health from vapor intrusion into the buildings.

What we need to also realize is that once we implement the remedy from whatever alternative that gets picked, it's going to be done in conjunction with the ongoing groundwater treatment that we've been talking about. Treatment plant on the Albea property or the former National Can, and then there is also a treatment plant further down-gradient by the apartments. So, these are going to work together. One is to reduce the volume of TCE in the source area but to continue to treat the groundwater so that it cleans up.

So, as part of the feasibility study we looked at several different methods for cleaning the area up, took that information and brought it down to 4 alternatives. And we'll step through each of those alternatives.

The 1st alternative is no further action, required by law, and it's basically something to compare it to. And that means nothing is being done at all. Again, it's only for a comparison. But that means even the treatment system, the soil vapor treatment system that's in the Albea or American Can facility currently. That wouldn't even be running. There's no coast to that. And basically nothing is being done. But, again, that's required by law and that's just for comparison. So, you can say I'm cleaning this up and not doing anything here. You know I know how much better it's going to be.

Second alternative is a limited action. So, we've got the existing vapor treatment system in the Albea building right now or the former ANC. It's a shallow vapor -- excuse me. It's a vapor extraction system and a sub-slab depressurization system. So, 2 things are going here; you've got some very shallow wells underneath the building into the soil that go about 5 feet deep extracting the soil vapors out of the soil and then you've got some other extraction points right underneath the slab of the building extracting any vapors that are under the building. And, again, the point here is to take the vapors out before they have any chance of migrating up and into the building. That's been running 3 years now and that would be our alternative 2, is just to continue to run that. It would protect the workers and the people inside the building, but do nothing to clean up the groundwater, which, again, is very deep. It's only the first few feet of the soil underneath the building.

This is just a sketch, which is a little difficult to see, but this is the current system. So, again this is the southwest corner of the building where the highest levels of TCE were found during our OU3 investigation. These purple and green dots here are the soil vapor extraction wells and they go down about 5 feet into the soil. There's 2 lines here of sub-slab depressurization ports, which, again, just go through the floor slab itself and extract the vapors that are underneath the floor. And then throughout the whole building you have got monitoring points that are checked on a periodic basis to make sure that the system is properly working.

THE PUBLIC: And how many of those are there all together? We can't really see them here. What is the total of those?

MR. LEONARD: Honestly, I do not remember. It wasn't designed by us. This was done by Albea themselves as a remedy to address the soil vapors going into the building. It was underneath EPA's oversight but not as part of the work I did. So, my apologies, but I don't know the exact number.

The 3rd alternative is in-situ chemical oxidation, and that would be done in conjunction with the shallow vapor system still operating. We want to continue the vapor system, the shallow one, because it protects the indoor workers so that any of the work that's being done to remedy the source underneath the building, as that decreases, as the remedy works, the people inside the building will still be protected by the shallow vapor extraction system.

The oxidation system; so, in this scenario a substance is taken and injected into the ground, and what it does to the TCE, it breaks it down into what we call water and innocuous bi-products. So that basically you're destroying the TCE that's in the ground. In addition to injecting these substances there also will have to be some environmental hydraulic fracturing. Because the material is relatively tight you've got to open up some pathways down there in order for this material to get in and get contact with the TCE. So, they actually just expand the material under the building just a little bit in order to get pathways for the treatment to be done. The cost on this alternative -- excuse me. I should go back one. My apologies.

Cost; alternative 1, since nothing is being done, no cost involved. And, again, it's just used for comparison purposes only.

Alternative 2, which is the limited action with the shallow wells, the present work on that is 2.37 million. And then for alternative 3, the present work is 12.6 million.

This next figure just outlines the conceptual design of what would be done with the oxidant. Again, this is the southwest corner of the building. This red line is the approximate area of the area to be treated. And what they do is put in several different, or in this case, couple of dozen injection points where the oxygen is injected into the ground. And we are going down between 60 to 100 feet. We have preferential pathways that are done by the hydraulic fracturing to open up some pathways, and there will be several rounds of treatment in order to treat TCE. And then in addition to that there's monitoring of both the soil and the groundwater to make sure that the treatment is all working.

THE PUBLIC: Excuse me. Now, this diagram, where is this actually located?

MR. LEONARD: This is the area here, this area A, is the American National Can. So, this is where all the alternatives are. The current extraction system is primarily in this area, and it's estimated that this alternative, the in-situ chemical oxidation will remove about 50 percent of the contaminants underneath the building.

The last alternative, alternative No. 4, is a deep SVE system. So, as we talked before, we've got the shallow SVE system out there, which is extracting the soil vapors down to about 5 feet. This system would go down to about 100 feet and be extracting soils from around 30 feet down to 100. It also would be working in conjunction with the shallow soil vapor extraction system. Again, as the alternative or remedy is treating the deeper stuff this will protect the vapors from coming inside the building. The deep system will work just like the shallow system does, where the gases get extracted, or the vapors get extracted. They get treated with activated carbon and then the treated vapors or air at that point gets discharged outside, no longer having any of the contaminants in it.

Now, as this system is running, if it's determined that we're not removing the TCE at a reasonable time frame or reasonable rate, there is an option to go in and treat a hot spot that we consider that's in this area, which is not coming up very well with the color. This area right in here, there's a square in here. Went the wrong way. There we go. There is the green I'm looking for. This is a hot spot area that we consider to have the highest levels of TCE. If we find that the deep SVE system is, again, not removing the TCE in a reasonable time frame, we would be looking to do in-situ thermal hot spot treatment.

What that consists of is putting

electrodes down into the soil, heating the soil up to very high temperatures and allowing the TCE to vaporize off, and then that would be collected by the deep SVE system. Again, those vapors are treated and then the air itself discharged.

Total present worth for just the deep SVE system, which, again, are these little green and black X's, these are the wells that are put in, will be 7.8 million dollars. The SVE system with the thermal hot spot treatment would be estimated at 12.7 million dollars, and it's estimated that this alternative would remove 90 percent or greater of the contaminants underneath the building.

THE PUBLIC: Without the hot spot you're talking about?

MR. LEONARD: Excuse me.

THE PUBLIC: You're saying 90 percent. Does that include dealing with the thermal hot spot or without the thermal hot spot?

MR. LEONARD: Well, it would be either way. We expect the SVE system alone to do it. If it doesn't then we use the hot spots. So, the overall estimate is 90 percent or better.

So, that runs through the 4

different alternatives. The last thing we'll do is talk about the 2 evaluation criteria and the preferred alternative.

So, EPA has developed evaluation criteria for comparing and evaluating all the different alternatives that we've developed for this site, and any EPA site. Those 9 criteria have been divided into 3 groups; threshold criteria, primary balancing criteria and modifying criteria.

So, for the threshold criteria, those 2 criteria that are listed under it must be met in order for the alternative to be selected. So, basically it's got to be protective of human health and the environment, and it has to be compliant with regulations and laws. Those must be met in order for an alternative to be selected.

The balancing criteria are used to distinguish the relative effectiveness of each alternative so decision makers can compare, evaluate and contrast the different alternatives. So, you look for both strengths and weaknesses. So, you're looking at things like permanence, how long is it effective, short term effectiveness, reduction of toxicity, mobility, and volume of the contaminants you're looking at. You also want to look at implementability, how easy is it to do it, and then, of course, cost.

Then finally you've got modifying criteria, which typically is considered after documents are reviewed, the proposed plan is reviewed, and it's done by 2 groups; yourself, the public, and, of course, the state, the DEP. And EPA is looking for their acceptance, their comments, your thoughts on what is being proposed, and then those questions are addressed as part of the ROD or remedy of decision.

So, EPA has proposed a remedy. It's alternative No. 4. The deep SVE with the optional in-situ thermal treatment. And the reasons are; the first two ones are the most critical, they meet the threshold. They protect human health and environment, this alternative, and it complies with the A laws, which are basically the laws and regulations. In addition it will achieve our remedial action objectives we outlined earlier. But then it also, the primary balancing criteria where we were talking previously about effectiveness, implementability, costs, toxicity, et cetera, it provides the best balance of addressing all of those. And then of course reduces the toxicity, mobility and volume through the treatment.

So, with that, just a couple of more slides providing just some final information. I think Kim went over this earlier; the proposed plan was released last week. That started the 30 day comment period on June 15th, and that will go through July 15th of this year. The administrative record, which provides all the documents that have been used or released or prepared during the OU3 work are available, either at the Warren County Health Department, up in Oxford, of course over at EPA, their office in New York, and then many of the documents that are an administrative record are available on the website, which was also provided in the proposed plan that you have today. And then finally contact information: Michelle Granger, again, as the remedial projector manner OU3, her contact information is provided in the proposed plan. Pat Seppi, who, unfortunately, couldn't be here this evening, is the community relations coordinator. So, she could also be contacted if you have questions. And as Kim had mentioned earlier, she'll get you the information for the 2 other remedial project managers.

Kim, at this point it's your's.

MS. O'CONNELL: Okay. We're just going to open it again for questions, and I will remind you to state your name. Yes.

MS. MARASCO: Marsha Marasco. Has the freeholders been up to date on everything at this point?

MS. O'CONNELL: Our primary contact, the local official we update most regularly is Christine Blanchard, the township manager. So, the freeholders are a county wide seat.

THE PUBLIC: Excuse me, Christine is what kind of manager?

MS. O'CONNELL: She's the township manager.

MS. WILSON: Who are you contacting now? She resigned a couple of weeks ago. Christine Blanchard is no longer the borough manager. We are without one.

MS. O'CONNELL: Oh, because I just spoke to her today. So, we have been contacting her on, you know, on this meeting, and we also provided her with the proposed plan and she posted it on the township's website a couple of weeks ago.

MS. WILSON: She resigned at our last town council meeting. So, that's why I was like hmm --

MS. O'CONNELL: Well, maybe it's not effective yet because I did not know that, but she posted our proposed plan on the -- or the notice of our proposed plan on the township website about a week ago.

MS. WILSON: And who else besides her?

MS. O'CONNELL: She's our contact in the town that we deal with. We've also dealt with throughout all of our projects with the mayor.

MS. WILSON: So now the mayor?

MS. O'CONNELL: We haven't dealt with the mayor. The mayor sort of delegated our work to her. We have been dealing with her permitting issues. We deal with the fire and the police or the emergency folks.

MS. MARASCO: Because the reports go on the mayor's desk. That I know for a fact. And they are supposed to review it. So, that's why I'm asking is the freeholders have ever questioned any of this since it's been ongoing for almost 3 decades now and we've gone through many hands of freeholders but I would think they'd still have to be privy as to what is going on at the borough with this, because they are involved with Warren County and Washington Borough.

MS. O'CONNELL: I mean our outreach for this proposed plan is, you know, we publish it in the Express Times newspaper, we notify the township officials. They posted notice on the town's website last week. There was a press release that we issued.

THE PUBLIC: Kevin Cavotta, the county health person for Warren County.

MS. O'CONNELL: We've dealt with him. Yes.

MS. BRUEN: Gail Ann Bruen. In the past in the Park Hill apartments we received individual notices. The only way I got an email from your office that I knew about tonight's meeting. There was one sheet of paper in the Park Hill apartments downstairs. Just one sheet of paper. Nothing else anywhere. Over 100 residents in that apartment building. So, you know, only that I got it from your office I would not have known that there was a meeting tonight, and I appreciate that but --

MS. O'CONNELL: We tried to do our outreach. The Park Hill apartments we were reaching out to everybody on the construction. The construction there happened in the parking lot of the Park Hill apartments, and, so, we had to notify people of the changes in the traffic pattern and all of that. That was very specific to that. You know, they are citizens of this town. So, you know, we did try to --

MS. BRUEN: I was glad to get an email from your office. I wouldn't have known about it. I'm am still not clear about what the ramifications are since we are not directly involved in this, you know, what the ramifications and all this are for Park Hill apartments.

MS. O'CONNELL: The Park Hill apartments are primarily affected by the cleanup that's going on there, which is that groundwater extraction and treatment system, which is that small treatment building in the parking lot, and the extraction wells have been constructed along Park Avenue.

MS. BRUEN: Well, I have specific

questions, which I will talk to you after, because I understand, if I listened to rightly, that you're talking about PCE as opposed to TCE or the other way around.

MS. O'CONNELL: PCE is the primary contaminant. Perchloroethylene. They're both chlorinated solvent, you know, contamination, but PCE is the primary contaminate at the Park Hill apartments. And TCE is the primary contaminate emanating from the former American Can facility. It's actually the primary contaminate in the area wide plume, groundwater contaminate plume, yes.

MS. BRUEN: The other thing is I don't understand where the plume goes and whether or not it does affect the apartments. And I was trying to trace where it is and what.

MS. O'CONNELL: You know, we should have had that other map. Do you have a pointer? This isn't the best map. We basically have this whole area, this is the American Can facility. This is Asbury Broadway Road. We marked it because it's about the midpoint of our groundwater contaminate plume. This is actually the study area. The plume is a little bit within this area. It goes down through Greenwich, through Franklin.

So, the American Can facility is the primary source of the TCE contamination that's moving down the valley. Right next to it over here is where the Park Hill apartments were, and that was formerly Tung Sol Tubing, and there was PCE disposal at that facility when it was operating as a factory, and that groundwater contamination also moves down the valley but it doesn't move as far down valley. It goes to -- it moves down towards the Vannatta Street well and then a little bit south of that and then it starts to dissipate. It's not -- it's not as wide spread as the TCE.

MS. BRUEN: But it was 40 feet down as opposed to --

MS. O'CONNELL: The groundwater --

MS. BRUEN: -- contamination.

MS. O'CONNELL: The groundwater levels at Park Hill apartments are about 40 feet below the surface. Groundwater is about, when you get over to American Can the groundwater is about over 110 feet below the ground surface.

THE PUBLIC: Now, the second question, in looking at the first -- the map on the right-hand side.

MS. O'CONNELL: This one?

MS. BRUEN: Yeah. Is that the Park Hill apartments?

MS. O'CONNELL: Nope. This is an empty warehouse that's been abandoned that's in some disrepair. And then right here is the entrance. There is a big entrance. It's called Albea facility.

MS. BRUEN: Right.

MS. O'CONNELL: And then Vikon Tile is an abandoned property here at the end of Taylor Street, that's the entrance. And then Warren Lumber Yard -- there is another -- some kind of furniture or wood operation going on there. It used to be called Warren Lumber Yard. We have these designations that we gave these properties a long time ago. We try to use the same designations.

MS. BRUEN: So, Park Hill apartments is not on that?

MS. O'CONNELL: No, it's about maybe a quarter a mile down 31. This is 31. It would be further down that way.

MS. BRUEN: Right. Okay. Thank you.

MS. CRISAFI: Cara Crisafi. Once

you implement this system underneath American Can how does that ultimately affect the plume going towards, I guess the Delaware River?

MS. O'CONNELL: Yes. Good question. We are trying to remove the source. Any additional source, any remaining source of groundwater contamination. Right now we are pumping over here. There's a groundwater pump and treatment system that's extracting, I think over 400 gallons a minute. This just started in March.

MS. CRISAFI: Is that Albea?

MS. O'CONNELL: This is Albea. There is also a treatment system over at Park Hill apartments.

MS. CRISAFI: What is that extracting?

MS. O'CONNELL: About 45 gallons a minute. So, we're extracting about over 400 gallons a minute here. This just started in March. The goal of that is to pump the most contaminated groundwater in the area. Some of the levels are several thousand parts per billion of TCE, and pretty much cutoff the head of the plume and allow this more residual lower levels to attenuate over time. It's also important to remove the source. So, the remaining TCE under the building, even though it was likely present at much higher levels historically, what it's doing now, is, it's caught up in the soil under the building. Some of it is vaporizing, and has, you know, caused an indoor air problem in the building, which has been addressed, you know, from a temporary basis, but we would like to remove the source of any future indoor air contamination, and some of it is slowly leeching, migrating down and adding to the groundwater contamination. So, the overall scheme for this TCE contamination is to remove the source that remains under the building, to actively extract, to pump the most contaminated groundwater and to let the rest of it attenuate.

MS. CRISAFI: What do you mean attenuate?

MS. O'CONNELL: When you cutoff the source -- right now the highest, the most contaminated groundwater is in this area, and just continues to decrease all the way down here until we get to the bottom, and the levels are just above 1 part per billion. So, it will really dilute. It will continue to decrease over time when you cut -- when we're cutting the source off.

MS. CRISAFI: But then how many feet down are you saying?

MS. O'CONNELL: It will take tens and tens of years, but we will be pumping. We are pumping. Actively pumping up here and reinjecting the clean -- cleaning the water, reinjecting it, and then this water will continue to move down and dilute the primary source, being the soil under the building, and the hot spot or the most contaminated groundwater will be cutoff, will no longer be contributing to the rest of the plume, and it will eventually attenuate. That will be a long-term process. And there is active monitoring to ensure that that's happening throughout the plume. That's part of our groundwater remedy monitoring natural attenuation.

MS. CRISAFI: It's going that way?

MS. O'CONNELL: We think that the plume is no longer migrating because it's kind of stable at the bottom. We have defined the plume at about 1, and we don't expect it to significantly increase, but we're looking to continue to monitor.

MS. CRISAFI: You said at about 1?

MS. O'CONNELL: Well, 1 part per

billion TCE is the drinking water standard. Our goal here, the overall big goal is restoration of this aquifer, and when you restore an aquifer you restore to drinking water standards. So, our goal would be to assure that the aquifer eventually gets down to below 1 part per billion TCE, and then it will meet drinking water standards at that point. That would be the very long term. That would be a very long term goal.

THE PUBLIC: And now is that going to involve fracking, at all, along that valley way that you just highlighted?

MS. O'CONNELL: No.

THE PUBLIC: So, when you start doing the cleanup on the river itself --

MS. O'CONNELL: There's no cleanup of any river.

THE PUBLIC: I mean on the plume. I'm sorry.

MS. O'CONNELL: Okay.

THE PUBLIC: You were talking about the Delaware River. On the plume you're anticipating going down 100 feet to clean and strip the water?

MS. O'CONNELL: They are extracting

water from, you know, what depth, Joe? They're extracting water from below 100 feet. They're extracting water in the highest area of contamination. They're bringing it up to the surface. They're sending it to the treatment plant where it's being treated, and the TCE is being removed, and then it's being -- the clean water is being reinjected.

MS. WILSON: Tauneah Wilson. May we have your contact information?

MS. O'CONNELL: Of course. Of course. Should I give it to you after the meeting?

MS. WILSON: No. Could you give it --

MS. O'CONNELL: Sure. Does anybody else need it besides her? My name is Kim O'Connell "O'" C-O-N-N-E-L-L. I'll give you my email, which is, O'Connell, one word oconnell.kim@EPA.gov. Michelle's information is, her email is on the proposed plan too. So, we will follow-up with you and give you more specifics on the vapor work. We will also look into the work, the construction work that's been done in the vicinity of your homes to see if there's anything there that may have led to a problem. You're saying this problem is new, the problem with the flooding is new.

MS. WILSON: The smell.

MS. O'CONNELL: There was construction in the area. I don't know exactly where your home is, or how close it is, but we will look into that and try to see if there's any relation at all.

MS. CRISAFI: I have a question. Cara Crisafi. Was Taylor Street school tested? That's pretty close to --

MS. O'CONNELL: No, Taylor Street school wasn't tested. Four properties were tested. But let me remind you, there's no significant surface water contamination. There's no -- we call it direct contact risk. The risk here is that the TCE in the deeper soil under the building is going to migrate to the air in the building or continue to migrate through the groundwater. The levels on the surface are relatively -- are low, or many are non detect. So, there's not a direct contact risk. People walking, even though there's a railroad track and it's not a highly accessible area, people walking and coming into the surface soils on these 4 properties are not being exposed to elevated levels of TCE.

MS. CRISAFI: Okay. I was just concerned about the vapors for Taylor.

MS. O'CONNELL: Oh, that school. I have to look to see. We did go through the valley.

MR. LEONARD: It was tested in 2010.

MS. O'CONNELL: Okay, 2010. We did go to the valley. So, it was tested --

MS. CRISAFI: I mean it was so close and yet Franklin elementary school is miles away.

MS. O'CONNELL: True. The water table comes up as it goes down, plus the --

MS. CRISAFI: As it goes down?

MS. O'CONNELL: As the contaminated groundwater moves down the valley, as water moves down the valley the water table comes up. So, the water table is very low in Washington Borough and it just comes up as it moves. That's the trend.

MR. BUTTON: It's more the topography changes. So, it's higher. Like ANC is sitting way up on the top of the hill. Whereas once you're down you kind of come back up. The water table is where it is, but the topography changes.

MS. O'CONNELL: There was also thought that there may be a fault down in the valley near the Pohatcong Creek. So, it was thought that that might be a reason why we saw some elevated vapor levels in that area.

MS. CRISAFI: But you never confirmed that?

MS. O'CONNELL: Well, we sampled. We did sample the school and some homes in that area.

MS. CRISAFI: Oh, but you know for sure there's a fault in that area?

MS. O'CONNELL: Yes. But the exact mapping of the whole fault is, you know -- but, yes, that's what the hydrogeologist determined that there was a fault. It's not clear exactly how that relates to vapor problems, but it's thought that it would be related. And I have to remind you that the elevated vapor in the area of Asbury Broadway Road was only slightly elevated, but we reacted with an abundance of caution because there was a school.

MS. CRISAFI: That's good.

MS. O'CONNELL: So, a system was installed.

THE PUBLIC: When will you start? What's the projection on starting to put the project together?

MS. O'CONNELL: Okay. So, our public comment period is going to end on July 15th. We expect to evaluate comments and issue a record of decision document, that's how we select our remedy, around September. We already have a settlement where private parties are going to implement this remedy. So, we'll have to do an engineering design. That usually takes about a year. It involves additional sampling. A schedule will be developed, but I will just give you a rough estimate; about a year and then the construction would happen after that.

MS. BRUEN: I am Gail Ann Bruen and on the record I would like to be appraised of what the status is of the most recent testing of, you know, Park Hill apartments for OU2. I understand, as you said 2 weeks ago, it was done. I'm also interested, do you have a criteria that you talked about, you know, in terms of volume and all the rest of it, about how this treatment facility has only been running for 2 weeks but, you know, I would like to know ongoing how it's measuring up to your criteria. Okay.

MS. O'CONNELL: Okay. Thank you.

MS. CRISAFI: Cara Crisafi. Who is paying for all of this?

MS. O'CONNELL: EPA has entered into a global settlement with a number of private parties that were related to the operations of the facility. So, at this point it's privately funded.

THE PUBLIC: But it's still considered a Superfund, right?

MS. O'CONNELL: It is a Superfund. Superfund is publicly funded and privately funded.

THE PUBLIC: So, federal.

MS. O'CONNELL: We are federal.

THE PUBLIC: I was just saying, you know, when it becomes a Superfund --

MS. O'CONNELL: Federal monies were expended early on before we entered into a settlement to do the early investigations, and then later on a settlement was reached. So, now it will be privately funded.

MR. LEONARD: We are still paying

for the plan at the Park Hill apartments.

MS. O'CONNELL: The PCE plan is publicly funded. Is that it?

Thank you everybody for coming. We appreciate you taking your time and we appreciate your comments and concerns. Thank you.

(Meeting concluded.)

C E R T I F I C A T E

I, GINA MARIE VERDEROSA-LAMM, a Certified Shorthand Reporter and Notary Public of the State of New Jersey, certify that the foregoing is a true and accurate transcript of the deposition of said witness(es) who were first duly sworn by me, on the date and place hereinbefore set forth.

I FURTHER CERTIFY that I am neither attorney, nor counsel for, nor related to or employed by, any of the parties to the action in which this deposition was taken, and further that I am not a relative or employee of any attorney or counsel employed in this action, nor am I financially interested in this case.

____
GINA MARIE VERDEROSA-LAMM, C.S.R.
LICENSE NO. XI2043

Attachment D: Written Comments

From: Alicia Lyding
Sent: Friday, July 15, 2016 4:25 PM
To: Granger, Michelle
Cc: Seppi, Pat
Subject: Pohatcong Valley Groundwater Contamination Site OU3

Ms. Granger,

Below are some questions I have on the Proposed Plan for the Pohatcong Valley Groundwater Contamination Site OU3.

1. In the WLY Ponded Area TCE was detected in surface water, how is surface water being addressed as part of this ROD?
2. Remedial Action Objectives assume that the land use will remain industrial, what controls will be required as part of the ROD to ensure that the land use does not change?
3. A site-specific indoor air health goal is proposed that is higher than the NJDEP Indoor Air Screening Level for Nonresidential. What was the basis for this alternative standard?
4. A Preliminary Remediation Goal (PRG) was established for TCE within the vadose zone, however no PRG were established for any of TCE daughter products (such as Vinyl Chloride). How will generation of daughter products due to the remediation be monitored? Without PRG for the daughter products how can you ensure the remediation is completely removing/addressing the daughter products that may be generated during remedial actions?
5. Alternative 3 proposes the injection of an oxidant from approximately 60 to 100 feet. How would this injection potentially impact the groundwater aquifer located directly below this zone? Would this have a potential impact on the local drinking water? What would be the proposed additional treatment required for the aquifer if the contaminants and oxidant migrate to the aquifer?
6. Due to the extremely high levels of TCE in the sub-slab soil gas will the exhaust stack of the SVE and SSD systems be tested to ensure ambient air concentrations are below appropriate levels? Was an air permit required to operate the existing systems?
7. As part of Alternative 4, will monitoring of the sub slab and indoor air at surrounding residents be conducted to ensure that soil gas levels do not become elevate due to the remedial action?

Thank you,
Alicia Lyding

ALBÉA

August 15, 2016

Michelle Granger
Remedial Project Manager, Southern New Jersey Remediation Section
U.S. Environmental Protection Agency
290 Broadway, 19th Floor
New York, NY 10007-1866
Granger.michelle@epa.gov

RE: Comments on the Proposed Plan for Operable Unit 3 of the Pohatcong Valley Groundwater Contamination Site

Dear Ms. Granger

I am writing to submit comments on behalf of Albéa Americas, Inc., the current owner of the Washington Facility, with respect to the June 15, 2016 Proposed Remedial Action Plan for Operable Unit 3 at the Pohatcong Valley Groundwater Contamination Site. Albéa appreciates the ongoing efforts by U.S. EPA and Pechiney Plastic Packing, Inc. to remediate the Site, and respectfully submits these comments for your consideration.

Albéa has fully cooperated with Site remediation work by U.S. EPA and PPPI to date, and Albéa intends to continue to cooperate and provide access to the Washington Facility for the ongoing work consistent with the terms of the Consent Decree for the Site. In this regard, Albéa would like to point out that Section 25 of the Consent Decree also commits U.S. EPA to "coordinate such access activities with [Albéa] in an effort to minimize adverse impacts on Washington Facility plant operations."

U.S. EPA's proposed plan for OU-3 appears to involve additional activities in a section of the Washington Facility that Albéa refers to as the "Molding Area." Albéa would like to inform you that the Molding Area is currently and will in the future be used for storage of equipment and materials and other plant operations that effectively occupy this entire space.

Albéa understands that PPPI is proposing a revision to the Agency's proposed plan for OU-3 that would involve proceeding immediately with the deferred component, *in situ* thermal treatment; and that would utilize diagonal drilling from outside the building footprint instead of staging work inside the Molding Area. Diagonal drilling would largely eliminate any potential disruption to plant operations, and implementing thermal treatment at the outset should lead to completion of the remedial activities much more quickly than a two-phase approach. Therefore, Albéa supports PPPI's alternative and requests that U.S. EPA move forward with that approach. We would encourage U.S. EPA to come to the Washington Facility to observe the Molding Area before making its final decision regarding OU-3.

Thank you for considering Albéa's comments. Please contact me if you would like to discuss or if there is any additional information Albéa can provide that would be of use to the Agency.

Sincerely,

Douglas Jerman
Plant Manager, Washington facility
Albéa Americas, Inc.

Rio Tinto

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Michelle Granger
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Southern New Jersey Remediation Section
U.S. Environmental Protection Agency
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E-mail address: granger.michelle@epa.gov

Re: Comments on USEPA's Proposed Plan for Operable Unit No. 3, Pohatcong Valley Groundwater Contamination Superfund Site, Warren County, New Jersey

Dear Ms. Granger:

On behalf of Pechiney Plastics Packaging, Inc. (PPPI), the Primary Settling Defendant for the Remedial Design/Remedial Action Consent Decree (CD)[1], we are submitting the enclosed two sets of comments regarding the Superfund Program Proposed Plan for Operable Unit 3 (OU3) dated June 2016, prepared by the U.S. Environmental Protection Agency (USEPA) Region 2 for the Pohatcong Valley Groundwater Contamination Superfund Site located in Warren County, New Jersey. As presented in the USEPA's Proposed Plan for OU3, the preferred alternative for achieving remedial action objectives for the soils impacted by Site-related contamination is Alternative 4, Deep Soil Vapor Extraction (SVE) with Optional In-Situ Thermal Hot-Spot Treatment.

The first set of comments has been prepared for PPPI by Ramboll Environ US Corporation (Ramboll Environ), and the second set has been prepared by Arcadis. The focus of both sets is a request by PPPI, supported by Albea, that USEPA consider revising its proposal to provide for immediate implementation of ISTR and to forego Deep SVE treatment as the remedial alternative.[2]

The Ramboll Environ submittal includes:

- General Comments on USEPA's Proposed Plan for Operable Unit (OU) 3
- Specific Comments on OU3 Remedial Investigation Report (CDM Smith, May 2016)
- Specific Comments on OU3 Feasibility Study Report (CDM Smith, June 2016)
- Specific Comments on USEPA Proposed Plan for Operable Unit 3 (June 2016)

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[1] In the matter of United States of America v. PPPI (Civil Action No. 09-cv-05692) and United States of America v. Bristol Myers Squibb Company, et. al. (Civil Action No. 14-cv-05798) effective March 11, 2015.

[2] PPPI requests that EPA include this transmittal letter in the administrative record as part of its comments and consider the content of this letter in making its final decision.

- Attachment A, a Tech Memo that provides a site-specific analysis of the soil treatment volume needed to ensure acceptable indoor worker risks[3]

While addressing a number of specific items in the PRAP, RI, and FS, the primary focus of the Ramboll Environ package is to provide a detailed technical and practical analysis of the rationale for proceeding directly to ISTR, and a proposal for the manner in which this revised approach could be effectively implemented. As further explained by Ramboll Environ, this approach would provide the following tangible benefits:

1. Achievement of a high degree of mass removal within the volume of soils targeted to be treated within OU3 to a higher degree and with a greater chance of success to achieve the USEPA's stated Remedial Action Objectives (RAOs);

2. Enabling implementation of the remedial action to achieve the RAOs for OU3 within a substantially shorter period of time;

3. Minimizing potential disruption to Albéa Americas, the Owner Settling Defendant to the CD, through the below-ground installation of the necessary wells, probes and appurtenances for ISTR and by using diagonal drilling to allow for the installation of above-ground remedial equipment from outside plant building; and

4. Providing a safer manner of implementation of remedial activities (e.g., from outside the plant building).

The primary reason for this proposed shift in approach – to forego Deep SVE and proceed directly with ISTR - is that based on actual site conditions, Deep SVE will not achieve the EPA's proposed remedial objectives. While PPPI appreciates EPA's willingness to initially try a potentially lesser cost approach than ISTR, because it would be a waste of time and money to devote a number of years to what will almost assuredly be a futile effort at this Site, the more effective, protective, and least disruptive solution would be to proceed directly to ISTR.

As explained in further detail in the Ramboll Environ submittal, it is important to understand the limitations of Deep SVE at this Site. The following key assumptions were made in the USEPA's Proposed Plan to support the use of SVE to address soil contamination at depth beneath the building:

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[3] Although the Final RI Report and the Final FS Report cite the reports of previous investigation activities performed by PPPI at the Washington plant, none of these documents are included in the USEPA Administrative Record for the Site, specifically:

- Environ International Corporation (ENVIRON). 2005. *Remedial Investigation Workplan, Pechiney Plastics Packaging, Inc. (Formerly American National Can Facility), Washington, New Jersey*. July;

- ENVIRON. 2007. *Remedial Investigation Report, Pechiney Plastics Packaging, Inc. (Formerly American National Can Facility), Washington, New Jersey, ISRA Case Numbers E86543 and E-88C57*. August; and

- ENVIRON. 2012. *Site Investigation Report, Pechiney Plastics Packaging, Inc., Washington, New Jersey, ISRA Case Number 20100171*. July.

Because the information in these reports was considered by USEPA and its contractors, and data and information from these reports were also included in PPPI's comments, copies of these reports will be formally submitted to the USEPA under separate cover; and PPPI requests that USEPA include these reports in the Administrative Record for OU3.

1. "*The lithology in the deep zone is similar to that of the shallow zone, and that SVE alone may be sufficient to meet cleanup goals.* " (USEPA Proposed Plan, page 13), and

2. "*No significant installation and operation issues would be anticipated for the deep SVE system, as the shallow SVE system has been installed without issue and is successfully operating.*" (USEPA Proposed Plan, page 16). Further, "*The implementation of Alternative 4 would take up space in the building and would be conducted outside the main production area and engineering controls are available to mitigate these challenges.* " (USEPA Proposed Plan, page 17).

As discussed in the Ramboll Environ comments, the lithology and the associated permeability of the deep, fine-grained soils of Area A are orders of magnitude less than those of the shallow subslab soils (consisting of sands and gravel of the building subgrade, likely from building construction), and therefore the ability to move vapors in the deep soils would be exceedingly difficult. This is further complicated by the presence of cobbles and boulders and sand layers observed to be present throughout the overburden of the deep soils as documented in the 2016 RI Report. These conditions would create impediments to complete ventilation and short-circuiting around less permeable silty soils, leading to extremely inefficient treatment of the deep soils in Area A. Even if the number of SVE wells is doubled, because of the low pore gas velocities projected for ventilation of such fine-grained soils, EPA's remedial objectives simply could not be met in anywhere near 3 to 5 years.

Additionally, a considerably larger number of SVE wells and the time necessary to attempt remediation of soils within Area A would present a significant disruption in the operations of Albéa Americas, the Owner Settling Defendant under the CD, and current owner of the facility. Because of the deep soil lithology and permeability, installation of a Deep SVE system within the building would take much longer to complete than the shallow subslab SVE System and depressurization system (SSDS) installed at the facility. At present, the former Molding Area is filled with stored materials and equipment from floor to ceiling and covering over 90% of the available floor space. A portion of the former Molding Area has also been converted to classrooms for training. The facility also has plans to resume operations in the former Molding Room in the very near future. Accordingly, to minimize potential disruption of activities within this area of the facility and to accommodate remediation of soils of Area A, time is of the essence.

As further explained in the Ramboll Environ comments, the USEPA-stated RAOs for OU3 (i.e., based on protectiveness of human health by keeping concentrations of trichloroethylene (TCE) to less than 7 $\mu g/m^3$ in indoor air, and keeping TCE concentrations in groundwater to less than 1 $\mu g/L$), can be achieved by targeting the specific zones within the deep soils in Area A where the majority of the mass of TCE was detected. Due to the limitations and inefficiencies of Deep SVE discussed above and limitations on the ability to effectively treat vadose zone soils using other technologies (i.e., ISCO), it is suggested that ISTR is the only logical remaining alternative for remediation of the OU3 soils. ISTR as a technology would not be encumbered by the practical and technical limitations of Deep SVE or ISCO, and would be able to achieve the high degree of mass reduction (i.e., in excess of 98% reduction in TCE mass) needed to achieve RAOs.

The Arcadis comments were commissioned by PPPI for an independent review of the PRAP, RI, and FS, by a fresh set of eyes, and a recommendation on how best to proceed to effectively remediate the OU3 soils underneath the Albea building. Arcadis' efforts were kept separate from those of Ramboll Environ: in fact, the two consultants did not communicate about the OU3 proposed plan – indeed they did not know that the other was preparing comments – until the day these final comment packages were being submitted to EPA.

Prior to commencing work on these comments, Arcadis had not done any work on and had not previously studied any aspect of the Pohatcong Site. Additionally, Arcadis' work was based solely on the documents contained in the OU3 administrative record. Arcadis did not review any of the historical data that had been collected at the Albea plant prior to the sampling EPA conducted as part of the RI, and Arcadis did not review any of historical data collected as part of the Pohatcong OU1 or OU2 work.

As Arcadis' separate comments reflect, based solely on the OU3 data collected by EPA and its knowledge of soil conditions in this area, Arcadis also concluded that SVE would not be an effective treatment technology and would not achieve OU3 cleanup objectives; and that it would be more effective, efficient, and expeditious to proceed directly to thermal treatment for the deep soils in OU3.

PPPI respectfully submits that each of the two sets of comments, standing alone, provide separate strong technical and practical justification to forego SVE and proceed directly to implement thermal treatment to address the OU3 deep soils under the Albea building. When read together, the fact that the independent technical analyses by Ramboll Environ and Arcadis both recommend foregoing SVE and implementing thermal treatment carry all the more weight.

In the continued spirit of cooperation with the USEPA under the CD for the Site, PPPI remains committed and looks forward to implementing an OU3 remedy. PPPI respectfully requests that EPA consider the revisions to the proposed plan that we have suggested to facilitate remediating the OU3 soils sooner, and in a safer more effective manner. Should you have any questions regarding the foregoing or the enclosed comments, please feel free to call on us.

Yours sincerely,

Roy Duckett

Attachments:
Ramboll Environ

- General Comments on USEPA's Proposed Plan for Operable Unit (OU) 3
- Specific Comments on OU3 Remedial Investigation Report (CDM Smith, May 2016)
- Specific Comments on OU3 Feasibility Study Report (CDM Smith, June 2016)
- Specific Comments on USEPA Proposed Plan for Operable Unit 3 (June 2016)
- Attachment A: Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building

- Attachment B - Figure B1, USEPA Soil Volume for Treatment

Arcadis

- Review of OU3 Proposed Plan and Relevant Documents

cc: *Via Electronic Mail*

USEPA, NJ Superfund Branch, Office of Regional Counsel (ATTN.: Attorney for Pohatcong Site)
Lauren Piana – Rio Tinto
Bruce White – Barnes & Thornburg, LLP
Doug Jerman, Albéa Americas
Christian Semonsen - Kirkland & Ellis, LLP
Bruce Kennington – Ramboll Environ
Bob Reisinger/Mike Bedard - Arcadis

COMMENTS on USEPA Proposed Plan for OU3
Pohatcong Valley Groundwater Contamination Superfund Site
Warren County, New Jersey

INTRODUCTION AND PROPOSED REMEDIAL APPROACH

Based on technical review of the alternatives considered by USEPA in the FS and the proposed plan, we believe that a more effective approach to remediating the OU3 deep soils beneath the plant would be to proceed directly to In Situ Hot Spot Treatment (ITSR) and to forego the multiyear Deep SVE treatment proposed as the initial phase of the preferred remedy. The key reasons for our request to revise the preferred alternative in this manner, and to eliminate the Deep SVE phase, are as follows:

- The soils encountered during installation and in which the shallow subslab SVE system has been successfully operating since July 2013 are far more permeable to air and not the same as the fine grained, less permeable soils with sand layers, cobbles and boulder in which the USEPA's proposed Deep SVE system would operate, and would render Deep SVE to be ineffective in achieving the USEPA's RAOs.
- Installation of a Deep SVE system as proposed by USEPA within Area A inside the Albéa building would result in significant disruption of the operations the facility both during installation and over many years during operation of the Deep SVE system.
- Given the detected concentrations of trichloroethylene (TCE) in soils within Area A of OU3 in excess of 120 milligrams per kilogram (mg/kg) during the USEPA OU3 RI activities and as high as 9,500 mg/kg during the remedial investigation activities undertaken by PPPI prior to 2007, and the stated limitations of Deep SVE with ISTR to remove 90% of TCE in soils, the USEPA's proposed remedial goal of 1 mg/kg is not achievable.
- The majority of TCE mass is present within a single location at a depth of 60 to 90 feet below the building slab. Ramboll Environ has estimated that the RAOs can be achieved through targeting treatment of this volume of soils within Area A, and that ISTR can achieve the degree of mass removal necessary to achieve the stated RAOs. Ramboll Environ performed its own evaluation of risk to achieve the RAOs as protective of human health from the vapor intrusion pathway included in the Tech Memo of Attachment A to these comments and the discussion included in Comment No. 7 and Comment No. 23, and as protective of the impact to groundwater pathway as provided in Comment No. 20, herein.
- Concentrations of TCE in soil vapor, below levels determined to be protective of human health from vapor intrusion to indoor air will also be protective of groundwater and can be used to demonstrate that RAOs have been achieved.

In short, Implementing ISTR as the primary treatment methodology would provide the following benefits over the two phase approach:

- Achievement of a high degree of mass removal within the volume of soils targeted to be treated within OU3 to a higher degree and with a greater chance of success to achieve the USEPA's stated Remedial Action Objectives (RAOs);

- Enabling implementation of the remedial action to achieve the RAOs for OU3 within a substantially shorter period of time;

- Minimizing potential disruption to Albéa Americas, the Owner Settling Defendant to the CD, through the below-ground installation of the necessary wells, probes and appurtenances for ISTR and by using diagonal drilling to allow for the installation of above-ground remedial equipment from outside plant building; and

- Providing a safer manner of implementation of remedial activities (e.g., from outside the plant building).

In order to understand why we are recommending revising the preferred remedy to utilize just ISTR, it is necessary to first understand the limitations of Deep SVE at the Site. Key assumptions were made in proposing Deep SVE to address soil contamination at depth beneath the building. These include the following as stated in the USEPA's Proposed Plan:

1. "*The lithology in the deep zone is similar to that of the shallow zone, and that SVE alone may be sufficient to meet cleanup goals.* " (USEPA Proposed Plan, page 13), and
2. "*No significant installation and operation issues would be anticipated for the deep SVE system, as the shallow SVE system has been installed without issue and is successfully operating.*" (USEPA Proposed Plan, page 16). Further, "*The implementation of Alternative 4 would take up space in the building and would be conducted outside the main production area and engineering controls are available to mitigate these challenges.* " (USEPA Proposed Plan, page 17).

As discussed in the specific comments that follow, the lithology and the associated permeability of deep, fine-grained soils of Area A are orders of magnitude less than those of the shallow subslab soils (consisting of sands and gravel of the building subgrade, likely from building construction) and therefore the ability to move vapors in the deep soils would be exceedingly difficult (see Comment No. 2, Comment No. 14, Comment No. 16, and Comment No. 24). This is further complicated by the documented presence of cobbles and boulders and sand layers observed to be present throughout the overburden of the deep soils as documented in the logs of soil boring conducted in Area A as presented in the 2016 RI Report. Cobbles and boulders would create an impediment to complete ventilation, and sand layers would result in short-circuiting around less permeable silty soils, both resulting in inefficient treatment of the soils in Area A. Given the foregoing regarding the presence of fine-grained soils consisting primarily of silts, boulders and cobbles and sand layers, to adequately ventilate the deep soils of Area A Ramboll Environ estimates that at least twice the number of SVE wells would be necessary to be installed to provide adequate pneumatic influence and to vent the volume of soils necessary to achieve the stated USEPA remedial action objectives. Further, and due to the low pore gas velocities projected for ventilation of such fine-grained soils, an attempt at remediation of the Area A soils using Deep SVE would take significantly longer than the time frame of 3 to 5 years that USEPA has projected in its Proposed Plan.

Additionally, a considerably larger number of SVE wells and the time necessary to execute such an attempt at remediation of soils within Area A would present a significant disruption in the operations of

Albéa Americas, the Owner Settling Defendant under the Consent Decree (CD)[1], and current owner of the facility (see Comment No. 5). Although the existing vapor mitigation system currently operating at the facility was installed in a manner that resulted in minimal disruption to the facility, this work was mostly performed at night, and over weekends and holidays when operations at the facility were temporarily shut down. Installation of a Deep SVE system at the Site would take much longer to complete than the shallow subslab SVE System and the subslab depressurization system (SSDS) installed at the facility.

Further, the former Molding Area was largely vacant at the time, and was not in use except for the transport of materials and equipment through this room (e.g., by forklift). At present, the former Molding Area is completely full with stored materials and equipment from floor to ceiling and covering over 90% of the available floor space. A portion of the former Molding Area has also been converted to classrooms where training is held. The facility also has plans to resume operations in the former Molding Room in the very near future. Accordingly, to minimize potential disruption of activities within this area of the facility and to accommodate remediation of soils of Area A, time is of the essence.

In the Proposed Plan for OU3, the USEPA identifies a Site-specific remediation goal of 1 part per million (ppm or mg/kg) trichloroethylene (TCE) in soil. Further, the USEPA states that deep SVE combined with In Situ Thermal Remediation (ISTR) will be able to achieve 90% removal of TCE in soil within the target remedial area. Concentrations of TCE in soils within Area A of OU3 have exhibited concentrations in excess of 120 mg/kg in the soils beneath Area A during the USEPA OU3 activities and 9,500 mg/kg during the remedial investigation activities undertaken by PPPI in the former Molding area (within the USEPA's Area A) prior to 2007. For soils with TCE concentrations in excess of 10,000 µg/kg, (or 10 mg/kg), 90% removal would result in TCE remaining at concentrations in excess of 1 mg/kg. In the case of the detections of TCE in soils during the OU3 RI in excess of 100,000 µg/kg, such treatment would result in soil concentrations remaining after treatment in excess of 10,000 µg/kg (or 10 mg/kg), an order of magnitude above the USEPA's proposed soil remedial goal (see Comment No. 1).

As presented in the general and specific comments that follow this introduction, Ramboll Environ performed a refinement of the calculations used to assess the vapor intrusion pathway using the same methods used by USEPA in development of its cleanup goals for OU3 (see Comment No. 7 and Comment No. 23). Through these refinements it is demonstrated that effective treatment of a smaller volume of soils where the bulk of the mass of soil contamination is located (i.e., specifically, the approximate 1,000 cubic yards (yd^3) of soils situated between approximately 60 to 90 feet beneath the slab of the building) will achieve the USEPA's stated Remedial Action Objectives (RAOs) by effectively reducing the contaminant mass in the vadose zone to minimize the potential human-health risks from vapor intrusion while also minimizing the impact to groundwater quality at the Site. As a conservative measure in performing these refined calculations, Ramboll Environ utilized both the results obtained by USEPA during the OU3 Remedial Investigation and also the earlier results obtained by PPPI prior to 2007. Both the extent of the soil impacts and the concentrations of TCE detected in the pre-2007 remedial investigation activities conducted by PPPI are larger and higher, respectively, than the results obtained by USEPA during

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[1] In the matter of United States of America v. PPPI (Civil Action No. 09-cv-05692) and United States of America v. Bristol Myers Squibb Company, et. al. (Civil Action No. 14-cv-05798) effective March 11, 2015.

the OU3 RI activities (i.e., performed after 2011). Also, and in review of the actual indoor air samples and subslab vapor obtained during the 2013 vapor mitigation response activities, Ramboll Environ developed a more conservative attenuation factor for the building slab than was used in the calculations presented in the 2016 FS Report.

Areas of shallow soil contamination located beneath the building slab of Area A were detected during the USEPA OU3 RI activities. The soil borings conducted by USEPA within Area A of OU3 were performed prior to July 2013, when the shallow subslab SVE system was installed. The shallow subslab SVE system has been operating continuously for the past 3 years with extraction points corresponding to the locations of the shallow soil contamination detected during the OU3 RI activities in Area A. Accordingly, it is fully expected that much of the mass of TCE in the shallow soils located beneath the slab in the former Molding Area has already been remediated through the operation of the shallow subslab SVE system. The degree of mass reduction could be verified during pre-design activities for OU3.

Ramboll Environ estimates that the USEPA-stated RAOs for OU3 (i.e., based on protectiveness of human health by keeping concentrations of trichloroethylene (TCE) to less than 7 µg/m^3 in indoor air, and keeping TCE concentrations in groundwater to less than 1 µg/L), would be achieved by targeting the zone where the majority of the mass of TCE was detected (i.e., 60 to 90 feet below the building slab) in Area A. Due to the limitations and inefficiencies of Deep SVE discussed above and in the comments that follow, the acknowledged limitations in the ability to reasonably treat vadose zone soils using other technologies such as in situ chemical oxidation (ISCO) to achieve the degree of mass removal necessary (i.e., in excess of approximately 99%), it is suggested that ISTR is the only logical remaining alternative for remediation of the soils in OU3 at the Site.

ISTR as a technology would not be encumbered by the limitations of Deep SVE or ISCO and would be able to achieve the high degree of mass reduction (i.e., in excess of 98% reduction in TCE mass within the volume of soils where it is estimated that over 95% of the total TCE mass is present at 60 to 90 feet beneath the building and the USEPA's Area A) as necessary to achieve the USEPA's stated RAOs. As treatment of the volume of soils to be protective of vapor intrusion is the same as the volume of soils to be protective of groundwater, it is proposed to demonstrate the performance of the selected remedy for OU3 through soil vapor sampling. If subslab concentrations have been sufficiently reduced in soil vapor, in the absence of engineering controls and after evaluation of rebound, to a concentration not expected to result in an unacceptable vapor intrusion risk (e.g., a concentration of approximately 400,000 µg/m^3), then the remedial action objectives will have been reached (see Comment No. 28).

In implementing ISTR at the Site for OU3, Ramboll Environ consulted qualified vendors experienced in the design and implementation of this technology. To further minimize potential disruption of facility operations, although it would entail significant additional cost, installation of the system components and operation of ISTR could be performed from outside the building by installation of heaters, extraction points and monitoring points through angled borings to target the subslab volume of soils to be treated, along with external installation of the necessary transformers, power supplies, vacuum blower(s) and off-gas treatment.

General and specific comments are presented below for each of the Final Remedial Investigation Report ("2016 RI Report") (CDM-Smith, May 11, 2016), the Final Feasibility Study Report ("2016 FS Report") (CDM-Smith, June 10, 2016) and the USEPA's Proposed Plan for OU3 ("USEPA OU3 PRAP") (June 2016) in page order rather than in order of significance.

GENERAL COMMENTS

1. The USEPA's proposed remedy, Alternative 4 - Deep SVE (with optional In Situ Thermal Remediation) will not be able to achieve the remedial action goals of 1 mg/kg in soil within the targeted remediation area. Specifically, in the third paragraph on page 13 of the USEPA OU3 PRAP, the USEPA states that deep SVE if employed also with In Situ Thermal Remediation (ISTR) will be able to achieve 90% removal of TCE in soil within the target remedial area. Concentrations of TCE in soils within Area A of OU3 have exhibited concentrations in excess of 120 mg/kg in the soils beneath Area A during the USEPA OU3 activities and 9,500 mg/kg during the remedial investigation activities undertaken by PPPI in the former Molding area (within the USEPA's Area A) prior to 2007.

   Page ES-13 of the 2016 RI Report, states, "*Directly underneath the ANC building, TCE detections in soil are concentrated around the sanitary sewer lines and floor drains in the former Blak-Sol operations area, in the southwestern corner of the building, where TCE degreasers are believed to have been located. During the OU3 RI, TCE exceeded the OU3 RI screening criterion (10 µg/kg) in 58 of the 165 soil samples collected below the ANC building. Vertically, TCE is present above 1,000 µg/kg throughout the overburden and into the weathered bedrock zone to a depth of approximately 100 feet bgs. This area has the highest concentrations of TCE in soil at the OU3 Study Area (**as high as 120,000 µg/kg TCE during the OU3 RI and as high as 9,500,000 µg/kg during the 2007 PPPI RI**).*" [emphasis added in **bold**]

   For soils with TCE concentrations in excess of 10,000 µg/kg, (or 10 mg/kg), 90% removal would result in TCE remaining at concentrations in excess of 1 mg/kg. In the case of the detections of TCE in soils during the OU3 RI in excess of 100,000 µg/kg, such treatment would result in soil concentrations remaining after treatment in excess of 10,000 µg/kg (or 10 mg/kg), an order of magnitude above the USEPA's proposed soil remedial goal.

2. Based on the current understanding of the deep soils within Area A of OU3, deep SVE will not be for treatment of soils to achieve the stated remedial objectives. As provided in Specific Comment No. 19 on the 2016 FS Report and Specific Comment No. 21 on the USEPA OU3 PRAP that follow, given the low permeability of the soil within the deep soils of Area A, the use of deep SVE with installation of vertical extraction wells is not practicable due to the high density of wells through the building slab (more than twice that presented in the 2016 FS Report) and the associated piping (even if routed vertically to run to the overhead of the ceiling of the former Molding area). The space required for these remedial components would effectively preclude access for use of the plant floor for facility operations by Albéa Americas, the current owner of the facility. Additionally, given the low permeabilities of the deep soils present (the 2016 RI Report presented soil hydraulic conductivity values ranging from approximately 2E-6 centimeters per second (cm/s) to 8E-8 cm/s for these soils) the use of SVE for remediation of TCE is not likely to be effective. SVE is typically more applicable for cases where unsaturated soils are relatively permeable (i.e., hydraulic conductivities in excess of 1E-3

cm/s to 1E-2 cm/s) (USEPA, Feb 1991). Removal of contaminants from fine grain soils consisting of silts and clays with permeabilities ranging from 1E-3 to 1E-6 has been demonstrated, however the effective treatment of such soils is limited (Parsons, 2001) (USEPA 2001) (USACE, 2002). Based on the logs of soil borings conducted through Area A of OU3 boring logs, boulders and cobbles were encountered throughout, along with layers of more highly permeable sands. Impermeable features such as bolder and cobbles would impede the ability to ventilate soils where present, and create “shadows” where movement of air through soil venting would be impeded leaving areas where soil treatment would be incomplete. The presence of permeable sand layers or veins in between fine grained soils of low permeability would create short-circuiting and incomplete venting of soils that would impede the treatment of the finer grained, less permeable soils. Both of these factors would result in incomplete treatment of the subsurface soils. Accordingly, the effectiveness of SVE in the deep soils of Area A at the Washington plant is highly questionable in the long term under the USEPA’s nine evaluation criteria and without results of pilot or treatability study to support its evaluation, deep SVE should have been eliminated from consideration as a remedial technology in the 2016 FS Report and the USEPA OU3 PRAP.

3. Given the above that a remedial objective of 1 mg/kg for remediation of TCE in soils is not practicably achievable using Deep SVE with ISTR, Ramboll Environ performed a more detailed evaluation of the available data for TCE in soils within the target treatment zone of Area A within the Washington plant. The results of this evaluation are discussed further in Comment No. 7 and Comment No. 23 that follow and are included in Attachment A to these comments (“Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building”). The purpose of this evaluation was to determine the minimum extent to which soil below the ANC building would have to be treated (or removed) in order to ensure that indoor worker soil vapor intrusion exposure would not result in unacceptable risk in the absence of engineering controls. This analysis is more refined than the approach used by CDM-Smith in deriving the TCE soil cleanup level of 1 mg/kg in the 2016 FS Report in that (1) it accounts for the fact that the bulk of the soil contamination was identified at depths at least 60 ft below ground surface (bgs) and (2) it uses a mass flux approach to identify the minimum extent of remediation needed to ensure acceptable indoor worker risks.

   The analysis demonstrates that not all soil below the ANC building with a concentration above 1 mg/kg would need to be treated in order to ensure acceptable risks in the absence of engineering controls. USEPA’s targeted soil treatment volume below the ANC building is approximately 41,000 yd^3, as depicted in Figure B-1 of Attachment B to these comments. This analysis demonstrates that only approximately 1,000 yd^3 of deep soil and approximately 70 yd^3 of shallow soil below the ANC building would warrant treatment in order to achieve the remedial objective. Further, and as presented in Specific Comment No. 20 on the 2016 FS Report discussed below, Ramboll Environ has assessed that treatment of the same volume of soil as is shown to be protective for vapor intrusion exposure would also be protective with consideration for leaching to groundwater. The target locations for treatment of the necessary volume of soils based on actual soil analytical results as necessary to address the vapor intrusion risks are shown in Figure A-4 of the Ramboll Environ Technical Memorandum provided in Attachment A to these comments.

4. It is recognized that with the low permeability soil and, the presence of cobbles and boulders likely to be encountered within the target soil volume to be treated, in situ chemical oxidation (ISCO) technology, evaluated as Alternative 3 in the 2016 FS Report, would not be expected to reasonably achieve these treatment efficiencies (i.e., in excess of 90% removal of TCE in soils). As discussed in General Comment No. 2 above regarding the limited effectiveness of SVE in the deep, low permeability

soils of Area A, and the impracticality of alternatives such as excavation beneath the operational areas of the Washington plant production areas, the only reasonable alternative for OU3 is suggested to be ISTR.

5. In the evaluation of the various remedial alternatives presented in the 2016 FS Report, the USEPA did not consider the feasibility of vertical installation of the various remedial components indoors and within the existing Albéa America's operational areas of the facility, nor the cost implications of such. Depending upon the remedial alternative, installation of such components and maintenance and monitoring activities will have varying durations that have the potential to disrupt or to preclude operations at the facility. The potential impact of such installations and operations within the existing operational areas of the facility was not fully evaluated by USEPA.

Specific Comments on OU3 Remedial Investigation Report
(CDM-Smith, May 11, 2016)

6. **Pages 2-1 and 2-2** – It is stated that, "*After completing the 2012 field investigation, EPA determined that some of the VOCs, SVOCs, pesticides, and PCBs analytical results from soil, sediment, groundwater, and surface water samples were of unknown quality; these results are not reported or used in this report….In order to replace the data from the 2012 investigation that was unusable, CDM Smith conducted additional sampling of soil, groundwater, sediments, and surface water from the same locations from December 2014 to March 2015 (2015 field investigation).*" Figures 2-1 and 2-3 show the soil boring locations from the 2012 and 2015 investigations, respectively. It appears that some of the locations from 2012 for which VOCs, SVOCs, pesticides, and PCB data were not reported were resampled in 2015 in approximately the same locations (e.g., 2015 locations VTC-SBS-220 through VTC-SBS-224 appear to be in approximately the same locations as 2012 locations VTC-SBS-20 through VTC-SBS-24). However, some of the ANC building interior boring locations appear to have been adjusted between the 2012 and 2015 investigations. For example, VOCs, SVOCs, pesticides, and PCB data were not reported for the soil borings advanced at locations PPP-SBI-01 through PPP-SBI-04 in 2012. Additional soil borings (such as PPP-SBI-250 through PPP-SBI-253) were advanced in 2015 and analyzed for VOCs, SVOCs, pesticides and PCBs, however, these do not appear to be located in the same locations as the 2012 borings. See for example Figure 1-4, which includes both 2012 and 2015 boring locations. Section 2 does not include an explanation of why the 2015 boring locations are different than the 2012 boring locations. Please note that the locations identified in this comment are not meant to be a comprehensive list of the 2015 locations that are different than the 2012 locations but rather representative examples.

Specific Comments on OU3 Feasibility Study Report
(CDM-Smith, June 10, 2016)

7. **Page 2-8 (Section 2.3.2)** – The USEPA indicated that treatment would target the area that exceeds 1 milligram per kilogram (mg/kg) of trichloroethylene (TCE), as shown on Figure 2-2 of the 2016 FS Report. Section 4.2.5.1 subsequently indicated that the recommended deep soil vapor extraction (SVE) system would be installed from 30 to 100 feet below ground surface (bgs). Based on the approximate 16,000 square feet area identified on Figure 2-2 of the 2016 FS Report and the target treatment zone thickness identified of 70 feet, this results in a USEPA target treatment volume of approximately 41,000 yd^3. The 2016 FS Report did not provide an evaluation of site soil data to demonstrate that treatment of this volume (41,000 yd^3) is necessary in order to achieve 1 mg/kg TCE. To assess a reasonable extent for treatment of soils beneath the building in Area A, Ramboll Environ performed an evaluation of the available soil data. The results of this evaluation are included in Attachment A to these comments ("Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building"). The purpose of this evaluation was to determine the minimum extent to which soil below the ANC building would have to be treated (or removed) in order to ensure that indoor worker soil vapor intrusion exposure would not result in unacceptable risk in the absence of engineering controls. This analysis is more refined than the approach used by CDM-Smith in deriving the TCE soil cleanup level of 1 mg/kg in the 2016 FS Report in that (1) it accounts for the fact that the bulk of the soil contamination was identified at depths at least 60 ft below ground surface (bgs) and (2) it uses a mass flux approach to identify the minimum extent of remediation needed to ensure acceptable indoor worker risks.

   The analysis demonstrates that not all soil below the ANC building with a concentration above 1 mg/kg would need to be treated in order to ensure acceptable risks in the absence of engineering controls. USEPA's targeted soil treatment volume below the ANC building is approximately 41,000 yd^3. This analysis demonstrates that only approximately 1,000 yd^3 of deep soil and approximately 70 yd^3 of shallow soil below the ANC building would warrant treatment in order to achieve the USEPA's remedial action objective.

8. **Page 2-14 (Section 2.5.7.1)** – The USEPA indicated that thermal technologies require "*little to no O&M*." It should be noted that, during the typical approximate 6-month operational timeframe of thermal remediation technologies, the following O&M activities are often conducted:

   - Conduct regular site visits to view site conditions and collect performance data (air flow rates, vapor contaminant concentrations at various locations in soil vapor extraction/treatment systems, air samples for discharge compliance testing, and water samples for discharge compliance testing).
   - Perform soil vapor extraction and treatment system optimization.
   - Monitor the respective remedial systems' performance via dial-up connections.
   - Perform routine soil vapor extraction/treatment system maintenance and repairs.

9. **Page 2-14 (Section 2.5.7.1.1, third paragraph)** – The USEPA indicated that "*ERH electrodes and SVE capture wells would be installed through the ANC building slab.*" However, alternate geometries for installation were not discussed. In review of potential installation options with qualified ISTR vendors, numerous cases exist and adequate performance has been demonstrated for horizontal and angled

borings for installation of electrodes or heating elements along with vapor extraction points (i.e., for removal of vapors and steam from soil heating). Although the complexity and cost of drilling and installation would increase significantly compared to vertical installations, such alternate installation geometry would significantly reduce the potential disruption of Albéa America's production operation activities within Area A of the Washington plant.

10. **Page 2-15 (Section 2.5.7.1.2, third paragraph)** – The USEPA indicated that "*TCH heating wells and SVE wells can be installed through the ANC building slab.*" Similar to ERH, TCH heating wells and extraction wells can be angled or horizontal such that they could be installed outside of the building slab, but the complexity and cost of drilling and installation also increases significantly compared to vertical installations.

11. **Page 2-16 (Section 2.5.7.3.1, first paragraph)** – The USEPA states that "*Hydraulic fracturing is a technology in which pressurized water or a slurry of chemical reagents is injected into the subsurface to increase permeability.*" Hydraulic fracturing does not affect formation permeability; the process simply emplaces a high permeability lens through the formation, the permeability of which remains the same.

12. **Page 2-16 (Section 2.5.7.3.1, first paragraph)** – The USEPA states that "*The typical distance of fracture propagation in silt and clay is 40 to 50 feet beyond the injection point.*" Based on information contained in Suthersan (1999), the radius of influence for a fracture well in unconsolidated materials is limited to 20 to 35 feet. Pages 3 and 4 of Appendix G identify an assumed hydraulic fracture radius of influence of 11 feet within the target treatment zone, rather than the 40 to 50 feet referenced on page 2-16.

13. **Pages 2-22 and 2-23 (Section 2.5.8.2)** – The USEPA indicated that if contaminated soil exceeds TCLP criteria, it would be disposed of in a RCRA Subtitle C landfill or treated to meet the Universal Treatment Standards (UTS) at a hazardous waste treatment facility prior to disposal. The first complete sentence on page 2-23 states that "*For contaminated soil with TCLP results of TCE exceeding 1 mg/L, treatment is required.*" The basis for the 1 mg/L TCLP value referenced above is unclear. 40 CFR Part 268 identifies hazardous wastes that are restricted from land disposal without prior treatment to UTS. Hazardous remediation wastes that are managed off-site are subject to the Land Disposal Restrictions (LDR) UTS for wastewater (liquid) or non-wastewater (solid). Hazardous soils must be treated to 90% reduction in concentration capped at 10 times the UTS for principal hazardous constituents. For TCE, 10 times the UTS equates to 60 mg/kg.

14. **Page 3-4, second complete paragraph** – The USEPA states that "*If implemented, it is anticipated that the in-situ thermal treatment alternative would be conducted from 60 to 100 feet bgs at the hot spot beneath the former molding area.*" No evaluation of site soil data is provided to support selection of this identified treatment depth interval.

15. **Page 3-4, third complete paragraph** – The USEPA states "*More than 90 percent mass removal is anticipated for this alternative.*" It is unclear if this estimated mass removal would result from implementation of SVE alone, or SVE in conjunction with thermal treatment of the identified subset of the SVE treatment area. Moreover, no literature or case study citations are provided to support this estimated 90 percent mass removal value.

16. **Page 4-11, first full paragraph** – Section 4.2.4.1 provided a description of implementation of Alternative 3, in-situ chemical oxidation using sodium permanganate as the selected oxidant, to achieve remedial action objectives for the impacted site soils. The sodium permanganate solution would be diluted to 10 percent strength for injection. Based on an assumed initial soil oxidant demand of 4 grams of permanganate per kilogram of soil, Appendix G identifies injection of 273,200 gallons of 10 percent sodium permanganate solution as part of an initial injection event, and 140,000 gallons of 6.53 percent sodium permanganate solution as part of a second injection event. Injection of such quantities of sodium permanganate solution represents 14 percent of the treatment zone pore volume as part of the initial injection event, and 19 percent of a reduced treatment zone pore volume as part of the second injection event. Based on Ramboll Environ's experience with regard to injection of liquid reagents into low permeability fine-grained soils, injection of such large percentages of target treatment zone pore volumes is unlikely to be achievable. Moreover, if the results of bench-scale testing indicate a soil oxidant demand that exceeds 4 grams of permanganate per kilogram of soil, even greater quantities of oxidant would need to be injected (with an even lower likelihood of success).

17. **Page 4-13, second paragraph** – The USEPA states "*Due to difficulty in evenly delivering oxidants to treat contaminants in the clayey silty soil and in the deep vadose zone, the overall effectiveness of this alternative is estimated to be 50 percent within the treatment zone.*" No literature or case study citations are provided to support this estimated 50 percent effectiveness value.

18. **Page 4-18, first paragraph** – The USEPA OU3 PRAP indicates that the Preferred Alternative for achieving remedial action objectives for the impacted site soils is Alternative 4, Deep SVE with Optional In-Situ Thermal Hot-Spot Treatment. As stated, the determination as to whether to implement the in-situ thermal treatment in the hot-spot area would be made by USEPA during the remedial design (based on SVE pilot study results) or during the operation of the deep SVE system based on SVE performance data. On page 4-18 (first sentence), the USEPA indicated that, based on potential impact of low soil moisture content on the effectiveness of electrical resistance heating (ERH), thermal conductive heating (TCH) is selected as the thermal process option. A primary factor that can limit the effectiveness of heating using ERH is moisture loss. Moisture loss is a concern because electrical resistance increases (electrical conductivity decreases) as soil moisture decreases, thereby resulting in reduced energy delivery to drier portions of the target treatment zone. ERH systems therefore often incorporate wetting systems around the electrodes and in the targeted treatment area to maintain a specified amount of soil moisture within the vadose zone (Kueper et. al., 2014). As such, implementation of ERH should be evaluated against implementation of TCH with respect to cost.

19. **Figure 4-2 of the Feasibility Study** - Conceptual Layout for Alternative 4, and Appendix G-3a of the Feasibility Study - Cost Estimate for Alternative 4 - Deep Soil Vapor Extraction without In Situ Thermal Hot Spot Treatment. The estimated number of SVE wells for treatment of the source zone soil in Area A presented in the 2016 FS Report is a total of 14 wells and assumes each SVE well will have a radius of influence of about 18 to 20 feet. Based on the approximate 16,000 square feet area identified on Figure 2-2 of the 2016 FS Report, this is approximately equivalent to one SVE well per 1,000 square feet (ft2) to 1,200 ft2 of treatment area. There is no supporting information presented in the 2016 FS Report on which this radius of influence is based. In consideration of the design recommendations provided in the USACE Engineering Design Manual for Soil Vapor Extraction and Bioventing (USACE, 2002), it is desirable to achieve pore-gas velocities in the treatment zone such that the maximum travel time is between 2 and 4 days from the edge of the treatment zone to the extraction wells

(USACE, 2002). It is also recommended that a minimum pore-gas velocity throughout the treatment zone should be between 0.001 cm/s, (about 3 ft/day) and 0.01 cm/s (about 30 ft/day) (USACE, 2002). In general, for SVE to be effective in reducing contaminant mass in a reasonable period of time requires at least 10 pore volume exchanges per day across the treatment zone (USACE, 2002). Based on these design recommendations and considering the USEPA's treatment volume and the estimated radius of influence of 18 to 20 feet per SVE well, USEPA's target treatment depth of 30 to 100 feet below ground surface, and an estimated soil air-filled porosity of 0.2, the approximate air extraction flow rate would need to be on the order of 100 cubic feet per minute (cfm) to 120 cfm per SVE well. This high air flow rate at the SVE well is not likely to be achieved within the subsurface soil in the OU3 area given the low values of intrinsic air permeability as discussed in Specific Comment No. 21 on the USEPA OU3 PRAP below. To accomplish the required minimum number of pore-volume exchanges would require a significant increase in the number of SVE wells to be installed within the treatment area. An estimate of the required SVE well spacing to achieve the recommended design of 10 pore volume exchange rates per day using an air flow extraction rate of 40 cfm per SVE well (based on the performance of the existing SVE/SSDS system) is approximately 11 feet. This results in approximately 30 SVE well locations within the defined treatment area. This is more than twice the number of SVE wells proposed in the 2016 FS Report. Consequently, doubling the number of wells will result in significant increases in remedy implementation cost and implementation issues as access to the identified areas for soil treatment within Area A inside the existing operating facility is limited and would result in significant disruption of manufacturing operations at the facility.

20. **Appendix C – Development of a PRG for Groundwater** - Regarding the development of a preliminary remedial goal (PRG) protective of groundwater, the following is provided in review of the methodology and calculations presented in Appendix C of the 2016 FS Report.

    a. Ramboll Environ was unable to reproduce the results obtained and reported in Appendix C of the 2016 FS Report. Using the inputs provided in the text, one arrives at a maximum concentration at Point of Compliance 2 that is about 25% lower than the value reported in the graphical output of the modelling results. It would be helpful to have the actual SEVIEW input files to determine why there is a discrepancy.

    b. The results presented in Appendix C of the 2016 FS Report are presented for two points of compliance, one on the downgradient edge of the suspected source area within Area A beneath the former Molding Room of the Washington plant, and the other at 950 feet downgradient of this suspected source area, corresponding to the location of the extraction wells POHPT1 and POHPT3 for the existing Groundwater Extraction and Treatment System for OU1 (TCE). As this location is not a source of drinking water, an alternative point of compliance is proposed, such as at a location where the groundwater would be reasonably assumed to be used for drinking water purposes. Accordingly, the existing Dale Avenue production well located approximately 6,200 feet from the suspected source area at the former ANC plant is proposed as a logical point of compliance downgradient of the suspected source area for use in calculations to determine a preliminary remediation goal.

    c. Appendix C of the 2016 FS Report presents a scenario that estimates the total mass of TCE in soils of 519 mg/kg used in the calculation of impacts to groundwater and is overly conservative. Specifically, Appendix C states, "*TCE Loading – Concentrations of TCE for each sub-layer of the model were developed by taking the* ***maximum concentration*** *observed in each layer within the source zone. This modeled source likely represents a greater mass of TCE than is actually present.*

This method is the accepted method in the NJDEP guidance and provides a conservative estimate of TCE source. Using this method, SESOIL calculated the source to be 519 kg of TCE." [emphasis added in ***BOLD***] (Appendix C Page C-5)

The lateral dimensions for the source term used in the model are 50 meters by 25 meters. The mass is then computed as a layered block of soil about 120-foot thick. This results in a total soil volume in this scenario of 1.6 million cubic feet (see Figure B-1 of Attachment B to these comments). From the results of TCE detected presented in the 2016 RI Report, the actual geometry of contaminated soils in this area is much different than this. In addition, the actual mass present is significantly different from that used in the calculation of Appendix C. As a conservative estimate of potential impact to groundwater, Ramboll Environ produced a 3-dimensional model of the soil concentrations based on all sampling results reported to date, including the results of soil samples obtained pre-2006 from the results of the RI activities conducted under the oversight of the NJDEP along with the results reported in the 2016 RI Report[2]. The computed volume of soil with TCE concentration above 1 mg/kg is 0.2 million cubic feet (0.8 million cubic feet for soil with TCE concentration above 0.2 mg/kg). Using these combined results, the computed total TCE mass in soil above 1 mg/kg is about 55 kg (70 kg for soil with TCE concentration above 0.2 mg/kg). This estimated mass is significantly lower than the mass used in the calculations performed for development of a preliminary remediation goal as presented in the in calculations of Appendix C in the 2016 FS Report.

These conservative assumptions regarding the source to groundwater impacts from TCE in soils have led to significant over-estimates of impact to groundwater.

d. As provided in the calculations of Appendix C of the 2016 FS Report, the use of SEVIEW to develop a preliminary remediation goal ignores the fact that the discharge of the contaminants occurred a very long time ago and that it has been demonstrated that concentrations in downgradient wells are either stable or decreasing (Ramboll Environ, November 2015). The USEPA uses SEVIEW to estimate the peak concentration for TCE expected in the future for groundwater near the source area or at an assumed compliance point. The statistical evaluation of results of groundwater monitoring performed at the Site to date at groundwater monitoring wells located downgradient of the OU3 suspected source area have demonstrated concentrations of TCE in groundwater to be stable or decreasing (Ramboll Environ, 2015). Accordingly, the use of a model that projects future concentrations to be on the rise and selection of modelled "peak" concentrations that may have already passed is an exceedingly conservative use of the model.

e. The adjustment of the infiltration rate through the soils beneath a slab of the building of the Washington plant is not supported. To create a pathway for migration of TCE in soils to groundwater, the use of infiltration to model the transport of TCE to the water table is logical, however the method employed, where the data at MW-13 is plotted to justify the value selected and concentrations from the simulations are somehow projected backwards to a value the model did not itself predict (purposefully ignoring the value the model did predict) lacks justification and is not technically supported.

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[2] From the pre-2006 RI results obtained by ENVIRON International Corporation under oversight of the NJDEP, the concentrations of TCE in soils are higher and the extent of impacts of TCE in soils are greater in areal extent and volume than the results for TCE in soils reported in the 2016 FS Report.

f. The inputs used by USEPA in its soil leaching to groundwater calculations as presented in Appendix C of the 2016 FS Report were overly conservative , and led to an unwarranted conclusion that remediation of a significant volume of soil to a high degree would be necessary to achieve RAO's.

To develop a proposed, revised preliminary remedial goal for protection of groundwater, Ramboll Environ employed the same method and tools as presented in the 2016 FS Report, but modified inputs to be more representative of actual site conditions instead of the overly conservative values employed by USEPA. Areas near high concentration locations were removed sequentially from the simulations to reduce the maximum concentration in a SEVIEW model sublayer. The modelling demonstrates that the volume requiring treatment to achieve the goal of 1 µg/L in groundwater at a modified point of compliance is the same treatment volume required to be protective of indoor air (see Figure A-4 of Attachment A, "Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building"), except that one area requires treatment to remove additional contaminant mass. This is a much smaller volume of soil that would be targeted for treatment as compared to the volume calculated by USEPA and depicted in Figure B-1 of Attachment B to these comments. The SEVIEW input parameter values were set to be the same as described in Appendix C, except that:

- The hydraulic gradient value used in the AT123D simulation was updated to 0.015 and is consistent with the value reported in the OU1 Remedial Investigation Report (CH2M HILL, 2005);
- The point of compliance was set as the Dale Avenue Well at a distance of 6,200 feet downgradient of the suspected source area at the former ANC plant, and is a down gradient location from which groundwater might be used for drinking water purposes;
- The vertical contaminant profile was computed using all measured concentrations and using a spatially weighted average concentration for the model layer intervals. [3]

Three simulations are shown:

- Base-case – no soil treatment;
- Case-1 - recommended treatment to be protective of indoor air;
- Case-2 – additional treatment beyond Case-1 necessary to achieve the groundwater PRG.

A summary of updated sublayer loads in the simulated scenarios is provided below in Table 1. The simulated TCE concentration in groundwater at the modified point of compliance associated with each scenario is compared to the 1 µg/L remediation goal for groundwater and shown below in Figure 2.

As shown in Table 1, the only difference between Case-1 and Case-2 is the lowering of the average concentration in Sublayer 3-10. The simulations show that to reach the preliminary remedial goal for groundwater, the soil concentration in Sublayer 3-10 needs to be lowered beyond what is necessary to be protective of indoor air. In order to lower the average concentration in that layer it is necessary to further reduce the soil concentration in the area represented by BS11 at a depth of 76 feet. That

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[3] Use of a spatially weighted average concentration over a layer is more representative of the true mass available that could impact groundwater. In the USEPA OU3 PRAP the maximum concentration within each layer was selected which resulted in an extreme exaggeration of the mass in the subsurface available to impact groundwater, and a situation not representative of the subsurface conditions.

location had a measured concentration of 9500 mg/kg during the 2006 sampling. To be protective of indoor air it is proposed to reduce the concentration at that location to 190 mg/kg. To meet the proposed remedial goal for groundwater the soil concentration in that area should be further reduced to 60 mg/kg.

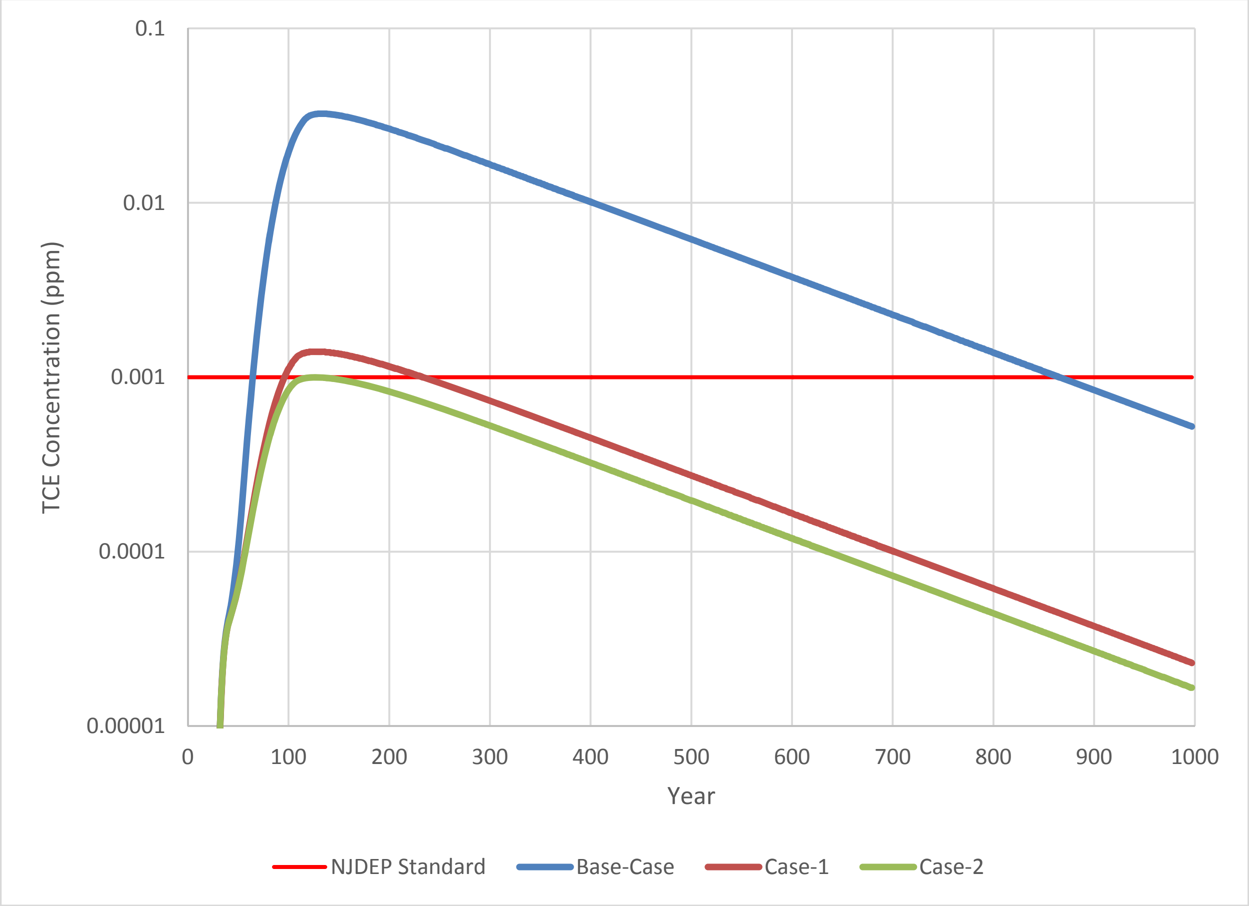
The SEVIEW simulations indicate that the soil treatment proposed to be protective of indoor air is nearly sufficient to be protective of groundwater (resulting in a TCE groundwater concentration of 1.4 µg/L at the modified point of compliance). To meet the remediation goal of 1 µg/L, the treatment volumes are the same. The only additional effort required to achieve the proposed remedial goal for groundwater is additional treatment as necessary to reduce contaminant mass at the location represented by the highest measured concentration of 9,500 mg/kg (during the pre-2007 remedial investigation activities performed by PPPI) at a depth of 76 feet.

Table 1. Summary of Changes in Sublayer Load in SESOIL Simulations.

Sublayer	Sublayer Top (feet)	Sublayer Bottom (feet)	Base-Case - No Soil Treatment TCE Concentration (mg/kg)	Case-1 - Post Treatment TCE Concentration (mg/kg)	Case-2 - TCE Concentration with Additional Treatment (mg/kg)
1-1	0.0	1.1	1.63	0.42	0.42
2-1	1.1	5.0	6.40	0.23	0.23
2-2	5.0	9.0	0.10	0.10	0.10
2-3	9.0	12.9	0.22	0.22	0.22
2-4	12.9	16.8	0.61	0.61	0.61
2-5	16.8	20.8	0.12	0.12	0.12
2-6	20.8	24.7	0.15	0.15	0.15
2-7	24.7	28.6	0.73	0.73	0.73
2-8	28.6	32.6	0.24	0.24	0.24
2-9	32.6	36.5	0.86	0.86	0.86
2-10	36.5	40.4	0.18	0.18	0.18
3-1	40.4	44.4	0.12	0.12	0.12
3-2	44.4	48.3	0.00	0.00	0.00
3-3	48.3	52.3	0.07	0.07	0.07
3-4	52.3	56.2	0.09	0.09	0.09
3-5	56.2	60.1	0.73	0.73	0.73
3-6	60.1	64.1	1.17	1.17	1.17
3-7	64.1	68.0	6.71	3.88	3.88
3-8	68.0	71.9	3.05	1.50	1.50
3-9	71.9	75.9	21.35	1.88	1.88
3-10	75.9	79.8	961.11	21.84	8.80
4-1	79.8	83.7	12.39	2.25	2.25
4-2	83.7	87.7	11.56	4.77	4.77
4-3	87.7	91.6	1.66	1.66	1.66
4-4	91.6	95.5	2.00	2.00	2.00

Sublayer	Sublayer Top (feet)	Sublayer Bottom (feet)	Base-Case - No Soil Treatment TCE Concentration (mg/kg)	Case-1 - Post Treatment TCE Concentration (mg/kg)	Case-2 - TCE Concentration with Additional Treatment (mg/kg)
4-5	95.5	99.5	2.16	0.53	0.53
4-6	99.5	103.4	0.94	0.94	0.94
4-7	103.4	107.4	0.01	0.01	0.01
4-8	107.4	111.3	0.01	0.01	0.01
4-9	111.3	115.2	0.20	0.20	0.20
4-10	115.2	119.2	0.12	0.12	0.12

Figure 2. Simulated TCE Concentration in Groundwater over time at proposed Point of Compliance (6,200 feet downgradient of Area A).



Specific Comments on USEPA's OU3 Proposed Plan
(June 2016)

21. **Page 4, 1st paragraph** - The USEPA's Proposed Plan states "*the glacial deposits are comprised of a mix of glacio-fluvial deposits and till and are characterized as a poorly sorted mixture of sand, silt, and clay, with larger clasts ranging from gravel to boulders. The moraine deposits range from 95 feet to greater than 140 feet thick at the OU3 Study Area. In general, the permeability of the glacial deposits is low.*"

    Laboratory geotechnical testing results from soil samples collected in the OU3 study area, as shown in Tables H1 through H-4 of Appendix H of the 2016 RI Report, document soil hydraulic conductivity values ranging from approximately 2E-6 centimeters per second (cm/s) to 8E-8 cm/s. Given this range of hydraulic conductivity, the equivalent intrinsic permeability of the soil based on methods used for calculating intrinsic permeability in soil as described in the U.S. Army Corps of Engineers Engineering Design Manual EM 1110-1-4001 for Soil Vapor Extraction and Bioventing, Section D-2 in Appendix D (USACE, 2002), is approximately $3x10^{-7}$ cm^2 to $1x10^{-8}$ cm^2. Assuming an effective water saturation content of 6% (based on a conservatively low soil moisture of 12% documented at boring PPP-SBI-04 from the laboratory test results for soil beneath the facility presented in the 2016 RI Report), the resulting intrinsic air permeability of the soil in the area targeted for SVE is estimated to be on the order of $2x10^{-7}$ cm^2 to $9x10^{-9}$ cm^2. These data confirm that the permeability of the soil in the OU3 area is extremely low. The permeabilities of the deep soils within Area A of OU3 are below those where SVE technology is likely to be effective (USEPA, 1991). Accordingly, without additional information (e.g., soil testing or pilot testing) the selection of SVE as a remedial technology for OU3 is not supported.

22. **Page 7** – On page 7 of the Proposed Plan, USEPA indicates that soil underlying the ANC building is being considered "Principal Threat" material. However, the specific basis for classifying this material as a Principal Threat is not explained. Providing a clear basis for this classification is important because an incorrect classification may preclude the evaluation and selection of remedial alternatives that meet the CERCLA remedy selection criteria (e.g., a remedy that is protective, implementable, and cost-effective).

    Principal Threat materials are those "*considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur*" (USEPA, 1991b). Also, as a general rule of thumb USEPA considers as a "*principal threat those source materials with toxicity and mobility characteristics that combine to pose a potential risk several orders of magnitude greater than the risk level that is acceptable for the current or reasonably anticipated future land use, given realistic exposure scenarios.*" (USEPA, 1997).

    Section 6.1 of the 2016 RI Report explains that under current and future land use the estimated risks for receptors exposed to site-related chemicals in soil, surface water and sediment at all exposure areas are below USEPA's risk management limits. The 2016 RI Report also explains that, prior to the installation and activation of the soil vapor extraction system/subslab depressurization system (SVE/SSDS) at the ANC building, indoor air concentrations of TCE were above the NJDOH's site-specific health goal of 7 $\mu g/m^3$ for workers.[4] More specifically, on Page 6 the Proposed Plan explains that

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[4] NJDOH considered this goal to be equal to a level that would result in a noncancer hazard quotient (HQ) of 1 for inhalation exposure of workers at the ANC building. At this concentration the lifetime incremental cancer risk associated with worker inhalation exposure would be approximately $3x10^{-6}$.

indoor air TCE concentrations were as high as 180 µg/. Site-specific exposure of workers in the ANC building to this air concentration would result in an incremental excess cancer risk of approximately 8 x 10^{-5} and noncancer HQ of approximately 30. These risk levels would not be consistent with USEPA's general rule of thumb for identifying Principal Threat material (i.e., "*several orders of magnitude greater*" than the acceptable risk level).

Also, the USEPA OU3 PRAP explains that the SVE/SSDS systems "*have reduced concentrations in the indoor and subslab air significantly*" (Page 6), that "*with the vapor mitigation systems operational, the vapor intrusion exposure is incomplete*" (Page 9), that the "*operation of the shallow SVE and SSD systems provides protection of human health from vapor intrusion*" (Page 12), and that recent sampling "*demonstrate that the system is effective.*" (Page 12) These conclusions also indicate that the soil contamination below the ANC building does not represent Principal Threat material since it is being "reliably contained" via the SVE/SSDS system.

23. **Page 11** – On Page 11 of the Proposed Plan, USEPA notes that a TCE soil cleanup level of 1 ppm (rounded up from 880 µg/kg) has been determined to be protective for human exposure via vapor intrusion exposure to subsurface soil contamination under the ANC building. This value was determined utilizing a site-specific attenuation factor estimated from subslab and indoor air sampling data in order to model potential indoor exposure risk.

    Appendix B of the 2016 FS Report provides the supporting information for derivation of the cleanup level of 880 µg/kg. In doing so, CDM-Smith utilized site-specific subslab soil gas and indoor air data in order to develop a site-specific subslab-to-indoor air attenuation factor (α) in order to model indoor air exposure risk from subslab soil gas concentrations. The site-specific subslab to indoor air attenuation factor of 0.000019 utilized by CDM-Smith appears to be a reasonable value considering the degree of attenuation identified across the entire ANC building slab during the Removal Action sampling performed in 2013 prior to the installation and activation of the SVE/SSDS. However, based upon a review of the subslab and indoor air concentrations observed in June 2016 from sampling locations where the bulk of the soil contamination has been identified (i.e., within the Molding Area), this underestimates the actual degree of attenuation. As explained in Attachment A ("Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building"), Ramboll Environ has utilized a subslab-to-indoor air attenuation factor of 0.000045 in modelling the migration of shallow soil contamination into the ANC building.

    The cleanup level proposed by CDM-Smith in the 2016 FS Report of 880 µg/kg is based upon the assumption that soil contamination is present at these levels immediately below the ANC building slab. It does not take into account the fact that the bulk of the TCE soil contamination was identified at depths 60 ft below ground surface (bgs) or greater. It also does not take into account that shallow (0-5 ft bgs) soil concentrations below the ANC building have very likely been significantly reduced due to the operation of the existing shallow SVE/SSDS system. As noted on Page 17 of the USEPA OU3 PRAP, the existing shallow SVE/SSDS systems "*are successfully remediating shallow soils under the building.*" In determining the extent to which soil would warrant cleanup under the ANC building, USEPA should consider the degree to which clean shallower soil (e.g., from 0 to 60 ft bgs) would help to attenuate soil vapor intrusion potential.

    Also, the remedial action objective would be better stated as, "*to reduce soil TCE concentrations below the ANC building as necessary to ensure that indoor worker soil vapor intrusion exposure would not result in unacceptable risk in the absence of engineering controls*". Achieving this objective would achieve the same protection but would not necessarily require the treatment of all soils beneath the former ANC building with a concentration above 1 mg/kg. Instead, it would allow the treatment of a volume of TCE-contaminated soil below the ANC building as necessary to reduce the total vapor flux of TCE into the building in order to achieve acceptable risks for the site-specific worker population (in the absence of engineering controls). As presented in Attachment A to these comments ("Tech Memo: Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building"), Ramboll Environ has performed an analysis to determine the extent to which soil below the ANC building would have to be treated (or removed) in order to achieve this objective. This analysis (1) accounts for the attenuation due to the presence of clean soil from 10 to 60 ft bgs and (2) determines what soil would warrant treatment in order to reduce the total TCE vapor flux from contaminated soil below the building and achieve a condition of acceptable risk within the ANC building in the absence of engineering controls.

24. **Page 13, 1st Paragraph** – The USEPA's Proposed Plan states that the shallow SVE system has been successfully remediating the shallow soil and the lithology in the deeper soils is similar to the shallow soils. Therefore, it is likely that the deep SVE would be effective in treating the deep vadose zone soil contamination. In addition, page 4-21, paragraph 4 of the Feasibility Study Report states that "*The existing shallow SVE system indicates that the heterogeneous low permeable soil beneath the building can achieve a significant radius of influence and air exchange rate under natural conditions.*"

    The assumption USEPA makes regarding the effectiveness of the shallow SVE/ SSDS being similar to how a deep SVE system will perform is not accurate. First, the primary objective of the shallow SVE system is to reduce the indoor air concentrations of TCE in the Albéa facility by 1) mitigating the sub slab concentrations of TCE; and, 2) maintaining a negative pressure in the subsurface immediately beneath the building floor slab. Although contaminant mass is being removed from the shallow soils by the system, its primary objective is to solely address the vapor migration pathway. Second, the zone of influence of the shallow SVE system is much greater than what would be expected by a deep SVE system due to the zone of higher permeability between the floor slab and the subsurface soil (void space that is present immediately beneath a floor slab and the presence of permeable, granular fill materials consisting of sand and gravel were observed to be present when installing the shallow SVE well points for this system). As vacuum measurements for the shallow SVE system are taken from the within the permeable zone just beneath the slab, the resulting vacuum influence of the SVE/SSDS system will be significantly greater than what would be expected in the deeper native soil beneath the building. As provided in Specific Comment No. 21 on the USEPA OU3 PRAP above, the deep soils within Area A at the Washington plant are orders of magnitude less permeable than the shallow, granular subgrade materials present beneath the building slab. Therefore, selection of the deep SVE alternative based on the assumption that it will perform similar to the shallow SVE system installed for mitigation of vapors beneath the building is inappropriate.

25. **Page 15** - The USEPA's Proposed Plan states that "*Alternative 4 would remove approximately 90 percent or more of the contaminant mass within the treatment zone, and the contamination beneath the ANC building would no longer serve as a significant source for groundwater contamination or vapor intrusion.*" There is no supporting information provided in the Feasibility Study Report or USEPA's Proposed Plan on how the estimate of 90% mass removal was derived for the deep SVE alternative. Based on the low values of soil air permeability discussed in Specific Comment No. 21 on the USEPA OU3 PRAP above and given the heterogeneous nature of the unsaturated soil in the OU3 area, it is unlikely that a high enough pore-gas velocity can be achieved throughout the treatment area given the number and spacing of proposed SVE wells to effectively reduce the contaminant mass by 90% or

greater, and within the 10-year timeframe that USEPA indicates is required to reach the Site-specific remediation goal of 1 mg/kg TCE. Furthermore, as SVE is a rate-limited mass transfer process and contaminant mass reduction depends greatly on achieving a sufficient pore-gas velocity throughout the treatment zone, any fine-grained soil zones having TCE concentrations above the remediation goal may not be subjected to the required amount of air flow or pore-volume exchanges. This is further complicated based on the presence of obstruction to vapor flow identified within soil borings conducted within Area A that include boulders and cobbles. Consequently, the alternative of using SVE alone is prone to failure at the onset and would necessitate the need for applying the thermal enhancement option at significantly higher costs.

26. **Page 16** – in the second paragraph, USEPA states, "*Alternative 4 involves the installation of deep SVE wells and piping inside the facility. However, this would be manageable as demonstrated by the shallow SVE system.*" This statement is incorrect and assumes that the number and location of deep SVE wells would be the same as for the existing vapor extraction points for the shallow vapor mitigation system. In review of the conceptual installation of the deep SVE system as provided in Specific Comment No. 19 on the 2016 FS Report above, the number of SVE wells that would be needed would be at least twice (over 30) that of the shallow SVE points installed for the existing vapor mitigation system located within Area A of the former ANC plant. This number of extraction wells and the associated piping would be a significant impediment and would likely make it impracticable for the facility to conduct operations in this area of the plant for many years.
27. **Page 17** - The USEPA's Proposed Plan states that "*No significant installation and/or operation issues are anticipated for the deep SVE system, as the currently operating shallow SVE system was installed in 2013 and is currently successfully operating at the Site in Area A.*" As shown in Figure 4-2 of the Feasibility Study - Conceptual Layout for Alternative 4, fourteen SVE well locations are proposed. The fourteen deep well installations would require the use of roto-sonic drilling equipment due to the presence of cobbles and boulders, and roto-sonic drilling equipment requires a considerable amount of open space and ceiling clearance to install the wells. The SVE/SSDS extraction points are installed to a depth of 2 and 5 feet only and could be installed using hand augers and small-scale soil boring equipment. The use of large-scale roto-sonic drilling equipment within the interior of the building will have significant effects on facility operations, implementation challenges, and cost. USEPA's assessment that installation of a deep SVE system is comparable to the installation of the shallow SVE/SSDS system warrants further evaluation.
28. **Page 17** – The Proposed Plan notes that after "*treatment, post-remediation sampling will be performed to confirm that remediation goals have been met.*" This is consistent with language in the 2016 FS Report that explains that after "*the completion of deep SVE treatment and in situ thermal treatment, if implemented, soil samples would be collected to evaluate the treatment effectiveness.*" As a remedial action objective is reduction of vapor intrusion to be protective of indoor air, it is suggested that a more effective and practical means for evaluating the effectiveness of treatment will be to utilize soil vapor probes and to sample subslab soil gas to determine if subslab concentrations have been reduced, in the absence of engineering controls, to a concentration that at a level not be expected to result in an unacceptable vapor intrusion risk (e.g., a concentration approximately 400,000 $\mu g/m^3$ consistent with that presented in Appendix B of the 2016 FS Report). It is noted that confirmation sampling by means of soils borings thro ugh Area A within the building would be highly disruptive to facility operations, would only represent a small volume as compared to the overall volume of the soils to be treated (i.e., may not be fully representative), and significant variability of concentrations (i.e., ability to reproduce results) could result from soils samples even if collected within a short distance from one another.

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RAMBOLL ENVIRON

ATTACHMENT A

TECHNICAL MEMORANDUM

Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building, Pohatcong Valley Groundwater Contamination Site, Operable Unit 3

RAMBOLL ENVIRON

ENVIRONMENT
& HEALTH

TECH MEMO

Date:	**August 11, 2016**
To:	**Roy Duckett, Rio Tinto**
From:	**Kevin Long, Ramboll Environ** **Bruce Kennington, Ramboll Environ**
cc:	**Bruce White, Barnes and Thornburg, LLP**
Subject:	**Basis for Alternative Soil Treatment Volume to Address Vapor Intrusion Exposure at the ANC Building, Pohatcong Valley Groundwater Contamination Site, Operable Unit 3**

Introduction

Ramboll Environ has performed a site-specific analysis to determine the minimum extent to which soil below the ANC building would have to be treated (or removed) in order to ensure that indoor worker soil vapor intrusion exposure would not result in unacceptable risk in the absence of engineering controls. This analysis is more refined than the approach used by CDM in deriving the TCE soil cleanup level of 1 mg/kg in the 2016 Final Feasibility Study Report in that that (1) it accounts for the fact that the bulk of the soil contamination was identified at depths at least 60 ft below ground surface (bgs) and (2) it uses a mass flux approach to identify the minimum extent of remediation needed to ensure acceptable indoor worker risks.

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The analysis demonstrates that not all soil below the ANC building with a concentration above 1 mg/kg would need to be treated in order to ensure acceptable risks in the absence of engineering controls. USEPA's targeted soil treatment volume below the ANC building is approximately 41,000 yd^3. This analysis demonstrates that only approximately 1,000 yd^3 of deep soil and approximately 70 yd^3 of shallow soil below the ANC building would warrant treatment in order to achieve the remedial objective.

The details of this analysis, and the calculations which form the basis of this alternative soil treatment volume, are presented in this memorandum.

Estimating Vapor Intrusion Risks by Calculating Mass Flux

For these calculations, the southwest corner of the ANC building was defined as the exposure area (Figure A-1). This area encompasses the area where subsurface soil TCE concentrations were identified above USEPA's proposed remedial goal of 1 mg/kg. It is also assumed to be an area where workers could have the highest potential for vapor intrusion exposure during the exposure period.

USEPA's proposed remedial goal is based upon the assumption that soil contamination is present immediately below the building slab. It does not take into account the fact that the bulk of the TCE soil contamination was identified at depths of at least 60 feet bgs (Figure A-2) and that shallow soil concentrations of TCE very likely have been reduced or eliminated due to operation of the existing SVE/SSDS system since July 2013. The distribution of TCE in soils at varying depth intervals (0 to 10 ft bgs, 0 to 60 ft bgs, 60 to 90 ft bgs and 90 to 145 ft bgs) is further illustrated in Figures A-2a to A-2d. In addition, the proposed remediation goal does not identify the soil boring locations and depth intervals where remediation should be performed in order to meet the design objective.

In order to identify the locations and depths where soil remediation will be necessary to achieve acceptable risks (i.e., cancer risk equal to or less than 10^{-4} and non-cancer HQ equal to or less than 1) for workers presumed to be exposed within the exposure area (in the absence of engineering controls), a mass flux analysis was performed. This mass flux analysis determines the allowable TCE vapor flux from contaminated soil below the building that would achieve an acceptable indoor air risk. More specifically, the analysis estimates the maximum mass flux from each soil boring within the exposure area, accounting for the TCE concentration at every sampled depth interval and the attenuation factor for each interval. Every soil boring analyzed for TCE is assigned a subarea of the exposure area based on a Thiessen polygon tessellation (see Figure A-1). Details of the mass flux calculations are discussed below.

For an individual soil concentration C_s, the indoor air inhalation HQ is calculated as follows:

$$HQ = C_{soil} \cdot C_{s,v} \cdot \alpha \cdot nHQ = C_{ia} \cdot nHQ$$

where:

- C_{soil} is the soil concentration;
- $C_{s,v}$ is the ratio of the equilibrium vapor concentration to the soil concentration. Based on the chemical properties of TCE and a soil type of loam (CDM 2016), this has a value of 429 kg/m^3;
- C_{ia} is the indoor air concentration;
- nHQ is the site-specific hazard quotient normalized by the indoor air concentration. This is based on TCE toxicity and site-specific exposure factors for workers at the ANC building (a value of 0.143 m^3/ug); and
- α is the soil-to-indoor-air attenuation factor.

For shallow soil (defined as less than 60 feet bgs), $\alpha = \alpha_{shallow}$ = 0.000045. This is the average of three empirical subslab-to-indoor air attenuation factors calculated using paired indoor air and subslab sampling data collected on June 18-19, 2013 in the Molding Area (which makes up much of the exposure area).

Table A-1: Estimation of Potential Subslab to Indoor Air Attenuation - Trichloroethene
Albea Facility, Washington, NJ

Sub-Slab Vapor			Indoor Air			$\alpha_{empirical}$
Location	**Date**	**Conc** (ug/m^3)	**Location**	**Date**	**Conc** (ug/m^3)	
CDM-SS-01	6/19/2013	2500000	CDM-IA-01	6/18/2013	175	7.0E-05
CDM-SS-02	6/19/2013	5010000	CDM-IA-02	6/18/2013	227	4.5E-05
CDM-SS-03	6/19/2013	8280000	CDM-IA-03	6/18/2013	156	1.9E-05
					Mean:	4.5E-05

This value is larger (more conservative) than the subslab-to-indoor-air attenuation factor of 0.000019 developed by CDM in the Final Feasibility Study Report (CDM 2016) to derive the soil remedial goal of 0.88 mg/kg (rounded up to 1 mg/kg by USEPA). Although paired indoor air and subslab soil gas data were collected at these locations in March 2016, the June 2016 were used because the higher subslab concentrations observed in June are more consistent with the soil concentrations under this part of the building, and thus, are expected to provide a better estimate of the attenuation associated with the building slab in the vicinity of the bulk of the soil contamination.

For soil deeper than 60 feet, $\alpha = \alpha_{60}$ = 0.000019. This site-specific attenuation factor reflects combined attenuation due to (1) diffusional resistance from clean vadose zone soil from 60 ft bgs to the bottom of the building slab[1] and (2) the attenuation $\alpha_{shallow}$ across the slab.

Thus if the indoor air concentration were 7 µg/m^3, it would result in an HQ of 1;

$$HQ = C_{ia} \cdot nHQ = \left(7\frac{ug}{m^3}\right) \cdot \left(0.143\frac{m^3}{ug}\right) = 1$$

At an indoor air concentration of 7 ug/m^3, the inhalation cancer risk is 3 x 10^{-6}, based on a similar calculation. Since this cancer risk is much lower than the USEPA cumulative cancer risk limit of 10^{-4}, the cancer risk does not control remedial action decisions, and the mass flux analysis can be based on the noncancer HQ.

To estimate the HQ from multiple samples with different concentrations at different depths, the flux from each boring is conservatively estimated based on the maximum potential flux among the samples in the boring. The total TCE mass flow rate into the exposure area is estimated by summing the mass flow rate calculated for all of the borings within the exposure area. For a particular boring, the maximum mass flux is calculated as follows:

$$J_i = \max_j J_{ij}$$

$$J_{ij} = C_{ij} \cdot C_{s,v} \cdot \alpha \cdot H_b \cdot ach$$

---

[1] Based on the same soil type of loam, organic carbon fraction of 0.002, and moisture content used to derive the soil remedial goal of 0.88 mg/kg.

where:

- J_i is the flux for boring i, the maximum of the flux based on any sample in the boring;
- J_{ij} is the flux based on sample j in boring i;
- C_{ij} is the concentration[2] in sample j in boring i;
- $\alpha = \alpha_{shallow}$ for samples shallower than 60 ft bgs and $\alpha = \alpha_{60}$ for samples 60 ft bgs or deeper;
- H_b is the height of the exposure area (10 ft); and
- *ach* is the assumed ventilation rate in the exposure area (1 air change per hour)

The total mass entering the exposure area is calculated as follows:

$$M_{total} = \sum_i M_i = \sum_i J_i \cdot A_i$$

where:

- M_{total} is the total mass flow rate into the exposure area;
- M_i is the mass flow rate associated with boring i; and
- A_i is the area associated with boring i (Thiessen polygon) within the exposure area.

The HQ is calculated as follows:

$$HQ = \frac{M_{total}}{Q_b} \cdot nHQ = \frac{M_{total}}{H_b \cdot A_b \cdot ach} \cdot nHQ$$

where:

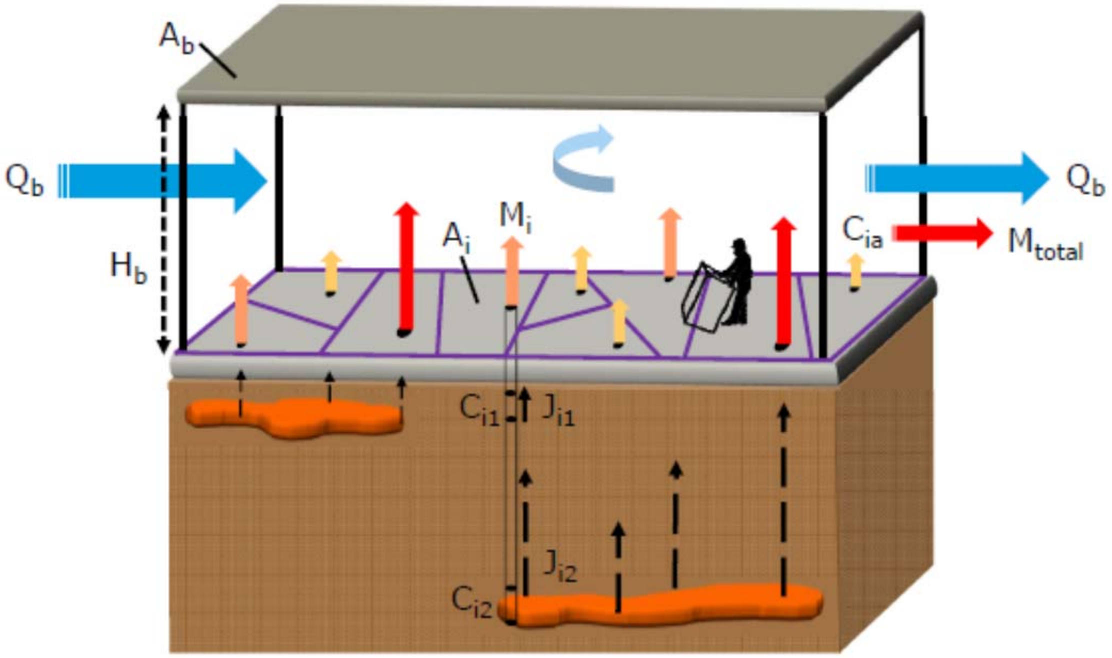
- Q_b is the ventilation rate of the exposure area = $H_b A_b\ ach$; and
- A_b is the area of the exposure area $= \sum_i A_i$.

A diagram illustrating these calculations is shown as Figure A-3. The numerical calculations are shown on Table A-2.

---

[2] Detected concentration, or ½ the detection limit for samples where TCE was not detected.

Figure A-3: Illustration of Mass Flux



Determining the Extent of Treatment Necessary to Achieve Acceptable Risks

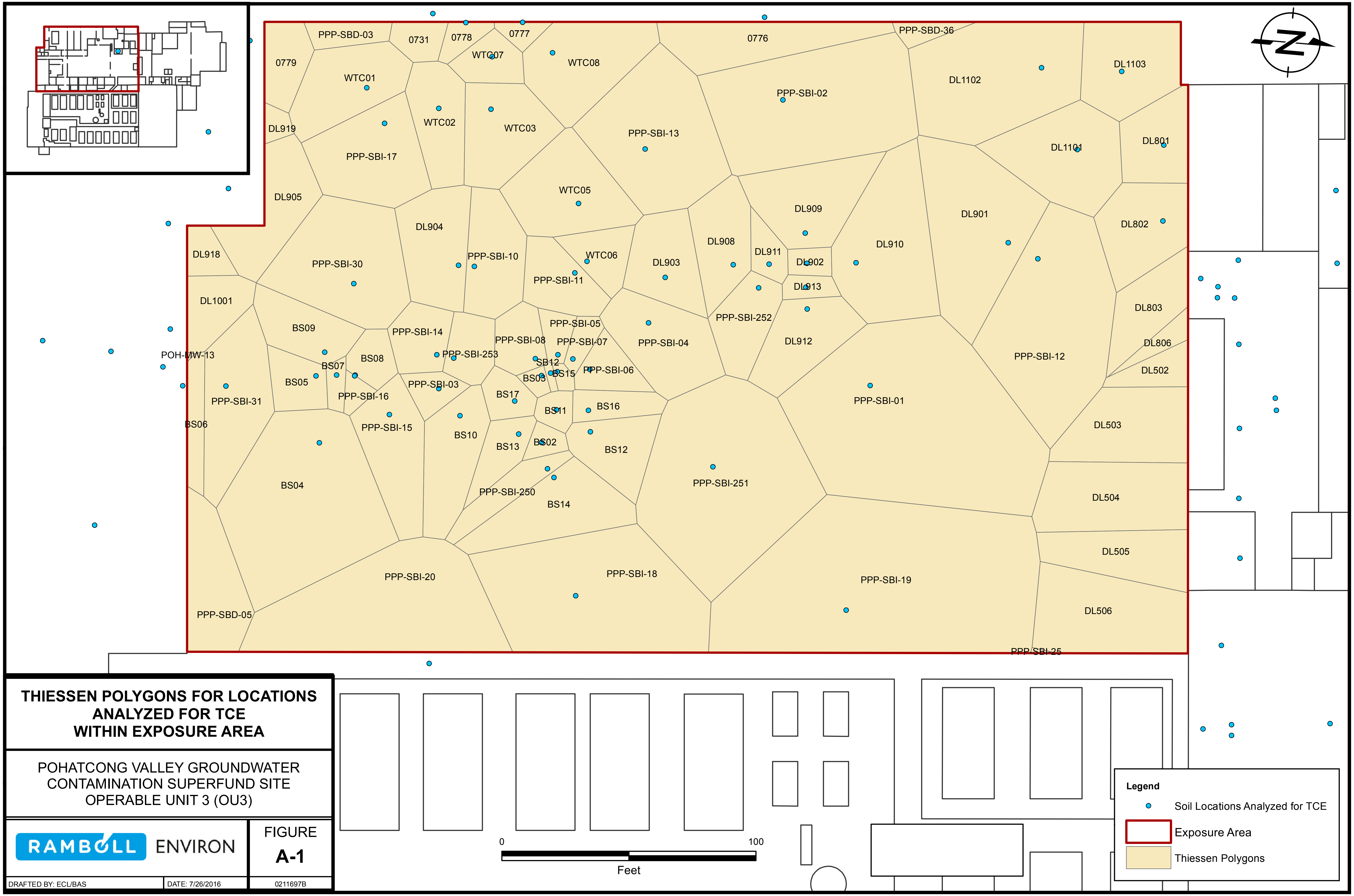
The mass flux analysis provides an effective tool for estimating potential risks associated with treatment of soil at different combinations of locations and depths.

In the absence of treatment, using the characterization data available, the mass flux analysis yields an HQ estimate for workers that is approximately 6. In order to determine the necessary extent of treatment to achieve an HQ of 1 for workers in the exposure area, an iterative analysis was performed in which soil with the highest concentrations within the exposure area was presumed to be treated (to an efficiency of 98%). This iterative simulation was performed until the simulated treatment achieved an HQ of 1. This analysis resulted in the identification of soil at 10 locations and 22 depth intervals, as shown on Figure A-4 and Table A-2. As shown in Table A-2, these locations and depths correspond to an estimated 1,000 cubic yards (yd^3) of deep soil (at depths ranging from 64 to 97 feet bgs) and 70 yd^3 of shallow soil (at depths ranging from 0 to 2 feet bgs) that would require treatment to achieve an HQ of 1.

References

CDM Smith. 2016. Final Feasibility Study Report, Pohatcong Valley Groundwater Contamination Superfund Site, OU3. June 10.

FIGURES



THIESSEN POLYGONS FOR LOCATIONS ANALYZED FOR TCE WITHIN EXPOSURE AREA

POHATCONG VALLEY GROUNDWATER
CONTAMINATION SUPERFUND SITE
OPERABLE UNIT 3 (OU3)

RAMBOLL ENVIRON

FIGURE
A-1

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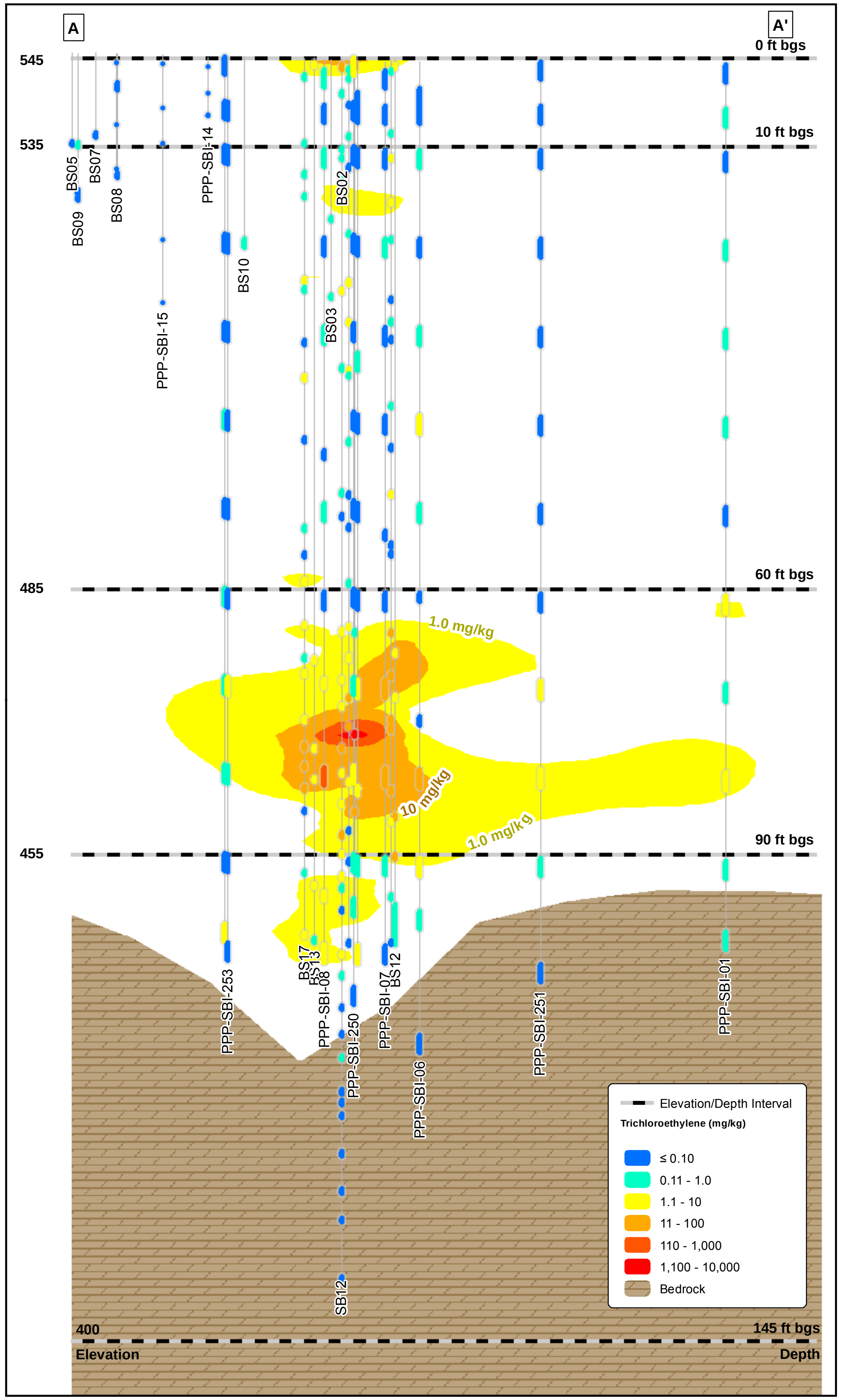
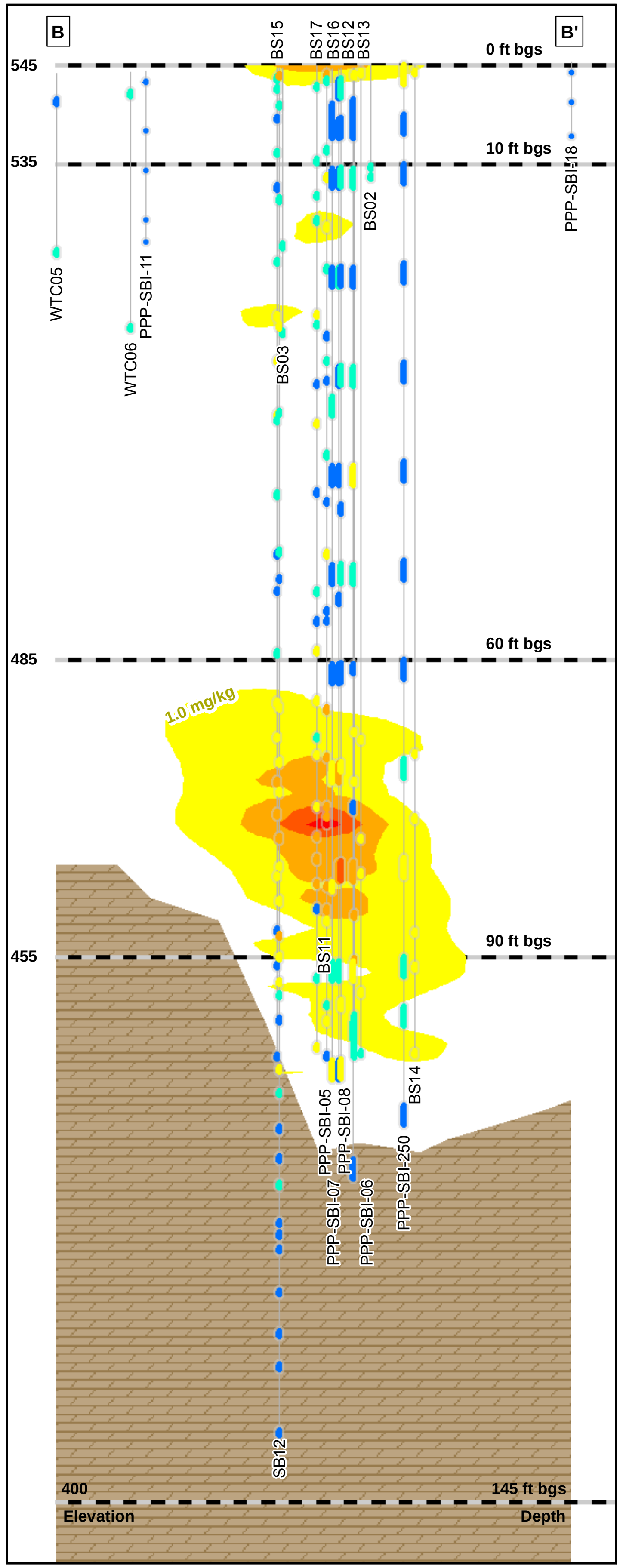
DATE: 7/26/2016
0211697B

D:\GIS\PROJECT\POHATCONG\DOCS\Figure A2 - Cross Section Combined 0 to145 bgs DRAFT 20160803.mxd





Highest TCE Result 0 - 145 ft bgs
- ● ≤ 0.10 (56)
- ● 0.11 - 1.0 (49)
- ● 1.1 - 10 (19)
- ● 11 - 100 (9)
- ● 110 - 1,000 (2)
- ● 1,100 - 9,500 (1)
- ━ Cross Section Line
- ⌐ ¬ 25 ft Buffer of Cross Section Line
- 🟨 TCE ≥ 1.0 mg/kg
- 🟥 USEPA OU3 Area A

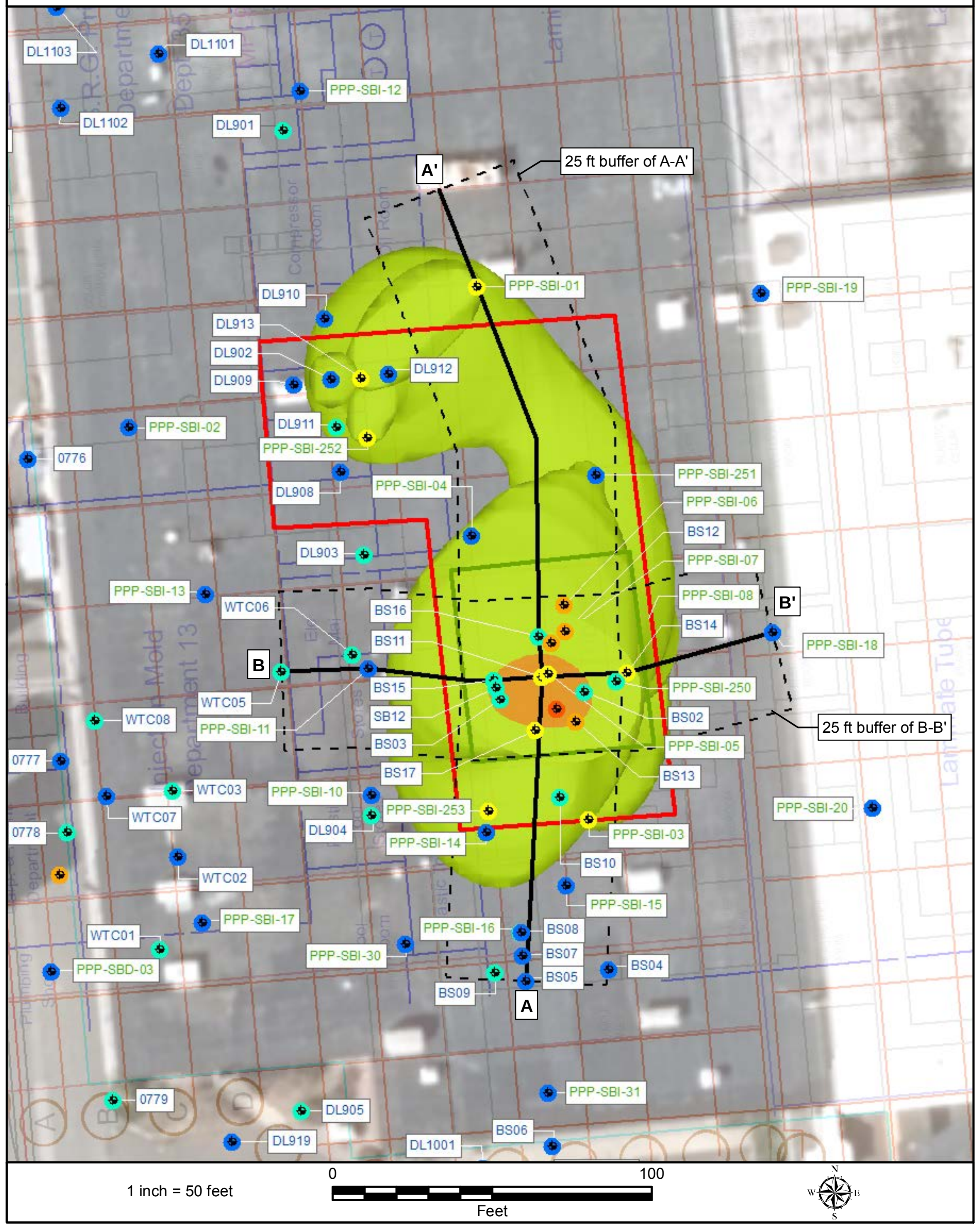
USEPA Potential ISTR Area
- 🟩 (In Situ Thermal Remediation)

Data Interpolation Notes

Three-dimensional plume volume and mass estimates prepared using C Tech's Earth Volumetric Studio (EVS) and EnterVol.
Analytical input data included approx. 1,150 soil samples kriged into a 3-D grid of approx. 1.8 million cells with a minimum XYZ resolution 4ft x 4ft x 0.5ft.
Semivariogram model: Range = 987.2 Sill = 0.8131 Nugget = 0
Kriged 1,287,500 points
TCE: Min 0.00023 Max 9,500 (mg/kg)
Standard Deviation-TCE: Min 0.025 Max 0.669

Location color indicates maximum TCE result reported.
Location label with blue font, completed 2006 or earlier.
Location label with green font, completed 2011 or later during USEPA OU3 RI.

Count of results in each category in parenthesis, e.g., "≤ 0.10 (8)"



RAMBOLL ENVIRON

PREPARED BY: KTS

DATE: 8/3/2016

Cross Section Notes
Horizontal scale 1 in = 50 ft
Vertical scale 3 in = 50 ft (or 1 in = 16⅔ ft)
Vertical exaggeration = 3
Results within 25 ft of cross section line A-A' projected onto cross section
Length of sample indicates reported sample start and stop depth

COMBINED pre-2006 ENVIRON AND USEPA OU3 RI ANALYTICAL RESULTS
TCE IN SOIL (mg/kg) from 0 ft bgs to 145 ft bgs
PVGCS Site - Washington, NJ

FIGURE
A-2

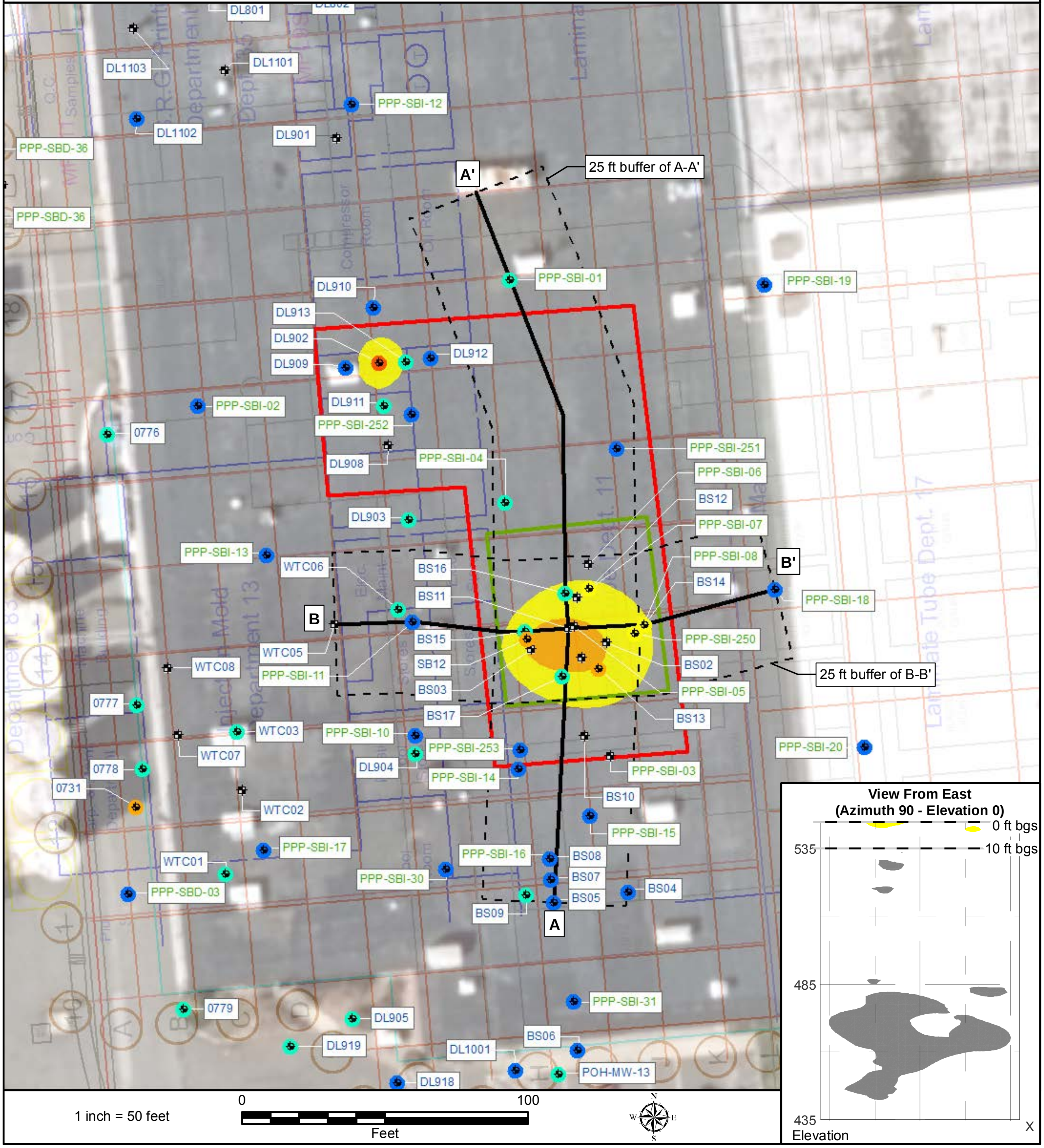
PROJECT: 0211697B

Highest TCE Result - 0 to 10 ft bgs

- ● ≤ 0.10 (28)
- ● 0.11 - 1.0 (20)
- ● 1.1 - 10 (3)
- ● 11 - 100 (3)
- ● 110 - 1,000 (1)
- ✚ Soil Boring or Monitoring Well Location
- ━ Cross Section Line
- ⌐ ¬ 25 ft Buffer of Cross Section Line
- 🟥 USEPA OU3 Area A
- 🟩 USEPA Potential ISTR Area *(In Situ Thermal Remediation)*
- 🟨 TCE ≥ 1.0 mg/kg

Location color indicates maximum TCE result reported for depth interval.
Location label with blue font, completed 2006 or earlier.
Location label with green font, completed 2011 or later during USEPA OU3 RI.

Count of results in each category in parenthesis, e.g., "≤ 0.10 (8)"



D:\GIS\PROJECT\POHATCONG\DOCs\Figure A-2a - 0 to 10 ft bgs 20160803.mxd

RAMBOLL ENVIRON

PREPARED BY: KTS

DATE: 8/3/2016

COMBINED pre-2006 ENVIRON AND USEPA OU3 RI ANALYTICAL RESULTS
TCE IN SOIL (mg/kg) from 0 ft bgs to 10 ft bgs
PVGCS Site - Washington, NJ

FIGURE
A-2a

PROJECT: 0211697B

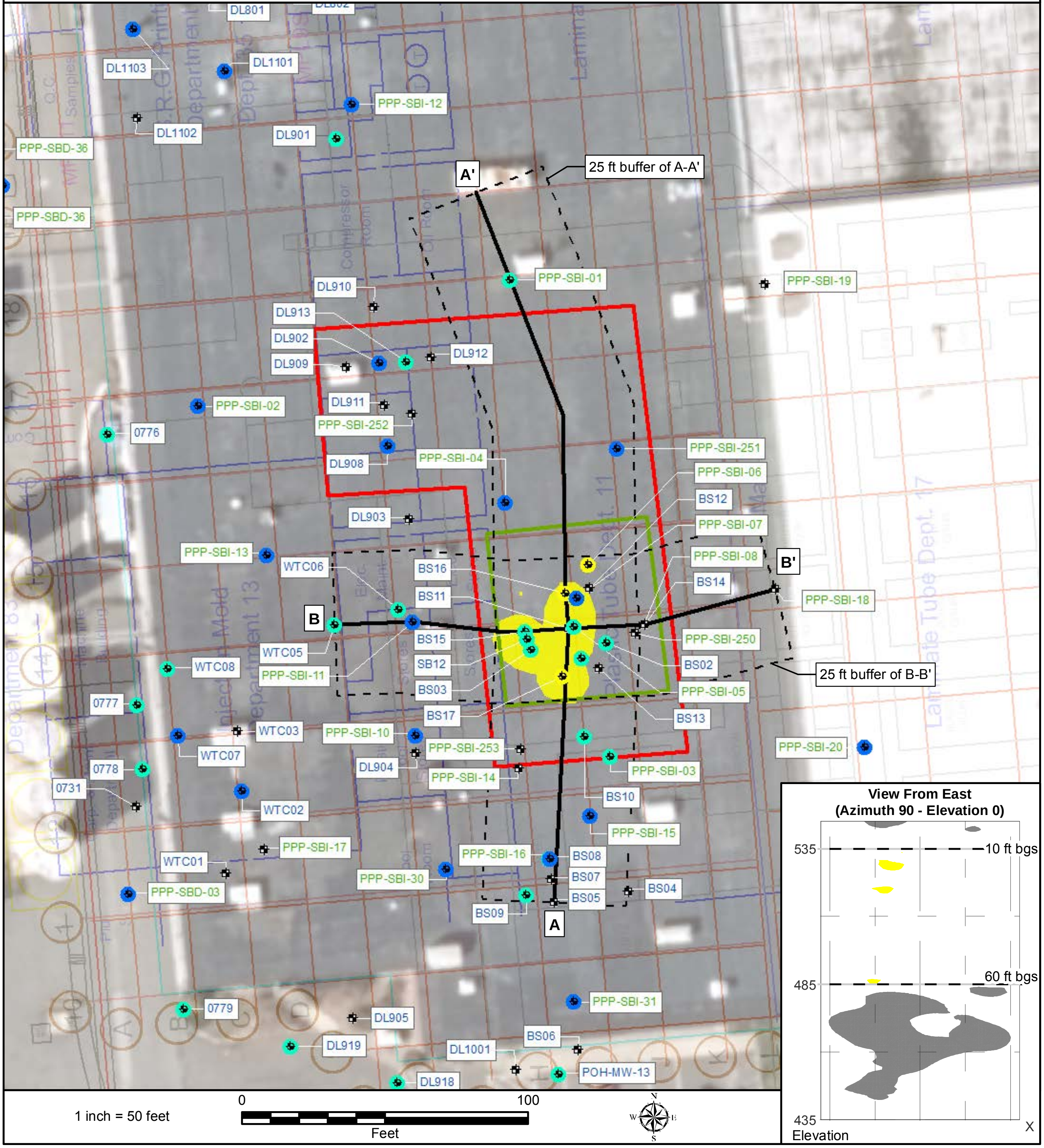
Highest TCE Result - 90 to 145 ft bgs

- ● ≤ 0.10
- ● 0.11 - 1.0
- ● 1.1 - 10
- ■ Soil Boring or Monitoring Well Location

- ━ Cross Section Line
- ⬚ 25 ft Buffer of Cross Section Line
- 🟩 USEPA Potential ISTR Area *(In Situ Thermal Remediation)*
- 🟥 USEPA OU3 Area A
- 🟨 TCE ≥ 1.0 mg/kg

Location color indicates maximum TCE result reported for depth interval.
Location label with blue font, completed 2006 or earlier.
Location label with green font, completed 2011 or later during USEPA OU3 RI.

Count of results in each category in parenthesis, e.g., "≤ 0.10 (8)"



RAMBOLL ENVIRON

PREPARED BY: KTS

DATE:8/3/2016

COMBINED pre-2006 ENVIRON AND USEPA OU3 RI ANALYTICAL RESULTS
TCE IN SOIL (mg/kg) from 10 ft bgs to 60 ft bgs
PVGCS Site - Washington, NJ

FIGURE

A-2b

PROJECT: 0211697B

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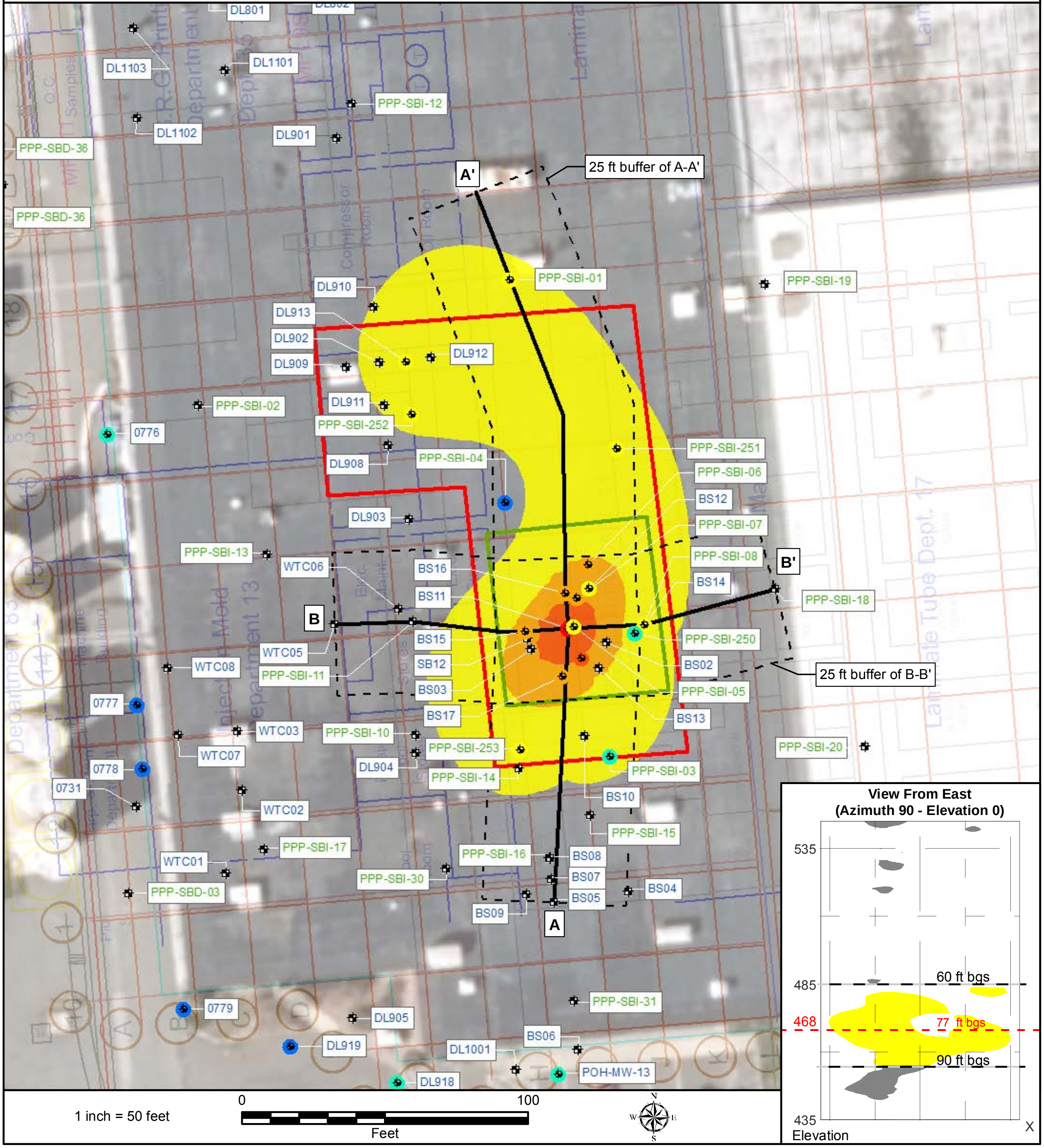
Highest TCE Result - 60 to 90 ft bgs

●	≤ 0.10 (5)
●	0.11 - 1.0 (5)
●	1.1 - 10 (8)
●	11 - 100 (5)
●	110 - 1,000 (1)
●	1,100 - 9,500 (1)
✦	Soil Boring or Monitoring Well Location
—	Cross Section Line
┅	25 ft Buffer of Cross Section Line
🟩	USEPA Potential ISTR Area *(In Situ Thermal Remediation)*
🟥	USEPA OU3 Area A
🟨	TCE ≥ 1.0 mg/kg

TCE soil volume shown in plan view cut horizontally at an elevation of 468 ft to show 77-90 ft bgs.
Location color indicates maximum TCE result reported for depth interval.

Location label with blue font, completed 2006 or earlier.
Location label with green font, completed 2011 or later during USEPA OU3 RI.
Count of results in each category in parenthesis, e.g., "≤ 0.10 (8)"



RAMBOLL ENVIRON

COMBINED pre-2006 ENVIRON AND USEPA OU3 RI ANALYTICAL RESULTS
TCE IN SOIL (mg/kg) from 60 ft bgs to 90 ft bgs
PVGCS Site - Washington, NJ

FIGURE

A-2c

PREPARED BY: KTS

DATE: 8/3/2016

PROJECT: 0211697B

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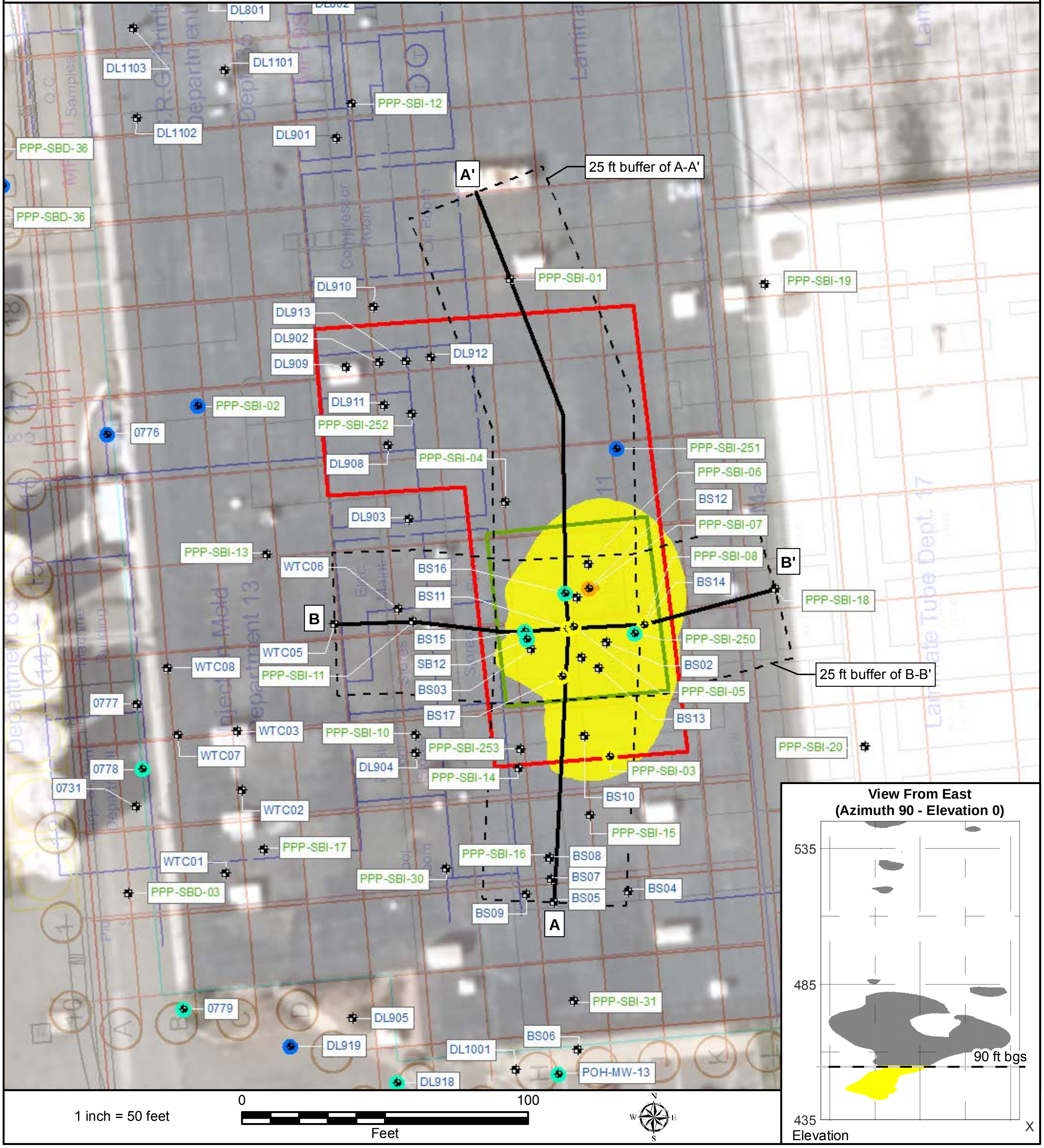
Highest TCE Result - 90 to 145 ft bgs

- ● ≤ 0.10 (5)
- ● 0.11 - 1.0 (8)
- ● 1.1 - 10 (5)
- ● 11 - 100 (1)

- ✛ Soil Boring or Monitoring Well Location
- — Cross Section Line
- ▭ 25 ft Buffer of Cross Section Line
- 🟩 USEPA Potential ISTR Area *(In Situ Thermal Remediation)*
- 🟥 EPA Treatment Zone

Location color indicates maximum TCE result reported for depth interval.
Location label with blue font, completed 2006 or earlier.
Location label with green font, completed 2011 or later during USEPA OU3 RI.

Count of results in each category in parenthesis, e.g., "≤ 0.10 (8)"



RAMBØLL ENVIRON	COMBINED pre-2006 ENVIRON AND USEPA OU3 RI ANALYTICAL RESULTS TCE IN SOIL (mg/kg) from 90 ft bgs to 145 ft bgs PVGCS Site - Washington, NJ	FIGURE **A-2d**
PREPARED BY: KTS	DATE:8/3/2016	PROJECT: 0211697B

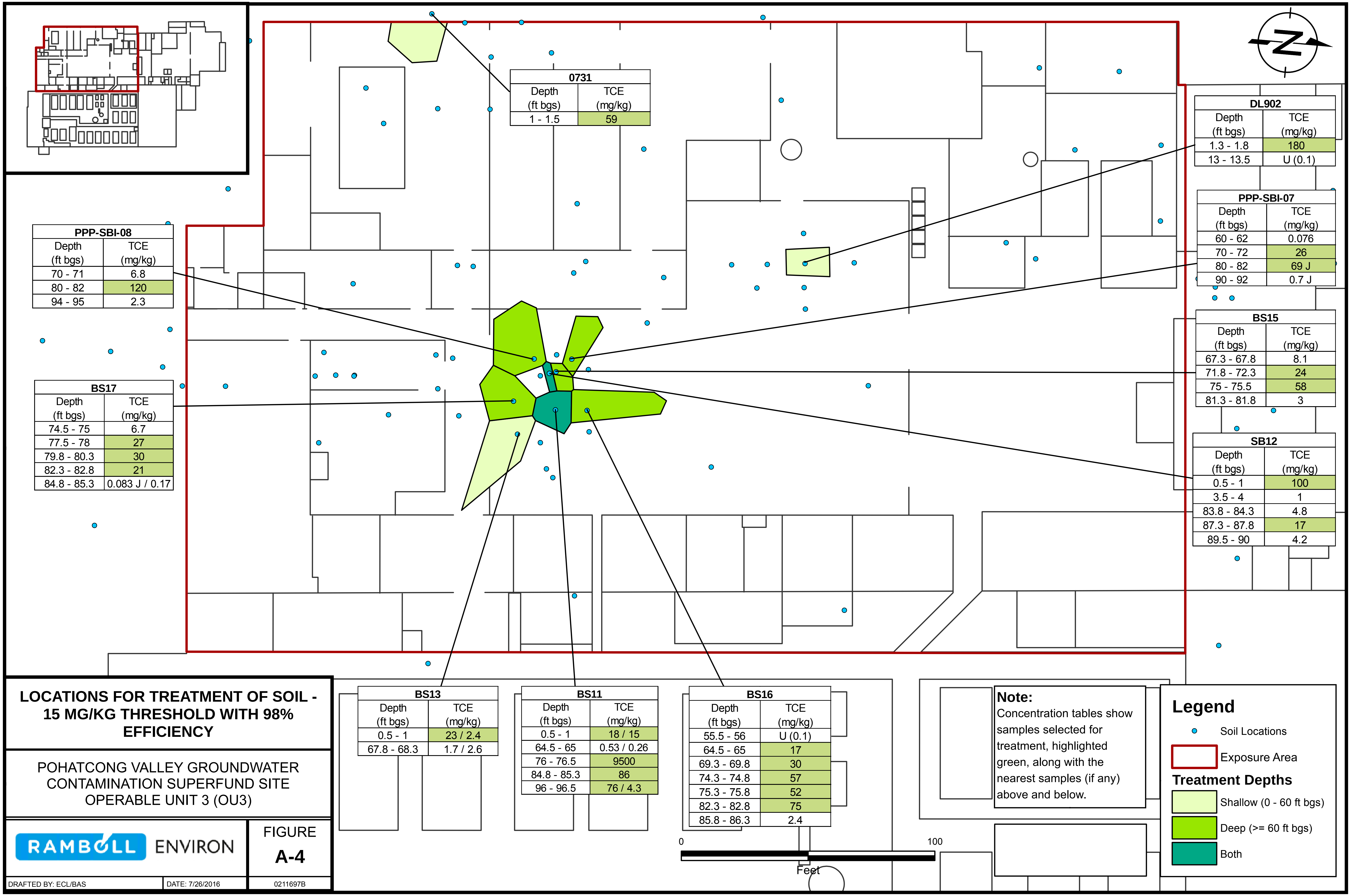
LOCATIONS FOR TREATMENT OF SOIL - 15 MG/KG THRESHOLD WITH 98% EFFICIENCY

POHATCONG VALLEY GROUNDWATER
CONTAMINATION SUPERFUND SITE
OPERABLE UNIT 3 (OU3)

RAMBOLL ENVIRON

FIGURE
A-4

DRAFTED BY: ECL/BAS
DATE: 7/26/2016
0211697B



0731

Depth (ft bgs)	TCE (mg/kg)
1 - 1.5	59

DL902

Depth (ft bgs)	TCE (mg/kg)
1.3 - 1.8	180
13 - 13.5	U (0.1)

PPP-SBI-08

Depth (ft bgs)	TCE (mg/kg)
70 - 71	6.8
80 - 82	120
94 - 95	2.3

PPP-SBI-07

Depth (ft bgs)	TCE (mg/kg)
60 - 62	0.076
70 - 72	26
80 - 82	69 J
90 - 92	0.7 J

BS15

Depth (ft bgs)	TCE (mg/kg)
67.3 - 67.8	8.1
71.8 - 72.3	24
75 - 75.5	58
81.3 - 81.8	3

BS17

Depth (ft bgs)	TCE (mg/kg)
74.5 - 75	6.7
77.5 - 78	27
79.8 - 80.3	30
82.3 - 82.8	21
84.8 - 85.3	0.083 J / 0.17

SB12

Depth (ft bgs)	TCE (mg/kg)
0.5 - 1	100
3.5 - 4	1
83.8 - 84.3	4.8
87.3 - 87.8	17
89.5 - 90	4.2

BS13

Depth (ft bgs)	TCE (mg/kg)
0.5 - 1	23 / 2.4
67.8 - 68.3	1.7 / 2.6

BS11

Depth (ft bgs)	TCE (mg/kg)
0.5 - 1	18 / 15
64.5 - 65	0.53 / 0.26
76 - 76.5	9500
84.8 - 85.3	86
96 - 96.5	76 / 4.3

BS16

Depth (ft bgs)	TCE (mg/kg)
55.5 - 56	U (0.1)
64.5 - 65	17
69.3 - 69.8	30
74.3 - 74.8	57
75.3 - 75.8	52
82.3 - 82.8	75
85.8 - 86.3	2.4

Note:
Concentration tables show samples selected for treatment, highlighted green, along with the nearest samples (if any) above and below.

Legend

● Soil Locations
🟥 Exposure Area

Treatment Depths

🟩 Shallow (0 - 60 ft bgs)
🟩 Deep (>= 60 ft bgs)
🟩 Both

TABLES

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
0731	293	1	1.5	59		1.3	TRUE	1.18E+00	1.93E-05	1.93E-05	5.25E-04	7.01E-05	11	
0776	1201	3.5	4		U	0.12	FALSE		9.80E-07	9.80E-07	1.09E-04	1.46E-05		
0776	1201	3.5	4		U	0.12	FALSE		9.80E-07					
0776	1201	9.3	9.8		U	0.12	FALSE		9.80E-07					
0776	1201	14	14.5		U	0.11	FALSE		8.98E-07					
0776	1201	19.5	20		U	0.11	FALSE		8.98E-07					
0776	1201	23.8	24.3		U	0.1	FALSE		8.17E-07					
0776	1201	29.5	30		U	0.1	FALSE		8.17E-07					
0776	1201	39.5	40		U	0.1	FALSE		8.17E-07					
0776	1201	43	43.5		U	0.11	FALSE		8.98E-07					
0776	1201	49.1	49.6		U	0.11	FALSE		8.98E-07					
0776	1201	54	54.5		U	0.094	FALSE		7.68E-07					
0776	1201	59.1	59.6		U	0.086	FALSE		7.02E-07					
0776	1201	59.1	59.6		U	0.098	FALSE		8.00E-07					
0776	1201	69.5	70		U	0.081	FALSE		2.75E-07					
0776	1201	79.6	80.1		U	0.11	FALSE		3.73E-07					
0776	1201	84	84.5		U	0.098	FALSE		3.32E-07					
0776	1201	89	89.5		U	0.094	FALSE		3.19E-07					
0776	1201	95	95.3		U	0.088	FALSE		2.99E-07					
0776	1201	98	98.2		U	0.057	FALSE		1.93E-07					
0777	156	5	5.5		U	0.12	FALSE		9.80E-07	9.80E-07	1.42E-05	1.89E-06		
0777	156	5	5.5		U	0.095	FALSE		7.76E-07					
0777	156	14	14.5		U	0.11	FALSE		8.98E-07					
0777	156	19.4	19.9		U	0.1	FALSE		8.17E-07					
0777	156	25	25.5		U	0.1	FALSE		8.17E-07					
0777	156	29	29.4		U	0.11	FALSE		8.98E-07					
0777	156	33	33.5		U	0.1	FALSE		8.17E-07					
0777	156	39.3	39.8		U	0.098	FALSE		8.00E-07					
0777	156	43	43.3		U	0.1	FALSE		8.17E-07					
0777	156	49	49.5		U	0.095	FALSE		7.76E-07					
0777	156	55	55.5		U	0.1	FALSE		8.17E-07					
0777	156	60	60.5		U	0.098	FALSE		3.32E-07					
0777	156	60	60.5		U	0.1	FALSE		3.39E-07					
0777	156	63.7	64.2		U	0.094	FALSE		3.19E-07					
0777	156	69.5	70		U	0.088	FALSE		2.99E-07					
0777	156	75	75.5		U	0.083	FALSE		2.82E-07					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	mg/m^2/s	mg/m^2/s	mg/s	mg/m^3	yd^3	yd^3
0777	156	80	80.5		U	0.093	FALSE		3.15E-07					
0777	156	83	83.2		U	0.1	FALSE		3.39E-07					
0778	205	5	5.5		U	0.11	FALSE		8.98E-07	8.98E-07	1.71E-05	2.28E-06		
0778	205	5	5.5		U	0.1	FALSE		8.17E-07					
0778	205	9	9.2		U	0.1	FALSE		8.17E-07					
0778	205	15	15.5		U	0.11	FALSE		8.98E-07					
0778	205	25	25.5		U	0.098	FALSE		8.00E-07					
0778	205	29.1	29.6		U	0.1	FALSE		8.17E-07					
0778	205	33	33.5		U	0.097	FALSE		7.92E-07					
0778	205	41	41.2		U	0.11	FALSE		8.98E-07					
0778	205	45	45.5		U	0.11	FALSE		8.98E-07					
0778	205	49	49.5		U	0.099	FALSE		8.09E-07					
0778	205	53.1	53.6		U	0.11	FALSE		8.98E-07					
0778	205	59.1	59.5		U	0.1	FALSE		8.17E-07					
0778	205	59.1	59.5		U	0.1	FALSE		8.17E-07					
0778	205	63.5	64		U	0.092	FALSE		3.12E-07					
0778	205	69.5	70		U	0.096	FALSE		3.26E-07					
0778	205	73.4	73.9		U	0.09	FALSE		3.05E-07					
0778	205	77.7	78.2		U	0.096	FALSE		3.26E-07					
0778	205	83	83.5		U	0.1	FALSE		3.39E-07					
0778	205	88	88.5		U	0.095	FALSE		3.22E-07					
0778	205	93	93.5		U	0.14	FALSE		4.75E-07					
0779	539	5.4	5.9		U	0.11	FALSE		8.98E-07	3.76E-06	1.88E-04	2.51E-05		
0779	539	5.4	5.9		U	0.1	FALSE		8.17E-07					
0779	539	9	9.5	0.23		0.096	FALSE	4.60E-03	3.76E-06					
0779	539	15.1	15.6		U	0.11	FALSE		8.98E-07					
0779	539	23.5	24		U	0.12	FALSE		9.80E-07					
0779	539	29.5	30		U	0.11	FALSE		8.98E-07					
0779	539	33.7	34.2		U	0.11	FALSE		8.98E-07					
0779	539	39.5	40		U	0.13	FALSE		1.06E-06					
0779	539	43.4	43.9		U	0.1	FALSE		8.17E-07					
0779	539	49.5	50		U	0.088	FALSE		7.19E-07					
0779	539	59.5	60		U	0.095	FALSE		7.76E-07					
0779	539	63	63.4		U	0.092	FALSE		3.12E-07					
0779	539	69.5	70		U	0.1	FALSE		3.39E-07					
0779	539	69.5	70		U	0.1	FALSE		3.39E-07					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft²	ft	ft	mg/kg		mg/kg		mg/kg	mg/m²/s	mg/m²/s	mg/s	mg/m³	yd³	yd³
0779	539	73	73.5		U	0.093	FALSE		3.15E-07					
0779	539	79	79.5		U	0.096	FALSE		3.26E-07					
0779	539	84	84.5		U	0.092	FALSE		3.12E-07					
0779	539	89.5	90		U	0.11	FALSE		3.73E-07					
0779	539	93.5	94		U	0.11	FALSE		3.73E-07					
0779	539	99.5	100		U	0.087	FALSE		2.95E-07					
BS02	168	10	10.5	1		0.091	FALSE	2.00E-02	1.63E-05	1.63E-05	2.55E-04	3.40E-05		
BS02	168	11	11.5	0.85		0.09	FALSE	1.70E-02	1.39E-05					
BS03	96	17.7	18.2	0.78		0.099	FALSE	1.56E-02	1.27E-05	1.27E-05	1.14E-04	1.52E-05		
BS03	96	26.5	27	0.58		0.093	FALSE	1.16E-02	9.47E-06					
BS04	3647	5.3	5.8		U	0.1	FALSE		8.17E-07	8.17E-07	2.77E-04	3.69E-05		
BS04	3647	8	8.5		U	0.1	FALSE		8.17E-07					
BS05	471	10	10.5		U	0.094	FALSE		7.68E-07	7.68E-07	3.36E-05	4.48E-06		
BS06	364	9.5	10		U	0.096	FALSE		7.84E-07	7.84E-07	2.65E-05	3.53E-06		
BS07	142	9	9.5		U	0.095	FALSE		7.76E-07	8.09E-07	1.06E-05	1.42E-06		
BS07	142	9	9.5		U	0.099	FALSE		8.09E-07					
BS08	339	3.3	4.2		U	0.098	FALSE		8.00E-07	8.98E-07	2.83E-05	3.77E-06		
BS08	339	13.5	14		U	0.11	FALSE		8.98E-07					
BS09	779	10	10.5	0.12		0.1	FALSE	2.40E-03	1.96E-06	1.96E-06	1.42E-04	1.89E-05		
BS09	779	15.3	15.8		U	0.096	FALSE		7.84E-07					
BS09	779	16	16.5		U	0.11	FALSE		8.98E-07					
BS10	1073	20.5	21	0.43		0.1	FALSE	8.60E-03	7.02E-06	7.02E-06	7.00E-04	9.34E-05		
BS10	1073	21	21.5	0.18		0.099	FALSE	3.60E-03	2.94E-06					
BS11	197	0.5	1	18		0.21	TRUE	3.60E-01	5.88E-06	1.29E-03	2.36E-02	3.14E-03	2	
BS11	197	0.5	1	15		0.11	FALSE	3.00E-01	2.45E-04					
BS11	197	64.5	65	0.53		0.086	FALSE	1.06E-02	3.60E-06					
BS11	197	64.5	65	0.26		0.087	FALSE	5.20E-03	1.76E-06					
BS11	197	76	76.5	9500		90	TRUE	1.90E+02	1.29E-03					74
BS11	197	84.8	85.3	86		0.52	TRUE	1.72E+00	1.17E-05					73
BS11	197	96	96.5	76		1	TRUE	1.52E+00	1.03E-05					41
BS11	197	96	96.5	4.3		0.11	FALSE	8.60E-02	2.92E-05					
BS12	791	0.5	1	1.5		0.1	FALSE	3.00E-02	2.45E-05	8.82E-05	6.48E-03	8.64E-04		
BS12	791	66.8	67.3	8.7		0.088	FALSE	1.74E-01	5.90E-05					
BS12	791	66.8	67.3	8		0.09	FALSE	1.60E-01	5.43E-05					
BS12	791	71.8	72.3	6.1		0.081	FALSE	1.22E-01	4.14E-05					
BS12	791	85.3	85.8	12		0.21	FALSE	2.40E-01	8.14E-05					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
BS12	791	89.8	90.3	13		0.13	FALSE	2.60E-01	8.82E-05					
BS12	791	95.5	100	0.16		0.084	FALSE	3.20E-03	1.09E-06					
BS13	465	0.5	1	23		0.43	TRUE	4.60E-01	7.51E-06	3.92E-05	1.69E-03	2.26E-04	4	
BS13	465	0.5	1	2.4		0.11	FALSE	4.80E-02	3.92E-05					
BS13	465	67.8	68.3	1.7		0.095	FALSE	3.40E-02	1.15E-05					
BS13	465	67.8	68.3	2.6		0.087	FALSE	5.20E-02	1.76E-05					
BS13	465	77.8	78.3	4		0.091	FALSE	8.00E-02	2.71E-05					
BS13	465	81.3	81.8	3.7		0.087	FALSE	7.40E-02	2.51E-05					
BS13	465	93.3	93.8	5.6		0.097	FALSE	1.12E-01	3.80E-05					
BS13	465	99.5	100	0.92		0.11	FALSE	1.84E-02	6.24E-06					
BS14	1306	0.5	1	1.5		0.1	FALSE	3.00E-02	2.45E-05	3.39E-05	4.12E-03	5.49E-04		
BS14	1306	69.3	69.8	1.1		0.09	FALSE	2.20E-02	7.46E-06					
BS14	1306	69.3	69.8	1.3		0.11	FALSE	2.60E-02	8.82E-06					
BS14	1306	75.8	76.3	1.6		0.093	FALSE	3.20E-02	1.09E-05					
BS14	1306	87.3	87.8	1.6		0.097	FALSE	3.20E-02	1.09E-05					
BS14	1306	90.8	91.3	4.9		0.11	FALSE	9.80E-02	3.32E-05					
BS14	1306	99.5	100	5		0.11	FALSE	1.00E-01	3.39E-05					
BS15	71	0.75	1.25	0.7		0.089	FALSE	1.40E-02	1.14E-05	5.50E-05	3.64E-04	4.86E-05		
BS15	71	0.75	1.25	0.95		0.11	FALSE	1.90E-02	1.55E-05					
BS15	71	1.8	2.3	0.41		0.1	FALSE	8.20E-03	6.70E-06					
BS15	71	4.8	5.3	0.087	J	0.1	FALSE	1.74E-03	1.42E-06					
BS15	71	8.3	8.8	0.11		0.11	FALSE	2.20E-03	1.80E-06					
BS15	71	11.8	12.3		U	0.091	FALSE		7.43E-07					
BS15	71	19.3	19.8	0.45		0.1	FALSE	9.00E-03	7.35E-06					
BS15	71	24.8	25.3	3.1		0.099	FALSE	6.20E-02	5.06E-05					
BS15	71	29.3	29.8	1.2		0.096	FALSE	2.40E-02	1.96E-05					
BS15	71	34.8	35.2	2.1		0.12	FALSE	4.20E-02	3.43E-05					
BS15	71	35.3	35.8	0.5		0.086	FALSE	1.00E-02	8.17E-06					
BS15	71	42.8	43.3	0.11		0.091	FALSE	2.20E-03	1.80E-06					
BS15	71	42.8	43.3	0.63		0.1	FALSE	1.26E-02	1.03E-05					
BS15	71	48.8	49.3		U	0.11	FALSE		8.98E-07					
BS15	71	52.5	53	0.092	J	0.11	FALSE	1.84E-03	1.50E-06					
BS15	71	58.8	59.3	0.43		0.1	FALSE	8.60E-03	7.02E-06					
BS15	71	63.8	64.3	5.3		0.095	FALSE	1.06E-01	3.60E-05					
BS15	71	67.3	67.8	8.1		0.13	FALSE	1.62E-01	5.50E-05					
BS15	71	71.8	72.3	24		0.36	TRUE	4.80E-01	3.26E-06					10

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	mg/m^2/s	mg/m^2/s	mg/s	mg/m^3	yd^3	yd^3
BS15	71	75	75.5	58		0.51	TRUE	1.16E+00	7.87E-06					13
BS15	71	81.3	81.8	3		0.093	FALSE	6.00E-02	2.04E-05					
BS15	71	86.8	87.3		U	0.1	FALSE		3.39E-07					
BS15	71	90.3	90.8		U	0.11	FALSE		3.73E-07					
BS15	71	90.3	90.8		U	0.1	FALSE		3.39E-07					
BS15	71	99.5	100		U	0.09	FALSE		3.05E-07					
BS16	386	1	1.5	0.82		0.1	FALSE	1.64E-02	1.34E-05	5.06E-05	1.81E-03	2.42E-04		
BS16	386	8	8.5	0.78		0.099	FALSE	1.56E-02	1.27E-05					
BS16	386	10.8	11.3	3.1		0.096	FALSE	6.20E-02	5.06E-05					
BS16	386	15.8	16.3	2		0.099	FALSE	4.00E-02	3.27E-05					
BS16	386	20	20.5	0.7		0.1	FALSE	1.40E-02	1.14E-05					
BS16	386	26.8	27.3		U	0.095	FALSE		7.76E-07					
BS16	386	29.3	29.8	0.24		0.099	FALSE	4.80E-03	3.92E-06					
BS16	386	31.3	31.8		U	0.094	FALSE		7.68E-07					
BS16	386	38.8	39.3	0.74		0.092	FALSE	1.48E-02	1.21E-05					
BS16	386	38.8	39.3	0.6		0.088	FALSE	1.20E-02	9.80E-06					
BS16	386	43.5	44	0.061	J	0.11	FALSE	1.22E-03	9.96E-07					
BS16	386	48.8	49.3	1.2		0.088	FALSE	2.40E-02	1.96E-05					
BS16	386	54.5	55		U	0.094	FALSE		7.68E-07					
BS16	386	55.5	56		U	0.1	FALSE		8.17E-07					
BS16	386	64.5	65	17		0.16	TRUE	3.40E-01	2.31E-06					99
BS16	386	69.3	69.8	30		0.45	TRUE	6.00E-01	4.07E-06					70
BS16	386	74.3	74.8	57		0.94	TRUE	1.14E+00	7.73E-06					43
BS16	386	75.3	75.8	52		0.89	TRUE	1.04E+00	7.06E-06					57
BS16	386	82.3	82.8	75		0.96	TRUE	1.50E+00	1.02E-05					75
BS16	386	85.8	86.3	2.4		0.1	FALSE	4.80E-02	1.63E-05					
BS16	386	94.3	94.8	0.64		0.13	FALSE	1.28E-02	4.34E-06					
BS16	386	94.3	94.8	0.45		0.14	FALSE	9.00E-03	3.05E-06					
BS16	386	99.5	100		U	0.14	FALSE		4.75E-07					
BS17	324	1.8	2.3	0.67		0.14	FALSE	1.34E-02	1.09E-05	1.63E-04	4.91E-03	6.56E-04		
BS17	324	9.3	9.8	1		0.11	FALSE	2.00E-02	1.63E-05					
BS17	324	12.8	13.3	0.88		0.1	FALSE	1.76E-02	1.44E-05					
BS17	324	15.3	15.8	0.76		0.095	FALSE	1.52E-02	1.24E-05					
BS17	324	24.8	25.3	1.8		0.1	FALSE	3.60E-02	2.94E-05					
BS17	324	25.8	26.3	0.27		0.11	FALSE	5.40E-03	4.41E-06					
BS17	324	31.8	32.3	0.088	J	0.088	FALSE	1.76E-03	1.44E-06					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
BS17	324	35.8	36.3	1.3		0.098	FALSE	2.60E-02	2.12E-05					
BS17	324	42.8	43.3		U	0.084	FALSE		6.86E-07					
BS17	324	42.8	43.3	0.06	J	0.082	FALSE	1.20E-03	9.80E-07					
BS17	324	52.8	53.3	0.23		0.094	FALSE	4.60E-03	3.76E-06					
BS17	324	55.8	56.3		U	0.082	FALSE		6.70E-07					
BS17	324	58.8	59.3	10		0.086	FALSE	2.00E-01	1.63E-04					
BS17	324	63.8	64.3	2.1		0.09	FALSE	4.20E-02	1.42E-05					
BS17	324	67.5	68	0.3		0.094	FALSE	6.00E-03	2.04E-06					
BS17	324	69.3	69.8	1.8		0.09	FALSE	3.60E-02	1.22E-05					
BS17	324	74.5	75	6.7		0.093	FALSE	1.34E-01	4.55E-05					
BS17	324	77.5	78	27		0.44	TRUE	5.40E-01	3.66E-06					32
BS17	324	79.8	80.3	30		0.19	TRUE	6.00E-01	4.07E-06					29
BS17	324	82.3	82.8	21		0.4	TRUE	4.20E-01	2.85E-06					30
BS17	324	84.8	85.3	0.083	J	0.13	FALSE	1.66E-03	5.63E-07					
BS17	324	84.8	85.3	0.17		0.12	FALSE	3.40E-03	1.15E-06					
BS17	324	91.8	92.3	0.63		0.092	FALSE	1.26E-02	4.27E-06					
BS17	324	98.8	99.3	2.8		0.1	FALSE	5.60E-02	1.90E-05					
DL1001	602	9.5	10		U	0.096	FALSE		7.84E-07	7.84E-07	4.38E-05	5.85E-06		
DL1101	1581	10	10.5		U	0.1	FALSE		8.17E-07	8.17E-07	1.20E-04	1.60E-05		
DL1102	2673	3.5	4		U	0.084	FALSE		6.86E-07	6.86E-07	1.70E-04	2.27E-05		
DL1103	1301	10	10.5		U	0.092	FALSE		7.51E-07	7.51E-07	9.08E-05	1.21E-05		
DL502	363	10	10.5		U	0.089	FALSE		7.27E-07	7.27E-07	2.45E-05	3.27E-06		
DL503	1360	10.2	10.7		U	0.12	FALSE		9.80E-07	9.80E-07	1.24E-04	1.65E-05		
DL504	1586	3.7	4.2		U	0.099	FALSE		8.09E-07	8.09E-07	1.19E-04	1.59E-05		
DL505	1068	7	7.5		U	0.11	FALSE		8.98E-07	8.98E-07	8.91E-05	1.19E-05		
DL505	1068	9	9.5		U	0.1	FALSE		8.17E-07					
DL506	1790	10	10.5		U	0.1	FALSE		8.17E-07	8.17E-07	1.36E-04	1.81E-05		
DL801	847	10	10.5		U	0.11	FALSE		8.98E-07	8.98E-07	7.07E-05	9.43E-06		
DL801	847	10	10.5		U	0.099	FALSE		8.09E-07					
DL802	1135	9	9.5		U	0.15	FALSE		1.23E-06	1.23E-06	1.29E-04	1.72E-05		
DL803	822	10	10.5		U	0.1	FALSE		8.17E-07	8.17E-07	6.24E-05	8.32E-06		
DL803	822	10	10.5		U	0.1	FALSE		8.17E-07					
DL806	206	10	10.5		U	0.1	FALSE		8.17E-07	8.17E-07	1.57E-05	2.09E-06		
DL901	2457	14	14.5	0.17		0.093	FALSE	3.40E-03	2.78E-06	3.27E-06	7.46E-04	9.95E-05		
DL901	2457	14	14.5	0.2		0.1	FALSE	4.00E-03	3.27E-06					
DL902	185	1.3	1.8	180		1.9	TRUE	3.60E+00	5.88E-05	5.88E-05	1.01E-03	1.35E-04	47	

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
DL902	185	13	13.5		U	0.1	FALSE		8.17E-07					
DL903	951	2.8	3.3		U	0.11	FALSE		8.98E-07	8.98E-07	7.94E-05	1.06E-05		
DL903	951	3.5	4		U	0.11	FALSE		8.98E-07					
DL904	1164	5.3	5.8		U	0.1	FALSE		8.17E-07	5.23E-06	5.65E-04	7.54E-05		
DL904	1164	5.3	5.8		U	0.1	FALSE		8.17E-07					
DL904	1164	9.5	10	0.32		0.1	FALSE	6.40E-03	5.23E-06					
DL905	1075	9.5	10		U	0.12	FALSE		9.80E-07	9.80E-07	9.79E-05	1.31E-05		
DL908	925	10.8	11.3	0.056	J	0.11	FALSE	1.12E-03	9.15E-07	9.15E-07	7.86E-05	1.05E-05		
DL908	925	14.5	15		U	0.095	FALSE		7.76E-07					
DL909	1301	1.3	1.8	0.059	J	0.12	FALSE	1.18E-03	9.64E-07	9.64E-07	1.16E-04	1.55E-05		
DL910	2101	1.3	1.8		U	0.1	FALSE		8.17E-07	8.17E-07	1.59E-04	2.13E-05		
DL911	285	1.3	1.8	0.12		0.11	FALSE	2.40E-03	1.96E-06	1.96E-06	5.19E-05	6.93E-06		
DL912	1025	1.3	1.8		U	0.1	FALSE		8.17E-07	8.17E-07	7.78E-05	1.04E-05		
DL913	185	2.3	2.8	0.32		0.1	FALSE	6.40E-03	5.23E-06	2.92E-05	5.00E-04	6.68E-05		
DL913	185	10.8	11.3	0.42		0.099	FALSE	8.40E-03	6.86E-06					
DL913	185	10.8	11.3	0.74		0.11	FALSE	1.48E-02	1.21E-05					
DL913	185	22.8	23.3		U	0.11	FALSE		8.98E-07					
DL913	185	37.5	38	0.1	J	0.1	FALSE	2.00E-03	1.63E-06					
DL913	185	44.3	44.8	0.5		0.092	FALSE	1.00E-02	8.17E-06					
DL913	185	48.8	49.3	0.36		0.093	FALSE	7.20E-03	5.88E-06					
DL913	185	59.3	59.8	0.87		0.092	FALSE	1.74E-02	1.42E-05					
DL913	185	60.8	61.3	1.6		0.086	FALSE	3.20E-02	1.09E-05					
DL913	185	76.3	76.8	4.3		0.097	FALSE	8.60E-02	2.92E-05					
DL913	185	82.3	82.8	1.2		0.091	FALSE	2.40E-02	8.14E-06					
DL913	185	94.8	95.3	0.94		0.12	FALSE	1.88E-02	6.38E-06					
DL913	185	94.8	95.3	0.79		0.12	FALSE	1.58E-02	5.36E-06					
DL913	185	95.5	100		U	0.087	FALSE		2.95E-07					
DL918	290	4.5	5		U	0.098	FALSE		8.00E-07	9.80E-07	2.64E-05	3.53E-06		
DL918	290	4.5	5		U	0.096	FALSE		7.84E-07					
DL918	290	8.5	9		U	0.093	FALSE		7.60E-07					
DL918	290	15	15.5		U	0.1	FALSE		8.17E-07					
DL918	290	19.5	20		U	0.12	FALSE		9.80E-07					
DL918	290	24	24.5		U	0.096	FALSE		7.84E-07					
DL918	290	31	31.5		U	0.1	FALSE		8.17E-07					
DL918	290	33.7	34.2		U	0.11	FALSE		8.98E-07					
DL918	290	39	39.5		U	0.1	FALSE		8.17E-07					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
DL918	290	43.5	44		U	0.11	FALSE		8.98E-07					
DL918	290	49	49.5		U	0.11	FALSE		8.98E-07					
DL918	290	55	55.5		U	0.11	FALSE		8.98E-07					
DL918	290	55	55.5		U	0.12	FALSE		9.80E-07					
DL918	290	59.5	60		U	0.11	FALSE		8.98E-07					
DL918	290	64.5	65		U	0.094	FALSE		3.19E-07					
DL918	290	69.5	70		U	0.091	FALSE		3.09E-07					
DL918	290	73.5	74		U	0.099	FALSE		3.36E-07					
DL918	290	79.5	80		U	0.091	FALSE		3.09E-07					
DL918	290	83.5	84		U	0.092	FALSE		3.12E-07					
DL918	290	89.2	89.7		U	0.099	FALSE		3.36E-07					
DL918	290	94	94.5		U	0.095	FALSE		3.22E-07					
DL918	290	98	98.5		U	0.12	FALSE		4.07E-07					
DL919	131	4.5	5		U	0.11	FALSE		8.98E-07	1.06E-06	1.29E-05	1.72E-06		
DL919	131	4.5	5		U	0.11	FALSE		8.98E-07					
DL919	131	9.5	10		U	0.12	FALSE		9.80E-07					
DL919	131	14.5	15		U	0.11	FALSE		8.98E-07					
DL919	131	19.5	20		U	0.12	FALSE		9.80E-07					
DL919	131	23.5	24		U	0.11	FALSE		8.98E-07					
DL919	131	29	29.5		U	0.11	FALSE		8.98E-07					
DL919	131	33.5	34		U	0.11	FALSE		8.98E-07					
DL919	131	39.5	40		U	0.12	FALSE		9.80E-07					
DL919	131	43.5	44		U	0.13	FALSE		1.06E-06					
DL919	131	49	49.5		U	0.094	FALSE		7.68E-07					
DL919	131	53.5	54		U	0.098	FALSE		8.00E-07					
DL919	131	53.5	54		U	0.1	FALSE		8.17E-07					
DL919	131	59.5	60		U	0.097	FALSE		7.92E-07					
DL919	131	64.5	65		U	0.097	FALSE		3.29E-07					
DL919	131	69.1	69.6		U	0.097	FALSE		3.29E-07					
DL919	131	74.5	75		U	0.093	FALSE		3.15E-07					
DL919	131	79.5	80		U	0.086	FALSE		2.92E-07					
DL919	131	83.7	84.2		U	0.095	FALSE		3.22E-07					
DL919	131	89	89.5	0.058	J	0.1	FALSE	1.16E-03	3.94E-07					
DL919	131	93.5	94	0.064	J	0.093	FALSE	1.28E-03	4.34E-07					
DL919	131	99.3	99.8	0.095		0.093	FALSE	1.90E-03	6.45E-07					
POH-MW-13	6	4	4.5		U	0.12	FALSE		9.80E-07	1.83E-06	1.02E-06	1.36E-07		

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
POH-MW-13	6	4	4.5		U	0.1	FALSE		8.17E-07					
POH-MW-13	6	8.5	9		U	0.1	FALSE		8.17E-07					
POH-MW-13	6	14	14.5		U	0.1	FALSE		8.17E-07					
POH-MW-13	6	19.5	20		U	0.11	FALSE		8.98E-07					
POH-MW-13	6	23.8	24.3		U	0.11	FALSE		8.98E-07					
POH-MW-13	6	29.5	30		U	0.087	FALSE		7.11E-07					
POH-MW-13	6	34	34.5		U	0.095	FALSE		7.76E-07					
POH-MW-13	6	38.5	39		U	0.1	FALSE		8.17E-07					
POH-MW-13	6	45	45.5		U	0.11	FALSE		8.98E-07					
POH-MW-13	6	50	50.5		U	0.1	FALSE		8.17E-07					
POH-MW-13	6	60	60.5		U	0.1	FALSE		3.39E-07					
POH-MW-13	6	60	60.5		U	0.11	FALSE		3.73E-07					
POH-MW-13	6	64.5	65		U	0.087	FALSE		2.95E-07					
POH-MW-13	6	69.5	70	0.2		0.14	FALSE	4.00E-03	1.36E-06					
POH-MW-13	6	74.5	75	0.098		0.088	FALSE	1.96E-03	6.65E-07					
POH-MW-13	6	79.5	80		U	0.1	FALSE		3.39E-07					
POH-MW-13	6	84.5	85	0.074	J	0.091	FALSE	1.48E-03	5.02E-07					
POH-MW-13	6	89.5	90	0.081	J	0.096	FALSE	1.62E-03	5.50E-07					
POH-MW-13	6	94.5	95	0.27		0.12	FALSE	5.40E-03	1.83E-06					
POH-MW-13	6	98	98.5		U	0.11	FALSE		3.73E-07					
PPP-SBD-03	303		2	0.0032	J		FALSE	6.40E-05	5.23E-08	5.23E-08	1.47E-06	1.97E-07		
PPP-SBD-03	303		2	0.0005	J		FALSE	1.00E-05	8.17E-09					
PPP-SBD-03	303	5	7		U	0.0059	FALSE		4.82E-08					
PPP-SBD-03	303	5	7		U	0.0063	FALSE		5.15E-08					
PPP-SBD-03	303	5	7		U	0.0055	FALSE		4.49E-08					
PPP-SBD-03	303	10	12		U	0.006	FALSE		4.90E-08					
PPP-SBD-03	303	10	12		U	0.0044	FALSE		3.59E-08					
PPP-SBD-03	303	20	22		U	0.0048	FALSE		3.92E-08					
PPP-SBD-03	303	20	22	0.00037	J		FALSE	7.40E-06	6.04E-09					
PPP-SBD-03	303	26	28	0.00027	J		FALSE	5.40E-06	4.41E-09					
PPP-SBD-03	303	26	28		U	0.0054	FALSE		4.41E-08					
PPP-SBD-03	303	32	33		U	0.0055	FALSE		4.49E-08					
PPP-SBD-03	303	41	42		U	0.0042	FALSE		3.43E-08					
PPP-SBD-03	303	50	52		U	0.004	FALSE		3.27E-08					
PPP-SBD-03	303	60	62	0.0015	J		FALSE	3.00E-05	1.02E-08					
PPP-SBD-03	303	70	72		U	0.004	FALSE		1.36E-08					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
PPP-SBD-05	1194		2		U	0.0048	FALSE		3.92E-08	4.08E-08	4.53E-06	6.04E-07		
PPP-SBD-05	1194	1	3		U	0.0046	FALSE		3.76E-08					
PPP-SBD-05	1194	5	7		U	0.0048	FALSE		3.92E-08					
PPP-SBD-05	1194	5	7		U	0.0046	FALSE		3.76E-08					
PPP-SBD-05	1194	10	11		U	0.0045	FALSE		3.68E-08					
PPP-SBD-05	1194	10	12		U	0.0046	FALSE		3.76E-08					
PPP-SBD-05	1194	20	22		U	0.0047	FALSE		3.84E-08					
PPP-SBD-05	1194	20	22		U	0.005	FALSE		4.08E-08					
PPP-SBD-05	1194	30	32		U	0.0046	FALSE		3.76E-08					
PPP-SBD-05	1194	30	32		U	0.0049	FALSE		4.00E-08					
PPP-SBD-05	1194	39	41		U	0.0049	FALSE		4.00E-08					
PPP-SBD-05	1194	40	42		U	0.0042	FALSE		3.43E-08					
PPP-SBD-05	1194	50	52		U	0.0046	FALSE		3.76E-08					
PPP-SBD-05	1194	60	62		U	0.0042	FALSE		1.42E-08					
PPP-SBD-05	1194	60	62		U	0.0047	FALSE		1.59E-08					
PPP-SBD-05	1194	67	69		U	0.0046	FALSE		1.56E-08					
PPP-SBD-05	1194	70	72		U	0.0047	FALSE		1.59E-08					
PPP-SBD-05	1194	80	82		U	0.0045	FALSE		1.53E-08					
PPP-SBD-05	1194	80	82		U	0.0042	FALSE		1.42E-08					
PPP-SBD-05	1194	90	91		U	0.0053	FALSE		1.80E-08					
PPP-SBD-05	1194	90	92		U	0.0041	FALSE		1.39E-08					
PPP-SBD-05	1194	98	100		U	0.0055	FALSE		1.87E-08					
PPP-SBD-05	1194	100	102		U	0.005	FALSE		1.70E-08					
PPP-SBD-05	1194	107	109	0.0018	J		FALSE	3.60E-05	1.22E-08					
PPP-SBD-05	1194	108	110		U	0.0046	FALSE		1.56E-08					
PPP-SBD-05	1194	122	124		U	0.0041	FALSE		1.39E-08					
PPP-SBD-36	185		2		U	0.0047	FALSE		3.84E-08	4.98E-08	8.54E-07	1.14E-07		
PPP-SBD-36	185	1	3		U	0.0046	FALSE		3.76E-08					
PPP-SBD-36	185	5	7		U	0.0045	FALSE		3.68E-08					
PPP-SBD-36	185	7	9		U	0.0049	FALSE		4.00E-08					
PPP-SBD-36	185	10	11		U	0.0049	FALSE		4.00E-08					
PPP-SBD-36	185	10	12		U	0.0044	FALSE		3.59E-08					
PPP-SBD-36	185	17	19		U	0.0052	FALSE		4.25E-08					
PPP-SBD-36	185	20	22		U	0.0061	FALSE		4.98E-08					
PPP-SBD-36	185	30	31		U	0.0045	FALSE		3.68E-08					
PPP-SBD-36	185	30	32		U	0.0052	FALSE		4.25E-08					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
PPP-SBD-36	185	40	41		U	0.0047	FALSE		3.84E-08					
PPP-SBD-36	185	40	42		U	0.006	FALSE		4.90E-08					
PPP-SBD-36	185	50	52		U	0.0042	FALSE		3.43E-08					
PPP-SBD-36	185	50	52		U	0.005	FALSE		4.08E-08					
PPP-SBD-36	185	51	52		U	0.005	FALSE		4.08E-08					
PPP-SBD-36	185	60	61		U	0.0045	FALSE		1.53E-08					
PPP-SBD-36	185	60	62		U	0.0042	FALSE		1.42E-08					
PPP-SBD-36	185	70	71		U	0.0049	FALSE		1.66E-08					
PPP-SBD-36	185	70	72		U	0.0049	FALSE		1.66E-08					
PPP-SBD-36	185	80	82		U	0.0048	FALSE		1.63E-08					
PPP-SBD-36	185	80	82		U	0.0041	FALSE		1.39E-08					
PPP-SBD-36	185	90	92		U	0.0064	FALSE		2.17E-08					
PPP-SBD-36	185	98	100		U	0.0072	FALSE		2.44E-08					
PPP-SBI-01	5782		2	0.096			FALSE	1.92E-03	1.57E-06	1.09E-05	5.88E-03	7.84E-04		
PPP-SBI-01	5782	5	7	0.16			FALSE	3.20E-03	2.61E-06					
PPP-SBI-01	5782	10	12	0.043			FALSE	8.60E-04	7.02E-07					
PPP-SBI-01	5782	20	22	0.2			FALSE	4.00E-03	3.27E-06					
PPP-SBI-01	5782	30	32	0.67			FALSE	1.34E-02	1.09E-05					
PPP-SBI-01	5782	40	42	0.35	J		FALSE	7.00E-03	5.72E-06					
PPP-SBI-01	5782	50	52	0.003	J		FALSE	6.00E-05	4.90E-08					
PPP-SBI-01	5782	60	62	1.3	J		FALSE	2.60E-02	8.82E-06					
PPP-SBI-01	5782	70	72	0.26			FALSE	5.20E-03	1.76E-06					
PPP-SBI-01	5782	80	82	1.2			FALSE	2.40E-02	8.14E-06					
PPP-SBI-01	5782	90	92	0.93	J		FALSE	1.86E-02	6.31E-06					
PPP-SBI-01	5782	98	10	0.3	J		FALSE	6.00E-03	2.04E-06					
PPP-SBI-02	3443		2	0.0074			FALSE	1.48E-04	1.21E-07	1.21E-07	3.87E-05	5.16E-06		
PPP-SBI-02	3443	5	7	0.004	J		FALSE	8.00E-05	6.53E-08					
PPP-SBI-02	3443	10	12		U	0.0045	FALSE		3.68E-08					
PPP-SBI-02	3443	20	22	0.0035	J		FALSE	7.00E-05	5.72E-08					
PPP-SBI-02	3443	30	32		U	0.0051	FALSE		4.17E-08					
PPP-SBI-02	3443	40	42		U	0.0044	FALSE		3.59E-08					
PPP-SBI-02	3443	50	52	0.0016	J		FALSE	3.20E-05	2.61E-08					
PPP-SBI-02	3443	60	62	0.0035	J		FALSE	7.00E-05	2.37E-08					
PPP-SBI-02	3443	70	72	0.0027	J		FALSE	5.40E-05	1.83E-08					
PPP-SBI-02	3443	80	82	0.0013	J		FALSE	2.60E-05	8.82E-09					
PPP-SBI-02	3443	90	92		U	0.0054	FALSE		1.83E-08					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
PPP-SBI-02	3443	98	100		U	0.0044	FALSE		1.49E-08					
PPP-SBI-03	293		2	0.025	J		FALSE	5.00E-04	4.08E-07	1.02E-05	2.77E-04	3.69E-05		
PPP-SBI-03	293	5	7	0.016			FALSE	3.20E-04	2.61E-07					
PPP-SBI-03	293	10	12	0.0088			FALSE	1.76E-04	1.44E-07					
PPP-SBI-03	293	20	22	0.03			FALSE	6.00E-04	4.90E-07					
PPP-SBI-03	293	30	32	0.02			FALSE	4.00E-04	3.27E-07					
PPP-SBI-03	293	40	42	0.18	J		FALSE	3.60E-03	2.94E-06					
PPP-SBI-03	293	50	52		UJ	0.0048	FALSE		3.92E-08					
PPP-SBI-03	293	60	62	0.11			FALSE	2.20E-03	7.46E-07					
PPP-SBI-03	293	70	72	0.87	J		FALSE	1.74E-02	5.90E-06					
PPP-SBI-03	293	80	82	0.42			FALSE	8.40E-03	2.85E-06					
PPP-SBI-03	293	90	92	0.019			FALSE	3.80E-04	1.29E-07					
PPP-SBI-03	293	98	100	1.5			FALSE	3.00E-02	1.02E-05					
PPP-SBI-04	1290	5	7	0.2			FALSE	4.00E-03	3.27E-06	3.27E-06	3.91E-04	5.22E-05		
PPP-SBI-04	1290	10	12	0.0081			FALSE	1.62E-04	1.32E-07					
PPP-SBI-04	1290	20	22	0.008			FALSE	1.60E-04	1.31E-07					
PPP-SBI-04	1290	30	32	0.058			FALSE	1.16E-03	9.47E-07					
PPP-SBI-04	1290	40	42	0.044			FALSE	8.80E-04	7.19E-07					
PPP-SBI-04	1290	50	52	0.0074			FALSE	1.48E-04	1.21E-07					
PPP-SBI-04	1290	60	62	0.033			FALSE	6.60E-04	2.24E-07					
PPP-SBI-04	1290	70	72	0.0056	J		FALSE	1.12E-04	3.80E-08					
PPP-SBI-04	1290	80	82	0.012			FALSE	2.40E-04	8.14E-08					
PPP-SBI-04	1290	90	92	0.041	J		FALSE	8.20E-04	2.78E-07					
PPP-SBI-05	221	3.5	5	0.0079			FALSE	1.58E-04	1.29E-07	4.14E-05	8.51E-04	1.14E-04		
PPP-SBI-05	221	5	7	0.031			FALSE	6.20E-04	5.06E-07					
PPP-SBI-05	221	10	12	0.091			FALSE	1.82E-03	1.49E-06					
PPP-SBI-05	221	20	22	0.054			FALSE	1.08E-03	8.82E-07					
PPP-SBI-05	221	33	35	0.15	J		FALSE	3.00E-03	2.45E-06					
PPP-SBI-05	221	40	42	0.017			FALSE	3.40E-04	2.78E-07					
PPP-SBI-05	221	50	52	0.00091	J		FALSE	1.82E-05	1.49E-08					
PPP-SBI-05	221	60	62	0.03			FALSE	6.00E-04	2.04E-07					
PPP-SBI-05	221	70	72	6.1			FALSE	1.22E-01	4.14E-05					
PPP-SBI-05	221	82	83	3.6			FALSE	7.20E-02	2.44E-05					
PPP-SBI-05	221	90	92	0.17	J		FALSE	3.40E-03	1.15E-06					
PPP-SBI-05	221	100	102	2			FALSE	4.00E-02	1.36E-05					
PPP-SBI-06	428	3	5	0.057			FALSE	1.14E-03	9.31E-07	8.82E-05	3.51E-03	4.68E-04		

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	mg/m^2/s	mg/m^2/s	mg/s	mg/m^3	yd^3	yd^3
PPP-SBI-06	428	5	7	0.032			FALSE	6.40E-04	5.23E-07					
PPP-SBI-06	428	10	12	0.18	J		FALSE	3.60E-03	2.94E-06					
PPP-SBI-06	428	20	22	0.04			FALSE	8.00E-04	6.53E-07					
PPP-SBI-06	428	30	32	0.27			FALSE	5.40E-03	4.41E-06					
PPP-SBI-06	428	40	42	1.1			FALSE	2.20E-02	1.80E-05					
PPP-SBI-06	428	50	52	0.11	J		FALSE	2.20E-03	1.80E-06					
PPP-SBI-06	428	60	61	0.0077	J		FALSE	1.54E-04	5.22E-08					
PPP-SBI-06	428	74	75	0.0011	J		FALSE	2.20E-05	7.46E-09					
PPP-SBI-06	428	80	82	13			FALSE	2.60E-01	8.82E-05					
PPP-SBI-06	428	90	92	1.8			FALSE	3.60E-02	1.22E-05					
PPP-SBI-06	428	96	98	0.96			FALSE	1.92E-02	6.51E-06					
PPP-SBI-06	428	110	112		U	0.0047	FALSE		1.59E-08					
PPP-SBI-07	199	1	3	0.01			FALSE	2.00E-04	1.63E-07	9.36E-06	1.73E-04	2.31E-05		
PPP-SBI-07	199	5	7	0.07			FALSE	1.40E-03	1.14E-06					
PPP-SBI-07	199	10	12	0.009			FALSE	1.80E-04	1.47E-07					
PPP-SBI-07	199	20	22	0.22	J		FALSE	4.40E-03	3.59E-06					
PPP-SBI-07	199	30	32	0.096			FALSE	1.92E-03	1.57E-06					
PPP-SBI-07	199	40	42	0.068			FALSE	1.36E-03	1.11E-06					
PPP-SBI-07	199	53	54	0.0016	J		FALSE	3.20E-05	2.61E-08					
PPP-SBI-07	199	60	62	0.076			FALSE	1.52E-03	5.16E-07					
PPP-SBI-07	199	70	72	26			TRUE	5.20E-01	3.53E-06					74
PPP-SBI-07	199	80	82	69	J		TRUE	1.38E+00	9.36E-06					74
PPP-SBI-07	199	90	92	0.7	J		FALSE	1.40E-02	4.75E-06					
PPP-SBI-07	199	100	102		U	0.004	FALSE		1.36E-08					
PPP-SBI-08	465	1	3	0.21	J		FALSE	4.20E-03	3.43E-06	4.61E-05	1.99E-03	2.66E-04		
PPP-SBI-08	465	5	7	0.049			FALSE	9.80E-04	8.00E-07					
PPP-SBI-08	465	10	12	0.41	J		FALSE	8.20E-03	6.70E-06					
PPP-SBI-08	465	20	22	0.054			FALSE	1.08E-03	8.82E-07					
PPP-SBI-08	465	30	32	0.57	J		FALSE	1.14E-02	9.31E-06					
PPP-SBI-08	465	44	45	0.026			FALSE	5.20E-04	4.25E-07					
PPP-SBI-08	465	50	52	0.13			FALSE	2.60E-03	2.12E-06					
PPP-SBI-08	465	60	62	0.051	J		FALSE	1.02E-03	3.46E-07					
PPP-SBI-08	465	70	71	6.8			FALSE	1.36E-01	4.61E-05					
PPP-SBI-08	465	80	82	120			TRUE	2.40E+00	1.63E-05					215
PPP-SBI-08	465	94	95	2.3			FALSE	4.60E-02	1.56E-05					
PPP-SBI-08	465	100	102	2.5			FALSE	5.00E-02	1.70E-05					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
PPP-SBI-10	1016	0.5	0.5		U	0.0058	FALSE		4.74E-08	4.74E-08	4.47E-06	5.96E-07		
PPP-SBI-10	1016	6	6		U	0.0052	FALSE		4.25E-08					
PPP-SBI-10	1016	12.5	12.5		U	0.0052	FALSE		4.25E-08					
PPP-SBI-11	718	1	1		U	0.0055	FALSE		4.49E-08	5.39E-08	3.60E-06	4.80E-07		
PPP-SBI-11	718	1	1		U	0.0056	FALSE		4.57E-08					
PPP-SBI-11	718	6	6		U	0.0066	FALSE		5.39E-08					
PPP-SBI-11	718	10	10		U	0.0059	FALSE		4.82E-08					
PPP-SBI-11	718	15	15		U	0.0062	FALSE		5.06E-08					
PPP-SBI-11	718	17.2	17.2		U	0.006	FALSE		4.90E-08					
PPP-SBI-12	3335	1	1		U	0.0054	FALSE		4.41E-08	4.74E-08	1.47E-05	1.96E-06		
PPP-SBI-12	3335	6	6		U	0.0058	FALSE		4.74E-08					
PPP-SBI-12	3335	12	12		U	0.0052	FALSE		4.25E-08					
PPP-SBI-12	3335	14.8	14.8		U	0.0051	FALSE		4.17E-08					
PPP-SBI-13	2486	0.7	0.7		U	0.0055	FALSE		4.49E-08	5.15E-08	1.19E-05	1.59E-06		
PPP-SBI-13	2486	6	6		U	0.0057	FALSE		4.66E-08					
PPP-SBI-13	2486	11	11		U	0.0054	FALSE		4.41E-08					
PPP-SBI-13	2486	17	17		U	0.0063	FALSE		5.15E-08					
PPP-SBI-14	563	1	1		U	0.0054	FALSE		4.41E-08	6.70E-08	3.50E-06	4.67E-07		
PPP-SBI-14	563	4	4		U	0.0082	FALSE		6.70E-08					
PPP-SBI-14	563	6.5	6.5		U	0.0058	FALSE		4.74E-08					
PPP-SBI-15	1193	1	1		U	0.0056	FALSE		4.57E-08	5.23E-08	5.79E-06	7.73E-07		
PPP-SBI-15	1193	6	6		U	0.0056	FALSE		4.57E-08					
PPP-SBI-15	1193	6	6		U	0.0056	FALSE		4.57E-08					
PPP-SBI-15	1193	10	10		U	0.0061	FALSE		4.98E-08					
PPP-SBI-15	1193	20.9	20.9		U	0.0055	FALSE		4.49E-08					
PPP-SBI-15	1193	28	28		U	0.0064	FALSE		5.23E-08					
PPP-SBI-16	126	1	1		U	0.0058	FALSE		4.74E-08	4.90E-08	5.76E-07	7.68E-08		
PPP-SBI-16	126	8	8		U	0.0055	FALSE		4.49E-08					
PPP-SBI-16	126	13	13		U	0.006	FALSE		4.90E-08					
PPP-SBI-17	1488	1	1		U	0.0058	FALSE		4.74E-08	5.96E-08	8.24E-06	1.10E-06		
PPP-SBI-17	1488	5.8	5.8		U	0.0073	FALSE		5.96E-08					
PPP-SBI-18	3645	1	1		UJ	0.0057	FALSE		4.66E-08	4.66E-08	1.58E-05	2.10E-06		
PPP-SBI-18	3645	4	4		UJ	0.0052	FALSE		4.25E-08					
PPP-SBI-18	3645	7.5	7.5		UJ	0.0054	FALSE		4.41E-08					
PPP-SBI-19	6648	1.3	1.3		UJ	0.0023	FALSE		1.88E-08	4.57E-08	2.82E-05	3.77E-06		
PPP-SBI-19	6648	5	5		UJ	0.0056	FALSE		4.57E-08					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	mg/m^2/s	mg/m^2/s	mg/s	mg/m^3	yd^3	yd^3
PPP-SBI-20	3252	4	4		UJ	0.0056	FALSE		4.57E-08	4.90E-08	1.48E-05	1.98E-06		
PPP-SBI-20	3252	10	10		UJ	0.006	FALSE		4.90E-08					
PPP-SBI-20	3252	15.5	15.5		UJ	0.0056	FALSE		4.57E-08					
PPP-SBI-25	11	0.5	0.5		U	0.006	FALSE		4.90E-08	8.66E-08	9.20E-08	1.23E-08		
PPP-SBI-25	11	6	6	0.0053	J		FALSE	1.06E-04	8.66E-08					
PPP-SBI-25	11	10.4	10.4		U	0.0053	FALSE		4.33E-08					
PPP-SBI-250	491		2	2.8			FALSE	5.60E-02	4.57E-05	4.57E-05	2.09E-03	2.78E-04		
PPP-SBI-250	491	5	7	0.00039	J		FALSE	7.80E-06	6.37E-09					
PPP-SBI-250	491	10	12	0.0045	J		FALSE	9.00E-05	7.35E-08					
PPP-SBI-250	491	20	22	0.0031	J		FALSE	6.20E-05	5.06E-08					
PPP-SBI-250	491	30	32	0.013			FALSE	2.60E-04	2.12E-07					
PPP-SBI-250	491	40	42	0.019			FALSE	3.80E-04	3.10E-07					
PPP-SBI-250	491	50	52	0.00062	J		FALSE	1.24E-05	1.01E-08					
PPP-SBI-250	491	60	62	0.0078			FALSE	1.56E-04	5.29E-08					
PPP-SBI-250	491	70	72	0.14			FALSE	2.80E-03	9.50E-07					
PPP-SBI-250	491	80	82	1.8			FALSE	3.60E-02	1.22E-05					
PPP-SBI-250	491	90	92	0.66	J		FALSE	1.32E-02	4.48E-06					
PPP-SBI-250	491	90	92	1	J		FALSE	2.00E-02	6.78E-06					
PPP-SBI-250	491	95	97	0.39	J		FALSE	7.80E-03	2.65E-06					
PPP-SBI-250	491	105	107	0.0022	J		FALSE	4.40E-05	1.49E-08					
PPP-SBI-251	4183		2		U	0.0049	FALSE		4.00E-08	2.04E-05	7.91E-03	1.06E-03		
PPP-SBI-251	4183	5	7		U	0.0054	FALSE		4.41E-08					
PPP-SBI-251	4183	10	12		U	0.005	FALSE		4.08E-08					
PPP-SBI-251	4183	20	22	0.024			FALSE	4.80E-04	3.92E-07					
PPP-SBI-251	4183	30	32	0.018			FALSE	3.60E-04	2.94E-07					
PPP-SBI-251	4183	40	42	0.0055			FALSE	1.10E-04	8.98E-08					
PPP-SBI-251	4183	50	52	0.0045			FALSE	9.00E-05	7.35E-08					
PPP-SBI-251	4183	60	62	0.0057			FALSE	1.14E-04	3.87E-08					
PPP-SBI-251	4183	70	72	2.3			FALSE	4.60E-02	1.56E-05					
PPP-SBI-251	4183	70	72	0.099			FALSE	1.98E-03	6.72E-07					
PPP-SBI-251	4183	80	82	3			FALSE	6.00E-02	2.04E-05					
PPP-SBI-251	4183	90	92	0.19			FALSE	3.80E-03	1.29E-06					
PPP-SBI-251	4183	102	104		U	0.005	FALSE		1.70E-08					
PPP-SBI-252	754		2	0.00063	J		FALSE	1.26E-05	1.03E-08	1.97E-05	1.38E-03	1.84E-04		
PPP-SBI-252	754	5	7		U	0.005	FALSE		4.08E-08					
PPP-SBI-252	754	10	12		U	0.0047	FALSE		3.84E-08					

Table A-2
Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
PPP-SBI-252	754	20	22	0.00048	J		FALSE	9.60E-06	7.84E-09					
PPP-SBI-252	754	30	32		U	0.0048	FALSE		3.92E-08					
PPP-SBI-252	754	40	42		U	0.0048	FALSE		3.92E-08					
PPP-SBI-252	754	50	52	0.00051	J		FALSE	1.02E-05	8.33E-09					
PPP-SBI-252	754	63	65	0.28			FALSE	5.60E-03	1.90E-06					
PPP-SBI-252	754	70	72	1.6			FALSE	3.20E-02	1.09E-05					
PPP-SBI-252	754	78	80	2.9			FALSE	5.80E-02	1.97E-05					
PPP-SBI-252	754	90	92	0.0027	J		FALSE	5.40E-05	1.83E-08					
PPP-SBI-253	469	5	7		U	0.0051	FALSE		4.17E-08	1.09E-05	4.73E-04	6.31E-05		
PPP-SBI-253	469	5	7		U	0.0036	FALSE		2.94E-08					
PPP-SBI-253	469	10	12	0.00032	J		FALSE	6.40E-06	5.23E-09					
PPP-SBI-253	469	20	22		U	0.0035	FALSE		2.86E-08					
PPP-SBI-253	469	30	32	0.00039	J		FALSE	7.80E-06	6.37E-09					
PPP-SBI-253	469	40	42		U	0.0041	FALSE		3.35E-08					
PPP-SBI-253	469	50	52	0.0012	J		FALSE	2.40E-05	1.96E-08					
PPP-SBI-253	469	60	62	0.0051			FALSE	1.02E-04	3.46E-08					
PPP-SBI-253	469	70	72	1.6			FALSE	3.20E-02	1.09E-05					
PPP-SBI-253	469	80	82	1			FALSE	2.00E-02	6.78E-06					
PPP-SBI-253	469	90	92	0.00086	J		FALSE	1.72E-05	5.83E-09					
PPP-SBI-253	469	100	102	0.0083			FALSE	1.66E-04	5.63E-08					
PPP-SBI-30	2097	1	1		U	0.0058	FALSE		4.74E-08	4.82E-08	9.39E-06	1.25E-06		
PPP-SBI-30	2097	5	5		U	0.0059	FALSE		4.82E-08					
PPP-SBI-30	2097	11	11		U	0.0059	FALSE		4.82E-08					
PPP-SBI-30	2097	14	14		U	0.0056	FALSE		4.57E-08					
PPP-SBI-30	2097	19	19		U	0.0058	FALSE		4.74E-08					
PPP-SBI-31	1463	1	1		U	0.0056	FALSE		4.57E-08	5.06E-08	6.88E-06	9.18E-07		
PPP-SBI-31	1463	6	6		U	0.0056	FALSE		4.57E-08					
PPP-SBI-31	1463	10	10		U	0.0062	FALSE		5.06E-08					
PPP-SBI-31	1463	17	17		U	0.0059	FALSE		4.82E-08					
SB12	36	0.5	1	100		0.94	TRUE	2.00E+00	3.27E-05	8.14E-05	2.76E-04	3.68E-05	2	
SB12	36	3.5	4	1		0.12	FALSE	2.00E-02	1.63E-05					
SB12	36	13	13.5	0.55		0.11	FALSE	1.10E-02	8.98E-06					
SB12	36	13	13.5	0.37		0.096	FALSE	7.40E-03	6.04E-06					
SB12	36	25.8	26.3	0.98		0.11	FALSE	1.96E-02	1.60E-05					
SB12	36	25.8	26.3	1.2		0.095	FALSE	2.40E-02	1.96E-05					
SB12	36	34.5	35	0.3		0.091	FALSE	6.00E-03	4.90E-06					

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Exposure Area TCE Soil Data and Flux Calculations - 98% Treatment Efficiency
Albea, Washington, NJ

Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
SB12	36	48.6	49.1	0.18		0.084	FALSE	3.60E-03	2.94E-06					
SB12	36	51.3	51.8		U	0.092	FALSE		7.51E-07					
SB12	36	64.3	64.8	8.5		0.089	FALSE	1.70E-01	5.77E-05					
SB12	36	69.8	70.3	7.2		0.094	FALSE	1.44E-01	4.88E-05					
SB12	36	72.8	73.3	4.4		0.082	FALSE	8.80E-02	2.99E-05					
SB12	36	77.5	78	9.8		0.087	FALSE	1.96E-01	6.65E-05					
SB12	36	77.5	78	12		0.089	FALSE	2.40E-01	8.14E-05					
SB12	36	80.3	80.8	6.9		0.1	FALSE	1.38E-01	4.68E-05					
SB12	36	83.8	84.3	4.8		0.12	FALSE	9.60E-02	3.26E-05					
SB12	36	87.3	87.8	17		0.18	TRUE	3.40E-01	2.31E-06					4
SB12	36	89.5	90	4.2		0.1	FALSE	8.40E-02	2.85E-05					
SB12	36	92	92.5	4.4		0.1	FALSE	8.80E-02	2.99E-05					
SB12	36	93.3	93.8	0.6		0.08	FALSE	1.20E-02	4.07E-06					
SB12	36	95.8	96.3		U	0.074	FALSE		2.51E-07					
SB12	36	100.8	101.3	3.8		0.098	FALSE	7.60E-02	2.58E-05					
SB12	36	103.2	103.7	0.26	J	0.26	FALSE	5.20E-03	1.76E-06					
SB12	36	103.2	103.7	0.26	J	0.26	FALSE	5.20E-03	1.76E-06					
SB12	36	106.8	107.3		U	0.28	FALSE		9.50E-07					
SB12	36	109.8	110.3		U	0.25	FALSE		8.48E-07					
SB12	36	112.5	113	0.2	J	0.29	FALSE	4.00E-03	1.36E-06					
SB12	36	116.3	116.8		U	0.24	FALSE		8.14E-07					
SB12	36	117.5	118		U	0.24	FALSE		8.14E-07					
SB12	36	119	119.5		U	0.26	FALSE		8.82E-07					
SB12	36	123.3	123.8		U	0.3	FALSE		1.02E-06					
SB12	36	127.5	128		U	0.28	FALSE		9.50E-07					
SB12	36	130.8	131.3		U	0.29	FALSE		9.84E-07					
SB12	36	137.5	138		U	0.28	FALSE		9.50E-07					
WTC01	1187	9	9.5		U	0.11	FALSE		8.98E-07	8.98E-07	9.91E-05	1.32E-05		
WTC02	915	9.3	9.8		U	0.1	FALSE		8.17E-07	8.17E-07	6.94E-05	9.26E-06		
WTC03	1190	6.1	6.6		U	0.12	FALSE		9.80E-07	9.80E-07	1.08E-04	1.45E-05		
WTC03	1190	8.8	9.3	0.054	J	0.098	FALSE	1.08E-03	8.82E-07					
WTC05	1436	2.6	3.1	0.055	J	0.1	FALSE	1.10E-03	8.98E-07	2.61E-06	3.49E-04	4.65E-05		
WTC05	1436	17.8	18.3	0.16		0.1	FALSE	3.20E-03	2.61E-06					
WTC06	497	1.9	2.4	0.52		0.1	FALSE	1.04E-02	8.49E-06	8.49E-06	3.92E-04	5.23E-05		
WTC06	497	25.5	26	0.18		0.099	FALSE	3.60E-03	2.94E-06					
WTC07	432	7.2	7.7		U	0.098	FALSE		8.00E-07	8.09E-07	3.25E-05	4.33E-06		

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Albea, Washington, NJ

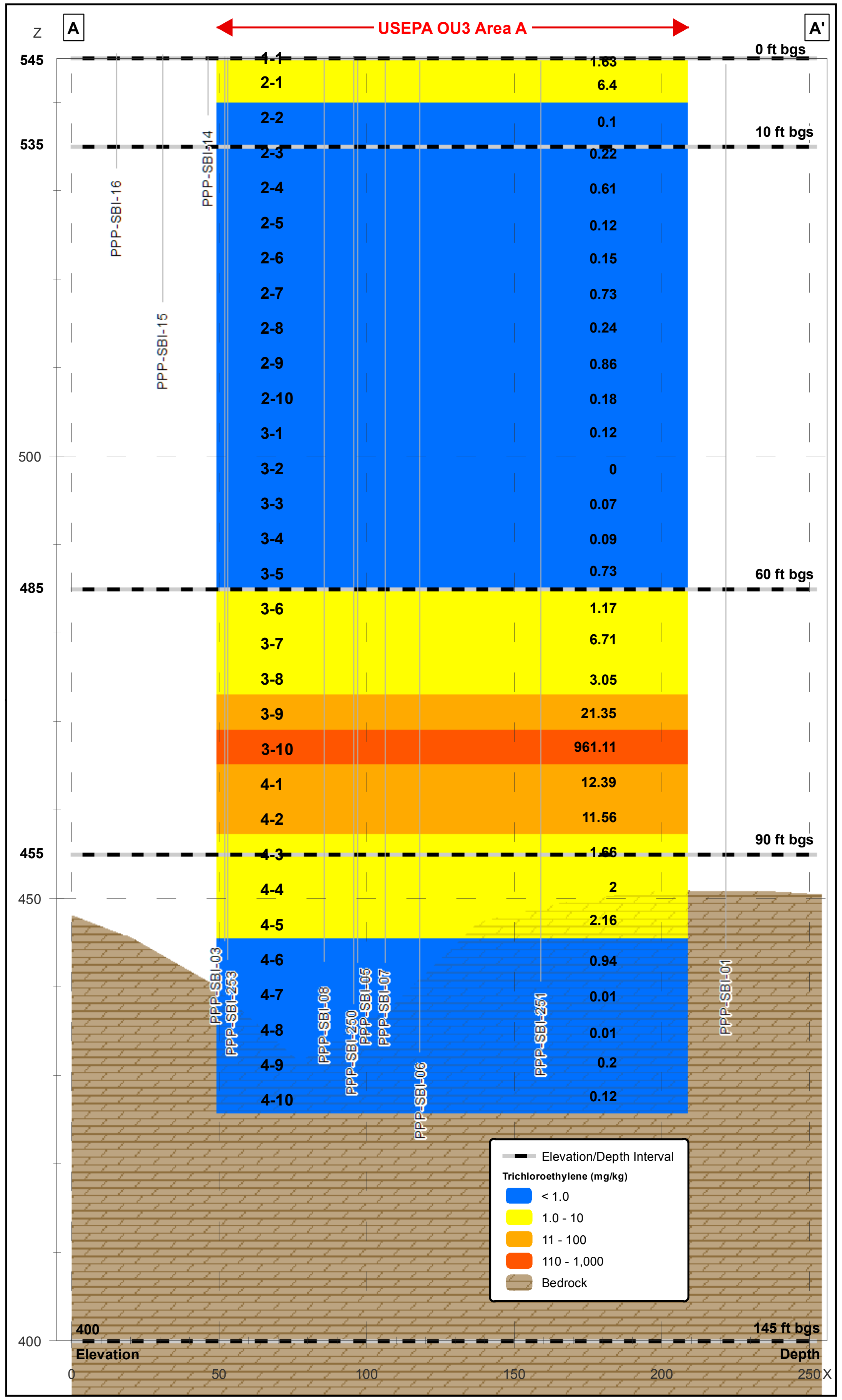
Location	Area	Start Depth	End Depth	Soil Conc	Qual	Limit	Treat	Treated Conc	Sample-Specific Flux	Boring-Specific Flux	Boring Mass Flow Rate	Boring Contribution to Indoor Air Conc	Treated Shallow Volume	Treated Deep Volume
									J_{ij}	J_i	M_i	$C_{ia,i}$		
	ft^2	ft	ft	mg/kg		mg/kg		mg/kg	$mg/m^2/s$	$mg/m^2/s$	mg/s	mg/m^3	yd^3	yd^3
WTC07	432	9.8	10.3		U	0.099	FALSE		8.09E-07					
WTC08	1433	10.3	10.8		U	0.11	FALSE		8.98E-07	8.98E-07	1.20E-04	1.60E-05		
WTC08	1433	10.3	10.8		U	0.11	FALSE		8.98E-07					
		Slab depth bgs				**DTS**	0.5	ft		**Sum:**	7.67E-02	1.02E-02	67	1011
		Indoor building height				**H_b**	3.05E+00	m		**Risk:**		4E-06		
		Air exchange rate				**ach**	1.00E+00	1/hr		**HQ:**		1E+00		
		Building ventilation rate				**Q_{bldg}**	7.50E+00	m^3/s						
		Deep attenuation factor				**α_{60}**	1.87E-05							
		Shallow attenuation factor				**$\alpha_{shallow}$**	4.50E-05							
		Saturation concentration				**C_{sat}**	6.73E+02	mg/kg						
		Threshold concentration				**C_{thr}**	15	mg/kg						
		Treatment efficiency				**F_{treat}**	98.0%							

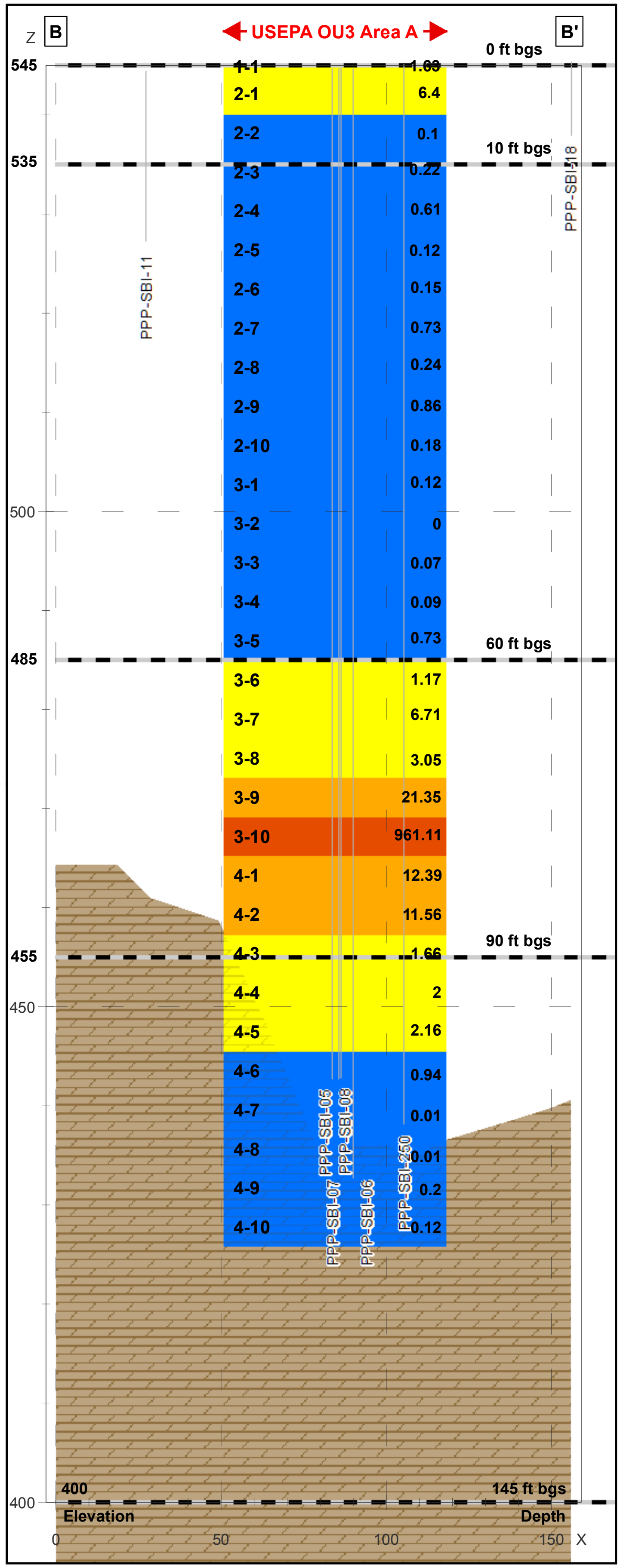
ATTACHMENT B

FIGURE B-1

USEPA Soil Volume for Treatment, OU3 RI Analytical Results, TCE IN SOIL (from 0 ft bgs to 145 ft bgs), PVGCS Site, Washington, NJ

D:\GIS\PROJECT\POHATCONG\DOCs\Draft Figure - EPA Data - Cross Sections A and B DRAFT 20160811.mxd





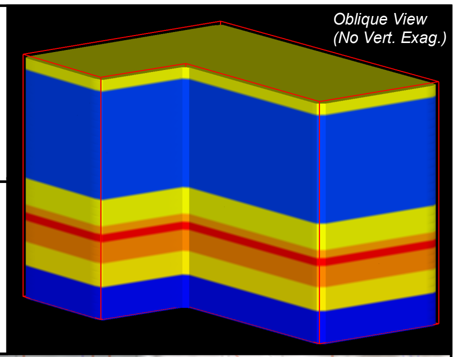
- Soil Boring or Monitoring Well Location
- Cross Section Line
- 25 ft Buffer of Cross Section Line

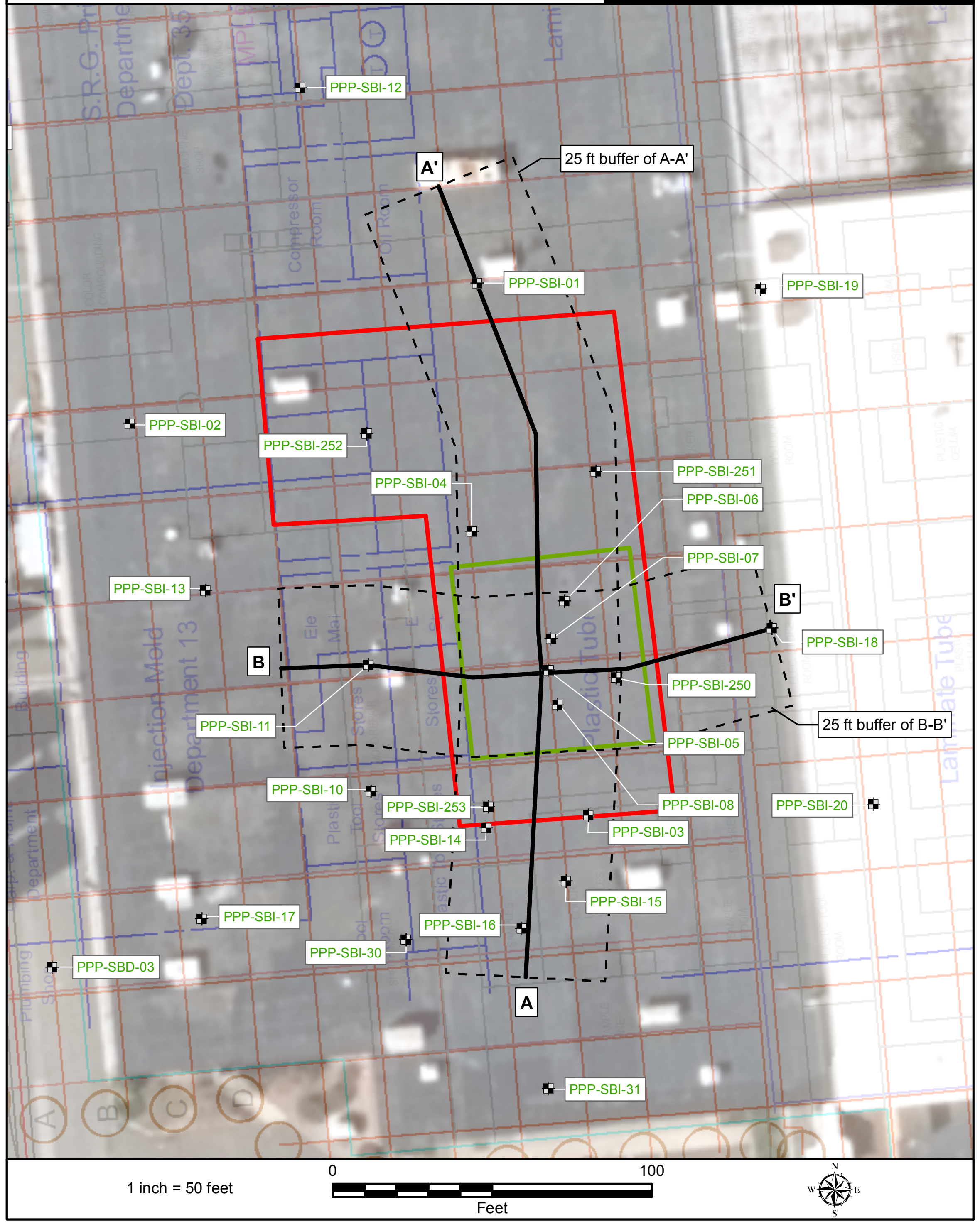
USEPA Potential ISTR Area

- 🟩 (In Situ Thermal Remediation)
- 🟥 USEPA OU3 Area A

All results shown in mg/kg.

Reference: CDM-Smith. 2016. Final Feasibility Study Report. Appendix C - Estimated TCE Flux to Groundwater from ANC Building Source Area.





RAMBOLL ENVIRON

PREPARED BY: KTS

DATE:8/15/2016

Cross Section Notes
Horizontal scale 1 in = 50 ft
Vertical scale 3 in = 50 ft (or 1 in = 16⅔ ft)
Vertical exaggeration = 3
Results within 25 ft of cross section line A-A' projected onto cross section
Length of sample indicates reported sample start and stop depth

USEPA Soil Volume for Treatment, OU3 RI Analytical Results
TCE IN SOIL (from 0 ft bgs to 145 ft bgs)
PVGCS Site, Washington, NJ

FIGURE
B-1

PROJECT: 0211697B

MEMO

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From:

Michael F. Bedard, P.E.

Date:

August 15, 2016

Arcadis Project No.:

NP000751.0002.00001

Subject:

Pohatcong Valley Groundwater Contamination Site - OU3 Proposed Plan and Relevant Documents Review

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Rio Tinto Legacy Management (RTLM) contracted Arcadis to review and prepare comments on the Proposed Plan released by the U.S. Environmental Protection Agency (USEPA) on June 15, 2016 for Operable Unit (OU) 3 at the Pohatcong Valley Groundwater Contamination Superfund Site, located in Warren County, New Jersey USA (Site). The review of the Proposed Plan also included review of other relevant documents contained in the OU3 Administrative Record.

Arcadis reviewed the following documents:

- Final Feasibility Study (FS) Report for Operable Unit 1 (OU1) (June 2005)
- Final Design Report for the Soil Vapor Extraction (SVE) and Mitigation System, Vapor Intrusion Response Activities (Volume 1) and Operation, Maintenance and Monitoring Plan, Vapor Intrusion Response Activities (Volume 2) (October 2015)
- Final Remedial Investigation (RI) Report for Operable Unit 3 (OU3) (May 11, 2016)
- Final FS Report for OU3 (June 10, 2016)
- Superfund Program Proposed Plan for OU3 (June 2016)

The document review specifically focused on Site information and data that is relevant to the evaluation of potential remedial technologies and Arcadis' opinion about their potential effectiveness for achieving the Remedial Action Objectives (RAOs) and Site-specific remediation goal of 1 milligram per kilogram (mg/kg) of trichloroethylene (TCE) in vadose zone soils. The memo presents key observations from the reviewed reports used to evaluate the remedial alternatives identified in the Proposed Plan, and documents Arcadis' recommendations with respect to what technologies are likely to achieve the RAOs in a timely and cost effective manner.

Remedial Action Objectives/Site-Specific Remediation Goal

The Final FS Report for OU 1 (June 2005) describes the development of Preliminary Remediation Goals (PRGs) for soils in the OU1 area (study area extending approximately 4.5 miles southward of the Site). The PRGs were used to establish volatile organic compound (VOC) concentrations in soil that will eliminate unacceptable risks to human health and the environment. USEPA chose a PRG of 1 mg/kg for TCE based on the New Jersey Impact to Groundwater Soil Cleanup Criteria.

Focusing on soils that contain TCE concentrations greater than 1 mg/kg, Arcadis identified the following key information within the RI and FS reports that are important with respect to evaluating potential remedial alternatives for the Site.

Key Information from the RI, FS, and Shallow SVE reports

The bulleted information list below was presented in the referenced reports. Text presented in quotation marks was copied directly from the respective report. Information presented in more than one report was only presented once.

Interior (beneath the American National Can (ANC) building)

- **Attachment 1** presents a summary of the boring log details and soil analytical data from the FS.
- Of the 35 soil borings in and around the ANC building that were sampled for TCE, there were 8 borings with soil concentrations of TCE greater than 1 mg/kg. All eight of these soil borings are located in one general area and are all deep borings (greater than 80 ft below ground surface (bgs)).
- A soil sample from boring PPP-SBI-08 had the highest concentration of TCE (120 mg/kg collected at a depth of 80 to 82 ft bgs).
- Boring PPP-SBI-07 had the highest photoionization detector (PID) readings recorded on the boring logs.
- Soil samples with the highest concentrations of TCE were observed at deeper depths (76 to 110 ft bgs) in the ANC area.
- All soil samples collected from shallow (less than 20 ft bgs) borings inside the ANC building had TCE concentrations less than the TCE soil remediation goal of 1 mg/kg.
- There is a distance of approximately 130 to 160 feet to the south and northwest between soil boring locations with TCE concentrations greater than the soil remediation goal of 1 mg/kg and the nearest deep soil boring locations with TCE less than this threshold. Refer to **Attachment 2** for details.

Final Design for the Shallow Soil Vapor Extraction and Mitigation System (October 2015) – [Shallow SVE Report]

- July 6, 2013 – Temporary 100 cubic feet per minute (cfm) SVE system was started. This system was connected to a total of three extraction wells (SVE-1, SVE-2, and SVE-4). These wells were constructed by cutting a hole through the concrete floor and placing a 4” PVC pipe about 1 foot below the floor surface. The pipe was sealed and the vacuum was applied directly to these wells.
- July 17, 2013 – Full-scale interim 500 cfm SVE system replaced the temporary system. This system was connected to a total of 16 extraction wells (SVE-1 through SVE-7 and SVE-9 through SVE-12 in the former molding area, SVE-8 in the maintenance area, and SVE-13P through SVE-16P in the production area). The original three SVE wells were extended to a depth of about 5 feet bgs. A 20-slot screen was placed about 1 to 4 ft bgs. All new SVE wells were constructed similarly
- July 2, 2014 – Full-scale long-term 500 cfm SVE system replaced the interim SVE system. The extraction well network remained the same.

- The primary objective of the long-term SVE system is to reduce the indoor air concentrations of TCE in the former ANC building (present Albea Facility) by: 1) mitigating the sub slab concentrations of TCE; and, 2) maintaining a negative pressure in the subsurface immediately beneath the building floor slab.
- Page 4 – "Impacted areas that are not in direct contact with the advective air flow will rely on diffusion of VOCs toward zones of enhanced air flow. Diffusion is a slow, rate-limiting process compared to advection (USACE, 2002). After the SVE system is operated continuously for an extended period of time, the system will become diffusion driven and removal rates will decrease to a non-zero asymptotic level. If the system is turned off, diffusion of VOCs from lower to higher permeability zones may occur, resulting in more effective mass removal upon restarting the system. This phenomenon is known as the "rebound" effect."
- The maximum design flow is 500 standard cubic feet per minute (scfm) and targeted vacuum is 10 to 12 inches of mercury ("Hg).
- The pneumatic radius of influence is 45 ft.
- Section 3.1 documents that approximately 6,695 pounds of TCE mass is present in vadose zone soils. The following TCE Mass Estimate table was presented in Appendix D.

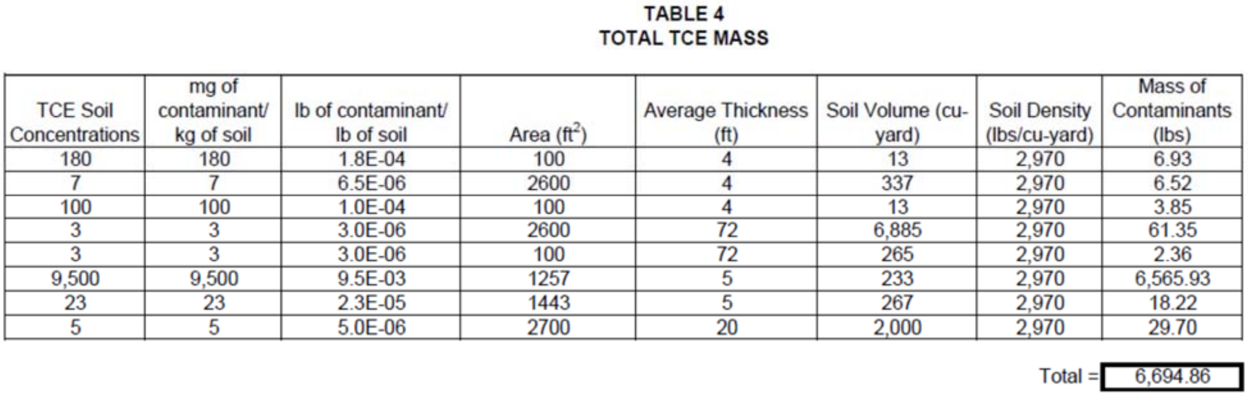


TABLE 4
TOTAL TCE MASS

TCE Soil Concentrations	mg of contaminant/ kg of soil	lb of contaminant/ lb of soil	Area (ft^2)	Average Thickness (ft)	Soil Volume (cu-yard)	Soil Density (lbs/cu-yard)	Mass of Contaminants (lbs)
180	180	1.8E-04	100	4	13	2,970	6.93
7	7	6.5E-06	2600	4	337	2,970	6.52
100	100	1.0E-04	100	4	13	2,970	3.85
3	3	3.0E-06	2600	72	6,885	2,970	61.35
3	3	3.0E-06	100	72	265	2,970	2.36
9,500	9,500	9.5E-03	1257	5	233	2,970	6,565.93
23	23	2.3E-05	1443	5	267	2,970	18.22
5	5	5.0E-06	2700	20	2,000	2,970	29.70
						Total =	6,694.86

- Table 4 from Appendix D of the Final Design Report for the Soil Vapor Extraction (SVE) and Mitigation System, Vapor Intrusion Response Activities (Volume 1) (October 2015) documents observed individual SVE well flowrates to range between about 6 and 33 cfm with a vacuum of about 20 to 60 inches of water ("H2O) or 1.5 to 4.5"Hg.
- **Attachment 3** presents a summary of the boring log details from the Final Design Report for the SVE and Mitigation System, Vapor Intrusion Response Activities (Volume 1).

<u>Final Feasibility Study Report for OU3 (June 10, 2016)</u>

- Page 1-23 – "Given the heterogeneous nature of the glacial soils in the vadose zone, the migration preferentially followed pathways with higher permeability. This means that during downward migration, contamination would encounter low permeability lenses and travel laterally, then continue deeper when another higher permeability pathway was encountered. Along the migration pathway in the vadose zone, some of the TCE mass has been retained in the soil by capillary forces in the pores of soil or adsorbed onto the surface of soil particles. Over time, the TCE diffused into the soil matrix beneath the ANC building."
- Alternatives – discussed in the Proposed Plan section below.

Superfund Program Proposed Plan for Operable Unit 3 (June 2016)

- "The U.S. Environmental Protection Agency's (EPA's) Preferred Alternative to address soil contamination in OU3 is Alternative 4: the construction of a deep Soil Vapor Extraction (SVE) system, with optional in-situ thermal hot-spot treatment to enhance mass removal."
- **Attachment 4** presents the Areas described in the bullet below.
- "Soils contaminated with TCE were grouped into three areas related to TCE contamination in the OU3 Study Area. These potential TCE contamination source areas have been designated during the OU3 RI as Areas A, B and C described below:
    - Area A: This area includes the soils beneath the southwestern portion of the ANC building. Drain Lines (DL) DL-9 and DL- 10, which connect to discharge structures on the down slope portions of the ANC property, originate in this area of the ANC building.
    - Area B: This area is located at the DL-9 discharge point. Area B also includes areas down slope of DL-9, including a small portion of the ANC property (west of the railroad spur) and the Warren Lumber Yard (WLY) ponded area that primarily lie in the railroad Right-of-Way (ROW)
    - Area C: This area is located at the DL-10 discharge point and includes areas down slope of this discharge on the ANC slope drainage area."
- "Glacial moraine deposits overlay the carbonate bedrock. The glacial deposits are comprised of a mix of glacio-fluvial deposits and till and are characterized as a poorly sorted mixture of sand, silt, and clay with larger clasts ranging from gravel to boulders. The moraine deposits range from 95 feet to greater than 140 feet thick at the OU3 Study Area. In general the permeability of the glacial deposits is low."
- "Soils with elevated levels of TCE in the vadose zone underlying the ANC building are considered principal threat wastes. Addressing these contaminated soils will have a positive impact on the planned groundwater remediation, as they are an ongoing source of contamination to groundwater and indoor air at this Site."
- The RAOs for the OU3 Study Area are:
    - For contaminated soil:
        - Reduce contaminant mass in the vadose-zone soil to minimize the impact to groundwater quality.
        - Reduce contaminant mass in the vadose-zone soil to minimize the potential human-health risks from vapor intrusion
    - For soil vapor:
        - Mitigate impacts to public health resulting from existing, or the potential for, soil vapor intrusion into buildings.
- "The Preferred Alternative, Alternative 4, provides the best balance of trade-offs among the alternatives with respect to the evaluation criteria. The Preferred Alternative will be protective of human health and the environment, comply with ARARs, and is expected to meet the RAOs for the Site. "

- Alternatives
    - Alternative 1 – No Action
        - Present worth of $0 with a timeframe to obtain the RAOs of greater than 100 years
        - This alternative is not considered further by the EPA because among other issues, it does not address the source in vadose zone soils.

- Alternative 2 – Limited Action
    - Continue to operate shallow SVE and subslab depressurization (SSD) system to treat 5 feet under ANC building
    - Will not address deeper vadose zone impacts
    - Present worth of $2.37 million with a timeframe of greater than 100 years to obtain the RAOs
    - This alternative is not considered further by the EPA because among other issues, it does not address the source in vadose zone soils.
- Alternative 3 – In situ Chemical Oxidation (ISCO)
    - Target treatment zone is 60 to 100 ft bgs
    - "The site soil consists of glacial till (silt and clay). It is generally difficult to evenly distribute a liquid amendment into such a formation. In order to enhance chemical distribution, environmental hydraulic fracturing would be implemented. Environmental hydraulic fracturing involves the injection of a proppant (consisting of guar gum and sand) under moderate pressure to create flow paths within a low permeability formation, so that the oxidant injected can be distributed to a larger radius from the injection points compared to the distribution without environmental hydraulic fracturing. During the remedial design various oxidants would be evaluated. Based on bench study and pilot study results, the most effective oxidant would be selected to treat the site contamination."
    - Present worth of $12.6 million with a timeframe to obtain the RAOs of greater than 30 years
    - This alternative is not considered further by the EPA because among other issues, it is estimated to address only 50% of the mass and is also technically more challenging to implement.
- Alternative 4 – Deep Soil Vapor Extraction with Optional In Situ Thermal Hot Spot Treatment (Preferred Alternative)
    - Continue to operate shallow SVE and SSD system to treat 5 feet under ANC building
    - Deep SVE would be installed from 30 to 100 ft bgs
    - Deep SVE system would operate under same principle as the shallow SVE system except that the extractions wells would be screened in deeper intervals
    - "The shallow SVE system has been successfully remediating the shallow soil, and the lithology in the deeper soils is similar to the shallow soils. Therefore, it is likely that the deep SVE would be effective in treating the deep vadose zone soil contamination."
    - Recommends conducting a pilot test and after the first few years (3 to 5 years) of operation if the extracted vapors reach an asymptotic level, the operation would be pulsed.
    - The FS Report recommends evaluating in situ thermal remediation as one of the optimization options for the deep SVE system.
    - The present worth of the deep SVE system is $7.8 million with a timeframe to achieve the soil remediation goal in about 10 years. Thermal enhancement increases the present worth to $12.7 million, but the timeframe is still about 10 years.

Evaluation of the Proposed Plan

Focusing first on the site characterization work, Arcadis believes the site characterization work and Site Conceptual Model reasonably represents the Site conditions. The reports document that the vadose zone soils are glacial till and consist of mostly silt and clay, which have low permeability. The reports document that most of the TCE with concentrations greater than 1 mg/kg (the vadose zone soil remediation goal) is present below the ANC building at a depth of between 70 and 100 ft bgs. The reports also properly documented that the TCE mass likely migrated to the deeper soils, through a portion of the heterogeneous glacial till soils that were more permeable, but also diffused into the less permeable silts and clays that make up most of the vadose zone soils.

Arcadis also agrees that the shallow SVE and SSD system is meeting the design objective of reducing the subslab vapor concentrations and applying a negative pressure to the subsurface, but Arcadis questions the EPA's conclusions that the design principals of the shallow SVE system would be appropriate for the deeper SVE system for the following reasons:

1. The analytical data documented that TCE was not detected in shallow soils at concentrations greater than 1 mg/kg.
2. The shallow SVE system well screens are between 1 to 4 ft bgs. The design of these SVE wells will allow the vacuum to short circuit to directly beneath the concrete slab. The vacuum and airflow will be transmitted through the interface of the concrete and the soil. The design basis of a SVE radius of influence (ROI) of 45 ft is based on the vacuum and air traveling between the soil and concrete and not directly through the soil. The shallow SVE system is collecting vapors that diffuse beneath the concrete slab. The shallow SVE system is not extracting TCE from the clay and silt soils. This idea is reinforced by the EPA reference to one of their own publications:

   > "Impacted areas that are not in direct contact with the advective air flow will rely on diffusion of VOCs toward zones of enhanced air flow. Diffusion is a slow, rate-limiting process compared to advection (USACE, 2002)."

3. Comparing the information presented on the **Attachment 5** cross section (RI Report) to the ANC interior (**Attachment 1**) and exterior (**Attachment 6**; FS Report) summaries Arcadis generated, the **Attachment 5** cross section does not appear to reflect the heterogeneities of glacial till. Key boring logs from the RI and Shallow SVE reports are included in **Attachments 1, 3** and **6**. Comparison of the RI and SVE logs clearly shows the SVE logs are mostly sand, while the deeper soils containing elevated TCE concentrations (the RI soil boring logs) are mostly clayey-silt with some pockets of sand, cobbles, and boulders. Furthermore, comparing the two shallow SVE boring log summaries in **Attachment 3** that Arcadis generated, shows that even the shallow borings are heterogeneous.

As for the site-specific remediation goal of 1 mg/kg of TCE in vadose zone soils, this value may be too conservative and therefore Arcadis suggests further evaluation of its technical basis. Arcadis reviewed the groundwater fate and transport modeling and vapor intrusion evaluation presented in the RI and FS Reports. A summary of Arcadis' review and some considerations for further evaluation are as follows:

1. Fate and transport modeling

   In general, Arcadis agrees with the overall conceptualization: less infiltration leads to longer residual mass residence time in the vadose zone and overall longer times to reach a target remediation goal. However, the report tended to be vague on multiple inputs, as well as unclear in other areas, and did not tend to tie field data to model results. In addition, the report did not seem to include a calibration although it appears that sufficient field data exist for such a calibration. Specific items that warrant further consideration are as follows:

   a. Model Construction

      i. Model layering seems more dense than presented via field soil concentrations at various depth intervals.

        ii. Individual layer-simulated lithology (silt, sand or clay) within overburden till not described.
        iii. No figure presenting alignment between subsurface geology or impacts via characterization program to understand chosen sub-layering.
        iv. Post vadose zone transport, groundwater flow is simulated within a weathered carbonate bedrock aquifer. Report states model is not suitable for a fractured bedrock environment and the estimate provided is only a potential value. However, no potentiometric surface map was presented, nor a discussion on an equivalent porous medium.

    b. Parameters
        i. Initialized TCE concentrations not clear within individual sub-layers. Report states TCE from average concentrations derived from model without any table of initial values, only simulated.
        ii. Report tends to be vague on input parameters for both the SESOIL and AT123D models.
        iii. Report states the effective porosity was calculated from Site data using a geomean, with a value 2/3 of total porosity for SESOIL. However, for AT123D the effective porosity is set with the same value, but referenced (without source) to a median literature lookup value for karst.
        iv. Report does not mention the use/non-use of degradation during dissolved phase transport.
    c. Outputs
        i. Report states that the 15 simulations of groundwater concentrations versus time are shown. However, only 12 simulations were presented.
        ii. Report states low infiltration simulations reasonably match what current groundwater concentrations should be. However, no mention of a direct comparison to field data was discussed.
2. Vapor intrusion modeling/evaluation

   Further evaluation of the Site-specific attenuation of soil vapor concentrations through the vadose zone seems warranted.

As for the identified remedial alternatives, Arcadis' opinions are summarized below:

1. Arcadis is concerned that Alternatives 1 and 2 do not address the source area.
2. Arcadis agrees that Alternative 3 should not be considered, but Arcadis does not agree that 50% of the TCE in the vadose zone would be addressed by using hydraulic fracturing to distribute a chemical oxidant (and we would like to understand the basis for the 50% destruction assumed). Arcadis believes that hydraulic fracturing will enhance the permeability of the permeable zones and will not enhance the permeability of the clays and silts.
3. As for Alternative 4, the preferred alternative, Arcadis recommends forgoing the deep SVE remediation because most of the TCE mass is present in diffusion-limited clays and silts, and because of the heterogeneous nature of Site soils. As per the abundance of published SVE design information available in the literature, SVE is applicable for remediation of soils with high air permeabilities, and much less applicable or even impracticable for the low-permeability silts and clays found at the Site The issues and limitations of applying SVE in heterogeneous soils, where mass removal rates will be limited by diffusion from low permeability zones has been well understood and studied for many years. Researches such as M. Truex, G. Beckett, D, Benson, and D. Digiulio have evaluated and documented the effect of diffusion limited mass transfer on the performance of SVE system and the difficulties of attempting to implement SVE systems for heterogeneous sites. The following figures from Suthersan, et al. sum up this problem (Suthan Suthersan, "Soil Vapor Extraction", Remediation Engineering: Design Concepts, Boca Raton, CRC Press LLC, 1999):

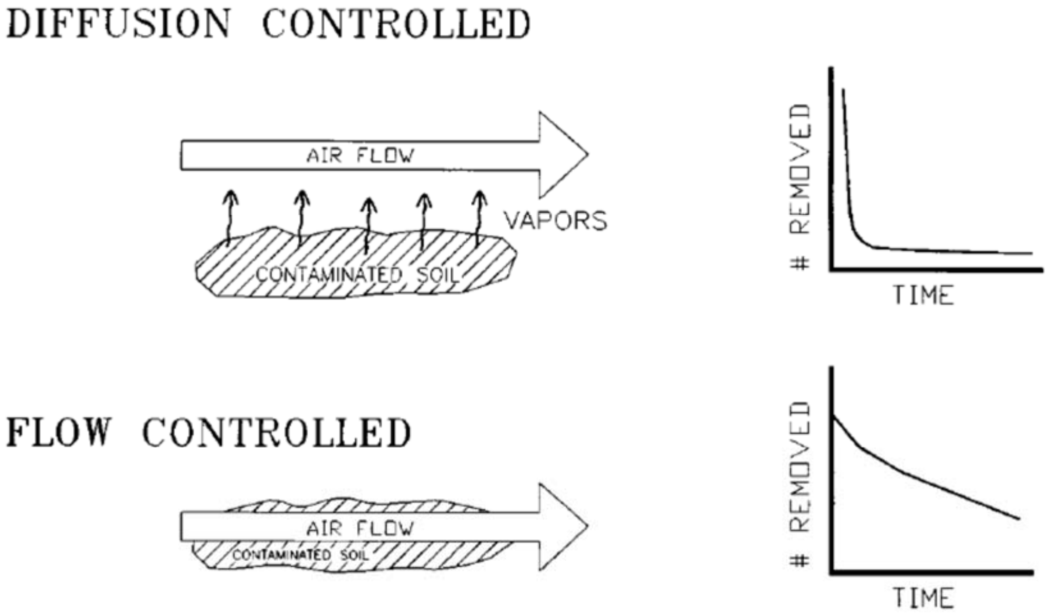


Figure 3.4 Decline in vapor concentrations under diffusion and flow-controlled regimes.

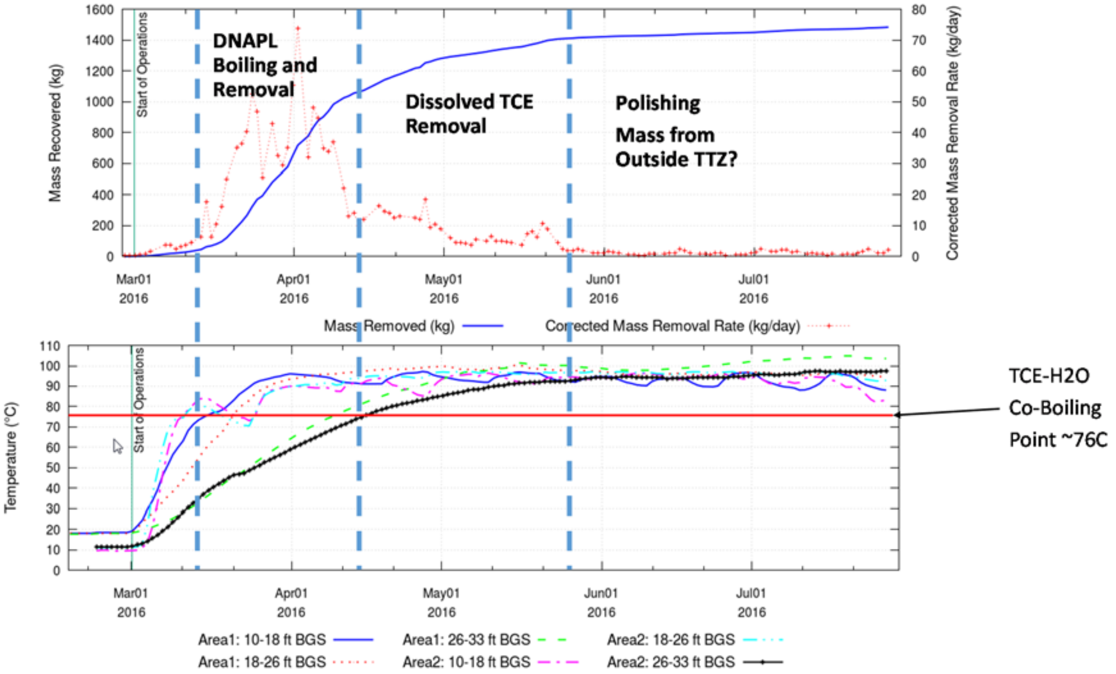
4. Based on Arcadis' experience in northern New Jersey and glacial till, Arcadis believes that if SVE is utilized, a more reasonable ROI would be about 10 to 15 ft (not the 45 ft presented in the Proposed Plan) when an airflow of 30 cfm at 15"Hg is applied. However, given the additional cost associated with the installation of the extra SVE wells and the larger treatment system, Arcadis believes that applying thermal remediation alone from the start will allow for the achievement of the soil remediation goal in a more timely and cost effective manner than SVE alone or SVE operating for 10 years and then applying thermal to address the residual TCE mass.
5. As discussed above, SVE for deep soils will not be effective in meeting the remedial objectives for deep soil treatment, due to the higher moisture contents and resulting lower relative air permeabilities of the deep soil and the likely presence of the majority of the mass in the low permeability silts and clays as a result of dense non-aqueous phase liquid (DNAPL) dissolution and forward diffusion into these soils. SVE in the deep soils may initially be effective at sweeping out the readily accessible mass present in the more permeable zones, but removal of the majority of the mass that is present in the low permeability soils will be limited by the slow process of cross diffusion and likely will take decades. To overcome the diffusion-limited mass transfer rates and effectively remediate the deep soils in an efficient and timely manner, the best remedial approach is to use an appropriate in situ thermal technology to thoroughly heat the deep soils to approximately 100 degrees Celsius (°C) in combination with effective pneumatic and hydraulic capture and off-gas treatment systems. Heating the impacted deep soil zones to 100 °C will result in boiling and steam/vapor formation within the pores of the low permeable silts and clays. The increased volatility of the target constituents of concern (COCs) at 100 °C, in combination with the formation of a vapor phase within the pores, will result in volatilization and stream stripping of the dissolved and sorbed COCs and any DNAPL, if present. The buoyancy and increased pore pressure generated as a result of steam bubble formation drives the COC mass laden vapors upwards where they can be intercepted and removed by the vapor extraction system for treatment.
6. **Attachment 7**, authored by Dr. Eva Davis of USEPA's Office of Research and Development, National Risk Management Research Lab, Groundwater and Ecological Restoration Research Laboratory in Ada, Oklahoma, outlines how implementing SVE and/or pump and treat in heterogeneous soils with diffusion limited mass transfer can lead to incomplete removal, rebound,

and failure to achieve the remedial objectives. The paper also discusses how in-situ thermal remediation (ISTR) overcomes these constraints due to changes in physical properties of the COCs that leads to much more favorable removal mechanisms (i.e., increased volatilization and stream stripping). Dr. Davis is USEPA's lead technical person for thermal remediation projects and provides support activities including: characterization for remediation purposes; evaluation of the applicability of thermal methods for a particular site; overview of design, construction, and operation; and performance assessments.

7. Attempting to implement SVE for the deep soils first, with the provision to possibly then implement ISTR technology if (when) the deep SVE system is unable to sufficiently remove COC mass, is problematic for the following reasons:
    a. It is well understood that for these types of geologic settings and contaminant distributions, SVE has a very low probability of being successful due to diffusion limited mass transfer.
    b. Any SVE system installed for the impacted deep soils will have to be substantially upgraded and/or removed in order to allow installation of an ISTR system:
        i. To be compatible with ISTR, the SVE wells would need to be constructed of materials suitable for 100˚C (e.g., stainless steel, fiberglass, etc.).
        ii. The SVE well layout may not be compatible with the ISTR wellfield layout and some or most of the SVE wells may need to be abandoned.
        iii. To allow efficient installation of the ISTR wellfield, the SVE manifold piping system will have to be disassembled and removed.
        iv. In addition, the SVE manifold system will likely have to be replaced with suitably sized piping for the increased flow rates associated with ISTR and that is also compatible with temperatures of approximately 100˚C (e.g., fiberglass, carbon steel, etc.).
        v. The extraction (i.e., blowers) and treatment system will also have to be substantially upgraded and/or replaced to be able to handle the steam load, increased COC removal rates, increased temperatures, and liquid condensate/groundwater treatment rates.
8. For these reasons, the best approach with regards to probability of success in: 1) meeting the performance objectives; 2) meeting the performance objectives within a predictable and efficient schedule (e.g., 1 year from construction, through operation, to completion); and 3) achieving the desired results in the most cost effective manner is to by-pass attempting to use SVE for the deep soils and directly implement ISTR.
9. With respect to ISTR technologies, the FS is generally on target that the most suitable approach would be to use Thermal Conduction Heating (TCH) due to uncertainty in maintaining sufficient moisture content to enable effective implementation of Electrical Resistance Heating (ERH) approaches. However, for these depths, there is currently only one TCH technology (electrically powered TCH) and associated vendor (TerraTherm/Cascade) capable of bidding and performing the work. To address this limitation, the following provides our recommendations to identify the best technology and approach and ensure competitive bids/pricing (or at the very least, more than one bid):
    a. Collect representative soil samples of the various geologic strata at 2-3 locations within the identified treatment area (a total of 10 to 12) for laboratory characterization of static and dynamic soil resistivity.
    b. If the resistivity testing indicates that the deep soils may be suitable for ERH, then prepare a Request for Proposal (RFP) for either electrically powered TCH or ERH and solicit proposals/bids.
    c. Identify the "Best Value" proposal based on: health and safety, robustness and flexibility of the heating design, probability of success in achieving the remedial objectives, probability of success in meeting the objectives on time, robustness and flexibility of the pneumatic and hydraulic control and treatment systems, and price.

10. If a thermal remedy is implemented for the Site, the heating and vapor capture systems must be designed to ensure minimal adverse impacts to the existing shallow SVE and SSD system. This will require careful evaluation and potential testing of vapor flow properties and conditions above and in the vicinity of the thermal treatment area. Testing could include installation of deep vapor extraction wells and operation of the wells to determine the anisotropy of the vapor permeability of the soils (k_h:k_v) and the potential connection between vapor extraction from the deep soils (e.g., 50 to 90 feet) and the operation of the shallow SVE and SSD system. Potential adverse impacts would be escape of COC and steam vapors from the deep thermal treatment interval up to the shallow soils and capture of the COC and steam vapors by the shallow soil systems. This could result in exceeding the COC loading and treatment rates of the shallow systems and/or the temperature rating of the wells, manifold piping, and equipment.
11. Due to significant access constraints within the ANC building, the thermal remedy would need to install the wells and manifold piping from outside the treatment area footprint and/or outside the building using angled and/or directional drilling techniques. The engineering and design details for installing the wells using angled and/or directional drilling techniques would need to be carefully evaluated and established during the final remedy design process.
12. Also, for any thermal remedy implemented for the Site, the performance of the system should be evaluated with respect to the following lines of evidence. Because collection of confirmatory soil samples at the Site would be very difficult due to access constraints within the ANC building, the following two lines of evidence would be relied upon for evaluation of ISTR treatment system performance:
    a. Heat-up and thoroughness or uniformity of heating within the targeted treatment zone (e.g., 90% of the temperature sensors within the treatment zone achieve 90°C).
    b. Mass removal rates and cumulative mass removed over time. Typically ISTR projects demonstrate a rapid and significant increase in removal rates (e.g., lbs/day of COCs) as significant portions of the site attain critical temperatures such as the co-boiling point of TCE and water (~76 °C at 1 atmosphere (ATM)) and the boiling point of water (100 °C at 1 ATM), followed by a pronounced decline in removal rates after two to three months of continued heating until the temperature performance criteria are met.

The following figures illustrate the concepts of how the temperature and COC removal lines of evidence are compared to evaluate performance of an ISTR system.



Diffusion Limited SVE References:

M.J. Truex, K.C. Carroll, and M. Oostrom, Assessing Soil Vapor Extraction Remediation Performance and Closure Assessment – 12188, WM2012 Conference, February 26 – March 1, 2012, Phoenix, AZ.

G.D. Beckett, D.A. Benson, Diffusion Limited SVE, 1996 AAPG Annual Convention, San Diego, CA.

D.C. Digiulio, Evaluation of Soil Venting Application, Chapter 9, EPA Environmental Engineering Source Book, Ed. By J. Russell Boulding, 1996. Ann Arbor Press, Inc., Chelsea, MI.

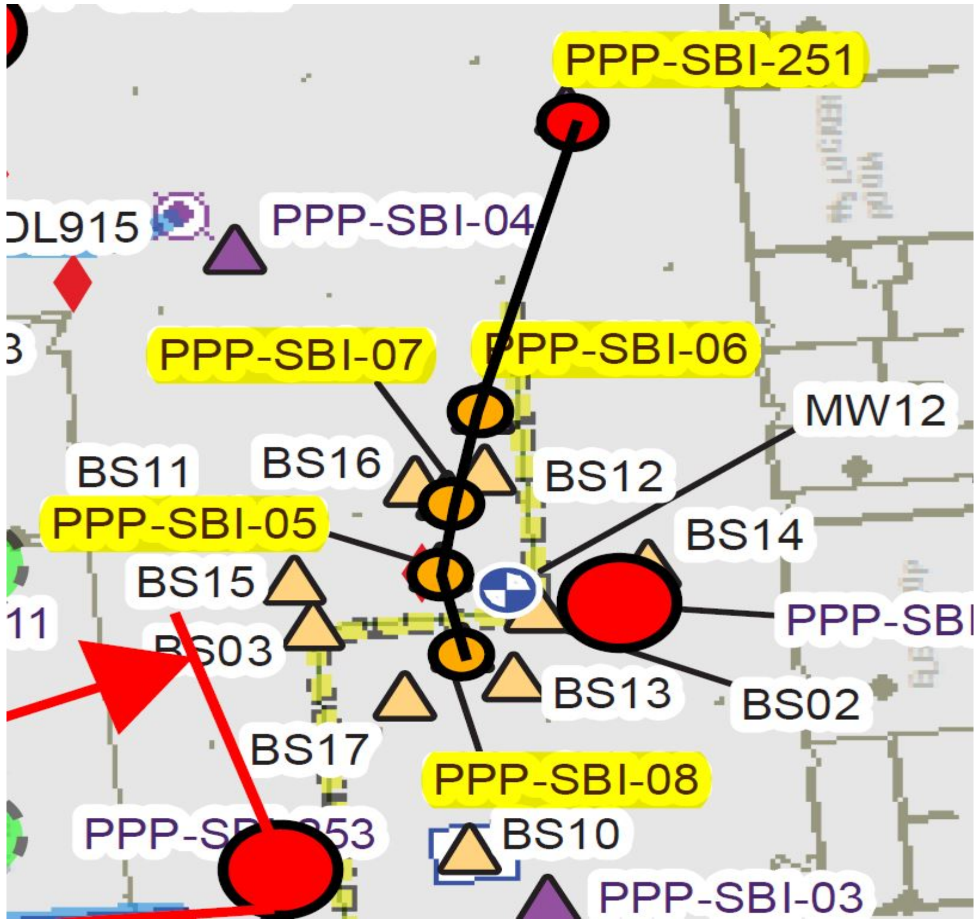
Attachment 1 – Interior Soil Boring and Analytical Summary

Rio Tinto - ANC

Elevation			Depth (ft bgs)	SBI-251 PID (ppmv)	SBI-06 PID (ppmv)	SBI-07 PID (ppmv)	SBI-05 PID (ppmv)	SBI-08 PID (ppmv)
546.0	-	545.0	1.0	0-20				
545.0	-	544.0	2.0	0-20		0-20		210
544.0	-	543.0	3.0	0-20		0-20		210
543.0	-	542.0	4.0	0-20	60-80	0-20	0-20	210
542.0	-	541.0	5.0	0-20	60-80	0-20	0-20	210
541.0	-	540.0	6.0	0-20	60-80	854	0-20	145
540.0	-	539.0	7.0	0-20	60-80	854	0-20	145
539.0	-	538.0	8.0	0-20	60-80	2700	0-20	145
538.0	-	537.0	9.0	0-20	60-80	2700	0-20	145
537.0	-	536.0	10.0	0-20	60-80	2700	0-20	145
536.0	-	535.0	11.0	0-20	235	2700	40-60	349
535.0	-	534.0	12.0	0-20	235	2700	40-60	349
534.0	-	533.0	13.0	0-20	235	2700	40-60	349
533.0	-	532.0	14.0	0-20	235	2700	40-60	349
532.0	-	531.0	15.0	0-20	235	2700	40-60	349
531.0	-	530.0	16.0	0-20	2500	2700	40-60	2669
530.0	-	529.0	17.0	0-20	2500	2700	40-60	2669
529.0	-	528.0	18.0	0-20	2500	2700	40-60	2669
528.0	-	527.0	19.0	0-20	2500	2700	40-60	2669
527.0	-	526.0	20.0	0-20	2500	2700	40-60	2669
526.0	-	525.0	21.0	0-20	2790	2700	40-60	975
525.0	-	524.0	22.0	0-20	2790	2700	40-60	975
524.0	-	523.0	23.0	0-20	700	2700	40-60	1190
523.0	-	522.0	24.0	0-20	2700	2700	40-60	1190
522.0	-	521.0	25.0	0-20	2700	2700	40-60	1190
521.0	-	520.0	26.0	0-20	2700	636	114	1190
520.0	-	519.0	27.0	0-20	2700	636	114	1190
519.0	-	518.0	28.0	0-20	2700	636	114	389
518.0	-	517.0	29.0	0-20	1020	636	114	389
517.0	-	516.0	30.0	0-20	1020	636	114	389
516.0	-	515.0	31.0	21	2700	2700	521	684
515.0	-	514.0	32.0	21	2700	2700	521	684
514.0	-	513.0	33.0	21	2700	2700	521	684
513.0	-	512.0	34.0	21	2700	2700	521	684
512.0	-	511.0	35.0	21	2700	2700	521	684
511.0	-	510.0	36.0	0-10	2700	2700	444	2700
510.0	-	509.0	37.0	0-10	2700	2700	444	2700
509.0	-	508.0	38.0	0-10	2700	2700	444	2700
508.0	-	507.0	39.0	0-10	2700	2700	444	2700
507.0	-	506.0	40.0	0-10	2700	2700	444	2700
506.0	-	505.0	41.0	0-10	2700	2700	910	1440
505.0	-	504.0	42.0	0-10	2700	2700	910	1440
504.0	-	503.0	43.0	0-10	2700	2700	910	1440
503.0	-	502.0	44.0	0-10	2700	2700	910	1440
502.0	-	501.0	45.0	0-10	2700	2700	910	1440
501.0	-	500.0	46.0	0-10	2700	2700	80-100	358
500.0	-	499.0	47.0	0-10	2700	2700	80-100	358
499.0	-	498.0	48.0	0-10	2700	2700	80-100	358
498.0	-	497.0	49.0	0-10	2700	2700	80-100	358
497.0	-	496.0	50.0	0-10	2700	2700	80-100	358
496.0	-	495.0	51.0	0-10	2700	497	80-100	400
495.0	-	494.0	52.0	0-10	2700	497	80-100	400
494.0	-	493.0	53.0	0-10	2700	497	80-100	400
493.0	-	492.0	54.0	0-10	2700	497	80-100	400
492.0	-	491.0	55.0	0-10	2700	497	80-100	400
491.0	-	490.0	56.0	0-10	2700	2700	80-100	80-100
490.0	-	489.0	57.0	0-10	2700	2700	80-100	80-100
489.0	-	488.0	58.0	0-10	2700	2700	80-100	80-100
488.0	-	487.0	59.0	0-10	2700	2700	80-100	80-100

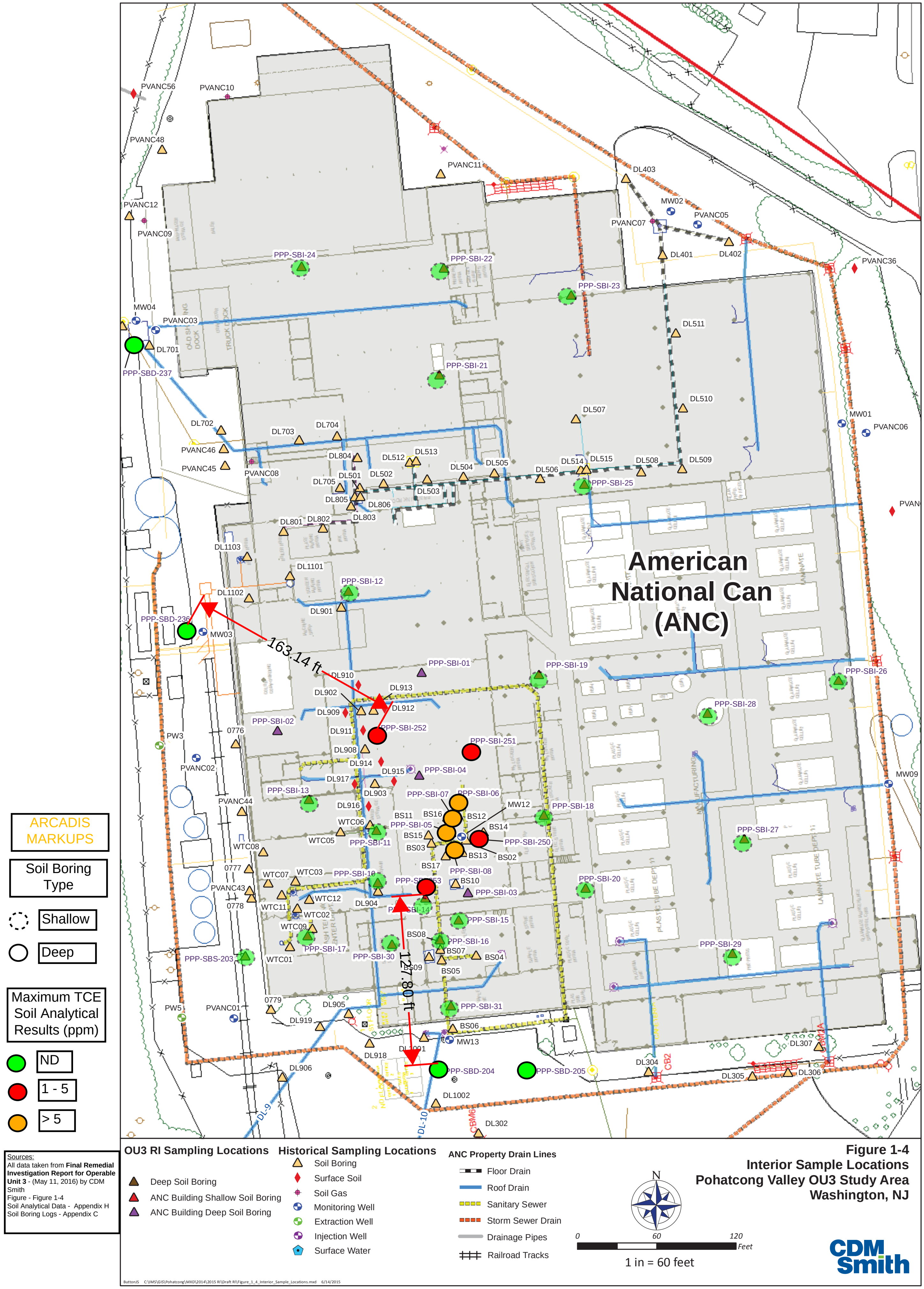
Elevation			Depth (ft bgs)	SBI-251 PID (ppmv)	SBI-06 PID (ppmv)	SBI-07 PID (ppmv)	SBI-05 PID (ppmv)	SBI-08 PID (ppmv)
487.0	-	486.0	60.0	0-10	2700	2700	80-100	80-100
486.0	-	485.0	61.0	13	2700	2700	20-40	707
485.0	-	484.0	62.0	13	2700	2700	20-40	707
484.0	-	483.0	63.0	13	2700	2700	20-40	707
483.0	-	482.0	64.0	13	2700	2700	20-40	0-20
482.0	-	481.0	65.0	13	2700	2700	20-40	0-20
481.0	-	480.0	66.0	90-110	2700	2700	419	2700
480.0	-	479.0	67.0	90-110	2700	2700	419	2700
479.0	-	478.0	68.0	90-110	2700	2700	419	2700
478.0	-	477.0	69.0	90-110	2700	2700	419	2700
477.0	-	476.0	70.0	90-110	2700	2700	419	2700
476.0	-	475.0	71.0	90-110	2700	2700	141	1467
475.0	-	474.0	72.0	90-110	2700	2700	141	525
474.0	-	473.0	73.0	90-110	2700	2700	523	525
473.0	-	472.0	74.0	90-110	2700	2700	523	525
472.0	-	471.0	75.0	90-110	2700	2700	523	525
471.0	-	470.0	76.0	90-110	2700	2700	523	525
470.0	-	469.0	77.0	90-110	2700	2700	523	20-40
469.0	-	468.0	78.0	90-110	2700	2700	1718	20-40
468.0	-	467.0	79.0	90-110	2700	2700	1718	20-40
467.0	-	466.0	80.0	90-110	2700	2700	1718	20-40
466.0	-	465.0	81.0	90-110	2700	2700	1767	2700
465.0	-	464.0	82.0	90-110	2700	2700	1767	2700
464.0	-	463.0	83.0	90-110	2700	2700	1767	2700
463.0	-	462.0	84.0	90-110	2700	2700	1767	2700
462.0	-	461.0	85.0	90-110	2700	2700	1767	2700
461.0	-	460.0	86.0	20-40	2140	2700	871	825
460.0	-	459.0	87.0	20-40	2140	2700	871	825
459.0	-	458.0	88.0	20-40	2140	2700	871	825
458.0	-	457.0	89.0	20-40	2140	2700	871	825
457.0	-	456.0	90.0	20-40	2140	2700	871	825
456.0	-	455.0	91.0	20-40	1245	1884	1281	2094
455.0	-	454.0	92.0	20-40	1245	1884	1281	2094
454.0	-	453.0	93.0	20-40	1245	1884	1281	2094
453.0	-	452.0	94.0	20-40	1245	1884	1281	2094
452.0	-	451.0	95.0	20-40	1245	1884	1281	2094
451.0	-	450.0	96.0	0-10	20-40	900	1065	410
450.0	-	449.0	97.0	0-10	20-40	900	1065	410
449.0	-	448.0	98.0	0-10	20-40	900	1065	410
448.0	-	447.0	99.0	0-10	20-40	900	1065	410
447.0	-	446.0	100.0	0-10	20-40	900	1065	410
446.0	-	445.0	101.0	0-10	20-40	409	363	500
445.0	-	444.0	102.0	0-10	0-20	409	363	500
444.0	-	443.0	103.0	0-10	0-20	409	363	500
443.0	-	442.0	104.0	0-10	0-20	409	363	500
442.0	-	441.0	105.0	--	0-20	409	363	500
441.0	-	440.0	106.0	--	0-20	387	121	186
440.0	-	439.0	107.0	--	60-80	387	121	186
439.0	-	438.0	108.0	--	60-80	387	121	186
438.0	-	437.0	109.0	--	60-80	387	121	186
437.0	-	436.0	110.0	--	60-80	387	121	186
436.0	-	435.0	111.0	--	0-20	--	0-20	385
435.0	-	434.0	112.0	--	0-20	--	0-20	385
434.0	-	433.0	113.0	--	0-20	--	0-20	385
433.0	-	432.0	114.0	--	0-20	--	0-20	385
432.0	-	431.0	115.0	--	0-20	--	--	385
431.0	-	430.0	116.0	--	0-20	--	--	65
430.0	-	429.0	117.0	--	--	--	--	--

Geology	BOULDER
	CONCRETE
	SILT
	CLAY
	GRAVEL
	SAND
	ORGANIC
	BEDROCK/WEATHERED BEDROCK
TCE Concentration in Soil	1 - 10 ppm
	10 - 20 ppm
	20 - 30 ppm
	30 - 50 ppm
	50 - 70 ppm
	70 - 100 ppm
	100 - 130 ppm



Sources:
Soil Boring Logs - Final Remedial Investigation Report for Operable Unit 3 - Appendix C (May 11, 2016) by CDM Smith
Analytical Data - Final Remedial Investigation Report for Operable Unit 3 - Appendix H (May 11, 2016) by CDM Smith

Attachment 2 - Interior Sample Locations



Sources:
All data taken from **Final Remedial Investigation Report for Operable Unit 3** - (May 11, 2016) by CDM Smith
Figure - Figure 1-4
Soil Analytical Data - Appendix H
Soil Boring Logs - Appendix C

Figure 1-4
Interior Sample Locations
Pohatcong Valley OU3 Study Area
Washington, NJ

Attachment 3 – Shallow SVE Soil Boring Summary

Rio Tinto - SVE

Elevation			Depth (ft bgs)	SVE-3	SVE-5	SVE-6	SVE-7	SVE-8
				PID (ppmv)	PID (ppmv)	PID (ppmv)	PID (ppmv)	PID (ppmv)
546.0	-	545.0	1.0	⬛	⬛	⬛	⬛	⬛
545.0	-	544.0	2.0	0	0	0	0	0
544.0	-	543.0	3.0	0	0	0	0	0
543.0	-	542.0	4.0	0	--	0	0	0
542.0	-	541.0	5.0	0	--	0	0	--
541.0	-	540.0	6.0	0	--	0	0	--
540.0	-	539.0	7.0	0	--	--	--	--
539.0	-	538.0	8.0	--	--	--	--	--

Geology

🟩	BOULDER
⬛	CONCRETE
▨	SILT
▩	CLAY
⬜	GRAVEL
🟫	SAND
▦	ORGANIC
🟧	BEDROCK/WEATHERED BEDROCK
🟦	TOPSOIL
🟥	SAND/SILTY CLAY

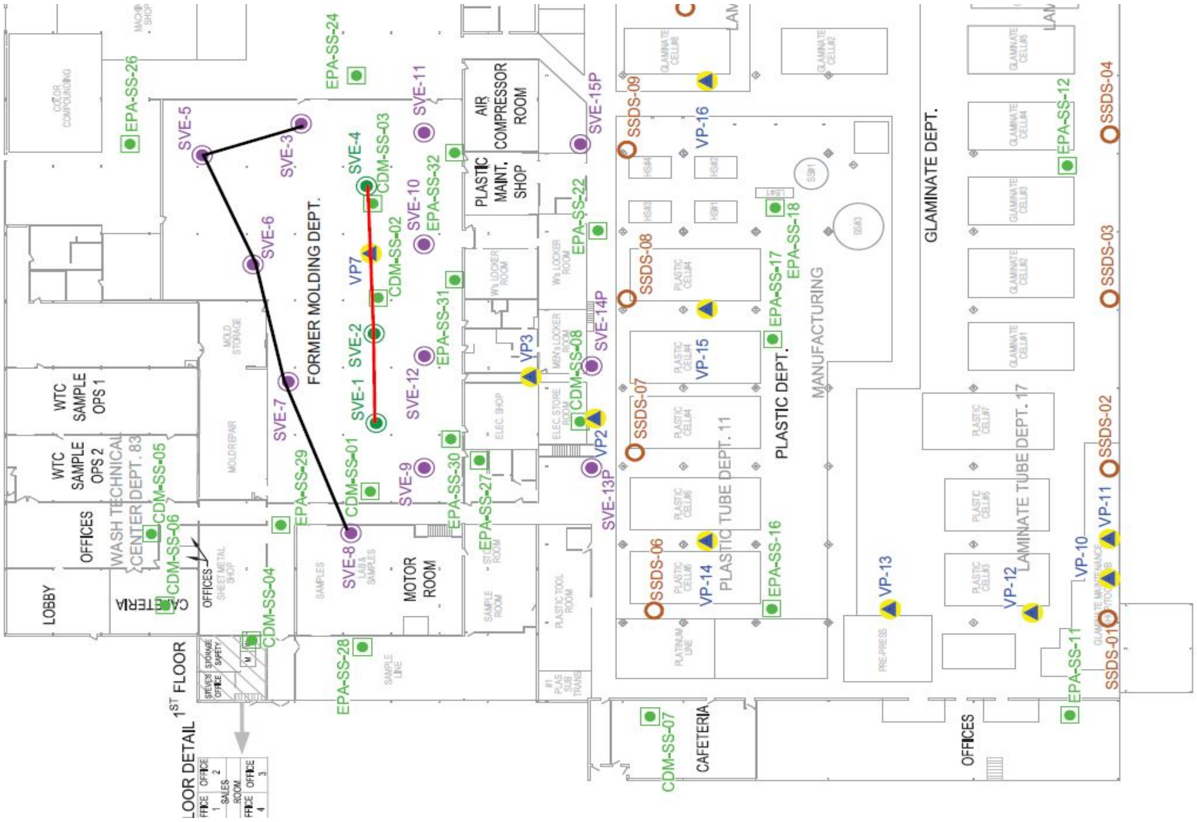
Elevation			Depth (ft bgs)	SVE-1	SVE-2	SVE-4
				PID (ppmv)	PID (ppmv)	PID (ppmv)
546.0	-	545.0	1.0	⬛	⬛	⬛
545.0	-	544.0	2.0	0	0	0
544.0	-	543.0	3.0	--	--	--
543.0	-	542.0	4.0	--	--	--
542.0	-	541.0	5.0	--	--	--
541.0	-	540.0	6.0	--	--	--
540.0	-	539.0	7.0	--	--	--
539.0	-	538.0	8.0	--	--	--

Geology

🟩	BOULDER
⬛	CONCRETE
▨	SILT
▩	CLAY
⬜	GRAVEL
🟫	SAND
▦	ORGANIC
🟧	BEDROCK/WEATHERED BEDROCK
🟦	TOPSOIL
🟥	SAND/SILTY CLAY

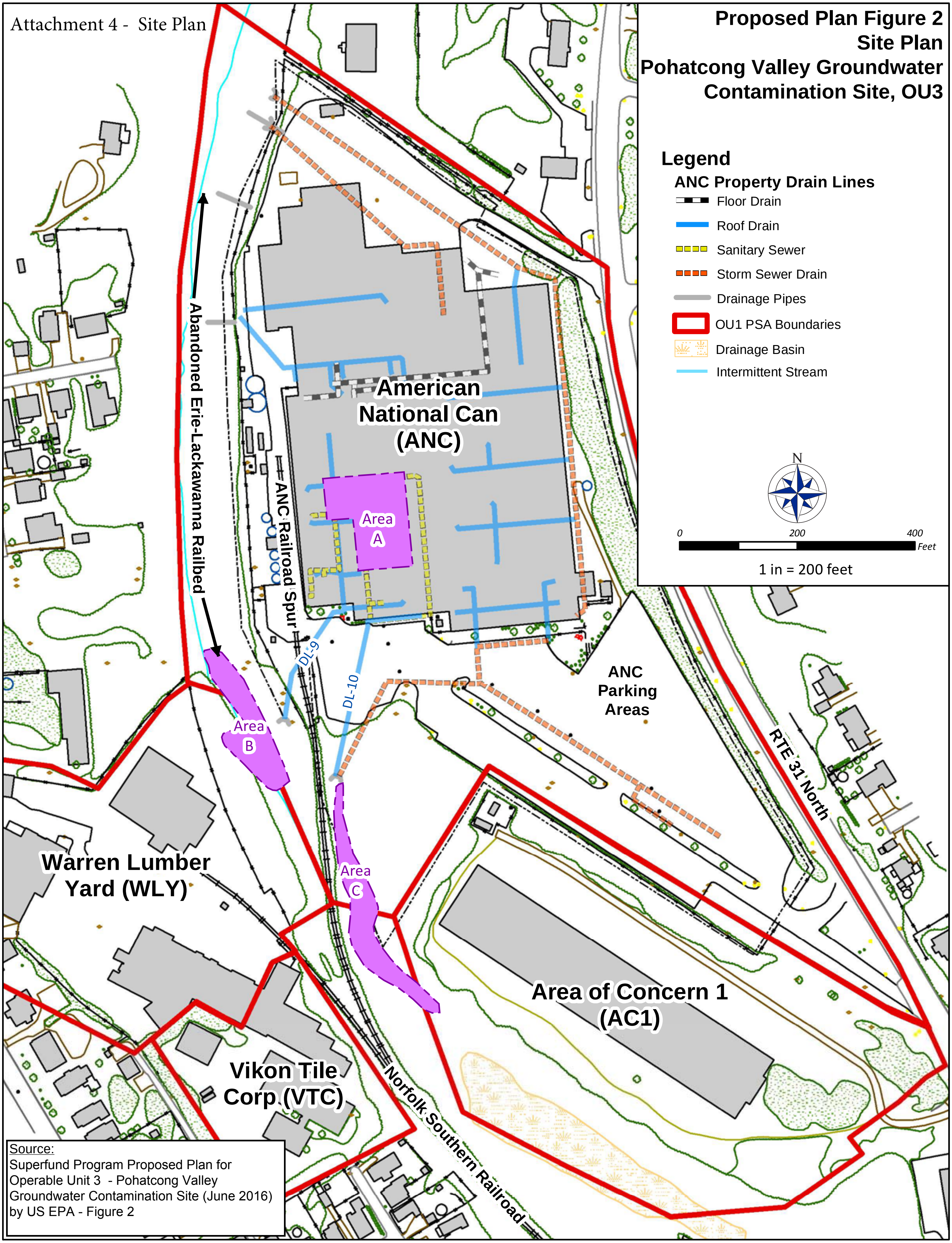
Notes:
Assumed surface elevation is equal to the surface elevation of the ANC borings since they are both located inside the building in the same area.
No soil samples were collected from the SVE soil borings.

Source: Soil Boring Logs taken from Appendix J of the Final Design Report for the Soil Vapor Extraction and Mitigation System.



Attachment 4 - Site Plan

Proposed Plan Figure 2
Site Plan
Pohatcong Valley Groundwater Contamination Site, OU3



Source:
Superfund Program Proposed Plan for Operable Unit 3 - Pohatcong Valley Groundwater Contamination Site (June 2016) by US EPA - Figure 2

Attachment 5 - Cross Section

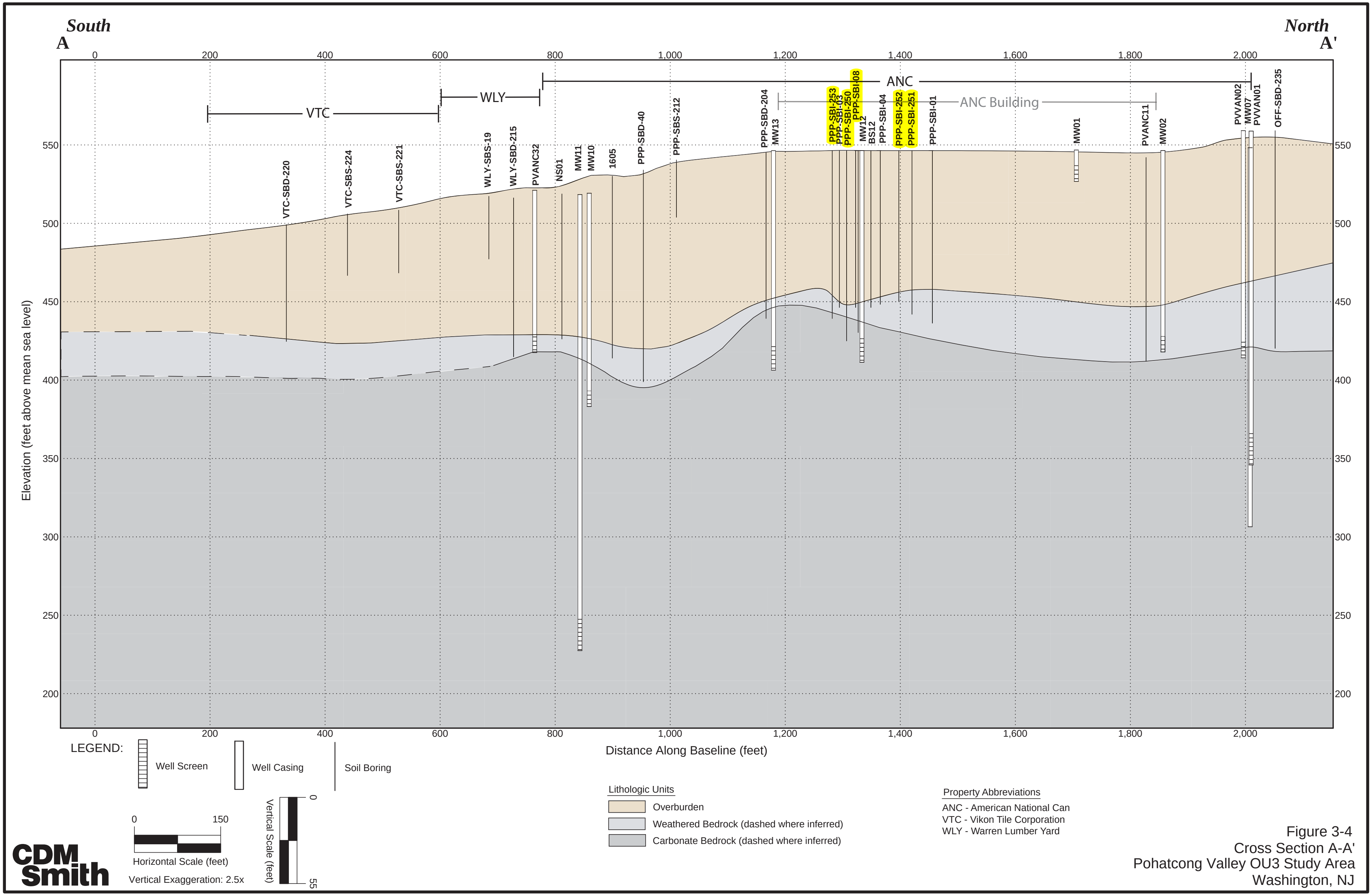


Figure 3-4
Cross Section A-A'
Pohatcong Valley OU3 Study Area
Washington, NJ

STANDARD CROSS SECTION: POHATCONG POHATCONG_VALLEY_FINAL(7-10-12).GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 7/23/12 REV.

Source: Final Remedial Investigation Report for Operable Unit 3 - (May 11, 2016) by CDM Smith - Figure 3-4
Soil borings with TCE concentrations above the PRG have been highlighted.

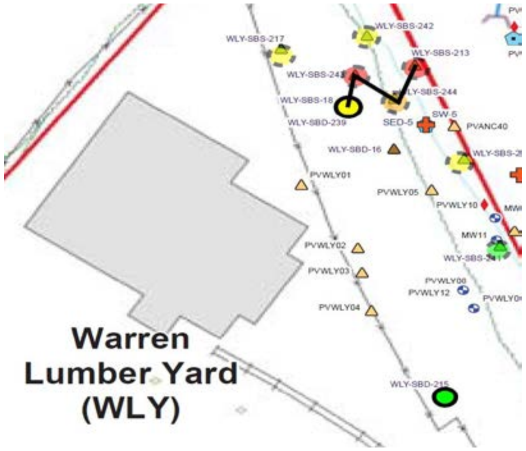
Attachment 6, Part A – Exterior Soil Boring and Analytical Summary

Rio Tinto - WLY

Elevation	Depth (ft bgs)	SBD-239	SBS-243	SBS-244	SBS-213
		PID (ppmv)	PID (ppmv)	PID (ppmv)	PID (ppmv)
516.0 - 515.0	1.0	0-10	0-10	200	0
515.0 - 514.0	2.0	0-10	0-10	200	0
514.0 - 513.0	3.0	0-10	0-10	200	0
513.0 - 512.0	4.0	0-10	0-10	200	0
512.0 - 511.0	5.0	0-10	0-10	200	0
511.0 - 510.0	6.0	0	--	513	0
510.0 - 509.0	7.0	0	--	513	0
509.0 - 508.0	8.0	0	--	513	0
508.0 - 507.0	9.0	0	--	513	0
507.0 - 506.0	10.0	0	--	513	0
506.0 - 505.0	11.0	--	0-10	0-10	0-10
505.0 - 504.0	12.0	--	0-10	0-10	0-10
504.0 - 503.0	13.0	--	0-10	0-10	0-10
503.0 - 502.0	14.0	--	0-10	0-10	0-10
502.0 - 501.0	15.0	--	0-10	0-10	0-10
501.0 - 500.0	16.0	0	0-20	0-10	0-10
500.0 - 499.0	17.0	0	0-20	0-10	0-10
499.0 - 498.0	18.0	0	0-20	0-10	0-10
498.0 - 497.0	19.0	0	0-20	0-10	0-10
497.0 - 496.0	20.0	0	0-20	0-10	0-10
496.0 - 495.0	21.0	0	0-10	0-10	0
495.0 - 494.0	22.0	0	0-10	0-10	0
494.0 - 493.0	23.0	0	0-10	0-10	0
493.0 - 492.0	24.0	0	0-10	0-10	0
492.0 - 491.0	25.0	0	0-10	0-10	0
491.0 - 490.0	26.0	0	20-40	20-40	0-10
490.0 - 489.0	27.0	0	20-40	20-40	0-10
489.0 - 488.0	28.0	0	20-40	20-40	0-10
488.0 - 487.0	29.0	0	20-40	20-40	0-10
487.0 - 486.0	30.0	0	20-40	20-40	0-10
486.0 - 485.0	31.0	0	60-80	0-20	0
485.0 - 484.0	32.0	0	60-80	0-20	0
484.0 - 483.0	33.0	0	60-80	0-20	0
483.0 - 482.0	34.0	0	60-80	0-20	0
482.0 - 481.0	35.0	0	60-80	0-20	0
481.0 - 480.0	36.0	20-40	--	--	0
480.0 - 479.0	37.0	20-40	--	--	0
479.0 - 478.0	38.0	20-40	--	--	0
478.0 - 477.0	39.0	20-40	--	--	0
477.0 - 476.0	40.0	20-40	--	--	0
476.0 - 475.0	41.0	0-10	--	--	--
475.0 - 474.0	42.0	0-10	--	--	--
474.0 - 473.0	43.0	0-10	--	--	--
473.0 - 472.0	44.0	0-10	--	--	--
472.0 - 471.0	45.0	0-10	--	--	--
471.0 - 470.0	46.0	0-20	--	--	--
470.0 - 469.0	47.0	0-20	--	--	--
469.0 - 468.0	48.0	0-20	--	--	--
468.0 - 467.0	49.0	0-20	--	--	--
467.0 - 466.0	50.0	0-20	--	--	--
466.0 - 465.0	51.0	20-40	--	--	--
465.0 - 464.0	52.0	20-40	--	--	--
464.0 - 463.0	53.0	20-40	--	--	--
463.0 - 462.0	54.0	20-40	--	--	--
462.0 - 461.0	55.0	20-40	--	--	--
461.0 - 460.0	56.0	20-40	--	--	--
460.0 - 459.0	57.0	20-40	--	--	--
459.0 - 458.0	58.0	20-40	--	--	--
458.0 - 457.0	59.0	20-40	--	--	--
457.0 - 456.0	60.0	20-40	--	--	--
456.0 - 455.0	61.0	0-10	--	--	--
455.0 - 454.0	62.0	0-10	--	--	--
454.0 - 453.0	63.0	0-10	--	--	--
453.0 - 452.0	64.0	0-10	--	--	--
452.0 - 451.0	65.0	0-10	--	--	--
451.0 - 450.0	66.0	80	--	--	--
450.0 - 449.0	67.0	80	--	--	--
449.0 - 448.0	68.0	80	--	--	--
448.0 - 447.0	69.0	80	--	--	--
447.0 - 446.0	70.0	80	--	--	--
446.0 - 445.0	71.0	--	--	--	--
445.0 - 444.0	72.0	--	--	--	--
444.0 - 443.0	73.0	--	--	--	--
443.0 - 442.0	74.0	--	--	--	--
442.0 - 441.0	75.0	--	--	--	--
441.0 - 440.0	76.0	--	--	--	--
440.0 - 439.0	77.0	--	--	--	--
439.0 - 438.0	78.0	--	--	--	--
438.0 - 437.0	79.0	--	--	--	--
437.0 - 436.0	80.0	--	--	--	--
436.0 - 435.0	81.0	177	--	--	--
435.0 - 434.0	82.0	177	--	--	--
434.0 - 433.0	83.0	177	--	--	--
433.0 - 432.0	84.0	177	--	--	--
432.0 - 431.0	85.0	177	--	--	--
431.0 - 430.0	86.0	102	--	--	--
430.0 - 429.0	87.0	102	--	--	--
429.0 - 428.0	88.0	102	--	--	--
428.0 - 427.0	89.0	102	--	--	--
427.0 - 426.0	90.0	102	--	--	--
426.0 - 425.0	91.0	20-40	--	--	--
425.0 - 424.0	92.0	20-40	--	--	--
424.0 - 423.0	93.0	20-40	--	--	--
423.0 - 422.0	94.0	20-40	--	--	--
422.0 - 421.0	95.0	20-40	--	--	--
421.0 - 420.0	96.0	0-10	--	--	--
420.0 - 419.0	97.0	0-10	--	--	--
419.0 - 418.0	98.0	0-10	--	--	--
418.0 - 417.0	99.0	0-10	--	--	--
417.0 - 416.0	100.0	0-10	--	--	--
416.0 - 415.0	101.0		--	--	--

Sources:
Soil Boring Logs - Final Remedial Investigation Report for Operable Unit 3 - Appendix C (May 11, 2016) by CDM Smith
Analytical Data - Final Remedial Investigation Report for Operable Unit 3 - Appendix H (May 11, 2016) by CDM Smith

Geology	🟩	BOULDER
	■	CONCRETE
	▨	SILT
	▨	CLAY
	▨	GRAVEL
	🟫	SAND
	🟦	ORGANIC
	🟨	BEDROCK/WEATHERED BEDROCK
TCE Concentration in Soil	☐	1 - 10 ppm
	☐	10 - 20 ppm
	☐	20 - 30 ppm
	☐	30 - 50 ppm
	☐	50 - 70 ppm
	☐	70 - 100 ppm
	☐	100 - 130 ppm



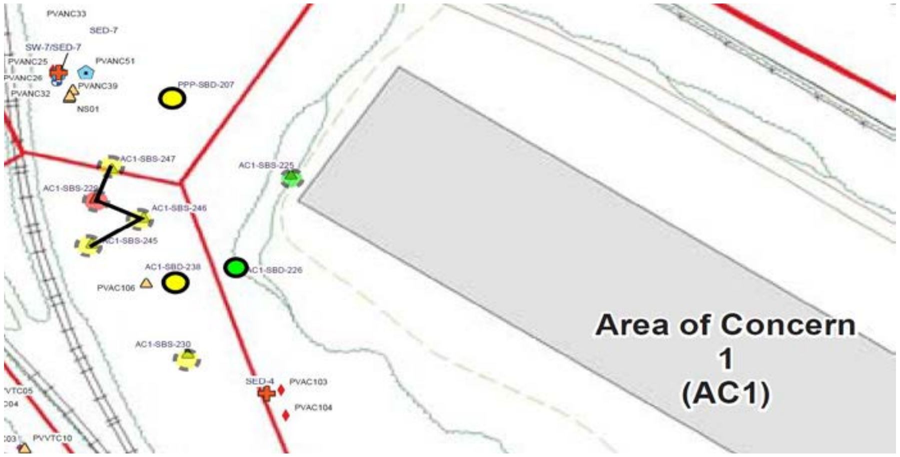
Attachment 6, Part B – Exterior Soil Boring and Analytical Summary

Rio Tinto - AC1

Elevation			Depth (ft bgs)	SBS-245	SBS-246	SBS-229	SBS-247
				PID (ppmv)	PID (ppmv)	PID (ppmv)	PID (ppmv)
516.0	-	515.0	1.0	0	0	0-10	0
515.0	-	514.0	2.0	0	0	0-10	0
514.0	-	513.0	3.0	0	0	0-10	0
513.0	-	512.0	4.0	0	0	0-10	0
512.0	-	511.0	5.0	0	0	0-10	0
511.0	-	510.0	6.0	0	0	0-10	0
510.0	-	509.0	7.0	0	0	0-10	0
509.0	-	508.0	8.0	0	0	0-10	0
508.0	-	507.0	9.0	0	0	0-10	0
507.0	-	506.0	10.0	0	0	0-10	0
506.0	-	505.0	11.0	0	0	0-10	0
505.0	-	504.0	12.0	0	0	0-10	0
504.0	-	503.0	13.0	0	0	0-10	0
503.0	-	502.0	14.0	0	0	0-10	0
502.0	-	501.0	15.0	0	0	0-10	0
501.0	-	500.0	16.0	0	0	0-10	0
500.0	-	499.0	17.0	0	0	0-10	0
499.0	-	498.0	18.0	0	0	0-10	0
498.0	-	497.0	19.0	0	0	0-10	0
497.0	-	496.0	20.0	0	0	0-10	0
496.0	-	495.0	21.0	0	0	0	0
495.0	-	494.0	22.0	0	0	0	0
494.0	-	493.0	23.0	0	0	0	0
493.0	-	492.0	24.0	0	0	0	0
492.0	-	491.0	25.0	0	0	0	0
491.0	-	490.0	26.0	0	0	0-10	0
490.0	-	489.0	27.0	0	0	0-10	0
489.0	-	488.0	28.0	0	0	0-10	0
488.0	-	487.0	29.0	0	0	0-10	0
487.0	-	486.0	30.0	0	0	0-10	0
486.0	-	485.0	31.0	0	0	0	0
485.0	-	484.0	32.0	0	0	0	0
484.0	-	483.0	33.0	0	0	0	0
483.0	-	482.0	34.0	0	0	0	0
482.0	-	481.0	35.0	0	0	0	0
481.0	-	480.0	36.0	--	--	0-10	--
480.0	-	479.0	37.0	--	--	0-10	--
479.0	-	478.0	38.0	--	--	0-10	--
478.0	-	477.0	39.0	--	--	0-10	--
477.0	-	476.0	40.0	--	--	0-10	--
476.0	-	475.0	41.0	--	--	--	--
475.0	-	474.0	42.0	--	--	--	--

Geology	
🟩	BOULDER
⬛	CONCRETE
🟨	SILT
◼	CLAY
⬜	GRAVEL
🟫	SAND
🟦	ORGANIC
🟧	BEDROCK/WEATHERED BEDROCK
🟦	TOPSOIL
🟥	SAND/SILTY CLAY

TCE Concentration in Soil	
▭	1 - 10 ppm
▭	10 - 20 ppm
▭	20 - 30 ppm
▭	30 - 50 ppm
▭	50 - 70 ppm
▭	70 - 100 ppm
▭	100 - 130 ppm



Sources:
Soil Boring Logs - Final Remedial Investigation Report for Operable Unit 3 - Appendix C (May 11, 2016) by CDM Smith
Analytical Data - Final Remedial Investigation Report for Operable Unit 3 - Appendix H (May 11, 2016) by CDM Smith

Attachment 7

How Heat Can Enhance In-situ Soil and Aquifer Remediation: Important Chemical Properties and Guidance on Choosing the Appropriate Technique – Eva L. Davis

United States Environmental Protection Agency
Office of Research and Development
Office of Solid Waste and Emergency Response
EPA/540/S-97/502 ✓
April 1997

EPA Ground Water Issue

How Heat Can Enhance In-situ Soil and Aquifer Remediation: Important Chemical Properties and Guidance on Choosing the Appropriate Technique

Eva L. Davis *

Background

The EPA Regional Ground Water Forum is a group of EPA professionals representing Regional Superfund and Resource Conservation and Recovery Act (RCRA) Offices, committed to the identification and resolution of ground-water issues impacting the remediation of Superfund and RCRA sites. Innovative technologies for subsurface remediation, including in-situ techniques based on heating the subsurface to enhance the recovery of organic contaminants, are being evaluated more often for specific sites as the limitations to the conventionally-used techniques are recognized. The purpose of this Issue Paper and the three companion Issue Papers (Davis, 1997a, b, c) is to provide to those involved in assessing remediation technologies some basic information on the thermal remediation techniques. In order to understand how heat can enhance a remediation process, it is essential to understand the properties of organic contaminants that affect their recovery. Thus, this Issue Paper contains in-depth information on the properties of some common organic contaminants which can affect their movement in and recovery from the subsurface, as well as information on how these properties are affected by temperature. Then, some basic information on which of the heat-based remediation techniques may be most appropriate for the subsurface conditions and the contaminants is also provided, as well as a comparison of the heat-based techniques to other in-situ remediation techniques. The three companion Issue Papers have been written to provide an explanation of how each of the three general types of processes (steam or hot air injection, electrical heating, and hot water injection) works, as well as preliminary information on the design of a system and some estimates of the expected costs. Thus, once the ground-water remediation specialist has determined which of the thermal methods may be appropriate for a particular site, the Issue Paper on that method may be consulted for more detailed information on how the process may be applied.

Introduction

Thermal treatment is a common and proven technology for the remediation of contaminated soils (Lighty et al., 1990), but in the past thermal treatment has been applied mainly to soils that have been excavated and are then incinerated to release and/or destroy the contaminants. However, excavation of contaminated soils is not always practical and can be extremely costly when the contamination occurs at great depths or covers a large area. Excavation also increases the risk of exposure to and further dispersion of the contaminants during material handling steps (Dev et al., 1989; *Superfund Report*, August 10, 1994). Heat-based in-situ remediation methods can be used in many places where excavation is not possible, such as under and around surface structures, and around empty underground tanks and utilities (U.S. EPA, 1995d). In many instances, heat-based in-situ remediation techniques have been found to be cost effective compared to the excavation and incineration option or other remediation techniques (Dev et al., 1989; Basile and Smith, 1994; Yow et al., 1995).

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Technology Support Project

Superfund Technology Support Center for Ground Water

National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
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Office of Solid Waste and Emergency Response, US EPA, Washington, DC

Walter W. Kovalick, Jr., Ph.D.
Director

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The most commonly used remediation technique for the recovery of organic contaminants from ground water has been pump-and-treat, which recovers contaminants dissolved in the aqueous phase. Vacuum extraction (also called soil venting) is quickly becoming popular for removal of volatile organic contaminants from the unsaturated zone in the gaseous phase (Ho and Udell, 1992; Shah et al., 1995). Both of these techniques can, in the initial remediation phase, rapidly recover contaminants at concentrations approximately equal to the solubility limit (pump-and-treat), or the maximum gas phase concentration of the contaminant (vacuum extraction). The maximum gas phase concentration will depend on whether the contaminant is present as a free phase or as a solute in the aqueous phase. During this initial phase, large amounts of the contaminants may be removed. The second phase of the remediation, however, is characterized by rapidly declining contaminant concentration in the effluent as the rate of mass transfer into the flowing phase controls the rate of removal. The third phase of the remediation is characterized by a *tailing* in the effluent of low contaminant concentrations. However, low effluent concentrations may not be a reliable indication of low contaminant levels remaining in the subsurface. Diffusion of contaminants from less-permeable areas into the regions where flow is occurring or the slow desorption of contaminants from the soil surface may control contaminant removal during this phase, and termination of the extraction process before these processes are complete may lead to significant rebounding of the ground water and/or soil air concentrations (Mackay and Cherry, 1989).

Thus, the rate-limiting properties of the systems are different in each of the three phases of the remediation: in the first phase, the solubility of the contaminant in the aqueous phase (pump-and-treat) or its maximum gas phase concentration (vacuum extraction); in the second phase, it is the mass transfer step, i.e, dissolution into the aqueous phase (pump-and-treat), or vaporization (vacuum extraction); and, during the third phase, it is diffusion from low permeability areas or the desorption rate (Shah et al., 1995).

Instances of soil and aquifer contamination by oily contaminants such as automatic transmission fluid (Abdul et al., 1990), coal tar (Gerencher et al., 1992) and creosote (Johnson, 1994) have been documented. Contaminants such as these oils are practically insoluble in water and have essentially no vapor pressure. Thus, they will be present in the subsurface as a nonaqueous phase liquid and must be recovered as such. The recovery of these types of products is often limited by slow movement to recovery wells caused by their high viscosity and the significant residual saturation left behind. Heat-based in-situ remediation techniques which overcome or lessen the influence of each of these limitations to the recovery of organic contaminants have been developed and are being field tested.

Properties of the Contaminants

Organic contaminants in the subsurface can be present as a separate nonaqueous phase liquid, dissolved in the aqueous phase, in the vapor phase in the soil gas, partitioned into the soil organic matter, or adsorbed onto the solid mineral phase. The relative amount of the contaminant in each of these phases is determined largely by the properties of the contaminant. Generally, the most important property of the soil in determining the distribution of contaminants is the soil organic matter, which normally controls the absorption of hydrophobic compounds.

Table 1 lists some of the relevant physical properties of volatile and semivolatile organic chemicals that have been, or have the potential to be, recovered using in-situ thermal techniques. Many of these are commonly found at Superfund sites and other sites where ground-water contamination has occurred (Roberts et al., 1982; Esposito et al., 1989; Newell et al., 1995). All of the properties listed are temperature dependent. Most of these organics are essentially immiscible with water; acetone and methanol are the exceptions. Many of these compounds have low viscosities and, thus, have the potential to flow readily in the liquid phase. Approximately half of these compounds are less dense than water; the other half are more dense than water. The density of an organic liquid relative to that of water is important in determining the vertical mobility of the contaminant. Those that are less dense than water will tend to float on the ground-water table, while those that are more dense than water may move downward through the aquifer if the pressure in the organic liquid is greater than the displacement pressure of the aquifer materials. Low permeability clay layers in the aquifer may restrict the vertical movement and allow the liquids to accumulate on top of the layer.

Table 1 is set up to list the chemicals in the order of lowest to highest boiling points. Observation of the vapor pressures shows that, in general, the lower the boiling point the higher the vapor pressure at 25°C. The contaminants with the lowest boiling points also generally have a lower heat of vaporization, thus these contaminants are relatively easy to volatilize. Compounds with higher boiling points have lower vapor pressures at ambient temperatures and a higher heat of vaporization, thus more energy is required to convert them to the gaseous phase. Laboratory experiments have shown that vaporization of even highly volatile compounds can cause a measurable decrease in the temperature of the system (Lingineni and Dhir, 1992).

Henry's law constants indicate whether the compound prefers to be in the gaseous or aqueous state. Henry's law applies to dilute solutions, and can be written as: $P_A = X_A H_c$, where P_A is the partial pressure of chemical A, X_A is the mole fraction of chemical A in solution, and H_c is a constant, commonly called the Henry's law constant. Thus, the Henry's law constants are a function of the aqueous solubility and vapor pressure of a compound, and the greater the Henry's law constant, the greater the extent to which the compound partitions to the air phase (Atkins, 1986). The constants given in the table are expressed in the dimensionless form, which is a ratio of the concentrations, C_{air}/C_{water}, where both concentrations are in mol/m^3. Due to difficulties involved in determining solubilities and vapor pressures, reported values of Henry's law constants sometimes vary by two orders of magnitude or more depending on the source of the data. Mackay and Shiu (1981) performed a critical review of the available data, and determined recommended values for many chemicals of environmental interest, and a standard deviation of the reported

Table 1. Properties of some organic chemicals that have been found at contaminated sites.

Organic Contaminant	Boiling Point °C	Density gm/cm^3	Viscosity cP 25°C	Water Solubility mg/l	Vapor Pressure mm Hg T$_1$, °C	Vapor Pressure mm Hg T$_2$, °C	Henry's Law Constant dimensionless 25°C	Octanol-Water Partition Coefficient	Diffusion Coefficient in Water cm^2/day	Diffusion Coefficient in Air cm^2/day	Heat of Vaporization[b] kJ/mol 25°C
Methylene Chloride (Dichloromethane)	40	1.3182 25°C	0.413	20,000 20°C[e]	260.9 10°C	>760 50°C	0.105 ± 0.008[n]	17.78[q]			28.82
1,2-Dichloroethylene (trans)	49	1.2444	0.317	600 20°C[e]	198.7 10°C	>760 50°C					
Acetone	56.3	0.7899	0.306	∞	121.7 10°C	622.4 50°C	0.000842[k]	1.74[e]	1.106[b,p,h] 25°C	9417.6[s] 0°C	30.99
1,1-Dichloroethane	57.4	1.17	0.464	5500 20°C[e]	125.8 10°C	608.6 50°C	0.234 ± 0.008[n]	30[d] 61.7[i]			30.62
1,2-Dichloroethylene (cis)	60	1.2649 25°C	0.445	800 20°C[e]	104.8 10°C	580.0 50°C					
Trichloromethane (Chloroform)	61.2	1.49	0.537	8000 20°C[e]	98.6 10°C	541.3 50°C	0.153 ± 0.012[n]	90[d] 79.4[i] 93.3[b] 91.2[q]		7862[s] 0°C	31.28
1-Hexene	63.5	0.675	0.252	50 20°C[e]	90.0 10°C	485.3 50°C	16.87 ± 0.40[n]	2455[r,h]		6212[h] 20°C	30.61
Methanol	64.6	0.791	0.544	∞	58.5 10°C	400 50°C		0.151 - 0.219	1.11[o] 15°C 1.6[s] 25°C 1.43[h] 25°C	14,688[g]	37.43
n-Hexane	68.7	0.659	0.300	9.5 20°C[e]	80.8 10°C	407.5 50°C	68.6 ± 10.1[n]	10,000[b] 12,883[r]		6143[h] 20°C	31.56
1,1,1-Trichloroethane	74.1	1.3303 25°C	0.793	4400 20°C	67.4 10°C	360.1 50°C	1.13 ± 0.016[n]	309[b] 300[d] 147.9[i]			32.50

Continued on next page.

Table 1 -- Continued.

Organic Contaminant	Boiling Point °C	Density gm/cm^3	Viscosity cP 25°C	Water Solubility mg/l	Vapor Pressure mm Hg T_1, °C	Vapor Pressure mm Hg T_2, °C	Henry's Law Constant dimensionless 25°C	Octanol-Water Partition Coefficient	Diffusion Coefficient in Water cm^2/day	Diffusion Coefficient in Air cm^2/day	Heat of Vaporization[b] kJ/mol 25°C
Carbon Tetrachloride	76.8	1.5833 25°C	0.908	800 20°C[e]	58.3 10°C	332.8 50°C	0.807 ± 0.161[n]	676.1[b,q] 436.5[c,i]			32.43
2-Butanone (Methyl Ethyl Ketone)	79.6	0.7994 25°C	0.405	26,800	52.6 10°C	314.3 50°C	0.0010[j] 0.00112[c,k]	1.820[e]			34.76
Benzene	80.1	0.88	0.604	1770 25°C	47.8 10°C	307.8 50°C	0.22 ± 0.01[n]	134.90[b,e,h,i,l]	0.881[b,h] 20°C 0.501[h] 2°C	7460[f] 7819.2[h] 20°C 6653[s] 0°C	33.83
Cyclohexane	80.7	0.7731 25°C	0.894	58 25°C	50.5 10°C	272.3 50°C	7.27 ± 0.81[n]	2754[h]	0.726[b,h] 20°C 0.397[h] 2°C	7430.4[s] 45°C 6212[h] 20°C	33.01
1,2-Dichloroethane	84	1.257	0.779	8700 20°C	40.0 10°C	278.6 50°C	0.044 ± 0.004[n]	30.2[b,i]			35.61
Trichloroethylene	87.3	1.4578 25°C	0.545	1100 25°C[e]	37.6 10°C	256.7 50°C	0.397[f] 0.38[i] 0.372[a]	195[b] 200[d] 339[r]	0.830[f]	7030[f]	34.54
Toluene	110.6	0.8647 25°C	0.56	515 - 540 25°C	14.3 10°C	579.1 100°C	0.27 ± 0.014[n]	537[b] 490[d,e,h,i,j] 447[r]	0.734[b,h] 20°C 0.389[h] 2°C	6570[f] 7119.4[h] 20°C 6566[s] 0°C 7603[s] 30°C 7430[o] 26°C 7949[o] 59°C	38.01

Continued on next page.

Table 1 -- Continued.

Organic Contaminant	Boiling Point °C	Density gm/cm^3	Viscosity cP 25°C	Water Solubility mg/l	Vapor Pressure mm Hg T_1, °C	Vapor Pressure mm Hg T_2, °C	Henry's Law Constant dimensionless 25°C	Octanol-Water Partition Coefficient	Diffusion Coefficient in Water cm^2/day	Diffusion Coefficient in Air cm^2/day	Heat of Vaporization[b] kJ/mol 25°C
4-Methyl 2-Pentanone	116.6	0.802	0.545	19000	4.3 10°C	381.0 100°C	0.0063[c]				40.61
Tetrachloro-ethylene	121.3	1.613 25°C	0.844	150 25°C	9.0 10°C	400 100°C	0.928 ± 0.161[n]	400[d,e] 407[q]			39.68
n-Octane	126	0.6986 25°C	0.508	0.7 20°C[e]	6.5 10°C	368.7 100°C	121 ± 20[n]	104,700[l] 151,356[h,r]		4910[f] 5166.7[h] 20°C 4363[s] 0°C	41.49
Chloro-benzene	131.7	1.1007 25°C	0.753	490 25°C	6.9 10°C	323.7 100°C	0.14 ± 0.02[n]	691.8[b,e,i] 955[r]		6394[o] 26°C 7776[o] 59°C 6480[s] 30°C	40.97
Ethylbenzene	136.2	0.8654 25°C	0.631	160 25°C	6.0 10°C	295.7 100°C	0.323 ± 0.028[n]	1412.5[b,h,i] 1349[r]	0.700[b,h] 20°C 0.380[h] 2°C	6333[h] 20°C	42.24
Xylenes	138.4 - 144.4	0.8577 - 0.8764 25°C	0.608 - 0.802	160 - 180 25°C	4.5 - 5.6 10°C	238.9 - 280.8 100°C	0.20[f] 9400[j] 0.202 - 0.286[c] 0.214[a]	1412 - 1585[b] 588.8 - 1584.9[e,h,l] 1349 - 1585[r]		5980[f] 5771.5[h] 20°C	42.40 - 43.43
n-Decane	174.2	0.730	0.838	0.052	3.0 25°C	77.7 100°C	282.5 ± 121[n]				51.38
Dichloro-Benzene (3 isomers)	173 - 180	1.2988 25°C (ortho isomer)	1.044 - 1.324	80 - 150 25°C	2.2 25°C	67.1 100°C	0.048 - 0.073[b]	2399 - 3981[b] 2399 - 2455[e]			36.18 - 49.00
Dodecane	216.5	0.75	1.383	0.0034		19.5 100°C	302.7 ± 100.9[n]	1537[l] 13 x 10^6 [h]			61.51

Continued on next page.

Table 1 -- Continued.

Organic Contaminant	Boiling Point °C	Density gm/cm^3	Viscosity cP 25°C	Water Solubility mg/l	Vapor Pressure mm Hg T_1, °C	Vapor Pressure mm Hg T_2, °C	Henry's Law Constant dimensionless 25°C	Octanol-Water Partition Coefficient	Diffusion Coefficient in Water cm^2/day	Diffusion Coefficient in Air cm^2/day	Heat of Vaporization^b kJ/mol 25°C
Naphthalene	218	0.97		32 25°C		22.7 100°C	0.02^{b,i} 0.05^m 0.017 ± 0.002^n	2239^{b,r} 2344.2^i 1738^l		4432^s 0°C	
1-Methyl naphthalene	244.8	1.020		28.5		0.043 kg/m3	0.0182 ± 0.0016^n	7413^r			
Hexadecane	286.9	0.773	3.032	0.0063	< 1	< 1					81.38
Phenanthrene	340	0.98		1.18			0.0016^{i,m} 0.0016 ± 0.00032^n	28,840^{e,i} 37154^r			72.50
Gasoline		0.73 0.7182^h 20°C	0.45 0.4 - 0.6^h 20°C	100 - 300 30 - 120^h						6272.6^h 20°C	

Superscripts

a - Baehr, 1987	b - Lide, 1993	c - Newell et al., 1995	d - Hunt et al., 1988	e - Verschueren, 1983	f - Ong et al., 1992
g - Thoma et al., 1992	h - Lyman et al., 1991	i - Ryan et al., 1988	j - Jury et al., 1990	k - Sanders, 1995	l - Johnson et al., 1990
m - Jury et al., 1984	n - Mackay and Shiu, 1981	o - Treybal, 1980	p - Tyn and Calus, 1975	q - Valsaraj, 1988	
r - Miller et al., 1985	s - Perry and Chilton, 1973				

values that were thought to be reliable. For chemicals for which their recommended values are available, they are listed in Table 1. For the other chemicals, all reported values that were located in the literature are listed to show the range in reported values. The Henry's law constants listed in the table show that at ambient temperatures, the alkanes and similar compounds, such as 1-hexene and cyclohexane, have a strong preference for the air phase rather than the aqueous phase, while the chlorinated solvents and compounds that contain a benzene ring tend to concentrate more in the aqueous phase. As the number of benzene rings in the compound increases, its preference for the aqueous phase increases. The ketones listed in Table 1 also have a very strong preference for the water phase.

The partition coefficient is defined as the ratio of the equilibrium concentration C of a dissolved substance in a system containing two largely immiscible solvents. Thus, the octanol-water partition coefficient is defined as $K_{ow} = C_{octanol}/C_{water}$. The octanol-water partition coefficient has proven useful as a means to predict soil absorption as well as biological uptake and biomagnification and related phenomenon (Verschueren, 1983). In general, the more hydrophobic a compound is, the greater its octanol-water partition coefficient and the greater its absorption onto soil organic matter (Karickhoff et al., 1979). However, this generalization is limited to hydrophobic organic compounds and soils which contain significant amounts of organic matter, on the order of at least 0.1 percent (Schwarzenbach and Westall, 1981; Weber et al., 1991). Most of the organic compounds listed in Table 1 are at least moderately hydrophobic, thus the octanol/water partition coefficient might be expected to indicate the degree of absorption of these compounds in surface soils or other soils with high organic carbon contents. It can be seen in Table 1 that there are also some large differences in the reported values for the octanol/water partition coefficients for a given organic compound depending on the source of the data. Despite these differences, the reported values show that most of the compounds listed have a strong preference for organic matter rather than the water phase, with the exception being the ketones and methanol. The absorption of contaminants into the soil organic matter will tend to limit the rate at which they can be recovered in either the aqueous or gaseous phase.

To illustrate what the Henry's law constants and octanol-water partition coefficients indicate about the distribution of an organic chemical in the subsurface, a few calculations were carried out using the equations given by Feenstra et al. (1991). The results of these calculations are shown in Table 2. A surface soil of loam texture with a bulk density of 1.28 gm/cm^3, a porosity of 0.30, a water saturation of 50 percent, and an organic matter content of 2 percent was assumed. Karickhoff et al.'s (1979) relationship between the octanol-water partition coefficient and the adsorption coefficient, K_d, was assumed to be valid: K_d $0.6f_{oc}K_{ow}$, where f_{oc} is the fraction of organic matter in the soil. In order to demonstrate the effect of soil properties on the distribution of an organic chemical, calculations were also done for the same chemicals for a sandy soil of bulk density 1.86 gm/cm^3, porosity 0.30, and organic matter 0.1 percent. Again, a 50 percent water saturation was assumed.

Table 2 shows that in soils with high organic carbon content, organic compounds may be highly associated with the solid material. Calculations for 1,1,1-trichloroethane (TCA) were carried out using the range of values that have been reported for K_{ow} for this chemical to illustrate the difference this can make in the calculated distributions. For soils with high organic matter content there is very little difference as most of the chemical is still associated with the solids. For low organic matter conditions the difference in the distribution is significant, and the lower K_{ow} value means that more of the chemical is recoverable in the water or air phase. Trichloroethylene (TCE) and TCA have similar K_{ow} values at ambient temperatures, but TCA has a Henry's law constant that is greater than that of TCE at temperatures around 20°C and, thus, much more of the TCA will be in the air phase. TCE is a volatile organic compound but, at 20°C, significantly more of its mass will be in the aqueous phase rather than in the gas phase; a very significant proportion of it will be associated with the solids. Acetone is highly volatile with a boiling point of 56°C, but its extremely low K_{ow} and H_c concentrate it in the aqueous phase. Because acetone is miscible with water and is a good solvent for many organic chemicals, acetone may significantly increase the transport of less soluble organic chemicals in ground water (Huling, 1989; Udell and Stewart, 1989).

The diffusion coefficient measures the rate at which molecules spread down a concentration gradient, and is dependent on the chemical nature of the system and the concentration, as well as the temperature and pressure. As can be seen from the coefficients listed in Table 1, diffusion in gases is much greater than diffusion in liquids, which is due to the considerably higher molecular concentration of liquids. When experimental data is not available, the diffusion coefficient for gases can be estimated fairly accurately by equations that have been developed based on the kinetic theory of gases. For liquids, diffusion coefficients cannot be estimated with the same degree of accuracy because a sound theory of the structure of liquids has not been developed. However, empirical correlations have been developed and can be used in the absence of laboratory data (Treybal, 1980). Observation of the values in the table shows that most of the organic compounds for which values could be located fall in the range of 5000 to 8000 cm^2/day for diffusion in air; methanol and acetone are again the exceptions with larger coefficients. All of the water diffusion coefficients, also, fall in a rather narrow range from 0.7 to 1.6 cm^2/day.

The properties listed in Table 1 are for pure chemicals, and do not consider the effects of a porous solid on the properties and behavior of the chemical. The vapor pressure, the diffusion coefficient in both air and water, and perhaps the viscosity, are all significantly affected by the presence of the chemical in porous media and the properties of that media. The partial pressure of a liquid is dependent on the curvature of the interface between the liquid and gaseous phases, and the values contained in Table 1 are for a flat interface. When the interface is curved, the partial pressure of the liquid is reduced. Although this effect is very small in sandy soils with a less than one percent reduction in vapor pressure, it becomes important in clay soils when the pore sizes are less than approximately 10^{-6} cm,

Table 2. Distribution of chemicals in low and high organic matter content soils.

	High Organic Matter			Low Organic Matter		
	Air	Water	Solids	Air	Water	Solids
1,1,1-Trichloroethane $P_{oct} = 300$	5%	5%	90%	26%	23%	51%
1,1,1-Trichloroethane $P_{oct} = 147.9$	6%	6%	88%	35%	31%	34%
Trichloroethylene 20°C	1.6%	4.6%	93.8%	14%	35%	52%
Trichloroethylene 90°C	30%	7%	63%	73%	16%	11%
Acetone	0.07%	85%	15%	0.08%	99%	1%

causing a decrease in vapor pressure of approximately 40 percent (Wilson et al., 1988). This effect can also be important when the medium is dry and the remaining liquid has receded into the smallest pores (Bear and Gilman, 1995). These capillarity effects will determine the level of cleanup that can be achieved by a venting process at a given temperature (Lingineni and Dhir, 1992).

Adsorption of the organic onto the solid phase or partitioning into the soil organic matter can also have the effect of lowering the partial pressure of an organic compound. Adsorption can occur from the liquid onto the solid and, when the water content is very low, from the vapor phase onto the soil surface (Lighty et al, 1990; Tognotti et al., 1991). Fares et al. (1995) have studied desorption of TCE from soils, and their data shows that the equilibrium vapor pressure of TCE as it desorbs from a soil is approximately an order of magnitude lower than the partial vapor pressure of TCE when no soil is present. Experiments performed by Arthurs et al. (1995) showed that the rate of volatilization of the liquid in the presence of a soil is about two orders of magnitude slower than from the pure liquid, and that the vaporization rate increases as the vapor pressure of the compound increases. Fares et al. (1995) and Keyes and Silcox (1994) found that the rate of desorption was linearly correlated with the inverse of the soil particle diameter. Hatzinger and Alexander (1995) found that organic compounds may become more tightly bound to the soil or organic matter with time, which reduces their desorption. Thus, the equilibrium partial pressure of a volatile contaminant in the pore space and mass transfer from the aqueous liquid or adsorbed phase will depend on the properties of the chemical and the soil environment in which it resides.

The diffusion coefficients listed in the table are for bulk air or water. In the pore spaces of a soil, diffusion in both the air and water phase is reduced because of the reduced cross-sectional area and increased path length caused by the presence of solid and liquid obstacles (Millington, 1959). Diffusion coefficients in porous media are a function of both the porosity of the soil and the water (or air) content of the pores. At low water contents, diffusivity in the water is also limited by the continuity of the water phase. For diffusion in water in porous media, Porter et al. (1960) found a nearly linear increase in effective diffusion as the water content increased, ranging from 4 to 30 percent of its diffusion in bulk water. Jin and Jury (1996) recommended the use of a second model developed by Millington (1959) for predicting gas phase diffusion in disturbed porous media: $D_s/D_a = a^2/n^{2/3}$, where D_s is the diffusion coefficient of a gas through soil, D_a is the diffusion coefficient in free air, a is the volumetric air content of the pores, and n is the porosity. They did not find a unique relationship for gaseous diffusion in undisturbed soils due to their heterogeneous nature. Measured gas phase diffusion in undisturbed soils is both higher and lower than predicted by this theory, but is not generally greater than about 40 percent of the diffusion in air, and the diffusion drops off rapidly as the air-filled porosity decreases.

Adsorption of water onto solid surfaces, particularly onto the reactive surfaces of clays, will increase the viscosity of the water in the layers immediately adjacent to the clay surface. Theoretical and experimental results of Kemper (1961a, 1961b) indicated that the first layer of water on the surface of a clay may have a viscosity on the order of 10 times that of the bulk water, and the viscosity of each adjacent layer of water then decreases rapidly to the viscosity of the bulk water. How much effect this has on bulk flow in soils depends on the thickness of the water films in proportion to the pore sizes. Neutral organic species will generally not be adsorbed to the surface of the soil as strongly as water. Therefore, neutral organics may have a smaller effective viscosity relative to that of water in porous media, allowing them to flow more readily. For clays that are highly reactive and swell in the presence of water, research has shown that the presence of organic chemicals may shrink the clay. Cracks may form which allow a much greater flow of the organic chemical than was possible with water (Anderson et al., 1985; Brown and Thomas, 1987; Fernandez and Quigley, 1988).

Table 3 lists a few of the viscous oils that have been found contaminating the subsurface. These oils are essentially non-volatile and are not soluble to an appreciable degree in water. Thus, they remain a separate liquid phase in the subsurface. All of these oils are mixtures of many different hydrocarbons. Coal tar and creosote also contain polycyclic aromatic hydrocarbons. When oils such as these are spilled to the subsurface and are exposed to air and water, "weathering" will occur, as the more volatile hydrocarbons volatilize to the pore air, and the more soluble hydrocarbons dissolve in the pore water. Water and air moving past these oils while they are trapped in the subsurface will enhance the weathering process. The loss of the "light" hydrocarbons by the weathering process will increase the specific gravity and viscosity of the remaining oil, and lower the surface and interfacial tensions. Measurements made in the author's laboratory, Robert S. Kerr Environmental Research Center, showed that a significant proportion of the crude oil was volatilized at room temperature, causing a 7-fold increase in viscosity. Creosote was found to contain few volatiles at room temperature, and weathering did not change its viscosity significantly. The specific gravity of both oils increased, and the surface and interfacial tensions decreased by approximately 5 to 10 dynes/cm by the weathering. Mungan (1964, 1966) has found that decreasing the interfacial tension in an immiscible displacement will increase recovery of the oil. Although decreases in interfacial tension will favor recovery of these oils, that may be offset by a decrease in mobility caused by the higher viscosities.

Research in the author's laboratory has shown that oils such as the crude oil listed in Table 3 flows more readily through some silica sands than would be predicted based on the intrinsic permeability of the sand measured with water and the density and viscosity of the crude oil. This is likely due to the nonpolar nature of these hydrocarbons which limits their adsorption to soil surfaces. The greater mobility of the crude oil would give it a greater tendency to spread as it enters the subsurface, but also should aid in its recovery by a displacement process such as hot water injection.

Mechanisms for Enhanced Recovery

In general, when an organic chemical is heated, its density is reduced, its vapor pressure is increased, its adsorption onto solid phases or absorption into soil organic matter is decreased, and its molecular diffusion in the aqueous and gaseous phase is increased (Isherwood et al., 1992). The viscosity of a liquid will decrease as the temperature is increased, but the viscosity of gases increases with temperature. Which of these effects of heat is important for the enhanced recovery of a particular contaminant depends mostly on the properties of the contaminant and the mechanism limiting the removal rate of the contaminant in the particular circumstance.

Available data on the expansion of organic chemicals such as those listed in Table 1 with temperature shows that these chemicals expand approximately 0.1 percent per degree Celsius. Thus, increasing the temperature by 100°C will increase the liquid volume by approximately 10 percent. Since the volume of a gas is directly proportional to temperature given in Kelvin, a 100°C increase in temperature will cause approximately a 30 percent increase in the gas volume. These changes are small compared to the volume change that occurs when a liquid is converted to a gas; water at 100°C has approximately a 1600-fold increase in volume when it is converted from a liquid to a vapor.

The expansion of liquids with temperature causes a reduction in the interaction between molecules, and thus a reduction in its viscosity. For the organic chemicals listed in Table 1, generally there is about a one percent change in viscosity per degree Celsius. Thus, the higher the viscosity of the liquid at ambient temperatures, the greater the reduction in viscosity as the temperature is increased. The viscosity of gases at ambient temperatures is approximately one to two orders of magnitude lower than the viscosity of liquids. However, the increase in the velocity of gas molecules with temperature is such that it causes greater interaction between molecules as the temperature increases, causing an increase in viscosity with temperature. This increase is proportional to the temperature in degrees Kelvin, so that a 100°C increase in temperature will increase the viscosity of a gas by about 30 percent.

The effect of temperature on solubility is dependent on the chemical. Increasing temperature will reduce the water-water, water-solute, and solute-solute interactions, so the net effect of temperature on solubility will depend on which interactions are affected to the greatest extent (Yalkowsky and Banerjee, 1992). Thus, some chemicals show increasing solubility with temperature while others show decreasing solubility with temperature. Maximum or minimum solubilities with temperature have also been found for some chemicals; many organic liquids exhibit minima in solubility at about room temperature (Yalkowsky and Banerjee, 1992). Measurements by Stephenson (1992) and the data compiled by Horvath (1982) show that the solubility of the organic chemicals listed in Table 1 often decreases in the temperature range of 0°C to 90°C, but the change in solubility in this temperature range is generally less than a factor of two.

Vapor pressures always increase with temperature. For the organics listed that have a boiling point of less than 100°C, the vapor pressure increases by a factor of 5 to 7 as the temperature increases from 10°C to 50°C. For those compounds that have a boiling point greater than 100°C, their vapor pressure generally increases by a factor of 40 to 50 by raising the temperature from 10°C to 100°C. Limited data on the desorption of organics from

Table 3. Properties of some oily contaminants.

	Boiling Range	Specific Gravity	Viscosity cp	Water Solubility mg/l	Vapor Pressure mm Hg	Surface Tension dynes/cm	Interfacial Tension dynes/cm
Automatic Transmission Fluid[a]	> 350°C	0.875 20°C		< 50 20°C	$< 2 \times 10^{-4}$	33.7	
Coal Tar[b]		25°C 0.9744 60°C 0.9469 85°C 0.9263	25°C 41.4 60°C 1.65 85°C 1.16				
Coal Tar[c]	50% can be distilled at 270°C	7°C 1.028 15°C 1.017 38°C 0.991 60°C 0.985	7°C 18.98 50°C 5.04 60°C 3.89			28.8	22 22°C
Creosote[d]	45 to 65% can be distilled at 315°C[e]	10°C 1.1060 20°C 1.1027 30°C 1.0957 40°C 1.0893 50°C 1.0816	10°C 35.7 20°C 19.8 30°C 12.4 40°C 8.57 50°C 6.17			10°C 32.4 20°C 33.5 30°C 29.0 40°C 25.0 50°C 26.8	9.65 10°C 7.83 20°C 6.16 30°C 5.31 40°C 5.90 50°C
Crude Oil[d]		10°C 0.8953 20°C 0.8883 30°C 0.8820 40°C 0.8760 50°C 0.8680	10°C 160.2 20°C 63.0 30°C 34.8 40°C 23.2 50°C 16.4			10°C 26.2 20°C 24.5 30°C 23.2 40°C 23.3 50°C 22.8	22.0 10°C 21.0 20°C 20.5 30°C 20.2 40°C 21.4 50°C

a - Abdul et al., 1990 b - Johnson and Guffey, 1990 c - Villaume et al., 1983 d - unpublished data from the author's lab
e - American Wood Preservers' Association Standards

soils shows that the exponential increase in the vapor pressure with temperature also holds when the organic chemical is in the presence of soils (Fares et al., 1995).

The combination of only small changes in solubility with temperature but large increases in vapor pressure results in increases in Henry's constant as a function of temperature. However, very few measurements of Henry's constants for chemicals of environmental concern as a function of temperature have been made, and most of these measurements are over a limited temperature range. Heron et al. (1996) calculated and measured H_c values for TCE as a function of temperature and found an order of magnitude increase when the temperature was raised from 20°C to 90°C. For the more soluble compounds such as dichloromethane or 2-butanone, and the water-miscible compounds such as acetone and methanol, H_c may not be influenced significantly by temperature.

Few measurements of K_{ow} and/or K_d have been made as a function of temperature, and most of the measurements that have been made are over very small temperature ranges. Although it has been shown for some systems that adsorption may increase with temperature over narrow temperature ranges (Weber et al., 1983), adsorption is, in general, an exothermic process and, thus, will decrease as the temperature increases. The magnitude of the effect of temperature is dependent on the particular chemical, the soil, and the water content, as these factors will determine the mechanism causing the adsorption (Cancela et al., 1992; Piatt et al., 1996). Heron et al. (1996) showed theoretically, based on heats of sorption, that adsorption from the aqueous phase onto soils can be expected to decrease by a factor of approximately 2.2 as the temperature is increased from 20°C to 90°C. Adsorption from the vapor phase onto dry soils generally has a larger heat of sorption, which leads to a greater influence of temperature on the adsorption process. For TCE, Heron et al. (1996) found approximately an order of magnitude decrease in adsorption onto dry soil as the temperature was increased from 20°C to 90°C. For high molecular weight organics such as PCBs, a large fraction of the organic may remain adsorbed to the soil at ambient temperatures, and significantly higher temperatures (300°C to 400°C) may be required for desorption to occur (Uzgiris et al., 1995).

Measured data has shown that the diffusion coefficient in liquids is proportional to temperature in degrees Kelvin. Increasing the temperature from 10°C to 100°C will increase the diffusion of a solute in the aqueous phase by approximately 30 percent (Treybal, 1980). The diffusion coefficient for gases is also dependent on temperature. Observation of the theoretical equation for diffusivity in the gas phase developed for mixtures of nonpolar gases or of a polar with a nonpolar gas shows that the diffusivity varies almost as $T^{3/2}$ (Treybal, 1980). Increasing the temperature from 10°C to 100°C will increase diffusion in the air phase by approximately 50 percent, while a temperature increase from 10°C to 300°C will increase diffusion by approximately 200 percent.

Essentially all of these changes with temperature can aid in the recovery of contaminants from the subsurface. The thermal expansion of a liquid with its accompanying decrease in viscosity will allow the heated liquid to flow more readily. For gases, the expansion with temperature will be largely offset by the increase in viscosity. However, since the viscosity of gases is approximately two orders of magnitude lower than the viscosity of liquids, conversion of a liquid to a gas will greatly increase its mobility. The act of expansion itself will aid in moving the fluids out of the pore space, with the greatest effects coming from the vaporization of a liquid to a gas. The increased diffusion of contaminants as the temperature increases in both the aqueous and gaseous phases will help to move contaminants from areas of low permeability to areas of high permeability and speed their recovery.

To demonstrate the effects of temperature on the distribution of organic contaminants between the phases in the subsurface, calculations were carried out using the data of Heron et al. (1996) for TCE at 90°C. The results are shown in Table 2. It can be seen that raising the temperature to 90°C significantly increases the concentration in the air phase under both the high and low soil organic matter conditions, while significantly decreasing the amount that is associated with the solids. Only small amounts remain in the liquid phase. Thus, as the temperature is increased, significantly more of the TCE can be recovered in the vapor phase. If the high organic matter content soil is considered under water saturated conditions, the amount of TCE in the water would approximately double as the temperature was increased from 20°C to 90°C, but 82 percent of the TCE would remain adsorbed to the solids. Under the low organic matter/water saturated conditions, there would be approximately a 30 percent increase in the amount of TCE in the water phase when the temperature is increased from 20°C to 90°C, leaving approximately 25 percent adsorbed to the solids.

This small effect of temperature on the concentration in the aqueous phase shows that raising the temperature would have a limited effect on the recovery in a pump-and-treat system. For the volatile and semivolatile organic compounds, such as those listed in Table 1, the enhanced vapor pressure and rate of vaporization are generally the most important mechanisms for enhanced recovery using the in-situ heat based remediation techniques. Some of the most volatile compounds, which includes TCE, benzene, and toluene, can be removed fairly efficiently from sandy soils by vacuum extraction alone (Ho and Udell, 1992; Gauglitz et al., 1994; Shah et al., 1995), and laboratory experiments on vacuum extraction have shown that the addition of heat had little effect on the vaporization of the less volatile compounds. For the higher boiling point compounds and when clays are present in the subsurface, the addition of heat as part of the remediation process will significantly increase volatilization and enhance the vacuum extraction process (Lingineni and Dhir, 1992). Recovery of most of these chemicals from the subsurface will be enhanced by either steam or hot air injection or by electrical heating processes.

For the volatile and semivolatile contaminants, steam stripping and steam distillation can also be important recovery mechanisms (Dev et al., 1989; Stewart and Udell, 1988). Steam distillation occurs when an immiscible liquid is present along with water, as the mixture of immiscible liquids will boil when the total pressure reaches one atmosphere, rather than when the pressure of the individual component reaches one atmosphere. Because both liquids are contributing to the vapor pressure, the vapor pressure reaches one atmosphere at a lower temperature than either of the individual components would (Atkins, 1986). Steam stripping enhances volatilization of a volatile organic compound by removing the vapor phase from contact with the aqueous phase, thus preventing the liquid and vapor phases from reaching equilibrium and allowing volatilization to continue. Steam stripping becomes important when an immiscible phase is not present (Dev et al., 1989).

For the types of contaminants listed in Table 3, the greatest enhancement effect coming from the addition of heat is likely to be a reduction in the viscosity of the oil phase. Highly viscous oils will generally show a substantial decrease in viscosity with only a moderate temperature increase above ambient temperatures (Herbeck et al., 1976), and the rate of decrease with temperature then drops off rapidly with continuing increases in temperature. Edmondson (1965) found that the greater the dependence of viscosity of the oil on temperature, the greater the increase in its recovery by a hot water displacement as the temperature increased. Other mechanisms for the increased recovery of oils by hot water include the thermal swelling of liquids (Willman et al., 1961), shifts in the relative permeabilities to oil and water with temperature, and decreases in the residual oil saturation (Edmondson, 1965; Davidson, 1969; Poston et al., 1970; Davis and Lien, 1993). Decreases in the interfacial tension with temperature for contaminants such as creosote may also aid in its recovery from the subsurface. Different researchers have found shifts of varying magnitudes and directions in relative permeability curves, but in all cases the increase in oil recovery as the temperature increases always appears to be greater than would be predicted based on the viscosity reduction alone. Capillary pressure-saturation curves measured for two phase water/oil systems have shown substantial decreases in the residual oil phase as the temperature increased (Davis, 1994), and thus, a greater portion of the oil may be recoverable as the temperature is increased.

Heat-based In-situ Remediation Techniques

There are three general methods that can be used to inject or apply heat to the subsurface to enhance remediation: injection in the form of hot gases such as steam or air, electromagnetic energy heating, and hot water injection. Another thermal remediation technique that relies on thermal conduction of soil to heat the subsurface is also under development (Iben et al., 1996), but will not be discussed here. All of these methods were first developed by the petroleum industry for enhanced oil recovery, and have more recently been adapted to soil and aquifer remediation applications. The two applications have significantly different objectives. In oil recovery operations, the reservoir initially has a large oil saturation, and the objective is to recover as much as possible economically. In these operations, a large residual oil saturation of as much as 50 percent or more may be acceptable. In contamination remediation applications, the initial saturation of the contaminant may be anywhere from essentially fully saturated to less than residual saturation, and the objective is to reduce the contaminant concentration to very low levels. The techniques of steam injection, electrical energy application, and hot water injection have been the subject of extensive research and development, and it has been established that these techniques are effective for the remediation of organic contaminants when they are appropriately applied (Fulton et al., 1991; Davis and Lien, 1993; U.S. EPA, 1995a; Newmark and Aines, 1995).

Injection of hot air has been tried in the laboratory and found to enhance the removal of contaminants from one-dimensional soil columns (Lingineni and Dhir, 1992; Shah et al., 1995). However, the use of hot air in the field is limited by the very low heat capacity of air (approximately 1 kJ/kg °C) (Ramey, 1967). Steam, with a heat capacity that is approximately four times that of air (approximately 4 kJ/kg °C), and heat of evaporation of more than 2000 kJ/kg, has been used successfully to heat soils, aquifers and reservoirs to enhance the recovery of contaminants and oils. However, the injection of steam will always leave behind a residual water saturation (Stewart and Udell, 1988), and contaminants that have a significant solubility in water may remain at high concentrations in this residual water or may even appear to increase in concentration (Udell and Stewart, 1989; U.S. EPA, 1991). For these situations, recovery of the contaminants may require that the soil be dried, and hot air injection may be applicable (Farrington, 1996).

Steam, hot air and hot water injection rely on contact between the injected fluid and the contaminant for the transfer of heat to and recovery of the contaminant. Steam injection will displace mobile contaminants in front of the steam as well as vaporize volatile residual contaminants, and therefore can recover volatile contaminants in both the liquid or vapor phase. Hot air injection has been used to recover contaminants only in the vapor phase. Hot water injection generally recovers contaminants only in the liquid phase. Thus, steam injection is applicable to volatile and semivolatile organic compounds that are immiscible with water, hot air is applicable to volatile and semivolatile organics that are water soluble, and hot water injection is applicable for the oils that have low volatility and very low solubility in water. The main mechanism for enhanced recovery using hot water is generally a reduction in the viscosity. Changes in relative permeability and reductions in residual saturation are likely to also aid in the recovery of nonvolatile oils. Hot water injection is most likely effective only when the nonaqueous phase is present in quantities greater than the residual saturation, as the main recovery mechanism is the physical displacement of the nonaqueous phase. Hot water injection may be most effective for light oils that are floating on top of the water table, as the lower-density hot water has a tendency to rise if injected below the water table. For oils that are more dense than water at ambient temperatures but less dense than water at the displacement temperature, heating of the subsurface by hot water injection may help to float these oils, which may aid in their recovery (Johnson and Guffey, 1990). Steam injection has a definite advantage over hot water injection when the contaminants have a low boiling point and are present as an immiscible phase, and thus can be steam distilled at the temperatures achieved by steam injection (Willman et al., 1961). Field trials have shown that steam injection can be carried out above or below the water table (Udell and Stewart, 1989; U.S. EPA, 1991; Aines et al., 1992).

There are limitations on the pressures that can be used for steam and hot water displacement processes, and this limits the viscosity of the fluid that can be displaced from a media with a certain permeability. However, volatilization processes using steam or hot air may still be possible in low permeability media (Farrington, 1996), and for highly viscous oil, it may be possible to heat the oil and lower its viscosity sufficiently to recover at least a portion of the oil by either a displacement process or gravity drainage (Hall and Bowman, 1973; Vogel, 1992).

Electrical energy has been applied to the soil in the low frequency range used for electrical power (called electromagnetic (EM), alternating current (AC), or resistivity heating) as well as in the radio frequency (RF) range. When EM heating is used, the water in the pore spaces of the soil absorbs essentially all the applied energy, so the evaporation of water limits the transport of energy in the soil and, therefore, limits the heating process. Thus, for the low frequency methods, the boiling point of water is the highest temperature that can be achieved. For semivolatile organic contaminants, the vapor pressure at 100°C may not be adequate to effectively recover the contaminants. For this reason, researchers have also developed the use of RF energy for soil heating. RF energy can be absorbed by the soil itself, and thus is not limited by a lack of water in the pore space. Using RF energy, the upper temperature limit of the technique is 300°C to 400°C (Dev, 1993; Sresty, 1994). For electrical heating, the electrical properties of the soil and the presence of water are important in determining the efficiency of the heating process (Dev et al., 1989; Marley et al., 1993). The electrical heating techniques are recommended for the removal of organic contaminants which exhibit a vapor pressure of at least 10 mm Hg in the treatment temperature range (Sresty, 1994). There is some evidence that high molecular weight organics, such as organopesticides, can be broken down to simpler organics such as acetone, benzene and toluene, at the temperatures and conditions that can be achieved by RF heating (U.S. EPA, 1995b&c; Swanstrom and Besmer, 1995). Electrical heating has been proven effective in sandy media (Dev, 1986), and also has a greater potential than steam or hot water injection to be effective in less permeable media such as clays. The higher water content generally found in the clay will aid in directing the electromagnetic energy to the clay and allow a faster heating rate and higher temperatures to be achieved. RF heating, however, is limited to the unsaturated zone. For contaminants trapped below the water table, dewatering would have to be done prior to electrical heating (U.S. EPA, 1995b).

Because steam injection (at least in its initial stages) and hot water injection are displacement processes, they can also recover nonvolatile contaminants dissolved in the aqueous phase, such as salts (Vaughan et al., 1993), but heat does not necessarily enhance the recovery of this type of inorganic contaminant. Metals, with the exception of mercury, cannot be recovered from soils by thermal means. Mercury has a significant vapor pressure at ambient temperatures, and it increases as the temperature increases. Adsorption onto soils and other materials can reduce its partial vapor pressure significantly, and it was found that drying soil samples to 100°C did not recover measurable amounts of mercury. At temperatures of 200°C and greater, significant amounts of mercury can be recovered from soils, reducing the residual remaining in the soil to as little as 1 part per million at 400°C (Dewing and Schluter, 1994).

Each of these thermal methods is generally applicable only to certain types of contaminated sites, and it is important that the appropriate heat-based remediation technique is chosen for a given site. The choice of technique must be based on both the characteristics of the subsurface and of the contaminants to be recovered. Steam or hot air injection or the electrical heating techniques are generally applicable for the types of chemicals that are listed in Table 1, while hot water injection is generally applicable for the nonvolatile oils listed in Table 3. The permeability of the media, the amount and type of heterogeneity, the amount of adsorption, and the solubility of the contaminant must all be considered when choosing between the technologies. Electrical heating may be favored in low permeable media and when there is significant heterogeneity. For highly soluble contaminants, drying the soil may be necessary and, thus, hot air or RF heating may be more applicable. Because desorption can be a slow process, higher temperatures and/or longer remediation times may be necessary when adsorption is significant.

Figure 1 can be used as a quick guide to determine which of the techniques would likely be applicable for a given situation; in some cases, more than one technique may be applicable. The principle that has been applied in developing this figure is to recommend the least severe technique, in terms of temperature and pressure requirements, that is likely to be able to recover the contaminants. For example, although hot water and steam injection may both be able to recover a nonvolatile, viscous oil, hot water injection is recommended because it will generally recover the same amount of this type of oil (Willman et al., 1961) at a lower temperature. Equipment and facilities for generating and handling hot water are relatively simple and inexpensive (Harmsen, 1971), but the generation and transport of steam involves more complex and expensive systems. Higher operating temperatures also mean greater safety risks (Herbeck et al., 1976). The Issue Paper specific to that technique can then be consulted for further information.

Comparison to Other In-situ Techniques

The one significant advantage of heat-based remediation techniques over other in-situ remediation techniques is that these methods do not require that chemicals of any sort be injected into the subsurface as part of the remediation effort. This is a very significant advantage over the surfactant and cosolvent techniques because surfactants and cosolvents may themselves have toxic properties, and it may not be possible to recover all of the injected chemicals. Also, when surfactants or cosolvents are used, the technique may be limited by a lack of contact between the injected chemical and the contaminants, which can be caused by low permeability layers within the media or by reductions in relative permeability to one phase because of the presence in the pores of another phase (Peters et al., 1991). With the in-situ heating techniques discussed in these Issue Papers, heating of the entire area to be treated has generally been accomplished (Aines et al., 1992; Gauglitz et al., 1994).

These heating techniques can be used with a technique such as vacuum extraction, with benefits that may be significantly greater than for either process used separately (Udell and Stewart, 1989; Jarosch et al., 1994). Also, these processes are applicable in heavily contaminated soils, the "hot spots" of contaminated sites, which generally are very important to clean up in order to stop the spread of the contamination, and where biological treatment may not be effective (Johnson and Guffey, 1990; Aines et al., 1992).

These thermal techniques initially may be limited by subsurface heterogeneities, which affects all other in-situ remediation techniques. When low permeability clay lenses are present in an aquifer, the injected fluids often bypass these low permeability areas and, therefore, do not contact the contaminants contained within them. With time, however, the heat will be conducted into the lower permeability areas. Also, the Dynamic Underground Stripping Process, developed by the Lawrence Livermore National Laboratory, circumvented this problem for the case where relatively thick clay layers are interbeded with sandy layers by combining both steam injection and electromagnetic heating with vacuum extraction (Newmark and Aines, 1995; Yow et al., 1995).

Research has shown that complete desorption of chemicals from clay soils, or soils containing a significant amount of natural organic material, may require extreme temperature conditions (Lighty et al., 1988; Tognotti et al., 1991), which may not be achievable in-situ. Thus, in many cases, a secondary or polishing step may be required to achieve very low contaminant concentrations (Yow et al., 1995). Hot water injection or shallow steam injection applications where low temperature and pressures are used may leave the subsurface system amenable to bioremediation. In fact, raising the temperature above ambient temperatures may, in many instances, enhance naturally occurring biodegradation of contaminants (Isherwood et al., 1992). However, if steam is injected into the deeper subsurface at high temperatures and pressures, or if the soil is heated to high temperatures using RF heating, the soil will likely require cooling

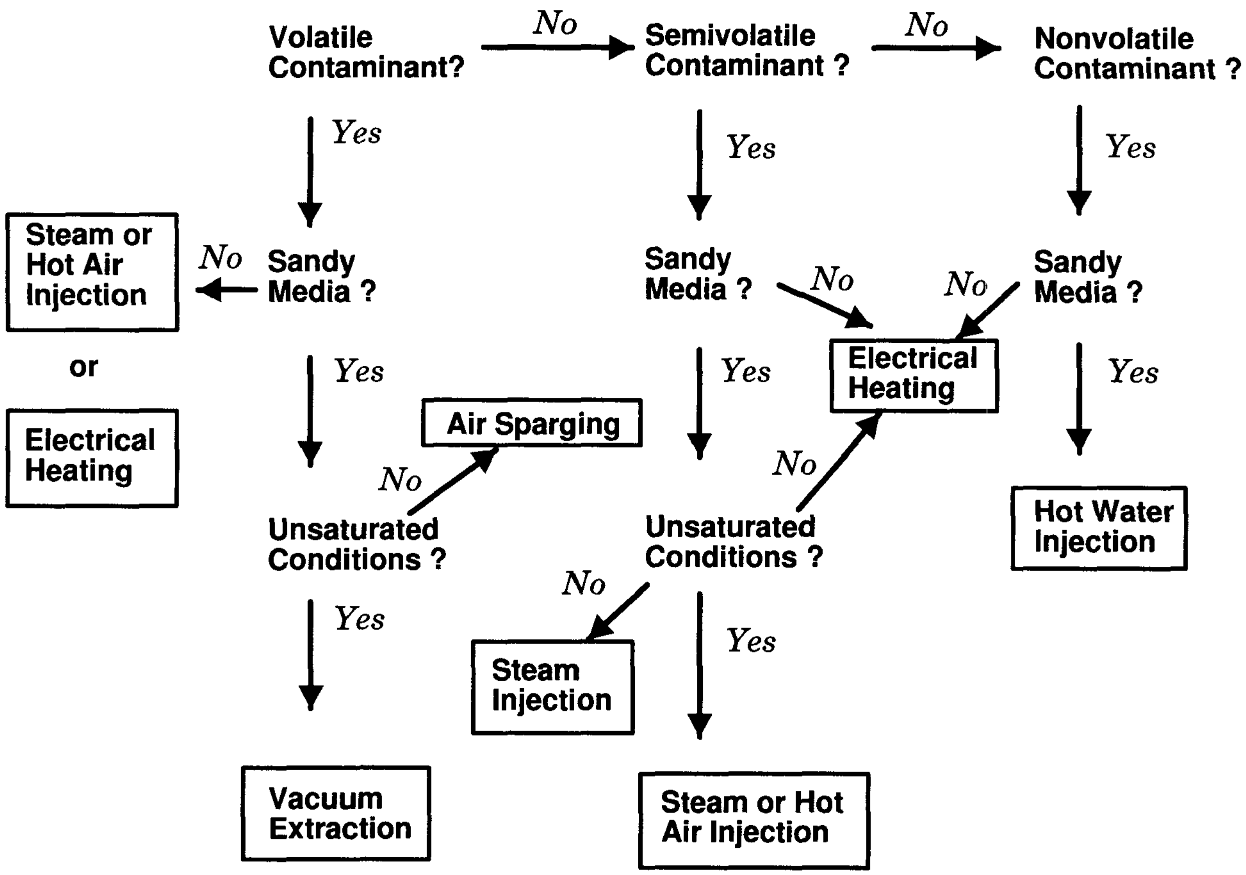

Figure 1. Flow Chart to indicate which of the thermal techniques may be applicable for a particular site.

before reestablishment of the microbial population can take place (U.S. EPA, 1991).

Notice

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