Final Feasibility Study Report

Pohatcong Valley Groundwater Contamination Site Operable Unit 1 Study Area

Washington and Franklin Townships Warren County, New Jersey

Prepared for

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CH2MHILL

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Acronyms

AC1	Area of Concern 1
ANC	American National Can
ARARs	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
cm^3	Cubic centimeter
C_o	Initial contaminant concentration
C_t	Remedial target concentration
DPE	Dual-Phase Extraction
DO	Dissolved oxygen
DOT	Department of Transportation
ELCR	Excessive Lifetime Cancer Risk
foc	Fraction of Organic Carbon
FS	Feasibility Study
ft	Feet
ft^2	square feet
ft^2/d	square feet per day
GAC	Granular Activated Carbon
GCL	Geosynthetic Liner
gpd	gallons per day
gpm	gallons per minute
GWQS	Groundwater Quality Standards
HDPE	High-density polyethylene
HI	Hazard Index
HHRA	Human Health Risk Assessment
ICs	Institutional Controls
IGWSCC	Impact to Groundwater Soil Cleanup Criteria
ISO	In Situ Oxidation
ISRA	Industrial Site Recovery Act
k	Hydraulic Conductivity
Kd	distribution partition coefficient

Koc	organic carbon partition coefficient
LDR	Land Disposal Restriction
LLDPE	Linear low-density polyethylene
LNL	L&L/Econowash Dry Cleaners
MCL	Maximum Contaminant Limit
MDL	Method Detection Limit
MIP	Membrane Interface Probe
MG	Million Gallons
mg/Kg	Milligrams per Kilogram
mL	milliliter
MNA	Monitored Natural Attenuation
MVS	Modern Valet Service
NCP	National Contingency Plan
NFA	No Further Action
NJAWC	New Jersey American Water Company
NJDEP	New Jersey Department of Environmental Protection
NPL	National Priority List
NRDCSCC	Non-residential Direct Contact Soil Cleanup Criteria
O&M	operation and maintenance
OU1	Operable Unit 1
OU2	Operable Unit 2
POTW	Publicly Owned Treatment Works
PCE	tetrachloroethylene
ppb	Parts per Billion
ppm	Parts per Million
PRGs	Preliminary Remediation Goals
PSAs	Potential Source Areas
PVGCS	Pohatcong Valley Groundwater Contamination Site
R^2	linear regression coefficient of determination
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RDCSCC	Residential Direct Contact Soil Cleanup Criteria
Rf	Retardation Factor
RI	remedial investigation
ROD	Record of Decision
scfm	standard cubic feet per minute
SDWA	Safe Drinking Water Act

SVE	Soil Vapor Extraction
TBC	To Be Considered
TC	Toxicity Characteristics
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TMV	Toxicity, Mobility or Volume
TOR	Time of Remediation
TVN	Tung Sol Tubing/Pohatcong Hosiery
µg/Kg	Microgram per kilogram
µg/L	Microgram per liter
USEPA	U.S. Environmental Protection Agency
USGS	U. S. Geologic Survey
UST	Underground Storage Tank
UTS	Universal Treatment Standard
VOC	volatile organic compound
VTC	Vikon Tile Corporation
WLY	Warren Lumber Yard

Executive Summary

This Feasibility Study (FS) Report documents the development and evaluation of remedial action alternatives by the United States Environmental Protection Agency, Region 2 (USEPA) for Operable Unit 1 (OU1) of the Pohatcong Valley Groundwater Contamination Site (PVGCS). OU1 for the PVGCS, also known as the OU1 Study Area, encompasses approximately 8.75 square miles (5,600 acres) in Warren County, New Jersey, consisting of rural, industrial, commercial, municipal, and residential land located within the Pohatcong Valley. The OU1 Study Area includes Washington Borough, and portions of Washington Township and Franklin Township in Warren County.

The western end of the OU1 Study Area is located in Broadway, New Jersey, and is coincident with the western end of the Well Restriction Area (WRA) defined by the New Jersey Department of Environmental Protection (NJDEP) in 1985. The NJDEP defined the WRA based on detected chlorinated volatile organic compounds, specifically trichloroethylene (TCE) and tetrachloroethylene (PCE), in the groundwater from domestic wells west of Washington Borough and the municipal wells within the Borough. After subsequent investigation activities and extension of public water supply connections to many of the homes within the WRA, the NJDEP referred the site to the USEPA for inclusion on the National Priority List (NPL). The NPL listing was completed in March 1989.

The USEPA initiated a remedial investigation to identify and evaluate potential source areas for the regional contamination. Through various phases of investigation, a total of 107 potential source area sites were evaluated based on the likelihood of VOC contamination, with 45 sites undergoing extensive, multiple-media sampling activities. These multi-media samples, consisting of soil, groundwater, sediment, and surface water, were each analyzed for greater than 150 contaminant compounds, and subsequently evaluated for human health and ecological risk impacts. The analyses identified only two compounds as contaminants of concern on a consistent basis in the regional soil and groundwater – TCE and PCE. Thus, the focus of this Feasibility Study is to present remedial alternatives for the TCE and PCE within the OU1 Study Area.

Of the potential source areas investigated, a number of locations were identified with elevated TCE and PCE analytical results of soil samples. Generally, the highest concentrations of TCE in soil were detected at the American National Can (ANC) and Area of Concern 1 (AC1) potential source area sites in the northeastern portion of the OU1 Study Area. The highest concentrations of PCE in soil were detected at the L&L/Econowash Dry Cleaners (LNL) and Modern Valet Service (MVS), and Tung Sol Tubing/Pohatcong Hosiery (TVN) potential source area sites within the eastern and southeastern portions of the OU1 Study Area. Groundwater samples collected throughout the OU1 Study Area indicate the presence of TCE and PCE that migrated through overburden soils from the potential source areas and into the regional groundwater aquifer. The TCE and PCE plumes have migrated several miles downgradient (westward) from their original source areas. The extent of the TCE plume is much larger than the PCE plume, which appears to be more localized in the Borough of Washington. The influent flow of the two municipal wells within the OU1

Study Area (Dale Avenue and Vannatta Street wells) contains TCE and PCE concentrations above the Federal Maximum Contaminant limit (MCL) of 5 µg/L (5 parts per billion [ppb]) and the NJDEP Groundwater Quality Standards (GWQS) of 1 µg/L (1 ppb). After TCE and PCE were detected in influent water samples from these wells, treatment systems were installed to remove the contaminants at the well head prior to adding the water to the distribution system.

Based on the TCE and PCE detected in soil and groundwater, Remedial Action Objectives (RAOs) were developed for protecting human health and the environment and the currently and potentially threatened resources. For impacted soil, the remedial action objectives were defined to: 1) prevent human exposure through contact, ingestion, or inhalation, 2) prevent erosion and offsite transport of contaminated soils, and 3) remediate contaminated soils, as necessary, to prevent further leaching of contaminants to groundwater. For groundwater, the remedial action objectives were defined to: 1) restore the groundwater aquifer to drinking water quality and 2) prevent human ingestion of contaminated groundwater.

To meet the Remedial Action Objectives for the OU1 Study Area, Preliminary Remediation Goals (PRGs) were developed to aid in defining the extent of contaminated media requiring remedial action. The PRGs were used to establish media-specific concentrations of TCE and/or PCE that will pose no unacceptable risk to human health and the environment. After an evaluation of applicable cleanup standards and potential risk pathways of contamination in soil and groundwater, USEPA has chosen soil PRGs of 1 mg/Kg (1 part per million [ppm]) and groundwater PRGs of 1 µg/L (1 ppb) for TCE and PCE. These PRGs are consistent with the NJDEP standards, specifically the Impact to Groundwater Soil Cleanup Criteria (IGWSCC) for soil and the Groundwater Quality Standards (GWQS) for groundwater.

The soil areas with TCE concentrations exceeding 1 mg/Kg (1 ppm) were identified at two locations, both within the general area of the American National Can (ANC) facility and the adjacent Area of Concern 1 (AC1). The first area, designated as ANC A within the FS Report, is assumed to be about 28,000 square feet in area and 100 feet in depth. The second area, designated as ANC B, is assumed to be about 2,000 square feet in area and 5 feet in depth. In addition, during the development of the site conceptual model of contaminant fate and transport, a calculation was made to estimate the TCE mass flux in groundwater near the American National Can (ANC) facility and the estimated TCE leaching from soil to groundwater from the known areas of soil contamination. The soil and groundwater mass flux values were expected to be in rough balance because the TCE groundwater plume exhibits characteristics suggesting it is near steady state conditions. However, the calculation results indicated that the TCE mass flux in known areas of soil contamination is less than the TCE mass flux in groundwater. Based on this discrepancy, it is suspected that an unidentified soil source in close proximity to the ANC facility (perhaps below the ANC building) is also contributing TCE mass to the groundwater. Therefore, a suspected area of soil contamination was defined as a new target area so that the selected remedy can include a contingency for remediation of such an area if it is identified in the current Industrial Site Recovery Act (ISRA) investigation or subsequent pre-remedial design investigations. The suspected target area, designated as ANC C, was estimated to be about 16,000 square feet in area and 100 feet in depth, and was assumed to be in close proximity to the ANC facility.

No soil target areas with concentrations of PCE over 1,000 µg/Kg (1 ppm) were identified during the investigation.

The area of groundwater contamination with TCE exceeding 1 µg/L (1 ppb) encompasses about 2,050 acres and extends about 28,000 feet downgradient from the source areas located in Washington Borough. The area of PCE contamination exceeding 1 µg/L (1 ppb) encompasses approximately 149 acres and extends approximately 6,000 feet downgradient from the source area located in Washington Borough. At the source areas in Washington Borough, the depth to the regional water table is about 100 feet below ground surface (bgs). At the downgradient edge of the OU1 Study Area, the depth to the regional water table is approximately 30 feet bgs. Both TCE and PCE have been detected in groundwater at depths of more than 200 feet below the water table.

Viable remedial technologies and process options for soil and groundwater were screened to assemble a large range of remedial alternatives. A series of six soil alternatives and seven groundwater alternatives were initially developed and screened for overall implementability, effectiveness, and cost. After the initial screening, four of the six soil alternatives and four of the seven groundwater alternatives were retained for a detailed evaluation against the seven National Contingency Plan (NCP) evaluation criteria. The soil and groundwater alternatives that were initially screened out were considered to be potentially ineffective, impractical, or not cost-effective during implementation. The remedial alternatives for soil and groundwater that were assembled are summarized in Tables ES-1 and ES-2, respectively.

The National Contingency Plan evaluation criteria that the retained four soil and four groundwater alternatives were evaluated for are:

- Overall protection of human health and the environment;
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs);
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

The additional two modifying criteria (Community Acceptance and State Acceptance) are to be evaluated following public comment and may be used to change the selection of the recommended alternative.

Ultimately, the USEPA, in consultation with the NJDEP and with input from the public, will use this information to select a remedial action alternative for the OU1 Study Area. The selected alternative will be formally defined in a Record of Decision (ROD) document in accordance with the National Contingency Plan (NCP).

Table ES-1

Summary of Remedial Alternatives for Soil

Pohatcong Valley Groundwater Contamination Site

Operable Unit 1

Feasibility Study

Target Area	Soil Alternative SO1 No Further Action	Soil Alternative SO2 Capping, Limited and Institutional Controls	Soil Alternative SO3 Dual Phase Extraction (DPE) and Shallow Soil Mixing	Soil Alternative SO4 Excavation and Offsite Disposal
ANC A	No action.	Limited excavation, multi-layer cap, monitored natural attenuation, and Institutional Controls (as needed).	Limited excavation, shallow soil mixing, pneumatic fracturing, DPE, and Institutional Controls (as needed).	Excavation to 15 feet below ground surface and offsite disposal. Pneumatic fracturing, DPE and Institutional Controls for remaining contamination, if necessary.
ANC B	No action.	Excavation to 5 feet below ground surface. Offsite disposal.	Excavation to 5 feet below ground surface. Offsite disposal.	Excavation to 5 feet below ground surface. Offsite disposal.
ANC C (Suspected Under ANC Building)	No action.	Existing Cap (Foundation), monitored natural attenuation, and Institutional Controls (as needed).	DPE and Institutional Controls (as needed).	Excavation to 15 feet below ground surface and offsite disposal. DPE and Institutional Controls for remaining contamination, if necessary.
Total Cost (Present Worth)	$0	$1,240,000	$4,400,000	$10,400,000

Assumed depths of contamination for costing purposes are: ANC A – 100 feet, ANC B – 5 feet, ANC C – 100 feet

ANC C alternatives based on calculated mass flux assumptions forwarded to USEPA on October 13, 2004. Changes in contaminant location and mass, soil volume, or mass flux may results in changes to alternatives and costs.

MNA – monitored natural attenuation

DPE – dual-phase extraction

Table ES-2

Summary of Remedial Alternatives for Groundwater

Pohatcong Valley Groundwater Contamination Site

Operable Unit 1

Feasibility Study

Target Area	Groundwater Alternative GW1 No Further Action	Groundwater Alternative GW2 Source Treatment and Monitored Natural Attenuation (MNA)	Groundwater Alternative GW3 Expanded Source Treatment and MNA	Groundwater Alternative GW4 Entire Plume Collection and Treatment
TCE Source Area	No action.	Groundwater extraction (420 gpm) of concentrations greater than 500 µg/L in TCE source area. Treatment, re-injection, Institutional Controls, and ANC production water treatment.	Groundwater extraction (1,400 gpm) of concentrations greater than 100 µg/L in TCE source area and near municipal supply wells. Treatment, re-injection, Institutional Controls, and ANC production water treatment.	Groundwater extraction (1,400 gpm) in TCE source area and municipal supply wells. Treatment, re-injection, Institutional Controls, and ANC production water treatment.
PCE Source Area	No action.	Groundwater extraction (100 gpm), treatment, re-injection, and Institutional Controls.	Groundwater extraction (420 gpm), treatment, re-injection, and Institutional Controls.	Captured in TCE Source Area Treatment System
Downgradient Plume (Between TCE Source Area and Downgradient Edge of OU1 Study Area)	No action.	Municipal well connection (remaining residents in OU1 Study Area), monitored natural attenuation, and Institutional Controls.	Municipal well connection (remaining residents in OU1 Study Area), monitored natural attenuation, and Institutional Controls.	Extraction (7,600 gpm), treatment, and re-injection along entire length of plume within OU1 Study Area, municipal well connection (remaining residents in OU1 Study Area), and Institutional Controls.
Total Cost (Present Worth)	$0	$8,060,000	$25,760,000	$46,840,000

MNA – monitored natural attenuation

gpm – gallons per minute

1.0 Introduction

1.1 Purpose and Organization of Report

This Feasibility Study (FS) Report documents the development and evaluation of remedial action alternatives for Operable Unit 1 (OU1) of the Pohatcong Valley Groundwater Contamination Site (PVGCS). OU1 for the PVGCS, also known as the OU1 Study Area, has been defined as the spatial area with groundwater contaminants trichloroethylene (TCE) and/or tetrachloroethylene (PCE) in excess of the Federal Maximum Contaminant Limit (MCL) of 5 micrograms per liter (µg/L) and the New Jersey Groundwater Quality Standards (GWQS) of 1 µg/L. Operable Unit 2 (OU2), whose study area is located downgradient of OU1, is currently in the planning phase of remedial investigation. This FS was prepared for the United States Environmental Protection Agency (USEPA) in accordance with Work Assignment No. 937-RI-CO-023J under RAC Contract Number 68-W6-0036.

The USEPA, in consultation with the New Jersey Department of Environmental Protection (NJDEP), and with public input, will use this information to select a remedial action alternative in its Record of Decision (ROD) in accordance with the National Contingency Plan (NCP). The criteria for remedy selections under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) require that Superfund remedial actions satisfy the following requirements.

- Protect human health and the environment;
- Comply with Applicable or Relevant and Appropriate Requirements (ARARs) of Federal and State environmental laws within a reasonable time frame;
- Be cost-effective;
- Use permanent solutions and alternative treatment technologies to the maximum extent practicable; and
- Satisfy the preference for treatment that reduces contaminant Toxicity, Mobility, or Volume (TMV).

As described in the USEPA Remedial Investigation/Feasibility Study (RI/FS) guidance document (USEPA, 1988) and in the *National Oil and Hazardous Substances Contingency Plan* (USEPA, 1990), the FS consists of three phases: the development of remedial alternatives, the screening of alternatives, and the detailed analysis of selected alternatives. The following steps were used in developing the remedial alternatives for the PVGCS.

- Identify ARARs;
- Develop Remedial Action Objectives (RAOs);
- Define remedial action goals; including:
  - Developing quantitative Preliminary Remediation Goals (PRGs) using chemical-specific ARARs and human health- and ecological-based risk levels
  - Identifying areas of contamination exceeding PRGs
- Develop general response actions;
- Identify and screen technologies (including innovative technologies);

- Identify and evaluate technology process options;
- Assemble remaining process options into remedial alternatives; and
- Evaluate the remedial alternatives in accordance with the NCP.

This report consists of six sections. Section 1 provides an introduction and summarizes background information, such as site physical description, site geology and hydrogeology, nature and extent of contamination, contaminant fate and transport, summary of human health and ecological risks, and an overall conceptual site model. The ARARs, RAOs, and PRGs that are intended to provide adequate protection of human health and the environment are discussed in Section 2. Chemical-specific remedial goals were developed for soil and groundwater based on: 1) the risk associated with the various concentrations of contaminants in those media, 2) ARARs, and 3) background concentrations, where applicable. Section 3 presents the developed general response actions that address remedial action goals and introduces the identification and screening of the technology types and process options. Remedial technologies were screened to reduce the number of technologies considered in the detailed alternatives. Section 4 presents the assembly of the remaining technologies into soil and groundwater remedial action alternatives that achieve some or all of the remedial action goals, and provide a range of levels of remediation and a corresponding range of costs. Section 4 also includes an initial screening of alternatives for general effectiveness, practicability, and cost-effectiveness during implementation. A detailed analysis of these soil and groundwater alternatives retained after the initial screening is presented in Section 5. Section 6 includes references used during the preparation of this FS.

1.2 Site Description

The PVGCS OU1 Study Area encompasses approximately 8.75 square miles (5,600 acres) in Warren County, New Jersey, consisting of rural, industrial, municipal, and residential land located within the Pohatcong Valley. The OU1 Study Area includes Washington Borough, and portions of Washington Township and Franklin Township in Warren County. Pohatcong Valley is a northeast/southwest trending valley that is bounded by mountains and is floored by unconsolidated deposits overlying carbonate rocks. Pohatcong Valley is part of the Delaware River watershed and is drained by Pohatcong Creek and associated tributaries. Groundwater occurs in perched and regional aquifers. The regional aquifer is areally extensive and is used by public water purveyors and some residential properties as a potable water source. Perched aquifers are limited in extent and are not used as a potable water source. Also, various industrial facilities use regional groundwater as a source of cooling and process water throughout the Valley. A site map indicating the OU1 Study Area is illustrated in Figure 1-1. A more detailed summary of the OU1 Study Area site conditions is included in the *PVGCS Remedial Investigation Report* (CH2M HILL, June 2005).

1.3 Site Geology and Hydrogeology

In general, the geology of the Pohatcong Valley consists of unconsolidated deposits of glacial origin overlaying weathered bedrock, and competent bedrock composed of limestone and dolomite with noted karstic features. The unconsolidated geology varies in

thickness over the Valley, but is generally between 50 and 100 feet thick in the OU1 Study Area.

Groundwater at the site is found in perched aquifers in the shallow overburden, and in a regional aquifer in the deep overburden and bedrock. The perched aquifers are localized and limited in extent, they do not represent a significant conduit for the migration of impacted groundwater and are not used as a potable water source. Regional groundwater, which is generally encountered in the overburden and bedrock at a depth of approximately 100 feet below ground surface (bgs) in the source area (at facilities in Washington Borough) and at a depth of approximately 30 feet bgs in the downgradient portion of the OU1 Study Area, is the primary focus of the remedial investigation and the alternatives developed in this FS. Groundwater in the regional aquifer generally flows to the southwest. Potable water supplies in the PVGCS are derived from the regional bedrock aquifer. Aquifer performance tests, conducted using the potable production wells and industrial wells, revealed that the transmissivity values of the regional aquifer range from about 2,000 to 8,600 square feet per day (ft^2/d) and storativity values range from 7×10^{-3} to 6×10^{-2}. In addition, anisotropic aquifer conditions were interpreted from the data analysis and indicates slightly higher transmissivity values parallel to the orientation of the valley (northeast/southwest direction) than perpendicular to the Valley. A more detailed summary of the site geology and hydrogeology for the OU1 Study Area is included in the *PVGCS Remedial Investigation Report* (CH2M HILL, June 2005).

1.4 Groundwater Use

The groundwater in Pohatcong Valley is used by residential and commercial properties as a source of potable drinking water, by industrial facilities as a source of cooling and process water, and by agricultural properties for irrigation purposes. New Jersey American Water Company (NJAWC) owns and operates the Dale Avenue and Vannatta Street municipal wells in which TCE and PCE were originally detected. About 65 and 124 million gallons of water are produced annually by the Dale Avenue and Vannatta Street municipal wells, respectively. After TCE and PCE were detected in influent water samples from these wells, treatment systems were installed to remove the contaminants at the well head prior to adding the water to the distribution system.

1.5 Nature and Extent of Contamination

The following sections provide details of the nature and extent of soil and groundwater contamination identified within the OU1 Study Area. A total of 107 potential source area (PSAs) were initially screened for investigation and 45 PSAs were retained for more detailed invasive investigation activities. Table 1-1 provides a breakdown of the activities performed to support the investigation objectives within the OU1 Study Area. Table 1-2 provides the number of samples collected by phase of work and sampling media. The OU1 RI Report presents the justification for the comprehensive investigation and screening of PSAs, and the sampling results from these PSAs were used to confirm which PSAs were considered in this FS. Note that during the OU1 RI, additional investigation activities were completed for surface water and sediment, but the results of the risk evaluations concluded that no risks were associated with the chlorinated volatile organic compounds (VOCs) detected in these

media. Therefore, this section focuses on the soil and groundwater media, which are the focus of the remainder of the FS.

1.5.1 Soil Contamination

Based on the results of soil samples collected during the remedial investigation, the highest concentrations of TCE and/or PCE were identified in Washington Borough. These PSAs were L&L/Econowash Dry Cleaners (LNL), Modern Valet Services (MVS), and Tung Sol Tubing/Pohatcong Hosiery (TVN) with elevated PCE concentrations and American National Can (ANC) and Area of Concern 1 (AC1) with elevated TCE concentrations. The locations of these PSAs are depicted on Figure 1-2.

Overall, only two of the PSAs were identified as potentially significant source areas for TCE groundwater contamination based on a comparison of TCE soil concentrations to the NJ Impact to Groundwater Soil Cleanup Criteria (IGWSCC) of 1 mg/Kg (1 part per million [ppm]). These are the American National Can (ANC) and Area of Concern 1 (AC1) PSAs. The AC1 PSA is located immediately adjacent to the ANC PSA. The distribution of TCE in soil is shown on Figure 1-3. The distribution of TCE in soil on the AC1 PSA is considered to be based on the current and historical surface water flow patterns from the concrete effluent structure at the ANC facility, as depicted on Figure 1-3. Based on information provided by the current owner of the ANC facility, surface discharges to this area may have been initiated in the 1950s.

Based on the RI soil investigation of the ANC PSA outside the facility building, the lateral extent of the TCE in soil is limited to an area of approximately 30,000 square feet within two source areas. The depth of the impacts in the two source areas at ANC/AC1 vary, with one location exhibiting impacts at shallow depths (less than 5 feet) and the other area with depths of contamination that may occur over the entire unsaturated zone (100 feet). Based on the concentrations of TCE detected in soils, the total mass of TCE remaining in these soils is estimated at about 1,940 pounds, with much of the mass present in the area surrounding soil sample locations PVAC106, PVANC25, PVANC33 and PVANC39. To account for a greater measured mass flux to groundwater than would be expected from identified source areas, a suspected source from adjacent to or below the ANC facility was included in this FS as "ANC C". This is supported by the detection and remediation of TCE-contaminated soil adjacent to the southwest corner of the manufacturing building at the ANC facility. TCE concentrations in these soils were detected at 400 mg/Kg (ppm), far in excess of the IGWSCC (1 ppm). The detailed rationale for including ANC C is presented in Appendix A.

A review of the soil sample results from the RI Report indicates that the highest concentrations of PCE in the OU1 Study Area were found at the LNL, MVS, and TVN PSAs and are summarized as follows.

- At the LNL facility, PCE was detected in soil over the analytical method detection limit (MDL) but below the New Jersey IGWSCC at concentrations up to 120 micrograms per kilogram (µg/Kg, parts per billion [ppb]), with the highest concentration of 120 µg/Kg (120 ppb) found in one sample at a depth of three feet bgs. At that location, PCE was also detected at 4 feet bgs at a concentration of 81 µg/Kg (81 ppb).
- The highest PCE concentration detected in soil at the MVS PSA was 590 µg/Kg (590 ppb), found in a surface soil sample (depth of 0.5 feet) south of the existing structure. At

that location, PCE was also detected over the MDL at samples collected at 2 feet bgs and 8 feet bgs.

- At the TVN PSA, the highest concentration of PCE was detected at a depth of 2 feet bgs at a concentration of 190 µg/Kg (190 ppb).

These three PSAs were identified in the RI Report as potentially significant source areas for the PCE groundwater plume. These target areas are much smaller in size (totaling approximately 6,200 square feet) and are in shallow soils (less than 5 feet deep). The concentrations of PCE are much lower than the TCE concentrations seen at the ANC/AC1 PSAs, with a total mass of PCE at the three PSAs totaling 0.5 pounds in soil. Although PCE was detected in soil at these locations, there were no soil sample exceedances of the New Jersey IGWSCC.

Overall, the concentrations of TCE within the ANC/AC1 PSAs are higher than the concentrations of PCE seen at the LNL/MVS/TVN PSAs. The TCE appears to be the main contributor to groundwater contamination within the OU1 Study Area, while the PCE groundwater plume is localized to the Borough of Washington within the OU1 Study Area.

1.5.2 Groundwater Contamination

Regionally, the distribution of TCE concentrations in groundwater throughout the PVGCS OU1 Study Area is shown on Figure 1-4, using analytical results from groundwater sampling conducted in 2002. The mapped TCE contaminant extent indicates that highly elevated TCE concentrations at the ANC/AC1 area have migrated hydraulically downgradient along the Pohatcong Valley for more than 5 miles. The highest TCE concentrations (560 to 2,100 µg/L, ppb) are located near the ANC/AC1 PSAs and immediately downgradient. The lateral extent of the TCE plume appears to be confined to near the center of the Valley. Based on the plume extent and average concentrations, there appears to be approximately 8,240 pounds of TCE within the groundwater plume.

Regionally, the distribution of PCE in the groundwater throughout the PVGCS is shown on Figure 1-5, based on analytical results of groundwater sampling in 2002. The mapped PCE plume illustrates that the highest PCE concentrations occur at the Vannatta Street municipal well at an influent concentration of 54 µg/L (54 ppb). The PCE concentrations in groundwater above 25 µg/L (25 ppb) appear to be centered around the Vannatta Street municipal well and the LNL/MVS areas. As stated above, the extent of the PCE plume is much smaller than the TCE plume and is localized to the Borough of Washington. The highest concentrations of PCE, ranging from 40 to 54 µg/L [ppb], are detected near the soil source area PSAs. There is an estimated 180 pounds of PCE within the groundwater plume. Based on this data, the TCE appears to be the main contributor to groundwater contamination in the OU1 Study Area.

1.6 Contaminant Fate and Transport

A fate and transport analysis of contaminants was conducted to evaluate how the identified contaminants degrade and where these contaminants may travel. The fate and transport analysis focused on discussing the contaminant characteristics, including natural attenuation mechanisms, and evaluating potential routes of migration along with the anticipated duration of the contamination in the environment. Details of the contaminant

fate and transport within the OU1 Study Area are also included in the *PVGCS Remedial Investigation Report* (CH2M HILL, June 2005).

TCE has migrated through the vadose zone unconsolidated deposits beneath the historical source areas and into the perched zones and regional groundwater aquifers. TCE was likely introduced into the soil at the American National Can (ANC) facility by surface spills and water discharges. Once in the soil, physical processes such as gravity and water infiltration act to enhance vertical migration into the soil column whereas other physical processes such as adhesion and surface tension act to restrain migration and retain some contaminants within the soil media. The remainder of the release will overcome static physical processes and continue downward migration. These physical processes together result in spreading of TCE and PCE vertically throughout the soil column under the original source areas.

Also, the pumping and re-injection of water as part of the ANC production process potentially results in contamination of groundwater in areas where soils are not impacted or were an original source to groundwater. The results of groundwater samples collected at the ANC re-injection well have ranged from 20 to 200 µg/L (ppb), which exceeds the New Jersey GWQS of 1 µg/L (1 ppb). Also, these localized flow patterns may cause contaminant migration in groundwater to areas beyond the areas where natural groundwater flow conditions would dictate flow.

TCE has generally spread in the direction of groundwater flow, with potential localized influences near the original source areas due to industrial water usage and re-injection. The extent of PCE has also followed the direction of groundwater flow, but has a much smaller area of impact when compared to the TCE area. The specific details of leaching and migration for the plume are described below.

1.6.1 TCE Fate and Transport

A TCE mass balance of contaminant leaching and migration was performed to verify the degree to which the known TCE source areas are contributing to the TCE plume and whether additional unknown sources may be present. Based on partitioning and leaching calculations (Appendix A, Table A-1), about 44 pounds/year of the estimated 1,940 pounds of TCE confirmed present in the ANC source areas are estimated to be currently leaching to groundwater. Under the assumption of no further action to remediate source areas, this mass flux rate is expected to continue for decades and slowly diminish with the passage of time. The mass flux to groundwater from the other PSAs is orders of magnitude lower.

The mass flux of TCE in groundwater leaving the source area, however, is estimated at 310 pounds/year (Appendix A, Table A-2), considerably more than the 44 pounds/year estimated to be leaching to groundwater. This wide discrepancy suggests that an additional source of TCE leaching to groundwater may be present at other locations, possibly in close proximity or below the ANC production facility building, where sampling has not yet been performed. To provide for more expeditious source remediation, a suspected source area was considered so that a contingency for remediation of such a source area can be included in the soil media alternatives and eventually in the selected remedy. Appendix A explains in detail the justification for including the suspected area ANC C in this FS to account for the discrepancy in mass flux between the amount leaching from known areas of contamination and the amount measured in the downgradient plume.

Once the TCE reaches the water table, lateral and vertical migration occurs based on the groundwater flow conditions (i.e., hydraulic head and the hydraulic conductivity). Since TCE is found at depths of up to 200 feet below the water table, a vertical component of migration is observed in the aquifer, possibly the result of withdrawal of groundwater at the Vannatta Street and Dale Avenue municipal wells from depths of up to 300 feet bgs, and at the ANC production/injection wells. In addition, withdrawal of groundwater could cause spreading of TCE by altering groundwater flow patterns. The OU1 plume of TCE extends approximately 28,000 feet from the source areas to the downgradient edge of the OU1 Study Area. Based on observed hydraulic gradients and as interpreted by an analytical flow model presented in the OU1 RI Report, a portion of the TCE plume is captured by the Dale Avenue municipal well. Little or no portion of the TCE plume is captured by the Vannatta Street municipal well.

Although natural attenuation of the plume is evident based on the substantial decline in concentrations with distance, the attenuation is primarily the result of dispersion. Degradation of TCE is not significant based on the absence of breakdown products of TCE (cis-1,2-dichloroethylene [DCE] and vinyl chloride) in groundwater and the lack of favorable anaerobic/reducing conditions for biodegradation of chlorinated VOCs downgradient of the source area. Within the source area, groundwater conditions are anaerobic and localized anaerobic degradation may be occurring. However, groundwater downgradient of the source area exhibits near saturated concentrations of dissolved oxygen, probably related to the karstic nature of the aquifer seen downgradient, thus limited anaerobic degradation.

TCE concentrations in groundwater have been fluctuating over time based on the Dale Avenue municipal well sampling results dating from 1986. The data show a downward trend (see Figure 1-6), although the trend is minimal. Based on these data and the lack of TCE degradation throughout the plume, it is believed that the TCE plume is relatively stable in the groundwater. Although the plume may be currently declining somewhat in concentration, it is expected to remain above NJ GWQS for over 100 years.

1.6.2 PCE Fate and Transport

A mass balance of PCE contaminant leaching and migration was performed to evaluate the degree to which the known PCE source areas are contributing to the PCE plume and whether additional unknown sources may be present. The total PCE mass in the soil at the three PSAs identified is about 0.5 pounds. The annual amount leached from the PCE source areas would be only a small fraction of this amount.

Much of the PCE plume is within the capture zone of the Vannatta Street municipal well. Based on the historical PCE concentrations in the well prior to treatment and an estimated average pumping rate of 300 gallons per minute (gpm), about 100 pounds of PCE are removed from the plume each year. This wide discrepancy between source area leaching and PCE mass removal from the plume suggests that a much more significant source existed at one time and/or there are one or more additional sources of PCE not yet found. A groundwater grab sample collected in this area exhibited the highest PCE concentrations (1,500 ug/L at 75 feet bgs), suggesting that a likely source of the PCE may have existed at these PSAs, but that it has since degraded or migrated away from these PSAs. Also there is only an estimated 180 pounds of PCE in the dissolved phase in groundwater.

Once the PCE reaches the water table, lateral and vertical migration occurs based on the groundwater flow conditions (i.e. hydraulic head and the hydraulic conductivity). Since PCE is found to depths of up to 200 feet below the water table, a vertical component of migration is observed in the aquifer, most likely the result of groundwater withdrawal at the Vannatta Street municipal well from depths of up to 300 feet bgs. The PCE plume extends westward approximately 7,000 feet from the source areas to the downgradient edge near the Dale Avenue municipal well. The more concentrated portion of the plume from LNL and MVS flows southeastward and is captured by the Vannatta Street municipal well.

As with the TCE plume, the PCE is not undergoing biological degradation within the current extent of the PCE plume. The PCE has migrated substantial distances and the breakdown products of PCE (e.g., TCE, cis-1,2-DCE, and vinyl chloride) are not generally seen in groundwater. Groundwater downgradient of the source areas exhibits near saturated concentrations of dissolved oxygen (DO), thus eliminating favorable anaerobic/reducing conditions for biodegradation of chlorinated VOCs. Dispersion appears to be the dominant mechanisms for reduction in PCE concentrations in downgradient portions of the plumes.

PCE concentrations in groundwater have been declining over time based on the Vannatta Street municipal well sampling results dating to 1985. The data show a clear downward trend over time (see Figure 1-7). A linear projection of this trend into the future suggests the plume may attain New Jersey GWQS in about 12 years. However, typically plumes reach an asymptote above the New Jersey GWQS where further declines are minor. As a result it may be several decades before the PCE plume declines to New Jersey GWQS.

1.7 Summary of Human Health and Ecological Risks

1.7.1 Exposure Pathways

The primary exposure pathways for soil contamination are human contact with surface soils, or vapors in the vadose zone migrating through the soils to the surface where they are released into the atmosphere, or into subsurface structures such as basements. The results of surface soil sampling suggest the soil direct contact pathway presents an unacceptable risk to human contact, thus requiring remedial actions.

Groundwater exposure pathways for TCE and PCE include the operation of residential, industrial, or commercial production wells. For residential wells, the groundwater may be a source of potable water, limited irrigation, and other domestic uses. However, the use of residential wells as a potable water source in the OU1 Study Area have been reduced or eliminated through implementation of the NJDEP Well Restriction Area and provision of community-based potable water supply. If, within the area impacted by the OU1 groundwater contamination, during the implementation of the OU1 remedial action, USEPA learns of any private properties that have not been connected to the public water supply, or USEPA learns of any private wells that are currently drawing water from within the area of the OU1 impacted contaminant plume, then these property owners will be given the opportunity to be connected to the public supply, and USEPA will evaluate the need for their wells to be closed. Commercial uses of groundwater are through the operation of public water supply wells by New Jersey American Water Company. As groundwater at

the New Jersey American Water Company (NJAWC)'s Dale Avenue and Vannatta Street municipal production wells are treated at the well head before discharge into the distribution system, the chlorinated VOCs are effectively removed to meet all applicable state and federal drinking water standards.

1.7.2 Human Health Risk Characterization

The Human Health Risk Assessment (HHRA) evaluated the hazards and risks associated with exposures to soil, groundwater, surface water, and sediment within the OU1 Study Area. The risks to human health associated with exposure to the chlorinated VOCs and the other constituents (metals, semi-volatile organic compounds [SVOCs], non-chlorinated VOCs) detected at the site were assessed. The results of the human health risks from other constituents are not summarized herein since the focus of the FS is to evaluate remedial alternatives for soil and groundwater impacted by chlorinated VOCs. Details of the full risk evaluation are included in the *Human Health Risk Assessment,* Section 6.2 of the OU1 RI Report (CH2M HILL, May 2005). Below is a summary of the human health risk evaluation for chlorinated VOCs at the PVGCS.

- Risks or hazards associated with chlorinated VOCs include soil at the ANC/AC1 PSA, the groundwater in the regional aquifer (both the TCE and PCE plumes), and any domestic wells within the OU1 Study Area. Exposure to TCE for all of these areas/media would result in risks and hazards above the USEPA target risk levels for both industrial and residential worker scenarios.
- The TCE detected in the surface and subsurface soil at the ANC/AC1 PSA may pose carcinogenic risks and/or non-carcinogenic hazards above USEPA target risk levels to child residents, lifetime residents, outside industrial workers, and construction workers. These hazards and risks are primarily associated with inhalation of TCE in volatile and fugitive emissions from the soil.
- Risks and hazards associated with potable use of the groundwater in the regional aquifer, for both residential and industrial scenarios, exceed USEPA target risk levels. The risks from both the TCE and PCE plume are associated with ingestion, dermal contact, and inhalation of vapors while showering.
- Use of groundwater from domestic wells within the OU1 Study Area as a residential, potable-water supply would result in non-carcinogenic hazards and carcinogenic risks above the USEPA target risk levels, associated with the TCE detected in these wells.

1.7.3 Ecological Risk Characterization

The Ecological Risk Assessment (ERA) focused on further evaluating risks associated with chlorinated VOCs and on further evaluating the specific risk questions identified at the completion of the Ecological Risk Screening. The following conclusions were derived from the conduct of the ERA:

- Complete exposure pathways exist for terrestrial plants/soil invertebrates, benthic macroinvertebrates and aquatic life at the site.
- There is the potential for adverse effects to terrestrial plants/soil invertebrates from the presence of TCE in ANC/AC1 soils, but the limited frequency and wide variance of exceedances suggest a localized area of potential adverse effect and a limited overall

potential for chlorinated VOCs to adversely affect the terrestrial plant/soil invertebrate community.

- ANC is likely to be the source of the TCE and other chlorinated VOCs to AC1, but the limited frequency of exceedance suggests a localized area of potential adverse effect and a limited overall potential adverse effect to the terrestrial plant/soil invertebrate community at AC1.

1.8 Conceptual Site Model

The following provides a summary of the site conditions based on data collected during the investigation activities at the PVGCS, as presented above. This conceptual site model is intended to provide a summary of site conditions related to the groundwater contamination seen in municipal supply wells in the Valley. The conceptual site model also presents the current understanding of the sources of contamination, the migration pathways and the fate of the contaminants. The model is based on interpretations of the existing data. Additional data, particularly that which are associated with source areas identified at the American National Can (ANC) facility, may result in revisions to the conceptual model as it becomes available.

Chlorinated volatile organic compounds (VOCs), specifically TCE and PCE, were detected in the groundwater from two public, potable-water supply wells in the 1970's. The USEPA then initiated a remedial investigation (RI) to identify and evaluate potential source areas (PSAs) of the chlorinated VOCs, delineate the extent of chlorinated VOC-impacted groundwater, and to evaluate the potential human health and ecological risk based on the occurrence and distribution of chlorinated VOCs in the PVGCS OU1 Study Area. Through various phases of the RI, a total of 107 PSAs were investigated to determine if they were source areas to the regional groundwater contamination within the PVGCS.

Of the PSAs investigated, the analytical results of soil samples collected throughout the Pohatcong Valley have yielded a limited number of soil locations with elevated chlorinated VOCs. Generally, the highest concentrations of TCE in soil were detected at the American National Can (ANC) and Area of Concern 1 (AC1) PSAs. These two PSAs were identified as potentially significant source areas for the TCE groundwater plume based on a comparison of TCE soil concentrations to the New Jersey Impact to Groundwater Soil Cleanup Criteria (IGWSCC) of 1,000 µg/Kg (1 ppm). Based on the concentrations of TCE detected in soils, the total mass of TCE remaining in these soils is estimated at approximately 1,940 pounds. The highest concentrations of PCE in soil were detected at the L&L/Econowash Dry Cleaners (LNL) and Modern Valet Service (MVS), and Tung Sol Tubing/Pohatcong Hosiery (TVN) PSAs. The concentrations of TCE detected at the ANC and AC1 PSAs are much higher than the concentrations of PCE seen at the LNL, MVS, and TVN PSAs and contribute more total contaminant mass to the groundwater plume. However, it is believed that these residual concentrations of PCE seen in soils are related to a historical release that has impacted groundwater.

TCE was likely introduced into the soil at the American National Can (ANC) facility by surface spills and water discharges. Once in the soil, physical processes such as gravity and water infiltration act to enhance vertical migration into the soil column whereas other physical processes such as adhesion and surface tension act to restrain migration and retain

some contaminants within the soil media. The remainder of the release will overcome static physical processes and continue downward migration. These physical processes together result in spreading of TCE and PCE vertically throughout the soil column under the original source areas.

The TCE and PCE groundwater plumes have migrated several miles downgradient from their original sources. The extent of the TCE plume is much larger than the PCE plume, which appears to be more localized in the Borough of Washington. The highest TCE concentrations (560 to 2,100 µg/L, ppb) are located near the ANC/AC1 PSAs and immediately downgradient. The lateral extent of the TCE plume appears to be confined to near the center of the Valley. Based on the plume extent and average concentrations, there appears to be over 8,200 pounds of TCE within the groundwater plume. A groundwater grab sample collected in this area exhibited the highest PCE concentrations (1,500 ug/L at 75 feet bgs), suggesting that a likely source of the PCE may have existed at these PSAs, but that it has since degraded or migrated away from these PSAs. Also there is only an estimated 180 pounds of PCE in the dissolved phase in groundwater.

The focus of the investigation activities completed at the PVGCS has been to evaluate the sources and extent of TCE and PCE present at the site. Although other compounds have been detected over the applicable laboratory analytical method detection limits (MDL) for some samples collected during the investigation (as documented in the RI Report), the focus of this FS is to present remedial alternatives for the chlorinated VOCs found in soil and groundwater, since they were defined as the primary contaminants of concern at the site.

TABLE 1-1
Summary of Remedial Investigation Activities Performed
PVGCS OU1 Study Area Feasibility Study

	Screening Phase	RI Investigation Phase		Total
		Phase 1	Phase 2	
Potential Source Areas (PSAs) Investigated *	107	37	16	** 45
Monitoring Wells Installed		17	28	45
Soil Borings Completed		92	60	152
Regional Water Supply Wells Sampled		29	25	*** 35
Overburden Drilling (total feet)		4,700	2,172	6,872
Bedrock Drilling (total feet)		1,100	1,161	2,261
Packer Tests Completed		22	34	56
Synoptic Groundwater Elevation Surveys (number of wells)		53	138	-----
Aquifer Performance Testing		0	3	3
Borehole Geophysical Survey (total feet)		8,900	2,100	11,000
Surficial Geophysical Survey (total feet)		15,000	8,080	23,080
Onsite Treatment of Investigation-Derived Groundwater (gallons)		120,000	200,000	320,000
Disposal of Investigation-Derived Solid Waste (55-gallon drums)		300	250	550

Notes:

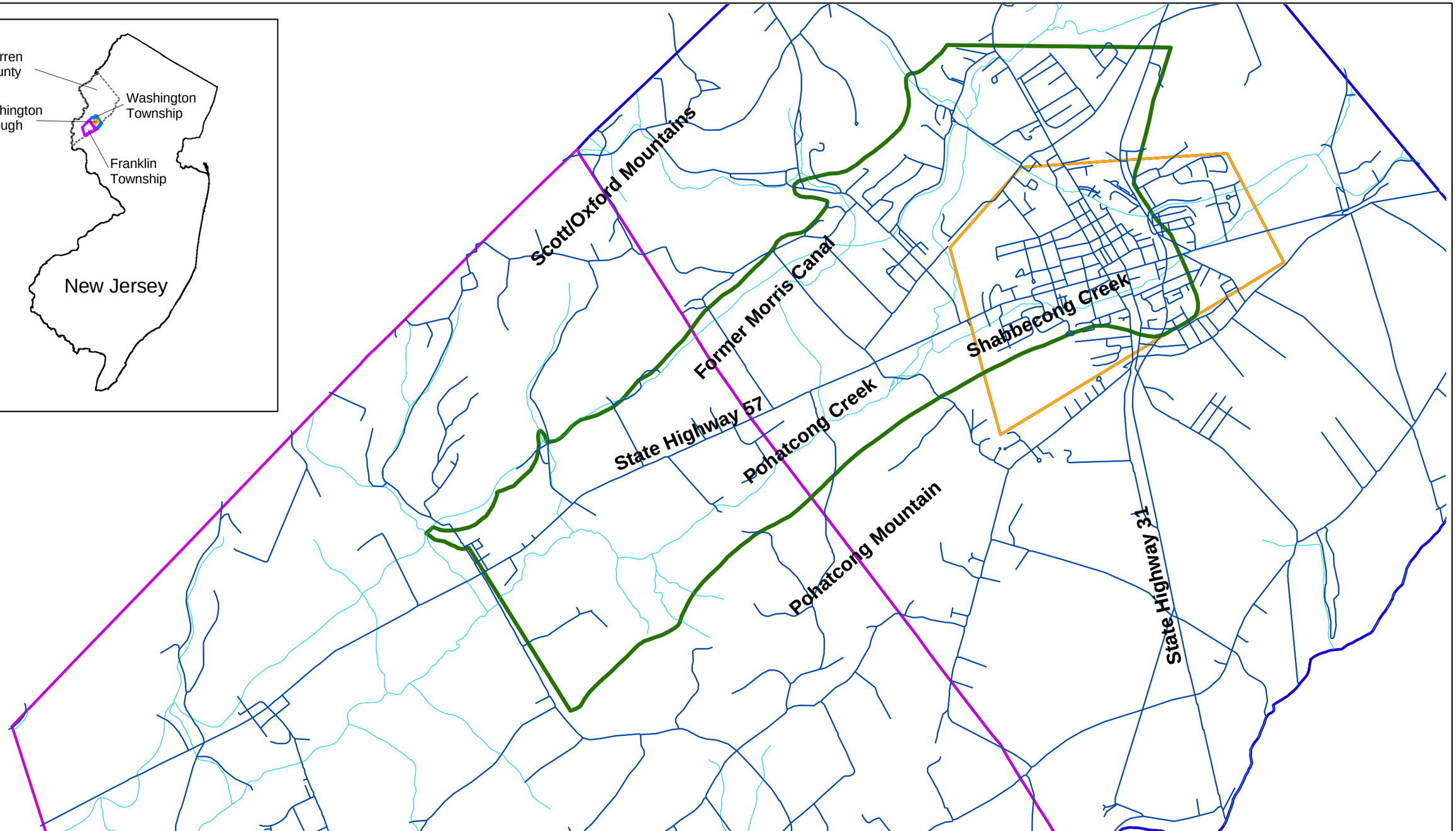
* Screening Phase of the RI identified 107 Potential Source Areas (PSAs). See RI Appendix A for PSA Profiles (ICF Kaiser, February 1999)

** PSA total consists of unique RI activity locations. The number of Phase 2 PSAs includes activities at 7 PSAs investigated where work had previously been performed in Phase 1, but additional delineation during Phase 2 was warranted.

*** Total Regional Water Supply Wells consists of unique RI sampling locations. Six of the 25 wells sampled during Phase 2 were not sampled previously; the remaining 19 wells had also been sampled during Phase 1.

TABLE 1-2
Summary of Environmental Samples Collected
PVGCS OU1 Study Area Feasibility Study

		RI Investigation Phase		
		Phase 1	**Phase 2**	**Total**
Soil Gas Samples		93	0	93
Soil Samples	Surface Soil Samples	19	76	95
	Subsurface Soil Samples	137	167	304
	Total Soil Samples	156	243	399
Groundwater Samples	Monitoring Wells	48	59	107
	Temporary Well Points	52	7	59
	Packer Test Samples	22	34	56
	Domestic Wells	19	16	35
	Other Well Types	17	12	29
	Total Groundwater Samples	158	128	286
Sediment Samples		13	8	21
Surface Water Samples		15	28	43
	Total Environmental Samples	435	407	842



Legend

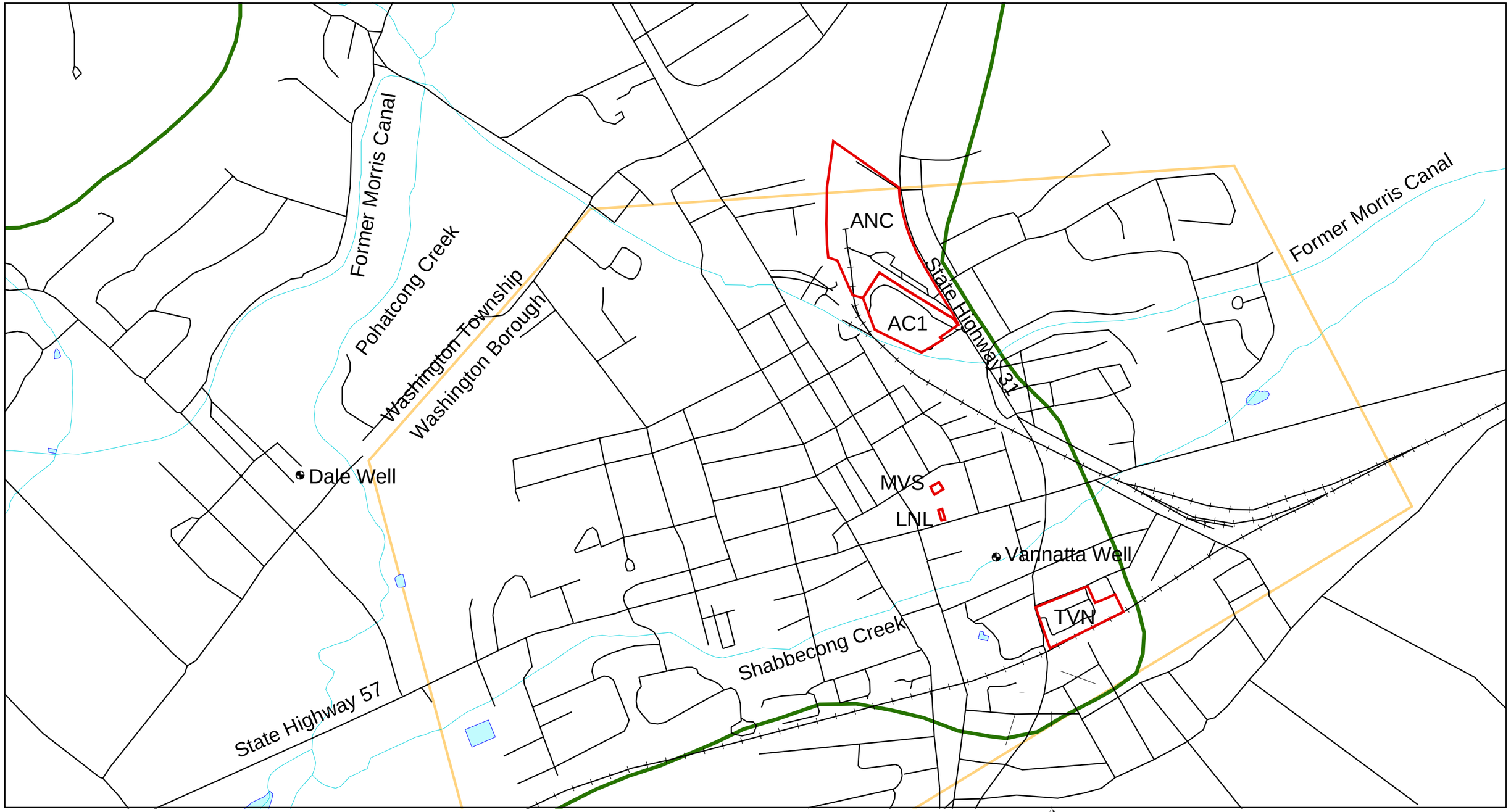
- Pohatcong OU1 Superfund Boundary
- Waterways
- Road Centerlines
- Franklin Township
- Washington Borough
- Washington Township

N

0 0.25 0.5 1 Miles

Figure 1-1
Location of the OU1 Study Area, Pohatcong Valley Groundwater Contamination Site
Feasibility Study
Pohatcong Valley, NJ

CH2MHILL



Legend

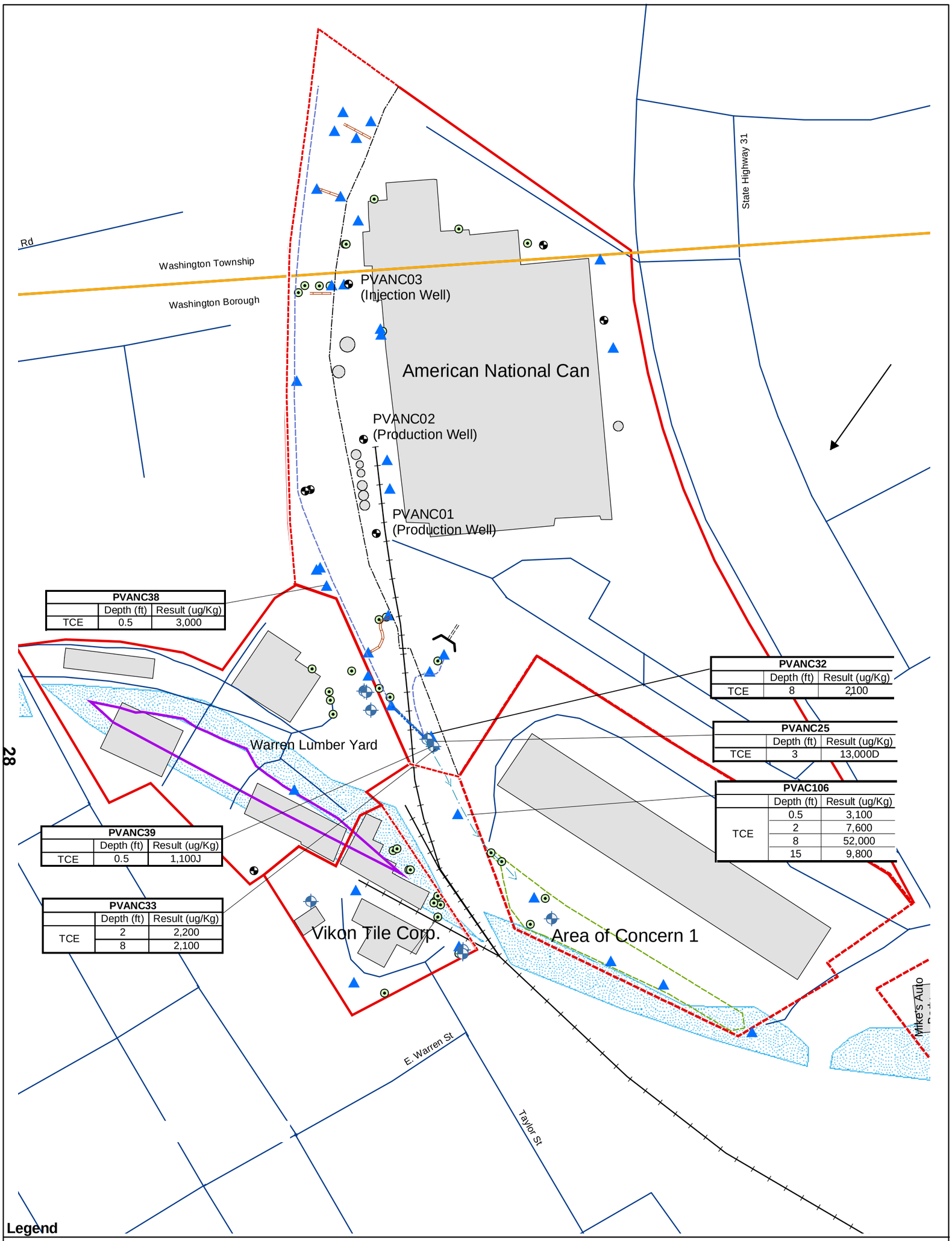
- Vannatta Well & Dale Well
- Approximate PSA Boundaries
- Road Centerlines
- Existing Railroad
- Pohatcong OU1 Study Area
- Standing Water
- Waterways
- Washington Borough

N

0 375 750 1,500 Feet

Figure 1-2
Soil Source Area PSAs
OU1 Feasibility Study
Pohatcong Valley, NJ

CH2MHILL



Legend

- Phase 1 Well Locations
- Phase 1 Sampling Locations
- Phase 2 Well Locations
- Phase 2 Sampling Locations
- Road Centerlines
- PSA Boundary (Approximate) with Fence
- PSA Boundary (Approximate) without Fence
- Area of Concern 1 -- Basin Area
- Fence Line (Approximate)
- Railroad Underdrain

J - Estimated quantity
D- Diluted sample analysis

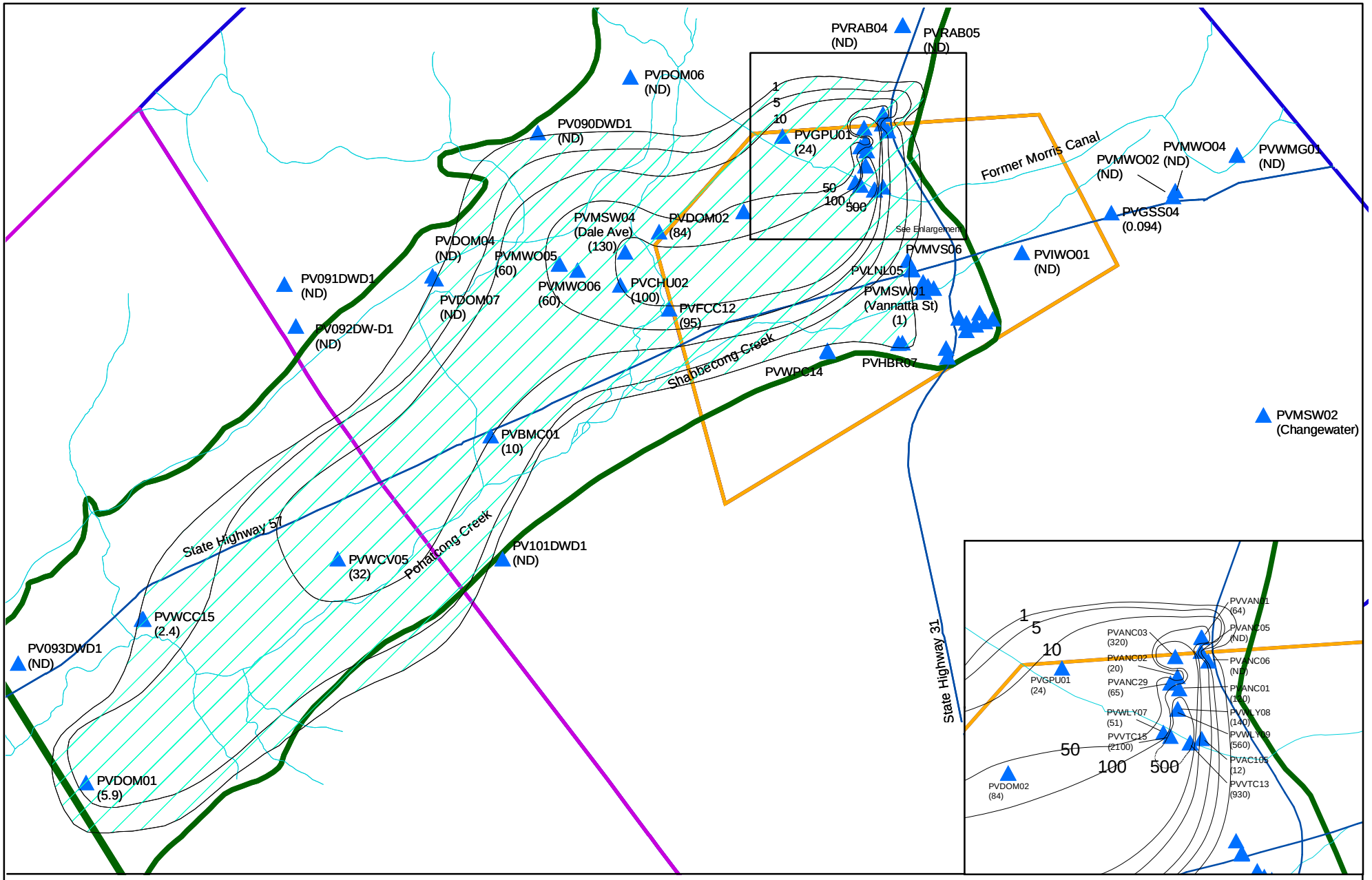
- Approximate Regional Groundwater Flow Direction
- Existing Railroad
- Former Morris Canal (Approximate)
- Washington Borough
- Former Morris Canal Island (Approximate)
- Structures
- Stormwater Runoff (presumed former path of flow)
- Stormwater Runoff (current path of flow)
- Railroad Underdrain
- Incised Channel
- Concrete Discharge Structure
- Pipeline
- ANC Production/Injection Wells

N

0 125 250 500 Feet

Figure 1-3
Soil Samples Exceeding PRGs
OU1 Feasibility Study
Pohatcong Valley, NJ

CH2MHILL



Legend

- Sampling Locations
- Waterways
- Road Centerlines
- Pohatcong OU1 Study Area
- Area Exceeding NJDEP Groundwater Quality Standards (1 ug/L)
- Franklin Township
- Washington Borough
- Washington Township

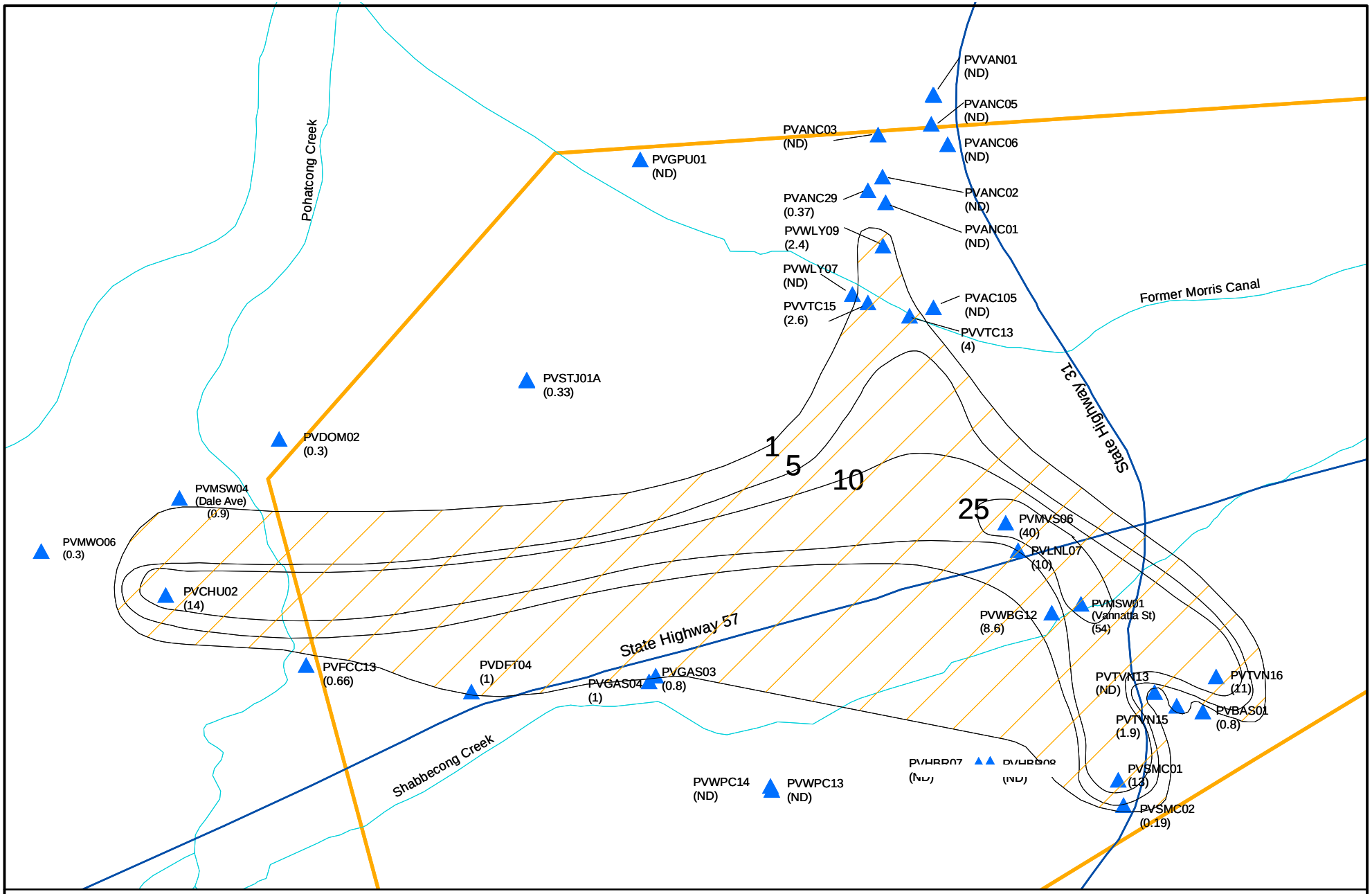
(32) - Concentration of TCE in ug/L
ND - Not detected above method detection limit

N

0 0.5 1 Mile

Figure 1-4
Extent of TCE Contamination
OU1 Feasibility Study
Pohatcong Valley, NJ

CH2MHILL



Legend

- Sampling Locations
- Waterways
- Road Centerlines
- Washington Borough
- Area Exceeding NJDEP Groundwater Quality Standards (1 ug/L)

(32) - Concentration of PCE in ug/L
ND - Not detected above the method detection limit

N

0 500 1,000 2,000 Feet

Figure 1-5
Extent of PCE Contamination
OU1 Feasibility Study
Pohatcong Valley, NJ

CH2MHILL

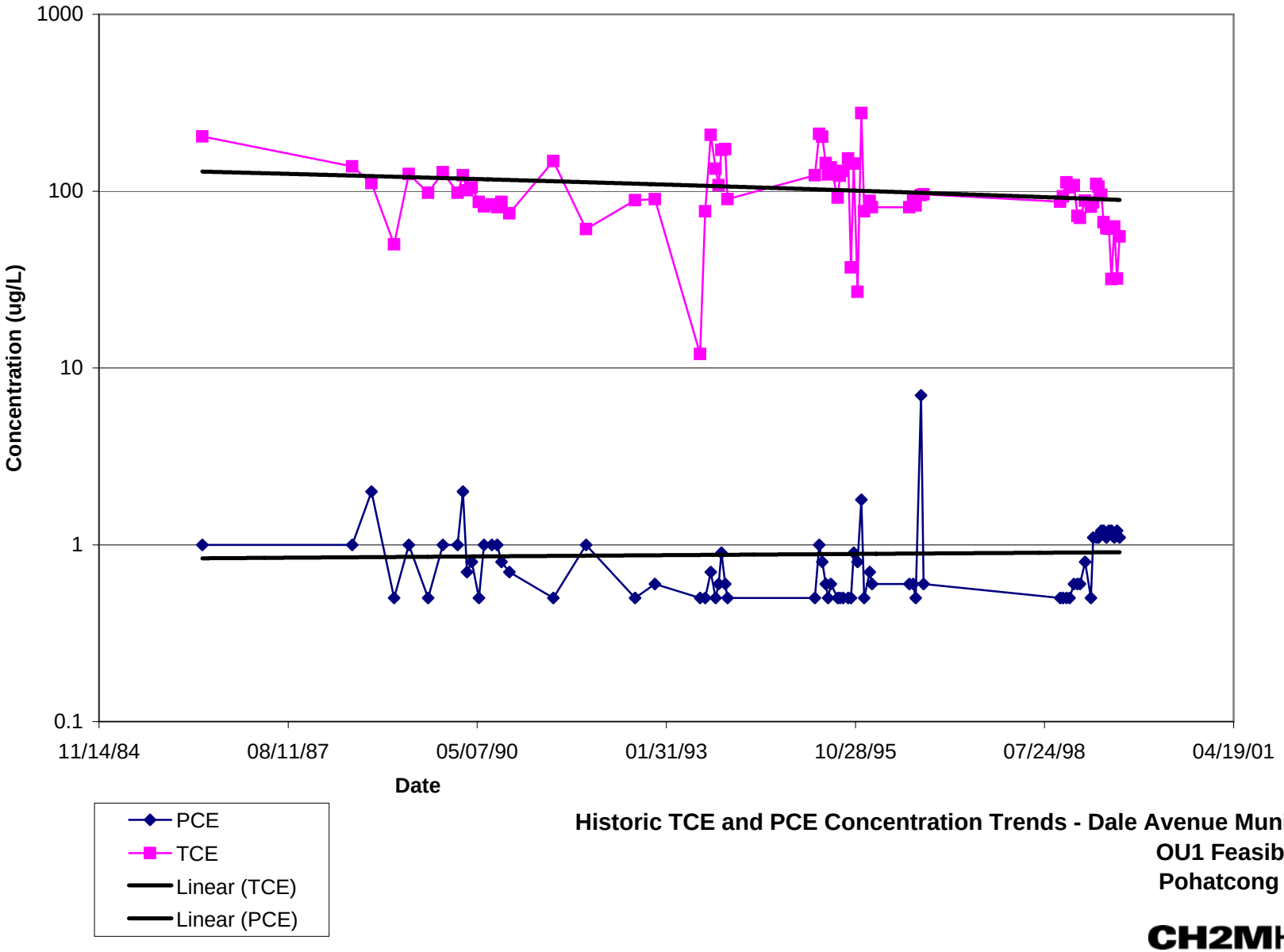


Figure 1-6
Historic TCE and PCE Concentration Trends - Dale Avenue Municipal Well
OU1 Feasibility Study
Pohatcong Valley, NJ

CH2MHILL

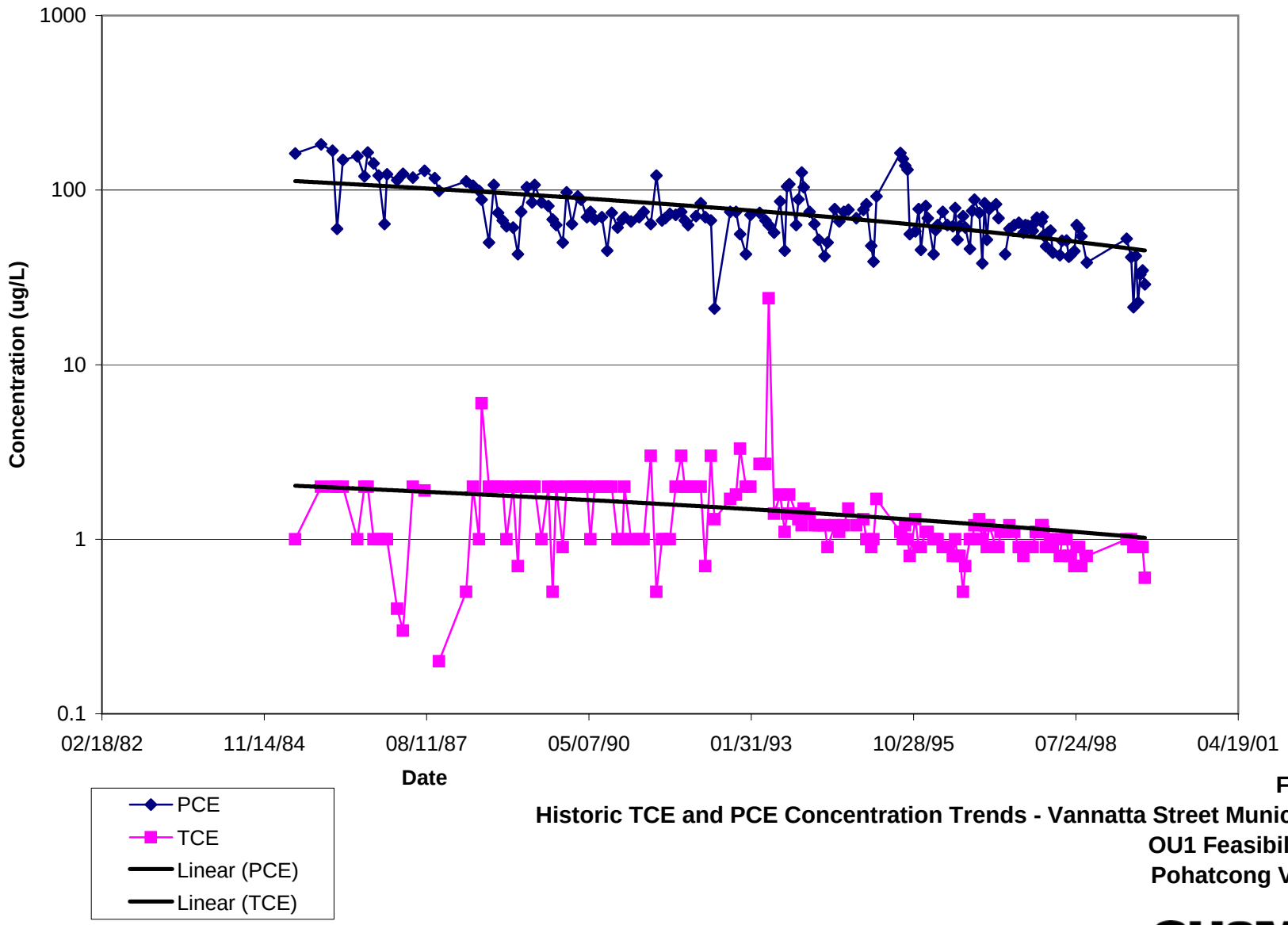


Figure 1-7
Historic TCE and PCE Concentration Trends - Vannatta Street Municipal Well
OU1 Feasibility Study
Pohatcong Valley, NJ

CH2MHILL

2.0 Development and Identification of ARARs, RAOs, and PRGs

2.1 Summary of Applicable or Relevant and Appropriate Requirements

Remedial actions must be protective of public health and the environment. Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or exceed Applicable or Relevant and Appropriate Requirements (ARARs). The purpose of this requirement is to make CERCLA response actions consistent with other pertinent federal and state environmental requirements, as well as to adequately protect public health and the environment.

Definitions of the ARARs and the "to be considered" (TBC) criteria are given below:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, environmental action, location, or other circumstance at a CERCLA site.
- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law, which while not "applicable," address problems or situations sufficiently similar (relevant) to those encountered at a CERCLA site, that their use is well suited (appropriate) to the particular site.
- TBC criteria are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing an interim remedial action, or are necessary for evaluating what is protective to human health and/or the environment. Examples of TBC criteria include the NJDEP Soil Cleanup Criteria (combined Tables 3-2 and 7-1 from the NJDEP's February 3, 1992 proposed rule titled Cleanup Standards for Contaminated Sites N.J.A.C. 7:26D), which includes the Residential Direct Contact Soil Cleanup Criteria (RDCSCC), the Non-Residential Direct Contact Soil Cleanup Criteria (NRDCSCC), and Impact to Groundwater Soil Cleanup Criteria (IGWSCC), as well as the USEPA Drinking Water Health Advisories, Reference Doses, and Cancer Slope Factors.

Another factor in determining which requirements must be addressed is whether the requirement is substantive or administrative. "Onsite" CERCLA response actions must comply with the substantive requirements but not with the administrative requirements of environmental laws and regulations as specified in the National Contingency Plan (NCP), 40 CFR 300.5, definitions of ARARs and as discussed in 55 FR 8756. Substantive requirements are those pertaining directly to actions or conditions in the environment. Administrative requirements are mechanisms that facilitate the implementation of the substantive requirements of an environmental law or regulation. In general, administrative

requirements prescribe methods and procedures (e.g., fees, permitting, inspection, reporting requirements) by which substantive requirements are made effective for the purposes of a particular environmental or public health program.

ARARs are grouped into three types: chemical-specific, location-specific, and action-specific. Included in Appendix B are the chemical-specific, action-specific, and location-specific ARARs for the Pohatcong Valley Groundwater Contamination Site (PVGCS) Operable Unit 1 (OU1) Study Area.

2.1.1 Chemical Specific ARARs

Chemical-specific ARARs include laws and requirements that establish health- or risk-based numerical values or methodologies for environmental contaminant concentrations or discharge. The chemical-specific ARARs for the OU1 Study Area can be classified into two categories: (1) residual concentrations of compounds that can remain at the site after treatment without presenting a threat to human health and the environment; and (2) land disposal restriction (LDR) concentrations that must be achieved if the contaminated media that is either a characteristic hazardous waste or contains a listed hazardous waste is excavated or extracted and later land disposed. Also, effluent concentrations that must be achieved in treatment of groundwater for discharge are also considered as chemical-specific ARARs.

2.1.1.1 Residual Concentrations

Potential ARARs or TBC for residual soil concentrations include the New Jersey Soil Cleanup Criteria (combined Tables 3-2 and 7-1 from the NJDEP's February 3, 1992 proposed rule titled Cleanup Standards for Contaminated Sites N.J.A.C. 7:26D), which includes the RDCSCC, the NRDCSCC, and the IGWSCC. For groundwater, Safe Drinking Water Act (SDWA) MCLs, the NJ GWQS (N.J.A.C. 7:9-6), and the New Jersey Secondary Drinking Water Standards (N.J.A.C. 7:10-7) are ARARs.

2.1.1.2 LDR Concentrations

The Resource Conservation and Recovery Act (RCRA) land disposal restrictions (LDRs) would apply to remedial actions performed at the site if waste generated by the remedial action (e.g., contaminated soil) contains a RCRA hazardous waste. Listed hazardous wastes as defined by RCRA regulation are not known to have been released at the site. As a result, excavated soils would not be required to be managed as listed hazardous wastes. If excavated and removed from the area of contamination (i.e., the soil is "generated"), the soil may be a characteristic hazardous waste.

Generated soils that exceed the Toxicity Characteristic Leaching Procedure (TCLP) limit must be managed as a hazardous waste and must meet the LDR Treatment Standards for contaminated soil (40CFR 268.49). The treatment standard for contaminated soil is the higher value of a 90 percent reduction in constituent concentrations or 10 times the Universal Treatment Standards (UTS). Treatment is required for the constituent (such as TCE or PCE) for which the soil is a characteristic hazardous waste as well as other "underlying hazardous constituents". Generators of contaminated soil can apply reasonable knowledge of the likely contaminants present to select constituents for monitoring (USEPA, October 1998. *Management of Remediation Waste Under RCRA*, EPA530-F-98-026).

2.1.2 Action Specific ARARs

Action-specific ARARs regulate the specific type of action or technology under consideration, or the management of regulated materials. The most important action-specific ARARs that may affect the remedial action objective (RAOs) and the development of remedial action alternatives is RCRA. RCRA regulations governing the identification, management, treatment, storage, and disposal of solid and hazardous waste would be ARARs for alternatives that generate waste that would be moved to a location outside the area of contamination. Such alternatives could include excavation of impacted soils. Requirements include waste accumulation, record keeping, container storage, disposal, manifesting, transportation and disposal. If any generated soil is characteristic hazardous waste, RCRA LDRs would apply and treatment would be required in accordance with RCRA prior to disposal. This includes treatment of other underlying hazardous constituents as required by 40 CFR 268.9(a).

2.1.3 Location Specific ARARs

Location-specific ARARs are requirements that relate to the geographical position of the site. State and federal laws and regulations that apply to the protection of wetlands, construction in floodplains, and protection of endangered species in streams or rivers are examples of location-specific ARARs.

2.2 Remedial Action Objectives

The USEPA *Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites* (USEPA, 1988a) and the NCP define RAOs as medium-specific or site-specific goals for protecting human health and the environment that are established on the basis of the nature and extent of the contamination, the resources that are currently and potentially threatened, and the potential for human and environmental exposure. Remediation goals are site-specific, quantitative goals that define the extent of cleanup required to achieve the RAOs. In this section, the RAOs have been developed for impacted soil and groundwater within the OU1 Study Area. RAOs have been based on the exposure pathways found to present unacceptable risks during the human health risk assessment (HHRA).

2.2.1 Remedial Action Objectives (RAOs) for Soil

The analytical results of surface and subsurface soil samples collected throughout the OU1 Study Area have yielded a limited number of chlorinated VOCs detected over the method detection limits. The highest concentrations of TCE in soils found during the OU1 RI are at the American National Can/Area of Concern 1 (ANC/AC1) PSAs, and represent a likely on-going source of TCE to groundwater and a potential impact to human health through direct contact or inhalation. The groundwater in the ANC/AC1 area and PSAs immediately downgradient (Vikon Tile Corporation [VTC] and Warren Lumber Yard [WLY] PSAs) exhibit the highest TCE concentrations throughout the OU1 Study Area, suggesting a likely nearby soil source of TCE.

The highest concentration of PCE in soils was found at the LNL/MVS and TVN areas, although detected at much lower concentrations, suggesting that the soils impacted with

PCE may no longer represent a significant on-going source to groundwater. PCE has not been detected in soil above the NJ IGWSCC of 1 ppm.

The main RAO for soils is to develop alternatives that will mitigate risks to onsite receptors, whether they are recreational users, industrial or construction workers, or potential residential future-users. In addition, contaminated soil at some locations within the OU1 Study Area may continue to be a source of contamination to groundwater. Consequently, an additional objective for remediating the contaminated soil is to allow the goals for groundwater remediation to be met. The RAOs for soil include the following:

- Prevention of human exposure, through contact, ingestion, or inhalation to contaminated soil that presents an unacceptable risk (i.e., hazard index [HI] greater than 1 or excess lifetime cancer risk (ELCR) greater than $1x10^{-4}$ to $1x10^{-6}$).
- Prevention of erosion and offsite transport of soils contaminated at concentrations posing unacceptable risk (i.e., HI greater than 1 or ELCR greater than $1x10^{-4}$ to $1x10^{-6}$).
- Remediation of contaminated soils, as necessary, to prevent further leaching of contaminants to groundwater that result in exceedances of NJ GWQS (1 ppb).

2.2.1.1 Prevent Human Exposure through Contact, Ingestion, or Inhalation

This RAO is intended to prevent unacceptable risks to potential future industrial/excavation worker, recreational users, or residential users within the area of the site as a result of exposure to contaminated soils.

2.2.1.2 Prevent Erosion and Offsite Transport

Possible erosion of surficial soils could result in the offsite migration of TCE or PCE at concentrations posing unacceptable risks through direct contact, ingestion, or inhalation. This RAO is intended to prevent unacceptable risks to offsite residents or workers as a result of exposure to contaminated soils.

2.2.1.3 Remediate Contaminated Soils to Control Leaching

Soil analytical data indicate that subsurface soil at the ANC/AC1 PSAs contain elevated concentrations of TCE, that are likely an original source to groundwater contamination. Also, the highest concentrations of TCE have been detected in groundwater at the ANC/AC1 PSAs and at PSAs immediately downgradient. Based on these results, it is apparent that contamination in soil has leached to the groundwater and will likely continue to leach in the absence of site remediation. The amount of leaching should be controlled to the extent that it does not result in continued loading to groundwater sufficient to cause further expansion of the groundwater plume, or result in an unreasonable time to remediate the groundwater.

2.2.2 RAOs for Groundwater

The TCE plume extends downgradient within the OU1 Study Area and appears to emanate from the ANC and AC1 PSAs (see Figure 1-3), based on concentrations of TCE detected in PSAs along the groundwater flow path. The groundwater in the MVS/LNL area (with a PCE concentration of 1,500 µg/L collected from a grab groundwater sample at 75 feet bgs)

exhibits the highest PCE concentrations throughout the OU1 Study Area (Figure 1-4). PCE was also detected at concentrations above the NJ GWQS in groundwater at the TVN site. As the PCE concentrations in soils from the MVS/LNL/TVN areas do not exceed the NJ IGWSCC, the likely source of the PCE has since degraded or migrated away.

The main RAO for groundwater is to develop alternatives that will mitigate risks to groundwater receptors. The focus will be to reduce risks in the vicinity of soil source areas, local public supply wells in the OU1 Study Area, and residential homes using groundwater for potable purposes (i.e., homes within OU1 that have not connected to potable water supplies). The RAOs for remediation of groundwater at PVGCS include the following:

- Restoration of the groundwater aquifer to drinking water quality in a reasonable timeframe.
- Prevention of human ingestion of contaminated groundwater that presents an unacceptable risk (i.e., NJ GWQS, MCLs, or in the absence of MCLs or NJ GWQS, a hazard index [HI] greater than 1 or excess lifetime cancer risk [ELCR] greater than $1x10^{-4}$ to $1x10^{-6}$) to existing and potential groundwater users in the area (including the municipal supply wells and the residents within the OU1 Study Area that have not connected to potable water).

2.3 Preliminary Remediation Goals (PRGs)

To meet the RAOs for the OU1 Study Area, Preliminary Remediation Goals (PRGs) were developed to aid in defining the extent of contaminated media requiring remedial action. This section presents the PRGs for the OU1 Study Area. The PRGs were used to establish media-specific concentrations of chlorinated VOCs that will eliminate unacceptable risks to human health and the environment.

2.3.1 PRGs for Soil

Based on the potential exposure risks and the RAOs, soil PRGs were developed for the exposure, depending on the current or proposed future use of each PSA. The human health exposure pathways include both the residential and non-residential exposures. The soil PRGs were developed for ingestion, dermal contact, and inhalation human health exposure pathways.

Soil PRGs for each of the above pathways are presented in Table 2-1. Included are the New Jersey Soil Cleanup Criteria (N.J.A.C. 7:7-1) for non-residential and residential land use, direct contact, and protection of groundwater soil cleanup criteria. Soil media cleanup levels for inhalation and ingestion are also included based on the USEPA methodology in the Soil Screening Guidance (*USEPA, 1996 – Soil Screening Guidance User's Manual, OSWER Publication 9355.4-23*). The New Jersey Impact to Groundwater Soil Cleanup Criteria were selected by the USEPA as PRGs, specifically a concentration goal of 1 mg/Kg (1 ppm) for both TCE and PCE. This PRG was used to develop the areas exceeding PRGs that will be the focus of remedial action for soils.

2.3.2 PRGs for Groundwater

PRGs were developed for groundwater based on the RAOs for the site and are summarized in Table 2-2. The USEPA Federal MCLs and the New Jersey Groundwater Quality Standards (GWQS) were identified. For this site, USEPA has selected the New Jersey GWQS of 1 µg/L (1 ppb) for both TCE and PCE to be used as PRGs.

2.4 Contaminated Media Exceeding PRGs

The areas exceeding PRGs for soil and groundwater at the PVGCS were developed by comparing results with the NJ IGWSCC and the NJ GWQS, respectively. Below is a discussion of the areas of soil and groundwater exceeding the PRGs.

2.4.1 Soil

The soil areas with chlorinated VOC concentrations exceeding the IGWSCC (concentrations of 1,000 µg/Kg (1 ppm) for both TCE and PCE) were identified at two PSAs: American National Can (ANC) and the adjacent Area of Concern 1 (AC1). These areas were identified for both surface soils and subsurface soils (Figure 2-1). In addition, ANC C, the suspected area under the ANC building, was identified as a new target cleanup area pending further investigation during the Remedial Design. The NJ IGWSCC for PCE was not exceeded in the areas investigated.

Figure 2-1 illustrates the target cleanup areas of TCE soil contamination at the ANC/AC1 PSAs. TCE was detected at concentrations over 1,000 µg/Kg (1 ppm) in target cleanup areas ANC A and ANC B. It has been assumed for costing purposes in this FS that ANC A will require remediation to the water table (a depth of approximately 100 feet). At ANC B, the target cleanup area west of the existing rail line, the remedial target cleanup area is shallow with TCE exceeding the PRG depth of 2 feet below grade. It has been assumed for costing purposes in this FS that the vertical depth of this target cleanup area is 5 feet deep. ANC C is assumed for costing purposes to contain TCE distributed similarly to ANC A over an approximately 16,000 square foot area. Appendix A explains in more detail how the volume of ANC C was estimated.

2.4.2 Groundwater

Figure 2-2 depicts the area within the OU1 Study Area with TCE concentrations exceeding the PRG (the NJ GWQS). This area encompasses approximately 2,050 acres and extends about 28,000 feet downgradient from the source area located in Washington Borough. Figure 2-3 depicts the area with PCE concentrations exceeding NJ GWQS. This area encompasses approximately 149 acres and extends approximately 6,000 feet downgradient from the source area located in Washington Borough. Both compounds have been detected at depths of more than 200 feet below the water table.

Table 2-1
Soil PRGs
PVGCS OU1 Study Area Feasibility Study

Parameter	NJDEP Soil Cleanup Criteria (mg/Kg)						EPA Generic SSLs[a] (mg/Kg)			
	Residential		Non Residential		Protection of GW		Ingestion		Inhalation Volatiles	
Acetophenone										
Aldrin	0.04		0.17		50		0.04	(e)	3	(e)
Aluminum										
Antimony	14		340			(h)	31	(b)	---	(c)
Arsenic	20	(e)	20	(e)		(h)	0.4	(e)	750	(e)
Barium	700		47000	(n)		(h)	5500	(b)	690000	(b)
Benzene	3		13		1		22	(e)	0.8	(e)
Benzo(a)anthracene	0.9		4		500		0.9	(e)	---	(c)
Benzo(a)pyrene	0.66	(f)	0.66	(f)	100		0.09	(e)(f)	---	(c)
Benzo(b)fluoranthene	0.9		4		50		0.9	(e)	---	(c)
Benzo(k)fluoranthene	0.9		4		500		9	(e)	---	(c)
Bromomethane	79		1000	(d)	1					
Cadmium	39		100			(h)	78	(b)(m)	1800	(e)
Carbazole							32	(e)	---	(c)
Chlordane - alpha							0.5	(e)	20	(e)
Chloroform	19	(k)	28	(k)	1		100	(e)	0.3	(e)
Chromium	240	(g)	20	(i)		(h)	390	(b)	270	(e)
Chrysene	9		40		500		88	(e)	---	(c)
Copper	600	(m)	600	(m)		(h)				
DDE-4,4'	2		9		50		2	(e)	---	(c)
DDT-4,4'	2		9		500		2	(e)	---	(g)
Dibenzo(a,h)anthracene	0.66	(f)	0.66	(f)	100		0.09	(e)(f)	---	(c)
Dibenzofuran										
Dichloroethylene-1,2 cis	79		1000	(d)	1		780	(b)	1200	(d)
Dieldrin	0.042		0.18		50		0.04	(e)	1	(e)
Ethylbenzene	1000	(d)	1000	(d)	100		7800	(b)	400	(d)
Fluoranthene	2300		10000	(c)	100		3100	(b)	---	(c)
Heptachlor	0.15		0.65		50		0.1	(e)	4	(e)
Heptachlor Epoxide							0.07	(e)	5	(e)
Indeno(1,2,3-cd)pyrene	0.9		4		500		0.9	(e)	---	(c)
Iron										
Lead	400	(p)	600	(q)		(h)	400	(k)	---	(k)
Manganese										
Mercury	14		270			(h)	23	(b)(l)	10	(b)(i)
Naphthalene	230		4200		100		3100	(b)	---	(c)
Nickel	250		2400	(k,n)		(h)	1600	(b)	13000	(e)
Pcb-araclor 1254	0.49		2		50		1	(h)	---	(h)
Pcb-araclor 1260	0.49		2	**	50	**	1	(h)	---	(h)
Phenanthrene										
Phthalate, bis(2-ethylhexyl) (DEHP)	49		210		100		46	(e)	31000	(d)
Pyrene	1700		10000	(c)	100		2300	(b)	---	(c)
Silver	110		4100	(n)		(h)	390	(b)	---	(c)
Tetrachloroethylene	4	(k)	6	(k)	1		12	(e)	11	(e)
Thallium	2	(f)	2	(f)		(h)	---	(c)	---	(c)
Toluene	1000	(d)	1000	(d)	500		16000	(b)	650	(d)
Trichloroethylene	23		54	(k)	1		58	(e)	5	(e)
Vanadium	370		7100	(n)		(h)	550	(b)	---	(c)
Vinyl chloride	2		7		10		0.3	(e)	0.03	(e)
Xylenes, total	410		1000	(d)	67	(s)				
Zinc	1500	(m)	1500	(m)		(h)	23000	(b)	---	(c)

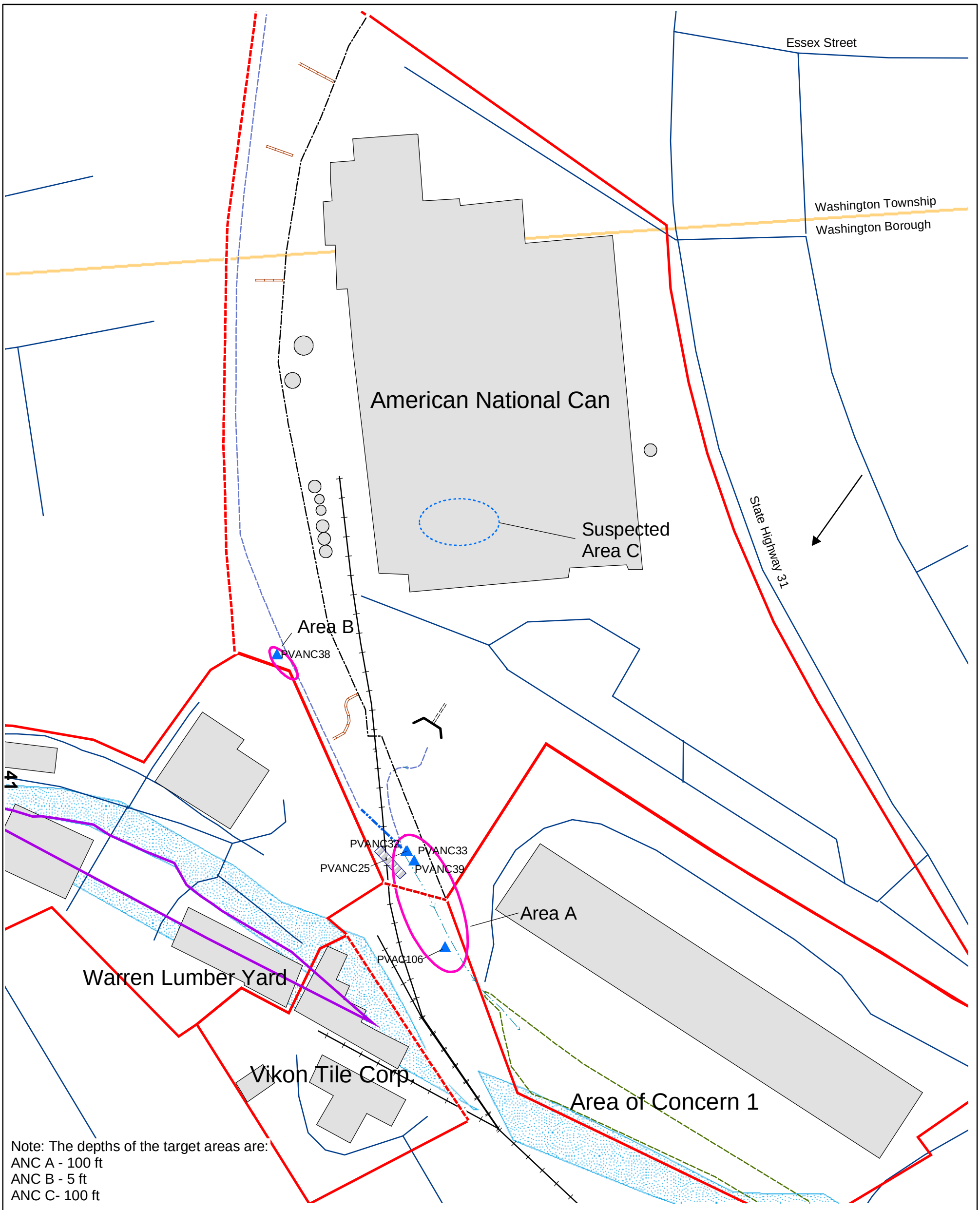
General Notes
Units are presented in mg/Kg
a - Provisional PRG 2000
b - Heptachlor used as surrogate
c - Total Chromium (1:6 ratio Cr VI:Cr III)+++ used as surrogate
d - Mercury chloride used as surrogate
e - Pyrene used as surrogate
ca - Cancer PRG
ca* (where: nc < 100X ca) ca**(where: nc < 10X ca)
nc - Noncancer PRG
sat - Soil Saturation
max - Ceiling limit
PRG - Preliminary Remediation Goal
SSL - Soil Screening Level
DAF - Dilution and attenuation factor

NJDEP Soil Cleanup Criteria Notes
(c) Health based criterion exceeds the 10,000 mg/Kg maximum for total organic contaminant
(d) Health based criterion exceeds the 1000 mg/Kg maximum for total volatile organic contaminants.
(e) Cleanup standard proposal was based on natural background.
(f) Health based criterion is lower than analytical limits; cleanup criterion based on practical quantitation level.
(g) Criterion based on the inhalation exposure pathway.
(h) The impact to ground water values for inorganic constituents will be developed based upon site specific chemical and physical parameters.
(i) Site specific determination required for SCC for the allergic contact dermatitis exposure pathway.
(k) Criteria based on inhalation exposure pathway, which yielded a more stringent criterion than the incidental ingestion exposure pathway.
(m) Criterion based on ecological (phytotoxicity) effects.
(n) Level of the human health based criterion is such that evaluation for potential environmental impacts on a site by site basis is recommended.
(p) Criterion based on the USEPA Integrated Exposure Uptake Biokinetic (IEUBK) model utilizing the default parameters.
The concentration is considered to protect 95% of target population (children) at a blood lead level of 10 ug/dl.
(q) Criteria were derived from a model developed by the Society for Environmental Geochemistry and Health (SEGH) and were designed to be protective for adults in the workplace.
(s) Criterion based on new drinking water standard.
** PCBs (Polychlorinated biphenyls) criteria are used.

Table 2-2
Groundwater PRGs
PVGCS OU1 Study Area Feasibility Study

ParamName	Federal MCL ug/L	Source	NJDEP Groundwater Quality Standards ug/L	Source
Aluminum		nc	200	N.J.A.C. 7:9-6
Antimony	6	nc	20	N.J.A.C. 7:9-6
Arsenic	10	ca	8	N.J.A.C. 7:9-6
Barium	2000	nc	2,000	N.J.A.C. 7:9-6
Benzene	5	ca*	1.0	N.J.A.C. 7:9-6
Beryllium	4	nc	20	N.J.A.C. 7:9-6
Cadmium	5	nc	4	N.J.A.C. 7:9-6
Chlordane - alpha	2	ca	0.50	(c) - N.J.A.C. 7:9-6
Chloroethane		ca	100	GWQS Interim
Chromium	100	nc	100	N.J.A.C. 7:9-6
Cobalt		nc	100	GWQS Interim
Copper	1300	nc	1,000	N.J.A.C. 7:9-6
Cresol-o		nc	350	Calculated
Cresol-p		nc	35	Calculated
Dichlorobenzene-1,3		nc	600	N.J.A.C. 7:9-6
Dichlorobenzene-1,4	75	ca	75	N.J.A.C. 7:9-6
Dichloroethane-1,1		nc	50	GWQS Interim
Dichloroethane-1,2	5	ca*	2.0	N.J.A.C. 7:9-6
Dichloroethene-1,2 trans	100	nc	100	N.J.A.C. 7:9-6
Dichloroethylene-1,2 cis	70	nc	70	GWQS Interim
Dichloropropane-1,2	5	ca*	1.0	N.J.A.C. 7:9-6
Dieldrin		ca	0.030	N.J.A.C. 7:9-6
Ether, bis(2-chloroethyl)		ca	10	N.J.A.C. 7:9-6
Ethylbenzene	700	ca	700	N.J.A.C. 7:9-6
Heptachlor Epoxide	0.2	ca*	0.20	N.J.A.C. 7:9-6
Iron		nc	300	N.J.A.C. 7:9-6
Manganese		nc	50	N.J.A.C. 7:9-6
Methyl isobutyl ketone (4-methyl-2-pentanone)		nc	400	N.J.A.C. 7:9-6
Methyl tertiary butyl ether (MTBE)		ca	70	GWQS Interim
Naphthalene		nc	300	GWQS Interim
Nickel		nc	100	N.J.A.C. 7:9-6
Nitrosodiphenylamine-n		ca	20	N.J.A.C. 7:9-6
Phenol		nc	4,000	N.J.A.C. 7:9-6
Selenium	50	nc	50	N.J.A.C. 7:9-6
Tetrachloroethylene	5	ca	1	N.J.A.C. 7:9-6
Thallium	2	nc	10	N.J.A.C. 7:9-6
Trichloroethane-1,1,2	5	ca	3	N.J.A.C. 7:9-6
Trichloroethylene	5	ca	1	N.J.A.C. 7:9-6
Vanadium		nc	49	Calculated
Vinyl chloride	2	ca	5	N.J.A.C. 7:9-6
Xylenes, total	10000	nc	1,000	GWQS Interim
Zinc		nc	5,000	N.J.A.C. 7:9-6

NOTE:
Units are presented in ug/L
a - Heptachlor used as surrogate
b - Chromium VI+++ used as surrogate
c - Chlordane used as surrogate
ca - Cancer PRG
ca* (where: nc < 100X ca) ca**(where: nc < 10X ca)
nc - Noncancer PRG
MCL - Maximum Contaminant Level
GWQS - NJDEP Groundwater Quality Standards
N.J.A.C. 7:9-6 - NJDEP Ground Water Quality Standards
Calculated - calculated according to N.J.A.C. 7:9-6.7.



Legend

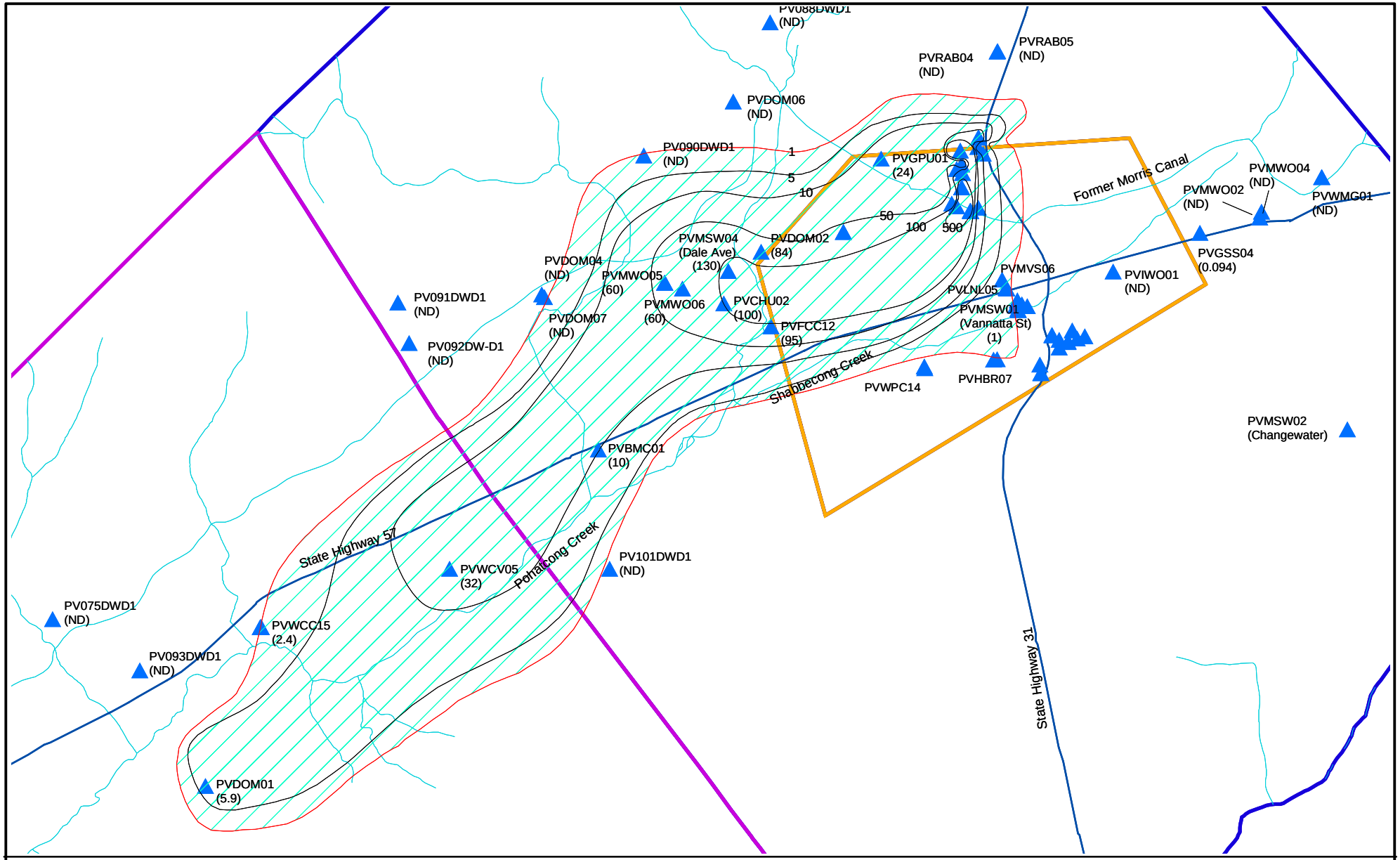
- Sampling Locations
- PSA Boundary (Approximate) with Fence
- PSA Boundary (Approximate) without Fence
- Area of Concern 1-- Basin Area
- Former Morris Canal (Approximate)
- Concrete Pipe Under Railroad Tracks
- Areas Exceeding PRGs
- Fence Line (Approximate)
- Approximate Regional Groundwater Flow Direction
- Existing Railroad
- Road Centerlines
- Former Morris Canal Island (Approximate)
- Structures
- Suspected Area C
- Stormwater Runoff (presumed former path of flow)
- Stormwater Runoff (current path of flow)
- Railroad Underdrain
- Incised Channel
- Concrete Discharge Structure
- Pipeline

Figure 2-1
ANC Target Cleanup Areas
OU1 Feasibility Study
Pohatcong Valley, NJ

N

0 62.5 125 250 Feet

CH2MHILL



Legend

- Sampling Locations
- Waterways
- Road Centerlines
- Franklin Township
- Washington Borough
- Washington Township
- Area Exceeding NJDEP Groundwater Quality Criteria (1 ug/L)

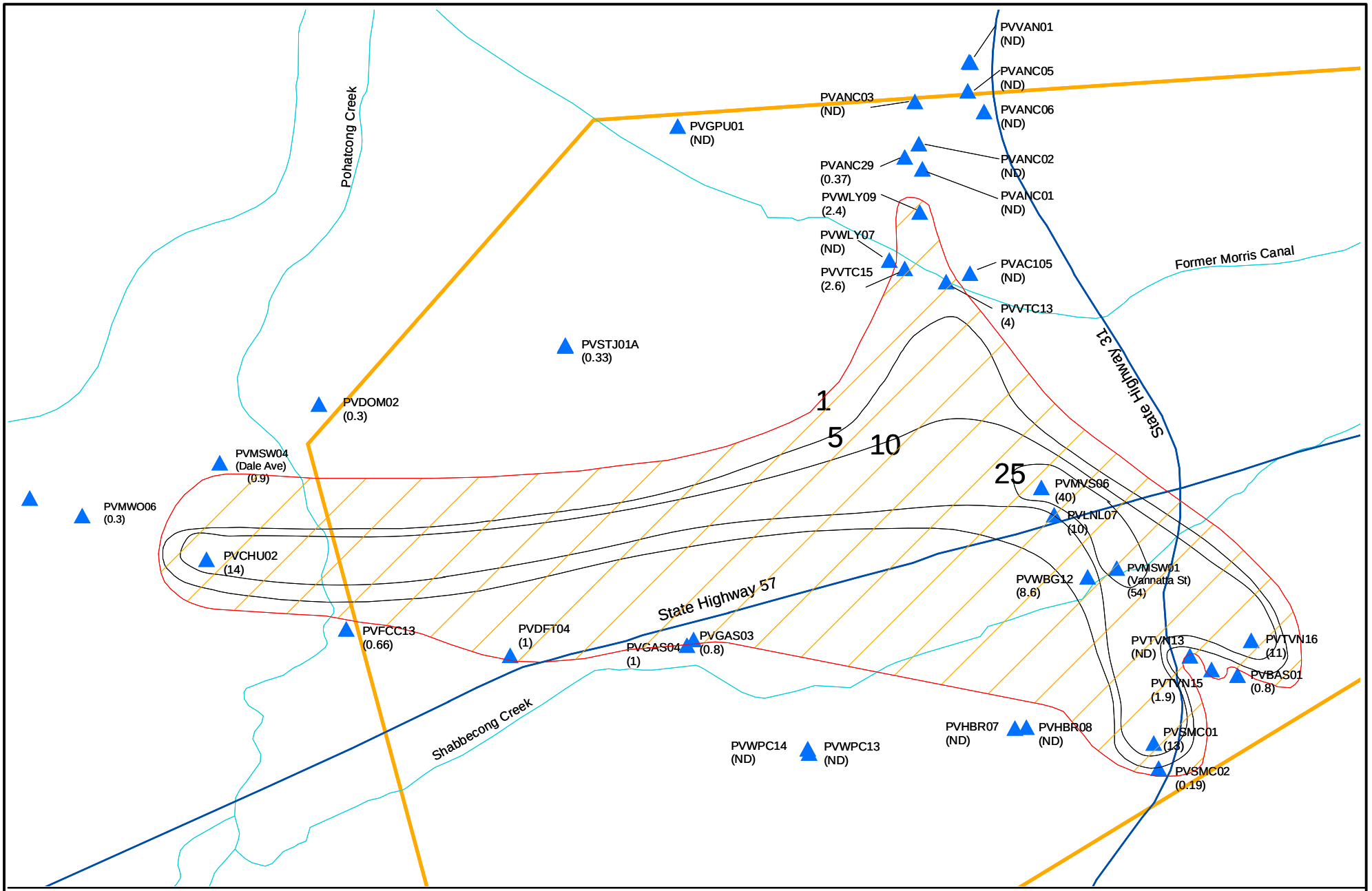
(32) - Concentration of TCE in ug/L
ND - Not detected above the method detection limit

N

0 0.5 1 Mile

Figure 2-2
TCE Groundwater Area Exceeding PRGs
OU1 Feasibility Study
Pohatcong Valley, NJ

CH2MHILL



Legend

- Sampling Locations
- Waterways
- Road Centerlines
- Washington Borough
- Area Exceeding NJDEP Groundwater Quality Criteria

(32) - Concentration of PCE in ug/L (2002)
ND - Not detected above method detection limit

Note: Sample results are from the June 2002 sampling event.

N

0 500 1,000 2,000 Feet

Figure 2-3
PCE Goundwater Area Exceeding PRGs
OU1 Feasibility Study
Pohatcong Valley, NJ

CH2MHILL

3.0 Identification and Screening of Technologies

3.1 General Response Actions

Identifying general response actions - basic actions that might be undertaken to remediate a site - is the first step in the alternatives analysis process. For each general response action, several possible remedial technologies may exist and can be further broken down into a number of process options. These technologies and process options are then screened based on several criteria. Technologies and process options remaining after screening are assembled into alternatives in Section 4. The following sections present general response actions that may be applicable to the Operable Unit 1 (OU1) Study Area.

3.1.1 General Response Actions for Soil

The general response actions for soil in the OU1 Study Area are:

- No Action
- Monitoring
- Institutional Controls
- Natural Attenuation
- Containment
- In Situ Treatment
- Excavation and Ex Situ Treatment
- Offsite Disposal

Table 3-1 lists general response actions and provides a brief description of each. Further discussions are provided in the following sections. Each general response action is discussed below, and an overview of some associated remedial technologies and process options that are representative of the response action is provided.

3.1.1.1 No Action

The no action response includes no further action for soil. The National Contingency Plan (NCP) requires that the no action alternative be retained throughout the FS process as a basis of comparison.

3.1.1.2 Monitoring

Monitoring can be implemented in combination with other general response actions such as containment or treatment to monitor the effectiveness of the chosen remedial action over the course of time. Monitoring may include inspections as well as sampling and analysis of soil.

3.1.1.3 Institutional Controls

Institutional controls for contaminated soil consist of limiting access through land use restrictions. Institutional controls could be used to limit human contact with subsurface soil that remains following excavation or containment of contaminated surface soil at a site. They include measures such as local ordinances, building permits, restrictive covenants on property deeds, state registries of contaminated sites and deed notices. The nature and extent of soil contamination left in place would be described, and excavation of subsurface soils would be limited. Where subsurface soil excavation is unavoidable, development of and adherence to a proper health and safety plan during soil excavation and disposal would be required.

3.1.1.4 Natural Attenuation

Natural attenuation is the process by which contaminant concentrations are reduced by various naturally occurring physical, chemical, and biological processes. The main processes include dilution, dispersion, biodegradation, and retardation. Only unaugmented natural processes are included in this general response action.

3.1.1.5 Containment

Containment is used to minimize the risk of contaminant migration and decrease the risk of direct contact exposures. Surface controls such as grading and revegetation can reduce erosion of contaminated soil due to winds or surface water runoff. Covers could also be used to prevent direct contact with contaminated soil. Capping can also be used to minimize infiltration and thus reduce leaching of chlorinated VOCs (TCE and PCE) to groundwater.

3.1.1.6 In-situ Treatment

In-situ treatment methods can be used to reduce contaminant concentrations in soil without excavation. A variety of in-situ methods are available for treating VOCs in soil, including soil vapor extraction (SVE), SVE with soil heating to increase volatility, in-situ chemical oxidation (ISO), and physical/chemical stabilization to reduce leachability. In-situ treatment is often one of the lowest cost alternatives that meets RAOs.

3.1.1.7 Excavation and Ex-situ Treatment

Excavation and removal of soil prevents direct contact, ingestion, or inhalation of contaminated soil. It also eliminates the potential migration of contaminants via windblown or surface water runoff erosion. Excavation can be performed to depths of about 20 feet using readily-available equipment. Deeper excavation is possible with more specialized equipment although costs can increase significantly. Excavation and offsite disposal provides assurance that contaminant mass is removed from target cleanup areas. The excavated soil may be disposed onsite or offsite, depending on state and federal requirements.

Treatment of excavated soils may be required to reduce leachability or contaminant concentrations prior to disposal. Physical/chemical and biological technologies can be used. SVE can be performed on excavated soil to remove VOCs. Excavating soil prior to performing SVE can increase removal effectiveness by homogenizing the soil and increasing

the soil permeability. Soil fixation or stabilization can be used to immobilize contaminant by physically binding them, enclosing them within a stable mass, or chemically treating them to reduce mobility. Ex-situ thermal treatment can also be performed on excavated soil, if concentrations warrant the relatively high costs of this technology. Ex-situ biological treatment is typically not applicable to compounds such as TCE and PCE because they are poorly degradable under the aerobic conditions that would be present aboveground.

3.1.1.8 Offsite Disposal

Excavated soil can be disposed at a Subtitle C or D Landfill, depending on if it is a characteristic hazardous waste and has not been contaminated from the release of a listed hazardous waste. Prior to disposal, the generated soil would be tested for hazardous waste characteristics. If necessary, the soil would be treated to meet land disposal restrictions (LDRs). If the soil requires treatment for TCE and PCE, the criteria for treatment are the higher concentration of 90 percent removal or 10 times the Universal Treatment Standard (UTS) (TCE – 60 mg/Kg (60 ppm), PCE – 60 mg/Kg (60 ppm)). Once treated to LDRs (using response actions discussed in Section 3.1.1.7), characteristic hazardous waste can be disposed in a RCRA Subtitle C landfill. If the soil is treated and is no longer a characteristic hazardous waste, it can be disposed in a Subtitle D landfill. The soil at the ANC target cleanup areas is not expected to be a characteristic hazardous waste because nearly all the measured TCE and PCE concentrations are below the levels at which the Toxicity Characteristic (TC) limits may be exceeded (TCE – 10 mg/Kg (10 ppm) and PCE – 14 mg/Kg (14 ppm)). For the purposes of the FS, it is assumed that listed hazardous wastes as defined by RCRA regulation were not known to have been released at the target cleanup areas. As a result, it is likely that excavated soil can be disposed at a Subtitle D landfill without prior treatment.

3.1.2 General Response Actions for Groundwater

The general response actions applicable to groundwater contaminated with chlorinated VOCs above PRGs are:

- No Action
- Monitoring
- Institutional Controls
- Alternate Water Supply
- Monitored Natural Attenuation
- Containment
- In Situ Treatment
- Collection, Treatment, and Discharge

Table 3-2 lists general response actions applicable to the contaminated groundwater and provides a brief evaluation of each. The following sections describe general response actions that may be applicable to the PVGCS. Each general response action is discussed below along with an overview of associated remedial technologies and process options that are representative of the response action.

3.1.2.1 No Action

The no action response includes no further action for groundwater. As with the no action alternative for soil, this alternative is retained through the FS process as a basis of comparison in accordance with the National Contingency Plan. The no action response for groundwater will be coupled with the no action option for soils as a basis of comparison.

3.1.2.2 Monitoring

Monitoring can be implemented in combination with other general response actions such as containment or treatment to monitor the effectiveness of the chosen remedial action over the course of time. Monitoring may include inspections as well as sampling and analysis of groundwater.

3.1.2.3 Institutional Controls

Institutional controls for groundwater include restrictive covenants that limit the potential future use of impacted groundwater. In New Jersey, the restrictive covenants are referred to as a Classification Exception Area (CEA). The CEA must include the area of impacted groundwater, the potential area of groundwater that may be impacted before completion of remedial actions, the contaminants and concentrations within the area, and an estimated duration of the CEA. Continued groundwater monitoring may also be necessary to track the direction and rate of movement of the groundwater contaminant plume as part of the institutional controls.

Other institutional controls include measures such as local ordinances, building permits, and state registries of contaminated sites. The institutional controls would specify the nature and extent of the groundwater contamination and prevent use until the groundwater contamination returns to drinking water standards.

3.1.2.4 Alternate Water Supply

This general response action provides an alternate water supply to homes within the OU1 Study Area that have not previously connected to municipal water in the past. This response action may also include treatment at wells (both production and municipal supply wells) that are currently pumping impacted water for use.

3.1.2.5 Monitored Natural Attenuation

Natural attenuation is the process by which contaminant concentrations are reduced by various naturally occurring physical, chemical, and biological processes. The main processes include dilution, biodegradation, and retardation. Only unaugmented natural processes are relied upon under this general response action. Augmentation through addition of electron acceptors or nutrients is considered an in situ treatment technology.

3.1.2.6 Containment

Containment refers to minimizing the spread of groundwater contaminants through passive hydraulic gradient controls. Passive gradient control can be achieved using a slurry or sheet-pile wall. Containment of groundwater can be effective in preventing the release of contaminants from the source areas and their subsequent migration.

3.1.2.7 In Situ Treatment

In situ treatment of groundwater entails treating the groundwater in the aquifer, which can be achieved by applying physical/chemical, biological, or thermal techniques. Examples of possible approaches to in situ treatment include chemical oxidation, permeable treatment beds, air sparging, and biological treatment technologies.

3.1.2.8 Collection, Treatment, and Discharge

In this response action, groundwater is collected using pumping wells, treated using physical, chemical, or biological treatment methods to remove the contaminants, and then discharged. The treated groundwater can be discharged by surface infiltration, by subsurface injection, or to surface water or Publicly Owned Treatment Works (POTW). The collection, treatment, and discharge response action also controls migration of impacted groundwater.

3.2 Technology Screening Methodology

In subsequent sections, the technology types and process options available for remediation of soil and groundwater are presented and screened. Screening of technology methods begins with development of an inventory of technology types and process options based on professional experience, published sources, computer databases, and other available documentation for the general response actions identified in Section 3.1.

Each technology type and process option retained after the screening is either a demonstrated, proven process, or a potential process that has undergone laboratory trials or bench-scale testing. The initial screening of technology types and process options is based on technical implementability. The factors included in this evaluation include the following: the state of technology development, site conditions, waste characteristics, the nature and extent of contamination, and the presence of constituents that could limit the effectiveness of the technology. Entire technologies or individual process options may be screened from further consideration based on technical implementability.

Process options that remain after the initial screening are further evaluated using a qualitative comparison based on effectiveness, implementability, and cost. Effectiveness is the ability of the process option to perform as part of a comprehensive remedial plan to meet RAOs under the conditions and limitations present at the site. Additionally, the National Contingency Plan defines effectiveness as the "degree to which an alternative reduces toxicity, mobility, or volume through treatment, minimizes residual risk, affords long-term protection, complies with ARARs, minimizes short-term impacts, and how quickly it achieves protection." This is a relative measure for comparison of process options that perform the same or similar functions. Implementability refers to the relative degree of difficulty anticipated in implementing a particular process option under regulatory, technical, and schedule constraints posed at the site. At this point, the cost criterion is comparative only and, similar to the effectiveness criterion, it is used to preclude further evaluation of process options that are very costly if there are other choices that perform similar functions with similar effectiveness. The cost criterion includes costs of construction and long-term costs to operate and maintain technologies that are part of an alternative.

Following the qualitative screening, those remedial technology types and process options that are considered viable for remediating the media at the site are carried forward for incorporation into alternatives.

3.3 Technology Screening for Soil Media

Table 3-3 presents the screening of remedial technologies and process options. The initial screening of remedial technologies is based on technical implementability. The remedial technologies and process options that remain after the initial screening are further evaluated using the qualitative comparison based on effectiveness, implementability, and cost. Those that are not considered feasible after screening are shown in italicized and bolded text on the table. Screening comments are provided to highlight items of interest or concern for each option. This approach highlights differences within a remedial technology group to allow the best process within each group to be identified and selected.

The following technologies were retained for further consideration:

- **No Action –** Retained to meet requirements of the National Contingency Plan. No remedial technologies are implemented with the option.
- **Soil Sampling (Effectiveness Monitoring) –** This technology includes sampling and laboratory analysis to monitor the effectiveness of any chosen remedial action over time. Note that this "technology" is not a stand-alone process option, but is included in the technology screening to be used in conjunction with other process options to monitor the effectiveness of remedial actions.
- **Pre-Design Investigations –** This technology involves performing additional investigation activities surrounding target cleanup areas to further refine the impacted areas. Pre-design activities for soil media will involve the installation of soil borings for sample collection and analysis. Note that as with soil sampling above, this "technology" is not a stand-alone process option, but is included in the technology screening to be used in conjunction with other process options to monitor the effectiveness of remedial actions.
- **Institutional Controls -** Institutional controls for soil consist of restricting access to contaminated soil through land use restrictions (such as deed notices under NJDEP requirements).
- **Monitored Natural Attenuation (MNA) -** Natural attenuation is the process by which contaminant concentrations are reduced by various naturally occurring physical, chemical, and biological processes. The main processes include dilution, biodegradation, and retardation.
- **Soil Cover –** This technology involves the placement of a soil cover over contaminated soils to prevent erosion and limit direct contact exposure. A cover is distinguished from a cap in that the purpose of the cover is not to limit infiltration. As part of this technology, surface controls such as grading and revegetation are usually included to reduce or eliminate erosion and surface water drainage.
- **Soil Multi-Layer Cap -** This technology involves the placement of a multi-layer soil cap over contaminated soils along with controls for managing surface drainage. This technology differs from a soil cover by the placement of a synthetic liner material to eliminate infiltration of surface water. As with the soil cover technology, surface

controls such as grading and revegetation are usually included to limit surface water infiltration.

- **In Situ Oxidation (ISO) -** ISO involves addition of an oxidant such as potassium permanganate to chemically oxidize TCE or PCE to carbon dioxide and water.
- **Shallow Soil Mixing –** This technology involves mixing of soils using excavation equipment (backhoes, front-end loaders, mixing augers) for the homogenization of soils and/or addition of oxidants or substrates for remediation of chlorinated VOCs. Standard depths of shallow soil mixing are to 15-20 feet.
- **Soil Vapor Extraction (SVE) –** This technology involves extraction of contaminants by establishing a vacuum in the soil column to extract soil vapor. Vapor extraction involves the volatilization of soil contamination into the vapor phase for collection and treatment.
- **Dual-Phase Extraction (DPE) –** This technology involves extraction of contaminants (both liquid and vapor-phase) by establishing a vacuum in the soil and groundwater column. Vapor extraction involves the volatilization of soil contamination into the vapor phase for collection and treatment.
- **Pneumatic Fracturing –** This technology involves pneumatically fracturing open boreholes to increase soil permeability and allow for easier in situ treatment.
- **Excavation of Shallow Soils –** This technology involves the physical removal of shallow contaminated soils. This technology is generally considered to depths of less than approximately 20 feet, which is the general limitation of standard excavation equipment.
- **Ex Situ Stabilization –** This technology involves the addition of a solidification agent such as cement to reduce the leachability of the contaminants. It would be used only if needed to meet LDR limits for soil prior to landfilling.
- **Offsite Disposal at Subtitle C/ D Landfill –** This technology involves the disposal of removed material in a RCRA Subtitle C or D permitted landfill.

Table 3-4 provides a summary of the remedial technologies retained and which are applicable for each soil area exceeding PRGs identified at the PVGCS. Also included in Table 3-4 are the principal VOC for each target cleanup area and the approximate depth of the impacted soils.

For soil areas exceeding PRGs only at shallow depths (less than 5 feet), technologies such as capping of impacted soils, natural attenuation, and excavation and offsite disposal are deemed applicable. Due to the shallow depths of contamination and estimates of chlorinated VOC mass in these soils, more extensive technologies such as SVE are not as effective and have higher costs. For areas with deeper contamination, remedial technologies such as in situ DPE and ISO are more applicable.

3.4 Technology Screening for Groundwater Media

Using the same methodology described in the preceding section, Table 3-5 presents the results of the screening of technology types and process options available for groundwater remediation.

The general response actions, remedial technologies, and associated process options that were retained after screening include:

- **Groundwater Sampling –** This technology includes sampling and analysis of groundwater samples to monitor the progress of any remedial action taken.
- **Pre-Design Investigations –** Pre-design investigations include the collection of groundwater samples to further refine the groundwater target cleanup areas, or the collection of data for bench-scale or pilot testing.
- **Groundwater Use Restrictions -** Institutional controls, in accordance with the NJDEP regulations (N.J.A.C. 7:26E-8.4) and designated as a CEA, are the applicable groundwater use restrictions for the site. The components of the CEA include the location of the restriction (which includes the potential migration locations before degradation reduces to below applicable cleanup criteria), the compounds detected over the applicable cleanup criteria within the restricted area, and the proposed duration of the restriction. This control will eliminate future use of the groundwater within this area and will restrict the installation of wells over the duration of the CEA.
- **Municipal Supply Well Connection -** This includes the connection of municipal water to homes within the OU1 Study Area that have not previously connected to municipal water. This technology provides protection of receptors within the area of impacted groundwater.
- **Production Well Treatment –** This technology includes treatment of generated water at the ANC facility, which is used in production.
- **Municipal Well Treatment –** This technology, which is currently being conducted, includes continued treatment of generated water prior to distribution to consumers.
- **Monitored Natural Attenuation (MNA) –**MNA is the process by which contaminant concentrations are reduced by various naturally occurring physical, chemical, and biological processes. The main processes include dilution, biodegradation, and retardation of impacted groundwater. Only unaugmented natural processes are considered under this technology.
- **In Situ Oxidation (ISO) –**ISO involves addition of an oxidant such as potassium permanganate to chemically oxidize TCE and PCE to carbon dioxide and water.
- **Groundwater Containment** - This technology involves the extraction of groundwater to create a hydraulic barrier preventing further migration of contaminants from the source area. Containment minimizes the spread of groundwater contaminants through active hydraulic gradient controls, such as groundwater pumping.
- **Expanded Source Containment –** This technology uses groundwater containment at strategic collection points throughout the valley to reduce impacts to the municipal supply wells.
- **Air Stripping Treatment –** This technology involves passing air over impacted groundwater to volatilize the contaminants from the liquid to vapor phase.
- **Adsorption –** This technology involves adsorbing contaminants to granular activated carbon (GAC) for disposal.
- **Re-Injection Discharge –** This technology involves discharge of impacted groundwater after treatment. Several groundwater discharge options are available of treated groundwater, such as injection of treated groundwater back into the unconfined aquifer, discharge to the publicly-owned treatment works (POTW), and discharge to surface water. Treatment requirements will be based on the selected discharge location and any applicable permitting requirements.

TABLE 3-1
General Response Actions for Soil Media
PVGCS OU1 Study Area Feasibility Study

General Response Action	Evaluation
No Action	Required by the NCP for comparison to other actions.
Monitoring	Used in conjunction with other containment and treatment general response actions to monitor effectiveness.
Institutional Controls	Reduces the likelihood of direct contact with or ingestion or inhalation of contaminated soil.
Natural Attenuation	Reduces contaminant concentrations through physical, chemical, and biological processes. The main processes include dilution, biodegradation, and retardation.
Containment	Minimizes the exposure to contaminated soil. Confines contamination and reduces mobility of contamination.
In Situ Treatment	Reduces mobility, toxicity, or volume of contaminated media in place.
Excavation and Ex Situ Treatment	Reduces mobility, toxicity, or volume of contaminated media via removal and treatment after excavation.
Offsite Disposal	Minimizes the likelihood of exposure to contaminants by placing them in a controlled environment after removal.

TABLE 3-2
General Response Actions for Groundwater
PVGCS OU1 Study Area Feasibility Study

General Response Action	Evaluation
No Action	Required by the NCP for comparison to other actions.
Monitoring	Used in conjunction with other containment and treatment general response actions to monitor effectiveness.
Institutional Controls	Eliminates ingestion of impacted groundwater by restricting groundwater use.
Alternate Water Supply	Eliminates exposure to impacted water by homeowners not currently connected to municipal water supply or treatment of municipal/production wells.
Monitored Natural Attenuation	Reduction of contaminants by various naturally occurring physical, chemical, and biological processes.
Containment	Minimizes the spread of impacted groundwater through active or passive hydraulic controls.
In Situ Treatment	Reduces mobility, toxicity, or volume of contaminated media in place using proven technologies.
Collection, Treatment, and Discharge	Collection involves removal of all impacted groundwater via pumping. Treatment of groundwater would take place ex situ, by conventional groundwater treatment methods, and the treated effluent would be discharged via surface water, groundwater, or sewer system.

TABLE 3-3

Technology/Process Option Evaluation—Soil Media

PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
No Action	No Further Action	None	No action.					Required for comparison by NCP; does not meet RAOs.
Monitoring	Soil Sampling	Soil sampling and subsequent laboratory analysis	Monitor the effectiveness of the chosen remedial action over the course of time.	Technically implementable	Not Applicable	Good	Low/Low	Does not meet RAOs when implemented alone; is applicable in conjunction with other technologies.
Monitoring	Pre-Design Investigations	Collection and analysis of additional soil samples.	Involves the collection of additional soil samples to further refine soil target areas and depths.	Technically implementable	Not Applicable	Good	Low/Low	Does not meet RAOs when implemented alone; is applicable in conjunction with other technologies.
Institutional Controls	Institutional Controls	Land Use Restrictions	Restrict access to contaminated soils through local ordinances, building permits, restrictive covenants on property deeds (Deed Notice) and state registries of contaminated sites.	Technically implementable	Fair	Fair	Low/Low	Does not meet RAOs when implemented alone; may be applicable in conjunction with other technologies.
Natural Attenuation	Sampling and Analysis	Soil sampling and subsequent laboratory analysis	Soil sampling and subsequent laboratory analysis to verify natural attenuation of COCs.	Technically implementable	None	Good	Low/Low	Potentially feasible.
Containment	Surface Controls	Grading	Reshape topography to control infiltration, runoff, and erosion.	Technically implementable	Demonstrated	Good	Low/Low	Potentially feasible only if used in conjunction with capping and other technologies.

TABLE 3-3

Technology/Process Option Evaluation—Soil Media

PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Containment	Surface Controls	Revegetation	Add topsoil, seed and fertilize to establish vegetation (to control erosion and reduce infiltration).	Technically implementable	Demonstrated	Good	Low/Low	Potentially feasible only if used in conjunction with capping and other technologies. Does not match future land use plans as a stand alone option for the treatment areas. Can be used in conjunction with other options to meet future use needs.
Containment	***Horizontal Subsurface Barriers***	***Block Displacement***	***Encapsulate block of soil with grout in conjunction with vertical barriers.***	***Not applicable to site geologic conditions***	***Fair***	***Fair***	***High/Low***	***Usually more feasible more homogeneous soils and larger volumes.***
Containment	Cover	Soil	Place clay over contaminated soils.	Technically implementable	Demonstrated	Good	Moderate/ Moderate	A soil cover does not provide infiltration control of surface water runoff.
Containment	Cap	Multi-layer	Cap includes a 2 foot thick clay layer and an Impermeable geomembrane liner. In addition a drainage layer and free-thaw protective layer are included in cap.	Technically implementable	Demonstrated	Good	High/ High	Potentially feasible at American National Can (ANC) site.
Containment	Cap	Asphalt	Place asphalt or concrete over contaminated soils.	Technically implementable	Demonstrated	Fair	Low/High	Potentially feasible at American National Can (ANC) site.
In situ Treatment	Physical/ Chemical	Oxidation	Degrade contaminants by chemical oxidation. Typical oxidants include ozone, hydrogen peroxide, potassium permanganate, sodium permanganate and sodium persulfate.	Technically implementable	Demonstrated in high permeability soils. Less effective in low permeability soil.	Low	Moderate/ High	Potentially feasible.

TABLE 3-3

Technology/Process Option Evaluation—Soil Media

PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
In situ Treatment	***Physical/ Chemical***	***Reduction***	***Degrade contaminants by chemical reduction. Addition of reducing agents such as zero valent iron to generate hydrogen used in the reductive dechlorination of TCE and PCE.***	***Technically implementable.***	***Demonstrated in high permeability soils. Less effective in low permeability soil.***	***Low***	***High/High***	***Typical zero valent iron dosage is 0.5 percent of soil mass. This dosage results in very high costs for all sites relative to other in situ technologies such as SVE.***
In situ Treatment	***Physical/ Chemical***	***Stabilization***	***Immobilize contam-inants using solidification agents.***	***Technically implementable***	***Potential***	***Fair***	***Moderate/ NA***	***Not applicable for volatile and semi-volatile contaminants because of potential for long-term weathering, resulting in contaminant releases from solidified waste.***
In situ Treatment	Physical/ Chemical	Shallow Soil Mixing	Excavation and mixing of soil in-place to improve soil properties for SVE and to improve delineation of COCs.	Technically implementable	Effective as an enhancement for other technologies such as SVE.	Fair	Moderate/ NA	Potentially feasible only as an enhancement for other technologies.
In situ Treatment	Physical/ Chemical	Soil Vapor Extraction (SVE)	Extract contaminants by establishing a vacuum.	Technically implementable	Effective but may need enhancements such as soil fracturing in low permeability soils.	Fair	Moderate/ NA	Potentially feasible. Off-gas may require additional treatment; additional O&M costs associated with activated carbon adsorption of PCE and TCE in vapors.

TABLE 3-3

Technology/Process Option Evaluation—Soil Media

PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
In situ Treatment	Physical/ Chemical	Dual Phase Extraction (DPE)	Extraction of groundwater to remove water and expose soils to vapor extraction. Similar to SVE but includes dewatering within the same well.	Technically implementable	Effective but may need enhancements such as soil fracturing in low permeability soils. Water extraction needed at areas such as ANC A where perched water is present.	Fair	Moderate/ NA	Potentially feasible. DPE is needed at sites such as American National Can (ANC) A where perched water is present above the water table.
In situ Treatment	***Physical/ Chemical***	***Washing/ Flushing***	***Wash or flush soil with water or surfactant.***	***Technically implementable***	***Potential***	***Fair to Good***	***Moderate to High/ NA***	***May have adverse impacts to local municipal supply wells. Also, less effective for smaller target areas with low concentrations.***
In situ Treatment	***Physical/ Chemical***	***Vitrification***	***Melt/solidify soil matrix using electric currents.***	***Technically implementable***	***Potential***	***Fair***	***High/NA***	***Limited commercial applications. Heating of soil may allow spreading to uncontaminated soil. Very costly technology relative to other technologies.***
In situ Treatment	Physical/ Chemical	Pneumatic Fracturing	Fracturing of the bedrock to increase permeability and thus increasing effectiveness of in situ treatment.	Technically implementable	Demonstrated as effective at sites, but effectiveness dependent on depth and area.	Fair	High/Low	Does not meet RAOs alone, but can be used in conjunction with other in situ technologies to increase effectiveness and treatment effectiveness.

TABLE 3-3

Technology/Process Option Evaluation—Soil Media

PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
In situ Treatment	***Biological***	***Enhanced Reductive Dechlorination***	***Degrade contaminants by stimulating biological growth through addition of an organic substrate such as edible oil, or lactate. The biodegradation of the substrate liberates hydrogen which is then used as the electron donor in reductive dechlorination of TCE and PCE.***	***Technically implementable.***	***Demonstrated in high permeability soils. Less effective in low permeability soil.***	***Low***	***High/High***	***The large amount of substrate required to result in reducing conditions makes this a very expensive technology for unsaturated zone soil. Also the reducing conditions result in mobilization of iron that may reduce the quality of the groundwater used as a drinking water supply.***
In situ Treatment	***Biological***	***Bioventing***	***Biologically degrade organics through stimulation of aerobic organisms by the addition of oxygen in air.***	***Technically implementable***	***Poor for chlorinated VOCs present at site.***	***Fair***	***Low/Low***	***Not effective for chlorinated VOCs.***
In situ Treatment	***Thermal***	***Hot Air or Steam Stripping***	***Inject hot air or steam/ recover vapors (a variation of vapor extraction).***	***Technically implementable***	***Potential***	***Fair to Good***	***High/NA***	***Much more costly than other in situ technologies such as vapor extraction and bioventing. Not needed for relatively low PCE and TCE concentrations at the target areas.***
In situ Treatment	***Thermal***	***Radio Frequency Stripping***	***Use network of Radio Frequency Transmitters to heat soil; collect vaporized contaminants with vapor extraction system.***	***Technically implementable***	***Potential***	***Fair to Good***	***High/NA***	***Much more costly than other in situ technologies such as vapor extraction and bioventing.***

TABLE 3-3

Technology/Process Option Evaluation—Soil Media

PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Excavation and Ex Situ Treatment	Excavation of Shallow Soils	Backhoe/Front-end Loader	Physically remove shallow soils.	Technically implementable	Demonstrated	Good	Low/NA	Can be executed to depths of about 20 feet.
Excavation and Ex Situ Treatment	Physical/ Chemical	Stabilization	Immobilize contam-inants.	Technically implementable	Potential	Fair	Moderate/ NA	Solidification to reduce leaching of TCE and PCE to below LDR limits may be needed prior to landfill disposal.
Excavation and Ex Situ Treatment	***Physical/ Chemical***	***Vapor Extraction***	***Purge volatiles by forcing clean air through soil piles.***	***Technically implementable***	***Potential***	***Good***	***Moderate/ NA***	***Large treated footprint needed for system does not match future land use plans.***
Excavation and Ex Situ Treatment	***Biological***		***Biological degradation of COC by controlling soil moisture and soil aeration.***	***Not technically implementable for TCE and PCE because they do not degrade adequately under aerobic conditions.***	***NA***	***NA***	***NA***	***Not applicable to compounds such as TCE and PCE because they are poorly degradable under aerobic conditions that would be present aboveground.***
Excavation and Ex Situ Treatment	***Thermal***	***Low-Temp Desorption***	***Desorbs contaminants/ treat off-gas***	***Technically implementable***	***Potential***	***Fair***	***High/NA***	***Not cost competitive; treatment of off-gas costly. Low soil concentration may dictate that technologies not necessary.***
Excavation and Ex Situ Treatment	***Thermal***	***Onsite Incineration***	***Combust soils at high temperature.***	***Technically implementable***	***Demonstrated***	***Fair***	***High/ NA***	***Not cost competitive. Extensive treatability testing required; air treatment and permitting requirements are substantial.***
Excavation and Ex Situ Treatment	***Thermal***	***Plasma***	***Expose soils to super-heated plasma.***	***Technically implementable***	***Potential***	***Poor***	***High/ NA***	***Extensive treatability testing required; costs similar to incineration; unproven technology.***
Excavation and Ex Situ Treatment	***Thermal***	***Infrared***	***Decompose contaminants with infrared radiation.***	***Unproven technology***	***Potential***	***Poor***	***High/NA***	***Extensive treatability testing required; costs similar to incineration; unproven technology.***

TABLE 3-3

Technology/Process Option Evaluation—Soil Media

PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Excavation and Ex Situ Treatment	***Thermal***	***Wet Air Oxidation***	***Use high temperature and pressure to thermally oxidize contaminants.***	***Technically implementable***	***Potential***	***Fair***	***High/ NA***	***Lengthy, extensive treatability testing required; energy consumptive, expensive.***
Excavation and Ex Situ Treatment	***Thermal***	***Offsite Incineration***	***Combust soils in offsite commercial incinerator.***	***Technically implementable***	***Demonstrated***	***Good***	***High/ NA***	***Not cost competitive when comparing to other offsite treatment/disposal options.***
Disposal	Offsite Disposal	RCRA Subtitle C or Subtitle D Landfill	Remove material for disposal in RCRA Subtitle C or D permitted landfill.	Technically implementable	Demonstrated	Fair	High/ NA	Soils are likely below any hazardous waste characterization limits and can be disposed in a Subtitle D Landfill. However soils will be tested and any soils failing TCLP limits may also be subject to land disposal restrictions prior to disposal in Subtitle C landfill.

Note: Italicized and bolded text indicates technology or process option was screened from further consideration.

TABLE 3-4
Technology Screening Summary – Soil Media
PVGCS OU1 Study Area Feasibility Study

Remedial Technologies or Process Options	**Soil Remedial Target Cleanup Areas**		
	ANC A	**ANC B**	**ANC C**
Principal COC	TCE	TCE	TCE
Approximate Terminal Depth of Impact (ft.)	100	5	100
Soil Sampling	X	X	X
Pre-Design Investigations	X	X	X
Institutional Controls	X	X	X
Monitored Natural Attenuation	X	X	X
Soil Cover	X		
Soil Multi-Layer Cap	X		
In Situ Oxidation	X		X
Shallow Soil Mixing	X		
Soil Vapor Extraction	X		X
Dual Phase Extraction	X		X
Pneumatic Fracturing	X		
Excavation of Shallow Soils	X	X	X
Ex Situ Stabilization	X	X	X
Offsite Disposal at Subtitle C/D Landfill	X	X	X

* - Based on current known extent of soil remedial target cleanup areas and suspected ANC C area (see Appendix A of FS) and were used for costing purposes.

TABLE 3-5
Technology/Process Option Evaluation—Groundwater
PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
No Action	No Further Action	None	No action					May result in exposure of future GW users; does not meet RAOs; required for comparison by NCP.
Monitoring	Groundwater Sampling	Continued groundwater sampling and laboratory analysis	Continue sampling and analysis of groundwater.	Technically implementable	Not Applicable	Good	Low/Low	Potentially applicable in conjunction with other technologies.
Monitoring	Pre-Design Investigations	Groundwater collection and laboratory analysis	Collection of additional groundwater data to further refine the extent of impacts. May also involve data collection for bench-scale testing.	Technically implementable	Not Applicable	Good	Low/Low	Potentially applicable in conjunction with other technologies.
Institutional Controls	Groundwater Use Restrictions	Access restrictions to groundwater	Property in the Classification Exception Area (CEA) impacted by contaminated groundwater may require restrictions on GW use.	Technically implementable	Demonstrated	Good	Moderate/ Low	Potentially applicable in conjunction with other technologies.
Alternate Water Supply	Municipal Supply Well Connection	Connection to public water supply system.	Restricts the usage of water within OU1 Study Area.	Technically implementable	Demonstrated	Poor	Low/Low	Potentially applicable in conjunction with other technologies.
Alternate Water Supply	Production Water Treatment	Treats production water prior to use.	Treats production water at American National Can (ANC) prior to use in facility operations.	Technically implementable	Demonstrated	Poor	Low/Low	Potentially applicable in conjunction with other technologies.
Alternate Water Supply	Municipal Well Treatment	Treats municipal well water prior to use.	Continued treatment of municipal well water prior to distribution to public.	Technically implementable	Demonstrated	Poor	Low/Low	Potentially applicable in conjunction with other technologies.

TABLE 3-5
Technology/Process Option Evaluation—Groundwater
PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Monitored Natural Attenuation (MNA)	Monitored Natural Attenuation	Monitored natural attenuation of groundwater.	Use of naturally occurring physical, chemical and biological processes such as dispersion, biodegra-dation and retardation to reduce concentrations of contaminants.	Technically implementable	Demonstrated	Good	Low/Low	Potentially feasible.
Containment	***Passive Hydraulic Controls***	***Slurry or Sheet-pile Wall***	***Physical barrier to groundwater migration.***	***Technically implementable***	***Demonstrated***	***Good***	***Moderate/ Low***	***Not feasible because depth to zone requiring containment is over 200 feet. Also it is not feasible to install containment walls into bedrock and there is no low permeability layer to key into.***
Containment	***Vertical Subsurface Barriers***	***Grout Curtain***	***Create subsurface barrier to horizontal GW flow by grout injection.***	***Technically implementable***	***Fair***	***Fair***	***High/NA***	***Not sufficiently effective or cost competitive for depths required.***
In Situ Treatment	Physical-Chemical	Oxidation	Inject/extract oxidants to degrade contaminants. Typical oxidants include ozone, hydrogen peroxide, potassium permanganate, sodium permanganate and sodium persulfate.	Technically implementable	Demonstrated in high permeability aquifers.	Fair. May be difficult to implement because of potential to degrade the water quality of the aquifer by increasing chromium concentration.	High/Low	Potentially feasible for PCE and TCE. Would require treatability testing.
In Situ Treatment	***Physical-Chemical***	***Air Sparging***	***Inject air into groundwater***	***Technically implementable***	***Potential***	***Fair***	***Moderate/ Moderate***	***Depth of contamination may cause problems for implementation and ensure capture of vapors.***

TABLE 3-5
Technology/Process Option Evaluation—Groundwater
PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
In Situ Treatment	***Physical-Chemical***	***Reduction***	***Degrade contaminants by chemical reduction. Addition of reducing agents such as zero valent iron (ZVI) to generate hydrogen used in the reductive dechlorination of TCE and PCE.***	***Technically implementable.***	***Demonstrated in high permeability aquifers.***	***Low***	***High/High***	***Not feasible due to high cost and potential degradation of groundwater quality. Typical zero valent iron dosage is 0.5% of soil mass. This dosage results in very high cost. Also ZVI results in reducing conditions and elevated dissolved iron that will degrade the quality of the groundwater used as a drinking water source. Once treatment is complete, iron remains elevated and would migrate toward the Dale Avenue Municipal well.***
In Situ Treatment	***Biological***	***Enhanced Reductive Dechlorination***	***Degrade contaminants by stimulating biological growth through addition of an organic substrate such as edible oil, or lactate. The biodegradation of the substrate liberates hydrogen which is then used as the electron donor in reductive dechlorination of TCE and PCE.***	***Technically implementable.***	***Demonstrated in high permeability aquifers.***	***Low***	***High/High***	***Not feasible. The large amount of substrate required to result in reducing conditions makes this a very expensive technology for unsaturated zone soil. Also the reducing conditions cause elevated dissolved iron that will degrade the quality of the groundwater used as a drinking water source. Once treatment is complete, iron remains elevated and would migrate toward the Dale Avenue Municipal well.***
In Situ Treatment	***Biological***	***Permeable Treatment Beds***	***Install downgradient treatment trenches to remove or degrade contaminants.***	***Very difficult to implement.***	***Potential***	***Fair***	***High/Low to High***	***Wall would have to be constructed to a depth in excess of 200 feet, the last 100 feet through bedrock. This is not reasonably achievable with existing trench excavation technology.***

TABLE 3-5
Technology/Process Option Evaluation—Groundwater
PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
In Situ Treatment	***Biological***	***Air Sparging***	***Inject air into groundwater***	***Not technically implementable for TCE and PCE because they do not degrade adequately under aerobic conditions.***	***NA***	***NA***	***NA***	***Not applicable to compounds such as TCE and PCE because they are poorly degradable under aerobic conditions that would be present aboveground.***
In Situ Treatment	***Thermal***	***Steam Injection/SVE***	***Inject steam, collect/treat, gases/liquids***	***Technically implementable***	***Poor effectiveness in fractured bedrock.***	***Fair***	***High/High***	***Not cost effective for low concentration VOCs.***
Collection	Extraction	Wells	Install wells to extract contaminated groundwater.	Technically implementable	Demonstrated	Good	Moderate/ Low	Feasible, but may result in net loss of groundwater for drinking water supply.
Collection	Active Hydraulic Controls	Pumping Wells	Extract GW to create hydraulic barrier to offsite migration of contaminants	Technically implementable	Demonstrated	Good	Moderate/ Low	Feasible, but may result in net loss of groundwater for drinking water supply.
Treatment	Physical-Chemical	Air Stripping	Phase separation by forced air	Technically implementable	Demonstrated	Good	Low/Moderate	Feasible.
Treatment	***Physical-Chemical***	***Steam Stripping***	***Phase separation by steam and forced air***	***Technically implementable***	***Potential***	***Fair***	***High/High***	***Not cost effective for low concentration VOCs.***
Treatment	Physical-Chemical	Adsorption	Treat with Granular Activated Carbon (GAC) or other adsorptive media	Technically implementable	Demonstrated	Good	Moderate/ Low	Cost effective for vapor-phase treatment, if used in conjunction with air stripping.
Treatment	***Physical-Chemical***	***Oxidation***	***Chemical, photo, or other oxidation***	***Technically implementable***	***Potential***	***Good***	***Moderate/ High***	***Not cost effective compared to air stripping for low concentration VOCs.***
Treatment	***Physical-Chemical***	***Ion Exchange***	***Treat with selected resins***	***Technically implementable***	***Potential***	***Fair***	***High/High***	***Treatability testing required; more costly than GAC.***

TABLE 3-5
Technology/Process Option Evaluation—Groundwater
PVGCS OU1 Study Area Feasibility Study

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Treatment	***Physical-Chemical***	***Reverse Osmosis***	***Remove contaminants by forcing water through high pressure membrane***	***Difficult operation, not effective for organics***	***Potential***	***Poor***	***High/High***	***Costly technology when compared to other options. High O&M costs related to system operations.***
Treatment	***Physical-Chemical***	***Liquid/Liquid Extraction***	***Extract contaminants based on solubility***	***Very high concentrations required***	***Potential***	***Poor***	***High/High***	***Costly technology when compared to other options. High O&M costs related to system operations.***
Treatment	***Biological***	***Aerobic***	***Degrade contaminants using aerobic microbes***	***Technically implementable***	***Potential***	***Good***	***High/High***	***TCE and PCE do not sufficiently degrade aerobically. However treatment in a biological treatment POTW can be effective because removals are achieved through volatilization and adsorption on sludge.***
Discharge	Surface	Storm Sewer System	Discharge treated water to Storm Sewer System	Technically implementable	Demonstrated	Fair to Good	Moderate/ Moderate	Potentially feasible although treated water needs to be injected into aquifer to maintain available water supply.
Discharge	Sewer	Publicly Owned Treatment Works (POTW)	Discharge untreated water to POTW	Technically implementable	Demonstrated	Fair to Good	Low/Low	Potentially feasible although treated water needs to be injected into aquifer to maintain available water supply.
Discharge	Subsurface	Injection Wells	Pump treated groundwater back into subsurface	Technically implementable	Demonstrated	Fair	Moderate/ High	Potentially feasible. Would require permitting.
Discharge	***Subsurface***	***Infiltration***	***Discharge treated groundwater into infiltration basins/ trenches***	***Technically implementable***	***Demonstrated***	***Fair***	***Moderate/ High***	***Not feasible. Low permeability soils do not allow sufficient infiltration to accept high flow rates.***

4.0 Development of Alternatives

The remedial technologies and process options that remained after screening were assembled into a range of alternatives. The remedial alternatives have been developed separately for contaminated soil and groundwater media to allow for a wider range of alternatives and greater flexibility in selecting the recommended alternatives. However, there may be situations where alternatives for soil and groundwater are coupled for a higher degree of effectiveness.

The specific details of the remedial components discussed for each alternative are intended to serve as representative examples to allow order-of-magnitude cost estimates. Other viable process options within the same remedial technology that achieve the same objectives may be evaluated during remedial design activities for the site.

Six soil media alternatives and seven groundwater media alternatives were initially developed based on the technologies retained from screening (in Section 3) to create a range of remedial actions and include each of the remaining technologies into at least one alternative. Tables 4-1 and 4-2 present matrixes of technologies that remained after initial screening and the alternatives into which they were incorporated for soil and groundwater, respectively. The assumptions, estimates of impacted media volumes, and treatment process conceptual design components within this FS were generated for cost estimating purposes as part of the FS. The results of pre-remedial design investigations and the remedial design will be used to evaluate the exact components of the remedial alternatives.

4.1 Development of Soil Media Remedial Alternatives

Soil remedial alternatives were developed for each of the soil target cleanup areas. The three soil media target cleanup areas evaluated in this FS are the American National Can (ANC) areas A, B, and C as presented in Section 2.4.1[1]. Areas A and B have been identified as a result of TCE concentrations detected above NJ Impact to Groundwater Soil Cleanup Criteria (IGWSCC). A third area, ANC C, defined as a suspected area is included for remediation of the area under the ANC building should pre-design investigations find significant contamination in that location exceeding the IGWSCC or other applicable PRGs. Appendix A provides additional information regarding ANC C and the rationale for including it in this FS.

4.1.1 Soil Remedial Alternatives

The ANC target cleanup areas contain TCE concentrations above the NJ IGWSCC. The highest concentrations of TCE detected within ANC A and B are 52 mg/Kg (52 ppm) and 3 mg/Kg (3 ppm), respectively. The estimated surficial extent of impact is about 28,000 square feet for ANC A, 2,000 square feet for ANC B, and 16,000 square feet for suspected area ANC C. TCE is assumed to exceed the PRG in soils at ANC A and C to a depth of 100

[1] Note that the ANC A area also includes a portion of the AC1 PSA, which is adjacent to the ANC PSA.

feet bgs. TCE exceeds the PRG at ANC B in shallow surficial soils to an assumed depth of 5 feet bgs.

The six alternatives were developed based on the current understanding of the extent of TCE contamination in soils. If additional soil contamination is found during pre-design investigations for soil at ANC or adjacent areas, the extent of remediation would be expanded to achieve PRGs. Specifically, the suspected area under the ANC building will be investigated, and the remedial action modified to accommodate the additional contamination if identified. It is anticipated that the remedial alternatives presented would be relevant for additional soil contamination not yet identified, unless the concentrations or volumes of impacts were much larger than already detected (e.g., a separate-phase liquid is discovered).

If TCE contamination exceeding remedial goals is limited to soil above 25 feet bgs, the DPE system component included in some of the alternatives may be modified to a simpler soil vapor extraction (SVE) system.

4.1.1.1 Soil Alternative S1 - No Further Action

The objective of Soil Media Alternative S1, the No Further Action (NFA) alternative, is to provide a baseline for evaluation of remedial alternatives, as required by the National Contingency Plan (NCP). There will be no additional remedial actions conducted at the PVGCS to control or remove chlorinated VOCs in soils under this alternative. It is expected that TCE will continue to impact groundwater. There will also be a risk from direct contact with the soil, or erosion of soil, if the affected areas within the PVGCS were developed in the future for industrial or commercial use.

4.1.1.2 Soil Alternative S2 - Soil Cover, Monitored Natural Attenuation and Institutional Controls

Soil Alternative S2 includes establishing a clean soil cover over ANC A soils to prevent direct contact and erosion of impacted soil, and allowing natural attenuation processes to reduce TCE concentrations in soil of ANC A and C to below PRGs. Institutional controls may be established to limit use of areas where contamination exceeding PRGs is left in place at ANC A and C, if necessary after remedial actions. Because of the limited horizontal and vertical extent of contamination at ANC B, it has been assumed for cost estimating purposes that soil in this area will be excavated and disposed offsite. Institutional controls will not be required for ANC B because no soil exceeding PRGs will be left in place. Limited excavation may also be conducted at ANC A, depending on the results of the pre-design investigations. Excavation (including the limited excavation at ANC A if deemed necessary after pre-design investigations) will be backfilled with certified clean fill material. The major components of this alternative are:

- Pre-Design Investigations (ANC A, B, and C)
- Excavation and Disposal (ANC A, if necessary, and B)
- Soil Cover (ANC A)
- Monitored Natural Attenuation (ANC A and C)
- Soil Monitoring (ANC A and C)
- Institutional Controls (ANC A and C)

Pre-Design Investigations

Pre-design investigations will be conducted to delineate the horizontal and vertical extent of TCE contamination more accurately. Surface and subsurface soil samples will be collected for laboratory analysis from ANC A, B, and C areas using a direct-push or hollow-stem auger drill rig to collect samples, depending on the depth of sampling. Concrete coring may be required in locations within the ANC building or in paved areas of the property. It was assumed for cost estimating purposes that ten soil borings to a total depth of 100 feet will be drilled at ANC A and C, with ten samples collected from each boring. At ANC B, three borings will be drilled with four samples collected from each to a depth of 15 feet bgs.

Excavation and Disposal

At ANC B, soils exceeding PRGs will be excavated for offsite disposal using standard construction equipment (backhoes, front-end loaders, etc.). Based on the shallow depths of the excavation assumed for costing purposes (approximately 5 feet bgs), it is not anticipated that sidewall stabilization of the excavation footprints will be necessary. The excavation will be sloped (assumed to be a 2:1 sloping) during the excavation. It has been assumed for cost estimating purposes that the in-situ volume of soil to be excavated is estimated at about 370 cubic yards. Soil confirmation sampling along the sidewalls and bottom of the excavations will be conducted to evaluate the adequacy of the excavation limits.

At ANC A, limited excavation and offsite disposal may be performed if pre-design investigations identify high concentrations of TCE or other contaminants in shallow soil. The volume of soil that may be excavated at ANC A is unknown, and will be assessed after the completion of pre-design investigations. Because the volume of soil is unknown, excavation at ANC A is not included in cost estimates for this alternative.

Temporary stormwater diversion and soil erosion and sediment control measures will be established prior to excavation. As necessary, staging areas will be created to allow for temporary stockpiling of soils during excavation. It has been assumed for costing purposes that the areas will be bermed and lined in accordance with the stormwater control measures. It is anticipated that a site-specific air permit (which will include air monitoring during the excavation) will be required. Details of stormwater diversion will be determined during remedial design.

Excavation areas will be backfilled with certified clean fill material. The backfill material will be similar in properties (porosity, grain-size) as the native material and will be compacted in lifts (assumed 2-foot thickness) to the ground surface. The area will be re-seeded with native grasses after backfilling.

It is not anticipated that the excavated soils will be characteristic hazardous or otherwise require treatment to meet LDRs prior to disposal. Toxicity Characteristic Leaching Procedure (TCLP) testing of the excavated soil at a rate of one sample per 200 cubic yards will be conducted (assumed as 2 samples for the ANC B area for costing purposes). If necessary, the soil will be treated at the landfill prior to disposal (most likely solidification to meet TCLP limits for TCE). It has been assumed for cost estimating purposes that ex situ stabilization will not be necessary prior to disposal at the Subtitle D landfill. However, the results of pre-design investigations will be used to evaluate treatment required and disposal options of soil after generation.

A certified waste hauler (either a hazardous or non-hazardous waste hauler, depending on the characterization of the soil) will be used to transport the soil offsite. The waste will be labeled and shipped in accordance with U.S. Department of Transportation (DOT) regulations. Manifests will accompany waste materials leaving the site. Based on the volumes of soil assumed for costing purposes, it is expected that this removal effort (assuming ANC B is the only area excavated) could be completed in one day if loaded from a stockpile.

The excavated VOC contaminated soils will be disposed at a Subtitle D landfill. Although the specific facility where the soils will be disposed of will be based on costs and performance reviews, it has been assumed for cost estimating purposes that the soils will be disposed at a Subtitle D Landfill within 200 miles of the Study Area. Disposal options for generated soil will be based on the results of soil samples collected during either pre-design investigations or excavation activities.

Soil Cover

A soil cover will be placed over exposed soil at ANC A to prevent erosion of soil exceeding the PRGs and to prevent direct contact. The soil cover would not minimize surface water infiltration and would not prevent continued leaching of TCE in the soil matrix to groundwater. Prior to placement of the soil cover, the area will be cleared of trees and brush and graded to minimize slopes. Some soil removal may be necessary for grading. It is assumed for costing purposes that the surface water runoff from areas upgradient of the ANC A area (such as the outfall location upgradient of this area) will continue to be directed toward the culvert that passes under the railroad to limit the volume of surface water that flows over the target cleanup area, but will be verified during remedial design. The cover on the target cleanup area will be sloped to the sides (east and west) so surface water directly falling on the area will drain from the soil cover as quickly as possible to prevent erosion of the soil cover. Overall flow of surface water directly on the target cleanup area is anticipated to flow southward to the AC1 area.

The soil removed during site grading will be tested and disposed offsite in a Subtitle C or D landfill. Based on current data, it is assumed for costing purposes that the soil can be disposed at a Subtitle D landfill. It has been assumed that erosion control matting will be used as a stormwater control during construction.

The soil cover will consist of 2 feet of certified clean soil. After placement of the soil cover, the area will be hydroseeded with grasses. Temporary erosion controls (such as biodegradable membranes) will be placed over the area until the grass cover is established. Details of the hydroseeding and temporary erosion controls will be defined during remedial design.

Monitored Natural Attenuation

Monitored natural attenuation (MNA) processes for soil include volatilization, leaching to groundwater, and degradation. Volatilization can be a significant loss mechanism for VOCs in surficial soils. Leaching of TCE downward will also result in diminishing concentrations in the surficial soils, although this process is expected to be slow because of the characteristics of the underlying vadose zone soils.

Some biodegradation may occur because anaerobic conditions favorable to reductive dechlorination are present in the soils based on sampling results of water perched in the ANC source area. However the lack of substantial concentrations of biodegradation products (e.g., cis-1,2-dichloroethene [DCE] and vinyl chloride) suggests that biodegradation is not a major attenuation mechanism for TCE in these soils and that the degradation may be related to physical processes.

It is likely that the factors discussed above have resulted in the persistence of TCE in soil at ANC. Some attenuation is expected to occur although TCE may persist in these soils for decades given the low soil permeability and limited suitable anaerobic environment for biodegradation.

Soil Monitoring

It has been assumed for cost estimating purposes that soil sampling to monitor the progress of natural attenuation will be conducted at ANC A and C every 5 years. For cost estimating purposes, this sampling program is assumed to include six samples from each of five borings to a 100-foot depth at both ANC A and ANC C. Concrete coring at ANC C may be required prior to sampling. The samples will be analyzed for VOCs. Results will be summarized and submitted to USEPA and the NJDEP. Details of the soil monitoring will be evaluated after pre-design investigations and remedial design activities are completed. It is assumed for cost estimating purposes that PRGs will be met at both ANC A and C after 30 years, or 6 sampling episodes. No costs for five-year reviews are included in the costs.

Institutional Controls

Institutional controls may consist of land use restrictions for the areas where contamination is left in place at concentrations exceeding PRGs (i.e., ANC A and C), as necessary after completion of the remedial actions. A restrictive covenant placed on the deeds of the target cleanup area properties identifying the areas of soil with TCE concentrations greater than the PRG. Institutional controls will not be required for ANC B because no soil exceeding PRGs will be left in place.

4.1.1.3 Soil Alternative S3 – Capping and Institutional Controls

The soil remedial objectives are met by the Soil Media Alternative S3 through the installation of a multi-layer soil cap at ANC A, the use of the existing cap at ANC C, and the excavation and offsite disposal of soils at ANC B. Capping prevents direct contact by receptors to contaminated media, limits erosion, and minimize leaching of TCE to groundwater. ANC C is already capped by the concrete foundation of the ANC building. As with Soil Alternative S2, because of the limited horizontal and vertical extent of contamination at ANC B, it has been assumed for cost estimating purposes that soil in this area will be excavated and disposed offsite. Institutional controls will be established (as necessary) to limit use of the target cleanup areas with remaining contamination under this alternative. Limited excavation may also be conducted at ANC A, depending on the results of the pre-design investigations. Excavations, including the ANC A limited excavation if necessary, will be backfilled with certified clean fill material. Institutional controls will not be required for ANC B because no soil exceeding PRGs will be left in place. The major components of Alternative S3 are:

- Pre-Design Investigations (Assumed at ANC A, B, and C for costing purposes)

- Excavation and Disposal (Assumed at ANC A and B for costing purposes)
- Soil Multi-Layer Cap (Assumed at ANC A for costing purposes)
- Institutional Controls (ANC A and C)

Soil monitoring is not included in this alternative because it is expected that there will be minimal further natural attenuation under this alternative. The cap prevents volatilization losses, limits infiltration and losses from leaching and prevents biodegradation by minimizing soil moisture necessary for microbial degradation. For cost estimation purposes, the cap is assumed to be maintained for a 50-year period.

Pre-Design Investigations

Pre-design investigations will be conducted as presented in Soil Alternative S2.

Excavation and Disposal

Excavation and disposal of impacted soil at ANC B will be conducted as described in Alternative S2.

At ANC A, limited excavation and offsite disposal may be performed if pre-design investigations identify high concentrations of TCE or other contaminants in shallow soil. The volume of soil that may be excavated at ANC A is unknown, and will be accessed after the completion of pre-design investigations. Because the volume of soil is unknown, excavation at ANC A is not included in cost estimates for this alternative.

Soil Multi-Layer Cap

It has been assumed for cost estimating purposes that the ANC A target cleanup area will be capped with a multi-layer soil and liner cap, because an asphalt cap was considered to be inconsistent with surrounding land use. The cap system will include a sequence of soils and geosynthetic materials (listed from the ground surface down):

- 1.5 foot vegetation layer
- 1 foot thick drainage layer
- 40 mil Linear low-density polyethylene (LLDPE) or high-density polyethylene (HDPE) geomembrane
- Geosynthetic clay liner (GCL)
- Bedding layer (where appropriate)

It has been assumed for costing purposes that a GCL with a maximum hydraulic conductivity of 1×10^{-7} cm/sec. A GCL will be used to reduce the amount of soil needed and to maintain existing grades if possible. Surface runoff from upgradient areas will likely need to be directed through the railroad culvert to minimize erosion of the cap. As with Soil Alternative S2, surface water drainage of water directly onto the cap will be directed off the cap and will continue to drain to the AC1 area. The total thickness of the multi-layer cap is about 2.5 feet. Exact details of the multi-layer cap will be defined during remedial design and will be based on the exact extent of contaminated media and available materials.

Prior to placement of the multi-layer cap, the area will be cleared of trees and brush, grubbed to remove roots, and graded to minimize slopes. Some soil removal will be necessary (particularly in the area surrounding the culvert below the railroad tracks) to lower the grade, provide shallow slopes to prevent erosion, and increase flow volumes through the pipe. The volume of soil removed is assumed for cost estimating purposes to

average approximately 1.5 feet over 50 percent of the cap area. It is anticipated that surface water runoff over the site will flow toward the culvert and then to the west side of the railroad tracks. Details of the actual volume of soil to be removed prior to cap installation and the surface water runoff requirements will be assessed during remedial design.

The soil removed during site grading will be tested and disposed offsite in a Subtitle C or D landfill. Based on current data, it is assumed for costing purposes that the soil will be placed in a Subtitle D landfill. Erosion control matting will be used in areas of past soil erosion. After cap construction, the area will be hydroseeded with grasses. Temporary erosion controls (such as biodegradable membranes) will be placed over the area until the grasses are established. As with Soil Alternative S2, details on seeding and temporary erosion controls will be defined during remedial design.

Following construction, the condition of the cap system will be monitored during site inspections of any institutional controls. For cost estimating purposes, it has been assumed that one percent of the cap will require maintenance annually.

Institutional Controls

Institutional controls will be similar to those discussed for Soil Alternative S2, if necessary. An additional restriction may be implemented to limit activities involving penetration of the cap, depending on the actions completed at each target cleanup area. Requirements for repair of the cap will also be included in case excavation through the cap is unavoidable.

4.1.1.4 Soil Alternative S4 - DPE and Shallow Soil Mixing

Soil Alternative S4 includes dual phase extraction (DPE) for ANC A and C to meet the soil RAOs. Prior to installation of the DPE system at ANC A, it has been assumed for costing that the soils to a depth of approximately 20 feet will be mixed to homogenize the soil and increase soil permeability. Mixing of the soils allows more accurate delineation of locations of underlying clay lenses within the silty soils and other potentially higher concentration areas. Because of the limited horizontal and vertical extent of contamination at ANC B, soil in this area will be excavated and disposed offsite, which has been assumed for costing purposes. In addition, limited excavation may be conducted at ANC A, depending on the results of the pre-design investigations. Details of the excavation areas, depths of shallow soil mixing, and details of the DPE system requirements will be defined during remedial design. Excavations will be backfilled with certified clean fill material.

This alternative minimizes leaching of contaminants to groundwater, prevents risks from direct contact to contaminated media, and limits erosion of contaminated soils by treating impacted soil to below the PRGs. This alternative will eliminate the need for long-term monitoring or institutional controls after treatment and will not limit future use of the target cleanup areas. The main components of this alternative are:

- Pre-Design Investigations (Assumed ANC A, B, and C for costing purposes)
- Excavation and Disposal (ANC A and B, and C if contamination identified outside the building limits – but not costed)
- Shallow Soil Mixing (Assumed at ANC A)
- Pneumatic Fracturing (Assumed at ANC A)
- Dual Phase Extraction (ANC A and C)
- Soil Monitoring (ANC A and C)

Note that excavation and offsite disposal may become part of this alternative for ANC A based on the results of pre-design investigations or unforeseen conditions encountered during shallow soil mixing. These activities were not included in costing or detailed evaluation of alternatives because the volume of soil to be excavated (if any) will be accessed during pre-design investigations.

Pre-Design Investigations

It has been assumed that pre-design investigations will be conducted as presented in Soil Alternative S2. Based on the results of the pre-design investigation, modifications to the treatment approach may be made from those assumed in this alternative. Of particular importance will be the depth of TCE contamination or potential areas of higher concentrations. If TCE is limited to the shallower silty soils, pneumatic fracturing may not be necessary and the DPE system may be modified to SVE only. Costs would be substantially lower if contamination is limited to the upper 20 feet of soil. If concentrated areas of TCE are detected in the pre-design investigations, excavation may be more viable rather than shallow soil mixing. It is assumed for cost estimating that details of the DPE system will be verified during a pilot study of pneumatic fracturing and DPE will be conducted.

Excavation and Disposal

It has been assumed that excavation and disposal of impacted soil at ANC B will be conducted as described in Alternative S2.

At ANC A, limited excavation and offsite disposal may be performed if pre-design investigations identify high concentrations of TCE or other contaminants in shallow soil. The volume of soil that may be excavated at ANC A is unknown, and will be assessed after the completion of pre-design investigations. Because the volume of soil is unknown, excavation at ANC A is not included in cost estimates for this alternative.

Shallow Soil Mixing

Prior to beginning shallow soil mixing at ANC A, the area will be cleared of brush and a temporary access road will be constructed. Storm water controls involving re-grading and culvert construction may be necessary to re-route stormwater. This will be undertaken to reduce infiltration into the area during DPE system installation and operation.

It has been assumed for cost estimating purposes that shallow soils will be mixed to a depth of approximately 20 feet under this alternative. These soils are the most heavily contaminated with TCE and are predominantly silts with thin lenses of sand. Mixing these soils will increase air movement through the otherwise less permeable zones and should reduce the time until PRGs are met. In addition, if areas of more concentrated TCE contamination are uncovered during soil excavation and mixing, these soils can be easily targeted for more intensive DPE, in situ oxidation, or excavation and disposal. Exact depths for shallow soil mixing will be evaluated during pre-design investigations or remedial design.

Mixing can be accomplished with a variety of construction equipment including rotating augers and blades, a spinning mixing attachment mounted to a hydraulic excavator, or standard excavator buckets working the soil repetitively until adequately homogenized. Mixing will likely be specified as a performance requirement and the specific technique

chosen by the excavation contractor. It has been assumed for cost estimating purposes that rotating augers will be used for shallow soil mixing.

Pneumatic Fracturing

Prior to installation of the DPE wells, it has been assumed for costing purposes that the open boreholes at ANC A only will be pneumatically fractured to increase soil permeability and TCE removal effectiveness. It is anticipated that the soil borings installed for DPE will be fractured vertically every 10 feet over an 80-foot depth. Fracturing was not considered for the ANC C area because of concerns regarding building stability during and after fracturing. If pre-design investigations conclude that ANC C is not located under the building, pneumatic fracturing may be viable.

Dual Phase Extraction

A general layout of the in situ DPE system prepared for costing purposes in this FS at ANC A is depicted in Figure 4-1. For costing purposes, it has been assumed that the system will consist of a total of 16 extraction well clusters that are interconnected by subsurface piping to a central treatment building. Each cluster will contain 4 wells with screens set approximately from 10 – 20 feet (within the mixed soil), 25 to 45 feet, 50 to 70 feet, and 75 to 95 feet (Figure 4-2). Each well will contain a level-controlled pump at the bottom to remove water that accumulates in the well. For cost estimating purposes, ten extraction well clusters are assumed to be required for the ANC C, which will be connected by piping to the central treatment building. The optimal location of the treatment building will be based on the remedial design. Piping between target cleanup areas will be run along existing street or utility right-of-ways, eliminating the need to lease additional land for piping runs. Screened depths for ANC C are assumed to be the same as for the ANC A area. A blower located in the treatment building will be used to apply vacuum to the subsurface to extract vapors from both locations. Details on the exact well locations, well depths, screen depths, piping, and treatment system(s) locations will be evaluated during remedial design.

The process equipment will be operated by an automatic control system that is set to extract from wells with similar screen depths. Generally, extraction will occur first from the wells screened in the mixed area (10 to 20 feet depth) for a period of time (exact times to be determined during pilot testing), and then the control system will switch to wells screened from 25 to 45 feet, followed by the next set (50 to 70 feet), and so on. Extraction will be conducted in this cyclical fashion to allow use of a smaller and less costly blower. When not under extraction, idle wells will be opened to the atmosphere through actuated solenoid valves to allow air to enter the subsurface. This area will flow to extraction wells, promoting vertical flow and reducing the potential for stagnant pockets in the subsurface. Details of the exact sequencing of system operations will be determined during remedial design, system installation, and startup.

It is assumed for costing purposes that TCE in the vapor stream will be removed using granular activated carbon (GAC) to meet air emission requirements. Based on the cyclical operation described above, flow rates are estimated to be about 400 standard cubic feet per minute (scfm), and TCE emission rates are estimated at 16 pounds per day during the first few months of operation (assumed for costing purposes to assess GAC usage). These estimates will be refined based on pilot test data prior to system design and construction. It has also been assumed that only a minimal volume of groundwater will be generated through the operation of the DPE system since the perched water zones seen in the target

cleanup area are limited in extent. It has been assumed that liquid-phase GAC will be used for treatment of groundwater prior to discharge to the POTW.

The main assumptions used to estimate the cost of this alternative are as follows.

- Target cleanup areas of 28,000 square feet (ANC A) and 16,000 square feet (ANC C)
- Pneumatic fracturing every 10 feet over an 80-foot depth for ANC A
- DPE wells on a 40-foot grid (20 foot radius of influence in mixed or fractured soil)
- 1 to 2 scfm per foot of DPE well screen, total flow rate of 400 scfm (cyclical operation)
- The DPE system will be operated for five years.
- Average concentration of TCE in soil is 6.3 mg/Kg (6.3 ppm), emission rate of 0.65 lb./hr, or 16 lb./day
- The optimal location of the treatment building will be defined during the remedial design. Piping between target cleanup areas is anticipated to be run along street right-of-ways (as applicable), eliminating the need to lease land.
- No pneumatic fracturing will be completed at ANC C unless the area is found to be located outside the footprint of the ANC building.

Soil Monitoring

Confirmation sampling will be conducted to verify the effectiveness of DPE. For cost estimating purposes, this sampling program is assumed to include six samples from each of five borings to a 100-foot depth at both ANC A and ANC C. Concrete coring at ANC C may be required prior to sampling. The samples will be analyzed for VOCs. Results will be summarized and submitted to USEPA and the NJDEP. Details of soil monitoring will be evaluated after completion of pre-design investigations and remedial design.

4.1.1.5 Soil Alternative S5 - In Situ Chemical Oxidation (ISO)

Soil Alternative S5 assumes for costing purposes the inclusion of ISO of TCE at ANC A and C. This alternative meets the objectives for minimizing leaching of contaminants to groundwater, preventing risks from direct contact, and preventing erosion of contaminated soils since the impacted soil will be treated to residual levels below the PRGs. Because of the limited horizontal and vertical extent of contamination at ANC B, it has been assumed for costing purposes that soil in this area will be excavated and disposed offsite. In addition, limited excavation may be conducted at ANC A, depending on the results of the pre-design investigations. The excavations will be backfilled with certified clean fill material. It has been assumed for costing purposes that institutional controls will not be required for ANC B because no soil exceeding PRGs will be left in place. This alternative will eliminate the need for long-term monitoring or institutional controls and will not limit future use of the target cleanup areas. The main components of this alternative are:

- Pre-Design Investigations (Assumed at ANC A, B, and C for costing purposes)
- Excavation and Disposal (Assumed at ANC A and B for costing purposes)
- Pneumatic Fracturing (Assumed at ANC A for costing purposes)
- In Situ Oxidation (Assumed at ANC A and C for costing purposes)
- Soil Sampling

Pre-design Investigations

It has been assumed for cost estimating purposes that pre-design investigations will be conducted as described for Soil Alternative S2. Based on the results of the pre-design investigation, modifications to the treatment approach may be made from those assumed in this alternative. Of particular importance will be the depth of TCE contamination. If TCE is limited to the shallower silty soils, pneumatic fracturing may not be necessary and the ISO system may be modified to include only shallower depths. It is also assumed for cost estimating that a pilot study of pneumatic fracturing and ISO will be conducted.

Soil samples will be collected to evaluate the soil oxidant demand. This will allow the proper dosage of potassium permanganate to be estimated. Additional oxidants such as sodium permanganate and persulfate will also be evaluated in bench-scale tests. Also, additional bench-scale testing will be completed to evaluate the extent to which permanganate may oxidize naturally-occurring metals and relatively insoluble Cr^{+3} to soluble and more toxic Cr^{+6} in soil. The actual oxidant will be evaluated during remedial design and pre-design investigations.

Based on the results of the pre-design investigation, modifications to the treatment approach may be made from those assumed in this alternative. Of particular importance will be the depth of TCE contamination encountered. If contamination is limited to the shallower silty soils at ANC A, it may be best to use a revised infiltration basin approach for delivery or perform limited excavation and offsite disposal. This will be evaluated as part of the pre-design. Once the delivery method is selected, the need for further pre-design pilot scale testing will be evaluated. It is assumed for cost estimating that pilot studies of pneumatic fracturing and permanganate injection will be conducted.

Excavation and Disposal

For cost estimating purposes, excavation and disposal of impacted soil at ANC B were evaluated for Alternative S2.

At ANC A, limited excavation and offsite disposal may be performed if pre-design investigations identify high concentrations of TCE or other contaminants in shallow soil. The volume of soil that may be excavated at ANC A is unknown, and will be assessed after the completion of pre-design investigations. Because the volume of soil is unknown, excavation at ANC A is not included in cost estimates for this alternative.

Pneumatic Fracturing

Pneumatic fracturing of the boreholes at ANC A may be performed to enhance distribution of the permanganate throughout the silt and clay soils. It is assumed for cost estimating purposes that the borings will be fractured every 10 vertical feet. Fracturing was not considered for the ANC C area because of concerns regarding building stability during and after fracturing. If pre-design investigations conclude that ANC C is not located under the building, pneumatic fracturing may be viable.

In Situ Oxidation

ISO involves the addition of an oxidant material such as potassium permanganate ($KMnO_4$) to chemically oxidize TCE to carbon dioxide and water. Two application approaches were considered: infiltration and injection. Under the infiltration approach, the oxidant material, assumed to be potassium permanganate for cost estimating purposes, will be added to

infiltration basins constructed over ANC A and allowed to leach through the soil. This approach could be used for the more permeable shallow silty soils in the upper 30 feet of ANC A, although it is not appropriate with deeper geologic conditions (isolated clay lenses within the silty soils). This approach will also not allow for infiltration under the building in ANC C. The second approach is to inject the permanganate through boreholes on a grid of locations throughout ANC A and C. This avoids the problem of slow infiltration rates and is the approach assumed for this alternative. Also, this allows for injection under the building in ANC C. It has been assumed for costing purposes that delivery will be through boreholes. However, if pre-design investigations suggest more effective delivery methods, these may be utilized.

Prior to drilling, the target cleanup areas will be cleared of brush and a temporary access road will be constructed. Soil borings are assumed for costing purposes to be installed on 20-foot centers in a grid pattern. Temporary casings will be installed in 5 foot sections to allow removal as the borehole is pneumatically fractured. For cost estimating purposes, it has been assumed that 60 injection locations will be installed at ANC A and 40 locations in ANC C. In ANC C, it has been assumed for cost estimating purposes that the concrete foundation will be cored through to install injection points. As a cost-saving measure, it has been also assumed that the injection of the oxidant material will immediately follow the pneumatic fracturing of soils in the same borehole.

Upon completion of the pneumatic fracturing, potassium permanganate will be injected. The main assumptions used to estimate the cost of this alternative are:

- Target cleanup areas of 28,000 square feet (ANC A) and 16,000 square feet (ANC C)
- Injection boreholes will be installed on a 20-foot grid
- Pneumatic fracturing every 10 feet over a 100 feet depth (ANC A)
- Potassium permanganate dosage of 2 grams/Kg soil
- No pneumatic fracturing will be completed at ANC C unless the area is found to be located outside the footprint of the ANC building.

Details of the ISO injection were used for cost estimating purposes. Details of the injection process will be evaluated during pre-design investigations and/or remedial design.

Soil Monitoring

A confirmation sampling program will be conducted as described for Soil Alternative S4. It is assumed for cost estimating purposes that treatment and monitoring beyond 2 years will not be necessary. However, additional treatment may be necessary based on pre-design investigations (when exact dosing is evaluated) or during implementation (when effectiveness is monitored).

4.1.1.6 Soil Alternative S6 - Excavation and Offsite Disposal

Soil Alternative S6 assumes for cost estimating purposes the removal of shallow soils with TCE concentrations greater than the PRGs for disposal offsite. Excavated soils will be replaced with clean fill material. Treatment of excavated soils will be conducted as necessary to meet LDRs. Soils remaining in place after excavation (i.e., soils more than 20 feet bgs) have been assumed for costing purposes to be treated by a DPE system similar to that described in Soil Alternative S4. The main components of this alternative are:

- Pre-Design Investigations (Assumed at ANC A, B, and C for costing purposes)
- Site Preparation/Restoration (Assumed at ANC C for costing purposes)
- Excavation, Treatment, and Disposal (Assumed at ANC A, B, and C for costing purposes)
- Pneumatic Fracturing (Assumed at ANC A for costing purposes)
- Dual Phase Extraction (Assumed at ANC A and C for costing purposes)
- Confirmation Soil Sampling

This alternative meets the objectives for minimizing leaching of contaminants to groundwater by removing impacted soil from the site and treating residuals to below PRGs. This alternative will completely eliminate the need for long-term monitoring or institutional controls and will not limit future use of the target cleanup area. Based on the characterization of soils, it has been assumed for costing purposes that treatment is unlikely to be necessary prior to disposal. It is also unlikely that the soil will be a hazardous waste and will be able to be disposed in a Subtitle D solid waste landfill. Details on soil handling, treatment, transportation, and disposal will be determined during pre-design investigations and/or remedial design.

Pre-Design Investigations

The pre-design investigations are assumed for costing purposes to be similar to those presented in Soil Alternative S2.

Site Preparation/Restoration

It has been assumed for costing purposes that the ANC C target cleanup area is located beneath the ANC building, and significant site preparation will be necessary prior to excavation of shallow soils if this is confirmed during pre-design investigations. Manufacturing or process equipment within the area to be excavated will need to be temporarily relocated, and the floor removed. It has been assumed for costing purposes that building supports (e.g., I-beams) within the building will be stabilized to prevent compromising the structural integrity of the building during excavation. Specialized equipment may be necessary to enter the building and emissions controls may be required to operate excavation equipment indoors. After excavation is completed, the excavation will be backfilled and the floor replaced. Details of the building support, stabilization, and structural support needed at the ANC building will be assessed during remedial design.

Costs to reconstruct the ANC facility and re-install equipment after remediation are not included in the cost estimate for this alternative. Although they are not considered "remedial costs", these costs would be incurred because ANC is an active facility.

Excavation, Treatment, and Disposal

It has been assumed for costing purposes that the excavation of soils exceeding PRGs will be completed using standard construction equipment (backhoes, front-end loaders, etc.). Based on the shallow depths of the excavation, it is not anticipated that sidewall stabilization of the excavation footprints will be necessary. The excavations at ANC A and B will be sloped (assumed to be 2:1) during the excavation. At ANC C and along the western portion of ANC A adjacent to the rail-line, shoring will be used to stabilize the excavation. The in situ volume of soil to be excavated is estimated for costing purposes to be about 20,222 cubic yards for ANC A, 481 cubic yards for ANC B, and 11,556 cubic yards for ANC C. Soil verification sampling along the sidewalls and bottom of the excavations will be

conducted to evaluate the adequacy of the excavation limits. The removal of soil is assumed for costing purposes to take approximately 32 days at ANC A, one day at ANC B, and 20 days at ANC C, assuming that there are no site access issues and that the soil is easily removed from the impacted areas. Details of the excavation extents, equipment to be utilized, required stabilization measures, and exact volumes of impacted soil to be removed will be based on pre-design investigation and/or remedial design.

A certified waste hauler (either a hazardous or non-hazardous waste hauler, depending on the characterization of the soil) will be used to transport the soil offsite. The waste will be labeled and shipped in accordance with U.S. DOT regulations. Manifests will accompany waste materials leaving the site.

Temporary stormwater diversion and soil erosion and sediment control measures will be established prior to excavation. As necessary, staging areas will be created to allow for temporary stockpiling of soils during excavation. The areas will be bermed and lined in accordance with the stormwater control measures. It is anticipated that a site-specific air permit (which will include air monitoring during the excavation) will be required. Stormwater diversion, soil erosion and sediment controls, and air monitoring requirements will be assessed during remedial design.

The excavation areas will be backfilled with clean-certified fill material. The backfill will be similar in properties (porosity, grain-size) as the native material and will be compacted in lifts (assumed at 2-foot thicknesses) to the ground surface. The area will be re-seeded with native grasses after backfilling and compaction.

It is not anticipated that the excavated VOC-contaminated soils will be characteristic hazardous waste or otherwise require treatment to meet LDRs prior to disposal. It has been assumed for costing purposes that TCLP testing of the excavated soil at a rate of one sample per 200 cubic yards will be conducted. If necessary the soil will be treated at the landfill prior to disposal (most likely solidification to meet TCLP limits for TCE). It has been assumed for cost estimating that ex situ stabilization will not be necessary. Details of sampling requirements, required treatment, and disposal options will be evaluated during remedial design.

The excavated VOC contaminated soils will be disposed at a Subtitle D landfill. Although the specific facility where the soils will be disposed of will be based on costs and performance reviews, it is anticipated that the soils will be disposed at a Subtitle D Landfill within 200 miles of the Study Area.

Pneumatic Fracturing

Prior to installation of the DPE wells, it has been assumed for costing purposes that the open boreholes will be pneumatically fractured to increase permeability. Pneumatic fracturing will be completed as discussed in Alternative S4. Fracturing was not considered when costing this alternative for the ANC C area because of concerns regarding building stability during and after fracturing. If pre-design investigations conclude that ANC C is not located under the building, pneumatic fracturing may be viable.

Dual Phase Extraction

The layout and operation of the DPE system has been assumed for costing purposes as the same as described for Soil Alternative S4. The main assumptions used to estimate the cost of this alternative are:

- Target cleanup area of 28,000 square feet (ANC A) and 16,000 square feet (ANC C)
- Pneumatic fracturing every 10 feet over an 80-foot depth for ANC A
- DPE wells on a 40-foot grid (20 foot radius of influence in mixed or fractured soil)
- 1 to 2 scfm per foot of DPE well screen, total flow rate of 400 scfm (cyclical operation)
- Average concentration of TCE in soil is 6,300 µg/Kg (6,300 µg/Kg), emission rate of 0.65 lb./hr, or 16 lb./day
- No pneumatic fracturing will be completed at ANC C unless the area is found to be located outside the footprint of the ANC building.

Details of the layout and operation of the DPE system will be evaluated during remedial design.

Confirmation Soil Sampling

A confirmation sampling program will be conducted as described for Soil Alternative S4. It is assumed for costing purposes that treatment and monitoring beyond 2 years will not be necessary. This will be verified during remedial design and operation of the DPE system.

4.2 Development of Groundwater Media Remedial Alternatives

The following section provides a summary of the alternatives developed for groundwater within the OU1 Study Area with concentrations of chlorinated VOCs over the PRGs.

4.2.1 Description of Alternatives

The remedial action objectives for the groundwater alternatives are:

- Restoration of the groundwater aquifer to drinking water quality in a reasonable timeframe; and
- Prevention of human ingestion of contaminated groundwater that presents an unacceptable risk (i.e., NJ GWQS [N.J,A,C, 7:9-6, MCLs, or in the absence of NJ GWQS or MCLs, a HI greater than 1, or ELCR greater than $1x10^{-4}$ to $1x10^{-6}$).

4.2.1.1 Groundwater Alternative G1 - No Further Action

The objective of the Groundwater Alternative G1 is to provide a baseline for comparison to other alternatives, as required by the National Contingency Plan (NCP). Groundwater Alternative G1 does not include further remedial action for groundwater. It does not include monitoring or institutional controls. Because it serves as a baseline, it is assumed that this alternative would be paired with the Soil Alternative S1—No Further Action.

4.2.1.2 Groundwater Alternative G2 - Monitored Natural Attenuation and Institutional Controls

Groundwater Alternative G2 relies on natural attenuation for the groundwater plumes while placing use restrictions on the areas of groundwater exceeding PRGs until groundwater returns naturally to concentrations below the PRGs.

The main remedial components of Groundwater Alternative G2 are:

- Groundwater Sampling
- Groundwater Use Restrictions
- Municipal Well Connection
- ANC Production Well Treatment
- Municipal Well Treatment
- Monitored Natural Attenuation (MNA)

This alternative will meet the RAOs for restoration of the groundwater at the site, prevention of ingestion of impacted groundwater, and eventually returning groundwater to drinking water quality.

Groundwater Sampling

As part of the pre-design investigation, it has been assumed for costing purposes that sampling of existing monitoring wells throughout Pohatcong Valley will be conducted. Throughout the natural attenuation process, groundwater sampling will be conducted to monitor the progress of remediation. It is anticipated for costing purposes that an additional 8 monitoring wells at four locations (2 wells nested at each location) will be installed and sampled, in addition to sampling approximately 50 existing monitoring wells throughout the OU1 Study Area. For costing purposes, the groundwater sampling component of natural attenuation is included as part of the MNA component, which includes documentation of remedial progress to USEPA and the NJDEP. Exact well locations, frequencies, and laboratory analysis will be evaluated during the remedial design effort.

Groundwater Use Restrictions

Groundwater institutional controls, designated as a Classification Exception Area (CEA) by the NJDEP, are the restrictive covenant used by the NJDEP to eliminate access to impacted groundwater by restricting use of the aquifer and preventing the installation of wells during the lifetime of the restriction. The CEA includes the area of impacted groundwater, the potential area of groundwater that may be impacted before completion of remedial actions (via migration), the contaminants and concentrations within the area, and an estimated duration of the restriction. Institutional controls related to groundwater use restrictions also include well drilling restrictions, designated as well restriction areas (WRAs) by the NJDEP, to prevent exposure to contaminated groundwater. There is currently a WRA within the OU1 Study Area that may need to be revised as part of this FS, along with the designation of a CEA for groundwater throughout the Valley. For the purposes of costing in this FS, it has been assumed that a CEA will be established and that the monitored natural attenuation components of this alternative will be used to collect data to document the status of the CEA.

Municipal Well Connection

This component includes the connection of municipal water to homes within the OU1 Study Area that have not already been connected in the past. This component provides protection of receptors within the area of impacted groundwater. Due to the longevity of remediation with this alternative, treatment of homeowner water at each individual wellhead was not deemed cost-effective. Therefore, this alternative only considers the connection to municipal water, which is reasonably available to the homes within the OU1 Study Area.

Based on data compiled by the NJDEP when the WRA was implemented and an estimate of the number of homes constructed with domestic wells since that time, approximately 60 homes are not currently connected to the municipal water supply. It has been assumed for costing purposes that 60 homes will be connected to the municipal water supply and that 50 percent of the homes will require a service-line connection of approximately 100 feet from the main pipeline to the home. The remaining 50 percent are assumed to require a connecting pipeline running approximately 1,000 feet from the main pipeline to the home (i.e., farmhouses set back from the road). Also, it has been assumed for costing purposes that existing domestic wells at the 60 homes will be abandoned by a New Jersey licensed drilling contractor.

ANC Production Well Treatment

ANC currently extracts groundwater from 2 wells adjacent to the west side of their facility for use in production. This water is used for process cooling water and is injected into the groundwater aquifer. The injected water contains TCE at concentrations ranging from 20 to 200 µg/L. Injection of this water results in water table mounding that could lead to the potential spreading of the TCE plume.

Under this alternative, it has been assumed for costing purposes that the extracted groundwater will need to be treated using a shallow tray air stripper to TCE concentrations below the PRG of 1 µg/L (1 ppb) prior to injection. The following assumptions were made for costing purposes:

- The average influent concentration (combined) from the two extraction wells is approximately 150 µg/L[2].
- The average flow rate (both for extraction and re-injection) is 205 gpm.

Given the relatively low TCE concentration, air stripper emission control is not expected to be necessary for vapors from the air stripper. Details of the ANC production well treatment process will be defined during remedial design.

Municipal Well Treatment

The New Jersey American Water Company (NJAWC) currently treats TCE and PCE impacted water from the Dale Avenue and Vannatta Street municipal wells prior to distribution to the public. The costs for the air stripping process are currently incurred by NJAWC. This technology was incorporated into each groundwater alternative to provide an evaluation of costs over the varying treatment times for each alternative.

[2] Estimate based on current concentrations observed in injection water from the ANC facility. These concentrations may vary due to potential additional source areas not yet investigated as part of the USEPA project (under NJDEP authority).

Monitored Natural Attenuation (MNA)

Natural attenuation is the process by which contaminant concentrations are reduced by processes such as volatilization, dispersion, adsorption, and biodegradation.

Based on the site groundwater data, aerobic conditions are present in the groundwater throughout the valley. These conditions are not conducive to biological degradation of TCE and PCE. However, other natural attenuation mechanisms such as advection and dispersion will result in declining concentrations over time. To provide a preliminary evaluation of the feasibility of the groundwater natural attenuation alternative, the Natural Attenuation Software (NAS) model was used to estimate remedial timeframes for MNA. The model was developed by the Naval Facilities Engineering Command - Southern Division, Virginia Tech University, and the U.S. Geological Survey (USGS). It allows a user to understand the decision-making framework and methodology for assessing MNA and estimating timeframes required for natural attenuation processes to lower contaminant concentrations and mass to predetermined regulatory goals. NAS is an analytical transport and decay model using historical centerline plume concentrations and an assumption of steady-state conditions to estimate time until remediation after the source area is removed or reduced in concentration. It models groundwater contaminant advection, dispersion, retardation, and biodegradation. Details of the model and a users guide are provided in Appendix D.

The time of remediation (TOR) for MNA is estimated at about 59 years following elimination of further TCE or PCE mass flux to groundwater. If further releases to groundwater continue, which is expected based on site data, the groundwater plume is expected to persist. Details of the TOR for Groundwater Alternative G2 are provided in Appendix D.

4.2.1.3 Groundwater Alternative G3 - In Situ Source Treatment and MNA

Alternative G3 includes the in situ oxidation (ISO) of TCE and PCE in the more concentrated portion of the groundwater plume. The objective is to remove a large portion of the TCE mass near the area of highest TCE concentrations to reduce the overall remediation timeframe from that of Groundwater Alternative G2. It is assumed for cost estimating purposes that natural attenuation processes will then be used for remediation of the remainder of the areas exceeding PRGs after in situ area treatment.

The main remedial components of Groundwater Alternative G3 are:

- Groundwater Sampling
- Pre-Design Investigations
- Groundwater Use Restrictions
- Municipal Well Connection
- ANC Production Well Treatment
- Municipal Well Treatment
- In Situ Oxidation (ISO)
- Monitored Natural Attenuation (MNA)

The groundwater use restrictions, municipal well connection, ANC production well treatment, and municipal well treatment components are assumed for costing purposes to be the same as described for Groundwater Alternative G2.

Groundwater Sampling

A pre-design investigation involving sampling of existing monitoring wells throughout the OU1 Study Area will be conducted. A confirmation sampling program will be conducted to verify the effectiveness of the remedy in the source area and throughout the plume to verify natural attenuation. For costing purposes, it has been assumed that three extraction wells and 13 monitoring wells will be sampled on a monthly basis to evaluate treatment performance. Samples will be analyzed for field parameters, VOCs, and metals. Details of the exact number of locations to be sampled, sampling frequency, and laboratory analytical parameters will be evaluated during the remedial design effort. Results will be summarized and submitted to USEPA and the NJDEP. It is assumed for cost estimating purposes that active treatment will be accomplished within 1 year. Note that the system operational time in the model assumes that there are no continuing source areas in soil that are leaching into groundwater. Therefore, this alternative needs to be coupled with an active soil remedy to achieve these remedial timeframes. For costing purposes, the groundwater sampling component is included under the MNA component, which includes documentation of remedial progress to USEPA and the NJDEP.

Pre-design Investigations

It is assumed for costing purposes that pre-design investigations will also be conducted to delineate the horizontal and vertical extent of TCE contamination more precisely. Delineation of the downgradient extent of the high concentration area will be the main focus of the investigation. It is anticipated for costing purposes that 8 monitoring wells at four locations (2 wells nested at each location) will be installed and sampled as part of the pre-design investigation, in addition to sampling approximately 50 existing monitoring wells throughout the OU1 Study Area. VOC concentrations and natural attenuation parameters will be evaluated at these wells. As with groundwater sampling, details of the exact number of locations to be sampled, sampling frequency, and laboratory analytical parameters will be evaluated during the remedial design effort.

Groundwater samples will also be used to estimate the oxidant demand and allow the proper dosage of oxidant material (assumed to be potassium permanganate) to be calculated. Alternate oxidants such as sodium permanganate and persulfate will be evaluated in bench-scale tests in addition to potassium permanganate. It is assumed for costing purposes that a pilot test of the selected oxidant material will be conducted to verify effectiveness and access the potential effects of the oxidant on the aquifer. Potential effects include residual oxidant material, increased metal concentrations and manganese dioxide precipitation.

Based on the results of the pre-design investigation, modifications to the treatment approach may be necessary. It is also possible that the in situ oxidation technology will be abandoned in favor of other alternatives based on the results of the pilot testing.

In Situ Oxidation (ISO)

The area of highest TCE concentrations (exceeding approximately 500 µg/L TCE) extending from soil target cleanup area ANC A to at least 750 feet downgradient will be the target cleanup area for in situ treatment. This zone is estimated to extend between 100 feet bgs to 175 feet bgs. ISO involves the addition of an oxidant to chemically oxidize TCE to carbon dioxide and water. As assumed for costing purposes, the oxidant will be injected into the bedrock groundwater through wells located along the upgradient perimeter of the target

area, as shown in Figure 4-3. It will be withdrawn through three extraction wells along the downgradient perimeter of the target cleanup area. It is anticipated that numerous pore volume flushes will be necessary to adequately distribute the oxidant solution throughout the target zone. Details of the exact locations and required number of injection and extraction points will be assessed during remedial design.

Oxidant will be added to extracted groundwater prior to injection. As a result, treatment of the TCE in the extracted groundwater will occur within the aquifer matrix. Ex-situ treatment using permanganate was considered, but deemed infeasible due to need for an excessively large tank or basin (1,200,000 gallons) to meet the required holding time of about 2 days. If required by the injection, the extracted groundwater could be treated in a shallow tray air stripper prior to injection, rather than adding oxidant and immediately injecting. The cost estimate assumes injection and treatment in situ will be acceptable.

For cost estimating purposes, it has been assumed that a treatment building to enclose the oxidant-addition process will be located on a leased portion of the property. Piping between target areas will be run along existing street or utility right-of-ways, eliminating the need to lease additional land. Because active remediation is expected to have been completed after one year, the costs for leasing the treatment building land are only included for the first year of this alternative. The exact location of treatment building(s), piping, and any other infrastructure necessary for the system will be evaluated during remedial design.

The main assumptions used to estimate the cost of this alternative are:

- Target cleanup area of approximately 300,000 square feet
- 3 injection wells each injecting approximately 140 gpm
- Oxidant dosage of 10 times the stoichiometric requirement for TCE oxidation
- Total required oxidant mass is 20,000 pounds
- Pore volume flush rate of 42 days
- Pumping and treatment building will require 10,000 square feet of leased property for one year

Monitored Natural Attenuation

The mechanisms of natural attenuation described in Groundwater Alternative G2 are assumed to be the same for costing purposes in this alternative. However, it is assumed that remedial timeframes under this alternative are shorter because higher concentration source areas will be actively remediated by ISO.

After in situ oxidation lowers groundwater concentrations of chlorinated VOCs to approximately 500 µg/L along the leading edge of the plume at ANC, modeling indicates that PRGs will be met via natural attenuation after 55 years. A 55 year timeframe for natural attenuation after injection was assumed for cost estimating purposes. Details of the NAS modeling run for Groundwater Alternative G3 are provided in Appendix D.

4.2.1.4 Groundwater Alternative G4 – Source Treatment and MNA

The objective of Groundwater Alternative G4 is to contain the most contaminated part of the TCE plume (concentrations exceeding approximately 500 µg/L, ppb) using a series of extraction wells along the downgradient edge of this source area. It is assumed for costing

purposes that natural attenuation will be the primary remedial technology for the downgradient portions of the plume.

The main remedial components of Groundwater Alternative G4 are:

- Groundwater Sampling
- Pre-Design Investigations
- Groundwater Use Restrictions
- Municipal Well Connection
- ANC Production Well Treatment
- Municipal Well Treatment
- Groundwater Containment
- Groundwater Treatment and Discharge (via Air Stripping, Adsorption)
- Monitored Natural Attenuation

The groundwater sampling, groundwater use restrictions, municipal well connection, ANC production well treatment, and municipal well treatment components are assumed for cost estimating purposes to be the same as described for Groundwater Alternative G2.

Pre-design Investigations

Pre-design investigations will be conducted to delineate the horizontal and vertical extent of TCE contamination more precisely. Delineation of the downgradient extent of the high concentration area (greater than approximately 500 µg/L) will be the main focus of the investigation. It is anticipated for costing purposes that 8 monitoring wells nested at four locations (2 wells at each location) will be installed and sampled as part of pre-design, in addition to sampling approximately 50 existing monitoring wells within the OU1 Study Area. Analysis for VOCs and natural attenuation parameters will be conducted at these wells. The exact locations, sampling, and laboratory analysis will be assessed during the remedial design effort.

Groundwater Containment

The objective of this component is to collect and treat the most concentrated portions of the impacted area (exceeding approximately 500 µg/L of TCE and the immediate source of PCE within the L&L/Econowash Dry Cleaners [LNL] area). It is assumed for costing purposes that the containment system will consist of two separate systems due to the distance between the extraction wells for the TCE and PCE locations. The exact location and number of treatment systems, along with the capture zone of the pumping wells will be defined during remedial design.

It is assumed for cost estimating purposes that the TCE containment system will consist of three high yield extraction wells, each pumping at approximately 140 gpm. The proposed locations of the pumping wells at ANC are along the downgradient edge of the 500 µg/L (500 ppb) concentration of TCE in groundwater, as shown in Figure 4-4. The capture zone of these wells is based on the data from the flow model and is also illustrated on Figure 4-4. It has been assumed for cost estimating purposes that the wells will be screened from 110 to 310 feet bgs and constructed of 8-inch black steel casing. The top 110 feet of well will be constructed as an overburden casing. Each well will require a total of 32 hours of development prior to use. It has been assumed that the development water will be treated and discharged as discussed below.

The PCE system will consist of one extraction well (similar in construction to the wells in the TCE system), placed within the LNL area. Due to the steep groundwater flow gradient within the LNL/Modern Valet Service (MVS) area and the level of detail of the existing flow model, a capture zone within the LNL/MVS areas could not be generated. It is anticipated, however, that focusing the pumping at this location will capture the highest concentrations of PCE detected in monitoring wells installed during the OU1 RI. This well will be approximately 280 feet deep, screened from 80 to 280 feet, and pumped at approximately 100 gpm. It has been assumed that the development water will be treated and discharged as discussed below.

Components of the treatment system(s) proposed in this alternative were for cost estimating purposes and were based on the groundwater modeling completed for the OU1 Study Area. Details of these design components will be evaluated during remedial design.

Groundwater Treatment and Discharge

As assumed for costing, both of the unit components for the ex situ treatment systems will be similar, with the exception of the flow capacity. The systems will consist of:

- An equalization basin to equilibrate flow
- Bag filtration for particulate removal
- A shallow tray air stripper to remove volatiles from the liquid phase to the gas phase
- Vapor-phase GAC for treatment of air emissions
- An effluent equalization tank

A process flow diagram for the ex situ treatment components used as a basis of cost is presented in Figure 4-5. The average influent concentration of TCE and PCE assumed for the groundwater treatment system is about 400 µg/L (400 ppb) and 20 µg/L (20 ppb), respectively. Shallow tray air stripping was chosen as the ex situ treatment technology for costing purposes due to the relatively low concentrations of TCE and PCE in influent groundwater and the removal effectiveness for this technology. Vapor-phase GAC was also chosen for air emission treatment for the same reasons. For costing purposes, it has been assumed for discharge permitting that effluent groundwater samples will be collected monthly for VOCs and pH. The overall system will be automated to allow for monitoring of system parameters from a remote location, thus limiting site visits to once each month for effluent sample collection. Details of the unit processes, flow rates, average influent and effluent concentrations, and air permitting requirements will be evaluated during remedial design.

After treatment, it has been assumed for costing that the generated water will be discharged to a series of injection wells (as depicted on Figure 4-4 for the TCE system) located upgradient of the extraction wells. Injection was chosen as the most viable discharge option since the municipal production wells are near the proposed pumping locations. The injection wells were placed upgradient of the extraction wells to achieve flushing of the contaminants to the extraction wells, and to minimize the potential for contaminants to be "pushed" downgradient due to the injection. The TCE system injection wells that were assumed for cost estimating purposes consists of four high-yield wells, constructed with black-steel to 340 feet (with 200 feet of open hole between 140 and 340 feet bgs). Each of the TCE injection wells has the capacity of 105 gpm. The PCE injection well is the same as the

PCE extraction well (one well 280 feet deep with injection capacity of 100 gpm). Details of the injection well network will be evaluated during remedial design.

As part of the modeling effort for this alternative, a remedial timeframe for the pumping areas to achieve PRGs was also calculated. For this alternative, the PRGs for TCE within the pumping area of influence were achieved in about 11 years. Note that based on the modeling, this system operational time assumes that there are no continuing source areas in soil that are leaching into groundwater. Therefore, this alternative needs to be coupled with an active soil remedy to achieve these remedial timeframes. The 11 year timeframe for operation was assumed for this alternative for cost estimating purposes.

The capture zone of the PCE pumping system could not be estimated using the model because the pumping rate for the extraction well was not sufficient to generate a recognizable capture zone at the LNL site. In addition, the internodal spacing of the model grid (200 ft) may be excessively coarse for reliable evaluation of this small of an area. Since a discrete capture zone was not developed, no time of remediation can be estimated for the PCE portion of Alternative G4. For costing purposes, it has been assumed that this system will operate for 11 years to achieve PRGs (the same timeframe as the TCE system). Details of the modeling effort are provided in Appendix C.

Each of the two treatment buildings (which were assumed necessary for costing but will be verified during remedial design) will be located on leased industrial property. Piping between target areas, where applicable, will be run along existing street or utility right-of-ways to eliminate the need to lease additional land. Because active remediation is expected to have been completed after 11 years, the costs for leasing the treatment building land are included for only the first 11 years of this alternative.

For costing purposes, the following assumptions were made.

- Influent concentrations of TCE and PCE will be 400 µg/L and 20 µg/L, respectively.
- The shallow tray air stripper will remove 95 percent of the TCE or PCE mass, depending on the system. It has been assumed that this entire removed mass will be transferred to the vapor phase.
- Effluent air discharge requirements for total VOCs will be 0.5 lbs/hour, based on NJDEP air permitting guidelines.
- Discharge requirements for treated groundwater will be less than 1 µg/L for chlorinated VOCs, and will include monthly effluent sampling for VOCs and pH to verify compliance.
- Each pumping and treatment building will require 10,000 square feet of leased property for eleven years.

An evaluation of the time to achieve PRGs in the Dale Avenue and Vannatta Street municipal wells was also completed for this alternative. Details of the modeling effort for remediation of these wells are included in Appendix D. The modeling effort demonstrates that the calculated timeframe for meeting the PRGs at the Dale Avenue well is about 10 years after completion of the active pumping operations.

Monitored Natural Attenuation (MNA)

The MNA processes discussed in Groundwater Alternative G2 are similar for this alternative, with the exception that the concentrated portions of the plumes are intercepted, thus eliminating a continuing source to downgradient groundwater. By eliminating the leading edge of the most concentrated portion of the plume, MNA modeling shows that time to achieve PRGs at the downgradient portion of the OU1 Study Area is 55 years. Details of the MNA modeling are provided in Appendix D.

4.2.1.5 Groundwater Alternative G5 – Expanded Source Treatment and MNA

Groundwater Alternative G5 is essentially the same as Groundwater Alternative G4, but includes additional measures to capture impacted groundwater flowing toward the Vannatta Street and Dale Avenue municipal supply wells faster than captured in Groundwater Alternative G4. This alternative modifies Groundwater Alternative G4 by installing additional extraction wells and increasing their pumping rate to increase the size of the capture zone.

The main remedial components of Groundwater Alternative G5 are:

- Groundwater Sampling
- Pre-Design Investigations
- Groundwater Use Restrictions
- Municipal Well Connection
- ANC Production Well Treatment
- Municipal Well Treatment
- Groundwater Containment
- Expanded Source Containment
- Groundwater Treatment and Discharge
- Monitored Natural Attenuation

The pre-design investigation, groundwater sampling, groundwater use restrictions, municipal well connection, ANC production well treatment, and municipal well treatment components are assumed for costing purposes to be the same as described for Groundwater Alternative G2.

Groundwater Containment

The objective of this component is to collect and treat the most concentrated portions of the area exceeding PRGs. As with Groundwater Alternative G4, the groundwater system is assumed for cost estimating purposes to consist of two separate systems due to the distance between pumping wells for the TCE and PCE locations.

The TCE system within the source area was assumed to consist of a series of three high yield extraction wells each pumping at about 280 gpm. The locations of the extraction wells would be situated as depicted in Figure 4-6, along the downgradient edge of the 500 µg/L (500 ppb) concentration of TCE in groundwater. The capture zone of these wells is based on the data from the flow and is also illustrated on Figure 4-6. Each of the wells will be an 8-inch, high-yield well, a total of 340 feet deep, screened from 140 to 340 feet bgs. The wells will be constructed of 8-inch black steel casing.

The PCE containment system will consist of one extraction well within the middle of the PCE source area, similar in construction to the wells for the TCE plume, and placed within the L&L/Econowash Dry Cleaners (LNL) area (Figure 4-7). This well will be approximately 280 feet deep, screened from 80 to 200 feet bgs, and pumped at approximately 210 gpm. It has been assumed that the development water will be treated and discharged as discussed below.

As with Groundwater Alternative G4, details on the locations of treatment systems, piping, and extraction and injection wells will be verified during remedial design.

Expanded Source Containment

To allow for groundwater currently captured by the two municipal supply wells (Vannatta Street and Dale Avenue municipal wells) to be treated sooner than in Groundwater Alternative G4, it has been assumed for costing purposes that the two systems discussed above will be expanded to capture a larger extent of the most concentrated groundwater.

Within the TCE target cleanup area, it is assumed that two additional wells will be installed along the lateral extent of the plume, for a total of five extraction wells. Overall flow rates will be increased to capture all impacted groundwater above 1 µg/L (1 ppb), as shown in Figure 4-6. When these two additional wells are included, the total flow rate of the TCE system is 1,400 gpm. This system will be expected to capture of the entire upgradient portion of the TCE plume that exceeds PRGs.

For the PCE area, one additional well will be added to the extraction system discussed above for a total of two extraction wells. The location of the additional well is indicated in Figure 4-7. This well will be constructed to the same depth as the first PCE well pump at approximately 210 gpm. When these additional well is included, the total flow rate of the PCE system is 420 gpm. The capture zone of these two wells is shown on Figure 4-7.

As with Groundwater Alternative G4, details on the locations of treatment systems, piping, and extraction and injection wells will be verified during remedial design.

Groundwater Collection, Treatment, and Discharge

Both of the unit components for the two ex-situ treatment systems are assumed for cost estimating purposes to be similar, although sized for a different flow capacity. The systems will consist of the following components.

- An equalization basin to equilibrate flow
- Bag filtration for particulate removal
- A shallow tray air stripper to remove VOCs from the liquid phase to the gas phase
- Vapor-phase GAC for treatment of air emissions
- And effluent equalization tank

A process flow diagram for the ex situ treatment components is presented in Figure 4-5. The average influent concentration of TCE and PCE assumed for the groundwater treatment system is about 50 µg/L (50 ppb) and 15 µg/L (15 ppb), respectively. Shallow tray air stripping was chosen as the ex situ treatment technology due to the relatively low concentrations of TCE and PCE in influent groundwater and the removal effectiveness of this technology. Vapor-phase GAC was also chosen for air emission treatment for these same reasons. For costing purposes, it has been assumed that effluent groundwater samples

will be collected monthly for discharge permitting for VOCs and pH. The overall system will be automated to allow for monitoring of system parameters from a remote location, to limit site visits to once per month for effluent sample collection. Details of the unit processes, flow rates, average influent and effluent concentrations, and air permitting requirements will be determined during remedial design.

After treatment, it is assumed for costing purposes that the generated water will be discharged to a series of injection wells (also depicted on Figures 4-6 and 4-7 for the TCE and PCE systems, respectively) for re-injection upgradient of the extraction wells. Re-injection was chosen as the most viable discharge option since the municipal wells are near the proposed pumping locations. The injection wells will be placed upgradient of the extraction wells to achieve flushing of the contaminants to the extraction wells, and so that contaminants are not "pushed" downgradient due to the injection. Exact locations of the injection wells will be defined based on remedial design.

The TCE injection system consists of a series of eight injection wells (see Figure 4-6) that have the capacity of injecting 175 gpm. The wells will be constructed to the same depths as the extraction wells for the TCE system, to terminal depths of 340 feet. The PCE injection system consists of a series of four injection wells (Figure 4-7) that each have the capacity of 105 gpm injection. These wells will be installed to a depth of 280 feet with the bottom 200 feet as open hole. Exact locations of the injection wells will be defined based on remedial design.

As part of the modeling effort for this alternative (see Appendix C), a remedial timeframe for the pumping areas to achieve PRGs was also calculated. For this alternative, the PRGs within the pumping influence area of TCE were achieved in an estimated 47 years. For costing purposes, it has been assumed that this system will require operation for 47 years. The PCE system will achieve PRGs within about 33 years. As with Groundwater Alternative G4, this system operational time assumes that there are no continuing source areas in soil that are leaching into groundwater. Therefore, this alternative may need to be coupled with an active soil remedy to achieve these remedial timeframes.

Each of the two treatment buildings were assumed for costing purposes to be located on leased industrial property. Piping between target areas, where applicable, will be run along existing street or utility right-of-ways to eliminate the need to lease additional land. Because active remediation is expected to have been completed after 47 and 33 years, for the TCE and PCE target cleanup areas, respectively, leasing costs for each building are included only for these lengths of time. The locations, number of systems, and piping layouts will be defined during remedial design.

For costing purposes, the following assumptions were made.

- Influent concentrations of TCE and PCE will be 50 µg/L (50 ppb) and 15 µg/L (15 ppb), respectively.
- The shallow tray air stripper will remove 95 percent of the TCE or PCE mass, depending on the system. It has been assumed that this entire mass will be transferred to the vapor phase.

- Effluent air discharge requirements for total VOCs will be 0.5 lbs/hour, based on NJDEP air permitting guidelines.
- Discharge requirements for treated groundwater will be less than 1 µg/L (1 ppb) for chlorinated VOCs, and will include monthly effluent sampling for VOCs and pH to verify compliance.
- The TCE pumping and treatment building will require 20,000 square feet of leased property for 47 years.
- The PCE pumping and treatment building will require 10,000 square feet of leased property for 33 years.

Model runs for the TCE and PCE plumes at the Dale Avenue and Vannatta Street municipal wells were not completed because the groundwater collection system capture zone is in close proximity to the wells. The time to remediate the two municipal wells is anticipated to be less than the 10 years required for Groundwater Alternative G4, which was assumed for costing purposes.

Monitored Natural Attenuation

The MNA monitoring discussed in Alternative G2 is similar for this alternative, with the exception that the concentrated portions of the plumes are intercepted, thus eliminating a continuing source to downgradient groundwater. By eliminating the leading edge of the most concentrated portion of the plume, MNA for the remainder of the TCE plume within the OU1 boundary reduces in timeframe to about 45 years to reach PRGs. It was assumed for cost estimating purposes that MNA will achieve PRGs 45 years during the active operations of the treatment system(s), which are assumed to be operating for 47 years.

4.2.1.6 Groundwater Alternative G6 – Downgradient Interception and Treatment

Groundwater Alternative G6 meets PRGs through the installation of five extraction wells placed at the leading edge of the plume such that over time the entire plume will be captured and treated ex situ. This alternative will protect human health and the environment downgradient of the OU1 boundary by eliminating the potential migration of VOCs.

The main remedial components of Groundwater Alternative G6 are as follows.

- Groundwater Sampling
- Pre-Design Investigations
- Groundwater Use Restrictions
- Municipal Well Connection
- ANC Production Well Treatment
- Municipal Well Treatment
- Groundwater Collection

The pre-design investigation, groundwater sampling, groundwater use restrictions, municipal well connection, ANC production well treatment, and municipal well treatment components are assumed for costing purposes to be the same as described for Alternative G2.

Groundwater Collection, Treatment, and Discharge

The OU1 TCE plume has an average plume width of about 3,000 feet, a thickness of 200 feet, and over 5 miles in length. The estimated flow rate to intercept the downgradient edge of the OU1 plume is approximately 3,000 gpm (or 4.3 million gallons per day). Based on flow modeling, it is assumed for costing purposes that this alternative will require a set of five extraction wells, a large-scale ex-situ treatment system placed near the leading edge of the plume, and discharge of treated groundwater to a set of four injection wells. The PRGs were estimated to be achieved in about 67 years. This time was calculated using the size of the plume to be captured and subsequently scaling up Groundwater Alternative G5 numbers of wells and total pumping rates. The groundwater treatment system is assumed for costing purposes to be similar in process to that presented for Groundwater Alternative G5, although significantly larger in scale to allow for the much higher throughput. This is assuming the soil source area is removed (i.e. that this alternative is coupled with an active soil remedial alternative) and that no active groundwater treatment will be conducted at the source area.

The treatment building is assumed to be located on leased industrial property. The size of the required property is assumed to be 40,000 square feet, for cost estimating purposes. Piping between extraction and injection wells and the treatment building will be run along existing street or utility right-of-ways to eliminate the need to lease additional land. Because active remediation is expected to have been completed after 67 years, leasing costs for the property are included in the cost estimate for 67 years. The exact flow rates, influent TCE concentrations, number and locations of extraction and injection wells, treatment system components, and the locations of systems and infrastructure will be assessed during remedial design.

4.2.1.7 Groundwater Alternative G7 – Entire Plume Collection and Treatment

Groundwater Alternative G7 meets PRGs through the capture and treatment of the entire groundwater plume. This alternative protects human health and the environment both within OU1 and downgradient of the plume by removing the contaminated groundwater from the regional aquifer. It complies with the ARARs and be effective long-term. This alternative includes groundwater collection and treatment to reduce the mobility of the TCE plume, and this alternative is more protective for municipal supply wells than the downgradient interception alternative.

The main remedial components of Groundwater Alternative G7 are as follows.

- Groundwater Sampling
- Pre-Design Investigations
- Groundwater Use Restrictions
- Municipal Well Connection
- ANC Production Well Treatment
- Municipal Well Treatment
- Groundwater Collection, Treatment and Discharge

The pre-design investigation, groundwater sampling, groundwater use restrictions, municipal well connection, ANC production well treatment, and municipal well treatment

components are assumed for costing purposes to be the same as described for Groundwater Alternative G2.

Groundwater Collection, Treatment, and Discharge

This alternative includes entire plume capture and treatment. It is assumed for costing purposes that it will require six sets of five extraction wells (30 wells total) oriented perpendicular to the migration of the plume, with each set spaced approximately 4,000 feet along the longitudinal extent of the OU1 plume. To completely capture the TCE plume, an estimated minimum of 1,500 gpm needs to be pumped at each set of extraction wells. This extraction system will produce a total of 9,000 gpm (or nearly 13 million gallons per day). The groundwater treatment system is assumed for costing purposes to be similar in process to that presented for Groundwater Alternative G5, although significantly larger in scale to allow for the much higher throughput (e.g., six treatment plants would be needed to treat the amount of water extracted under this alternative). Under this alternative, groundwater PRGs are assumed to be met in approximately 22 years. This time was calculated using the size of the plume to be captured and subsequently scaling up Groundwater Alternative G5 numbers of wells and total pumping rates.

The treatment building is assumed for costing purposes to be located on leased industrial property. The size of the required property is assumed to be 40,000 square feet, for cost estimating purposes. Piping between extraction and injection wells and the treatment building will be run along existing street or utility right-of-ways to eliminate the need to lease additional land. Because active remediation is expected to have been completed after 22 years, leasing costs for the property are included in the cost estimate for 22 years.

The exact flow rates, influent TCE concentrations, number and locations of extraction and injection wells, treatment system components, and the locations of systems and infrastructure will be determined during remedial design.

4.3 Initial Screening of Alternatives

A preliminary evaluation of the soil and groundwater remedial alternatives was completed to access whether alternatives could be initially screened out prior to the detailed evaluation presented in Section 5. These alternatives were removed from consideration and were not evaluated as part of the detailed analysis of alternatives.

4.3.1 Initial Screening of Soil Alternatives

The six soil alternatives were initially evaluated on the basis of implementability, effectiveness, and cost. Two alternatives were considered to have poor effectiveness. The following sections provide a summary of the screening-level evaluation for the alternatives that were eliminated.

4.3.1.1 Soil Alternative S2 – Soil Cover, Natural Attenuation, and Institutional Controls

Soil Alternative S2 relies on the soil cover to meet the first two remedial action objectives related to human exposure to the soil and preventing erosion. It relies on monitoring and natural attenuation to address the third remedial objective addressing leaching of contaminants to groundwater. Since a soil cover does not eliminate or limit infiltration of

surface water to groundwater, the remedial action objective to prevent leaching is not effectively met and the ARAR for meeting the groundwater PRGs are not achieved.

This alternative is also not considered effective either in the long- or short-term, since it allows continued leaching of soil contamination to groundwater, which is expected to continue for decades. Also, this alternative does not reduce the toxicity, mobility, or volume of contamination through treatment.

In summary, this soil alternative does not meet the remedial action objectives for the OU1 Study Area, specifically to remediate soils as necessary to prevent leaching of contamination that results in groundwater exceeding the PRG. As a result, Soil Alternative S2 will not be considered further within this FS.

4.3.1.2 Soil Alternative S5 – In Situ Chemical Oxidation

Soil Alternative S5 has poor technical effectiveness because of the presence of the low permeability soils in the soil target cleanup areas. In low permeability soils, oxidation technologies often require repeated applications because initial oxidant additions do not adequately contact the contaminants diffused into the low permeability soils. Permanganate does at least partially address this concern because it remains an active oxidant for many months, thus allowing the TCE to be treated as it slowly diffuses out of the soils not initially contacted by the oxidant. However, another drawback for permanganate is that manganese dioxide is formed as the permanganate is reduced during the oxidation of TCE and other naturally occurring organics. The manganese dioxide precipitates on the soil matrix, potentially reducing the permeability (i.e., clogging) of existing and pneumatically induced fractured clay lenses within the silty soils. This could diminish overall TCE removal effectiveness.

Soil Alternative S5 would also require the most monitoring for the protection of the community and the environment during implementation because permanganate can oxidize naturally occurring metals and relatively insoluble Cr(III) to soluble and more toxic Cr(VI) in soils. Monitoring to detect Cr(VI) formation would be needed to evaluate if mitigation to reduce the Cr(VI) to Cr(III) is necessary. Some leaching of unreacted potassium permanganate to the groundwater with subsequent migration toward the Dale Avenue municipal well could also occur. Groundwater monitoring would be necessary to detect any residual permanganate. Mitigation involving injection of dissolved sugar could be performed to complete the reaction of permanganate to MnO_2, if necessary.

In summary, in situ oxidation has poor effectiveness because the low permeability soils make delivery and adequate distribution of the oxidant very difficult and costly. The limited delivery of materials to contaminants in soils may require multiple doses and even then may not achieve adequate treatment in the soil matrix. Also, additional monitoring would be required to protect human health and the environment to verify that the municipal supply wells would not be impacted during the injection. As a result, Soil Alternative S5 will not be considered further within this FS.

4.3.1.3 Remaining Soil Alternatives

The following soil alternatives were retained after the initial screening and will be carried forward to the detailed analysis of alternatives (Section 5).

- **Soil Alternative S1 – No Further Action**. This alternative is renamed ***Soil Alternative SO1*** for the remainder of the FS.
- **Soil Alternative S3 – Capping and Institutional Controls**. This alternative is renamed ***Soil Alternative SO2*** for the remainder of the FS.
- **Soil Alternatives S4 – DPE and Shallow Soil Mixing.** This alternative is renamed ***Soil Alternative SO3*** for the remainder of the FS.
- **Soil Alternative S6 – Excavation and Offsite Disposal.** This alternative is renamed ***Soil Alternative SO4*** for the remainder of the FS.

4.3.2 Initial Screening of Groundwater Alternatives

The seven groundwater alternatives were initially evaluated on the basis of implementability, effectiveness, and cost. Three alternatives were considered to be impractical and not cost-effective. The following sections provide a summary of the screening-level evaluation for the alternatives that were eliminated.

4.3.2.1 Groundwater Alternative G2 – Monitored Natural Attenuation and Institutional Controls

TCE concentrations in groundwater have been fluctuating over time based on the Dale Avenue municipal well sampling results dating from 1986. The data show a downward trend (see Figure 1-6), although the trend is minimal. Based on these data and the lack of TCE degradation throughout the plume, the TCE plume is considered to be relatively stable in the groundwater. Although the plume may be currently declining somewhat in concentration, it is expected to remain above NJ GWQS for over 100 years. Groundwater Alternative G2 is not protective of human health and the environment since the municipal supply wells will continue to be impacted for decades.

Groundwater Alternative G2 is also not effective over either long-term or short-term, since treatment will still be required for many decades at the Dale Avenue and Vannatta Street municipal supply wells. Also, monitored natural attenuation is not considered an active reduction of toxicity, mobility, or volume (TMV) through treatment.

In summary, Groundwater Alternative G2 will not be evaluated in the detailed evaluation since impacts to the Dale Avenue and Vannatta Street municipal supply wells will continue for decades under this alternative. This is not considered a reasonable time frame to achieve the groundwater PRGs given the site-specific circumstances.

4.3.2.2 Groundwater Alternative G3 – In Situ Source Treatment and MNA

Similar to using in situ treatment for soils as discussed in Soil Alternative S5, Groundwater Alternative G3 has potential community and environmental impacts to the municipal supply wells from unreacted permanganate remaining in the aquifer. Permanganate could also cause an increase in Cr(VI) within the treatment area because of the strongly oxidizing conditions. Cr(VI) may reduce back to immobile Cr(III) outside the treatment zone, but fracture flow could cause rapid migration to municipal wells.

Groundwater Alternative G3 also has potential difficulties in delivering oxidants in fractured bedrock, which would limit the effectiveness of the alternative. Also, the

effectiveness of Groundwater Alternative G3 diminishes if the precipitating manganese dioxide fills the fractures needed to distribute the permanganate sufficiently or if multiple injections are necessary over time to meet PRGs.

Groundwater Alternative G3 may have community and environmental impacted related to unreacted permanganate in the aquifer, could increase Cr(VI) within the treatment areas, and may require excessive or multiple doses before achieving PRGs. As a result, this groundwater alternative will not be considered further within this FS.

4.3.2.3 Groundwater Alternative G6 – Downgradient Interception and Treatment

Groundwater Alternative G6 involves the collection of groundwater at the downgradient portion of the OU1 Study Area for treatment. Groundwater Alternative G6 is not considered to be effective since this alternative requires impacted groundwater to naturally migrate through the valley prior to collection and treatment. The large volume of pumping at the leading edge of the plume may damage natural resources such as the streams and wetlands along Pohatcong Creek, since there is a potential for significant dewatering which would impact the habitats in these areas. The time until remedial objectives are attained is an estimated 67 years, because it requires the remainder of the plume to naturally migrate into the collection area of the wells. This is excessive relative to other groundwater remedial alternatives evaluated in the FS.

The implementability of this alternative is also considered to be poor because the treatment system would be very large and would require multiple operators and high-yield extraction and injection wells. Because of the large scale of the treatment system, the long duration required to achieve cleanup, and the fact that this alternative does not protect upgradient public supply wells, community and state acceptance may be difficult to obtain.

In summary, this groundwater alternative has significant disadvantages relative to potential natural resources damages, time until remedial objectives are met, and implementability concerns. As a result, it will not be considered further within this FS.

4.3.2.4 Remaining Groundwater Alternatives

The following groundwater alternatives were retained after the initial screening and will be carried forward to the detailed analysis of alternatives (Section 5). Table 4-4 summarizes the components of each alternative and indicates whether or not the alternative was retained for detailed analysis.

- **Groundwater Alternative G1 – No Further Action.** This alternative is renamed ***Groundwater Alternative GW1*** for the remainder of the FS.
- **Groundwater Alternatives G4 – Source Treatment and MNA.** This alternative is renamed ***Groundwater Alternative GW2*** for the remainder of the FS.
- **Groundwater Alternative G5 – Expanded Source Treatment and MNA.** This alternative is renamed ***Groundwater Alternative GW3*** for the remainder of the FS.
- **Groundwater Alternative G7 – Entire Plume Collection and Treatment.** This alternative is renamed ***Groundwater Alternative GW4*** for the remainder of the FS.

TABLE 4-1

Soil Remedial Alternatives

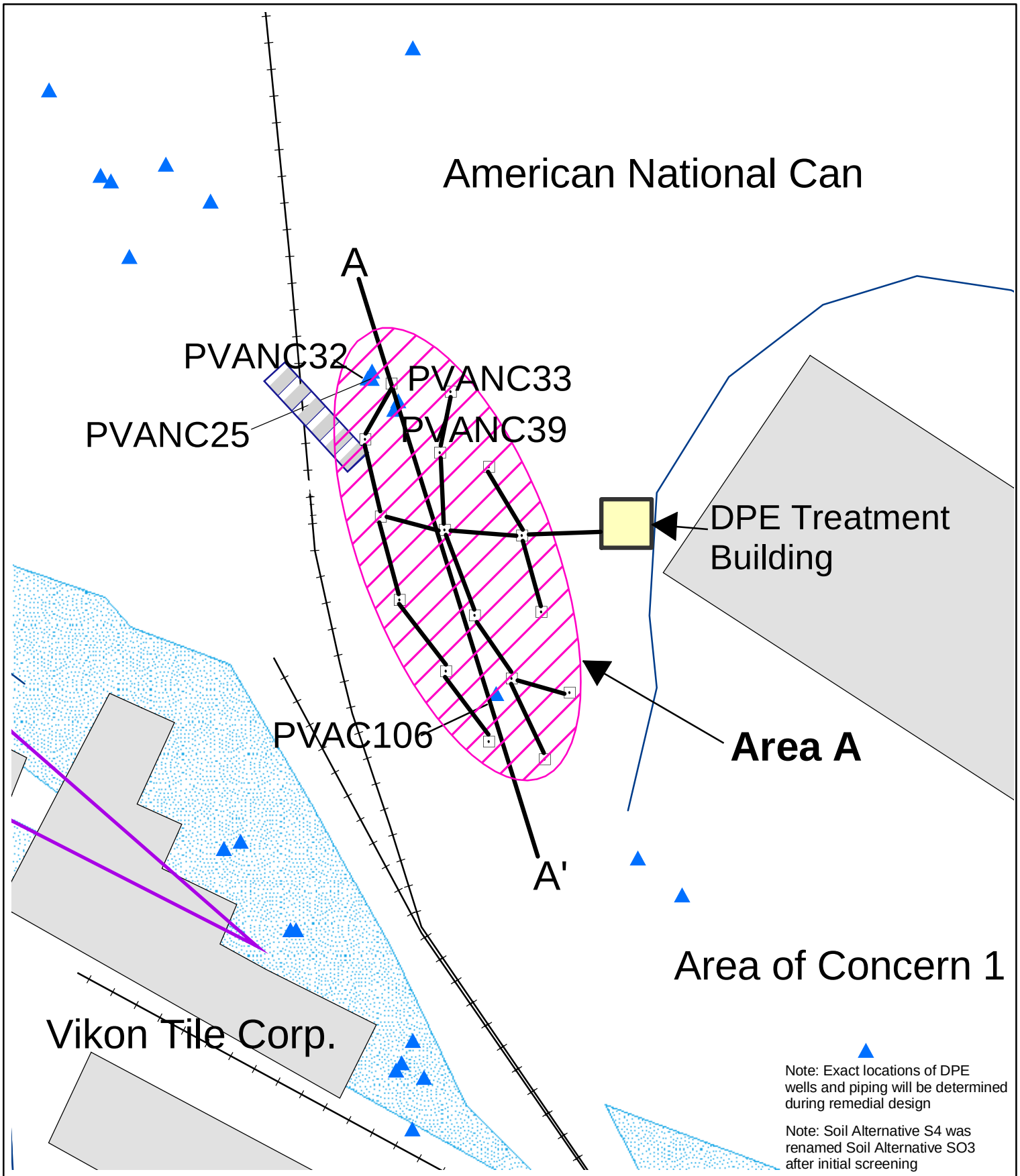
PVGCS OU1 Study Area Feasibility Study

Remedial Technologies or Process Options	**Soil Alternative S1** **No Further Action**	**Soil Alternative S2** **Soil Cover, Natural Attenuation, and Institutional Controls**	**Soil Alternative S3** **Capping and Institutional Controls**	**Soil Alternative S4** **DPE and Shallow Soil Mixing**	**Soil Alternative S5** **In Situ Chemical Oxidation**	**Soil Alternative S6** **Excavation and Offsite Disposal**
Soil Monitoring		X	X	X	X	X
Pre-Design Investigations		X	X	X	X	X
Institutional Controls		X	X			
Monitored Natural Attenuation		X				
Soil Cover		X				
Soil Multi-Layer Cap			X			
In Situ Oxidation					X	
Shallow Soil Mixing				X		
Dual Phase Extraction (DPE)				X		X
Pneumatic Fracturing				X	X	X
Excavation of Shallow Soils		X	X	X	X	X
Ex Situ Stabilization		X	X	X	X	X
Offsite Disposal at Subtitle C/ D Landfill		X	X	X	X	X
Retained for Detailed Evaluation (Yes/No)	Yes - Soil Alternative **SO1**	No	Yes – Soil Alternative **SO2**	Yes – Soil Alternative **SO3**	No	Yes – Soil Alternative **SO4**

TABLE 4-2

Groundwater Remedial Alternatives
PVGCS OU1 Study Area Feasibility Study

Remedial Technologies or Process Options	Groundwater Alternative G1 No Further Action	Groundwater Alternative G2 MNA and Institutional Controls	Groundwater Alternative G3 In Situ Source Treatment and MNA	Groundwater Alternative G4 Source Treatment and MNA	Groundwater Alternative G5 Expanded Source Treatment	Groundwater Alternative G6 Downgradient Interception and Treatment	Groundwater Alternative G7 Entire Plume Collection and Treatment
Groundwater Sampling		X	X	X	X	X	X
Pre-Design Investigations			X	X	X	X	X
Groundwater Use Restrictions		X	X	X	X	X	X
Municipal Well Connection		X	X	X	X	X	X
ANC Production Well Treatment		X	X	X	X	X	X
Municipal Well Treatment		X	X	X	X	X	X
Monitored Natural Attenuation (MNA)		X	X	X	X	X	X
In Situ Oxidation			X				
Groundwater Treatment				X	X		X
Expanded Groundwater Treatment					X		X
Air Stripping Treatment				X	X	X	X
Groundwater Collection						X	X
Adsorption				X	X	X	X
Injection Discharge				X	X	X	X
Retained for Detailed Evaluation (Yes/No)	Yes – Groundwater Alternative **GW1**	No	No	Yes – Groundwater Alternative **GW2**	Yes – Groundwater Alternative **GW3**	No	Yes – Groundwater Alternative **GW4**



Legend

- Soil Sampling Locations
- DPE Wells
- DPE Piping
- ANC A Target Area

A — A' Cross section, see figure 4-3

N

0 25 50 100 Feet

Figure 4-1
Soil Alternatives S4 - ANC A
DPE System Layout
OU1 Feasibility Study
Pohatcong Valley, NJ

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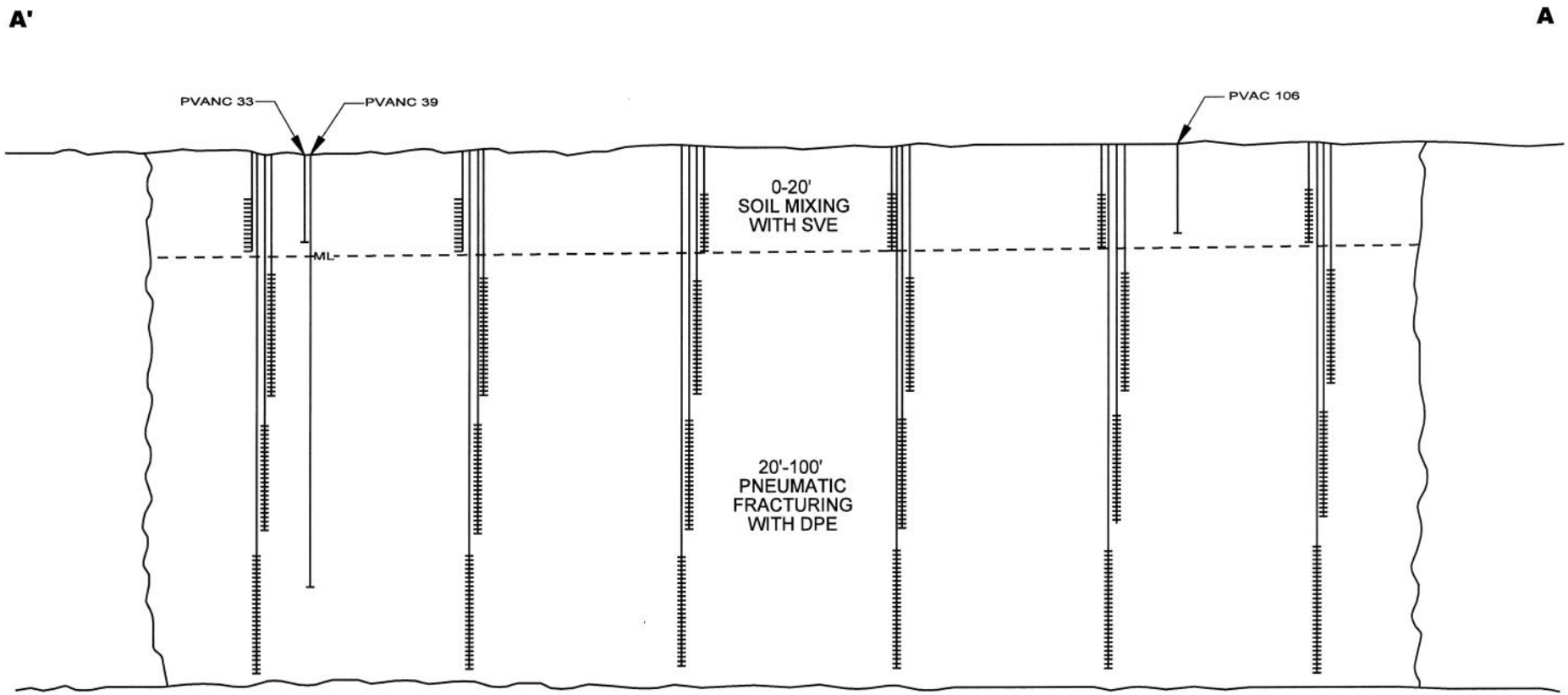

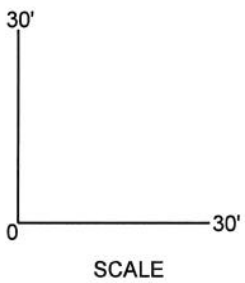

Figure 4-2
Soil Alternatives S4
Dual Phase Extraction (DPE) System Cross-Section
OU1 Feasibility Study
Pohatcong Valley, NJ

NOTE: SOIL ALTERNATIVE S4 WAS RENAMED SOIL ALTERNATIVE SO3 AFTER INITIAL SCREENING.

SEE FIGURE 4-1 FOR CROSS-SECTION LINE

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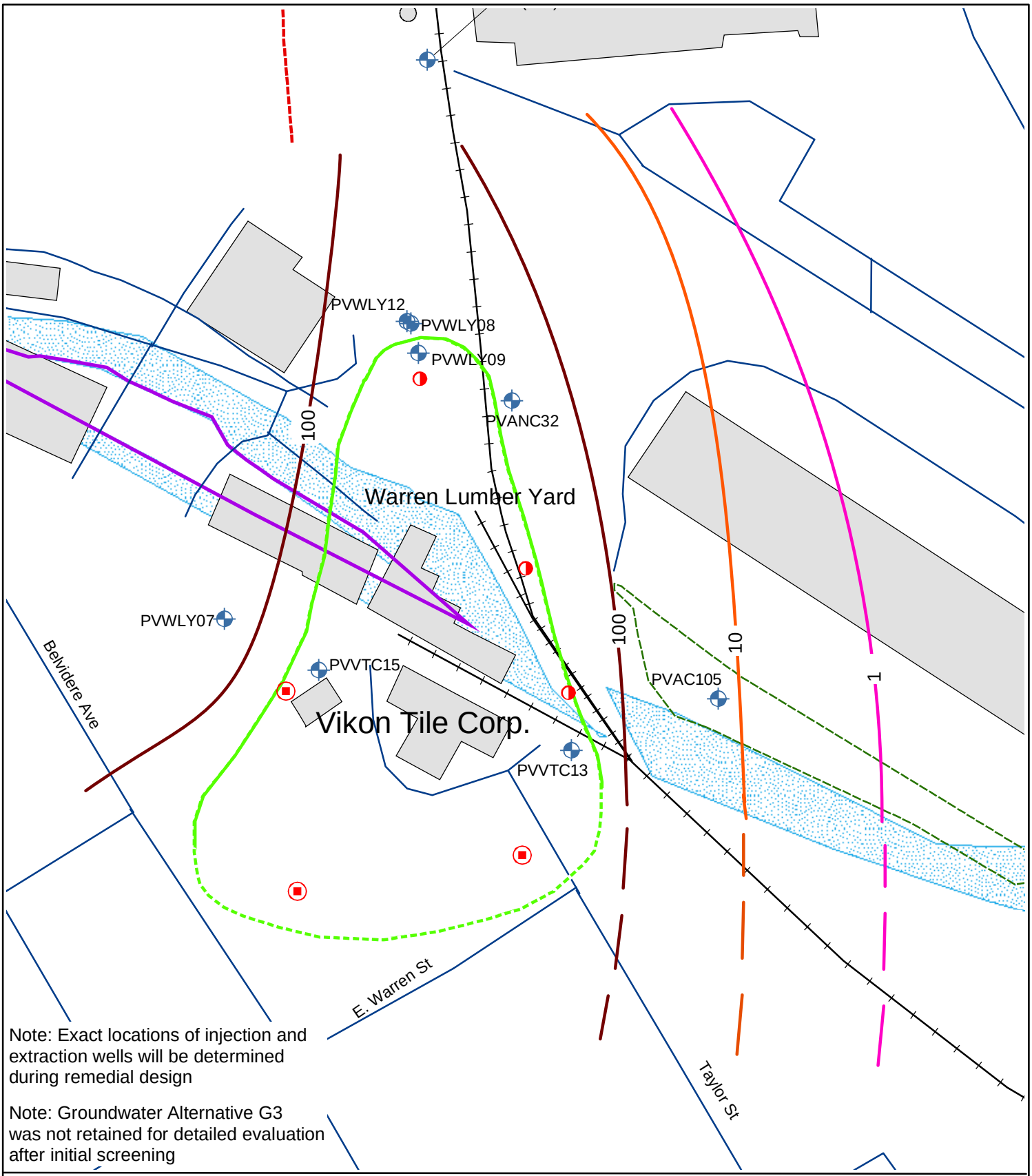

Note: Exact locations of injection and extraction wells will be determined during remedial design

Note: Groundwater Alternative G3 was not retained for detailed evaluation after initial screening

Legend

- Proposed Injection Well Location
- Proposed Extraction Well Location
- 500 ug/L TCE
- 100 ug/L TCE
- 10 ug/L TCE
- 1 ug/L TCE

N

0 50 100 200 Feet

Figure 4-3
Groundwater Alternative G3 - Injection/Extraction System Layout
OU1 Feasibility Study
Pohatcong Valley, NJ

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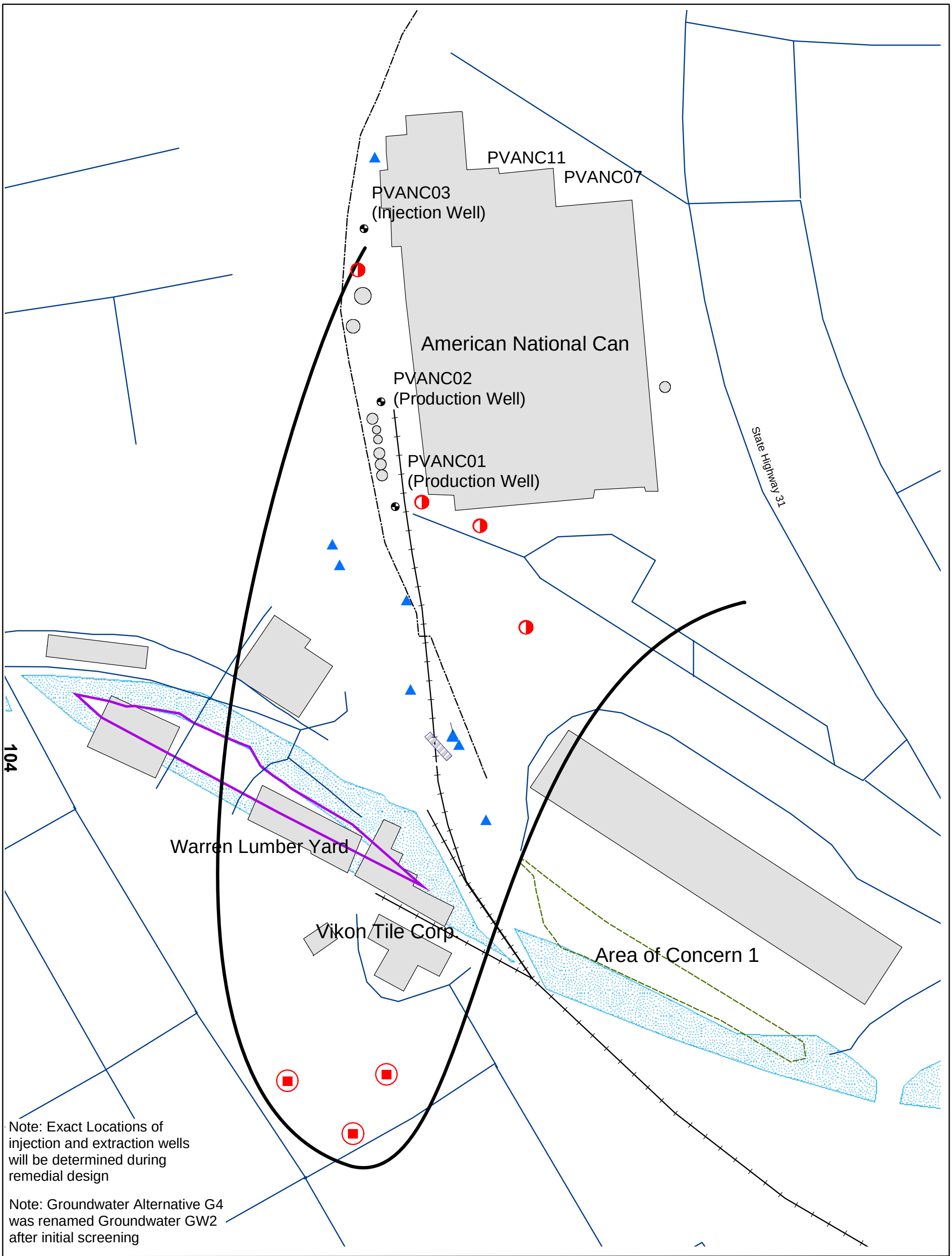

104

Legend

- Area of Concern 1-- Basin Area
- Former Morris Canal (Approximate)
- Fence Line (Approximate)
- Concrete Pipe Under Railroad Tracks
- Injection Well
- Extraction Well
- Existing Railroad
- Road Centerlines
- Former Morris Canal Island (Approximate)
- Structures
- Capture Zone Boundary
- ANC Production/Injection Wells

N

0 75 150 300 Feet

Figure 4-4
Groundwater Alternative G4 - Source Treatment
OU1 Feasibility Study
Pohatcong Valley, NJ

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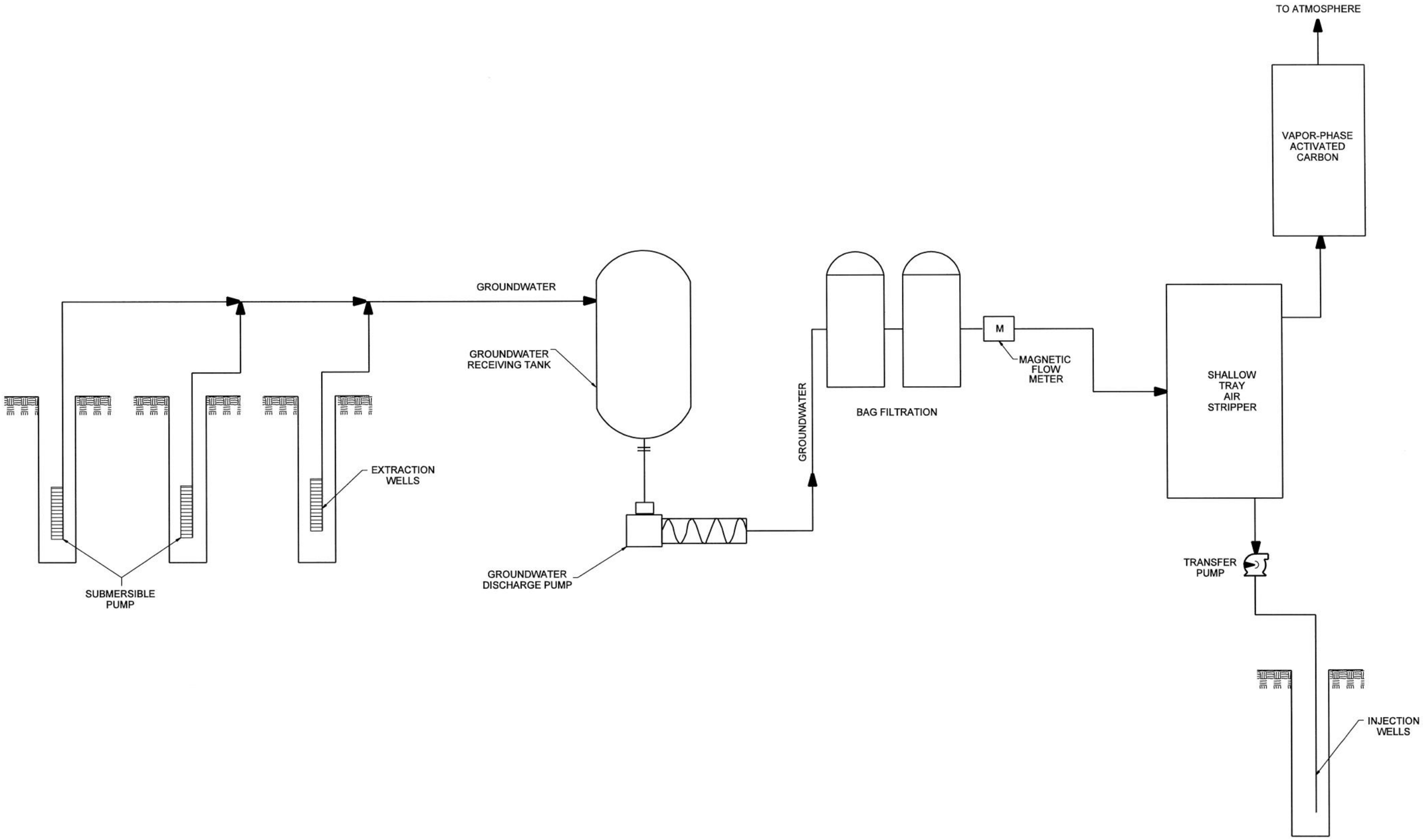

Figure 4-5
Groundwater Alternative G4
Ex Situ Treatment
System Components
OU1 Feasibility Study
Pohatcong Valley, NJ

NOTE: GROUNDWATER ALTERNATIVE G4 WAS RENAMED GROUNDWATER ALTERNATIVE GW2 AFTER INITIAL SCREENING.

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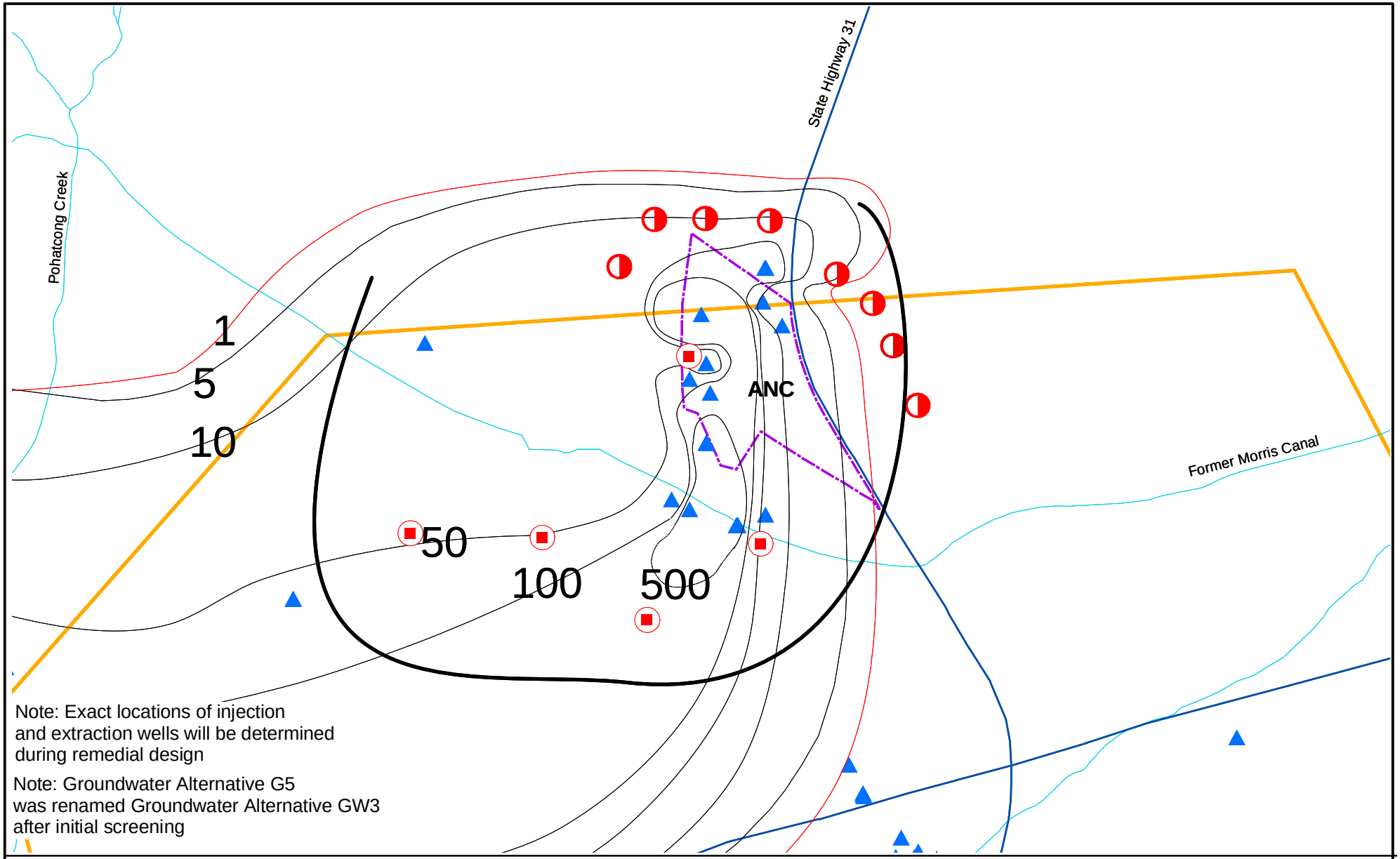

Note: Exact locations of injection and extraction wells will be determined during remedial design

Note: Groundwater Alternative G5 was renamed Groundwater Alternative GW3 after initial screening

Legend

- Waterways
- Road Centerlines
- Extraction Well
- Injection Well
- Washington Borough
- American National Can
- Capture Zone Boundary

N

0 0.25 0.5 Mile

Figure 4-6
Groundwater Alternative G5
TCE Well Layout
OU1 Feasibility Study
Pohatcong Valley, NJ

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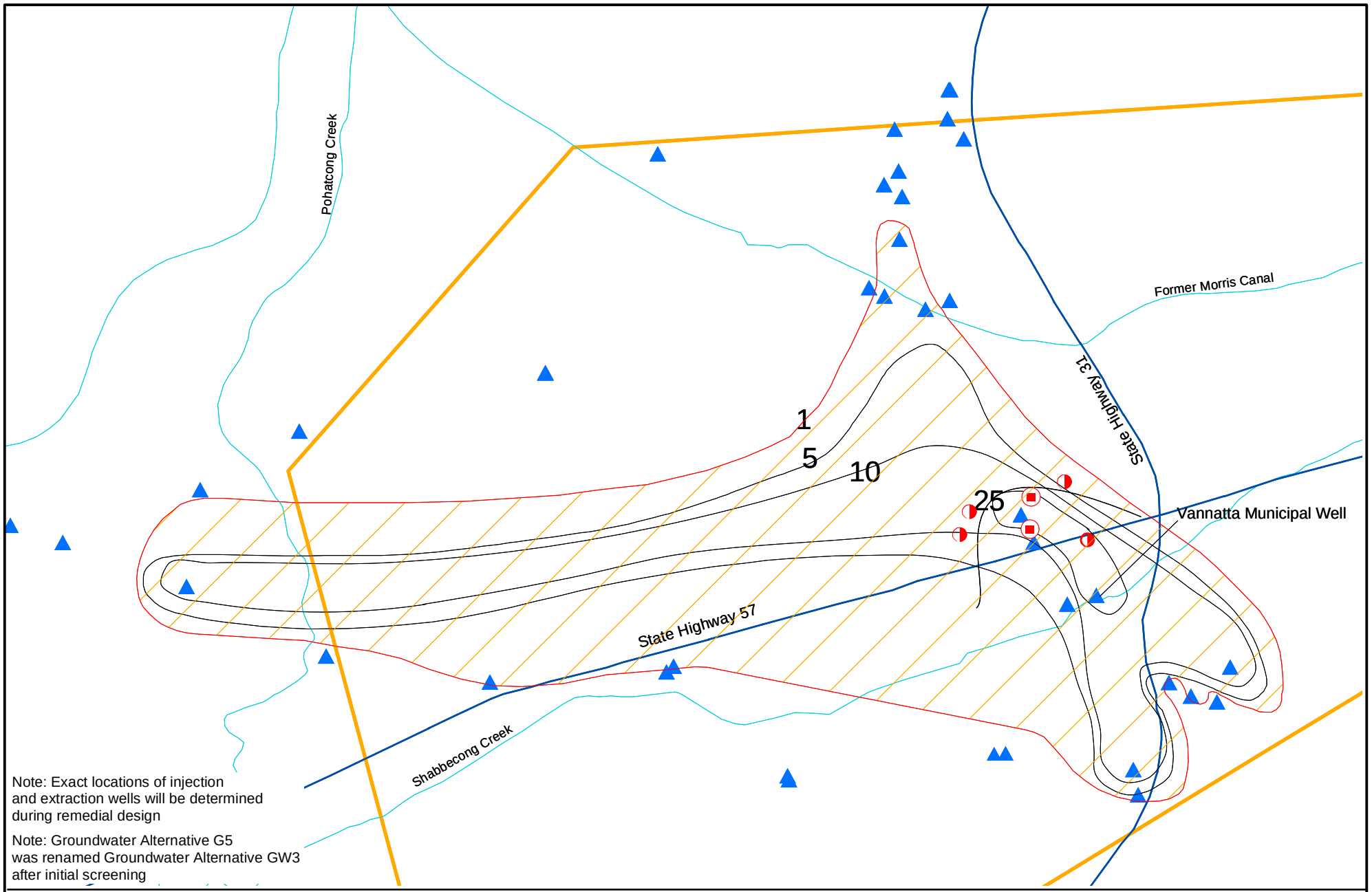

Legend

- Sampling Locations
- Waterways
- Road Centerlines
- Washington Borough
- Area Exceeding PRGs
- Extraction Well
- Injection Well
- Capture Zone Boundary

N

0 500 1,000 2,000 Feet

Figure 4-7
Groundwater Alternative G5
PCE Well Layout
OU1 Feasibility Study
Pohatcong Valley, NJ

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5.0 Detailed Analysis of Alternatives

5.1 Introduction

The detailed analysis of alternatives presents the relevant information needed to compare the remedial alternatives assembled for the Operable Unit 1 (OU1) Study Area of the Pohatcong Valley Groundwater Contamination Site (PVGCS). The detailed analysis of alternatives follows the development of alternatives, and precedes the selection of a final remedy. Screening of alternatives was not needed because the number of alternatives was not excessive for detailed evaluation. The extent to which alternatives are fully evaluated during the detailed analysis is influenced by the available data and the number and types of alternatives being analyzed.

Detailed analysis of alternatives consists of the following components:

- A detailed evaluation of each alternative against seven of the nine National Contingency Plan (NCP) evaluation criteria (the final two criteria of Community Acceptance and State Acceptance are completed after public comment); and
- A comparative evaluation.

The detailed evaluation is presented in a table format. The comparative evaluation is presented in text and highlights the most important factors distinguishing the alternatives. Please note that the designation of the alternatives from Section 4 of this report were changed as follows:

Section 4 Designation (Soil)	Section 5 Designation (Soil)	Section 4 Designation (Groundwater)	Section 5 Designation (Groundwater)
S1	SO1	G1	GW1
S2	Not Retained	G2	Not Retained
S3	SO2	G3	Not Retained
S4	SO3	G4	GW2
S5	Not Retained	G5	GW3
S6	SO4	G6	Not Retained
		G7	GW4

5.2 Evaluation Criteria

In accordance with the National Contingency Plan (NCP), remedial actions must:

- Be protective of human health and the environment;
- Attain Applicable or Relevant and Appropriate Requirements (ARARs) or provide grounds for invoking a waiver of ARARs that cannot be achieved;
- Be cost-effective;
- Utilize permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable; and
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume (TMV) as a principal element.

In addition, the National Contingency Plan emphasizes long-term effectiveness and related considerations including:

- The long-term uncertainties associated with land disposal;
- The goals, objectives, and requirements of the Solid Waste Disposal Act;
- The persistence, toxicity, and mobility of hazardous substances and their constituents, and their propensity to bio-accumulate;
- The short- and long-term potential for adverse health effects from human exposure;
- Long-term maintenance costs;
- The potential for future remedial action costs if the selected remedial action fails; and
- The potential threat to human health and the environment associated with excavation, transportation, disposal, or containment.

Provisions of the National Contingency Plan require that each alternative be evaluated against nine criteria listed in 40 CFR 300.430(e)(9). These criteria were published in the March 8, 1990 *Federal Register* (55 FR 8666) to provide grounds for comparison of the relative performance of the alternatives and to identify their advantages and disadvantages. This approach is intended to provide sufficient information to adequately compare the alternatives and to select the most appropriate alternative for implementation at the site as a remedial action. The criteria are divided into three groups: threshold, balancing, and modifying criteria. Threshold criteria must be met by a particular alternative for it to be eligible for selection as a remedial action. There is little flexibility in meeting the threshold criteria—either they are met by a particular alternative, or that alternative is not considered acceptable. The two threshold criteria are:

1. Overall protection of human health and the environment;

2. Compliance with ARARs;

If ARARs cannot be met, a waiver may be obtained in situations where one of the six exceptions listed in the National Contingency Plan occur (see 40 CFR 300.430 (f)(1)(ii)(C)(1 to 6).

Unlike the threshold criteria, the five balancing criteria weigh the tradeoffs between alternatives. A low rating on one balancing criterion can be compensated by a high rating on another. The five balancing criteria include:

3. Long-term effectiveness and permanence

4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost

The two modifying criteria are evaluated following public comment and are used to change the selection of the recommended alternative. The modifying criteria are:

8. Community Acceptance
9. State Acceptance

5.2.1 Threshold Criteria

To be eligible for selection, an alternative must meet the two threshold criteria, or if an ARAR is not met, justify that a waiver is appropriate.

5.2.1.1 Overall Protection of Human Health and the Environment

Protection is the primary requirement that remedial actions must meet under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). A remedy is protective if it adequately eliminates, reduces, or controls all current and potential risks posed by the site through pathways. The assessment against this criterion describes how the alternative achieves and maintains protection of human health and the environment.

5.2.1.2 Compliance with ARARs

Compliance with ARARs is one of the statutory requirements of remedy selection. ARARs are cleanup standards, standards of control, and other substantive environmental statutes or regulations which are either "applicable" or "relevant and appropriate" to the CERCLA cleanup action (42 USC 9621 [d] [2]). ARARs are listed in Appendix B of this report. Applicable requirements address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site. Relevant and appropriate requirements are those that while not applicable, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to environmental or technical factors at a particular site. The assessment against this criterion describes how the alternative complies with ARARs or presents the rationale for waiving an ARAR. ARARs can be grouped into three categories:

- **Chemical-specific:** ARARs are health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, establish the amount or concentration of a chemical that may remain in or be discharged to the environment.
- **Location-specific:** ARARs restrict the concentration of hazardous substances or the conduct of activities solely because they are in specific locations, such as flood plains, wetlands, historic places, and sensitive ecosystems or habitats.
- **Action-specific:** ARARs include technology- or activity-based requirements that set controls, limits, or restrictions on design performance of remedial actions or management of hazardous constituents.

5.2.2 Balancing Criteria

The five criteria listed below are used to weigh the tradeoffs between alternatives.

5.2.2.1 Long-term Effectiveness and Permanence

This criterion reflects CERCLA's emphasis on implementing remedies that will ensure protection of human health and the environment in the long term as well as in the short term. The assessment of alternatives against this criterion evaluates the residual risks at a site after completing a remedial action or enacting a no action alternative and includes evaluation of the adequacy and reliability of controls.

5.2.2.2 Reduction of TMV through Treatment

This criterion addresses the statutory preference for remedies that employ treatment as a principal element. The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies an alternative may employ. The criterion is specific to evaluating only how treatment reduces toxicity, mobility, or volume (TMV) and does not address containment actions such as capping.

5.2.2.3 Short-term Effectiveness

This criterion addresses short-term impacts of the alternatives. The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment (i.e., minimizing any risks associated with an alternative) during the construction and implementation of a remedy until the response objectives have been met.

5.2.2.4 Implementability

The assessment against this criterion evaluates the technical and administrative feasibility of the alternative and the availability of the goods and services needed to implement it.

5.2.2.5 Cost

Cost encompasses all engineering, construction, and operations and maintenance (O&M) costs incurred over the life of the project. The assessment against this criterion is based on the estimated present worth of these costs for each alternative. Present worth is a method of evaluating expenditures such as construction and O&M that occur over different lengths of time. This allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented. The present worth of a project represents the amount of money, which if invested in the initial year of the remedy and disbursed as needed, would be sufficient to cover all costs associated with the remedial action. Note that five-year review costs, which are considered periodic costs, are not included in the alternative costs. As stated in the RI/FS guidance (EPA, 1988a), these estimated costs are expected to provide an accuracy of plus 30 percent to minus 50 percent. Appendix E provides a breakdown of the cost estimate for each of the alternatives listed in Tables 4-3 and 4-4.

The level of detail required to analyze each alternative against these evaluation criteria depends on the nature and complexity of the site, the types of technologies and alternatives being considered, and other project-specific considerations. The analysis is conducted in

sufficient detail to understand the significant aspects of each alternative and to identify the uncertainties associated with the evaluation.

The cost estimates presented below have been developed strictly for comparing the alternatives. The final costs of the project and the resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, the implementation schedule, the firm selected for final engineering design, and other variables. Therefore, final project costs will vary from the cost estimates. Because of these factors, project feasibility and funding needs must be reviewed carefully before specific financial decisions are made or project budgets are established to help access proper project evaluation and adequate funding.

The cost estimates are order-of-magnitude estimates having an intended accuracy range of +30 to -50 percent. The range applies only to the alternatives as they are defined in Section 4 and does not account for changes in the scope of the alternatives. Selection of specific technologies or processes to configure remedial alternatives is not intended to limit flexibility during remedial design, but to provide a basis for preparing cost estimates. The specific details of remedial actions and cost estimates would be refined during final design.

5.3 Detailed Analysis of Soil Media Alternatives

The analysis consists of detailed and comparative evaluations of the remedial alternatives.

5.3.1 Detailed Evaluation

The following four alternatives for the soils were developed and described in Section 4 for the three target cleanup areas:

- Soil Alternative SO1 - No Further Action (NFA)
- Soil Alternative SO2 - Capping and Institutional controls
- Soil Alternative SO3 – Dual Phase Extraction (DPE) and Shallow Soil Mixing
- Soil Alternative SO4- Excavation and Offsite Disposal

These alternatives were evaluated in detail using the seven evaluation criteria described in Section 5.1. The detailed evaluations for these soil media alternatives are presented in Table 5-1.

5.3.2 Comparative Analysis

5.3.2.1 Overall Protection of Human Health and the Environment

The remedial action objectives pertinent to the target cleanup areas are as follows.

- Prevention of human exposure, through contact, ingestion, or inhalation to contaminated soil that presents an unacceptable risk (i.e., Hazard index [HI] greater than 1 or Excessive Lifetime Cancer Risk [ELCR] greater than $1x10^{-4}$ to $1x10^{-6}$)
- Prevention of erosion and offsite transport of soils contaminated at concentrations posing unacceptable risk (i.e., HI greater than 1 or ELCR greater than $1x10^{-4}$ to $1x10^{-6}$)

- Remediation of contaminated soils to prevent further leaching of contaminants to groundwater that result in groundwater in excess of NJ IGWSCC

As shown on Table 5-1, the NFA alternative is not protective because it allows continued leaching of TCE to groundwater without any means to evaluate the time until PRGs are met.

The remaining soil alternatives are also all considered protective of public health and the environment. Soil Alternative SO2 is protective because it prevents direct contact, erosion and reduces leaching by capping the soils and using institutional controls to prevent exposure. Soil Alternative SO3 uses in situ treatment and in situ soil mixing to remove the majority of TCE present in the target cleanup areas. Soil Alternative SO4 uses excavation and offsite disposal as well as in situ treatment to achieve the same result.

5.3.2.2 Compliance with ARARs

The alternatives other than SO1 and SO2 are expected to meet ARARs, which are presented in Appendix B. The main ARAR is the chemical specific NJ IGWSCC of 1 mg/Kg (1 ppm) for soil. Leaching of TCE and PCE to groundwater at concentrations that could cause NJ GWQS exceedance (1 ug/L, 1 ppb) would not be addressed under Soil Alternative SO1, but is addressed under the remaining alternatives. Action-specific ARARs would be met under all the alternatives.

5.3.2.3 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of alternatives vary largely as a result of the adequacy and reliability of the systems implemented. Soil Alternative SO4 offers the highest degree of long-term effectiveness because it is expected to achieve the greatest removal of TCE from the soils. Excavation provides assurance that residual contamination is not left in remediated areas, because the areas are filled with clean material. Excavation also allows for flexibility during implementation. If additional areas of contamination are discovered, the excavation could be easily extended. Installation of a DPE system in ANC C, if needed, allows for mass removal in this area where excavation would not be feasible (because of the ANC building over the assumed location of the target cleanup area).

Soil Alternative SO3 - DPE and Shallow Soil Mixing is the next best alternative for long-term effectiveness. It is rated somewhat lower because it may not remove the entire amount of TCE in the treated areas, as excavation would. The shallow soil mixing included in Soil Alternative SO3 both improves removal effectiveness while allowing the areas of greatest TCE contamination to be identified and more precisely targeted for remediation. This may be particularly important for the subsequent fracturing of the underlying clay lenses within the silty soils where removal will be more difficult.

Soil Alternative SO2 - Capping and Institutional Controls is not considered particularly effective in the long-term for ANC A. This is because of the potential for lateral movement of infiltration from areas outside the capped area to the soils below the cap. The reduced infiltration through the cap will likely result in a lower hydraulic head causing lateral flow inward to areas below the cap and subsequent slow leaching to groundwater. In addition, this alternative would have no effect on ANC C, which is already capped by the ANC building foundation.

Soil Alternative SO1 is considered the least effective alternative because it does not remove TCE or limit leaching to groundwater.

5.3.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Soil Alternatives SO3 and SO4 include treatment of soils to remove and destroy TCE. Soil Alternative SO4 offers the greatest potential reduction in toxicity, mobility, and treatment (TMV) because it completely removes contaminated soil in accessible areas and uses a proven technology to reduce TMV in ANC C. Soil Alternative SO3 would also be effective at reducing TMV because it homogenizes the soil and allows areas of greatest contamination to be more accurately delineated and targeted for DPE treatment. Soil Alternative SO3 is expected to remove up to about 90 percent of the TCE (approximately 1,750 pounds of TCE) in the ANC A and B target cleanup areas, and a similar percentage in ANC C.

5.3.2.5 Short-term Effectiveness

The alternatives have minimal impacts with respect to the protection of workers, the community or the environment during remedial construction, assuming adequate monitoring is conducted and mitigative actions are taken.

Soil Alternative SO2 will potentially have an adverse effect on the AC1 area adjacent to ANC A because re-routing of storm water away from that area may be necessary. The type of storm water controls would be evaluated during pre-design of the selected remedy.

Air monitoring would be important for the shallow soil mixing of Soil Alternative SO3 and the excavation in Soil Alternative SO4 to evaluate the appropriate PPE for workers. In addition, emission control techniques such as the use of dust suppressants and minimizing the open working area of the excavation would be employed as needed to minimize adverse effects on workers and the community from volatile emissions of TCE.

The time until the Remedial Action Objectives (RAOs) are achieved is estimated to be 1 to 2 years for Soil Alternatives SO3 and SO4. Under Soil Alternatives SO1 and SO2, RAOs may not be achieved for decades because of the slow leaching of contaminants to groundwater.

5.3.2.6 Implementability

The main technical implementability challenge for Soil Alternative SO2 would be to design storm water controls to minimize the potential for infiltration and lateral flow to areas below the cap. Surface water controls may cause drainage changes into AC1 as well as other expensive storm water controls. Soil Alternative SO3 also requires storm water controls to minimize water infiltration through the ANC A target cleanup area during DPE, though these are not as critical as in Soil Alternative SO2. Adequate fracturing of clay lenses within the silty soils to achieve good air permeability or oxidant distribution during injection is a technical challenge for Soil Alternatives SO3 and SO4. Fracturing beneath the building has been determined to be infeasible due to structural stability concerns for the building. In addition, Soil Alternative SO4 has major implementation challenges because of the impact to ongoing ANC operations and the extensive structural stabilization required during excavation.

5.3.2.7 Cost

An overview of the cost analysis performed for the alternatives presented in Table 4-3 and the detailed breakdowns for each of the alternatives are presented in Appendix E.

The NFA alternative (Soil Alternative SO1) has no present worth cost. Soil Alternative SO2 is the next least expensive alternative in terms of present worth, costing $1,240,000. Soil Alternative SO3 present worth cost is $4,400,000 followed by Soil Alternative SO4 at $10,400,000.

5.4 Detailed Analysis of Groundwater Media Alternatives

5.4.1 Detailed Evaluation

The following alternatives for groundwater were retained following alternative screening:

- Groundwater Alternative GW1 – No Further Action (NFA)
- Groundwater Alternative GW2 – Source Treatment and MNA
- Groundwater Alternative GW3 – Expanded Source Treatment and MNA
- Groundwater Alternative GW4 – Entire Plume Collection and Treatment

These four alternatives were evaluated in detail using the seven evaluation criteria described in Section 5.1. The detailed evaluations for these groundwater media alternatives are presented in Table 5-5.

5.4.2 Comparative Analysis

5.4.2.1 Overall Protection of Human Health and the Environment

The groundwater remedial action objectives are as follows:

- Restoration of the groundwater aquifer to state and federal drinking water quality standards in a reasonable timeframe
- Prevention of human ingestion of contaminated groundwater that presents an unacceptable risk (i.e., NJ GWQS, MCLs, or in the absence of MCLs or NJ GWQS, a HI greater than 1 or ELCR greater than $1x10^{-4}$ to $1x10^{-6}$)

The considered alternatives prevent human ingestion of contaminated groundwater (via alternative water supply), therefore this RAO is not compared between alternatives.

The NFA alternative is not considered protective because it does not include groundwater monitoring or institutional controls to prevent access to contaminated groundwater. Future exposure to groundwater would result in unacceptable risks.

The remaining alternatives are considered protective. Groundwater Alternatives GW2, and GW3 have components of MNA for the downgradient portion of the plumes, but with more aggressive remediation in upgradient soil source areas. Groundwater Alternative GW4 includes active removal and treatment of all impacted groundwater. These alternatives are considered more protective of human health and the environment than the No Further Action Alternative (GW1) because they shorten the time to reach PRGs, with Groundwater

Alternative GW4 considered the most protective because the PRGs will be achieved sooner than the other alternatives.

5.4.2.2 Compliance with ARARs

Appendix B presents a compilation of all the State and Federal chemical-specific, location-specific, and action-specific ARARs considered for the PVGCS. With the exception of NFA alternative, each alternative satisfies the ARARs.

Air treatment for the emissions would be required to meet Clean Air Act and applicable NJDEP-specific ARARs for the groundwater pumping alternatives (Groundwater Alternatives GW2, GW3, and GW4).

5.4.2.3 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of the groundwater collection and treatment alternatives, GW2, GW3, and GW4, is better than the No Further Action Alternative (GW1), because these alternatives involve active reduction in TCE/PCE concentrations in groundwater near the soil source areas.

Two of the groundwater collection and treatment alternatives, Groundwater Alternatives GW2 and GW3, are similar in their long-term effectiveness and permanence due to the relatively high flow rates and expected low loading rates of impacts in the groundwater. Groundwater Alternative GW3 ranks higher in long-term effectiveness and permanence because a larger mass of TCE and PCE near the original sources would be removed. However, this alternative will take longer time to complete than Groundwater Alternative GW2.

The NFA Groundwater Alternative GW1 is less effective in the long-term and less permanent since natural processes are the only technology relied on to reduce the concentrations of TCE and PCE and these processes take an unreasonably long time to achieve PRGs.

5.4.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Groundwater Alternative GW4 is the best alternative for the reduction of TMV since it relies on active treatment processes to remove and treat most of the TCE and PCE (assuming 99 percent). Groundwater Alternative GW3 is the next best alternative for reduction of TMV since it removes and destroys the most TCE and PCE, assuming 99 percent removal of TCE and PCE for injection, but relies on natural attenuation to treat the downgradient portion of the plume. Groundwater Alternative GW2 also removes 99 percent of TCE and PCE generated during pumping, but the capture zone is smaller than that of Groundwater Alternative GW3. Groundwater Alternative GW1 does not reduce TMV through treatment.

5.4.2.5 Short-term Effectiveness

Groundwater Alternatives GW2 and GW3 have minimal impacts with respect to the protection of workers during remedial construction, protection of community during remedial action, and environmental impacts of remedial action. Groundwater Alternative GW4 also has minimal impacts to workers during remedial construction and protection of the community during remedial action. However, there is a significant potential impact to the environment during implementation of Groundwater Alternative GW4 since this

alternative will involve active pumping of large volumes of groundwater throughout the valley, which will impact water supplies and surface water (i.e. creeks near the downgradient portions of the OU1 Study Area).

The NFA alternative has no construction-related impacts because it involves no remedial action.

The short-term effectiveness with respect to the time until the RAOs are achieved is shortest for the groundwater collection and treatment alternatives, Groundwater Alternatives GW2 and GW3, because these alternatives are actively reducing the concentrations of groundwater. Time to meet RAOs is longest for Groundwater Alternative GW1, which would take decades to achieve RAOs.

5.4.2.6 Implementability

The quantities of extracted groundwater in Groundwater Alternative GW4 may present technical difficulty. Permitting will be required for Groundwater Alternatives GW2 and GW3. Siting of the required treatment plants may pose challenges for Groundwater Alternatives GW2, GW3, and GW4, although resources are available to design and build the treatment plant.

5.4.2.7 Cost

A summary of the estimated costs for each of the groundwater media alternatives is presented in Table 5-2 and Appendix E. The table breaks down the estimated capital, operations and maintenance, and present net worth cost.

The NFA alternative has no present worth cost. The Groundwater Alternative GW2 present worth cost is $8,060,000. Groundwater Alternative GW3 is the second-most costly alternative at $25,760,000. The most costly alternative is Groundwater Alternative GW4 at a present worth cost of $46,840,000.

The cost estimates presented above have been developed strictly for comparing the alternatives. The final costs of the project and the resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, the implementation schedule, the firm selected for final engineering design, and other variables. Therefore, final project costs will vary from the cost estimates.

The cost estimates are order-of-magnitude estimates having an intended accuracy range of +30 to -50 percent. The range applies only to the alternatives as they are defined in Section 4 and does not account for changes in the scope of the alternatives. Selection of specific technologies or processes to configure remedial alternatives is intended not to limit flexibility during remedial design, but to provide a basis for preparing cost estimates. The specific details of remedial actions and cost estimates would be refined during final design.

TABLE 5-1
Detailed Evaluation of Soil Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Soil Alternative SO1—No Further Action	Soil Alternative SO2—Capping and Institutional Controls	Soil Alternative SO3—DPE and Shallow Soil Mixing	Soil Alternative SO4—Excavation and Offsite Disposal
1. Overall Protection of Human Health and the Environment				
	▪ Leaching of TCE will continue to cause exceedance of PRGs in groundwater. ▪ Direct contact with soils could pose risks within the 10-4 to 10-6 ELCR range. ▪ Erosion of soils exceeding PRGs will continue.	▪ Capping will minimize leaching of TCE to groundwater by limiting infiltration. ▪ Cap prevents direct contact risks and erosion of contaminated soils. ▪ Institutional Controls will minimize the potential for contact with contaminated soil left in place.	▪ Treatment of soils exceeding PRGs will minimize leaching of TCE to groundwater. ▪ The treatment of soils to below PRGs will eliminate unacceptable risks from direct contact and erosion of soils.	▪ The excavation of all soils exceeding PRGs will eliminate leaching of TCE to groundwater at concentrations that could cause PRG exceedance.
2. Compliance with ARARs[A]				
	▪ Would likely continue in the short term to cause exceedance of NJ GWQS and EPA MCLs in groundwater. ▪ Does not comply with New Jersey chemical specific TBC. ▪ ARARs are not met because monitoring is not conducted and natural attenuation processes would not be evaluated.	▪ Achieves MCLs in groundwater by essentially eliminating leaching. ▪ Complies with New Jersey chemical specific TBCs for soil because natural attenuation monitoring is conducted.	▪ Achieves MCLs in groundwater by minimizing leaching. ▪ Complies with New Jersey chemical specific TBC of 1 mg/Kg through treatment. ▪ Emissions from excavation would be controlled as necessary to meet Clean Air Act ARARs.	▪ Meets ARAR for achieving MCLs in groundwater because soils resulting in leaching of TCE to groundwater are removed. ▪ Complies with New Jersey chemical specific TBC of 1 mg/Kg through removal. ▪ Emissions from excavation would be controlled as necessary to meet Clean Air Act ARARs. ▪ Testing would be performed to meet ARARs for disposal of hazardous waste.

TABLE 5-1
Detailed Evaluation of Soil Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Soil Alternative SO1—No Further Action	Soil Alternative SO2—Capping and Institutional Controls	Soil Alternative SO3—DPE and Shallow Soil Mixing	Soil Alternative SO4—Excavation and Offsite Disposal
3. Long-term Effectiveness and Permanence				
(a) Magnitude of residual risks	▪ Risk would slowly diminish over several decades as soil contaminants naturally attenuate to concentrations less than PRGs.	▪ Risk would slowly diminish over several decades as soil contaminants naturally attenuate. ▪ Leaching would diminish, although some lateral infiltration and subsequent leaching could occur.	▪ Once treatment is completed, TCE leaching would be greatly reduced. PRGs will likely be met in the majority of the target cleanup area.	▪ Once excavation is completed, TCE leaching would be eliminated. TCE concentrations would be less than 1,000 mg/Kg, the PRG.
(b) Adequacy and reliability of controls	▪ Not applicable.	▪ The multi-layer cap may not adequately control leaching to groundwater because of the potential for lateral flow into soils below the cap. ▪ Deed restrictions are necessary to maintain the integrity of the cap. They are considered adequate and reliable.	▪ DPE is typically effective, although effectiveness diminishes in low permeability soils. Soil mixing and pneumatic fracturing will improve removal effectiveness.	▪ Controls not needed because soil exceeding PRGs is removed.
4. Reduction of Toxicity, Mobility, or Volume through Treatment				
(a) Treatment process used	▪ None.	▪ None.	▪ Dual phase extraction removes TCE from soil. Air stripping treatment removes TCE from extracted water, and GAC adsorption removes TCE from vapors.	▪ Solidification of TCE-contaminated soil failing TCLP limits would be performed if necessary.

TABLE 5-1
Detailed Evaluation of Soil Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Soil Alternative SO1—No Further Action	Soil Alternative SO2—Capping and Institutional Controls	Soil Alternative SO3—DPE and Shallow Soil Mixing	Soil Alternative SO4—Excavation and Offsite Disposal
(b) Degree and quantity of TMV reduction	▪ Not applicable	▪ Not applicable.	▪ DPE, air stripping, and GAC are expected to remove up to about 1,750 pounds of TCE, or about 90 percent of the estimated TCE mass present in the soils of ANC A and B.	▪ The estimated volume of soil to be excavated is 32,000 cubic yards. Solidification, if necessary, would greatly reduce contaminant mobility, but would increase volume by about 30 percent.
(c) Irreversibility of TMV reduction	▪ Not applicable	▪ Not applicable.	▪ TCE adsorbed on GAC would be destroyed during carbon regeneration processes.	▪ Solidification is reversible although solidified TCE soil will be below a landfill cap.
(d) Type and quantity of treatment residuals	▪ Not applicable.	▪ Not applicable.	▪ Spent GAC is the main treatment residual. An estimated 15,000 pounds of spent carbon would be generated assuming a 10:1 (carbon mass to TCE mass) carbon usage rate.	▪ The solidified TCE-contaminated soil would be placed in a Subtitle D landfill. At most, the volume of solidified soil is expected to be 41,600 cubic yards.
(e) Statutory preference for treatment	▪ Preference is not met.	▪ Preference is not met.	▪ Preference is met.	▪ Preference not met for soil because treatment is unlikely to be needed.
5. Short-term Effectiveness				
(a) Protection of workers during remedial action	▪ No remedial construction, so no risks to workers.	▪ Limited excavation, cap construction and soil sampling in contaminated soil. Minimal risks to workers.	▪ Excavation and mixing of TCE contaminated soil could result in potential exposure of workers via TCE inhalation. Proper health and safety procedures would be included in the Health and Safety Plan for construction.	▪ Excavation and mixing of TCE contaminated soil could result in potential exposure of workers via TCE inhalation. Proper health and safety procedures would be included in the Health and Safety Plan for construction.

TABLE 5-1
Detailed Evaluation of Soil Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Soil Alternative SO1—No Further Action	Soil Alternative SO2—Capping and Institutional Controls	Soil Alternative SO3—DPE and Shallow Soil Mixing	Soil Alternative SO4—Excavation and Offsite Disposal
(b) Protection of community during remedial action	▪ No remedial construction, so no short-term risks to community.	▪ Limited disturbance of contaminated soil presents minimal risks to the community.	▪ Short-term health- related risks to community will be minimized through air monitoring and dust and contaminant emission suppression. ▪ Air emissions from DPE system would be controlled as required by the air emissions permit. It is assumed this would require treatment such as vapor phase GAC.	▪ Short-term health- related risks to community will be minimized through air monitoring and dust and contaminant emission suppression. ▪ Safety-related risks to community are relatively short term and are associated with truck traffic to remove excavated soil. Approximately 2,000 truck loads are expected to be required.
(c) Environmental impacts of remedial action	▪ No remedial construction, so no environmental impacts from remedial action.	▪ Limited excavation, cap construction and soil sampling in contaminated soil is expected to have minimal impacts.	▪ Environmental impacts will likely be limited to emissions of contaminants in dust and some migration via erosion. Impacts can be controlled through dust suppression and implementation of an erosion control plan. Impacts are expected to be relatively minor.	▪ Environmental impacts will likely be limited to emissions of contaminants in dust and some migration via erosion. Impacts can be controlled through dust suppression and implementation of an erosion control plan. Impacts are expected to be relatively minor.
(d) Time until RAOs are achieved	▪ The RAO to prevent further TCE leaching to groundwater at concentrations that result in exceedance of NJ GWQS may not be met for many decades.	▪ The RAOs to prevent further TCE leaching to groundwater at concentrations that result in exceedance of NJ GWQS may not be met for decades because of the potential for lateral flow into soils below cap.	▪ The RAO to prevent further TCE leaching to groundwater at concentrations that result in exceedance of NJ GWQS would be met once the soil is treated, within about 5 years.	▪ The RAO to prevent further TCE leaching to groundwater at concentrations that result in exceedance of NJ GWQS would be met once the soil is removed, less than 1 year from start of design.
6. Implementability				
(a) Technical feasibility	▪ No impediments.	▪ The main technical challenge would be to design storm water controls to minimize the potential for infiltration and lateral flow to areas below the cap.	▪ The main technical challenge would be to design storm water controls to reduce infiltration into the ANC A target area. ▪ Adequate fracturing of clay soils to achieve adequate air flow is a technical challenge.	▪ No impediments.

TABLE 5-1
Detailed Evaluation of Soil Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Soil Alternative SO1—No Further Action	Soil Alternative SO2—Capping and Institutional Controls	Soil Alternative SO3—DPE and Shallow Soil Mixing	Soil Alternative SO4—Excavation and Offsite Disposal
(b) Administrative feasibility	▪ No impediments.	▪ Wetlands issue may require additional time to resolve.	▪ Wetlands issue may require additional time to resolve.	▪ No impediments.
(c) Availability of services and materials	▪ None needed.	▪ Services and materials are available.	▪ Services and materials are available.	▪ Services and materials are available.
7. Total Cost				
Direct Capital Cost	$0	$1,130,000	$3,700,000	$10,400,000
O&M Cost	$0	$4,900	$160,000	$130,000
Total Present Worth Cost	$0	$1,240,000	$4,400,000	$10,400,000

[A] For a detailed listing and analysis of key ARARs, see Appendix B.

TABLE 5-2
Detailed Evaluation of Groundwater Media Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Groundwater Alternative GW1[A] No Further Action	Groundwater Alternative GW2[B] Source Treatment and MNA	Groundwater Alternative GW3[B] Expanded Source Treatment and MNA	Groundwater Alternative GW4 Entire Plume Collection and Treatment
1. Overall Protection of Human Health and the Environment				
	• TCE and PCE are expected to persist in groundwater at concentrations exceeding the PRGs for approximately 60 years. However, because monitoring is not included in this alternative, it will be impossible to tell when PRGs are met. There is a potential for human exposure to contaminated groundwater under this alternative because some homeowners are currently using groundwater for potable purposes.	• This alternative actively treats the groundwater area with the highest concentrations of TCE and PCE, reducing the timeframe until PRGs are met to about 55 years. • The potential for human exposure to contaminated groundwater will be minimized through institutional controls. • Removal and treatment ex situ of the high concentration portions of the TCE and PCE groundwater plumes may minimize the potential for further migration of the groundwater plume downgradient.	• This alternative reduces the concentrations of TCE and PCE in groundwater at the soil source areas, thus reducing the timeframe until PRGs are met to about 47 years. • The potential for human exposure to contaminated groundwater will be minimized through institutional controls. • This alternative will meet PRGs at the municipal wells sooner than Groundwater Alternative GW1 or GW2, allowing for the elimination of well head treatment sooner under this alternative. • This alternative minimizes the potential for further migration of the groundwater plume through removal of the highest concentration areas of the plumes.	• This alternative actively reduces the concentrations of TCE and PCE in the entire plume, thus reducing the timeframe until PRGs are met to about 22 years. • The potential for human exposure to contaminated groundwater will be minimized through institutional controls. • This alternative will meet PRGs at the municipal wells sooner than the other alternatives, allowing for the elimination of well head treatment sooner. • This alternative minimizes the potential for further migration of the groundwater plume through removal of all impacted groundwater.

TABLE 5-2
Detailed Evaluation of Groundwater Media Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Groundwater Alternative GW1[A] No Further Action	Groundwater Alternative GW2[B] Source Treatment and MNA	Groundwater Alternative GW3[B] Expanded Source Treatment and MNA	Groundwater Alternative GW4 Entire Plume Collection and Treatment
2. Compliance with ARARs[C]				
	• Would meet ARARs when TCE and PCE concentration in groundwater do not exceed NJ GWQS, which could take over 100 years.	• Would meet ARARs when groundwater PRGs are met. Under this alternative, this would take 55 years for downgradient portion of plume. • Groundwater treatment would be necessary to meet ARARs for discharge. • Collected groundwater may need to be specially handled to meet ARARs associated with treatment, storage, recycle, and/or disposal of hazardous wastes. • Air treatment may be necessary to meet Clean Air Act requirements.	• Would meet ARARs when groundwater PRGs are met. Under this alternative, this would take 47 years for downgradient portion of plume. • Groundwater treatment would be necessary to meet ARARs for discharge. • Collected groundwater may need to be specially handled to meet ARARs associated with treatment, storage, recycle, and/or disposal of hazardous wastes. • Air treatment may be necessary to meet Clean Air Act requirements.	• Would meet ARARs when groundwater PRGs are met. Under this alternative, this would take approximately 22 years. • Groundwater treatment would be necessary to meet ARARs for discharge. • Collected groundwater may need to be specially handled to meet ARARs associated with treatment, storage, recycle, and/or disposal of hazardous wastes. • Air treatment may be necessary to meet Clean Air Act requirements.
3. Long-Term Effectiveness and Permanence				
(a) Magnitude of residual risks	• No significant change in risk because no action taken. Reduction in risk relating to TCE and PCE contamination in groundwater exceeding groundwater PRGs would occur slowly, and may take over 100 years.	• Residual risks will be eliminated once the groundwater collection system remediates groundwater within the highest concentration areas and MNA remediates the downgradient portion of the plumes to below PRGs. However this will take decades.	• Residual risks will be eliminated once the groundwater collection system remediates groundwater within the highest concentration areas and MNA remediates the downgradient portion of the plumes to below PRGs. This will take decades to achieve, but is expected to take less time than Groundwater Alternative GW2.	Residual risks will be eliminated once the groundwater collection system remediates groundwater to below PRGs. This will take approximately 22 years to achieve, but is expected to take less time than all other alternatives.

TABLE 5-2
Detailed Evaluation of Groundwater Media Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Groundwater Alternative GW1[A] No Further Action	Groundwater Alternative GW2[B] Source Treatment and MNA	Groundwater Alternative GW3[B] Expanded Source Treatment and MNA	Groundwater Alternative GW4 Entire Plume Collection and Treatment
(b) Adequacy and reliability of controls	• Not applicable.	• Requires reliance on institutional controls for groundwater. These controls will be necessary for decades under this alternative. Effectiveness will depend on all homeowners agreeing to connect to municipal water supply.	• Requires reliance on institutional controls for groundwater. These controls will be necessary for decades under this alternative. Effectiveness will depend on all homeowners agreeing to connect to municipal water supply.	Requires reliance on institutional controls for groundwater during remedial actions. These controls will be necessary for decades under this alternative. Effectiveness will depend on all homeowners agreeing to connect to municipal water supply.
4. Reduction of Toxicity, Mobility, or Volume through Treatment				
(a) Treatment process used	• None.	• Will remove up to 99 percent of TCE or PCE from extracted groundwater in source areas.	• Will remove up to 99 percent of TCE or PCE from extracted groundwater in source areas.	• Will remove up to 99 percent of TCE or PCE from extracted groundwater over entire OU1 Study Area.
(b) Degree and quantity of TMV reduction	• PRGs would eventually be met through natural attenuation, although the process may take over 100 years.	• Pore exchange modeling shows that groundwater treatment should reduce the highest groundwater TCE concentration of 2,100 ug/L to below PRGs in 11 years of operation if no further source loadings occur. However given the likelihood of further loadings from other sources, treatment may continue for decades.	• Pore exchange modeling shows that groundwater treatment should reduce the TCE concentrations within the soil source areas of 2,100 ug/L to below PRGs in 47 years of operation if no further source loadings occur. The PCE concentrations will be to PRGs within 33 years, assuming no additional source. However given the likelihood of further loadings from other sources, treatment may continue for decades.	• Pore exchange modeling shows that groundwater treatment should reduce the highest groundwater TCE concentration of 2,100 ug/L to below PRGs in 22 years of operation if no further source loadings occur. However given the likelihood of further loadings from other sources, treatment may continue for decades.
(c) Irreversibility of TMV reduction	• Natural degradation of the plume is irreversible.	• Treatment is irreversible. Contaminants adsorbed to the carbon would be removed irreversibly during the regeneration process. • Natural degradation of the remainder of the plume is irreversible.	• Treatment is irreversible. Contaminants adsorbed to the carbon would be removed irreversibly during the regeneration process. • Natural degradation of the remainder of the plume is irreversible.	• Treatment is irreversible. Contaminants adsorbed to the carbon would be removed irreversibly during the regeneration process.

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TABLE 5-2
Detailed Evaluation of Groundwater Media Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Groundwater Alternative GW1[A] No Further Action	Groundwater Alternative GW2[B] Source Treatment and MNA	Groundwater Alternative GW3[B] Expanded Source Treatment and MNA	Groundwater Alternative GW4 Entire Plume Collection and Treatment
(d) Type and quantity of treatment residuals	• None.	• Residuals are limited to vapor-phase carbon and bag filter particulate matter. Activated carbon will need to be regenerated.	• Residuals are limited to vapor-phase carbon and bag filter particulate matter. Activated carbon will need to be regenerated.	• Residuals are limited to vapor-phase carbon and bag filter particulate matter. Activated carbon will need to be regenerated.
(e) Statutory preference for treatment as a primary element	• Preference not met for groundwater because no treatment beyond natural attenuation would occur.	• Preference met for groundwater source areas. • Preference not met for remainder of plume because no treatment beyond natural attenuation would occur.	• Preference met for groundwater source areas. • Preference not met for remainder of plume because no treatment beyond natural attenuation would occur.	• Preference met for groundwater.
5. Short-Term Effectiveness				
(a) Protection of workers during remedial action	• No remedial construction, so no risks to workers.	• Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil contaminants during well installation. • During remedial operations, risk to workers are limited to normal safety related risks related to treatment operations.	• Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil contaminants during well installation. • During remedial operations, risk to workers are limited to normal safety related risks related to treatment operations.	• Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil contaminants during well installation. During remedial operations, risk to workers are limited to normal safety related risks related to treatment operations.

TABLE 5-2
Detailed Evaluation of Groundwater Media Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Groundwater Alternative GW1[A] No Further Action	Groundwater Alternative GW2[B] Source Treatment and MNA	Groundwater Alternative GW3[B] Expanded Source Treatment and MNA	Groundwater Alternative GW4 Entire Plume Collection and Treatment
(b) Protection of community during remedial action	• No remedial construction, so no short-term risks to community.	• Health- and safety-related risks to community are expected to be minimal. Treatment equipment will be designed to meet required noise levels. • Safety-related risks to community during remedial operations may be posed as a result of truck traffic to transport activated carbon. • If poorly designed, the volume of water generated by the municipal supply wells may be reduced.	• Health- and safety-related risks to community are expected to be minimal. Treatment equipment will be designed to meet required noise levels. • Safety-related risks to community during remedial operations may be posed as a result of truck traffic to transport activated carbon. • If poorly designed, the volume of water generated by the municipal supply wells may be reduced.	• Health- and safety-related risks to community are expected to be minimal. Treatment equipment will be designed to meet required noise levels. • Safety-related risks to community during remedial operations may be posed as a result of truck traffic to transport activated carbon. If poorly designed, the volume of water generated by the municipal supply wells may be reduced.
(c) Environmental impacts of remedial action	None.	• Environmental impacts during remedial operations are limited to the minor truck traffic and air emissions from air stripper system. This impact should be minimal with appropriate air emission controls. • Discharge of treated groundwater would comply with NJDPES permitting requirements to minimize environmental impact.	• Environmental impacts during remedial operations are limited to the minor truck traffic and air emissions from air stripper system. This impact should be minimal with appropriate air emission controls. • Discharge of treated groundwater would comply with NJDPES permitting requirements to minimize environmental impact.	• Environmental impacts during remedial operations are limited to the minor truck traffic and air emissions from air stripper system. This impact should be minimal with appropriate air emission controls. • Discharge of treated groundwater would comply with NJDPES permitting requirements to minimize environmental impact.

TABLE 5-2
Detailed Evaluation of Groundwater Media Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Groundwater Alternative GW1[A] No Further Action	Groundwater Alternative GW2[B] Source Treatment and MNA	Groundwater Alternative GW3[B] Expanded Source Treatment and MNA	Groundwater Alternative GW4 Entire Plume Collection and Treatment
(d) Time until RAOs are achieved	• Attainment of NJ GWQS will take over 100 years, and will not be measurable due to the lack of a monitoring program. • RAOs for the protection of human health will be not be met until PRGs are achieved.	• NJ GWQS would be met in source areas in approximately 11 years. • Approximately 55 years would be required for the remainder of the plume to meet NJ GWQS. • RAOs for the protection of human health will be met after the implementation of Institutional Controls.	• NJ GWQS would be met in source areas after approximately 47 years for TCE and approximately 33 years for PCE.	• NJ GWQS would be met after approximately 22 years of operations for both TCE and PCE.
6. Implementability				
(a) Technical feasibility	• No impediments.	• No impediments.	• Very large water volumes may be difficult to handle via conventional methods. Required ex situ systems may be extensive.	• Very large water volumes may be difficult to handle via conventional methods. Required ex situ systems may be extensive.
(b) Administrative feasibility	• No impediments.	• Will require permitting prior to discharge of effluent. Siting the treatment facility may present challenges.	• Will require permitting prior to discharge of effluent. Siting the treatment facility may present challenges.	• Will require permitting prior to discharge of effluent. Siting the treatment facility may present challenges.
(c) Availability of services and materials	• None needed.	• Necessary engineering services and materials are readily available for installation and operation of system. • Resources are available to design and build the treatment system, although siting the plant may present challenges.	• Necessary engineering services and materials readily available for installation and operation of system. • Resources are available to design and build the treatment system, although siting the plant may present challenges.	• Necessary engineering services and materials readily available for installation and operation of system. Resources are available to design and build the treatment system, although siting the plant may present challenges.

TABLE 5-2
Detailed Evaluation of Groundwater Media Alternatives
PVGCS OU1 Study Area Feasibility Study

Criterion	Groundwater Alternative GW1[A] No Further Action	Groundwater Alternative GW2[B] Source Treatment and MNA	Groundwater Alternative GW3[B] Expanded Source Treatment and MNA	Groundwater Alternative GW4 Entire Plume Collection and Treatment
7. Total Cost				
Direct Capital Cost	$0	$2,552,000	$3,399,000	$10,811,000
O&M Cost	$0	$606,000	$996,000	$2,373,000
Total Present Worth Cost	$0	$8,060,000	$25,760,000	$46,840,000

[A] For the purposes of this analysis, it is assumed that this groundwater alternative would be paired with a soil alternative resulting in no additional mass flux to groundwater.

[B] For the purposes of this analysis, it is assumed that this groundwater alternative would be paired with Soil Alternative SO1, No Further Action. Mass flux to groundwater would continue.

[C] For a detailed listing and analysis of key ARARS, see Appendix B.

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Appendix A

Estimate of TCE and PCE Mass in Soil and Groundwater

Estimate of TCE and PCE Mass in Soil and Groundwater

Introduction

During development of the site conceptual model of contaminant fate and transport, a calculation was made to estimate the TCE mass in soil at the American National Can (ANC) areas, the TCE mass flux in groundwater near the ANC facility, and the estimated TCE leaching from soil to groundwater from the known areas of soil contamination exceeding Preliminary Remediation Goals (PRGs). In addition to the calculation of the TCE masses and mass flux at ANC, CH2M HILL calculated the estimated mass of PCE in the groundwater plumes. These calculations were done to provide and overall estimate of the contaminant mass contained in the soil and groundwater.

The soil and groundwater mass flux values for TCE at the ANC areas were expected to be in rough balance because the TCE groundwater plume exhibits characteristics suggesting it is near steady state conditions (i.e., the plume is roughly stable in TCE concentration and extent). However, the calculation results indicated that the TCE mass flux in known areas of soil contamination is less than the TCE mass flux in groundwater. Based on this discrepancy, it is suspected that an unidentified soil source in close proximity to the ANC facility (perhaps below the ANC building) is also contributing TCE mass to the groundwater. Review of ANC documents and drawings, which discuss historic operations, and remedial efforts, and depict sumps and trenches in the ANC building, provide information supporting the potential that an unidentified TCE soil source may be present under the ANC building.

USEPA requested that an estimate of the size and potential TCE concentrations in soil of a suspected area be prepared so that the selected remedy can include a contingency for remediation of such an area if it is identified in the current Industrial Site Recovery Act (ISRA) investigation or subsequent pre-remedial design investigations. This will allow more rapid remediation of source areas compared to the much more lengthy process required for preparing a Record of Decision (ROD) amendment.

It is recognized that the calculations presented below are based on reasonable assumptions, but are still subject to uncertainty. They are intended only to be used for the purpose discussed above. Cost estimates prepared to allow inclusion of this suspected area in the FS soil remedial alternatives are likewise subject to uncertainty.

Methodology and Results

The method used to estimate the impacted volume of soil and TCE concentration for a suspected source area included estimates of:

1. The TCE mass flux within groundwater downgradient of the ANC site.

2. The TCE mass flux leaching from soil to groundwater from the known ANC areas of soil contamination.
3. The suspected area that contributes the difference between the TCE groundwater mass flux and the TCE leaching mass flux from known soil source areas.

The method used to estimate the contaminant mass contained in groundwater and soil are as follows:

1. The area under the contoured plume or soil source is estimated along with the plume or soil thickness to calculate a volume. For groundwater, this volume is for both water and rock and is then multiplied by the assumed porosity of 15 percent (0.15) to calculate the volume of water in the plume.
2. The average contaminant concentration in the plume or soil was multiplied by the calculated volume estimate the amount of contaminant within the plume or soil column. A conversion factor is applied to the result to express the mass in terms of pounds.

TCE Mass Flux within Groundwater

The TCE mass flux in groundwater at a location immediately downgradient of the ANC facility was estimated using site-specific parameters from the RI Report and the groundwater flow model. To assess the mass flux within the groundwater, a cross-sectional line was constructed across the area of highest TCE concentrations in groundwater perpendicular to observed groundwater flow. The cross-sectional line, therefore, was drawn immediately downgradient of the identified TCE Soil Source Area A. Using Figure 5-6 in the RI Report, the width of the greater than 500 µg/L concentrations was estimated to be about 500 ft, the width of the greater than 50 µg/L and less than 500 µg/L was estimated to be about 500 ft (250 ft on either side of the 500 µg/L contour), and the width of the greater than 5 µg/L and less than 50 µg/L was estimated to be 2,200 ft (1,700 ft and 500 ft to the north and south of the 50 µg/L contour, respectively). The depth of the plume was estimated based on the cross-section presented in the RI Report (Figure 5-8), which show the greater than 500 µg/L, greater than 50 and less than 500 µg/L, and greater than 5 and less than 50 µg/L concentrations extending to about 50 ft, 150 ft, and 200 ft, respectively.

Mass flux calculations and results are presented in Table A-1. The TCE mass flux in groundwater downgradient of the ANC facility is estimated at 310 pounds/year.

TCE Mass Flux Leaching from Soil to Groundwater from Known ANC Source Areas

The FS identified soil contamination in excess of the PRGs within areas in the immediate vicinity of the ANC facility based on results of the RI. More than 99 percent of the identified TCE mass in soil is present in the ANC A area. As a result, subsequent calculations were performed using the ANC A area.

The ANC A area is estimated to have an average soil concentration of about 6,300 µg/Kg (6.3 ppm) over an area of 28,000 square feet (FS Report, Figure 2-1). Leaching of the TCE in soil to groundwater is estimated based on the distribution coefficient (Kd), calculated using an foc value of 0.002 (NJDEP/USEPA default) and a Koc value of 126 mL/g (FS Report Appendix C), and the average soil concentration to provide an estimated average pore

water concentrations. Using a yearly precipitation infiltration of about 1 foot per year, the total mass of TCE leaching from soil to groundwater is calculated on a yearly basis.

Mass flux calculations and results are presented in Table A-2. The TCE mass flux from ANC A area is estimated to be about 44 pounds/year.

Suspected Area

The difference between the estimated TCE mass flux within groundwater and the TCE mass flux leaching from known soil source areas near ANC is 266 pounds/year. Such a relatively large mass flux to groundwater requires very high TCE pore water concentrations and/or very large areas of contamination.

Mass flux rates on this scale may be a result of Dense Non-Aqueous Phase Liquids (DNAPLs) present in the unsaturated zone. DNAPLs serve as very long-term (decades) sources of TCE because the relatively low solubility of TCE (1,100 mg/L) results in slow dissolution of the DNAPL into pore water leaching to groundwater. If DNAPL is an additional source to groundwater, the pore water concentration of TCE could be near the solubility limit. However in practice, DNAPLs spread over large areas tend not to be uniform and it is likely that an average pore water concentration would be much less than the solubility limit. To account for this, an average pore water concentration of 25 percent of solubility, or 275 mg/L was assumed. The area of the suspected source was then calculated based on:

- A TCE mass flux to groundwater of 266 pounds/year.
- A TCE pore water concentration of 275 mg/L.
- A yearly precipitation infiltration of 1 foot.

The calculations are presented in Table A-3. The size of the suspected area is 16,000 square feet, which is somewhat smaller than the ANC A area. The suspected mass of TCE in the area is far more uncertain because the amount of DNAPL to cause pore water concentrations near solubility is less dependent on the mass of DNAPL and more dependent on the geometry of the DNAPL distribution. The suspected area is referred to as ANC C in this FS.

Contaminant Mass in Groundwater

Based on the TCE and PCE plume maps provided in the RI Report, the TCE and PCE contaminant mass in the groundwater and in the identified TCE soil source area (ANC A) was calculated (Table A-4). Based on these calculations, there is an estimated 8,240 pounds of TCE in groundwater, 1,940 pounds of TCE in the ANC A area, and 180 pounds of PCE in groundwater.

Table A-1
TCE Mass Flux Leaching fromSoil to Groundwater at American National Can (ANC) A Area
PVGCS OU1 Study Area Feasibility Study

ANC A Soil Source Area (sf)	28,000	Pohatcong FS Estimate
ANC A Soil Source Area Average TCE (ug/kg)	6,300	Pohatcong FS Estimate
foc (g/g)	0.0020	USEPA and NJDEP Default Value (Basis and Background Document Impact to Groundwater Pathway - Table 1; NJDEP)
TCE Koc (mL/g)	126	Pohatcong FS Estimate, Groundwater Flow Model Appendix C.
TCE Kd (mL/g)	0.25	Kd = Koc x foc
Calculated Average TCE Soil Pore Water Concentration (ug/l)	25,000	Pore water conc = Soil Average TCE Concentration / Kd
Yearly Infiltration (ft)	1	Precipitation that Infiltrates per year
Average Mass Flux to Groundwater (lbs/yr)	**44**	Surface area x Yearly Infiltration/yr x Calculated Average Soil Pore Water Concentration x conversion factor (ug/yr to lbs/yr)

Table A-2
TCE Mass Flux within Groundwater
PVGCS OU1 Study Area Feasibility Study

Plume Immediately Downgradient of ANC		
Plume width ft. (>500 ug/L)	500	Pohatcong RI Report
Plume width ft. (>50 and <500 ug/L)	500	Pohatcong RI Report
Plume width ft. (>5 and <50 ug/L)	2200	Pohatcong RI Report
Plume thickness ft. (>500 ug/L segment)	50	Pohatcong RI Report (Thickness of >500 ug/L is about 50 ft; Thickness of plume >50 ug/L is about 150 ft, and thickness of plume >5 ug/L is about 200 ft)
Plume thickness ft. (>50 ug/L segment)	150	Pohatcong RI Report (Thickness of >500 ug/L is about 50 ft; Thickness of plume >50 ug/L is about 150 ft, and thickness of plume >5 ug/L is about 200 ft)
Plume thickness ft. (>5 ug/L segment)	200	Pohatcong RI June 2003 Figure 5-8 (Thickness of >500 ug/L is about 50 ft; Thickness of plume >50 ug/L is about 150 ft, and thickness of plume >5 ug/L is about 200 ft)
Hydraulic conductivity (K) ft/day	33	Pohatcong FS Estimate, Groundwater Flow Model Appendix C.
Effective porosity (ne)	0.15	Pohatcong FS Estimate, Groundwater Flow Model Appendix C.
Groundwater gradient (I) ft/ft	0.013	Pohatcong RI Report. Gradient in area of ANC calculated based on 20'/ 1,550' = 0.013.
Groundwater velocity ft/d	2.86	V = K*I/ne
TCE Retardation Factor (Rf)	1.47	Pohatcong FS April 2004, Groundwater Flow Model Appendix C.
TCE Migration Velocity ft/d	1.95	TCE migration velocity = Gw velocity / Rf
Average Concentration (>500 ug/l segment)	1200	Average of 2,100 ug/L in PVVTC15, 930 ug/L in PVVTC13, and 560 ug/L in PVWLY09 (Pohatcong FS Esimate)
Average Concentration (>50 and <500 ug/l segment)	127	Average of concentration in wells PVANC01, PVANC03, PVANC29, PVVAN01, PVWLY07, and PVWLY08 concentrations (Pohatcong FS Estimate)
Average Concentration (>5 ug/l segment)	18	Average of 12 ug/L in PVAC106, 20 ug/L in PVANC02, and 24 ug/L in PVGPU01 (Pohatcong FS Estimate)
Average Flux (pounds/yr) for >500 ug/L segment	**200**	Plume width x thickness x effective porosity x groundwater velocity x average concentration x conversion factor (ug/d to lbs/yr)
Average Flux (pounds/yr) for >50 and <500 ug/L segment	**60**	Plume width x thickness x effective porosity x groundwater velocity x average concentration x conversion factor (ug/d to lbs/yr)
Average Flux (pounds/yr) for >5 ug/L segment	**50**	Plume width x thickness x effective porosity x groundwater velocity x average concentration x conversion factor (ug/d to lbs/yr)
Total Average Flux (pounds/yr)	**310**	

Table A-3
Hypothetical Additional Area Leaching TCE from Soil to Groundwater
PVGCS OU1 Study Area Feasibility Study

TCE Mass Flux within GW (pounds/yr)	310	See TCE Mass Flux in GW Calculations (Table A-1).
TCE Mass Flux from soil to GW from ANC A (pounds/yr)	44	See TCE Leaching Mass Flux Calculations (Table A-2).
Mass Flux Difference (pounds/yr)	266	Difference between TCE mass flux in GW leaving ANC Area and ANC A TCE mass flux to groundwater.
Hypothetical Area Contributing TCE to GW		
Yearly Infiltration (ft)	1	Precipitation that Infiltrates per year
Average Mass Flux to Groundwater (lbs/yr)	266	Difference between TCE mass flux in GW leaving ANC Area and ANC A TCE mass flux to groundwater (see above).
Average Soil Pore Water Concentration (ug/l)	275,000	Assume 1/4 of TCE solubility of 1,100,000 ug/L because large mass flux requires near DNAPL concentrations.
Calculated Area (sf)	**16,000**	Calculated Area = Mass Flux Soil to Groundwater divided by product of Yearly Infiltration and Average Soil Pore Water Concentration. A conversion factor is applied to correct the units.

Table A-4
Estimated TCE in Soil and Groundwater and PCE in Groundwater
PVGCS OU1 Study Area Feasibility Study

ANC A Area (TCE)	ave. concentration	6300	ug/Kg	
	area	28000	ft^2	
	depth	100	ft	
	volume	2800000	ft^3	
	weight	308000000	lbs	110 lbs/ft^3 (est. from Field Engineers Manual)
	weight	139706459.2	kg	1 lb = 0.45 kg
	TCE weight	8.80151E+11	ug	
	TCE weight	880150693	mg	1000 ug = 1 mg
	TCE weight	880150.693	g	1000 mg = 1 g
	TCE weight	880.150693	kg	1000 g = 1 kg
	TCE weight	1940.73	pounds	2.205 pounds/kg
	TOTAL TCE IN ANC A SOIL	1940.73	pounds	

TCE Groundwater Plume

Area under 500 ug/L isoconcentration contour x plume thickness x porosity x average TCE concentration

Area	300000	ft^2	(7 acres)
Thickness	120	ft	
Volume	36000000	ft^3	Rock and water
Porosity	0.15		
Volume	5400000	ft^3	Water
Volume	40392000	gal	7.48 gal/ft^3
Volume	152883720	L	3.785 L/gal
Ave TCE conc.	1200	ug/L	High = 2,100 ug/L; Low = 500 ug/L; Most of plume about 1,200 ug/L
TCE weight	1.8346E+11	ug	
TCE weight	183460464	mg	1000 ug = 1 mg
TCE weight	183460.464	g	1000 mg = 1 g
TCE weight	183.460464	kg	1000 g = 1 kg
TCE weight	404.53	pounds	2.205 pounds/kg

Table A-4
Estimated TCE in Soil and Groundwater and PCE in Groundwater
PVGCS OU1 Study Area Feasibility Study

TCE Groundwater Plume

Area under 100 to 500 ug/L isoconcentration contour x plume thickness x porosity x average TCE concentration

Area	8700000	ft^2	(200 acres)
Thickness	175	ft	
Volume	1522500000	ft^3	Rock and water
Porosity	0.15		
Volume	228375000	ft^3	Water
Volume	1708245000	gal	7.48 gal/ft^3
Volume	6465707325	L	3.785 L/gal
Ave TCE conc.	250	ug/L	High = 500 ug/L; Low = 100 ug/L
TCE weight	1.61643E+12	ug	
TCE weight	1616426831	mg	1000 ug = 1 mg
TCE weight	1616426.831	g	1000 mg = 1 g
TCE weight	1616.426831	kg	1000 g = 1 kg
TCE weight	3564.22	pounds	2.205 pounds/kg

Area under 50 to 100 ug/L isoconcentration contour x plume thickness x porosity x average TCE concentration

Area	11000000	ft^2	(250 acres)
Thickness	200	ft	
Volume	2200000000	ft^3	Rock and water
Porosity	0.15		
Volume	330000000	ft^3	Water
Volume	2468400000	gal	7.48 gal/ft^3
Volume	9342894000	L	3.785 L/gal
Ave TCE conc.	75	ug/L	High = 100 ug/L; Low = 50 ug/L
TCE weight	7.00717E+11	ug	
TCE weight	700717050	mg	1000 ug = 1 mg
TCE weight	700717.05	g	1000 mg = 1 g
TCE weight	700.71705	kg	1000 g = 1 kg
TCE weight	1545.08	pounds	2.205 pounds/kg

Table A-4
Estimated TCE in Soil and Groundwater and PCE in Groundwater
PVGCS OU1 Study Area Feasibility Study

TCE Groundwater Plume

Area under 10 to 50 ug/L isoconcentration contour x plume thickness x porosity x average TCE concentration

Area	36000000	ft^2	(825 acres)
Thickness	200	ft	
Volume	7200000000	ft^3	Rock and water
Porosity	0.15		
Volume	1080000000	ft^3	Water
Volume	8078400000	gal	7.48 gal/ft^3
Volume	30576744000	L	3.785 L/gal
Ave TCE conc.	25	ug/L	High = 50 ug/L; Low = 10 ug/L
TCE weight	7.64419E+11	ug	
TCE weight	764418600	mg	1000 ug = 1 mg
TCE weight	764418.6	g	1000 mg = 1 g
TCE weight	764.4186	kg	1000 g = 1 kg
TCE weight	1685.54	pounds	2.205 pounds/kg

Area under 5 to 10 ug/L isoconcentration contour x plume thickness x porosity x average TCE concentration

Area	74000000	ft^2	(1700 acres)
Thickness	200	ft	
Volume	14800000000	ft^3	Rock and water
Porosity	0.15		
Volume	2220000000	ft^3	Water
Volume	16605600000	gal	7.48 gal/ft^3
Volume	62852196000	L	3.785 L/gal
Ave TCE conc.	7.5	ug/L	High = 10 ug/L; Low = 5 ug/L
TCE weight	4.71391E+11	ug	
TCE weight	471391470	mg	1000 ug = 1 mg
TCE weight	471391.47	g	1000 mg = 1 g
TCE weight	471.39147	kg	1000 g = 1 kg
TCE weight	1039.42	pounds	2.205 pounds/kg

TOTAL TCE IN GROUNDWATER	8238.79	pounds

Table A-4
Estimated TCE in Soil and Groundwater and PCE in Groundwater
PVGCS OU1 Study Area Feasibility Study

PCE Groundwater Plume

Area under 25 ug/L isoconcentration contour x plume thickness x porosity x average PCE conc.

Area	375000	ft^2	(8 acres)
Thickness	200	ft	
Volume	75000000	ft^3	Rock and water
Porosity	0.15		
Volume	11250000	ft^3	Water
Volume	84150000	gal	7.48 gal/ft^3
Volume	318507750	L	3.785 L/gal
Ave PCE conc.	40	ug/L	High = 45 ug/L; Low = 25 ug/L
PCE weight	12740310000	ug	
PCE weight	12740310	mg	1000 ug = 1 mg
PCE weight	12740.31	g	1000 mg = 1 g
PCE weight	12.74031	kg	1000 g = 1 kg
PCE weight	28.09	pounds	2.205 pounds/kg

Area under 10 to 25 ug/L isoconcentration contour x plume thickness x porosity x average PCE conc.

Area	3875000	ft^2	(89 acres)
Thickness	200	ft	
Volume	775000000	ft^3	Rock and water
Porosity	0.15		
Volume	116250000	ft^3	Water
Volume	869550000	gal	7.48 gal/ft^3
Volume	3291246750	L	3.785 L/gal
Ave PCE conc.	17.5	ug/L	High = 25 ug/L; Low = 10 ug/L
PCE weight	57596818125	ug	
PCE weight	57596818.13	mg	1000 ug = 1 mg
PCE weight	57596.81813	g	1000 mg = 1 g
PCE weight	57.59681813	kg	1000 g = 1 kg
PCE weight	127.00	pounds	2.205 pounds/kg

Table A-4
Estimated TCE in Soil and Groundwater and PCE in Groundwater
PVGCS OU1 Study Area Feasibility Study

PCE Groundwater Plume

Area under 5 to 10 ug/L isoconcentration contour x plume thickness x porosity x average PCE conc.

Area	1770000	ft^2	(40 acres)
Thickness	200	ft	
Volume	354000000	ft^3	Rock and water
Porosity	0.15		
Volume	53100000	ft^3	Water
Volume	397188000	gal	7.48 gal/ft^3
Volume	1503356580	L	3.785 L/gal
Ave PCE conc.	7.5	ug/L	High = 10 ug/L; Low = 5 ug/L
PCE weight	11275174350	ug	
PCE weight	11275174.35	mg	1000 ug = 1 mg
PCE weight	11275.17435	g	1000 mg = 1 g
PCE weight	11.27517435	kg	1000 g = 1 kg
PCE weight	24.86	pounds	2.205 pounds/kg

TOTAL PCE IN GROUNDWATER	179.96	pounds

Appendix B
ARARs

Appendix B
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements
PVGCS Feasibility Study

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Resource Conservation and Recovery Act	Identification and Listing of Hazardous Waste	40 CFR 261	Defines those solid wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and 270.	ARAR for wastes or treatment residues which are hazardous as defined by RCRA and are to be disposed of off-site.
Federal Safe Drinking Water Act	National Primary Drinking Water Standards - Maximum Contaminant Level Goals (MCLGs) and Maximum Contaminant Levels (MCLs)	40 CFR 141	Establishes health-based standards for public drinking water systems. Also establishes drinking water quality goals set at levels at which no adverse health effects are anticipated, with an adequate margin of safety. The NCP specifically states that MCLs will be used as ARARs for useable aquifers rather than the more stringent MCLGs.	ARAR because the site groundwater aquifer is classified as a Class IIA Source of Drinking Water. The MCLs have been applied to the remediation of groundwater.
Federal Safe Drinking Water Act	National Secondary Drinking Water Standards-Secondary MCLs	40 CFR 143	Establishes standards for public drinking water systems for those contaminants which impact the aesthetic qualities of drinking water (secondary MCL).	To Be Considered (TBC). Secondary MCLs are based on aesthetic criteria and do not reflect public health concerns. They are considered TBC and will be attained where possible.
Quality Criteria for Water	Water Quality Criteria	40 CFR 131 Quality Criteria for Water, 1976, 1980, and 1986	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	TBC. Water is discharged to surface water, these are used in setting effluent discharge limits.
Federal Clean Water Act; National Pollution Discharge Elimination System (NPDES)	Toxic Pollutant Effluent Standards	40 CFR 129	Establishes effluent standards or prohibitions for certain toxic pollutants; I.e., aldrin/dieldrin, DDT, DDD, DDE, endrin, toxaphene, benzideine, and PCBs.	ARAR if toxic pollutants are in groundwater requiring treatment.
National Ambient Air Quality Standards (NAAQS)	Ambient Air Quality Standards	40 CFR 50	Defines air quality levels adequate to protect public health/welfare. Defines emissions limitations for sulfur oxides, particulate matter, carbon monoxide, ozone, nitrogen oxide, and lead.	Potential ARAR for remedial alternatives resulting in air emissions if these toxic polluntants are present.
Federal Resource Conservation and Recovery Act	Groundwater Protection Standards and Maximum Concentration Limits	40 CFR 264, Subpart F	Establishes standards for groundwater protection for several metals and pesticides.	ARAR. These maximum concentration limits are applicable to RCRA regulated units and are considered relevant and appropriate.

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Sludge Quality Criteria	Criteria for Sludge	NJAC 7:14-4 Appendix B-1	New Jersey Water Pollution Control Act Contaminant Indicators.	Potential ARAR for remedial alternatives resulting in the generation of sludges during groundwater or soil treatment.
New Jersey Department of Environmental Protection Residential Direct Contact Soil Cleanup Criteria	Residential Soil Cleanup Standards in New Jersey	N.J.A.C. 7-26D	Direct contact cleanup criteria for soils at residential sites.	TBC. Not promulgated. NJDEP requires delineation of contamination to residential levels.
NJDEP Non-Residential Direct Contact Soil Cleanup Criteria	Non-Residential Soil Cleanup Standards in New Jersey	N.J.A.C. 7-26D	Direct contact cleanup criteria for soils at industrial or commercial sites.	TBC. Not promulgated.Criteria may be considered in setting cleanup goals for contaminated soils at source areas or areas where industrial activities are planned.
NJDEP Impact to Groundwater Soil Cleanup Criteria	Soil Cleanup Standards that are Protective of Groundwater in New Jersey	N.J.A.C. 7-26D	Soil cleanup criteria for protection of groundwater.	TBC. Not Promulgated. Criteria may be considered in setting cleanup goals for contaminated soils at source areas.
State of New Jersey Statutes and Rules	Groundwater Quality Standards	N.J.A.C. 7:9-6 Groundwater Quality Standards	Establishes standards for the protection of ambient groundwater quality. Used as the primary basis for setting numerical criteria for groundwater cleanups.	ARAR for Class IIA aquifers.
Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs)	Maximum Contaminant Levels	A-280 Amendments	Establishes State criteria for drinking water.	Potential ARAR is State MCLs are more stringent than Federal MCLs.
State of New Jersey Statutes and Rules	Drinking Water Standards-Maximum Contaminant Levels (MCLs)	N.J.A.C. 7:10 Safe Drinking Water Act	Establishes MCLs that are generally equal to or more stringent the SDWA MCLs.	ARAR. The Site aquifer is a drinking water supply source.

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
State of New Jersey Statutes and Rules	National Secondary Drinking Water Standards-Secondary MCLs	N.J.A.C. 7:10-7 Safe Drinking Water Act	Establishes standards for public drinking water systems for those contaminants which impact the aesthetic qualities of drinking water.	TBC. Secondary MCLs are based on aesthetic criteria and do not reflect public health concerns. They are considered TBCs in that they will be attained where possible.
New Jersey Pollutant Discharge Elimination System (NJPDES)	Surface Water Discharge Criteria	N.J.A.C. 7:14a	Establishes discharge standards when written into permits.	Potential ARAR if treated water is discharged to surface water.
Surface Water Criteria	New Jersey Criteria for Surface Water Quality	N.J.A.C. 7:9-4	Criteria for surface water classes	Potential ARAR if treated water is discharged to surface waters.
Prohibition of Air Pollution and Ambient Air Quality Standards	Air Quality Standards	N.J.A.C. 7:27-5 and N.J.A.C.7:27-13	Prohibits air pollution and establishes ambient air quality standards	Potential ARAR for remedial alternatives which include technologies that result in air emissions.

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Discharge of Groundwater or Wastewater				
Federal Clean Water Act	National Pollution Discharge Elimination System (NPDES)	40 CFR 122 and 125	Issues permits for discharge into navigable waters. Establishes criteria and standards for imposing treatment requirements on permits.	ARAR, although state ARAR takes precedence for discharge permit. Disposal of groundwater to the surface water. NPDES permit may not be required since New Jersey has an approved SPDES permit program (NJDPES).
Federal Clean Water Act	General Pretreatment Regulations for Existing and New Sources of Pollution	40 CFR 403	Prohibits discharge of pollutants to a POTW which cause or may cause pass-through or interference with operations of the POTW.	ARAR. Discharge of pollutants including those that could cause fire or explosion or result in toxic vapors or fumes to POTW.
Federal Clean Water Act	Effluent Guidelines and Standards for the Point Source Category	40 CFR 414	Requires specific effluent characteristics for discharge under NPDES permits.	ARAR, although state ARAR takes precedence for discharge permit. Disposal of groundwater to the surface water. NPDES permit may not be required since New Jersey has an approved SPDES permit program (NJDPES).
Federal Safe Drinking Water Act	Underground Injection Control Program	40 CFR 144	Establishes performance standards, well requirements, and permitting requirements for groundwater re-injection wells.	Potential ARAR if remedial alternative includes discharge of treated groundwater to potable water supply aquifer. May also apply to the injection of surfactants or oxidants into the aquifer.
Federal Clean Water Act	Ambient Water Quality Criteria	40 CFR 131.36	Establishes criteria for surface water quality based on toxicity to aquatic organisms and human health.	Potential ARAR if remedial alternative includes groundwater discharge to surface water. Federally-approved New Jersey groundwater and surface water standards take precedence over the Federal criteria.
Federal Clean Water Act	Water Quality Criteria Summary		Includes non-promulgated guidance values for surface water based on toxicity to aquatic organisms and human health. Issued by the EPA office of Science and Technology, Health and Ecological Criteria Division.	Potential ARAR if remedial alternative includes groundwater discharge to surface water. Supplements above-referenced Ambient Water Criteria.

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Water Pollution Control Act	Protection of water	33 U.S.C. 1251	Protects and maintains the chemical, physical, and biological integrity of the nation's water.	Potential ARAR for remedial actions which may affect water quality.
Water Treatment and Disposal				
Effluent Limitations	Discharge requirements	33 U.S.C. 1251 Section 301	Technology-based discharge limitations for point sources of conventional, nonconventional, and toxic pollutants.	Potential ARAR for remedial actions which include discharge of wastewater.
Water Quality Related Effluent Limitations	Discharge requirements	33 U.S.C. 1251 Section 302	Protection of intended uses of receiving waters (e.g., public water supply, recreations uses).	Potential ARAR for remedial actions which include discharge of wastewater.
Toxic and Pretreatment Effluent Standards	Pretreatment standards for discharge into POTWs.	33 U.S.C. 1251 Section 307	Establishes list of toxic pollutants and promulgates pretreatment standards for discharge into POTWs.	Potential ARAR for remedial actions which include discharge of wastewater.
National Pollutant Discharge Elimination System (NPDES)	Permitting for discharge into navigable waters.	33 U.S.C. 1251	Issues permits for discharge into navigable waters.	Potential ARAR for remedial actions involving discharge to surface water.
Disposal of Dredged and Fill Material	Requires permitting of discharges of dredged and fill material to navigable waters.	33 U.S.C. 1251 Section 404	Requires permitting of discharges of dredged and fill material to navigable waters.	Potential ARAR for remedial alternatives which require discharge of dredged and fill material to navigable waters.
State of New Jersey Statutes and Rules	The New Jersey Pollutant Discharge Elimination System	N.J.A.C. 7:14A	Establishes standards for discharge of pollutants to surface and groundwaters.	ARAR. New Jersey has a state approved program. Disposal of treated groundwater to surface water.
State of New Jersey Statutes and Rules	Groundwater Quality Standards	N.J.A.C. 7:9-6 Groundwater Quality Standards	Establishes standards for the protection of ambient groundwater quality. Used as the primary basis for setting numerical criteria for groundwater cleanups and discharges to groundwater.	ARAR. Disposal of treated groundwater by reinjection.
State of New Jersey Statutes and Rules	Surface Water Quality Standards	N.J.A.C. 7:9B Surface Water Quality Standards	Establishes standards for the protection and enhancement of surface water resources.	ARAR. Disposal of treated groundwater by discharge to surface water.

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Wastewater Discharge Requirements	Wastewater discharge requirements	N.J.A.C. 7:9-5.1	Minimum treatment requirements and effluent standards for discharge to surface water.	Potential ARAR if waters generated by treatment technology are discharged to surface water.
Worker and Community Right to Know Act	Protects workers and community	P.L. 1983c.315 P.L. 1985c.543 Executive Order #161	Notification of presence of hazardous substances to State Emergency Planning Commissions and to local Emergency Planning Committees.	ARAR. Applies to all on-site treatment alternatives.
Safe Drinking Water	Protects public water supply wells	N.J.S.A. 58:12A	Regulates periodic testing of Public Community Water Systems.	ARAR. Periodic water supply monitoring may be part of the remediation alternatives.
Interim Safe Drinking Water Testing Schedule	Protects public water supply wells	N.J.A.C. 7:10-14.1 et.seq.	Requires periodic testing, analysis, and reporting for Public Community Water Systems.	ARAR. Periodic water supply monitoring may be part of the remediation alternatives.
New Jersey Safe Drinking Water Act	Protects public water supply wells	N.J.A.C. 7:10	Sets standards for drinking water including MCLs, disinfecting requirements, secondary drinking water regulations, and monitoring requirements.	Potential ARAR if criteria are more stringent than the Federal MCLs.
Disposal of Hazardous Waste				
RCRA Criteria for Classification of Solid Waste Disposal Facilities and Practices	Classification of Disposal Facilities	40 CFR 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on heath or the environment and thereby constitute prohibited open dumps.	Potential ARAR for remedial alternatives which include disposal of non-hazardous waste on-site. The current Subtitle D program is principally aimed at municipal and industrial solid waste.
RCRA Hazardous Waste Management Systems, General	General Waste Management Practices	40 CFR 260	Establishes procedures and criteria for modification or revocation of any provision in 40 CFR Part 260-265.	Potential ARAR. Establishes general requirements for hazardous waste management.
Federal Resource Conservation and Recovery Act	Identification and Listing of Hazardous Waste	40 CFR 261	Identifies solid wastes which are subject to regulation as hazardous wastes.	ARAR. Generation of a hazardous waste possibly including spent carbon or contaminated soil. Hazardous waste must be handled and disposed of in accordance with RCRA. Chemical testing and characterization of waste required.

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Federal Resource Conservation and Recovery Act	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes requirements (e.g., EPA ID numbers and manifests) for generators of hazardous waste.	ARAR. Waste that is characterized as hazardous.
Federal Resource Conservation and Recovery Act	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards which apply to persons transporting manifested hazardous waste within the United States.	ARAR. Transport of waste that is characterized as hazardous.
Federal Resource Conservation and Recovery Act	Standards Applicable to Owners and Operators of Treatment, Storage and Disposal Facilities	40 CFR 264	Establishes the minimum national standards which define acceptable management of hazardous waste.	ARAR. Generation and storage of hazardous waste.
Federal Resource Conservation and Recovery Act	Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 265	Establishes minimum national standards that define the periods of interim status and until certification of final closure or if the facility is subject to post-closure requirements, until post-closure responsibilities are fulfilled.	Potential ARAR since remedies should be consistent with the more stringent 40 CFR 264 standards, as these represent the ultimate RCRA compliance standards and are consistent with CERCLA's goal of long-term protection of public health and welfare and the environment.
Federal Resource Conservation and Recovery Act	Interim Standards for Owners and Operators	40 CFR 267	Establishes minimum national standards that define acceptable management of hazardous waste for new land disposal facilities.	Potential ARAR. CERCLA actions should be consistent with requirements of 40 CFR 264.
Federal Resource Conservation and Recovery Act	Land Disposal Restrictions	40 CFR 268	Identifies hazardous wastes which are restricted from land disposal. All listed and characteristic hazardous waste or soil or debris contaminated by a RCRA hazardous waste and removed from a CERCLA site may not be land disposed until treated as required by LDRs.	ARAR. Waste to be disposed as a RCRA waste.
Federal Resource Conservation and Recovery Act	Hazardous Waste Permit Program	40 CFR 270	Establishes provisions covering basic EPA permitting requirements.	Potential ARAR. A permit is not required for on-site CERCLA response actions. Substantive requirements are added in 40 CFR 264.
State of New Jersey Statutes and Rules	Hazardous Waste	N.J.A.C. 7:26C Hazardous Waste	Establishes rules for the operation of hazardous waste facilities in the state of New Jersey	Potential ARAR depending on hazardous waste disposal location.

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Federal Resource Conservation and Recovery Act	RCRA	40 CFR 265	Establishes organic air emission standards for tanks, surface impoundments, and containers.	Potential ARAR for hazardous waste treatment, storage, and disposal facilities (TSDFs) that receive new or re-issued permits or Class 3 modifications after 5 January 1995.
Federal Hazardous Material Transportation Act	Hazardous Materials Transportation Regulations	49 CFR 107, 171-177	Regulates transportation of hazardous materials.	Potential ARAR since response action may involve transportation of hazardous materials.
General Remediation				
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and Superfund Amendments and Reauthorization Act of 1986 (SARA)	National Contingency Plan	40 CFR 300, Subpart E	Outlines procedures for remedial actions and for planning and implementing off-site removal actions.	ARAR.
State of New Jersey Statutes and Rules	Technical Requirements for Site Remediation	N.J.A.C. 7:26E	Established minimum regulatory requirements for investigation and remediation of contaminated sites in New Jersey.	ARAR.
Federal Occupational Safety and Health Act	Worker Protection	29 CFR 1904	Requirements for recording and reporting occupation injuries and illnesses	ARAR. Under 40 CFR 300.38, requirements of OSHA apply to all activities which fall under jurisdiction of the National Contingency Plan.
Emergency Response Notice of Release of Hazardous Substance to Atmosphere	Notification of Air Releases	NJSA 7:26, 26:2C-19	Control exposure to air pollution by immediate notification to the department hotline of any air release incident.	Potential ARAR for any remedial alternative having the potential to result in an air release.
Water Pollution Control	Notification of Spills	NJAC 7:21(E)	Immediate notification of any spill of hazardous substances.	Potential ARAR for remedial alternatives having potential for a spill of a hazardous substance.
Noise Control Act	Restrictions of Noise	NJSA 13:1G-1 et.seq.	Prohibits and restricts noise which unnecessarily degrades the quality of life.	Potential ARAR for all remedial action.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA for a site in Manville, New Jersey (June 2003).

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Disposition of Material Generated During Site Investigations (NJDEP)	Investigation derived waste management	NJDEP's Guidance Document	Provides guidance on the disposition of IDW.	Potential ARAR. To be considered during investigation.
Noise Pollution	Restrictions of Noise	NJAC 7:29-1	Sets maximum limits of sound from any industrial, commercial, public service or community service facility.	Potential ARAR for all remedial actions.
Federal Occupational Safety and Health Act	Worker Protection	29 CFR 1904	Worker Protection	ARAR. Under 40 CFR 300.38, requirements of OSHA apply to all activities which fall under jurisdiction of the National Contingency Plan.
General Requirements for Permitting Wells	Well Permitting	NJAC 7:9-7	Regulates permit procedures, general requirements for drilling and installation of wells, licensing of well driller and pump installer, construction specification, and well casing.	Potential ARAR when installing new wells or if existing wells should require modification.
Sealing of Abandoned Wells	Well Abandonment Procedures	NJAC 7:9-9	General requirements for sealing of all wells (e.g., single cased, multiple cased, hand dug, test wells, boreholes and monitoring wells, abandoned wells).	Potential ARAR if any existing wells need to be abandoned and sealed.
Well Drillers and Pump Installers Act	Drilling Contractor Requirements	NJSA 58:4A-5 et.seq.	Well drillers licensing, supervision, inspection and sampling.	Potential ARAR when additional wells are installed.
Requirement for Groundwater Monitoring	Groundwater Monitoring	N.J.A.C. 7:26-9	Groundwater monitoring system requirements.	Potential ARAR for any remedial alternative requiring groundwater monitoring.
Off-Gas Management				
Federal Clean Air Act	National Primary and Secondary Ambient Air Quality Standards	40 CFR 50	Establishes emission limits for six pollutants (SO2, PM10, CO, O3, NO2, and Pb).	Emission of air polluntants may be of concern for some remedial technologies.
Permitting Requirements	Permtting Conditions for air pollution control	N.J.A.C. 7:27-8	Establishes permit conditions for air pollution control apparatus.	ARAR if remedial action includes a technology that would result in air emissions.
Air Pollution Control	Permtting Conditions for air pollution control	N.J.A.C. 7:27-11 and 17	Controls and prohibits air pollution, particle emissions, and toxic VOC emissions.	Potential ARAR if remedial action includes a technology that would result in air emissions.

Appendix B
Potential Action-Specific Applicable or Relevant and Appropiate Requirements
PVGCS Feasibility Study

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Operating Standards for Hazardous Waste Incinerators	Incineration Requirements	N.J.A.C. 7:26-10	Specifies maximum air contaminant emissions rates, testing requirements, and minimum design standards.	Potential ARAR if remedial alternative includes incineration.
Interim Standards for Hazardous Waste Incinerators.	Incineration Requirements	N.J.A.C. 7:26-11	Specifies maximum air containment emission rates, testing requirement, and minimum design standards during interim status.	Potential ARAR if remedial alternative includes incineration.
Incinerator Permit Regulations	Incinerator Permitting	N.J.A.C. 7:26-12	Delineates the information needs to be submitted in Part A and B of the permit application.	Potential ARAR if remedial alternative includes incineration.
Federal Clean Air Act	Standards of Performance for New Stationary Sources	40 CFR 60	Provides emissions requirements for new stationary sources.	ARAR.
Federal Clean Air Act	National Emission Standards for Hazardous Air Pollutants	40 CFR 61	Provides emission standards for 8 contaminants including benzene and vinyl chloride. Identifies 25 additional contaminants, as having serious health effects but does not provide emission standards for these contaminants.	ARAR.
State of New Jersey Statutes and Rules	Standards for Hazardous Air Pollutants	N.J.A.C. 7:27 Air Pollution Control	Rule that governs the emitting of, and such activities that result in, the introduction of contaminants into the ambient atmosphere.	ARAR.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA for a site in Manville, New Jersey (June 2003).

Appendix B
Potential Location-Specific Applicable or Relevant and Appropiate Requirements
PVGCS Feasibility Study

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Executive Order Floodplain Management	Floodplain Management	Exec. Order No. 11988 40 CFR 2 6:302(b) and Appendix A	Requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the maximum extent possible, the adverse impacts associated with direct and indirect development of a floodplain.	Potential ARAR if remedial activities take place in or near a 100-year or 500-year floodplain.
Federal Flood Plains Regulatory Requirements	Regulatory Requirements	(RCRA Location Standards (40 CFR 264.18)	This regulation outlines the requirements for constructing a RCRA facility on a 100-year flood plain.	Potential ARAR if remedial alternatives include construction in or near a 100-year floodplain.
National Wildlife System	Protects national wildlife	16 U.S.C. 668 50 CFR 27	Restricts activities within a National Wildlife Refuge.	Potential ARAR if site is on or adjacent to a wildlife refuge.
Wild and Scenic Rivers Act	Prohibits adverse effects on scenic rivers.	16 U.S.C. 1274 40 CFR 6:302	Prohibits adverse effects on scenic rivers.	Potential ARAR for remedial alternatives which may impact rivers.
Clean Water Act	Prohibits discharge of dredged or fill material into wetlands	33 U.S.C. 1251 Section 404, 40 CFR 230, 231	Prohibits discharge of dredged or fill material into wetlands without a permit. Preserves and enhances wetlands.	Potential ARAR for remedial alternatives which involve disturbance to wetlands.
Endangered Species Act	Protects endangered species	16 U.S.C. 1531	Restricts activities where endangered species may be present.	Potential ARAR if endangered species are observed at the site during ecological site assessments.
Policy Floodplains/Wetlands Assessment	Floodplain assessment	EPA 1985 Statement	Provides federal policy for the assessment of floodplains and wetlands	Potential ARAR for remedial alternatives that affect wetlands and floordplains.
Farmland Protection Policy Act (FPPA) of 1980 and 1995	Protects farmland from nonagricultural uses	7 U.S.C. 4201 et seq	Instructs the Department of Agriculture, in cooperation with other agencies and other units of the Federal government, to develop criteria for identifying the effects of Federal programs on the conversion of farmland to nonagricultural uses. It does not provide a basis for any action.	Potential ARAR for remedial alternatives that affect farmlands within the site.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA for a site in Manville, New Jersey (June 2003).

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
National Historic Preservation Act	Protects historic places	16 U.S.C. 470	Requires federal agencies to take into account the effect of any federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or is eligible for inclusion in the National Register of Historic Places.	ARAR since source areas are included or eligible for inclusion in the National Register of Historic Places.
U.S. Army Corps of Engineers Nationwide Permit Program	Army Corp. of Engineers Permit Program	33 CFR 330	Prohibits activity that adversely affects a wetland if a practical alternative that has less effect is available.	Potential ARAR for remedial alternatives which have the potential to affect wetlands.
Historic Sites, Buildings and Antiquities Act	Protects national landmarks	16 U.S.C. ss 461-457	Requires federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Potential ARAR if source areas are included on the National Registry of Natural Landmarks.
Rivers and Harbors Act of 1899	Army Corp. of Engineers Permit Program	33 CFR 320-330	Establishes a COE permit program for dams, dikes, dredging, and other construction in navigable waters of the U.S.	Potential ARAR if remedial actions occur on Federal Property.
Executive Order Protecting Wetlands	Protection of Wetlands	Executive Order No. 11990	Requires Federal agencies to minimize the destruction, loss, or degradation of all wetlands affected by Federal activities.	Potential ARAR for remedial alternatives which have the potential to affect wetlands.
Fish and Wildlife Coordination Act	Requires approval for modification of water body	16 U.S.C. 661 40 CFR 2 6:302(g)	Requires consultation with the U.S. Fish and Wildlife Services when a Federal department or agency proposes or authorizes any modification of any stream or other water body, and adequate provision for protection of fish and wildlife resources.	Potential ARAR since any disturbance and restoration or replacement of wetlands must be coordinated with the Fish and Wildlife Service.
National Ambient Air Quality Standards (NAAQS)	Air Quality Standards	40 CFR 50	Establishes non-attainment zones with respect to health-based criteria.	Potential ARAR for remedial activities which emit restricted contaminants into the atmosphere.
Federal Endangered and Non-Game Species Act	Protection of threatened and endangered species	N.J.S.A. 23:2A-1	Standards for the protection of threatened and endangered species.	Not an ARAR because no listed species identified at the site.
Flood Hazard Area Regulations	Protection of floodplains	N.J.A.C. 7:13	Protects floodplains through permitting requirements for construction and development activities	Potential ARAR if remedial activities are located in or near a 100- or 500-year floodplain.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA for a site in Manville, New Jersey (June 2003).

Appendix B
Potential Location-Specific Applicable or Relevant and Appropiate Requirements
PVGCS Feasibility Study

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Flood Hazard Area Control Act	Delineates flood hazard areas	N.J.S.A. 58: 16A-50	Delineates flood hazard areas and regulates use.	Potential ARAR if remedial activities are in or near a 100- or 500-year floodplain.
Wetland Act of 1970	Establishes wetland regulated activities	N.J.S.A. 13:9A-1 et.seq.	Establishes listing and permitting requirements for regulated activities	Potential ARAR. Establishes listing and permitting requirements for regulated activities
Freshwater Wetlands Protection Act	Establishes freshwater wetlands regulated activities	N.J.S.A. 13:9B	Establishes listings and permitting requirements for regulated activities in state freshwater wetlands	Potential ARAR. Establishes listings and permitting requirements for regulated activities in state freshwater wetlands
Open Lands Management	Considers recreational projects during remediation	N.J.A.C. 7:2-12.1 et.seq.	Considers impact of remedial actions on recreational projects funded by Open Lands Management Grants.	Potential ARAR for remedial actions on recreational projects funded by Open Lands Management Grants.
Natural Areas System	Protects natural area sites	N.J.A.C. 7:2-11	Protects natural area sites listed under the Natural Areas Register.	Potential ARAR if remedial actions occur on natural area sites listed under the Natural Areas Register.
State Trails System	Protects state trails	N.J.S.A. 13:8-30 et. seq.	Requires that use of trail does not interfere with nature; maintains natural and scenic qualities.	Potential ARAR. Requires that use of trail does not interfere with nature; maintains natural and scenic qualities.
New Jersey Wild and Scenic Rivers System	Protects Scenic River systems	N.J.S.A. 13:8-45 et. seq.	Governs component river area, flood hazard area, or part of state park, wildlife refuge or similar area.	Potential ARAR. Governs component river area, flood hazard area, or part of state park, wildlife refuge or similar area.
New Jersey Threatened Plant Species	Lists threatened plant species.	New Jersey's Threatened Plan Species	Lists threatened plant species.	Potential ARAR if remedial actions impact threatened plant species.
Endangered Plant/Animal Species Habitats	Lists threatened habitats where endangered species occur.	New Jersey's Endangered Species Act	Lists threatened habitats where endangered species occur.	Potential ARAR. Lists threatened habitats where endangered species occur.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA for a site in Manville, New Jersey (June 2003).

Appendix C
Source Area Capture Zone Modeling

Conceptual Design of Groundwater Extraction and Re-injection Systems, OU1 Study Area

Introduction

The purpose of this appendix is to describe the mathematical modeling of groundwater flow to simulate the capture of the trichloroethylene (TCE) and tetrachloroethylene (PCE) plumes by extraction wells in the Carbonate Aquifer at the Operable Unit 1 (OU1) Study Area within the Pohatcong Valley Groundwater Contamination Site (PVGCS). Mathematical modeling was used to determine the number and placement of pumping and injection wells required to intercept and remove groundwater contamination from the regional carbonate aquifer for four discreet pumping/injection alternatives (Groundwater Alternatives G4 and G5[1]) included in the PVGCS OU1 Feasibility Study. Each alternative considered re-injection of extracted water to prevent excessive withdrawals from the Carbonate Aquifer and to better control the size of the catchment area. The time of remediation for reducing the concentrations of TCE and PCE to below PRGs was estimated for several of the pumping and injection modeling runs.

Modeling simulations were performed separately for the TCE and PCE plumes. Each plume appears to be a discrete unit that is influenced by unique hydraulic and geochemical conditions. Analyses involved delineating the capture zone for each pumping well, and where possible, injection fronts for each injection well. To maintain conservative conditions throughout the simulations, analyses were based on the simulation of advective groundwater flow. For the purposes of the modeling, groundwater Alternatives 4A and 5A (GW2) apply to the TCE plume while Alternatives 4B and 5B (GW3) apply to the PCE plume.

Groundwater Extraction Alternatives

Two distinct modeling scenarios were simulated each in Groundwater Alternatives G4 (GW2) and G5 (GW3). Groundwater Alternative G4A - Source Treatment (500 µg/L isopleth) of the TCE plume involved removing the greatest contaminant mass in the TCE plume marked by the approximate 500 microgram per liter (µg/L) concentration isopleth (Figure C-1). Extraction and injection wells were tested in the immediate area of the Vikon Tile Company (VTC) and American National Can (ANC) properties. Equipotentials in this area of the model grid are relatively straight with little deflection. Thus, resulting capture zones are well defined and develop without requiring an excessive number of wells, and/or unreasonably elevated pumping rates. Ambient pumping and injection occurs at the ANC property, however, pumping and extraction rates are low, and do not appear to influence the local ambient hydraulic gradient.

[1] Note that the designation of Groundwater Alternatives are prior to initial screening. Groundwater Alternative G4 was renamed GW2 and Groundwater Alternative G5 was renamed GW3 after initial screening.

In Groundwater Alternative G4B - Source Treatment of the PCE Plume at LNL, a relatively low capacity extraction well was tested at the L&L/Econowash Dry Cleaners (LNL) site to intercept the relatively narrow portion of the PCE plume marked by the 25 µg/L isopleth (Figure C-2). The location of this well was chosen based on the elevated concentrations of PCE (at 1,500 µg/L) within a groundwater grab sample at the LNL PSA. Gradients in this portion of the OU1 Study Area are relatively complex, influenced by recharge across the southern boundary of the Valley, converging flow paths toward the center of the Shabbecong Valley and pumping at the Vannatta Street municipal well.

Groundwater Alternative 5A - Capture of the TCE Plume to the 1 µg/L Isopleth ANC area, involves capturing the TCE plume to the 1 µg/L isopleth in the area immediately downgradient of ANC (Figure C-1). Interception of the full width of the TCE plume prevents further migration to the Dale Avenue municipal well, and other downgradient receptors. Injection wells installed upgradient of the TCE plume help direct flow toward the extraction wells.

Groundwater Alternative 5B - Every extraction alternative includes injection wells to recharge all water withdrawn from the carbonate aquifer. Conceptually, disposal of treatment effluent back into carbonate aquifer precludes dumping treated water to local surface water bodies. Withdrawal from the aquifer is conserved, helping to support water levels in the unit. Injection of treated water enhances the hydraulic gradient toward the pumping well(s) increasing flow velocities to the well(s). Moreover, flushing aquifer pores with uncontaminated water should also enhance the diffusion based recovery efficiency of the pumping system. In Groundwater Alternative 5B injection wells are used to form a hydraulic barrier between the extraction well system and the Vannatta Street municipal well.

Capture Zone Analysis

The capture zone or catchment area of a well is the area over which a pumping well obtains groundwater over a specified period of time. The size of a capture zone for a single well, or well gallery depends on aquifer porosity, thickness, hydraulic conductivity, simulation, time, and anisotropy of the aquifer. Capture zone geometry is controlled by the magnitude and uniformity of the local hydraulic gradient. Deflections in potentiometric lines caused by the heterogeneities in the hydrologic system can influence the geometry and orientation of a capture zone or injection front.

Similar to a capture zone, an injection front is the area over which an injection well recharges water to the aquifer over a specified period of time. As flowpaths do not terminate at the injection well, an injection front is more difficult to define than a capture zone. Forward tracked particle paths are released at the injection well for a specific time of travel. Subsequently, the front is defined by connecting the ends of time-equivalent pathlines emanating from the injection well.

To mathematically simulate the interception of contaminants in the groundwater of the regional carbonate aquifer, CH2M HILL applied an analytical groundwater flow model, CAPZONE (Bair, et Al, 1992) coupled with a semi-analytical particle tracking code called GWPATH (Schaeffer, 1992). Both the flow and particle tracking codes are based on the

assumption of flow in a homogeneous and isotropic aquifer of infinite extent. GWPATH, however, also contains an algorithm that accommodates simulating flow in an anisotropic aquifer. CAPZONE/GWPATH simulations were also presented in the PVGCS OU1 Remedial Investigation (RI) Report. During development of the model for the RI report CAPZONE simulations were calibrated against actual measured hydraulic heads. In addition, the calibrated solution was verified with transient hydraulic data from long-term aquifer tests at production wells within the OU1 Study Area. The calibrated solution underwent sensitivity analysis to help quantify hydraulic parameters that most influence the model solution. A description of model calibration, verification and a sensitivity analysis is presented in Section 4 of the RI Report.

CAPZONE Modeling

Although the mathematical model is described in the RI Report, for the convenience of the reader a brief description of model set-up is presented here. CAPZONE is an analytical flow model that can be used to simulate two-dimensional flow systems characterized by isotropic and homogeneous, confined, leaky-confined, or unconfined flow conditions. CAPZONE computes drawdowns at the intersections of a uniformly spaced, rectangular grid, produced by up to 100 recharge or pumping wells using either the Theis equation (1935), or the Hantush and Jacob (1955) equation for a leaky confined aquifer. Unconfined flow is simulated using the Theis equation with a correction factor developed by Jacob (1940). Evaluating unconfined flow in this manner is appropriate as long as flow is generally horizontal, and drawdowns are less than 25 percent of the saturated aquifer thickness. Simple boundary conditions (recharge, surface water, negative) are simulated by applying image well theory.

Drawdowns computed by CAPZONE can then be subtracted from water levels that can form either a uniform or a non uniform hydraulic gradient. The ambient gradient can be either suspected or represent an observed water level distribution. The non uniform option is particularly useful for capture zone analysis in the Carbonate Aquifer as the gradients and groundwater flow directions vary widely across the forked valley system that encompasses the OU1 Study Area. Gradients are unique in the two forks of the Valley and complex at the junction of the Pohatcong and Shabbecong Creeks (Figure C-3).

Limitations

With the non-uniform gradient option, CAPZONE represents an intermediate technology between sophisticated, numerical methods and simpler analytical codes. Based on two-dimensional, well hydraulics equations, the model has limited application to three dimensional or heterogeneous flow systems with complex internal boundary conditions or significant vertical flow between units. Although a significant data base of hydrogeologic information was developed during the RI, a large number of simplifying assumptions would still have to be formulated to construct a numerical model for the site. With a large number of input assumptions, the accuracy of a numerical model is degraded, and its capabilities become similar to an analytical model.

Drawdown/drawup induced by pumping and injection wells, respectively, were simulated using a potentiometric surface developed from a synoptic survey collected at site monitoring wells in May 2002. Therefore, drawdowns do not incorporate the influence of

non-uniform water level distribution. Thus, the water level distribution computed by subtracting the well drawdowns from the observed water levels differs from drawdowns that considered non-uniform water levels as an initial condition. These differences cause some uncertainty in the flow rate and capture zone (and injection front) of the pumping well. Variability in such parameters as hydraulic conductivity and aquifer thickness add to this uncertainty. Consequently, modeling results represent a rough approximation of the actual conditions at the site.

Application

To apply CAPZONE, the boundaries of the simulated area are defined, and then the area is divided into a grid. For the PVGCS site, the grid contains 75 columns and 70 rows (Figure C-4) with an individual square node spacing of 200 ft. Thus, the overall grid size was 15,000 ft by 14,000 ft. This same grid size and orientation was applied to simulations for both the TCE and PCE plumes.

Carbonate Aquifer The regional carbonate aquifer was simulated as a single unconfined aquifer unit with a saturated thickness of 200 ft. The assumption for aquifer thickness is based on the thickness of aquifer influenced by elevated concentrations of TCE or PCE in the presumed source areas. Calibrated hydraulic characteristics include a transmissivity of 50,000 gpd/ft and a storage coefficient of 0.09 (Table C-1). These values are within the range of parameters estimated from the results of aquifer tests at the Dale Avenue and Vannatta Street municipal wells.

TABLE C-1
Aquifer Model Input Parameters at PVGCS: CAPZONE/GWPATH Simulations

Parameter	units	Carbonate Aquifer
Transmissivity	gpd/ft	50,000
Hydraulic Conductivity	ft/day	33
Porosity	fraction	0.15
Storage Coefficient		0.09
Saturated thickness	ft	200
Non-uniform gradient		yes
Rows		75
Columns		70
Spacing	ft	200

The observed potentiometric surface used for CAPZONE simulations was selected from the May 2002 synoptic measurement episode (Figure C-3). The synoptic episode included all the existing monitoring wells installed at the site, which provided a sufficient number of data points for contouring purposes. The potentiometric surface was digitized using SURFER and imported into CAPZONE for superposition of the resultant drawdown from CAPZONE output.

GWPATH Modeling

Computed heads from CAPZONE were used as input for GWPATH to assess forward tracked flowpaths and time-related, capture zones of the wells. GWPATH is a computer-based program for estimating horizontal or vertical fluid pathlines and travel times in saturated, complex groundwater environments. In addition to forward or reverse tracking of pathlines, GWPATH will compute contributing areas to pumping wells. GWPATH is a post processor to groundwater flow models (analytical or numerical) that produces a hydraulic head field over a rectangular grid.

Groundwater pathline diagrams were developed by distributing forward tracked particles across the model grid. These particles move with the gradient for the duration of the period assigned by the modeler, or can end at sinks such as wells. A period of 10 years was selected for the forward tracking of particles based on the size of the OU1 Study Area grid and the estimated time required for all particles to exit the grid or be intercepted at sinks. For the four PVGCS groundwater alternatives involving groundwater extraction, forward tracked particles were evenly distributed across discreet areas of the model grid involving the areas of focus. A denser spacing of particles was utilized closer to the pumping and injection wells to better delineate capture-zone/injection-front geometry for individual wells and locate downgradient stagnation points. Forward tracked pathlines were used to estimate trajectories and advective travel times of particles strategically positioned in the model domain. Capture zones for wells were estimated by separating particle pathlines that terminated at the well from pathlines that continue downgradient.

Modeling Results

Alternative G4A Source Treatment (500 µg/L isopleth) of the TCE Plume. Three extraction wells pumping at 200,000 gallons per day (gpd), or approximately 140 gpm each (Table C-2), are required to capture the length of the 500 µg/L isopleth of the TCE plume (Figure C-5). Extraction wells are closely spaced at approximately 200 feet apart each on the Vikon Tile Company (VTC) property, at the 500 µg/L isopleth of the TCE plume. The capture zone formed by the extraction wells is 1,700 ft across at its widest point in the upgradient direction. One of the wells, in addition to enhancing the upgradient portion of the capture zone, draws some water from downgradient areas.

A gallery of four injection wells was installed upgradient of the contaminant plume and within the boundary of the composite capture zone (Figure C-5). Each of the four injection wells operating at 105 gpm is intended to recharge the carbonate aquifer at rate of 150,000 gpd. Installation of the injection wells in the catchment area enhances the interception of flow from upgradient portions of the plume by the extraction wells and should shorten the time required for remediation. However, with the increase in gradient toward the pumping wells, the wells are satisfied by flow from upgradient areas, narrowing the capture zones and causing downgradient stagnation points for the gallery to migrate upgradient toward the wells.

TABLE C-2
Summary of Extraction and Injection Wells In Groundwater Extraction Alternatives

Alternative Number	Alternative Description	Number of Extraction Wells	Extraction Rate (gpm) each well	Number of Injection Wells	Injection Rate (gpm) each well
G4A	Source Treatment of TCE Plume	3	140	4	105
G4B	Source Treatment of PCE Plume	1	100	1	100
G5A	Capture of the TCE Plume	5	280	8	175
G5B	Capture of the PCE Plume	2	210	4	105

Groundwater Alternative G4B: Source Treatment of PCE Plume at LNL. An extraction/ injection well pair was tested at 100 gpm each to capture an approximately 100 foot wide area at the LNL site (Table C-2). The containment area is situated across the greatest mass of contamination in the PCE plume marked by the 25 µg/L isopleth (Figure C-2). The intention of Groundwater Alternative G4B was to reduce contaminant mass in the carbonate aquifer at LNL without concern whether contaminants migrating across the site were completely intercepted.

The pumping rate for the extraction well was not sufficient to generate a recognizable capture zone at the LNL site. Hydraulic gradients in this area are elevated (0.03 ft/ft) and local equipotentials are influenced by converging flowpaths toward the centerline of the Shabbecong Valley and pumping at the Vannatta Street municipal well. In addition, the internodal spacing of the model grid (200 ft) may be too coarse for reliable evaluation of this small of an area. Since a discrete capture zone was not developed, no time of remediation can be estimated for Groundwater Alternative G4B.

Groundwater Alternative G5A: Capture of the TCE Plume to the 100 µg/L Isopleth ANC Area. Groundwater Alternative 5A involves interception of the entire width of the TCE plume to the estimated 100 µg/L isopleth immediately downgradient of American National Can (ANC). The extraction system is intended to prevent TCE from migrating down the Valley toward the Dale Avenue municipal well or to the south toward the Vannatta Street municipal well. Five extraction wells pumping at 400,000 gpd (280 gpm) each are required to form a capture zone approximately 6,300 ft across to intercept the width of the TCE plume (Figure C-6). Extraction wells were located in staggered positions to enhance the overall width of the containment area. Similar to Alternative G5A, one extraction well in addition to enhancing the composite capture zone of the five wells, intercepts some of its flow from areas downgradient of the containment area.

To recharge treated effluent to the regional carbonate aquifer, enhance hydraulic gradients toward the pumping wells, and flush contaminants through the aquifer, eight injection wells, operating at 175 gpm each, were placed upgradient of the 100 µg/L isopleth of the TCE plume in the catchment area of the extraction wells. Injection wells are intended to recharge the carbonate aquifer at a rate of 250,000 gpd, each. Hydraulic gradients in this area of model domain are relatively elevated, so injection fronts for the injection wells are not well defined.

Groundwater Alternative G5B Capture of the PCE Plume. Groundwater Alternative 5B involves capturing the PCE plume to the 25 µg/L isopleth originating in the area of the LNL site to prevent further contamination to the Vannatta Street municipal well. Because of the elevated gradients, pumping from the Vannatta Street municipal well and the close proximity to the center of the Valley, flow paths in this area are relatively complex. Furthermore, the Vannatta Street municipal well lies slightly up- and cross-gradient to the LNL site.

Given the complexity of the flow regime, significant pumping rates are required to generate a recognizable capture zone at the LNL site. Two closely spaced extraction wells pumping at 300,000 gpd (210 gpm) each are required to generate a capture zone that prevents flow toward the Vannatta Street municipal well. The extraction wells generated a capture zone 2,000 feet wide that impinges on the downgradient area of the capture zone for the Vannatta Street municipal well (Figure C-7). The width of the capture zone for the two wells is sufficient to intercept the PCE plume to the 25 µg/L isopleth. Four injection wells recharging the Carbonate Aquifer are positioned around the extraction wells and adjacent to the Vannatta Street municipal well to create a hydraulic barrier to PCE migration.

Time of Remediation

The intent of this section is to estimate the time required to reduce concentrations within the TCE and PCE plumes from their most recent elevated concentrations to below the New Jersey Groundwater Quality Standards (GWQS) of 1.0 µg/L (1 ppb). These estimates of remediation time assume that a significant source in the vadose zone or a dense non aqueous phase liquid (DNAPL) is absent. DNAPL was not encountered in soil and the results of the groundwater samples do not indicate its presence. Concentrations of constituents in groundwater are significantly less than the one percent of the solubility limit typically associated with the potential presence of DNAPL.

Applied Model

Given the limitations presented by site contaminants and hydrologic conditions, approximate remediation times were calculated for the pumping/injection system in the regional carbonate aquifer using the Mixed-Reactor approach (Zheng et al., 1991). This approach assumes that constituent concentrations are removed by flushing the aquifer system with uncontaminated water that mixes completely with the contaminated water as it migrates through the aquifer. This approach considers both the natural retardation of TCE and PCE and an asymptotic (i.e., logarithmic) removal curve. The analytical solution for estimating the pore volume exchanges using the mixed reactor approach is:

$$PV = -R \ln\left(\frac{Ct}{Co}\right)$$

where:

PV = the number of pore volumes

R = the retardation factor

Co = the initial groundwater contamination concentration

Ct = the groundwater contaminant cleanup target concentration

The retardation factor, R, is defined as:

$$R = 1 + Kd \left(\frac{P}{n} \right)$$

where:

P = the bulk density of the bedrock

n = the porosity of the bedrock

Kd = the distribution partition coefficient of the bedrock

The water partition coefficient, Kd, is defined as the organic carbon partition coefficient (Koc) multiplied by the fraction of organic carbon (foc) in the aquifer matrix.

Site-specific input parameters for the Carbonate Aquifer that were used in the determination of the remediation times are presented in Table C-3. The basis and assumptions for these input parameters are discussed below.

TABLE C-3
Site-Specific Input Parameters for Remediation Time Analyses
PVGCS

Parameter	Units	Alternative 4A	Alternative 5A	Alternative 5B
Pore volume (PV) within the contiguous plume bound by the capture zone	MG	2,360	34,800	7,270
Area of plume in capture zone	ft^2	935,000	13,722,000	3,434,300
Initial contaminant concentration TCE (Co)	µg/L	2,100	2,100	NA
Initial contaminant concentration PCE (Co)	µg/L	NA	NA	54
Remedial target concentration TCE (Ct)	µg/L	1	1	NA
Remedial target concentration PCE (Ct)	µg/L	NA	NA	1
Retardation factor TCE (Rf)	Dimensionless	1.47	1.47	NA
Retardation factor PCE (Rf)	Dimensionless	NA	NA	2.37
Bulk density of aquifer sediments (P)	$\mu g/cm^3$	2.25	2.25	2.25
Porosity		0.15	0.15	0.15
Distribution coefficient TCE (Kd)	mL/g	0.0315	0.0315	NA
Distribution coefficient PCE (Kd)	mL/g	NA	NA	0.091
Organic carbon partition coefficient TCE (Koc)	mL/g	126	126	NA
Organic carbon partition coefficient PCE (Koc)	mL/g	NA	NA	364
Fraction of organic carbon (foc)	g/g	0.00025	0.00025	0.00025

Pore Volumes—Carbonate Aquifer

Selected pores volumes for Alternatives G4A, G5A, and G5B were based on the area of the TCE or PCE plume contained within the capture zone, multiplied by the thickness of aquifer affected by contamination (200 ft), and the porosity (15 percent) of the regional carbonate aquifer. In Groundwater Alternative 4A, one equivalent pore volume of the aquifer considering an area of 935,000 square feet (ft^2), thickness of 200 feet, and porosity of 15 percent is 209.8 million gallons (MG) in the area containing the 500 µg/L TCE isopleth. One pore volume for Alternative 5A contains the area (13,722,000 ft^2) inside the 1.0 µg/L isopleth of the TCE plume, and is the largest under consideration at 34,800 MG. The estimated pore volume for the northern end of the PCE plume (3,434,300 ft^2) near the Vannatta Street municipal well in Groundwater Alternative 5B is 7,270 MG.

Initial groundwater TCE and PCE Concentrations—Regional Carbonate Aquifer

The initial groundwater TCE concentration for the carbonate aquifer in Groundwater Alternatives G4A and G5A was selected from the highest concentration from the most recent round of sampling (2002). The highest TCE concentration was 2,100 µg/L, at Vikon

Tile Company (VTC) monitoring well (PVVTC). The greatest PCE concentration (54 µg/L) for Groundwater Alternative 5B occurred at the Vannatta Street municipal well.

The NJ GWQS for groundwater (1.0 µg/L) was used as the Groundwater Preliminary Remedial Goal (PRG) for both TCE and PCE. The PRG would be the maximum permissible concentration of TCE and PCE in water that is delivered to users through a public water supply system.

Modeling Results

Pore volumes required to reduce TCE concentrations in the central portion of the plume (500 µg/L) from 2,100 to 1.0 µg /L in Groundwater Alternative G4A were approximately 11.2. To estimate the time of remediation using the batch reactor method, the number of pore volumes multiplied by volume of water in a single pore volume is divided by the total continuous pumping rate for the extraction well system. Thus in Groundwater Alternative G4A, given a continuous total pumpage for the three extraction wells of 420 gpm, the time required to remove this volume of water from the carbonate aquifer exceeds 11 years (Table C-4). In Groundwater Alternative G5A, the same number of pore volumes (11.3) are required to attain a TCE concentration of 1.0 µg /L, however the time of remediation is 47 years because of the significantly larger volume of water required for removal. In Groundwater Alternative G5B, 9.4 pore volumes of a portion of the PCE plume must be removed to reduce concentrations from 54 µg /L to 1.0 µg /L, which requires 33 years of continuous pumping.

Remediation times assume continuous pumping at the simulated extraction rates at all the wells in the extraction well galleries. If the extraction well systems are shut down for periods of maintenance or used in a pulsed-pumping scheme, the times of remediation can increase significantly.

TABLE C-4
Required Number of Pore Volumes and Time of Remediation
PVGCS Feasibility Study

Alternative	Constituent	Required Number of Pore Volumes	Time of Remediation (years)
4A (GW2 for TCE)	TCE	11.2	11
5A (GW3 for TCE)	TCE	11.3	47
5B (GW3 for PCE)	PCE	9.4	33

Remediation of groundwater using pump and treat technology has been associated with relatively extended (30 plus years) periods of remedial operations. Calculations based on conditions within the OU1 Study Area estimate shorter periods of remediation to reduce constituent concentrations below the New Jersey GWQS for Alternative G4A. A number of factors contribute to a mathematical solution that infers relatively rapid remediation. These factors include: relatively low initial concentrations for both TCE and PCE; remediation of only plume fragments, and therefore small pore volumes; and the relatively high

transmissivity of the Carbonate Aquifer; which accommodates relatively high pumping and injection rates.

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Appendix D
Attenuation of Plume Residuals

NAS - Natural Attenuation Model Data

Introduction

This appendix presents the results of the evaluation of the time of remediation (TOR) for the groundwater remedial alternatives for the PVGCS OU1 Study Area TCE and PCE plumes. This evaluation is for the portions of the plumes outside of the active remediation capture zones.

The primary tool used for estimating time for remediation is the Natural Attenuation Software (NAS) developed by the Naval Facilities Engineering Command - Southern Division, Virginia Tech, and USGS. Software can be downloaded from the URL http://www.cee.vt.edu/nas/. The *Natural Attenuation Software User's Guide* provides information on how to set up and use the software (Brauner et al, 2001) and the article *Methodology for Estimating Times of Remediation Associated with Monitored Natural Attenuation* (Chapelle, et al., 2003) provides the background documentation of the approach and equations used in the natural attenuation calculations.

Modeling

The NAS is used to estimate the TOR under the basic assumption that the current groundwater contaminant plume is at steady state conditions. This is believed to be the case for the TCE and PCE plumes as discussed in the PVGCS Remedial Investigation Report. It is based on many simplifying assumptions and is intended as a tool to assist in making TOR estimates.

NAS uses an analytical solution that incorporates the groundwater velocity, contaminant retardation, dispersion and an estimated decay rate to calculate the TOR. The decay rate is based on the steady state assumption and user input concentration data along the centerline of the plume. The decay rate calculated by the model represents the decline in user input groundwater concentrations over distance from the source area and assuming model-specified dispersion coefficients. Although the actual biological degradation rate is believed to be minimal because of the oxic conditions present in the plume (TCE and PCE degrade only very slowly under oxic conditions), the decay rate used by the model does not introduce significant error because it is counterbalanced by a lower-model assumed dispersivity. In essence, the model assigned decay rate represents the actual observed decay but assigns more of the decline in concentrations to biological decay than to dispersivity. Other limitations to the NAS model are that it assumes simple groundwater flow conditions; it is highly sensitive to estimates of the retardation coefficient of the chlorinated VOCs, it only approximates complex processes that occur in the field; and it assumes steady state conditions.

The TOR estimates should be viewed as general order-of-magnitude estimates that are useful for comparing alternatives, but should not be viewed as definitive estimates of the

actual time to achieve drinking water MCLs. Often a tailing effect happens as a result of slow diffusion out of low permeability zones. As a result, actual times to achieve MCLs may be longer than those estimated here.

Model Input Assumptions

The initial input parameters are presented in Table D-1. Natural attenuation data was also input into the model although the model only uses the data to interpret redox conditions of various portions of the plume. The data is not used in estimating decay rates.

TABLE D-1
NAS Input Parameters
PVGCS Feasibility Study

Input	Value	Source
Hydraulic Conductivity (K)	33 ft/day	Permeability used in the groundwater flow model.
Hydraulic Gradient	0.0067 ft/ft	Overall gradient in plume.
Porosity	0.15	Value used in groundwater flow model.
Fraction Organic Carbon	0.00025	Estimated based on travel distance of plume over 50 years elapsed since potential TCE source release.
Retardation Factor (Rf)		Calculated using Koc x fraction of organic carbon (foc);
PCE	2.37	PCE Koc = 364 L/Kg;
TCE	1.47	TCE Koc = 126 L/Kg.
Longitudinal Dispersivity	72.5	Assigned by model based on plume length.
Source Width		Estimated based on Groundwater RI data.
PCE Plume	50 ft	
TCE Plume	300 ft	

An important model assumption is that further mass flux from soil to groundwater is not occurring following site remediation. This is because without control of additional leaching of chlorinated VOCs from soil to groundwater, the mass flux may continue unabated for decades. If this occurs, groundwater concentrations would not begin declining until the source is removed or the mass flux controlled.

Modeling Procedure and Results

Each of the groundwater remedial alternatives was modeled. The most upgradient portion of the plume not captured by the groundwater extraction system of the alternative was modeled as the source area. The TOR is based on meeting the New Jersey Groundwater Water Quality Standard of 1 µg/L for PCE and TCE. NAS was used to estimate the TOR for various locations along the plume centerline. NAS calculates the TOR for a selected point along the plume centerline assuming the mass flux from the source area has either been

eliminated or reduced to a concentration such that the target concentration (in our case, 1 µg/L) is met at the specified location. Various distances along the plume centerline are input until the highest TOR value is found. This location then is the point at which the TOR is chosen as representative of the alternative.

Table D-2 summarizes the remedial alternatives evaluated, the distances along the plume centerline resulting in the highest TOR, and the resulting TORs. Details of input parameters and results for each run are presented in Attachment 1.

Groundwater Alternative G2 MNA[1]

Groundwater Alternative G2 - MNA includes groundwater monitoring of natural attenuation but does not include any groundwater remediation.

The initial model run was for the portion of the plume downgradient of the Dale Avenue municipal well, located about 5,500 feet downgradient of the source. Monitoring well PVVTC15 (at the Vikon Tile Company site) is used as the source location with a concentration of 2,100 µg/L TCE. See Attachment 1 for additional centerline plume concentrations input.

Multiple distances along the plume centerline were input and TORs were calculated for each. The highest TOR value was chosen as the TOR representative of the G2 MNA alternative. The corresponding distance from the source was 23,000 feet, which is the location of the downgradient OU1 Study Area. The TOR is 59 years for this location.

A second model run was for the TOR at the Dale Avenue municipal well. The TOR is 14 years for this location.

Groundwater Alternatives G3- In Situ Source Treatment and MNA and G4- Source Treatment and MNA[2]

Both Alternatives G3 and G4 (GW2) address the same area of the TCE plume, the portion with concentrations exceeding approximately 500 µg/L. Following remediation, only TCE at concentrations less than approximately 500 µg/L will remain. This is the portion of the TCE plume modeled with NAS for TOR. As a result, both of these alternatives will have the same TOR for the untreated downgradient portion of the plume.

The source location was assumed to be at the downgradient edge of the current 500 µg/L contour, or about 1,600 feet downgradient of monitoring well PVVTC15 (at the Vikon Tile Company site), the source location of Groundwater Alternative G2. The source concentration was set at 500 µg/L. Multiple distances along the plume centerline were input and TORs were calculated for each. The highest TOR value was 55 years and it also occurred at the downgradient end of the OU1 Study Area, a distance of 21,400 feet from the most upgradient portion of the plume following source remediation. (file PVGCS G3a-1ugl.nas).

[1] Note that Groundwater Alternative G2 was not retained for detailed evaluation after initial screening.

[2] Note that Groundwater Alternative G3 was not retained for detailed evaluation after initial screening and that Groundwater Alternative G4 was renamed GW2.

A second model run was for the TOR at the Dale Avenue municipal well. The TOR is 10 years for this location.

Groundwater Alternative G5- Expanded Source Treatment and MNA[3]

TCE Plume

Under Groundwater Alternative G5 (GW3) the groundwater collection system captures the entire TCE plume and PCE plume to the 1 µg/L contour near the sources. For the TCE plume the capture zone downgradient of American National Can (ANC) encompasses TCE exceeding 100 µg/L.

The source containment capture zone corresponds to the monitoring well PVFCC12, located 5,500 feet downgradient, near the Dale Avenue municipal well. This well had a TCE concentration of 95 µg/L. This location was set as the most upgradient location with a concentration of 95 µg/L.

Multiple distances along the plume centerline were input to NAS and TORs were calculated for each. The highest TOR value was 45 years and it occurred at the downgradient end of the OU1 Study Area, a distance of 17,500 feet from the source containment capture zone boundary.

A second model run for the TCE plume was not run for the Dale Avenue municipal well because the groundwater collection system capture zone is in close proximity to the well.

PCE Plume

Under Groundwater Alternative G5 (GW3) the groundwater collection system also captures the PCE plume to the 1 µg/L contour near the most likely sources, the L&L/Econowash Dry Cleaners (LNL) and Modern Valet Services (MVS) sites. For the PCE plume the capture zone encompasses PCE exceeding 40 µg/L. This location is represented by monitoring well PVMVS06 located 250 feet upgradient of the LNL source area. This location was set as the most upgradient location with a concentration of 40 µg/L. Also located along the plume centerline is PVCHU02 at 6,250 feet downgradient (9 µg/L). These are the only two wells that are downgradient of the Groundwater Alternative G5 (GW3) capture zone. Because the NAS model requires a minimum of 3 wells, a third suspected well was added. Several runs were made with varying locations of this well to evaluate the effect on the TOR calculations. It was found it had little effect and a location near the upgradient well was chosen and it was given a similar concentration (39 µg/L).

Multiple distances along the plume centerline were input to NAS and TORs were calculated for each. The highest TOR was 17 years and it occurred at the most downgradient location, a distance of 6,500 feet from the source.

A second model run for the PCE plume was not run for the Vannatta Street municipal water supply well because the well is in close proximity to the source extraction wells of Groundwater Alternative G5 (GW3).

[3] Groundwater Alternative G5 was renamed Groundwater Alternative GW3 after initial screening.

References

Brauner, Steven, M. Widdowson, F. Chapelle, E. Mendez, and C.C. Casey. *Natural Attenuation Software (NAS) User's Guide. 2001*.

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Table D-2
Time of Remediation Estimates
PVGCS OU1 Study Area Feasibility Study

Location	Groundwater Alternative G1 No Further Action	Groundwater Alternative G2 MNA and ICs (1)	Groundwater Alternative G3 In Situ Source Treatment and MNA (2)	Groundwater Alternative G4 Source Treatment and MNA (3)	Groundwater Alternative G5 Expanded Source Treatment (4)
	Time to Achieve NJ DEP Groundwater Quality Standard of 1 ug/L				
Main Components- TCE Plume	none	MNA	3 EWs; Q = 420 gpm	3 EWs; Q = 420 gpm	3 EWs; Q = 1,400 gpm
Main Components- PCE Plume	none	MNA	none	1 EW; Q = 100 gpm	2 EW Q = 420 gpm
Downgradient to Superfund Boundary					
TCE Plume a.					
Time to Achieve 1 ug/L in Groundwater	**> 100 years**	***59 years***	***55 years***	***55 years***	***45 years***
Plume Length Modeled		23,000 feet	21,400 feet	21,400 feet	17,500 feet
Initial Concentration at Plume Upgradient Boundary (Co)		2,100 ug/L	500 ug/L	500 ug/L	100 ug/L
Distance from source requiring greatest time of remediation		Downgradient End of OU1 Study Area	Downgradient End of OU1 Study Area	Downgradient End of OU1 Study Area	Downgradient End of OU1 Study Area
Dale Avenue Municipal Well					
TCE Plume (a)					
Time to Achieve 1 ug/L in Groundwater	**> 100 years**	***14* years**	***10* years**	***10* years**	***N/A***
Plume Length Modeled		5,500 feet	3,900 feet	3,900 feet	
Initial Concentration at Plume Upgradient Boundary (Co)		2,100 ug/L	500 ug/L	500 ug/L	
PCE Plume (b)					
Time to Achieve 1 ug/L in Groundwater	**> 50 years**		**Uncertain (b)**	**Uncertain (c.)**	***17* years**
Plume Length Modeled					*6,500 feet*
Initial Concentration at Plume Upgradient Boundary					40 ug/L

a. All Time of remediation estimates for TCE plume assume no further mass flux to groundwater, other than for Groundwater Alternative G1 - No further action.
b. Time of remediation for PCE plume is uncertain for altrnatives that do not include containment of source area because PCE release to groundwater may continue.
c. Time of remediation for PCE plume is uncertain for Groundwater Alternative G4, hot spot containment, but it may be similar to Groundwater Alternative G5 if source is limited to LNL area.
N/A = not applicable.
(1) - Groundwater Alternative G2 was not retained after initial screening.
(2) - Groundwater Alternative G3 was not retained after initial screening.
(3) - Groundwater Alternative G4 was renamed Groundwater Alternative GW2 after initial screening.
(4) - Groundwater Alternative G5 was renamed Groundwater Alternative GW3 after initial screening.

Appendix E
Detailed Cost Tables

COMPARISON OF TOTAL COST OF REMEDIAL ALTERNATIVES

Site: PVGCS OU1 Study Area
Location: Soil Media: ANC A, B, and C Target Areas
Phase: Feasibility Study

Base Year 2005
Date April 25, 2005

	Soil Alternative SO1	Soil Alternative SO2	Soil Alternative SO3	Soil Alternative SO4
	No Further Action	Capping and Institutional Controls	DPE and Shallow Soil Mixing	Excavation and Offsite Disposal
Total Project Duration (Years)	50	50	5	2
Capital Cost	$0	$1,130,000	$3,700,000	$10,400,000
Annual O&M Cost	$0	$4,900	$160,000	$130,000
Total Periodic Cost	$0	$0	$0	$0
Total Present Value of Alternative	$0	$1,240,000	$4,400,000	$10,400,000

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost estimates are likely to occur as a result of new information and data collected during the engineering design of the remedial alternatives. This is an order-of-magnitude cost estimate that is expected to be within +30 to -50 percent of the actual project costs.

Alternative: **Soil Alternative SO1** **COST ESTIMATE SUMMARY**
Name: **No Further Action**

Site: PVGCS OU1 Study Area
Location: Soil Media: ANC A, B, and C Target Areas
Phase: Feasibility Study
Base Year: 2005
Date: 4/25/2005

Description: No additional actions undertaken.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
None					
TOTAL CAPITAL COST				**$0**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
None	0	LS	$5,000	$0	
TOTAL ANNUAL O&M COST				**$0**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
None		0	LS	$0	$0	
TOTAL PERIODIC COST					**$0**	

PRESENT VALUE ANALYSIS

Discount Rate = 3.5%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (3.5%)	PRESENT VALUE	NOTES
CAPITAL COST	0	$0	$0	1.000	$0	
ANNUAL O&M COST	1 to 50	$0	$0	23.46	$0	
		$0			$0	
TOTAL PRESENT VALUE OF ALTERNATIVE					**$0**	

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative: **Soil Alternative SO2** **COST ESTIMATE SUMMARY**

Name: **Capping and Institutional Controls**

Site: PVGCS OU1 Study Area
Location: Soil Media: ANC A, B, and C Target Areas
Phase: Feasibility Study
Base Year: 2005
Date: 4/25/2005

Description: Multi-layer cap constructed over ANC A. ANC B excavated to 5 feet and filled with clean soil. Existing foundation for cap at ANC C. Institutional controls include deed notices describing the soil contamination and restrictions of site use at ANC A and C.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Pre-Design Investigations					
ANC A Soil Investigation					
Soil Borings	1000	LF	$47	$47,000	Miller Drilling Quote.
Soil Samples	100	EA	$230	$23,000	Means, 33-02-0508
QC Samples	10	LS	$230	$2,300	Means, 33-02-0508
Sampling Labor	120	HRS	$80	$9,600	CH2M Est. - 2 persons
Equipment	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	55	HRS	$80	$4,400	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$94,700	
Allowance for Misc. Items	20%			$18,940	
SUBTOTAL				$113,640	
ANC B Soil Investigation					
Soil Samples	9	EA	$230	$2,070	Means, 33-02-0508
QC Samples	1	LS	$230	$230	Means, 33-02-0508
Sampling Labor	16	HRS	$80	$1,280	CH2M Est. - 2 persons
Equipment - hand augers	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	5	HRS	$80	$400	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$12,380	
Allowance for Misc. Items	20%			$2,476	
SUBTOTAL				$14,856	
ANC C Soil Investigation					
Review Existing Data/Workplan	1	LS	$50,000	$50,000	
Soil Borings	1000	LF	$47	$47,000	Miller Drilling Quote.
Concrete Coring (Area C)	10	EA	$500	$5,000	
Soil Samples	100	EA	$230	$23,000	Means, 33-02-0508
QC Samples	10	LS	$230	$2,300	Means, 33-02-0508
Sampling Labor	140	HRS	$80	$11,200	CH2M Est. - 2 persons
Equipment	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	55	HRS	$80	$4,400	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$151,300	
Allowance for Misc. Items	20%			$30,260	
SUBTOTAL				$181,560	
Institutional Controls	2	LS	$15,000	$30,000	ANC A and C
Soil Cap- ANC A					
Mobilization/Demobilization	1	LS	$5,000	$5,000	
Silt Fencing	1,000	FT	$3.00	$3,000	MEANS 18 05 0206
Clear and Grub	1.0	AC	$8,100	$8,100	MEANS 17 01 0106
Access Road- 8 inch Gravel Base	74	CY	$35.00	$2,590	MEANS 18 02 0101
Rough Grading	3111	SY	$5.00	$15,555	MEANS 17 03 0101
Soil Excavation and Truck Loading	778	CY	$6.00	$4,668	MEANS 17 03 0276 (2)
TCLP Sample Analysis	5	EA	$200	$1,000	1 samp/200 CY; MEANS 33 02 1705
Subtiltle D Landfill Transport and Disposal	1011	CY	$100	$101,100	Bethlehem, PA Landfill Quote
Place Erosion Control Matting	1556	SY	$1.50	$2,334	Penta Wood Products Site
Place GCL	28000	SF	$1.00	$28,000	MEANS 33 08 0508
Place 40 Mil Geomembrane	28000	SF	$2.00	$56,000	MEANS 33 18 0571
Import and Place Fill Sand Drainage layer (1ft)	1037	CY	$12.00	$12,444	MEANS 17 03 0423
Import and Place Fill (1.5ft)	1556	CY	$12.00	$18,672	MEANS 17 03 0423
Hydroseed	1.0	AC	$5,030	$5,030	MEANS 18 05 0402
SUBTOTAL				$263,493	
Excavation and Disposal - ANC B					
Mobilization/Demobilization	1	LS	$15,000	$15,000	Includes submittals
Silt Fencing	500	FT	$3.00	$1,500	MEANS 18 05 0206
Clear and Grub	0.1	AC	$8,100.00	$810	MEANS 17 01 0106
Access Road- 8 inch Gravel Base	30	CY	$35.00	$1,050	MEANS 18 02 0101
Soil Excavation and Truck Loading	481	CY	$6.00	$2,886	MEANS 17-03-0276
TCLP Sample Analysis	3	EA	$200	$600	1 samp/200 CY; MEANS 33 02 1705
Subtiltle D Landfill Transport and Disposal	481	CY	$100	$48,100	Bethlehem, PA Landfill Quote
Import and Place Fill	722	CY	$12.00	$8,658	MEANS 17 03 0423/CCI for fill factor
Rough Grading	333	CY	$5.00	$1,665	MEANS 17 03 0101
Hydroseed Upon Completion	0.1	AC	$5,030.00	$503	MEANS 18 05 0402
Soil Samples	12	EA	$230	$2,760	Means, 33-02-0508
QC Samples	2	EA	$230	$460	Means, 33-02-0508
Sampling Labor	30	HRS	$80	$2,400	CH2M Est. - 2 persons
Equipment - hand augers and meters	1	LS	$1,000	$1,000	CH2M Est.
Consumables	1	LS	$500	$500	CH2M Est.
Data Validation	7	HRS	$80	$560	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$94,852	
Allowance for misc sampling Items	20%			$18,970	
SUBTOTAL				$113,822	
SUBTOTAL				**$717,371**	

Alternative: **Soil Alternative SO2** **COST ESTIMATE SUMMARY**

Name: **Capping and Institutional Controls**

Contingency	25%	$179,343	10% Scope + 15% Bid
SUBTOTAL		$896,714	
Project Management	6%	$53,803	USEPA 2000, p. 5-13, $500K - $2MM
Remedial Design	12%	$107,606	USEPA 2000, p. 5-13, $500K - $2MM
Construction Management	8%	$71,737	USEPA 2000, p. 5-13, $500K - $2MM
SUBTOTAL		$233,146	
TOTAL CAPITAL COST		**$1,130,000**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Cap Semi-Annual Inspection					
Inspection Labor	2	Hr	$60	$120	
Cap Repair	1.0	LS	$2,635	$2,635	Assumes 1% of area requires repair annually
Cap Inspection and Repair Report	0.5	LS	$1,000	$500	Biennial Report to NJDEP
SUBTOTAL				$3,255	
Contingency	30%			$976	10% Scope + 20% Bid
SUBTOTAL				$4,231	
Project Management	5%			$212	
Technical Support	10%			$423	
TOTAL ANNUAL O&M COST				**$4,900**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
None		0	LS	$0	$0	
TOTAL PERIODIC COST					**$0**	

PRESENT VALUE ANALYSIS

Discount Rate = 3.5%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (3.5%)	PRESENT VALUE	NOTES
CAPITAL COST	0	$1,130,000	$1,130,000	1.000	$1,130,000	
ANNUAL O&M COST	1 to 50	$245,000	$4,900	23.456	$114,933	
		$1,400,000			$1,244,933	
TOTAL PRESENT VALUE OF ALTERNATIVE					**$1,240,000**	

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Unit price is higher than MEANS because of small area and need to excavate close to buiildings.

Alternative: **Soil Alternative SO3** **COST ESTIMATE SUMMARY**

Name: **DPE and Shallow Soil Mixing**

Site: PVGCS OU1 Study Area
Location: Soil Media: ANC A, B, and C Target Areas
Phase: Feasibility Study
Base Year: 2005
Date: 4/25/2005

Description: In situ dual phase extraction. Soils at ANC A from 0 - 20 feet would be mixed and soil from 20 - 100 feet would be pneumatically fractured (40 foot spacing). DPE well clusters would be installed at ANC A and C to extract from 10 - 20 feet, 25 - 45 feet, 50 - 70 feet, and 75 to 95 feet. 16 extraction well clusters would be installed in ANC A to achieve 20 foot radius of influence (40 foot spacing). ANC B excavated to 5 feet and filled with clean soil.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Pre-Design Investigations					
ANC A Soil Investigation					
Soil Borings	1000	LF	$47	$47,000	Miller Drilling Quote.
Soil Samples	100	EA	$230	$23,000	Means, 33-02-0508
QC Samples	10	LS	$230	$2,300	Means, 33-02-0508
Sampling Labor	120	HRS	$80	$9,600	CH2M Est. - 2 persons
Equipment	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	55	HRS	$80	$4,400	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$94,700	
Allowance for Misc. Items	20%			$18,940	
SUBTOTAL				$113,640	
ANC B Soil Investigation					
Soil Samples	9	EA	$230	$2,070	Means, 33-02-0508
QC Samples	1	LS	$230	$230	Means, 33-02-0508
Sampling Labor	16	HRS	$80	$1,280	CH2M Est. - 2 persons
Equipment - hand augers	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	5	HRS	$80	$400	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$12,380	
Allowance for Misc. Items	20%			$2,476	
SUBTOTAL				$14,856	
ANC C Soil Investigation					
Review Existing Data/Workplan	1	LS	$50,000	$50,000	
Soil Borings	1000	LF	$47	$47,000	Miller Drilling Quote.
Concrete Coring (Area C)	10	EA	$500	$5,000	
Soil Samples	100	EA	$230	$23,000	Means, 33-02-0508
QC Samples	10	LS	$230	$2,300	Means, 33-02-0508
Sampling Labor	140	HRS	$80	$11,200	CH2M Est. - 2 persons
Equipment	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	55	HRS	$80	$4,400	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$151,300	
Allowance for Misc. Items	20%			$30,260	
SUBTOTAL				$181,560	
DPE/Fracturing Pilot Test					
Pilot Test	1	LS	$100,000	$100,000	
ANC A - Soil Mixing and DPE Installation					
Site Preparation					
Mobilization/Demobilization for Site Preparation	1	LS	$5,000	$5,000	
Silt Fencing	1,000	CY	$3.00	$3,000	MEANS 18 05 0206
Clear and Grub	1.0	AC	$8,100	$7,810	MEANS 17 01 0106
Access Road- 8 inch Gravel Base	74	CY	$35.00	$2,590	MEANS 18 02 0101
Hydroseed Upon Completion	1.0	AC	$5,030	$4,850	MEANS 18 05 0402
SUBTOTAL				$23,250	
Shallow Soil Mixing					
Mobilization/Demobilization for Mixing	1	LS	$25,000	$25,000	Includes submittals; Bid
Excavation ANC A	20,741	CY	$6.00	$124,444	MEANS 17-03-0276
Mixing ANC A	1	MO	$20,000	$20,000	Lang Tool In Situ Blender
SUBTOTAL				$169,444	
Pneumatic Fracturing					
Mobilization/Demobilization for Fracturing	1	LS	$25,000	$25,000	Includes submittals; ARS Bid
Soil Borings	3000	FT	$47	$141,000	Miller Drilling Quote.
Pre & Post Fracture Survey	1	LS	$2,500	$2,500	
Pneumatic Fracturing	30	SB	$15,000	$450,000	ARS Technologies Estimate.
SUBTOTAL				$618,500	
DPE Well Installation					
Mobilization/Demobilization for DPE Installation	1	LS	$10,000	$10,000	CH2M Est.
Drilling/Well Construction - 2-inch	2160	LF	$30	$64,800	SJB Services Quote
Drilling/Well Construction - 4-inch	1520	LF	$45	$68,400	Project Exper- M.G.
Trenching	1000	LF	$30	$30,000	Project Exper- M.G.
Conveyance System	1000	LF	$24	$24,000	Project Exper- M.G./CCI
Pneumatic Pumps	16	EA	$3,000	$48,000	Project Exper- M.G.
Fittings, Valves, Miscellaneous Appertanances	1	LS	$12,000	$12,000	Project Exper- M.G.
Reporting	240	HRS	$80	$19,200	CH2M Est.
SUBTOTAL				$276,400	
Allowance for Misc. Items	20%			$55,280	
SUBTOTAL				$331,680	
ANC B - Excavation and Disposal					
Mobilization/Demobilization	1	LS	$15,000	$15,000	Includes submittals
Silt Fencing	500	FT	$3.00	$1,500	MEANS 18 05 0206
Clear and Grub	0.1	AC	$8,100.00	$810	MEANS 17 01 0106
Access Road- 8 inch Gravel Base	30	CY	$35.00	$1,050	MEANS 18 02 0101
Soil Excavation and Truck Loading	481	CY	$6.00	$2,886	MEANS 17-03-0276
TCLP Sample Analysis	3	EA	$200	$600	1 samp/200 CY; MEANS 33 02 1705
Subtiltle D Landfill Transport and Disposal	481	CY	$100	$48,100	Bethlehem, PA Landfill Quote
Import and Place Fill	722	CY	$12.00	$8,658	MEANS 17 03 0423/CCI for fill factor
Rough Grading	333	0	$5.00	$1,665	MEANS 17 03 0101
Hydroseed Upon Completion	0.1	AC	$5,030.00	$503	MEANS 18 05 0402
Soil Samples	12	EA	$230	$2,760	Means, 33-02-0508
QC Samples	2	EA	$230	$460	Means, 33-02-0508
Sampling Labor	30	HRS	$80	$2,400	CH2M Est. - 2 persons
Equipment - hand augers and meters	1	LS	$1,000	$1,000	CH2M Est.
Consumables	1	LS	$500	$500	CH2M Est.
Data Validation	7	HRS	$80	$560	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$94,852	
Allowance for misc sampling Items	20%			$18,970	
SUBTOTAL				$113,822	
ANC C - DPE Installation					

Alternative: **Soil Alternative SO3** **COST ESTIMATE SUMMARY**

Name: **DPE and Shallow Soil Mixing**

DPE Well Installation					
Mobilization/Demobilization for DPE Installation	1	LS	$10,000	$10,000	CH2M Est.
Concrete Coring	10	SB	$500	$5,000	
Drilling/Well Construction - 2-inch	1350	LF	$30	$40,500	SJB Services Quote
Drilling/Well Construction - 4-inch	950	LF	$45	$42,750	Project Exper- M.G.
Trenching	500	LF	$30	$15,000	Project Exper- M.G.
Conveyance System	500	LF	$24	$12,000	Project Exper- CCI
Pneumatic Pumps	10	EA	$3,000	$30,000	Project Exper- M.G.
Fittings, Valves, Miscellaneous Appertanances	1	LS	$12,000	$12,000	Project Exper- M.G.
Reporting	240	HRS	$80	$19,200	CH2M Est.
SUBTOTAL				$186,450	
Allowance for Misc. Items	20%			$37,290	
SUBTOTAL				$223,740	
DPE Treatment Building					
Remediation Building w/ Electrical & HVAC	1	LS	$75,000	$75,000	Project Exper- M.G.
DPE Process Equipment	1	LS	$120,000	$120,000	Project Exper- M.G.
Vapor Treatment Equipment (GAC)	4	EA	$10,000	$40,000	Project Exper- M.G.
Groundwater Treatment Equipment (GAC)	1	EA	$10,000	$10,000	Project Exper- M.G.
Control System w/ Autodialer, Remote Telemetry	1	LS	$50,000	$50,000	Project Exper- M.G.
Fittings, Valves, Miscellaneous Appertanances	1	LS	$12,000	$12,000	Project Exper- M.G.
Startup - Labor	240	HRS	$80	$19,200	CH2M Est. - 2 persons
Equipment	1	LS	$2,000	$2,000	CH2M Est.
Consumables	1	LS	$1,000	$1,000	CH2M Est.
Laboratory Analysis of Vapor by TO-14	20	EA	$250	$5,000	CH2M Est.
Reporting	240	HRS	$80	$19,200	CH2M Est.
SUBTOTAL				$353,400	
Allowance for Misc. Items	20%			$70,680	
SUBTOTAL				$424,080	
Soil Confirmation Sampling					
Shallow Soil Samples	10	EA	$200	$2,000	Miller Drilling Quote.
Concrete Coring (Area C)	5	EA	$500	$2,500	
Soil Borings	1000	LF	$47	$47,000	Miller Drilling Quote.
Soil Samples	60	EA	$230	$13,800	Means, 33-02-0508
QC Samples	6	LS	$230	$1,380	Means, 33-02-0508
Sampling Labor	100	HRS	$80	$8,000	CH2M Est. - 2 persons
Equipment - hand augers and meters	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	33	HRS	$80	$2,640	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$85,720	
Allowance for Misc. Items	20%			$17,144	
SUBTOTAL				$102,864	
SUBTOTAL				**$2,520,301**	
Contingency	25%			$630,075	10% Scope + 15% Bid
SUBTOTAL				$3,150,376	
Project Management	5%			$157,519	USEPA 2000, p. 5-13, $2MM - $10MM
Remedial Design	8%			$252,030	USEPA 2000, p. 5-13, $2MM - $10MM
Construction Management	6%			$189,023	USEPA 2000, p. 5-13, $2MM - $10MM
SUBTOTAL				$598,571	
TOTAL CAPITAL COST				**$3,700,000**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Leasing Industrial Space for Treatment Building	5000	SF	$6.30	$31,500	Assumed area (Avg - Coldwell Bankers)
Routine Operations, Maintenance, Monitoring	700	Hr	$75	$52,500	
Laboratory Analysis (Water & Vapor)	12	Months	$2,000	$24,000	
Data Validation, Database Management	80	Hr	$80	$6,400	
Annual Report Preparation	80	Hr	$80	$6,400	
O&M Project Management	1	LS	$13,395	$13,395	15% of Subtotal
Electricity	12	Months	$2,200	$26,400	$0.11 per KW-Hr
TOTAL ANNUAL O&M COST				**$160,000**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
None		0	LS	$0	$0	
TOTAL PERIODIC COST					**$0**	

PRESENT VALUE ANALYSIS

Discount Rate = 3.5%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (3.5%)	PRESENT VALUE	NOTES
CAPITAL COST	0	$3,700,000	$3,700,000	1.000	$3,700,000	
Annual O&M Cost	0 to 5	$320,000	$160,000	4.515	$722,408	
TOTAL PRESENT VALUE OF ALTERNATIVE		$4,020,000			**$4,400,000**	

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative: **Soil Alternative SO4** **COST ESTIMATE SUMMARY**

Name: **Excavation and Offsite Disposal**

Site: PVGCS OU1 Study Area
Location: Soil Media: ANC A, B, and C Target Areas
Phase: Feasibility Study
Base Year: 2005
Date: 4/25/2005

Description: Excavation of shallow soils in ANC A, B, and C.
Offsite Disposal in Subtitle D Landfill. Backfill with clean soil.
DPE of deep soils in ANC A and C.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Pre-Design Investigations					
ANC A Soil Investigation					
Soil Borings	1000	LF	$47	$47,000	Miller Drilling Quote.
Soil Samples	100	EA	$230	$23,000	Means, 33-02-0508
QC Samples	10	LS	$230	$2,300	Means, 33-02-0508
Sampling Labor	120	HRS	$80	$9,600	CH2M Est. - 2 persons
Equipment	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	55	HRS	$80	$4,400	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$94,700	
Allowance for Misc. Items	20%			$18,940	
SUBTOTAL				$113,640	
ANC B Soil Investigation					
Soil Samples	9	EA	$230	$2,070	Means, 33-02-0508
QC Samples	1	LS	$230	$230	Means, 33-02-0508
Sampling Labor	16	HRS	$80	$1,280	CH2M Est. - 2 persons
Equipment - hand augers	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	5	HRS	$80	$400	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$12,380	
Allowance for Misc. Items	20%			$2,476	
SUBTOTAL				$14,856	
ANC C Soil Investigation					
Review Existing Data/Workplan	1	LS	$50,000	$50,000	
Soil Borings	1000	LF	$47	$47,000	Miller Drilling Quote.
Concrete Coring (Area C)	10	EA	$500	$5,000	
Soil Samples	100	EA	$230	$23,000	Means, 33-02-0508
QC Samples	10	LS	$230	$2,300	Means, 33-02-0508
Sampling Labor	140	HRS	$80	$11,200	CH2M Est. - 2 persons
Equipment	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	55	HRS	$80	$4,400	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$151,300	
Allowance for Misc. Items	20%			$30,260	
SUBTOTAL				$181,560	
DPE/Fracturing Pilot Test					
Pilot Test	1	LS	$100,000	$100,000	
ANC A - Excavation and DPE					
Site Preparation					
Mobilization/Demobilization	1	LS	$5,000	$5,000	
Silt Fencing	74	CY	$3.00	$222	MEANS 18 05 0206
Clear and Grub	1.0	AC	$8,100	$8,100	MEANS 17 01 0106
Access Road- 8 inch Gravel Base	259	CY	$35.00	$9,065	MEANS 18 02 0101
Hydroseed Upon Completion	1.0	AC	$5,030	$5,030	MEANS 18 05 0402
SUBTOTAL				$27,417	
Excavation and Disposal					
Mobilization/Demobilization	1	LS	$15,000	$15,000	Includes submittals
Silt Fencing	500	FT	$3.00	$1,500	MEANS 18 05 0206
Clear and Grub	0.1	AC	$8,100.00	$810	MEANS 17 01 0106
Access Road- 8 inch Gravel Base	30	CY	$35.00	$1,050	MEANS 18 02 0101
Soil Excavation and Truck Loading	20222	CY	$6.00	$121,332	MEANS 17-03-0276
TCLP Sample Analysis	102	EA	$200	$20,400	1 samp/200 CY; MEANS 33 02 1705
Subtiltle D Landfill Transport and Disposal	20222	CY	$100	$2,022,200	Bethlehem, PA Landfill Quote
Import and Place Fill	30333	CY	$12.00	$363,996	MEANS 17 03 0423/CCI for factor
Rough Grading	3111	SY	$5.00	$15,555	MEANS 17 03 0101
Hydroseed Upon Completion	1.0	AC	$5,030.00	$5,030	MEANS 18 05 0402
Soil Samples	50	EA	$230	$11,500	Means, 33-02-0508
QC Samples	5	EA	$230	$1,150	Means, 33-02-0508
Sampling Labor	100	HRS	$80	$8,000	CH2M Est. - 2 persons
Equipment - hand augers and meters	1	LS	$1,000	$1,000	CH2M Est.
Consumables	1	LS	$500	$500	CH2M Est.
Data Validation	27.5	HRS	$80	$2,200	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
Allowance for misc sampling Items	20%			$6,150	
SUBTOTAL				$2,603,773	
Pneumatic Fracturing					
Mobilization/Demobilization for Fracturing	1	LS	$25,000	$25,000	Includes submittals; ARS Bid
Soil Borings	3000	FT	$47	$141,000	Miller Drilling Quote.
Pre & Post Fracture Survey	1	LS	$2,500	$2,500	
Pneumatic Fracturing	24	SB	$15,000	$360,000	ARS Technologies Estimate.
SUBTOTAL				$528,500	
DPE Well Installation					
Mobilization/Demobilization for DPE Installation	1	LS	$10,000	$10,000	CH2M Est.
Drilling/Well Construction - 2-inch	2160	LF	$30	$64,800	SJB Services Quote
Drilling/Well Construction - 4-inch	1520	LF	$45	$68,400	Project Exper- M.G.
Trenching	1000	LF	$30	$30,000	Project Exper- M.G.
Conveyance System	1000	LF	$24	$24,000	CCI Est.
Fittings, Valves, Miscellaneous Appertanances	1	LS	$12,000	$12,000	Project Exper- M.G.
Reporting	240	HRS	$80	$19,200	CH2M Est.
Pneumatic Pumps	10	EA	$3,000	$30,000	Project Exper- M.G.
SUBTOTAL				$258,400	
Allowance for Misc. Items	20%			$51,680	
SUBTOTAL				$310,080	
ANC B - Excavation and Disposal					
Mobilization/Demobilization	1	LS	$15,000	$15,000	Includes submittals
Silt Fencing	500	FT	$3.00	$1,500	MEANS 18 05 0206
Clear and Grub	0.1	AC	$8,100.00	$810	MEANS 17 01 0106
Access Road- 8 inch Gravel Base	30	CY	$35.00	$1,050	MEANS 18 02 0101
Soil Excavation and Truck Loading	481	CY	$6.00	$2,886	MEANS 17-03-0276
TCLP Sample Analysis	3	EA	$200	$600	1 samp/200 CY; MEANS 33 02 1705
Subtiltle D Landfill Transport and Disposal	481	CY	$100	$48,100	Bethlehem, PA Landfill Quote
Import and Place Fill	722	CY	$12.00	$8,658	MEANS 17 03 0423/CCI for fill factor
Rough Grading	333	0	$5.00	$1,665	MEANS 17 03 0101
Hydroseed Upon Completion	0.1	AC	$5,030.00	$503	MEANS 18 05 0402
Soil Samples	12	EA	$230	$2,760	Means, 33-02-0508
QC Samples	2	EA	$230	$460	Means, 33-02-0508
Sampling Labor	30	HRS	$80	$2,400	CH2M Est. - 2 persons
Equipment - hand augers and meters	1	LS	$1,000	$1,000	CH2M Est.
Consumables	1	LS	$500	$500	CH2M Est.
Data Validation	7	HRS	$80	$560	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$94,852	
Allowance for misc sampling Items	20%			$18,970	
SUBTOTAL				$113,822	
ANC C - Excavation and DPE					
Site Preparation					
Mobilization/Demobilization	1	LS	$5,000	$5,000	CH2M Est.
Removal of Concrete Floor	2133	SY	$10	$21,333	CH2M Est.
Disposal of Concrete	600	TON	$30	$18,000	CH2M Est.

Alternative: **Soil Alternative SO4** **COST ESTIMATE SUMMARY**

Name: **Excavation and Offsite Disposal**

Shoring/Stabilization	1	LS	$200,000	$200,000	CCI Est.
Foundation Stabilization	7	EA	$7,000	$49,000	CH2M Est.
SUBTOTAL				$293,333	
Excavation and Disposal					
Mobilization/Demobilization	1	LS	$15,000	$15,000	Includes submittals
Soil Excavation and Truck Loading	11556	CY	$6.00	$69,336	MEANS 17-03-0276
TCLP Sample Analysis	59	EA	$200	$11,800	1 samp/200 CY; MEANS 33 02 1705
Subtiltle D Landfill Transport and Disposal	11556	CY	$100	$1,155,600	Bethlehem, PA Landfill Quote
Import and Place Fill	17334	CY	$12.00	$208,008	MEANS 17 03 0423/CCI
Grading	1778	SY	$5.00	$8,890	MEANS 17 03 0101
Rebuilding Concrete Floor	296	CY	$400	$118,400	
Soil Samples	50	EA	$230	$11,500	Means, 33-02-0508
QC Samples	5	EA	$230	$1,150	Means, 33-02-0508
Sampling Labor	100	HRS	$80	$8,000	CH2M Est. - 2 persons
Equipment - hand augers and meters	1	LS	$1,000	$1,000	CH2M Est.
Consumables	1	LS	$1,500	$1,500	CH2M Est.
Data Validation	27.5	HRS	$80	$2,200	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
Allowance for misc sampling Items	20%			$6,350	
SUBTOTAL				$1,625,134	
DPE Well Installation					
Mobilization/Demobilization for DPE Installation	1	LS	$10,000	$10,000	CH2M Est.
Concrete Coring	10	SB	$500	$5,000	
Drilling/Well Construction - 2-inch	1350	LF	$30	$40,500	SJB Services Quote
Drilling/Well Construction - 4-inch	950	LF	$45	$42,750	Project Exper- M.G.
Trenching	500	LF	$30	$15,000	Project Exper- M.G.
Conveyance System	500	LF	$24	$12,000	CCI Est.
Pneumatic Pumps	16	EA	$3,000	$48,000	Project Exper- M.G.
Fittings, Valves, Miscellaneous Appertanances	1	LS	$12,000	$12,000	Project Exper- M.G.
Reporting	240	HRS	$80	$19,200	CH2M Est.
SUBTOTAL				$204,450	
Allowance for Misc. Items	20%			$40,890	
SUBTOTAL				$245,340	
DPE Treatment Building					
Remediation Building w/ Electrical & HVAC	1	LS	$75,000	$75,000	Project Exper- M.G.
DPE Process Equipment	1	LS	$120,000	$120,000	Project Exper- M.G.
Vapor Treatment Equipment (GAC)	4	EA	$10,000	$40,000	Project Exper- M.G.
Control System w/ Autodialer, Remote Telemetry	1	LS	$50,000	$50,000	Project Exper- M.G.
Fittings, Valves, Miscellaneous Appertanances	1	LS	$12,000	$12,000	Project Exper- M.G.
Startup - Labor	240	HRS	$80	$19,200	CH2M Est. - 2 persons
Equipment	1	LS	$2,000	$2,000	CH2M Est.
Consumables	1	LS	$1,000	$1,000	CH2M Est.
Laboratory Analysis of Vapor by TO-14	20	EA	$250	$5,000	CH2M Est.
Reporting	240	HRS	$80	$19,200	CH2M Est.
SUBTOTAL				$343,400	
Allowance for Misc. Items	20%			$68,680	
SUBTOTAL				$412,080	
DPE Confirmation Sampling					
Concrete Coring (Area C)	5	EA	$500	$2,500	
Soil Borings	1000	LF	$47	$47,000	Miller Drilling Quote.
Soil Samples	50	EA	$230	$11,500	Means, 33-02-0508
QC Samples	3	LS	$230	$690	Means, 33-02-0508
Sampling Labor	100	HRS	$80	$8,000	CH2M Est. - 2 persons
Equipment - hand augers and meters	1	LS	$1,000	$1,000	CH2M Est.
Consumables	2	LS	$500	$1,000	CH2M Est.
Data Validation	26.5	HRS	$80	$2,120	CH2M Est.
Reporting	80	HRS	$80	$6,400	CH2M Est.
SUBTOTAL				$80,210	
Allowance for Misc. Items	20%			$16,042	
SUBTOTAL				$96,252	
SUBTOTAL				**$6,665,788**	
Contingency	25%			$1,666,447	10% Scope + 15% Bid
SUBTOTAL				$8,332,235	
Project Management	5%			$416,612	USEPA 2000, p. 5-13, >$100MM
Remedial Design	6%			$499,934	USEPA 2000, p. 5-13, >$100MM
Construction Management	6%			$499,934	USEPA 2000, p. 5-13, >$100MM
SUBTOTAL				$1,416,480	
TOTAL CAPITAL COST				**$9,700,000**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Leasing Industrial Space for Building	5000	SF	$6.30	$31,500	Assumed area
Routine Operations, Maintenance, Monitoring	400	Hr	$75	$30,000	
Laboratory Analysis (Water & Vapor)	12	Months	$2,000	$24,000	
Data Validation, Database Management	40	Hr	$80	$3,200	
Annual Report Preparation	80	Hr	$80	$6,400	
O&M Project Management	1	LS	$9,540	$9,540	15% of Subtotal
Electricity	12	Months	$2,200	$26,400	$0.11 per KW-Hr
TOTAL ANNUAL O&M COST				**$130,000**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
None		0	LS	$0	$0	
TOTAL PERIODIC COST					**$0**	

PRESENT VALUE ANALYSIS

Discount Rate = 3.5%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (3.5%)	PRESENT VALUE	NOTES
CAPITAL COST	0	$9,700,000	$9,700,000	1.000	$9,700,000	
Annual O&M Cost	0 to 5	$260,000	$130,000	5.000	$650,000	
TOTAL PRESENT VALUE OF ALTERNATIVE		9,960,000			**$10,400,000**	

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

TABLE E-1
Estimated Quantities Calculations
PVGCS OU1 Study Area
Soil Media: ANC A, B, and C Target Areas
Feasibility Study

Description of Quantity
Estimated Quantities for:

ANC A

Silt Fencing	1,000	FT	Perimeter of RTA distance = 350' + 350' + 80'+ 80' = 860'. Round to 1,000'
ANC A Clear and grub Area	42,000	SF	RTA area of 28,000 sf + 50% for access
ANC A Clear and grub Area	1.0	AC	RTA area of 28,000 sf + 50% for access
Temporary access road	74	CY	Gravel volume = 300' x 10' wide x 8" thick /12/27
Cover Area	28,000	SF	Area = 350' x 80'
Cover Area	3,111	SY	
Soil Excavation Volume for Grade establishment	259	CY	Assume an average of 1 foot of soil is removed over 25% of area.
Ex Situ Volume	337	CY	Assume 30% expansion
Erosion control matting	1,556	SY	Assume 50% of area requires matting
Cover Soil 1.5 ft thick	1,556	CY	
Top Soil 0.5 ft thick	519	CY	
Hydroseed Area	1.0	AC	

ANC B

RTA Area	2,000	SF	
RTA Area	222	SY	
Depth	5	FT	
In Situ Volume	10000	CF	
In Situ Volume	370	CY	
Sand Protective Layer (1 ft)	74	CY	
Soil Weight	312	TON	
Soil Ex Situ Volume	481	CY	Assumes 30% volume increase
Truck Loads of Soil	32	LOADS	Assumes 15 cy/truck
Backfill Volume	722	CY	Assumes 50% increase for compaction, trucking inflation
Soil Verification Samples	12	EA	
Silt Fencing	500	FT	Perimeter of RTA distance = 100' + 100' + 70'+ 70' = 340'. Round to 500'
ANC B Clear and grub Area	3,000	SF	RTA area of 2,000 sf + 50% for access
ANC B Clear and grub Area	0.1	AC	RTA area of 2,000 sf + 50% for access
Temporary access road	30	CY	Gravel volume = 100' x 10' wide x 8" thick /12/27
Cover Area	2000	SF	
Cover Area	222	SY	
Erosion control matting	56	SY	Assume 25% of area requires matting
Cover Soil 4.5 ft thick	333	CY	
Top Soil 0.5 ft thick	37	CY	
Hydroseed Area	0.1	AC	

Additional Quantities for: Soil Alternative SO2 Capping and Institutional Controls

ANC A			
Soil Excavation Volume for Grade establishment	778	CY	Assume an average of 1.5 foot of soil is removed over 50% of area.
Ex Situ Volume	1011	CY	Assume 30% expansion
1.0 foot Drainage Layer	1037	CY	
40 Mil Liner and GCL Area	3111	SY	

Additional Quantities for: Soil Alternative SO3 DPE and Shallow Soil Mixing

ANC A			
ANC A Area	28000	SF	
Soil Mixing Volume	20741	CY	Assume an average of 20 ft mixing depth.
Soil Borings	3,000	FT	100 feet/boring x 30 borings = 3,000 LF
Pneumatic Fracturing	30	SB	Grid on 40 foot centers
DPE Well Clusters	16	EA	Screened 10 -20, 25 - 45, 50 - 70, 75 - 95.
Drilling/Well Construction Footage, 2-inch	2160	LF	135' per DPE well cluster
Drilling/Well Construction Footage, 4-inch	1520	LF	95' per DPE well cluster
Trenching ANC A	1000	LF	Based on conceptual layout, 3' deep, native pipe
Electrical Costs	$1,100	MONTH	10,000 KW-Hr/Month @ $0.11/KW-Hr
Shallow Verification Samples	5	EA	
Soil Verification Borings	500	LF	
Soil Verification Samples	25	EA	
ANC C			
ANC C Area	16000	SF	Based on assumed average concentration and back calculations from measured flux to groundwater
DPE Well Clusters	10	EA	Screened 10 -20, 25 - 45, 50 - 70, 75 - 95.
Drilling/Well Construction Footage, 2-inch	1350	LF	135' per DPE well cluster, 20' per SVE well.
Drilling/Well Construction Footage, 4-inch	950	LF	95' per DPE well cluster
Trenching ANC C	500	LF	Distance from ANC C to ANC A
Electrical Costs	$1,100	MONTH	10,000 KW-Hr/Month @ $0.11/KW-Hr
Shallow Verification Samples	5	EA	
Soil Verification Borings	500	LF	
Soil Verification Samples	25	EA	
Treatment Building			
Footprint	2500	SF	Estimated size of treatment building (50' x 50')
Leasing Cost	6.3	SF	Average of industrial leasing costs for NJ (Coldwell B

Additional Quantities for: Soil Alternative SO4 Excavation and Offsite Disposal

ANC A			
RTA Area	28,000	SF	
RTA Area	3,111	SY	
Depth	15	FT	
In Situ Volume	420000	CF	
In Situ Volume	15556	CY	
Sand Protective Layer (1 ft)	1037	CY	
Soil Weight	13104	TON	
Soil Ex Situ Volume	20222	CY	Assumes 30% volume increase
Truck Loads of Soil	1348	LOADS	Assumes 15 cy/truck
Backfill Volume	30333	CY	Assumes 50% increase for compaction, trucking inflation
Soil Verification Samples	20	EA	
ANC A Clear and grub Area	42,000	SF	RTA area of 28,000 sf + 50% for access
ANC A Clear and grub Area	1.0	AC	RTA area of 28,000 sf + 50% for access
Hydroseed Area	1.0	AC	
ANC C			
RTA Area	16,000	SF	
RTA Area	1,778	SY	
Depth	15	FT	
In Situ Volume	240000	CF	
In Situ Volume	8889	CY	
Sand Protective Layer (1 ft)	593	CY	
Soil Weight	7488	TON	
Soil Ex Situ Volume	11556	CY	Assumes 30% volume increase
Truck Loads of Soil	770	LOADS	Assumes 15 cy/truck
Backfill Volume	17333	CY	Assumes 50% increase for compaction, trucking inflation
Soil Verification Samples	20	EA	
I-beams in Area to Stabilize	7	EA	I beams placed 50 feet apart
Quantity of concrete demo waste	600	TON	150 lbs per CY
New Concrete thickness	0.5	FT	
New Concrete volume	296	CY	

Table E-2
Unit Costs Derived from Means Unit Prices
PVGCS OU1 Study Area
Soil Media: ANC A, B, and C Target Areas
Feasibility Study

Means Category	Description	Units	Labor Unadjusted Cost	Labor Productivity Factor (a)	Labor Adjusted Cost	Equipment Unadjusted Cost	Equipment Productivity Factor	Equipment Adjusted Cost	Materials Cost	Subtotal	Local Cost Factor (b)	Subtotal	Contractor Mark-Up Overhead	Contractor Mark-Up Profit	Estimated Unit Cost
ENVIRONMENTAL REMEDIATION COST DATA - UNIT PRICE (Ref. 1)															
17-01-0106	Clear and Grub Heavy brush and Light Trees	AC	$2,729.00	82%	$3,328.05	$2,485.00	100%	$2,485.00	$0.00	$5,813.05	1.11	$6,452.48	15%	10%	$8,100
17-03-0101	Rough Grading	SY	$0.95	82%	$1.16	$2.55	100%	$2.55	$0.00	$3.71	1.11	$4.12	15%	10%	$5.00
17-03-0201	Excavation, Spoil to Side	CY	$0.43	82%	$0.52	$0.41	100%	$0.41	$0.00	$0.93	1.11	$1.04	15%	10%	$1.00
17-03-0276	Excavation, 1 Cy Hydraulic Excavator,	CY	$1.52	82%	$1.85	$2.14	100%	$2.14	$0.00	$3.99	1.11	$4.43	15%	10%	$6.00
17-03-0202	Trenching, 1 CY Gradall, Light Soil, 95 CY per hour	CY	$1.71	82%	$2.09	$2.99	100%	$2.99	$0.00	$5.08	1.11	$5.63	15%	10%	$7.00
17-03-0401	Trench Backfill, 3 CY, 950	CY	$0.45	82%	$0.55	$0.66	100%	$0.66	$0.00	$1.21	1.11	$1.34	15%	10%	$2.00
17-03-0415	Backfill with excavated material	CY	$2.43	82%	$2.96	$0.81	100%	$0.81	$0.33	$4.10	1.11	$4.55	15%	10%	$6.00
17-03-0423	Backfill with Offsite Borrow, 6" Lifts, Spreading, Compaction	CY	$1.00	82%	$1.22	$2.10	100%	$2.10	$5.63	$8.95	1.11	$9.93	15%	10%	$12.00
18-01-0102	Gravel, Delivered & Dumped	CY	$1.78	82%	$2.17	$1.62	100%	$1.62	$21.11	$24.90	1.11	$27.64	15%	10%	$35
18-01-0105	Asphalt, Stabilized Base Course	CY	$0.61	82%	$0.74	$1.28	100%	$1.28	$32.38	$34.40	1.11	$38.19	15%	10%	$48
18-02-0101	Gravel, Delivered and Dumped	CY	$1.78	82%	$2.17	$1.62	100%	$1.62	$21.11	$24.90	1.11	$27.64	15%	10%	$35
18-02-0312	Asphalt Wearing Course	TN	$14.26	82%	$17.39	$14.24	100%	$14.24	$30.98	$62.61	1.11	$69.50	15%	10%	$87
18-05-0206	Silt Fence	LF	$1.41	82%	$1.72	$0.00	100%	$0.00	$0.70	$2.42	1.11	$3	15%	10%	$3.00
18-05-0302	Deliver and Spread Topsoil	CY	$4.06	82%	$4.95	$2.89	100%	$2.89	$20	$28	1.11	$31	15%	10%	$39
18-05-0402	Hydroseeding and Watering	ACRE	$67.71	82%	$82.57	$52.39	100%	$52.39	$3,491	$3,626	1.11	$4,025	15%	10%	$5,030
33-02-1705	TCLP VOC Analysis	EA	$0.00	82%	$0.00	$0.00	100%	$0.00	$144.34	$144.34	1.11	$160	15%	10%	$200
33-02-0508	VOC Analysis	EA	$0.00	82%	$0.00	$0.00	100%	$0.00	$166.00	$166.00	1.11	$184	15%	10%	$230
33-08--0508	Geocomposit Membrane Liner	SF	$0.09	82%	$0.11	$0.07	100%	$0.07	$0.53	$0.71	1.11	$0.79	15%	10%	$1.00
33-18-0571	40 Mil HDPE Liner	SF	$0.90	82%	$1.10	$0.16	100%	$0.16	$0.30	$1.56	1.11	$1.73	15%	10%	$2.00
33-19-0210	Dump Truck Transportation HW, 200-299 Miles	MI	$0.00	82%	$0.00	$0.00	100%	$0.00	$2.32	$2.32	1.11	$2.58	15%	10%	$3.00
33-19-0217	Dump Truck Transportation HW, 900-999 Miles	MI	$0.00	82%	$0.00	$0.00	100%	$0.00	$2.00	$2.00	1.11	$2.22	15%	10%	$3.00
33-19-7264	Landfill HW Disposal	CY	$0.00	82%	$0.00	$0.00	100%	$0.00	$148.00	$148.00	1.11	$164.28	15%	10%	$205
33-19-7270	Landfill Solid Waste Disposal	CY	$0.00	82%	$0.00	$0.00	100%	$0.00	$93.50	$93.50	1.11	$103.79	15%	10%	$130
33-23-0101	2" PVC, Schedule 40, Well Casing	LF	$2.34	82%	$2.85	$6.67	100%	$6.67	$1.15	$10.67	1.11	$12	15%	10%	$15
33-23-0256	2" PVC, Schedule 40, Well Screen	LF	$3.92	82%	$4.78	$11.18	100%	$11.18	$2.07	$18.03	1.11	$20	15%	10%	$25
33-23-0555	4" Submersible Pump, 56-95 gpm, 41'<Head<100', 3 HP, w/ controls	EA	$0.00	100%	$0.00	$0.00	100%	$0.00	$3,042	$3,042.00	1.11	$3,377	15%	10%	$4,221
33-23-0561	4" Submersible Pump, 96-200 gpm, 101'<Head<150', 7.5 HP, w/ controls	EA	$0.00	100%	$0.00	$0.00	100%	$0.00	$4,481	$4,481.00	1.11	$4,974	15%	10%	$6,217
33-23-1180	Mob/demob, Drill Equipment or Trencher, Crew	EA	$438.25	82%	$534.45	$1,250.00	100%	$1,250.00	$243	$2,026.95	1.11	$2,250	15%	10%	$2,812
33-26-0406	4" PVC Piping, with Fittings	LF	$9.81	82%	$11.96	$0.45	100%	$0.45	$2.96	$15.37	1.11	$17.06	15%	10%	$21
33-42-0101	Electrical Charge	KWH	$0.00	100%	$0.00	$0.00	100%	$0.00	$0.07	$0.07	1.11	$0.08	0%	0%	$0
33-42-0102	1.5 HP Motor, Electric Charge	MO	$0.00	100%	$0.00	$0.00	100%	$0.00	$62	$61.83	1.11	$69	0%	0%	$69
33-42-0106	Misc. Electrical Site Usage	MO	$0.00	100%	$0.00	$0.00	100%	$0.00	$275	$274.80	1.11	$305	0%	0%	$305

NOTES:

(a) Productivity factor of 82% applied to labor unit costs where applicable. See Ref. 1 for details.
(b) Local cost factor of 1.11 applied for the Warren County, New Jersey. See Ref. 1 for details.
(c) Subcontractor overhead (15%) and profit (10%) included in unit cost were applicable. See Ref 2 for details.

REFERENCES:

1. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA.
2. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Additional Unit Cost Information

Description	Units	Unit Cost	Notes
Soil Borings	LF	$47	Miller Drilling Quote
Subtiltle D Landfill Transport and Disposal	CY	$100	Bethlehem, Pa. Landfill quote

COMPARISON OF TOTAL COST OF REMEDIAL ALTERNATIVES

Site: PVGCS OU1 Study Area
Location: Groundwater Media
Phase: Feasibility Study

Base Year: 2005
Date: April 25, 2005

	Groundwater Alternative GW1 No Further Action	**Groundwater Alternative GW2** Source Treatment and MNA	**Groundwater Alternative GW3** Expanded Source Treatment and MNA	**Groundwater Alternative GW4** Entire Plume Collection and Treatment
Total Project Duration (Years)	60	55	47	22
Capital Cost	$0	$2,552,000	$3,399,000	$10,811,000
Annual O&M Cost	$0	$606,000	$996,000	$2,373,000
Total Periodic Cost	$0	$9,350,000	$48,347,000	$63,077,000
Total Present Value of Alternative	$0	$8,060,000	$25,760,000	$46,840,000

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost estimates are likely to occur as a result of new information and data collected during the engineering design of the remedial alternatives. This is an order-of-magnitude cost estimate that is expected to be within -30 to +50 percent of the actual project costs.

Alternative: **Groundwater Alternative GW1** **COST ESTIMATE SUMMARY**
Name: **No Further Action**

Site: PVGCS OU1 Study Area
Location: Groundwater Media
Phase: Feasibility Study
Base Year: 2005
Date: 4/25/2005

Description: No additional actions undertaken.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
None					
TOTAL CAPITAL COST				**$0**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
None	0	LS	$5,000	$0	
TOTAL ANNUAL O&M COST				**$0**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
None		0	LS	$0	$0	
TOTAL PERIODIC COST					**$0**	

PRESENT VALUE ANALYSIS

Discount Rate = 3.5%

http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (3.5%)	PRESENT VALUE	NOTES
CAPITAL COST	0	$0	$0	1.000	$0	
ANNUAL O&M COST	1 to 60	$0	$0	24.94	$0	
		$0			$0	
TOTAL PRESENT VALUE OF ALTERNATIVE					**$0**	

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative: **Groundwater Alternative GW2** **COST ESTIMATE SUMMARY**
Name: **Source Treatment and MNA**

Site: PVGCS OU1 Study Area
Location: Groundwater Media
Phase: Feasibility Study
Base Year: 2005
Date: 4/25/2005

Description: Containment of TCE plume over 500 ug/L through series of 3 pumping wells and one pumping well for PCE. Total flows of 420 gpm (TCE plume) and 100 gpm (PCE plume). Assumes two treatment systems operating for 11 years.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Groundwater Use Restrictions	1	LS	$15,000	$15,000	
Pre-Design Investigations					
Install New Monitoring Wells					
Mobilization/Demobilization	1	LS	$25,000	$25,000	
Soil Borings	1,360	FT	$47	$63,920	Miller Drilling Quote.
2" Well Casing	1,360	FT	$15	$20,400	33-23-0101
2" Well Screen	1,360	FT	$25	$34,000	33-23-0256
Installation Oversight Labor	160	HR	$80	$12,800	CH2M Est.
SUBTOTAL				$156,120	
Contingency	30%			$46,836	10% Scope + 20% Bid
SUBTOTAL				$202,956	
Sample Existing and New Wells					
Groundwater Samples	58	LS	$110	$6,380	Contractor Estimate
QC Samples	7.8	LS	$110	$858	Contractor Estimate
Samping Labor	120	HRS	$80	$9,600	CH2M Est. - 2 persons
Equipment - meters	1	LS	$2,000	$2,000	CH2M Est.
Consumables	1	LS	$400	$400	CH2M Est.
Data Validation	32.9	HRS	$80	$2,632	CH2M Est.
Reporting	16	HRS	$80	$1,280	CH2M Est.
SUBTOTAL				$23,150	
Allowance for Misc. Items	20%			$4,630	
SUBTOTAL				$27,780	
Contingency	30%			$8,334	10% Scope + 20% Bid
				$36,114	
Site Preparation					
Site Preparation	1	LS	$10,000	$10,000	
Silt Fencing and Erosion Controls (Temp.)	1	LS	$500	$500	
Surveying	1	LS	$0	$0	
SUBTOTAL				$10,500	
Water Supply Connection					
Door-to-Door Survey	40	HR	$80	$3,200	
Connection to Municipal Supply System(100')	30	LS	$3,000	$90,000	
Connection to Municipal Supply System(1000')	30	LS	$4,500	$135,000	
Home Well Abandonment	16,500	LF	$10	$165,000	Contractor Estimate
SUBTOTAL				$393,200	
ANC Production Well Treatment					
Shallow Tray Air Stripper	1	EA	$105,000	$105,000	Contractor Estimate
Miscellenous Piping and Fittings	1	LS	$2,000	$2,000	
SUBTOTAL				$107,000	
Groundwater Extraction/Injection Wells					
TCE PLUME					
Mobilization	1	LS	$24,264	$24,264	
12-inch Borehole	980	LF	$30	$29,400	
8-inch Well Casing	980	LF	$35	$34,300	
Well Grout Seal	980	LF	$20	$19,600	
8-inch Borehole	1400	LF	$25	$35,000	
Well Development	224	HR	$250	$56,000	
25-Horsepower Pump and Motor	4	EA	$20,000	$80,000	
Wellhead Piping, Vault, etc.	7	LS	$7,000	$49,000	
Installation Oversight Labor	160	HR	$80	$12,800	CH2M Est.
SUBTOTAL				$340,364	
PCE PLUME					
Mobilization	1	LS	$5,488	$5,488	
12-inch Borehole	160	LF	$30	$4,800	
8-inch Well Casing	160	LF	$35	$5,600	
Well Grout Seal	160	LF	$20	$3,200	
8-inch Borehole	400	LF	$25	$10,000	
Well Development	64	HR	$250	$16,000	
15-Horsepower Pump and Motor	1	EA	$15,000	$15,000	
Wellhead Piping, Vault, etc.	2	LS	$7,000	$14,000	
Installation Oversight Labor	160	HR	$80	$12,800	CH2M Est.
SUBTOTAL				$86,888	
Groundwater Treatment Systems					
Excavation for Building Foundation	2	LS	$10,000	$20,000	Contractor Estimate
Concrete Building Foundation	2	LS	$15,000	$30,000	Contractor Estimate
Concrete Footer	2	LS	$15,000	$30,000	Contractor Estimate
GW Treatment Building	2	LS	$20,000	$40,000	Contractor Estimate
Miscellaneous (Construction)	1	LS	$5,000	$5,000	CH2M Est.
Paved Access Road	14	TONS	$57	$798	CH2M Est.
10,000 gal EqualizationTank	2	EA	$8,726	$17,452	33-10-9662
Bag Filteration (2 filters/system)	4	EA	$4,334	$17,336	33-13-0117
Air Stripper	2	EA	$105,000	$210,000	Contractor Estimate
Activated Carbon Unit	4	EA	$2,000	$8,000	33-13-1942
4" Venturi Flow Meter	4	EA	$4,000	$16,000	CH2M Est.
4" Steel Pipe (Exposed)	4,000	LF	$13	$50,320	33-26-0104
4" Steel Fittings (Exposed)	20	EA	$119	$2,380	33-27-0534/0552/0562
4" Check Valve	10	EA	$292	$2,920	33-27-0404
4" Butterfly Valve	10	EA	$544	$5,437	33-27-0424
Pressure Gauge Assembly	4	EA	$276	$1,104	Grainger Estimate
Effluent Tank (Gravity Feed)	2	EA	$8,726	$17,452	33-10-9662
Gravity Discharge Piping (8" HDPE)	200	LF	$8	$1,546	33-26-0514
Air Stripper Drain Line (4" HDPE)	100	LF	$4	$391	33-26-0512
Misc. (pipe stands, brackets, etc.)	1	LS	$5,000	$5,000	CH2M Est.
SUBTOTAL				$481,136	
Electrical Service (GW Treatment Systems and Wells)					
Electrical service	1	LS	$10,000	$10,000	CH2M Est.
SUBTOTAL				$10,000	
SUBTOTAL				**$1,683,158**	
Contingency	25%			$420,789	10% Scope + 15% Bid
SUBTOTAL				$2,103,947	
Project Management	5%			$105,197	USEPA 2000, p. 5-13, $2MM-$10MM
Engineering Design and Planning	8%			$168,316	USEPA 2000, p. 5-13, $2MM-$10MM
Construction Management	6%			$126,237	USEPA 2000, p. 5-13, $2MM-$10MM
Permitting (Air and Re-Injection)	1	LS	$30,000	$30,000	CH2M Est.
Operations and Maintenance Manual	1	LS	$7,500	$7,500	CH2M Est.
Procurement	1	LS	$2,500	$2,500	CH2M Est.
Construction Completion and QA/QC Report	1	LS	$8,000	$8,000	CH2M Est.
TOTAL CAPITAL COST				**$2,552,000**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES

Alternative: **Groundwater Alternative GW2** **COST ESTIMATE SUMMARY**

Name: **Source Treatment and MNA**

Treatment Building Property Leasing					
Property Leasing for TCE Treatment Building	15,000	SF	$7	$105,000	OMI Estimate
Property Leasing for PCE Treatment Building	15,000	SF	$7	$105,000	OMI Estimate
Inspection and Monitoring					
Monthly Site Visits					
Labor for Visit/Compliance Sampling	96	HR	$80	$7,680	CH2M Est. - 1 person/mth
Effluent Sampling (GW)	12	LS	$110	$1,320	Contractor Estimate
VOC Analysis (Method TO-14) - Offgas	4	LS	$150	$600	Contractor Estimate
Reporting (Quarterly)	4	LS	$8,000	$32,000	CH2M Est.
Other Expenses (Shipping, supplies, etc.)	1	LS	$1,000	$1,000	CH2M Est.
SUBTOTAL				$42,600	
Allowance for Misc. Items	20%			$8,520	
SUBTOTAL				$51,120	
Contingency	30%			$15,336	
ANC Production Well Treatment Maintenance					
Shallow Tray Air Stripper - Cleaning	1	EA	$10,000	$10,000	CH2M est. - $2500 per quarter
Treatment System Maintenance					
O&M Staff (labor, overheads, vehicles, etc)	2	EA	$120,000	$240,000	OMI Estimate - 2 people
Carbon Usage	1	LS	$40,000	$40,000	OMI Estimate
Line and Pump Acid Cleaning	1	LS	$30,000	$30,000	OMI Estimate
Pump Rebuilds	1	LS	$3,000	$3,000	OMI Estimate
ANC, Vannatta Street, and Dale Avenue Sampling					
Monthly Site Visits					
Labor for Visit/Compliance Sampling	48	HR	$80	$3,840	CH2M Est. - 1 person/mth
Effluent Sampling (GW)	24	LS	$110	$2,640	Contractor Estimate
TOTAL ANNUAL O&M COST				**$606,000**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Groundwater Sampling Every 5 years	5					
Groundwater Samples		10	LS	$110	$1,100	Contractor Estimate
QC Samples		4	LS	$110	$440	Contractor Estimate
Groundwater Sampling, Level D						
Labor		48	HRS	$80	$3,840	CH2M Est. - 2 persons
Equipment - meters		1	LS	$500	$500	CH2M Est.
Consumables		1	LS	$200	$200	CH2M Est.
Data Validation		7	HRS	$80	$560	CH2M Est.
Reporting		16	HRS	$80	$1,280	CH2M Est.
SUBTOTAL					$7,920	
Allowance for Misc. Items		20%			$1,584	
SUBTOTAL					$9,504	
Contingency		30%			$2,851	10% Scope + 20% Bid
Groundwater Sampling Every 5 years						
SUBTOTAL	5				$12,355	
SUBTOTAL	5				$12,000	
Groundwater Sampling Every 5 years	10				$12,355	
SUBTOTAL	10				$12,000	
Groundwater Sampling Every 5 years	15				$12,355	
SUBTOTAL	15				$12,000	
Groundwater Sampling Every 5 years	20				$12,355	
SUBTOTAL	20				$12,000	
Groundwater Sampling Every 5 years	25				$12,355	
SUBTOTAL	25				$12,000	
Groundwater Sampling Every 5 years	30				$12,355	
SUBTOTAL	30				$12,000	
Groundwater Sampling Every 5 years	35				$12,355	
SUBTOTAL	35				$12,000	
Groundwater Sampling Every 5 years	40				$12,355	
SUBTOTAL	40				$12,000	
Groundwater Sampling Every 5 years	45				$12,355	
SUBTOTAL	45				$12,000	
Groundwater Sampling Every 5 years	50				$12,355	
SUBTOTAL	50				$12,000	
Groundwater Sampling Every 5 years	55				$12,355	
SUBTOTAL	55				$12,000	

PRESENT VALUE ANALYSIS

Discount Rate = 3.5%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (3.5%)	PRESENT VALUE	NOTES
CAPITAL COST	0	$2,552,000	$2,552,000	1.000	$2,552,000	
ANNUAL O&M COST	1 to 11	$6,666,000	$606,000	9.002	$5,454,940	
PERIODIC COST	5	$12,000	$12,000	0.84	$10,104	
PERIODIC COST	10	$12,000	$12,000	0.71	$8,507	
PERIODIC COST	15	$12,000	$12,000	0.60	$7,163	
PERIODIC COST	20	$12,000	$12,000	0.50	$6,031	
PERIODIC COST	25	$12,000	$12,000	0.42	$5,078	
PERIODIC COST	30	$12,000	$12,000	0.36	$4,275	
PERIODIC COST	35	$12,000	$12,000	0.30	$3,600	
PERIODIC COST	40	$12,000	$12,000	0.25	$3,031	
PERIODIC COST	45	$12,000	$12,000	0.21	$2,552	
PERIODIC COST	50	$12,000	$12,000	0.18	$2,149	
PERIODIC COST	55	$12,000	$12,000	0.15	$1,809	
		$9,350,000			$8,061,237	
TOTAL PRESENT VALUE OF ALTERNATIVE					**$8,060,000**	

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative: **Groundwater Alternative GW3** **COST ESTIMATE SUMMARY**

Name: **Expanded Source Treatment and MNA**

Site: PVGCS OU1 Study Area
Location: Groundwater Media
Phase: Feasibility Study
Base Year: 2005
Date: 4/25/2005

Description: Containment of TCE plume over 5 ug/L through series of 5 extraction wells and containment of PCE over 25 ug/L through a series of 2 extraction wells. Total flows of 1,400 gpm (TCE plume) and 420 gpm (PCE plume). Assumes two treatment systems operating for 47 years.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Groundwater Use Restrictions	1	LS	$15,000	$15,000	
Pre-Design Investigations					
Install New Monitoring Wells					
Mobilization/Demobilization	1	LS	$25,000	$25,000	
Soil Borings	1,360	FT	$47	$63,920	Miller Drilling Quote.
2" Well Casing	1,360	FT	$15	$20,400	33-23-0101
2" Well Screen	1,360	FT	$25	$34,000	33-23-0256
Installation Oversight Labor	160	HR	$80	$12,800	CH2M Est.
SUBTOTAL				$156,120	
Contingency	30%			$46,836	10% Scope + 20% Bid
SUBTOTAL				$202,956	
Sample Existing and New Wells					
Groundwater Samples	58	LS	$110	$6,380	Contractor Estimate
QC Samples	7.8	LS	$110	$858	Contractor Estimate
Samping Labor	120	HRS	$80	$9,600	CH2M Est. - 2 persons
Equipment - meters	1	LS	$2,000	$2,000	CH2M Est.
Consumables	1	LS	$400	$400	CH2M Est.
Data Validation	32.9	HRS	$80	$2,632	CH2M Est.
Reporting	16	HRS	$80	$1,280	CH2M Est.
SUBTOTAL				$23,150	
Allowance for Misc. Items	20%			$4,630	
SUBTOTAL				$27,780	
Contingency	30%			$8,334	10% Scope + 20% Bid
				$36,114	
Site Preparation					
Site Preparation	1	LS	$10,000	$10,000	
Silt Fencing and Erosion Controls (Temp.)	1	LS	$500	$500	
Surveying	1	LS	$1,000	$1,000	
SUBTOTAL				$11,500	
Water Supply Connection					
Door-to-Door Survey	40	HR	$80	$3,200	
Connection to Municipal Supply System(100')	30	LS	$3,000	$90,000	
Connection to Municipal Supply System(1000')	30	LS	$4,500	$135,000	
Home Well Abandonment	16,500	LF	$10	$165,000	Contractor Estimate
SUBTOTAL				$393,200	
ANC Production Well Treatment					
Shallow Tray Air Stripper	1	EA	$105,000	$105,000	Contractor Estimate
Miscellenous Piping and Fittings	1	LS	$2,000	$2,000	
SUBTOTAL				$107,000	
Groundwater Extraction/Injection Systems					
TCE PLUME					
Mobilization	1	LS	$43,176	$43,176	
12-inch Borehole	1700	LF	$30	$51,000	
8-inch Well Casing	1700	LF	$35	$59,500	
Well Grout Seal	1700	LF	$20	$34,000	
8-inch Borehole	2720	LF	$25	$68,000	
Well Development	416	HR	$250	$104,000	
35-Horsepower Pump and Motor	5	EA	$25,000	$125,000	
Wellhead Piping, Vault, etc.	13	LS	$7,000	$91,000	
Installation Oversight Labor	160	HR	$80	$12,800	CH2M Est.
SUBTOTAL				$588,476	
PCE PLUME					
Mobilization	1	LS	$5,000	$5,000	
12-inch Borehole	560	LF	$30	$16,800	
8-inch Well Casing	560	LF	$25	$14,000	
Well Grout Seal	560	LF	$20	$11,200	
8-inch Borehole	1120	LF	$25	$28,000	
Well Development	224	HR	$250	$56,000	
35-Horsepower Pump and Motor	2	EA	$25,000	$50,000	
Wellhead Piping, Vault, etc.	6	LS	$7,000	$42,000	
Installation Oversight Labor	160	HR	$80	$12,800	CH2M Est.
SUBTOTAL				$235,800	
Groundwater Treatment Systems					
Excavation for Building Foundation	2	LS	$10,000	$20,000	Contractor Estimate
Concrete Building Foundation	2	LS	$15,000	$30,000	Contractor Estimate
Concrete Footer	2	LS	$15,000	$30,000	Contractor Estimate
GW Treatment Building	2	LS	$20,000	$40,000	Contractor Estimate
Miscellaneous (Construction)	1	LS	$5,000	$5,000	CH2M Est.
Paved Access Road	14	TONS	$57	$798	
10,000 gal EqualizationTank	2	EA	$8,726	$17,452	33-10-9662
Bag Filteration (2 filters/system)	4	EA	$4,334	$17,336	33-13-0117
Air Stripper	2	EA	$135,000	$270,000	Contractor Estimate
Activated Carbon	4	EA	$2,000	$8,000	33-13-1942
4" Venturi Flow Meter	4	EA	$4,000	$16,000	CH2M Est.
4" Steel Pipe (Exposed)	4000	LF	$13	$50,320	33-26-0104
4" Steel Fittings (Exposed)	20	EA	$119	$2,380	33-27-0534/0552/0562
4" Check Valve	10	EA	$292	$2,920	33-27-0404
4" Butterfly Valve	10	EA	$544	$5,437	33-27-0424
Pressure Gauge Assembly	4	EA	$276	$1,104	Grainger Estimate
Effluent Tank (Gravity Feed)	2	EA	$8,726	$17,452	33-10-9662
Gravity Discharge Piping (8" HDPE)	200	LF	$8	$1,546	33-26-0514
Air Stripper Drain Line (4" HDPE)	100	LF	$4	$391	33-26-0512
Misc. (pipe stands, brackets, etc.)	1	LS	$5,000	$5,000	CH2M Est.
SCADA/computer control system	1	LS	$150,000	$150,000	OMI Estimate
SUBTOTAL				$691,136	
Electrical Service (GW Treatment Systems and Wells)					
Electrical Service	1	LS	$10,000	$10,000	CH2M Est.
SUBTOTAL				$10,000	
SUBTOTAL				**$2,291,182**	
Contingency	25%			$572,795	10% Scope + 15% Bid
SUBTOTAL				$2,863,977	
Project Management	5%			$143,199	USEPA 2000, p. 5-13, >$10MM
Engineering Design and Planning	6%			$171,839	USEPA 2000, p. 5-13, >$10MM
Construction Management	6%			$171,839	USEPA 2000, p. 5-13, >$10MM
Permitting (Air and Re-Injection)	1	LS	$30,000	$30,000	CH2M Est.
Operations and Maintenance Manual	1	LS	$7,500	$7,500	CH2M Est.
Procurement	1	LS	$2,500	$2,500	CH2M Est.
Construction Completion and QA/QC Report	1	LS	$8,000	$8,000	CH2M Est.

Alternative: **Groundwater Alternative GW3** — **COST ESTIMATE SUMMARY**

Name: **Expanded Source Treatment and MNA**

TOTAL CAPITAL COST	**$3,399,000**

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Treatment Building Property Leasing					
Property Leasing for TCE Treatment Building	30,000	SF	$7	$210,000	Estimate from OMI
Property Leasing for PCE Treatment Building	20,000	SF	$7	$140,000	Estimate from OMI
Inspection and Monitoring					
Monthly Site Visits					
Labor for Visit/Compliance Sampling	96	HR	$80	$7,680	CH2M Est. - 1 person/mth
Effluent Sampling (GW)	12	LS	$110	$1,320	Contractor Estimate
VOC Analysis (Method TO-14) - Offgas	4	LS	$150	$600	Contractor Estimate
Reporting (Quarterly)	4	LS	$8,000	$32,000	CH2M Est.
Other Expenses (Shipping, supplies, etc.)	1	LS	$1,000	$1,000	CH2M Est.
SUBTOTAL				$42,600	
Allowance for Misc. Items	20%			$8,520	
SUBTOTAL				$51,120	
Contingency	30%			$15,336	
ANC Production Well Treatment Maintenance					
Shallow Tray Air Stripper - Cleaning	1	EA	$10,000	$10,000	CH2M est. - $2500 per quarter
Treatment System Maintenance					
O&M Staff (labor, overheads, vehicles, etc)	4	EA	$120,000	$480,000	OMI Estimate - 4 people
Carbon Usage	1	LS	$50,000	$50,000	OMI Estimate
Line and Pump Acid Cleaning	1	LS	$30,000	$30,000	OMI Estimate
Pump Rebuilds	1	LS	$3,000	$3,000	OMI Estimate
ANC, Vannatta Street, and Dale Avenue Sampling					
Monthly Site Visits					
Labor for Visit/Compliance Sampling	48	HR	$80	$3,840	CH2M Est. - 1 person/mth
Effluent Sampling (GW)	24	LS	$110	$2,640	Contractor Estimate
TOTAL ANNUAL O&M COST				**$996,000**	Includes both leases

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Groundwater Sampling Every 5 years	5					
Groundwater Samples		10	LS	$110	$1,100	Contractor Estimate
QC Samples		4	LS	$110	$440	Contractor Estimate
Groundwater Sampling, Level D						
Labor		48	HRS	$80	$3,840	CH2M Est. - 2 persons
Equipment - meters		1	LS	$500	$500	CH2M Est.
Consumables		1	LS	$200	$200	CH2M Est.
Data Validation		7	HRS	$80	$560	CH2M Est.
Reporting		16	HRS	$80	$1,280	CH2M Est.
SUBTOTAL					$7,920	
Allowance for Misc. Items		20%			$1,584	
SUBTOTAL					$9,504	
Contingency		30%			$2,851	10% Scope + 20% Bid
Groundwater Sampling Every 5 years SUBTOTAL	5				$12,355	
SUBTOTAL	5				$12,000	
Groundwater Sampling Every 5 years	10				$12,355	
SUBTOTAL	10				$12,000	
Groundwater Sampling Every 5 years	15				$12,355	
SUBTOTAL	15				$12,000	
Groundwater Sampling Every 5 years	20				$12,355	
SUBTOTAL	20				$12,000	
Groundwater Sampling Every 5 years	25				$12,355	
SUBTOTAL	25				$12,000	
Groundwater Sampling Every 5 years	30				$12,355	
SUBTOTAL	30				$12,000	
Groundwater Sampling Every 5 years	35				$12,355	
SUBTOTAL	35				$12,000	
Groundwater Sampling Every 5 years	40				$12,355	
SUBTOTAL	40				$12,000	
Groundwater Sampling Every 5 years	45				$12,355	
SUBTOTAL	45				$12,000	

PRESENT VALUE ANALYSIS

Discount Rate = 3.5%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (3.5%)	PRESENT VALUE	NOTES
CAPITAL COST	0	$3,399,000	$3,399,000	1.000	$3,399,000	
ANNUAL O&M COST	1 to 47	$40,232,000	$856,000	22.899	$19,601,919	
ANNUAL O&M COST	1 to 33	$4,620,000	$140,000	19.390	$2,714,629	
PERIODIC COST	5	$12,000	$12,000	0.84	$10,104	
PERIODIC COST	10	$12,000	$12,000	0.71	$8,507	
PERIODIC COST	15	$12,000	$12,000	0.60	$7,163	
PERIODIC COST	20	$12,000	$12,000	0.50	$6,031	
PERIODIC COST	25	$12,000	$12,000	0.42	$5,078	
PERIODIC COST	30	$12,000	$12,000	0.36	$4,275	
PERIODIC COST	35	$12,000	$12,000	0.30	$3,600	
PERIODIC COST	40	$12,000	$12,000	0.25	$3,031	
		$48,347,000			$25,763,336	
TOTAL PRESENT VALUE OF ALTERNATIVE					**$25,760,000**	

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative: **Groundwater Alternative GW4** **COST ESTIMATE SUMMARY**

Name: **Entire Plume Collection and Treatment**

Site: PVGCS OU1 Study Area
Location: Groundwater Media
Phase: Feasibility Study
Base Year: 2005
Date: 4/25/2005 0:00

Description: Entire TCE plume collection through series of 5 extraction wells per treatment system
Total flow of 9000 gpm.
Assumes six treatment systems operating for 22 years.
* scaleup from 1 to 6 systems

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Groundwater Use Restrictions	1	LS	$15,000	$15,000	
Pre-Design Investigations					
Install New Monitoring Wells					
Mobilization/Demobilization	1	LS	$25,000	$25,000	
Soil Borings	1,360	FT	$47	$63,920	Miller Drilling Quote.
2" Well Casing	1,360	FT	$15	$20,400	33-23-0101
2" Well Screen	1,360	FT	$25	$34,000	33-23-0256
Installation Oversight Labor	160	HR	$80	$12,800	CH2M Est.
SUBTOTAL				$156,120	
Contingency	30%			$46,836	10% Scope + 20% Bid
SUBTOTAL				$202,956	
Sample Existing and New Wells					
Groundwater Samples	58	LS	$110	$6,380	Contractor Estimate
QC Samples	7.8	LS	$110	$858	Contractor Estimate
Samping Labor	120	HRS	$80	$9,600	CH2M Est. - 2 persons
Equipment - meters	1	LS	$2,000	$2,000	CH2M Est.
Consumables	1	LS	$400	$400	CH2M Est.
Data Validation	32.9	HRS	$80	$2,632	CH2M Est.
Reporting	16	HRS	$80	$1,280	CH2M Est.
SUBTOTAL				$23,150	
Allowance for Misc. Items	20%			$4,630	
SUBTOTAL				$27,780	
Contingency	30%			$8,334	10% Scope + 20% Bid
				$36,114	
Site Preparation					
Site Preparation	1	LS	$10,000	$10,000	
Silt Fencing and Erosion Controls (Temp.)	1	LS	$500	$500	
Surveying	1	LS	$0	$0	
SUBTOTAL				$10,500	
Water Supply Connection					
Door-to-Door Survey	40	HR	$80	$3,200	
Connection to Municipal Supply System(100')	30	LS	$3,000	$90,000	
Connection to Municipal Supply System(1000')	30	LS	$4,500	$135,000	
Home Well Abandonment	16,500	LF	$10	$165,000	Contractor Estimate
SUBTOTAL				$393,200	
ANC Production Well Treatment					
Shallow Tray Air Stripper	1	EA	$105,000	$105,000	Contractor Estimate
Miscellenous Piping and Fittings	1	LS	$2,000	$2,000	
SUBTOTAL				$107,000	
Groundwater Extraction/Injection Systems					
Mobilization	6	LS	$43,176	$259,056	scaleup from 1 to 6 systems
12-inch Borehole	10,200	LF	$30	$306,000	scaleup from 5 to 30 wells
8-inch Well Casing	10,200	LF	$35	$357,000	scaleup from 5 to 30 wells
Well Grout Seal	10,200	LF	$20	$204,000	scaleup from 5 to 30 wells
8-inch Borehole	16,320	LF	$25	$408,000	scaleup from 8 to 48 wells
Well Development	2,496	HR	$250	$624,000	scaleup from 1 to 6 systems
35-Horsepower Pump and Motor	30	EA	$25,000	$750,000	scaleup from 5 to 30 wells
Wellhead Piping, Vault, etc.	78	LS	$7,000	$546,000	scaleup from 1 to 6 systems
Installation Oversight Labor	160	HR	$80	$12,800	CH2M Est.
SUBTOTAL				$3,466,856	
Groundwater Treatment Systems					
Excavation for Building Foundation	6	LS	$10,000	$60,000	Contractor Estimate + scaleup*
Concrete Building Foundation	6	LS	$15,000	$90,000	Contractor Estimate + scaleup
Concrete Footer	6	LS	$15,000	$90,000	Contractor Estimate + scaleup
GW Treatment Building	6	LS	$200,000	$1,200,000	OMI estimate
Miscellaneous (Construction)	6	LS	$5,000	$30,000	CH2M Est. + scaleup
Paved Access Road	42	TONS	$57	$2,394	
10,000 gal EqualizationTank	6	EA	$8,726	$52,356	33-10-9662
Bag Filteration (2 filters/system)	12	EA	$4,334	$52,008	33-13-0117
Air Stripper	6	EA	$135,000	$810,000	Contractor Estimate + scaleup
Activated Carbon	12	EA	$2,000	$24,000	33-13-1942
4" Venturi Flow Meter	12	EA	$4,000	$48,000	CH2M Est. + scaleup
4" Steel Pipe (Exposed)	12,000	LF	$13	$150,960	33-26-0104
4" Steel Fittings (Exposed)	60	EA	$119	$7,140	33-27-0534/0552/0562
4" Check Valve	30	EA	$292	$8,760	33-27-0404
4" Butterfly Valve	30	EA	$544	$16,310	33-27-0424
Pressure Gauge Assembly	12	EA	$276	$3,312	Contractor Estimate + scaleup
Effluent Tank (Gravity Feed)	6	EA	$8,726	$52,356	33-10-9662
Gravity Discharge Piping (8" HDPE)	600	LF	$8	$4,638	33-26-0514
Air Stripper Drain Line (4" HDPE)	300	LF	$4	$1,173	33-26-0512
Misc. (pipe stands, brackets, etc.)	6	LS	$5,000	$30,000	CH2M Est. + scaleup
SCADA/computer control system	1	LS	$350,000	$350,000	OMI Estimate
SUBTOTAL				$3,083,407	
Electrical Service (GW Treatment Systems and Wells)					
Electrical Service	6	LS	$10,000	$60,000	CH2M Est.
SUBTOTAL				$60,000	
SUBTOTAL				$7,375,033	
Contingency	25%			$1,843,758	10% Scope + 15% Bid
SUBTOTAL				$9,218,791	
Project Management	5%			$460,940	USEPA 2000, p. 5-13, >$10MM
Engineering Design and Planning	6%			$553,127	USEPA 2000, p. 5-13, >$10MM
Construction Management	6%			$553,127	USEPA 2000, p. 5-13, >$10MM
Permitting (Air and Re-Injection)	1	LS	$7,500	$7,500	CH2M Est.

Alternative: **Groundwater Alternative GW4** **COST ESTIMATE SUMMARY**

Name: **Entire Plume Collection and Treatment**

Operations and Maintenance Manual	1	LS	$7,500	$7,500	CH2M Est.
Procurement	1	LS	$2,500	$2,500	CH2M Est.
Construction Completion and QA/QC Report	1	LS	$8,000	$8,000	CH2M Est.
TOTAL CAPITAL COST				**$10,811,000**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Treatment Building Property Leasing					
Property Leasing for Treatment Building	90,000	SF	$7	$630,000	OMI Estimate
Inspection and Monitoring					
Monthly Site Visits					
Labor for Visit/Compliance Sampling	96	HR	$80	$7,680	CH2M Est. - 1 person/mth
Effluent Sampling (GW)	12	LS	$110	$1,320	Contractor Estimate
VOC Analysis (Method TO-14) - Offgas	4	LS	$150	$600	Contractor Estimate
Reporting (Quarterly)	4	LS	$8,000	$32,000	CH2M Est.
Other Expenses (Shipping, supplies, etc.)	1	LS	$1,000	$1,000	CH2M Est.
SUBTOTAL				$42,600	
Allowance for Misc. Items	20%			$8,520	
SUBTOTAL				$51,120	
Contingency	30%			$15,336	
Treatment System Maintenance					
O&M Staff (labor, overheads, vehicles, etc)	12	EA	$120,000	$1,440,000	OMI Estimate - 12 people
Carbon Usage	1	LS	$100,000	$100,000	OMI Estimate
Line and Pump Acid Cleaning	1	LS	$80,000	$80,000	OMI Estimate
Pump Rebuilds	1	LS	$50,000	$50,000	OMI Estimate
ANC, Vannatta Street, and Dale Avenue Sampling					
Monthly Site Visits					
Labor for Visit/Compliance Sampling	48	HR	$80	$3,840	CH2M Est. - 1 person/mth
Effluent Sampling (GW)	24	LS	$110	$2,640	Contractor Estimate
TOTAL ANNUAL O&M COST				**$2,373,000**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Groundwater Sampling Every 5 years	5					
Groundwater Samples		10	LS	$110	$1,100	Contractor Estimate
QC Samples		4	LS	$110	$440	Contractor Estimate
Groundwater Sampling, Level D						
Labor		48	HRS	$80	$3,840	CH2M Est. - 2 persons
Equipment - meters		1	LS	$500	$500	CH2M Est.
Consumables		1	LS	$200	$200	CH2M Est.
Data Validation		7	HRS	$80	$560	CH2M Est.
Reporting		16	HRS	$80	$1,280	CH2M Est.
SUBTOTAL					$7,920	
Allowance for Misc. Items		20%			$1,584	
SUBTOTAL					$9,504	
Contingency		30%			$2,851	10% Scope + 20% Bid
Groundwater Sampling Every 5 years						
SUBTOTAL	5				$12,355	
SUBTOTAL	5				$12,000	
Groundwater Sampling Every 5 years	10				$12,355	
SUBTOTAL	10				$12,000	
Groundwater Sampling Every 5 years	15				$12,355	
SUBTOTAL	15				$12,000	
Groundwater Sampling Every 5 years	20				$12,355	
SUBTOTAL	20				$12,000	
Groundwater Sampling Every 5 years	25				$12,355	
SUBTOTAL	25				$12,000	

PRESENT VALUE ANALYSIS

Discount Rate = 3.5%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (3.5%)	PRESENT VALUE	NOTES
CAPITAL COST	0	$10,811,000	$10,811,000	1.000	$10,811,000	
ANNUAL O&M COST	1 to 22	$52,206,000	$2,373,000	15.167	$35,991,587	
PERIODIC COST	5	$12,000	$12,000	0.84	$10,104	
PERIODIC COST	10	$12,000	$12,000	0.71	$8,507	
PERIODIC COST	15	$12,000	$12,000	0.60	$7,163	
PERIODIC COST	20	$12,000	$12,000	0.50	$6,031	
PERIODIC COST	25	$12,000	$12,000	0.42	$5,078	
		$63,077,000			$46,839,469	
TOTAL PRESENT VALUE OF ALTERNATIVE					**$46,840,000**	

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

TABLE E-3
Estimated Quantities Calculations
PVGCS OU1 Study Area
Groundwater Media
Feasibility Study

Description of Quantity

Estimated Quantities for: Alternatives 2-4 Domestic Well Abandonment

Home Well Abandonment	16,500	LF	Assume 60 domestic wells approximately 250 feet deep. Assume an additional 10% contingency. CT&E estimate of $10 per foot.
Connection to Municipal Supply System(100')	30	LS	Quote from Courageous Plumbing & Heating. Price includes excavation, materials, connections, testing, repair of sidewalk/asphlat. Does not include permit.
Connection to Municipal Supply System(1000')	30	LS	Quote from Courageous Plumbing & Heating. Price includes excavation, materials, connections, testing, repair of sidewalk/asphlat. Does not include permit.

Estimated Quantities for: Alternatives 3-4 Treatment Building

Alts. 3 and 4 Treatment Building/Property Size	10,000	SF	50 x 50 foot building plus 25-foot buffer on all sides
Alt. 5 Treatment Building/Property Size	20,000	SF	Two 50 x 50 foot buildings with 25-foot buffers
Alts. 6 and 7 Treatment Building/Property Size	40,000	SF	100 x 100 foot building plus 50-foot buffer on all sides
Leasing Price for Industrial Property	7	USD	

TABLE E-4
Unit Costs Derived from Means Unit Prices - Alt. G3
Pohatcong Valley Groundwater Contamination Site, N. J.
Groundwater
Feasibility Study

Means Category	Description	Units	Labor Unadjusted Cost	Equipment Unadjusted Cost	Materials Cost	Estimated Unit Cost
ENVIRONMENTAL REMEDIATION COST DATA - UNIT PRICE (Ref. 1)						
17-01-0106	Clear and Grub Heavy brush and Light Trees	AC	$2,729.00	$2,485.00	$0.00	$8,066
17-03-0101	Rough Grading	SY	$0.95	$2.55	$0.00	$5
17-03-0201	Excavation, Spoil to Side	CY	$0.43	$0.41	$0.00	$1
17-03-0276	Excavation, 1 Cy Hydraulic Excavator,	CY	$1.52	$2.14	$0.00	$6
17-03-0202	Trenching, 1 CY Gradall, Light Soil, 95 CY per hour	CY	$1.71	$2.99	$0.00	$7
17-03-0401	Trench Backfill, 3 CY, 950	CY	$0.45	$0.66	$0.00	$2
17-03-0415	Backfill with excavated material	CY	$2.43	$0.81	$0.33	$6
17-03-0423	Backfill with Offsite Borrow, 6" Lifts, Spreading, Compaction	CY	$1.00	$2.10	$5.63	$12
18-01-0102	Gravel, Delivered & Dumped	CY	$1.78	$1.62	$21.11	$35
18-01-0105	Asphalt, Stabilized Base Course	CY	$0.61	$1.28	$32.38	$48
18-02-0101	Gravel, Delivered and Dumped	CY	$1.78	$1.62	$21.11	$35
18-02-0312	Asphalt Wearing Course	TN	$14.26	$14.24	$30.98	$87
18-05-0206	Silt Fence	LF	$1.41	$0.00	$0.70	$3
18-05-0302	Deliver and Spread Topsoil	CY	$4.06	$2.89	$20	$39
18-05-0402	Hydroseeding and Watering	ACRE	$67.71	$52.39	$3,491	$5,031
33-02-1705	TCLP VOC Analysis	EA	$0.00	$0.00	$144.34	$200
33-02-0508	VOC Analysis	EA	$0.00	$0.00	$166.00	$230
33-08--0508	Geocomposit Membrane Liner	SF	$0.09	$0.07	$0.53	$1
33-10- 9660	5,000 Gallon Above-Ground Tank	EA	$1,087.00	$156.87	$4,250.00	$7,954
33-12-9905	Chemical Feeder	EA	$631.75	$0.00	$1,463.00	$3,099
33-13-0117	50-100 gpm cartridge Filter	EA	$46.04	$0.00	$4,567.00	$6,415
33-18-0571	40 Mil HDPE Liner	SF	$0.90	$0.16	$0.30	$2
33-19-0210	Dump Truck Transportation HW, 200-299 Miles	MI	$0.00	$0.00	$2.32	$3
33-19-0217	Dump Truck Transportation HW, 900-999 Miles	MI	$0.00	$0.00	$2.00	$3
33-19-7264	Landfill HW Disposal	CY	$0.00	$0.00	$148.00	$205
33-23-0101	2" PVC, Schedule 40, Well Casing	LF	$2.34	$6.67	$1.15	$15
33-23-0103	6" PVC, Schedule 40, Well Casing	LF	$3.37	$9.60	$4.03	$25
33-23-0203	6" PVC, Schedule 40, Well Screen	LF	$5.61	$16.00	$9.17	$44
33-23-0256	2" PVC, Schedule 40, Well Screen	LF	$3.92	$11.18	$2.07	$25
33-23-0555	4" Submersible Pump, 56-95 gpm, 41'<Head<100', 3 HP, w/ controls	EA	$0.00	$0.00	$3,042	$4,221
33-23-0561	4" Submersible Pump, 96-200 gpm, 101'<Head<150', 7.5 HP, w/ controls	EA	$0.00	$0.00	$4,481	$6,217
33-23-1180	Mob/demob, Drill Equipment or Trencher, Crew	EA	$438.25	$1,250.00	$243	$2,812
33-26-0406	4" PVC Piping, with Fittings	LF	$9.81	$0.45	$2.96	$21
33-42-0101	Electrical Charge	KWH	$0.00	$0.00	$0.07	$0
33-42-0102	1.5 HP Motor, Electric Charge	MO	$0.00	$0.00	$62	$69
33-42-0106	Misc. Electrical Site Usage	MO	$0.00	$0.00	$275	$305

NOTES:

(a) Productivity factor of 82% applied to labor unit costs where applicable. See Ref. 1 for details.
(b) Local cost factor of 1.11 applied for the Warren County, New Jersey. See Ref. 1 for details.
(c) Subcontractor overhead (15%) and profit (10%) included in unit cost were applicable. See Ref 2 for details.

REFERENCES:

1. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA.
2. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Additional Unit Cost Information

Description	Units	Unit Cost
Soil Borings	LF	$47
Subtiltle D Landfill Transport and Disposal	CY	$100

TABLE E-5
Unit Costs Derived from Means Unit Prices
PVGCS OU1 Study Area
Groundwater Media
Feasibility Study

Means Category	Description	Units	Labor Unadjusted Cost	Labor Productivity Factor (a)	Labor Adjusted Cost	Equipment Unadjusted Cost	Equipment Productivity Factor	Equipment Adjusted Cost	Materials Cost	Subtotal	Local Cost Factor (b)	Subtotal	Contractor Mark-Up Overhead	Contractor Mark-Up Profit	Estimated Unit Cost
ENVIRONMENTAL REMEDIATION COST DATA - UNIT PRICE (Ref. 1)															
17-03-0101	Rough Grading	SY	$0.95	82%	$1.16	$2.55	100%	$2.55	$0.00	$3.71	1.11	$4.12	15%	10%	$5.00
17-03-0201	Excavation, Spoil to Side	CY	$0.43	82%	$0.52	$0.41	100%	$0.41	$0.00	$0.93	1.11	$1.04	15%	10%	$1.00
17-03-0202	Trenching, 1 CY Gradall, Light Soil, 95 CY per hour	CY	$1.71	82%	$2.09	$2.99	100%	$2.99	$0.00	$5.08	1.11	$5.63	15%	10%	$7.00
17-03-0401	Trench Backfill, 3 CY, 950	CY	$0.45	82%	$0.55	$0.66	100%	$0.66	$0.00	$1.21	1.11	$1.34	15%	10%	$2.00
17-03-0415	Backfill with excavated material	CY	$2.43	82%	$2.96	$0.81	100%	$0.81	$0.33	$4.10	1.11	$4.55	15%	10%	$6.00
17-03-0423	Backfill with Offsite Borrow, 6" Lifts, Spreading, Compaction	CY	$1.00	82%	$1.22	$2.10	100%	$2.10	$5.63	$8.95	1.11	$9.93	15%	10%	$12.00
17-03-0517	Spread/Compact Lg. Areas, 6" Lifts, D8 and Towed Sheepsfoot	CY	$0.22	82%	$0.27	$0.48	100%	$0.48	$0.00	$0.75	1.11	$0.83	15%	10%	$1.00
18-01-0102	Gravel, Delivered & Dumped	CY	$1.78	82%	$2.17	$1.62	100%	$1.62	$21.11	$24.90	1.11	$27.64	15%	10%	$35.00
18-01-0105	Asphalt, Stabilized Base Course	CY	$0.61	82%	$0.74	$1.28	100%	$1.28	$32.38	$34.40	1.11	$38.19	15%	10%	$48.00
18-02-0312	Asphalt Wearing Course	TN	$14.26	82%	$17.39	$14.24	100%	$14.24	$30.98	$62.61	1.11	$69.50	15%	10%	$87.00
33-02-1806	VOC Analysis (Method TO-14) - Offgas	EA	$0.00	82%	$0.00	$0.00	100%	$0.00	$144.34	$144.34	1.11	$160	15%	10%	$200.00
33-02-0508	VOC Analysis	EA	$0.00	82%	$0.00	$0.00	100%	$0.00	$166.00	$166.00	1.11	$184	15%	10%	$230.00
33-19-0210	Dump Truck Transportation HW, 200-299 Miles	MI	$0.00	82%	$0.00	$0.00	100%	$0.00	$2.32	$2.32	1.11	$2.58	15%	10%	$3.00
33-19-0217	Dump Truck Transportation HW, 900-999 Miles	MI	$0.00	82%	$0.00	$0.00	100%	$0.00	$2.00	$2.00	1.11	$2.22	15%	10%	$3.00
33-19-7264	Landfill HW Disposal	CY	$0.00	82%	$0.00	$0.00	100%	$0.00	$148.00	$148.00	1.11	$164.28	15%	10%	$205.00
33-19-7270	Landfill Solid Waste Disposal	CY	$0.00	82%	$0.00	$0.00	100%	$0.00	$93.50	$93.50	1.11	$103.79	15%	10%	$130.00
33-23-0101	2" PVC, Schedule 40, Well Casing	LF	$2.34	82%	$2.85	$6.67	100%	$6.67	$1.15	$10.67	1.11	$12	15%	10%	$15.00
33-23-0256	2" PVC, Schedule 40, Well Screen	LF	$3.92	82%	$4.78	$11.18	100%	$11.18	$2.07	$18.03	1.11	$20	15%	10%	$25.00
33-23-0555	4" Submersible Pump, 56-95 gpm, 41'<Head<100', 3 HP, w/ controls	EA	$0.00	100%	$0.00	$0.00	100%	$0.00	$3,042	$3,042.00	1.11	$3,377	15%	10%	$4,221.00
33-23-0561	4" Submersible Pump, 96-200 gpm, 101'<Head<150', 7.5 HP, w/ controls	EA	$0.00	100%	$0.00	$0.00	100%	$0.00	$4,481	$4,481.00	1.11	$4,974	15%	10%	$6,217.00
33-23-1180	Mob/demob, Drill Equipment or Trencher, Crew	EA	$438.25	82%	$534.45	$1,250.00	100%	$1,250.00	$243	$2,026.95	1.11	$2,250	15%	10%	$2,812.00
33-26-0406	4" PVC Piping, with Fittings	LF	$9.81	82%	$11.96	$0.45	100%	$0.45	$2.96	$15.37	1.11	$17.06	15%	10%	$21.00
33-42-0101	Electrical Charge	KWH	$0.00	100%	$0.00	$0.00	100%	$0.00	$0.07	$0.07	1.11	$0.08	0%	0%	$0.00
33-42-0102	1.5 HP Motor, Electric Charge	MO	$0.00	100%	$0.00	$0.00	100%	$0.00	$62	$61.83	1.11	$69	0%	0%	$69.00
33-42-0106	Misc. Electrical Site Usage	MO	$0.00	100%	$0.00	$0.00	100%	$0.00	$275	$274.80	1.11	$305	0%	0%	$305.00

NOTES:

(a) Productivity factor of 82% applied to labor unit costs where applicable. See Ref. 1 for details.
(b) Local cost factor of 1.11 applied for the Warren County, New Jersey. See Ref. 1 for details.
(c) Subcontractor overhead (15%) and profit (10%) included in unit cost were applicable. See Ref 2 for details.

REFERENCES:

1. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA.
2. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).